ZBORNIK

STRUČNIH RADOVA

2018

Impresum

Nakladnici:
Gral Široki Brijeg
Hering Široki Brijeg

Za nakladnike:
Ružica Mikulić
Ladislav Bevanda

Urednik:
Grgo Mikulić

Prijevod na engleski jezik:
Dinko Jurić

Lektura i korektura:
Sanja Čolak
Dinko Jurić
Grgo Mikulić

Design i grafička priprema:
Emil Kordić

Tisak:
Grafotisak, Grude

CIP

Sadržaj / Contents

Uvodnik

Živimo u vremenu u kojem se znanost i tehnologija razvijaju takvom brzinom da je to gotovo pa i nemoguće pratiti. Količina novoga znanja i novih informacija stvara se svakim danom u toj mjeri da se može govoriti i o svakodnevnim otkrićima za koja bismo mogli reći da su u neku ruku i revolucionarna.

U ranijim razdobljima, od jedne do druge znanstvene revolucije prolazila su stoljeća, danas se takva razdoblja mjere mjesecima, a nerijetko i danima.

Razdoblje u kojem smo trenutno, a i koje nam tek predstoji, po svemu sudeći bit će istinsko ''Znanstveno doba''; ne samo kada je u pitanju stjecanje novih znanja, nego i primjena istih.

Vrijeme u kojem smo prvi dio života posvećivali učenju, obrazovanju, stručnom osposobljavanju, a drugi dio života primjenjivanju tog stečenoga znanja, definitivno je iza nas. Pred nama je vrijeme cijeloživotnoga kontinuiranoga učenja i usavršavanja, primjene toga znanja i kroz primjenu stjecanje novih vještina.

Suvremeno vrijeme od suvremenoga čovjeka traži i očekuje maksimalnu efikasnost u svemu, kako u stjecanju novih znanja, tako i u primjeni tih znanja u praksi i stvarnome životu; kako u formuliranju pitanja koja pred znanost postavlja tehnologija, praksa i životna stvarnost, tako i u brzini i kvaliteti znanstvenih odgovora na ta pitanja.

Samo gospodarski subjekti koji budu gradili sustave, koji će profilirati znanstvenike i stručnjake, znanost i tehnologiju o primjeni znanja u gospodarstvu i u životu čovjeka kao socijalnoga bića, moći će biti nositelji gospodarskoga i svekolikoga socijalnoga razvoja, koji će biti stalan i neprekidan, a što će se opet pozitivno odraziti na izbjegavanje kriza i planiranje bez skrivenih rizika. Kontinuirano ulaganje u profesionalno usavršavanje, unapređivanje znanja, osposobljavanje i edukacija su ključni elementi razvoja i pojedinca i društva općenito.

Ovaj Zbornik na neki način je prilog ostvarenju toga cilja i pokazatelj kako već postoje gospodarski subjekti kao što je Hering d.d. iz Širokoga Brijega, koji je izgradio takav sustav koji ne samo da potiče znanstveno-stručna istraživanja, nego svojim aktivnostima i sam pridonosi takvom znanstveno-tehnološkom i uopće gospodarskom razvitku sredine u kojoj djeluje.

Nekolicina onih koji su u nekom dijelu svog znanstveno-stručnog usavršavanja imali doticaja s Heringom našli su svoje mjesto u ovom Zborniku, te im ovim putem upućujemo zahvalnost za njihov prinos društvu.

Urednik

Editorial

We live in the age where science and technology develop in such a speed which is almost impossible to follow. The great quantity of new knowledge and new information is created every day to such an extent that it is plausible to talk about daily discoveries that might be called revolutionary in a way.

Whereas, in the earlier periods, centuries had to pass from one scientific revolution to another, nowadays, such periods are measured by months and sometimes even by days.

Everything points to the fact that the age where we are at the moment and also the forthcoming one, will be a real "Scientific Age"; not only concerning acquisition of new knowledge, but its application as well. The age where we used to devote the first part of our lives to learning, education and professional development, and another part of our lives to applying the acquired knowledge is definitely behind us. We are faced with the age of continuous whole-life learning and development, the application of this knowledge and acquisition of new skills through the application.

Contemporary age demands and expects a contemporary human to be extremely efficient in everything, both when acquiring new knowledge and when applying that knowledge in practice and in real life; both in shaping the questions posed to science by technology, practice and reality, and in promptness and quality of scientific answers to those questions.

Only those economic entities that create systems to shape scientists and professionals, science and technology about the implementation of knowledge in economy and in the life of a human as a social being, will be able to become holders of continuous and uninterrupted economic and total social growth, which will in turn have a positive influence to avoiding crisis and to planning without hidden risks. Continuous investment into professional development, enhancement of knowledge, training and education are the key elements of both individual development and the development of society in general.

In a way, this Proceedings is a contribution to the realization of that goal and an indicator that there are already economic entities such as Joint Stock Company Hering d.d. from Široki Brijeg, which has created such a system that not only encourages scientific and professional research, but through its activities it also contributes to such scientific, technological and generally economic development of the area where it operates.

A number of those who had some contact with Hering during a part of their scientific and professional development have found their place in this Proceedings, and in this way we express our gratitude for their contribution to society.

Editor

Mr.sc. Ladislav Bevanda, dipl.ing.građ.
Hering d.d. Široki Brijeg

Marin Nikolić, mag.ing.građ
Hering d.d. Široki Brijeg

ANALIZA UTJECAJA PROJEKTNIH RIZIKA I RIZIKA POSLOVNOG SUSTAVA PRILIKOM FORMIRANJA PONUDBENE CIJENE

ANALYSIS OF PROJECT RISKS AND BUSINESS SYSTEM RISKS IMPACT DURING BID PRICE CREATION

ANALIZA UTJECAJA PROJEKTNIH RIZIKA I RIZIKA POSLOVNOG SUSTAVA PRILIKOM FORMIRANJA PONUDBENE CIJENE

Mr.sc. Ladislav Bevanda, dipl.ing.građ.
Hering d.d. Široki Brijeg

Marin Nikolić, mag.ing.građ
Hering d.d. Široki Brijeg

Sažetak: Rad prikazuje rezultate istraživanja procjene utjecaja projektnih te rizika poslovnog sustava na formiranje ponudbene cijene i budžet izvođača projekta kod projekata izvođenja građevinskih radova.

Prilikom formiranja jediničnih cijena za ponudu izvođenja građevinskih radova implementiraju se procijenjeni utjecaji projektnih rizika na ukupne cijene rada, materijala, usluge drugih, strojeva i opreme, te općih posrednih troškova gradilišta. Implementiranje procjena utjecaja ostalih poslovnih rizika na budžet projekta provodi se procjenom utjecaja poslovnih rizika na ukupne indirektne posredne troškove poslovnog sustava koji se prenose na budžet projekta. Na ovaj način uvodi se negativni utjecaj rizika na sve komponente cijene ponude. Primjenom ovog modela procjene rizika mogu se procijeniti rezerve za rizike kod projekata izvođenja građevinskih radova u fazi ponude pa se tako procjenjeni u uneseni u ponudu i budžet projekta mogu pratiti u eventualnoj realizaciji projekata.

Ključne riječi: upravljanje rizicima, ponudbena cijena, budžet izvođača prjekta

1. Uvod

Radom je prikazana analizira građevinskih projekata (dalje ''projekti'') i to od strane izvođača radova s aspekta rizika troškova u ugovornoj (ponudbenoj) cijeni. Građevinski poslovni sustav (uglavnom građevinski, u daljem tekstu ''poslovni sustav'') preuzima projekt formirajući projektni sustav za realiziranje takvog projekta. Poslovni sustav, dakle, formira projekte, potporno utječe na projektne sustave te osigurava njihovu financijsku stabilnost te dugoročnu profitabilnost u interesu cijeloga poslovnog sustava. Projektni sustav definiran od strane poslovnog sustava u uvjetima zadane cijene, roka i kvalitete realizira izvođački projekt uz potporu poslovnog sustava (izvorne organizacije).

ANALYSIS OF PROJECT RISKS AND BUSINESS SYSTEM RISKS IMPACT DURING BID PRICE CREATION

M.Sc.Ladislav Bevanda, BCE
Hering d.d. Široki Brijeg

Marin Nikolić, MCE
Hering d.d. Široki Brijeg

Abstract: This paper presents results of research of estimation of impact of both project risks and business system risks to the formation of contractor's bid price and budget in projects of executing construction works.

During creation of unit prices for bids to execute construction works, the estimated impacts of project risks are implemented to the total cost of labor, materials, others' services, machinery, equipment, and general indirect costs of construction site. The implementation of the estimation of other business risks to the project budget is conducted through the assessment of business risks impact to the total indirect intermediary costs of business system which are transmitted to the project budget. In this way, a negative impact of risk is introduced to all components of bid price. Using this model of risk assessment, it is possible to estimate risk reserves for execution of construction project in tender phase; estimated in this way and included into the bid and project budget, they can be monitored during potential realization of projects.

Key words: risk management, bid price, contractor's budget

1. Introduction

This paper analyzes the execution of construction projects (hereinafter "projects") by contractors from cost risk aspects in the contract (bid) price. The construction business system (mainly construction, hereinafter referred to as the "business system") takes over the project by forming a project system for the realization of such a project. The business system takes over projects, supports project systems and ensures their financial stability and long-term profitability in the interests of the entire business system. The project system defined by the business system under given pricing, deadline and quality conditions realizes the construction project supported by the business system (of the original organization). At the beginning of

Na početku svakog projekta postoji velika količina rizika troškova koji proizlazi iz neizvjesnosti oko načina na koji će se projekt izvoditi (Smith i sur, 2006). Količina rizika veoma je ovisna i o okruženju u kojem se projekt realizira.

Rizik predstavlja neizvjesnost u ishod očekivanih događaja u budućnosti, odnosno on je situacija u kojoj nismo sigurni što će se dogoditi, a odražava vjerojatnost mogućih ishoda oko neke očekivane vrijednosti. Pri tome očekivana vrijednost predstavlja prosječni rezultat nepredvidivih situacija koje se opetovano ponavljaju (Srića, 2011). Stanje troškova poslovnog sustava koje je poduzeo projekt i troškova projektnog sustava međusobno utječu jedan na drugi. Poslovni sustav svojom potpornom funkcijom ako je potrebno može poboljšati troškovne performanse projekta ali isto tako projektni sustav svojim stanjem troškova u realizaciji utječe na troškovno stanje i performanse poslovnog sustava. Utjecaji mogu biti pozitivni i/ili negativni. Pozitivni utjecaji su dobro došli i njih u ovom radu nećemo razmatrati. U radu će se najprije napraviti kratak pregled literature o utjecaju rizika na ponudbenu cijenu kod izvođača radova. Rezultatima istraživanja analizirat će se utjecaj obilježja projekta na pojavu izvora rizika te utjecaj izvora rizika na uvećanje odgovarajućeg dijela cijene prilikom formiranja ponude za izvođenje projekta odnosno potencijalnog budžeta projekta izvođača radova.

Također će biti prikazani rezultati istraživanja utjecaja vjerojatnosti pojave rizika poslovnog sustava na strukturu poslovnog uspjeha cijelog sustava te utjecaja pokretača poslovnih rizika na vjerojatnost pokretanja poslovnih rizika. Ovim radom prikazat će se dakle i analizirati rezultati istraživanja utjecaja rizika na ponudbenu cijenu izvođača radova a sve u svrhu formiranja kvantitativnog modela za izračun ponudbene cijene za izvođače građevinskih radova koja bi u sebi na adekvatan način sadržavala i moguće negativne utjecaja rizika na pojedine dijelove cijene prilikom izvođenja projekta.

2. Pregled literature

Građevinski projekti izloženi su većem intenzitetu djelovanja rizika zbog složenosti i jedinstvenih obilježja projekata poput dugog vremena izvođenja, složenih procesa, nepristupačnog okruženja, financijskog intenziteta i dinamičkih organizacijskih struktura (Flanagan i Norman, 1993., Akintoye i MacLeod, 1997, Smith, 2003). Stoga za izvođača građevinskih radova pravilno definiranje utjecaja rizika na cijenu izvođenja projekata predstavlja neizostavan dio uspješno izvedenih građevinskih projekata. Izvođači su tradicionalno koristili visoke premije za pokriće pojave eventualnih rizika prilikom izvođenja radova, ali kako je konkurencija postala snažnija, ovaj pristup više nije mogao biti učinkovit (Baloi i Price, 2003). Kao standard u stručnoj literaturi postavljeno je da izvođači u svojim ponudbenim cijenama obično uključuju skrivenu premiju za rizik (Hackett i dr, 2007).

Dosadašnja istraživanja su pokazala da premije rizika čine oko 0-5% cijene ponuđača za izvođenje građevinskih radova (Neufville i King, 1991; Shash, 1993; Smith i Bohn, 1999).

U posljednja tri desetljeća formiran je značajan broj formalnih i analitičkih modela utjecaja rizika na cijenu radova koji izvođači mogu uključiti u postupak određivanja cijene prilikom spremanja ponude za izvođenje radova (npr. fuzzy set model formiran od strane Zenga i sur., 2007; fuzzy logic-based artificial neural network mode formiran od strane Liu i Ling, 2005, fuzzy set model formiran each project there is a large amount of cost risk arising from uncertainty about the way the project will be run (*Smith et al.., 2006*). The amount of risk also depends on the general business environment in which the project is realized.

The risk represents uncertainty in the outcome of expected events in the future, namely, it is a situation where we are uncertain of what will happen and it reflects the probability of possible outcomes related to a certain expected value. Here, the expected value is the average result of unpredictable situations frequently repeated. (*Srića, 2011*). The cost of the business system taken over by the project and the cost of the project system interact with each other. If necessary, the business system with its support function can improve cost-effectiveness of a project but also the project system with its cost performance during realization affects the cost and performance of the business system. The effects can be both positive and/or negative. Positive influences are welcome and they will not be discussed in this paper. Indeed, a brief overview of the literature on impact of risk on the contractor's price will be made first. Through the results of the research we will also analyze the impact of the project's characteristics on the occurrence of risk sources and the impact of the risk sources on the increase of the appropriate share of the price when forming a bid for the project execution or the potential project budget of the contractor.

It will also show the results of the study of impacts of the risk occurrence probability of a business system on the business success structure of the whole system and the impact of business risk drivers on the probability of starting business risks. This paper will therefore present and analyze the results of the research of the impact of the risk on the contractor's bid price, all with the purpose of forming a quantitative model for the calculation of the bid price for construction works contractors, which would adequately contain the possible negative effects of the risk on certain parts of the price during a project execution.

2. Literature overview

Construction projects are exposed to greater intensity of risk impact due to the unique features and complexity of construction projects such as long running times, complex processes, inaccessible environments, financial intensity and dynamic organizational structures (*Flanagan and Norman, 1993, Akintoye and MacLeod, 1997, Smith, 2003*). Consequently, the proper definition of the impact of the risk on the cost of the execution of projects represents an indispensable part of successful construction projects for the contractor of construction works. Contracators have traditionally used high premiums to cover possible risks when conducting works, but as competition became more powerful, this approach could no longer be effective (*Baloi and Price, 2003*). It is accepted as a standard in the professional literature that contractors usually include a hidden risk premium in their bid prices (*Hackett et al., 2007*).

Previous research has shown that risk premiums make up about 0-5% of the tenderers' bid price for carrying out construction works (*Neufville and King, 1991; Shash, 1993; Smith and Bohn, 1999*).

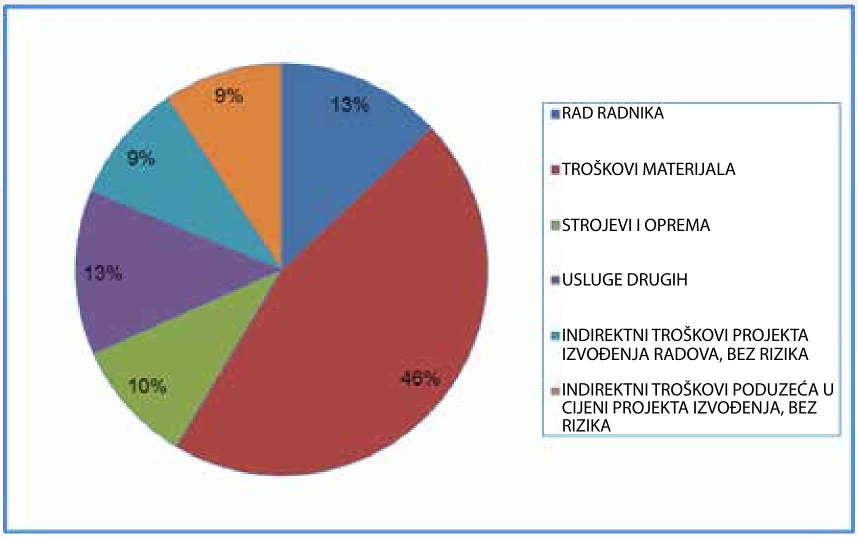
During previous three decades, a significant number of formal and analytical models of price risk impacts have been formed, which can be used by contractors in cost-pricing procedures when preparing a bid for works (eg. Fuzzy set model formed by Zenga et al., 2007; Fuzzy logic-based Artificial neural network mode formed by Liu and Ling, 2005, Fuzzy set model formed by Paek et al., 1993, a fuzzy set model formed by od strane Paek i sur., 1993, fuzzy set model formiran od strane Taha i sur., 1993, i tehnika utemeljena na dijagramu utjecaja Al-Bahar i Crandall, 1990) (Laryea i Hughes, 2011). Međutim, način na koji izvođači zapravo izračunavaju utjecaj rizika na formiranje ponudbene cijene nije jasno artikuliran u građevinskoj literaturi (Laryea i Hughes, 2008). Također, nekoliko empirijskih studija provedenih među izvođačima građevinskih radova pokazalo je vrlo rijetko korištenje ovih modela u praksi.

3. Metodologija istraživanja

Pregledom literature utvrđen je nedostatak modela uključivanja utjecaja rizika pri formiranju ponudbene cijene projekta od strane izvođača građevinskih radova. Zbog toga je formirana i provedena anketa među građevinskim organizacijama čiji će rezultati poslužiti u formiranju modela izračuna jedinične cijene projekta koji će u sebi imati uključene i negativne utjecaje rizika na istu. Rezultate istraživanja dobili smo na osnovu ankete provedene među 40 građevinskih organizacija za izvođenje građevinskih projekata s područja Bosne i Hercegovine i to po 10 građevinskih organizacija s područja Sarajeva, Mostara, Banja Luke i Tuzle. Za svaki od pojedinih dijelova istraživanja bit će objašnjena metodologija analize podataka i određivanja rezultata.

4. Analiza rezultata istraživanja

Prikazani su rezultati istraživanja na pitanje koji je najčešći udio pojedinih komponenti cijene u poslovima građevinskih organizacija koje su obuhvaćene istraživanjem.



Slika 1. Udio pojedinih komponenti cijene u poslovima građevinskih organizacija obuhvaćenih istraživanjem

Taha et al., 1993, and techniques based on the Al-Bahar and Crandall influence diagram, 1990) (*Laryea and Hughes, 2011*). However, the way in which contractors actually calculate the impact of risk on the formation of a bid price is not clearly articulated in construction literature (*Laryea and Hughes, 2008*). Several empirical studies carried out by construction contractors have also shown that these models are rarely used in practice.

3. Research methodology

A review of the literature found a lack of a model for incorporating the impact of risk into the formation of the bid price of the project by the contractors of construction works. For this reason, a survey has been formed and conducted among construction organizations, whose results will serve to form a model of unit price calculation that will have negative risks included. The results were obtained on the basis of a survey conducted among 40 construction organizations for construction projects in the territory of Bosnia and Herzegovina, namely 10 construction organizations from Sarajevo, Mostar, Banja Luka and Tuzla, respectively. The methodology of data analysis as well as the methodology of establishing the results will be explained for each of the individual parts of the research.

4. Analysis of research results

The results of the research are presented for the question of the most common share of individual cost components in the work of construction organizations that were covered by the research.

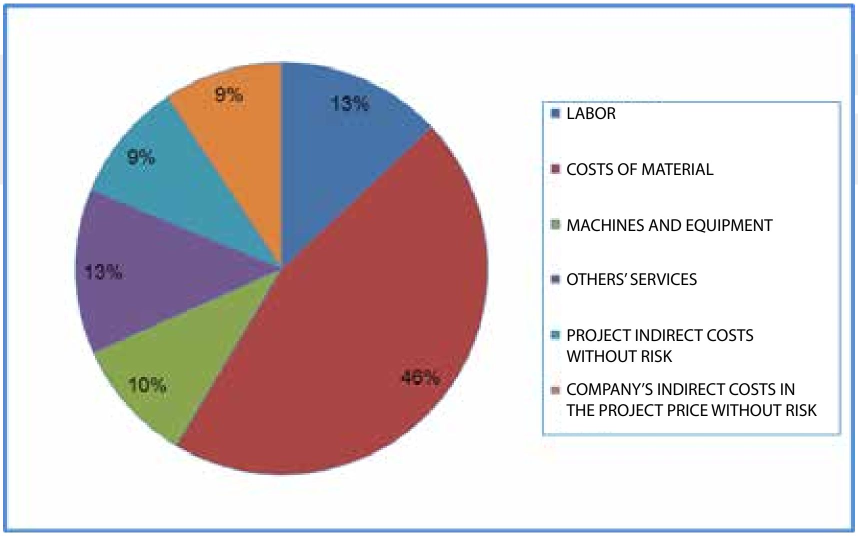
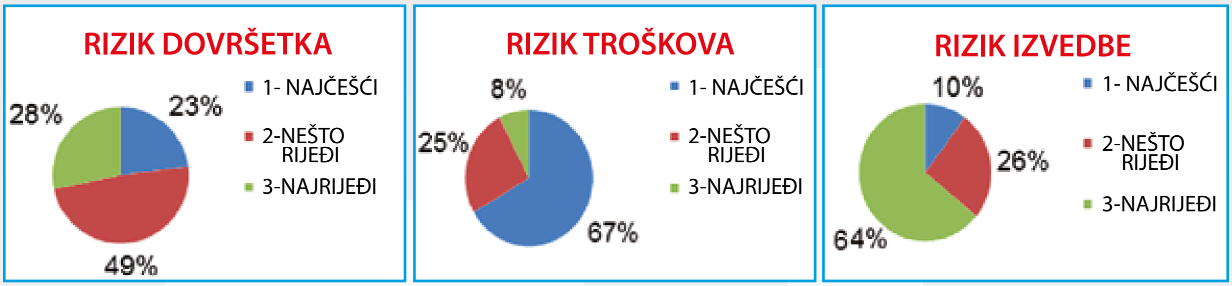


Figure 1. The share of individual cost components in the work of construction organizations involved in the research

Rezultati nam pokazuju da najveći udio pri formiranju cijene u poslovima ispitanih organizacija imaju troškovi materijala. Samim time možemo zaključiti da i obilježja projekta koja imaju najveći utjecaj na povećanje vjerojatnosti pojave rizika koji se odnose na troškove materijala imaju najveći utjecaj na povećanje cijene odnosno budžeta projekta kod ispitanih izvođača radova.

Istraživanjem su poredani rizici dovršetka radova unutar planiranog vremena, troškova unutar proračuna te opsega projekta u traženoj kvaliteti po učestalosti pojave od 1 do 3. 1 predstavlja najčešće a 3 najrjeđe pojavljivani rizik prilikom izvođenja radova.



Slika 2. Učestalost pojave rizika pri izvođenju projekata

Iz rezultata istraživanja vidimo da su izvođači radova ocijenili da je najučestaliji rizik troškova s 67% što upućuje na potrebu detaljnijeg sagledavanja rizika i njihovog utjecaja na troškove, odnosno na budžet kod izvođača radova.

4.1 Utjecaj obilježja projekta na vjerojatnost pojave izvora projektnih rizika

Provedenim istraživanjem analizirani su utjecaji obilježja projekata na vjerojatnost pojave izvora rizika koji onda mogu dovesti do promjene cijena izvođenja odnosno budžeta kod izvođača građevinskih radova.

Svaki rizik ima svoj uzrok. Svaki uzrok rizika ima određenu vjerojatnost njegovog nastupanja. Istraživanjem će se utvrditi koliko obilježja nekog projekta i projektnog okruženja utječu na vjerojatnost pojave vanjskih odnosno unutarnjih izvora rizika. U vanjske izvore rizika svrstani su pravni, politički, ekonomski, socijalni i prirodni, dok su u unutarnje izvore rizika svrstani upravljanje, tehnička dokumentacija, ljudski faktor, opskrba i logisitika, te ugovaranje.

The results show that the cost of material has the largest share in price formation in the works of the surveyed organizations. Thus, we can conclude that the features of the project that have the greatest impact on increasing the probability of risk-related material costs have the greatest impact on the price increase or project budget for the surveyed contractors,

The research has ordered the risks of completing the works within the planned time, the costs within the budget and within the scope of the project with the requested quality by the frequency of the occurrence from 1 to 3. 1 represents the most frequent and 3 the least frequent risk during the execution of works.

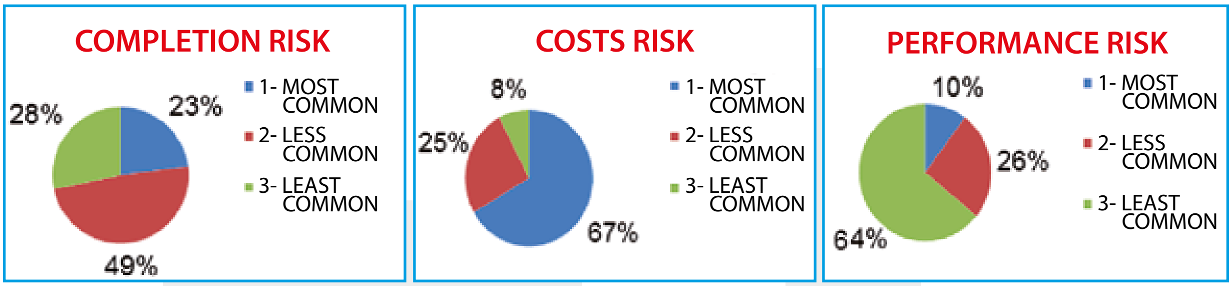


Figure 2. Frequency of occurrence of risk in project execution

From the results of the research we can see that the contractors rated the cost risk as the most frequent one with 67% of occurence, indicating the need for a more detailed account of risks and their impact on the costs, i.e. on the budget of contractors.

4.1 Impact of project features on probability of occurrence of project risk sources

The research has analyzed the impact of project features on the probability of the occurrence of risk sources which can later result in the changes of execution cost, i.e. contractor's budget.

Each risk has its cause. Each cause of the risk has a certain probability of its occurrence. The research will determine how much the project features and project environment affect the probability of occurrence of external or internal risk sources. External risk sources are classified as legal, political, economic, social and natural, while internal risk sources are classified as management, technical documentation, human factor, supply and logistics, and contracting.

Tablica 1. Vanjski i unutarnji izvori rizika

Vanjski izvori rizika				
Pravni	***Politički***	***Ekonomski***	***Socijalni***	***Prirodni***
Lokalni propisi	Promjene politike	Ekonomska politika	Obrazovanje, kultura	Klima
Dozvole	Izbori	Cijene, pristojbe	Sezonski rad	Tlo
Suglasnosti	Rat	Uvjeti financiranja	Štrajk	Požari
Promjene zakona	Sporazumi	Tečaj valute	Fluktuacija ljudi	Potresi, poplave
Standardi				
Unutarnji izvori rizika				
Upravljanje	***Tehnička dokumentacija***	***Ljudski faktor***	***Opskrba i logistika***	***Ugovaranje***
Nerealni ciljevi	Nepotpunost	Produktivnost	Nestašice	Vrsta ugovora
Loša kontrola	Netočnost	Bolovanje	Isporuke	Kratki rokovi
Tehnologija organizacije	Nezavršenost	Motivacija	Pouzdanost strojeva	Nerealna cijena
	Nova rješenja	Propusti	Nedostatak ljudi	Odnosi sudionika

U ovom dijelu rada prikazani su rezultati istraživanja koliki % pojedina obilježja projekta imaju na vjerojatnost pojave izvora rizika. Pod obilježjima projekta i projektnog okruženja analizirani su intenziteti utjecaja tehnologije, rokova, mogućnosti podizvođača, konflikti resursa, sigurnost, okoliš, učešće državne regulative, politički interesi, broj ključnih suradnika, kompleksnost projekata, resursi i radna snaga, broj lokacija izvođenja radova, financiranje i utjecaj na troškove projekta, veličina i tip izgradnje s gledišta zaštite okoliša i zaštite na radu, potrebe kvalitete, javno učešće te programi odvijanja izvođenja projekta. Istraživanjem rizika ispitano je koliki utjecaj na pojavu rizika imaju pojedina obilježja projekta na skali od 1 do 10. 1 predstavlja najmanji a 10 najveći utjecaj na vjerojatnost pojave rizičnog događaja. Vrijednost moda za svaki od ispitanih uzroka predstavlja razinu utjecaja odnosno pripadajuću vjerojatnost pojave izvora rizika. Intenzitet utjecaja podijeljen je u 5 razreda.

Table 1. External and internal risk sources

External risk sources				
Legal	***Political***	***Economic***	***Social***	***Natural***
Local regulations	Change in politics	Economic politics	Education, culture	Climate
Permits	Elections	Prices, taxes	Seasonal work	Soil
Approvals	War	Terms of financing	Strike	Fire
Changes to the law	Agreements	Currency exchange rate	Fluctuation of people	Earthquakes, flooding
Standards				
Internal risk sources				
Management	***Technical documentation***	***Human factor***	***Supply and logistics***	***Contracting***
Unreal goals	Incompleteness	Productivity	Shortages	Contract types
Bad controlling	Inaccuracy	Sick leave	Deliveries	Short deadlines
Organizational technology	Incompletion	Motivation	Reliability of machines	Unreasonable price
	New solutions	Omissions	Lack of people	Relationships between participants

In this section, the results of the research show what percentage certain project features have on probability of risk source to occur. Within the project features and the project environment, the following issues were analyzed: intensity impact of technology, deadlines, sub-contractors' potentials, resource conflicts, safety, environment, participation of government regulation, political interests, number of key collaborators, complexity of projects, resources and labor force, number of works locations, financing and impact on project costs, size and type of construction from the point of view of environmental protection and occupational safety, quality requirements, public participation and project implementation programs. Risk study investigated the amount of impact that individual project features have on risk occurrence on a scale of 1 to 10. 1 represents the least and 10 the greatest impact on the probability of occurrence of a risk event. The mode value for each of the studied causes is the level of impact or the belonging probability of a risk source occurrence. Impact intensity is divided into 5 classes.

Tablica 2. Razredi intenziteta utjecaja obilježja projekta na izvor rizika

Intenzitet utjecaja	Očekivanje iz teorijske razdiobe	Mod	Vjerojatnost pojave rizika
Vrlo nizak utjecaj VNU	0-2	0-2	0-20 %
Nizak utjecaj NU	2-4	2-4	20-40 %
Umjeren utjecaj UU	4-6	4-6	40-60 %
Visok utjecaj VU	6-8	6-8	60-80 %
Vrlo visok utjecaj VVU	8-10	8-10	80-100 %

Prikazani su i pojedinačno analizirani rezultati za sva nabrojana obilježja projekta i projektnog okruženja. Rezultati su svrstani u razrede intenziteta utjecaja djelovanja obilježja projekta na svaki pojedini projektni izvor.

OBILJEŽJA PROJEKTA - UZROCI	VANJSKI					UNUTARNJI				
	PRAVNI	POLITIČKI	EKONOMSKI	SOCIJALNI	PRIRODNI	UPRAVLJANJE	TEHNIČKA DOKUMENTACIJA	LJUDSKI FAKTOR	OPSKRBA I LOGISTIKA	UGOVARANJE
TEHNOLOGIJA	8	9	5	3	4	7	5	4	10	7
	VVU	VVU	UU	NU	UU	VU	UU	UU	VVU	VU
ROKOVI	10	10	1	10	5	6	9	9	3	4
	VVU	VVU	VNU	VVU	UU	VU	VVU	VVU	NU	UU
MOGUĆNOSTI PODIZVOĐAČA	7	10	1	4	6	2	7	9	3	10
	VU	VVU	VNU	UU	VU	NU	VU	VVU	NU	VVU
SUČELJAVANJE POTREBA	4	1	7	9	10	4	3	1	10	3
	UU	VNU	VU	VVU	VVU	UU	NU	VNU	VVU	NU
SIGURNOST	1	2	4	7	1	3	5	10	9	10
	VNU	NU	UU	VU	VNU	NU	UU	VVU	VVU	VVU
OKOLIŠ	10	2	7	4	5	5	7	9	3	5
	VVU	NU	VU	UU	UU	UU	VU	VVU	NU	UU
UČEŠĆE DRŽAVNE REGULATIVE	1	10	8	4	5	3	7	8	9	5
	VNU	VVU	VVU	UU	UU	NU	VU	VVU	VVU	UU
POLITIČKO VIĐENJE	2	1	3	4	5	6	6	3	9	10
	NU	VNU	NU	UU	UU	VU	VU	NU	VVU	VVU
BROJ KLJUČNIH SUDIONIKA	5	10	2	9	10	6	7	7	5	10
	UU	VVU	NU	VVU	VVU	VU	VU	VU	VU	VVU
KOMPLEKSNOST PROJEKTA	8	9	6	6	2	4	1	3	4	5
	VVU	VVU	VU	VU	NU	UU	VNU	NU	UU	UU
RESURSI / RADNA SNAGA/ PRODUKTIVNOST	7	2	3	6	2	6	5	1	5	8
	VU	NU	NU	VU	NU	VU	UU	VNU	UU	VVU
BROJ LOKACIJA GRADILIŠTA	10	10	6	9	4	7	5	6	2	7
	VVU	VVU	VU	VVU	UU	VU	UU	UU	NU	VU
FINANCIRANJE / UTJECAJ NA TROŠKOVE	8	10	3	2	10	3	7	5	8	6
	VVU	VVU	NU	NU	VVU	NU	VU	UU	VVU	VU
ZAŠTITA OKOLIŠA	10	9	5	2	1	5	4	3	9	10
	VVU	VVU	UU	NU	VNU	UU	UU	NU	VVU	VVU
POTREBE KVALITETE	10	10	8	3	4	1	3	2	8	7
	VVU	VVU	VVU	NU	UU	VNU	NU	NU	VVU	VU
JAVNO UČEŠĆE	3	2	2	7	10	5	5	3	3	8
	NU	NU	NU	VU	VVU	UU	UU	NU	NU	VVU
PROGRAMI ODVIJANJA	3	2	2	9	6	4	5	1	4	6
	NU	NU	NU	VVU	VU	UU	UU	VNU	UU	VU

Slika 3. Intenziteti utjecaja obilježja projekta na vjerojatnost pojave izvora rizika

Table 2. Intensity classes of project features' impact on risk sources

Impact intensity	Expectations of theoretic classification	Mode	Risk occurrence probability
Very low impact VNU/VLI	0-2	0-2	0-20 %
Low impact NU/LI	2-4	2-4	20 - 40 %
Moderate impact UU/MI	4-6	4-6	40 - 60 %
High impact VU/HI	6-8	6-8	60 - 80 %
Very high impact VVU/VHI	8-10	8-10	80 - 100 %

The results for each of the listed project features and project environment are presented and analyzed separately. The results were classified into the classes of impact intensity of project features on each project source.

PROJECT FEATURES – CAUSES	EXTERNAL					INTERNAL				
	LEGAL	POLITICAL	ECONOMIC	SOCIAL	NATURAL	MANAGEMENT	TECH. DOC.	HUMAN FACT.	SUPP & LOG	CONTRACTING
TECHNOLOGY	8	9	5	3	4	7	5	4	10	7
	VVU	VVU	UU	NU	UU	VU	UU	UU	VVU	VU
DEADLINES	10	10	1	10	5	6	9	9	3	4
	VVU	VVU	VNU	VVU	UU	VU	VVU	VVU	NU	UU
SUBCONTRACTORS' COMPETENCE	7	10	1	4	6	2	7	9	3	10
	VU	VVU	VNU	UU	VU	NU	VU	VVU	NU	VVU
CONFRONTING REQUIREMENTS	4	1	7	9	10	4	3	1	10	3
	UU	VNU	VU	VVU	VVU	UU	NU	VNU	VVU	NU
SAFETY	1	2	4	7	1	3	5	10	9	10
	VNU	NU	UU	VU	VNU	NU	UU	VVU	VVU	VVU
ENVIRONMENT	10	2	7	4	5	5	7	9	3	5
	VVU	NU	VU	UU	UU	UU	VU	VVU	NU	UU
STATE REGULATIONS PARTICIPATION	1	10	8	4	5	3	7	8	9	5
	VNU	VVU	VVU	UU	UU	NU	VU	VVU	VVU	UU
POLITICAL ASPECT	2	1	3	4	5	6	6	3	9	10
	NU	VNU	NU	UU	UU	VU	VU	NU	VVU	VVU
NUMBER OF KEY PARTICIPANTS	5	10	2	9	10	6	7	7	5	10
	UU	VVU	NU	VVU	VVU	VU	VU	VU	VU	VVU
PROJECT COMPLEXITY	8	9	6	6	2	4	1	3	4	5
	VVU	VVU	VU	VU	NU	UU	VNU	NU	UU	UU
RESOUJRCES/ LABOR FORCE/ PRODUCTIVITY	7	2	3	6	2	6	5	1	5	8
	VU	NU	NU	VU	NU	VU	UU	VNU	UU	VVU
NUMBER OF SITE LOCATIONS	10	10	6	9	4	7	5	6	2	7
	VVU	VVU	VU	VVU	UU	VU	UU	UU	NU	VU
FINANCING / COST IMPACT	8	10	3	2	10	3	7	5	8	6
	VVU	VVU	NU	NU	VVU	NU	VU	UU	VVU	VU
ENVIRONMENT PROTECTION	10	9	5	2	1	5	4	3	9	10
	VVU	VVU	UU	NU	VNU	UU	UU	NU	VVU	VVU
QUALITY REQUIREMENTS	10	10	8	3	4	1	3	2	8	7
	VVU	VVU	VVU	NU	UU	VNU	NU	NU	VVU	VU
PUBLIC INVOLVEMENT	3	2	2	7	10	5	5	3	3	8
	NU	NU	NU	VU	VVU	UU	UU	NU	NU	VVU
RUNNING SCHEDULE	3	2	2	9	6	4	5	1	4	6
	NU	NU	NU	VVU	VU	UU	UU	VNU	UU	VU

Figure 3. Impact intensity of project features to the probability of risk sources occurrence

Prema rezultatima istraživanja obilježja projekta koja uključuju promjene u tehnologiji imaju nizak utjecaj na pojavu socijalnih izvora rizika. Obilježja projekta vezanih uz tehnologiju najveći utjecaj imaju na pojavu izvora rizika vezane za opskrbu i logistiku stoga što bilo kakva promjena u tehnologiji može dovesti do povećanja troškova projekta odnosno budžeta uslijed problema s nabavkom radne snage ili opreme za izvođenje radova na takvom projektu. Također, promjena tehnologije izvođenja može tražiti nove dozvole ili suglasnosti što znači da tehnologija ima vrlo visok utjecaj na mogućnost pojave pravnih izvora rizika. Rezultati istraživanja vezani za obilježja projekta povezana s rokovima pokazuju nam da ovakva obilježja projekta imaju vrlo nizak i nizak utjecaj na pojavu ekonomskih izvora rizika te izvora rizika vezanih za opskrbu i logistiku iako teoretski gledano produžetak rokova ili odugovlačenje u izvođenju može snažno utjecati na pojavu izvora rizika uslijed promjene tečaja valute u kojoj je ugovoreno izvođenje ili uslijed nedostatka radne snage potrebne za druge projekte. Produžetak izvođenja projekta uzrokuje mogućnost pojave rizika zbog potrebe za novim dozvolama ili suglasnostima, promjenama politika uslijed dugotrajnog izvođenja, motivacije ili fluktuacije radnika, smanjene produktivnosti itd.

Očekivani rezultati istraživanja su takvi da obilježja projekata povezana s mogućnostima podizvođača, obilježja građevinskih projekta koji se izvode imaju visok utjecaj na vjerojatnost pojave rizika vezanih za upravljanje te opskrbu i logistiku zbog moguće loše kontrole, nepostojanja adekvatne opreme i strojeva kod podizvođača, ili eventualnog nedostatka ljudi uslijed nerealnih ciljeva koje je podizvođač preuzeo. Ipak, prema rezultatima provedenog istraživanja ovakva obilježja projekta imaju vrlo nizak utjecaj na vjerojatnost pojave ekonomskih izvora rizika te nizak utjecaj na vjerojatnost pojave rizika vezanih za upravljanje i opskrbu i logistiku.

Rezultati pokazuju da na projekte kod kojih dolazi do sučeljavanje potreba i sposobnosti obilježja projekta imaju vrlo nizak utjecaj na vjerojatnost pojave političkih i izvora rizika vezanih za ljudski faktor. Rezultati istraživanja pokazuju da ovakva obilježja projekta najveći mogući utjecaj imaju na vjerojatnost pojave izvora rizika vezanog za opskrbu i logistiku zbog preklapanja ili nestašice pojedinih resursa, nedostatka radne snage ili nemogućnosti isporuke ključnih resursa. Rezultat koji smo dobili istraživanjem za vjerojatnost pojave prirodnih izvora rizika u odnosu na teoriju zbunjuje jer je vrlo teško zaključiti zašto ovoliko velik utjecaj sučeljavanje potreba i sposobnosti ima na vjerojatnost pojave prirodnih izvora rizika. Prema rezultatima istraživanja obilježja projekta vezana za sigurnost najveći utjecaj imaju na vjerojatnost pojave izvora rizika vezanih za ljudski faktor te ugovaranje. Iz rezultata istraživanja možemo zaključiti da utjecaj sigurnosti kao obilježja projekta ima u prosjeku nizak utjecaj na vanjske izvore rizika te veliki utjecaj na vjerojatnost pojave unutarnjih izvora rizika što je očekivano stoga što se sigurnost pri izvođenju uglavnom kontrolira iz unutrašnjosti same organizacije.

Prikazani rezultatima istraživanja ukazuju nam na to da obilježja projekta koja se povezuju s okolišom u prosjeku imaju umjeren utjecaj na vjerojatnost pojave kako unutarnjih tako i vanjskih izvora rizičnih događaja. Dodatni zahtjevi za okoliš podrazumijevaju veću vjerojatnost pojave rizičnih događaja zbog potrebe za dodatnim suglasnostima i dozvolama te mogu prouzrokovati eventualno smanjenje produktivnosti, česta bolovanja kod radne snage ili propuste zbog strogih zahtjeva sa zaštitom okoliša.

According to the results of the research, project features that involve changes in technology have a low impact on the occurrence of social risk sources. Technology-related features have the greatest impact on the supply and logistics risk source, as any change in technology can lead to increased project or budget costs due to workforce procurement or procurement of equipment for performing such a project. Also changing the technology of performance may require new permits or approvals, which means that technology has a very high impact on the potential for the occurrence of legal risk sources. The research results related to project features associated with deadlines show that such features of a project have very low and low impact on the occurrence of economic sources of risk and sources of supply and logistics risks although theoretically the extension of deadlines or delay in execution can strongly influence the occurrence of risk sources due to a change in the exchange rate of the currency in which the performance was contracted or because of the lack of workforce needed for other projects Prolongation of a project is causing the risk because of the need for new permits or approvals, policy changes due to long-lasting execution, motivation or employee fluctuation, reduced productivity,etc.

Expected results of the research are such that project features associated with the capabilities of subcontractors of the construction project features being performed have a high impact on the probabillity of occurrence of management risk and supply and logistics risks due to possible bad control, lack of adequate equipment and machinery on the part of subcontractors or possible lack of people due to unrealistic goals the subcontractor undertook. However, according to the results of the research, such features of the project have a very low impact on the probability of the occurrence of economic risk sources and a low impact on the probability of management risk and supply and logistics risks.

The results show that project features have a very low impact on the probability of the occurrence of political and human factor risk sources on the projects where there is confronting of requirements and competence. The research findings show that such features of a project have the greatest potential impact on the probability of supply and logistics risk sources due to overlap or scarcity of resources, lack of workforce, or inability to deliver key resources. The result we have obtained by investigating the probability of the occurrence of natural risk sources is confusing compared with theory, because it is very difficult to conclude why such a large impact of confronting of requirements and capabilities is likely to result in natural risk sources. According to the research results, the safety related project features have the greatest impact on the probability of the occurrence of risk factors related to the human factor and contracting. From the results of the research we can conclude that the impact of safety as a project feature on average has a low impact on external risk sources and a great influence on the probability of occurrence of internal risk sources as expected because safety at execution is mainly controlled from within the organization itself.

The displayed research results show that the environmental related project features on average have a moderate impact on the probability of occurrence of both internal and external sources of risk events. Additional environmental requirements imply a higher probability of occurrence of risk events due to the need for additional approvals and permissions, and can lead to possible productivity reductions, frequent illnesses in the workforce or omissions due to strict environmental protection requirements.

According to the results of the research, the participation of government regulations on average has a high impact on the probability of occurrence of risk events during project execution. These project

Prema rezultatima istraživanja učešće državne regulative ima u prosjeku visok utjecaj na vjerojatnost pojave rizičnih događaja prilikom izvođenja projekta. Ovakva obilježja projekta imaju vrlo visok utjecaj na vjerojatnost pojave političkih, ekonomskih te izvora rizika vezanih za ljudski faktor te opskrbu i logistiku. Rezultat vrlo visokog utjecaja učešća državne regulative na mogućnost pojave rizika vezanih za ljudski faktor i opskrbu i logistiku s obzirom na pretpostavke nije očekivan, ali možemo zaključiti da su izvođači radova imali česta neočekivana negativna iskustva vezana za ovakve uzroke i izvore rizičnih događaja koji su im doveli do povećanja budžeta prilikom izvođenja radova.

Unatoč očekivanjima da obilježja projekta povezana s političkim viđenjem imaju visok utjecaj na vjerojatnost pojave svih vrsta izvora rizika a pogotovo vanjskih rezultati su u potpunosti suprotni. Utjecaj ovog obilježja projekta na vjerojatnost pojave vanjskih izvora rizičnog događaja prema rezultatima istraživanja je u prosjeku niska te ni za jedan od vanjskih izvora ne prelazi intenzitet umjerenog utjecaja na vjerojatnost pojave rizičnog događaja. U prosjeku političko viđenje ima visok utjecaj na mogućnost pojave unutarnjih izvora rizika što nema baš mnogo poveznica s očekivanim rezultatima jer se ipak očekivalo da političko viđenje i politički interesi mnogo veći utjecaj imaju na mogućnost pojave vanjskih izvora rizika.

Prema rezultatima istraživanja predstavljena obilježja projekta vezana za broj ključnih sudionika imaju visok utjecaj na vjerojatnost izvora rizičnih događaja u projektu te kao takva imaju i visok utjecaj na povećanje cijena a time i budžeta projekta kod izvođača koji izvode projekt s takvim obilježjima. Ostaje nejasno na osnovu čega su se ispitane organizacije izjasnile da im ovakva obilježja projekta imaju vrlo veliki utjecaj na ove izvore rizika jer je teško teorijski povezati veći broj ključnih sudionika i eventualne preferirane podizvođače te dobavljače s povećanom vjerojatnosti pojave izvora rizika vezanih za promjene politike, obrazovanje i kulturu, sezonski rad radnika ili utjecaj klime ili eventualne požare prilikom izvođenja projekta.

Prema rezultatima istraživanja kompleksnost projekta ima u prosjeku umjeren utjecaj na vjerojatnost pojave izvora rizičnih događaja kod izvođenja projekata. Ipak gledano odvojeno kompleksnost projekta ima visok utjecaj na vanjske izvore a nizak utjecaj na unutarnje izvore rizičnih događaja. Najveći utjecaj kompleksnost projekta prema rezultatima istraživanja ima na vjerojatnost pojave političkih izvora rizika. Ukoliko projekt ima ovakva obilježja prema istraživanju vjerojatnost pojave političkog izvora rizika kreće se od 80 do 100 %.

Prema rezultatima istraživanja iznad, obilježja projekta vezana za resurse i produktivnost radne snage imaju u prosjeku umjeren utjecaj na vjerojatnost pojave izvora rizika. Na vjerojatnost pojave vanjskih izvora rizika ovakva obilježja projekta očekivano imaju nizak utjecaj stoga što se ovakva obilježja uglavnom odnose na radnu snagu i na unutarnja pitanja organizacije. Najveći utjecaj prema istraživanju ovakva obilježja projekta imaju na vjerojatnost pojave rizika vezanih sa ugovaranjem i to vrlo visok utjecaj sto znači da je vjerojatnost pojave izvora rizika vezanog za ugovaranje između 80 i 100%.

Prema rezultatima istraživanja obilježja projekta povezana s brojem lokacija izvođenja radova imaju općenito visok utjecaj na vjerojatnost pojave rizika. Ovakvi rezultati istraživanja koje smo dobili ispitivanjem građevinskih organizacija koje izvode radove nisu očekivani jer teorijski je teško povezati zbog čega ovakva obilježja projekta imaju vrlo veliki utjecaj na socijalne ili političke izvore rizika.

features have a very high impact on the probability of occurrence of political, economic and human risk factors as well as supply and logistics ones. The result of a very high impact of the participation of state regulations on the probability of occurrence of human factor and supply and logistics risk factors was not expected, but we can conclude that the contractors had frequent unexpected negative experiences related to such causes and sources of risk events that resulted into increase of the budget when executing works.

Despite the expectations that political project features will have a high impact on the probability of occurrence of all types of risk sources, especially the external ones, the results are completely opposite. The impact of this project feature on the probability of occurrence of external risk sources events according to the results of the research is low on average, and concerning external sources, it does not exceed the intensity of moderate impact on the probability of occurrence of a risk event. On average, political aspects have a high impact on the potential for internal risk sources, which does not have much to do with the expected results, as it was expected that political aspects and political interests have much greater impact on the probability of occurrence of external risk sources.

According to the research results, the project features related to the number of key participants have a high impact on the probability of risk sources events in a project and as such they have a high impact on the price increase and thus on the project budget of the contractors executing the project with such features. What were the basis on which the surveyed organizations stated that these project features have a very high impact on these risk sources remains unclear, as it is theoretically difficult to associate a greater number of key participants and probably preferred subcontractors and suppliers with increased probability of the occurrence of the risk sources related to policy change, education and culture, seasonal work or the impact of the climate or eventual fires during the project execution.

According to the research results, the project complexity on average has moderate impact on the probability of occurrence of risk sources events during project execution. However, when considered separately, the complexity of a project has a high impact on external sources and low impact on internal sources of risk events. According to the research results, project complexity has the greatest impact on the probability of the emergence of political risk sources. If the project has such features, the probability of the emergence of a political risk source ranges from 80 to 100% according to the research.

According to research findings, the project feature related to resources and labor force productivity have moderate impact on the probability of occurrence of risk sources on average. These project features are expected to have a low impact on the probability of external risk sources because these features are mainly related to the workforce and the internal issues of an organization. According to the research, such project features have the greatest impact on the probability of occurrence of contracting risks, and this is a very high impact, which means that the probability of a source of contracting risk is 80 -100%.

According to the results of the research, the project features associated with the number of work locations have a generally high impact on the probability of risk occurrence. Such research results obtained by examining construction organizations that execute works are not expected because it is theoretically difficult to understand why such project features have a very high impact on social or political risk sources. According to the research results, this category of project features has the lowest impact on the probability of the occcurrence of economic, social and management risk sources.

Prema rezultatima istraživanja ova kategorija obilježja projekta ima najmanji utjecaj na vjerojatnost pojave ekonomskih, socijalnih te izvora rizika vezanih za upravljanje. Vrlo visok intenzitet utjecaja ova kategorija obilježja projekta ima na vjerojatnost pojave pravnih, političkih, prirodnih te izvora rizika vezanih za opskrbu i logistiku. Ukoliko je projekt javni to uzrokuje da veliki utjecaj na njega ima promjena politike, promjena vlasti na izborima ili eventualni politički sporazumi. Izvođenje projekta preko dvije godine ima utjecaj na vrlo visok utjecaj na vjerojatnost pojave rizika vezanih za opskrbu i logistiku.

U skladu s očekivanjima, obilježja projekta povezana s trajanjem projekta većim od dvije godine što dovodi do značajnijih utjecaja na financiranje izvođenja projekta imaju vrlo visok utjecaj na vjerojatnost pojave pravnih, političkih te izvora rizika povezanih sa ugovaranjem te opskrbom i logistikom. Zbog strožih ekoloških zahtjeva postoji rizik od povećanja cijene i budžeta uslijed rizika izazvanih dodatnim dozvolama, suglasnostima ili posebnim standardima.

Prema rezultatima istraživanja najmanji, odnosno vrlo nizak utjecaj karakteristike projekta povezane s veličinom i tipom izgradnje s gledišta zaštite okoliša i odvoženja otpada imaju na izvore rizičnih događaja koji se odnose na upravljanje. Vrlo visok utjecaj obilježja projekta vezana za potrebe kvalitete imaju na mogućnost pojave pravnih, političkih te izvora rizika vezanih s opskrbom i ugovaranjem. Visoki zahtjevi kvalitete povećavaju mogućnost porasta troškova uslijed nekih specijalnih isporuka materijala, nedostatka kvalitetnih ljudi te ne mogućnosti pribavljanja pouzdane opreme za izvođenje radova u skladu sa zahtijevanim razinama kvalitete.

Prema rezultatima istraživanja obilježja projekta vezana za potrebe kvalitete najveći utjecaj ima na vjerojatnost prirodnih izvora rizika. Vrlo visok utjecaj ovakva obilježja projekta imaju i na izvore rizika koji se odnose na ugovaranje. Ovakva obilježja projekta utječu na kompleksnost ugovaranja, vrlo komplicirane odnose sudionika te kao takvi mogu dovesti do značajnog povećanja budžeta izvođenja projekta uslijed rizika izazvanih utjecajem javnih konzultacija na odnose sudionika u projektu.

Prikazani rezultati istraživanja ukazuju nam na to da obilježja projekta vezana za javno učešće općenito imaju nizak ili umjeren utjecaj na vjerojatnost izvora rizičnih događaja tijekom izvođenja projekta. Programi odvijanja s posebnim potrebama oko radnog vremena povećavaju vjerojatnost izvora rizika vezanih za sezonski rad, štrajkove ili fluktuaciju ljudi uslijed takvih okolnosti te imaju veoma visok intenzitet utjecaja na vjerojatnost pojave rizičnih događaja prilikom izvođenja projekata.

Analizirani rezultati ovako formiranih intenziteta utjecaja uzroka pojave izvora rizika koristit će se pri formiranju modela za izračun jediničnih kao i ukupne ponudbene cijene za izvođenje projekata bez obzira na očekivanja i bez ikakvih prilagođavanja obzirom na pretpostavke uoči istraživanja.

4.2 Utjecaj izvora projektnih rizika na pojavu rizika dovršetka, troškova te rizika izvedbe

Nakon što je istraživanjem utvrđen utjecaj obilježja projekta na vjerojatnost pojave izvora rizika pristupilo se procjeni kaje posljedice izaziva pojava pojedinih izvora rizika, odnosno koliki utjecaj pojedini izvor rizika ima na rizik dovršetka radova, troškova, te rizik izvedbe u zadanim granicama.

This category of project features has very high impact intensity to the probability of occurrence of legal, political, natural and supply and logistics risk sources. If a project is the public one, it causes change of policy, change of government in elections or possible political agreements to have a major influence on it. Project executions lasting over two years have an influence on very high impact on the probability of occurrence of supply and logistics risks.

As expectated, the project features associated with project duration over two years, which result in significant impact on project financing, have a very high impact on the probability of occurrence of legal, political, contracting, supply and logistics risk sources. Due to stricter ecological requirements, there is a risk of price and budget increases due to risks caused by additional permits, approvals or special standards.

According to the research results, project features related to the size and type of construction from the point of view of environmental protection and waste disposal have the lowest or very low impact on management related risk sources. Project quality-related features have very high impact on the probability of occurrence of legal, political and supply and contracting risk sources. High quality demands increase the possibility of increased costs due to some special delivery of materials, lack of high quality people, and due to the lack of reliable equipment to perform the works in accordance with the required quality levels.

According to the results of the research, the project features related to the needs of quality have the greatest impact on the probability of occurrence of natural risk sources. Such project features also have a very high impact on the risks involved in contracting. These project features affect the complexity of contracting and complicated relationships between the participants, and as such can lead to a significant increase in project implementation budget due to the risks caused by the influence of public consultation on the relationship of the participants in the project.

The research results show that the public involvement project features generally have a low or moderate impact on the probability of occurrence of sources of risk events during a project implementation. Implementation programs with specific needs concerning working hours increase the probability of risk sources related to seasonal work, strikes or fluctuations in people due to such characteristics and have a very high impact on the probability of occurrence of risky events during the project execution.

The analyzed results of thus established impact intensity of the causes of the occurrence of risk sources will be used to form the model for calculating the unit price as well as the total bid price for the execution of projects regardless of expectations and without any adjustments with respect to the presumptions prior to the research.

4.2 Impact of project risk sources on the occurrence of completion, costs and performance risks

After the research has established the impact of project features on the probability of occurrence of risk sources, an assessment has been made to determine the consequences of the occurrence of certain risk sources, i.e. the impact of a certain risk source on the completion of works, costs and

Stupanj utjecaja određivao se kroz anketu među građevinskim organizacijama. Stupnjevi utjecajaja podjeljeni su u tri razreda od 1 do 3 gdje 1 predstavlja najveći a 3 najmanji utjecaj na rizike dovršetka, troškova te rizik izvedbe. Prikazani su rezultati izjašnjavanja anketiranih organizacija u postotcima za svaki stupanj utjecaja.

IZVOR RIZIKA	STUPANJ UTJECAJA	RIZIK DOVRŠETKA (%)	RIZIK TROŠKOVA (%)	RIZIK IZVEDBE (%)
PRAVNI	1	37,50	22,50	20,00
	2	25,00	37,50	20,00
	3	37,50	40,00	60,00
POLITIČKI	1	27,50	30,00	25,00
	2	25,00	27,50	27,50
	3	47,50	42,50	47,50
EKONOMSKI	1	32,50	53,50	20,00
	2	35,00	27,50	42,50
	3	32,50	20,00	37,50
SOCIJALNI	1	30,00	37,50	27,50
	2	22,50	37,50	20,00
	3	47,50	25,00	52,50
PRIRODNI	1	45,00	17,50	30,00
	2	42,50	35,00	32,50
	3	12,50	47,50	37,50
UPRAVLJANJE	1	30,00	25,00	40,00
	2	35,00	47,50	25,00
	3	25,00	27,50	35,00
TEHNIČKA DOKUMENTACIJA	1	30,00	25,00	47,50
	2	40,00	32,50	22,50
	3	30,00	42,50	30,00
LJUDSKI FAKTOR	1	47,50	32,50	40,00
	2	35,00	50,00	25,00
	3	17,50	17,50	35,00
OPSKRBA I LOGISTIKA	1	47,50	42,50	15,00
	2	27,50	40,00	45,00
	3	25,00	17,50	40,00
UGOVARANJE	1	47,50	27,50	37,50
	2	22,50	52,50	30,00
	3	30,00	20,00	32,50

Slika 4. Stupanj utjecaja izvora rizika na pojavu rizika dovršetka, troškova, te izvedbe

Prema rezultatima istraživanja najveći utjecaj na neizvjesnost dovršetka izvođenja građevinskog projekta imaju pravni izvori rizika, prirodni, rizici upravljanja, te izvori rizika povezani sa ljudskim faktorom, ugovaranjem, te opskrbom i logistikom. Najmanji pak utjecaj na neizvjesnost dovršetka izvođenja građevinskog projekta u planiranom vremenu prema rezultatima istraživanja imaju politički rizici.

Najveći utjecaj na neizvjesnost ostvarenja troškova unutar proračuna kod izvođenja građevinskih projekata imaju politički, ekonomski te socijalni rizici dok 47,5 % odnosno 42,50 % ispitanika smatra da najmanji utjecaj na troškove imaju prirodni te rizici vezani za tehničku dokumentaciju.

performance risks within the set limits. Impact levels were determined through a survey among construction organizations. Impact levels were divided into three classes from 1 to 3 where 1 represents the highest and 3 the lowest impact on the risks of completion, cost and performance. The results of the surveyed organizations are shown in percentages for each impact level.

RISK SOURCE	IMPACT DEGREE	COMPLETION RISK (%)	COST RISK (%)	PERFORMANCE RISK (%)
LEGAL	1	37,50	22,50	20,00
	2	25,00	37,50	20,00
	3	37,50	40,00	60,00
POLITICAL	1	27,50	30,00	25,00
	2	25,00	27,50	27,50
	3	47,50	42,50	47,50
ECONOMIC	1	32,50	53,50	20,00
	2	35,00	27,50	42,50
	3	32,50	20,00	37,50
SOCIAL	1	30,00	37,50	27,50
	2	22,50	37,50	20,00
	3	47,50	25,00	52,50
NATURAL	1	45,00	17,50	30,00
	2	42,50	35,00	32,50
	3	12,50	47,50	37,50
MANAGEMENT	1	30,00	25,00	40,00
	2	35,00	47,50	25,00
	3	25,00	27,50	35,00
TECHNICAL DOCUMENTATION	1	30,00	25,00	47,50
	2	40,00	32,50	22,50
	3	30,00	42,50	30,00
HUMAN FACTOR	1	47,50	32,50	40,00
	2	35,00	50,00	25,00
	3	17,50	17,50	35,00
SUPPLY AND LOGISTICS	1	47,50	42,50	15,00
	2	27,50	40,00	45,00
	3	25,00	17,50	40,00
CONTRACTING	1	47,50	27,50	37,50
	2	22,50	52,50	30,00
	3	30,00	20,00	32,50

Figure 4. Impact levels of risk sources on the occurrence of risk of completion, cost and performance

According to the research results, legal, natural, management, human resources, contracting, supply and logistics risks have the greatest impact on the uncertainty of completing the construction project. Political risks have the least impact on the uncertainty of completing a construction project in the planned time, according to the research results.

Political, economic and social risks have the greatest impact on the uncertainty of realizing the costs within the budget in executing construction projects, whereas 47.50% and 42.50% of respondents believe that natural and technical documentation risks, respectively, have the least impact on the costs.

Rizici koji najveći utjecaj imaju na neizvjesnost ostvarenja opsega projekta u traženoj kvaliteti su rizici upravljanja za koje to smatra 40% ispitanih izvođača radova te rizici tehničke dokumentacije za koje to smatra 47,50 % ispitanih izvođača. Najmanji pak utjecaj na neizvjesnost ostvarenja projekta u traženoj kvaliteti imaju pravni, politički, ekonomski, socijalni te rizici ljudskog faktora, opskrbe i logistike, ugovaranja te rizici povezani s upravljanjem.

4.3 Utjecaj izvora projektnih rizika na uvećanje odgovarajućeg dijela cijene u fazi pripreme ponude za izvođenje projekta

Istraživanjem smo došli do podataka koliko u postotku pojedini već navedeni izvori rizika uvećavaju odgovarajući dio cijene izvođenja građevinskih radova u fazi pripreme ponude. U rezultatima istraživanja kao relevantan podatak uzeli smo srednju vrijednost svih 40 odgovora ispitanih izvođača radova. Anketirane organizacije su na temelju dosadašnjih iskustava naveli rezervacije uslijed utjecaja izvora rizika za pojedine dijelove cijene izvođenja projekta. Rezultati rezervacije prikazani su u postotcima s obzirom na pojedini dio cijene.

IZVOR RIZIKA	DIREKTNI TROŠKOVI				INDIREKTNI TROŠKOVI PROJEKTA I GRADILIŠTA IZVOĐENJA RADOVA
	RAD RADNIKA	MATERIJAL	STROJEVI I SREDSTVA	USLUGA DRUGIH	
PRAVNI	2,50%	1,88%	1,92%	2,40%	2,23%
POLITIČKI	1,73%	1,43%	1,33%	1,33%	1,98%
EKONOMSKI	4,68%	4,48%	4,28%	3,90%	4,05%
SOCIJALNI	3,23%	2,38%	2,30%	2,35%	2,18%
PRIRODNI	2,50%	1,82%	1,98%	1,55%	2,28%
UPRAVLJANJE	2,95%	3,18%	3,15%	2,00%	3,50%
TEHNIČKA DOKUMENTACIJA	2,93%	3,38%	2,53%	2,83%	2,85%
LJUDSKI FAKTOR	4,35%	3,83%	3,28%	3,33%	3,18%
OPSKRBA I LOGISTIKA	3,73%	3,73%	4,25%	3,48%	4,20%

Slika 5. Utjecaj izvora rizika na uvećanje pojedinog dijela cijene

Pravni izvori rizika najveći utjecaj ima na povećanje dijela cijene projekta povezanu s cijenom rada radnika (2,50%) i usluga drugih dok najmanji utjecaj ima na povećanje dijela cijene koji se odnosi na cijenu materijala (1,88%) te strojeva i sredstava.

Risks having the greatest impact on the uncertainty of realizing the scope of the project in the required quality are management risks, as considered by 40% of the contractors, and the risks of technical documentation as considered by 47,50% of the contractors. Legal, political, economic, social, human, supply and logistics, contracting, management risks and management-related risks have the least impact on the uncertainty of the project realization in the required quality.

4.3 Impact of project risk sources on the increase of corresponding part of the price during the preparation of a bid for project execution

The research presented the data about the extent to which the percentage of the individual previously mentioned risk sources increase the corresponding part of the cost of construction works during the bid preparation phase. As a relevant data in the research results, we took the mean of all 40 responses of the surveyed contractors. Surveyed organizations have mentioned reservations based on past experiences due to the impact of risk sources for individual parts of the project execution cost. The results of reservation are shown in percentages per a portion of the price.

RISK SOURCE	DIRECT COSTS				PROJECT AND SITE INDIRECT COSTS
	LABOR	MATERIAL	MACHINERY AND ASSETS	OTHERS' SERVICES	
LEGAL	2,50%	1,88%	1,92%	2,40%	2,23%
POLITICAL	1,73%	1,43%	1,33%	1,33%	1,98%
ECONOMIC	4,68%	4,48%	4,28%	3,90%	4,05%
SOCIAL	3,23%	2,38%	2,30%	2,35%	2,18%
NATURAL	2,50%	1,82%	1,98%	1,55%	2,28%
MANAGEMENT	2,95%	3,18%	3,15%	2,00%	3,50%
TECHNICAL DOCUMENTATION	2,93%	3,38%	2,53%	2,83%	2,85%
HUMAN FACTOR	4,35%	3,83%	3,28%	3,33%	3,18%
SUPPLY AND LOGISTICS	3,73%	3,73%	4,25%	3,48%	4,20%

Figure 5. Impact of risk sources on the increase of a certain portion of the price

Legal risk sources have the greatest impact on the increase in the part of the project cost associated with labor cost (2.50%) and others' services, whereas it has the lowest impact on the increase in the cost price related to the cost of material (1.88%), machinery and assets.

Politički izvori rizika najveći utjecaj imaju na povećanje dijela cijene projekta vezan za indirektne troškove projekta i gradilišta i to 1,98% a najmanji na povećanje dijela cijene vezan za direktne troškove strojeva te usluga drugih (1,33 %). Prosječno gledano prema rezultatima istraživanja pravni izvori rizika imaju najmanji utjecaj na povećavanje dijelova cijena izvođenja građevinskog projekta.

Ekonomski izvori rizika najveći utjecaj imaju na povećanje dijela cijene vezane za rad radnika (4,68%) te materijala (4,48%) a u najmanjoj mjeri utječu na povećanje dijela cijene vezanog za usluge drugih i to 3,80%. Promatrajuću ukupne rezultate istraživanja možemo zaključiti da ekonomski izvori rizika imaju u prosjeku najveći utjecaj na povećanje dijelova odnosno ukupne cijene projekta.

Socijalni izvori rizika najveći utjecaj imaju podjednak utjecaj na povećanje svakog od dijelova cijene projekta ali najveći utjecaj imaju na povećanje dijela cijene vezane za rad radnika a najmanji na indirektne troškove projekta i gradilišta.

Prirodni izvori rizika gledajući ukupne rezultate istraživanja također imaju prosječno nizak utjecaj na povećanje dijelova cijene projekta. Najmanji utjecaj imaju na povećanje dijela cijene vezan za usluge drugih i to 1,55%.

Izvori rizika vezani s upravljanjem najveći utjecaj imaju na povećanje cijene vezane za indirektne troškove projekta i gradilišta (3,50%) a najmanji na usluge drugih (2,00%)

Izvori rizika vezani za tehničku dokumentaciju najveći utjecaj imaju na povećanje dijela cijene projekta povezane s direktnim troškovima materijala (3,38%) a najmanji na dio cijene vezan za strojeve i sredstva obavljanja građevinskih radova (2,53%).

Izvori rizika vezani za ljudski faktor gledano prosječno, imaju utjecaja na dijelove cijene projekta odmah poslije ekonomskih te izvora rizika vezanih za opskrbu i logistiku. Najveći utjecaj imaju na povećanje dijela cijene projekta povezan s radom radnika i to 4,35%.

Izvori rizika vezani za opskrbu i logistiku, kako smo već rekli, imaju intenzitet utjecaja na povećanje dijelova cijena projekta odmah poslije ekonomskih izvora rizika. Najveći utjecaj imaju na povećanje dijela cijene vezan za strojeve i sredstva (4,25%) a najmanji na usluge drugih (3,48%).

4.4 Utjecaj izvora projektnih rizika na uvećanje odgovarajućeg dijela cijene u fazi realizacije projekta

Rezultati istraživanja postotnog povećanja pojedinog dijela cijene kao posljedice prethodno navedenih rizika u fazi realizacije projekta nastali su na osnovu evidencija pojedinih izvođača radova. Anketirane organizacije su na temelju dosadašnjih iskustava naveli povećanje cijene uslijed utjecaja izvora rizika za pojedine dijelove cijene izvođenja projekta u fazi realizacije projekta. Samo u slučaju nepostojanja evidencija izvođači su dali svoju procjenu. Rezultati rezervacije prikazani su u postotcima s obzirom na pojedini dio cijene.

Political risk sources have the greatest impact on the increase of part of the project price related to the indirect costs of the project and the construction site, which is 1.98%, and the lowest impact to the increase of the cost is related to the direct costs of machinery and others' services (1.33%). On average, according to research results, legal risk sources have the lowest impact on increasing the construction cost of a construction project.

Economic risk sources have the greatest impact on the increase in the share of labor cost (4.68%) and material (4.48%), and to the lowest extent they affect the increase of part of the cost related to the services of others, namely 3.80%. Looking at the overall results of the research we can conclude that the economic risk sources on average have the greatest impact on both the increase of the parts and the total cost of the project.

Social risk sources have an equal greatest impact on the increase in each of the parts of the project cost, but the greatest impact is on increasing the share of labor-related costs and the least on the indirect costs of the project and the construction site.

Considering overall research results, natural risk sources also have an average low impact on the increase in project cost. The lowest impact is on the increase in the share of cost related to others' services, and this is 1.55%.

Management related risk sources have the greatest impact on the increase in costs related to the indirect costs of the project and the construction site (3.50%) and the lowest impact on others' services (2.00%)

Risk sources related to technical documentation have the greatest impact on the increase of a part of the cost of the project related to direct costs of material (3.38%) and the lowest impact to the cost of machinery and construction works (2.53%).

Human resources related risk sources, on average, have the third-largest impact on parts of the cost of the project immediately after economic and supply and logistics risk sources. They have the greatest impact on the increase of a part of the project cost associated with the labor and this is 4.35%.

Risk sources of supply and logistics, as we have already mentioned, have intensity impact on the increase in the cost of the project immediately after the economic risk sources. They have the greatest impact on the increase in the cost of machinery and equipment (4.25%) and the lowest on others' services (3.48%).

4.4 Impact of project risk sources on the increase of the corresponding part of the price during the project implementation phase

The research results of the percentage increase of an individual share of the price as a consequence of the above mentioned risks in the project implementation phase were created on the basis of the records of individual contractors. Based on previous experience, surveyed organizations have indicated price increases due to the impact of risk sources for individual parts of the project execution cost in the project implementation stage. Only in the absence of evidence the contractors gave their estimates. The results of the reservation are shown in percentages per portion of the price.

IZVOR RIZIKA	DIREKTNI TROŠKOVI				INDIREKTNI TROŠKOVI PROJEKTA I GRADILIŠTA IZVOĐENJA RADOVA
	RAD RADNIKA	MATERIJAL	STROJEVI I SREDSTVA	USLUGA DRUGIH	
PRAVNI	2,43%	1,88%	2,40%	2,33%	2,63%
POLITIČKI	1,21%	0,85%	1,00%	1,08%	1,43%
EKONOMSKI	3,60%	4,05%	3,85%	3,90%	3,38%
SOCIJALNI	2,10%	1,40%	2,30%	3,40%	1,43%
PRIRODNI	1,80%	1,53%	1,55%	1,53%	1,98%
UPRAVLJANJE	2,98%	3,13%	2,73%	2,80%	2,68%
TEHNIČKA DOKUMENTACIJA	2,93%	2,75%	2,55%	2,68%	2,48%
LJUDSKI FAKTOR	3,85%	3,23%	2,55%	3,15%	2,95%
OPSKRBA I LOGISTIKA	2,95%	3,40%	3,00%	3,25%	3,10%
UGOVARANJE	2,90%	3,28%	2,50%	2,70%	2,38%

Slika 6. Utjecaj izvora rizika na uvećanje pojedinog dijela cijene u fazi realizacije projekta

U fazi realizacije najveći postotak na povećanje dijela cijene vezanog za troškove rada radnika imaju ekonomski rizici (3,60%) te rizici vezani za ljudski faktor (3,85%) dok najmanji utjecaj na dio cijene vezan za troškove rada radnika imaju prirodni rizici i to 1,80% te politčki izvori rizika i to 1,21 %.

Na dio cijene povezan sa troškovima materijala najveći postotak povećanja uzrokuju ekonomski izvori rizika (4,05%) te izvori rizika vezani za opskrbu i logistiku i to 3,40%. Najmanji postotak povećanja dijela cijene vezanog za troškove materijala od navedenih izvora rizika uzrokuju socijalni i to 1,40% te politički 0,85%.

Kod dijela cijene vezan za troškove strojeva i sredstava u fazi realizacije najveći postotak povećanja uzrokuju ekonomski (3,85%) te pravni izvori rizika (3,00%) dok najmanji postotak povećanja od svih navedenih izvora rizika uzrokuju prirodni (1,55%) te politički izvori (1,00%).

Povećanje dijela cijene vezanog za troškove podizvođača u postotku najviše čine ekonomski (3,90%) te rizici vezani za opskrbu i logistiku (3,25%) dok najmanji postotak povećanja uzrokuju prirodni izvori (1,53%) te politički izvori rizika (1,08%).

Na dio cijene povezan sa općim troškovima projekta i gradilišta izvođenja radova najveći postotak povećanja uzrokuju ekonomski (3,38%) te izvori rizika vezani za opskrbu i logistiku (3,10%) dok najmanji postotak povećanja od navedenih izvora rizika uzrokuju socijalni i politički izvori rizika i to u iznosu od 1,43%.

RISK SOURCE	DIRECT COSTS				PROJECT AND SITE INDIRECT COSTS OF WORKS EXECUTION
	LABOR	MATERIAL	MACHINERY AND ASSETS	OTHERS' SERVICES	
LEGAL	2,43%	1,88%	2,40%	2,33%	2,63%
POLITICAL	1,21%	0,85%	1,00%	1,08%	1,43%
ECONOMIC	3,60%	4,05%	3,85%	3,90%	3,38%
SOCIAL	2,10%	1,40%	2,30%	3,40%	1,43%
NATURAL	1,80%	1,53%	1,55%	1,53%	1,98%
MANAGEMENT	2,98%	3,13%	2,73%	2,80%	2,68%
TECHNICAL DOCUMENTATION	2,93%	2,75%	2,55%	2,68%	2,48%
HUMAN FACTOR	3,85%	3,23%	2,55%	3,15%	2,95%
SUPPLY AND LOGISTICS	2,95%	3,40%	3,00%	3,25%	3,10%
CONTRACTING	2,90%	3,28%	2,50%	2,70%	2,38%

Figure 6. Impact of risk sources to the increase of an individual part of the price during project implementation phase

In the stage of implementation, economic risks (3.60%) and risks related to the human factor (3.85%) have the highest percentage of increase in part of the cost related to the labor costs, while natural risks (1.80%) and political risk sources (1.21%) have the lowest impact on a share of labor cost.

The highest percentage increases in the part of the cost associated with the costs of material is caused by economic risk sources (4.05%) and by the sources of supply and logistics risks (3.40%). The smallest percentage increase in the total price related to materials costs is caused by social (1.40%) and political risk sources (0.85%) out of the mentioned risk sources.

Concerning the part of the price related to the costs of machinery and assets during the implementation stage, the highest percentage of increase is caused by economic (3.85%) and legal risk sources (3.00%), while the lowest percentage increase is caused by natural (1.55% and political risk sources (1.00%) out of all mentioned risk sources.

The increase of a part related to the subcontractors' costs is mostly caused by economic (3.90%) and supply and logistics risk sources (3.25%), while the lowest increase percentage is caused by natural resources (1.53%) and political risk sources, 08%).

Regarding the part of the price related to the general costs of the project and construction site, the highest increase percentage is caused by economic (3.38%) and supply and logistics risk sources (3.10%), while the lowest increase percentage is caused by social and political risk sources in the amount of 1.43%, out of all mentioned risk sources.

4.5 Utjecaj rizika poslovnog sustava na strukturu poslovnog uspjeha i stanje poslovnog sustava

Vjerojatnost pojave rizičnog događaja u ovisnosti je o obilježjima poslovnog okruženja i poslovnog sustava. Pojava rizični događaj ima utjecaj na promjene u poslovnom sustavu a samim time i na promjene u projektnom sustavu. Istraživanjem rizičnih događaja ispitano je koliki intenzitet utjecaja na strukturu poslovnog uspjeha i stanje poslovnog sustava imaju rizici poslovnog sustava. Intenzitet utjecaja podijeljen je u pet razreda i to vrlo visoki, visoki, umjeren, nizak te vrlo nizak utjecaj i to od 15 kao najveći mogući i 0 kao najmanji mogući utjecaj. Razred intenziteta utjecaja određuje se na osnovu tablice razreda inteziteta.

Tablica 3. Razredi intenziteta utjecaja rizika troškovnog sustava na poslovni sustav

Intenzitet utjecaja	Srednja vrijednost	Mod
Vrlo nizak utjecaj VNU	0-3	0-3
Nizak utjecaj NU	3-6	3-6
	3-9	0-3
Umjeren utjecaj UU	6-9	3-6
	6-9	6-9
Visok utjecaj VU	6-9	9-12
	6-9	>12
Vrlo visok utjecaj VVU	>9	>12

Prikazani su i analizirani rezultati utjecaja za sve rizike troškovnog sustava na troškove poslovnog sustava a time i na njegov uspjeh. Prikazani su i svrstani u razrede intenziteta utjecaji rizika poslovnog sustava na strukturu poslovnog uspjeha.

Analizom rezultata anketnog istraživanja vidljivo je da izmjene zakonodavstva i propisa kao rizik poslovnog sustava visok utjecaj imaju na ulaganja u osnovna sredstva te na bruto dobit dok najmanji intenzitet utjecaja imaju na ukupan prihod poslovnog sustava i to umjeren utjecaj. U prosjeku gledano najveći utjecaj na uspjeh poslovnog sustava imaju rizici poslovnog sustava povezani sa pritiskom cijena odnosno padom cijena uslijed raznih uzroka. Intenzitet utjecaja ovog poslovnog rizika vrlo je visok i na troškove funkcioniranja poslovnog sustava, ulaganje u obrtna sredstva, bruto dobit te ukupan prihod. Ovi poslovni rizici visok intenzitet utjecaja imaju i na ulaganje u osnovna obrtna sredstva. Prosječno gledano najmanji pak utjecaj na poslovni sustav imaju rizici poslovnog sustava povezani s ekologijom, energetskom učinkovitosti te regulacijom zaštite okoliša. Prema rezultatima istraživanja njihov intenzitet utjecaja je nizak na ulaganja u obrtna sredstva, troškove funkcioniranja poslovnog sustava, ulaganje u obrtna sredstva te ukupan prihod.

4.5 Impact of business system risk on the structure of business success and the state of business

The probability of occurrence of a risk event depends on the business environment and business system features. The occurrence of a risk event influences the changes in the business system and thus it affects the changes in the project system. By investigating risk events, it was examined what impact the intensity of the risks of the business system has on the structure of business success and on the state of the business system. Impact intensity is divided into five classes, namely very high, high, moderate, low, and very low impact, ranging from 15 as the highest possible to 0 as the lowest possible impact. The class of intensity impacts is determined according to the intensity class table.

Table 3. Classes of impact intensity of cost system risks on business system

Impact intensity	Mean value	Mode
Very low impact VNU	0-3	0-3
Low impact NU	3-6	3-6
	3-9	0-3
Moderate impact UU	6-9	3-6
	6-9	6-9
High impact VU	6-9	9-12
	6-9	>12
Very high impact VVU	>9	>12

The impact results of all cost system risks on business system costs and thus on its success are presented and analyzed. The impacts of business system risks on the structure of business success are introduced and classified into intensity classes.

The analysis of the results of the survey shows that changes in legislation and regulations as a business system risk have a high impact on investment in basic assets and on gross profit, whereas they have the lowest impact intensity on the overall business system revenues, namely, moderate impact. On average, the highest impact on the business system success is made by business system risks along with price pressure or decrease of prices due to various causes. The impact intensity of this business risk is very high for the cost of operating a business system, investment in working capital, gross profit and total revenues. These business risks also have a high intensity impact on investment in basic working capital. On average, the lowest impact on the business system is made by business system risks related to ecology, energy efficiency, and environmental regulation. According to research results, their impact intensity is low on investment in working capital, operating system costs, investment in working capital and total income.

RIZICI POSLOVNOG SUSTAVA	ULAGANJE U OSNOVNA STALNA SREDSTVA (SS)		TROŠKOVI FUNKCIONIRANJA POSLOVNOG SUSTAVA (HP)		ULAGANJE U OBRTNA SREDSTVA (OS)		BRUTO DOBIT		UKUPAN PRIHOD	
	srednja vrijednost	mod	srednja vrijednost	mod	srednja vrijednost	mod	srednja vrijednost	mod	srednja vrijednost	mod
izmjena zakonodavstva, propisa, prilagodbe, regulativa	7,45	10	8,20	5	8,15	5	7,64	10	8,03	4
	VISOK UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ	
mogućnost pristupa kreditima	8,90	10	7,15	10	8,44	10	6,64	5	7,40	5
	VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ		NIZAK UTJECAJ	
spor oporavak, dvostruki učinak recesije, dupli nakon kratkog oporavka	9,75	15	8,43	10	9,5	10	9,3	10	9,37	15
	VRLO VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VRLO VISOK UTJECAJ	
problemi u upravljanju talentima, fluktuacija, obrazovanje, obučavanje	7,18	9	7,18	10	6,97	5	6,58	5	6,24	5
	VISOK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ	
tržišta u nastojanju, tranzicija	9,42	10	8,48	5	7,9	5	7,85	5	8,19	15
	VISOK UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ	
aktivnosti na rezanju troškova	7,18	5	7,19	10	6,62	10	6,83	10	6,67	5
	UMJEREN UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ	
novi netradicionalni suradnici, novi poslovni modeli	6,74	5	7,51	10	7,03	8	7,2	7	6,72	6
	UMJEREN UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ	
ekologija, energetska učinkovitost, regulacija zaštita okoliša	5,13	2	5,63	2	5,26	5	6,08	3	5,67	5
	NIZAK UTJECAJ		NIZAK UTJECAJ		NIZAK UTJECAJ		UMJEREN UTJECAJ		NIZAK UTJECAJ	
trend socijano prihvatljivog i društveno odgovornog poslovanja	6,19	5	7,66	5	7,27	5	7,62	3	7,27	10
	UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ	
spajanje, ulaganja i akvizicije	6,12	10	6,31	1	5,97	1	6,68	10	7,15	8
	VISOK UTJECAJ		UMJEREN UTJECAJ		VRLO NIZAK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ	
nemogućnost inoviranja, inovacije	7,88	11	7,66	10	7,11	1	7,17	10	7,69	7
	VISOK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ	
izmjena u održavanju infrastrukture, izmjena ulaganja u infrastrukturu	8,70	10	8,32	10	7,86	10	8,13	10	7,84	10
	VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ	
rizik novih tehnologija, koliko uvođenje novih tehnologija može utjecati na poslovanje	8,70	10	7,77	10	7,90	10	7,00	10	6,85	10
	VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ	
porezni rizik, rizik promjene porezne politike	8,18	5	8,00	3	7,63	5	9,14	10	8,44	10
	UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ	
pritisci cijena - pad cijena usljed raznih uzroka	8,92	15	9,43	15	9,73	15	9,92	15	9,58	15
	VISOK UTJECAJ		UMJEREN UTJECAJ		VRLO VISOK UTJECAJ		VRLO VISOK UTJECAJ		VRLO VISOK UTJECAJ	

Slika 7. Utjecaj rizika troškova poslovnog sustava na strukturu poslovnog uspjeha i stanje poslovnog sustav

4.6 Utjecaj rizika poslovnog sustava na uvećanje odgovarajućeg dijela troškova poslovnog sustava

U ovom dijelu istraživanja analiziran je utjecaj koji izvor rizika vrši na dio stanja poslovnog sustava. Rezultatima su prikazane srednje vrijednosti za koje izvođači smatraju da pojedini izvori rizika poslovnog sustava utječu na stanje poslovnog sustava. Za izvore poslovnog sustava koji utječu na troškove poslovnog sustava za više od 1% kažemo da značajno utječu na troškove dok na one ispod 1% kažemo da samo utječu na troškove poslovnog sustava. Za rezultate utjecaja s prosječnom vrijednosti manjom od 0 smatramo da ne utječu na troškove funkcioniranja poslovnog sustava.

Značajan utjecaj na ulaganja u osnovna obrtna sredstva kao izvor poslovnog rizika imaju izmjene zakonodavstva, spor oporavak od recesije, tržišta u nastajanju i tranzicije, nemogućnost inoviranja, izmjena državnih ulaganja u infrastrukturu, rizik novih tehnologija , porezni rizik te najveći utjecaj od 3,08% pritisci cijena odnosno pad cijena uslijed razlika uzroka.

BUSINESS SYSTEM RISKS	INVESTMENT IN BASIC FIXED ASSETS (SS)		BUSINESS SYSTEM FUNCTIONING COSTS (HP)		INVESTMENT IN WORKING ASSETS (OS)		GROSS PROFIT		TOTAL REVENUES	
	Mean value	mode	Mean value	mode	Mean value	mode	Mean value	mode	Mean value	mode
changes in legislation, regulations, adjustments, legislature	7,45	10	8,20	5	8,15	5	7,64	10	8,03	4
	HIGH IMPACT		MODERATE IMPACT		MODERATE IMPACT		HIGH IMPACT		MODERATE IMPACT	
availability of credits	8,90	10	7,15	10	8,44	10	6,64	5	7,40	5
	HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		MODERATE IMPACT		LOW IMPACT	
slow recovery, double effect of recession, double after a short recovery	9,75	15	8,43	10	9,5	10	9,3	10	9,37	15
	VERY HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		VERY HIGH IMPACT	
problems in managing talents, employee turnover, education, training	7,18	9	7,18	10	6,97	5	6,58	5	6,24	5
	HIGH IMPACT		HIGH IMPACT		MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT	
new, developing markets, transition	9,42	10	8,48	5	7,9	5	7,85	5	8,19	15
	HIGH IMPACT		MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT		HIGH IMPACT	
cost cutting activities	7,18	5	7,19	10	6,62	10	6,83	10	6,67	5
	MODERATE IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		MODERATE IMPACT	
new non-traditional collaborator, new business models	6,74	5	7,51	10	7,03	8	7,2	7	6,72	6
	MODERATE IMPACT		HIGH IMPACT		MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT	
ecology, energy efficiency environment protection management	5,13	2	5,63	2	5,26	5	6,08	3	5,67	5
	LOW IMPACT		LOW IMPACT		LOW IMPACT		MODERATE IMPACT		LOW IMPACT	
trend of socially acceptable and responsible behavior	6,19	5	7,66	5	7,27	5	7,62	3	7,27	10
	MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT		HIGH IMPACT	
merger, investment, acqusition	6,12	10	6,31	1	5,97	1	6,68	10	7,15	8
	HIGH IMPACT		MODERATE IMPACT		VERY LOW IMPACT		HIGH IMPACT		MODERATE IMPACT	
unavailability of innovation, innovations	7,88	11	7,66	10	7,11	1	7,17	10	7,69	7
	HIGH IMPACT		HIGH IMPACT		MODERATE IMPACT		HIGH IMPACT		MODERATE IMPACT	
change in infrastructure maintenance, change of investment in infrastructure	8,70	10	8,32	10	7,86	10	8,13	10	7,84	10
	HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT	
risk of new technologies, to what extent can intr oduction of new techn. influence business	8,70	10	7,77	10	7,90	10	7,00	10	6,85	10
	HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT	
taxation risk, risk of changing taxati. policy	8,18	5	8,00	3	7,63	5	9,14	10	8,44	10
	MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT		HIGH IMPACT		HIGH IMPACT	
price pressure - price drop due to various causes	8,92	15	9,43	15	9,73	15	9,92	15	9,58	15
	HIGH IMPACT		MODERATE IMPACT		VERY HIGH IMPACT		VERY HIGH IMPACT		VERY HIGH IMPACT	

Figure 7. Impact of business system cost risk on the business success structure and the state of business system

4.6 Impact of business system risk on increase of the corresponding part of business system costs

This part of the study analyzes the impact of the risk source on a part of the business system. The results show the mean values for contractors who believe that some of the business system risk sources are affecting the business system. For business system resources that affect the business system costs by more than 1%, we say they have a significant impact on costs, while for those below 1% we say that they only affect the business system costs. For the impact results with an average value below 0, we consider them not to affect the operating costs of a business system.

Significant impact on investment in basic working capital as a business risk source is made by the changes in legislation, slow recovery from recession, emerging markets and transition, inability to innovate, changes of government investment in infrastructure, the risk of new technologies, tax risk and the highest impact of 3.08% is made by price pressures or price drops due to various causes.

Na troškove funkcioniranja poslovnog sustava značajan utjecaj imaju izmjene zakonodavstva, spor oporavak od recesije, novi netradicionalni suradnici, trend socijalno prihvatljivog i društveno odgovornog poslovanja, nemogućnost inoviranja, izmjena državnih ulaganja u infrastrukturu, rizik novih tehnologija, porezni rizik te pritisci cijena odnosno pad cijena. I na troškove funkcioniranja poslovnog sustava najveći utjecaj imaju pritisci cijena i to 3,13 % dok na njih utjecaj nemaju spajanja, ulaganja i akvizicije (0,00%).

RIZICI POSLOVNOG SUSTAVA	ULAGANJE U OSNOVNA STALNA SREDSTVA (SS)	TROŠKOVI FUNKCIONIRANJA POSLOVNOG SUSTAVA (HP)	ULAGANJE U OBRTNA SREDSTVA (OS)	BRUTO DOBIT	UKUPAN PRIHOD
izmjena zakonodavstva, propisa, prilagodbe, regulativa	1,95%	2,63%	2,42%	1,13%	1,26%
mogućnost pristupa kreditima	0,87%	0,28%	1,26%	-0,30%	0,10%
spor oporavak, dvostruki učinak recesije, dupli nakon kratkog oporavka	1,14%	2,78%	1,64%	0,58%	-7,08%
problemi u upravljanju talentima, fluktuacija, obrazovanje, obučavanje	0,08%	0,28%	0,05%	-0,13%	-0,13%
tržišta u nastojanju, tranzicija	2,08%	0,38%	1,08%	0,56%	0,82%
aktivnosti na rezanju troškova	0,26%	0,70%	0,00%	0,10%	-0,21%
novi netradicionalni suradnici, novi poslovni modeli	0,87%	1,13%	1,10%	0,38%	0,85%
ekologija, energetska učinkovitost, regulacija zaštita okoliša	0,64%	0,90%	0,90%	0,50%	0,60%
trend socijano prihvatljivog i društveno odgovornog poslovanja	0,49%	1,03%	0,55%	0,55%	0,35%
spajanje, ulaganja i akvizicije	0,56%	0,00%	0,18%	0,00%	0,05%
nemogućnost inoviranja, inovacije	1,36%	1,13%	0,74%	-0,13%	-0,15%
izmjena u održavanju infrastrukture, izmjena ulaganja u infrastrukturu	1,23%	1,08%	0,18%	-0,13%	-0,69%
rizik novih tehnologija, koliko uvođenje novih tehnologija može utjecati na poslovanje	1,28%	1,74%	0,77%	0,63%	-0,16%
porezni rizik, rizik promjene porezne politike	2,48%	1,64%	1,90%	1,51%	1,26%
pritisci cijena - pad cijena usljed raznih uzroka	3,18%	3,13%	2,92%	1,50%	1,34%

Slika 8. Utjecaj rizika troškova poslovnog sustava na uvećanje dijela troškova poslovnog sustva

Na ulaganje u obrtna sredstva značajan utjecaj imaju izmjene zakonodavstva, mogućnost pristupa kreditima, spor oporavak, tržišta u nastajanju, novi netradicionalni suradnici, porezni rizik te pritisci cijena. Najmanji intenzitet utjecaja na ulaganje u obrtna sredstva imaju problemi u upravljanju talentima i to 0,05% dok najveći utjecaj imaju izvori rizika povezani s pritiskom cijena 2,92%.

Značajan utjecaj na bruto dobit imaju izvori rizika poslovnog sustava povezani sa izmjenama zakonodavstva, porezni rizici te pritisci cijena odnosno pad cijena uslijed raznih uzroka. Najveći utjecaj na bruto dobit imaju porezni rizici i to 1,51% a ispitanici smatraju da na bruto dobit nemaju utjecaja

Changes in legislation, slow recovery from recession, new non-traditional collaborators, a trend of socially acceptable and socially responsible business, the inability to innovate, the change of government investment in infrastructure, the risk of new technologies, the tax risk, and price pressure or price drop have a significant impact on the costs business system. Price pressures also have high impact on costs of business system functioning (3.13%), whereas these are not impacted by merger, investment and acquisitions (0.00%).

BUSINESS SISTEM RISKS	INVESTMENT IN BASIC FIXED ASSETS (SS)	COSTS OF BUSINESS SISTEMS FUNCTIONING (HP)	INVESTMENT IN WORKING ASSETS (OS)	GROSS PROFIT	TOTAL REVENUES
changes in legislation, regulations, adjustments, legislature	1,95%	2,63%	2,42%	1,13%	1,26%
availability of credits	0,87%	0,28%	1,26%	-0,30%	0,10%
slow recovery, double effect of recession, double after a short recovery	1,14%	2,78%	1,64%	0,58%	-7,08%
problems in managing talents, employee turnover, education, training	0,08%	0,28%	0,05%	-0,13%	-0,13%
new, developing markets, transition	2,08%	0,38%	1,08%	0,56%	0,82%
cost cutting activities	0,26%	0,70%	0,00%	0,10%	-0,21%
new non-traditional collaborator, new business models	0,87%	1,13%	1,10%	0,38%	0,85%
ecology, energy efficiency environment protection management	0,64%	0,90%	0,90%	0,50%	0,60%
trend of socially acceptable and responsible behavior	0,49%	1,03%	0,55%	0,55%	0,35%
merger, investment, acqusition	0,56%	0,00%	0,18%	0,00%	0,05%
unavailability of innovation, innovations	1,36%	1,13%	0,74%	-0,13%	-0,15%
change in infrastructure maintenance, change of investment in infrastructure	1,23%	1,08%	0,18%	-0,13%	-0,69%
new technologies risk, to what extent can intr oduction of new techn. influence business	1,28%	1,74%	0,77%	0,63%	-0,16%
taxation risk, risk of changing taxati. policy	2,48%	1,64%	1,90%	1,51%	1,26%
price pressure - price drop due to various causes	3,18%	3,13%	2,92%	1,50%	1,34%

Figure 8. Impact of business system cost risk on the increase of a part of business system costs

Changes in legislation, access to credit, slow recovery, emerging markets, new non-traditional collaborators, tax risk and price pressures have a significant impact on investment in working capital. The minimum intensity of the impact on investment in working capital is posed by problems in managing talents and this is 0.05%, while the greatest impact is related to price pressure risks - 2.92%.

Significant impact on gross profit is made by business system risk sources related with changes in legislation, tax risks and price pressure or price drop risks due to various causes. The highest impact on gross profit is made by tax risks (1.51%) and respondents believe that gross profit is not affected by poslovni rizici povezani sa mogućnostima pristupa kreditu, problemima u upravljanju talentima te nemogućnosti inovacija i izmjene državnih ulaganja u infrastrukturu.

Na ukupan prihod poslovnog sustava značajan utjecaj imaju izvori rizika povezani sa izmjenama zakonodavstva i propisa te porezni rizici kao i pritisci cijena odnosno pad cijena uslijed raznih uzroka.

Ovaj dio istraživanja može poslužiti kao preporuka za identificiranje veličine utjecaja koji izvor rizika izaziva na određeni dio stanja poslovnog sustava. Naravno da pri tome treba voditi računa o izboru nekog izvora rizika po intenzitetu veze indentificiranih rizika, kao i vjerojatnosti pojave promatranog rizika.

4.7 Utjecaj pokretača poslovnih rizika na vjerojatnost pokretanja poslovnih rizika

U ovom dijelu rada analiziranu su rezultati istraživanja pojava koje pokreću poslovni rizik iz pasivnog u aktivno stanje. Utjecaji pokretača na pojedini izvor rizika svrstani su u pet intenziteta utjecaja.

Tablica 4. Razredi intenziteta utjecaja pokretača na pojedini izvor rizika

Intenzitet utjecaja	Opredjeljenje ispitanika
Vrlo nizak utjecaj VNU	0-20 %
Nizak utjecaj NU	20-40 %
Umjeren utjecaj UU	40-60 %
Visok utjecaj VU	60-80 %
Vrlo visok utjecaj VVU	80-100 %

Relevantnim se smatra pokretač rizika ako najmanje 20% anketiranih organizacija procjenjuje da taj pokretač može pokrenuti rizik iz pasivnog u aktivno stanje.

Prem rezultatima istraživanja možemo zaključiti da svi pokretači poslovnih rizika osim novih netradicionalnih suradnika te rizika novih tehnologija mogu dovesti do pokretanja rizika pada prihoda iz pasivnog u aktivno stanje. Visok utjecaj na rizik od pada prihoda imaju spor oporavak od recesije, porezni rizik, te pritisci cijena.

Najčešći pokretač rizika koji može dovesti do pokretanja rizika iz pasivnog u aktivno stanje prema istraživanju je pokretač rizika vezna za spor oporavak od recesije a pokretač rizika koji najmanje utječe na pokretanje rizika je pokretač vezan za nove netradicionalne suradnike te rizik od novih tehnologija. Do pokretanja rizika gubitka kupaca i gubitka partnera prema ispitanicima dolazi jako rijetko. Na pokretanje gubitka kupaca utječu samo pokretači rizika vezani za spor oporavak od recesije te nemogućnosti inoviranja dok na aktiviranje rizika od gubitka partnera utječu samo pokretači rizika povezani sa mogućnostima pristupa kreditima i to niskim intenzitetom.

business risks related to the possible access to credits, talent management problems, and inability to innovate and the change of government investment in infrastructure.

The total revenue of a business system is significantly impacted by the risk sources related to changes in legislation and regulations, tax risks as well as price pressures or price drops due to various causes.

This part of the research can serve as a recommendation for identifying the size of the impact that the source of the risk poses to a certain part of the business system state of affairs. It is certainly necessary to take into account the choice of a risk source by the intensity of the link of identified risk as well as the probability of occurrence of the observed risk.

4.7 Impact of business risk initiators on probability of initiating business risks

This part of the paper analyzes the research results of the phenomena that initiate business risk from the passive to the active state. The impacts of initiators on a particular risk source are classified into five impact intensities.

Table 4. Classes of the intensity of initiators' impact to individual risk sources

Impact intensity	Respondents' attitude
Very low impact VNU	0-20 %
Low impact NU	20 - 40 %
Moderate impact UU	40 - 60 %
High impact VU	60 - 80 %
Very high impact VVU	80 - 100 %

A risk initiator is considered as relevant if at least 20% of the surveyed organizations estimate that it is able to change a passive risk into an active risk.

According to the research results we can conclude that all business risk initiators other than new non-traditional collaborators and the risk of new technologies may lead to initiating the income drop risk from passive into active state. High impact on the income drop risk is made by a slow recovery from recession, tax risk and price pressures.

According to the research, the most common risk initiator that can lead to risk initiation from passive to active state is the risk initiator related to slow recovery from recession and the least risk-driving initiator is the initiator related to new non-traditional collaborators and the risk of new technologies. Initiating the risk of losing customers and losing partners is very rare according to the respondents. Only the initiators of risk related to slow recovery from recession and the inability to innovate affect the initiation of customer loss, whereas risk initiators associated with credit access impact the activation of loss of partner risk with low intensity

RIZICI POSLOVNOG SUSTAVA	PAD PRIHODA	RAST SUDSKIH SPOROVA	FLUKTUACIJA KLJUČNIH KADROVA	GUBICI KUPACA	GUBICI NATJEČAJA	NELIKVIDNOST	GUBITAK PARTNERA	OTKAZIVANJA DOBAVLJAČA	IZOSTANAK POTPORE BANAKA
izmjena zakonodavstva, propisa, prilagodbe, regulativa	55,00% UMJEREN	47,50% UMJEREN	15,00%	7,50%	17,50%	27,50% NIZAK	10,00%	5,00%	10,00%
mogućnost pristupa kreditima	27,50% NIZAK	12,50%	10,00%	15,00%	30,00% NIZAK	52,50% UMJEREN	22,50% NIZAK	20,00% NIZAK	40,00% UMJEREN
spor oporavak, dvostruki učinak recesije, dupli nakon kratkog oporavka	67,50% VISOK	20,00% NIZAK	20,00% NIZAK	40,00% UMJEREN	20,00% NIZAK	30,00% NIZAK	15,00%	20,00% NIZAK	10,00%
problemi u upravljanju talentima, fluktuacija, obrazovanje, obučavanje	35,00% NIZAK	7,50%	45,00% UMJEREN	10,00%	2,50%	7,50%	5,00%	10,00%	10,00%
tržišta u nastojanju, tranzicija	37,50% NIZAK	5,00%	22,50% NIZAK	10,00%	12,50%	10,00%	12,50%	15,00%	10,00%
aktivnosti na rezanju troškova	22,50% NIZAK	10,00%	25,00% NIZAK	7,50%	7,50%	17,50%	10,00%	12,50%	12,50%
novi netradicionalni suradnici, novi poslovni modeli	12,50%	17,50%	12,50%	10,00%	15,00%	12,50%	10,00%	17,50%	20,00% NIZAK
ekologija, energetska učinkovitost, regulacija zaštita okoliša	25,00% NIZAK	25,00% NIZAK	10,00%	7,50%	12,50%	5,00%	2,50%	5,00%	2,50%
trend socijano prihvatljivog i društveno odgovornog poslovanja	27,50% NIZAK	15,00%	22,50% NIZAK	2,50%	17,50%	15,00%	7,50%	10,00%	10,00%
spajanje, ulaganja i akvizicije	27,50% NIZAK	5,00%	7,50%	2,50%	15,00%	12,50%	12,50%	5,00%	5,00%
nemogućnost inoviranja, inovacije	25,00% NIZAK	7,50%	12,50%	20,00% NIZAK	15,00%	15,00%	12,50%	10,00%	22,50% NIZAK
izmjena u održavanju infrastrukture, izmjena ulaganja u infrastrukturu	35,00% NIZAK	22,50% NIZAK	15,00%	15,00%	15,00%	5,00%	7,50%	10,00%	10,00%
rizik novih tehnologija, koliko uvođenje novih tehnologija može utjecati na poslovanje	15,00%	10,00%	15,00%	15,00%	15,00%	5,00%	7,50%	10,00%	10,00%
porezni rizik, rizik promjene porezne politike	62,50% VISOK	27,50% NIZAK	12,50%	15,00%	7,50%	27,50% NIZAK	15,00%	15,00%	12,50%
pritisci cijena - pad cijena usljed raznih uzroka	67,50% VISOK	12,50%	30,00% NIZAK	10,00%	22,50% NIZAK	22,50% NIZAK	17,50%	37,50% NIZAK	10,00%

Slika 9. Utjecaj pokretača rizika na pojedini izvor rizika

4.8 Rezultati istraživanja prihoda i rezerviranja za rizike u ukupnom prihodu poslovnog sustava

U istraživanju je provedeno ispitivanje najčešćeg iznosa rezerviranja za poslovne rizika obuhvaćeno kroz indirektne troškove poduzeća u ukupnoj cijene projekta. Najčešći odgovor anketiranih je da za poslovne rizike u cijenama svojih projekata rezerviraju 1%. Prema Pert razdiobi s 80% vjerojatnosti moglo bi se smatrati usvajanje iznosa od 2,53% cijene za poslovne rizike.

Istraživanjem je također napravljeno ispitivanje koliko % uobičajeno poslovni sustavi planiraju rast prihoda u narednoj godini ili razdoblju u odnosu na prihod u protekloj godini odnosno razdoblju. Najčešći odgovor anketiranih je da planiraju 10% veći prihod u sljedećem razdoblje u odnosu na prethodni. Prema Pert razdiobi s 80% vjerojatnosti moglo bi se smatrati 12,83% planiranog rasta prihoda u odnosu na prethodno razdoblje.

Analizirani su također rezultati postotka prihoda za iduću godinu ili razdoblje koji su već osigurani u vrijeme izrade plana. Najčešći odgovor anketiranih je da je samo 30% prihoda osigurano u trenutku donošenja plana. Prema Pert razdiobi s 80% vjerojatnosti moglo bi se smatrati usvajanje od 44,80% za osigurani prihod u trenutku izrade poslovnog plana.

BUSINESS SYSTEM RISKS	DROP IN REVENUES	INCREASE IN COURT DISPUTES	KEY PERSONNEL TURNOVER	LOSS OF CUSTOMERS	LOSS OF TENDERS	INSOLVENCY	LOSS OF PARTNER	SUPPLIER CANCELLATION	BANKS' SUPPORT FAILURE
changes in legislation, regulations, adjustments, legislature	55,00% MODERATE	47,50% MODERATE	15,00%	7,50%	17,50%	27,50% LOW	10,00%	5,00%	10,00%
availability of credits	27,50% LOW	12,50%	10,00%	15,00%	30,00% LOW	52,50% MODERATE	22,50% LOW	20,00% LOW	40,00% MODERATE
slow recovery, double effect of recession, double after a short recovery	67,50% HIGH	20,00% LOW	20,00% LOW	40,00% MODERATE	20,00% LOW	30,00% LOW	15,00%	20,00% LOW	10,00%
problems in managing talents, employee turnover, education, training	35,00% LOW	7,50%	45,00% MODERATE	10,00%	2,50%	7,50%	5,00%	10,00%	10,00%
new, developing markets, transition	37,50% LOW	5,00%	22,50% LOW	10,00%	12,50%	10,00%	12,50%	15,00%	10,00%
cost cutting activities	22,50% LOW	10,00%	25,00% LOW	7,50%	7,50%	17,50%	10,00%	12,50%	12,50%
new non-traditional collaborator, new business models	12,50%	17,50%	12,50%	10,00%	15,00%	12,50%	10,00%	17,50%	20,00% LOW
ecology, energy efficiency environment protection management	25,00% LOW	25,00% LOW	10,00%	7,50%	12,50%	5,00%	2,50%	5,00%	2,50%
trend of socially acceptable and responsible behavior	27,50% LOW	15,00%	22,50% LOW	2,50%	17,50%	15,00%	7,50%	10,00%	10,00%
merger, investment, acqusition	27,50% LOW	5,00%	7,50%	2,50%	15,00%	12,50%	12,50%	5,00%	5,00%
unavailability of innovation, innovations	25,00% LOW	7,50%	12,50%	20,00% LOW	15,00%	15,00%	12,50%	10,00%	22,50% LOW
change in infrastructure maintenance, change of investment in infrastructure	35,00% LOW	22,50% LOW	15,00%	15,00%	15,00%	5,00%	7,50%	10,00%	10,00%
risk of new technologies, to what extent can introduction of new techn. influence business	15,00%	10,00%	15,00%	15,00%	15,00%	5,00%	7,50%	10,00%	10,00%
taxation risk, risk of changing taxati. policy	62,50% HIGH	27,50% LOW	12,50%	15,00%	7,50%	27,50% LOW	15,00%	15,00%	12,50%
price pressure - price drop due to various causes	67,50% HIGH	12,50%	30,00% LOW	10,00%	22,50% LOW	22,50% LOW	17,50%	37,50% LOW	10,00%

Figure 9. Impact of risk initiators on individual risk sources

4.8 Results of revenues and risk provisions research in total business system revenues

The study investigated the most common amount of business risk provisions covered by the company's indirect costs in the total price of project. The respondents most commonly answered that they reserve 1% for business risks in the prices of their projects. According to Pert distribution with an 80% probability, the adoption of an amount of 2.53% of the cost for business risks could be considered.

The survey also investigated by what percentage business systems usually plan to increase revenues over the next year or period relative to the revenues in the previous year or period. The most common respondents' answer was that they plan 10% higher revenues over the next period compared to the previous one. According to Pert distribution with an 80% probability, 12.83% of planned revenue growth could be considered as compared to the previous period.

The results of the revenues percentage for the next year or the period that had already been provided at the time of developing the plan were also analyzed. The most commonly respondents answered that only 30% of revenues was provided at the time of the plan's adoption. According to Pert distribution with an 80% probability, an adoption of 44.80% for insured revenues at the time the business plan was created could be considered.

5. Doprinosi istraživanja i buduća istraživanja

Kako smo pregledom literature konstatirali nedostatak modela uključivanja utjecaja rizika pri formiranju ponudbene cijene projekta od strane izvođača građevinskih radova napravljena je anketa za istraživanje utjecaja rizika na ponudbenu cijenu i budžet projekta kod izvođača projekata. Radom su analizirani rezultati istraživanja. Ovdje nisu analizirane međuovisnosti rezultata pojedinih dijelova istraživanja niti je obrađen način primjene ovih rezultata. Ovakvi rezultati istraživanja poslužit će za formiranje modela izračuna ponudbene cijene i budžeta projekta koji će na adekvatan način uključiti sve utjecaje rizika na projekte i poslovne sustave. Usporedbom rezultata i uspostavljanjem međuovisnosti rezultata s obzirom na utjecaj rizika na projektne i poslovne sustave rezultati će se pripremiti za primjenu u budućem modelu. Primjenom ovakvog modela izvođač radova izbjeći će prevelike rezervacije za rizik u svojoj ponudbenoj cijeni te na taj način povećati mogućnost za osiguravanje ugovora te povećanje prihoda poslovnog sustava. Izvođač radova će također pirmjenom ovakvog modela izbjeći premale rezervacije za rizike koji mogu u toku realizacije projekta dovesti do katastrofalnih posljedica za sam projekt ali i cijeli poslovni sustav. U nastavku istraživanja pristupit će se formiranju ovoga modela te eventualnim dodatnim istraživanjima za povećanje detaljnosti planiranog modela. Također će se osigurati primjena i verificiranje formiranoga modela na određenom broju projekata.

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5. Contributions of research and future research

As a the literature overview found a lack of a model for incorporating the risk impact when a contractor of construction works forms the project bid price, a poll was conducted to investigate the impact of risk on the bid price and the contractor's project budget. The research results were analyzed in the paper. The interdependence of the results of certain parts of the survey has not been analyzed here, nor has the way of applying these results been addressed. These research results will be used to form the model of bid price and project budgets that will adequately include all project and business system risk impacts. By comparing the results and establishing the interdependence of results with regard to the impact of risk on project and business systems, the results will be prepared for application in the future model. By applying this model, the contractor will avoid excessive risk provisions in its bid price, thereby increasing the possibility to be awarded a contract and to increase the revenues of the business system. By the application of such model, the contractor will also avoid too scarce reservations for the risks, which could cause disasterous consequences for the project as well as for the entire business system during the project implementation. In the follow up to this research, the formation of this model will be introduced and potential further research conducted in order to create a more detailed model. Also, the application and verification of the formed model will be provided for a certain number of projects.

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HI
HERING

Prof. dr. sc. Alen Harapin, dipl. ing. građ
Sveučilište u Splitu, Građevinski i arhitektonski fakultet

Doc.dr.sc. Dragan Ćubela, dipl.ing.građ.
Sveučilište u Mostaru, Građevinski fakultet

Mr.sc.Ladislav Bevanda, dipl.ing.građ.
Mario Jurišić dipl.ing.građ.
HERING d.d. Široki Brijeg

Ivo Rako, dipl.ing. građ., Goran Miloloža, dipl.ing.građ.,
Danijela Dujlović, dipl.ing.građ.
LAVČEVIĆ-inženjering d.o.o

IZRAČUN OPLATE I SKELE ZA ARMIRANOBETONSKU KUPOLU SPORTSKE DVORANE VIŠNJIK U ZADRU

CALCULATION OF FORMWORK AND SCAFFOLD FOR REINFORCED CONCRETE DOME OF VIŠNJIK SPORTS HALL IN ZADAR

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Prof dr. sc. Alen Harapin, dipl. ing. građ
Sveučilište u Splitu, Građevinski i arhitektonski fakultet

Doc.dr.sc. Dragan Ćubela, dipl.ing.građ.
Sveučilište u Mostaru, Građevinski fakultet

Mr.sc.Ladislav Bevanda, dipl.ing. građ.,
Mario Jurišić, dipl.ing.građ.
HERING d.d. Široki Brijeg

Ivo Rako, dipl.ing. građ., Goran Miloloža, dipl.ing.građ.,
Danijela Dujlović, dipl.ing.građ.
LAVČEVIĆ-inženjering d.o.o

Sažetak

U radu se ukratko opisuje izračun oplate i skele za armiranobetonsku kupolu sportske dvorane Višnjik u Zadru. Veličina i složenost strukture zahtijeva kontrolu svih kritičnih elemenata oplate i skele u svim fazama izgradnje koje se uspostavljaju kroz tehnologiju građenja. Štoviše, veličina projekta i relativno dugo razdoblje izgradnje diktiraju dodatnu analizu djelovanja opterećenja na oplatu i skelu tijekom izgradnje.

Ključne riječi: betonska kupola, oplata i skela, izračun oplate i skele, opterećenja na oplatu i skelu

Uvod

Sportska dvorana Višnjik u Zadru vjerojatno je najveća građevina koja se trenutno gradi u Hrvatskoj. Na slikama 1, 2 i 3 prikazani su neki crteži s dimenzijama ove zgrade, kao i kompjuterska vizualizacija završenog projekta. Također se može naznačiti da će gotova građevina biti izrađena od 14.000 m^3 betona i 1.400 t armature, kao i 60.000 m^3 skele i 20.000 m^2 oplate.

CALCULATION OF FORMWORK AND SCAFFOLD FOR REINFORCED CONCRETE DOME Višnjik SPORTS HALL IN ZADAR

Prof. Alen Harapin, Phd BCE*
University of Split, Faculty of Civil Engineering and Architecture

Assistant Prof. Dragan Ćubela, Phd BCE*
University of Mostar, Faculty of Civil Engineering

M.Sc.Ladislav Bevanda BCE*
Mario Jurišić BCE*
HERING d.d. Široki Brijeg

Ivo Rako BCE*., Goran Miloloža BCE*.,
Danijela Dujlović BCE*
LAVČEVIĆ-inženjering d.o.o

Abstract

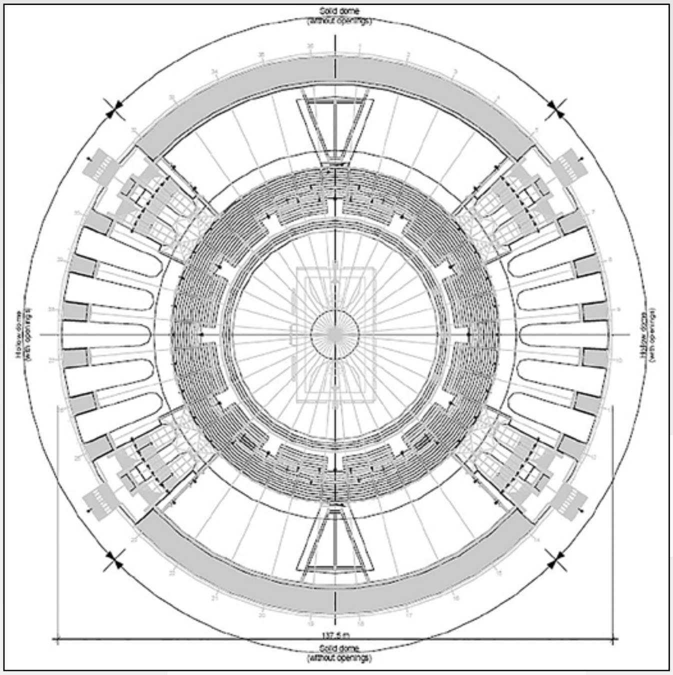
The paper shortly describes calculation of formwork and scaffold for reinforced concrete dome of sports hall Višnjik in Zadar. The size and complexity of the structure requires control of all critical elements of formwork and scaffold in all construction phases which are established through building technology. Moreover, the size of the project and relatively long construction period dictate some additional analyzing of load acting on formwork and scaffold during construction.

Keywords: concrete dome, formwork and scaffold, calculation of formwork and scaffold, loads on formwork and scaffold

Introduction

Sports hall Višnjik in Zadar is probably the biggest building currently under construction in Croatia. Some drawings with dimensions of this building, as well as computer visualization of completed project, are shown in figures 1, 2 & 3. Also, it can be specified that the finished building will be made of: 14,000 m^3 of concrete and 1,400 t of reinforcement, as well as: 60,000 m^3 of scaffold and 20,000 m^2 of formwork.

* Four-year study BCE



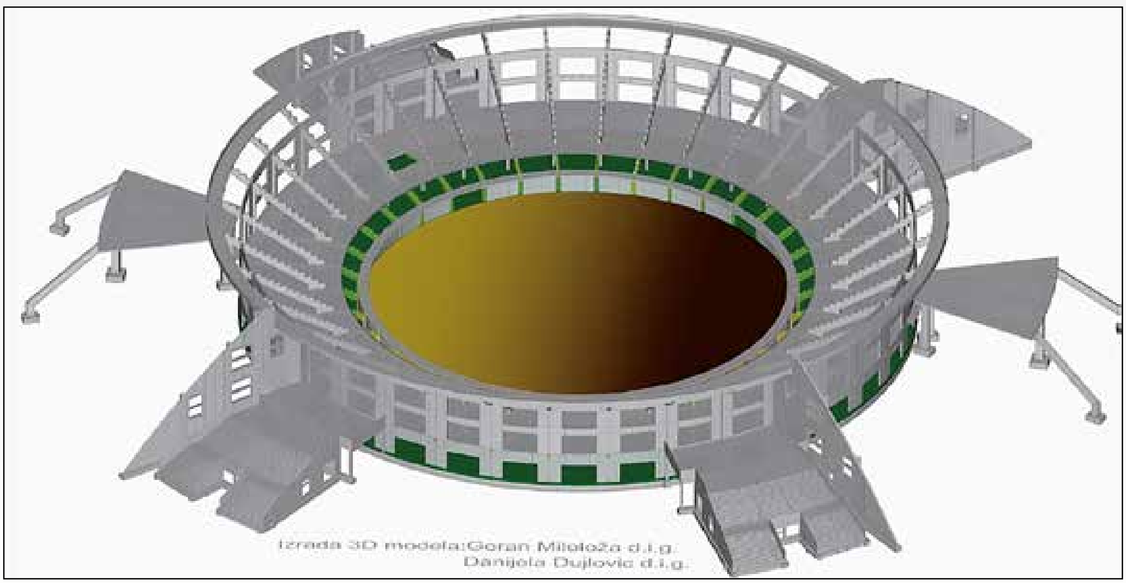
Ova građevina bi se mogla koristiti u mnoge svrhe. Pored glavne dvorane s auditorijem, koja može primiti oko 8.100 posjetitelja, građevina ima dvije manje dodatne dvorane za različite sportske treninge, kao i mnoge druge prateće sadržaje poput teretane, kafića, restorana i uredskih prostorija.

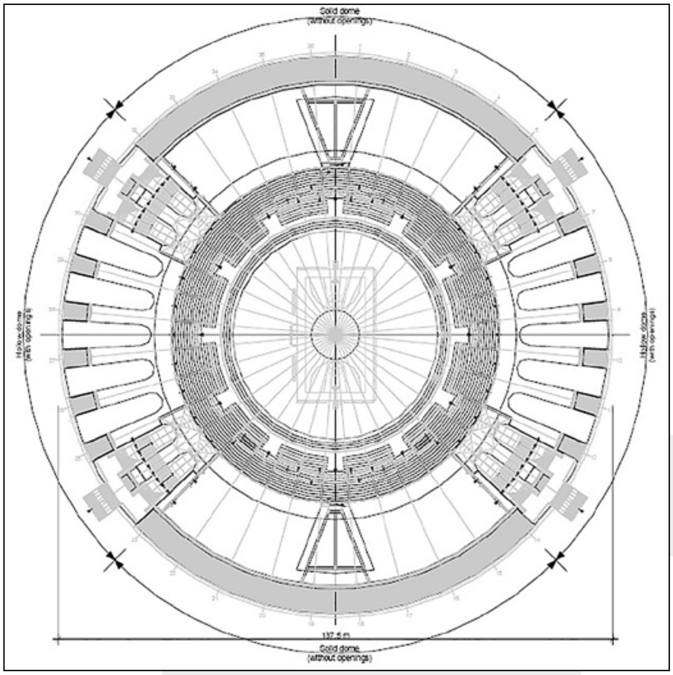
Investitor ovog velikog projekta je: Ministarstvo znanosti, obrazovanja i športa Republike Hrvatske i Grada Zadra. Procijenjeni troškovi građevinskih radova iznose oko 65 milijuna kuna.

(bez otvora)

Slika 1. Plan sportske dvorane Višnjik

Slika 2. Kompjuterska vizualizacija sportske dvorane Višnjik (auditorijum i unutarnja struktura)





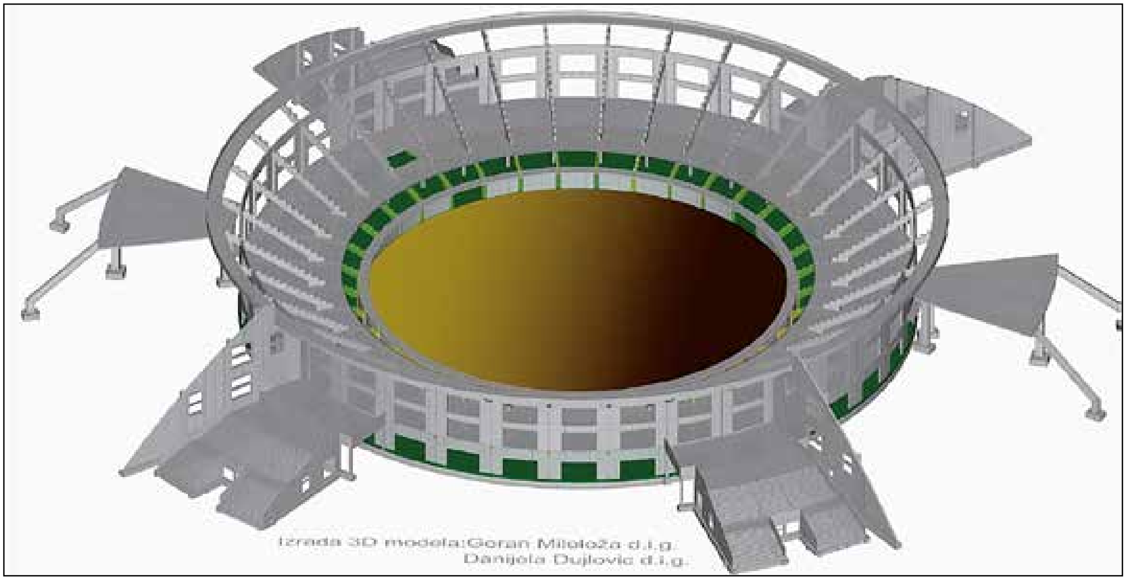
The Building could be used for many purposes. Besides the main hall with auditorium, which can take about 8,100 visitors, the building has two additional smaller halls for different sports trainings as well as many other accompanying amenities like fitness room, café bar, restaurant and office rooms.

The investor of this big project is the Ministry of Science, Education and Sport of the Republic of Croatia and City of Zadar. Estimated costs of civil engineering works is about HRK 65 million.

(without openings)

Figure 1. Plan of sports hall Višnjik

Figure 2. Computer visualization of sport hall Višnjik (auditorium and inner structure)



O strukturi i tehnologiji građenja

Glavna struktura nosivosti zgrade je armiranobetonska kupola, od temelja do vrha dvorane (19,16 m), a iznad toga je rešetkasta struktura čeličnih šupljih profila. Ova kupola je dio površine kugle sa polumjerom R = 95,46 m, tj. kalota R = 70,05 m s visinom h = 30,52 m. Ova ljuska, u strukturnom smislu, oslabljena je slijedom ulaznih otvora koji suprotne strane kupole čine slabijima. Ljuska se temelji na prednapregnutom betonskom prstenu.

Odabrana tehnologija je monolitna konstrukcija, betonirana u oplati na gradilištu.

Zbog veličine građevine i potrebne količine oplate i skele, nemoguće je izraditi svu skelu i oplatu odjednom, tako da se oplata i skela moraju praviti u dijelovima tijekom napredovanja izgradnje i betoniranja.

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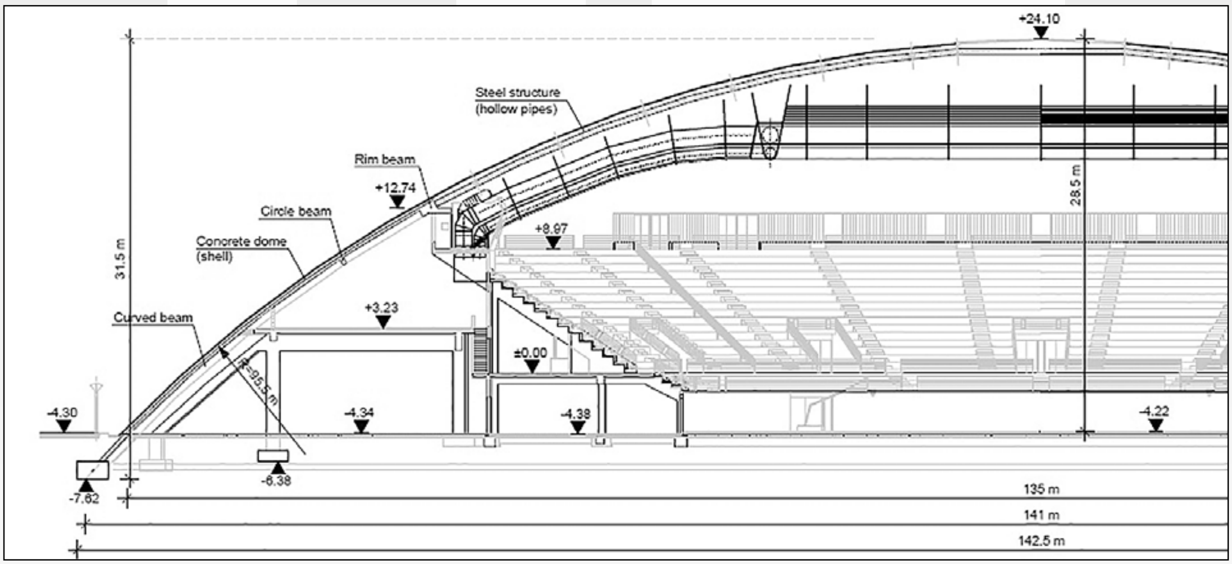

Slika 3. Poprečni presjek sportske dvorane Višnjik

Opterećenja

Glavno pitanje pri izračunu skele i oplate je pitanje odabira vrste i intenziteta opterećenja te odabira odgovarajućeg konstrukcijskog modela izračuna.

Analiziraju se sljedeća opterećenja: težina same skela i oplate, korisno opterećenje betona (svježeg i otvrdnutog), hidrostatski pritisak tijekom betoniranja, pokretna opterećenja radnika i vjetar.

Ovdje se ne analizira opterećenje snijega, jer nije uobičajeno uzimati ga u obzir za ove strukture (oplate i skele). Iznimke su specifične strukture skele i oplate, kada to opterećenje treba uzeti u obzir

About structure and construction technology

The main bearing structure of the building is reinforced concrete dome - shell, from foundations to the top of auditorium (19.16 m), and above that there is the truss structure of steel hollow profiles. This dome is part of sphere surface with radius of R=95.46 m, i.e. calotte of R=70.05 m with height of h=30.52 m. This shell, in structural sense, is softened with sequence of entrance openings which weaken opposite sides of dome. Shell is based on prestressed concrete ring.

Chosen technology is monolithic construction, concreted in formwork on the site. Because of building size and required quantity of formwork and scaffold, it is impossible to make the whole scaffold and formwork at once, so formwork and scaffold must be executed in sequences during construction and concreting progress.

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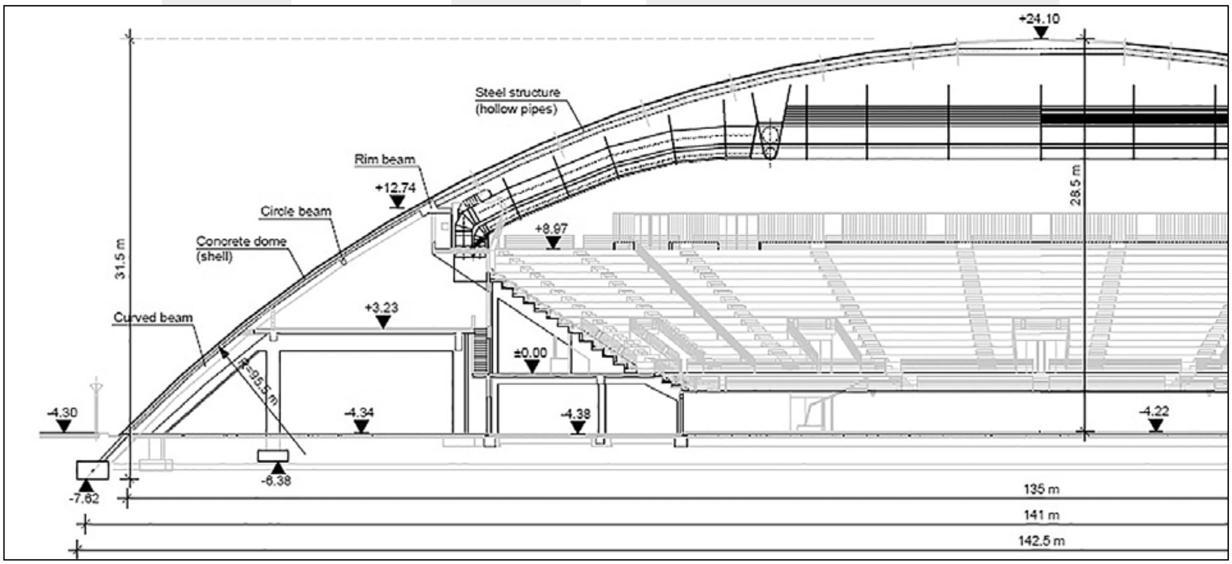


Figure 3. Cross-section of sport hall Višnjik

Loads

The main question about scaffold and formwork calculation is a matter of selection of type and intensity of loads and selection of adequate construction model of the calculation.

The following loads are analyzed: self weight of scaffold and formwork, useful load of concrete (fresh and hardened), hydrostatic pressure during concreting, moveable loads of workers and wind.

Snow load is not analyzed here, because it is not common to take it into account for these structures (formwork and scaffold). Exceptions are specific structures of scaffold and formworks, when that u skladu sa zakonskim propisima, kada je to vrlo značajno sa aspekta stabilnosti skele i oplate. Za ovu strukturu (kupola), snijeg može biti značajan s obzirom na planiranu dinamiku radova i vijek trajanja skela i oplate. S druge strane, uvjetovano klimatskom zonom gradilišta (mediteranska obala), opterećenje snijegom nije dominantno u odnosu na sva druga relevantna opterećenja (svježi beton i drugi utjecaji tijekom betoniranja), pa se ne uzima u izračun.

Samoopterećenje oplate i skele izračunava se prema stvarnim količinama i volumnim masama korištenih materijala. Drvena građa je od drva četinara, 2. razreda. Volumenska masa od 7,0 kN/m^3 je uključena u izračun.

Korisno opterećenje betona uzeto u izračun iznosilo je 25,0 kN/m^3. Količina težine betona povećava se prema dinamičkim utjecajima tijekom betoniranja. Koriste se dinamički koeficijenti (prema HRN U.C9.400):

- 1,20 - za podne i ležajne elemente oplate (drvene daske i remenate na dijelu krute kupole, drvene daske, uzdužne remenate, poprečni presjeci i H20 nosači na šupljem dijelu kupole);
- 1,10 - za donje dijelove oplate (nosive drvene grede) i skele.

Posebna pažnja u statičnom proračunu posvećena je elementima na koje dodatno utječe hidrostatski tlak. Intenzitet hidrostatskog tlaka ovisi o brzini betoniranja, konzistenciji betona i visini betoniranog sektora. Dobiveni parametri (prema DIN 18-218) su: tekuća konzistencija betona, brzina betoniranja od 1,0 m / h i visina betoniranog sektora od 2,7 m. Na šupljem dijelu kupole (zakrivljene grede) planira se simultano betoniranje dvaju sektora.

U obzir je uzeto opterećenje radnika intenziteta od 1,0 kN/m^2 (HRN U.C9.400).

Posebna pozornost posvećuje se utjecajima vjetra na skele i oplate. Utjecaj pritiska vjetra nije od bitne važnosti, ali usisni utjecaj je značajniji. Usisavanje može uzrokovati problem podizanja oplate i skele, kada su one neopterećne (bez betona i pojačanja). U slučaju utjecaja pritiska vjetra, stabilnost strukture osigurava se dijagonalnim i horizontalnim spojnicama. U slučaju usisnog utjecaja vjetra na neopterećenu površinu, dijagonalna i vodoravna spojnica nije dovoljna, pa se dodaju i zatege.

Intenzitet opterećenja vjetra izračunava se prema Tehničkim propisima za opterećenje vjetrom, format 1964.

Ukupni opterećenje vjetrom je:

- $w = c \cdot w_0$ (kN/m^2 - okomito na površinu oplate), gdje je: w_0 osnovno opterećenje vjetra, a c je koeficijent oblika.

  Intenzitet osnovnog opterećenja vjetra izračunava se prema geografskoj zoni građevine (zona vjetra) i maksimalnim utjecajima vjetra glede izlaganja građevine vjetru.
- Za utjecaj tlaka: w_0=1.1 kN/m^2 (vertikalna projekcija) za prvu fazu oplate (visina oplate do 10 m); i w_0=1.3 kN/m^2 (vertikalna projekcija) za ostale faze oplate (visin oplate iznad 10 m);
- Za utjecaj usisavanja: w_0=0.8 kN/m^2 (vertikalna projekcija) za prvu fazu oplate (visina oplate do 10 m); i w_0=1.1 kN/m^2 (vertikalna projekcija) za ostale faze oplate (visina oplate iznad 10 m);

has to be taken into account, pursuant to legal regulations, when it is very significant from scaffold and formwork stability aspect. For this structure (dome), snow can be significant given the planned dynamic of works and lifetime of scaffold and formwork structure. On the other hand, depending on the site climate zone (Mediterranean coast), snow load is not dominant compared to all other relevant loads (fresh concrete and other influences during concreting), so it is not taken into calculation.

Self weight of formwork and scaffold is calculated according to real volumes and volume masses of used materials. Lumber is made of conifer wood, 2nd class. Volume weight 7.0 kN/m^3 is taken in calculation.

- Useful load of concrete taken into calculation was 25.0 kN/m^3. Quantity of concrete weight is increased according to dynamic influences occurring during concreting. Used dynamic coefficients are (according to HRN U.C9.400)1.20 - for formwork floor and bearing elements (wooden planks and centrings on part of solid dome, and wooden planks, longitudinal centrings, cross-section elements and H20 girders on hollow part of dome);
- 1.10 - for lower parts of formwork (bearing wooden beams) and scaffold.

Special attention in static calculation is paid to elements which are additionally influenced by hydrostatic pressure. Intensity of hydrostatic pressure depends on: velocity of concreting, consistency of concrete and height of concreted sector. Acquired parameters (according to DIN 18-218) are: liquid consistency of concrete, 1.0 m/h velocity of concreting and 2.7 m height of concreted sector. On hollow part of dome (curved beams) simultaneous concreting of two sectors are planned.

Considered load of workers is intensity of 1.0 kN/m^2 (HRN U.C9.400).

Special care is paid to wind influences on scaffold and formwork, too. Wind pressure influence is not essential, but sucking influence is more significant. Sucking can cause problem of lifting formwork and scaffold, when these are unloaded (without concrete and reinforcement). In case of wind pressure influence stability of structure is assured by diagonal and horizontal braces. In case of sucking wind influence on unloaded surface, diagonal and horizontal brace is not enough, so tie rods are added.

Wind load intensity is calculated according to Technical regulations for wind load, form 1964. Total wind load is:

- $w = c \cdot w_0$ (kN/m^2 - perpendicular to formwork surface), where: w_0 is base wind load, and c is shape coefficient.

  Base wind load intensity is calculated according to geographic zone of building (wind zone) and the maximum wind impacts regarding building's exposition to wind.
- For pressure influence: w_0=1.1 kN/m^2 (vertical projection) for first phase of formworking (height of formwork up to 10 m); and w_0=1.3 kN/m^2 (vertical projection) for other phases of formworking (height of formwork above 10 m);
- For sucking influence: w_0=0.8 kN/m^2 (vertical projection) for first phase of formworking (height of formwork up to 10 m); and w_0=1.1 kN/m^2 (vertical projection) for other phases of formworking (height of formwork above 10 m);

Zahvaljujući specifičnom obliku, koeficijent oblika je:

- za utjecaj tlaka (smjer vjetra sa izvana unutra), kao i za jednodjelni krov (u skladu sa ranije navedenim pravilnikom):

  $c = 1.7 - 0.9$ ($c_{sr} = 1.3$ – prosječna vrijednost) – ovisno o kosini oplate

- Za utjecaj usisavanja (smjer vjetra sa izvana unutra), kao i za jednodjelni krov (u skladu sa ranije navedenim pravilnikom):

- $c = 1.6$ donja polovica površine oplate

  $c = 1.9$ gornja polovica površine oplate

Tangencijalni (lateralni) utjecaj vjetra je 10% od uobičajenog (okomitog) utjecaja vjetra $w_t = 0.1$ kN/m^2.

Na kraju, elementi skele i oplate izračunati su i dimenzionirani za sve relevantne kombinacije opterećenja prema teoriji dopuštenih naprezanja. Izračunske sheme uključuju sve faze betoniranja, u skladu sa stečenom shemom betoniranja.

Model izračunavanja

Tijekom odabira prikladnog proračunskog modela raspravljalo se o nekoliko rješenja. Najjednostavnije rješenje svakako je raščlaniti strukturu u nekoliko jednostavnih statičkih modela i razmotriti ih odvojeno. Ovo rješenje ima prednosti u jednostavnosti i laganoj razrješivosti, kao i jednostavnu kontrolu rezultata i veći faktor sigurnosti.

Drugo, potpuno suprotno rješenje je napraviti kompletni prostorni model koji bi najbolje opisao stvarnu situaciju. No, ovo rješenje zahtijeva veliku količinu računalnog vremena, kao i dodatno vrijeme za kontrolu ulaznih i izlaznih podataka.

Konačno odabrano rješenje je:

- Izračun elemenata oplate izrađuje se modelom izračuna jednostavne ravnine.

- Izračun elemenata skele izrađuje se složenim prostornim modelom izračuna.

Ovaj model može bolje opisati ponašanje sustava, uključujući njegovu stabilnost.

Ovaj model također nije kompletan prostorni model, već prostorni model karakteristično strukturnih segmenata.

Izračunavanje oplatnih elemenata i dimenzioniranje elemenata vrši se računalnim programom TOWER 3D MODEL BUILDER 5.5.

Svi elementi (drveni ili čelični) dimenzionirani su prema teoriji dopuštenih naprezanja. Paralelno s dimenzioniranjem obavlja se proračun odstupanja, gdje je dopušteno odstupanje ograničeno na L/500 (L - raspon strukturnog elementa) ili L/250 za elemente konzole. Statični sustavi su definirani prema formiranju elemenata i njihovim vezama. Neki statički sustavi za oplatu su navedeni u nastavku:

Due to specific shape, shape coefficient c is:

- for pressure influence (wind direction from outside to inside), as well as for single pitched roof (according to mentioned book of regulations):

  $c = 1.7 - 0.9$ ($c_{sr} = 1.3$ - average value) - depending on formwork slope

- for sucking influence (wind direction from outside to inside), as well as for single pitched roof (according to mentioned book of regulations):

  $c = 1.6$ lower half of formwork surface

  $c = 1.9$ upper half of formwork surface

Tangential (lateral) wind influence is 10% of normal (perpendicular) wind influence $w_t = 0.1$ kN/m^2.

Finally, scaffold and formwork elements are calculated and dimensioned for all relevant combinations of loads according to theory of allowable stresses. Calculation schemes include all concreting phases, in accordance with acquired concreting scheme.

Calculation model

During selection of adequate calculation model, a couple of solutions were discussed. The simplest solution is certainly to break the structure in a few simple static models and consider them separately. This solution has advantages in simplicity and easy solvability, as well as easy control of results and greater safety factor.

Secondly, totally opposite solution, is to make complete spatial model which would describe real situation to the best. But, this solution requires great amount of computational time, and also additional time for input and output data control.

Final selected solution is:

- Calculation of formwork elements is done by simple plane calculation model.
- Calculation of scaffold elements is done by complex spatial calculation model.

This model can better describe behaviour of the system, including its stability.

This model also is not complete spatial model, but spatial model of characteristically structural segments.

Formwork elements calculation and elements dimensioning are done by computer program TOWER 3D MODEL BUILDER 5.5.

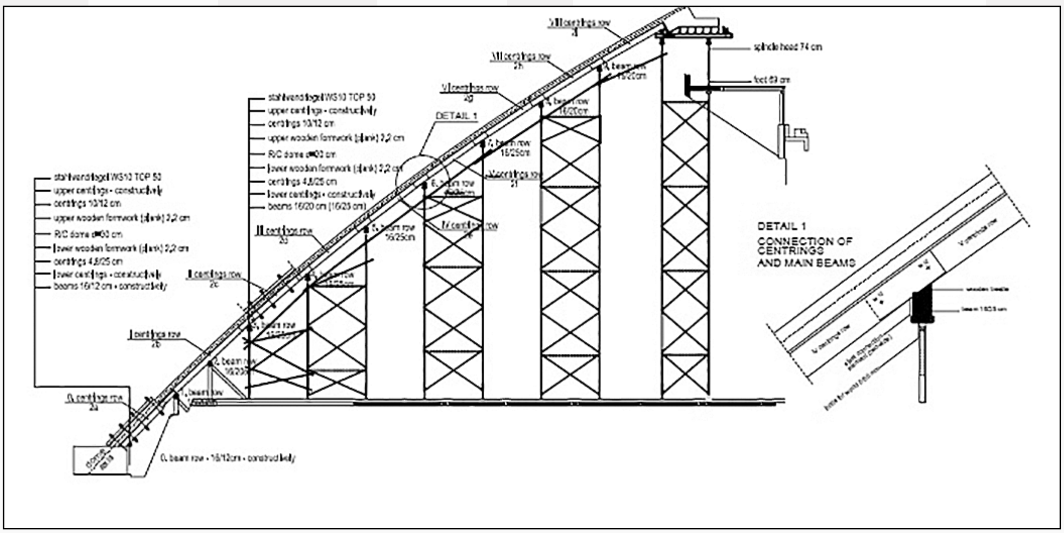
- All elements (wooden or steel) are dimensioned in accordance with theory of allowable stresses. Parallel with dimensioning, deflection calculations are done, where allowable deflection is limited to L/500 (L - structural element span), or L/250 for console elements. Static systems are defined according to the elements formation and its connections. Some static systems for formwork

- Drvene daske – kontinuirani nosači na dva ili više potpornja poduprti s remenatama.
- Remenate – konzolne grede na dva potpornja, poduprti s glavnim nosivim gredama.
- Glavne nosive grede – konzolne grede na dva potpornja sa dvostranom konzolom, poduprte sa STAXO tornjevma. Na krajevima grede imaju šarke za vezu, tako da statički predstavljaju neprekidne nosače preko nekoliko polja sa šarkom na spojevima greda.
- Nosači H20 - neprekidni nosači preko tri polja, poduprti s glavnim nosivim gredama.

Svi navedeni elementi izračunavaju se za sva relevantna opterećenja i njihove kombinacije. Analiziraju se sve faze betoniranja u skladu s planiranom dinamikom betoniranja. Poseban izračun se vrši za usisni utjecaja vjetra na elemente skele i oplate s odgovarajućim proračunom veznih šipki-zatega za prevenciju dizanja. U nekim slučajevima, pod usisnim opterećenjem vjetrom, struktura mijenja svoj statički model, što se uzima u obzir tijekom izračuna.

Neki karakteristični prikazi modela izračuna za prvu fazu oplate prikazani su na sljedećim slikama (Slike 5-8).

Kao što je prije spomenuto, izračuni elemenata skele i oplate izrađeni su za neovisne segmente prostornog modela kupole. Prema planiranim metodama globalnog osiguranja stabilnosti skela, neovisni segmenti moraju simulirati ponašanje cjelokupne strukture. Također, s odgovarajućim materijalnim svojstvima korištenih materijala, modelirana je adekvatna krutost koja je vrlo važna s aspekta globalne stabilnosti



Slika 4. Poprečni presjek skele i oplate kroz čvrstu kupolu

Neki karakteristični prikazi modela proračuna za prvu fazu oplate prikazani su u sljedećim slikama. (Slike 5-8).

are listed below: Wooden planks - continuous girders on two or more supports, supported with centrings.

- Centrings - cantilever beam on two supports, supported with main bearing beams.
- Main bearing beams - cantilever beams on two supports with two-sided console, supported with STAXO towers. Beams have hinge connection on ends, so statically they present continuous girders over several fields with hinge on beams connections.
- H20 girders - continuous girders over three fields, supporting with main bearing beams.

All listed elements are calculated for all relevant loads and their combinations. All concreting phases are analyzed, according to planned concreting dynamic. Special calculation is done for sucking wind influence on scaffold and formwork elements with adequate calculation of tie rods for lifting prevention. In some cases, under sucking wind load, structure changes its static model, which is considered during calculation.

Some characteristic views of calculation model for the first phase of formworking are shown in following figures (Figure 5-8).

As mentioned before, calculations of scaffold and formwork elements are done for independent segments of spatial dome model. According to planned methods of global stability assurance of scaffold, independent segments have to simulate behaviour of whole structure. Also, with appropriate material characteristics of used materials, adequate stiffness is modelled, which is very important from global stability aspect.

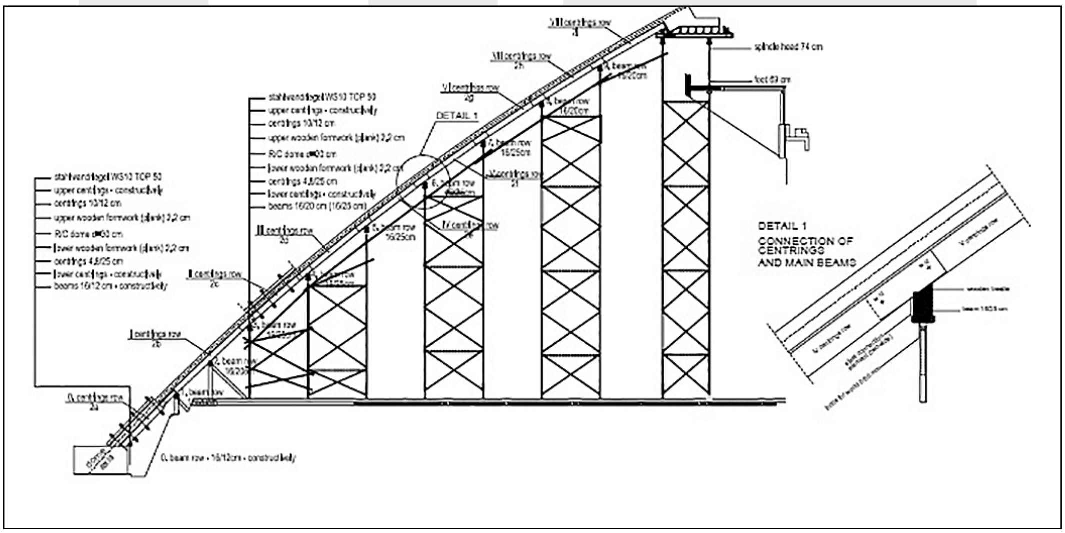
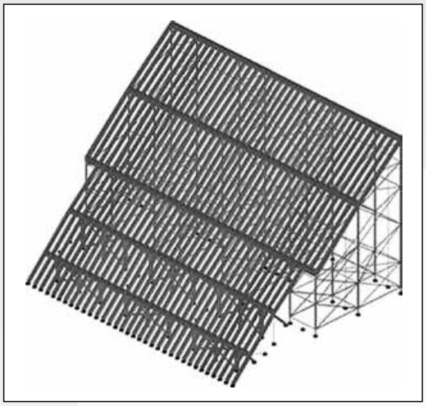


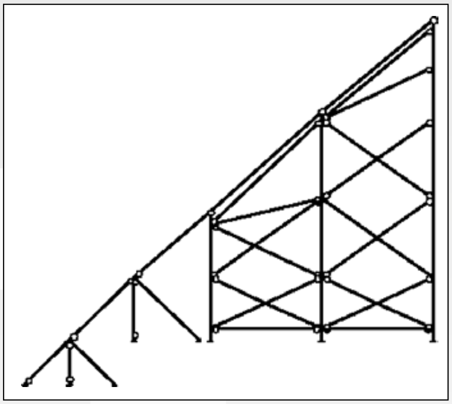
Figure 4. Cross-section of scaffold and formwork through solid dome

Some characteristic views of calculation model for the first phase of formworking are shown in following figures. (Figure 5-8).

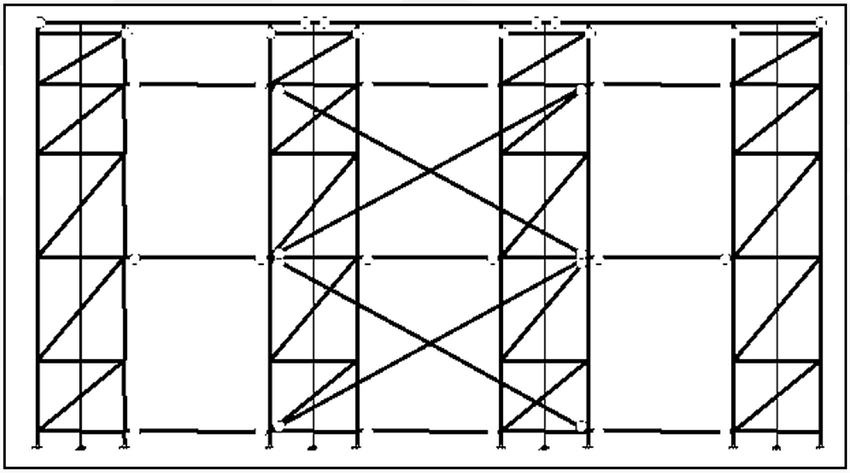
Prva faza formiranja skele sastoji se od dva reda drvenih nogara i tri reda STAXO tornjeva (prvo zaseban toranj i dvostruki tornjevi). Slika 5 prikazuje karakteristični prostorni segment. Ovaj segment sastoji se od četiri tornja s pripadajućom oplatom i skelom na drvenim potpornjima. U radijalnom smjeru, pored očvršćenja samih STAXO tornjeva (u vodoravnoj i okomitoj ravnini), svi tornjevi su dodatno pričvršćeni i povezani čeličnim cijevnim sustavom od 48 mm (slike 5-7). Spajanje skele i oplate na drvenim nogarama (prva dva reda) s ostalim dijelovima skele i oplate osigurano je samom čvrstoćom oplate.



Slika 5. Presjek prostornog (3D) prizora



Slika 6. Karakterističan poprečni okvir



Slika 7. Karakteristični tangencijalni okvir

U tangencijalnom smjeru dva tornja skele su povezana sa cijevnim pojačanjima (tornjevi blizanci – Slika 7), a ta veza je osigurana sa horiziontalnim čeličnim cijevima. Model izračuna pokazuje kako

The first phase of scaffold forming consists of two rows of wooden trestles and three rows of STAXO towers (first separate tower and twin towers). Figure 5 shows characteristic spatial segment. This segment consists of four towers with pertaining formwork and scaffold on wooden shores. In radial direction, besides bracing of STAXO towers themselves (in horizontal and vertical plane), all towers are additionally fastened and bonded with steel pipe system 48 mm (Figures 5-7). Connection of scaffold and formwork on wooden trestles (first two rows) with other parts of scaffold and formwork is assured with formwork stiffness by itself.

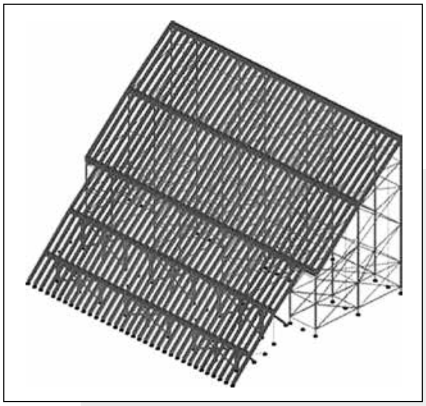


Figure 5. Spatial (3D) view cross section

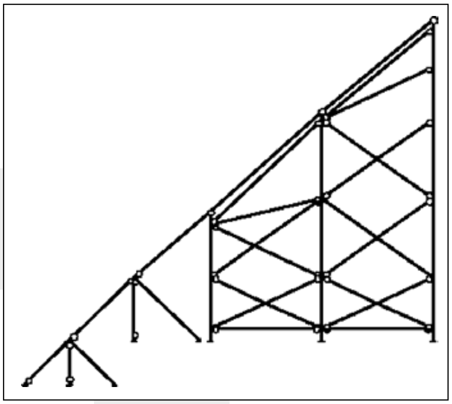


Figure 6. Characteristic transversal frame

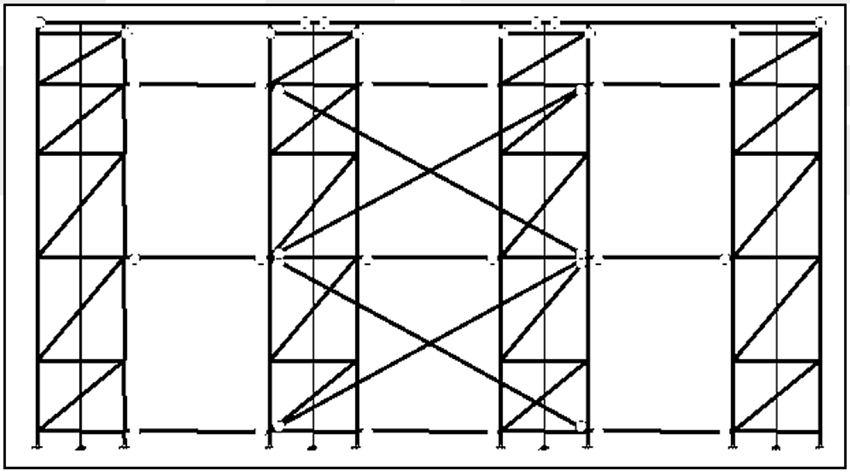


Figure7. Characteristic tangential frame

In tangential direction two scaffold towers are connected with pipe bracing (twin towers - Figure 7), and that connection is assured with horizontal steel pipes. Calculation model shows that all spatial bi sve prostorne konstrukcije bile sigurne glede nosivosti i po stabilnosti. Prva dva reda podupirača (drvene nogare) su osigurana tangncijalno sa drvenim dijagonalama (koje mogu izdržati jedino sile naprezanja), pa je tako veza cijele strukture ispod glavnih nosivih greda osigurana (Slika 7). U radijalnom smjeru stupovi su pričvršćeni sa dijagonalnim pojačanjima, a također i sa oplatom.

Statički izračun se vrši za sve faze betoniranja kupole. Karakteristični slučajevi su:

- Faza neopterećene oplate, kada su skele i oplate nestabilne za usisni utjecaj vjetra, jer je prisutan rizik od podizanja cijele strukture ili nekih dijelova strukture. Taj se problem pojavljuje u svim neopterećenim oplatama. Skele su osigurane zategama koje pričvršćuju skelu za tlo (baza). Zatege su oblikovane sa čeličnim elementima koji mogu podnijeti samo vlačnu silu (Slika 8 - okomiti elementi u sredini STAXO tornjeva).
- Faza potpuno opterećene oplate, kada je vrlo važno kontrolirati utjecaja tlaka kojeg stvara vjetar na svježu betoniranu površinu, jer u ovom slučaju sva opterećenja izravno utječu na tornjeve STAXO (drveni stupovi i podnožja).

Sve ostale međufaze također se kontroliraju (betoniranje vjenaca).

Posebna pažnja posvećena je statičkom proračunu u:

- Kontroli tlačnih sila u vezicama,
- Kontroli vlačnih sila u zategama,
- Reakciji u podupiračima – kontroli moguće pojave negativnih okomitih reakcija (podizanje podupirača),
- utonuću podupirača pod stalnim opterećenjem (težina same oplate i skele i težina betona),
- kontroli naprezanja i stabilnosti za sve elemente skele.

Slika 9 . Postavljanje oplate i skele

Na isti način se modeliraju i statički obrađuju sve ostale faze oplate i skele za čvrstu kupolu, uključujući i dio rubne grede koja pripada ovome dijelu kupole.

constructions would be safe in bearing and from stability aspect. First two rows of support (wooden trestles) are tangentially assured with wooden diagonals (which can take only tension forces), so connection of whole structure under main bearing beams is assured (Figure 7). In radial direction columns are fasten with diagonal bracings, and with formwork too.

Static calculation is made for all dome concreting phases. Characteristic cases are:

- The phase of unloaded formwork, when scaffold and formwork are unstable to sucking wind influences, because a risk of whole structure lifting or some parts of structure is present. This problem occurs in all unloaded formwork. Scaffold is assured by tie rods which fasten scaffold to ground (base). Tie rods are modeled with steel elements which can take only tension force (Figure 8 - vertical elements in the middle of STAXO towers).
- The phase of total loaded formwork, when it is very important to control pressure influence of wind on fresh concreted surface, because, in this case, all loads directly affect STAXO towers (wooden columns and footings).

All other mid-phases are also controlled (concreting circles).

Special attention was paid on static calculation in:

- Control of pressure forces in braces,
- Control of tension forces in tie rods,
- Reactions in supports - control of possible occurrence of negative vertical reactions (lifting of supports),
- supports shrinking under permanent load (self weight of formwork and scaffold and self weight of concrete),
- stresses and stability control for all scaffold elements.

Figure 9. Placing of formwork and scaffold

In an equivalent way all other phases of formwork and scaffold for solid dome are modeled and statically treated, including the part of rim beam which belong to this part of the dome.

Na dijelu šuplje kupole se javljaju dodatni problemi utjecaja bočnoga vjetra na zakrivljene grede između otvora. Skela se pričvršćuje prostornim zategama, što je korisno i u slučajevima usisnog opterećenja vjetra. Također se modeliraju i statički obrađuju sve ostale faze oplate i skele za čvrstu kupolu, uključujući dio rubne grede koji pripada šupljem dijelu kupole.

Koristeći predočene modele izračuna doneseni su važni zaključci o montiranju skele i oplate, njihovom ojačanju radijalno i tangencijalno, kao i montaža i uklanjanje zatega. Ovi zaključci mogu biti vrlo značajni za projekt građevne tehnologije, a isto tako i pri razvoju dinamičkog plana izgradnje.

Zaključak

Oplata i skela su privremene strukture koje služe jedino tijekom radova izgradnje. U mnogim slučajevima ovo razdoblje je kratko te su oplata i skela tipski proizvodi, pa se često ignorira izračun njihove statike. Ali sudeći po prethodnoj raspravi, jasno je predočeno kako je izračunavanje skele i oplate u istom rangu kao izračunavanje same građevine. Iako su oplata i skela privremene strukture, one se moraju izgraditi i izračunati uzevši u obzir sva opterećenja do kojih može doći tijekom izgradnje, ali s druge strane, moraju biti racionalne i ekonomične. Racionalnost i ekonomičnost su posebice važni pri montaži i uklanjanju, ali također pri mogućem premještanju, osiguravanju slobodnog radnog prostora pod njom i mogućnosti višestruke uporabe. Racionalnost i ekonomičnost za skelu ove veličine se također treba odražavati u korištenju elemenata sa traženim dimenzijama, jer bi rabljenje većih dijelova, budući da su dijelovi brojni, znatno povećalo ukupnu cijenu strukture. Dok izbor za uporabu većih dijelova za elemente trajnih građevina može imati ekonomsku opravdanost, jer se većim dimenzijama smanjuju naprezanja i povećava izdržljivost, kod skele i oplate, pogotovo ove veličine, to nije slučaj.

Reference

[1] Arhitektonski projekt: „Sportska dvorana Višnjik u Zadru", Arhitektonski biro Hržić, Zagreb, 2003., projektant: Marijan Hržić (na hrvatskom jeziku)

[2] Strukturni projekt: „Sportska dvorana Višnjik u Zadru ", D&Z, Zadar, 2003., projektant: Davorin Uglešić (na hrvatskom jeziku)

[3] Strukturni projekt: „Sportska dvorana Višnjik u Zadru – izračun skele i oplate", Sveučilište u Zagrebu, Građevinski fakultet, Zagreb, 2004., projektanti: Milutin Anđelić i Damir Lazarević (na hrvatskom jeziku)

[4] Radni projekt: „Sportska dvorana Višnjik u Zadru - projekt skele i oplate ", Sveučilište u Splitu, Građevinski i arhitektonski fakultet, 2005., projektanti: Alen Harapin, Ladislav Bevanda, Mario Jurišić i Dragan Ćubela (na hrvatskom jeziku)

[5] STAXO –projektantski priručnik (na njemačkom jeziku)

[6] Kompjuterski program: TOWER 3D Builder, ver. 5.5, Radimpex, Beograd, vlasnik: HERING d.o.o. Široki Brijeg i Građevinski fakultet, Sveučilište u Mostaru

On the part of hollow dome, additional problems of lateral wind influence on curved beams between openings occur. Scaffold is fastened with spatial tie rods, which is also useful in wind sucking load cases. All other phases of formwork and scaffold for solid dome are modeled and statically treated too, including the part of the rim beam which belongs to hollow part of the dome.

With presented calculating models, important conclusions about installation of scaffold and formwork, their stiffening in radial and tangential direction, as well as installation and dismantling of tie rods are made. These conclusions can be very significant in building technology design, as well as in development of dynamic construction plan.

Conclusion

Formwork and scaffold are temporal structures which serve only during construction work. In many cases this period is short and scaffold and formwork are typical products, so their static calculation is often ignored. But, according to previous discussion, it is clearly presented that calculation of scaffold and formwork is of the same rank as calculation of structure itself. Even though formwork and scaffold are temporal structures, they must be constructed and calculated to consider all loads which can appear during construction, but on the other hand, they have to be rational and economical. Rationality and economy are especially important in its installation and dismantling, but also in relocation possibilities, assurance of free workspace under it and possibilities of multiple usages. Rationality and economy of scaffold this size also have to be in using elements with required dimensions, because usage of bigger parts, since parts are numerous, would considerably increase a total price of the structure. Till choosing to use bigger parts for permanent building's elements can have economic justification, because greater dimensions decrease stresses and increase durability, on scaffold and formwork, especially of this size, this cannot be the case.

References

[1] Architectural design: "Sports hall Višnjik in Zadar", Arhitektonski biro Hržić, Zagreb, 2003, designer: Marijan Hržić (in Croatian)

[2] Structural design: "Sports hall Višnjik in Zadar", D&Z, Zadar, 2003, designer: Davorin Uglešić (in Croatian)

[3] Structural design: "Sports hall Višnjik in Zadar - calculation of scaffold and formwork", University of Zagreb, Faculty of Civil Engineering, Zagreb, 2004, designers: Milutin Anđelić and Damir Lazarević (in Croatian)

[4] Work design: "Sports hall Višnjik in Zadar - design of scaffold and formwork", University of Split, Faculty of Civil Engineering and Architecture, 2005, designers: Alen Harapin, Ladislav Bevanda, Mario Jurišić and Dragan Ćubela (in Croatian)

[5] STAXO -designer's manual (in German)

[6] Computer program: TOWER 3D Builder, ver. 5.5, Radimpex, Beograd, owner: HERING d.o.o. Široki Brijeg and Faculty of Civil Engineering, University of Mostar

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Mr.sc.Ladislav Bevanda, dipl.ing. građ.
Mario Jurišić, dipl.ing.građ.
Sveučilište u Mostaru, Građevinski fakultet Mostar; Hering d.d. Široki Brijeg

GRAĐEVINSKA KALKULACIJA – TEMELJ KVALITETE UPRAVLJANJA GRAĐEVINSKIM PROJEKTOM

CONSTRUCTION PRICE CALCULATION – BASIS OF CONSTRUCTION PROJECT QUALITY MANAGEMENT

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Mr.sc.Ladislav Bevanda, dipl.ing. grað.
Mario Jurišić, dipl.ing.građ.
Sveučilište u Mostaru, Građevinski fakultet Mostar; Hering d.d. Široki Brijeg

Sažetak

Rad obrazlaže postupak kalkulacije građevinskog projekta na način transparentan za sve sudionike u projektu, koji im omogućava utjecaj na realizaciju građevinskog projekta u svim fazama i aspektima. Predlaže se metodologija izrade kalkulacije koja se može primijeniti na sve faze i vrste procesa u projektu (upravljačke procese i procese u vezi proizvoda projekta). Predložena metodologija jasno definira interese i procese svih sudionika u projektu. Izloženi postupak kalkulacije građevinskog projekta je temeljna pretpostavka planiranja, izvršenja, kontrole i verifikacije projekta. Autori u ovom radu daju prijedloge za građevinsku kalkulaciju koja bi bila podloga za kvalitetu u upravljanju projektima (ISO 10006:1998) i za upravljanje ekonomijom kvalitete (ISO 10014:1998). Predložena kalkulacija pretendira svoju primjenu za sve vrste proizvoda: software, hardware, usluge i procesni proizvod. Metodologija kalkuliranja uvodi, osim terminiranja-normiranja procesa u vezi sa proizvodom projekta, i normiranje upravljačkih procesa na svim razinama, čime se "faktorsko" pridruživanje indirektnih troškova projekta u velikoj mjeri dokida i postiže potpuna transparentnost troškova.

Ključne riječi: upravljanje projektom, građevinska kalkulacija, kvaliteta u upravljanju projektom, upravljanje ekonomijom kvalitete

1. Uvod

Tradicionalni pristup izračunu troškova građevinskog projekta podrazumijeva podjelu troškova na indirektne i direktne troškove. Pod direktnim troškovima podrazumijevaju se troškovi pojedinačnih izvršenja pozicija građevinskog objekta (sklopova) za koje su najčešće prihvaćene prosječne norme učinaka za pripadne tehnološke mogućnosti proizvodnje (utrošci rada radnika, materijala, usluga, opreme i strojeva). Pod indirektnim troškovima se podrazumijevaju svi ostali troškovi projekta, čija je

CONSTRUCTION PRICE CALCULATION – BASIS OF CONSTRUCTION PROJECT QUALITY MANAGEMENT

M.Sc.Ladislav Bevanda BCE*
Mario Jurišić BCE*
University of Mostar, Faculty of Civil Engineering; Hering d.d. Široki Brijeg

Abstract

This paper describes calculation procedure of construction project in a transparent way for all participants in a project, enabling them to have an impact on the realization of construction project in all its phases and aspects. A methodology of making calculation is proposed that may be applicable to all project phases and processes (management processes and processes relating to project product). The proposed methodology clearly defines interests and processes of all project participants. Presented procedure of construction project calculation is basic precondition for planning, execution, control and verification of a project. The authors of this paper give their proposals for construction calculation that would be basis for high quality of project management (ISO 10006:1998) and for economy quality management (ISO 10014:1998). The proposed calculation is intended to be applied to all sorts of products: software, hardware, services and process-based products. Besides nominating and standardizing processes related to project product, the methodology of calculation also introduces the standardization of managing processes at all levels, which highly reduces "factor" joining of project indirect costs and achieves complete transparency of costs.

Key words: project management, construction calculation, quality project management, quality economy management.

1. Introduction

Traditional approach to cost calculation of construction project divides costs on indirect and direct costs. Direct costs are those of individual executions of positions of building structure for which most often accepted average standards of outputs are those for corresponding technological possibilities of production (expenditures of labor, material, services and machines). Indirect costs are all other tradicionalna podjela sljedeća: troškovi gradilišta i troškovi poduzeća. Nastale prilike u kompletnom gospodarstvu (tržno gospodarstvo, tranzicija, visok stupanj rizika u poslovanju), izražena potreba za uspostavom sustava kvalitete, te kvalitetom u upravljanju projektima, zahtijevaju nove poglede na troškove projekta, koji bi omogućili transparentniju troškovnu strukturu.

2. Glavni dio rada

Često isticana potreba uspostave sustava za upravljanje kvalitetom i osiguranje kvalitete u poslovnom sustavu, te kvalitete u upravljanju projektima iziskuje: definiranje (uspostavu) sustava, definiranje procesa, definiranje procedura, definiranje postupaka, radne upute i specifikacije. Ako se radi o upravljanju građevinskim projektima situacija je tim teža što se građevinski projekti svaki put odvijaju na novoj lokaciji, u potpuno novim uvjetima i nijedan (ili rijetko koji) proizvod nije isti. Proces upravljanja projektom podrazumijeva "planiranje, organiziranje, nadgledanje i kontroliranje svih vidova projekta u trajnom procesu postizanja njegovih ciljeva", a obuhvaća sljedeće procese: upravljanje cjelokupnim projektom, upravljanje obujmom projekta, upravljanje vremenom, upravljanje troškovima, upravljanje kvalitetom, upravljanje ljudskim resursima, upravljanje sredstvima, upravljanje komunikacijama, upravljanje rizikom, upravljanje nabavom (ISO 10006). Dakle, modeli za uspostavu sustava kvalitete i upravljanje projektima moraju biti dovoljno opći da obuhvate veliki broj različitih situacija koje se mogu dogoditi u građevinskim projektima. U ovom radu istaći ćemo, vezano za građevinski projekt: definiranje sustava, definiranje procesa, u okviru uspostave sustava za upravljanje kvalitetom, model kalkuliranja troškova projekta, koji će biti kvalitetna podloga procesima upravljanja projektom.

Tradicionalnom postavkom troškova projekta, gdje se izračun cijene koštanja građevinskih projekata (C_k) bazirao na egzaktnom izračunu direktnih troškova (pojedinačnih izvršenja pozicija objekta) tako što se za pojedini radni proces sumiraju rad (R_{pi}), materijal (M_{pi}), usluge (U_{pi})i sredstva (oprema) (S_{pi}), a indirektni troškovi (I_{tr}) obračunavaju se na razne načine (bez standardnog modela) i pridružuju se u ukupne troškove multiplicirajući dio direktnih troškova (rad radnika) bezdimenzionalnim faktorom F:

$$C_k = R_{pi} x (1+F) + M_{pi} + U_{pi} + S_{pi} \quad (1)$$

$$F = ((I_{tr})/R_{pi})) \quad (2)$$

Među temeljnim zahtjevima u pogledu troškova projekta koje ističu norme ISO 10006 (smjernice za kvalitetu u upravljanju projektima) i ISO 10014 (smjernice za upravljanje ekonomijom kvalitete) su:

- predviđanje i upravljanje svim troškovima projekta i osiguranje završetka projekta unutar ograničenja proračuna projekta kroz: razvoj troškovne strukture projekta, izradu proračuna projekta, kontrolu troškova projekta, project expenditures and its traditional division is the following: site expenditure and company expenditure. The current situation in the overall economy (market economy, transition, high risk degree in business operations,…), a respectful need for establishing of a quality system as well as for good quality in project managing require new approaches to project costs that would make possible more transparent cost structure.

2. Main section

The frequently stressed need for establishing a system of quality management and providing good quality in business system as well as for project managing quality requires a definition (establishment) of system, definition of procedures, working instructions and specifications. The situation is even more difficult regarding construction projects managing because construction projects develop in a different location every time, with completely new conditions and no (or hardly any) product is the same. The process of project managing means planning, organizing, supervising and controlling all project levels in a permanent process of accomplishing its goals, and comprises the following processes: overall project management, management of project scope, time management, costs management, quality management, human resources management, assets management, communication management, procurement management (ISO 10006). Consequently, models for establishing of quality system and project management must be universal in order to cover a large number of various situations that may occur in construction projects. Regarding construction project, we are going to point out the following: definition of system, definition of process, in the frame of establishing of system for quality management, a model of project costs calculation that would be a proper basis for the processes of project management.

By the traditional form of project costs the calculation of cost price of construction projects (C) was based on exact calculation of direct costs (individual executions of structure position) in the way that work (Rpi), material (Mpi), service (Upi) and assets (equipment) (Spi) are summed for each working process, and indirect costs (Itr) are calculated in various ways (without any standard model) and are joined into total costs by multiplying a part of direct costs (labor) with non-dimensional factor F:

$$Ck = Rpix(1+F) + Mpi + Upi + Spi \qquad (1)$$

$$F = ((Itr)/Rpi)) \qquad (2)$$

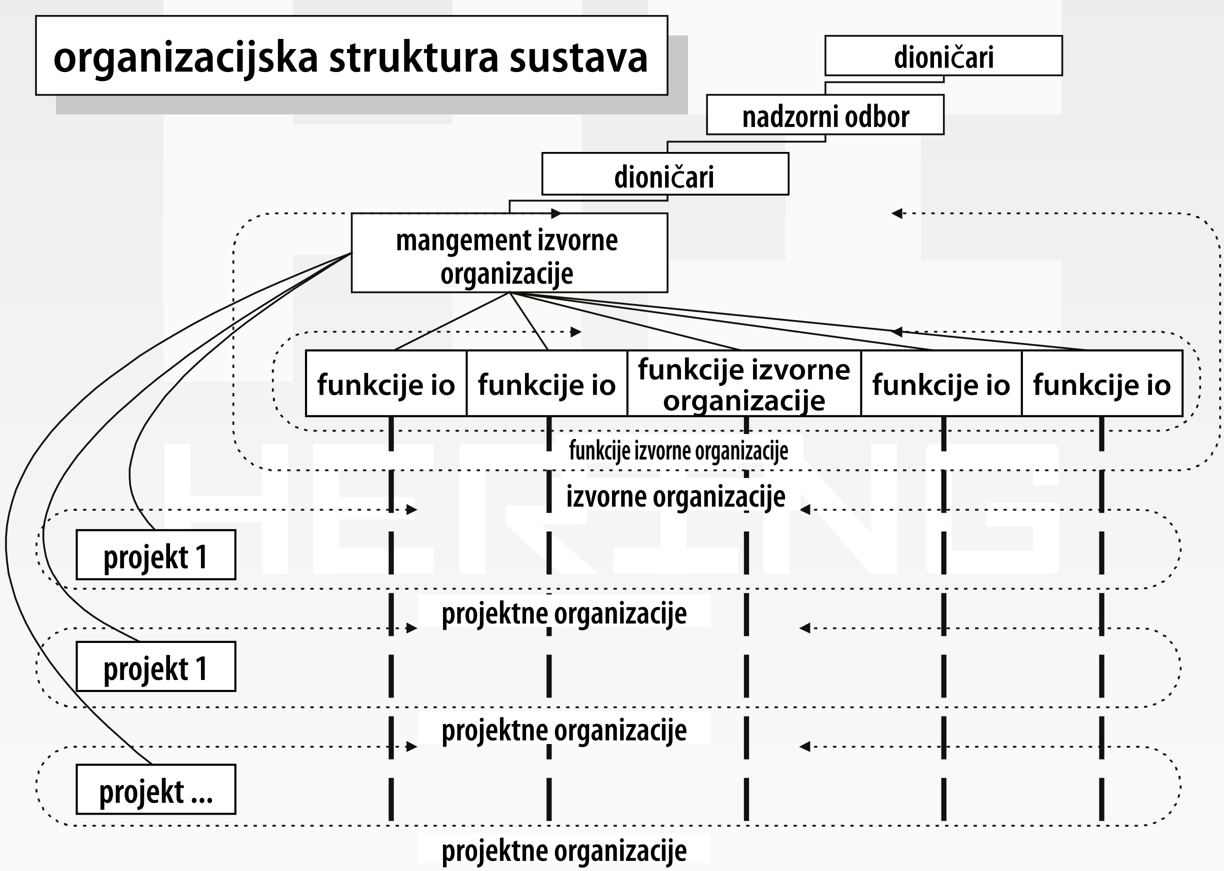
Here are some of basic requirements regarding project costs stressed by standards ISO 10006 (directions for quality project management) and ISO 10014 (directions for economy quality management):

- predicting and managing all project costs and providing the finalization of project within the limits of project calculation through: development of project cost structure, development of project budget and project costs control;

- raspoređivanje svih troškova s obzirom na faze projekta (project phase), organizacijske jedinice OBS (organizational breakdown structure), radne cjeline WBS (work breakdown structure), ključne resurse RBS (resource breakdown structure), te vrste troškova (account codes), ili neke druge podjele troškova specifične za pojedinu struku, a ne njihova apsorpcija u opće troškove,
- razlikovanje troškova sukladnosti (saobraznosti, zbog kvalitete) i troškova nesukladnosti (nesaobraznosti, zbog nekvalitete).

2.1. Definiranje sustava

Organizacija je grupa ljudi i ustanova sa uređenim odgovornostima, ovlastima i odnosima. Izvorna organizacija je organizacija koja je odlučila poduzeti projekt i dodijeliti ga projektnoj organizaciji. Projektna organizacija je organizacija koja provodi projekt.



Slika 1. Struktura sustava

- distribution of all costs in regard to the phases of project (project phases), organizational units OBS (organizational breakdown structure), work divisions WBS (work breakdown structure), key resources RBS (resource breakdown structure), and types of costs (account codes), or some other divisions of costs specific for particular structure and not their inclusion into general costs;
- distinguishing between conformity costs (compliance, due to good quality) and non-conformity costs (non-compliance, due to bad quality).

2.1. Definition of system

Organization is a group of people and institutions with regulated responsibilities, authorities and relations. Original organization is such an organization which has decided to undertake a project and to allocate it to a project organization. Project organization is such an organization which carries out a project.

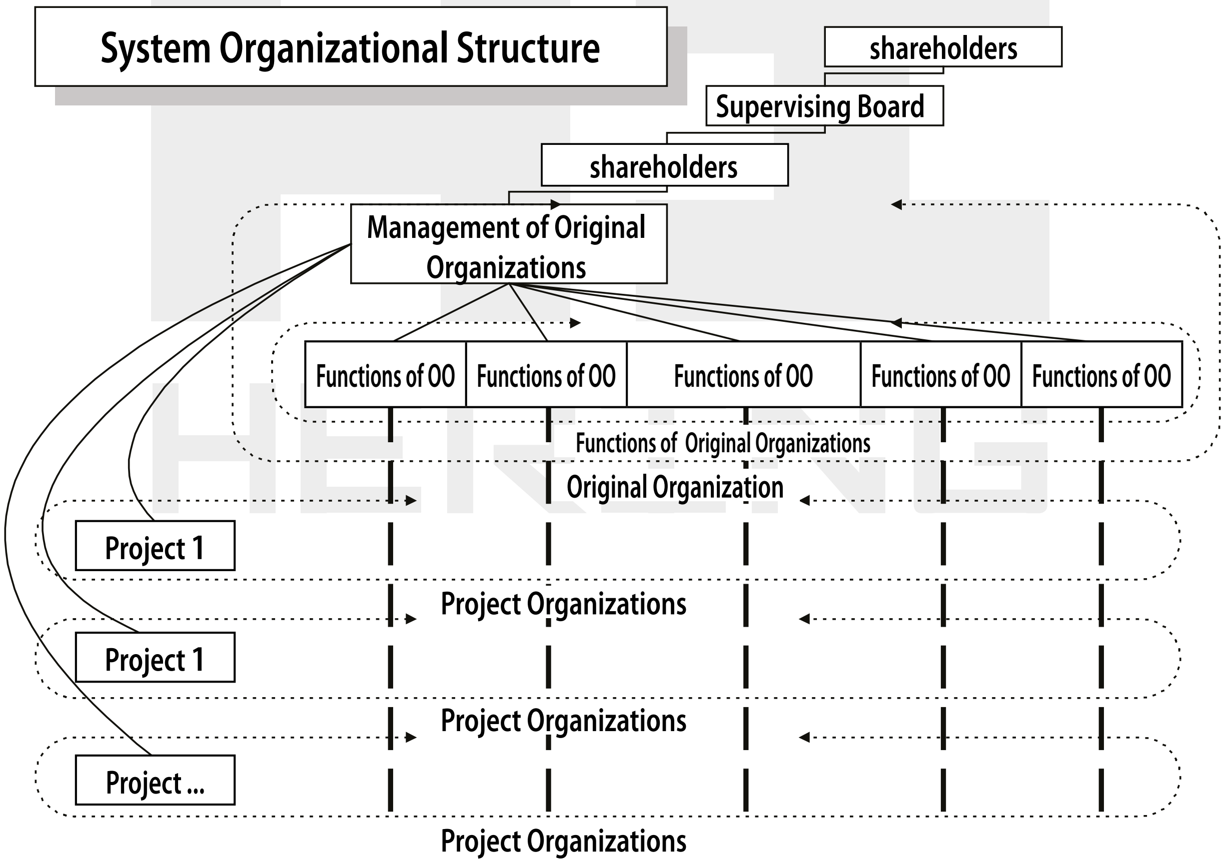
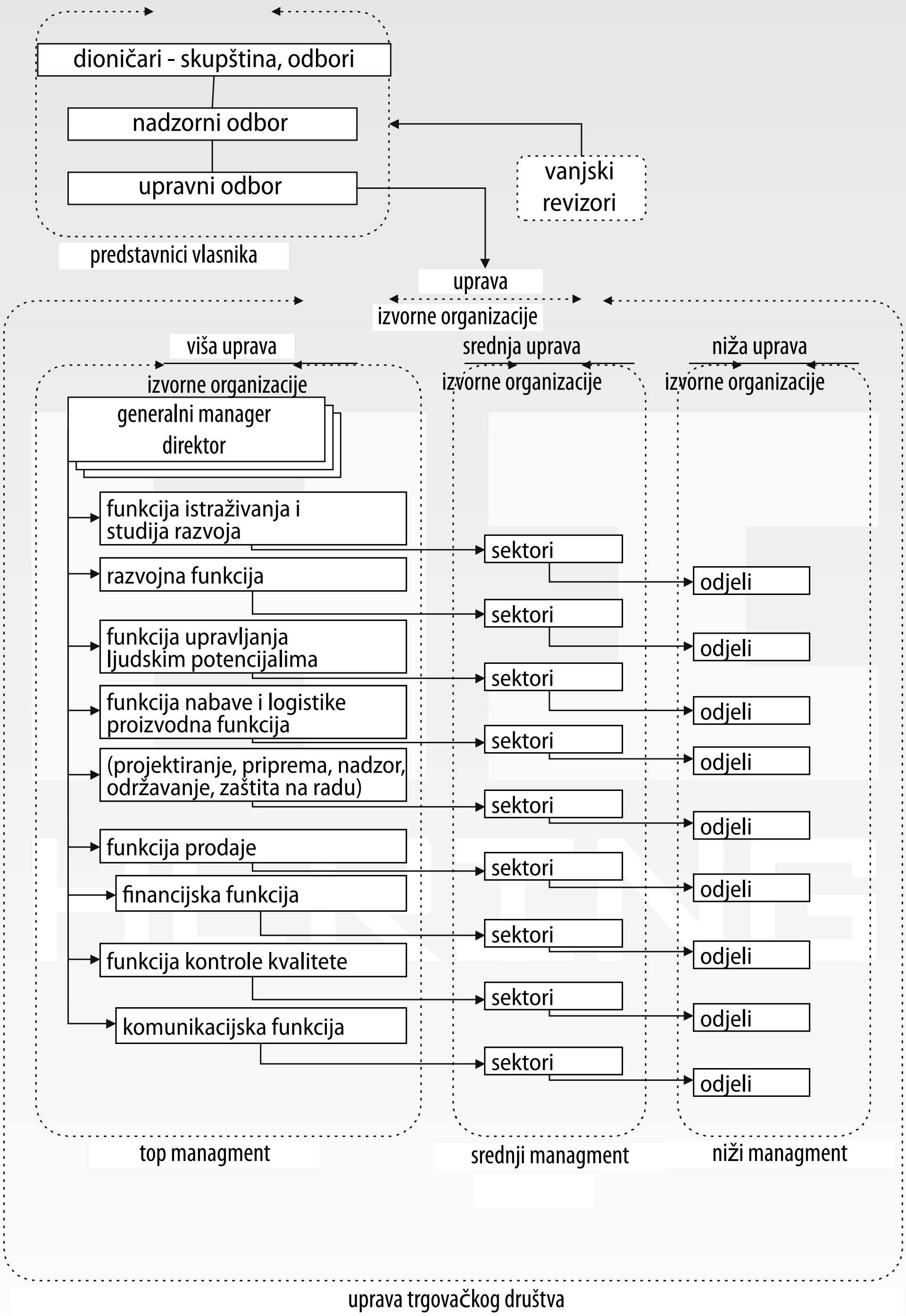


Figure 1. Structure of system



Slika 2. Uprava izvorne organizacije

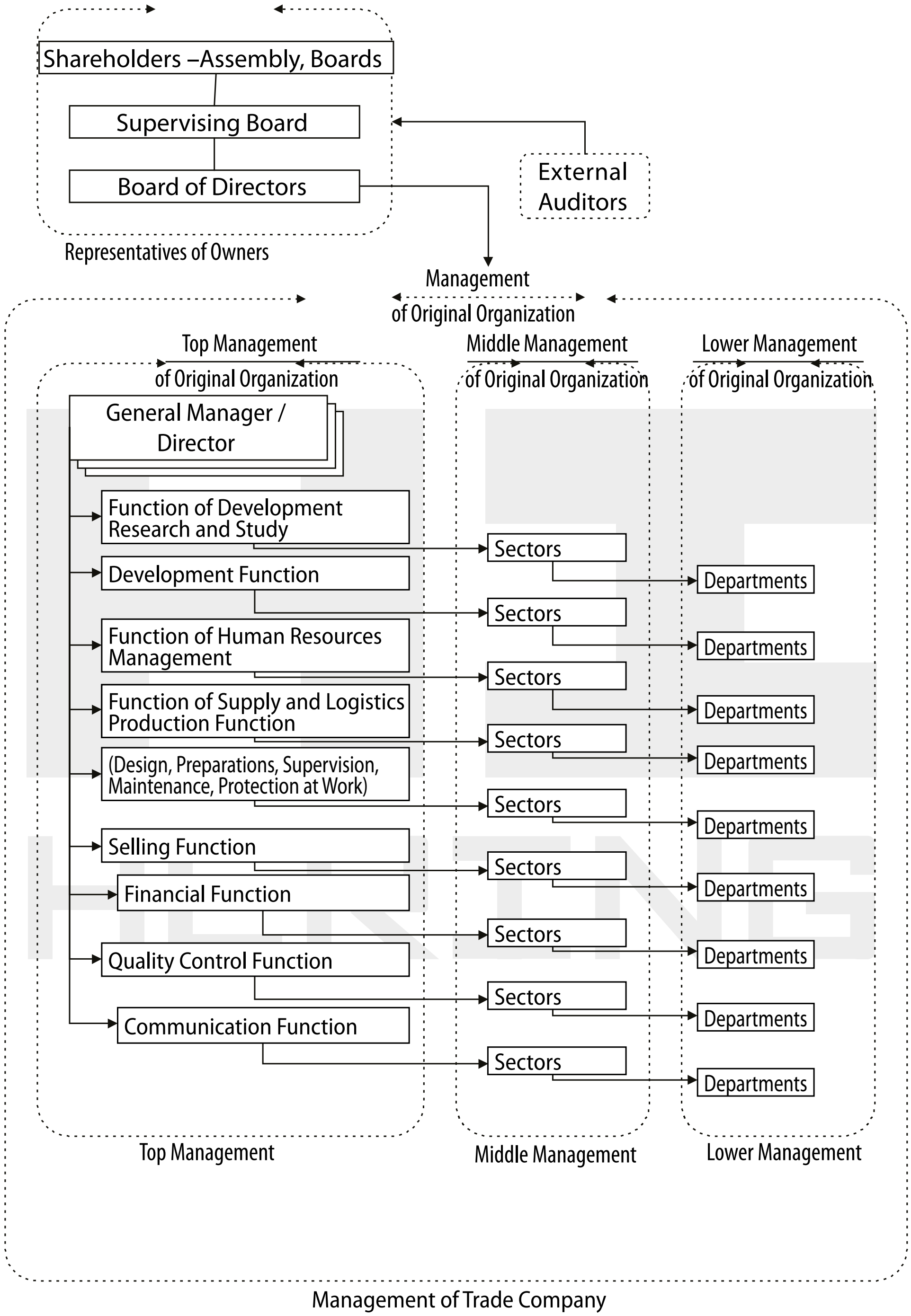
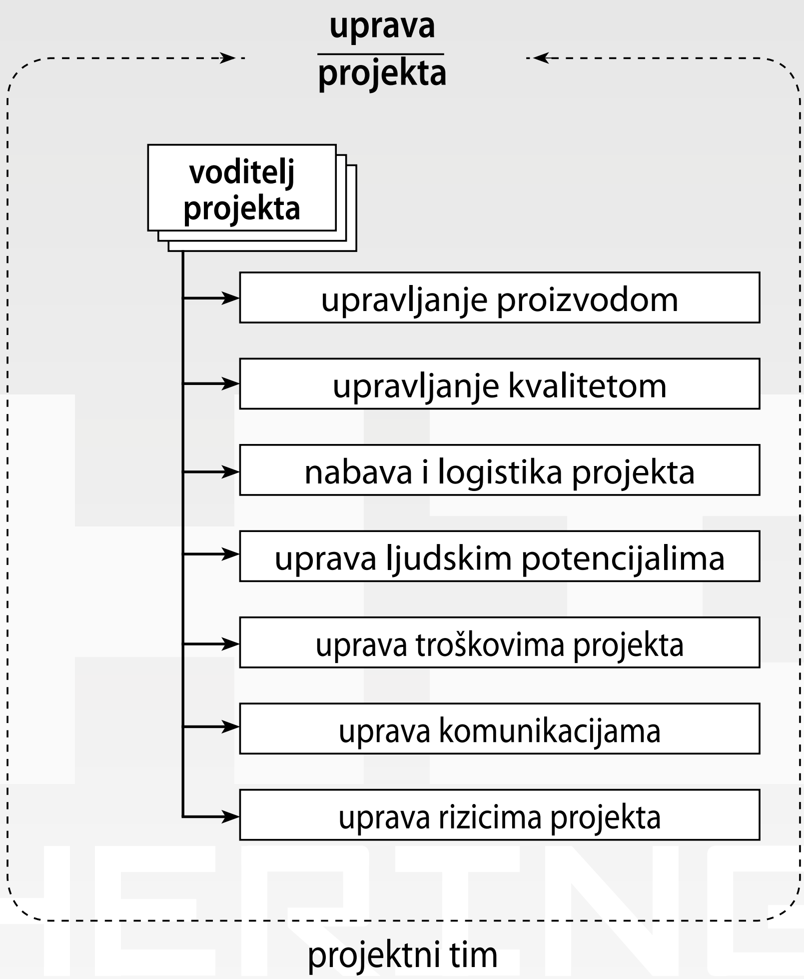


Figure 2. Management of original organization



Slika 3. Projektna uprava

Opću shemu realizacije građevinskog projekta (hardware) predočuje se shemama uprave gradnje i uprave gradilišta, s nositeljima funkcija.

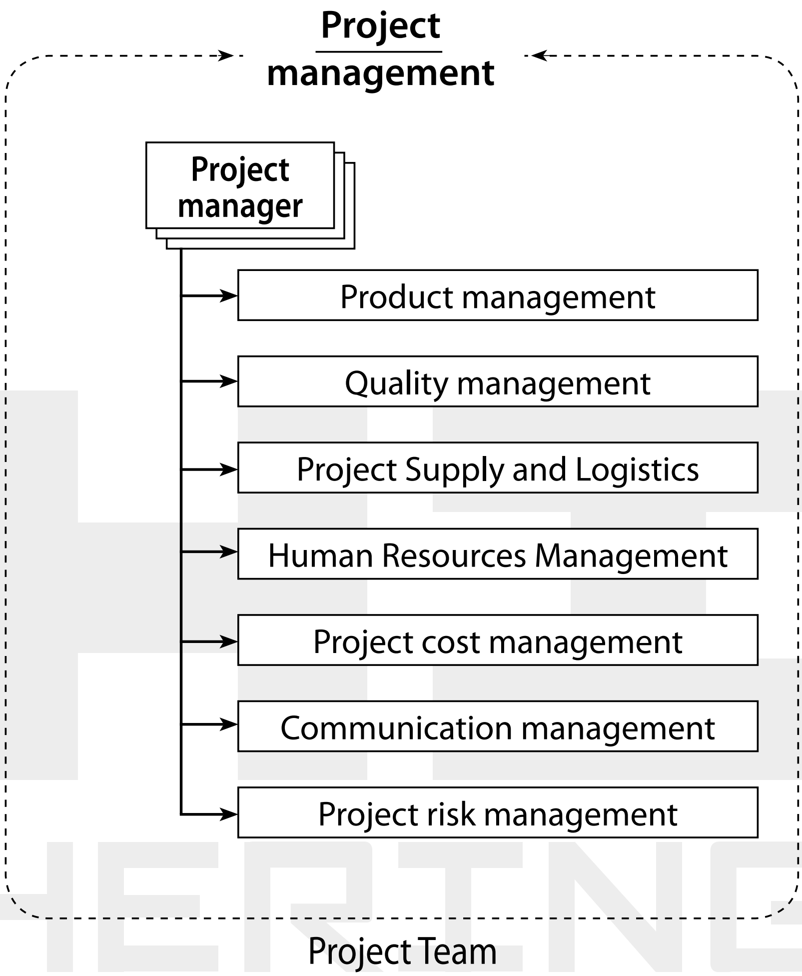
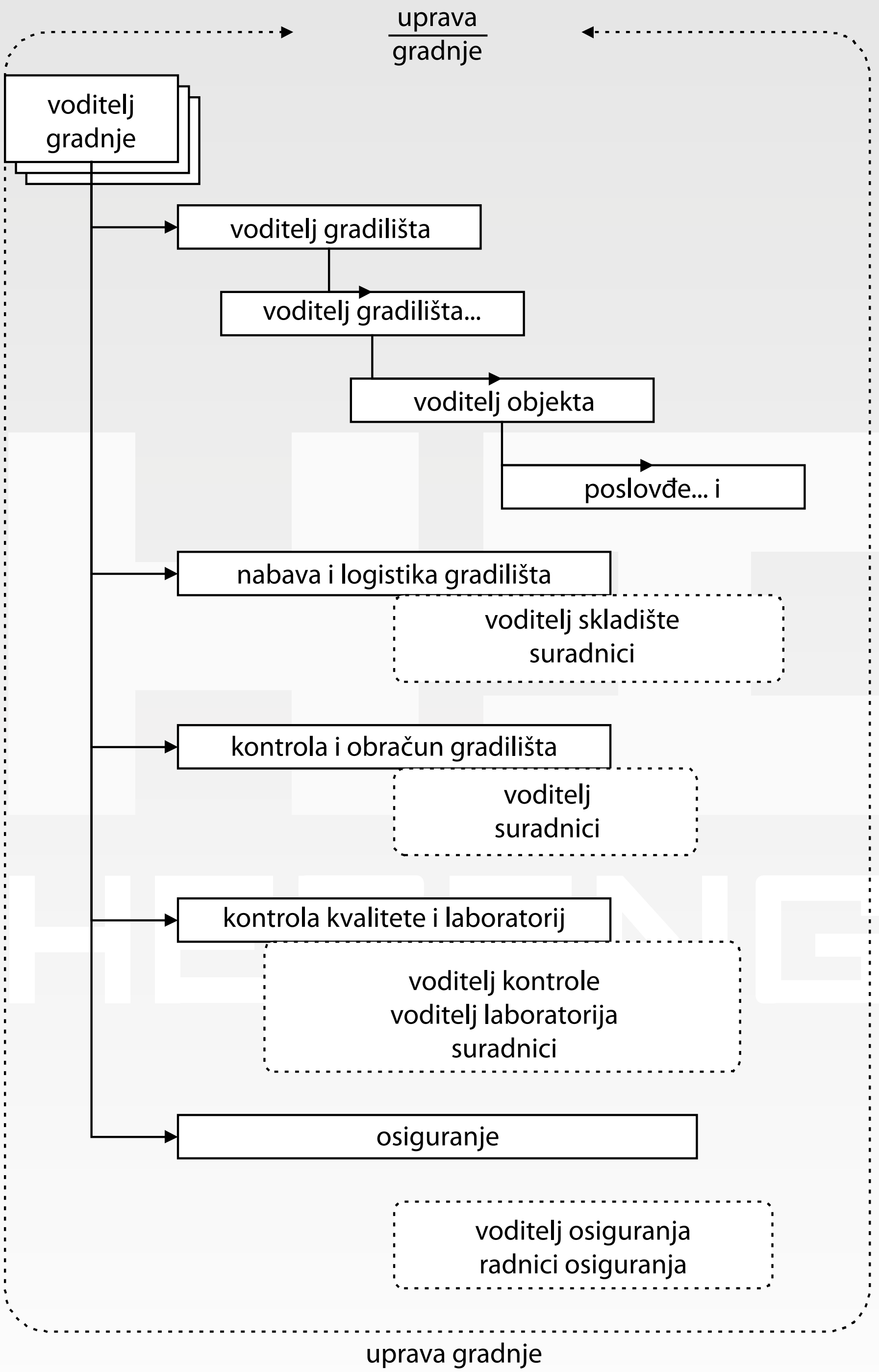


Figure 3. Project Managment

General scheme of the realization of a construction project (hardware) is presented with the schemes of Construction Management and Site Management with the holders of work positions.



Slika 4. Uprava gradnje

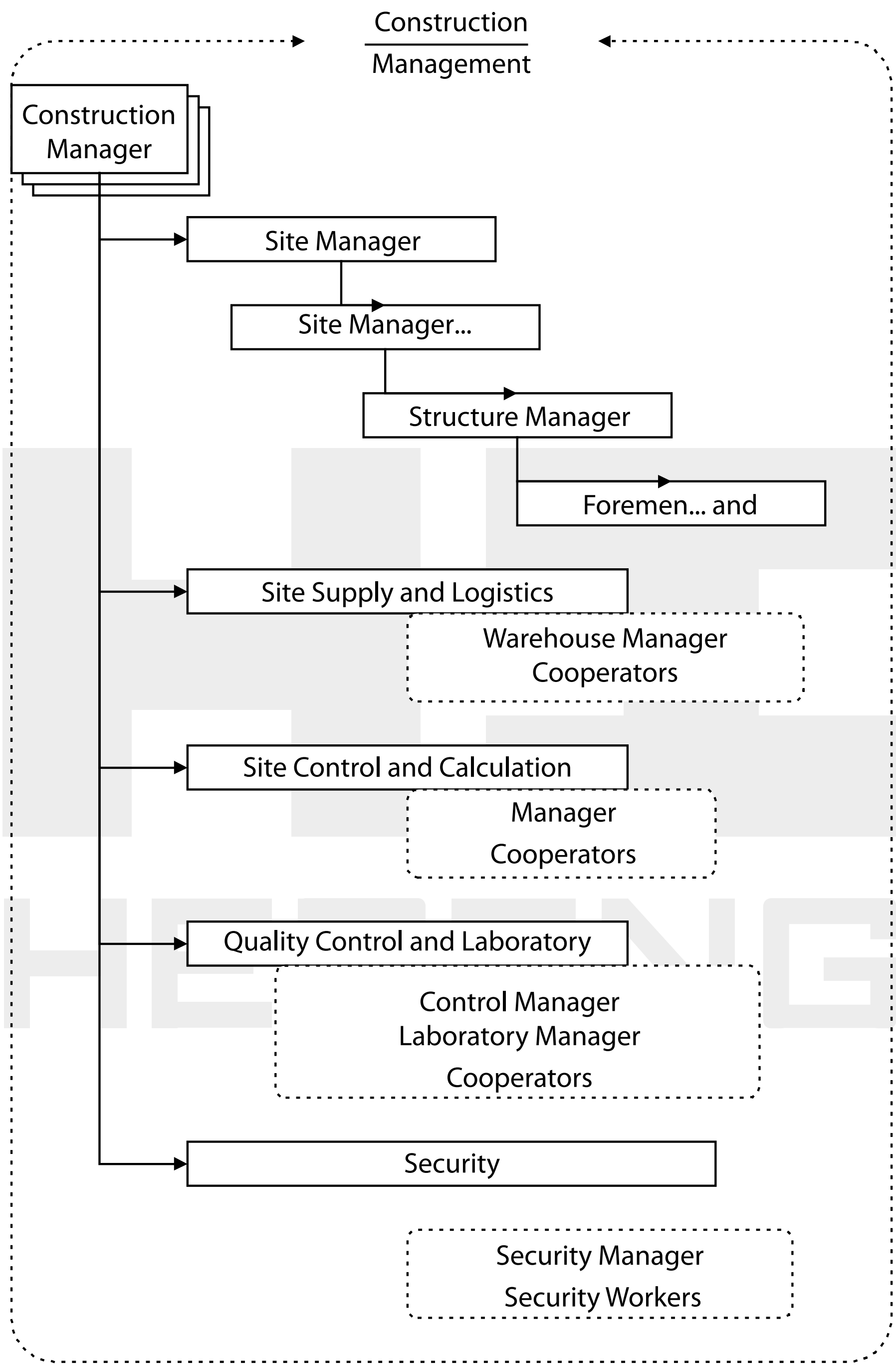
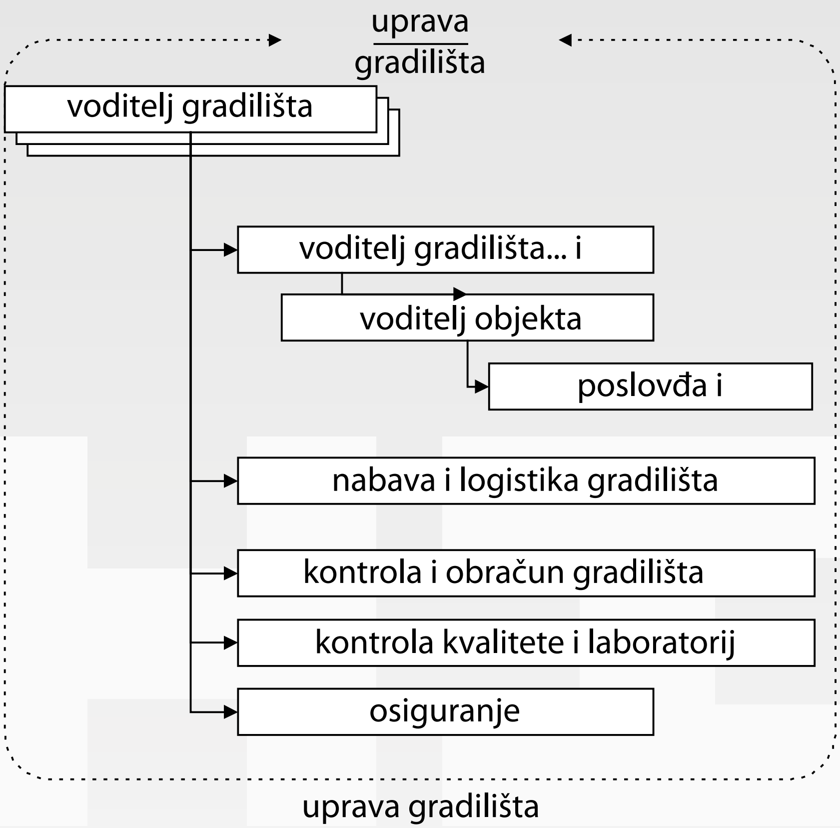


Figure 4. Constrution Management



Slika 5. Uprava gradilišta

Faze projekta:

KONCIPIRANJE

- zamisao, zahtjev s tržišta
- istraživanje
- idejna tehnička dokumentacije
- uvjeti uređenja prostora
- prethodne suglasnosti
- investicijska studija
- studija izvodljivosti
- osiguranje financiranja
- imovinsko pravni odnosi

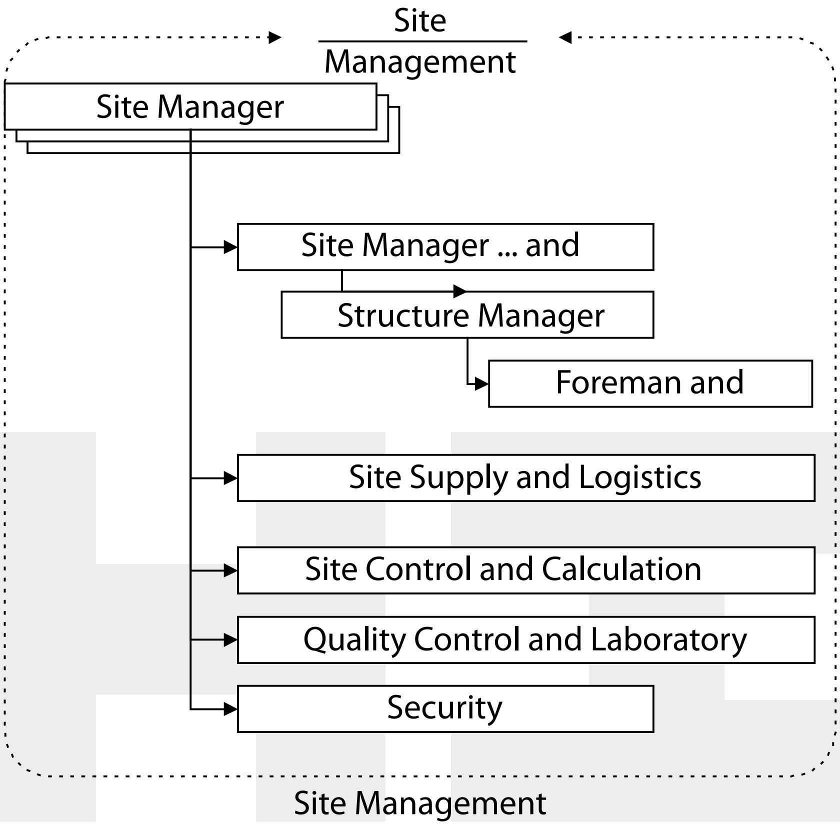


Figure 5. Cosntruction Site Management

Project Phases:

CONCEPT

- idea, market demand
- research
- preliminary technical documentation
- requirements of establishing construction site
- preliminary approvals
- investment study
- feasibility study
- provision of funds
- property-legal relations

DEFINIRANJE

- prikupljanje ponuda i odabir projektanata za izradu tehničke dokumentacije
- projektni program i zadatak
- izrada i nadzor nad tehničkom dokumentacijom
- suglasnosti na tehničku dokumentaciju
- revizija i korekcije
- građevna dozvola
- prikupljanje ponuda za građenje
- idejni projekt organizacije građenja
- izrada kalkulacije
- izbor izvođača i ugovaranje radova

IZVOĐENJE

- izvedbeni projekt organizacije građenja
- uvođenje izvođača u posao
- pripremni radovi
- građenje
- isporuka i montaža opreme
- tehnički pregled
- primopredaja
- uporabna dozvola
- prihvaćanje
- certifikat građevinske inspekcije

UPORABA OBJEKTA, JAMSTVENI ROK I ODRŽAVANJE

Razine promatranja upravljanja građevinskim projektima (objekt,hardware, kao najsloženiji) su:
Predstavnici vlasnika-vlasnici -pd
Izvorna organizacija-trgovačko društvo -io
Projektna uprava - up
Uprava gradnje - gr
Uprava gradilišta - grs
Instalacija i deinstalacija gradilišta -si
Izvršenja pojedinačnih pozicija - pi.

Razine promatranja fizičkog modela građevinskog projekta – hardware sa aspekta proizvoda projekta:

DEFINITION

- collecting tenders and selecting designers to develop technical documentation
- project program and task
- development and supervision of technical documentation
- approval of technical documentation
- revision and corrections
- building permit
- collecting tenders for construction works
- preliminary draft of building organization
- calculation
- selecting a contractor and contracting works

PERFORMANCE

- working design of construction organization
- introducing contractor to works
- preliminary works
- construction
- delivery and assembly of equipment
- technical inspection
- takeover
- operating license
- acceptance
- building inspection certificate

USE OF BUILDING STRUCTURE, DEFECTS LIABILITY PERIOD AND MAINTENANCE

Levels of observation of building projects managing (structure, hardware, as the most complex) are:
Representatives of Owners - Owners - pd
Original organization - trade company - io
Project management - up
Construction management - gr
Site management - grs
Site establishment and dismantling -si
Execution of individual positions - pi.

Levels of observation of physical model of building structure – hardware from project product point of view:

Projekt,

Faza,

Pod-faza-Aktivnosti,

Kompleksni procesi,

Radni procesi-norme rada.

Radnim procesom (normom rada) se u ovom kontekstu smatra prosječna količina svih resursa (vrijeme, materijal, strojevi, ostalo) koji su potrebni kvalificiranoj grupi (timu) za izvršenje određene tipizirane jedinice proizvoda (softwrae, hardware, usluga, procesni proizvod) po određenom postupku i redosljedu radnih operacija, određenim alatima i strojevima, u normalnim uvjetima okruženja uz normalno zalaganje i zamor. Tipizacija je vezana uz određene dogovorene standarde opisivanja pozicija proizvoda. Radni proces podrazumijeva da se za vrijeme njegovog trajanja ne mijenja sastav radne grupe.

2.2. Definiranje procesa

Procesom smatramo svaku aktivnost koja prima ulaze i pretvara ih u izlaze. Temeljna podjela procesa razlikuje procese upravljanja i procesi u vezi proizvoda projekta (dizajn, proizvodnja i verifikacija, bilo da se radi o softwareu, hardwareu, usluzi ili procesnom proizvodu).

Kroz proces realizacije građevinskog projekta razlikujemo (bilo da se radi o hardware-građevinski objekt) H, software-tehnička dokumentacija, program S, uslugama U, procesnom proizvodu P) :

1. Procesi u vezi upravljanja:
- procese predstavnika vlasnika (H,S,U,P),
- procese izvorne organizacije (H,S,U,P),
- procesi projektne uprave (H,S,U,P),
- procesi uprave gradnje (H),
- procesi uprave gradilišta (H),
- procesi u vezi proizvoda projekta (H,S,U,P):
- instalacija i deinstalacija gradilišta (H),
- prosječne norme učinaka (H),
- priručnik za konzultantske usluge u investicijskoj gradnji KOPROJEKT Zagreb 1991 (S,U),
- normativi usluga (U),
- normativi procesnih proizvoda (P)

Radne procese predstavnika vlasnika čine procesi organa skupštine dioničara, procesi nadzornog odbora, procesi upravnog odbora, te vanjskih revizora I najčešće su zamagljena i nedovoljno definirana skupina poslova, koju treba određivati na godišnjoj razini kao presječnom obračunskom razdoblju.

Design,

Phase,

Sub-phase-Activities,

Complex processes,

Work processes - work standards.

In this regard work process (work standard) is average quantity of all resources (time, material, machines, other,..) which are necessary for a skilled group (team) to carry out a particular standard product unit (software, hardware, services, process-based product) in a particular way and order of work operations by particular tools and machines in regular circumstances engaging regular effort and wear. Standardization is related to certain agreed standards of description of product positions. Work process means that the composition of work group does not change during the work process itself.

2.2. Definition of process

Process is every activity that turns inputs and results into outputs. Basic division of processes distinguishes between managing processes and processes related to project products (design, production and verification of either software, hardware, service or a process-based product).

Within the process of realization of construction project there are (ether hardware-constructed structure H, software-technical documentation, program S, services U or process-based product P):

1. Processes related to management:

- processes of representatives of owners (H,S,U,P),
- processes of original organization (H,S,U,P),
- processes of project management (H,S,U,P)
- processes of construction management (H),
- processes of site management (H),
- processes related to project product (H,S,U,P):
- site establishment and dismantling (H),
- average output standards (H),
- manual for consulting services in investment construction KOPROJEKT Zagreb 1991 (S,U),
- standards of services (U),
- standards of process-based products (P)

Work processes of owners' representatives consist of the processes of the bodies of assembly of shareholders, processes of supervising board, processes of board of directors, and of external auditors. They are mostly vague and insufficiently defined group of activities that have to be defined annually as an interim budgetary period.

Primjer radni procesi predstavnika vlasnika:

- odbori dioničara
- rad odbora za reviziju,
- rad odbora za naknade,
- rad odbora za imenovanje,
- rad povremenih odbora,
- vanjska revizija
- rad vanjske revizije,
- nadzorni odbor
- postavljanje uprave ,
- nadzor vođenja poslova izvorne organizacije,
- pregled poslovnih knjiga, dokumentacije,
- vrijednosnih papira i ostalih stvari IO,
  izvještavanje glavne skupštine i odbora dioničara,
- sazivi skupština i odbora dioničara,
- davanje raznih suglasnosti,
- zastupanje dioničara prema upravi,
- sjednice odbora,
- upravni odbor
- definiranje svrhe i ciljeva trgovačkog društva-izvorne organizacije,
- određivanje strategije i planova za postizanje definirane svrhe i ciljeva,
- ustanovljavanje politike trgovačkog društva u provođenju planova,
- postavljanje glavnog izvršnog direktora i nadgledanje njegovog rad.

Radne procese izvorne organizacije čine procesi više, srednje, niže uprave izvorne organizacije (trgovačkog društva, poduzimatelja projekta). Često su općenito opisani u pravilnicima o sistematizaciji radnih mjesta i sl.

Radni procesi - elementarne operacije, uprave izvorne organizacije:

VIŠA UPRAVA-IZVRŠNI MANAGEMENT

Aktivnosti glavnog direktora i funkcija IO
Planiranje,
Organiziranje,
Vođenje,
Kontroling,
Odlučivanje,
Aktivnosti tajništva,

Examples of work processes of owners' representatives:

- shareholders' boards
- auditing board activities
- compensation board activities
- appointing board activities
- periodical board activities,
- external audit
- external audit activities
- supervising board
- appointing management,
- supervision of business management of original organization,
- audit of business records, documentation,
- securities and other issues of original organization,
- reporting to the general assembly and shareholders board,
- convening shareholders assemblies and boards,
- issuing various approvals,
- representing shareholders towards management,
- board meetings,
- board of directors
- definition of purpose and goals of trade company - original organization ,
- determining strategy and plans to achieve the defined purpose and goals,
- establishing policy of trade company in order to implement plans,
- appointing chief executive officer and supervising his work.

Work processes of original organization consist of the processes of top, middle and lower management of the original organization (trade company, project contractor). They are often described in general terms in job classification regulations and the like.

Work processes – basic operations of original organization management:

TOP MANAGEMENT - EXECUTIVE MANAGEMENT

CEO's activities and the function of Executive Board
Planning,
Organizing,
Managing,
Controlling,
Decision making,
Secretariat activities,

SREDNJA UPRAVA

- rad sektora funkcija istraživanja i studija razvoja,
- rad sektora razvojna funkcija,
- upravljanje promjenama,
- okončanje projekta,

NIŽA UPRAVA

- razvoj koncepcije,
- razvoj i kontrola obima projekta,
- definicija aktivnosti,
- kontrola aktivnosti,

Procese projektne uprave čine niže pobrojani procesi na realizaciji projekta :

POSTAVLJANJE CILJA PROJEKTA I UPRAVLJANJE OSTALIM PROJEKTNIM PROCESIMA, MEĐUOVISNOST UPRAVLJACKIH PROCESA

- iniciranje projekta i plana projekta,
- interakcijsko upravljanje,
- upravljanje promjenama,
- okončanje projekta,

PROCESI VEZANI ZA DJELOKRUG RADA

- razvoj koncepcije,
- razvoj i kontrola obima projekta,
- definicija aktivnosti,
- kontrola aktivnosti,

PROCESI VEZANI VREMENOM

- planiranje međuovisnosti projektnih aktivnosti,
- procjena trajanja aktivnosti,
- razvoj rasporeda aktivnosti,
- kontroliranje rasporeda,

PROCESI POVEZANI S TROŠKOVIMA

- procjena troškova,
- proračun troškova,
- kontrola troškova,

MIDDLE MANAGEMENT

- activities of the sector of the functions of development research and study
- activities of development function sector,
- managing changes,
- finalization of project,

LOWER MANAGEMENT

- concept development,
- development and control of the scope of project,
- definition of activities,
- control of activities.

Processes of project management consist of the below listed processes in project realization:

DEFINING PROJECT GOAL AND MANAGING OTHER PROJECT PROCESSES. INTERDEPENDENCE OF MANAGEMENT PROCESSES

- initiation of project and plan of project,
- interaction of managing,
- managing changes,
- finalization of project,

PROCESSES RELATED TO SCOPE OF WORK

- development of concept,
- development and control of the scope of project,
- definition of activity,
- control of activity,

TIME RELATED PROCESSES

- planning of interdependence of project activities,
- estimate of activity time,
- development of activity schedule,
- control of schedule,

COST RELATED PROCESSES

- cost estimate,
- cost calculation,
- cost control.

PROCESI UPRAVLJANJA KVALITETOM PROCESI U VEZI SA SREDSTVIMA

- planiranje sredstava,
- kontrola sredstava,

PROCESI U VEZI SA OSOBLJEM

- definiranje organizacijske strukture projekta,
- izbor osoblja i formiranje tima,

PROCESI U SVEZI S KOMUNUKACIJAMA PROCESI POVEZANI S RIZIKOM (ISO 10006:1998)

Radni procesi uprave gradnje čine aktivnosti na upravljanju gradnjom i trenutno čine nestandardiziranu grupu zadaća u upravljanju s više gradilišta.

Radne procese gradilišta sačinjavaju poslovi uprave gradilišta i isto su neizgrađen i nedefiniran sustav zadaća u upravljanju gradilištem.

Radni procesi instalacije i deinstalacije gradilišta čine poslovi na uspostavi uvjeta za realizaciju građevinskog objekta (hardware) u okvirima zadane tehnologije.

Radni procesi pojedinačnih izvršenja čine poslovi na izradi pojedinih pozicija (elemenata objekta, hardwarea) proizvoda projekta (visokogradnja):

INSTALACIJA I DEINSTALACIJA GRADILIŠTA, GRAĐEVINSKI RADOVI

I Rušenja i demontaže
II Zemljani radovi
III Betonski i armiranobetonski radovi
IV Zidarski radovi
V Izolatorski radovi
VI Tesarske konstrukcije
VII Metalne konstrukcije
VIII Ostali građevinski radovi

ZANATSKI RADOVI

I Limarski radovi
II Pokrivački radovi i izolacija ravnih krovova
III Stolarski radovi
IV Bravarski radovi

PROCESSES OF QUALITY MANAGEMENT PROCESSES RELATED TO ASSETS

- planning of assets,
- control of assets.

PERSONNEL RELATED PROCESSES

- definition of organization of project structure,
- selection of personnel and formation of team.

COMMUNICATIONS RELATED PROCESSES RISK RELATED PROCESSES (ISO 10006:1998)

Work processes of construction management consist of activities related to construction management and they presently represent a non-standardized group of tasks in managing several construction sites.

Work processes of construction site consist of site management activities and they are also neither defined nor completed system of tasks in site management.

Work processes of site installation and disassembly consist of activities aiming to establish conditions for the realization of building structure (hardware) in the framework of the defined technology.

Work processes of individual executions consist of activities of individual positions (elements of structure, hardware) of project products (building construction):

SITE INSTALLATION AND DISASSEMBLY CONSTRUCTION WORKS

I Demolition and removal,
II Earth-works,
III Concrete and reinforced-concrete works,
IV Masonry works,
V Waterproofing works,
VI Carpentry structures,
VII Metal structures,
VIII Other construction works

CRAFT WORKS

I Sheet-metal works,
II Roof covering and damp-proofing of deck roofs,
III Joiner´s work/Carpentry,
IV Locksmith´s works,
V Final masonry works,

V Završni zidarski radovi
VI Gipsarski radovi
VII Montažni zidovi i stropovi
VIII Staklarski radovi
IX Kamenorezački radovi
X Keramičarski radovi
XI Soboslikarsko-ličilački radovi
XII Parketarski radovi
XIII Podo-polagački radovi
XIV Ostali zanatski radovi

INSTALACIJSKI RADOVI

I Hidrotehničke instalacije
II Elektroinstalacije
III Termo-tehničke instalacije:
IV Plin
V Dizala (osobna, teretna i malo-teretna)
VI Ostali instalacijski radovi

Radni procesi instalacije deinstalacije gradilišta i pojedinačnih izvršenja, npr. u Njemačkoj su sadržani u standardnim opisi LV-Position (Leistungsverzeichnis), kojima odgovaraju prihvaćeni normativi prosječnih učinaka (ARH-Tabele, Arbeitszeit-Richtwerte-Tabellen), a koji su zajedno u skladu sa Općima tehničkim uvjetima za građevinske radove (Verdingungsordnung für Bauleistungen -VOB), koji su baziraju na DIN standardima. U Sjedinjenim Američkim Državama su radni procesi instalacije i deinstalacije gradilišta, te pojedinačnih izvršenja, uglavnom, sadržani u CSI's SPEC-DATA (R) standardima nacionalne profesionalne udruge u građevinskoj industriji Construction Specifications Institute (CSI) i (construction cost data books) R.S. Means' Cost Data vodeće sjeverno-američke tvrtke za informacije o cijenama građenja R.S. Means.

Radni procesi tehnički i konzultantskih usluga u realizaciji građevinskih projekata (S,H,U,P) mogu se odrediti iz priručnika za konzultantske usluge u investicijskoj gradnji KOPROJEKT Zagreb 1991 (H,S). U Njemačkoj se u pravilniku za određivanje troškova (naknada, honorara) arhitekata i inženjerskog osoblja pri realizaciji građevinskih projekata, Honorarordnung für Architekten und Ingenieure HOAI (zadnje izdanje 1996), dati opisi radova arhitekata i inženjera u realizaciji projekta, te honorarne skupine i pripadajuće naknade.

VI Plaster work,
VII Prefabricated walls and ceilings,
VIII Glazier works,
IX Stone cutting works,
X Tile works,
XI Painting works,
XII Strip flooring works,
XIII Flooring works,
XIV Other craft works

INSTALLATION WORKS

I Hydrotechnic installations,
II Electrical installations,
III Thermo-technical installations,
IV Gas,
V Lifts (passenger lifts, trunk lifts),
VI Other installation works.

Work processes of site installation and disassembly and those of individual executions, in Germany for instance, are included in standard descriptions LV-Position (Leistungsverzeichnis), to which established standards of average outputs correspond (ARH-Tables, Arbeitszeit-Richtwerte-Tabellen), and together they are in conformity with general technical requirements for construction works (Verdingungsordnung für Bauleistungen -VOB) based on DIN standards. As far as the United States of America is concerned, work processes of site installation and disassembly and those of individual executions are mainly included in CSI´s SPEC-DATA (R) - standards of national professional association in construction industry, the Construction Specifications Institute (CSI) and (construction cost data books) R.S. Means' Cost Data of a leading North-American company for information on construction price, R.S. Means.

Work processes of technical and consulting services in realization of construction projects (S,H,U,P) may be defined from the manual for consulting services in investment building KOPROJEKT Zagreb 1991 (H,S). In Germany, the cost regulations (payments, fees) of architects and engineering staff in realization of building projects, Honorarordnung für Architekten und Ingenieure HOAI (latest edition 1996), describe works of architects and engineers in realization of project and part-time groups with corresponding payments.

Radni procesi na realizaciji usluga kao proizvoda projekta definiraju se raznim autonomnim normativima usluga (U).

Radni procesi na realizaciji procesnih proizvoda kao proizvoda projekta definiraju se raznim autonomnim normativima za pojedine procesne proizvode (P).

Ovakav način prikazivanja i kalkuliranja troškova uz respektiranje prirode troškova, srodnosti troškova, projektnih faza, te životnog vijeka projekta, u svjetskoj literaturi se zove Environmental Cost Handling Options and Solutions (ECHOS). Iz tog su nastali standardi Environmental Remediation Estimating Methods Handbook sa, za kalkulaciju, 50 standardnih pomoćnih tehnologija (step-by-step) formiranja cijene i ECHOS Environmental Remediation Cost Data Books. Također, kao posljedica ovog pristupa, su stvoreni razni modeli građevinskih projekata (objekata) kojima se brzo izračunavaju troškovi, (projekt PACES-*Parametric Construction Cost Estimating System*), unoseći kao ulazne podatke relevantne podatke (parametre) građevinskih objekata.

2.3. Model građevinske kalkulacije

"Da se udovolji različitim zahtjevima, da se svlada stalno usavršavanje i poboljšavanje, da se upravlja promjenama, potrebna je jedinstvena predodžba i način gledanja cjeline i njezinih dijelova-fraktalna struktura (fraktal potječe iz teorije kaosa i znači sličan sebi) - u svakom se detalju odražava cjelovita struktura". Tako su uvijek projekti skup faza projekta, faze projekta skup pod-faza-aktivnosti, aktivnosti skup kompleksnih procesa, kompleksni procesi skup radnih procesa, te ih se tako treba i formirati kalkulativno. Na svakoj projektnoj razini je nužno omogućiti raščlambu troškova prema naprijed iznesenom, pa bi obrasci (1) i (2) izgledali:

$$C_k = ((R_{pi}+R_{si}+R_{grs}+R_{gr}+R_{up}+R_{io}+R_{pd})xP_1+$$
$$+(M_{pi}+M_{si}+M_{grs}+M_{gr}+M_{up}+M_{io}+M_{pd})xP_2+$$
$$+(U_{pi}+U_{si}+U_{grs}+U_{gr}+U_{up}+U_{io}+U_{pd})xP_3+$$

$$+(S_{pi}+S_{si}+S_{grs}+S_{gr}+S_{up}+S_{io}+S_{pd})+$$
$$+(BSA-(S_{pi}+S_{si}+S_{grs}+S_{gr}+S_{up}+S_{io}+S_{pd}))$$
$$+Risk+ FxP_4+ OxP_5+DxP_d)xP_o$$

$$C_k = (RxP_1+MxP_2+UxP_3+S+Ris+FxP_4+OxP_5+DxP_d)xP_o$$

Work processes on realization of services as project products are defined with various autonomous standards of services (U).

Work processes on realization of process-based products as project products are defined with various autonomous standards for individual process-based products (P).

The world literature calls this way of presenting and calculating costs respecting nature of costs, relationship of costs, project phases and project life-cycle, the Environmental Cost Handling Options and Solutions (ECHOS). As a result there are Environmental Remediation Estimating Methods Handbook standards with 50 standard additional technologies (step-by-step) for calculation of price forming and ECHOS Environmental Remediation Cost Data Books. As a result of this approach, various models of construction projects (structures) are created as well, by means of which costs may be easily calculated (project PACES-Parametric Construction Cost Estimating System), entering inputs relevant data (parameters) of construction structures.

2.3. Model of construction calculation

"In order to meet various requirements, to make oneself master of permanent perfecting and improvement, it is necessary to have a unique picture and way of viewing the whole as well as its parts – fractal structure (fractal originates from the theory of chaos and means to be like oneself) – a whole structure reflects in each of its details". In that way, projects are a group of project phases; project phases are a group of sub-phases – activities; activities consist of complex processes; complex processes are a group of work processes, and as such they should be formed in a calculating process. At each project level, it is necessary to enable cost analysis according to the aforementioned, thus term (1) and term (2) are as follows:

$$C_k = ((R_{pi}+R_{si}+R_{grs}+R_{gr}+R_{up}+R_{io}+R_{pd})xP_1+$$
$$+(M_{pi}+M_{si}+M_{grs}+M_{gr}+M_{up}+M_{io}+M_{pd})xP_2+$$
$$+(U_{pi}+U_{si}+U_{grs}+U_{gr}+U_{up}+U_{io}+U_{pd})xP_3+$$

$$+(S_{pi}+S_{si}+S_{grs}+S_{gr}+S_{up}+S_{io}+S_{pd})+$$
$$+(BSA-(S_{pi}+S_{si}+S_{grs}+S_{gr}+S_{up}+S_{io}+S_{pd}))$$
$$+Risk+FxP_4+OxP_5+DxP_d)xP_o$$

$$C_k = (RxP_1+MxP_2+UxP_3+S+Ris+FxP_4+OxP_5+DxP_d)xP_o$$

$$R_{pi}=\sum_i r_{pi},\ R_{si}=\sum_j r_{si},\ R_{grs}=\sum_k r_{grs},R_{gr}=\sum_l r_{gr},\ R_{up}=\sum_m r_{up},\ R_{io}=\sum_n r_{io},\ R_{pd}=\sum_o r_{pd},$$

$$M_{pi}=\sum_i m_{pi},\ M_{si}=\sum_j m_{si},\ M_{grs}=\sum_k m_{grs},\ M_{gr}=\sum_l m_{gr},\ M_{up}=\sum_m m_{up},\ M_{io}=\sum_n m_{io},\ M_{pd}=\sum_o m_{pd}$$

$$U_{pi}=\sum_i u_{pi},\ U_{si}=\sum_l u_{si},\ U_{grs}=\sum_l u_{grs},\ U_{gr}=\sum_l u_{gr},\ U_{up}=\sum_m u_{up},\ U_{io}=\sum_l u_{io},\ U_{pd}=\sum_l u_{pd}$$

$$S_{pi}=\sum_i s_{pi},\ S_{si}=\sum_i s_{si},\ S_{grs}=\sum_i s_{grs},\ S_{gr}=\sum_i s_{gr},\ S_{up}=\sum_i s_{up},\ S_{io}=\sum_i s_{io},\ S_{pd}=\sum_i s_{pd}$$

pa je

$$F = ((R_{si}+R_{grs}+R_{gr}+R_{up}+R_{io}+R_{pd})xP_1+(M_{si}+M_{grs}+M_{gr}+M_{up}+M_{io}+M_{pd})xP_2+(U_{si}+U_{grs}+U_{gr}+U_{up}+U_{io}+U_{pd})xP_3+(S_{si}+S_{grs}+S_{gr}+S_{up}+S_{io}+S_{pd})+BSA\text{-}S+Risk+OxP_4+FxP_5+DxP_d))xP_o)/\ (R_{pi}xP_1) \ldots \quad (2'')$$

$$C_k= R_{pi}xP_1x(1+F)+ M_{pi}xP_2+ U_{pi}\ xP_3+ S_{pi} \ldots \quad (1'')$$

gdje je:

R–rad, M-materijal, U-usluge, S-sredstva rada, Risk- rizik, F-financiranje, D-dobit, O- ostalo, P_1-porez i doprinosi na osobne dohotke, P_2-porez na materijal, P_3 -porez na usluge, P_4 -porez na uložena sredstva za financiranje projekta, P_5 -porez na razne ostale troškove, P_d-porez na dobit, P_o-porez ili takse na ukupan prihod, BSA-odraz bilanca stanja (aktive i pasive) na kalkulaciju cijene kotanja projekta, i-broj (kompleksnih)radnih procesa pojedinačnih izvršenja, j-broj (kompleksnih)radnih procesa instalacije i deinstalacije gradilišta, k-broj (kompleksnih)radnih procesa upravljanja gradilištem, l-broj (kompleksnih)radnih procesa upravljanja gradnjom, m-broj (kompleksnih) radnih procesa upravljanja projektom, n-broj (kompleksnih) radnih procesa upravljanja izvornom organizacijom, o-broj (kompleksnih) radnih procesa predstavnika vlasnika (dioničara). Ovakav pristup i dalje zadržava mogućnost da ugovorni troškovnik radova kao takav ostaje prilog ugovoru, gdje su u jediničnim cijenama sadržani indirektni troškovi, ali da se na svakoj razini osigura njihova transparenost.

3. Zaključak

Iz izloženog se nameće potreba:

- regulativnog (zakonskog) definiranja vrsta troškova građevinskih projekata (kao DIN 276) na razini državne uprave,
- novog standardiziranja općih tehničkih uvjeta za radove i usluge u građevinarstvu, opisivanja radova, te normiranja radnih procesa pojedinačnih izvršenja (bilo da se radi o izvođenju radova –hardware, izradi tehničke dokumentacije-software, uslugama ili procesnim proizvodima), instalacije i deinstalacije gradilišta, upravljanja gradilištem, upravljanja gradnjom, upravljanja

$$R_{pi}=\sum_{i} r_{pi},\ R_{si}=\sum_{j} r_{si},\ R_{grs}=\sum_{k} r_{grs},R_{gr}=\sum_{l} r_{gr},\ R_{up}=\sum_{m} r_{up},\ R_{io}=\sum_{n} r_{io},\ R_{pd}=\sum_{o} r_{pd},$$

$$M_{pi}=\sum_{i} m_{pi},\ M_{si}=\sum_{j} m_{si},\ M_{grs}=\sum_{k} m_{grs},\ M_{gr}=\sum_{l} m_{gr},\ M_{up}=\sum_{m} m_{up},\ M_{io}=\sum_{n} m_{io},\ M_{pd}=\sum_{o} m_{pd}$$

$$U_{pi}=\sum_{i} u_{pi},\ U_{si}=\sum_{l} u_{si},\ U_{grs}=\sum_{l} u_{grs},\ U_{gr}=\sum_{l} u_{gr},\ U_{up}=\sum_{m} u_{up},\ U_{io}=\sum_{l} u_{io},\ U_{pd}=\sum_{l} u_{pd}$$

$$S_{pi}=\sum_{i} s_{pi},\ S_{si}=\sum_{i} s_{si},\ S_{grs}=\sum_{i} s_{grs},\ S_{gr}=\sum_{i} s_{gr},\ S_{up}=\sum_{i} s_{up},\ S_{io}=\sum_{i} s_{io},\ S_{pd}=\sum_{i} s_{pd}$$

therefore

$$F = ((R_{si}+R_{grs}+R_{gr}+R_{up}+R_{io}+R_{pd})xP_1+(M_{si}+M_{grs}+M_{gr}+M_{up}+M_{io}+M_{pd})xP_2+(U_{si}+U_{grs}+U_{gr}+U_{up}+U_{io}+U_{pd})xP_3+(S_{si}+S_{grs}+S_{gr}+S_{up}+S_{io}+S_{pd})+BSA\text{-}S+Risk+OxP_4+FxP_5+DxP_d))xP_o)/\ (R_{pi}xP_1)\ \ldots \quad (2'')$$

$$C_k= R_{pi}xP_1x(1+F)+ M_{pi}xP_2+ U_{pi}\ xP_3+ S_{pi}\ \ldots \quad (1'')$$

where:

R –work, M-material, U-services, S- working assets, Risk- risk, F- finance, D- profit, O- other, P1 –taxes and contributions assessed on personal incomes, P2 –taxes on material, P3 –taxes on services, P4 –taxes on project financing investments, P5 –tax on various other costs, Pd –profit tax, Po –total revenue tax, BSA-reflection of balance sheet (assets and liabilities) to cost calculation of project, i-number of (complex) work processes of individual executions, j- number of (complex) work processes of site installation and disassembly, k- number of (complex) working processes of site managing, l- number of (complex) working processes of project managing, n-number of (complex) working processes of original organization management, o- number of (complex) working processes of owners' representatives (shareholders). Such an approach retains the possibility that contractual bill of quantities as such remains as a part of contract where indirect costs are included into unit prices, and that their transparency be provided at each level.

3. Conclusion

All the above mentioned requires:

- regulatory (legal) definition of types of costs of building projects (as DIN 276) at the government administration level,
- new standardization of general technical conditions for works and services in building construction, definition of works and standardization of work processes of individual executions (whether execution of works - hardware, development of technical documentation - software, services or process-based products), site installation and disassembly, site management, construction

projektima, upravljanja izvornim organizacijama, kao i radnim procesima predstavnika vlasnika, te stvaranja opće prihvaćenog modela kalkulacije troškova građevinskog projekta i opterećenje (poreza i pristojbi), na razini strukovnih društva, u svrhu kvalitetnog upravljanja građevinskim projektima, te stvaranja pretpostavki za uspostavljanje sustava kvalitete 9001:2000 u trgovačkim društvima sa građevinskom djelatnošću.

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HI
HERING

Marija Kvesić, mag.ing.građ.
Pro-Most d.o.o. Mostar

FORMALNO PRAVNO VAŽEĆI TEHNIČKI PROPISI ZA BETON, TE CERTIFICIRANJE BETONARA PREMA NORMI EN 206-1

FORMALLY AND LEGALLY APPLICABLE TECHNICAL REGULATIONS FOR CONCRETE AND CERTIFICATION OF CONCRETE BATCHING PLANTS ACCORDING TO EN 206-1 NORM

FORMALNO PRAVNO VAŽEĆI TEHNIČKI PROPISI ZA BETON, TE CERTIFICIRANJE BETONARA PREMA NORMI EN 206-1

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Sažetak

U posljednjih nekoliko godina užurbano se radi na preuzimanju i prihvaćanju Europskih normi iz područja proizvodnje betona. Tehnički zahtjevi postaju stroži. U namjeri da proizvodi budu prihvaćeni na internacionalnoj razini, proizvođači moraju biti u stanju dokazati da njihova roba i usluge postižu naložene zahtjeve, što podrazumijeva da moraju imati certifikat za proizvod koji plasiraju vani.

Certifikat i sama procedura izdavanja istog je baziran na "Pravilnik o tehničkim propisima za građevinske proizvode koji se ugrađuju u betonske konstrukcije" koji stupa na snagu 31. prosinca 2010. god. Ovaj pravilnik se poziva na europsku normu za betona EN 206-1.

U radu je dat osvrt na to koliko su sukladni pravilnik i norme, te koliko je uistinu primjenjivo u praksi izvesti certifikaciju i djelovati prema njoj.

Ključne riječi: certificiranje, pravilnik, sukladnost

Uvod

Poznato je da eurokodvi predstavljaju set europskih standarda u oblasti građevinarstva. Razvijeni su na osnovu najnovijih naučnih dostignuća postignutih u suradnji eksperata članica Europske unije u proteklih trideset godina, te predstavljaju bez dvojbi najsuvremenije propise u svijetu u oblasti građevinarstva. Kao takvi trebaju postati i osnova za procjenu kvaliteta građevinskih proizvoda i dobivanje CE oznake od čega je sve i nastalo. Implementacija eurokodva kao i CE oznake nastaje u namjeri da proizvodi budu prihvaćeni na internacionalnoj razini sa zajedničkim istraživanjima i ispitivanjima, ujednačavanjem razine sigurnosti objekata u različitim dijelovima Europe, sve kao produkt kvalitetnog proizvoda koji je potrebno plasirati vani.

FORMALLY AND LEGALLY APPLICABLE TECHNICAL REGULATIONS FOR CONCRETE AND CERTIFICATION OF CONCRETE BATCHING PLANTS ACCORDING TO EN 206-1 NORM

Marija Kvesic MCE
Pro-Most d.o.o. Mostar

Abstract

Over the last few years, there has been a lot of activity taking over and accepting European standards in the field of concrete production. The technical requirements are getting stricter. In order to be internationally accepted, manufacturers must be able to demonstrate that their goods and services achieve the ordered demands , which implies that for the products they sell internationally they must have a specific certification. The certificate and the issuing procedure itself is based on the "Code on Technical Regulations for Construction Products Built in Concrete Constructions", which enters into force on 31st December 2010. This Code refers to the European standard for concrete EN 206-1.

This paper gives an overview of how the Code complies with the Standard, and how applicable the certification really is in practice, as well as acting in compliance with it.

Keywords: certification, regulation, compliance

Introduction

It is well known that Eurocodes represent a set of European standards in the field of civil engineering. They have been developed on the basis of the most recent scientific achievements achieved in the cooperation of experts of the European Union in the past thirty years and without doubt they present the most modern regulations in the world in the field of civil engineering. As such, they should also become the basis for assessing the quality of construction products and obtaining a CE mark from which everything has arisen. The implementation of Eurocodes as well as the CE markings is intended to make products internationally accepted with joint research and testing, by harmonizing the level of security of facilities in different parts of Europe, all as a product of high quality that needs to be marketed abroad.

The Eurocodes are divided into their sets, whose parts are also the standards (hereinafter referred to as norms). An attempt is made to implement them and to translate them into the local language

Eurokodovi su podijeljeni na svoje setove čiji dio su i standardi (u daljnjem tekstu norme). Isti se pokušavaju implementirati, te prevesti na lokalni jezik kroz tehničke komitete osnovane od strane Instituta za standardizaciju Bosne i Hercegovine. Važno je staknuti da je veliki dio posla odrađen zahvaljujući stručnom timu ljudi koji čine te tehničke komitete.

Zakonska regulativa za implementaciju gore navedenih normi još uvijek ne postoji, stoga je pitanje jesmo li uopće dužni primjenjivati ove norme iako se kroz neke pravilnike i zahtijevaju.

Formalno pravno važeći tehnički propisi za beton, te certificiranje betonara u praksi

Zakonska primjena eurokodova u Bosni i Hercegovini nije obvezna iako se pojedini važeći pravilnici pozivaju na nju. Javlja se jaz. Strani investitori koji ulažu u izgradnju Bosne i Hercegovine zahtijevaju projektiranje prema eurokodovima. Pa tako npr. ukoliko želimo dokazati identičnost klase betona specificirane projektom (EC2) prilikom izgradnje nekog objekta, referiramo se na normu EN 206-1.

Ono što je bitno istaknuti da u Bosni i Hercegovini još uvijek fiktivno vrijede propisi i standardi naslijeđeni kao zajednička vlasništvo iz bivše zajedničke države. Područje proizvodnje betona u našoj zakonskoj regulativi za betonske konstrukcije još uvijek je donekle pokriveno „Pravilnikom o tehničkim normativima za beton i armirani beton" (u daljnjem tekstu PBAB) iz 1987. god. Iako je još u prosincu 2008. godine donesen "Pravilnik o tehničkim propisima za građevinske proizvode koji se ugrađuju u betonske konstrukcije"(u daljnjem tekstu Pravilnik), a on stupa na snagu 31. prosinca 2010. god. još uvijek nije u potpunosti primjenjiv. Uvođenjem ovog Pravilnika točno je specificirano da njime prestaju biti primjenjivi stari pravilnici među kojima je i PBAB. U "Pravilniku o tehničkim propisima za građevinske proizvode koji se ugrađuju u betonske konstrukcije", vidljiv je tijek proizvodnje betona i uvjeti iste.

Poznato je da je beton kao građevinski proizvod sastavljen je od cementa, agregata, vode i dodatka betonu poput aditiva itd. Pravilnik jasno naglašava da u svaku građevinu koja se gradi nakon gore spomenutog datuma u 2010. god. mora biti ugrađen materijal prema Pravilniku, no dali je to zaista tako?

Koliko ste vidjeli građevina sagrađenih od 2010. god. gdje je vidljiv certifikat građevinskog proizvoda, odnosno izjava o usklađenosti za projektirani beton? Jako malo zaista.

Jedan od načina zadovoljavanja krajnjeg korisnika primjenjuje se kroz certifikacije betonara, odnosno dobivanjem gotovog proizvoda za koji je moguće na osnovu certifikata izdati Izjavu o usklađenosti. Time je jasno da tehnička svojstva betona moraju ispunjavati opće i posebne zahtjeve bitne za krajnju namjenu betona i moraju biti specificirana prema normi EN 206-1. Proizvođačima betona je nametnuto da sami odgovaraju za svoj proizvod i za njegovo plasiranje vani. Unutrašnje kontrole proizvodnje betona provodi se prema istoj normi te mora obuhvatiti sve mjere nužne za održavanje i osiguranje karakteristika betona u skladu sa zahtjevima norme. Neke od tih zahtjeva norme pri proizvodnji betona nije moguće ispuniti do kraja, te se isti u praksi ni ne ispunjavaju.

through the technical committees established by the Institute for Standardization of Bosnia and Herzegovina. It is important to point out that much of the work has been done owing to the expert team of people who make these technical committees.

The legal regulations for the implementation of the above-mentioned norms do not yet exist, so the question is whether we are even obliged to apply these standards even though they are required by some ordinances.

Formally and legally applicable technical regulations for concrete and certification of concrete batching plants in practice

The legal application of Eurocodes in Bosnia and Herzegovina is not mandatory, although some applicable regulations call for it. A gap is created. Foreign investors who invest in the construction of Bosnia and Herzegovina demand designing by Eurocodes. Thus, for example, if we want to prove the identity of the concrete class specified by the project (EC2) when constructing an object, we refer to EN 206-1.

What is important to point out is that in Bosnia and Herzegovina still fictitiously are applied the rules and standards inherited as common property from the former common country. The area of concrete production in our concrete legislation for concrete structures is still covered by the "Ordinance on Technical Standards for Concrete and reinforced concrete" (hereinafter referred to as PBAB) from 1987. Although the "Code on Technical Regulations for Construction Products Built in Concrete Constructions" (hereinafter referred to as the Code) was adopted in December 2008, and will enter into force on 31 December 2010, it is still not fully applicable. By the introduction of this Code, it is precisely specified that the old rules, including the PBAB, will cease to be applicable. In the "Code on Technical Regulations for Construction Products Built in Concrete Constructions", the course of concrete production and its conditions are visible.

It is known that concrete as a construction product is made up of cement, aggregates, water and additions such as additives, etc. It is expressly stated in the Code that all the buildings, which are to be constructed after the aforementioned date of 2010, have to be constructed using materials pursuant to the Code, but is it really like that?

How many buildings have you seen built since 2010 where the construction product certificate or statement of conformity for the designed concrete is visible. Very few indeed.

One way of satisfying the end customer is through concrete certification, ie. obtaining a finished product for which a Declaration of Conformity can be issued based on the certificate. It is thus clear that the technical properties of the concrete must meet the general and special requirements essential for the end use of concrete and must be specified according to EN 206-1. Manufacturers of concrete are forced to be responsible for their product and to market it abroad by themselves. Internal control of concrete production is carried out according to the same standard and must include all measures necessary to maintain and ensure the characteristics of concrete in accordance with the requirements

Proizvođači betona postaju dio najzakinutijeg sektora u procesu projektiranja, izgradnje i plasiranja proizvoda krajnje zadovoljnom korisniku.

Ne usklađenost Pravilnika i normi se javlja pri samom ulazu proizvodnje zahtijevanog betona. Naime u Bosni i Hercegovini postoji osam akreditiranih laboratorija koje nemaju sve akreditirane metode prema Europskim normama za potrebna ispitivanje pri proizvodnji i kontroli kvalitete svježeg i očvrslog betona.

Komponente betona se ispituju na žalost još uvijek i po pravilnicima i normama, odnosno opremom i načinom ispitivanja koje ta laboratorija može ispuniti. Pojedina ispitivanja nisu u skladu sa Europskim zahtjevima, prema tome ne mogu se plasirati kao gotov proizvod za proizvodnju betona prema normi EN 206-1, odnosno za dobivanje certifikata gotovog proizvoda.

Pravilnik kaže da krajnji proizvod mora imati certifikat o proizvodnji. Ako počnemo od prve komponente za proizvodnju betona zvane agregat, prema normi EN 206-1 agregat je potrebno ispitivati svakodnevno prema određenim zahtjevima, no taj isti agregat ne mora biti certificiran. Većinu laboratorijskih ispitivanja na agregatu zaista je moguće vršiti prema europskim normama, no što s onim dijelom koje nije moguće ispitati prema zahtijevanim normama?

Za ispitivanje aditiva kao i za ispitivanje vode za proizvodnju betona nemamo adekvatnu laboratoriju koja može ispitati njihove karakteristike prema Europskim normama, npr. za vodu EN 1008. Ispitivanja se obično rade prema drugim Pravilnicima naslijeđenim iz bivše nam države, te kao takva nisu sukladna zahtjevima norme EN 206-1. Ova ispitivanja obično radimo u drugoj državi i takav dokument se prilaže kao važeća dokumentacija. Pitanje je, je li je takav dokument pravno važeći i u Bosni i Hercegovini koja nije članica CENA?

Pri ispitivanju očvrslog betona neki od čestih zahtjeva su i ispitivanje betona na utjecaj mraza i soli, prema Europskoj normi to su zahtjevi XF, točnije XF2 i XF4. Na žalost i ova ispitivanja su jedna od onih koje nije moguće odraditi u Bosni i Hercegovini prema zahtijevanim Europskim normama koje je potrebno ispuniti za dobivanje krajnjeg certifikata proizvoda.

Još jedna u nizu ne sukladnosti javlja se kod zahtjevi za količinu cementa za izradu betona. U tablici u Pravilniku zahtjevi su prepisani iz PBAB-a, nisu uopće u skladu sa zahtjevima cementa za izradu betona koje nam preporučuje EN 206-1. Ukoliko ste proizvođač betona i radite na certifikaciji svojih proizvoda što ste dužni poštovati, je li su to zahtjevi iz pravilnika ili su to pak zahtjevi iz normi prema kojima radite i certifikaciju?

Zakon o građevinskim proizvodima kaže da se usklađenost građevinskog proizvoda sa tehničkom specifikacijom u postupku ocjenjivanja usklađenosti utvrđuje provedbom jedne ili više slijedećih radnji:

- početno ispitivanje tipa građevinskog proizvoda koje provodi proizvođač, odnosno pravno lice ovlašteno za ocjenjivanje usklađenosti.
- ispitivanje uzoraka iz proizvodnje prema utvrđenom planu ispitivanja od proizvođača ili pravnog lica ovlaštenog za ocjenjivanje

of the standard. Some of these requirements for the norm for the production of concrete cannot be entirely fulfilled, and are not met in practice. Concrete manufacturers become part of the most oppressed sector in the process of designing, building and placing products to a highly satisfied customer.

Non-compliance of the Code and norms occurs at the entrance of the production of the required concrete. Namely, there are eight accredited laboratories in Bosnia and Herzegovina that do not have all accredited methods according to European standards for the required testing in the production and quality control of fresh and hardened concrete.

Unfortunately, the concrete components are still being tested according to the regulations and standards, in other words, using equipment and testing methods, which a certain laboratory can meet. Individual tests do not comply with European requirements, therefore they cannot be sold as a finished product for the production of concrete according to EN 206-1, ie obtain a certificate of finished product.

The Code states that the end product must have a production certificate. If we start from the first component for the production of concrete called aggregate, according to EN 206-1 the aggregate needs to be tested on a daily basis according to certain requirements, but this aggregate does not have to be certified. Most of the laboratory tests on the aggregate can really be done according to European norms, but what to do with the part that cannot be examined according to the required norms?

For the testing of additives as well as for the testing of water for the production of concrete we do not have an adequate laboratory that can examine their characteristics according to European norms, eg for water EN 1008. Tests are usually done according to other Regulations inherited from the former country and as such are not compliant with the requirements of the norm EN 206-1. These tests are usually done in another country and such a document is attached as valid documentation. The question is whether such a document is legally valid also in Bosnia and Herzegovina which is not a CENA member?

When testing hardened concrete, some of the common requirements are testing of impact of the frost and salt on concrete, according to European norms, XF requirements, namely XF2 and XF4. Unfortunately, these tests are some of the things that cannot be done in Bosnia and Herzegovina according to the required European standards that need to be met to obtain the final product certification.

Another non-conformity occurs with requirements for the amount of cement for the production of concrete. In the table in the Code , the requirements are copied from PBAB, and they are not entirely in compliance with the requirements for cement for the preparation of concrete recommended by EN 206-1. If you are a concrete manufacturer and work on certifying your products, what are your obligations to comply with, whether with the requirements of the ordinance or with the requirements of the norms under which you are performing certification?

The Construction Products Act states that the compliance of a construction product with technical specification in the conformity assessment procedure is determined by one or more of the following actions:

- ispitivanje slučajnih uzoraka uzetih iz proizvodnje
- stalna tvornička kontrola i početni nadzor tvorničke kontrole proizvodnje
- stalni nadzori, procjena i ocjenjivanje tvorničke kontrole.

Za primjenu ovog zakona, odnosno njegovog pravilnika potrebna je ustanova za potvrđivanje proizvoda, odnosno osoba ovlaštena za provedbu radnji početnog nadzora tvornice, radnji početnog nadzora tvorničke kontrole proizvodnje, radnji stalnog nadzora, procjene i ocjene tvorničke kontrole proizvodnje odnosno osoba ovlaštena za izdavanje potvrde o tvorničkoj kontroli proizvodnje i/ili potvrde o sukladnosti, prema normi BAS EN 450011.

U studenom 2013. godine donesena je obavijest od Instituta za akreditiranje Bosne i Hercegovine o novoj normi za certifikacijska tijela koja certificiraju proizvode BAS EN ISO/IEC 17065. Objavljivanjem ove norme povlači se norma BAS EN 45011:2000. Prema odluci IAF (International Accreditation Forum) određeno je da se zahtjevi novog izdanja norme moraju implementirati do rujna 2015. godine. Naime, nakon ovog datuma sve akreditacije izdate prema BAS EN 45011 prestaju važiti.

Zaključak

Postavlja se niz pitanja na koje je potrebno dati zakonske i stručne odgovore. Pravilnici zahtijevaju jedno, no u praksi je moguće izvesti nešto sasvim drugo. Uvesti neku normu u jednu državu poput Bosne i Hercegovine zaista nije lako. Možda je potrebno prije svega obučiti i laboratorijski osposobiti akreditirane metode prema EN-u, točnije omogućiti krajnjem korisniku uporabu pravno važećeg proizvoda. Sama implementacija norme EN 206-1 u Bosnu i Hercegovinu nije kompletirana, te kao takva nije spremna ući u uporabu. Postavlja se pitanje, zašto se ne koriste stari pravilnici dok se ne dobije potpuna mogućnost korištenja europskih normi, ili pak ukoliko će se koristiti europske norme zašto se u potpunosti ne izostave stari pravilnici? Postoji li pravno ovlaštena osoba za izdavanje istih? Pred Bosnom i Hercegovinom velika su odricanja i noviteti na koje svi moramo biti spremni kako u procesu projektiranja, tako i u procesu izgradnje i plasiranja proizvoda krajnje zadovoljnom korisniku. Prvi korak je na državnim institucijama da zakonski omoguće primjenu noviteta i tako potpomognu stručne timove inženjera za rješavanje postavljenih izazova.

- Initial testing of the type of construction product carried out by the manufacturer, or a legal entity authorized to assess compliance.
- Examination of samples from production according to the established test plan by the manufacturer or legal entity authorized for the evaluation
- testing of random samples taken from production
- Constant factory control and initial supervision of factory production control
- Permanent supervision and assessment and evaluation of factory control

For the application of this law, or its code it is necessary to have a product certification body or a person authorized to carry out initial factory inspection activities, initial supervision of factory production control, continuous monitoring work, evaluation and evaluation of factory production control or a person authorized to issue a certificate of factory production control and / or conformity certification, according to BAS EN 450011.

In November 2013, a notice was issued by the Accreditation Institute of Bosnia and Herzegovina about the new norm for certification bodies certifying the products of BAS EN ISO / IEC 17065. By publishing this norm, the norm EN 45011: 2000 is withdrawn. According to the IAF (International Accreditation Forum) definition, the requirements for a new standard norm issue have to be implemented until September 2015. Namely, after this date all accreditations issued in accordance with BAS EN 45011 will expire.

Conclusion

There are a number of questions that need legal and professional answers. Regulation requires certain things, but in practice it is possible to perform something completely different. Introducing a norm standard in a country like Bosnia and Herzegovina is not at all easy. It may be necessary, first and foremost, to teach and laboratory train the accredited methods in compliance with the EN, specifically to enable the end user to use the legally valid product. The implementation of EN 206-1 in Bosnia and Herzegovina is not complete and as such it is not ready to go into use. The question arises as to why old rules are not used until the full use of European norms is obtained or if European standards are used, why not exclude old rules completely? Is there a legally authorized person to issue them? Bosnia and Herzegovina faces great abnegations and innovations, which we all have to be ready for, both within the processes of designing and within the processes of construction and marketing the products to highly satisfied user. The first step is for state institutions to legally enforce novelty and thus assist expert teams of engineers to solve the challenges posed.

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HERING

Ivana Karačić, dipl.ing.građ
Hering d.d. Široki Brijeg

METODE I PROCEDURE REKONSTRUKCIJE TUNELA IVAN

METHODS AND PROCEDURES OF IVAN TUNNEL RECONSTRUCTION

METODE I PROCEDURE REKONSTRUKCIJE TUNELA "IVAN"

Ivana Karačić, dipl.ing.građ
Hering d.d. Široki Brijeg

Sažetak

Najkompleksniji dio projekta rekonstrukcije željezničke pruge od Sarajeva do Bradine, koja uključuje čak 19 mostova i 11 tunela, čine tri kilometra tunela „Ivan" kroz koji se dosad zbog dotrajalosti pruge promet odvijao vrlo otežano, brzinom oko 20 km/h.

U ovom radu ćemo se dotaknuti plana radova u tunelu „Ivan" u kojem se opisuje način i metodologija novog sustava šina, električnih instalacija, popravke tunelskih obloga što se temelji na odobrenoj projektnoj dokumentaciji. Radovi su planirani s velikim oprezom, metodologija se temelji na 30 sati rada, a promet je zaustavljen. Postupak se ponavlja stalno, 30 sati radni interval u tunelu i 42 sata za prijevoz i usluge potrebne za Željeznice Federacije Bosne i Hercegovine. Na temelju sveobuhvatne analize nadgrađa tunela Ivan, usvojeno je kao najbolje rješenje korištenje pred-napregnutih armiranobetonskih pragova integriranih u betonske ploče, s tim da se pazi da se uskladi da je minimalna količina vode koja dira mrežu za GIŠ 5,05 m, u skladu s projektnom dokumentacijom.

U radu su ukratko prikazane dvije faze rekonstrukcije pruge, a daje se i prikaz novog sistema pruge te popravka šina.

Ključne riječi: pruga, željeznica, šine, popravka, tunel.

1. Uvod

Početak radova planiran je s velikim oprezom, jer je vrlo važno napomenuti da se metodologija temelji na 30 sati rada i provodi se promet kroz tunel "Ivan" na raspolaganju Željeznica Federacije Bosne i Hercegovine za prijevoz; nakon isteka 30 radnih sati. Postupak se ponavlja kontinuirano 30h radni interval u tunelu i 42h za prijevoz i usluge potrebne Željeznica FBiH. Prema projektnom rješenju iz 1977. postojeći tehnički elementi željeznice su:

- Pruga: 1,435 mm
- Rmin: 300.00 m

METHODS AND PROCEDURES OF IVAN TUNNEL RECONSTRUCTION

Ivana Karačić BCE
Hering d.d. Široki Brijeg

Abstract

The most complex part of the reconstruction project of the railway line from Sarajevo to Bradina, which includes as many as 19 bridges and 11 tunnels, is presented by three kilometers of Ivan Tunnel, through which the traffic was very difficult with speed of about 20 km/h due to deterioration of the railway line.

In this paper, we will discuss the work plan for Ivan Tunnel in which the following issues are described: the manner and methodology of the new system of tracks, electrical installations, repair of tunnel lining based on approved project documentation. The beginning of works is planned with extreme caution; methodology is based on 30 hours of work during which the traffic through Ivan Tunnel would be suspended. The procedure is to be repeated constantly: a 30-hour work interval in the tunnel and 42 hours for transportation and services necessary to the Railway of the Federation of Bosnia and Herzegovina.

Based on a comprehensive analysis of the superstructure of Ivan Tunnel, the use of prestressed reinforced concrete sleepers integrated in a concrete slab has been adopted as the best solution, taking care of compliance with a minimum amount of water contact network to RUE (Rail upper edge) of 5.05 m in accordance with the project documentation.

In this paper two phases of reconstruction of the railway line are summarized and there is an overview of the new system of tracks and repair of rails.

Key words: tracks, railway line, rails, repair, tunnel.

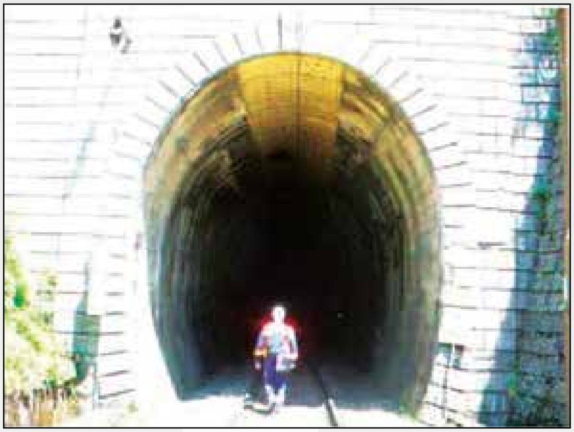
1. Introduction

The commencement of the works was planned very carefully as the methodology is based on 30 hours of construction, which is followed by traffic through Ivan Tunnel at the disposal of the Railway of the Federation of Bosnia and Herzegovina for transport. The procedure is to be repeated continually: 30 hours of construction in tunnel and 42 hours for transport and services necessary to the Railway of the Federation of Bosnia and Herzegovina. According to the project decision of 1977 the existing technical elements of the railway are:

- Railway line : 1.435 mm
- Rmin: 300.00 m

- Imax: 13,35 %
- Šine: S-49, 22.5m duljine zatvorene u DTS
- Pragovi: Čelični pragovi tipa BSC Workington tvrtke Pandroll Limited London
- Zastor: Čvrsti vapnenački zastor.

Slika 1. Pogled na ulaz u tunel



Slika 2. Pogled na izlaz iz tunela

Slika 3. Dio tunela prekriven vodom i blatom

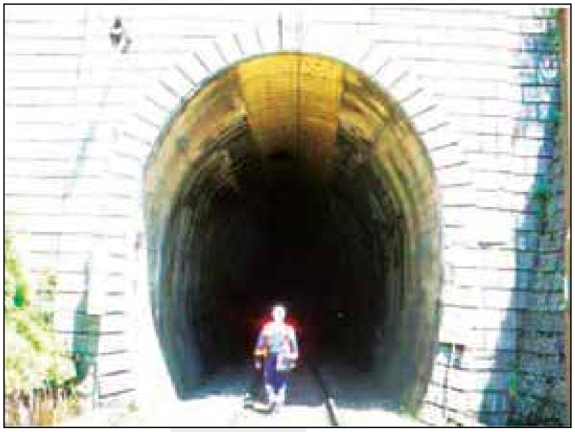
Slika 4 . Detaljni prikaz stanja pruge na pojedinim dijelovima

Na temelju sveobuhvatne analize gornjeg stroja tunela "Ivan", od željezničke konstrukcije normalne pruge do danas, prihvaćeno je kao najbolje rješenje korištenje pred-napregnutih armiranobetonskih pragova integriranih u betonsku ploču, vodeći računa da se pridržavaju minimalna količina vodoopskrbne mreže na GIS 5,05 m, sukladno projektnoj dokumentaciji. Traženi tehnički elementi željeznice za tunel Ivan su:

- Pruga: 1,435 mm
- Rmin: 300,00 m

- Imax: 13.35%
- Rails: S-49, 22.5m long, sealed in DTS
- Sleepers: Steel sleepers type BSC Workington, Pandroll Ltd. London
- Ballast: Firm limestone ballast

Picture 1. Tunnel entrance



Picture 2. Tunnel exit

Picture 3. Part of the tunnel filled with water and mud

Picture 4. Detailed image of tracks condition at certain parts

Based on comprehensive analyses of superstructure of Ivan Tunnel, all the way since the construction of the railway until today, the use of pre-stressed reinforced concrete sleepers integrated into a concrete slab was accepted as the best solution, bearing in mind to abide to minimum amount of water supply network on the RUE (rail upper edge) 5.05 m, compliant to the project documentation. Required technical elements of railway in Ivan Tunnel:

- Railway line : 1.435 mm

- Imax: 13.35 %
- Šine: 60E1 težina 60,21 kg/m' prema EN 13674-1, kvaliteta R260, kvaliteta vanjske tračnice za krivulje R<350 m je R350HT
- Pragovi : Pred-napregnuti betonski pragovi l=2.30m
- Zastor : Umjesto zastora predviđa se betonska ploča C25/30.

Proces rekonstrukcije tračnice u tunelu "Ivan" planira se uzduž testne kampade Dužina = 18 metara tijekom svakog prekida željezničkog prijevoza (zatvaranje željeznice) tijekom razdoblja od 30 sati i uklanjanje elektro-postrojenja u dodiru s uzemljenjem mreža nadzemnih vodova na mjestu radova.

Rekonstrukcija kolosijeka u suspenziji 30 H sastojat će se od dvije različite etape (faze):

1. Čišćenje drobljenog kamena i središnjeg kanala; iskopavanje; postavljanje nove kampade
2. Uklanjanje privremenih oslonaca; završna armatura; betoniranje betona.

Prije početka rekonstrukcije kolosijeka u tunelu i zbog velikih količina vode u šinama obavljeni su pripremni radovi na iskopavanju odvodnih jaraka s obje strane vrata prema lijevim i desnim abutmentima. Ove radove bilo je potrebno napraviti prije početka većih radova i sve pripreme za početak obnove kolosijeka kao i za sigurnost prolaza vlakova u prijelaznom razdoblju do završetka obnove kolosijeka u tunelu „Ivan".

2. Prva faza rekonstrukcije željeznice

U prvom zatvaranju željezničke pruge za promet unutar razdoblja od 30 sati planira se u prvoj fazi rekonstrukcije pruge radna kampada u dužini od 18 m.

Prva faza rekonstrukcije željeznice sastoji se od sljedećih radova:

- pripremnih radova na isključenju elektro-postrojenja na kontaktnim linijama, zatvaranje željeznice za razdoblje od 30 sati i dobivanje dozvole za strojeve prema planu i rasporedu ulaska i izlaska pojedinih strojeva
- demontaža postojećeg kolosijeka za radnu kampadu, uključujući rezanje postojeće tračnice u dužini od 18 metara, uklanjanje tračnica, metalnih pragova i željezničkog pribora na prethodno određeno mjesto tj. tamo gdje se pristupa skidanju tračnica, pragova i pribora i uklanjanja, određenog za njega - skladište.
- iskopavanje, utovar i transport vapnenca zavjese na odlagalište izvan tunela Ivan
- uklanjanje i odlaganje u niše metalnih kapica iz srednjeg odvodnog kanala
- rušenje zidova postojećih kanala u debljini min. 5 cm

- Rmin: 300.00 m
- Imax: 13.35%
- Rails: 60E1, weight 60.21 kg/m, according to EN 13674-1, quality of outer rail for curves R<350m is R350HT
- Sleepers – Pre-stressed concrete sleepers l=2.30 m
- Ballast: Concrete slab C25/30 is planned instead of ballast.

Reconstruction process in Ivan Tunnel is planned to be executed along the test section 18 m long during each closure of railway traffic during the period of 30 hours and removing electrical equipment in contact with the grounding of network of overhead cables at the location of works.

The reconstruction of tracks during suspension of 30 h will consist of two different phases:

1. Cleaning crushed stone and central canal; digging; setting new section;
2. Removing temporary supports; final reinforcement; concreting.

Before the start of reconstruction of tracks in Ivan Tunnel, preliminary works of cutting drainage ditches on both sides of the door towards left and right abutments were executed due to large quantity of water on rails. These works were necessary to execute before major works and comprehensive preparations for the start of tracks reconstruction as for the safe passage of trains in a transitional period until the completion of tracks reconstruction in Ivan Tunnel.

2. First phase of railway reconstruction

A working section in the length of 18 m is planned to be executed within the first phase of railway reconstruction during the first hold-up of railway traffic within the period of 30 hours.

The first phase of railway line reconstruction consists of the following tasks:

- preliminary works of disconnecting electrical equipment in contact lines, hold-up of railway traffic in the period of 30 hours, and obtaining a permission for machines needed pursuant to the plan and schedule of entry and exit of certain machines;
- dismantling the existing tracks within the working section, including cutting of existing rails in the length of 18 m; removal of rails, metal sleepers and railway accessories to previously defined places, namely, in the places where rails, sleepers and accessories are removed as well as removable elements thereof, to a warehouse.
- excavation, loading and transport of ballast limestone to a dump outside Ivan Tunnel;
- removal and disposal of metal caps from central drainage canal to niche;
- demolition of walls of existing canals minimum 5 cm thick;
- boring horizontal holes 0.65 cm on vertical walls of central drainage canal for fitting PVC pipe 50/60

- bušenje vodoravnih rupa 065mm na okomitim stjenkama srednjeg odvodnog kanala za postavljanje PVC cijevi 50/60 mm dužine L = 50 cm ispod betonske ploče, svaka dužina od 1,2 m zida - iskapanje inspekcijskih šahtova u niši za električne kabele
- mehanički utovar iskopanog materijala na vagone sa kolosiječnim vozilom i transport u privremeno odlagalište izvan tunela
- čišćenje postojećeg srednjeg odvodnog kanala i transport blata i mulja na privremeno odlagalište izvan tunela. Na mjestu kraja radne kampade mora se postaviti privremena drvena prepreku u kanalu kako bi se spriječilo ponovno blokiranje istog pri akumuliranju novog blata, budući da je pad tunela od sredine do izlaznih portala
- pranje površina (kamena ili betona) s visokotlačnom pumpom pod tlakom za bolje prianjanje betona s SN vezom u kontaktu sa stijenom i ispiranje postojećeg srednjeg odvodnog kanala, tako da je u funkciji
- instalacija vodoravnih PVC cijevi 050mm
- postavljanje metalnih pokrova preko središnjeg kanala i PVC filma preko širine kanala
- postavljanje drvenih nosača ispod betonskih pragova na izravnatoj površini načinjenoj od šljunka ili betona, ovisno o površini supstrata
- ugradnja novog sustava kolosijeka ispred tunela "Ivan" za radnu kampadu (pragovi, armature, tračnice E60)
- postavljanje novog sustava kolosijeka u dužini od 18 m korištenjem željezničkih bagera (Slika)
- Prva pruga postavljena na privremeno podešene podloge
- ugradnja armaturnih šipki za betonsku ploču (dio koji nije pripremljen na postaji)
- ugradnja prijelaznih komada "čipke" s tračnica 60E1 tračnica S49 s nove na staru prugu
- postavljanje posebnog alata za horizontalno podešavanje svako 3 metra od bočnog presjeka kako bi se osigurala bočna stabilnost pruge i vodoravno položenih tračnica
- radovi na otvaranju željezničkog prometa za razdoblje od 42 sata s ograničenjem brzine od 10 km / sat.

3. Druga faza rekonstrukcije željeznice

Druga faza rekonstrukcije željeznice napravljena je od sljedećih radova:

- preliminarni radovi na isključenju elektro-postrojenja u kontaktnoj liniji, zatvaranje željeznice za razdoblje od 30 sati i dobivanje dozvole za strojeve prema planu i rasporedu ulaska i izlaska pojedinih strojeva
- ugradnja specijalnih alata za vertikalnu prilagodbu neposredno prije betoniranja i samo na dužini radnih dijelova koji se planiraju betonirati
- ugradnja drvenih nosača ispod pragova se radi postupno sa tijekom betoniranja
- montažu inspekcijskog šahta u nišu

mm, with length L = 50 cm under concrete slab after each length of 1.2 m - excavating inspection manholes in niches for electrical cables;

- mechanical loading of excavated material on carriages with track vehicle and transport to temporary dump outside the tunnel;
- cleaning of the central drainage canal and transport of mud and sludge to a temporary dump outside the tunnel. At the spot where a section finishes, a temporary wooden barrier must be placed in the canal in order to prevent repeated blocking of it by accumulation of new mud, as the tunnel is tilted from its middle to the exit portals;
- washing of surfaces (stone or concrete) using high-pressure pump under pressure for better grip of concrete to SN bond in contact with stone, and rinsing of the existing central drainage canal, so it works;
- installing of horizontal pipes 050 mm;
- placing metal covers over central canal and PVC film over the width of canal;
- placing wooden supports under concrete sleepers on leveled surface made of gravel or concrete, depending on the surface of substrate;
- integrating new track system outside Ivan Tunnel for a working section (sleepers, reinforcement, rails E60);
- placing new track system in the length of 18 m using railway excavator (Figure);
- first railway line placed on temporarily set adjustment pads;
- installing reinforcement bars for concrete slab (a part which was not prepared at the station
- installing transition pieces, 'laces' from rails 60E1 to the rails S49, from the new to the old railway tracks;
- placing a special tool for horizontal adjustment on each 3 m from a side cross section, in order to ensure side stability of the railway and horizontally placed rails;
- works on opening the railway traffic for the period of 42 hours with speed limited to 10 km/h.

3. Second phase of railway reconstruction

The second phase of railway reconstruction consists of the following works:

- preliminary works of disconnecting electrical equipment in contact lines, hold-up of railway traffic in the period of 30 hours, and obtaining a permission for machines needed pursuant to the plan and schedule of entry and exit of certain machines;
- installing special tools for vertical adjustment directly before concreting only at the length of working parts planned to be concreted;
- installing wooden supports under sleepers is to be executed gradually as concreting progresses,
- installing inspection manhole in a niche;
- final vertical and horizontal adjustment of rails; geodetic measurements and engineer's verification

- Završna vertikalna i horizontalna prilagodba tračnica; Geodetska mjerenja i potvrda inženjera (Geodetski odjel inženjera)
- montaža oplate i vertikalne PVC cijevi 050mm u betonsku ploču novog sustava tračnice
- postupak ispitivanja staze prije betoniranja; geodet i geodetski inženjer
- Prva faza betonske ploče novog sustava pruge
- postavljanje privremenih konstrukcija za njegovanje mladih betonskih ploča (grede, ploče, geotekstil, grijanje)
- postavljanje privremenih konstrukcija za njegovanje površine betona nakon 12 sati stvrdnjavanja svježeg betona
- montažu AB šahtova u nišu i sekundarnu kanalizaciju
- testovi novog kolosijeka i željezničkog zatvaranja prometa za razdoblje od 42 sata s ograničenjem brzine od 10 km / sat.

S obzirom da je prva faza rekonstrukcije kolosijeka montirana armatura, prema projektu ojačanja i pravilima struke, prije betoniranja dijela br. 1 još uvijek je neophodno postavljanje posebnog vertikalnog alata i konačno postavljanje tračnica, nakon čega se može se pristupiti betoniranju ploče.

4. Novi sustav tračnica

U svim daljnjim željezničkim zatvaranjima za promet od 30h planirano je da se dvije faze rekonstrukcije pruge rade istodobno na dvije različite prve faze kampade ISKOPI - na jednoj kampadi Dužina = 36 m druga faza - ARMATURA I BETON preko D = 36m, na prethodno pripremljenoj kampadi. Kada ste usvojili tehnologiju novog sustava na tračnicama tada će 36m raditi na razvoju duljih kampada.

Slika 5. Pripremljeni iskopi podloge, nova drenažna središnja linija i novi pragovi i tračnice za postavljanje

(Geodetic Engineers Department);

- installing framework and vertical PVC pipes 050 mm into concrete slab of the new rail system;
- procedure of testing the tracks before concreting; Surveyor Contractor and Engineer Surveyor;
- first phase of concrete slab of the new railway system;
- installing temporary structures for curing younger concrete slabs (beams, sheets, geotextile, top heating);
- placing temporary structures for curing concrete surfaces after 12 hours of hardening of fresh concrete;
- fitting RC manhole covers in a niche and secondary drainage canal;
- testing new tracks and hold-up of railway traffic for the period of 42 hours with speed limit of 10 km/h;

Considering that reinforcement was mounted in the first phase of the track reconstruction, according to the reinforcement design and the rules of profession, before concreting section number 1, it is necessary to set specific vertical tools and final placing of rails, which may be followed by concreting of a slab.

4. New system of tracks

For further 30-hour hold-ups of railway traffic, two phases of rail reconstruction are planned to be executed simultaneously at two different section phases: EXCAVATION – at one section in the length of 36 m, and the second phase: REINFORCEMENT AND CONCRETING over the length of 36 m on a previously prepared section. When new track system technology is adopted, then the length of 36 m will be developed into the following section.

Picture 5. Prepared substrate excavations, new central drainage line and new sleepers and rails

5. Popravak obloge

Uzdužni profil geo-radara odredio je deformaciju, ali bez bunara koje smo predložili i video snimke iza obloge ne mogu točno prepoznati njihove praznine niti njihove dimenzije. Stoga je prijedlog rehabilitacije tunela temeljen na geološkim istraživanjima i vizualnom pregledu tunela Ivan, a dijelom i ispitivanjem dijela starih projekata iz arhiva Željeznica FBiH. Budući da je vanjski beton, koji je predmet rehabilitacije iz 2007. godine, prema fotografijama i vizualnom pregledu, vlaga se pojavljuje ne samo na pukotinama koje se mogu jasno odvojiti, već se voda susreće na cijeloj površini, smatramo da predloženi čine radijaciju fleksibilne poliesterske ploče na sidrima nacrta tehničke dokumentacije 1503-1. Točan iznos utvrđuje se u suradnji s inženjerom na licu mjesta. Ovisno o intenzitetu vode i veličini otvora koje treba popuniti, prikladno rješenje može biti kombinacija i potrebne djelomične injekcije obloge, kao i shortkret (s potrebnim pripremnim radom) projektna dokumentacija 1503- 2.

Budući da rehabilitacija tunela "Ivan" nije glavni zadatak ovog projekta, a na kritičnom putu s metodologijom predviđamo da Rehabilitacija obloge ulazi u završnu fazu nakon što je 50% radova dovršeno na donjem dijelu iste željezničke pruge. Radovi se planiraju na temelju zajedničkog pregleda sa Inženjerom i sukladno tome svi iznosi su približni i nisu određeni budući da smo svjesni činjenice da je proračun za rekonstrukciju tunela Ivan ograničen.

Redoslijed radova

Faza obnove obloge tunela sastoji se od sljedećih radova:

- postavljanje skela na vagone; za tražene radne platforme
- uklanjanje loših betonskih slojeva i supstrata; ispiranje cijele površine koja je unaprijed određena sa Inženjerom
- na mjestima gdje dolazi do drenažne infiltracije i vlaženja postaviti cijevi za ispuštanje površine sušenja za primjenu debljine mlaznice od 10-15 cm
- obaviti vezivanje svoda za ubrizgavanje kao na rasporedu i kako je opisano u projektnoj dokumentaciji
- ubrizgavanje injekcijske smjese u dijelove zida za punjenje šupljina u kamenim oblozima (nakon vizualnog pregleda).

5. Repair of lining

A deformation without wells, which we had suggested, was detected in geo-radar longitudinal profile, and the caverns behind the lining or their dimensions could not be precisely recognized on video recordings. Therefore, the proposal for the tunnel reconstruction was based on geologic researches and visual inspection of Ivan Tunnel, and partly on the insight into a part of previous projects from the archive of the Railways of the Federation of Bosnia and Herzegovina., The outer concrete layer was rehabilitated in 2007 and according to photographs and visual inspection, there is moisture not only in the cracks which are clearly distinguishable, but water is present over the whole surface; thus, it is supposed that the mentioned deformations are made by radiation of flexible polyester plates on the anchors of technical documentation plan 1503-1. The exact quantity is to be established in cooperation with the Engineer at the spot. Depending on the intensity of water and the size of cracks which should be filled, a suitable solution could be a combination of necessary partly injections of lining and shotcrete (with necessary preliminary work), project documentation 1503-2.

As the rehabilitation of Ivan Tunnel is not the primary task of this project, and in critical way with methodology, the rehabilitation of lining is expected to take place in the final phase after 50 % of works has been completed in the lower part of the same railway line. The works are planned on the grounds of joint inspection with the Engineer and, compliant to this, all quantities are approximate and not determined as we are aware that the budget for the reconstruction of Ivan Tunnel is limited.

Order of works

The reconstruction phase of the tunnel lining consists of the following works:

- setting scaffolding onto carriages; for required work platforms;
- removal of improper concrete layers and substrate; rinsing the entire surface defined in advance with the Engineer;
- in the places where there are drainage infiltration and moisture, placing of pipes for releasing drying areas for the application of jet mortar 10-15 mm thick;
- execution of bonding vault for injecting as in schedule and as described in project documentation;
- injecting the wall sections in order to fill cracks in stone lining (after the visual inspection).

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HERING

Marin Nikolić, mag.ing.građ.
Hering d.d. Široki Brijeg

Doc.dr.sc Ivana Burcar Dunović, dipl.ing.građ
Sveučilište u Zagrebu, Građevinski fakultet

METODE PLANIRANJA GRAĐENJA INFRASTRUKTURNIH PROJEKATA

PLANNING METHODS FOR CONSTRUCTION OF INFRASTRUCTURE PROJECTS

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Doc.dr.sc Ivana Burcar Dunović, dipl.ing.građ
Sveučilište u Zagrebu, Građevinski fakultet

Sažetak

Planiranje građenja infrastrukturnih projekata zahtjeva veliku pozornost zbog nepostojanja adekvatne primjene metoda planiranja pri planiranju ove vrste projekata. Važnost planiranja građenja utvrđena je još u davnim vremenima a danas planiranje predstavlja najviše pažnje od svih faza građenja kako bi sam projekt na kraju bio uspješan. Poznato je ipak da većina infrastrukturnih projekata prekorači ili vremenski rok građenja ili planirana sredstva za građenje što znači da se planiranju ovih projekata ne posvećuje dovoljna pažnja. Rad prikazuje kratak povijesni razvoj metoda planiranja, osnovne karakteristike metode te mogućnost njene primjene pri planiranju građenja infrastrukturnih projekata. Cilj rada je dobiti odgovor na pitanje može li se primjenom tradicionalnih metoda planiranja građenja infrastrukturnih projekata osigurati izvođenje projekta na vrijeme i u okviru planiranih novčanih sredstava, koliko se one danas samostalno primjenjuju te koje metode planiranja će se primjenjivati za planiranje budućih sve kompleksnijih infrastrukturnih projekata. Kvalitetno planiranje građenja jedan je od glavnih uvjeta uspješnosti cijeloga projekta, a kvalitetno planiranje moguće je ostvariti jedino pomoću adekvatne metode planiranja.

Metode planiranja: gantogram; mrežno planiranje; planiranje građenja; infrastrukturni projekt; CPM; PERT

1. Uvod

Pojam planiranje podrazumjeva plan za završetak projekta na temelju logičnog rasporeda aktivnosti (Popescu i Charoenngam, 1995). Planiranje građenja predstavlja proces utvrđivanja pravilnog redoslijeda planiranih aktivnosti, određivanje realnog trajanja svake aktivnosti te određivanje početnog i krajnjeg datuma trajanja za svaku aktivnost (Oberlander, 2000). Ono podrazumjeva predviđajanje događaja koji

PLANNING METHODS FOR CONSTRUCTION OF INFRASTRUCTURE PROJECTS

Marin Nikolić MCE
Hering d.d. Široki Brijeg

Assistant Prof. Ivana Burcar Dunović, Phd, BCE*
University of Zagreb, Faculty of Civil Engineering

Abstract

Planning the construction of infrastructure projects requires great attention due to the lack of proper application of planning methods in planning this type of projects. The importance of construction planning has been ascertained long time ago, and today planning requires the most attention of all stages of construction, so that the project itself be successful. Nevertheless, it is well known that most infrastructure projects exceed either the time limit for construction or resources planned for that construction, meaning that planning of these projects is not given enough attention. The paper presents a brief historical development of planning methods, the basic characteristics of methods and the possibility of their application in the planning of infrastructure projects construction. The aim of this paper is to answer the question whether the application of traditional planning methods for the construction of infrastructure projects can be used to ensure project execution on time and within the planned funds, to what extent they are currently applied independently, and which planning methods will be applied for the planning of future, even more complex infrastructure projects. High quality construction planning is one of the main conditions for the success of the entire project, and it is possible to achieve high quality planning only through an adequate planning method.

Planning methods: Gantt chart; network planning; construction planning; infrastructure project; CPM; PERT

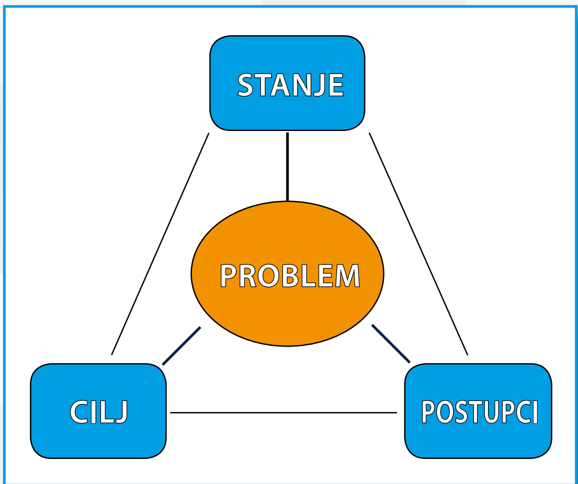
1. Introduction

The concept of planning implies a plan for completing a project, which is based on a logical schedule of activities (Popescu and Charoenngam, 1995). Planning of construction represents the process of establishing the proper order of planned activities, determining the realistic duration of each activity and determining the starting and ending dates for each activity (Oberlander, 2000). It implies prediction of events that are to be executed during a construction on the basis of established bi se trebali u građenju odvijati na temelju postavljene organizacije, određene tehnologije raspoloživih sredstava za rad i uvjeta pod kojima se predviđa građenje (Lozančić, 1995).

Svrha rada je kroz kratak povijesni pregled prikazati primjenu tradicionalnih metoda planiranja infrastrukturnih projekata te utvrditi mogućnost njihove primjene u planiranju budućih projekata. Pitanje na koje se traži odgovor je može li se primjenom tradicionalnih metoda planiranja napraviti adekvatan plan građenja modernih infrastruktunih projekata. Zbog svoje usmjerenosti na pojedine vrste projekata tradicionalne metode planiranja građenja sve se rijeđe samostalno primjenjuju u planiranju građenja infrastrukturnih projekata zbog njihove kompleknosti. Razvoj novih metoda zasnovanih na tradicionalnim metodama planiranja građenja trebao bi omogućuti efikasnije planiranje i doprinijeti uspješnom ostvarenju građenja infrastruktunih projekata.

Planiranjem građenja vršimo postavljanje ciljeva za predvidivu budućnost. Da bi ciljevi bili što točnije predviđeni a plan što realniji, na početku postavljamo tri pitanja:

1. Gdje se nalazimo sada (stanje)
2. Kuda želimo (cilj)
3. Na koji način ćemo doći do cilja (postupci)



Ilustracija 1. Shema temeljnih pitanja pri planiranju

Početkom razvoja suvremenog planiranja smatra se razvoj dinamičkog plana - gantograma, neposredno prije početka prvog svjetskog rata. Međutim, može se reći da koncept planiranja nije nov; piramide su danas stare oko 3000 godina, Sun Tzu je pisao o planiranju i strategiji ratovanja prije 2500 godina, prije 200 godina građene su transkontinentalne željeznice, itd. Niti jedna od ovih aktivnosti ne bi mogla biti izvedena bez planiranja (Weaver, 2006).

organization, a certain technology of available resources for work, and the conditions under which a construction is envisaged (Lozančić, 1995).

The purpose of this paper is to present the application of traditional methods of infrastructure projects planning through a brief historical review, and to determine the possibility of their application in the planning of future projects. The question which needs to be answered is whether an adequate plan for the construction of modern infrastructure projects can be developed by implementing traditional planning methods. Due to their focus on particular types of projects, traditional construction planning methods are used independently with decreasing frequency in the planning of infrastructure projects construction because of their complexity. Development of new methods based on traditional methods of planning construction should enable more efficient planning and contribute to the successful realization of the construction of infrastructure projects.

By construction planning, we set goals for the predictable future. In order to predict the goals as precisely as possible and to make plans as realistic as possible, we ask three questions at the beginning:

1. Where are we now? (De facto situation)
2. Where do we want to go? (Goal)
3. How shall we reach the goal? (Procedures)

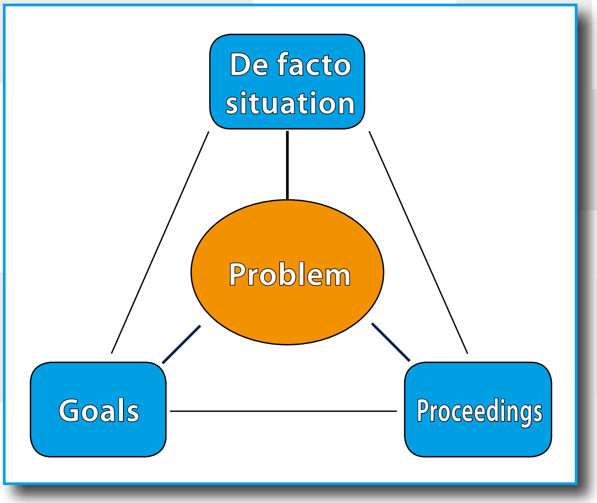


Figure 1. Scheme of basic planning issues

It is deemed that the beginning of contemporary planning development is marked by the development of a dynamic plan, namely gantt chart, just before the start of the First World War. However, it is plausible to claim that the concept of planning is not completely new; the pyramids are about 3,000 years old today, Sun Tzu wrote about planning and strategy of war 2,500 years ago, transcontinental railroads were built 200 years ago, etc. None of these activities could be performed without planning (Weaver, 2006).

Do razvoja prvih metoda planiranja projekata došlo je s povećanjem složenosti projekata. Zbog očite praktične važnosti, s intenzivnim istraživanjem planiranja projekata započelo se u kasnim pedesetim godinama dvadesetoga stoljeća. Njihov razvoj posebno je napredovao s početkom upotrebe računala u planiranju građenja. Danas se računala koriste za prikazivanje svih vrsta planova neovisno o kojoj metodi planiranja je riječ. Unatoč svim uloženim naporima, brojna istraživanja pokazuju da infrastrukturni projekti često prelaze planirani vremenski rok te sredstva namjenjena za građenje što pokazuje da metode planiranja građenja u slučaju infrastrukturnih projekata još uvijek nisu pronašli pravi put do svoje praktične primjene.

Izbor metode planiranja građenja infrastrukturnog projekta varira u ovisnosti o veličini projekta, kompleksnosti, trajanju, osoblju te zahtjevima investitora. Svaka od metoda planiranja mora podržavati neke osnovne preduvjete za učinkovito korištenje. Planeri i korisnici očekuju od svake metode da:

- bude jednostavna i lako razumljiva
- omogućuje vidljivost alternative i korištenja pretpostavki u analizi scenarija
- prikazuje planirano stanje: rad-vrijeme-novac
- može prikazati stvarno stanje izvršenja: rad-vrijeme-novac
- može prikazati prognostičku sliku: rad-vrijeme-novac
- omogućuje dodavanje detalja po potrebi
- posljedice djelovanja rizika u planu čini vidljivima
- omogućuje izradu sumarnih podataka po potrebi (Radujković i suradnici, 2012)

U planiranju građenja infrastrukturnih projekata kroz povijest koristile su se sljedeće metode:

- gantogrami
- ciklogrami
- ortogonalni planovi
- mrežno planiranje

2. Karakteristike infrastrukturnih projekata

Ekonomski, na infrastrukturu se može gledati kao elemente ekonomije koja dopušta proizvodnju dobara i usluga koje same nisu dio proizvodnog procesa. Infrastruktura se tipično odnosi na tehničke strukture i sisteme koji podržavaju društvo, kao npr. ceste, vodovod, kanalizacija, elektroopskrba, itd. Širi kontekst infrastrukture obuhvaća i socijalne usluge kao što su škole i bolnice, informatičku tehnologiju, neformalne i formalne kanale komunikacije, političke i socijalne mreže ili sustav vjerovanja članova pojedine grupe. Generalno se infrastruktura može podijeliti u dvije kategorije: civilnu infrastrukturu i socijalnu infrastrukturu. Civilna infrastruktura podržava najosnovnije potrebe društva i gospodarstva (energija, telekomunikacije, transport i voda), dok je socijalna infrastruktura

Development of first project planning methods was a result of an increase in the complexity of projects. Due to the obvious practical importance, the intensive exploration of project planning began in the late 1950s. Their development has particularly advanced with the start of computer use in construction planning. Today computers are used to present all types of plans, regardless of which planning method is concerned. Despite all the efforts made, numerous studies have shown that infrastructure projects often exceed the planned time frame and resources for construction, which shows that, in the case of infrastructure projects, construction planning methods have not yet found the right path to their practical application.

The choice of planning methods for the construction of an infrastructure project varies depending on the size of the project, its complexity, duration, staff and the requirements of the investor. Each of the planning methods has to support some basic prerequisites for effective use. Planners and users expect each method to:

- be simple and readily understandable;
- enable the vision of an alternative solution and the prospect of exploitation of assumptions in scenario analysis
- show the planned relationship: work-time-money
- be able to demonstrate the real level of performance: work-time-money
- be able to demonstrate prognostic picture: work-time-money
- enable additions of details if necessary
- make risk impact consequences visible
- enable development of summary data if necessary (Radujković et al. 2012)

The following methods have been used in planning the construction of infrastructure projects throughout the history:

- Gant Charts
- Cyclographs
- Orthogonal plans
- Network planning

2. Characteristics of infrastructure projects

Concerning economic gain, infrastructure may be viewed as elements of economy that allow the production of goods and services, but they are not part of the manufacturing process themselves. Infrastructure typically refers to technical structures and systems that support community, such as roads, water supply, sewage, electricity, etc. The wider context of infrastructure includes social services such as schools and hospitals, information technology, informal and formal channels of communication, political and social network or belief system of members of a particular group. Generally speaking, infrastructure can be divided into two categories: civil infrastructure and social infrastructure. Civil infrastructure supports the most basic needs of society and economy (energy, telecommunications, transport and water), while social infrastructure is necessary for the development of cultural norms neophodna za razvoj kulturnih normi i promoviranje zdrave populacije (sudovi, administrativne službe, škole, bolnice i popravne ustanove). (Al-Bahar and Crandal, 1990)

U ovom radu obrađivat će se civilna infrastruktura koja obuhvaća sljedeće vrste:

- transportna infrastruktura
- energetska infrastruktura
- infrastruktura za gospodarenje vodama
- komunikacijska infrastruktura
- infrastruktura za zbrinjavanje otpada
- mreže za praćenje i mjerenje zemlje

Većina infrastrukture ima karakteristiku da se proteže duž većih udaljenosti, a njihova izgradnja između ostalog izvedbu niza građevina kojima je transport općenito osnovna namjena. Zbog određenih prvenstveno oblikovnih karakteristika navedeni objekti mogu se uvjetno nazvati linijski objekti (linijske građevine). Kod takvih se objekata na određenoj većoj dužini uglavnom ne mijenja osnovni oblik njihovog poprečnog presjeka ili ne mijenja oblik nosivog i namjenskog dijela njihove konstrukcije. Ovisno o namjeni građevine i obliku terena gdje je položen, zemljani dio linijskih objekata je najčešće promjenjiv po obliku. Zbog toga zemljani radovi čine neki općeniti objekt koji ima razvučena, izdužena i sl. svojstva (u smislu oblika) manje ili više linijskom građevinom. Tu se može izuzeti tunele, kod kojih je iskop projektno uglavnom stalan po obliku i veličini uz neka odstupanja, ovisno o vrsti podgrade i obloge tunela (isto se može reći npr. za iskop rovova i kanal u ravnici). Tamo, gdje to nije tako, nakon izvedbe po dužini promjenljivih zemljanih radova neki općeniti objekt može se sagledavati kao linijski objekt (npr. Izvedba donjeg i gornjeg ustroja prometnica nakon završetka iskopa i nasipa, te ostalih objekata u nekom brdovitom terenu).

3. Pregled metoda planiranja i način njihovog korištenja

3.1. Gantogram

Bar chart je grafički prikaz projektnih aktivnosti projekta prikazanih u vremenu bez međusobne povezanosti pojedinih aktivnosti (Popescu i Charoenngam, 1995). Bar chart je izvorno razvijen od strane Henry L. Gantta 1917. godine te je po njemu i dobio naziv Gantt chart. Točnije, prvi gantogram osmislio je Karol Adamiecki, poljski inženjer i ekonomist, i taj gantogram nosio je naziv garmonogram (garmonograf). Međutim, kako ga nije objavio do 1931. godine, ovaj plan nosi ime po Ganttu, koji je 1910. svoju verziju objavio u časopisu The Engineering Magazine (Matijević, 2012). Henry Gantt formulirao je jednostavnu grafičku metodu koja prikazuje plan proizvodnog procesa u vremenu. Jako brzo ova grafička metoda postaje popularna, osobito u građevinarstvu, zbog svoje sposobnosti da na jednostavan način grafički prikazuje projektne aktivnosti na vremenskoj skali.

and the promotion of a healthy population (courts, administrative services, schools, hospitals and correctional institutions). (Al-Bahar and Crandal, 1990)

This paper will cover civil infrastructure that includes the following types

- transport infrastructure
- power infrastructure
- water management infrastructure
- communications infrastructure
- waste management infrastructure
- network for soil monitoring and measuring

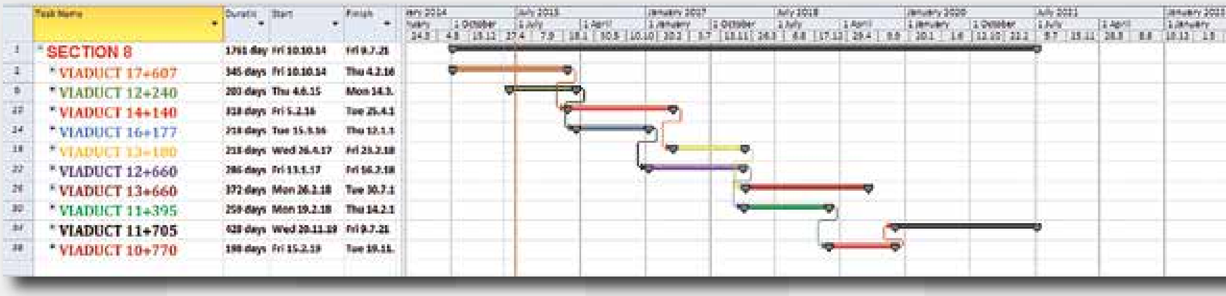
One of the features that most infrastructure has is extending over longer distances, and their construction consists of, among other things, the execution of a series of structures whose primary purpose is basically transport. Due to certain primarily designed features, the mentioned structures could be tentatively called line structures. Basic cross-section shape of such structures mainly does not change along certain distances, in other words, the shape of the supporting and bearing part of their structure does not change. Depending on the purpose of a construction and the shape of the terrain where it is laid, the ground part of the line structures is most often variable in shape. Due to this, earth works make a general object with extended, elongated and similar properties (in terms of shape) more or less a line structure. Tunnels may be exempted since the excavation project is mainly of a permanent shape and size with some deviations, depending on the type of tunnel floor and lining (the same applies to digging trenches and canals in the plain). Where this is not the case, after the execution of longitudinally changeable earthworks, some general objects may be considered as line structures (eg, the execution of lower and upper road structures after the excavation and backfilling, as well as other objects in a hilly terrain).

3. Review of planning methods and manner of their use

3.1. Gant Chart

A bar chart is a graphical representation of project activities displayed in time without interrelationship between certain activities (Popescu and Charoenngam, 1995). The bar chart was originally developed by Henry L. Gantt in 1917 and was named Gantt chart after him. More precisely, the first Gantt Chart was developed by Karol Adamiecki, a Polish engineer and economist, and that 'gant chart' was called harmonograph (harmonogram). However, as it had not been published until 1931, this plan was named after Gantt, who published his version in 1910 in The Engineering Magazine (Matijević, 2012). Henry Gantt formulated a simple graphic method that shows the production process schedule in time. This graphic method became popular very quickly, especially in the construction industry, due to its ability to graphically display project activities on a time scale.

Sve do 1960. godine planovi projekata prikazivani su pomoću bar charta (Lewis, 2011). Gantogram je učinkovita metoda za ukupno planiranje projekta, ali je u prošlosti bio veoma ograničen za detaljniji prikaz građevinskih radova, jer nije prikazivao povezanost pojedinih aktivnosti što je predstavljalo važan čimbenik pri planiranju građenja složenijih projekata kao što su infrastrukturni projekti. Uvođenjem prikaza veza između pojedinih aktivnosti nastao je dijagram s brzim i točnim uvidom u međusobnu ovisnost aktivnosti.



Ilustracija 2. Gantogram s prikazanim vezama između aktivnosti

3.2. Mrežno planiranje

Pojava sve složenijih projekata kod kojih planiranje postojećim metodama nije postizalo zadovoljavajuće rezultate, kao i težnja za metodom planiranja koja bi omogućila primjenu računala, doveli su do razvoja mrežnog planiranja. Prve teorije mrežnog planiranja nastale su istovremeno u Francuskoj i SAD-u. Početkom 1957. godine tvrtka DuPont Corporation izradila je prijedlog mrežnog planiranja vremena, čija je značajna točka bila razdvajanje analize vremena od analize strukture. Ovaj postupak je u prvo vrijeme bio nazvan ''Production Planning and Scheduling System'' a zatim ''Critical Path Method''(Metoda kritičnog puta) ili skraćeno CPM. Metoda je brzo stekla široku primjenu u planiranju svih vrsta projekata pa tako i u građevinarstvu. Godine 1958. američka mornarica razvila je novu metoda planiranja nazvanu Program Evaluation and Review Technique ili skraćeno PERT. Poznato je više stotina raznih metoda mrežnog planiranja koje su izvedene od dvije osnovne metode CPM i PERT. U stručnoj literaturi modifikacije ovih metoda imaju razne skraćenice i one se međusobno razlikuju metodološki, jer su mnoge od njih prilagođene potrebama određenih preduzeća. Navode se neke od njih: TOPS (The Operational PERT System), CPS (Critical Path Scheduling), CPPS (Critical Path Planing and Scheduling), CPA (Critical Path Analysis), RAMPS (Resource Allocatin and Multi - Project Scheduling), i dr.

Metoda mrežnog planiranja predstavlja grafički model koji prikazuje aktivnosti koje su međusobno povezane kako bi se prikazao njihov slijed (Oberlander, 2000). Mrežni dijagrami se u osnovi dijele na dvije vrste: mreže sa strijelicama te mreže sa čvorovima.

Until 1960, project plans were presented using bar charts (Lewis, 2011). The Gantt Chart is an effective method for overall project planning, but in the past it was very limited for a more detailed insight in construction works because it did not show the relationship between certain activities, which was an important factor in planning the construction of more complex projects such as infrastructure projects. By introducing a link between certain activities, a diagram with a quick and accurate insight into the interdependence of activities was created.

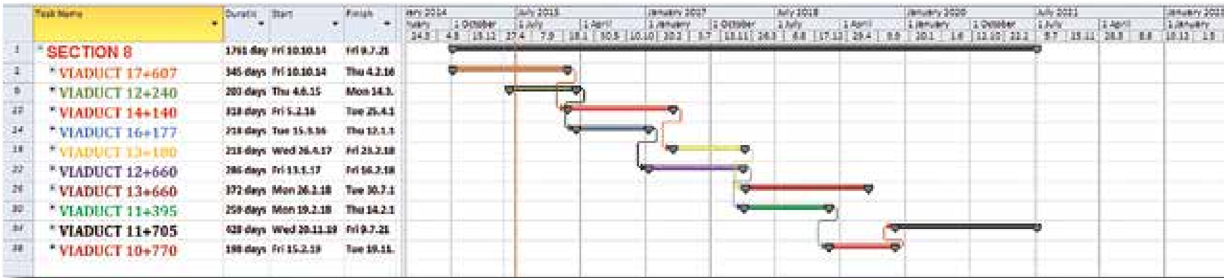
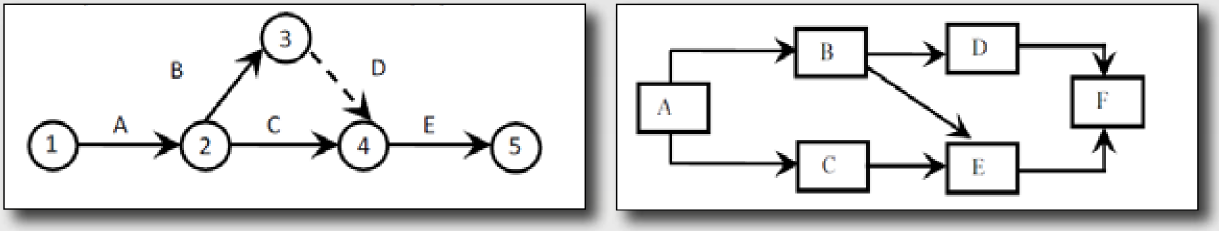


Figure 2. Gantt Chart showing relations between activities

3.2. Network planning

The emergence of more complex projects where planning by existing methods did not yield satisfactory results, as well as the search for a planning method that would allow the use of computers led to the development of network planning. The first network planning theories were made simultaneously in France and the United States. In the beginning of 1957, DuPont Corporation made a proposal for network time planning, whose significant point was the separation of time analysis from structure analysis. This procedure was first called “Production Planning and Scheduling System” and then “Critical Path Method” or abbreviated CPM. The method quickly gained wide application in planning of all types of projects, and so it did in construction. In 1958, the US Navy developed a new planning method called Program Evaluation and Review Technique or abbreviated PERT. There are hundreds of different network planning methods that are derived from the two basic methods of CPM and PERT. In the professional literature the modifications of these methods have different abbreviations and they differ methodologically, because many of them are tailored to the needs of certain companies. Some of these are: TOPS (The Operational PERT System), CPS (Critical Path Scheduling), CPPS (Critical Path Planing and Scheduling), CPA (Critical Path Analysis), RAMPS (Resource Allocation and Multi - Project Scheduling), and others.

The method of network planning is a graphical model showing activities that are interrelated to show their sequence (Oberlander, 2000). There are basically two types of Network diagrams: network with arrows and network with nodes.



A,B…F - aktivnosti

Ilustracija 3. (a) mrežni plan sa strijelicama
(b) mrežni plan sa čvorovima

Mreže sa strijelicama veliku primjenu imale su u 1960-ih i 1970-ih a nakon toga dijagrami (napredni oblik mreže s čvorovima) postaju izbor u mrežnom planiranju (Mubarak, 2010). Razvoj mrežnog planiranja doveo je do povećanja razvijenosti cijelokupnog upravljanja projektima. Osnovnu mrežnog planiranja je eliminiranje potrebe za menadžmentom za krizne situacije zbog toga što mrežno planiranja daje slikovit prikaz cijeloga projekta (Kerzner, 2009). Sljedeće informacije za upravljanje mogu se dobiti iz mrežnog dijagrama:

- povezanost aktivnosti
- vrijeme završetka projekta
- utjecaj kasnog starta
- utjecaj preuranjenog starta
- ustupaka između resursa i vremena
- neuspjeh u planiranju/izvedbi
- procjena uspješnosti

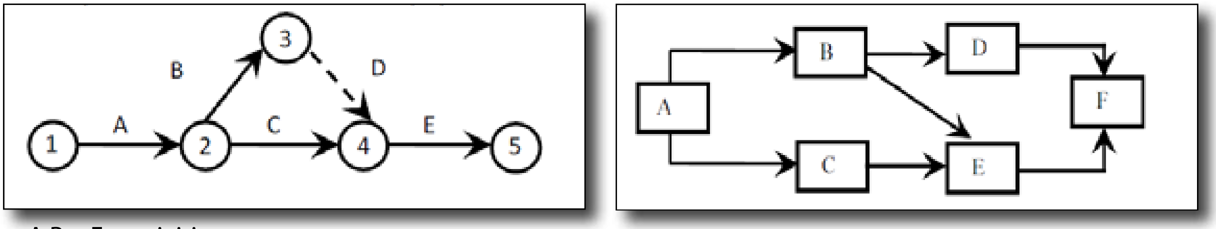
Tehnika mrežnog planiranja može se podijeliti u tri faze:

Analiza strukture:

- Popis aktivnosti (raščlanjenje cjelokupnog tehnološkog procesa na manje organizacijske cjeline
- Određivanje veza između aktivnost (u skladu sa usvojenom tehnologijom proizvodnje)
- Određivanje trajanja aktivnosti (na bazi urađenih statičkih planova)
- Određivanje potrebnih resursa (radne snage, mehanizacije, materijala i troškova)
- Izrada strukture plana - mreže, koja prikazuje međuovisnost odvijanja aktivnosti i shematski se prikazuje krugovima.

Analiza vremena:

- određivanje početka i završetka aktivnosti
- određivanje dinamike angažiranja resursa



A,B…F - activities

Figure 3. (a) network plan with arrows
(b) network plan with nodes

Networks with arrows were widely used in the 1960s and 1970s, and then diagrams (advanced form of node networking) became a choice in network planning (Mubarak, 2010). The development of network planning has led to an increase in the development of overall project management. Basic gain of network planning is elimination of the need for crisis management because network planning provides a picturesque view of a vivid insight into the whole project (Kerzner, 2009). The use of network diagram could provide the following management information:

- interrelationship of activities
- project completion time
- impact of delayed commencement
- impact of early commencement
- compromises between resources and time
- failure in planning/execution
- estimation of success

Network planning technique may be divided into three stages:

Structure analysis:

- List of activities (breakdown of the entire technological process into smaller organizational units
- Determining the relationship between activities (in accordance with the adopted production technology)
- Determining the duration of activities (based on the developed static plans)
- Determining the required resources (labor, mechanization, materials and costs)
- Creating the structure of a plan - network which shows the interdependence of activities and is schematically shown by circles.

Time analysis:

- determining the commencement and completion of activities
- determining dynamics of resources engagement

Optimizacije mrežnog plana;

Pored konvencionalnog tipa veze kraj - početak (FS, finish to start) sa odgovarajućim tehnološkim zastojima gdje je to neophodno, primjenjuju se i druge veze:

- početak - početak (SS, start to start)
- kraj - kraj (FF, finish to finish)

čime se omogućava realno prikazivanje tehnologije i dinamike građenja.

3.3. Vremensko lokacijski dijagrami (V-L dijagrama)

3.3.1. Ciklogram

Metoda ciklogramskog planiranja počela se razvijati s industrijalizacijom proizvodnje poslije drugog svjetskog rata. Za projekte s istim aktivnostima koje se ponavljaju više puta, kao što su katovi zgrada, dionice puteva ili segmenti stupova u literaturi se može pronaći veliki broj metoda planiranja koje su dostupne pod različitim imenima. Neke od njih su: Line of Balance (O'Brien, 1969; Carr i Meyer, 1974; Halpin i Woodhead, 1976; Harris i Evans, 1977.); Construction Planning Technique (Peer, 1974; Selinger, 1980); Repetitive Scheduling Model (Carr i Meyer, 1974), itd. Sve su ovo varijante dinamičkog plana, u našoj literaturi poznatog kao ciklogram.

Ciklogram je grafička metoda linijskog planiranja posebno prilagođena dinamičkom planiranju radova koje karakterizira neprekidan lančani slijed aktivnosti (Radujković i suradnici, 2012). Pogodan je za dinamičko planiranje radova koji imaju neprekidni lančani tok aktivnosti, tj. aktivnosti se ciklično ponavljaju, ali je nepregledan ako projekt ima veći broj aktivnosti. Odvijanje radnih operacija, odnosno aktivnosti, ukoliko je to potrebno, može se podijeliti na veći broj jednakih dijelova ili etapa, a to je moguće uraditi kod objekata koji imaju izraženu dužinu (npr. prometnice, potporni ziovi, kanali) ili visinu (segmenti stupova mosta). Specijalizirane radne grupe kreću se od jedne pozicije do druge gdje izvode indentičan građevinski proces (gradnja stupa mosta s jednakim segmentima). Pri tome broj etapa treba da je veći od broja operacija. Zbog ovih karakteristika ciklogram je vrlo povoljan pri planiranju građenja autocesta.

Prednosti ciklogramskog planiranja su sljedeće:

- omogućava brz, lak i detaljan uvid u stanje radova, odnosno laku usporedbu planiranog i realiziranog stanja na projektu i sa faktora vremena i sa faktora planiranih i izvršenih radova
- omogućava brzo i lako sagledavanje promjena u toku realizacije plana, zbog djelovanja okruženja na projekt, i brzo djelovanje na te promjene
- omogućava lako izbjegavanje štetnih djelovanja vremenskih i prostornih zazora, što omogućava optimalnu paralelizaciju aktivnosti u okviru projekta (Kurij, 2007)

Optimization of network plan:

In addition to the conventional finish-to-start (FS) connection with corresponding technological pauses, where necessary, other connections are applied as well:

- start to start (SS)
- finish to finish (FF)

thus enabling realistic display of technology and construction dynamics.

3.3. Time and Location Diagram (T-L Diagram)

3.3.1. Cyclograph

The method of cyclographic planning began to develop with the industrialization of production after World War II. In the literature there is a number of planning methods for projects with the same activities that repeat several times, such as floors of buildings, road sections, or column segments, available under different names. Some of them are: Line of Balance (O'Brien, 1969; Carr and Meyer, 1974; Halpin and Woodhead, 1976; Harris and Evans, 1977.); Construction Planning Technique (Peer, 1974; Selinger, 1980); Repetitive Scheduling Model (Carr and Meyer, 1974), etc. These are all variants of a dynamic plan known in our literature as the cyclogram

Cyclogram is a graphical method of line planning specifically adapted to dynamic planning of works characterized by uninterrupted chain sequence of activities (Radujković et al., 2012). It is suitable for dynamic planning of works that have an uninterrupted chain of activities, i.e. activities are cyclically repetitive, but it is not easily understandable if the project has a greater number of activities. Execution of work operations or activities could be divided into a greater number of equal parts or stages, if necessary, and this might be done with objects of a significant length (eg. traffic roads, supporting walls, channels) or height (segments of bridge columns). Specialized working groups move from one position to another, where they perform identical construction processes (construction of a bridge column with equal segments). Throughout this process the number of stages should be greater than the number of operations. Due to these characteristics, cyclogram is very advantageous when planning highway construction.

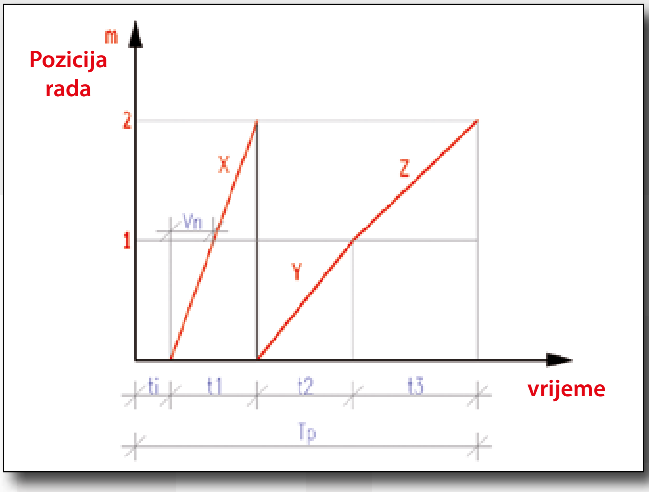
The benefits of cyclographic planning are the following:

- It enables a quick, easy and detailed insight into the state of the works, namely, a good comparison of the planned and realized state of the project both by time factors and by factors of planned and executed works
- It enables quick and easy observation of changes during the plan implementation, due to the environmental impact on the project, thus enabling the rapid response to these changes
- It enables easy avoidance of harmful effects of time and space gaps, which enables optimum parallelization of activities within a project (Kurij, 2007)

Ciklogram pripada prostornim planovima te se prikazuje u prvom kvadrantu koordinatnog sustava. Na apscisi se predočuje vrijeme, a na ordinati prostorne jedinice objekata koje se nazivaju graditeljske jedinice ili radne etape.

Trajanje građenja prikazano ciklogramom izračunava se pomoću formule:

$$Tp = t_i + \sum_{1}^{n-1} t + mxv_n$$



Ilustracija 4. Primjer konstrukcije ciklograma

t_i – vrijeme pripreme cikličkog izvođenja radova

$t_{1,2,3}$ – vrijeme trajanje aktivnosti x,y, z

m – broj pozicija građenja

v_n – vrijeme potrebno za izvođenje aktivnosti X na poziciji rada 1

n – broj aktivnosti u ciklogramu

U ovisnosti od modula cikličnosti aktivnosti, procesi građenja mogu se podijeliti na:

- ritmičke – sve aktivnosti imaju isti takt
- aritmičke – aktivnosti imaju različite taktove

Ritmički i aritmički procesi građenja, ovisno od toga je li se za aktivnosti realiziraju s ili bez vremenskog zastoja, mogu biti:

- kontinuirani – aktivnosti se realizuju bez vremenskog zastoja
- diskontinuirani (isprekidani) – aktivnosti se realiziraju s vremenskim zastojima

Cyclograms belong to spatial plans and are displayed in the first quadrant of the coordinate system. The abscissa shows time, and the ordinate spatial units of objects called building units or work stages.

Construction duration displayed by cyclograms is calculated using the formula:

$$Tp = t_i + \sum_{1}^{n-1} t + mxv_n$$

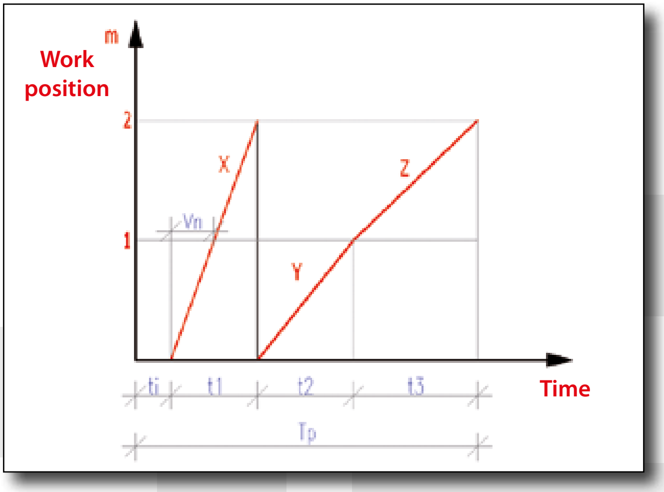


Figure 4. An example of cyclogram structure

t_i –preparation time for cyclic works execution

$t_{1,2,3}$ –time of activities x, y, z duration

m –number of constructing positions

v_n –time needed for execution of activity X in work position 1

n –number of activities in cyclogram

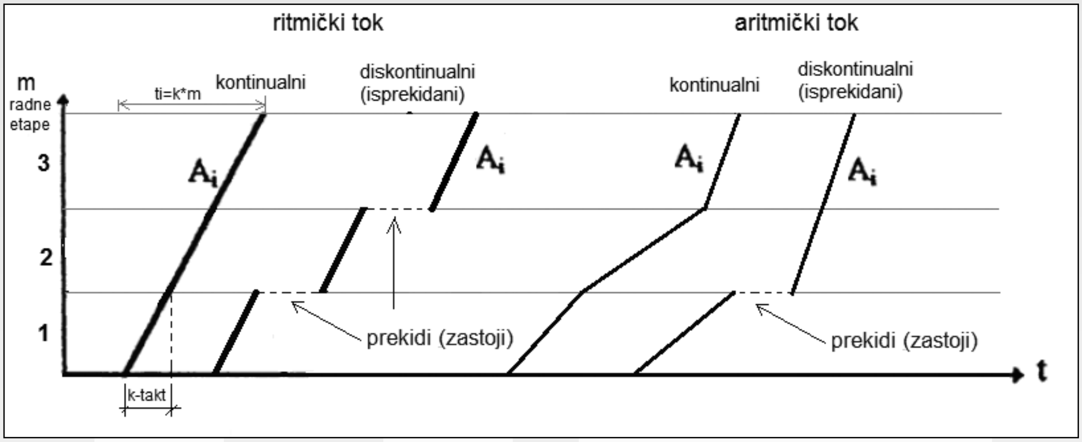
Depending on the cyclic activity module, the construction processes can be divided into:

- rhythmic – all activities have the same rhythm
- arrhythmic –activities have different rhythms

Depending on whether activities are carried out with or without time breaks, rhythmic and arrhythmic construction processes can be:

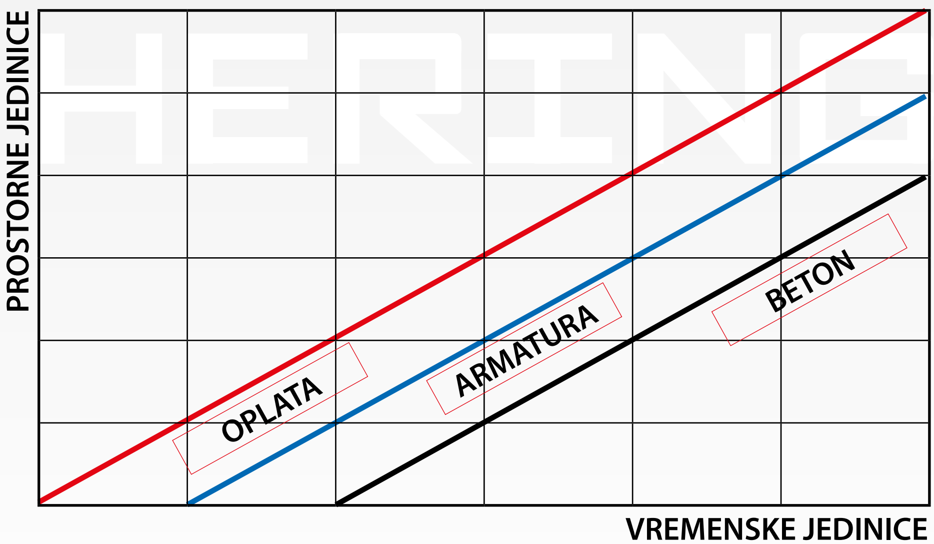
- continued – activities are realized without a time break
- discontinued (interrupted) – activities are realized with time breaks

Navedene vrste procesa građenja prikazane su na sljedećoj slici.



Ilustracija 5. Vrste procesa građenja

Ritmički tokovi predstavljaju pravilno odvijanje radova i u vremenu i u prostoru, dok aritmički predstavljaju nepovoljno odvijanje radova. Kod aritmičkih tokova postoje i točke kritičnog približavanja radova, koje mogu ugroziti radove na izgradnji objekta. Početni ciklogram se uglavnom prepravlja i poboljšava (tj. optimizira), čime se dolazi do konačnog rješenja.



Ilustracija 6. Kontinuirani procesi građenja

The mentioned types of construction processes are shown in the following picture.

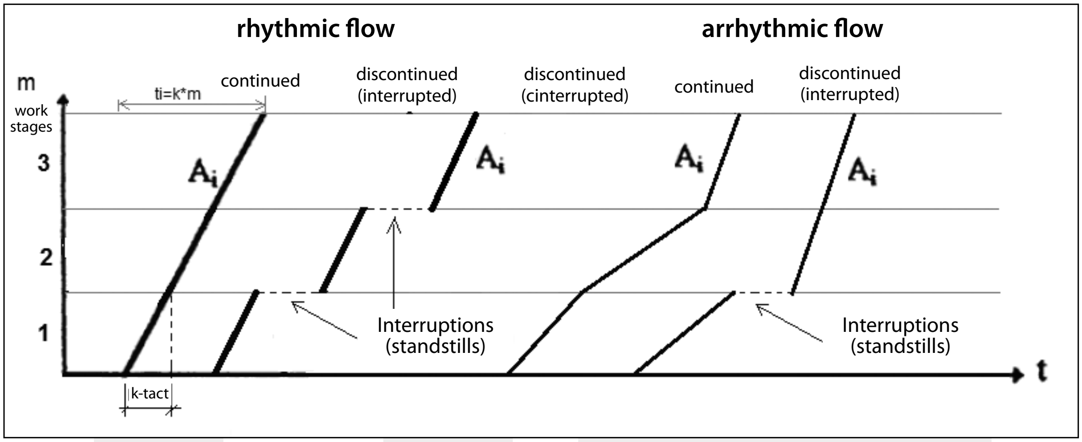


Figure 5. Types of construction proces

Rhythmic flows represent regular execution of works, both in time and space, whereas the arrhythmic ones represent unfavorable execution of works. In the arrhythmic flows, there are also points of critical impendency of works, which can endanger works on the construction of an object. The initial cyclogram is mostly revised and improved (i.e. optimized), resulting in a final solution.

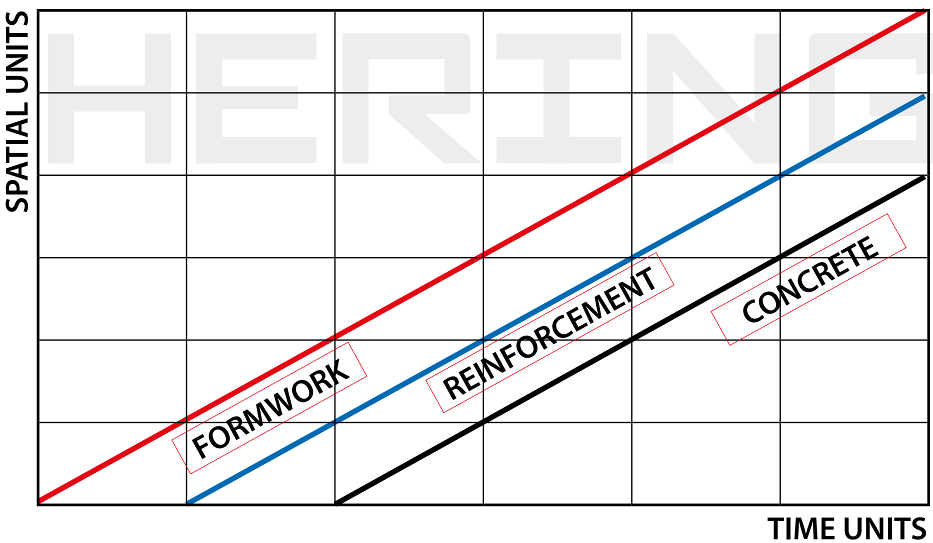
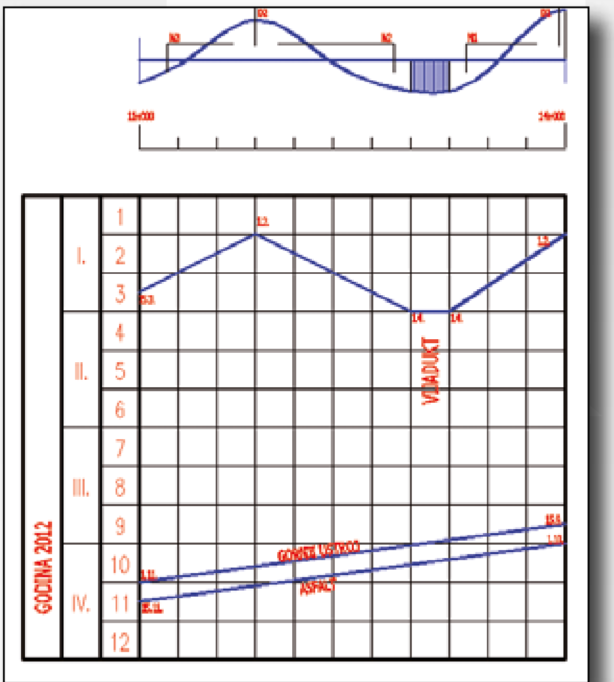


Figure 6. Continued construction processes

3.3.2. Ortogonalni planovi

Za cjevovode, tunele, puteve, itd. gdje se napredovanje radova mjeri u smislu horizontalne dužine, kroz povijest se pojavljuju različite metode planiranja pod raznim nazivima: Time Versus Distance Diagram (Gorman 1972.); Linear Balance Chart (Barrie i Paulson, 1978.); Linear Scheduling Method (Johnston, 1981; Chrzanowski i Johnston, 1986; Russell i Casselton, 1988); i dr. Iako je svaka od ovih metoda razvijena za ispunjenje svojih pojedinačnih ciljeva, sve su one slične u tome da planiraju rad nanošenjem inteziteta aktivnosti koje se ponavljaju u vremenu. Ove metode planiranja kod nas se nazivaju ortogonalnim planom.

Ortogonalni planovi također pripadaju prostornim planovima, prikazuju napredovanje radova u odnosu na prostorne jedinice objekta i vrijeme, te se prikazuju u četvrtom kvadrantu koordinatnog sustava, pri čemu se na ordinati prikazuje vrijeme a na apscisi prostorne jedinice objekta. Aktivnosti su u planu prikazane linijama, a trajanje svake aktivnosti određuje se njenom projekcijom na vremensku os. Može se zaključiti da ortogonalni plan daje dobar pregled odnosa rada - mjesto rada - vrijeme rada, pa je metoda bila popularna kod planera linijskih građevina koji su htjeli korisnicima plana jasnije vizualno prikazati podatke (Radujković i suradnici, 2012).



Ilustracija 7. Primjer ortogonalnog plana građenja poddionice autoceste

Najveći nedostaci ortogonalnog plana su nepostojanje prioriteta izvršenja pojedinih aktivnosti, preglednost kod složenijih projekata te nepostojanje veza između pojedinih aktivnosti. Ortogonalni plan kao metoda planiranja nikada nije doživio široku primjenu a danas se gotovo i ne primjenjuje.

3.3.2. Orthogonal plans

Regarding pipelines, tunnels, roads, etc. where the progress of work is measured in terms of horizontal length, different planning methods appear under different names throughout the history: Time Versus Distance Diagram (Gorman 1972.); Linear Balance Chart (Barrie and Paulson, 1978); Linear Scheduling Method (Johnston, 1981; Chrzanowski and Johnston, 1986; Russell and Casselton, 1988); etc. Although each of these methods was developed to fulfill their individual goals, they are all similar by planning the work by applying intensity of activities which are repeated over time. These planning methods are referred to as orthogonal plans in our region.

Orthogonal plans are also spatial plans, showing progression of works in relation to spatial structure units and to time, and are displayed in the fourth quadrant of the coordinate system, where the ordinate shows time and the abscissa shows spatial unit of the structure. In the plan activities are shown with lines, and the duration of each activity is determined by its projection on the time axis. It can be concluded that the orthogonal plan gives a good overview of the work relation - the place of work - the time of work, so that the method was popular with the planners of line structures who wanted the users of the plan to visualize the data more clearly (Radujković et al., 2012)

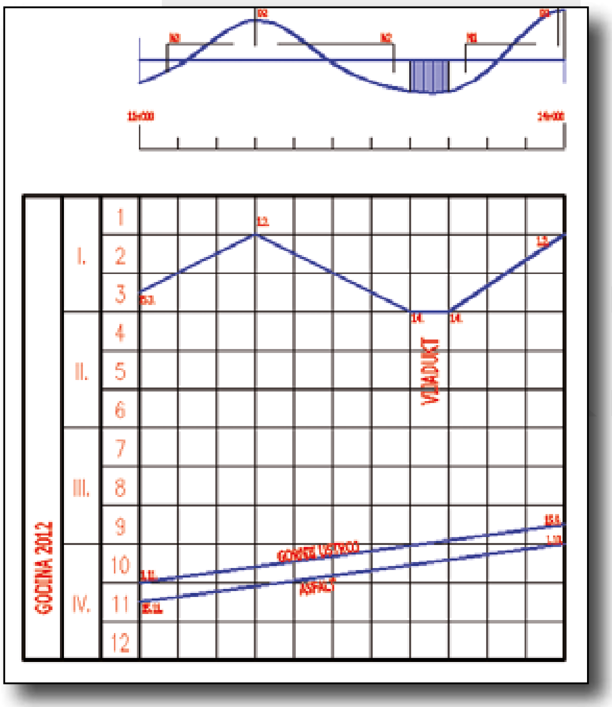


Figure 7. An example of orthogonal plan of the construction of motorway sub-section

The greatest shortcomings of the orthogonal plan are the lack of priority for the execution of certain activities, the visibility of complex projects and the lack of links between individual activities. The orthogonal plan as a planning method has never experienced a wide application and is practically not applied today.

3.4. Korištenje metoda planiranja u praksi

Brojni izvori tvrde da se primjenom mrežnog planiranja mogu znatno smanjiti prekoračenja početno planiranih troškova i vremena u projektu (Meredith, 1995). Međutim, mnogi projekt menadžeri te voditelji radova preferiraju gantogram za planiranje građenja zbog jednostavnosti njegove izrade i korištenja, jednostavnosti korištenja računala pri primjeni ove metode te lakom pravljenju ispravki u samom planu.

Istraživanjem tradicionalnih metoda planiranja građenja te mogućnosti njihove samostalne primjene može se utvrditi da se samostalnom primjenom pojedine metode planiranja građenja ne može osigurati adekvatno planiranje kompleksnog infrastrukturnog projekta zbog njihove usmjerenosti na specifičnosti pojedinih projekata te ograničenja u jasnim prikazima planova složenijih projekata. S obzirom na kompleksnost infrastrukturnih projekata potrebna je kombinirana primjena tradicionalnih metoda planiranja građenja kroz različite računalne pakete kako bi se stvorio efikasan plan građenja. Takav plan olakšava proces upravljanja građenjem i samo građenje te doprinosi uspješnosti projekta kao cjeline.

Iako većina današnjih programskih paketa podržavaju kombiniranu tehniku mrežnog planiranja i gantograma, korištenje mrežnog planiranja je nedovoljno zastupljeno. Pri planiranju složenih infrastrukturnih projekata mrežno planiranje omogućuje povezivanje velikog broja aktivnosti u koherentnu cjelinu, jednostavni su za unošenje izmjena u plan te intervencija u slučaju pojave kašnjenja u građenju. Međutim, aktivnosti u praksi planiraju se na razini koja ne omogućava optimizaciju resursa s obzirom na vrijeme i mjesto njihovog korištenja.

Mrežno planiranje ima veliki broj prednosti u odnosu na ostale metode planiranja:

- mrežni plan pokazuje veze između pojedinih aktivnosti
- mrežni plan prikladan je za matematičku obradu
- mrežnim planom određen je kritični put aktivnosti
- aktivnosti su podjeljene na kritične i nekritične
- moguće je optimiziranje troškova
- grafički prikaz mrežnog dijagrama daje dobru preglednost i tehnološki slijed radova
- pogodni su za rad na računalima

3.4. Practical use of planning methods

Numerous sources argue that using network planning can significantly reduce the exceeding of originally planned project costs and duration (Meredith, 1995). However, many project managers and work managers prefer using Gantt Chart for construction planning due to its simple development and use, due to the simple use of computer when applying this method, and due to the possibility of making corrections in the plan itself quite easily.

By exploring traditional planning methods of construction and the possibility of their independent use, it is obvious that by independent application of individual construction planning methods, the adequate planning of complex infrastructure project cannot be provided due to their focus on the specificity of individual projects and the limitations in clear presenation of plans in more complex projects. Given the complexity of infrastructure projects, a combined application of traditional methods of construction planning through different computing packages is necessary to create an efficient construction plan. Such a plan facilitates the process of construction management and construction itself, contributing to the success of the project as a whole.

Although most today's software packages support combined network planning and Gantt chart techniques, the use of network planning is under-represented. When planning complex infrastructure projects, network planning allows connecting a large number of activities to a coherent whole, it is easy to make changes to the plan and interventions in case of delays in construction. However, in practice activities are planned at a level that does not allow for resource optimization in terms of time and place of their use.

Network planning has a number of advantages over other planning methods:

- network plan shows links between individual activities
- network plan is suitable for mathematical processing
- network plan identifies a critical path of activity
- activities are divided into critical and non-critical
- optimization of costs is possible
- graphic representation of network diagram gives a good overview and technological sequence of works
- they are suitable for working on computers

Ilustracija 8. (a) aktivnosti u gantogramu prikazane kao cijeli objekti
(b) Primjer prikaza plana projekta razdijeljenog
do sitnih detalja izrađenog u računalnom paketu MS Project

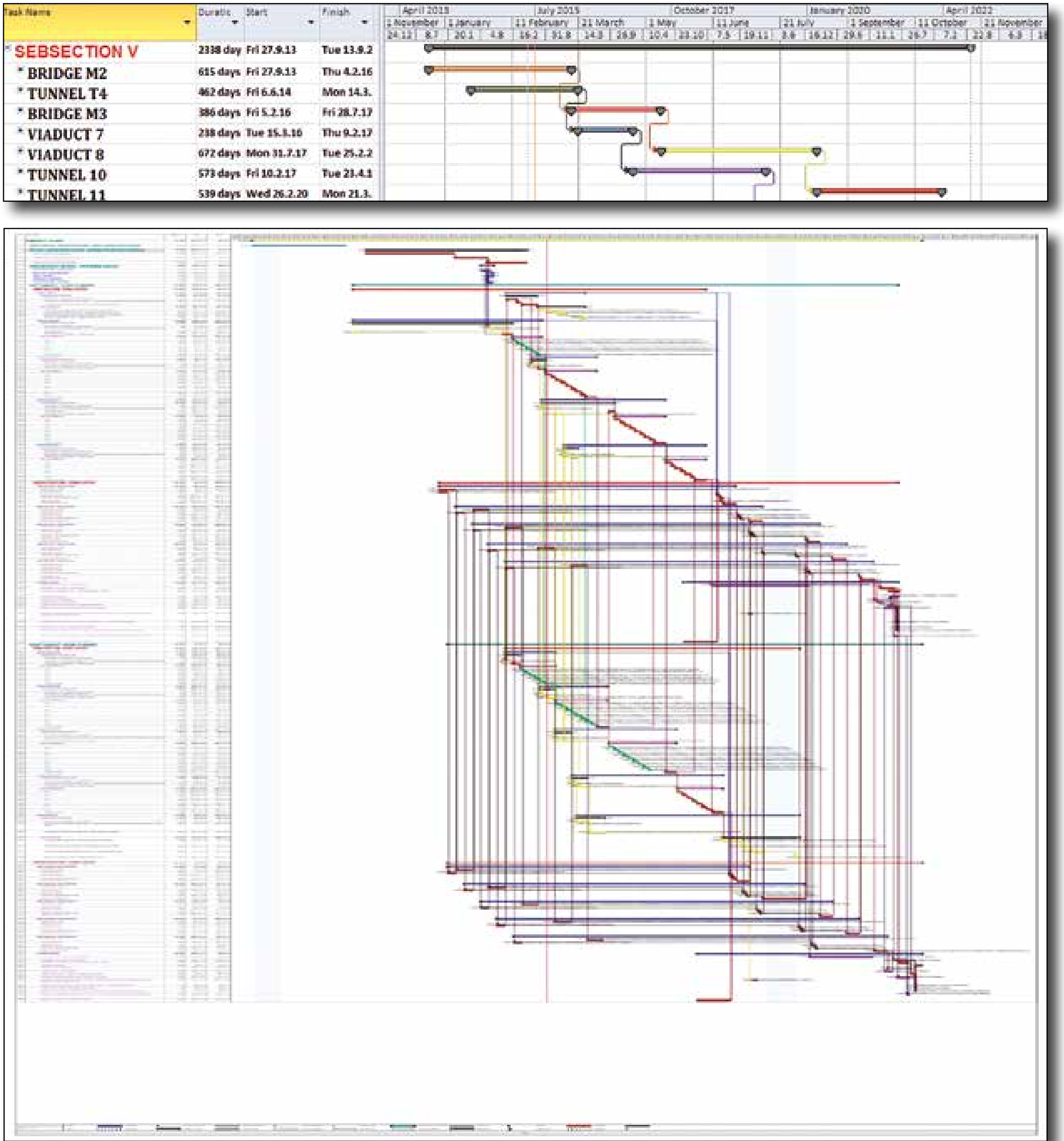
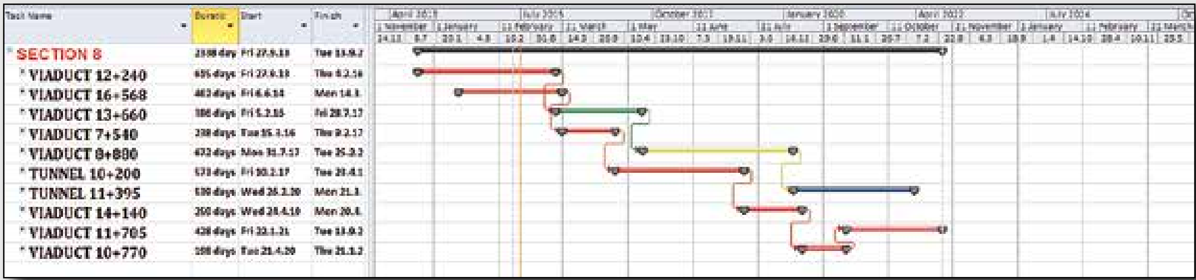


Figure 8. **(a)** activities shown as whole objects in Gantt Chart
(b) an example of a project plan image split into detailed fractions developed with a computing package MS Project



Ilustracija 9. Prikaz kritičnog puta u gantogramu crvenom bojom

Ovakav prikaz ukazuje na dijelove projekta na koje je potrebno obratiti posebnu pozornost pri građenju kako bi se na vrijeme mogli usmjeriti potrebni resursi te kako bi se građenje izvršilo u planiranom vremenskom roku (npr. koncentracija resursa na izvođenju odvodnje pri gradnji dionice autoceste).

Pri građenju svih vrsta infrastrukturnih projekata ritmična gradnja je najpoželjnija zbog jednostavnosti planiranja, smanjenje troškova pripremnih radova, smanjenja troškova uređenja gradilišta te ostvarenja minimalnog ukupnog vremena građenja kroz minimalne veličine koraka pojedinačnih procesa.

Kod infrastrukturnih projekata vrlo je bitno ostvariti kontinuitet korištenja građevinske mehanizacije i opreme, a Gantt chart ne može ukazati na kontinuiranost izvedbe pojedine aktivnosti pri građenju. Zato su se vremensko lokacijski dijagrami često koristili za linijske objekte prije pojave računalnih paketa koji koriste kombinaciju Gantt chart i mrežni dijagram.

Pojavom računalnih programa koji koriste vremensko lokacijski (V-L) dijagram dolazi do promjena dosadašnje prakse planiranja linijskih projekata. Ključna prednost V-L dijagrama je u vizualnom protoku podataka okupljenih u jednom planu. CPM rasporedi i mrežni dijagrami podatke prikazuju više analitički i ne omogućuju korisniku vizualni prikaz povezanosti između projektnog plana i samog projekta. Linearni projekti prestavljaju jedinstveni izazov zato što se radne skupine i oprema premještaju po gradilištu tijekom izvedbe projekta.

Korištenjem tradicionalnih dijagrama prikazivanje mjesta izvođenja radova i vremena u kojemu je taj rad izveden zahtjevala je razradu plana do detalja većih nego što praktičari smatraju da je potrebno. Prednost V-L dijagrama je u tome što omogućuje komunikaciju opsega projekta prikazivanjem detalja projekta i raspored izvedbe u isto vrijeme. Oni mogu dati više informacija zbog načina na koji se podaci uz udaljenost mogu pripisati svakom individualnom zadatku.

Veza između gradilišta i informacija o rasporedu omogućuje brže i dublje razumijevanje plana izvedbe konstrukcije. Moguće je izraditi usklađen plan bez nepotrebne detaljne razrade radi mogućnosti ukazivanja na potencijalne greške i rizike u slučaju preklapanja linija te dodatnih funkcija programskih paketa poput održavanja udaljenosti, sinkroniziranja nasljednika, sinkroniziranja brzine i računanje točke susretanja.

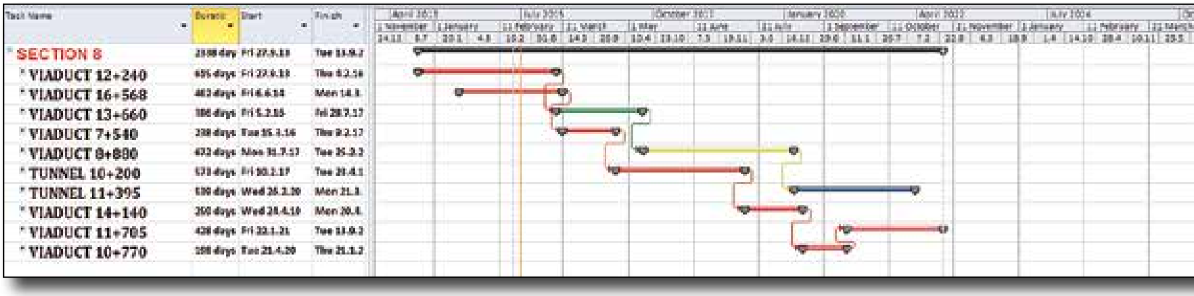


Figure 9. Red-color display of critical way in Gantt chart

Such a presentation points to parts of the project that need to be given special attention during construction, in order to be able to direct the necessary resources in time and to execute construction in the planned time limit (eg., concentration of resources on the drainage during the construction of a motorway section).

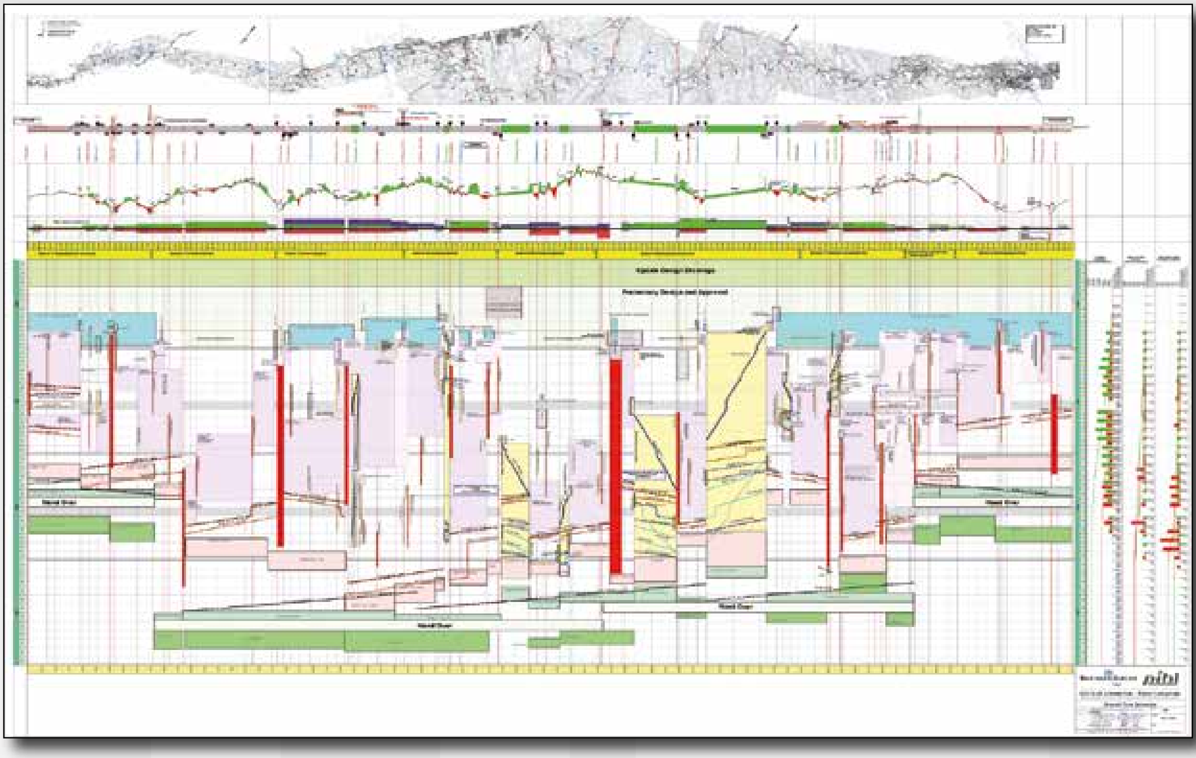
The rhythmic construction is most desirable in the construction of all types of infrastructure projects because of the simple planning, the reduction of the cost of preparatory works, the reduction of construction site costs and the achievement of the minimum total construction time through the minimum pace of individual processes.

In infrastructure projects, it is very important to realize the continuity of the use of construction machinery and equipment, and the Gantt chart cannot indicate the continuity of execution of a particular construction activity. That is why time-location diagrams were often used for line objects before the occurrence of computer packages that use a combination of Gantt chart and network diagram.

The appearance of computer programs using the time-location (T-L) diagram has caused the changes to the current practice of planning line projects. The key advantage of the T-L diagram is in the visual flow of data gathered in one plan. CPM schedules and network diagrams show data more analytically and do not allow the user to visualize the link between the project plan and the project itself. Line projects present a unique challenge because workgroups and equipment move across the site during project execution.

Using traditional charts to present the location of execution and the time in which this execution was performed required the elaboration of the plan to more details than the practitioners consider necessary. The advantage of the T-L diagram is that it allows communication of project scope by displaying project details and it enables the schedule of execution at the same time. It can provide more information due to the way in which data besides the distance can be attributed to each individual assignment.

The link between a construction site and information on the schedule enables a faster and deeper understanding of the structure execution plan. It is possible to develop a harmonized plan without unnecessary detailed elaboration for the potential of pointing to potential errors and risks in case of overlapping of the lines and additional functions of program packages such as distance maintenance, successor synchronization, speed synchronization, and meeting point calculation.



Ilustracija 10. Primjer vremensko lokacijskog dijagrama izrađenog računalnim paketom TILOS (www.tilos.org)

Također je moguće definirati ograničena područja u kojima se ne dopušta planiranje zadataka u danom vremenskom i prostornom prozoru zbog problema koji onemogućavaju pristup području ili predstavljaju ekološke probleme ili područja ili prostorno vremenska područja slabijeg intenziteta rada (utjecaj vremenskih prilika ili karakteristika terena).

Napredak se može bilježiti na 3 načina: bazirano na postotku izvršenja, bazirano na količini rada ili bazirano na udaljenosti. U svakom slučaju precizne informacije s lokacije gdje je rad dovršen su nužne. Ovaj napredak se može prikazati pomoću jednostavnog grafikona, koji pokazuje dovršene sektore.

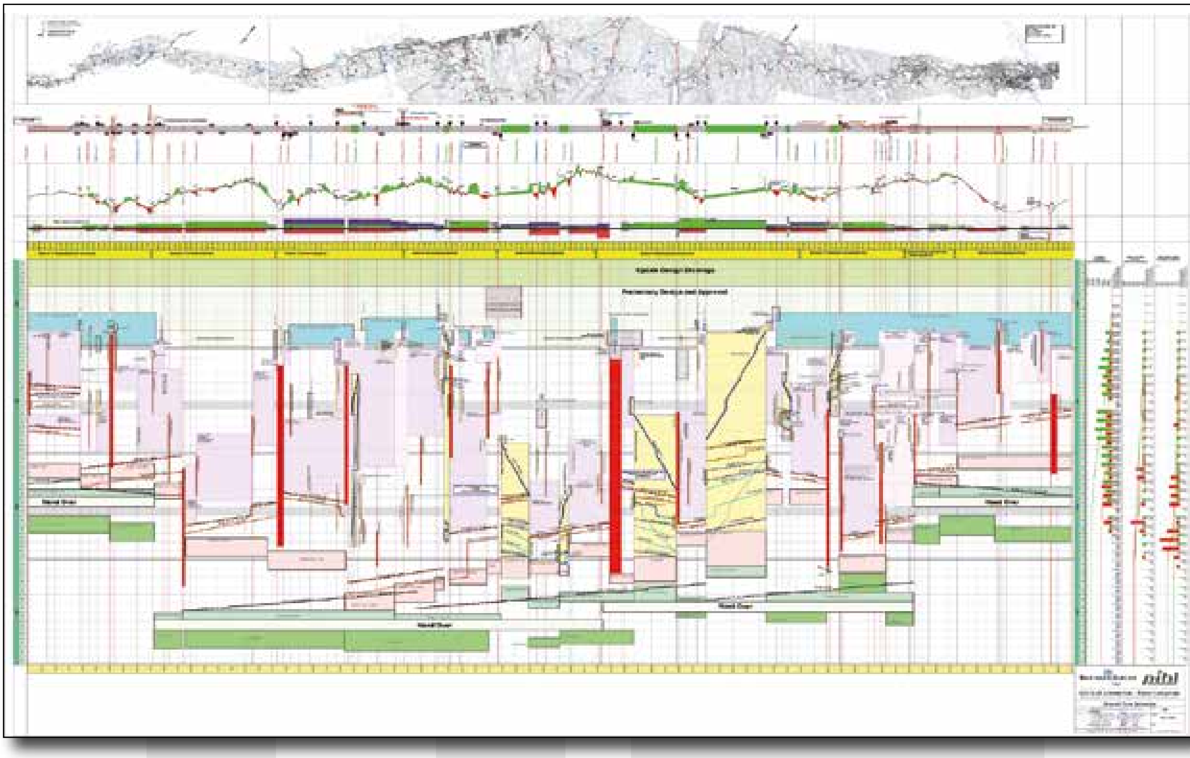


Figure 10. An example of Time-Location diagram developed by computer package TILOS (www.tilos.org)

It is also possible to define restricted areas that do not allow scheduling of tasks in a given time and space window due to problems that prevent access to the area or pose ecological problems or areas or spatial temporal areas of lower operating intensity (weather conditions or terrain characteristics).

Progress can be recorded in 3 ways: based on the percentage of execution, based on quantity of work or based on distance. In any case, precise information from the location where work is completed is necessary. This progress can be presented using a simple graph that shows completed sectors.

4. Zaključak

Svaki infrastrukturni projekt ima različite karakteristike. Ova tvrdnja upućuje na zaključak da je za planiranje građenja svakog infrastruktunog projekta potrebno odrediti adekvatnu metodu planiranja. Zbog toga se do danas razvio veliki broj metoda planiranja koje se primjenjuju u većoj ili manjoj mjeri. Poznato je da građenje infrastruktunih projekata često prekoračuje vremenski rok i planirane troškove. Kao osnovni uzrok nastanka kašnjenja ili povećanja koštanja projekta smatra se pogrešan odabir metode planiranja.

Projekt menadžeri u praksi primjenjuju jednostavnije metode planiranja zasnovane na gantogramima za čiju pripremu izdvajaju manje vremena što za posljedicu ima loše planirane projekte. Potrebno je da projekt menadžeri u praksi više pažnje posvete planiranju kroz primjenu adekvatnijih metoda planiranja što će na početku projekta zahtjevati veći utrošak vremena ali će na kraju projekta dati bolje rezultate i pokazati opravdanost primjene složenijih metoda planiranja.

Radi kompleksnosti i različitosti struktura infrastrukturnih projekata, metoda planiranja građenja mora se odabrati vodeći računa o svim dijelovima infrastruktunog projekta kako bi plan što uspješnije bio proveden u djelo.

Međutim, vjerojatno je da niti jedna od postojećih metoda planiranja neće zadovoljiti sve dijelove građenja infrastruktunog projekta. Zbog njihove kompleksnosti infrastrukturni projekti zahtjevaju kombiniranu primjenu različitih metoda planiranja te njihovu prilagodbu uvjetima svakog pojedinog projekta.

Projekti poput mostova ili crpnih stanica mogu biti planirani u posebnih podprojektima i zatim njihovi najvažniji i za projekt potrebni podaci mogu se povezati u vremensko prostornom dijagramu.

Istraživanje primjene tradicionalnih metoda planiranja građenja, te pitanja mogućnosti njihove primjene u planiranju modernih instrastrukturnih projekata, ukazalo je na mogućnosti i način njihove primjene u prošlosti, neadekavtnu primjenu u sadašnjosti koja se očituje kroz česta pa gotovo i stalna kašnjenja u građenju infrastrukturnih projekata te prekoračenje planiranih troškova za građenje i mogućnost njihove primjene u planiranju budućih projekata. Rad ukazuje na potrebu konstantnog unaprijeđenja tradicionalnih metoda planiranja kroz njihovu kombiniranu primjenu te razvoj novih metoda planiranja kako bi planovi građenja bili što točniji i tako pridonijeli uspješnosti ne samo građenja nego i inftrastrukturnog projekta u cjelosti.

Vodeći računa da će u budućnosti projekti postajati još kompliciraniji i da će se od metoda planiranja građenja zahtijevati primjena na takvim projektima, vrlo će važan biti razvoj metoda planiranja te njihova prilagodba izazovima koje će donijeti karakteristike infrastrukturnih projekata u budućnosti.

4. Conclusion

Each infrastructure project has different characteristics. This statement suggests that construction planning of each infrastructure project requires an adequate planning method. For this reason, a large number of planning methods have been developed so far, and they are implemented to a greater or lesser extent. It is well known that construction of infrastructure projects often exceeds the time schedule and planned costs. The primary cause of delay or project cost increase is considered to be the wrong choice of a planning method.

In practice Project managers apply simpler planning methods based on Gantt charts which are prepared more quickly, resulting in poorly planned projects. It is necessary that project managers take more care of planning in practice through the application of more adequate planning methods, which will require more time in the beginning of the project but will give better results in the end of the project and justify the application of more complex planning methods.

Due to the complexity and diversity of infrastructure projects structure, the construction planning methods must be selected taking into account all parts of the infrastructure project in order to implement the plan as successfully as possible.

However, it is possible that none of the existing planning methods would meet the needs of all the components of an infrastructure project. Because of their complexity, infrastructure projects require the combined application of different planning methods and their adjustment to the requirements of each project.

Projects like bridges or gas stations can be planned in separate subprojects and then the most important data which are necessary for the project can be interconnected in the time-location diagram.

The research of the application of traditional construction planning methods and of the issue of their application in planning modern infrastructure projects has pointed to the possibilities and the way of their application in the past, the inadequate application in the present, which is manifested by frequent and almost ever present delays in the construction of infrastructure projects and by exceeding the planned construction costs; and also to the possibility of their application in the planning of future projects. The paper points to the need of constant improvement of traditional planning methods through their combined application and through the development of new planning methods to make construction plans as accurate as possible, thus contributing to the success of not only construction but also of the infrastructure project as a whole.

Keeping in mind that in the future the projects will become even more complex and that the application of construction planning methods will be necessary for such projects, developing planning methods will be very important, as well as their adjustment to the challenges that will be posed by characteristics of infrastructure projects in the future.

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HERING

Mr.sc.Ladislav Bevanda, dipl.ing. građ.
Hering d.d. Široki Brijeg
Sveučilište u Mostaru, Građevinski fakultet Mostar

ORGANIZACIJA I TEHNOLOGIJA GRAĐENJA CRKVE UZNESENJA BLAŽENE DJEVICE MARIJE NA ŠIROKOM BRIJEGU

ORGANIZATION AND TECHNOLOGY OF CONSTRUCTION OF THE CHURCH OF THE ASSUMPTION OF BLESSED VIRGIN MARY IN ŠIROKI BRIJEG

ORGANIZACIJA I TEHNOLOGIJA GRAĐENJA CRKVE UZNESENJA BLAŽENE DJEVICE MARIJE NA ŠIROKOM BRIJEGU

Mr.sc.Ladislav Bevanda, dipl.ing. građ.
Hering d.d. Široki Brijeg
Sveučilište u Mostaru, Građevinski fakultet Mostar

Sažetak

Autor u članku istražuje moguće postupke realizacije projekta i izvođenja radova na predmetnoj građevini u pogledu tehničkih i tehnoloških mogućnosti građevinske proizvodnje, na ovim prostorima i općenito, vremena u kojem je građena. Za pojedine konstruktivne dijelove ove inženjerske konstrukcije analizom se ukazuje na složenost postupaka građenja kojima su ovladali ondašnji graditelji za ostvarenje ovog pothvata. Iako uz minimalne tehničko-tehnološke i financijske mogućnosti, "neimari" tog vremena su pokazali dominaciju čovjekova graditeljskog uma i duha, uspijevajući sagraditi ovakvu inženjersku građevinu. U tijeku realizacije ovog projekta mogu se, također, identificirati prepoznatljive standardne faze građevinskog projekta i njihove specifičnosti s obzirom na vrijeme i okolnosti: koncipiranje, definiranje, realizacija i korištenje. Kroz životni vijek ove građevine do danas se prepoznaju i svi procesi upravljanja projektima, ukazujući da građevinari prirodno funkcioniraju u skladu s metodama i principima znanosti o upravljanju projektima. U radu se skreće pozornost i na svu složenost odnosa uobičajenih sudionika u projektu.

Ključne riječi: projekt, izgradnja, tehnologija, faze projekta, upravljanje projektom, organizacija.

1. Koncipiranje

Društvene prilike u prvoj polovici devetnaestog stoljeća omogućile su puku u Hercegovini ponovno slobodnije izražavanje vjere, te su žitelji s redovnicima u tu svrhu poduzimali različite aktivnosti za ostvarenje višegodišnjih sputavanih želja za obnavljanjem i izgradnjom novih crkava i samostana na mjestima starih, manjih ili uništenih. Franjevci rodom iz Hercegovine dobili su 1844. godine dopuštenje Svete Stolice da mogu ponovo graditi crkvu i samostan u Hercegovini. Tako će se u vremenu koje slijedi podizati nove i veće građevine, koje su odgovarale potrebama vjernika i redovnika.

ORGANIZATION AND TECHNOLOGY OF CONSTRUCTION OF THE CHURCH OF THE ASSUMPTION OF BLESSED VIRGIN MARY IN ŠIROKI BRIJEG

M.Sc.Ladislav Bevanda, BCE*
Hering d.d. Široki Brijeg
University of Mostar, Faculty of Civil Engineering

Abstract

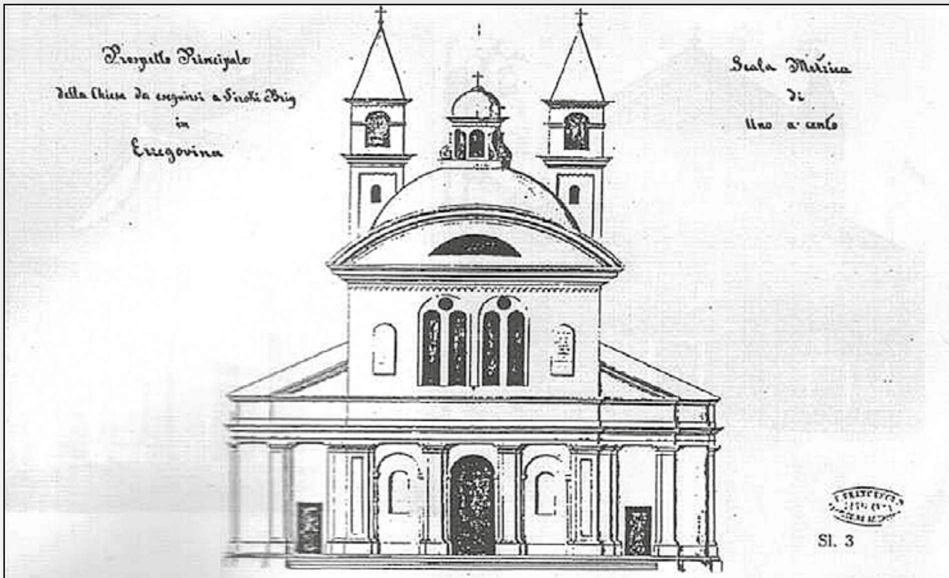
In this paper, the author analyses possible procedures of project realization and execution of works on the subject structure in terms of technical and technological possibilities of construction production in this area and, in general, in the time when it was built. The analysis of certain constructive parts of this engineering structure points to the complexity of the construction procedures which were mastered by the builders of that time in order to realize this venture. Although they had minimal technical-technological and financial capabilities, the builders of that time demonstrated the domination of human architectural mind and spirit by constructing such an engineering structure successfully. It is possible to identifiy recognizable standard phases of construction project and their unique characteristics regarding the time and circumstances during the realization of this project: concept, definition, realization and use. All project management processes could be recognized throughout the lifecycle of this building, indicating that constructors naturally function in accordance with the methods and principles of project management science. The paper draws attention to the complexity of the relationship between usual participants in a project.

Key words: project, construction, technology, project phases, project management, organization.

1. Concept

The social background in the first half of the nineteenth century enabled the people in Herzegovina to express their faith more freely, and consequently the local residents with their friars undertook various activities in order to fulfill their long-lasting craving for renewal and construction of new churches and monasteries in places of old, small or destroyed ones. In 1844, the Franciscans born in Herzegovina were granted a permission to build a church and monastery in Herzegovina by the Holy See. Thus, in the time to come, new and larger buildings would be erected, meeting the needs of believers and priests.

Nakon osnivanja Apostolskog vikarijata 1847. godine, uspostavlja se i Hercegovačka franjevačka kustodija, na čijem čelu je od 1852. godine fra Petar Bakula, koji je, vodeći u Rimu godine 1862. generalnu skupštinu Franjevačkog reda, iskoristio prigodu i u Hercegovinu, koja u ono vrijeme gotovo da nema obrazovanih ljudi, poveo Mattea Lorenzonija[1] kapucina-laika iz Vicenze, čiji je crtački talent omogućio mnoge planove za brojne građevine i u ovim krajevima. Izradio je u to vrijeme nacrte za crkvu na Širokom Brijegu koji nisu ostvareni zbog nedostatka majstora na ovim prostorima za ovaj zahvat, te siromaštva puka i nemoći Provincije i samostana na Širokom Brijegu da planiranu gradnju financiraju. Ova crkva je trebala biti dužine 48,2 m, a širine 21,8 m, zamišljena kao trobrodna bazilika u stilu talijanskog baroka, s kupolom poviše glavnoga oltara i s dva tornja.



Slika 1. Nacrt za pročelje crkve na Širokom Brijegu, rađen od 1863. do 1866. (Matteo Lorenzoni, 1804.-1880.)

Kako je, za vrijeme privremene austro-ugarske vlasti do aneksije 1908. godine, 22. 2. 1880. godine, bio izglasan Zakon o upravljanju Bosnom i Hercegovinom, a 26. 2. 1880. godine povjerena civilna uprava nad BiH Zajedničkom ministarstvu financija i 29. 10. 1880. osnovana Zemaljska vlada u

1 Matteo Lorenzoni (1804.-1880., Vicenze) arhitekt koji je na molbu Starješinstva Provincije od 1863. boravio i radio kao arhitekt u Hercegovini pomažući novoosnovanoj Kustodiji. Nacrt za crkvu na Širokom Brijegu radio je po uzoru na Crkvu sv. Spasitelja u Veneciji. Za boravka na Širokom Brijegu on je izradio nacrte za most na Ugrovači i na rijeci Mlade kod Vitine, od kojih ovaj prvi i danas služi svojoj svrsi, a drugi je obnovljen. Po njegovim je nacrtima izgrađena franjevačka Crkve sv. Petra i Pavla u Mostaru koja je u potpunosti srušena 9. svibnja 1992. u Domovinskom ratu. Temeljni kamen za crkvu u Mostaru postavljen je 6. ožujka 1866. Nakon odlaska iz Mostara 1867. godine još je dvije znamenite građevine: crkva u mjestu Cardo kod Bastije na Korzici (1869.-1873.) i crkva u mjestu Bonjardinu , provincija Permanbuco u Brazilu (1875.). Crkva u Mostaru i ove crkve sadrže zajedničke oblikovne i dimenzijske elemente. Po povratku iz Brazila uskoro je umro.

After the founding of the Apostolic Vicariate in 1847, the Herzegovinian Franciscan Custody was established, and from 1852 was headed by Fr. Petar Bakula, who used the occasion of the General Assembly of the Franciscan Order in Rome in 1862, to take Matteo Lorenzoni[1], the Capuchin Laik from Vicenza to Herzegovina. His drawing talent enabled many plans for numerous buildings in these areas and in Herzegovina too, which at that time almost had no educated people. At that time, he created drawings for the church in Široki Brijeg, which were not realized due to the lack of masters in this area for this operation, and due to the poverty and impossibility of the Province and Monastery in Široki Brijeg to finance the planned construction. This church should have been 48.2 m long and 21.8 m wide, conceived as a three-nave basilica of Italian baroque style, with dome above the main altar and two towers.

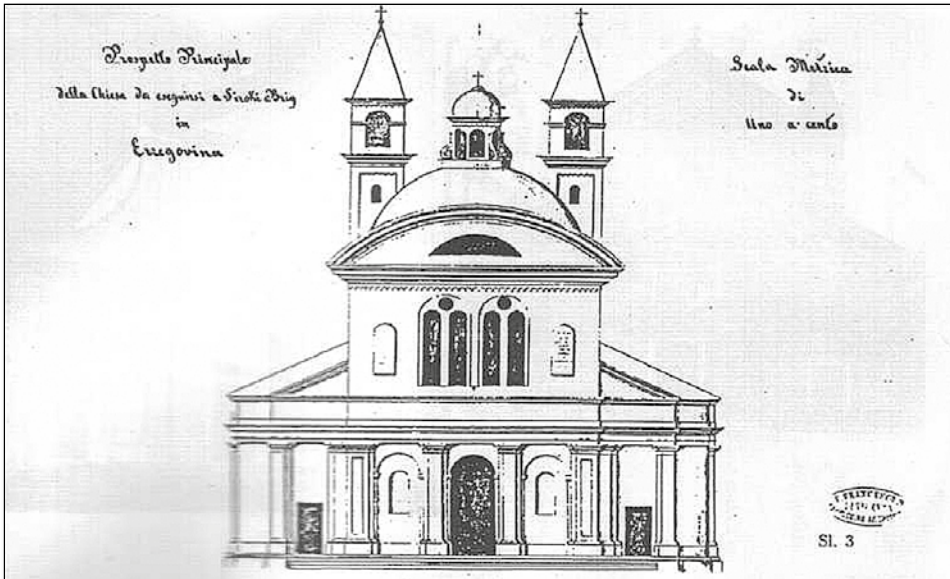


Figure 1. Drawing of the facade of the church in Široki Brijeg, built between 1863 and 1866 (Matteo Lorenzoni, 1804-1880)

As during the interim Austro-Hungarian government until the annexation of 1908, the Law on Management of Bosnia and Herzegovina was adopted on 22 February 1880, and the Civil Administration

1 Matteo Lorenzoni (1804.-1880, Vicenze), an architect who lived and worked in Herzegovina from 1863 as an architect assissting the newly established Custody after the invitation of the Province Seniority. He developed the design for the church in Široki Brijeg modeled on the Church of St. Savior in Venice. During his stay in Široki Brijeg, he made drawings for the Ugrovača river bridge and a bridge on the Mlade river in the vicinity of Vitina, the first of which still serves its purpose today, and the other one has been restored. The Franciscan Church of St. Peter and Paul in Mostar was built by his designs used as a model, but it was completely destroyed on 9 May 1992 in the Homeland War. The foundation stone for the church in Mostar was laid on 6 March 1866. After leaving Mostar in 1867, he designed two more famous buildings: the church in Cardo near Bastia in Corsica (1869-1883) and the church in Bonjardin, Pernambuco in Brazil (1875). The church in Mostar and these two churches contain common form and dimensional elements. He died shortly after he returned from Brazil.

Sarajevu, te time donekle izgradila vlast i na nižim razinama (kotari, okružne oblasti), to je značilo da će se poslovi gradnje objekata podređivati državnom upravnom ustroju. Uskoro je 13. 9. 1884. donesen Gruntovnički zakon za Bosnu i Hercegovinu, Naputak za provođenje Gruntovničkog zakona, Naputak za vođenje gruntovnice u BiH, te Naredba u pogledu ustrojstva i djelokruga gruntovničkih povjerenstava i uredovanja kod istih.

Godine 1892. franjevačka kustodija u Hercegovini dobila je naslov Provincija Marijina uznesenja. Iako su u tim vremenima redovnici na čelu svojih zajednica u Hercegovini povećavali nastojanja k izgradnji crkava, to im nije polazilo za rukom, ponajvećma zbog neimaštine a i teškoća s vlastima koje su, u balansiranju između podupiranja vjerskih zajednica, uglavnom svima uskraćivale značajniju pomoć i odobrenja za gradnje vjerskih objekata, što je posebno pogađalo opustošenu Hercegovinu. Nakon što su širokobriješki franjevci usmeno od Starješinstva Provincije tražili da se sagradi nova crkva na Širokom Brijegu, na zasjedanju u Mostaru 19. 10. 1892., Starješinstvo Provincije dopušta gradnju, ali uz uvjet da Provinciju to išta košta, tj. o trošku Samostana.

Ovim se završava faza zamisli i otpočinju nastojanja za izradu idejnih rješenja, tj. za koncipiranje projekta, te zaokružuje strateški proces postavljanja cilja projekta. Definirane su okvirne karakteristike projekta vođene izraženim potrebama i odabrana je lokacija.

Od spomenutog redovničkog dopuštenja Provincije za gradnju pa do 31. 12. 1903. godine, kada Starješinstvo Franjevačke provincije piše Okružnoj mjesnoj oblasti s molbom da im "izašalju Inžinira" da učini nacrt za civilno dopuštenje gradnje crkve, ne bilježe se značajnije aktivnosti oko planiranja gradnje crkve zbog sveprisutnog siromaštva i vjerojatno znatnih administrativnih problema oko odobrenja za gradnju, uvjetovanog stanjem u zemlji i nastojanjima Austro-ugarske Monarhije da uspostavi potpunu vlast u Bosni i Hercegovini.

Nakon zahtjeva Starješinstva Provincije, zadatak izrade idejnog nacrta za novu crkvu na Širokom Brijegu Okružna oblast u Mostaru, povjerava inž. Škrobiću početkom godine 1904.

Razina očuvane dokumentacije ukazuje da je ovaj nacrt služio nekoj vrsti isprave koju danas razumijevamo kao dokumentaciju za načelnu suglasnost, urbanističku ili lokacijsku dozvolu. Vjerojatno je upravna procedura već u ono vrijeme zahtijevala ovaj korak pri ishođenju odobrenja za gradnju. U ovoj fazi, s obzirom da je postojao spomenuti Gruntovnički zakon, zemljište je bilo izvjesno riješeno. Najaktivniju ulogu u ovoj fazi projekta imaju inicijatori, redovnici u samostanu na Širokom Brijegu koji se cijelo vrijeme konsultiraju sa Starješinstvom Provincije i preko njega traže dopuštenja od Zemaljske vlade, a s njom komuniciraju preko Okružne oblasti.

of Bosnia and Herzegovina was entrusted to the Joint Ministry of Finance on 26 February 1880 and the Land Government was established in Sarajevo on 29 October 1880, thus forming some authorities at lower levels (districts, county regions), it meant that construction work would be subject to the state administrative structure. Soon, the following acts were adopted: the Land Registry Law of Bosnia and Herzegovina on 13 September 1884, the Instruction for Implementation of the Land Registry Law, the Instruction on Keeping Land-Registers in Bosnia and Herzegovina, and the Ordinance Concerning the Structure and Jurisdiction of Land-Registry Commissions and their Procedures.

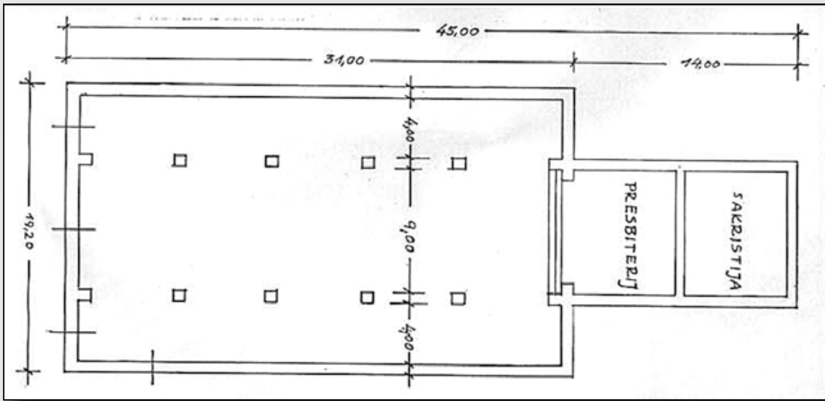
In 1892 the Franciscan Custody in Herzegovina was granted the title of the Province of Mary's Assumption. Although the priests who led their communities in Herzegovina tried hard to build churches at that time, they did not have much success, mostly due to the lack of resources and difficulties with the authorities which, while balancing in providing support to various religious communities, largely denied any significant assistance and approvals to construction of religious buildings, which particularly affected the ravaged Herzegovina. After the Franciscans from Široki Brijeg had orally asked the Province Seniority to build a new church in Široki Brijeg, in Mostar on 19 October 1892, the Province Seniority allowed the construction, but provided that the Province would not bear the expenses, that is, it would be to the cost of the Monastery.

This marked the end of the conceiving stage and the beginning of efforts to develop conceptual solutions, i.e. to design the project, and this completed the strategic process of setting the project goal. The framework characteristics of the project led by expressed needs were defined and the location was selected.

From the aforementioned Province permission for construction until 31 December 1903, when the Seniority of the Franciscan Province wrote to the Local County District with the request to send them an engineer to make a draft for civil permission for the construction of the church, there were no significant activities regarding planning the church construction because of the omnipresent poverty and probably the considerable administrative obstacles in obtaining the construction permit, conditioned by the state of the country and the efforts of the Austro-Hungarian Monarchy to establish full rule in Bosnia and Herzegovina

After the request of the Province Seniority, the County District Office in Mostar assigned the task of developing the preliminary design for the new church in Široki Brijeg to engineer Škrobić in the beginning of 1904.

The level of the preserved documentation suggests that this design served as a sort of document that we now understand as a documentation for a primary consent, urban planning or location permit. The administrative procedure at that time probably required this step when it came to obtaining a construction permit. At this stage the question of land was certainly resolved, as the Land Registry Law was in existence. The most active part in this phase of the project was played by the initiators, the priests of the Monastery of Široki Brijeg, who consulted the Province Seniority all the time and sought the permission from the Land Government, which was communicated through the County District Office.



Slika 2. Idejni plan inž. Škrobića, početak 1904.

2. Definiranje

Rukovodeći se tim idejnim rješenjem, austrijski inženjer M. David[2] , koji je u ono vrijeme na prostoru Hercegovine radio za austrijsku vladu, napravio je novi plan za crkvu na Širokom Brijegu. Plan inž. Davida karakterizira stil kasnoromaničke trobrodne bazilike, te pet rastera i jedan zvonik od 50 m.

Ovaj plan (vjerojatno načelno odobren i poslan od Zemaljske vlade iz Sarajeva Starješinstvu Provincije u Mostar) odnio je 3. svibnja 1904. provincijal fra Anđeo Nuić na Široki Brijeg, te su samostanski diskreti i gvardijan fra Stanko Kraljević, kao savjetnik, odobrili plan.

U ovoj fazi je, dakle, odabran projektant, izrađeni idejni nacrti, te pribavljena suglasnost korisnika i naručitelja na idejnu tehničku dokumentaciju i sve je bilo spremno za zahtjev za odobrenje za gradnju.

Pri svemu se uočavaju složeni odnosi među funkcijama projektanta, naručitelja, korisnika, te konzultanata i civilne uprave u zemlji. U okvirima današnje regulative ova faza projekta bi se odnosila na konačan projektni zadatak, odabir projektanta, usvajanje idejnog rješenja od redovnika i Zemaljske vlade, te izdavanje lokacijske dozvole ili urbanističke suglasnosti.

Starješinstvo Franjevačke provincije 9. 6. 1904. izdalo je redovničku dozvolu za gradnju crkve na Širokom Brijegu prema spomenutom planu i 16. 6. 1904. poslalo je zahtjev uz plan za odobrenje gradnje Zemaljskoj vladi preko Okružne oblasti u Mostaru.

2 Max (Maksimilijan) David (Alttitschein, Moravska, 7. Prosinca 1859. Godine) bio je Vladin inženjer u Okružnoj oblasti u Mostaru. Završio Visoku tehničku školu u Brnu koju je pohađao u dva navrata, od 1877. Do 1879. I od 1880. Do 1883. godine. Najprije radi kao asistent na Visokoj tehničkoj školi u Brnu, a zatim kod nekoliko firmi u Čehoslovačkoj. U Bosni i Hercegovini u Okružnoj oblasti u Mostaru je od 21. svibnja 1890. godine. U Tuzlu je prešao 1907. godine (Lit: Wiener Bauindustrie- Zeitung, WIEN. XX, 41, 10. prosinca 1898. godine, 390-391. Izvor: Arhiv Bosne i Herzegovine-personalni list (Krzović, 1987., str.248). Kao projektant, njegovo ime se veže za zgradu Okružnog suda u Mostaru, 1891.-1892. (Krzović, 1987., str.21), dogradnju Djevojačke škole milosrdnih sestara u Mostaru, 1903. godine (Krzović, 1987., str 23)), Biskupski Dvor u Mostaru (Vego, 2006., str. 122).

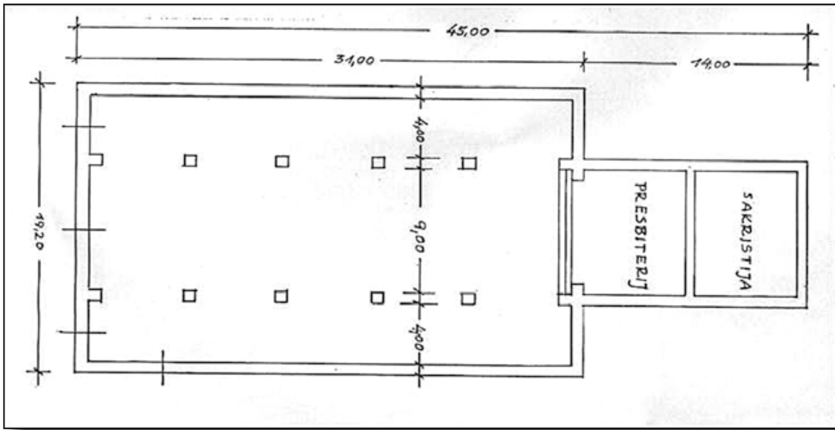


Figure 2. Preliminary Design of engineer Škrobić, early 1904.

2. Definition

Guided by this conceptual solution, Austrian engineer M. David[2], who worked for the Austrian government in Herzegovina at that time, made a new plan for the church in Široki Brijeg. His plan reflected the style of the late romanticism three-nave basilica with five grids and one 50-meter-tall bell tower.

On 3 May 1904, this plan (probably basically approved and sent by the Government of Sarajevo to the Province Seniority of Mostar) was brought by the Provincial Fr. Anđeo Nuić to Široki Brijeg and it was approved by both the abbot, Fr. Stanko Kraljević as a counselor, and the monastery counselors.

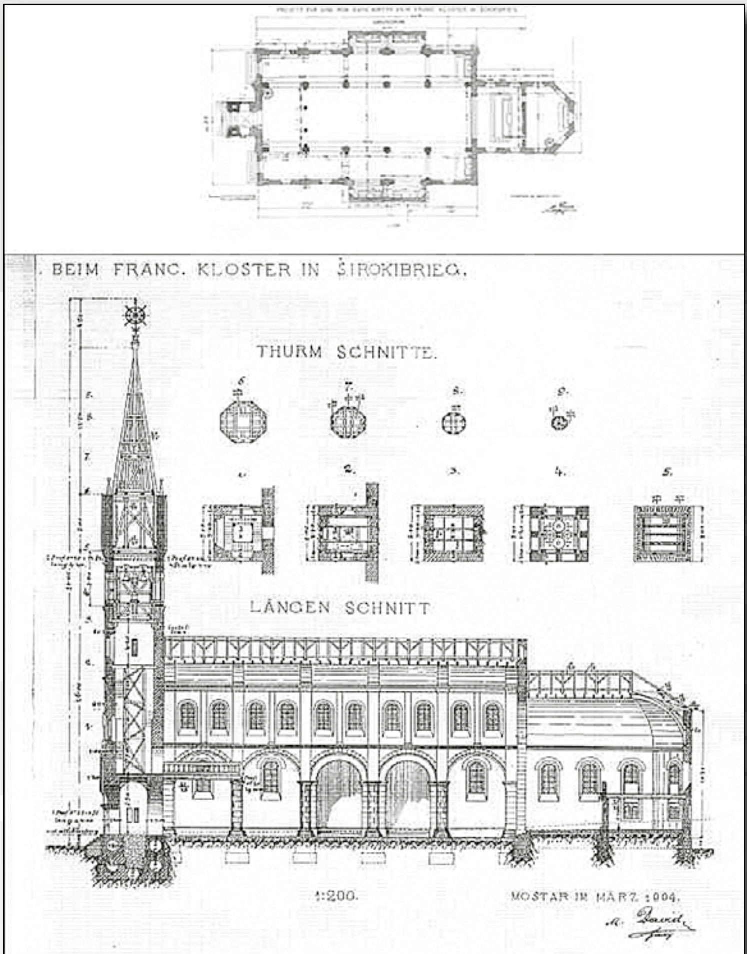
At this stage, therefore, a designer was selected, preliminary drawings were made, and beneficiary and employer's consent was obtained on the preliminary technical documentation and everything was ready for the request for construction approval.

Complex relationships between the functions of designer, employer, beneficiary, consultants and civil authorities in the country could be noticed everywhere. Within the framework of today's regulations, this project phase would refer to the final project assignment, the selection of a designer, the adoption of the conceptual solution by priests and the national government, and the issuance of a location permit or urban planning approval.

On 9 June 1904 the Seniority of the Franciscan Province issued a clerical permit to build a church in Široki Brijeg according to aforementioned plan and on 16 June 1904, it submitted a request and the plan for the approval of construction to the Land Government through the County District of Mostar.

2 Max (Maximilian) David (Alttitschein, Moravia, 7 December 1859) was a government engineer in the County District of Mostar. He graduated from the Technical College in Brno, which he attended in two turns, from 1877 to 1879 and from 1880 to 1883. First, he worked as an assistant at Brno Technical College and then at several firms in Czechoslovakia. He was in Bosnia and Herzegovina in the County District in Mostar from 21 May 1890. He moved to *Tuzla in 1907. (Literature: Wiener Bauindustrie-Zeitung, WIEN XX, 41, 10 December 1898, 390-391 Source: Archive of Bosnia and Herzegovina - Personal List (Krzović, 1987, p. 248). As a designer he is related to the County Court building in Mostar, 1891 - 1892 (Krzović, 1987, p.21), the extension of the Girls' School Sisters of Charity in Mostar, 1903 (Krzović, 1987, pp. 23)), Bishop's Court in Mostar (Vego, 2006, p. 122).*

Tek 20. 12. 1904. Provincija dobiva odgovor da Zemaljska vlada ne može izdati odobrenja, jer ne može potpomoći izgradnju dok Redodržavno franjevačko starješinstvo ne dokaže da posjeduje sredstva za gradnju.



Slika 3. M. David - Prvi plan za novu crkvu na Širokom Brijegu, ožujak 1904.

Uskoro je 25. 1. 1905. Provincija pismom Zemaljskoj vladi dokazala da je namakla sredstva za gradnju.

U ožujku 1905. godine inž. David je izradio nove izmijenjene nacrte. Crkva je po tom novom izmijenjenom projektu trobrodna s glavnom lađom širine 10.30 metara i dvijema bočnim lađama širine 4.30 metara. U produžetku glavne lađe nalazi se apsida dužine oko 14.50 metara. Crkva je 50 m duga, 26 m široka s dva zvonika od 32 m koji do danas nisu dovršeni.

Not before 20 October 1904 did the Province receive the answer that the Land Government could not issue permits, because it could not support the construction until the National Franciscan Seniority proved to have the resources to commit the construction.

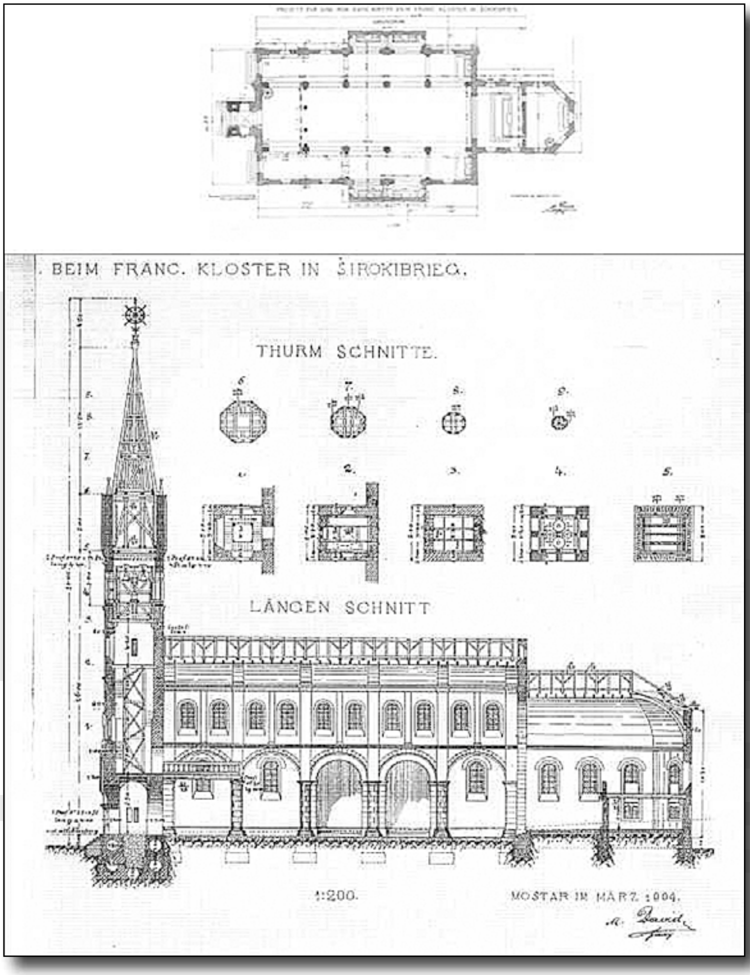


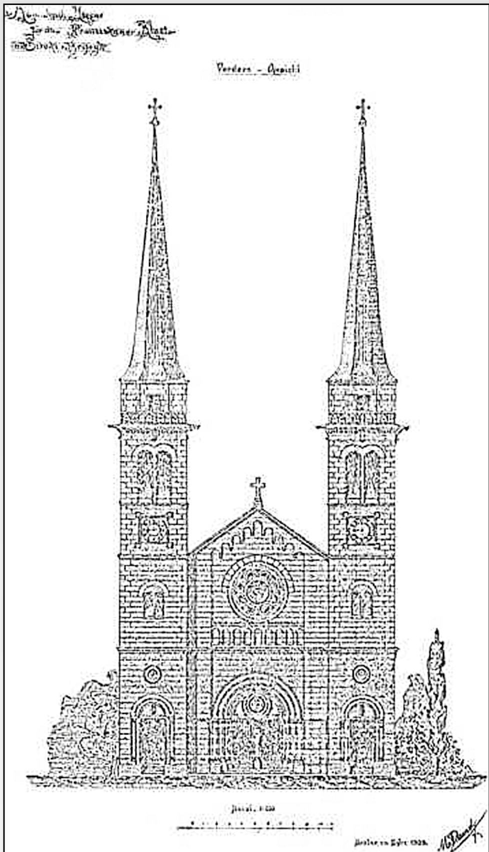
Figure 3. M. David - The First Plan for the New Church in Široki Brijeg, March 1904

Soon on 25 January 1905, the Province wrote a letter to the Land Government with the evidence that it had obtained the funds for construction.

In March 1905, engineer David made new revised drawings. According to that new design, the church was to be a new, three-nave project with the main nave 10.30 meters wide and two side naves 4.30 meters wide each. In the extension of the main nave there would be an apse about 14.50 meters long. The church would be 50 m long, 26 m wide with two 32-meter-tall bell towers which have actually never been completed.

Visoka Zemaljska vlada je potom 16. 3. 1905. izdala dozvolu za gradnju pod brojem 40680/I i ponovno se očitovala da ne može subvencionirati gradnju iz zemaljskih sredstava jer ona "prekoračuje faktične potrebe". Imajući sada i redovničku i civilnu dozvolu Starješinstvo Provincije temeljem svih odobrenih dokumenata odlučuje i obvezuje 2. 5. 1905. gvardijana fra Stanka Kraljevića da gradi crkvu na Širokom Brijegu i "nadgleda i majstore isplaćuje". Pored toga se navodi u "Kronici fra Leona Petrovića" da je "Voditelj rađe - palir - od početka p. o. fra Didak Buntić[3] višegodišnji profesor naše gimnazije". Zbog odsutnosti biskupa fra Paškala Buconjića u to vrijeme blagoslov temeljnog kamena odgođen je do 20. 6. 1905.

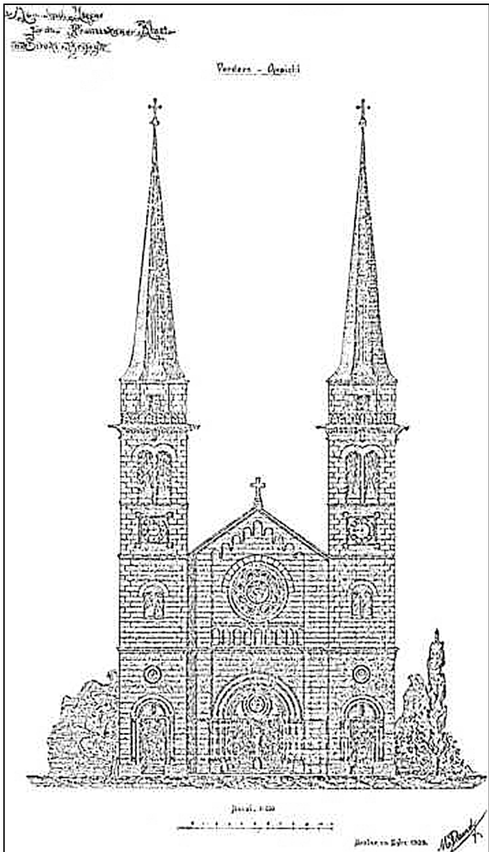
U spisu "Ostavština Ise Kršnjavija" (Državni arhiv Republike Hrvatske), dr. Iso Kršnjavi piše da je za pohoda biskupu o. Buconjiću 1909. godine želio osobno upoznati fra Didaka nakon što se ranije s njim dopisivao, pa je došao na Široki Brijeg i ondje mu on "pokaza svoj crtež i crtež građevinskog savjetnika Vancaša[4], koje je neke promjene Didakove i gdje predlagao"



Slika 4. Konačni plan inž. Davida po kojem će crkva na Širokom Brijegu biti građena (u potpisu inž. David i "Marz 1905")

3 Fra Didak Buntić (1871.-1922.) Rođen je 9. listopada 1871. na Paoči. Na krštenju je dobio ime Franjo, a u legendu je ušao kao fra Didak Buntić, dobrotvor Hercegovine, graditelj širokobriješke bazilike, ravnatelj Franjevačke gimnazije na Širokom Brijegu, borac protiv nepismenosti, skrbnik za talentirane hercegovačke srednjoškolce i studente, spasitelj hercegovačke sirotinje, hrvatski rodoljub i domoljub, karizmatični preporoditelj, narodni zastupnik i provincijal. O njemu je napisano: "Bio je naš kruh i naše oči, naš Mojsije, naš Ćiril i Metod, naš Leonida..." (web site "majčino selo"). Starješinstvo je Provincije odlučilo 1938. godine fra Didakove posmrtne ostatke prenijeti u crkvu na Širokom Brijegu, što je i učinjeno.

4 Inž. Josip pl. Vancaš rođen je u Sopronu 22. 3. 1859. Studirao na Visokoj tehničkoj školi u Beču 1876.-81. a potom radio u atelieru F. Fellnera i H. Helmera, te kod F. Schmidta od kojih usvaja primjenu eklektičko-historijskih stilova. Na poziv bosanske vlade dolazi 1883. u Sarajevo gdje je proveo najveći dio života i bio vodeća ličnost u arhitekturi. Za vrijeme djelatnosti u Bosni 1883.-1921. sagradio je 102 stambene kuće, 70 crkava, 12 škola, 10 banaka, 10 palača, 10 vladinih i općinskih zgrada, 6 hotela i kavana i izveo niz pregradnja. Radio je nacrte za oltare te za stambene i crkvene interieure. Po Vancašovim projektima izgrađena je Katedrala u Sarajevu i obnovljena Crkva sv. Petra i Pavla u Gorici kod Livna (prvi plan " iz polovine 19. stoljeća splitskog graditelja Franja Moise početkom dvadesetog stoljeća, u vrijeme početka gradnje crkve na Širokom Brijegu, dopunio je također arh. Josip pl. Vancaš). Pridonio je urbanom razvitku Sarajeva dajući smjernice za izgradnju prostora oko negdašnje zgrade Izvršnog vijeća (sada Predsjedništva BiH), četvrti Koševo, te za potez Strossmayerove ulice koja i danas predstavlja najkompaktniju urbanu cjelinu iz onog vremena. Glavni su mu radovi neogotička katedrala (1884.-89.), neorenesansna palača Zemaljske vlade (danas Predsjedništvo), hotel Europa i Ajas-pašin dvor u Sarajevu, pseudo-folklorni paviljon Bosne i Hercegovine na Milenijskoj izložbi u Budimpešti (1896.), palača Prve hrvatske štedionice u Zagrebu (1898.-1900.), palača Normann u Osijeku, te hotel Union i zgrade Gradske štedionice i Pučke štedionice u Ljubljani. Umro je u Zagrebu 15. 12. 1932.



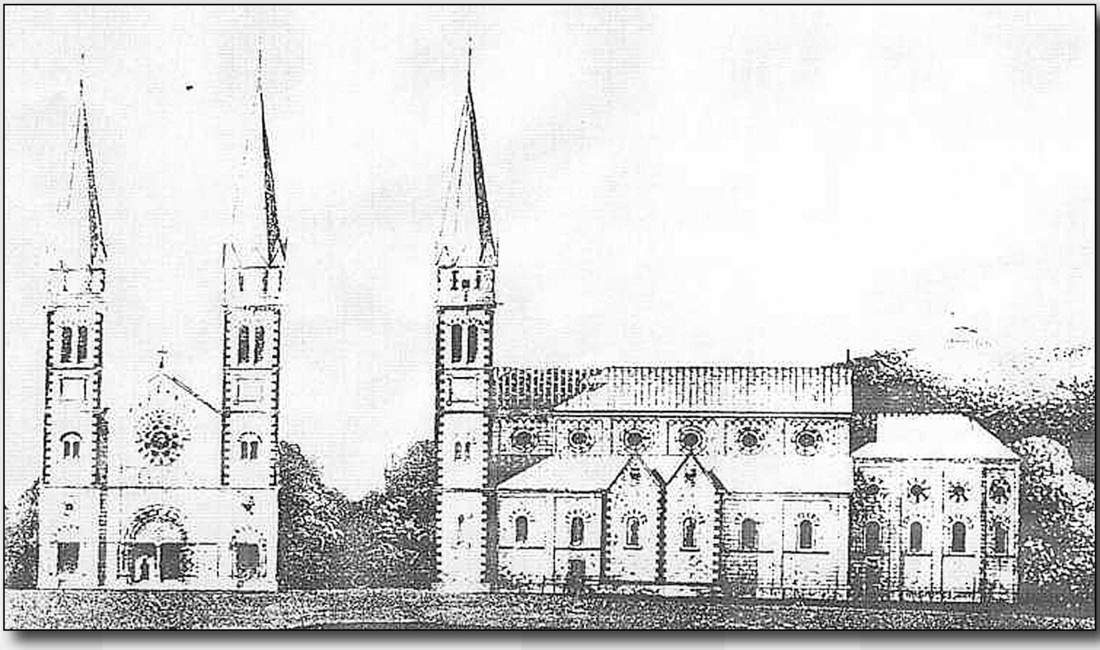
On 16 May 1905, the Supreme Land Government issued a building permit number 40680/I and re-declared that it could not subsidize the construction out of government funds because it "exceeds the factual needs". Having both clerical and civil licenses, based on all approved documents, on 2 May 1905, the Provincial Seniority decided to assign Abbot Fr. Stanko Kraljević the duty to build a church in Široki Brijeg and "to supervise and pay the masters". In addition, it is stated in the "Chronicle of Fr. Leon Petrović" that "the head of the works, the foreman, has been a professor in our gymnasium for years, ever since the beginning of p.o. Fr. Didak Buntić[3]." Due to the absence of Bishop Fr. Paškal Buconjić at that time, the blessing of the foundation stone was postponed until 20 June 1905.

In the written document "The Heritage of Iso Kršnjavi" (State Archives of the Republic of Croatia), Dr. Iso Kršnjavi wrote that during his visit to Bishop Buconjić in 1909, he wanted to meet Fr. Didak personally after he had corresponded with him earlier, and came to Široki Brijeg where he "showed his drawing and the drawing of the construction consultant Vancaš[4], who proposed some Didak's changes to it".

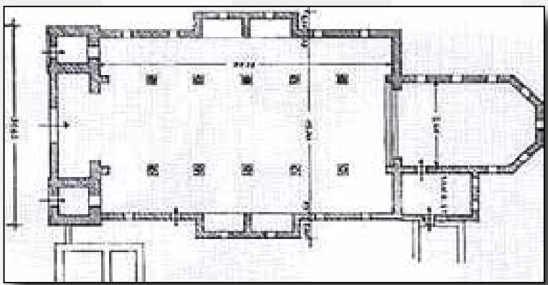
Figure 4. Final design of engineer David by which the church in Široki Brijeg would be built (signed by engineer David, 'March 1905')

3 Fr. Didak Buntić (1871-1922) was born on 9 July 1871 in Paoča. When baptized, he was named Franjo, and he became the legend as Fr. Didak Buntić, the Charity of Herzegovina, the builder of the Basilica in Široki Brijeg, the Headmaster of the Franciscan Gymnasium (High School) in Široki Brijeg, a fighter against illiteracy, a guardian of talented Herzegovinian high school and university students, the savior of the Herzegovinian poor people, the Croatian patriot, the charismatic reformer, the people's representative and the Provincial. He was described as follows: "He was our bread and our eyes, our Moses, our Cyril and Methodius, our Leonid ..." (web site 'majčino selo'). In 1938, the Province Seniority decided that Didak's remains be moved to the church in Široki Brijeg, which was done.

4 Engineer Josip noble Vancaš was born in Sopron on 22 March 1859. He studied at the Technical College in Vienna from 1876 to 1881 and then worked in F. Fellner and H. Helmer's atelier, and later at F. Schmidt's, from whom he adopted the use of eclectic-historical styles. At the invitation of the Bosnian government he came to Sarajevo in 1883, where he spent most of his life and was a leading figure in architecture. During his work in Bosnia from 1883 to 1921 he built 102 residential houses, 70 churches, 12 schools, 10 banks, 10 palaces, 10 government and municipal buildings, 6 hotels and inns and carried out a series of remodeling. He worked on drawings for altars and for residential and ecclesiastical interiors., Sarajevo Cathedral was built and the Church of St Peter and Paul in Gorica near Livno was reconstructed after Vancaš's projects (the first plan of the mid-nineteenth century of Franj Moisa, a builder from Split, was also supplemented by architect Josip noble Vancaš in the beginning of the twentieth century, at the time of the construction of the church in Široki Brijeg). He contributed to the urban development of Sarajevo by providing guidelines for the construction of area around the former building of the Executive Committee (now the Presidency of Bosnia and Herzegovina), the Koševo quarter, and the line of Strossmayer Street which still represents the most compact urban unit from that time. His main works are the neo-Gothic cathedral (1884-1889), the neo-Renaissance palace of the Land Government (today's Presidency), the Hotel Europa and the Ajas-Pasha Palace in Sarajevo, the pseudo-folklore pavilion of Bosnia and Herzegovina at the Millennium Exhibition in Budapest (1896), the Palace of the First Croatian Savings Bank in Zagreb (1898-1900), the Normann Palace in Osijek, and the Union Hotel and the City Savings Bank and the People's savings bank in Ljubljana. He died in Zagreb on 15 December 1932.



Slika 5. Nacrti konačnog plana inž. Davida po kojem je crkva u Širokom Brijegu građena (pročelja i tloris)



Ovim završava okvirno faza definiranja ovog projekta, tj. ishođenje odobrenja za gradnju, te je i sama gradnja mogla otpočeti. Određen je voditelj radova i projektni tim za realizaciju projekta, a od ranije su osigurani početni resursi za gradnju.

3. Izvođenje konstrukcije

Već je napomenuto da je "vođa rađe" bio fra Didak Buntić, što bi se danas poistovjetilo, s obzirom na ovlasti, s voditeljem projekta. Ova građevina je svakako slika veličine uma i duha ovog velikog čovjeka. Gvardijan fra Stanko Kraljević je u početku bio zadužen za isplaćivanje radnika. Način osiguravanja financiranja vidi se u dopisu od 25. 1. 1905. gdje Starješinstvo Provincije izvješćuje Zemaljsku vladu

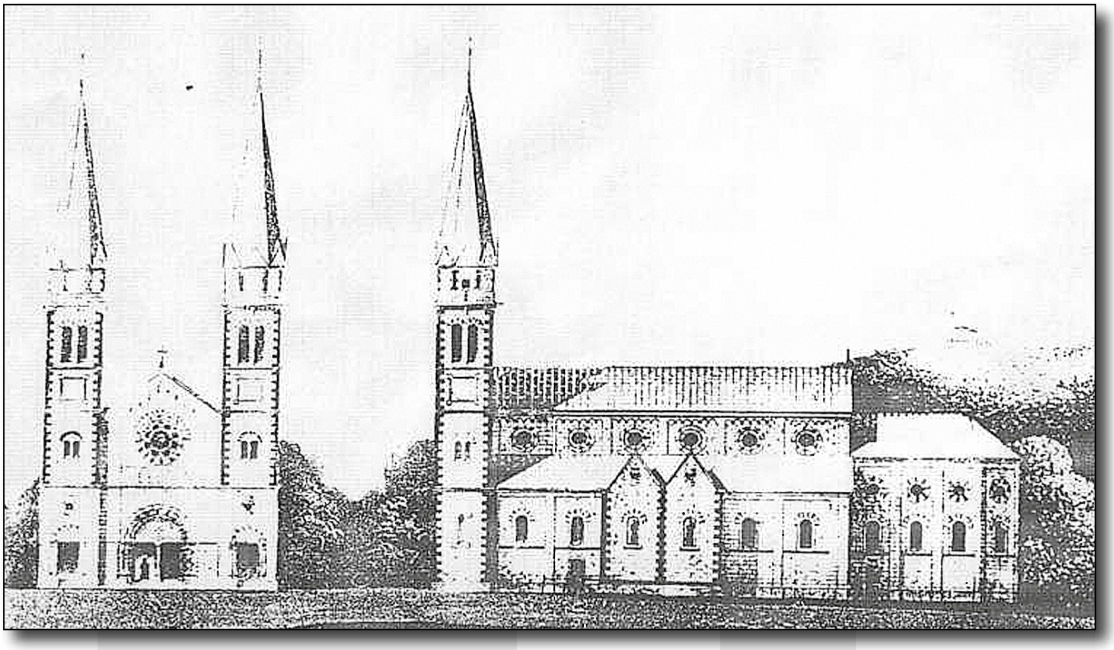
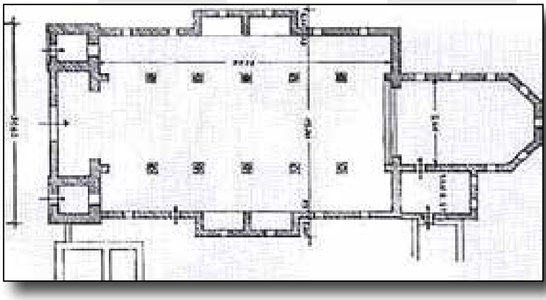


Figure 5. Drawings of the final engineer David’s design, by which the church in Široki Brijeg was built (facades and ground plan)



This roughly marks the end of this project defining phase, namely, obtaining construction approvals, thus the construction itself could begin. Works manager and project team to implement the project were appointed, and initial resources for construction had previously been provided.

3. Execution of construction

It has already been mentioned that the “head of the works” was Fr. Didak Buntić, which, according to the authorities he had, could now be identified as a project manager. This building is certainly a reflection of the size of wisdom and spirit of this great man. The abbot, Fr. Stanislav Kraljević was initially responsible for paying the workers. The manner of providing financing is visible in the letter o svojim planovima za osiguranje resursa za gradnju, kako bi im se odobrila gradnja: *"imademo procićen klak preko 100 tovara", "imademo u pripravi šume da se može odmah još koja klačina upaliti", "pijesak (pržinu) imademo pripravljenu", "kamena imade izvađena oko 2.000 kubični metara, i to većinom je uklesan", "temelji za crkvu jesu sa tri strane izkopani", "imademo gotova novca na Banki", "što crkvenog što od župe sakupljenog novca ima", "Župa je se obvezala dati", "po našim Župama u Hercegovini mislimo ukupiti"* Tijekom gradnje fratri su po cijelom svijetu prikupljali milodare za gradnju s više ili manje uspjeha. Zemaljska je vlada izbjegavala bilo kakvu pomoć, pa i onu kreditnu.

U početku je fra Didak doveo strane majstore (iz Dalmacije i Italije), a kasnije je "50 čobana izučilo klesarski zanat", zapisuje fra Didak 1914. godine. Ondašnje tehnološke mogućnosti bitno su određivale i plan građevina, kao i izbor materijala i njihovu primjenu. Vapnenački blokovi od kojih je cijela crkva sazidana vađeni su iz kamenoloma u neposrednoj blizini. U kamenolomima su veće stijene lomljene korištenjem dinamita, koji je pribavljan preko Starješinstva Provincije, što ukazuje da je uporaba eksploziva i onda bila pod nadzorom države, kao i rukovatelji (palitelji) koje je odobravala država (Protokol Provincije iz godine 1905.). Tako dobivene gromade su se oblile, te vukle kotrljajući ili dovozile zapregama do mjesta gradnje. Horizontalni transport obavljan je na drvenim nosilima ("traljama", "tragačama"), kasnije "karijolama" (taćkama).

Slika 6: Korištenje željeza pri gradnji crkve

Vertikalni transporti obavljani su ručnim vitlima s užetom na bubnju. Ručna vitla s prijenosnim zupčanicima i uređajem za osiguranje od pada koristila su se tek od 1967. godine za dograđivanja južnoga zvonika (svjedočenje sudionika). U prvim godinama gradnje kao vezivo se koristio samo vapneni mort spravljan od vapna dobivenog iz seoskih klačina i dovožen u vrećama i pletenim sanducima na konjima[5]. Do 1911. godine završeni su zidovi i drveni krov pokriven eternitom[6], bez stropa u centralnoj lađi. U početku gradnje bilo je dostupno samo kovano željezo i ugrađivano je u zidove za povećavanje nosivosti zidova na vlačna naprezanja, kao zatege u visini donjeg pojasa krovne visulje, kao "serklaži" u vrhovima zidova, kao klamfe (pijavice) pri spajanju krovne građe i za

5 Cementara u Splitu postoji od 1865. godine, ali cement je bio preskup i transport ograničen.

6 U Anhovu u Sloveniji ova proizvodnja postoji od 1905. godine. Za Salonit Vranjic nisam mogao utvrditi početak proizvodnje.

of 25 January 1905 where the Province Seniority reported to the Land Government about its plans for securing construction resources in order to have the construction approved: "We have over a 100 loads of cracked lime", "we have the wood prepared so that we can instantly burn several kilns", "we have sand ready", "there is about 2,000 cubic meters of stone, mostly cut stone", "the church foundations are dug along three sides", "we have cash in the Bank", "there is some church money and the money collected in the parish", "the parish is committed to give", "we intend to collect it in our parishes in Herzegovina". During the construction, friars collected donations for the construction all over the world with more or less success. The Land Government denied any kind of assistance, not even granting a credit.

In the beginning, Fr. Didak brought foreign masters (from Dalmatia and Italy), and later "50 shepherds learned carving craft", Fr. Didak wrote in 1914. The technological possibilities of that time also determined the construction plan and the choice of materials and their application. Limestone blocks which were used to construct the whole church were brought from the quarries in the immediate vicinity. In the quarries, larger rocks were broken using dynamite, which was obtained through the Province Seniority, which indicates that the use of explosives was under state supervision, as well as the operators (combustors) and they had to be approved by the state (Provincial Protocol of 1905). Huge pieces of stone thus obtained were rounded up, and they were rolled or drifted by teams down to the site of construction. Horizontal transport was carried out on wooden carriers ('trays', 'tracers'), later by wheel barrows.

Figure 6: Use of iron during the church construction

Vertical transports were carried out with hand windlass with a rope drum. Manual windlass with gears and fall arresters were used from 1967 for the construction of the southern bell tower (testimonies of the participants). In the first years of construction, only lime mortar was used as a binder. It was made out of lime obtained from village kilns and brought in bags and plaited boxes on horses[5]. The walls and the wooden roof covered with asbestos cement roofing[6], were completed by 1911, without the ceiling in the central nave. At the beginning of the construction, only wrought iron was available and it was built into the walls to increase the bearing capacity to tensile stresses, as tie rods at the lower edge of the roof hanging truss, as tie beams in the upper ends of the walls, as

5 Cement factory in Split has existed since 1865, but cement was too expensive and transport was limited.

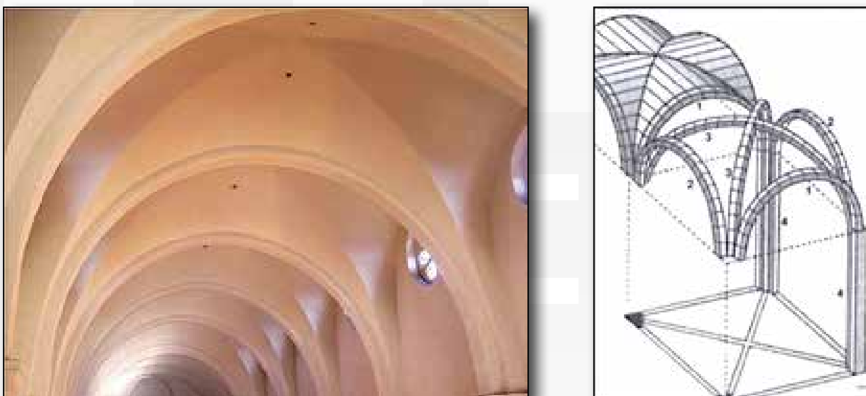
6 In Anhovo, Slovenia, this production has existed since 1905. I could not determine the start of production of Salonit Vranjic.

razne plošne limove koji su, spajani zakovicama obmotavali građu (slika 6). Željezo se obrađivalo u kovačkim radionicama.[7]

Prvotno je bio predviđen (inž. David) drveni ravni kasetirani strop u centralnoj lađi. Križni kameni svodovi u sporednim malim lađama su od kamena u vapnenom mortu i nije bilo zapreka da ne budu završene već 1911. godine do pokrivanja.

Sigurno su graditelji ukrućivali vanjske zidove i pridržavali arkade, koje podužno povezuju vrhove stupova glavne lađe, da osiguraju nastavak zidova srednje lađe iznad arkada do vrha za dosjedanje krovne konstrukcije.

Zbog male zakrivljenosti ovaj svod u bočnoj lađi potpuno je pritisnut i mogao je služiti ukrućivanju. Konstrukcija od drvene građe na koju je svođen ("ćemeren") kameni svod bočnih lađa bila je za ondašnje prilike velik izazov. Podupiranje i oplaćivanje ovakva križnog svoda pripada u najzahtjevnije zadaće na ovom objektu. Kako je upitno postojanje modernijih pilana u ono vrijeme, drvena građa za skelu svoda je najviše bila ručno obrađivano a oblo drvo vezano pijavicama (klamfama). Oplatna ploha je iz piljenih dasaka od drvenih oblica. Sjeverni je zvonik dovršen 1927. godine. Kako je cement bio dostupniji i mogućnosti transporta poboljšane, planirani drveni je strop srednje lađe preprojektiran u armiranobetonski. Problem je bio što je ovaj svod u centralnoj lađi znatno zakrivljeniji pa su takvi lučni konstruktivni elementi s dominantnim silama zatezanja morali biti izvedeni od armiranog betona, koji je već bio u uporabi na našim prostorima. Križni armiranobetonski svod izveden je nad glavnom lađom i apsidom 1939. godine po projektu Stjepana Podhorskog.[8]



Slika 7. Križni svod

7 Iako su visoke peći u Varešu otvorene 1891. godine i bile prve visoke peći na Balkanu, problemi cijena i transporta za veću uporabu željeza vjerojatno su bili nesavladivi.

8 Arhitekt Stjepan Podhorsky rođen je 21. prosinca 1875. u Zagrebu. Nakon što je završio osnovnu školu i realku, Podhorsky se upisuje u Graditeljsku školu, koju završava 1896. u skupini "prvih apsolvenata graditeljskog tečaja. God. 1903. Podhorsky odlazi u Beč na dalje školovanje, na Akademiju lijepih umjetnosti kod profesora Viktora Lunza. Osnovao je 20. svibnja 1905. Klub hrvatskih arhitekata. Zapažene su mu gradnje: vila Heim u Nazorovoj ulici (1906.), zgrada pravoslavne općine u Bogovićevoj ulici (1907.), stambena zgrada i ljekarna Gayer na križanju Kačićeve i Ilice (1908.), Obrtni dom na Mažuranićevu trgu (1908./10.), obnova crkve u Oštarijama, obnove Crkve Sv. Križa u Križevcima (1910.), bazilika sv. Ćirila i Metoda

clamps when joining the roofing material, and as various flat sheets wrapped around the material and clamped with rivets (Figure 6). Iron was prepared in blacksmith workshops[7].

Originally, a wooden flat cassette ceiling in the central nave was planned (Engineer David). The crossed stone vaults in the side naves are made of stone with lime mortar and there were no obstructions to be completed by 1911 when the structure was covered by the roof.

The builders must have stiffened the exterior walls and supported the arcades, which longitudinally connected the tops of the main nave columns, in order to ensure the continuation of the central nave walls above the arcade to reach the top for fitting the roof construction.

Due to the low curvature this vault in the side nave was completely pressed and could be used for stiffening. The construction of the wooden structure on which stone vault of the side naves was built was a great challenge in that time. Supporting and providing formwork for such a cross vault is the most demanding task in this object. As the existence of modern sawmills at that time is questionable, the wooden material for the vault scaffolding was mostly hand-crafted, and the rounded wood was connected by clamps. Formworks surface was made of sawn boards made of wooden logs. The northern bell tower was completed in 1927. As cement became more accessible and transport capabilities improved, the planned wooden ceiling of the central nave was redesigned into a reinforced concrete one. The problem was that this vault in the central nave was considerably curved, so such arched constructive elements with the dominant tensile forces had to be executed in reinforced concrete, which was already in use in our area. The cross reinforced concrete vault was executed above the main nave and apse in 1939 by Stjepan Podhorsky.[8]

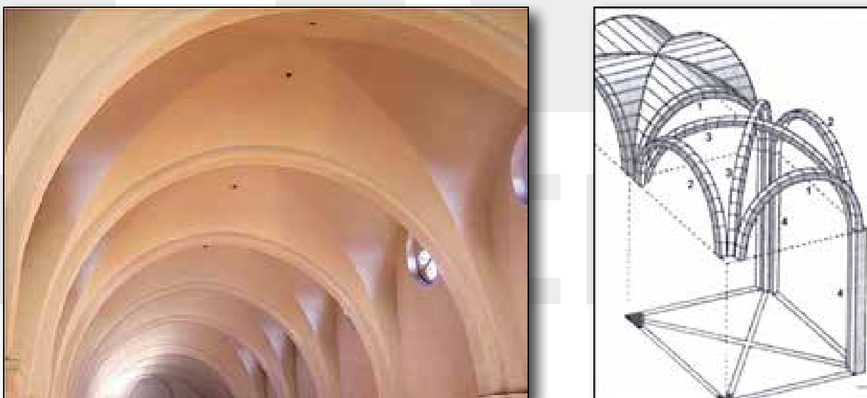


Figure 7. Cross vault

7 Although the blast furnaces in Vareš opened in 1891 and were the first blast furnaces in the Balkans, the problems of price and transport for the greater use of iron were probably insuperable.

8 Architect Stjepan Podhorsky was born on 21 December 1875 in Zagreb. After completing primary school and general-program secondary school, Podhorsky enrolled in the Construction School, which he completed in the group of "first undergraduates of constructing course" in 1896. In 1903 Podhorsky went to Vienna for further education at the Academy of Fine Arts at Professor Victor Luntz. He founded the Croatian Architects Club on 20 May 1905. His significant constructions: the villa Heim in Nazorova ulica (1906), the building of Ortodox municipality in Bogovićeva ulica (1907), a residential building and a pharmacy Gayer at the crossing of Kačićeva and Ilica (1908), Craftsmen's house on Mažuranićev trg (1908/10), restoration of the church in Oštarije, restoration of the Church of Holy Cross in Križevci (1910), the Basilica of Sts. Cyril and Methodius.

Kako armiranobetonski križni svod nije bio predviđen morali su se za dosjed svoda na vrhovima stupova izvesti konzolni elementi, što je izazivalo zatezanja na vrhovima stupova sa strane bočnih lađa, pa je duž cijele bočne lađe, u visini vrha stupova centralne lađe, kao protuteret, betonirana armirano-betonska ploča. Crkva je pokrivena bakrom 1931. godine. Inž. Stjepan Podhorsky je 1932. godine izradio plan za dogradnju započetih zvonika, a 1934. godine planove za ispovjedaonice.

U borbama za obranu Širokoga Brijega od Mrtvog dana 1944. godine do 7. 2. 1945. godine crkva je dosta stradala. Oštećeno je pročelje crkve i uništen krov. Tek 1958. godine fratri su se usudili popravljati pročelja. Od 1961. godine radi se ograda oko crkve i samostana, te zasađuju bagremovi. Radikalna rekonstrukcija samostana započela je 23. 7. 1962. Na 31. 12. 1963. je "izlivena terasa između crkve i samostana; probijena vrata u prizemlju i na spratu pa se po suhom može ući u crkvu" Orgulje u crkvi postavljene su 24. 12. 1964. Vađenje i klesanje kamena za stube pred crkvom započelo 11. 7. 1965., a 19. 7. 1965. započeta je česma na dvorištu ispred crkve. Radovi na pokrivanju crkve salonitom započeti 26. 7. 1965. Inž. fra Pio Nuić s dvojicom tehničara snimio je zvonik za projektiranje dogradnje južnoga zvonika 14. 4. 1966. Od 17. 7. 1966. izrađivana je crkva i štokovani su stupovi.

Tek je 10. 10. 1966. poslana molba na Općinu Lištica da dozvole dovršiti crkvene tornjeve i 25. 10. 1966. dobivena je dozvola. Po dobivanju dozvole započelo se 31. 3. 1967. s klesanjem kamena za dograđivanje južnog zvonika. Konačno je "zvonik uz samostan završen betonskom dekom na 25. X. 1968 godine. Time su oba zvonika izidana do iste visine".

4. Zaključak

Građevinski pothvati koji nas stalno iznova oduševljavaju i nadahnjuju nikada nisu bili proizvod slučajnosti nego su plod sustavne snage umnih ljudi svakog vremena. Svjedok tomu je i ova impresivna građevina za koju možemo s pravom tvrditi da je, sustavnom snagom uma svojih tvoraca, uspješno prošla sve faze u životnom vijeku projekta, po principima znanosti o upravljanju projektima, na čemu joj i danas mogu pozavidjeti mnogi projekti. Onodobna opća zakonska i građevinska regulativa, te stručna znanja bili su minorni da bi značajnije doprinijeli svojim utjecajem kvaliteti ovog projekta. Cijeli graditeljski pothvat na Širokom Brijegu - samostan, crkva, gimnazija, konvikt i okolni sadržaji - svjedoče o snazi i veličini ljudi, a prije svega fra Didaka Buntića, koji su nam, usprkos izuzetnim teškoćama i minimalnim mogućnostima svog vremena, ostavili nedostižne uzore da nas nadahnjuju i obvezuju i nakon sto godina.

Jesmo li toga dostojni? "Povijest je svjedok vremena, svjetlo istine, život pamćenja, učiteljica života i glasnica starine" (Marko T. Ciceron).

Since the reinforced concrete cross vault had not been planned originally, the cantilevered elements had to be executed in order to fit the vault to the tops of the columns, causing the tightening on the tops of the columns on the side of the lateral naves. Therefore, a reinforced concrete slab was executed as a counterbalance along one side of lateral naves, in the height of the upper end of the central nave columns. The church was covered with copper in 1931. Engineer Stjepan Podhorsky made a plan for the expansion of the bell towers in 1932, and the plans for confession chambers in 1934.

During the battles for the defense of Široki Brijeg between All Souls' Day of 1944 to 7 February 1945, the church suffered significant damage. The facade of the church was damaged and the roof was destroyed. Only in 1958 the friars dared repair the facades. As of 1961, a fence was erected around the church and monastery, and black locust trees were planted. The radical reconstruction of the monastery began on 23 July 1962. "A terrace was constructed between the church and the monastery on 31 December 1963; the doors were executed both on the ground floor and on the first floor so that the church could be entered over dry surface." The organs were set up in the church on 24 December 1964. The excavation and cutting of stone for the stairs in front of the church began on 11 July 1965, and on 19 July 1965 the drinking fountain was started in the courtyard in front of the church. Works on covering the church with asbestos boards began on 26 July 1965. Assisted with two technicians, engineer Fr. Pio Nuić surveyed the bell tower for the design of the southern bell tower on 14 April 1966.

Only on 10 October 1966, a request was made to the Lištica Municipality to allow the church towers to be completed, and the permission was granted on 25 October 1966. After the license had been granted, the cutting of the stone for the southern bell tower started on 31 March 1967. Finally, "the bell tower adjacent to the monastery was completed with a concrete slab on 25 October 1968. Thus, both bell towers were constructed in the same height".

4. Conclusion

Engineering feats that constantly delight and inspire us are never a product of coincidence but grapes of methodical power of wise people of all times. This impressive building also witnesses it, as we can rightly claim that, conducted by the methodical power of the mind of its creators it successfully passed all the phases of a project life cycle according to the principles of project management science, of which many projects could be envious even today.

At that time, general legal and building regulations, as well as professional knowledge, were not comprehensive enough to provide a significant contribution to the quality of this project by their influence. The entire construction venture in Široki Brijeg – monastery, church, gymnasium, convent school and surrounding facilities – testify of the power and size of the people, and especially of Fr. Didak Buntić, who, despite the exceptional difficulties and minimal potentials of their time, left us unattainable models to inspire and commit us even one hundred years later.

Are we worthy of that? "History is truly the witness of times past, the light of truth, the life of memory, the teacher of life, the messenger of antiquity" (Marcus T. Cicero).

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Sto godina nove crkve na Širokom Brijegu /One hundred years of the new church in Široki Brijeg
20. lipnja 1905. - 20. lipnja 2005. / 20 June 1905 - 20 June 2005

Zbornik radova / Proceedings
Nakladnik / PUBLISHED BY Franjevački samostan Široki Brijeg The Franciscan Monastery Široki Brijeg
Za nakladnika / FOR THE PUBLISHER fra Branimir Musa
Uredništvo / EDITORIAL BOARD dr. Ivo Čolak fra Vendelin Karačić dr. Antun Karaman
Urednik / EDITOR dr. Ivo Čolak
Fotografije / PHOTOS Kruno Hrkać i drugi
Lektor / LANGUAGE EDITOR fra Vendelin Karačić
Prijevod na engleski / ENGLISH TRANSLATION Goran Šamo Danijela Kožul Ivana Medić
Računalna obrada i prijelom / COMPUTER PROCESSING AND LAYOUT Damir Zadro Božo Penavić, prof.
Tisak / PRINTED BY Fram-Ziral, Mostar
Naklada / EDITION 1500 primjeraka / 1500 copies

CIP - Katalogizacija u publikaciji Nacionalna i univerzitetska biblioteka Bosne i Hercegovine, Sarajevo
726.54(497.6 Široki Brijeg)"1905/2005"(091)
ZNANSTVENO-stručni skup Sto godina nove crkve na Širokom Brijegu (2005)
Sto godina nove crkve na Širokom Brijegu : 1905.-2005. / Znanstveno-stručni skup Sto godina nove crkve na Širokom Brijegu, 20 lipnja 2005. ; [prijevod na engleski, English translation Goran Šamo, Danijela Kožul, Ivana Medić ; fotografije, photos Kruno Hrkać i drugi]. - Široki Brijeg : Franjevački samostan ; Mostar : Građevinski fakultet Sveučilišta, 2006. - 555 str. : ilustr.
Tekst na uporedo hrv. i engl. jeziku. - "... skup, koji je održan ... 20. lipnja 2005. ..." ->
Proslov. - Bibliografija i bilješke uz tekst
ISBN 9958-9170-4-1
COBISS.BH-ID 15229702

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Scientific and professional symposium

One hundred years of new church in Široki Brijeg

20 June 2005

Zbornik radova / Proceedings
Nakladnik / PUBLISHED BY Franjevački samostan Široki Brijeg The Franciscan Monastery Široki Brijeg
Za nakladnika / FOR THE PUBLISHER fra Branimir Musa
Uredništvo / EDITORIAL BOARD dr. Ivo Čolak fra Vendelin Karačić dr. Antun Karaman
Urednik / EDITOR dr. Ivo Čolak
Fotografije / PHOTOS Kruno Hrkać et al.
Lektor / LANGUAGE EDITOR fra Vendelin Karačić
Prijevod na engleski / ENGLISH TRANSLATION Goran Šamo Danijela Kožul Ivana Medić
Računalna obrada i prijelom / COMPUTER PROCESSING AND LAYOUT Damir Zadro Božo Penavić, prof.
Tisak / PRINTED BY Fram-Ziral, Mostar
Naklada / EDITION 1500 primjeraka / 1500 copies

CIP - Katalogizacija u publikaciji Nacionalna i univerzitetska biblioteka Bosne i Hercegovine, Sarajevo
726.54(497.6 Široki Brijeg)"1905/2005"(091)
ZNANSTVENO-stručni skup Sto godina nove crkve na Širokom Brijegu (2005)
Sto godina nove crkve na Širokom Brijegu : 1905.-2005. / Znanstveno-stručni skup Sto godina nove crkve na Širokom Brijegu, 20 lipnja 2005 ; [prijevod na engleski, English translation Goran Šamo, Danijela Kožul, Ivana Medić ; fotografije, photos Kruno Hrkać i drugi]. - Široki Brijeg : Franjevački samostan ; Mostar : Građevinski fakultet Sveučilišta, 2006. - 555 str. : ilustr.
Tekst na uporedo hrv. i engl. jeziku. - "... skup, koji je održan ... 20. lipnja 2005. ..." ->
Proslov. - Bibliografija i bilješke uz tekst
ISBN 9958-9170-4-1
COBISS.BH-ID 15229702

HI
HERING

Mr. sc. Ladislav Bevanda, dipl. ing. građ.,
Građevinski fakultet u Mostaru i Hering d.d Široki Brijeg

Prof. dr. sc. Mladen Radujković, dipl. ing. građ.,
Sveučilište u Zagrebu, Građevinski fakultet

PROCESNA GRAĐEVINSKA KALKULACIJA I PROCJENA RIZIKA

PROCESS-BASED CALCULATION OF CONSTRUCTION WORK AND RISK ASSESSMENT

PROCESNA GRAĐEVINSKA KALKULACIJA I PROCJENA RIZIKA

Mr. sc. Ladislav Bevanda, dipl. ing. građ., Građevinski fakultet u Mostaru i Hering d.d Široki Brijeg
Prof. dr. Sc. Mladen Radujković, dipl. ing. građ., Sveučilište u Zagrebu, Građevinski fakultet

Sažetak

Opisan je jedan od mogućih postupaka "procesne" građevinske kalkulacije projekata i procjenjivanja rizika u kalkulaciji cijene projekta izvođenja radova. Procesno raščlanjenim troškovima procjenjuju se moguća opterećenja uslijed rizika; svake vrste troška na svaki izvor rizika. Kvantificirani utjecaji rizika simuliraju se i dobija raspon cijene za pokrivanje rizika. Odluka o pokrivenosti rizika je presudna za konačnu procjenu troškova u građevinskoj kalkulaciji projekata izvedbe.

Ključne riječi: procesna građevinska kalkulacija, procjena rizika, upravljanje projektom, upravljanje rizikom, procjena troškova kalkulacije cijene

1 Uvod

U životnom vijeku svakog građevinskog projekta potrebno je osigurati trajno upravljanje svim procesima koji utječu na krajnji uspjeh [1], [3]. Navedeni pristup jednako vrijedi za sve sudionike i poslovne procese vezane uz projekt jer uspjeh projekta uglavnom svima donosi neke dobrobiti. Pritom je posebno važno integrirati procese izvorne organizacije čiji je projekt, privremene projektne organizacije koja upravlja projektom i organizacije koja predstavlja ulagače kapitala. Da bi se osigurao uspjeh projekta i poslovne politike izvorne organizacije, potrebno je već u fazi pripreme projekta građevinskom kalkulacijom, omogućiti učinkovitost i transparentnost resursa projekta i potencijala poslovnog sustava, koja će u fazi ostvarenja projekta osigurati jasne ciljeve i odnose među organizacijskim cjelinama i procesima.

U tehničkoj dokumentaciji građevinskog projekta određene su jednoznačne količine nepovratnoga reprodukcijskoga trošenja resursa u proizvodnim procesima koji čine samo uži dio pojma projektnih troškova - tj. „izravni troškovi". Navedeni troškovi određuju se prema vlastitim internim ili prihvaćenim „prosječnim normama učinaka i utrošaka", tj. „standardnim normativima" i sl. [5]. Poznato je da osim "izravnih" postoje i "neizravni troškovi" nastaju i u vezi s ulogama drugih funkcija nužnih za organizaciju

PROCESS-BASED CALCULATION OF CONSTRUCTION WORK AND RISK ASSESSMENT

MSc. Ladislav Bevanda BCE*, Faculty of Civil Engineering Mostar and Hering d.d. Široki Brijeg
Prof. Mladen Radujković, Phd BCE, University of Zagreb, Faculty of Civil Engineering

Abstract

This paper describes one of the possible procedures of "process-based" construction calculations of projects and risk assessment in price calculation for a project of construction works. Potential risk-related expenditures are estimated for costs broken down to individual processes, namely, for each type of cost, all types of risk sources. Quantified risk impacts are simulated and price range for risk coverage is obtained. Risk coverage decision is crucial for final cost assessment in construction calculation of executing projects.

Key words: process-based calculation of construction work, risk assessment, project management, risk management, estimating costs during price calculation

1 Introduction

During the life cycle of each construction project it is necessary to provide a constant management of all processes that affect the final success [1], [3]. The mentioned approach equally applies to all participants and business processes related to a project as a project success results in some benefits to mainly all of them. Thereat, it is especially important to integrate the processes of an original organization, namely temporary project organization that manages the project, and the organization that represents the investor of capital. In order to provide project success and business policy of the original organization, in the preliminary stage it is necessary to enable effectiveness and transparency of project resources and business system potential by calculation of construction work, which will provide clear goals and relations between organizational units and processes during the project realization stage.

Unambiguous quantities of irreversible reproductive resources consumption in production processes, representing only smaller part of the notion of project costs, namely "direct costs" are defined in technical documentation of a construction project. The mentioned costs are defined according to their own internal or accepted "average standards of effects and expenses", in other words, pursuant to "standard norms" and the like [5]. It is well known that besides "direct" there are ostvarivanja projekata. Iako ovi troškovi nemaju obilježje reprodukcijskog trošenja, sastavni su dijelovi ukupne cijene koštanja projekata [6].

2 Građevinski poslovni i projektni sustavi i njihovi procesi

Ambicije poslovnog sustava iskazuju se misijom, «razlog postojanja», bilo da su u sustavu toga svjesni ili ne i bilo da je napisana ili nije. Misiju je moguće ostvariti ako je uprava poslovnog sustava u stanju zamisliti «buduće željeno stanje» - viziju poslovnog sustava. Uvažavajući interese ključnih sudionika, te misiju i viziju poslovnog sustava, za poslovni uspjeh nužno je odrediti «strateške pravce djelovanja» - strategiju. Strategija se ostvaruje konkretnim procesima poslovnog sustava kao rezultat analiza: potencijala i poslovanja sustava, organizacije funkcija sustava i signala iz okružja, tokova procesa i aktivnosti unutar funkcija poslovnog i projektnog sustava [8], [19].

Strategijsko upravljanje izloženim tijekom od misije do mjerljivih ciljeva iskazanih skupom poslovnih procesa bitnih za uspjeh poslovanja, nazivamo uravnoteženom kartom postignuća (uspjeha) (Balanced Scorecard, BSC). BSC se izražava zajedničkim ciljevima - performansama procesa, najčešće grupiranim unutar slijedećih perspektiva: financije, kupci, unutrašnja učinkovitost, inovacije, zaposlenici, uprava. Koristeći se svojim funkcijama, svi upravljački podsustavi planiraju, organiziraju, vode, kontroliraju i kadrovski popunjavaju procese u sustavu, primarno radi ostvarivanja pozitivnih mjerljivih uspjeha svih područja i procesa [7], [8]. Da bi se u poslovanju osigurao procesni pristup nužno je provesti sljedeće korake [14]:

a) identificirati glavne procese
b) utvrditi pojedinačne procese u okviru svakoga glavnog procesa
c) za svaki pojedinačni proces odrediti: unutarnje i vanjske dobavljače, unutarnje i vanjske kupce, vlasnike, početak i kraj, ulaze i izlaze, kontrolne mehanizme, resurse i aktivnosti
d) definirati uloge i odgovornosti za sprovođenje svake aktivnosti procesa
e) definirati potrebne dokumente i drugu potporu za aktivnosti i procese.

U praksi postoji više različitih podjela poslovnih procesa npr. izvorne organizacije (prema prof A.W. Scheeru, ARIS, prema BS 6143-1, BS 6143-2, ...), ali i podjela prema vlasnicima procesa i vrsti sustava:

1. procesi predstavnika ulagača
2. procesi uprave izvorne organizacije
3. procesi privremene organizacije koja upravlja projektom
4. procesi izvršenja.

Poznato je da se projektni proizvod ostvaruje projektnim procesom [1], [3], [4], [12]. Koristeći se ovim pristupom moguće je procese projekta podijeliti na:

also “indirect costs” that occur in relation with the role of other functions necessary for organizing the realization of a project. Although these costs are not characterized as reproduction expenses, they are integral parts of accumulated price of project costs.

2 Business and Project Systems in Construction, and Processes Thereof

The ambitions of business system are demonstrated by a mission “cause of existence“, notwithstanding whether the business system is aware of this or not, and whether it is written or not. It is possible to realize the mission if the management of business system is able to envisage the “desired future situation” – business system vision. Observing both the interests of key participants, and the mission and the vision of the business system, in order to have a business success, it is necessary to define “strategic acting directions” – the strategy. The strategy is realized through concrete processes of business system as the results of analyzes of: the system potentials and business, the organization of the system function and surrounding signals, courses of processes and activities within the functions of business and project system [8], [19].

Strategic management of the exhibited course from mission to measurable goals expressed by a group of business processes important for a success in business is represented by a balanced card of achievements (successes) (Balanced Scorecard, BSC). BSC is expressed by mutual goals – process performances, mostly grouped within the following perspectives: finances, customers, internal effectiveness, innovations, employees, management. Using their functions, all managing sub-systems plan, organize, conduct, control and provide personnel for the processes in the system, primarily in order to realize positive, measurable successes in all areas and processes [6], [8]. The implementation of the following measures is necessary for providing a process-based approach to a business:

a) identifying major processes
b) determining individual processes within each major process;
c) for each individual process, determining: internal and external suppliers, internal and external customers, owners, start and finish, inputs and outputs, controlling mechanisms, resources and activities;
d) defining roles and responsibilities for conducting each process activity;
e) defining necessary documents and other support for the activities and processes.

In practice, there are more different divisions of business processes, for example, original organizations (according to prof. A.W. Scheer, ARIS, according to BS 6143-1, BS 6143-2, ...), but there is also a division by process owners and system type:

1. processes of investors’ representatives;
2. processes of original organization management;
3. processes of a temporary organization that manages the project;
4. execution processes.

It is well known that a project product is realized by a project process [1], [3], [4], [12]. Using this approach enables division of project processes on:

a) procese upravljanja projektom (“planiranje, organiziranje, nadgledanje i kontroliranje svih vidova projekta u trajnom procesu postizanja njegovih ciljeva”, ISO 1006, [4]). Među metodama za upravljanje projektima najčešće se koriste: PRINCE2 (Projects IN Controlled Environments), PMBOK (Project Management Institute - A Guide to the Project Management Body of Knowledge), ISO 1006, ICB (IPMA Competence Baseline International Project Management Association). Npr. prema PMI ovi procesi uključuju upravljanja cjelinom i ciljevima projekta; sadržajem projekta; vremenom, troškovima i kvalitetom; ljudskim resursima; komunikacijama; rizikom; nabavom i logistikom [20]
b) na procese u vezi s proizvodom projekta, tj. pojedinačna izvršenja svih pozicija građevine uključivo i potrebnu pripremu koje ostvaruju izvršitelji.

Način upravljanja i ostvarivanja projekta spoznavanjem životnog vijeka projekta i svih projektnih procesa, te postavljanjem mjerljivih ciljeva, koji se mogu iskazati skupom parametara (performansi, obilježja) projektnih procesa bitnih za uspjeh projekta, nazivamo uravnotežena karta uspjeha projekta - Project Scorecard (PSC). Jedan od ključnih poznatih postupaka u kojem se postavljaju mjerljivi ciljevi projektnih procesa jest i ponudbena kalkulacija. Nakon dobivanja posla radi se ugovorna kalkulacija, a pri izvršenju izvođačka kalkulacija koja uzima u obzir trenutno stanje potencijala i resursa izvođača, ali i stanje na tržištu. Ova se kalkulacija može više puta revidirati tijekom ostvarivanja projekta [1], [3], [4], [19]. Nakon završetka projekta radi se naknadna kalkulacija koja je podloga za ocjenu uspješnosti projekta - ispunjenja PSC-a, a što nadalje služi pri periodičnoj ocjeni uspješnosti poslovanja poslovnog sustava - ispunjenje BSC-a.

3 Dekompozicija poslovnih i projektnih procesa

Stalan nadzor procesa podrazumijeva dekompoziciju poslovnih procesa do razine prepoznavanja mjerljivih performansi procesa. U modeliranju procesa mora se težiti udovoljavanju različitim zahtjevima da bi se svladalo stalno usavršavanje i poboljšavanje te da bi se upravljalo promjenama (ISO 9001) [4]. Stoga je potrebna jedinstvena predodžba i način spoznavanja cjeline i njezinih dijelova - fraktalna struktura - tj. da se u svakom detalju odražava cjelovita struktura sustava. Da bi se to ostvarilo, a i kao osnovni uvjet uspostave informacijskih sustava za upravljanje, potrebno je uspostaviti standardizirane klasifikacijske modele: vrstu usluga i proizvoda poslovnog i projektnog sustava, vrste proizvoda projekta, strukturu potencijala sustava, standardnih procesa izvorne i projektne organizacije, elementarnih radnih procesa od kojih se izgrađuju aktivnosti i procesi, općih i tehničkih uvjeta za jednoznačno određenje pojedinih procesa, standardnih troškovničkih specifikacija po kojima se ostvaruju i ugovaraju usluge i projektni proizvodi, obilježja poslovnih procesa (BSC), obilježja projektnih procesa (PSC), obilježja projektnih proizvoda, specifičnih struktura troškova prema vrstama proizvoda projekta (DIN 276, HKAIG, ...), specifičnih vrijednosti pojedinih troškova prema bitnim obilježjima proizvoda projekta, fizičkih dijelova proizvoda projekta, faza projekata, funkcija organizacije, fizičkih dijelova organizacije, standardno klasificiranih resursa, standardnih obveza na resurse i usluge, specifičnih računovodstvenih modela troškovnih struktura poslovanja i projekta [1], [6], [7], [14].

a) project management processes ("planning, organizing, monitoring and controlling all aspects of a project in a permanent process of achieving its goals", ISO 1006, [4]). Most commonly used project management methods are: PRINCE2 (Projects IN Controlled Environments), PMBOK (Project Management Institute - A Guide to the Project Management Body of Knowledge), ISO 1006, ICB (IPMA Competence Baseline International Project Management Association). For example, according to PMI, these processes include the management of a complete project and project objectives; management of project content; time, cost and quality management; human resources management; communications management; risk management; procurement and logistics management [20];
b) processes related to a project product, i.e. individual execution of all structure positions, including the required preparation realized by contractor.

Project Scorecard (PSC) is the manner of project management and implementation by identifying project lifecycle and all project processes; by setting measurable goals that can be expressed by a set of parameters (performance, features) of project-related processes that are essential to project success. One of the key well-known processes in which the measurable goals of project processes are set is a tender calculation. Contractual calculations are made after being awarded a contract and performance calculation is made during the execution, taking into account the current state of the contractor's potentials and resources, as well as the market situation. This calculation can be revised several times during project implementation [1], [3], [4], [19]. After the completion of the project, the subsequent calculation is made as the basis for the evaluation of the project performance - PSC fulfillment, which is later used for the periodic assessment of the operating success of business system - the fulfillment of BSC.

3 Decomposition of Business and Project Processes

Continuous process monitoring implies decomposition of business processes to the level of recognition of measurable process performances. In the course of modeling processes, we must try to meet different requirements in order to overcome continuous improvement and enhancement, and to manage the changes (ISO 9001) [4]. Therefore, what is necessary is a unique concept and the way of recognizing the whole and its parts, a fractal structure, in other words, ability to reflect the complete structure of the system in each its detail. In order to achieve this, and as a basic condition for the establishment of information management systems, it is necessary to establish standardized classification models: the type of services and products of the business and project system, project product types, structure of system potentials, standard processes of the original and project organization, elementary work processes out of which activities and processes are built, general and technical conditions for unambiguous definition of individual processes, standard spending specifications on whose basis services and project products are realized and stipulated, characteristics of business processes (BSC), characteristics of project processes (PSC), characteristics of project products, specific cost structure according to project product types (DIN 276, HKAIG, ...), specific values of individual costs according to the essential features of the project product, physical parts of the project product, project phases, organization functions, physical parts of the organization, standard classified resources, standard resource and service obligations, specific cost accounting model of business operations and project [1], [6], [7], [14] Sa strane ugovornih odnosa troškovnička specifikacija radova je osnovni ugovorni dokument i naručitelju opisuje uslugu i proizvod koji treba ostvariti. To znači da je potrebno trajno sve analize svoditi i na troškovničku specifikaciju. Pritom će se u ovom pristupu primijeniti podjela u kojoj se glavni procesi sastoje od potprocesa [21], a potprocesi od aktivnosti. Aktivnosti se sastoje od standardnih radnih procesa (pozicija), koji se dijele na operacije, operacije na postupke, postupci na pokrete. Standardni radni procesi služe za iznalaženje norma rada i utrošaka pri organizaciji rada, tehnološkom redoslijedu, planiranja i sl. i uvijek se sastoje od rada radnika, materijalnih troškova (predmeti rada), opreme i sredstava (sredstva rada) i usluga drugih za radni proces. Glavni procesi su skup potprocesa ili aktivnosti koji u logičkom redoslijedu i odnosima čine cjelovit sustav poslovanja organizacije pri ostvarivanju nekog pothvata-projekta i pod izravnom su odgovornosti vrhovnih funkcija uprave izvorne organizacije. Potprocese sačinjavaju aktivnosti koje u logičkom redoslijedu i odnosima povezanim čine cjeloviti svrsishodno zaokružen proces i pod odgovornosti su jednoga funkcionalnog dijela izvorne ili projektne organizacije. Aktivnosti - kompleksni radni proces sastoji se od većeg broja standardiziranih radnih procesa među kojima postoji vremenska i organizacijska povezanost u svrhu dobivanja funkcionalnog dijela planiranog proizvoda projekta i najčešće predstavljaju dio razvijene radne strukture (WBS - Work Breakdown Structure) ili detaljne sheme aktivnosti - DSA.

S druge strane, troškovničke specifikacije komponiraju se od radnih procesa pojedinačnih izvršenja te ponovnog dekomponiranja za formiranje dijela stvarnih planskih aktivnosti, WBS-a.

Ukupne aktivnosti plana ostvarenja građevinskog poslovnog i projektnog sustava izvođenja radova mogu se komponirati, ovisno o analizi obilježja proizvoda projekta, iz radnih i poslovnih procesa (dijelova ili više njih):

a) procesa izvorne organizacije: predstavnika vlasnika i uprave, b) projektnih procesa: uprave projekta, uprave gradilišta i gradnje, instalacije i deinstalacije gradilišta i pojedinačnih izvršenja.

Građevinski sustav svoje ukupne procese, zajedno s projektnim procesima, izražava kao jednostavan zbroj procesa, ali isto se za naručitelja mora moći jasno izraziti troškovničkom specifikacijom.

4 Tradicijski model građevinske kalkulacije

Građevinskom kalkulacijom proračunavaju se troškovi i cijena proizvoda projekta u fazi definiranja i izvođenja projekata na temelju troškovničke specifikacije [5], [6]. Pozicije rada troškovnika najčešće se formiraju iz standardnih radnih procesa pojedinačnih izvršenja, što je razina do koje se u građevinarstvu najčešće normiraju radne zadaće, tj. pojedinačna izvršenja. Primjenjujući uobičajeni troškovnički izračun cijene projekta, ukupna cijena je zbroj umnožaka količina pojedinih stavki troškovnika i jediničnih cijena pripadajućih stavki, kako slijedi:

Concerning contractual relations, the bill-of-quantities specification of works is the basic contract document describing the service and the product to be realized to the employer. This means that all analyzes need to be kept to the bill-of-quantities specification permanently. In this approach, a division will be applied in which the main processes comprise of sub-processes [21], and sub-processes are made of activities. The activities consist of standard work processes (positions), which are divided into operations, operations to procedures, procedures to movements. Standard work processes are used to find work and cost standards in the organization of work, technological order, planning and so on, and they always consist of labor, material costs (work items), equipment and resources (working tools) and others' services for the work process. The main processes are a set of sub-processes or activities that, in logical order and relationships, form a complete business organization system when implementing a venture-project and top management functions of the original organization are directly responsible for the same. Sub-processes consist of activities that in logical order and interrelations make a complete, deliberately rounded process and under the responsibility of one of the functional parts of the original or project organization. Activities - the complex work process consisting of a number of standardized work processes, interconnected in time and out of organization with the purpose of obtaining a functional part of the planned project product and they usually represent a part of a developed work structure (WBS - Work Breakdown Structure) or detailed scheme of activities – DSA.

On the other hand, bill-of-quantities specifications are composed out of work processes of individual executions and repeated decomposition to form part of actual planning activities, WBS.

Overall activity of the plan to realize a construction business and project system of works execution can be composed, depending on the analysis of the characteristics of the project product, from the work and business processes (parts or more):

a) processes of the original organization: representatives of owners and management; b) project processes: project management, construction site management and construction management, installation and removal of construction sites and individual executions.

The constructing system expresses its overall processes, together with project processes, as a simple sum of processes, but the same must be clearly expressed by the bill-of-quantities specification for the employer.

4 Traditional model of construction calculation

Construction calculation is used to calculate the cost and price of the project product in the definition and execution phase of projects based on the bill-of-quantities specification [5], [6]. Work positions in a bill of quantities are most commonly formed from standard work processes of individual executions, which is the level to which work assignments are usually standardized in construction, i.e. individual executions. When applying a common bill-of-quantities calculation of a project price, the total price is the sum of products of the amount of individual items of the bill of quantities and the unit prices of corresponding items, as follows:

$$C_p = \sum_{i=1}^{n} k_i \times C_i \qquad (1)$$

gdje je:

C_P - kompletna cijena projekta

K_I - količina i-te stavke troškovnika

C_I- jedinična cijena i-te stavke troškovnika.

Jediničnu cijenu i-te stavke čine izravni dio i neizravni dio :

$$\mathbf{C_I = (D_{ti} + I_{ti})} \qquad \mathbf{(2)}$$

gdje izravni dio čine

$$\mathbf{D_{ti} =(P_{pi} + m_{pi} + u_{pi} + a_{pi})} \qquad \mathbf{(3)}$$

koji su zbroj reprodukcijskih utrošaka za jedinicu troškovničke pozicije, formiran na bazi zbrajanja utrošaka resursa standardnih radnih procesa za poziciju troškovnika, a Iti je neizravni dio troškova jedinične cijene. Ostale oznake znače:

p_{pi} - bruto troškovi rada radnika

m_{pi} - normirani troškovi ugrađenog materijala (predmeta rada)

u - normirani troškovi usluga drugih

a_{pi} - normirani troškovi amortizacije sredstava rada, sve za jedinicu troškovničke stavke.

U praksi se najčešće primjenjuju sljedeći načini raspodjele neizravnih troškova u jedinične cijene troškovničkih stavki:

a) neizravni troškovi dijele se samo na radnu snagu pojedinačnih izvršenja skupa standardnih normiranih radnih procesa koji sačinjavaju troškovničku stavku; jedinična cijena i-te stavke troškovničke specifikacije dobije se kao:

$$\mathbf{C_i = ppi \times (1+F) + m_{pi} + u_{pi} + a_{pi}} \qquad \mathbf{(4)}$$

gdje je F bezdimenzijski faktor kojim se uvećava radna snaga pojedinačnih izvršenja reproduktivnog trošenja stavki troškovnika za “pokriće” neizravnih troškova, a neizravni dio troška u jediničnoj cijeni troškovničke stavke je

$$\mathbf{I_{ti} = p_{pi} \times F} \qquad \mathbf{(5)}$$

b) ako se neizravni troškovi projekta dijele na ukupne troškove troškovničke specifikacije kao skupa standardnih normiranih radnih procesa koji sačinjavaju troškovničku stavku:

$$\mathbf{C_i = (p_{pi} + m_p i + u_p i + a_{pi}) \times F1} \qquad \mathbf{(6)}$$

gdje je F1 bezdimenzijski faktor kojim se uvećavaju ukupni ili jedinični izravni troškovi stavki troškovnika za obuhvaćanje neizravnih troškova.

Prikazani način kalkuliranja izravnih i neizravnih troškova na bazi troškovničke specifikacije uobičajen je i kod većine softvera iako na različitim izvornim bazama daje slične logičke modele i rezultate u smislu vrste i kvalitete analiza i izvješća koja nude [5], [7], [19].

$$C_p = \sum_{i=1}^{n} k_i \times C_i \qquad \textbf{(1)}$$

where:

C_P – Total Project Price

K_I - quantity of i^{th} item of bill of quantities

C_I- unit price of i^{th} item of bill of quantities

Unit price of i^{th} item consists of direct and indirect part :

$$\mathbf{C_I = (D_{ti} + I_{ti})} \qquad \textbf{(2)}$$

where the direct part consists of

$$\mathbf{D_{ti} =(P_{pi} + m_{pi} + u_{pi} + a_{pi})} \qquad \textbf{(3)}$$

which are the sum of reproduction expenditures for a unit of bill-of-quantities position, formed adding the resources of standard work processes for a position in a bill of quantities, and it is the i^{th} indirect part of the cost of the unit price. Other symbols mean:

p_{pi} - Gross cost of labor

m_{pi} – standardized cost of installed material (work subjects)

u – standardized others' service

a_{pi} - standardized cost of operating assets amortization, all for the unit of a bill-of-quantities item.

The following manners of distribution of indirect costs into unit prices of bill-of-quantities items are most commonly used in practice:

a) indirect costs consist only of the workforce of individual execution of a set of usual standardized work processes that comprise a bill-of-quantities item; the unit price of the i^{th} item of the bill-of-quantities specification is obtained as:

$$\mathbf{C_i = ppi \times (1+F) + m_{pi} + u_{pi} + a_{pi}} \qquad \textbf{(4)}$$

where F is a non-dimensional factor which increases the work force of individual executions of reproductive use of bill-of-quantities items for "covering" indirect costs and the indirect part of the cost in the unit price in the bill-of-quantities item is

$$\mathbf{I_{th} = p_{pi} \times F} \qquad \textbf{(5)}$$

b) if indirect costs of a project are distributed to the total cost of the bill-of-quantities specification as a set of usual standardized work processes that comprise the bill-of-quantities item:

$$\mathbf{C_i = (p_{pi} + m_p i + u_p i + a_{pi}) \times F1} \qquad \textbf{(6)}$$

where F1 is a non-dimensional factor which increases total or individual direct costs of the bill-of-quantities item to include indirect costs.

This method of calculation of both direct and indirect costs based on the bill-of-quantities specification is common to most of the software programs, although different original bases are provided with similar logical models and results in terms of the type and quality of analysis and reports that are offered [5], [7], [19].

5 Analiza neizravnih troškova

U procesima strateškog planiranja uprava poslovnog sustava donosi: politiku cijena, okvirne planove ostvarenja obujma proizvoda projekta za sve programe tvrtke, planove svih procesa i aktivnosti (upravljanja organizacijom i povezanim poduzećima, predstavnika vlasnika, funkcija izvorne organizacije...), odluke o planiranoj dobiti i dividendi te procjenjuje rizik čime se definiraju mjerljivi poslovni ciljevi za plansko razdoblje.

U fazi pripreme projekata, u procesima izrade ponude i planiranja, dijelovi izvorne organizacije odgovorni za kalkulacije i pripremu s vrhom uprave utvrđuje sljedeće elemente kalkulacije cijene projekata: procese projektne uprave, uprave gradnje i gradilišta, instalacije i deinstalacije gradilišta, pojedinačnih izvršenja pozicija projekata koje nisu sadržane u troškovničkim stavkama, pojedinačnih izvršenja troškovničkih stavki projekata, procese i vrijednosti procijenjenog rizika, čime se definiraju mjerljivi projektni ciljevi [12], [19]. S obzirom na to da analiziramo kalkulaciju, najvažniji proces u tom smislu jest utvrđivanje „politike cijena“ za planirano razdoblje na razini poslovnog sustava, u kojem su, između ostalog, sljedeće bitne analize za kalkuliranje troškova poslovanja i projekata: analiza svih trendova u bilancama iz poslovnih aktivnosti, analiza plana ukupnoga godišnjeg prihoda - ostvarenih projekata, usvajanje metodologije određivanja preliminarne cijene projekta, usvajanje načina procjenjivanja komparativnih nedostataka i prednosti u odnosu na konkurenciju („slobodne upravljačke veličine“) za svaki projekt posebno, na koji imaju utjecaj i bilance stanja i uspjeha poduzeća a i vrsta i zahtjevi projekata koji se kalkuliraju i pretendiraju izvoditi, usvajanje metodologije određivanja godišnjih troškova procesa predstavnika vlasnika, usvajanje metodologije određivanja godišnjih troškova procesa izvorne organizacije (“hladni pogon”).

Ukupan planirani godišnji prihod U_p procjenjujemo na temelju trenda trenutno ugovorenih poslova, stanja potencijala tvrtke, istraživanjima stanja na tržištu, procjenom konkurentnosti tvrtke, usporedbom s konkurencijom, analiza trenda investicija na tržištu, stanjem raspoloživosti vlastitih resursa, i sl. Preliminarnu cijenu nuđenih projekata C_{pp} procjenjujemo nekom od metoda za procjenjivanje cijene projekata. Procjenjivanja komparativnih nedostataka i prednosti u odnosu na konkurenciju određujemo općenito i u svakoj pojedinačnoj kalkulaciji na temelju analiza:

a) stanja potencijala poslovnog sustava prema potencijalnom projektnom proizvodu (stanja strukture potencijala, zaliha, trend dobivenih ugovora, stanje obrtnih sredstava, izloženosti riziku, trenutna poslovna situacija, mogućnost kreditiranja, posebni uvjeti natječaja, ...)
b) tehnološkog i organizacijskog potencijala ponuđača (mogućnost izmjene tehnologije, materijala i opreme, posjedovanje posebne ključne tehnologije, trenutna organizacija pogoduje ostvarenju projekta, ...).

Godišnja planirana profitna stopa D, kao dodana vrijednost, tj. dio povećanja potencijala poslovnog sustava, procijeniti će se na temelju: uloženog kapitala vlasnika, stalnih sredstava, ugovorene dividende, očekivane cijene dionica, cijene kapitala na tržištu, obveza, pokrivanja amortizacije opreme

5 Analysis of Indirect Costs

In the process of strategic planning, the management of a business system makes: pricing policy, framework plans for achieving the range of project product for all programs of the company, plans of all processes and activities (management of organizations and affiliated companies, owners' representatives, original organization functions...), decisions on planned profits and dividends, and it assesses the risk, thus defining measurable business objectives for the planning period.

During the project preparation phase, in the processes of making offers and planning, parts of the original organization responsible for the calculation and preparation determine the following elements of project pricing together with the top management: project management processes, construction and construction site management, installation and removal of construction sites, individual execution of project positions that are not included in bill-of-quantities items, individual executions of bill-of-quantities items of projects, processes and values of estimated risk, thus defining measurable project objectives [12], [19]. Given that we analyze the calculation, the most important process in this regard is the determination of the "pricing policy" for the planned period on a business system level, which includes, among other things, the following essential analyzes for the calculation of business and project expenses: analysis of all trends in balance sheets from business activities, analysis of the total annual revenue plan - realized projects, adoption of the preliminary cost estimation methodology, adoption of the method for assessment of competitive disadvantages and advantages compared with the competition ("free management size") for each separate project, which is influenced by the balance sheet and the profit-and-loss account of the company, as well as the types and requirements of projects that are being calculated and intended to be executed, the adoption of the methodology for determining annual costs of the processes of the owner's representative, the adoption of the methodology for determining the annual costs of the original organization process ("overhead expenses").

Total expected annual revenues U_p are estimated based on the trend of currently contracted assignments, company potentials, market research, company competitiveness assessment, comparison with competition, market trend analysis, availability of own resources, etc. Preliminary price of offered projects C_{pp} is estimated by one of the cost estimation methods. The evaluation of comparative disadvantages and advantages over the competition is determined in general and in each individual calculation based on the analysis of:

a) the state of the business system potentials compared to the potential project product (state of the potentials structure, supply, trend of awarded contracts, working assets, risk exposure, current business situation, credit possibility, special conditions of the tender ...)
b) tenderer's technological and organizational potential (possibility of change of technology, materials and equipment, possession of specific key technology, current organization favorable for project realization, ...).

Planned annual profit rate D, as added value, i.e. part of the increase in business system potential, will be assessed on the basis of: invested capital of the owner, fixed assets, contracted dividends, expected stock price, market price of capital, liabilities, depreciation of equipment and assets which will not be utilized in that year, company exposure, profit allocation or loss coverage plans, ..

i sredstava koje se neće iskoristiti u toj godini, izloženosti tvrtke, planova za raspoređivanje dobiti ili pokrića gubitaka, ..

Planirani godišnji troškovi procesa predstavnika vlasnika i povrat od uloženog potencijala (dividenda, kapitalizirana dobit) T_{pv} projiciraju se na temelju stanja za slične prijašnje godine, kao okvirne vrijednosti. Planirani godišnji troškovi uprave izvorne organizacije za ostvarivanje plana T_{uio} procjenjuju se na osnovi stanja resursa i ukupnog prihoda za prijašnje godine kao približne vrijednosti, s odstupanjima koliko uprava procjenjuje da su okolnosti izmijenjene u odnosu na razdoblje s kojim se uspoređuje. Točnija procjena T_{pv} i T_{uio} moguća je analizom svih poslovnih procesa i aktivnosti za ostvarivanje BSC-a [6], [7]

Navedeni troškovi poslovnog sustava u cijeni projekata, često se određuju preliminarno ako se ne analiziraju svi procesi te pridružuju proporcionalno postotku udjela vrijednosti konkretnog projekta u ukupnom prihodu za plansko razdoblje, s tim da se i moguća odstupanja moraju uzimati u obzir s obzirom da različito složeni projekti iziskuju različit angažman izvorne organizacije, ma koliko po vrijednosti bili isti. Stoga je

$$(C_p / U_p) x(T_{pv} + T_{uio}) \tag{7}$$

dio troškova uprave izvorne organizacije i predstavnika vlasnika koji se pridružuju konkretnom projektu.

Rezultat analize troškova projekta su sljedeće procijenjene minimalne vrijednosti:

T_{pu} - troškovi projektne uprave,
T_{ugr} - troškovi uprave gradnje i gradilišta,
T_{si} - troškovi instalacije i deinstalacije gradilišta,
T_{pi} - troškovi pojedinačnih izvršenja.

Konačno minimalnu ukupnu cijenu projekta prije procjene rizika čine [6], [7], [19]:

$$C_{pmin} = (C_{pp} / U_p) x(T_{pv} + T_{io}) + T_{pu} + T_{ugr} + T_{si} + T_{pi} + U_v + D \tag{8}$$

Za procjenu rizika Rsk mogu se primijeniti razne metode ili iskustvene procjene pa je konačna ukupna cijena projekta sa procjenom rizika C_p:

$$C_{pp} / U_p) x(T_{pv} + T_{io}) + T_{pu} + T_{ugr} + T_{si} + T_{pi} + U_v + D + R_{isk} \tag{9}$$

Dakle neizravni su troškovi projekta

$$I_{tr} = (C_{pp} / U_p) x(T_{pv} + T_{io}) + T_{PU} + T_{ugr} + T_{si} + U_v + D + Ri_{sk} \tag{10}$$

pri čemu troškovničku specifikaciju čine samo troškovi pojedinačnih izvršenja. Ako su u troškovničkim specifikacijama i pozicije osim pojedinačnih izvršenja, za njihov iznos umanjiti će se indirektni troškovi i distribuirati također na troškovničku specifikaciju.

6 Procesni pristup građevinskoj kalkulaciji

S obzirom na to da različiti procesi u projektnom i poslovnom sustavu imaju različiti rizik, paušalna procjena utjecaja rizika na cijenu projekta često ne daje stvarnu sliku utjecaja rizika na cijenu projekta, The planned annual cost of owner's representative processes and return on invested potentials (dividends, capitalized profits) T_{pv} are projected on the grounds of the situation for similar previous years as a framework value. The planned annual management costs of the original organization for the implementation of the T_{uio} plan are estimated on the basis of the resource status and total revenues for the previous years as approximate values, with deviations that the management estimates that the circumstances have been altered compared to the period to be compared. A more accurate assessment of T_{pv} and T_{uio} is possible by analyzing all business processes and activities for achieving BSC [6], [7].

The mentioned expenses of business system in project price are often established preliminary, if all processes are not analyzed and joined proportionally to the percentage of the share of value of a certain project in a total revenue for the planning period, bearing in mind that potential deviations must be considered regarding that variously complex projects need various engagement of the original organization, no matter if they are equal in value. Therefore

$$(C_p / U_p) x(T_{pv} + T_{uio}) \quad (7)$$

a part of expenses of the management of the original organization and of the owner's representative which is joined to the relevant project.

The following estimated minimum values are the result of project cost analysis:

T_{pu}- expenses of project management

T_{ugr}- expenses of construction and constutruction site management

T_{si}- expenses of installing and removing construction site

T_{pi}- expenses of individual executions

Final minimum total project price before risk assessment consists of [6], [7], [19]:

$$C_{pmin} = (C_{pp} / U_p)x(T_{pv} + T_{io}) + T_{pu} + T_{ugr} + T_{si} + T_{pi} + U_v + D \quad (8)$$

Various methods or experiential estimation may be applied to assess risk Rsk, thus the final total project price with risk assessment C_p:

$$C_{pp} / U_p)x(T_{pv} + T_{io}) + T_{pu} + T_{ugr} + T_{si} + T_{pi} + U_v + D + R_{isk} \quad (9)$$

Therefore, indirect project costs are

$$I_{tr} = (C_{pp} / U_p)x(T_{pv} + T_{io}) + T_{PU} + T_{ugr} + T_{si} + U_v + D + Ri_{sk} \quad (10)$$

where the bill-of-quantities specification consists only of the expenses of individual executions. If there are positions besides individual executions in bill-of-quantities specification, the indirect costs will be decreased for their amount and also distributed to bill-of-quantities specification.

6 Process-based approach to construction calculation

Considering that different processes in project and business system have different levels of risk, lump-sum estimation of risk impact to project price often fails to provide a realistic image of risk impact to the project price, therefore, it is correct to try structuring processes and analyzing risk pa je ispravno nastojati strukturirati procese i pojedinačno za njih analizirati rizik, kako bi se dobila realnija slika utjecaja rizika na cijenu projekta [11], [13], [14].

Ukupan prihod građevinskoga poslovnog sustava kojim se ostvaruju projektni proizvodi čini zbroj svih procesa i potprocesa

$$P_1 = \sum_{i=1}^{n} P_i \tag{11}$$

Cijena bilo kojeg poslovnog procesa (potprocesa) dobije se kao zbroj umnožaka pripadajuće količine pojedine aktivnosti u procesu k_{aj} i jedinične cijene aktivnosti $_{Aa,j}$, pa je

$$P_i = \sum_{j=1}^{m} k_{a,j} \times A_{a,j} \tag{12}$$

Način dobivanja jedinične cijene bilo koje aktivnosti u poslovnom i radnom procesu dobije se kao zbroj umnožaka pripadnih količina radnih procesa $k_{rp,k}$ i jedinične cijene radnih procesa $cr_{p,k}$ koja se dobije iz standardiziranih (normiranih) radnih procesa

$$A_{a,j} = \sum_{k=1}^{o} k_{rp,k} \times c_{rp,k} \tag{13}$$

Cijena standardiziranoga radnog ili poslovnog procesa dobije se kao zbroj umnožaka pripadnih količina i vrsta osnovnih resursa: radne snage, materijala, potrebnih sredstava i usluge drugih za ostvarivanje radnoga ili poslovnog procesa i jedinične cijene pripadnih resursa [5]:

Rad

$$\sum_{l=1}^{p} k_{p,l} \times p_l \tag{14}$$

Materijal

$$\sum_{q=1}^{r} k_{m,q} \times m_q \tag{15}$$

Sredstva

$$\sum_{u=1}^{v} k_{a,u} \times a_u \tag{16}$$

Usluge drugih

$$\sum_{s=1}^{t} k_{u,s} \times u_s \tag{17}$$

individually for each of them in order to obtain more realistic picture of risk impact to the project price [11], [13], [14].

The total revenue of a construction business system that is used to realise project products is made up of all processes and sub-processes.

$$P_1 = \sum_{i=1}^{n} P_i \tag{11}$$

The price of any business process (sub-process) is obtained as a sum of products of corresponding amount of individual activities in process k_{aj} and unit price of an activity $A_{a,j}$, thus

$$P_i = \sum_{j=1}^{m} k_{a,j} \times A_{a,j} \tag{12}$$

The way of reaching a unit price of any activity within a business and work process is obtained as a sum of products of corresponding quantities of work processes $k_{rp,k}$ and the unit price of work processes $c_{rp,k}$ which is obtained from standard (normed) work processes.

$$A_{a,j} = \sum_{k=1}^{o} k_{rp,k} \times c_{rp,k} \tag{13}$$

The price of a standardized work of business process is obtained as a sum of products of corresponding quantities and types of basic resources: workforce, material, necessary resources and others' services for realization of work or business process and unit price of corresponding resources [5]:

Labor

$$\sum_{l=1}^{p} k_{p,l} \times p_l \tag{14}$$

Material

$$\sum_{q=1}^{r} k_{m,q} \times m_q \tag{15}$$

Resources

$$\sum_{u=1}^{v} k_{a,u} \times a_u \tag{16}$$

Others' services

$$\sum_{s=1}^{t} k_{u,s} \times u_s \tag{17}$$

Ukupno

$$c_{rp,k}\sum_{l=1}^{p}k_{p,l}\times p_l+\sum_{q=1}^{r}k_{m,q}\times m_q+\sum_{s=1}^{t}k_{u,s}\times u_s+\sum_{u=1}^{v}k_{a,u}\times a_u \quad \textbf{(18)}$$

Pripadne količine osnovnih resursa za sve vrste procesa dobiju se metodama za normiranje rada i materijala te sredstava rada, a cijene su uglavnom minimalne s tržišta. Procesi prema vlasnicima ili reagiranju na rizike mogu se strukturirati kao:

P_{pv} - predstavnika vlasnika

P_{uio} - uprave izvorne organizacije

P_{up} - uprave projekta

P_{ug} - uprave gradnje i gradilišta

P_{si} - instalacije i deinstalacije gradilišta

P_{pi} - pojedinačnih izvršenja fizičkih dijelova projekta.

Svi procesi sastoje se od aktivnosti. Aktivnosti obavljaju funkcionalne cjeline organizacije. Zbroj aktivnosti po procesima je jednak zbroju aktivnosti po funkcijama organizacije.

Kako «kod radnog procesa se za vrijeme njegova trajanja ne mijenja sastav radne grupe», a građevinska praksa do sada uglavnom poznaje normiranja rada na pojedinačnim izvršenjima fizičkih dijelova proizvoda projekta, ovdje se insistira na standardizaciji elementarnog radnog procesa unutar svih vrsta procesa i aktivnosti [6], [7]. Predloženi pristup može poslužiti kao jedan od načina. Pri ovom smo i dalje u mogućnosti sve procese, aktivnosti a i troškove zbrojiti u ukupnu cijenu poslovnog sustava

$$P_1=\sum_{i=1}^{n}P_i=\sum_{1}^{a}P_{pv,a}+\sum_{1}^{b}P_{uio,b}+\sum_{1}^{c}P_{up,c}+\sum_{1}^{d}P_{ug,d}+\sum_{1}^{e}P_{si,e}+\sum_{1}^{f}P_{pi,f} \quad \textbf{(19)}$$

Gdje je

n = a+b+c+d+e+f **(20)**

zbroj svih procesa, a po a i b zbrojeni procesi izvorne organizacije, po c, d, e, f zbrojeni svi procesi projektne organizacije. Promatrajući samo jedan projekt bez analize rizika minimalnu cijenu projekta čine projektni procesi i na raniji način dodjeljivanja izloženi pripadni troškovi izvorne organizacije:

$$P_{p,\min}=P_{io}+P_{po}=\left(\Delta\left(\sum_{1}^{a}P_{pv,a}+\sum_{1}^{b}P_{uio,b}\right)\right)+$$
$$\left(\sum_{1}^{c1}P_{up,c1}+\sum_{1}^{d1}P_{ug,d1}+\sum_{1}^{e1}P_{si,e1}+\sum_{1}^{f1}P_{pi,f1}\right)+Uv+D \quad \textbf{(21)}$$

gdje je u projektu pripadajući (proporcionalni) dio procesa izvorne organizacije

Total

$$c_{rp,k}\sum_{l=1}^{p}k_{p,l}\times p_l+\sum_{q=1}^{r}k_{m,q}\times m_q+\sum_{s=1}^{t}k_{u,s}\times u_s+\sum_{u=1}^{v}k_{a,u}\times a_u \quad \textbf{(18)}$$

Corresponding quantities of basic resources for all types of processes are obtained by the methods for standardization of labor, materials and working assets, and prices are generally minimal, market prices. Processes towards owners or towards risk responses can be structured as:

P_{pv} – owner's representative

P_{uio} – management of original organization

P_{up} – project management

P_{ug} – construction and site management

P_{si} – installation and removal of site

P_{pi} - of individual executions of physical project parts.

All the processes consist of activities. Activities are performed by functional units of organization. Sum of activities per processes equals the sum of activities by the functions of organization.

As "during a work process the composition of its work group is unchangeable", and construction practice has mainly seen standardization of work at individual executions of physical part of project product so far, herewith it is insisted to standardize elementary work process within all types of processes and activities [6], [7]. The proposed approach could be used as one of the mathods. In this way it is possible to sum up all processes, activities and costs into a total price of business system.

$$P_1=\sum_{i=1}^{n}P_i=\sum_{1}^{a}P_{pv,a}+\sum_{1}^{b}P_{uio,b}+\sum_{1}^{c}P_{up,c}+\sum_{1}^{d}P_{ug,d}+\sum_{1}^{e}P_{si,e}+\sum_{1}^{f}P_{pi,f} \quad \textbf{(19)}$$

Where

n = a+b+c+d+e+f **(20)**

is the sum of all processes; a and b being processes of original organization, and c, d, e, f all processes of project organization. When observing only one project without risk analysis, the minimum project price consists of project processes and corresponding expenses of original organization exposed in the earlier manner of distribution:

$$P_{p,\min}=P_{io}+P_{po}=\left(\Delta\left(\sum_{1}^{a}P_{pv,a}+\sum_{1}^{b}P_{uio,b}\right)\right)+$$
$$\left(\sum_{1}^{c1}P_{up,c1}+\sum_{1}^{d1}P_{ug,d1}+\sum_{1}^{e1}P_{si,e1}+\sum_{1}^{f1}P_{pi,f1}\right)+Uv+D \quad \textbf{(21)}$$

where, in project, the corresponding (proportional) part of the original organization process is

$$P_{io} = \left(\Delta\left(\sum_{1}^{a} P_{pv,a} + \sum_{1}^{b} P_{uio,b}\right)\right) \quad \textbf{(22)}$$

cl, dl, e1, f1 količine projektnih procesa promatranog projekta i

$$P_{pv,\min} = \Delta\left(\sum_{1}^{a} P_{pv,a}\right) \quad \textbf{(23)}$$

$$P_{uio,\min} = \Delta\left(\sum_{1}^{b} P_{uio,b}\right) \quad \textbf{(24)}$$

najmanji pripadni procijenjeni troškovi procesa predstavnika vlasnika i uprave izvorne organizacije, a

$$P_{up,\min} = \left(\sum_{1}^{c1} P_{up,c1}\right) \quad \textbf{(25)}$$

$$P_{up,\min} = \left(\sum_{1}^{c1} P_{up,c1}\right) \quad \textbf{(26)}$$

$$P_{si,\min} = \left(\sum_{1}^{e1} P_{si,e1}\right) \quad \textbf{(27)}$$

$$P_{pi,\min} = \left(\sum_{1}^{f1} P_{pi,f1}\right) \quad \textbf{(28)}$$

minimalni pripadni procijenjeni troškovi procesa projektne uprave, uprave gradilišta i gradnje, instalacije i deinstalacije gradilišta, te pojedinačnih izvršenja pozicija promatranog projekta, U_V procijenjena «slobodna upravljačka vrijednost», D procijenjena dobitna stopa.

7 Analiza rizika

Ako pretpostavimo da su do sada analizirane komponente cijene projekta u građevinskoj kalkulaciji, u nastojanju prema izradi cjenovno što prihvatljivije ponude, iskazane s najmanjim vrijednostima, sigurno će ih dinamika čimbenika, koji utječu na cijenu, izmijeniti. Kvalificiranje i kvantificiranje utjecaja pojedinih pojava - izvora rizika, u tijeku izvršavanja projekta, koji imaju utjecaj na promjenu vrijednosti komponenata cijene projekta i samog projekta, smatramo procjenjivanjem rizika u projektima. Procjenjivanje rizika u projektima teče u 4 faze: identificiranje rizika, procjenjivanje rizika, razvoj reagiranja na rizik i kontrola rizika [10], [11], [13]. U ovom će se radu pri procjenjivanju

$$P_{io}=\left(\Delta\left(\sum_{1}^{a}P_{pv,a}+\sum_{1}^{b}P_{uio,b}\right)\right)$$ **(22)**

cl, dl, e1, f1 quantities of project processes of observed project and

$$P_{pv,\min}=\Delta\left(\sum_{1}^{a}P_{pv,a}\right)$$ **(23)**

$$P_{uio,\min}=\Delta\left(\sum_{1}^{b}P_{uio,b}\right)$$ **(24)**

minimum corresponding assessed costs of the processes of owner's representative and the management of the original organization, and

$$P_{up,\min}=\left(\sum_{1}^{c1}P_{up,c1}\right)$$ **(25)**

$$P_{up,\min}=\left(\sum_{1}^{c1}P_{up,c1}\right)$$ **(26)**

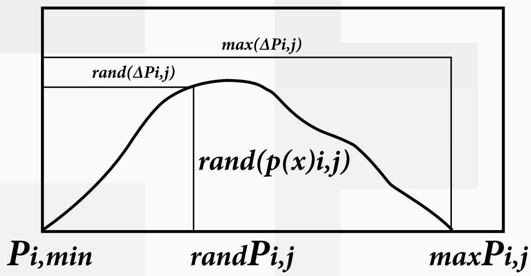
$$P_{si,\min}=\left(\sum_{1}^{e1}P_{si,e1}\right)$$ **(27)**

$$P_{pi,\min}=\left(\sum_{1}^{f1}P_{pi,f1}\right)$$ **(28)**

minimum corresponding estimated costs of the processes of project management, construction site and construction management, installation and removal of construction site, and individual executions of positions of observed project, U_V estimated "free management value", D estimated profit rate.

7 Risk analysis

If it is assumed that the components of project price in construction calculation analyzed so far, endeavoring to develop an offer which would be as acceptable as possible, are expressed in minimum values, they are certain to be changed by the dynamics of factors which influence the price. Qualification and quantification of impacts of individual occurrences - risk sources, during project execution, which influence changes in the value of the components of project price and project itself is considered to be risk assessment in projects. Project risk assessment has 4 stages: identifying risk, risk assessment, course of risk response and risk management [10], [11], [13]. When assessing and i kvantificiranju rizika primijeniti metoda Monte Carlo [2], [9], [15], [16], [17], [18]. Pri identifikaciji rizika u građevinskim projektima potrebno je napraviti kontrolne karte u kojima će se specificirati mogući uzroci-izvori rizika, njihova vjerojatnost i jačina njihova utjecaja na pojedinu komponentu cijene projekta. Jedna od podjela izvora rizika jest na vanjske izvor rizika (pravni, politički, ekonomski, socijalni, prirodni) i unutarnje izvore rizika (upravljanje, tehnička dokumentacija, ljudski čimbenik, opskrba i logistika, ugovaranje) [10], [11]. Svaki od izvora rizika će na različite načine i s različitom vjerojatnošću utjecati na pojedinu grupu poslovnih i projektnih procesa u različitim vrstama. Da bismo sa dovoljno sigurnosti mogli usvojiti odgovarajuću razdiobu vjerojatnosti povećanja pojedinog dijela cijene projekta potrebno je provoditi kontinuirana istraživanja (ankete) na više projekata unutar različitih poslovnih sustava sa svrhom određivanja krivulje vjerojatnosti razdiobe povećanja pojedinog dijela cijene projekta zbog pojedinoga identificiranog uzroka rizika. Osim na ovaj način mogu se na temelju velikog iskustva, usvajati okvirne očekivane granične vrijednosti i vrste razdiobe vjerojatnosti povećanja cijene poradi rizika (slika 1.).



Slika 1. Razdioba vjerojatnosti povećanja pojedinog dijela cijene projekta «i», kao posljedica pojedinog rizika «j»

Do procjenjivanja rizika dobivene vrijednosti komponenata cijene u kalkulaciji projekta smatramo minimalnim i one su

$$P_{pv} + p_{uio} + P_{up} + P_{ug} + P_{si} + P_{pi} + U_v + D \quad \textbf{(29)}$$

Komponente cijene projekta predstavnika vlasnika ppv i uprave izvorne organizacije pio izračunane su kao u dijelu 5. Analiza neizravnih troškova, izraz (7):

$$p_{pv} = (C_{pp} / U_p) \text{ X } P_{pv} \quad \textbf{(30)}$$

$$p_{io} = (C_{pp} / U_p) \text{ X } P_o \quad \textbf{(31)}$$

Pretpostavimo da smo u mogućnosti imati ili iznaći relativnu razdiobu vjerojatnosti $p(x)_{ij}$ utjecaja pojedinog rizika j (r-ukupan broj rizika) $AP_{I,J}$ na povećanje pojedine komponente cijene projekta ($P_{i,min}$ (p_{pv}, p_{uio}, P_{up}, P_{ug}, P_{si}, P_{pi}, U_v, D) od tog rizika (bilo da je izmjerena ili iskustveno pretpostavljena). Iz ove analize proizišle bi slučajne vrijednosti povećanja pojedinih komponenata cijene projekta ovisno o vrsti izvora rizika. Svakoj pojedinoj minimalnoj vrijednosti komponente cijene projekta pripada jedna razdioba vjerojatnosti povećanja zbog rizika (tablica 1.).

quantifying risk, the Monte Carlo method [2], [9], [15], [16], [17], [18] will be applied. When identifying risk in construction projects, it is necessary to develop control cards which will specify potential risk causes-sources, probability of their occurrence and volume of their impact to certain components of project price. Risk sources may be divided to external risk sources (legal, political, economic, social, natural) and internal risk sources (management, technical documentation, human factor, supply and logistics, contracting) [10], [11]. Each risk source will impact a certain group of business and project processes with various degree of possibility in various types. In order to be able to securely adopt a corresponding distribution of probability of the increase of a certain part of project price, it is necessary to conduct a continuous research (polls) in more projects within various business systems with the aim of establishing the curve of distribution probability of price increase of a particular project segment as a result of a particular identified risk cause. Furthermore, on the grounds of sumptuous experience, it is possible in addition to this manner, to adopt framework anticipated limit values and types of distribution of price increase probability due to risk (Figure 1).

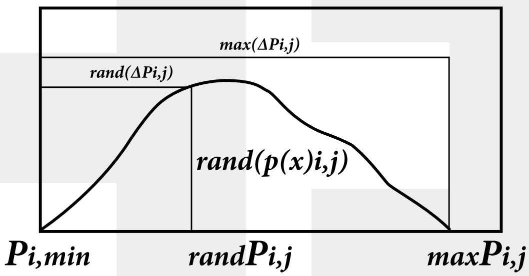


Figure 1. Distribution of probability of increase of a certain segment of project price "i", as a consequence of a certain risk "j"

The obtained values of price components in project calculation are considered as minimal values until the risk assessment, and they are

$$P_{pv} + p_{uio} + P_{up} + P_{ug} + P_{si} + P_{pi} + U_v + D \quad (29)$$

The components of a project price of the owner's representative Ppv and of the management of the original organization Pi0 are calculated as in part 5 - Analysis of indirect costs, expression (7):

$$p_{pv} = (C_{pp} / U_p) \text{ X } P_{pv} \quad (30)$$

$$p_{io} = (C_{pp} / U_p) \text{ X } P_o \quad (31)$$

Let's assume that we might have or find relative probability distribution $p(x)_{ij}$ of particular risk impact j (r-total number of risks) $AP_{I,J}$ to the increase of an individual component of project price $P_{i,min}$ (p_{pv}, p_{uio}, P_{up}, P_{ug}, P_{si}, P_{pi}, U_v, D) due to that risk (whether measured or assumed by experience). This analysis would result in random values of increase of certain components of project price depending on the type of risk source. One increase probability distribution caused by risk belongs to each individual minimal value of a project price component (Table 1).

$\min cijena\ R_{min}$	1	…	j	…	r
$P_{1,\min}$	$p(x)_{1,1}$	…	$p(x)_{1,\mathrm{j}}$	…	$p(x)_{1,\mathrm{r}}$
…	…	…		…	…
$P_{i,\min}$	$p(x)_{i,1}$	…	$p(x)_{i,\mathrm{j}}$	…	$p(x)_{i,\mathrm{r}}$
…	…	…		…	…
$P_{n,\min}$	$p(x)_{n,1}$	…	$p(x)_{j,\mathrm{i}}$	…	$p(x)_{r,\mathrm{n}}$

Tablica 1. Matrica rizika «j» i razdioba vjerojatnosti povećanja pojedinih minimalnih dijelova cijene projekta «i»

Najveća moguća procijenjena vrijednost pojedine komponente «i» cijene projekta (i =1 ... n) jest zbroj minimalne vrijednosti pojedine komponente cijene projekta i svih najvećih mogućih vrijednosti povećanja max AP_{ij}, iz pripadne razdiobe «1» poradi rizika za tu komponentu cijene

$$P_{i,\max} = P_{i,\min} + \sum_{j} \max \Delta P_{i,j} \qquad \textbf{(32)}$$

bez obzira na njihovu vjerojatnost $p(x)_{ij}$ Najveća vrijednost procijenjene slučajne ukupne cijene projekta je zbroj najvećih vrijednosti pojedinih komponenata cijene projekta

$$P_{\max} = \sum_{i=1}^{n} P_{i,\max} = \sum_{i=1}^{n} \left(P_{i,\min} + \sum^{j} \max \Delta P(x)_{i,j} \right) \qquad \textbf{(33)}$$

Očito je da bi ovako usvojena cijena proizvela najveću cijenu sa stopostotnim iznosom rezervacije za rizik. Za procjenu konkretnih vrijednosti u rasponu od najmanje do najveće cijene koristimo se simulacijom.

8 Analiza rizika simulacijom Monte Carlo

Pri procjeni rizika simulacijom Monte Carlo pojedinu procijenjenu vrijednost komponente cijene projekta i tako dobivenu ukupnu cijenu projekta smatramo slučajnom nezavisnom varijablom. Bilo koju slučajnu cijenu projekta Pk možemo dobiti kao zbroj pojedinih slučajnih vrijednosti komponenata randPi cijene projekta

$$P_{\max} = \sum_{i=1}^{n} randP_i \qquad \textbf{(34)}$$

Pojedina slučajna vrijednost komponente projekta (slika 2.) se može dobiti kao zbroj minimalne vrijednosti te komponenti cijene Pi,min i slučajnih povećanja rand APj, te komponente cijena kojima odgovaraju slučajne vrijednosti vjerojatnosti rand (p(x)i,1) pripadne razdiobe povećanja cijene zbog pojedinog rizika

$min\ price\ \ R_{min}$	1	…	j	…	r
$P_{1,\min}$	$p(x)_{1,1}$	…	$p(x)_{1,\mathrm{j}}$	…	$p(x)_{1,\mathrm{r}}$
…	…	…		…	…
$P_{i,\min}$	$p(x)_{i,1}$	…	$p(x)_{i,\mathrm{j}}$	…	$p(x)_{i,\mathrm{r}}$
…	…	…		…	…
$P_{n,\min}$	$p(x)_{n,1}$	…	$p(x)_{j,\mathrm{i}}$	…	$p(x)_{r,\mathrm{n}}$

Table 1. Risk matrix "j" and distribution probability of increase of particular minimal segments of project price "i"

The greatest possible estimated value of an individual component "i" of project price (i =1 ... n) is a sum of a minimum value of individual component of project price and all highest possible values of increase max AP_{ij}, from the corresponding distribution "1" due to the risk for that price component.

$$P_{i,\max} = P_{i,\min} + \sum_{j} \max \Delta P_{i,j} \tag{32}$$

notwithstanding their probability $p(x)_{ij}$ The highest value of estimated random total project price is the sum of highest values of individual components of project price

$$P_{\max} = \sum_{i=1}^{n} P_{i,\max} = \sum_{i=1}^{n} \left(P_{i,\min} + \sum^{j} \max \Delta P(x)_{i,j} \right) \tag{33}$$

It is obvious that the price adopted in this way would produce the highest price with a 100 percent amount of risk provisions. In order to estimate real values ranging from the lowest to the highest price, we use simulation.

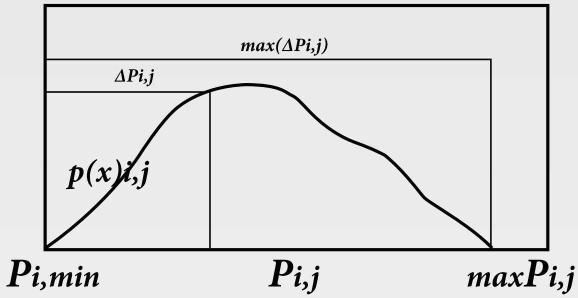
8 Risk analysis by Monte Carlo simulation

When assessing risk through Monte Carlo simulation, an individual assessed value of project price component and total project price obtained in this way is considered to be a random independent variable. It is possible to obtain any random project price Pk as a sum of individual random values of project price components randPi.

$$P_{\max} = \sum_{i=1}^{n} randP_i \tag{34}$$

An individual random value of project component (Figure 2) can be obtained as a sum of minimum value, of price Pi,min component, random increases rand Apj and a component of prices which correspond to random values of probability rand (p(x)i,1) of belonging distribution increase due to individual risk

$$randP_i = P_{i,\min} + \sum_{1}^{j} rand\Delta P_i \left(rand\left(p(x)_{i,j} \right) \right) \tag{35}$$



Slika 2. Slučajni dio cijene projekte ''i'' uslijed rizika ''j''

Ovom se metodom procjenjuje rizik u rasponu između najveće i najmanje vrijednosti ukupne cijene projekta statističkom obradom slučajnih vrijednosti. Iz teorije vjerojatnosti za procjenu populacije na temelju uzorka, za širinu intervala 3σ imamo pouzdanost 99,73%, pa se broj uzoraka (broja iteracija za simuliranje k = 1 ... m) određuje iz zadane apsolutne pogreške

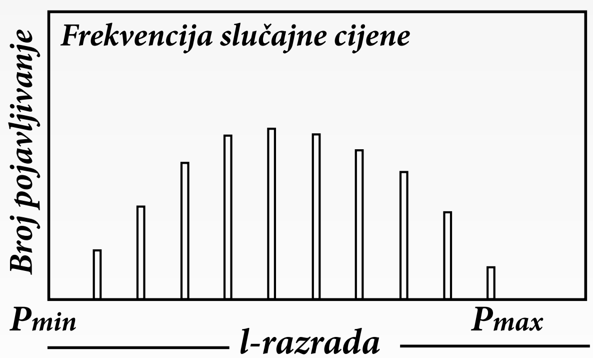
$$\mu = 3\sigma/\sqrt{m} \tag{36}$$

gdje je σ standardno odstupanje slučajne varijable, a m broj iteracija za zadanu apsolutnu pogrešku ju. Standardna odstupanja uzorka a računamo između najmanje ukupne Pmin, najveće ukupne Pmax i srednje vrijednosti između najmanje i najveće vrijednosti slučajne vrijednosti cijene projekta (Pmax+Pmax)/2, kao uzorka populacije slučajnih nezavisnih varijabli, cijena projekta. Za broj potrebnih iteracija za simulaciju, na temelju odabranog postotka pogreške p% od srednje vrijednosti između najmanje i najveće cijene projekta (Pmax+Pmax)/2, apsolutnu pogrešku računamo kao

$$\mu = \left((P_{\max} + P_{\max})/2 \right) \times p\% \tag{37}$$

nakon čega je potreban broj iteracija (uzoraka) iz apsolutne pogreške

$$m = (3\sigma/\mu)^2 \tag{38}$$



Slika 3. Histogram (frekvencija) ukupne slučajne cijene projekta s procijenjenim rizikom

$$randP_i = P_{i,\min} + \sum_{1}^{j} rand\Delta P_i\left(rand\left(p(x)_{i,j}\right)\right) \quad (35)$$

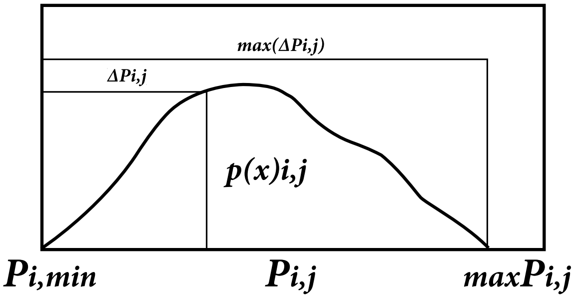


Figure 2. Random segment of project price "i" due to risk "j"

This method evaluates risk ranging from the lowest to the highest value of total project price by statistical treatment of random values. From probability theory for the sample-based estimation of population, for the interval width 3σ there is 99.73% of confidence, so the number of samples (number of iterations for simulations k = 1 ... m) is determined out of given absolute mistake.

$$\mu = 3\sigma/\sqrt{m} \quad (36)$$

where σ is a standard deviation of random variables, and m is the number of iterations for given absolute mistake ju. Standard deviations of sample *a* is calculated between the least total Pmin, the highest total Pmax and medium value between the leasr and highest values of random values of project price (Pmax + Pmax)/2, as a sample of population of random independent variables, project prices. For the number of iterations necessary for simulation, based on the selected percentage of error of p% of the mean value between the least and the highest project cost (Pmax + Pmax) / 2, we calculate the absolute error as

$$\mu = \left((P_{\max} + P_{\max})/2\right) \times p\% \quad (37)$$

after which , the necessary number of iterations (samples) from absolute error is

$$m = (3\sigma/\mu)^2 \quad (38)$$

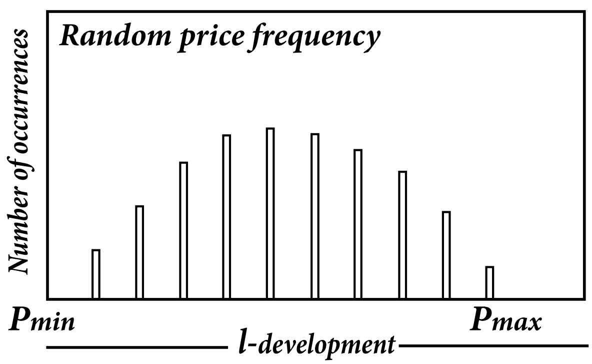


Figure 3. Histogram (of frequencies) of total random project price estimated by risk

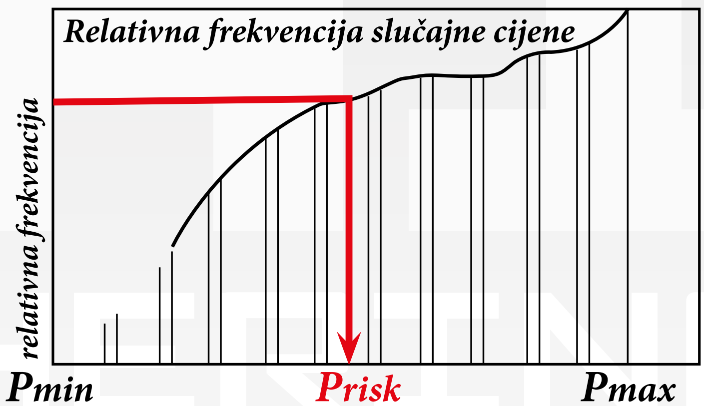
Izvršavanjem dobivenog broja iteracija m slučajnih vrijednosti cijene projekta dobivenih na ovaj način, dobije se niz slučajnih vrijednosti cijene projekta P_k. k = 1, ... m, od minimalne do maksimalne cijene projekta. Za dobivanje histograma frekvencija slučajnih ukupnih cijena u rasponu između najmanje i najveće podijeli se raspon na željeni broj razreda *l*, gdje se dobije korak za pojedini razred za histogram frekvencija ukupne cijene u pojedinom razredu (slika 3.).

Nakon toga se izračuna broj slučajno dobivenih cijena kumulativno do vrijednosti u pojedinom izabranom razredu - kumulativna apsolutna frekvencija cijena i kumulativna relativna frekvencija ukupne slučajne cijene (slika 4.). Izborom postotka pokrivenosti rizika prisk, tj. ordinate kumulativne relativne frekvencije i na temelju toga dobivene vrijednosti slučajne cijene projekta s pokrivenošću rizika prisk 100%, na apscisi prisk dobivamo procijenjeni pokriveni rizik prisk 100%, % na temelju prethodne analize i pokrivenost rizika u projektu

$$R_{isk} = P_{risk} - P_{min} \qquad (39)$$

Konačno se dobije prva bliža cijena projekta

$$P_p = p_{pv} + p_{uio} + P_{up} + P_{ug} + P_s i + P_{pi} + U_v + D + R_{isk} \qquad (40)$$



Slika 4. Kumulativna frekvencija ukupne slučajne cijene projekta s procijenjenim rizikom

s prethodno procijenjenom cijenom projekta. Nakon prve okvirne cijene projekta pp koja se temeljila, u dijelu troškova predstavnika vlasnika i izvorne organizacije, na Cpp preliminarnoj cijeni projekta, može se sada obnavljati prethodni proračun konačne cijene projekta Pp s procjenom rizika prethodno prikazanom uz uvrštavanje bližih vrijednosti konačnih troškova predstavnika vlasnika i konačnih troškova izvorne organizacije na temelju prve bliže, prethodno procijenjene cijene projekta. Ovaj se postupak može eventualno i više puta ponavljati do željenog odstupanja konačne cijene od okvirne procijenjene. Na kraju se navedena analiza procjene svih troškova projekta može jednako valjano primijeniti i za formiranje jediničnih cijena u troškovničkoj specifikaciji, gdje su neizravni troškovi

As a result of executing the obtained number of iterations of *m* random values of project price obtained in this way, a set of random values P_k. k = 1, ... *m* is obtained, from minimum to maximum project price. To obtain a histogram of frequencies of total random prices ranging between the least and highest, it is necessary to divide the range on desired number of classes I, where a pace is provided for individual class for histogram of frequencies of total price at individual class (Figure 3).

Then, we calculate the number of randomly obtained prices cumulatively to the value in individual selected class – cumulative absolute price frequency and cumulative relative frequency of total random price (Figure 4). Selecting risk coverage percentage Prisk, namely ordinate of cumulative relative frequency and thus obtained value of random project price with risk coverage Prisk 100%, we obtain estimated covered risk Prisk 100% on abscissa Prisk on the grounds of the previous analysis and risk coverage in project.

$$R_{isk} = P_{risk} - P_{min} \qquad \textbf{(39)}$$

Finally, the first closer project price is obtained

$$P_p = p_{pv} + p_{uio} + P_{up} + P_{ug} + P_s i + P_{pi} + U_v + D + R_{isk} \qquad \textbf{(40)}$$

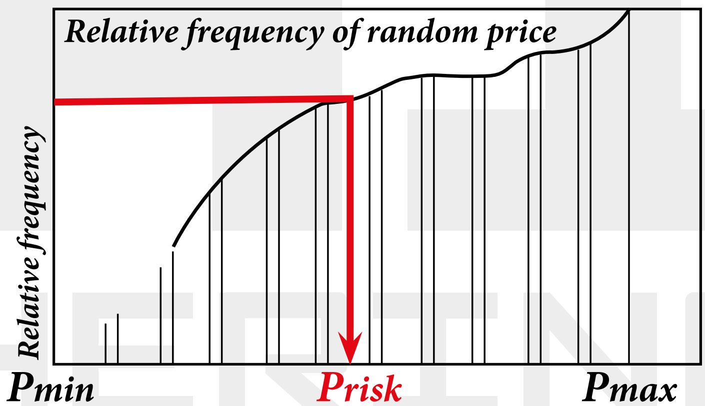


Figure 4 . Cumulative frequency of total random project price with estimated risk

with previously estimated project price. After the first framework project price which was based, at the costs of the owner's representative and original organization, upon Cpp preliminary project price, now it is possible to recalculate the previous calculation of the final project price Pp with risk assessment previously displayed with including of closer values of final expenses of the owner's representative and final expenses of the original organization based on the close, previously estimated project price. This procedure may potentially be repeated several times to the desired deviation of the final price from the indicative, estimated one. In the end, the mentioned analysis of the assessment of all project costs may be equally properly applied to form unit prices in bill-of-quantities specification, where the indirect costs are

$$I_{tr} = \left(\Delta \left(\sum_{1}^{a} P_{pv,a} + \sum_{1}^{b} P_{uio,b} \right) \right) +$$

$$\left(\sum_{1}^{c1} P_{up,c1} + \sum_{1}^{d1} P_{ug,d1} + \sum_{1}^{e1} P_{si,e1} \right) + Uv + D + Risk \tag{41}$$

a izravni troškovi troškovničke specifikacije

$$P_{pi,\min} = D_t = \left(\sum_{1}^{f1} P_{pi,f1} \right) \tag{42}$$

koji su i dalje zbroj aktivnosti složenih iz standardnih radnih procesa pojedinačnih izvršenja. Ovim je faktor za neizravne troškove

$$F = \left(\Delta \left(\sum_{1}^{a} P_{pv,a} + \sum_{1}^{b} P_{uio,b} \right) \right) +$$

$$\left(\sum_{1}^{c1} P_{up,c1} + \sum_{1}^{d1} P_{ug,d1} + \sum_{1}^{e1} P_{si,e1} \right) + Uv + D + Risk / \left(\sum_{i=1}^{n} k_i \times p_{pi} \right) \tag{43}$$

a jedinična cijena u troškovničkoj specifikaciji i dalje kao u izrazu (4).

9 Zaključak

Radi što pouzdanije kalkulacije troškova projekta nužno je iznalaženje modela razdioba vjerojatnosti $p(x)_{i,j}$ vrijednosti utjecaja pojedinih izvora rizika na povećanje pojedine, rizično osjetljive, komponente cijene projekta. Pritom procesna podjela troškova u građevinskoj kalkulaciji svrstava troškove u rizično srodne skupine. Statističkom analizom rezultata simulacije ocijenili bi se rizici s marginalnim i katastrofalnim utjecajem na ukupnu cijenu projekta i isplanirali odgovarajuće rezerve za pokrivanje rizika u cijeni projekta te kvalitetna reagiranja na pojedine rizične događaje.

$$I_{tr}=\left(\Delta\left(\sum_{1}^{a}P_{pv,a}+\sum_{1}^{b}P_{uio,b}\right)\right)+$$
$$\left(\sum_{1}^{c1}P_{up,c1}+\sum_{1}^{d1}P_{ug,d1}+\sum_{1}^{e1}P_{si,e1}\right)+Uv+D+Risk \tag{41}$$

and direct costs of bill-of-quantities specification

$$P_{pi,\min}=D_t=\left(\sum_{1}^{f1}P_{pi,f1}\right) \tag{42}$$

which are still a sum of activities made up from standard work processes of individual executions. Thus, the indirect costs factor is

$$F=\left(\Delta\left(\sum_{1}^{a}P_{pv,a}+\sum_{1}^{b}P_{uio,b}\right)\right)+$$
$$\left(\sum_{1}^{c1}P_{up,c1}+\sum_{1}^{d1}P_{ug,d1}+\sum_{1}^{e1}P_{si,e1}\right)+Uv+D+Risk/\left(\sum_{i=1}^{n}k_i\times p_{pi}\right) \tag{43}$$

and unit price in bill-of-quantities specification is still the same as in expression (4).

9 Conclusion

For reliable calculation of project costs, it is necessary to find a model of probability distribution of $p(x)_{i,j}$ value of the impact of individual risk sources to the increase of individual, hazardously unstable components of project price. In this course, the process-based distribution of costs in the calculation of construction work classifies costs into risk related groups. Applying statistical analysis of simulation results would enable assessing risks with marginal and disastrous impact to overall project price and planning corresponding provisions for covering risk in the project price and effective response to individual hazardous events.

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HERING

Mr. sc. Ladislav Bevanda, dipl. ing. građ.,
Hering d.d. Široki Brijeg

Mr.sc. Dragan Katić, dipl.ing.građ.,
Građevinski fakultet Mostar

PROJEKTNA BODOVNA TABLICA U GRAĐEVINSKIM PROJEKTIMA

PROJECT SCORECARD IN CONSTRUCTION PROJECT

PROJEKTNA BODOVNA TABLICA U GRAĐEVINSKIM PROJEKTIMA

Mr. sc. Ladislav Bevanda, dipl. ing. građ., Hering d.d. Široki Brijeg
Mr.sc. Dragan Katić, dipl.ing.građ., Građevinski fakultet Mostar

Sažetak

Ovaj rad opisuje metodologiju mjerenja uspjeha građevinskih projekata sa stajališta građevinske tvrtke. Tradicionalni pokazatelji uspješnosti (vrijeme, trošak, kvaliteta) nisu dovoljni za uravnoteženi prikaz uspjeha ili neuspjeha projekta. Oni su pokazatelji koji zaostaju jer su rezultati provedbe projekta i ne pokazuju one pokazatelje koji vode ka uspješnosti građevinskih projekata. Projektna bodovna tablica (PSC) je metodologija prevođenja projektnih planova i ciljeva u kriterij uspjeha kroz financijske i nefinancijske pokazatelje u sustavu mjerenja performansi. Za svaki od definiranih ciljeva projekta potrebno je odrediti kritične čimbenike uspjeha i odgovarajuće ključne pokazatelje uspješnosti. PSC je utemeljen na zahtjevima projektnih tehničkih specifikacija i upravljanju projekta. Doprinos PSC aplikacije je provedba učinkovitosti izgradnje strategije građevinske tvrtke kroz njezine projekte.

Ključne riječi: mjera uspjeha, projektna bodovna tablica, građevinski projekti

1. Uvod

Građevinska industrija općenito ima lošu ocjenu zbog neučinkovite realizacije projekata. Ovaj rad kratko opisuje projektne bodovne kartice koji mjere uspješnost građevinskih projekata s gledišta građevinskih tvrtki.

Tijekom posljednja dva desetljeća brojne su industrije uvele nove metode i tehnike (paralelno inženjerstvo, lean-proizvodni sustav, TQM, itd.) kako bi poboljšali svoju uspješnost izvođenja. Glavni pokretač tih filozofija je optimizacija djelovanja organizacije, kako unutar tako i izvan nje, na svojim tržišnim mjestima. Neizbježno, to je dovelo do promišljanja sustava upravljanja poslovnim rezultatima kroz učinkovito mjerenje uspjeha(Kagioglou et al., 2001).

Organizacije tradicionalno mjere svoj uspjeh samo financijski. Ovaj ograničeni pristup mjerenju uspješnosti nije dovoljan jer pokazuje rezultate odluka donesenih u prošlosti, nema utjecaja na

PROJECT SCORECARD IN CONSTRUCTION PROJECT

MSc. Ladislav Bevanda, BCE*, Hering d.d. Široki Brijeg
MSc. Dragan Katić, BCE*, Faculty of Civil Engineering Mostar

Abstract

This paper describes performance measurement methodology of construction projects from constructors' point of view. Traditional performance indicators (time, cost, quality) are not sufficient for balanced perspective of project success or failure. They are lagging indicators because they constitute results of project execution and do not show indicators leading to construction project successful performance. Project Scorecard (PSC) is a methodology of translating project plans and goals into performance criteria through financial and non-financial indicators in performance measurement system. There is a need to determine critical success factors and corresponding key performance indicators for each defined project goal. PSC is based on the demands of project's technical specifications and on project management. PSC application enables the efficiency of strategy development of a construction company through its projects.

Key words: performance measurement, project scorecard, construction projects

1. Introduction

Construction industry in general has a bad rating due to ineffective project realization. This paper gives a brief description of project scorecards which measure the performance of construction projects as seen by construction companies.

Throughout the previous two decades, numerous industries have introduced new methods and techniques (concurrent engineering, lean-production system, TOM, etc.) in order to improve their performance. The major driver of those philosophies has been the optimization of a corporation's performance, both internally and externally on the marketplace. This inevitably resulted into contemplating over the management performance system through effective performance measurement (Kagioglou et al., 2001).

Traditionally, organizations measure their success only financially. This limited approach to performance measurement is not sufficient as it shows the results of decisions made in past, it has no poboljšanje trenutnog uspjeha i ne pokazuju uzroke takvih rezultata. Vrlo je važno vidjeti kako mjeriti organizacijsku izvedbu, kao i utjecaj na tržišni udio, pa se to može prihvatiti od potencijalnih investitora, zaposlenika i kupaca. Za ove, najvažnije je sustav koji predstavlja ravnotežu između financijskih rezultata i uputa za daljnju izvedbu. Istodobno, taj isti sustav snabdijeva potencijalne nematerijalne imovine i pomaže organizacijama u provođenju različitih strategija.

Sve organizacije danas stvaraju održivu vrijednost iskorištavanjem njihove nematerijalne imovine, poput ljudskog kapitala, baze podataka i informacijskih sustava, visokokvalitetnih procesa, odnosa s kupcima i robnih marki, inovativnih sposobnosti i kulture. Budući da nematerijalna imovina neke organizacije može lako predstavljati više od 75 posto svoje vrijednosti, tada formuliranje i izvršenje strategije treba izričito riješiti njihovu mobilizaciju i usklađivanje (Kaplan& Norton, 2004).

Novo područje istraživanja se razvilo, čiji su ciljevi bili identificirati točan broj i vrste mjera uspjeha na način koji je integriran u strategiju tvrtke.

2. Upravljanje poslovnim rezultatima u građevini

Upravljanje poslovnim rezultatom definira se kao korištenje mjerenja uspješnosti rezultata kako bi se postigla pozitivna promjena u kulturi organizacije, poslovnog sustava i procesa, postavili dogovoreni ciljevi, učinkovito iskoristili resurse, informirala uprava o potrebi promjena strateških ciljeva potraživanja i rezultati se mogu razmijeniti kako bi se potaknulo kontinuirano poboljšanje sustava (Vukomanović i sur., 2008).

Početkom 1990-tih u godinama razvijanja alata za upravljanje poslovnim rezultatima razvila se balansirana bodovna tablica (BSC) autora R. Kaplana i D. Nortona kao jedan od najvažnijih izuma na području upravljanja. BSC rezultira kao pomoć organizacijama da rade kroz učinkovito mjerenje organizacijskih izvedbi, povećanje nematerijalne imovine i strategije implementacije putem financijskih i nefinancijskih pokazatelja.

Godine 2005. Neely je proveo ankete o citatnoj analizi rada na području mjerenja uspjeha kako bi istražio razvoj na terenu na globalnoj razini. Prema ovom istraživanju, kroz citatnu analizu podataka, očita je dominacija Kaplan i Norton i BSC. Između 1991. i 1995. godine 10 najčešće citiranih radova navodi se 514 puta. 56,8 posto od tih 514 citata djeluje od Nortona na uravnoteženu bodovnu karticu, a to se u posljednjih nekoliko godina povećalo (60 posto citata iz 2002., 58 posto citata u 2003. i 59 posto citata u 2004. godini).

BSC ispituje organizacijsku strategiju i čini je jasnijom kroz prizmu različitih perspektiva. Mjere odabrane u BSC-u predstavljaju alat koji viša uprava može koristiti za pomoć zaposlenicima i vanjskim dioničarima prema rezultatima i pokazateljima učinkovitosti koji pomažu organizacijama da ostvare svoju misiju i strateške ciljeve (Niven, 2002.).

BSC omogućuje menadžerima da pogledaju poslovanje s četiri važne perspektive. Ona daje odgovor na četiri osnovna pitanja (Letza, 1996.):

- Perspektiva korisnika: kako nas korisnici vide?

influence to improving of a current performance and it fails to point to the causes of such results. It is very important for the measurement of a corporate performance, as well as for the influence on the market share, to be visible, so it could be accepted by potential investor, employees and customers. They deem that the system which represents a balance between financial results and instructions for further execution is the most important. Simultaneously, that same system provides potential intangible assets and assists corporations to implement various strategies.

Nowadays all corporations create sustainable value by exploiting their intangible property, like human capital, databases and information systems, high-quality processes, customer relationships and trade names, innovative capabilities and culture. As intangible property of an organization could readily make more than 75% of its value, then, the strategy formulating and execution should expressly settle their mobilization and alignment (Kaplan & Norton, 2004).

New research area has been developed; its objectives being identifying the correct number and type of performance measurements in the way integrated into a company's strategy.

2. Performance management in construction

Performance management is defined as the use of performance measurement in order to gain a positive change in the culture of a corporation, business system and process, to set arranged objectives, to exploit resources effectively, to inform the management of the need to change strategic goals of demand and the results could be exchanged in order to stimulate continuous improvement of the system (Vukomanović et al. 2008).

In the early 1990s, in the years of developing tools for business performance management, the balanced scorecard was developed by the authors R. Kaplan and D. Norton, and it presents one of the most important inventions in management area. The BSC results into an aid to corporations to operate through efficient measurement of corporate performances through increase of intangible property and through strategies of implementation, both by financial and non-financial indicators.

In 2005, Neely conducted a poll on citation analysis of work in the area of performance measurement in order to do research on development in the field on a global level. According to this research through citation data analyzing, the domination of Kaplan and Norton and BSC is obvious. Between 1991 and 1995, ten most commonly cited papers were mentioned 514 times. 56.8% of these 514 quotations act by Norton to balanced scorecard and this has increased in several recent years (60% quotations in 2001, 58% of quotations in 2001 and 59% in 2004).

BSC investigates corporate strategy and makes it clearer through a prism of various perspectives. The measures selected in BSC present tools which may be used by senior management to help its employees and external shareholders towards results and indicators of efficiency that help corporations to realize their mission and strategic goals (Niven, 2002).

BSC enables managers to perceive the business from four important perspectives. This answers four basic questions (Letza, 1996).

- Customer perspective: How do users see us?

- Unutarnja perspektiva: Na što moramo ukazivati?
- Inovacije i perspektiva učenja: Možemo li nastaviti poboljšavati i stvarati vrijednosti?
- Financijska perspektiva: Kako izgledamo dioničarima?

Sljedeće ključne riječi su najvažnije u BSC-u:

- Ciljevi: Kratke izjave koje opisuju što moramo učiniti u svakoj od četiri perspektive kako postići naš strateški plan.
- Mjere: Pokazatelji koje koristimo za praćenje našeg uspjeha u postizanju naših ciljeva.
- Ciljevi: Kvantitativne vrijednosti koje određuju uspješnost mjerenja.
- Inicijative: Što trebamo učiniti, da bismo dobili ciljeve.

BSC može biti proširen s novom perspektivom kao što je projekt i dobavljači i prilagodba građevinarstvu.

Glavni problem BSC-a je pronalaženje optimalnog izbora modela ključnih pokazatelja uspješnosti i nemogućnosti vrednovanja (Vukomanović et al., 2008).

3. Projektna bodovna tablica u građevinskim projektima

Predmet mjerenja uspješnosti je ogroman i brojni autori kontinuirano pridonose literaturi na ovu temu. Većina autora je suglasna da menadžeri mjere iz dva glavna razloga. Ili žele znati gdje su i što moraju poboljšati ili žele utjecati na ponašanje svojih podređenih (Beatham et al., 2004).

U transformacijskom procesu misije, vizija i strategije za građevinsku tvrtku kao poslovni sustav definira mjerljive ciljeve ključne za uspjeh poslovanja. Građevinske tvrtke provode svoje aktivnosti kroz građevinske projekte.

Balansirana bodovna tablica (BSC) građevinske tvrtke sadrži ciljeve i mjere koje predstavljaju osnovu za razvoj, posebno balansiranu bodovnu karticu na razini projekta poznatoj pod nazivom Projektni pokazatelj projekta (PSC). PSC se koristi za mjerenje i kontrolu ciljeva projekta.

Projektna bodovna tablica(PSC) se temelji na zahtjevima tehničke specifikacije i zahtjevima vezanim uz upravljanje projektom. PSC je način upravljanja i provođenja projekta kroz niz mjerljivih ciljeva projekta koji su ključni za uspjeh projekta. Ti mjerljivi ciljevi određeni su skupom ključnih pokazatelja uspješnosti (KPIs).

KPIs su kompilacije podatkovnih mjera koje se koriste za procjenu izvedbe radova u građevinskim radnjama. To su metode upravljanja koje se koriste za procjenu učinkovitosti zaposlenika određenog zadatka. Ove procjene tipično uspoređuju stvarne i procijenjene izvedbe u smislu obrade i proizvoda (Cox et al., 2003). KPI je metoda za mjerenje uspjeha građevinskog projekta. Oni potiču druge sudionike projekta (vlasnici, poduzetnici, kupci) na njihov doprinos u konačnom uspjehu projekta. Cilj KPI je mjerenje projekta i uspješnosti tvrtke.

- Internal perspective: What do we have to point to?
- Innovations and learning perspective: Can we continue to improve and create values?
- Financial perspective: What do we look like to shareholders?

The following key words are the most important in BSC:

- Goals: Short statements describing what we have to do within each of four perspectives; how to realize our strategic plan.
- Measures: Indicators we use to monitor our performance in achieving our goals.
- Targets: Quantitative values that determine measuring success.
- Initiatives: What we should do in order to get the given goals.

BSC could be extended with new perspectives as a project and suppliers and adjustment to construction industry.

The major task of BSC is detecting an optimal choice of models of essential performance indicators and inabilities of benchmarking (Vukmanović et al., 2008).

3. Project scorecard in construction projects

The issue of performance measurement is enormous and numerous authors continually contribute to the literature on this topic. Most authors agree that managers have two major reasons for conducting measurement: they either wish to know where they are and what they have to improve, or they wish to influence behavior of their subordinates (Beatham et al., 2004).

Within the process of transformation, missions, vision and strategies define measurable goals essential for successful business of a construction company as a business system. The activities of construction companies are implemented through construction projects.

The Balanced Scorecard (BSC) of a construction company contains goals and measurements that create a ground for development of a specifically balanced scorecard on the level of a project, which is known as Project Scorecard. Project Scorecard is used for measurement and control of project goals.

Project Scorecard (PSC) is based on the requirements of technical specifications and requirements related to project management. Project Scorecard is the manner of managing and implementing a project through a set of measurable project goals that are essential for the project success. Those measurable goals are determined by the set of key indicators of performance (KPIs).

Key Performance Indicators are data measurement compilations which are used to estimate execution of works in construction operations. They are the management methods that are used to evaluate efficiency of employees in a certain task. These estimates typically compare the actual and estimated executions in terms of process and product (Cox et al., 2003). KPI method constitutes a measuring method for construction project performance. These indicators encourage other project participants (owners, entrepreneurs, customers) to make their contributions in a final project success. The aim of KPI is to measure projects and the company performance.

Uspjeh projekta gotovo je krajnji cilj svakog projekta. Međutim, vlasnici, projektanti, konzultanti, izvođači imaju svoje ciljeve i kriterije za mjerenje uspjeha. To znači različite stvari različitim ljudima (Chan & Chan, 2004).

Planovi i ciljevi projekta transformirani su u kriterij uspjeha kroz financijske i nefinancijske pokazatelje sustava poslovanja. Za svaki skup ciljeva definirani su kritični čimbenici uspjeha s odgovarajućim mjerama uspješnosti (pokazatelji). Skup ključnih pokazatelja uspješnosti sadrži zapostavljene i vodeće pokazatelje. Vodeći pokazatelji dijagnosticiraju trenutne izvedbe i omogućuju korektivne korake prema odstupanju od određenog cilja tijekom izvršenja projekta.

Izrada mjera uspjeha je proces s ulaznim i izlaznim informacijama. Svaka mjera uspjeha mora sadržavati naslov, svrhu, vezu, cilj, formulu, učestalost mjerenja, učestalost pregleda, tko mjeri, izvor podataka, tko posjeduje mjeru, što rade, tko djeluje na podacima, što oni čine, bilješke i komentare (Neely i sur., 1997).

Vrijeme, trošak i kvaliteta (željezni trokut) temeljni su kriterij uspjeha projekta, ali nisu dovoljni za uravnotežen prikaz izvedbe projekta ili uspjeha.

Skup KPI uključuje objektivne i subjektivne pokazatelje za mjerenje izvedbe građevinskih projekata. Prema Vukomanoviću (2006.) top deset KPI-a u građevinskim projektima su kvaliteta, troškovi gradnje, vlasnici koji sudjeluju u izgradnji, promjene u podršci projektu, povećanje vremena gradnje, zadovoljstvo kupaca, zadovoljstvo zaposlenika u tvrtki, inovacije i učenje, vrijeme izgradnje i identifikacija interesa klijenata.

Kao rezultat procesa kaskadne misije, vizije i strategije u uravnoteženim projektnim bodovnim tablicama, a potom u ciljevima projekta pomoću mjerenja uspjeha ili KPI-a stvara se projektna bodovna tablica građevinskog projekta prikazanog na slici 1.

PROJEKTNA BODOVNA TABLICA				
PERSPEKTIVA	**MJERE**	**CILJ**	**PERFORAL**	**INICIJATIVA**
FINANCIJE				
KUPAC				
INTERNO				
INOVACIJE I UČENJE				

Slika 1. Projektna bodovna tablica

The ultimate aim of almost every project is the project success. However, owners, designers, consultants and contractors all have their own objectives and criteria of performance measurement. This means that different people need different things (Chan & Chan, 2004).

Project plans and goals are transformed into performance criterion through financial and non-financial indicators of business system. Critical performance factors with corresponding performance measures (indicators) are defined for each set of goals. The set of key performance indicators contains both lagging and leading indicators. The leading indicators diagnose current performance and enable corrective measures for deviations from a defined target during project execution.

Developing performance measures is a process with both input and output of information. Each performance measure has to contain a title, purpose, relation, target, formula, measurement frequency, inspection frequency, who performs measuring, source of information, who owns the measure, what they do, who works with data, what they do, notes and comments (Neely et al., 1997).

Time, cost and quality (the iron triangle) are the basic criteria of project performance, but they are not sufficient for balanced display of project performance or success.

A set of Key Performance Indicators consists of both objective and subjective indicators for measuring construction project performance. According to Vukomanović (2006) ten top KPIs in construction projects are quality, construction costs, owners who are involved in construction, changes in project support, extension of construction period, customer satisfaction, satisfaction of employees of the company, innovations and learning, construction time and identification of client's interests.

The Project Scorecard of construction project is created, as shown in Figure 1, as a result of a process of cascading mission, vision and strategy in balanced project scorecards, and then it appears in project goals by means of performance measurement or KPI measurement.

PROJECT SCORECARD				
PERSPECTIVE	MEASURES	TARGET	PERFORAL	INITIATIVE
FINANCIAL				
CUSTOMER				
INTERNAL				
INNOVATION AND LEARNING				

Fig. 1. Project scorecard

Realizirano postizanje mjera uspješnosti (pokazatelja) na razini projekta predstavljaju ulazne podatke za procjenu učinka na razini građevinskih tvrtki putem uravnotežene bodovne kartice.

4. Zaključak

Cilj ovog rada bio je istaknuti projektnu bodovnu karticu kao metodologiju prevođenja projektnih planova i ciljeva u kriterij uspjeha kroz mjere izvedbe (pokazatelji) u sustavu mjerenja uspjeha. Mjerenje uspjeha građevinskih projekata kroz projektnu bodovnu karticu osigurava učinkovitu provedbu strategije izgradnje tvrtke kroz njene projekte.

Za daljnje istraživanje preporuka je pronalaženje optimalnog modela izbora mjera uspješnosti ili ključnih pokazatelja uspješnosti za ocjenu rezultata projekta.

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The realized achievement of performance measures (indicators) on a project level presents input data for performance estimation on a level of construction companies through the balanced scorecard.

4. Conclusion

The aim of this paper was to point out the project scorecard as a methodology of translating project plans and goals into a criterion of success through performance measurement (indicators) in the system of successful performance measurement. Performance measurement of construction projects through project scorecard provides efficient implementation of a company development strategy through its projects.

The recommendation for further research is to find an optimal selection of a model of performance measures, or key performance indicators to evaluate project results.

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Ivana Karačić, dipl.ing.građ.,
Hering d.d. Široki Brijeg

Marija Kvesić, mag.ing.građ.,
Pro-Most d.o.o. Mostar;

SANACIJA KOLOSIJEKA U TUNELU IVAN - BETON UMJESTO KOLOSIJEČNOG ZASTORA

REHABILITATION OF TRACK IN IVAN TUNNEL - CONCRETE INSTEAD OF BALLAST

SANACIJA KOLOSIJEKA U TUNELU IVAN - BETON UMJESTO KOLOSIJEČNOG ZASTORA

Ivana Karačić, dipl.ing.građ.,
Hering d.d. Široki Brijeg

Marija Kvesić, mag.ing.građ.,
Pro-Most d.o.o. Mostar;

Sažetak

Glavnim projektom sanacije tunela Ivan, po prvi put u BiH je umjesto klasičnog gornjeg stroja s tucaničkim zastorom predviđen koncept gradnje gornjeg stroja primjenom betona sa integriranim prednapregnutim betonskim pragovima.

U radu je dat osvrt na važnosti betonskih građevina, tunela, kao dio poveznice kako bi se savladala prelazna prepreka.

Ključne riječi: tunel, beton u skučenom prostoru.

1. Uvod

Novim konceptom gradnje gornjeg stroja urađen je kolosijek u dužini od 3079 m. Tokom cijele sanacije tunela Ivan radovi su se izvodili pod zatvorom pruge sa isključenjem napona u neprekidnom vremenskom intervalu od 30h, a nakon toga je bio prekid radova u trajanju od 42h za potrebe neometanog odvijanja prometa. Ovo je ujedno bio i najveći izazov na projektu, s obzirom da je za tako kratko vremensko razdoblje bilo potrebno za jednu kampadu uraditi sve pripremne radove (montaža armature, montaža alata za vertikalno i horizontalno pozicioniranje šina, prenošenje projektiranje osovine i nivelete GIŠ-a) dovesti i ugraditi beton, njegovati ga i ispitati njegovu čvrstoću koja nije smjela biti manja od 7 MPa prije puštanja prometa.

2. Receptura betona sa šifrom CG 400I-MC

Zahtijevana klase betona prema tenderskoj dokumentaciji je C25/30 i ista je spravljana na betonari „Agi“ iz Konjica. Za navedenu marku korištena je receptura sa šifrom CG 400I-MC sa maksimalnim zrnom agregata Dmax 16 mm koju je napravio i dokazao izvođač radova Hering d.d.

REHABILITATION OF TRACK IN IVAN TUNNEL - CONCRETE INSTEAD OF BALLAST

Ivana Karačić, BCE*,
Hering d.d. Široki Brijeg

Marija Kvesić, MCE
Pro-Most d.o.o. Mostar;

Abstract

The main project of the Rehabilitation of Ivan tunnel, for the first time in Bosnia and Herzegovina, provided for the concept of constructing track bed structure applying concrete with integrated pre-stressed concrete sleepers instead of classical track bed structure with crushed stone bed.

This paper gives an overview of the importance of concrete structures, tunnels, as parts of communication for managing obstacles.

Key words: tunnel, concrete in narrow enclosed space

1. Introduction

A new construction concept of track bed structure was used in building railway tracks in the distance of 3,079 m. During the rehabilitation of Ivan tunnel, the works were executed with closed traffic and voltage turned off in the course of an uninterrupted period lasting for 30 hours, which was followed by an interruption of works lasting for 42 hours for the purpose of undisturbed traffic. At the same time this was the biggest challenge in the project considering that in such a short period, for one cycle, it was necessary to execute all preliminary works (reinforcement fitting, fitting of tools for horizontal and vertical positioning of tracks, transferring of projected axis and leveling the upper rail edge), deliver and place concrete, cure it, test its hardness whose minimum mustn't be lower than 7MPs before allowing the traffic.

2. Concrete formula coded CG 400I-MC

The demanded concrete class according to the tender document was C25/30 and it was prepared in the concrete batching plant "Agi" from Konjic. The mentioned make was prepared by a formula

Za proizvodnju betona upotrijebljeni su sljedeći materijali:

- separirani agregat iz separacija kamenoloma "Podorašac" (frakcije 0/4, 4/8, 8/16mm) (ispitan u skladu sa BAS EN 12620);
- cement - Kakanj cement CEM II/ B-W 42,5N (odgovara zahtjevima BAS EN 197-1);
- voda - gradski vodovod (ispitana u skladu sa BAS EN 1008);
- dodaci za beton superplastifikator MC Bauchemia Powerflow 5695 (odgovaraju zahtjevima standarda BAS EN 934-2).

Receptura sa šifrom CG 400l-MC za 1m^3:

- Cement CEM II 42,5N 400 kg
- v/c 0,38
- Voda 152 l
- Dodatak 1 MC Powerflow 5695 0,8 %
- Uvučeni zrak 1,0 %

Agregat „Podorašac" 1977,5 kg

- 0-4 mm 1087,6 kg
- 4-8 mm 138,40 kg
- 8-16 mm 751,5 kg

Odabir sastava betona uzet je na osnovu sljedećih kriterija:

- izvođenja radova;
- krajnjeg korištenja betona;
- uvjeta njegovanja;
- dimenzija konstrukcije (razvoj topline hidratacije);
- uvjeta okoline kojima će konstrukcija biti izložena (prema razredima izloženosti BAS EN 206-1, točka 4.1.).

3. Novi koncept gradnje gornjeg stroja primjenom betona

Prema Glavnom projektu za tunel Ivan novi koncept gradnje gornjeg stroja projektiran je na način da su betonski prednapregnuti pragovi integrirani u AB ploču. Pragovi su dužine L=230cm, a debljina betona ispod pragova je min 8cm, a max 14cm.

coded CG 400I-MC with a maximum of aggregate grain Dmax 16 mm, which was made and proved by the Contractor Hering d.d.

The following materials are necessary for manufacturing of concrete:

- separated aggregate from separation of quarry "Podorašac" (fractions 0/4, 4/8, 8/16mm) (tested in conformity with BAS EN 12620);
- cement - Kakanj cement CEM II/ B-W 42,5N (in conformity with requirements of BAS EN 197-1);
- water – urban water supply (tested in conformity with BAS EN 1008);
- concrete additives superplasticizer MC Bauchemia Powerflow 5695 (in conformity with standard BAS EN 934-2).

Formula coded CG 400I-MC for 1m^3:

- Cement CEM II 42,5N 400 kg
- v/c 0,38
- Water 152 l
- Additive 1 MC Powerflow 5695 0,8 %
- Inserted air 1,0 %

Aggregate "Podorašac" 1977.5 kg

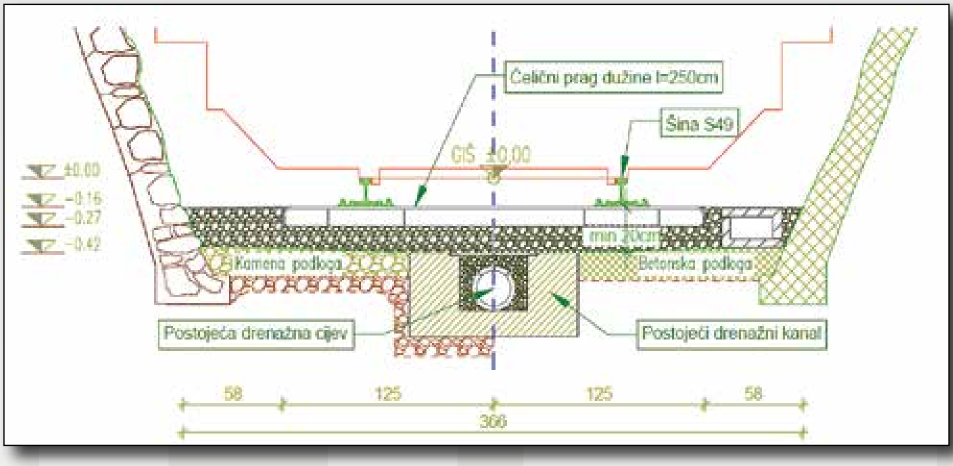
- 0-4 mm 1087.6 kg
- 4-8 mm 138.40 kg
- 8-16 mm 751.5 kg

Concrete composition is selected on the grounds of the following criteria:

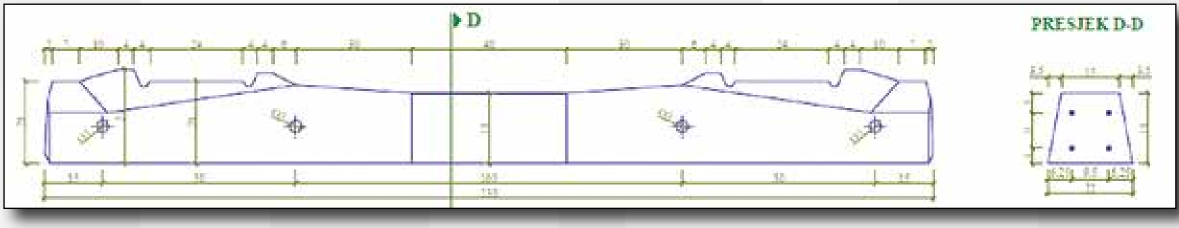
- execution of works;
- final use of concrete;
- curing requirements;
- dimensions of structure (heat development of hydration);
- surrounding condition that will impact the structure (according to exposure classes (BAS EN 206-1, clause 4.1.).

3. New concept of track bed structure construction using concrete

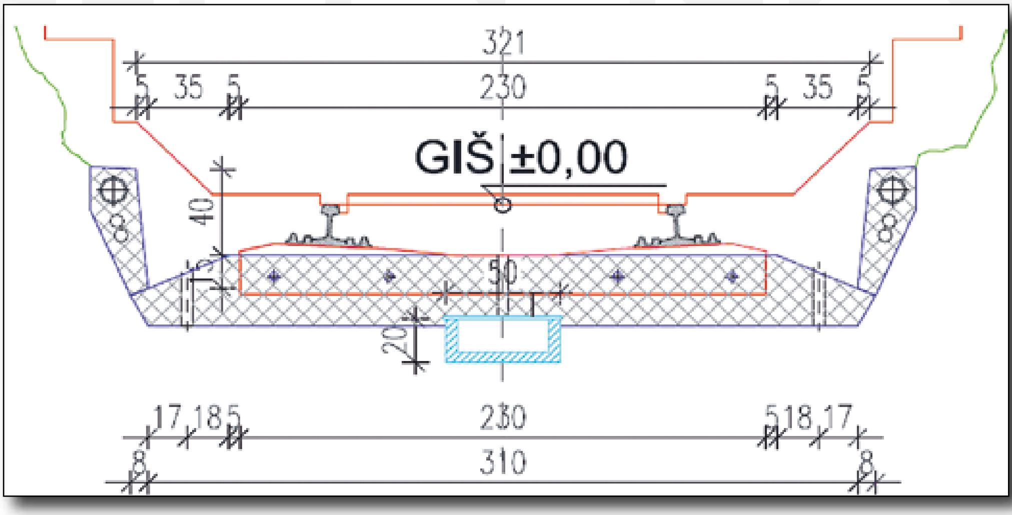
According to the main project of Ivan tunnel, the new concept of track bed structure construction was designed in such a manner that prestressed concrete sleepers were integrated in RC slab. The sleepers were L=230cm and the concrete under the sleepers was minimum 8 cm and maximum 14 cm thick.



Slika 1. Prikaz kolosijeka u tunelu Ivan prije sanacije



Slika 2. Prednapregnuti betonski prag TIP BH70-230



Slika 3. Prikaz novog kolosijeka

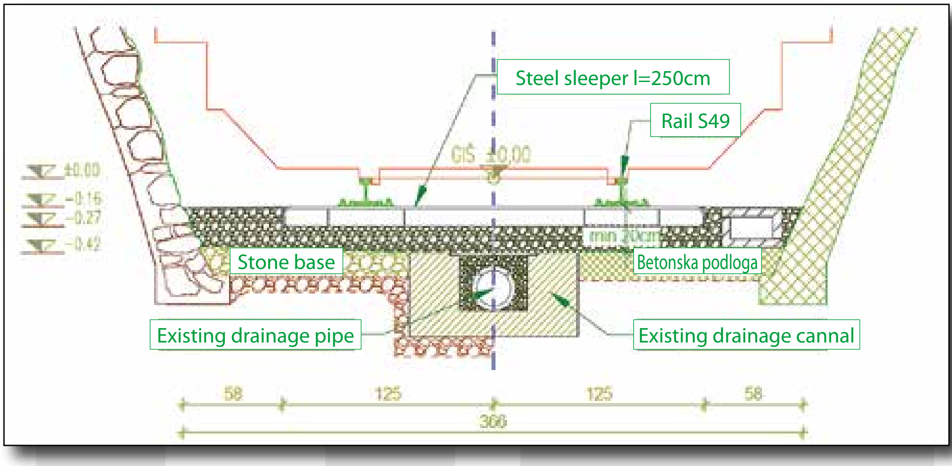


Figure 1. - Railway tracks in Ivan tunnel before rehabilitation

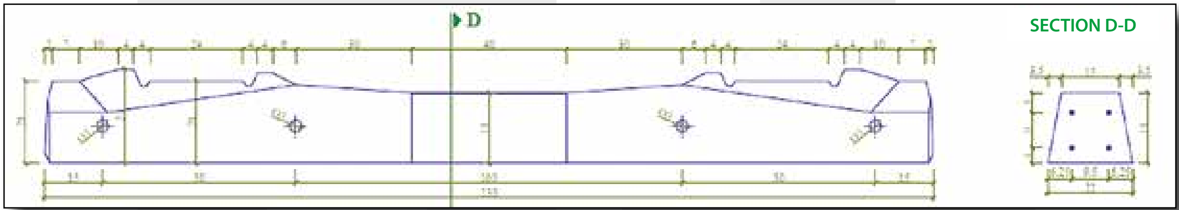


Figure 2. - Prestressed concrete sleeper TIP BH70-230

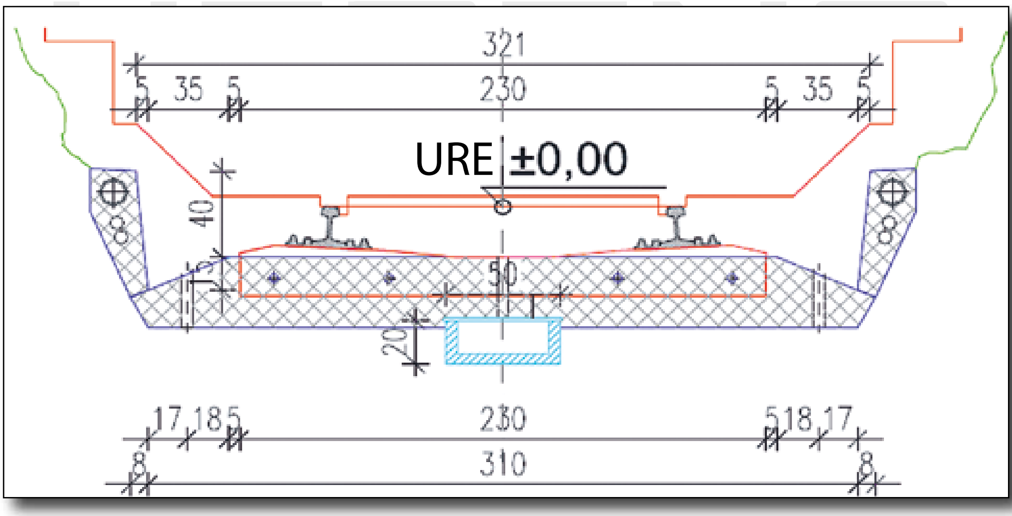
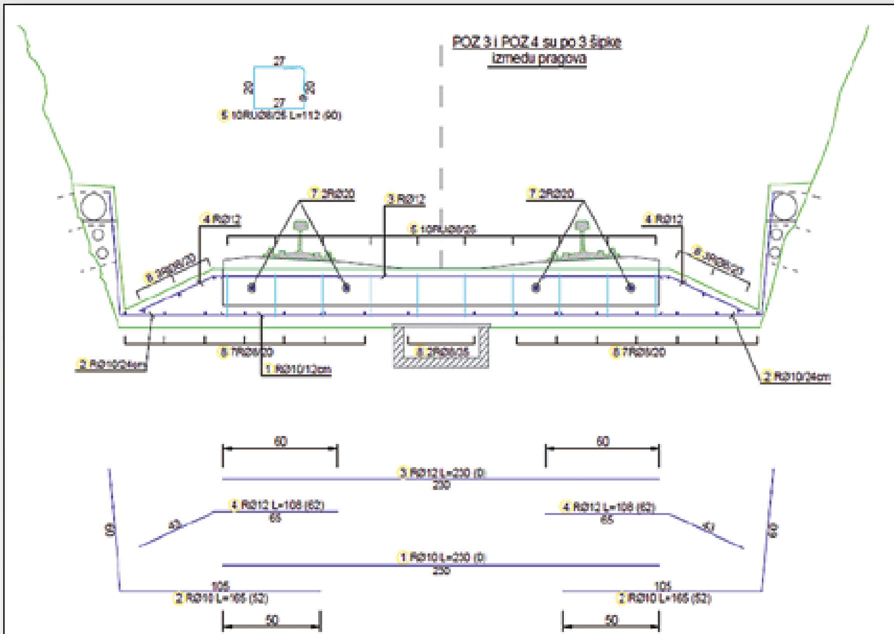


Figure 3. New railway track (URE – Upper Rail Edge)

Betoniranje tunela Ivan u dužini od 3079m urađeno je za 59 ciklusa (kampada). Prosječna dužina kampade je 52m, s tim da je minimalna bila 18m a maksimalna 66m.



Slika 4. Shema armiranja ploče

4. Proces proizvodnje betona

Po završetku svih pripremnih radova na radnoj kampadi u tunelu Ivan i prijemu od strane Inženjera počinjao je proces proizvodnje betona na betonari „AGI" iz Konjica doziranjem sastavnih materijala u bubanj miješalice.

Slika 5. Betonara Agi- Konjic

Concreting in Ivan tunnel at the length of 3,079 m was executed in 59 construction cycles. Average length of a cycle was 52 m, the least being 18 m, and the longest 66 m.

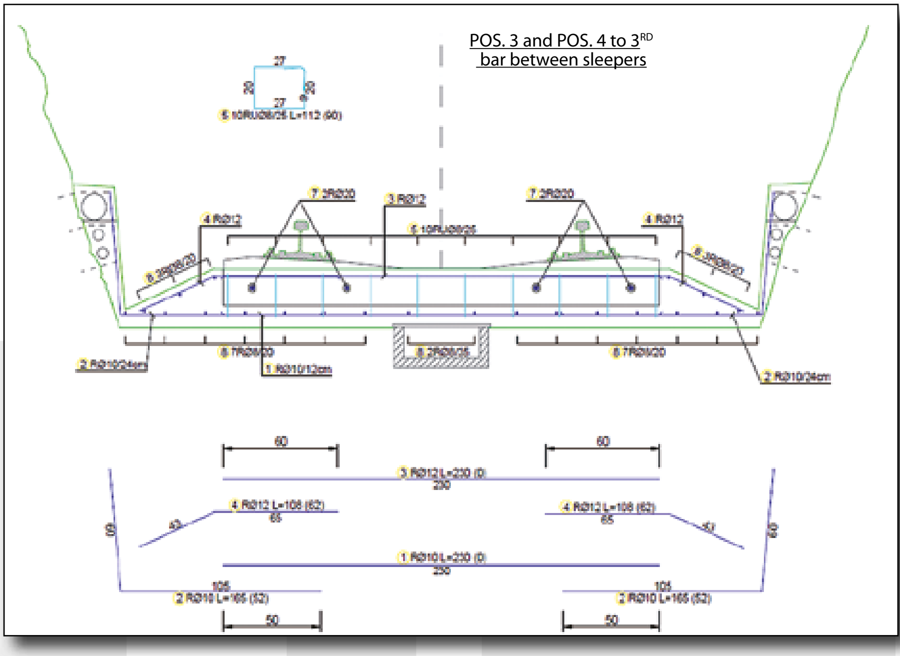


Figure 4. - Scheme of slab reinforcement

4. Concrete manufacturing process

After completing all preliminary works at the workshop cycle in Ivan tunnel and after the Engineer's acceptance, the process of concrete manufacturing started in the concrete batching plant "AGI" in Konjic by batching ingredients into the mixer drum.

Figure 5. - Concrete batching plant Agi- Konjic

4.1. Doziranje sastavnih materijala

Prvo se vršilo doziranje agregata, zatim je išao cement, voda i kemijski dodatak po zadanoj recepturi betona. Doziranja sastavnih materijala su određivana preko vaga koje su u skladu s zahtjevima točke 9.6.2.2. norme BAS EN 206-1.

4.2. Punjenje bubnja miješalice

Kada se sve komponente doziraju kreće pražnjenje u miješalicu. Prvi se prazni agregat. Dodavanje cementa započinje nakon dodatka 90 % agregata. Nakon toga dodaje se voda i dodatak MC Powerlow 5695.

4.3. Miješanje betona

Miješanje se dokazuje ispitivanjem proizvodne sposobnosti i započinje sa dozažom agregata. Vrijeme miješanja određuje se na osnovu ispitivanja homogenosti sastava betona. Vrata bubnja otvaraju se u poluautomatskom režimu i beton ulazi u mikser. Vrata miješalice se u poluautomatskom režimu zatvaraju kada se cijela količina betona isprazni iz bubnja miješalice u mikser.

5. Isporuka (transport) betona

Transport betona od betonare do tunela Ivan vršio je se sa dva auto miksera. Mikseri su radili po principu da dok se prvi mikser puni na betonari iza njega je već parkiran drugi mikser. Drugi mikser se puni odmah po završetku punjenja prvog. Napunjeni mikseri idu prema gradilištu udaljenosti cca. 20 min, gdje se vršilo prepumpavanje betona u mikser zapremine 15m3 koji se nalazio na teretnom vagonu serije Regs. Prepumpavanje se vršilo izravno iz miksera preko produženog lijevka.

Slika 6. Mikser na teretnom vagonu serije Regs

4.1. Batching of ingredients

Aggregates were added first, then cement, water and chemical additive pursuant to the given formula of concrete. The batching of ingredients was determined by scales which were in conformity with clause 9.6.2.2. of standard BAS EN 206-1.

4.2. Filling mixer drum

When all components were batched, the content was emptied into a mixer. Aggregate was emptied first. Cement adding started after the addition of 90% of aggregate. Then water was added and the additive MC Powerlow 5695.

4.3. Mixing of concrete

Mixing was evidenced by testing production ability and aggregate batching started. Mixing duration was determined on the grounds of testing homogenous composition of concrete. Drum door opens in semiautomatic order and concrete goes into the mixer. Mixer door closes in semiautomatic order when the complete quantity of concrete is emptied from mixer drum into mixer.

5. Delivery (transportation) of concrete

Concrete transportation from the concrete batching plant to Ivan tunnel was executed by two mixer trucks. Mixer trucks were coordinated in such a manner that while one truck was filled at the plant, the other was parked behind it. The other mixer truck started to take concrete as soon as the first one finished. Full mixer trucks drove to the construction site which was approximately 20 minutes away, where the concrete was pumped into a mixer of 15 m^3 which was mounted on a cargo carriage of Regs series. The pumping was direct from a mixer over the extended hopper.

Figure 6. - Mixer mounted on a cargo carriage of Regs series

Mikser koji je bio na vagonu u ljetnom razdoblju obvezno se morao rashlađivati prije prepumpavanja betona, kako prevelika vrućina ne bi prouzrokovala skupljanje betona i kako bi se spriječila prebrza dehidracija betona. Nakon prepumpavanja betona u mikser na vagonu isti je transportiran u tunel na mjesto ugradnje TMD pružnim vozilom. Obzirom da su radovi izvođeni pod zatvorom pruge u neprekidnom vremenskom razdoblju od 30h i da su počinjali u 11h, proces ugradnje betona se odvijao u toku noći od 21h do 3h ujutro. Transport betona od trenutka miješanja na betonari do početka ugradnje je trajao oko 1÷1,5h.

Slika 7. Beton transportiran do mjesta ugradnje

6. Određivanje konzistencije svježeg betona metodom slijeganja (slump test)

Konzistencija betona utvrđuje se metodom slijeganja prema BAS EN 12350-2 i provodi se kako na betonari prije nego beton krene na gradilište, tako i na mjestu ugradnje betona. U slučaju gustog betona na samom mjestu ugradnje dodavao se odgovarajući superplastifikator po uputama odgovornog tehnologa ali samo u slučaju da nije prošlo više od 1,5 sati od vremena miješanja betona, s tim da je se posebna pažnja posvetila sljedećem:

- za svako dodavanje kemijskog dodatka na gradilištu zabilježeni su podaci o trenutnoj konzistenciji dobavljenog betona, starosti betona i dodatnoj potrebnoj količini kemijskog dodatka. Poslije miješanja ponovo su izmjerene karakteristike svježeg betona i to zabilježeno.

The mixer which was mounted on a carriage had to be cooled during the summer before pumping of concrete in order to prevent concrete contracting caused by excessive heat and too fast dehydration of the concrete. After the concrete was pumped into a mixer on a carriage it was transported into the tunnel to the location of placing by TMD rail vehicle. As the works were executed when traffic was closed during an uninterrupted time period of 30 hours beginning at 11:00 o'clock, the process of concrete placing was performed during the night from 21:00 o'clock till 3:00 o'clock in the morning. The transportation of concrete from the moment of mixing in the plant to the start of placing was about 1 to 1.5 hours.

Figure 7. - Concrete transported to the location of placing

6. Determining consistency of fresh concrete by slump test method

Concrete consistency was determined by slump test according to BAS EN 12350-2 and was done both in the plant before the concrete started towards the construction site and at the location of concreting. If concrete was too thick, a relevant superplasticizer was added at the very location of concreting, according to the instructions of a responsible laboratory technician, but only in case that the period of 1.5 hours from the original mixing of concrete was not exceeded, and special attention was paid to the following:

- For each addition of chemical additive on the site, the data were recorded on a current consistency of delivered concrete, age of concrete and necessary additional quantity of chemical additive. The features of fresh concrete were measured again after mixing and they were recorded.

- poslije dodavanja kemijskog dodatka beton je se morao adekvatno umiješati i to sa većom brzinom okretanja bubnja, najmanje 1min. na 1m3.

Nakon transporta betona na gradilište a prije samog prepumpavanja laborant je provjeravao konzistenciju betona metodom slijeganja (slump test) i nakon toga odobravao ili ne odobravao prepumpavanje istog u mikser na vagonu.

Za provjeru konzistencije laborant je osiguravao sljedeća ispitna sredstva:

- Kalup za formiranje ispitnog uzorka (prema BAS EN 12350-2);
- Šipka za zbijanje promjera (16±1) mm i dužine (600±5) mm sa zaobljenim krajevima,prema BAS EN 12350-2;
- Metar, 0-300 mm;
- Bazna ploča na koju se stavlja kalup;
- Posuda za ponovno miješanje;
- Kvadratna lopata;
- Vlažna krpa;
- Lopatica široka približno 100 mm;
- Timer ili sat koji može mjeriti do 1s.

Prije početka ispitivanja sva ispitna sredstva su bila pripremljena, izvršen njihov pregled i ustanovljena njihova ispravnost. Nakon toga laborant je uzimao uzorak za ispitivanje usklađen sa normom BAS EN 12350-1. Uzima se najmanje 1,5 puta veća količina od procijenjene za ispitivanje. Uzorak se ponovo izmiješa upotrebom posude za ponovno miješanje i kvadratne lopate. Sam postupak određivanja konzistencije betona laborant je izvršavao sukladno normi BAS EN 12350-2.

7. Ugradnja betona

Ugradnja betona klase C25/30 u tunelu Ivan vršena je pomoću stacionarne pumpe i horizontalno položenih cijevi. Maksimalna dužina horizontalno položenih cijevi je bila 70m. Prije ugradnje betona obavezno je vršena kontrola svih potrebnih karakteristika svježeg betona kao i otpremnog lista, kojeg je morao imati svaki mikser, koji je na gradilište dostavljao beton. Betoniranje se izvodilo u dva sloja, u prvom sloju je betoniran dio ploče ispod pragova debljine cca 14cm, a u drugom sloju dio ploče između pragova. Za zbijanje betona korištena su dva previbratora sa iglama promjera Φ 70mm. Površinska obrada betona urađena je ručnim zaglađivanjem.

- After batching the chemical additive, the concrete had to be adequately mixed with greater drum rotating speed, at least for 1 minute per 1 m^3.

After the transportation of concrete to the site and before pumping into another mixer, the laboratory technician checked the consistency of concrete by slump test and afterwards he approved or disapproved of pumping the concrete into the mixer mounted on a carriage.

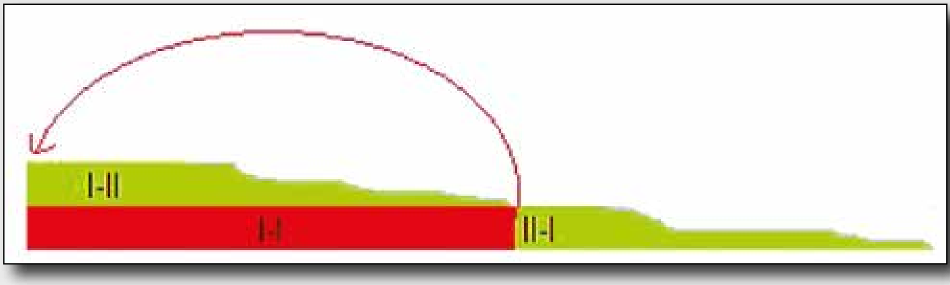
In order to check the consistency, the laboratory technician provided the following testing equipment:

- Mould for forming the testing sample (according to BAS EN 12350-2);
- Compacting rod diameter (16±1) mm and (600±5) mm long with rounded ends, according to BAS EN 12350-2;
- Meter, 0-300 mm;
- Base slab for placing the mould;
- Container for repeated mixing;
- Square spade;
- Dump cloth;
- Shovel approximately 100 mm wide;
- Timer or watch that can measure up to 1s.

Prior to the commencement of testing, all testing equipment was prepared, examined and their functionality ascertained of. After that the laboratory technician took a testing sample in conformity with BAS EN 12350-1. The amount to be taken should be at least 1.5 times larger than the quantity estimated as necessary for testing. The sample was mixed again using a square spade and a container for repeated mixing. The procedure of determining the concrete consistency was performed in conformity with the standard BAS EN 12350-2.

7. Concrete placing

Placing Class C25/30 concrete in Ivan tunnel was executed by a stationary pump and horizontally placed pipes. Maximum length of horizontal pipes was 70 m. Prior to the concreting, the compulsory control of all necessary features of fresh concrete was conducted. Dispatch note, which was obligatory for each mixer truck which delivered concrete to the site, was checked. The concreting was executed in two layers; the part of the slab under sleepers approximately 14 cm thick was concreted in the first layer, and a part of the slab between sleepers in the second. The concrete was compacted with two pre-vibrators with rods of 70 mm in diameter. Surface of the concrete was treated by manual smoothing.



Slika 8. Shema betonaže

Da bi se eliminirali nepovoljni utjecaji uslijed deformacija skupljanja betona kako je projektom i predviđeno na svakih šest metara izvedene su dilatacijske spojnice. Zatvaranje dilatacijskih spojnica izvršeno je pomoću trajno elastičnog kita.

Slika 9. Ugrađen i površinski obrađen beton

8. Uzorkovanje betona

Uzorkovanje betona vršeno je prema planu uzorkovanja iz projekta betona za tunel Ivan. Odgovornost za uzimanje uzoraka betona na gradilištu bila je na radniku zaposlenom na radnom mjestu laborant, kao i vođenje i popunjavanje izvještaja kojim je popraćen svaki uzeti uzorak. Uzorkovanje se provodilo prema normi BAS EN 12350-1:1999. Nakon uzorkovanja uzorci su prvih 10h njegovani u istim uslovima kao i AB ploča to iz razloga da bi dobili realne rezultate čvrstoće AB ploče. Poslije isteka 10 sati od zadnje ugrađenog betona kocke se premještaju u laboratoriju gdje se na 3 kocke odmah utvrđivala tlačna čvrstoća betona prema normi BAS EN 12390-3, a ostale njegovale prema BAS EN 12390-2 – Izrada i njegovanje uzoraka za ispitivanje čvrstoće do isteka 28 dana.

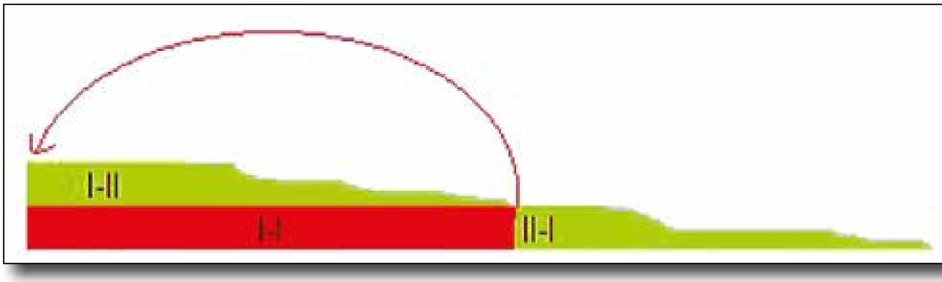


Figure 8. - Concreting scheme

In order to eliminate adverse impacts caused by the deformation of concrete contracting as anticipated in the project, expansion joints were executed after each six meters of concreting. The shutting of extension joints was executed by permanent flexible putty.

Figure 9. - Placed concrete with treated surface

8. Concrete sampling

Concrete sampling was executed according to the sampling plan from a concrete project for Ivan tunnel. The worker employed at the position of laboratory technician was responsible for taking samples of concrete on the construction site, and completing a report which followed each taken sample. Sampling was conducted according to the standard BAS EN 12350-1:1999. After sampling, the samples were cured first 10 hours in the same conditions as RC slab in order to get realistic results of RC slab hardness. After the expiry of 10 hours from the last concrete placing, the concrete cubes were moved to laboratory where the pressure hardness of the concrete was determined immediately for three cubes according to the standard BAS EN 12390-3, and the others were cured according to BAS EN 12390-2 – Creation and curing of hardness testing samples to the expiry of 28 days.

Slika 10. Uzeti uzorci na gradilištu

9. Njega mladog betona

Nakon završetka betoniranja jedne kampade mladi beton se morao njegovati kako bi ga zaštitili od:

- Naglog isparavanja vode iz svježeg betona;
- Prebrzog hlađenja površine betona;
- Visoke i niske temperature.

Mladi beton se njegovao tako da se cijela kampada prekrivala duplom PVC folijom i geotekstilom (3. razred njege) i po potrebi vlažila gornja površina AB ploče (2. razred njege) kako bi se spriječilo naglo isparavanje vode iz svježeg betona koje može dovesti do poremećaja u procesu hidratacije, neravnomjernog očvršćivanja, smanjene čvrstoće i gustoće, pojave vlastitih napona i površinskih naprslina.

Slika 11. Njega mladog betona grijanjem pomoću topova

Figure 10. - Samples taken at the construction site

9. Young concrete curing

After one cycle was concreted, the young concrete had to be cured to protect it from:

- Sudden water evaporation out of the fresh concrete;
- Too quick cooling of the concrete;
- High and low temperatures.

The young concrete was cured by covering the whole cycle by double PVC folia and geotextile (curing of 3rd class) and if necessary by watering the upper surface of RC slab (curing of 2nd class) in order to prevent sudden water evaporation out of fresh concrete which might cause defects in the process of hydration, uneven hardening, lower hardness and density, occurrence of own tensions and surface cracks.

Figure 11. - Curing young concrete by heat using guns

S obzirom da je temperatura u tunelu Ivan bila niska i u ljetnom razdoblju (max 15°C), pored gore navedenog, mladi beton se morao dodatno zagrijavati pomoću „topova“ koji su postavljani s obje strane betonirane kampade, a koja je prethodno pokrivena PVC folijom i geotekstilom preko pomoćne privremene metalne konstrukcije.

10. Kontrola kvalitete betona

Kontrola kvalitete betona pratila je se kontinuirano, osim određivanja konzistencije i temperature betona kako na betonari tako i na gradilištu, redovno se uzimao i minimalni broj uzoraka predviđen prema projektu betona. Uzimanje uzoraka, priprema ispitnih uzoraka i ispitivanje karakteristika svježeg betona provodi se prema normama BAS EN 12350, a ispitivanje karakteristika očvrslog betona prema normama niza BAS EN 12390.

Slika 12. AB ploča u tunelu Ivan

Since the temperature in Ivan tunnel was low even in summer period (maximum 15°C), besides the previously mentioned measures, the young concrete had to be additionally heated by the "guns" which were positioned on both sides of the concreted cycle, which had previously been covered by PVC folia and geotextile over additional temporary metal framework.

10. Concrete quality control

Concrete quality control was conducted continuously, besides determining its consistency and temperature both in the plant and on the construction site, a minimum number of samples was regularly taken as planned by the concrete project. Sampling, preparation of testing samples and testing characteristics of fresh concrete was conducted according to the standards BAS EN 12350 and testing characteristics of hardened concrete according to the standards of BAS EN 12390.

Figure 12. - RC slab in Ivan tunnel

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HERING

Mr.Sc.Ladislav Bevanda, dipl.ing.građ.
Hering d.d. Široki Brijeg

Marin Nikolić, mag.ing.građ
Hering d.d. Široki Brijeg

UTJECAJ RIZIKA NA PONUDBENU CIJENU I BUDŽET PROJEKTA KOD IZVOĐAČA GRAĐEVINSKIH RADOVA

THE IMPACT OF RISK ON BID PRICE AND PROJECT BUDGET FOR CONTRACTORS

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Mr.Sc.Ladislav Bevanda, dipl.ing.građ.
Hering d.d. Široki Brijeg

Marin Nikolić, mag.ing.građ
Hering d.d. Široki Brijeg

Sažetak

Procjena rizika je neizostavan proces u poslovanju svih a posebno onih poslovnih sustava koji se bave realizacijom projekata izvođenja radova i bitno utječe na njihovu konkurentnost i stabilnost poslovanja. Donošenje poslovnih odluka zahtjeva prepoznavanje potencijalnih rizika te procjene njihovog utjecaja na projekte i cijeli sustav. Izvođači građevinskih radova trpe značajne financijske posljedice zbog nekvalitetne procjene utjecaja rizika na formiranje njihovog budžeta projekata pri izradi ponude.

Rad prikazuje rezultate istraživanja procjene utjecaja rizika na formiranje ponudbene cijene i budžet izvođača projekta kod projekata izvođenja građevinskih radova. Prikazani rezultati identificiraju i procjenjuju utjecaje projektnih rizika na budžet izvođača pri izradi ponude u projektima izvođenja građevinskih radova koji se realiziraju obračunskom metodom „primjene jediničnih cijena prema stvarno izvedenim radovima obračunatim u skladu s građevinskom knjigom". Također se procjenjuje utjecaj ostalih poslovnih rizika na vrijednosti prijenosa potencijala organizacije (apsorpcije) koja realizira projekt izvođenja građevinskih radova na budžet projekta dajući ukupan iznos ponude.

Prilikom formiranja jediničnih cijena za ponudu izvođenja građevinskih radova implementiraju se procijenjeni utjecaji projektnih rizika na ukupne cijene rada, materijala, usluge drugih, strojeva i opreme, te općih posrednih troškova gradilišta. Implementiranje procjena utjecaja ostalih poslovnih rizika na budžet projekta provodi se procjenom utjecaja poslovnih rizika na ukupne indirektne posredne troškove poslovnog sustava koji se prenose na budžet projekta. Na ovaj način uvodi se negativni utjecaj rizika na sve komponente cijene ponude. Primjenom ovog modela procjene rizika mogu se procijeniti rezerve za rizike kod projekata izvođenja građevinskih radova u fazi ponude koje se mogu pratiti u eventualnoj realizaciji ovih projekata. Ovakva procjena rizika čini osnovu za točnije određivanje budžeta i ukupne troškove izvršenja građevinskog projekta i stabilnijeg poslovanja cijele organizacije.

Ključne riječi: upravljanje rizikom, ponudbena cijena, proračun projekta, izvođač, poslovni sustav

THE IMPACT OF RISK ON BID PRICE AND PROJECT BUDGET FOR CONTRACTORS

Mr.Sc.Ladislav Bevanda, BCE*
Hering d.d. Široki Brijeg

Marin Nikolić, MCE
Hering d.d. Široki Brijeg

Abstract

Estimate of risk is an essential process in management of all business systems, especially those which deal with execution of construction works, and it significantly affects their competitiveness and operation stability. Business decision-making requires identification of potential risks and estimation of their impact on projects and the whole system.

This paper presents the results of research of estimation of risk impact to the formation of contractor's bid price and budget for construction projects. The presented results identify and estimate project risk impact to the contractor's budget during the tender phase for execution of construction projects which are implemented by calculation method *"of applying unit prices according to really executed works calculated in accordance with the bill of quantities".*

During creation of bid price, risk project impacts apply to the total cost of labor, materials, other's services, machinery, equipment, and general indirect costs of construction site. Impact estimation of other business risks to the project budget is conducted through the impact estimation of business risks to the total indirect intermediary costs of business system which are transmitted to project budget. Negative risk impact is introduced to all components of bid price and project budget as well as the entire business system. Using this model, it is possible to estimate risk reserves for execution of construction project in tender phase, which can be monitored during potential realization of these projects. This risk estimation forms the basis for more accurate budget and total cost of the execution of construction project and more stable business of entire organization.

Keywords: risk management, bid price, project budget, contractor, business system

1. Uvod

U radu se analiziraju građevinski projekti izvođenja (dalje ‹›projekti›») i to od strane izvođača radova s aspekta rizika troškova u ugovornoj (ponudbenoj) cijeni. Građevinski poslovni sustav (uglavnom građevinski, u daljem tekstu ‹›poslovni sustav›») preuzima projekt formirajući projektni sustav za realiziranje takvog projekta. Poslovni sustav preuzima projekte, potporno utječe na projektne sustave te osigurava njihovu financijsku stabilnost te dugoročnu profitabilnost u interesu cijeloga poslovnog sustava. Projektni sustav definiran od strane poslovnog sustava u uvjetima zadane cijene, roka i kvalitete realizira izvođački projekt uz potporu poslovnog sustava (izvorne organizacije). Na početku svakog projekta postoji velika količina rizika troškova koji proizlazi iz neizvjesnosti oko načina na koji će se projekt izvoditi (*Smith N., Merna T., Jobling P., 2006*). Količina rizika također ovisi i od općeg poslovnog ambijenta u kojem se projekt realizira.

Rizik predstavlja neizvjesnost u ishod očekivanih događaja u budućnosti, odnosno on je situacija u kojoj nismo sigurni što će se dogoditi, a odražava vjerojatnost mogućih ishoda oko neke očekivane vrijednosti. Pri tome očekivana vrijednost predstavlja prosječni rezultat nepredvidivih situacija koje se opetovano ponavljaju. (*Srića, 2011*). Stanje troškova poslovnog sustava koje je poduzeo projekt i troškova projektnog sustava međusobno utječu jedan na drugi. Poslovni sustav svojom potpornom funkcijom ako je potrebno može poboljšati troškovne performanse projekta ali isto tako projektni sustav svojim stanjem troškova u realizaciji utječe na troškovno stanje i performanse poslovnog sustava. Utjecaji mogu biti pozitivni i/ili negativan. Pozitivni utjecaji su dobro došli i njih u ovom radu nećemo razmatrati. U radu će se najprije napraviti kratak pregled literature o utjecaju rizika na ponudbenu cijenu kod izvođača radova. Slijedi prikaz modela formiranja ponudbene cijene od strane izvođača građevinskih radova za projekte kod kojih se ugovoru sklapa s izvođačem koji ponudi najnižu cijenu uz tehnički zadovoljavajuću ponudu na osnovu predmjera i predračuna. Rezultatima istraživanja analizirat će se utjecaj obilježja projekta na pojavu izvora rizika te utjecaj izvora rizika na uvećanje odgovarajućeg dijela cijene prilikom formiranja ponude za izvođenje projekta odnosno potencijalnog budžeta projekta izvođača radova. Također će biti prikazani rezultati istraživanja utjecaja vjerojatnosti pojave rizika poslovnog sustava na strukturu poslovnog uspjeha cijelog sustava te utjecaja pokretača poslovnih rizika na vjerojatnost pokretanja poslovnih rizika. Ovim radom prikazat će se dakle i analizirati rezultati istraživanja utjecaja rizika na ponudbenu cijenu izvođača radova a sve u svrhu formiranja kvantitativnog modela za izračun ponudbene cijene za izvođače građevinskih radova koja bi u sebi na adekvatan način sadržavala i moguće negativne utjecaja rizika na pojedine dijelove cijene prilikom izvođenja projekta.

2. Pregled literature

Građevinarstvo je kao i mnoge druge industrije izloženo većem intenzitetu djelovanja rizika zbog jedinstvenih obilježja i složenosti građevinskih projekata poput dugog vremena izvođenja, složenih procesa, nepristupačnog okruženja, financijskog intenziteta i dinamičkih organizacijskih struktura (*Flanagan i Norman, 1993., Akintoye i MacLeod, 1997, Smith, 2003*). Stoga za izvođača građevinskih radova pravilno definiranje utjecaja rizika na cijenu izvođenja projekata predstavlja neizostavan

1. Introduction

This paper analyzes the execution of construction projects (hereinafter "projects") by contractors from cost risk aspects in the contract (bid) price. The construction business system (mainly construction, hereinafter referred to as the "business system") takes over the project by forming a project system for the realization of such a project. The business system takes over projects, supports project systems and ensures their financial stability and long-term profitability in the interests of the entire business system. The project system defined by the business system under given pricing, deadline and quality conditions realizes the construction project supported by the business system (of the original organization). At the beginning of each project there is a large amount of cost risk arising from uncertainty about the way the project will be run (*Smith et al., 2006*). The amount of risk also depends on the general business environment in which the project is realized.

The risk represents uncertainty in the outcome of expected events in the future, namely, it is a situation where we are uncertain of what will happen and it reflects the probability of possible outcomes related to some expected value. Here, the expected value is the average result of unpredictable situations frequently repeated (*Srića, 2011*). The cost of the business system taken over by the project and the cost of the project system interact with each other. If necessary, the business system with its support function can improve cost-effectiveness of a project but also the project system with its cost performance during realization affects the cost and performance of the business system. The effects can be both positive and/or negative. Positive influences are welcome and they will not be discussed in this paper. Indeed, a brief overview of the literature on impact of risk on the bid price of the contractor will be made first. The following is an overview of the model of bid price formation by contractors for projects where the contract is concluded with the contractor who offers the lowest price with a technically satisfactory offer based on the bill of quantities and pro-forma invoice. Through the results of the research we will also analyze the impact of the project's characteristics on the occurrence of risk sources and the impact of the risk sources on the increase of the appropriate share of the price when forming a bid for the project execution or the potential project budget of the contractor. It will also show the results of the study of impacts of the risk occurrence probability of a business system on the business success structure of the whole system and the impact of business risk drivers on the probability of starting business risks. This paper will therefore present and analyze the results of the research of the impact of the risk on the contractor's bid price, all with the purpose of forming a quantitative model for the calculation of the bid price for construction works contractors, which would adequately contain the possible negative effects of the risk on certain parts of the price during a project execution.

2. Literature overview

Construction, as well as many other industries, is exposed to greater intensity of risk impact due to the unique features and complexity of construction projects such as long running times, complex processes, inaccessible environments, financial intensity and dynamic organizational structures (*Flanagan and Norman, 1993, Akintoye and MacLeod, 1997, Smith, 2003*). Consequently, the proper definition of the impact of risk on the cost of the execution of projects represents an indispensable dio uspješno izvedenih građevinskih projekta. Izvođači su tradicionalno koristili visoke premije za pokriće pojave eventualnih rizika prilikom izvođenja radova, ali kako je konkurencija postala snažnija, ovaj pristup više nije mogao biti učinkovit (*Baloi and Price, 2003*). Kao standard u stručnoj literaturi postavljeno je da izvođači u svojim ponudbenim cijenama obično uključuju skrivenu premiju za rizik (*Hackett i dr, 2007*). Dosadašnja istraživanja su pokazala da premije rizika čine oko 0-5% cijene ponuđača za izvođenje građevinskih radova (*Neufville i King, 1991; Shash, 1993; Smith i Bohn, 1999*).

U posljednjem razdoblju formiran je značajan broj formalnih i analitičkih modela utjecaja rizika na cijenu radova koji izvođači mogu uključiti u postupak određivanja cijene prilikom spremanja ponude za izvođenje radova (npr. fuzzy set model formiran od strane Zenga i dr., 2007; fuzzy logic-based artificial neural network mode formiran od strane Liu i Ling, 2005, fuzzy set model formiran od strane Paek i sur., 1993, fuzzy set model formiran od strane Taha i sur., 1993, i tehnika utemeljena na dijagramu utjecaja Al-Bahar i Crandall, 1990) (*Laryea i Hughes, 2011*). Međutim, način na koji izvođači zapravo izračunavaju utjecaj rizika na formiranje ponudbene cijene nije jasno artikuliran u građevinskoj literaturi (*Laryea i Hughes, 2008*). Također, nekoliko empirijskih studija provedenih među izvođačima građevinskih radova pokazalo je da se ovi modeli vrlo rijetko koriste u praksi.

3. Formiranje ponudbene cijene

U nastavku će se prikazati formiranje jedinične cijene prilikom formiranja ponude za izvođenje građevinskih radova koje će uključivati utjecaje rizika na iznose jediničnih cijena.

U istraživanju su analizirani projekti koje izvođač pribavlja kroz proces nabave ugovora na natječajima po kriteriju najniže cijene i tehnički zadovoljavajuće ponude, što je na našem tržištu izvođenja građevinskih radova najčešći slučaj. Stoga, prevelika rezervacija za rizike troškova projekta i troškove poslovnog sustava može uzrokovati neuspjehom na natječaju i izostankom ugovora, a premale rezervacije za rizike u pravilu uzrokuju gubitke u prihvaćenim ugovorima iz projektnog budžeta, a što se uglavnom posljedično s vremenom prenese na poslovni sustav i ugrozi ga, po zakonu spojenih posuda. Isto se može dogoditi i s rizicima poslovnog sustava koji može ugroziti projektne budžete izostankom adekvatne „potporne" funkcije u smislu sredstava, novca, logistike i resursa.

Većina današnjih ponuda za izvođenje građevinskih radova formira se na osnovu predmjera i predračuna. Iz toga možemo zaključiti da se i prihodi izvođača građevinskih radova uglavnom realiziraju prema takvim ugovorima. To podrazumijeva da se vrijednost izvršenja izračunava kao suma umnožaka pojedinih količina stavki troškovnika $k_{i,j}$ (količina»i"-te stavke projekta ''j"-og troškovnika) i najčešće sveobuhvatne jedinične cijene $c_{i,j}$ (comprehensive unit price) za pojedini projekt ''j" (1):

$$c_{pr,j} = \sum_i k_{i,j} * c_{i,j} \quad \textbf{(1)}$$

Prihod poslovnog sustava za sve projekte u nekom portfoliju je zbroj „j" takvih prethodnih projektnih kombinacija količina i cijena:

$$\sum_i c_{pr,j} = \sum_i \sum_j k_{i,j} * c_{i,j}$$

part of successful construction projects for the contractor of construction works. Contractors have traditionally used high premiums to cover possible risks when conducting works, but as competition became more powerful, this approach could no longer be effective (*Baloi and Price, 2003*). It is accepted as a standard in the professional literature, that contractors usually include a hidden risk premium in their bid prices (*Hackett et al., 2007*). Previous research has shown that risk premiums make up about 0-5% of the tenderers' bid price for carrying out construction works (*Neufville and King, 1991; Shash, 1993; Smith and Bohn, 1999*).

A significant number of formal and analytical models of price risk impacts have been formed, which can be used by contractors in cost-pricing procedures when preparing a bid for works (eg. Fuzzy set model by Zenga et al., 2007; Fuzzy logic-based Artificial neural network mode by Liu and Ling, 2005, Fuzzy set model by Paek et al., 1993, a fuzzy set model formed by Taha et al., 1993, and techniques based on the Al-Bahar and Crandall influence diagram, 1990) (*Larye and Hughes, 2011*). However, the way in which contractors actually calculate the impact of risk on the formation of a bid price is not clearly articulated in construction literature (*Larye and Hughes, 2008*). Several empirical studies carried out by construction contractors have also shown that these models are rarely used in practice.

3. Forming a bid price

Below, the unit price formation will be shown when forming a bidding offer for construction works, which will include risk impacts on unit price amounts.

The research analyzes projects that a contractor obtains through a procurement process in tendering procedures according to the lowest price criterion and technically satisfactory bids, which is most common in our construction works market. Therefore, too large provisioning for project cost risks and business system costs can cause failure in the tendering process and the absence of a contract, whereas too small provisioning for risks will, as a rule, lead to losses in accepted contracts from the project budget, which is largely consequently transmitted to the business system endangering it by the time. The same can happen with business system risks that can endanger project budgets by not providing adequate "support" in terms of funds, money, logistics, and resources.

Most of today's bids for construction works are based on bill of quantities and pro-forma invoice. Consequently, we can conclude that the revenues of construction contractors are mostly realized through such contracts. This implies that the value of execution is calculated as the sum of the multiplications of individual quantities of items in the bill of quantities $k_{i,j}$ (quantity of 'i'-item of bill of quantites of project 'j'), and the most comprehensive unit price $c_{i,j}$ for an individual project 'j' (Đukan, *1986*) (1):

$$c_{pr,j} = \sum_i k_{i,j} * c_{i,j} \quad \textbf{(1)}$$

The business system revenue for all projects in a portfolio is the sum of "j" of such prior project combinations of quantities and prices:

$$\sum_i c_{pr,j} = \sum_i \sum_j k_{i,j} * c_{i,j}$$

Stavke troškovnika nisu ni aktivnosti plana, nisu ni raščlanjene strukture troškova (cost breakdown structure). One kao takve ne mogu poslužiti ni za formiranje raščlanjene strukture rizika troškova izvođačevog projekta (risk breakdown structure).

Ugovorna (ponudbena) cijena za takve projekte iskazuje se kao $c_{pr,j} = \sum_i k_{i,j} * c_{i,j}$, iako se u suštini sastoji od budžeta projekta $BP_{p,j}$ (troškovi projektnog sustava) na koji se dodaje dio indirektnog troška poslovnog sustava $\Delta IC_{tr,j,pos}$ koji provodi projekt (General Overhead) (prijenos potencijala poslovnog sustava u ugovornu cijenu za realizaciju projekta).

$$c_{pr,j} = BP_{p,j} + \Delta IC_{tr,j,pos} = \sum_i k_{i,j} + c_{i,j}$$

Značajno je razlikovati negativne utjecaje rizika na troškove projektnog i poslovnog sustava kako se ne bi taj utjecaj općenito tretirao kao neki ‹‹lump sum››. Za građevinsku organizaciju je veoma važna mogućnost razdvajanja rizika negativnih utjecaja na troškove projekta od rizika negativnih utjecaja na troškovno stanje poslovnog sustava (organizacije) kako bi se mogle identificirati odgovornosti i nositelji rizika, jer oni nisu isti u projektnom i poslovnom sustavu.

Sljedećom analizom prikazat će se jedan od načina identificiranja okvirnih raščlanjenih struktura troškova projektnog sustava i poslovnog sustava, koja bi mogla poslužiti za sagledavanje njihovih međusobnih utjecaja, kao i utjecaja oba na ponudbenu (ugovornu) cijenu. Prethodno opisan ukupan prihod iz projekata ostvaruje se kako slijedi (2):

$$U_{pp} = \sum_i c_{p,j} = \sum_j \sum_i k_{i,j} * c_{i,j} = \sum_j \sum_i BP_{p,j} * IC_{p,j} \quad \textbf{(2)}$$

$$IC_{tr,pos} = \sum_j \Delta IC_{tr,j,pos}$$

Budžet projekta ''j'' sastoji se od direktnih troškova $Dt_{i,j}$ (rad, materijal, usluge drugih, strojevi pojedinačnih izvršenja stavke ''i'' predmjera i predračuna projekta ''j'') (3) i općih troškova gradilišta / projekta ''j'' ($GC_{tr,gr,j}$).

$$BP_j = \left(Dt_{i,j}\right) + \left(CG_{tr,gr,j}\right)$$

$$Dt_{i,j} = \sum_i k_{j,i} * r_{j,i} + \sum_i k_{j,i} * m_{j,i} + \sum_i k_{j,i} * u_{j,i} + \sum_i k_{j,i} * s_{j,i}$$

$$Dt_{j,i} = \sum_i k_{j,i} * \left(r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i}\right) \quad \textbf{(3)}$$

Zahtjev poslovanja je da su prihodi veći od troškova (4):

$$U_{pp} \geq \sum_i c_{p,j} \geq \sum_i BP_{p,j} + IC_{tr,pos}$$

$$\sum_i c_{p,j} = \sum_j \sum_i k_{i,j} * c_{i,j} \geq \sum_j BP_{p,j} + IC_{tr,pos} \quad \textbf{(4)}$$

Količine su u izvođenju građevinskih radova uglavnom mjerljive a cijene fiksne, te je prihod odnosno primitc $U_{pp} = \sum_i c_{p,j} = \sum_j \sum_i k_{i,j} * c_{i,j}$ uglavnom izvjesni i pouzdani, a troškovi i izdaci neizvjesni i nepouzdani zbog opterećenja uslijed utjecaja rizika. Ovako dolazimo do osnovnog pitanja koje se obrađuje u ovom radu a to je implementiranje utjecaja rizika u ugovornu cijenu a sve u cilju ostvarenja temeljnoga zahtijeva poslovanja.

$$\sum_j \sum_i k_{i,j} * c_{i,j} = \left(Dt_{i,j}\right) + \left(GC_{tr,gr,j}\right)$$

Items of bill of quantities are neither the plan activities, nor the cost breakdown structures. As such, they cannot even be used to form a risk breakdown structure of the costs of the contractor's project.

The contractual (bid) price for such projects is expressed as $c_{pr,j} = \sum_i k_{i,j} * c_{i,j}$, although essentially it consists of the budget of the $BP_{p,j}$ project (Project system costs) to which it is necessary to add a part of the indirect cost of the business system $\Delta IC_{tr,j,pos}$, which executes the project (General Overhead) (transferring the business system potentials to the contract price for project realization).

$$c_{pr,j} = BP_{p,j} + \Delta IC_{tr,j,pos} = \sum_i k_{i,j} + c_{i,j}$$

It is important to distinguish the negative impact of risk on the cost of the project and business system so that this impact would not generally be treated as a "lump sum". For a construction organization, it is very important to be able to distinguish the risk of negative impacts on project costs from the risk of negative impacts on the cost of the business system (organization) so that it is possible to identify the responsibilities and risk carriers, because they are not the same in the project and business systems.

The following analysis will show one of the ways of identifying general analyzed structures of project system and business system costs, which could serve to reflect their mutual influence as well as the impact of both of them to the bid (contractual) price. The project revenue described above is realized as follows (2).

$$U_{pp} = \sum_i c_{p,j} = \sum_j \sum_i k_{i,j} * c_{i,j} = \sum_j \sum_i BP_{p,j} * IC_{p,j} \tag{2}$$

$$IC_{tr,pos} = \sum_j \Delta IC_{tr,j,pos}$$

The budget of the project "j" consists of the direct costs $Dt_{i,j}$ (work, materials, services of others, machines of individual execution of the item "i" of project bill of quantities and pro-forma invoice "j") (3) and the general costs of the construction site / the project '"j" ($GC_{tr,gr,j}$).

$$BP_j = \left(Dt_{i,j}\right) + \left(CG_{tr,gr,j}\right)$$

$$Dt_{i,j} = \sum_i k_{j,i} * r_{j,i} + \sum_i k_{j,i} * m_{j,i} + \sum_i k_{j,i} * u_{j,i} + \sum_i k_{j,i} * s_{j,i}$$

$$Dt_{j,i} = \sum_i k_{j,i} * \left(r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i}\right) \tag{3}$$

The business requirement is that revenues are higher than costs (4):

$$U_{pp} \geq \sum_i c_{p,j} \geq \sum_i BP_{p,j} + IC_{tr,pos}$$

$$\sum_i c_{p,j} = \sum_j \sum_i k_{i,j} * c_{i,j} \geq \sum_j BP_{p,j} + IC_{tr,pos} \tag{4}$$

In the case of construction works, the quantities are usually measurable and the prices are fixed, thus the income, namely revenues are largely certain and reliable, whereas costs and expenditures are uncertain and unreliable due to risk-based burdens. Thus, we come to the basic question that is addressed in this paper, which is the implementation of the risk impact in the contract price, all in order to achieve the basic business requirement.

$$\sum_j \sum_i k_{i,j} * c_{i,j} = \left(Dt_{i,j}\right) + \left(GC_{tr,gr,j}\right)$$

$$Dt_{j,i} = \sum_i k_{j,i} * (r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i})$$

Ponudbeni i ugovorni iznosi $\sum_j \sum_i k_{i,j} * c_{i,j} = (Dt_{i,j}) + (GC_{tr,gr,j})$ procjenjuju se u vrijeme izrade ponude a prije ugovaranja dok se stvarni troškovi $Dt_{j,i} = \sum_i k_{j,i} * (r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i})$ i $GC_{tr,gr,j}$ događaju u kasnijem vremenu koje može biti različito od planiranog i za više godina.

U ovom istraživanje sa aspekta rizika ne govorimo o slučajevima rizika koji se na bilo koji način mogu ‹‹kompenzirati›› tj. o rizicima koje izvođač po prirodi posla ima pravo potraživati ako je tako ugovoreno. Analiziramo dakle rizike koji ni u kojem slučaju neće izvođaču biti nadoknađeni, kompenzirani, odnosno u svakom slučaju moraju biti rezervirani u cijeni.

U sljedećem dijelu rada prikazani su identificirani, za analizu rizika srodni, cost breakdown structure, resources breakdown structure i risk breakdown structure. Slijede izrazi za identificirane projektne troškove i ukupne troškove u poslovnom sustavu:

Iz izraza za ukupne prihode poslovnog sustava (2) izvođenjem dolazimo do izraza za identificirane projektne troškove (5).

$$U_{pp} = \sum_j c_{p,j} = \sum_j BP_{p,j} + IC_{tr,pos} \quad \textbf{(2)}$$

$$\sum_j cp_j * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = \sum_j BP_{p,j}$$

$$\left[\sum_j \left(\sum_i k_{i,j} * c_{i,j}\right)\right] * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = \sum_j BP_{p,j}$$

$$c_{p,j} * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = BP_{p,j}$$

$$\left(\sum_i k_{i,j} * c_{i,j}\right) * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = BP_{p,j}$$

$$c_{p,j} = BP_{p,j} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$c_{p,j} = \left(\sum_i k_{i,j} * c_{i,j}\right) = BP_{p,j} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right] \quad \textbf{(5)}$$

Daljnjom analizom prikazanih izraza dolazimo do izraza za ukupne troškove poslovnog sustava (6)

$$\left(\sum_i k_{i,j} * c_{i,j}\right) + \Delta IC_{tr,j,pos} = BP_{p,j} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$\Delta IC_{tr,j,pos} = BP_{p,j} * \left\{\left[\frac{1}{\left(\frac{U_{pp} - IC_{tr,pos}}{U_{pp}}\right)}\right] - 1\right\}$$

$$Dt_{j,i} = \sum_i k_{j,i} * (r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i})$$

Bidding and contractual amounts $\sum_j \sum_i k_{i,j} * c_{i,j} = (Dt_{i,j}) + (GC_{tr,gr,j})$ are estimated at the time of bidding and before contracting whereas the real costs $Dt_{j,i} = \sum_i k_{j,i} * (r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i})$ and $GC_{tr,gr,j}$ occur at a later time that may be different than the planned by several years.

In this risk-based study, we are not talking about risk cases that can be "compensated" in any way, that is, the risks that the contractor is naturally entitled to claim if so agreed. We therefore analyze the risks that in no event will be indemnified, compensated, and in any case they have to be included in the price.

The following section presents and identifies related risk analysis, cost breakdown structure, resource breakdown structure and risk breakdown structure. The following are the terms for identified project costs and total business system costs:

From the term for total business system revenue (2), we come up to the term for identified project costs (5).

$$U_{pp} = \sum_j c_{p,j} = \sum_j BP_{p,j} + IC_{tr,pos} \qquad \textbf{(2)}$$

$$\sum_j cp_j * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = \sum_j BP_{p,j}$$

$$\left[\sum_j \left(\sum_i k_{i,j} * c_{i,j}\right)\right] * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = \sum_j BP_{p,j}$$

$$c_{p,j} * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = BP_{p,j}$$

$$\left(\sum_i k_{i,j} * c_{i,j}\right) * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = BP_{p,j}$$

$$c_{p,j} = BP_{p,j} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$c_{p,j} = \left(\sum_i k_{i,j} * c_{i,j}\right) = BP_{p,j} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right] \qquad \textbf{(5)}$$

By further analyzing the terms shown, we come to terms for total business system costs (6)

$$\left(\sum_i k_{i,j} * c_{i,j}\right) + \Delta IC_{tr,j,pos} = BP_{p,j} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$\Delta IC_{tr,j,pos} = BP_{p,j} * \left\{\left[\frac{1}{\left(\frac{U_{pp} - IC_{tr,pos}}{U_{pp}}\right)}\right] - 1\right\}$$

$$\Delta IC_{tr,j,pos} = BP_{p,j} * \left\{\left[\frac{1}{(U_{pp}-IC_{tr,pos})}\right] - \left(\frac{U_{pp}-IC_{tr,pos}}{U_{pp}-IC_{tr,pos}}\right)\right\}$$

$$\Delta IC_{tr,j,pos} = BP_{p,j} * \frac{IC_{tr,pos}}{U_{pp}-IC_{tr,pos}} = BP_{p,j} * \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}$$

$$\sum_j \Delta IC_{tr,j,pos} = \left(\sum_j BP_{p,j}\right) * \frac{IC_{tr,pos}}{U_{pp}-IC_{tr,pos}} = \left(\sum_j BP_{p,j}\right) * \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}$$

$$IC_{tr,j,pos} = \sum_j \Delta IC_{tr,j,pos} = \left(\sum_j BP_{p,j}\right) * \frac{IC_{tr,pos}}{U_{pp}-IC_{tr,pos}} = \left(\sum_j BP_{p,j}\right) * \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}$$

$$\sum_i c_{p,j} = \sum_j BP_{p,j} + IC_{tr,pos}$$

$$\sum_i c_{p,j} = \sum_j BP_{p,j} + \left(\sum_j BP_{p,j}\right) * \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}$$

$$\sum_i c_{p,j} = \sum_j BP_{p,j} * \left\{1 + \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}\right\}$$

$$\sum_i c_{p,j} = \sum_j BP_{p,j} * \left\{\frac{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]} + \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}\right\}$$

$$\sum_j c_{p,j} = \sum_j BP_{p,j} * \left\{\frac{1}{\left[1-\frac{1}{\left(\frac{U_{pp}}{IC_{tr,pos}}\right)}\right]}\right\} = \sum_j BP_{p,j} * \frac{U_{pp}}{U_{pp}-IC_{tr,pos}}$$

$$\sum_j c_{p,j} = \sum_j BP_{p,j} * \frac{1}{1-\frac{IC_{tr,pos}}{U_{pp}}} \qquad \textbf{(6)}$$

$$c_{p,j} = BP_{p,j} * \left[\frac{1}{1-\left(\frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$BP_j = \left(Dt_{i,j}\right) + \left(CG_{tr,gr,j}\right)$$

$$Dt_{i,j} = \left(\sum_i k_{j,i} * r_{j,i} + \sum_i k_{j,i} * m_{j,i} + \sum_i k_{j,i} * u_{j,i} + \sum_i k_{j,i} * s_{j,i}\right)$$

$$Dt_{i,j} = \sum_i k_{j,i} * dt_{j,i}$$

$$dt_{j,i} = \left(r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i}\right)$$

$$\Delta IC_{tr,j,pos} = BP_{p,j} * \left\{\left[\frac{1}{(U_{pp}-IC_{tr,pos})}\right] - \left(\frac{U_{pp}-IC_{tr,pos}}{U_{pp}-IC_{tr,pos}}\right)\right\}$$

$$\Delta IC_{tr,j,pos} = BP_{p,j} * \frac{IC_{tr,pos}}{U_{pp}-IC_{tr,pos}} = BP_{p,j} * \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}$$

$$\sum_j \Delta IC_{tr,j,pos} = \left(\sum_j BP_{p,j}\right) * \frac{IC_{tr,pos}}{U_{pp}-IC_{tr,pos}} = \left(\sum_j BP_{p,j}\right) * \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}$$

$$IC_{tr,j,pos} = \sum_j \Delta IC_{tr,j,pos} = \left(\sum_j BP_{p,j}\right) * \frac{IC_{tr,pos}}{U_{pp}-IC_{tr,pos}} = \left(\sum_j BP_{p,j}\right) * \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}$$

$$\sum_i c_{p,j} = \sum_j BP_{p,j} + IC_{tr,pos}$$

$$\sum_i c_{p,j} = \sum_j BP_{p,j} + \left(\sum_j BP_{p,j}\right) * \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}$$

$$\sum_i c_{p,j} = \sum_j BP_{p,j} * \left\{1 + \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}\right\}$$

$$\sum_i c_{p,j} = \sum_j BP_{p,j} * \left\{\frac{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]} + \frac{1}{\left[\left(\frac{U_{pp}}{IC_{tr,pos}}\right)-1\right]}\right\}$$

$$\sum_j c_{p,j} = \sum_j BP_{p,j} * \left\{\frac{1}{\left[1-\frac{1}{\left(\frac{U_{pp}}{IC_{tr,pos}}\right)}\right]}\right\} = \sum_j BP_{p,j} * \frac{U_{pp}}{U_{pp}-IC_{tr,pos}}$$

$$\sum_j c_{p,j} = \sum_j BP_{p,j} * \frac{1}{1-\frac{IC_{tr,pos}}{U_{pp}}}$$

(6)

$$c_{p,j} = BP_{p,j} * \left[\frac{1}{1-\left(\frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$BP_j = \left(Dt_{i,j}\right) + \left(CG_{tr,gr,j}\right)$$

$$Dt_{i,j} = \left(\sum_i k_{j,i} * r_{j,i} + \sum_i k_{j,i} * m_{j,i} + \sum_i k_{j,i} * u_{j,i} + \sum_i k_{j,i} * s_{j,i}\right)$$

$$Dt_{i,j} = \sum_i k_{j,i} * dt_{j,i}$$

$$dt_{j,i} = \left(r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i}\right)$$

$$Dt_{i,j} = \sum_i k_{j,i} * (r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i})$$

Kako smo već naveli izvođač iz jediničnih cijena i količina radova formira budžet eventualnog projekta.

Budžet projekta kod izvođača radova standardno se formira kao suma cijene rada radnika (R_j), cijene materijala (M_j), usluga drugih (U_j), strojeva i opreme (S_j) te općeg troška projekta odnosno gradilišta (GC_j) (7). Svaki projekt ima za sebe opće troškove gradilišta/projekta koji je posredan.

$$B_{p,j} = \{[(R_j) + (M_j) + (U_j) + (S_j)] + (GC_j)\} \quad \textbf{(7)}$$

$$c_{p,j} = \left(\sum_i k_{i,j} * c_{i,j}\right) = B_{p,j} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$(R_j) = \sum_i k_{j,i} * r_{j,\boldsymbol{i}}$$

$$(M_j) = \sum_i k_{j,i} * m_{j,i}$$

$$(U_j) = \sum_i k_{j,i} * u_{j,i}$$

$$(U_j) = \sum_i k_{j,i} * u_{j,i}$$

Iz izraza za budžet projekta također se može formirati izraz za izračun projektnih troškova (9) odnosno troškova poslovnog sustava (8).

$$\left(\sum_i k_{i,j} * c_{i,j}\right) = \{[(R_j) + (M_j) + (U_j) + (S_j)] + (GC_j)\} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$U_{pp} - IC_{tr,pos} = \sum_J c_{p,j} - IC_{tr,pos} = \sum_j BP_{p,j}$$

$$U_{pp} * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = \sum_j c_{p,j} * \left(1 - \frac{IC_{tr,pos}}{\sum_j c_{p,j}}\right) = \sum_j BP_{p,j}$$

$$\sum_j c_{p,j} = \left(\frac{1}{\left(1 - \frac{IC_{tr,pos}}{\sum_j c_{p,j}}\right)}\right) * \sum_j BP_{p,j}$$

$$\left(\sum_i k_{i,j} * c_{i,j}\right) = \{[(R_j) + (M_j) + (U_j) + (S_j)] + (GC_j)\} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$\sum_j c_{p,j} = \left(\frac{1}{\left(1 - \frac{IC_{tr,pos}}{\sum_j c_{p,j}}\right)}\right) * \sum_j BP_{p,j}$$

$$\sum_j c_{p,j} = \left(\sum_i k_{i,j} * c_{i,j}\right) = \left(\sum_i k_{i,j} * dt_{i,j}\right) * f_{GC,tr,gr,j} * f_{IC,tr,pos} \quad \textbf{(8)}$$

$$Dt_{i,j} = \sum_i k_{j,i} * (r_{j,i} + m_{j,i} + u_{j,i} + s_{j,i})$$

As we have already mentioned, a contractor forms the budget of any project according to unit prices and quantities of work.

The budget of the contractor's project is usually formed as a sum of the cost of labor (R_j), cost of material (M_j), others' services (U_j), machinery and equipment (S_j) and general project or site cost (GC_j). Each project has its own general indirect costs of the construction site/project.

$$B_{p,j} = \{[(R_j) + (M_j) + (U_j) + (S_j)] + (GC_j)\} \quad \textbf{(7)}$$

$$c_{p,j} = \left(\sum_i k_{i,j} * c_{i,j}\right) = B_{p,j} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$(R_j) = \sum_i k_{j,i} * r_{j,i}$$

$$(M_j) = \sum_i k_{j,i} * m_{j,i}$$

$$(U_j) = \sum_i k_{j,i} * u_{j,i}$$

$$(U_j) = \sum_i k_{j,i} * u_{j,i}$$

The term for calculation project costs (9) or business system costs (8) can also be formed from the expression for the project budget.

$$\left(\sum_i k_{i,j} * c_{i,j}\right) = \{[(R_j) + (M_j) + (U_j) + (S_j)] + (GC_j)\} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$U_{pp} - IC_{tr,pos} = \sum_J c_{p,j} - IC_{tr,pos} = \sum_j BP_{p,j}$$

$$U_{pp} * \left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right) = \sum_j c_{p,j} * \left(1 - \frac{IC_{tr,pos}}{\sum_j c_{p,j}}\right) = \sum_j BP_{p,j}$$

$$\sum_j c_{p,j} = \left(\frac{1}{\left(1 - \frac{IC_{tr,pos}}{\sum_j c_{p,j}}\right)}\right) * \sum_j BP_{p,j}$$

$$\left(\sum_i k_{i,j} * c_{i,j}\right) = \{[(R_j) + (M_j) + (U_j) + (S_j)] + (GC_j)\} * \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right]$$

$$\sum_j c_{p,j} = \left(\frac{1}{\left(1 - \frac{IC_{tr,pos}}{\sum_j c_{p,j}}\right)}\right) * \sum_j BP_{p,j}$$

$$\sum_j c_{p,j} = \left(\sum_i k_{i,j} * c_{i,j}\right) = \left(\sum_i k_{i,j} * dt_{i,j}\right) * f_{GC,tr,gr,j} * f_{IC,tr,pos} \quad \textbf{(8)}$$

$$c_{i,j} = dt_{i,j} * f_{GC,tr,gr,j} * f_{IC,tr,pos} \qquad \textbf{(9)}$$

$f_{GC,tr,gr,j}$ (10) predstavlja koeficijent općeg troška gradilišta / projekta pojedinog projekta kojim se multipliciraju direktni troškovi projekta da bi se u cijenu uključili posredno opći troškovi gradilišta / projekta. Posebno se izračunava za svaki projekt.

$f_{IC,tr,pos}$ (11) predstavlja koeficijent indirektnog troška poslovnog sustava kojim se multipliciraju budžeti projekata da bi se u cijenu uključili posredno potencijali poslovnog sustava (indirektni troškovi). Uglavnom je jedinstven za cijeli poslovni sustav.

Kako smo već naveli da se u većini građevinski ugovori realiziraju prema predmjeru i predračunu, kao sume umnožaka "$k_{i,j}$" - količina "i" te stavke projekta "j" (troškovnik , BoQ bill of quantities) i sveobuhvatne jedinične cijene "$c_{i,j}$" - comprehensive unit price je za pojedini projekt "j", izračun i implementacija općih troškova projekta/gradilišta i indirektnih troškova poslovnog sustava u jedinične cijene se vrši kako slijedi:

$$c_{pr,j} = \sum_i k_{i,j} * c_{i,j}$$

$$c_{i,j} = dt_{i,j} * f_{GC,tr,gr,j} * f_{IC,tr,pos}$$

$$c_{pr,j} = f_{GC,tr,gr,j} * f_{IC,tr,pos} * \sum_i dt_{i,j}$$

$$BP_{p,j} = f_{GC,tr,gr,j} * \sum_i dt_{i,j}$$

$$f_{GC,tr,gr,j} * \sum_i dt_{i,j} = \left(Dt_{i,j}\right) + \left(GC_{tr,gr,j}\right)$$

$$Dt_{i,j} = \left(\sum_i k_{j,i} * r_{j,i} + \sum_i k_{j,i} * m_{j,i} + \sum_i k_{j,i} * u_{j,i} + \sum_i k_{j,i} * s_{j,i}\right)$$

$$f_{GC,tr,gr,j} = 1 + \frac{\left(GC_{tr,gr,j}\right)}{\left(\sum_i k_{j,i} * r_{j,i} + \sum_i k_{j,i} * m_{j,i} + \sum_i k_{j,i} * u_{j,i} + \sum_i k_{j,i} * s_{j,i}\right)} \qquad \textbf{(10)}$$

$$f_{GC,tr,gr,j} = 1 + \frac{\left(GC_{tr,gr,j}\right)}{\left(R_j + M_j + U_j + S_j\right)}$$

$$f_{GC,tr,gr,j} = 1 + \frac{\left(GC_{tr,gr,j}\right)}{\sum_i k_{j,i} * (r_{j,i} + m_{i,j} + u_{i,j} + s_{i,j}}$$

$$f_{IC,tr,gr,j} = \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right] \qquad \textbf{(11)}$$

Kako se indirektni troškovi poslovnog sustava (12) izračunavaju kao suma ulaganje u osnovna stalna sredstva (SS), troškova funkcioniranja poslovnog sustava (HP), ulaganja u obrtna sredstva (OS) te profita koeficijent indirektnog troška poslovnog sustava deifnira se onda sljedećim izrazom (13). Na kraju dolazimo do izraza za formiranje ugovorne ponudbene cijene na osnovu budžeta projekta te koeficijenta općeg troška gradilišta (14).

$$IC_{tr,pos} = SS + HP + OS + Profit \qquad \textbf{(12)}$$

$$c_{i,j} = dt_{i,j} * f_{GC,tr,gr,j} * f_{IC,tr,pos} \quad \textbf{(9)}$$

$f_{GC,tr,gr,j}$ (10) represents the coefficient of general site/project cost of an individual project, which multiplies direct project costs in order to include the general costs of the construction site/project into the price indirectly. It is specifically calculated for each project.

$f_{IC,tr,pos}$ (11) represents the coefficient of the business system indirect cost, which multiplies project budgets in order to include the business system potentials (indirect costs) into the price indirectly. It is mostly unique for entire business system.

As we have already stated, in most construction contracts, they are realized according to bill of quantities and pro-forma invoice, as the sum of the product "$k_{i,j}$"-quantities of „i" item of the project "j" (bill of quantities, BoQ) and the comprehensive unit price"$c_{i,j}$" is for each individual project "j", the calculation and implementation of the overall cost of the project/site and the indirect costs of the business system into unit prices are as follows:

$$c_{pr,j} = \sum_i k_{i,j} * c_{i,j}$$

$$c_{i,j} = dt_{i,j} * f_{GC,tr,gr,j} * f_{IC,tr,pos}$$

$$c_{pr,j} = f_{GC,tr,gr,j} * f_{IC,tr,pos} * \sum_i dt_{i,j}$$

$$BP_{p,j} = f_{GC,tr,gr,j} * \sum_i dt_{i,j}$$

$$f_{GC,tr,gr,j} * \sum_i dt_{i,j} = (Dt_{i,j}) + (GC_{tr,gr,j})$$

$$Dt_{i,j} = \left(\sum_i k_{j,i} * r_{j,i} + \sum_i k_{j,i} * m_{j,i} + \sum_i k_{j,i} * u_{j,i} + \sum_i k_{j,i} * s_{j,i}\right)$$

$$f_{GC,tr,gr,j} = 1 + \frac{(GC_{tr,gr,j})}{(\sum_i k_{j,i} * r_{j,i} + \sum_i k_{j,i} * m_{j,i} + \sum_i k_{j,i} * u_{j,i} + \sum_i k_{j,i} * s_{j,i})} \quad \textbf{(10)}$$

$$f_{GC,tr,gr,j} = 1 + \frac{(GC_{tr,gr,j})}{(R_j + M_j + U_j + S_j)}$$

$$f_{GC,tr,gr,j} = 1 + \frac{(GC_{tr,gr,j})}{\sum_i k_{j,i} * (r_{j,i} + m_{i,j} + u_{i,j} + s_{i,j}}$$

$$f_{IC,tr,gr,j} = \left[\frac{1}{\left(1 - \frac{IC_{tr,pos}}{U_{pp}}\right)}\right] \quad \textbf{(11)}$$

As the business system's indirect costs (12) are calculated as a sum of investment in basic fixed assets (SS), business system costs (HP), investment in working capital (OS) and the profit, the coefficient of the business system's indirect cost is then defined by the following term (13). In the end, we come up with the term for forming the contract bid price based on the project budget and the coefficient of business system indirect costs (14).

$$IC_{tr,pos} = SS + HP + OS + Profit \quad \textbf{(12)}$$

$$f_{IC,tr,pos} = \frac{1}{\left\{1-\left[\frac{SS+HP+OS+Profit}{U_{pp}}\right]\right\}} \tag{13}$$

$$BP_{p,j} = \left(\sum_i k_{i,j} * dt_{i,j}\right) * f_{GC,tr,gr,j}$$

$$BP_{p,j} + \Delta IC_{tr,j,pos} = BP_{p,j} * f_{GC,tr,gr,j}$$

$$\Delta IC_{tr,j,pos} = BP_{p,j} * \left(f_{GC,tr,gr,j} - 1\right)$$

$$c_{p,j} = BP_{p,j} + BP_{p,j} * \left(f_{GC,tr,gr,j} - 1\right) \tag{14}$$

4. Metodologija istraživanja

Pregledom literature utvrđen je nedostatak modela uključivanja utjecaja rizika pri formiranju ponudbene cijene projekta od strane izvođača građevinskih radova. Zbog toga je formirana i provedena anketa među građevinskim organizacijama čiji će rezultati poslužiti u formiranju modela izračuna jedinične cijene projekta koji će u sebi imati uključene i negativne utjecaje rizika na istu. Rezultate istraživanja dobili smo na osnovu ankete provedene među 40 građevinskih organizacija za izvođenje građevinskih projekata. Za svaki od pojedinih dijelova istraživanja bit će objašnjena metodologija analize podataka i određivanja rezultata.

5. Analiza rezultata istraživanja

Općenito budžet projekta trebao bi se temeljiti na realnoj dinamici izvođenja radova, uzimajući u obzir proračun resursa, produktivnost, vremenski povezane troškove, te rizike (*Smith N., Merna T., Jobling P., 2006*).

Iz standardnog izraza za formiranja budžeta projekta (7) vidimo da on u sebi ne sadrži utjecaj eventualnih rizika koji se mogu pojaviti u tijeku izvođenja projekta na pojedinačne cijene a time i na cjelokupni budžet projekta izvođača radova.

Povećanja vrijednosti pojedinih dijelova cijene projekta od rizika su postotna povećanja osnovne cijene, minimalne, a u stvari su slučajne varijable s nekom razdiobom, ili jednostavnije slučajne varijable s beta pert razdiobom. Utjecaj obilježja projekta i projektnog okruženja na uzroke pojedinih rizika u konačnici utječe na komponente budžeta projekta. Utjecaj rizika dovodi do povećanja koštanja rada radnika, materijala, strojeva i opreme, usluga drugih, općih troškova gradilišta i projekta te se oni u izračunu računaju na sljedeći način:

R+Rr rad + utjecaj rizika na cijenu rad

M+Mr materijal + utjecaj rizika na cijenu materijala

U+Ur usluge drugih + utjecaj rizika na cijenu usluga drugih

S+Sr oprema i strojevi + utjecaj rizika na cijenu strojeva i opreme

$$f_{IC,tr,pos} = \frac{1}{\left\{1-\left[\frac{SS+HP+OS+Profit}{U_{pp}}\right]\right\}} \quad (13)$$

$$BP_{p,j} = \left(\sum_i k_{i,j} * dt_{i,j}\right) * f_{GC,tr,gr,j}$$

$$BP_{p,j} + \Delta IC_{tr,j,pos} = BP_{p,j} * f_{GC,tr,gr,j}$$

$$\Delta IC_{tr,j,pos} = BP_{p,j} * \left(f_{GC,tr,gr,j} - 1\right)$$

$$c_{p,j} = BP_{p,j} + BP_{p,j} * \left(f_{GC,tr,gr,j} - 1\right) \quad (14)$$

4. Research methodology

The literature overiview found a lack of a model for incorporating the impact of risk into the formation of bid price of the project by contractors of construction works. For this reason, a survey has been formed and conducted among construction organizations whose results will serve to form a model of unit price calculation that will have negative risks included. The results were obtained on the basis of a survey conducted among 40 construction organizations for construction projects. The methodology of data analysis as well as the methodology of establishing the results will be explained for each of individual parts of the research.

5. Analysis of research results

Generally, the budget of a project should be based on the realistic performance of the work, taking into account the budget of resources, productivity, time-related costs and risks (*Smith et al., 2006*).

Concerning the standard term for project budgeting (7), it is obvious that it does not contain impact of potential risks, which may arise during the project execution for individual prices and thus for the entire project budget of the contractor.

Risk-based increases in the value of individual parts of the project cost are percentage increases of the basic price, minimum, and in fact they are random variables with some distribution, or simpler random variables with beta pert distribution. The impact of project features and project environment on the causes of certain risks ultimately affects the project budget components. The impact of risk leads to an increase in the cost of labor, materials, machinery and equipment, others' services, general costs of the construction site and the project, and they are calculated in the following way:

R+Rr labor + risk impact to labor price

M+Mr material + risk impact to the price of material

U+Ur others' services + risk impact to the price of others' services

S+Sr equipment and machinery + risk impact to the price of equipment and machinery

GC+GCr opći gradilišni trošak + utjecaj rizika na opći gradilišni trošak

Analizom utjecaja rizika na budžet projekta odnosno implementacijom utjecaja rizika dobiva se izraz za formiranje budžeta projekta kod izvođača radova koje u sebi ima uključeno djelovanje rizika na pojedine dijelove cijene projekta (15):

$$BP_{r,j} = \{[(R + R_r) + (M + M_r) + (U + U_r) + (S + S_r)] + (GC + GC_r)\} \tag{15}$$

Prikazani su rezultati istraživanja na pitanje koji je najčešći udio pojedinih komponenti cijene u poslovima građevinskih organizacija koje su obuhvaćene istraživanje.

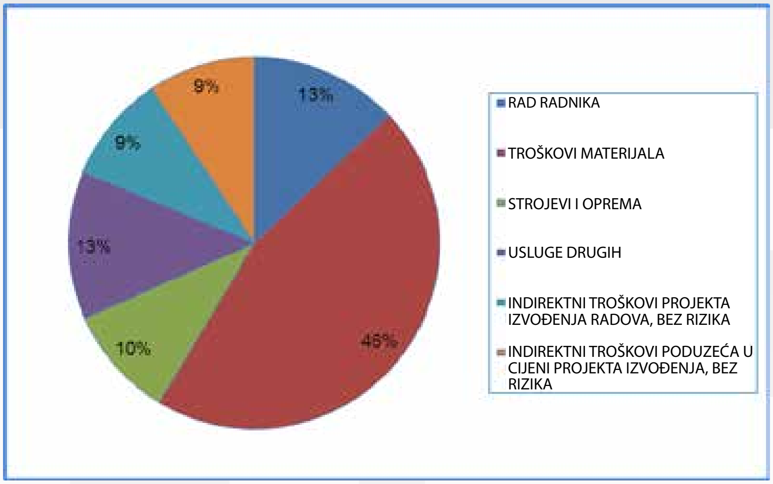

Figure 1. Udio pojedinih komponenti cijene u poslovima građevinskih organizacija obuhvaćenih istraživanjem

Rezultati nam pokazuju da najveći udio pri formiranju cijene u poslovima ispitanih organizacija imaju troškovi materijala. Samim time možemo zaključiti da i obilježja projekta koja imaju najveći utjecaj na povećanje vjerojatnosti pojave rizika koji se odnose na troškove materijala imaju najveći utjecaj na povećanje cijene odnosno budžeta projekta kod ispitanih izvođača radova.

Istraživanjem su poredani rizici dovršetka radova unutar planiranog vremena, troškova unutar proračuna te opsega projekta u traženoj kvaliteti po učestalosti pojave od 1 do 3. 1 predstavlja najčešće a 3 najrjeđe pojavljivani rizik prilikom izvođenja radova.

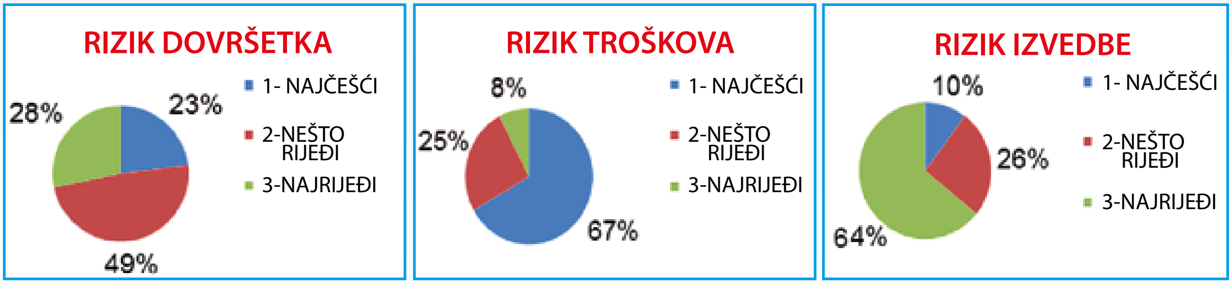

Figure 2. Učestalost pojave rizika pri izvođenju projekata

GC+GCr general construction site cost + risk impact to general construction site cost

The analysis of risk impact on a project budget or risk impact implemenatation provides a term for the creation of a contractor's project budget, which includes risk-impact on individual parts of project cost (15):

$$BP_{r,j} = \{[(R + R_r) + (M + M_r) + (U + U_r) + (S + S_r)] + (GC + GC_r)\} \quad (15)$$

The results of the research are presented for the question of the most common share of individual cost components in the work of construction organizations that were covered by the research.

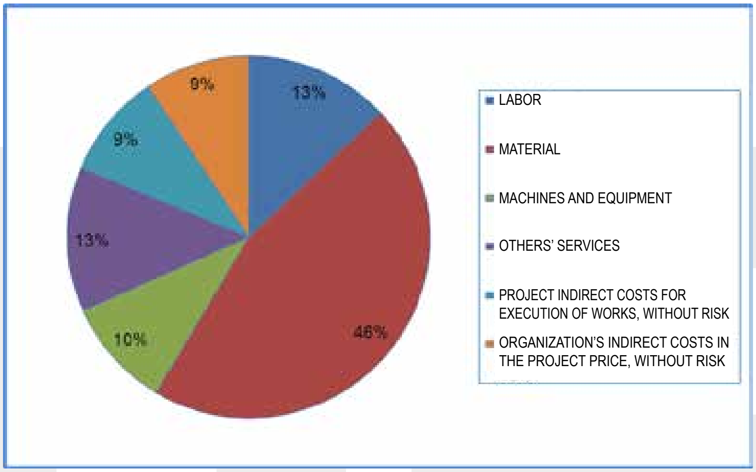

Figure 1. The share of individual cost components in the work of construction organizations involved in the research

The results show that the cost of material has the largest influence in price formation in the works of the surveyed organizations. Thus, we can conclude that the features of the project that have the greatest impact on increasing the probability of risk-related material costs have the greatest impact on the price increase or project budget for the surveyed contractors.

The research has ordered the risks of completing the works within the planned time, the costs within the budget and within the scope of the project with the requested quality by the frequency of the occurrence from 1 to 3. 1 represents the most frequent and 3 the least frequent risk during the execution of the works.

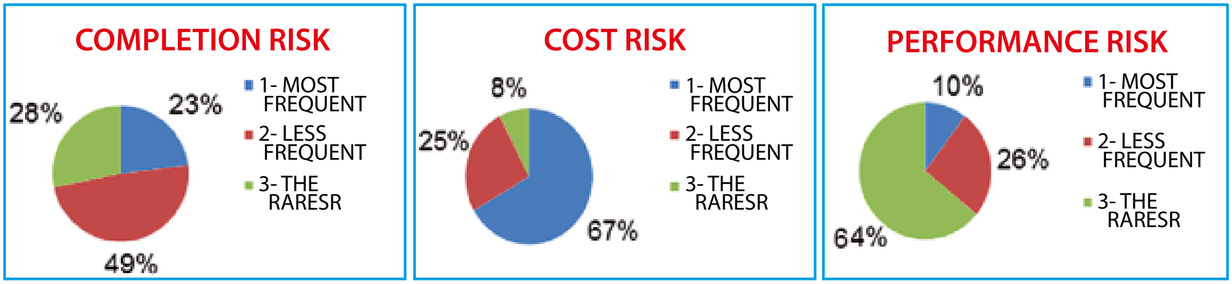

Figure 2. Frequency of occurrence of risk in project execution

Iz rezultata istraživanja vidimo da su izvođači radova ocijenili da je najučestaliji rizik troškova s 67 % što upućuje na potrebu detaljnijeg sagledavanja rizika i njihovog utjecaja na troškove odnosno na budžet kod izvođača radova.

5.1 Utjecaj obilježja projekta na vjerojatnost pojave izvora rizika

Provedenim istraživanjem analizirani su utjecaji obilježja projekata na vjerojatnost pojave izvora rizika koji onda mogu dovesti do promjene cijena izvođenja odnosno budžeta kod izvođača građevinskih radova.

Svaki rizik ima svoj uzrok. Svaki uzrok rizika ima određenu vjerojatnost njegovog nastupanja. Istraživanja će se utvrditi koliko obilježja nekog projekta i projektnog okruženja utječu na vjerojatnost pojave vanjskih odnosno unutarnjih izvora rizika. U vanjske izvore rizika svrstani su pravni, politički, ekonomski, socijalni i prirodni dok su unutarnje izvore rizika svrstani upravljanje, tehnička dokumentacija, ljudski faktor, opskrba i logisitika te ugovaranje.

Table 1. Vanjski i unutarnji izvori rizika

Vanjski izvori rizika				
Pravni	***Politički***	***Ekonomski***	***Socijalni***	***Prirodni***
Lokalni propisi	Promjene politike	Ekonomska politika	Obrazovanje, kultura	Klima
Dozvole	Izbori	Cijene, pristojbe	Sezonski rad	Tlo
Suglasnosti	Rat	Uvjeti financiranja	Štrajk	Požari
Promjene zakona	Sporazumi	Tečaj valute	Fluktuacija ljudi	Potresi, poplave
Standardi				
Unutarnji izvori rizika				
Upravljanje	***Tehnička dokumentacija***	***Ljudski faktor***	***Opskrba i logistika***	***Ugovaranje***
Nerealni ciljevi	Nepotpunost	Produktivnost	Nestašice	Vrsta ugovora
Loša kontrola	Netočnost	Bolovanje	Isporuke	Kratki rokovi
Tehnologija organizacije	Nezavršenost	Motivacija	Pouzdanost strojeva	Nerealna cijena
	Nova rješenja	Propusti	Nedostatak ljudi	Odnosi sudionika

From the results of the research we can see that the contractors rated the cost risk as the most frequent one with 67%, indicating the need for a more detailed account of risks and their impact on costs, i.e. on the budget of contractors.

5.1 Impact of project features on probability of occurrence of risk sources

The research has analyzed the impact of project features on the probability of the occurrence of risk sources which can later result in changes of the execution cost or the contractor's budget.

Each risk has its cause. Each cause of the risk has a certain probability of its occurrence. The research will determine how much the project features and project environment affect the probability of occurrence of external or internal risk sources. External risk sources are classified as legal, political, economic, social and natural, while internal risk sources are classified as management, technical documentation, human factor, supply and logistics, and contracting.

Table 1. External and internal risk sources

External risk sources				
Legal	***Political***	***Economic***	***Social***	***Natural***
Local regulations	Change in politics	Economic politics	Education, culture	Climate
Permits	Elections	Prices, taxes	Seasonal work	Soil
Approvals	War	Terms of financing	Strike	Fire
Changes to the law	Agreements	Currency exchange rate	Fluctuation of people	Earthquakes, flooding
Standards				
Internal risk sources				
Management	***Technical documentation***	***Human factor***	***Supply and logistics***	***Contracting***
Unreal goals	Incompleteness	Productivity	Shortages	Contract types
Bad controlling	Inaccuracy	Sick leave	Deliveries	Short deadlines
Organizational technology	Incompletion	Motivation	Reliability of machines	Unreasonable price
	New solutions	Omissions	Lack of people	Relationships between participants

In this section, the results of the research show what percentage certain project features have on probability of risk source to occur. Within the project features and the project environment, the

U ovom dijelu rada prikazani su rezultati istraživanja koliki % pojedina obilježja projekta imaju na vjerojatnost pojave izvora rizika. Pod obilježjima projekta i projektnog okruženja analizirani su intenziteti utjecaja tehnologije, rokova, mogućnosti podizvođača, konflikti resursa, sigurnost, okoliš, učešće državne regulative, politički interesi, broj ključnih suradnika, kompleksnost projekata, resursi i radna snaga, broj lokacija izvođenja radova, financiranje i utjecaj na troškove projekta, veličina i tip izgradnje s gledišta zaštite okoliša i zaštite na radu, potrebe kvalitete, javno učešće te programi odvijanja izvođenja projekta. Istraživanjem rizika ispitano je koliki utjecaj na pojavu rizika imaju pojedina obilježja projekta na skali od 1 do 10. 1 predstavlja najmanji a 10 najveći utjecaj na vjerojatnost pojave rizičnog događaja. Vrijednost moda za svaki od ispitanih uzroka predstavlja razinu utjecaja odnosno pripadajuću vjerojatnost pojave izvora rizika. Intenzitet utjecaja podijeljen je u 5 razreda.

Table 2. Razredi intenziteta utjecaja obilježja projekta na izvor rizika

Intenzitet utjecaja	Očekivanje iz teorijske razdiobe	Mod	Vjerojatnost pojave rizika
Vrlo nizak utjecaj VNU	0-2	0-2	0-20 %
Nizak utjecaj NU	2-4	2-4	20 - 40 %
Umjeren utjecaj UU	4-6	4-6	40 - 60 %
Visok utjecaj VU	6-8	6-8	60 - 80 %
Vrlo visok utjecaj VVU	8-10	8-10	80 - 100 %

Prikazani su i pojedinačno analizirani rezultati za sva nabrojana obilježja projekta i projektnog okruženja. Rezultati su svrstani u razrede intenziteta utjecaja djelovanja obilježja projekta na svaki pojedini projektni izvor.

Prema rezultatima istraživanja obilježja projekta koja uključuju promjene u tehnologiji imaju nizak utjecaj na pojavu socijalnih izvora rizika. Obilježja projekta vezana za tehnologiju najveći utjecaj imaju na pojavu izvora rizika vezane za opskrbu i logistiku stoga što bilo kakva promjena u tehnologiji može dovesti do povećanja troškova projekta odnosno budžeta uslijed problema s nabavkom radne snage ili opreme za izvođenje radova na takvom projektu.

Također promjena tehnologije izvođenja može tražiti nove dozvole ili suglasnosti što znači da tehnologija ima vrlo visok utjecaj na mogućnost pojave pravnih izvora rizika. Rezultati istraživanja vezani za obilježja projekta povezana s rokovima pokazuju nam da ovakva obilježja projekta imaju vrlo nizak i nizak utjecaj na pojavu ekonomskih izvora rizika te izvora rizika vezanih za opskrbu i logistiku iako teoretski gledano produžetak rokova ili odugovlačenje u izvođenju može snažno utjecati na pojavu izvora rizika uslijed promjene tečaj valute u kojoj je ugovoreno izvođenje ili uslijed nedostatka radne snage potrebne za druge projekte. Produžetak izvođenja projekta uzrokuje mogućnost pojave rizika zbog potrebe za novim dozvolama ili suglasnostima, promjenama politika uslijed dugotrajnog izvođenja, motivacije ili fluktuacije radnika, smanjene produktivnosti itd.

following issues were analyzed: intensity of technology impact, deadlines, sub-contractors' potentials, resource conflicts, security, environment, participation of government regulation, political interests, number of key collaborators, complexity of projects, resources and labor force, number of work locations, financing and impact on project costs, size and type of construction from the point of view of environmental protection and occupational safety, quality requirements, public participation and project implementation programs. Risk study investigated the amount of impact that individual project features have on the occurrence of the risks on a scale of 1 to 10. 1 represents the least and 10 the greatest impact on the probability of occurrence of a risk event. The mode value for each of the studied causes is the level of impact or the belonging probability of the occurrence of the risk source. Impact intensity is divided into 5 classes.

Table 2. Intensity classes of the project features' impact on risk sources

Impact intensity	Expectations of theoretic classification	Mode	Risk occurrence probability
Very low impact VNU/VLI	0-2	0-2	0-20 %
Low impact NU/LI	2-4	2-4	20-40 %
Moderate impact UU/MI	4-6	4-6	40-60 %
High impact VU/HI	6-8	6-8	60-80 %
Very high impact VVU/VHI	8-10	8-10	80-100 %

The results for each of the listed project features and the project environment are presented and analyzed separately. The results were classified into the classes of impact intensity of project features on each project source.

According to the results of the research, project characteristcs that involve changes in technology have a low impact on the occurrence of social risk sources. Technology-related features have the greatest impact on the supply and logistics risk source, as any change in technology can lead to increased project or budget costs due to workforce procurement or procurement of equipment for performing such a project. Any modification in technology of execution of works can also require new permits or approvals, which means that technology has a very high impact to the possibility of occurrence of legal risk sources.

The research results related to project characteristics associated with deadlines show that such features of a project have very low and low impact on the occurrence of economic sources of risk and sources of supply and logistics risks although theoretically the extension of deadlines or delay in execution can strongly influence the occurrence of risk sources due to a change in the exchange rate of the currency in which the performance was contracted, or because of the lack of workforce needed for other projects. Prolonging a project execution results into a possible occurrence of risk due to the need for new permits or approvals, need for a change in policy because of long-lasting execution, motivation or turnover of workers, lowered productivity, etc.

OBILJEŽJA PROJEKTA - UZROCI	VANJSKI					UNUTARNJI				
	PRAVNI	POLITIČKI	EKONOMSKI	SOCIJALNI	PRIRODNI	UPRAVLJANJE	TEHNIČKA DOKUMENTACIJA	LJUDSKI FAKTOR	OPSKRBA I LOGISTIKA	UGOVARANJE
TEHNOLOGIJA	8	9	5	3	4	7	5	4	10	7
	VVU	VVU	UU	NU	UU	VU	UU	UU	VVU	VU
ROKOVI	10	10	1	10	5	6	9	9	3	4
	VVU	VVU	VNU	VVU	UU	VU	VVU	VVU	NU	UU
MOGUĆNOSTI PODIZVOĐAČA	7	10	1	4	6	2	7	9	3	10
	VU	VVU	VNU	UU	VU	NU	VU	VVU	NU	VVU
SUČELJAVANJE POTREBA	4	1	7	9	10	4	3	1	10	3
	UU	VNU	VU	VVU	VVU	UU	NU	VNU	VVU	NU
SIGURNOST	1	2	4	7	1	3	5	10	9	10
	VNU	NU	UU	VU	VNU	NU	UU	VVU	VVU	VVU
OKOLIŠ	10	2	7	4	5	5	7	9	3	5
	VVU	NU	VU	UU	UU	UU	VU	VVU	NU	UU
UČEŠĆE DRŽAVNE REGULATIVE	1	10	8	4	5	3	7	8	9	5
	VNU	VVU	VVU	UU	UU	NU	VU	VVU	VVU	UU
POLITIČKO VIĐENJE	2	1	3	4	5	6	6	3	9	10
	NU	VNU	NU	UU	UU	VU	VU	NU	VVU	VVU
BROJ KLJUČNIH SUDIONIKA	5	10	2	9	10	6	7	7	5	10
	UU	VVU	NU	VVU	VVU	VU	VU	VU	VU	VVU
KOMPLEKSNOST PROJEKTA	8	9	6	6	2	4	1	3	4	5
	VVU	VVU	VU	VU	NU	UU	VNU	NU	UU	UU
RESURSI / RADNA SNAGA/ PRODUKTIVNOST	7	2	3	6	2	6	5	1	5	8
	VU	NU	NU	VU	NU	VU	UU	VNU	UU	VVU
BROJ LOKACIJA GRADILIŠTA	10	10	6	9	4	7	5	6	2	7
	VVU	VVU	VU	VVU	UU	VU	UU	UU	NU	VU
FINANCIRANJE / UTJECAJ NA TROŠKOVE	8	10	3	2	10	3	7	5	8	6
	VVU	VVU	NU	NU	VVU	NU	VU	UU	VVU	VU
ZAŠTITA OKOLIŠA	10	9	5	2	1	5	4	3	9	10
	VVU	VVU	UU	NU	VNU	UU	UU	NU	VVU	VVU
POTREBE KVALITETE	10	10	8	3	4	1	3	2	8	7
	VVU	VVU	VVU	NU	UU	VNU	NU	NU	VVU	VU
JAVNO UČEŠĆE	3	2	2	7	10	5	5	3	3	8
	NU	NU	NU	VU	VVU	UU	UU	NU	NU	VVU
PROGRAMI ODVIJANJA	3	2	2	9	6	4	5	1	4	6
	NU	NU	NU	VVU	VU	UU	UU	VNU	UU	VU

Figure 3. Intenziteti utjecaja obilježja projekta na vjerojatnost pojave izvora rizika

Očekivani rezultati istraživanja su takvi da obilježja projekata povezana s mogućnostima podizvođača obilježja građevinskih projekta koji se izvode imaju visok utjecaj na vjerojatnost pojave rizika vezanih za upravljanje te opskrbu i logistiku zbog moguće loše kontrole, nepostojanja adekvatne opreme i strojeva kod podizvođača ili eventualnog nedostatka ljudi uslijed nerealnih ciljeva koje je podizvođač preuzeo. Ipak, prema rezultatima provedenog istraživanja ovakva obilježja projekta imaju vrlo nizak utjecaj na vjerojatnost pojave ekonomskih izvora rizika te nizak utjecaj na vjerojatnost pojave rizika vezanih za upravljanje i opskrbu i logistiku.

Rezultati pokazuju da na projekte kod kojih dolazi do sučeljavanja potreba i sposobnosti, obilježja projekta imaju vrlo nizak utjecaj na vjerojatnost pojave političkih i izvora rizika vezanih za ljudski faktor. Rezultati istraživanja pokazuju da ovakva obilježja projekta najveći mogući utjecaj imaju na vjerojatnost pojave izvora rizika vezanog za opskrbu i logistiku zbog preklapanja ili nestašice pojedinih resursa, nedostatka radne snage ili nemogućnosti isporuke ključnih resursa. Rezultat koji smo dobili

PROJECT FEATURES – CAUSES	EXTERNAL					INTERNAL				
	LEGAL	POLITICAL	ECONOMIC	SOCIAL	NATURAL	MANAGEMENT	TECH. DOC.	HUMAN FACT.	SUPP & LOG	CONTRACTING
TECHNOLOGY	8	9	5	3	4	7	5	4	10	7
	VVU	VVU	UU	NU	UU	VU	UU	UU	VVU	VU
DEADLINES	10	10	1	10	5	6	9	9	3	4
	VVU	VVU	VNU	VVU	UU	VU	VVU	VVU	NU	UU
SUBCONTRACTORS' COMPETENCE	7	10	1	4	6	2	7	9	3	10
	VU	VVU	VNU	UU	VU	NU	VU	VVU	NU	VVU
CONFRONTING REQUIREMENTS	4	1	7	9	10	4	3	1	10	3
	UU	VNU	VU	VVU	VVU	UU	NU	VNU	VVU	NU
SAFETY	1	2	4	7	1	3	5	10	9	10
	VNU	NU	UU	VU	VNU	NU	UU	VVU	VVU	VVU
ENVIRONMENT	10	2	7	4	5	5	7	9	3	5
	VVU	NU	VU	UU	UU	UU	VU	VVU	NU	UU
STATE REGULATIONS PARTICIPATION	1	10	8	4	5	3	7	8	9	5
	VNU	VVU	VVU	UU	UU	NU	VU	VVU	VVU	UU
POLITICAL ASPECT	2	1	3	4	5	6	6	3	9	10
	NU	VNU	NU	UU	UU	VU	VU	NU	VVU	VVU
NUMBER OF KEY PARTICIPANTS	5	10	2	9	10	6	7	7	5	10
	UU	VVU	NU	VVU	VVU	VU	VU	VU	VU	VVU
PROJECT COMPLEXITY	8	9	6	6	2	4	1	3	4	5
	VVU	VVU	VU	VU	NU	UU	VNU	NU	UU	UU
RESOUJRCES/ LABOR FORCE/ PRODUCTIVITY	7	2	3	6	2	6	5	1	5	8
	VU	NU	NU	VU	NU	VU	UU	VNU	UU	VVU
NUMBER OF SITE LOCATIONS	10	10	6	9	4	7	5	6	2	7
	VVU	VVU	VU	VVU	UU	VU	UU	UU	NU	VU
FINANCING / COST IMPACT	8	10	3	2	10	3	7	5	8	6
	VVU	VVU	NU	NU	VVU	NU	VU	UU	VVU	VU
ENVIRONMENT PROTECTION	10	9	5	2	1	5	4	3	9	10
	VVU	VVU	UU	NU	VNU	UU	UU	NU	VVU	VVU
QUALITY REQUIREMENTS	10	10	8	3	4	1	3	2	8	7
	VVU	VVU	VVU	NU	UU	VNU	NU	NU	VVU	VU
PUBLIC INVOLVEMENT	3	2	2	7	10	5	5	3	3	8
	NU	NU	NU	VU	VVU	UU	UU	NU	NU	VVU
RUNNING SCHEDULE	3	2	2	9	6	4	5	1	4	6
	NU	NU	NU	VVU	VU	UU	UU	VNU	UU	VU

Figure 3. Impact intensity of project characteristics to the probability of risk sources occurrence

Expected results of the research are such that project characteristics associated with the capabilities of subcontractors of the construction project features being performed have a high impact on the probabillity of occurrence of management risk and supply and logistics risks due to possible bad control, lack of adequate equipment and machinery on the part of subcontractors or possible lack of people due to unrealistic goals the subcontractor undertook. Nevertheless, according to the results of the conducted research, such project features have very low impact on the possibility of occurrence of economic risk sources and low impact on the possibility of occurrence of risks related to management or supply and logistics.

The results show that project features have a very low impact on the probability of occurrence of political risk sources and risk sources related to the human factor in projects where there is confrontation between needs and capabilities. Research results show that such project features have the strongest possible impact on the probability of occurrence of risk sources related to supply and logistics due to overlapping or shortage of certain resources, lack of labor force or inability to deliver key resources.

istraživanjem za vjerojatnost pojave prirodnih izvora rizika u odnosu na teoriju zbunjuje jer je vrlo teško zaključiti zašto ovoliko velik utjecaj sučeljavanje potreba i sposobnosti ima na vjerojatnost pojave prirodnih izvora rizika. Prema rezultatima istraživanja obilježja projekta vezana za sigurnost najveći utjecaj imaju na vjerojatnost pojave izvora rizika vezanih za ljudski faktor te ugovaranje. Iz rezultata istraživanja možemo zaključiti da utjecaj sigurnosti kao obilježja projekta ima u prosjeku nizak utjecaj na vanjske izvore rizika te veliki utjecaj na vjerojatnost pojave unutarnjih izvora rizika što je očekivano stoga što se sigurnost pri izvođenju uglavnom kontrolira iz unutrašnjosti same organizacije.

Prikazani rezultati istraživanja ukazuju nam na to da obilježja projekta koja se povezuju s okolišom u prosjeku imaju umjeren utjecaj na vjerojatnost pojave kako unutarnjih tako i vanjskih izvora rizičnih događaja. Dodatni zahtjevi za okoliš podrazumijevaju veću vjerojatnost pojave rizičnih događaja zbog potrebe za dodatnim suglasnostima i dozvolama te mogu prouzrokovati eventualno smanjenje produktivnosti, česta bolovanje kod radne snage ili propuste zbog strogih zahtjeva sa zaštitom okoliša.

Prema rezultatima istraživanja učešće državne regulative ima u prosjeku visok utjecaj na vjerojatnost pojave rizičnih događaja prilikom izvođenja projekta. Ovakva obilježja projekta imaju vrlo visok utjecaj na vjerojatnost pojave političkih, ekonomskih te izvora rizika vezanih za ljudski faktor te opskrbu i logistiku. Rezultat vrlo visokog utjecaja učešća državne regulative na mogućnost pojave rizika vezanih za ljudski faktor i opskrbu i logistiku s obzirom na pretpostavke nije očekivan, ali možemo zaključiti da su izvođači radova imali česta neočekivana negativna iskustva vezana za ovakve uzroke i izvore rizičnih događaja koji su im doveli do povećanja budžeta prilikom izvođenja radova.

Unatoč očekivanjima da obilježja projekta povezana s političkim viđenjem imaju visok utjecaj na vjerojatnost pojave svih vrsta izvora rizika a pogotovo vanjskih rezultati su u potpunosti suprotni. Utjecaj ovog obilježja projekta na vjerojatnost pojave vanjskih izvora rizičnog događaja prema rezultatima istraživanja je u prosjeku niska te ni za jedan od vanjskih izvora ne prelazi intenzitet umjerenog utjecaja na vjerojatnost pojave rizičnog događaja. U prosjeku političko viđenje ima visok utjecaj na mogućnost pojave unutarnjih izvora rizika što nema baš mnogo poveznica s očekivanim rezultatima jer se ipak očekivalo da političko viđenje i politički interesi mnogo veći utjecaj imaju na mogućnost pojave vanjskih izvora rizika.

Prema rezultatima istraživanja predstavljena obilježja projekta vezana za broj ključnih sudionika imaju visok utjecaj na vjerojatnost izvora rizičnih događaja u projektu te kao takva imaju i visok utjecaj na povećanje cijena a time i budžeta projekta kod izvođača koji izvode projekt s takvim obilježjima. Ostaje nejasno na osnovu čega su se ispitane organizacije izjasnile da im ovakva obilježja projekta imaju vrlo veliki utjecaj na ove izvore rizika jer je teško teorijski povezati veći broj ključnih sudionika i eventualne preferirane podizvođače te dobavljače s povećanom vjerojatnosti pojave izvora rizika vezanih za promjene politike, obrazovanje i kulturu, sezonski rad radnika ili utjecaj klime ili eventualne požare prilikom izvođenja projekta.

Prema rezultatima istraživanja kompleksnost projekta ima u prosjeku umjeren utjecaj na vjerojatnost pojave izvora rizičnih događaja kod izvođenja projekata. Ipak gledano odvojeno kompleksnost projekta ima visok utjecaj na vanjske izvore a nizak utjecaj na unutarnje izvore rizičnih događaja. Najveći utjecaj kompleksnost projekta prema rezultatima istraživanja ima na vjerojatnost

The result obtained in research, concerning probability of occurrence of natural risk sources, makes confusion as, compared with the theory, it is very difficult to conclude why confrontation of needs and capabilities has such huge impact on the probability of occurrence of natural risk sources. According to the research results, project features related to security have the highest impact on the probability of occurrence of risk sources related to human factor and contracting. From the results of the research we can conclude that the impact of security as a project characteristic on average has a low impact on external risk sources and a great influence on the probability of occurrence of internal risk sources as expected because safety at execution is mainly controlled from within the organization itself.

The displayed research results show that the environmental related project characteristics on average have a moderate impact on the probability of occurrence of both internal and external sources of risk events. Additional environmental requirements imply a higher probability of occurrence of risk events due to the need for additional approvals and permissions, and can lead to possible productivity reductions, frequent illnesses in the workforce or omissions due to strict environmental protection requirements.

According to the results of the research, the participation of government regulations on average has a high impact on the probability of occurrence of risk events during project execution. Such project features have a very high impact on the probability of occurrence of political and economic risk sources, as well as risk sources related to human factor and supply and logistics. The result of a very high impact of the participation of state regulations on the probability of occurrence of human factor and supply and logistics risk factors was not expected, but we can conclude that the contractors had frequent unexpected negative experiences related to such causes and sources of risk events that resulted into increase of the budget when executing the works.

In spite of the expectations that project features related to political aspect have high impact on the probability of occurrence of all kinds of risk sources, especially the external ones, the results are completely opposite. The impact of this project feature on the probability of occurrence of external sources of risk events, according to the research results, is on average low and does not surpass the intensity of moderate impact on the probability of occurrence of a risk event for any of external sources. On average, political aspect has high impact on the probability of occurrence of internal risk sources, which does not have many references with the expected results, as it still was expected that political views and political interests have much greater impact on the probability of occurrence of external risk sources.

According to the research results, the project characteristics related to the number of key participants have a high impact on the probability of risk sources events in a project and as such they have a high impact on the price increase and thus on the project budget of the contractors executing the project with such features. It remains unclear why the responding organizations have stated that such project features have very high impact on these risk sources, as it is difficult to relate theoretically the greater number of key participants and potential preferred subcontractors and suppliers with higher probability of occurrence of risk sources related to the policy change, education and culture, seasonal work or climate impact or potential fires during a project execution.

According to the research results, the project complexity on average has moderate impact on the probability of occurrence of risk sources events during project execution. However, when considered pojave političkih izvora rizika. Ukoliko projekt ima ovakva obilježja prema istraživanju vjerojatnost pojave političkog izvora rizika kreće se od 80 do 100 %.

Prema rezultatima istraživanja iznad obilježja projekta vezana za resurse i produktivnost radne snage imaju u prosjeku umjeren utjecaj na vjerojatnost pojave izvora rizika. Na vjerojatnost pojave vanjskih izvora rizika ovakva obilježja projekta očekivano imaju nizak utjecaj stoga što se ovakva obilježja uglavnom odnose na radnu snagu i na unutarnja pitanja organizacije. Najveći utjecaj prema istraživanju ovakva obilježja projekta imaju na vjerojatnost pojave rizika vezanih sa ugovaranjem i to vrlo visok utjecaj sto znaci da je vjerojatnost pojave izvora rizika vezanog za ugovaranje između 80 i 100%.

Prema rezultatima istraživanja obilježja projekta povezana s brojem lokacija izvođenja radova imaju općenito visok utjecaj na vjerojatnost pojave rizika. Ovakvi rezultati istraživanja koje smo dobili ispitivanjem građevinskih organizacija koje izvode radove nisu očekivani jer teorijski je teško povezati zbog čega ovakva obilježja projekta imaju vrlo veliki utjecaj na socijalne ili političke izvore rizika. Prema rezultatima istraživanja ova kategorija obilježja projekta ima najmanji utjecaj na vjerojatnost pojave ekonomskih, socijalnih te izvora rizika vezanih za upravljanje. Vrlo visok intenzitet utjecaja ova kategorija obilježja projekta ima na vjerojatnost pojave pravnih, političkih, prirodnih te izvora rizika vezanih za opskrbu i logistiku. Ukoliko je projekt javni to uzrokuje da veliki utjecaj na njega ima promjena politike, promjena vlasti na izborima ili eventualni politički sporazumi. Izvođenje projekta preko dvije godine ima utjecaj na vrlo visok utjecaj na vjerojatnost pojave rizika vezanih za opskrbu i logistiku.

U skladu s očekivanjima obilježja projekta povezana s trajanjem projekta većim od dvije godine što dovodi do značajnijih utjecaja na financiranje izvođenja projekta imaju vrlo visok utjecaj na vjerojatnost pojave pravnih, političkih te izvora rizika povezanih sa ugovaranjem te opskrbom i logistikom. Zbog strožih ekoloških zahtjeva postoji rizik od povećanja cijene i budžeta uslijed rizika izazvanih dodatnim dozvolama, suglasnostima ili posebnim standardima.

Prema rezultatima istraživanja najmanji odnosno vrlo nizak utjecaj karakteristike projekta povezane s veličinom i tipom izgradnje s gledišta zaštite okoliša i odvoženja otpada imaju na izvore rizičnih događaja koji se odnose na upravljanje. Vrlo visok utjecaj obilježja projekta vezana za potrebe kvalitete imaju na mogućnost pojave pravnih, političkih te izvora rizika vezanih s opskrbom i ugovaranjem. Visoki zahtjevi kvalitete povećavaju mogućnost porasta troškova uslijed nekih specijalnih isporuka materijala, nedostatka kvalitetnih ljudi te ne mogućnosti pribavljanja pouzdane opreme za izvođenje radova u skladu sa zahtijevanim razinama kvalitete.

Prema rezultatima istraživanja obilježja projekta vezana za potrebe kvalitete najveći utjecaj ima na vjerojatnost prirodnih izvora rizika. Vrlo visok utjecaj ovakva obilježja projekta imaju i na izvore rizika koji se odnose na ugovaranje. Ovakva obilježja projekta utječu na kompleksnost ugovaranja, vrlo komplicirane odnose sudionika te kao takvi mogu dovesti do značajnog povećanja budžeta izvođenja projekta uslijed rizika izazvanih utjecajem javnih konzultacija na odnose sudionika u projektu.

Prikazani rezultati istraživanja ukazuju nam na to da obilježja projekta vezana za javno učešće općenito imaju nizak ili umjeren utjecaj na vjerojatnost izvora rizičnih događaja tijekom izvođenja separately, the complexity of a project has a high impact on external sources and low impact on internal sources of risk events. According to the research, project complexity has the highest impact on the probability of occurrence of political risk sources. If projects have such features, then, according to the research, the probability of occurrence of political risk sources ranges between 80 and 100%.

According to research findings, the project feature related to resources and labor force productivity have moderate impact on the probability of occurrence of risk sources on average. These project features are expected to have a low impact on the probability of external risk sources because these features are mainly related to the workforce and the internal issues of an organization. According to the research, such project features have the highest impact on the probability of occurrence of risks related to contracting, namely, very high impact, meaning that the probability of occurrence of risk sources related to contracting ranges between 80 and 100%.

The project characteristics associated with the number of work locations have a generally high impact on the probability of risk occurrence. Such research results obtained by examining construction organizations that execute works are not expected because it is theoretically difficult to understand why such project features have a very high impact on social or political risk sources. According to the research results, this category of project features has the lowest impact on the probability of occurrence of economic, social and the risk sources related to management. This category of project features has very high impact intensity on the probability of occurrence of legal, political, natural and the risk sources related to supply and logistics. If a project is the issue of public procurement, this results into huge impact of policy change, change of government at elections or potential political agreements. When a project execution lasts for more than two years, there is very high impact on the probability of occurrence of risk related to supply and logistics.

Complying with the expectations, project features related to a project lasting longer than two years lead to significant impact on financing the project execution, having very high impact on the probability of occurrence of legal, political and those risk sources related to the contracting and supply and logistics. Owing to strict environmental requirements, there is a risk of price and budget increase caused by risk started by additional permits, approvals or specific standards.

According to the research results, project features related to the size and type of construction from the point of view of environmental protection and waste disposal have the lowest or very low impact on management related risk sources. Project features related to quality requirements have very high impact on the probability of occurrence of legal, political and risk sources related to supply and contracting. High quality demands increase the possibility of increased costs due to some special delivery of materials, lack of high quality people, and due to the lack of reliable equipment to perform the works in accordance with the required quality levels.

According to the results of the research, the project features related to quality requirements have the highest impact on the probability of occurrence of natural risk sources. Such project features also have a very high impact on risks involved in contracting. Project features like these ones influence complexity of contracting, very complicated relations between participants, and they can result in significant increase of the budget for project execution due to risks caused by the impact of public consultations to relationships between participants in a project.

The research results show that the public involvement project features generally have a low or moderate impact on the probability of occurrence of sources of risk events during a project projekta. Programi odvijanja s posebnim potrebama oko radnog vremena povećavaju vjerojatnost izvora rizika vezanih za sezonski rad, štrajkove ili fluktuaciju ljudi uslijed takvih okolnosti te imaju veoma visok intenzitet utjecaja na vjerojatnost pojave rizičnih događaja prilikom izvođenja projekata.

Analizirani rezultati ovako formiranih intenziteta utjecaja uzroka pojave izvora rizika koristit će se pri formiranju modela za izračun jediničnih kao i ukupne ponudbene cijene za izvođenje projekata bez obzira na očekivanja i bez ikakvih prilagođavanja s obzirom na pretpostake uoči istraživanja.

5.2 Utjecaj izvora rizika na pojavu rizika dovršetka, troškova te rizika izvedbe

Nakon što je istraživanjem utvrđeno utjecaj obilježja projekta na vjerojatnost pojave izvora rizika pristupilo se procjeni kaje posljedice izaziva pojava pojedinih izvora rizika, odnosno koliki utjecaj pojedini izvor rizika ima na rizik dovršetka radova, troškova te rizik izvedbe u zadanim granicama. Stupanj utjecaja određivao se kroz anketu među građevinskim organizacijama. Stupnjevi utjecaja podjeljeni su u tri razreda od 1 do 3 gdje 1 predstavlja najveći a 3 najmanji utjecaj na rizike dovršetka, troškova te rizik izvedbe. Prikazani su rezultati izjašnjavanja anketiranih organizacija u postotcima za svaki stupanj utjecaja.

IZVOR RIZIKA	STUPANJ UTJECAJA	RIZIK DOVRŠETKA (%)	RIZIK TROŠKOVA (%)	RIZIK IZVEDBE (%)
PRAVNI	1	37,50	22,50	20,00
	2	25,00	37,50	20,00
	3	37,50	40,00	60,00
POLITIČKI	1	27,50	30,00	25,00
	2	25,00	27,50	27,50
	3	47,50	42,50	47,50
EKONOMSKI	1	32,50	53,50	20,00
	2	35,00	27,50	42,50
	3	32,50	20,00	37,50
SOCIJALNI	1	30,00	37,50	27,50
	2	22,50	37,50	20,00
	3	47,50	25,00	52,50
PRIRODNI	1	45,00	17,50	30,00
	2	42,50	35,00	32,50
	3	12,50	47,50	37,50
UPRAVLJANJE	1	30,00	25,00	40,00
	2	35,00	47,50	25,00
	3	25,00	27,50	35,00
TEHNIČKA DOKUMENTACIJA	1	30,00	25,00	47,50
	2	40,00	32,50	22,50
	3	30,00	42,50	30,00
LJUDSKI FAKTOR	1	47,50	32,50	40,00
	2	35,00	50,00	25,00
	3	17,50	17,50	35,00
OPSKRBA I LOGISTIKA	1	47,50	42,50	15,00
	2	27,50	40,00	45,00
	3	25,00	17,50	40,00
UGOVARANJE	1	47,50	27,50	37,50
	2	22,50	52,50	30,00
	3	30,00	20,00	32,50

Figure 4. Stupanj utjecaja izvora rizika na pojavu rizika dovršetka, troškova te izvedbe

implementation. Programs of realization with specific requirements surrounding working hours increase the probability of risk sources related to seasonal work, strikes or labor turnover caused by such circumstances and have very high impact intensity on the probability of occurrence of risk events during project execution.

The analyzed results of the intensities of causes of risk source occurrence formed in this way are going to be used to form a model for the calculation of both unit prices and total bid price for project execution regardless of expectations and without any adjustments concerning presumptions prior to the research.

5.2 Impact of risk sources on the occurrence of completion, costs and performance risks

After the research has established the impact of project features on the probability of occurrence of risk sources, an assessment has been made to determine the consequences of the occurrence of certain risk sources, ie the impact of a certain risk source on the completion of works, costs and performance risks within the set limits. An impact level was determined through a survey among construction organizations. Impact levels were divided into three classes from 1 to 3 where 1 represents the highest and 3 the lowest impact on the risks of completion, cost and performance. The results of the surveyed organizations are shown in percentages for each impact level.

RISK SOURCE	IMPACT DEGREE	COMPLETION RISK (%)	COST RISK (%)	PERFORMANCE RISK (%)
LEGAL	1	37,50	22,50	20,00
	2	25,00	37,50	20,00
	3	37,50	40,00	60,00
POLITICAL	1	27,50	30,00	25,00
	2	25,00	27,50	27,50
	3	47,50	42,50	47,50
ECONOMIC	1	32,50	53,50	20,00
	2	35,00	27,50	42,50
	3	32,50	20,00	37,50
SOCIAL	1	30,00	37,50	27,50
	2	22,50	37,50	20,00
	3	47,50	25,00	52,50
NATURAL	1	45,00	17,50	30,00
	2	42,50	35,00	32,50
	3	12,50	47,50	37,50
MANAGEMENT	1	30,00	25,00	40,00
	2	35,00	47,50	25,00
	3	25,00	27,50	35,00
TECHNICAL DOCUMENTATION	1	30,00	25,00	47,50
	2	40,00	32,50	22,50
	3	30,00	42,50	30,00
HUMAN FACTOR	1	47,50	32,50	40,00
	2	35,00	50,00	25,00
	3	17,50	17,50	35,00
SUPPLY AND LOGISTICS	1	47,50	42,50	15,00
	2	27,50	40,00	45,00
	3	25,00	17,50	40,00
CONTRACTING	1	47,50	27,50	37,50
	2	22,50	52,50	30,00
	3	30,00	20,00	32,50

Figure 4. Impact levels of risk sources on the occurrence of risk of completion, cost and performance

Prema rezultatima istraživanja najveći utjecaj na neizvjesnost dovršetka izvođenja građevinskog projekta imaju pravni izvori rizika, prirodni, rizici upravljanja, te izvori rizika povezani sa ljudskim faktorom, ugovaranjem te opskrbom i logistikom. Najmanji pak utjecaj na neizvjesnost dovršetka izvođenja građevinskog projekta u planiranom vremenu prema rezultatima istraživanja imaju politički rizici.

Najveći utjecaj na neizvjesnost ostvarenja troškova unutar proračuna kod izvođenja građevinskih projekata imaju politički, ekonomski te socijalni rizici dok 47,5 % odnosno 42,50 % ispitanika smatra da najmanji utjecaj prema na troškove imaju prirodni te rizici vezani za tehničku dokumentaciju.

Rizici koji najveći utjecaj imaju na neizvjesnost ostvarenja opsega projekta u traženoj kvaliteti su rizici upravljanja za koje to smatra 40% ispitanih izvođača radova te rizici tehničke dokumentacije za koje to smatra 47,50 % ispitanih izvođača. Najmanji pak utjecaj na neizvjesnost ostvarenja projekta u traženoj kvaliteti imaju pravni, politički, ekonomski, socijalni te rizici ljudskog faktora, opskrbe i logistike, ugovaranja te rizici povezani s upravljanjem.

5.3 Utjecaj izvora rizika na uvećanje odgovarajućeg dijela cijene u fazi pripreme ponude za izvođenje projekta

Istraživanjem smo došli do podataka koliko u postotku pojedini već navedeni izvori rizika uvećavaju odgovarajući dio cijene izvođenja građevinskih radova u fazi pripreme ponude. U rezultatima istraživanja kao relevantan podatak uzeli smo srednju vrijednost svih 40 odgovora ispitanih izvođača radova. Anketirane organizacije su na temelju dosadašnjih iskustava naveli rezervacije uslijed utjecaja izvora rizika za pojedine dijelove cijene izvođenja projekta. Rezultati rezervacije prikazani su u postotcima s obzirom na pojedini dio cijene.

IZVOR RIZIKA	DIREKTNI TROŠKOVI				INDIREKTNI TROŠKOVI PROJEKTA I GRADILIŠTA IZVOĐENJA RADOVA
	RAD RADNIKA	MATERIJAL	STROJEVI I SREDSTVA	USLUGA DRUGIH	
PRAVNI	2,50%	1,88%	1,92%	2,40%	2,23%
POLITIČKI	1,73%	1,43%	1,33%	1,33%	1,98%
EKONOMSKI	4,68%	4,48%	4,28%	3,90%	4,05%
SOCIJALNI	3,23%	2,38%	2,30%	2,35%	2,18%
PRIRODNI	2,50%	1,82%	1,98%	1,55%	2,28%
UPRAVLJANJE	2,95%	3,18%	3,15%	2,00%	3,50%
TEHNIČKA DOKUMENTACIJA	2,93%	3,38%	2,53%	2,83%	2,85%
LJUDSKI FAKTOR	4,35%	3,83%	3,28%	3,33%	3,18%
OPSKRBA I LOGISTIKA	3,73%	3,73%	4,25%	3,48%	4,20%

Figure 5. Utjecaj izvora rizika na uvećanje pojedinog dijela cijene

According to the research results, legal, natural, management, human resources, contracting, supply and logistics risks have the greatest impact on the uncertainty of completing the construction project. Political risks have the least impact on the uncertainty of completing a construction project in the planned time, according to the research results.

Political, economic and social risks have the greatest impact on the uncertainty of realizing the costs within the budget in executing construction projects, whereas 47,50% and 42,50% of respondents believe that natural and technical documentation risks have the least impact on the costs.

Risks having the greatest impact on the uncertainty of realizing the scope of the project in the required quality are management risks, as considered by 40% of the contractors, and the risks of the technical documentation as considered by 47,50% of the contractors. Legal, political, economic, social, human, supply and logistics, contracting and management risks have the least impact on the uncertainty of the project realization in the required quality.

5.3 Impact of risk sources on the increase of certain parts of the cost during the preparation of a bid for the project execution

The research presented the data about the extent to which the percentage of the individual previously mentioned risk sources increase the corresponding part of the cost of construction works during the bid preparation phase. As a relevant data in the research results, we took the mean of all 40 responses of the surveyed contractors. Surveyed organizations have mentioned reservations based on past experiences due to the impact of the risk sources for individual parts of project execution cost. The results of the reservation are shown in percentages per a portion of cost.

RISK SOURCE	DIRECT COSTS				PROJECT AND SITE INDIRECT COSTS
	LABOR	MATERIAL	MACHINERY AND ASSETS	OTHERS' SERVICES	
LEGAL	2,50%	1,88%	1,92%	2,40%	2,23%
POLITICAL	1,73%	1,43%	1,33%	1,33%	1,98%
ECONOMIC	4,68%	4,48%	4,28%	3,90%	4,05%
SOCIAL	3,23%	2,38%	2,30%	2,35%	2,18%
NATURAL	2,50%	1,82%	1,98%	1,55%	2,28%
MANAGEMENT	2,95%	3,18%	3,15%	2,00%	3,50%
TECHNICAL DOCUMENTATION	2,93%	3,38%	2,53%	2,83%	2,85%
HUMAN FACTOR	4,35%	3,83%	3,28%	3,33%	3,18%
SUPPLY AND LOGISTICS	3,73%	3,73%	4,25%	3,48%	4,20%

Figure 5. Impact of risk sources on the increase of a certain part of the price

Legal risk sources have the greatest impact on the increase in the part of the project cost associated with labor cost (2.50%) and others' services, whereas it has the lowest impact on the increase in the cost price related to the cost of material (1.88%), machinery and assets.

Pravni izvori rizika najveći utjecaj ima na povećanje dijela cijene projekta povezanu s cijenom rada radnika (2,50%) i usluga drugih dok najmanji utjecaj ima na povećanje dijela cijene koji se odnosi na cijenu materijala (1,88%) te strojeva i sredstava.

Politički izvori rizika najveći utjecaj imaju na povećanje dijela cijene projekta vezan za indirektne troškove projekta i gradilišta i to 1,98% a najmanji na povećanje dijela cijene vezan za direktne troškove strojeva te usluga drugih (1,33 %). Prosječno gledano prema rezultatima istraživanja pravni izvori rizika imaju najmanji utjecaj na povećavanje dijelova cijena izvođenja građevinskog projekta.

Ekonomski izvori rizika najveći utjecaj imaju na povećanje dijela cijene vezane za rad radnika (4,68%) te materijala (4,48%) a u najmanjoj mjeri utječu na povećanje dijela cijene vezanog za usluge drugih i to 3,80%. Promatrajuću ukupne rezultate istraživanja možemo zaključiti da ekonomski izvori rizika imaju u prosjeku najveći utjecaj na povećanje dijelova odnosno ukupne cijene projekta.

Socijalni izvori rizika imaju podjednak utjecaj na povećanje svakog od dijelova cijene projekta ali najveći utjecaj imaju na povećanje dijela cijene vezane za rad radnika a najmanji na indirektne troškove projekta i gradilišta.

Prirodni izvori rizika gledajući ukupne rezultate istraživanja također imaju prosječno nizak utjecaj na povećanje dijelova cijene projekta. Najmanji utjecaj imaju na povećanje dijela cijene vezan za usluge drugih i to 1,55%.

Izvori rizika vezani s upravljanjem najveći utjecaj imaju na povećanje cijene vezane za indirektne troškove projekta i gradilišta (3,50%) a najmanji na usluge drugih (2,00%)

Izvori rizika vezani za tehničku dokumentaciju najveći utjecaj imaju na povećanje dijela cijene projekta povezane s direktnim troškovima materijala (3,38%) a najmanji na dio cijene vezan za strojeve i sredstva obavljanja građevinskih radova (2,53%).

Izvori rizika vezani za ljudski faktor gledano prosječno imaju treći po redu veličinu utjecaja na dijelove cijene projekta odmah poslije ekonomskih te izvora rizika vezanih za opskrbu i logistiku. Najveći utjecaj imaju na povećanje dijela cijene projekta povezan radom radnika i to 4,35%.

Izvori rizika vezani za opskrbu i logistiku, kako smo već rekli, imaju intenzitet utjecaja na povećanje dijelova cijena projekta odmah poslije ekonomskih izvora rizika. Najveći utjecaj imaju na povećanje dijela cijene vezan za strojeve i sredstva (4,25%) a najmanji na usluge drugih (3,48%).

5.4 Utjecaj izvora rizika na uvećanje odgovarajućeg dijela cijene u fazi realizacije projekta

Rezultati istraživanja postotnog povećanja pojedinog dijela cijene kao posljedice prethodno navedenih rizika u fazi realizacije projekta nastali su na osnovu evidencija pojedinih izvođača radova. Anketirane organizacije su na temelju dosadašnjih iskustava naveli povećanje cijene uslijed utjecaja izvora rizika za pojedine dijelove cijene izvođenja projekta u fazi realizacije projekta. Samo u slučaju nepostojanja evidencija izvođači su dali svoju procjenu. Rezultati rezervacije prikazani su u postotcima s obzirom na pojedini dio cijene.

Political risk sources have the greatest impact on the increase of the part of project cost related to the indirect costs of project and construction site, which is 1.98%, and the lowest impact to the increase of cost is related to the direct costs of machinery and others' services (1.33%). On average, according to research results, legal risk sources have the lowest impact on increasing the construction cost of a construction project.

Economic risk sources have the greatest impact on the increase in the share of labor cost (4.68%) and material (4.48%), and to the lowest extent they affect the increase of the part of cost related to the services of others, namely 3.80%. Looking at the overall results of the research we can conclude that the economic risk sources on average have the greatest impact on both the increase of the parts and the total cost of the project.

Social risk sources have an equal greatest impact on the increase in each of the parts of the project cost, but the greatest impact is on increasing the share of labor-related costs and the least on the indirect costs of the project and the construction site.

Considering overall research results, natural risk sources also have an average low impact on the increase in project cost. The lowest impact is on the increase in the share of cost related to others' services, and this is 1.55%.

Management related risk sources have the greatest impact on the increase in costs related to the indirect costs of the project and the construction site (3.50%) and the lowest impact on others' services (2.00%)

Risk sources related to technical documentation have the greatest impact on the increase of a part of the cost of the project related to direct costs of material (3.38%) and the lowest impact to the cost of machinery and construction works (2.53%).

Human resources related risk sources, on average, have the third-largest impact on parts of the cost of the project immediately after economic and supply and logistics risk sources. They have the greatest impact on the increase of a part of the project cost associated with the labor and this is 4.35%.

Risk sources of supply and logistics, as we have already mentioned, have intensity impact on the increase in the cost of the project immediately after the economic risk sources. They have the greatest impact on the increase in the cost of machinery and equipment (4.25%) and the lowest on others' services (3.48%).

5.4 Impact of risk sources on the increase of the corresponding part of cost during the project realization phase

The research results of the percentage increase of an individual share of the price as a consequence of the above mentioned risks in the project realization phase were created on the basis of the records of individual contractors. Based on previous experience, surveyed organizations have indicated price increases due to the impact of risk sources for individual parts of the project execution cost in the project implementation stage. Only in the absence of evidence the contractors gave their estimates. The results of the reservation are shown in percentages per part of the price.

IZVOR RIZIKA	DIREKTNI TROŠKOVI				INDIREKTNI TROŠKOVI PROJEKTA I GRADILIŠTA IZVOĐENJA RADOVA
	RAD RADNIKA	MATERIJAL	STROJEVI I SREDSTVA	USLUGA DRUGIH	
PRAVNI	2,43%	1,88%	2,40%	2,33%	2,63%
POLITIČKI	1,21%	0,85%	1,00%	1,08%	1,43%
EKONOMSKI	3,60%	4,05%	3,85%	3,90%	3,38%
SOCIJALNI	2,10%	1,40%	2,30%	3,40%	1,43%
PRIRODNI	1,80%	1,53%	1,55%	1,53%	1,98%
UPRAVLJANJE	2,98%	3,13%	2,73%	2,80%	2,68%
TEHNIČKA DOKUMENTACIJA	2,93%	2,75%	2,55%	2,68%	2,48%
LJUDSKI FAKTOR	3,85%	3,23%	2,55%	3,15%	2,95%
OPSKRBA I LOGISTIKA	2,95%	3,40%	3,00%	3,25%	3,10%
UGOVARANJE	2,90%	3,28%	2,50%	2,70%	2,38%

Figure 6. Utjecaj izvora rizika na uvećanje pojedinog dijela cijene u fazi realizacije projekta

U fazi realizacije najveći postotak na povećanje dijela cijene vezanog za troškove rada radnika imaju ekonomski rizici (3,60%) te rizici vezani za ljudski faktor (3,85%) dok najmanji utjecaj na dio cijene vezan za troškove rada radnika imaju prirodni rizici i to 1,80% te politčki izvori rizika i to 1,21 %.

Na dio cijene povezan sa troškovima materijala najveći postotak povećanja uzrokuju ekonomski izvori rizika (4,05%) te izvori rizika vezani za opskrbu i logistiku i to 3,40%. Najmanji postotak povećanja dijela cijene vezanog za troškove materijala od navedenih izvora rizika uzrokuju socijalni i to 1,40% te politički 0,85%.

Kod dijela cijene vezan za troškove strojeva i sredstava u fazi realizacije najveći postotak povećanja uzrokuju ekonomski (3,85%) te pravni izvori rizika (3,00%) dok najmanji postotak povećanja od svih navedenih izvora rizika uzrokuju prirodni (1,55%) te politički izvori (1,00%).

Povećanje dijela cijene vezanog za troškove podizvođača u postotku najviše čine ekonomski (3,90%) te rizici vezani za opskrbu i logistiku (3,25%) dok najmanji postotak povećanja uzrokuju prirodni izvori (1,53%) te politički izvori rizika (1,08%).

Na dio cijene povezan sa općim troškovima projekta i gradilišta izvođenja radova najveći postotak povećanja uzrokuju ekonomski (3,38%) te izvori rizika vezani za opskrbu i logistiku (3,10%) dok najmanji postotak povećanja od navedenih izvora rizika uzrokuju socijalni i politički izvori rizika i to u iznosu od 1,43%.

RISK SOURCE	DIRECT COSTS				PROJECT AND SITE INDIRECT COSTS OF WORKS EXECUTION
	LABOR	MATERIAL	MACHINERY AND ASSETS	OTHERS SERVICES	
LEGAL	2,43%	1,88%	2,40%	2,33%	2,63%
POLITICAL	1,21%	0,85%	1,00%	1,08%	1,43%
ECONOMIC	3,60%	4,05%	3,85%	3,90%	3,38%
SOCIAL	2,10%	1,40%	2,30%	3,40%	1,43%
NATURAL	1,80%	1,53%	1,55%	1,53%	1,98%
MANAGEMENT	2,98%	3,13%	2,73%	2,80%	2,68%
TECHNICAL DOCUMENTATION	2,93%	2,75%	2,55%	2,68%	2,48%
HUMAN FACTOR	3,85%	3,23%	2,55%	3,15%	2,95%
SUPPLY AND LOGISTICS	2,95%	3,40%	3,00%	3,25%	3,10%
CONTRACTING	2,90%	3,28%	2,50%	2,70%	2,38%

Figure 6. Impact of risk sources to the increase of an individual part of the price during project realization

In the stage of realization, economic risks (3.60%) and risks related to the human factor (3.85%) have the highest percentage of increase in part of the cost related to the labor costs, while natural risks (1.80%) and political risk sources (1.21%) have the lowest impact on a share of labor cost.

The highest percentage increases in the part of cost associated with material costs is caused by economic risk sources (4.05%) and by the sources of supply and logistics risks (3.40%). The smallest percentage increase in the total cost related to materials costs is caused by social (1.40%) and political risk sources (0.85%) out of the mentioned risk sources.

Concerning the part of the price related to the costs of machinery and assets during the implementation stage, the highest percentage of increase is caused by economic (3.85%) and legal risk sources (3.00%), while the lowest percentage increase is caused by natural (1.55% and political risk sources (1.00%) out of all mentioned risk sources.

The increase of a part related to the subcontractors' costs is mostly caused by economic (3.90%) and supply and logistics risk sources (3.25%), while the lowest increase percentage is caused by natural resources (1.53%) and political risk sources, 1,08%).

Regarding the part of the price related to the general costs of the project and construction site, the highest increase percentage is caused by economic (3.38%) and supply and logistics risk sources (3.10%), while the lowest increase percentage is caused by social and political risk sources in the amount of 1.43%, out of all mentioned risk sources.

5.5 Utjecaj rizika poslovnog sustava na strukturu poslovnog uspjeha i stanje poslovnog sustava

Vjerojatnost pojave rizičnog događaja u ovisnosti je o obilježjima poslovnog okruženja i poslovnog sustava. Pojava rizični događaj ima utjecaj na promjene u poslovnom sustavu a samim time i na promjene u projektnom sustavu. Istraživanjem rizičnih događaja ispitano je koliki intenzitet utjecaja na strukturu poslovnog uspjeha i stanje poslovnog sustava imaju rizici poslovnog sustava. Intenzitet utjecaja podijeljen je u pet razreda i to vrlo visoki, visoki, umjeren, nizak te vrlo nizak utjecaj i to od 15 kao najveći mogući i 0 kao najmanji mogući utjecaj. Razred intenziteta utjecaja određuje se na osnovu tablice razreda inteziteta.

Table 3. Razredi intenziteta utjecaja rizika troškovnog sustava na poslovni sustav

Intenzitet utjecaja	Srednja vrijednost	Mod
Vrlo nizak utjecaj VNU	0-3	0-3
Nizak utjecaj NU	3-6	3-6
	3-9	0-3
Umjeren utjecaj UU	6-9	3-6
	6-9	6-9
Visok utjecaj VU	6-9	9-12
	6-9	>12
Vrlo visok utjecaj VVU	>9	>12

Prikazani su i analizirani rezultati utjecaja za sve rizike troškovnog sustava na troškove poslovnog sustava a time i na njegov uspjeh. Prikazani su i svrstani u razrede intenziteta utjecaji rizika poslovnog sustava na strukturu poslovnog uspjeha.

Analizom rezultata anketnog istraživanja vidljivo je da izmjene zakonodavstva i propisa kao rizik poslovnog sustava visok utjecaj imaju na ulaganja u osnovna sredstva te na bruto dobit dok najmanji intenzitet utjecaja imaju na ukupan prihod poslovnog sustava i to umjeren utjecaj. U prosjeku gledano najveći utjecaj na uspjeh poslovnog sustava imaju rizici poslovnog sustava povezani sa pritiskom cijena odnosno padom cijena uslijed raznih uzroka. Intenzitet utjecaja ovog poslovnog rizika vrlo je visok i na troškove funkcioniranja poslovnog sustava, ulaganje u obrtna sredstva, bruto dobit te ukupan prihod. Ovi poslovni rizici visok intenzitet utjecaja imaju i na ulaganje u osnovna i obrtna sredstva. Prosječno gledano najmanji pak utjecaj na poslovni sustav imaju rizici poslovnog sustava povezani s ekologijom, energetskom učinkovitosti te regulacijom zaštite okoliša. Prema rezultatima istraživanja njihov intenzitet utjecaja je nizak na ulaganja u obrtna sredstva, troškove funkcioniranja poslovnog sustava, ulaganje u obrtna sredstva te ukupan prihod.

5.5 Impact of business system risk on the structure of business success and the state of business system

The probability of occurrence of a risk event depends on the business environment and business system features. The occurrence of a risk event influences the changes in the business system and thus it affects the changes in the project system. By investigating risk events, it was examined what impact the intensity of the risks of the business system has on the structure of business success and on the state of the business system. Impact intensity is divided into five classes, namely very high, high, moderate, low, and very low impact, ranging from 15 as the highest possible to 0 as the lowest possible impact. The class of intensity impacts is determined according to the intensity class table.

Table 3. Intensity classes of impact of cost system risks on business system

Impact intensity	Mean value	Mode
Very low impact VNU	0-3	0-3
Low impact NU	3-6	3-6
	3-9	0-3
Moderate impact UU	6-9	3-6
	6-9	6-9
High impact VU	6-9	9-12
	6-9	>12
Very high impact VVU	>9	>12

The impact results of all cost system risks on business system costs and thus on its success are presented and analyzed. The impacts of business system risks on the structure of business success are introduced and classified into intensity classes.

The analysis of the results of the survey shows that changes in legislation and regulations as a business system risk have a high impact on investment in basic assets and on gross profit, whereas they have the lowest impact intensity on the overall business system revenues, namely, moderate impact. On average, the highest impact on the business system success is made by business system risks along with price pressure or decrease of prices due to various causes. The impact intensity of this business risk is very high for the cost of operating a business system, investment in working capital, gross profit and total revenues. These business risks also have a high intensity impact on investment in basic working capital. On average, the lowest impact on business system is made by business system risks related to ecology, energy efficiency, and environmental regulation. According to research results, their impact intensity is low on investment in working capital, operating system costs, investment in working capital and total income.

RIZICI POSLOVNOG SUSTAVA	ULAGANJE U OSNOVNA STALNA SREDSTVA (SS)		TROŠKOVI FUNKCIONIRANJA POSLOVNOG SUSTAVA (HP)		ULAGANJE U OBRTNA SREDSTVA (OS)		BRUTO DOBIT		UKUPAN PRIHOD	
	srednja vrijednost	mod	srednja vrijednost	mod	srednja vrijednost	mod	srednja vrijednost	mod	srednja vrijednost	mod
izmjena zakonodavstva, propisa, prilagodbe, regulativa	7,45	10	8,20	5	8,15	5	7,64	10	8,03	4
	VISOK UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ	
mogućnost pristupa kreditima	8,90	10	7,15	10	8,44	10	6,64	5	7,40	5
	VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ		NIZAK UTJECAJ	
spor oporavak, dvostruki učinak recesije, dupli nakon kratkog oporavka	9,75	15	8,43	10	9,5	10	9,3	10	9,37	15
	VRLO VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VRLO VISOK UTJECAJ	
problemi u upravljanju talentima, fluktuacija, obrazovanje, obučavanje	7,18	9	7,18	10	6,97	5	6,58	5	6,24	5
	VISOK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ	
tržišta u nastojanju, tranzicija	9,42	10	8,48	5	7,9	5	7,85	5	8,19	15
	VISOK UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ	
aktivnosti na rezanju troškova	7,18	5	7,19	10	6,62	10	6,83	10	6,67	5
	UMJEREN UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ	
novi netradicionalni suradnici, novi poslovni modeli	6,74	5	7,51	10	7,03	8	7,2	7	6,72	6
	UMJEREN UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ	
ekologija, energetska učinkovitost, regulacija zaštita okoliša	5,13	2	5,63	2	5,26	5	6,08	3	5,67	5
	NIZAK UTJECAJ		NIZAK UTJECAJ		NIZAK UTJECAJ		UMJEREN UTJECAJ		NIZAK UTJECAJ	
trend socijano prihvatljivog i društveno odgovornog poslovanja	6,19	5	7,66	5	7,27	5	7,62	3	7,27	10
	UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ	
spajanje, ulaganja i akvizicije	6,12	10	6,31	1	5,97	1	6,68	10	7,15	8
	VISOK UTJECAJ		UMJEREN UTJECAJ		VRLO NIZAK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ	
nemogućnost inoviranja, inovacije	7,88	11	7,66	10	7,11	1	7,17	10	7,69	7
	VISOK UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ		UMJEREN UTJECAJ	
izmjena u održavanju infrastrukture, izmjena ulaganja u infrastrukturu	8,70	10	8,32	10	7,86	10	8,13	10	7,84	10
	VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ	
rizik novih tehnologija, koliko uvođenje novih tehnologija može utjecati na poslovanje	8,70	10	7,77	10	7,90	10	7,00	10	6,85	10
	VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ	
porezni rizik, rizik promjene porezne politike	8,18	5	8,00	3	7,63	5	9,14	10	8,44	10
	UMJEREN UTJECAJ		UMJEREN UTJECAJ		UMJEREN UTJECAJ		VISOK UTJECAJ		VISOK UTJECAJ	
pritisci cijena - pad cijena usljed raznih uzroka	8,92	15	9,43	15	9,73	15	9,92	15	9,58	15
	VISOK UTJECAJ		UMJEREN UTJECAJ		VRLO VISOK UTJECAJ		VRLO VISOK UTJECAJ		VRLO VISOK UTJECAJ	

Figure 7. Utjecaj rizika troškova poslovnog sustava na strukturu poslovnog uspjeha i stanje poslovnog sustav

5.6 Utjecaj rizika poslovnog sustava na uvećanje odgovarajućeg dijela troškova poslovnog sustava

U ovom dijelu istraživanja analiziran je utjecaj koji izvor rizika vrši na dio stanja poslovnog sustava. Rezultatima su prikazane srednje vrijednosti za koje izvođači smatraju da pojedini izvori rizika poslovnog sustava utječu na stanje poslovnog sustava. Za izvore poslovnog sustava koji utječu na troškove poslovnog sustava za više od 1% kažemo da značajno utječu na troškove dok na one ispod 1% kažemo da samo utječu na troškove poslovnog sustava. Za rezultate utjecaja s prosječnom vrijednosti manjom od 0 smatramo da ne utječu na troškove funkcioniranja poslovnog sustava.

Značajan utjecaj na ulaganja u osnovna obrtna sredstva kao izvor poslovnog rizika imaju izmjene zakonodavstva, spor oporavak od recesije, tržišta u nastajanju i tranzicije, nemogućnost inoviranja, izmjena državnih ulaganja u infrastrukturu, rizik novih tehnologija , porezni rizik te najveći utjecaj od 3,08% pritisci cijena odnosno pad cijena uslijed razlika uzroka.

BUSINESS SYSTEM RISKS	INVESTMENT IN BASIC FIXED ASSETS (SS)		BUSINESS SYSTEM FUNCTIONING COSTS (HP)		INVESTMENT IN WORKING ASSETS (OS)		GROSS PROFIT		TOTAL REVENUES	
	Mean value	mode	Mean value	mode	Mean value	mode	Mean value	mode	Mean value	mode
changes in legislation, regulations, adjustments, legislature	7,45	10	8,20	5	8,15	5	7,64	10	8,03	4
	HIGH IMPACT		MODERATE IMPACT		MODERATE IMPACT		HIGH IMPACT		MODERATE IMPACT	
availability of credits	8,90	10	7,15	10	8,44	10	6,64	5	7,40	5
	HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		MODERATE IMPACT		LOW IMPACT	
slow recovery, double effect of recession, double after a short recovery	9,75	15	8,43	10	9,5	10	9,3	10	9,37	15
	VERY HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		VERY HIGH IMPACT	
problems in managing talents, employee turnover, education, training	7,18	9	7,18	10	6,97	5	6,58	5	6,24	5
	HIGH IMPACT		HIGH IMPACT		MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT	
new, developing markets, transition	9,42	10	8,48	5	7,9	5	7,85	5	8,19	15
	HIGH IMPACT		MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT		HIGH IMPACT	
cost cutting activities	7,18	5	7,19	10	6,62	10	6,83	10	6,67	5
	MODERATE IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		MODERATE IMPACT	
new non-traditional collaborator, new business models	6,74	5	7,51	10	7,03	8	7,2	7	6,72	6
	MODERATE IMPACT		HIGH IMPACT		MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT	
ecology, energy efficiency environment protection management	5,13	2	5,63	2	5,26	5	6,08	3	5,67	5
	LOW IMPACT		LOW IMPACT		LOW IMPACT		MODERATE IMPACT		LOW IMPACT	
trend of socially acceptable and responsible behavior	6,19	5	7,66	5	7,27	5	7,62	3	7,27	10
	MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT		HIGH IMPACT	
merger, investment, acqusition	6,12	10	6,31	1	5,97	1	6,68	10	7,15	8
	HIGH IMPACT		MODERATE IMPACT		VERY LOW IMPACT		HIGH IMPACT		MODERATE IMPACT	
unavailability of innovation, innovations	7,88	11	7,66	10	7,11	1	7,17	10	7,69	7
	HIGH IMPACT		HIGH IMPACT		MODERATE IMPACT		HIGH IMPACT		MODERATE IMPACT	
change in infrastructure maintenance, change of investment in infrastructure	8,70	10	8,32	10	7,86	10	8,13	10	7,84	10
	HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT	
risk of new technologies, to what extent can introduction of new techn. influence business	8,70	10	7,77	10	7,90	10	7,00	10	6,85	10
	HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT		HIGH IMPACT	
taxation risk, risk of changing taxati. policy	8,18	5	8,00	3	7,63	5	9,14	10	8,44	10
	MODERATE IMPACT		MODERATE IMPACT		MODERATE IMPACT		HIGH IMPACT		HIGH IMPACT	
price pressure - price drop due to various causes	8,92	15	9,43	15	9,73	15	9,92	15	9,58	15
	HIGH IMPACT		MODERATE IMPACT		VERY HIGH IMPACT		VERY HIGH IMPACT		VERY HIGH IMPACT	

Figure 7. Impact of business system cost risk on the business success structure and the state of business system

5.6 Impact of business system risk on increase of the corresponding part of business system costs

This part of the study analyzes the impact of the risk source on a part of the business system. The results show the mean values for contractors who believe that some of the business system risk sources are affecting the business system. For business system resources that affect the business system costs by more than 1%, we say they have a significant impact on costs, while for those below 1% we say that they only affect the business system costs. As for the impact results with an average value below 0, we consider them not to affect the operating costs of a business system.

Significant impact on investment in basic working capital as a business risk source is made by the changes in legislation, slow recovery from recession, emerging and transition markets, inability to innovate, changes of government investment in infrastructure, the risk of new technologies, tax risk, and the highest impact of 3.08% is made by price pressures or price drops due to various causes.

RIZICI POSLOVNOG SUSTAVA	ULAGANJE U OSNOVNA STALNA SREDSTVA (SS)	TROŠKOVI FUNKCIONIRANJA POSLOVNOG SUSTAVA (HP)	ULAGANJE U OBRTNA SREDSTVA (OS)	BRUTO DOBIT	UKUPAN PRIHOD
izmjena zakonodavstva, propisa, prilagodbe, regulativa	1,95%	2,63%	2,42%	1,13%	1,26%
mogućnost pristupa kreditima	0,87%	0,28%	1,26%	-0,30%	0,10%
spor oporavak, dvostruki učinak recesije, dupli nakon kratkog oporavka	1,14%	2,78%	1,64%	0,58%	-7,08%
problemi u upravljanju talentima, fluktuacija, obrazovanje, obučavanje	0,08%	0,28%	0,05%	-0,13%	-0,13%
tržišta u nastojanju, tranzicija	2,08%	0,38%	1,08%	0,56%	0,82%
aktivnosti na rezanju troškova	0,26%	0,70%	0,00%	0,10%	-0,21%
novi netradicionalni suradnici, novi poslovni modeli	0,87%	1,13%	1,10%	0,38%	0,85%
ekologija, energetska učinkovitost, regulacija zaštita okoliša	0,64%	0,90%	0,90%	0,50%	0,60%
trend socijano prihvatljivog i društveno odgovornog poslovanja	0,49%	1,03%	0,55%	0,55%	0,35%
spajanje, ulaganja i akvizicije	0,56%	0,00%	0,18%	0,00%	0,05%
nemogućnost inoviranja, inovacije	1,36%	1,13%	0,74%	-0,13%	-0,15%
izmjena u održavanju infrastrukture, izmjena ulaganja u infrastrukturu	1,23%	1,08%	0,18%	-0,13%	-0,69%
rizik novih tehnologija, koliko uvođenje novih tehnologija može utjecati na poslovanje	1,28%	1,74%	0,77%	0,63%	-0,16%
porezni rizik, rizik promjene porezne politike	2,48%	1,64%	1,90%	1,51%	1,26%
pritisci cijena - pad cijena usljed raznih uzroka	3,18%	3,13%	2,92%	1,50%	1,34%

Figure 8. Utjecaj rizika troškova poslovnog sustava na uvećanje dijela troškova poslovnog sustva

Na troškove funkcioniranja poslovnog sustava značajan utjecaj imaju izmjene zakonodavstva, spor oporavak od recesije, novi netradicionalni suradnici, trend socijalno prihvatljivog i društveno odgovornog poslovanja, nemogućnost inoviranja, izmjena državnih ulaganja u infrastrukturu, rizik novih tehnologija, porezni rizik te pritisci cijena odnosno pad cijena. I na troškove funkcioniranja poslovnog sustava najveći utjecaj imaju pritisci cijena i to 3,13 % dok na njih utjecaj nemaju spajanja, ulaganja i akvizicije (0,00%).

Na ulaganje u obrtna sredstva značajan utjecaj imaju izmjene zakonodavstva, mogućnost pristupa kreditima, spor oporavak, tržišta u nastajanju, novi netradicionalni suradnici, porezni rizik te pritisci cijena. Najmanji intenzitet utjecaja na ulaganje u obrtna sredstva imaju problemi u upravljanju talentima i to 0,05% dok najveći utjecaj imaju izvori rizika povezani s pritiskom cijena 2,92%.

Značajan utjecaj na bruto dobit imaju izvori rizika poslovnog sustava povezani sa izmjenama zakonodavstva, porezni rizici te pritisci cijena odnosno pad cijena uslijed raznih uzroka. Najveći utjecaj na bruto dobit imaju porezni rizici i to 1,51% a ispitanici smatraju da na bruto dobit nemaju utjecaja

BUSINESS SISTEM RISKS	INVESTMENT IN BASIC FIXED ASSETS (SS)	COSTS OF BUSINESS SISTENS FUNCTIONING (HP)	INVESTMENT IN WORKING ASSETS (OS)	GROSS PROFIT	TOTAL REVENUES
changes in legislation, regulations, adjustments, legislature	1,95%	2,63%	2,42%	1,13%	1,26%
availability of credits	0,87%	0,28%	1,26%	-0,30%	0,10%
slow recovery, double effect of recession, double after a short recovery	1,14%	2,78%	1,64%	0,58%	-7,08%
problems in managing talents, employee turnover, education, training	0,08%	0,28%	0,05%	-0,13%	-0,13%
new, developing markets, transition	2,08%	0,38%	1,08%	0,56%	0,82%
cost cutting activities	0,26%	0,70%	0,00%	0,10%	-0,21%
new non-traditional collaborator, new business models	0,87%	1,13%	1,10%	0,38%	0,85%
ecology, energy efficiency environment protection management	0,64%	0,90%	0,90%	0,50%	0,60%
trend of socially acceptable and responsible behavior	0,49%	1,03%	0,55%	0,55%	0,35%
merger, investment, acqusition	0,56%	0,00%	0,18%	0,00%	0,05%
unavailability of innovation, innovations	1,36%	1,13%	0,74%	-0,13%	-0,15%
change in infrastructure maintenance, change of investment in infrastructure	1,23%	1,08%	0,18%	-0,13%	-0,69%
new technologies risk, to what extent can introduction of new techn. influence business	1,28%	1,74%	0,77%	0,63%	-0,16%
taxation risk, risk of changing taxati. policy	2,48%	1,64%	1,90%	1,51%	1,26%
price pressure - price drop due to various causes	3,18%	3,13%	2,92%	1,50%	1,34%

Figure 8. Impact of business system cost risk on the increase of a part of business system costs

Changes in legislation, slow recovery from recession, new non-traditional collaborators, a trend of socially acceptable and socially responsible business, the inability to innovate, the change of government investment in infrastructure, the risk of new technologies, the tax risk, and price pressure or price drop have a significant impact on the business system costs. Price pressures also have high impact on costs of operating the business system (3.13%), whereas they are not impacted by merger, investment and acquisitions (0.00%).

Changes in legislation, access to credit, slow recovery, emerging markets, new non-traditional partners, tax risk and price pressures have a significant impact on investment in working capital. The minimum intensity of the impact on investment in working capital is posed by problems in managing talents and this is 0.05%, while the greatest impact is related to price pressure risks-2.92%.

Significant impact on gross profit is made by business system risk sources related with changes in legislation, tax risks and price pressure or price drop risks due to various causes. The highest impact on gross profit is made by tax risks (1.51%) and respondents believe that gross profit is not affected by poslovni rizici povezani sa mogućnostima pristupa kreditu, problemima u upravljanju talentima te nemogućnosti inovacija i izmjene državnih ulaganja u infrastrukturu.

Na ukupan prihod poslovnog sustava značajan utjecaj imaju izvori rizika povezani sa izmjenama zakonodavstva i propisa te porezni rizici kao i pritisci cijena odnosno pad cijena uslijed raznih uzroka.

Ovaj dio istraživanja može poslužiti kao preporuka za identificiranje veličine utjecaja koji izvor rizika izaziva na određeni dio stanja poslovnog sustava. Naravno da pri tome treba voditi računa o izboru nekog izvora rizika po intenzitetu veze indentificiranih rizika, kao i vjerojatnosti pojave promatranog rizika.

5.7 Utjecaj pokretača poslovnih rizika na vjerojatnost pokretanja poslovnih rizika

U ovom dijelu rada analiziranu su rezultati istraživanja pojava koje pokreću poslovni rizik iz pasivnog u aktivno stanje. Utjecaji pokretača na pojedini izvor rizika svrstani su u pet intenziteta utjecaja.

Table 4. Razredi intenziteta utjecaja pokretača na pojedini izvor rizika

Intenzitet utjecaja	Opredjeljenje ispitanika
Vrlo nizak utjecaj VNU	0-20 %
Nizak utjecaj NU	20-40 %
Umjeren utjecaj UU	40-60 %
Visok utjecaj VU	60-80 %
Vrlo visok utjecaj VVU	80-100 %

Relevantnim se smatra pokretač rizika ako najmanje 20% anketiranih organizacija procjenjuje da taj pokretač može pokrenuti rizik iz pasivnog u aktivno stanje.

Prem rezultatima istraživanja možemo zaključiti da svi pokretači poslovnih rizika osim novih netradicionalnih suradnika te rizika novih tehnologija mogu dovesti do pokretanja rizika pada prihoda iz pasivnog u aktivno stanje. Visok utjecaj na rizik od pada prihoda imaju spor oporavak od recesije, porezni rizik te pritisci cijena.

Najčešći pokretač rizika koji može dovesti do pokretanja rizika iz pasivnog u aktivno stanje prema istraživanju je pokretač rizika vezna za spor oporavak od recesije a pokretač rizika koji najmanje utječe na pokretanje rizika je pokretač vezan za nove netradicionalne suradnike te rizik od novih tehnologija. Do pokretanja rizika gubitka kupaca i gubitka partnera prema ispitanicima dolazi jako rijetko. Na pokretanje gubitka kupaca utječu samo pokretači rizika vezani za spor oporavak od recesije te nemogućnosti inoviranja dok na aktiviranje rizika od gubitka partnera utječu samo pokretači rizika povezani sa mogućnostima pristupa kreditima i to niskim intenzitetom.

business risks related to the possible access to credits, talent management problems, and inability to innovate and the change of government investment in infrastructure.

The overall revenue of the business system is significantly impacted by the risk sources related to changes in legislation and regulations, tax risks as well as price pressures or price drops due to various causes.

This part of the research can serve as a recommendation for identifying the size of the impact that the source of the risk poses to a certain part of the business system state of affairs. It is certainly necessary to take into account the choice of a risk source by the intensity of the link of identified risk as well as the probability of occurrence of the observed risk.

5.7 Impact of business risk initiators on probability of initiating business risks

This part of the paper analyzes the research results of the phenomena that initiates the business risk from the passive to the active state. The impacts of initiators on a particular risk source are classified into five impact intensities.

Table 4. Classes of the intensity of initiators impact to individual risk sources

Impact intensity	Respondents' attitude
Very low impact VNU	0-20 %
Low impact NU	20-40 %
Moderate impact UU	40-60 %
High impact VU	60-80 %
Very high impact VVU	80-100 %

A risk initiator is considered as relevant if at least 20% of the surveyed organizations estimate that initiator as able to initiate a risk from the passive to the active state.

According to the research results we can conclude that all business risk initiators other than new non-traditional collaborators and the risk of new technologies may lead to initiating the income drop risk from passive into active state. High impact on the income drop risk is made by a slow recovery from recession, tax risk and price pressures.

According to the research, the most common risk initiator that can lead to risk initiation from passive to active state is the risk initiator related to slow recovery from recession and the least risk-driving initiator is the initiator related to new non-traditional collaborators and the risk of new technologies. Initiating the risk of losing customers and losing partners is very rare according to the respondents. Only the initiators of risk related to slow recovery from recession and the inability to innovate affect the initiation of customer loss, whereas risk initiators associated with credit access impact the activation of loss of partner risk with low intensity.

RIZICI POSLOVNOG SUSTAVA	PAD PRIHODA	RAST SUDSKIH SPOROVA	FLUKTUACIJA KLJUČNIH KADROVA	GUBICI KUPACA	GUBICI NATJEČAJA	NELIKVIDNOST	GUBITAK PARTNERA	OTKAZIVANJA DOBAVLJAČA	IZOSTANAK POTPORE BANAKA
izmjena zakonodavstva, propisa, prilagodbe, regulativa	55,00% UMJEREN	47,50% UMJEREN	15,00%	7,50%	17,50%	27,50% NIZAK	10,00%	5,00%	10,00%
mogućnost pristupa kreditima	27,50% NIZAK	12,50%	10,00%	15,00%	30,00% NIZAK	52,50% UMJEREN	22,50% NIZAK	20,00% NIZAK	40,00% UMJEREN
spor oporavak, dvostruki učinak recesije, dupli nakon kratkog oporavka	67,50% VISOK	20,00% NIZAK	20,00% NIZAK	40,00% UMJEREN	20,00% NIZAK	30,00% NIZAK	15,00%	20,00% NIZAK	10,00%
promlemi u upravljanju talentima, fluktuacija, obrazovanje, obučavanje	35,00% NIZAK	7,50%	45,00% UMJEREN	10,00%	2,50%	7,50%	5,00%	10,00%	10,00%
tržišta u nastojanju, tranzicija	37,50% NIZAK	5,00%	22,50% NIZAK	10,00%	12,50%	10,00%	12,50%	15,00%	10,00%
aktivnosti na rezanju troškova	22,50% NIZAK	10,00%	25,00% NIZAK	7,50%	7,50%	17,50%	10,00%	12,50%	12,50%
novi netradicionalni suradnici, novi poslovni modeli	12,50%	17,50%	12,50%	10,00%	15,00%	12,50%	10,00%	17,50%	20,00% NIZAK
ekologija, energetska učinkovitost, regulacija zaštita okoliša	25,00% NIZAK	25,00% NIZAK	10,00%	7,50%	12,50%	5,00%	2,50%	5,00%	2,50%
trend socijano prihvatljivog i društveno odgovornog poslovanja	27,50% NIZAK	15,00%	22,50% NIZAK	2,50%	17,50%	15,00%	7,50%	10,00%	10,00%
spajanje, ulaganja i akvizicije	27,50% NIZAK	5,00%	7,50%	2,50%	15,00%	12,50%	12,50%	5,00%	5,00%
nemogućnost inoviranja, inovacije	25,00% NIZAK	7,50%	12,50%	20,00% NIZAK	15,00%	15,00%	12,50%	10,00%	22,50% NIZAK
izmjena u održavanju infrastrukture, izmjena ulaganja u infrastrukturu	35,00% NIZAK	22,50% NIZAK	15,00%	15,00%	15,00%	5,00%	7,50%	10,00%	10,00%
rizik novih tehnologija, koliko uvođenje novih tehnologija može utjecati na poslovanje	15,00%	10,00%	15,00%	15,00%	15,00%	5,00%	7,50%	10,00%	10,00%
porezni rizik, rizik promjene porezne politike	62,50% VISOK	27,50% NIZAK	12,50%	15,00%	7,50%	27,50% NIZAK	15,00%	15,00%	12,50%
pritisci cijena - pad cijena usljed raznih uzroka	67,50% VISOK	12,50%	30,00% NIZAK	10,00%	22,50% NIZAK	22,50% NIZAK	17,50%	37,50% NIZAK	10,00%

Figure 9. Utjecaj pokretača rizika na pojedini izvor rizika

5.8 Rezultati istraživanja prihoda i rezerviranja za rizike u ukupnom prihodu poslovnog sustava

U istraživanju je provedeno ispitivanje najčešćeg iznosa rezerviranja za poslovne rizika obuhvaćeno kroz indirektne troškove poduzeća u ukupnoj cijene projekta. Najčešći odgovor anketiranih je da za poslovne rizike u cijenama svojih projekata rezerviraju 1%. Prema Pert razdiobi s 80% vjerojatnosti moglo bi se smatrati usvajanje iznosa od 2,53% cijene za poslovne rizike.

Istraživanjem je također napravljeno ispitivanje koliko % uobičajeno poslovni sustavi planiraju rast prihoda u narednoj godini ili razdoblju u odnosu na prihod u protekloj godini odnosno razdoblju. Najčešći odgovor anketiranih je da planiraju 10% veći prihod u sljedećem periodu u odnosu na prethodni. Prema Pert razdiobi s 80% vjerojatnosti moglo bi se smatrati 12,83% planiranog rasta prihoda u odnosu na prethodno razdoblje.

Analizirani su također rezultati postotka prihoda za iduću godinu ili razdoblje koji su već osigurani u vrijeme izrade plana. Najčešći odgovor anketiranih je da je samo 30% prihoda osigurano u trenutku donošenja plana. Prema Pert razdiobi s 80% vjerojatnosti moglo bi se smatrati usvajanje od 44,80% za osigurani prihod u trenutku izrade poslovnog plana.

BUSINESS SYSTEM RISKS	DROP IN REVENUES	INCREASE IN COURT DISPUTES	KEY PERSONNEL TURNOVER	LOSS OF CUSTOMERS	LOSS OF TENDERS	INSOLVENCY	LOSS OF PARTNER	SUPPLIER CANCELLATION	BANKS' SUPPORT FAILURE
changes in legislation, regulations, adjustments, legislature	55,00% MODERATE	47,50% MODERATE	15,00%	7,50%	17,50%	27,50% LOW	10,00%	5,00%	10,00%
availability of credits	27,50% LOW	12,50%	10,00%	15,00%	30,00% LOW	52,50% MODERATE	22,50% LOW	20,00% LOW	40,00% MODERATE
slow recovery, double effect of recession, double after a short recovery	67,50% HIGH	20,00% LOW	20,00% LOW	40,00% MODERATE	20,00% LOW	30,00% LOW	15,00%	20,00% LOW	10,00%
problems in managing talents, employee turnover, education, training	35,00% LOW	7,50%	45,00% MODERATE	10,00%	2,50%	7,50%	5,00%	10,00%	10,00%
new, developing markets, transition	37,50% LOW	5,00%	22,50% LOW	10,00%	12,50%	10,00%	12,50%	15,00%	10,00%
cost cutting activities	22,50% LOW	10,00%	25,00% LOW	7,50%	7,50%	17,50%	10,00%	12,50%	12,50%
new non-traditional collaborator, new business models	12,50%	17,50%	12,50%	10,00%	15,00%	12,50%	10,00%	17,50%	20,00% LOW
ecology, energy efficiency environment protection management	25,00% LOW	25,00% LOW	10,00%	7,50%	12,50%	5,00%	2,50%	5,00%	2,50%
trend of socially acceptable and responsible behavior	27,50% LOW	15,00%	22,50% LOW	2,50%	17,50%	15,00%	7,50%	10,00%	10,00%
merger, investment, acqusition	27,50% LOW	5,00%	7,50%	2,50%	15,00%	12,50%	12,50%	5,00%	5,00%
unavailability of innovation, innovations	25,00% LOW	7,50%	12,50%	20,00% LOW	15,00%	15,00%	12,50%	10,00%	22,50% LOW
change in infrastructure maintenance, change of investment in infrastructure	35,00% LOW	22,50% LOW	15,00%	15,00%	15,00%	5,00%	7,50%	10,00%	10,00%
risk of new technologies, to what extent can introduction of new techn. influence business	15,00%	10,00%	15,00%	15,00%	15,00%	5,00%	7,50%	10,00%	10,00%
taxation risk, risk of changing taxati. policy	62,50% HIGH	27,50% LOW	12,50%	15,00%	7,50%	27,50% LOW	15,00%	15,00%	12,50%
price pressure - price drop due to various causes	67,50% HIGH	12,50%	30,00% LOW	10,00%	22,50% LOW	22,50% LOW	17,50%	37,50% LOW	10,00%

Figure 9. Impact of risk initiators on individual risk source

5.8 Results of revenues research and of provisions for risks in total business system revenues

The study investigated the most common amount of business risk provisions covered by the company's indirect costs in the total cost of the project. The respondents most commonly answered that they reserve 1% for business risks in the prices of their projects. According to Pert distribution with an 80% probability, the adoption of an amount of 2.53% of the cost for business risks could be considered.

The survey also investigated by what percentage the business systems usually plan to increase revenues over the next year or period relative to the revenues in the previous year or period. The most common respondents' answer was that they plan 10% higher revenues over the next period compared to the previous one. According to Pert distribution with an 80% probability, 12.83% of planned revenue growth could be considered as compared to the previous period.

The results of the revenues percentage for the next year or the period that had already been provided at the time of developing the plan were also analyzed. The most commonly respondents answered that only 30% of revenues was provided at the time of the plan's adoption. According to Pert distribution with an 80% probability, an adoption of 44.80% for insured revenues at the time the business plan was created could be considered.

6. Doprinosi istraživanja i buduća istraživanja

Kako smo pregledom literature konstatirali nedostatak modela uključivanja utjecaja rizika pri formiranju ponudbene cijene projekta od strane izvođača građevinskih radova napravljena je anketa za istraživanje utjecaja rizika na ponudbenu cijenu i budžet projekta kod izvođača projekata. Radom su analizirani rezultati istraživanja. Ovdje nisu analizirane međuovisnosti rezultata pojedinih dijelova istraživanja niti je obrađen način primjene ovih rezultata. Ovakvi rezultati istraživanja poslužit će za formiranje modela izračuna ponudbene cijene i budžeta projekta koji će na adekvatan način uključiti sve utjecaje rizika na projekte i poslovne sustave. Usporedbom rezultata i uspostavljanjem međuovisnosti rezultata s obzirom na utjecaj rizika na projektne i poslovne sustave rezultati će se pripremiti za primjenu u budućem modelu. Primjenom ovakvog modela izvođač radova izbjeći će prevelike rezervacije za rizik u svojoj ponudbenoj cijeni te na taj način povećati mogućnost za osiguravanje ugovora te povećanje prihoda poslovnog sustava. Izvođač radova će također pirmjenom ovakvog modela izbjeći premale rezervacije za rizike koji mogu u toku realizacije projekta dovesti do katastrofalnih posljedica za sam projekt ali i cijeli poslovni sustav. U nastavku istraživanja pristupit će se formiranju ovoga modela te eventualnim dodatnim istraživanjima za povećanje detaljnosti planiranog modela. Također će se osigurati primjena i verificiranje formiranoga modela na određenom broju projekata.

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6. Contributions of research and future research

As a review of the literature found a lack of a model for incorporating the risk impact when a contractor of construction works forms the project bid price, a questionnaire was developed to investigate the impact of risk on the bid price and the contractor's project budget. The research results were analyzed in the paper. The interdependence of the results of certain parts of the research has not been analyzed here, nor is the way of applying these results addressed. These research results will be used to form the model of bid price and project budgets that will adequately include all project and business system risk impacts. By comparing the results and establishing the interdependence of results with regard to the impact of risk on project and business systems, the results will be prepared for application in the future model. By applying this model, the contractor will avoid excessive risk provisions in its bid price, thereby increasing the possibility to be awarded a contract and to increase the revenues of the business system. By the application of such model, the contractor will also avoid too scarce reservations for the risks that could cause disasterous consequences for the project as well as for the entire business system during the project implementation. In the follow up to this research, the formation of this model will be introduced and potential further research conducted in order to create a more detailed model. Also, the application and verification of the formed model on a number of projects will be ensured.

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HI

HERING

Franjo Zelenika, mag.ing.građ
Hering d.d. Široki Brijeg

Miroslav Matijević, ing.građ.
Hering d.d. Široki Brijeg

UGRADNJA BETONA NA VELIKIM VISINAMA - PRIMJER MOSTOVI STUDENČICA I TREBIŽAT

CONCRETE PLACING AT GREAT HEIGHTS – CASE STUDY: STUDENČICA AND TREBIŽAT BRIDGES

UGRADNJA BETONA NA VELIKIM VISINAMA - PRIMJER MOSTOVI STUDENČICA I TREBIŽAT

Franjo Zelenika, mag.ing.građ
Hering d.d. Široki Brijeg

Miroslav Matijević, ing.građ.
Hering d.d. Široki Brijeg

Sažetak

Stalna su nastojanja suvremenog građevinarstva da se unaprijedi proizvodnja uvođenjem suvremenih tehnologija građenja. Izvođači su u neprekidnoj utrci s vremenom s ciljem zadovoljavanja sve većih prohtjeva investitora uz dostizanje tražene kvalitete i primjene inovativnosti u projektima.

U radu je dat osvrt na važnost armiranobetonskih građevina, mostova, kao dijelova autoceste za svladavanje umjetne ili prirodne prepreke kao i uspješna primjena metoda ugradnje betona na velikim visinama.

Ključne riječi: mostovi, ugradnja betona, autocesta

Uvod

Autocesta je najviša klasa javnih cesta namijenjena sigurnom prometovanju vozila velikom brzinom. Dijelom se sastoji i od mostova i vijadukata koji su često armiranobetonske građevine koje omogućavaju da autocesta prijeđe preko prirodnih ili umjetnih prepreka. Mostovi Studenčica i Trebižat omogućavaju prijelaz autoceste koridora 5C u zahtjevnom okolišu preko rijeka i dolina rijeka Studenčica i Trebižat. Zahtijevan okoliš je uvjetovao da su ovi objekti dužine cca 600 i 400 m, visine nad tlom skoro 90 i cca 70 m. Ovolike visine su uvjetovale velike raspone (da se smanji broj visokih stupova rasponi su 120 m) a ovakve su konstrukcije velikih volumena što znači da je potrebno ugraditi velike količine betona u kratkom vremenu. Na poziciji svakog mosta rađena su dva paralelna mosta, a predviđeno vrijeme građenja je bilo 20 mjeseci. Takav zadatak je zahtijevao jako dobro planiranje ugradnje betona i odabir učinkovitih načina transporta betona na mjesto ugradnje.

CONCRETE PLACING AT GREAT HEIGHTS – CASE STUDY: STUDENČICA AND TREBIŽAT BRIDGES

Franjo Zelenika, MCE
Hering d.d. Široki Brijeg

Miroslav Matijević, CE
Hering d.d. Široki Brijeg

Abstract

Contemporary civil engineering constantly endeavors to enhance production by introducing contemporary construction technologies. All the time contractors are involved in a race against time in order to satisfy increasingly higher demands of Investors, reaching required quality and using innovations in projects.

This paper reviews the importance of reinforced-concrete buildings - bridges, as segments of a motorway managing artificial or natural obstacles, and it describes a successful application of a method of concrete placing at great heights.

Key words: bridges, concrete placing, motorway

Introduction

Motorways represent the highest class of public roads with a purpose of safe traffic of vehicles travelling at high speed. Bridges and viaducts also make a part of it and they are usually reinforced-concrete structures that enable motorways to run over natural or artificial obstacles. The bridges of Studenčica and Trebižat enable the motorway of corridor 5c to pass over the rivers Studenčica and Trebižat in demanding surroundings of valleys and rivers. The demanding surroundings conditioned these objects to be approximately 500 and 400 m long, almost 90 and approximately 70 m high above the ground. Such heights conditioned long spans (in order to reduce the number of tall piers, the spans are 120 m long) and structures like these have enormous volumes, which means that it is necessary to place huge quantities of concrete in a short time. At the location of each bridge, two parallel bridges were built, and the planned construction period was 20 months. Such a task required very effective planning of concrete placing and selection of effective ways of transportation of concrete to the location of placing.

Slika 1. Most Sudenčica, armiranobetonska građevina, autocesta, koridor 5c

Most Studenčica

Mostovi Studenčica prelaze široku dolinu i rijeku Studenčicu na visini od oko 90m iznad tla i dužine su po 555m. Ukupna širina svakog od dva mosta, zajedno s ogradama iznosi 12,42 m (0,46+0,50+2,50+2x3,75+2x0,50+0,46). Donji ustroj se sastoji od upornjaka U0 i U6, te stupova S1, S2, S3, S4 i S5.

Rasponski sklop

Rasponi oba mosta:	70,00+3x120,00+80,00+45,00 m
tip rasponske konstrukcije:	prednapeti armiranobetonski, sandučastog poprečnog presjeka
gradivo rasponske konstrukcije:	C 40/50, armatura B 500B, užad za prednapinjanje Y 1860S7

Stupovi su šuplji, poligonalnog oblika i promjenjive geometrije po visini.

Dio sanduka konstantne visine kod upornjaka U0 izvodi se na skeli, a dijelovi sanduka promjenjive visine od stupova S1, S2, S3 i S4 prema sredinama raspona izvode se slobodno konzolom gradnjom.

Slika 2. Most Sudenčica, faza izgradnje

Figure 1. Studenčica Bridge, a reinforced-concrete structure, motorway, corridor 5c

Studenčica Bridge

Studenčica bridges cross a wide valley and the Studenčica river at the height of about 90 m above the ground and each of them is 555 m long. The total width of each bridge, with fences is 12.42 m (0.46+0.50+2.50+2x3.75 +2x0.50+0.46). The substructure is made up of abutments U0 and U6, and piers S1, S2, S3, S4 and S5.

Span structure

Spans of both bridges:	70,00+3x120.00+80,00+45.00 m
Span structure type:	pre-stressed reinforced-concrete, box cross-section
Span structure material:	C 40/50, reinforcement B 500B, pre-stressing cables Y 1860S7

Piers are hollow, of polygonal shape and of different heights.

The box segment of constant height next to abutment U0 is executed on scaffolding, and the box segment of changeable height from piers S1, S2, S3 and S4 towards the span centers are executed by balanced free cantilevering.

Picture 2. Studenčica Bridge, construction stage

Slika 3. Most Trebižat, armiranobetonska građevina, autocesta, koridor 5C

Most Trebižat

Mostovi Trebižat prelaze široku dolinu i rijeku Trebižat na visini od oko 70m iznad tla i dužine su 380 m i 365 m. Ukupna širina svakog od dva mosta, zajedno s ogradama iznosi 12,42 m (0,46+0,50+2,50+2x3 ,75+2x0,50+0,46). Donji ustroj je takav da u osama 0 i 5 imamo upornjake lijevog mosta, dok u osama 1 i 6 imamo upornjake desnog mosta. Između su srednji stupovi a samo sa S2 i S3 se rasponska konstrukcija radi metodom slobodno konzolne gradnje. Ostali dijelovi rasponske konstrukcije se rade na skeli.

Rasponski sklop

Rasponi lijevi most: 50,00+80,00+120,00+80,00+50,00 m
Rasponi desni most: 80,00+120,00+80,00+50,00+35 m
tip rasponske konstrukcije: prednapeti armiranobetonski, sandučastog poprečnog presjeka
gradivo rasponske konstrukcije: C 40/50, armatura B 500B, užad za prednapinjanje Y 1860S7
Stupovi su šuplji, poligonalnog oblika i promjenjive geometrije po visini.

Slika 4. Faza izgradnje, izgradnja dijela rasponske konstrukcije mosta Trebižat na skeli

Figure 3. Trebižat Bridge, a reinforced-concrete structure, motorway, corridor 5C

Trebižat Bridge

Trebižat bridges span a wide valley and the Trebižat River at the height of about 70 m above the ground with the length of 380 m and 365 m, respectively. Total width of each of the two bridges with the fences is 12.42 m (0.46+0.50+2.50+2x3.75+2x0.50+0.46). The substructure is such that there are abutments of the left bridge in axes 0 and 5, and the abutments of the right bridge in axes 1 and 6. There are central piers between them and only from piers S2 and S3 the span structure is executed by the method of balanced free cantilevering. Other segments of span structure are executed on scaffolding.

Span structure

Spans – left bridge: 50.00+80.00+120.00+80.00+50.00 m
Spans – right bridge: 80.00+120.00+80.00+50.00+35 m
Span structure type: pre-stressed reinforced-concrete, box cross-section
Span structure material: C 40/50, reinforcement B 500B, pre-stressing cables Y 1860S7
Piers are hollow, of polygonal shape and of different heights.

Figure 4. Construction stage, construction of span structure of Trebižat bridge on scaffolding

Betoniranje rasponske konstrukcije

Beton se proizvodi u tvornici betona postavljenoj na gradilište mosta Studenčica. Beton se preuzima iz tvornice betona automixerima i transportira do slijedećeg sredstva transporta koje je ovisno o poziciji elementa koji betoniramo: autopumpa za beton, stacionarna pumpa za beton i pripadni cjevovod ili koš za transport betona gradilišnom dizalicom (kibla). Potrebno je osigurati dovoljan broj automiksera za osiguravanje kontinuirane ugradnje betona bez praznih hodova ili dugih čekanja na pojedinoj poziciji. Važno je da cio proces ide kontinuirano, od proizvodnje preko prvog transporta, pa preko drugog transporta i ugradnje. Sva sredstva u procesu proizvodnje, transporta i ugradnje trebaju po kapacitetu biti međusobno usklađeni. Za zadovoljenje ovih zahtjeva treba biti usklađena i receptura betona.

- Za betoniranje ovih segmenata koristili su se slijedeća mehanizacija i postrojenja: Postrojenje za proizvodnju svježeg betona – tvornica betona Stetter 90 (stvarni kapacitet 60 m^3/sat, zapremina silosa za cement 2x100 t)
- Automješalice (mikseri) različitog kapaciteta (6 m^3-12 m^3)
- Stacionarna pumpa za beton Putzmeister BSA 1409 D sa cjevovodom promjera 125 mm
- Autopumpe za beton sa hidraulički pokretanom rukom sa cijevi promjera 125 mm
- Toranjske dizalice sa korpama za svježi beton
- Razdjeljivač za beton ručni promjera cijevi 125 mm

Slika 5. Tvornica betona na gradilištu mosta Studenčica

Betoniranje rasponske konstrukcije vršeno je najvećim dijelom uz pomoć stacionarnih pumpi za beton. Korištene su 3 pumpe tipa Putzmeister BSA 1409 D, te dvije pokretne pumpe (autopumpe) koje su korištene na gradilištu, proizvođača Schwing na vozilu Mercedes. Tek ponegdje ugradnju je pomagala gradilišna dizalica sa koševima za beton (kiblama).

Concreting span structure

Concrete was manufactured in a concrete batching plant located on the construction site of the Studenčica bridge. Concrete mixing trucks were used to take concrete and transport it to its next means of transportation which depended on location of elements being concreted: concreting pumping truck, stationary concrete pump with its pipeline or bucket for concrete transport to the construction crane. It was necessary to provide enough mixer trucks in order to ensure continuous placing of concrete without pauses or long waiting for individual positions. It is important that the whole process flows continuously from manufacturing over transportation, another transportation and placing. All components in the processes of manufacturing, transportation and placing should be mutually coordinated by capacities. To satisfy these demands, concrete formulas should also be coordinated.

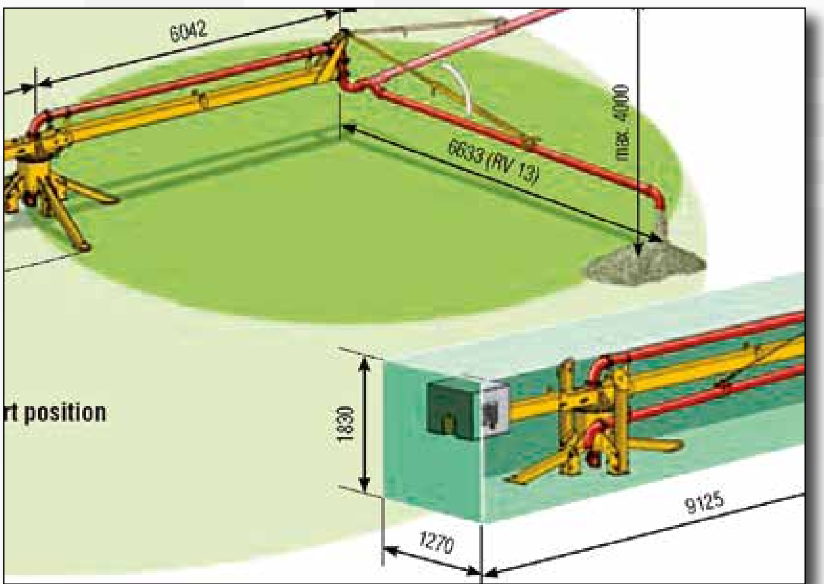
- The following machinery and plants were used for concreting those segments: Production of fresh concrete - Concrete batching plant Stetter 90 (real capacity 60 m^3/hour, volume of silo for cement - 2x100 t)
- Truck mixers of various capacities (6 m^3-12 m^3)
- Stationary concrete pump Putzmeister BSA 1409 D with pipeline of diameter 125 mm
- Concrete pumping trucks with hydraulic driven boom with pipe diameter 125 mm
- Tower cranes with buckets for fresh concrete
- Manual concrete distributer, pipe diameter 125 mm

Figure 5. Concrete batching plant on a construction site of Studenčica Bridge

Concreting span structure was executed mainly with the help of stationary concrete pumps. At the site three pumps of type Putzmeister BSA 1409 D and two mobile pumps of Schwing make mounted on Mercedes trucks were used. The concreting was occasionally helped by construction crane with buckets of concrete.

Slika 6. Faza izgradnje, izrada baznog dijela rasponske konstrukcije

Prvi segmenti betoniranja pojedinih segmenata rasponske konstrukcije imale su po 80 m^3 betona, dok su zadnji segmenti imali oko 45 m3. Naravno, zadnji segmenti su od stupa uz koji se pumpao beton bili udaljeni 55 m, pa je i transport cijevima bio dulji. Isti dan su se betonirali segmenti na obadvije strane sa jednog stupa i to cijeli segmenti (donja ploča, rebra, gornja ploča). Ovaj proces je trajao oko 8 sati i sadržao je 6 sati rada na transportu betona. Ostalo je bila priprema cijevi i preusmjeravanje sa jednog kraja konzole na drugi.



Slika 7. Razastirač za beton

Figure 6. Construction stage, execution of base segment of span structure

First segments of concreting individual segments of span structure had 80 m^3 of concrete each, whereas final segments had about 45 m^3. Naturally, the final segments were 55 m away of piers which were used for pumping, thus the transportation through the pipes was longer. The segments on both sides of a pier, i.e. complete segments, were concreted (lower slab, ribs, upper slab) on the same day. This process lasted about 8 hours and consisted of 6 hours on concrete transportation. The rest was preparation of pipes and redirecting from one end of cantilever to another.

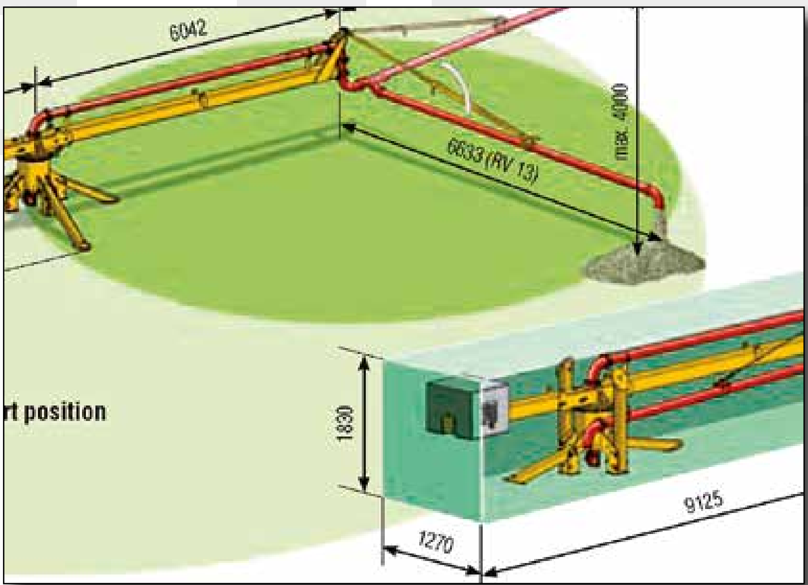


Figure 7. Concrete spreading

Slika 8. Stacionarna pumpa – Putzmeister BSA 1409 D

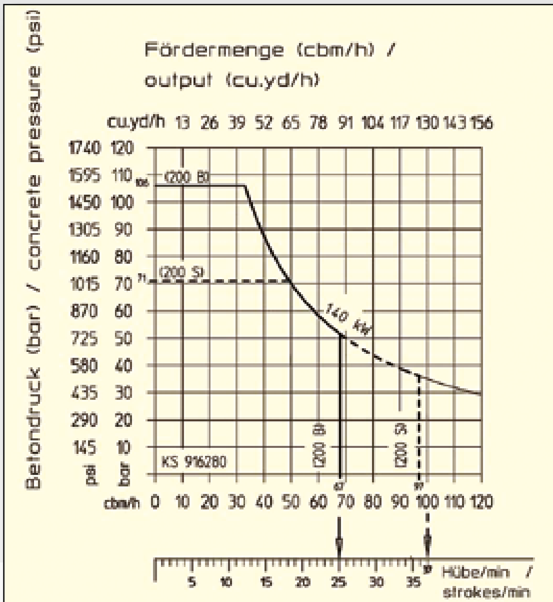
Betoniranje završnih segmenata stupova rađeno je koševima za beton. Ciklus ugradnje pojedinog koša kapaciteta 1m^3 trajao je 5,0min. Dakle za segment od 50m3 betoniranje je trajalo 5h. Montažom cjevovoda za beton i korištenjem stacionarne pumpe vrijeme betoniranja je višestruko umanjeno. Sam kapacitet stacionarne pumpe za beton nadmašuje kapacitet tvornice betona.

Slika 9. Cjevovod za beton S3 desno Most Studenčica

Figure 8. Stationary pump – Putzmeister BSA 1409 D

Concreting of final pier segments was executed by buckets for concrete. The concreting cycle of each individual bucket lasted for 5.0 minutes. Thus for a segment of 50 m^3, concreting took 5 hours. The time needed for concreting was decreased by the fitting of concrete pipeline and use of stationary pump. The capacity of stationary concrete pump exceeds the capacity of the concrete batching plant.

Figure 9. Concrete pump S3 right, Studenčica Bridge



Slika 10. Dijagram kapaciteta stacionarne pumpe BSA 1409

Slika 11. Princip rada i sastavni dijelovi stacionarne pumpe za beton: 1.mikser za opskrbu betonom, 2.stacionarna pumpa;3.zatvarač za regulaciju protoka;4.razastirač za beton;5.mikser za povrat betona

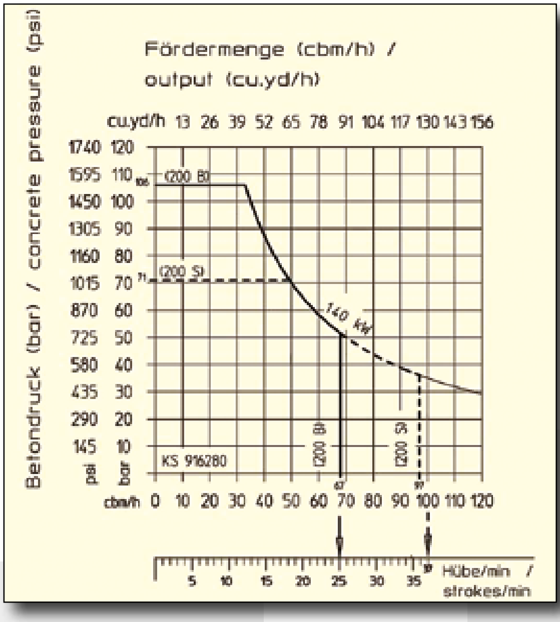


Figure 10. Diagram showing capacity of stationary pump BSA 1409

Figure 11. Operating mode and integral parts of stationary concrete pump: 1. truck mixer for concrete delivery, 2. stationary pump; 3. shutter regulating flow; 4. concrete spreader; 5. truck mixer for return of concrete

Betoniranje donje ploče segmenta rasponske konstrukcije radilo se kroz otvor ostavljen u oplati gornje ploče.

Slika 12. Betoniranje donje ploče segmenta u oplati za slobodno konzolnu gradnju

Prilikom pumpanja betona, materijal cijevi se troši jer je pri pumpanju izložen abraziji. Opseg trošenja ovisi o sastavu betona. Posebno su agresivna zrna agregata eruptivnog porijekla koji imaju veliku čvrstoću i tvrdoću i time nepovoljno utiču na trajnost cjevovoda za beton. U zonama najvećih tlakova (podnožje stupova) vršena je redovna kontrola i zamjena istrošenih dijelova sustava. Kao posebno osjetljivo mjesto ističe se dno stupa gdje cjevovod za beton prelazi iz horizontalnog u vertikalni položaj (koljeno), i gdje su najveći tlakovi.

Slika 13. i 14. Ugradnja betona rasponske konstrukcije građene slobodno konzolnom gradnjom i na skeli

Concreting the lower segment slab of span structure was executed through an opening set in concreting formwork of the upper slab.

Figure 12. Concreting of segment lower slab in formwork of balanced free cantilevering

During concrete pumping, the pipe material wears out because it is exposed to abrasion during pumping. Wearing range depends on the composition of concrete. Grains of aggregates of eruptive origin are specifically aggressive as they are very hard and sturdy, thus influencing adversely concrete pump lifecycle. Regular checks were conducted at the zones of highest pressure (bottom of the piers), and worn-out parts of the system were replaced. The bottom of a pier where concrete pipeline is directed from horizontal into vertical position (angle band), where the pressure is the highest, appeared as a specifically sensitive place.

Figure 13 and 14. Concreting span structure constructed by balanced free cantilevering and on scaffolding

Slika 15. Betoniranje rasponske konstrukcije S4D mosta Studenčica s kombiniranim transportom betona autopumpom i stacionarnnom pumpom s razastiračem za beton

Umjesto zaključka

Kod zahtjeva za velike količine betona u uvjetima komplicirane ugradnje vrlo je važno da kontrolirate i upravljate svim procesima proizvodnje, transporta i ugradnje betona. Vrlo je važna pravovremena doprema materijala kod betoniranja velikih presjeka (recimo naglavne ploče i veliki temelji). Tada treba uskladiti kapacitet za prihvat materijala (agregat, cement) i paralelno sa proizvodnjom vršiti dopremu (dopunjavanje) skladišta uz betonaru. Važno je uskladiti kapacitet svih faza transporta i ugradnje. Treba se uskladiti brzina proizvodnje, transport sa dovoljno mixera, pumpe ili posude i dizalice koje omogućavaju dostavu betona u količini približno jednakoj proizvodnji ili malo većoj, odgovarajući broj radnika za opsluživanje cijelog procesa i ugradnju sa dovoljno sredstava koja omogućavaju ugradnju i zbijanje dovoljne količine betona u jedinici vremena. Nama su se u ovom primjeru stacionarne pumpe pokazale jako učinkovitima.

Figure 15. Concreting span structure S4D of Studenčica bridge using combined concrete transportation by pump truck and stationary concrete pump with concrete spreader

Instead of conclusion

When large quantities of concrete are required and the conditions for concrete placing are complicated, it is very important to control and manage all the processes of production, transportation and placing of concrete. Prompt delivery of concrete is highly important when concreting huge sections (for example, head slabs and large foundations). A capacity for acceptance of material (aggregate, cement) should be coordinated, and the storehouse next to the concrete batching plant should be continuously supplied during the production. It is important to coordinate the capacity of all transportation stages and concreting. It is necessary to cordinate the elements such as production rate, transportation with enough concrete mixer trucks, pumps or containers and cranes which enable concrete delivery in quantities that approximately equal to the production or a bit more, corresponding number of workers to handle the whole process with concrete placing using enough resources that enable placing and compacting satisfactory amount of concrete per time unit. In this case we witnessed stationary pumps as being very effective.

Slika 16., 17., 18. Faza izgradnje / **Figure 16., 17., 18.** Construction stage

Slikovni prikaz izgradnje
Photo display of construction

Izgradnja rasponske konstrukcije mosta Studenčica slobodnom konzolnom gradnjom
Construction of span structure of Studenčica Bridge by balanced free cantilevering

Izgradnja rasponske kostrukcije mosta Trebižat oslonjene o tlo
Construction of Trebižat Bridge span structure resting on the ground

Izgradnja rasponske konstrukcije mosta Trebižat
Construction of span structure of Trebižat Bridge

Most Studenčica / Studenčica Bridge

Most Trebižat / Trebižat Bridge

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HERING

Marin Nikolić, mag.ing.građ.
Hering d.d. Široki Brijeg

Doc.dr.sc Ivana Burcar Dunović, dipl.ing.građ
Sveučilište u Zagrebu, Građevinski fakultet

UTJECAJ KOMPLEKSNOSTI PROJEKTA NA NAGRAĐIVANJA PROJEKTNIH TIMOVA ZA IZVOĐENJE GRAĐEVINSKIH PROJEKATA

INFLUENCE OF PROJECT COMPLEXITY ON REWARDING PROJECT TEAMS EXECUTING CONSTRUCTION PROJECTS

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Marin Nikolić, mag.ing.građ.
Hering d.d. Široki Brijeg

Doc.dr.sc Ivana Burcar Dunović, dipl.ing.građ
Sveučilište u Zagrebu, Građevinski fakultet

1. Uvod

Uspjeh projektno orijentiranih organizacija ovisi o pojedinačnom uspjehu njihovih projekata kako s financijskog gledišta tako i s gledišta reputacije. Financijski uspjeh osobito građevinskih projekata značajno ovisi o članovima tima koji provodi projekt odnosno o postojanju sustava njihovog nagrađivanja. U slučaju izvođenja građevinskih projekata to se najviše odnosi na postojanje financijskih nagrada i poticaja. Pregledom literature analizirat će se istraživanja iz polja nagrađivanja, metode mjerenja uspješnosti izvršenja u građevinarstvu te elementi projekta koja utječu na njegovu kompleksnost. Utvrdit će se postoji li modeli nagrađivanja u građevinarstvu koje osim rezultata mjerenja izvršenja uključuju i utjecaj kompleksnosti projekta. Na osnovu pregleda literature i ciljeva istraživanja postavit će se hipoteze istraživanja te detaljnije pojasniti metodologija pomoću koje će se nastojati doći do modela za nagrađivanje članova projektnih timova kod izvođenja građevinskih projekata.

Rezultat istraživanja bit će model nagrađivanja projektnih timova koji će osim rezultata mjerenja izvršenja u obzir uzimati i kompleksnost projekta kao i način na koji je projektni tim upravljao izvođenjem projekta. Takav model služit će za pravedno nagrađivanje projektnih timova za izvođenje projekata bez obzira na karakteristike projekata koji su im povjereni na izvođenje.

2. Pregled literature

2.1 Sustavi nagrađivanja i mjerenje rezultata izvršenja

Nagrade se mogu definirati kao financijske i nefinancijske naknade koje se daju u skladu s individualnim ili timskim postignućima (*Armstrong, 1993*). Kerr (1985) je definirao sustave nagrađivanja kao mehanizme koji oblikuju ponašanje pojedinca kroz strategiju cijele organizacije. Jacobsen i

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Marin Nikolić, MCE
Hering d.d., Široki Brijeg,

Assist. Prof. Ivana Burcar Dunović, PhD BCE
Faculty of Civil Engineering Zagreb

1. Preamble

The success of project oriented organizations depends on the individual success of their projects, both from a financial and a reputational point of view. Financial success, especially for construction projects, depends significantly on the members of the team implementing the project as well as on the existence of the system of their rewarding. In the case of construction projects, this is related mostly to the existence of financial rewards and incentives. A review of the literature will analyze the researches in the area of rewarding, the method of measuring execution efficacy in the construction industry and the elements of the project that influence its complexity. It will be established whether there are models of rewarding in construction that include the impact of the project complexity besides the results of performance measurement. Based on a review of the literature and research objectives, research hypotheses will be set and we will clarify the methodology which will attempt to reach the model for rewarding members of project teams executing construction projects.

The research result will be a model for rewarding project teams, which will take into consideration both the complexity of the project, and the way the project team manages the project and the results of performance measurement. Such a model will be used for equitable rewarding of project teams for project execution, regardless of the characteristics of projects entrusted to them for execution.

2. Literature overview

2.1 Reward systems and performance management

Rewards may be defined as financial and non-financial benefits that are awarded in accordance with individual or team achievements (*Armstrong, 1993*). Kerr (*1985*) defined reward systems as mechanisms that shape the behavior of an individual through the strategy of the entire organization.

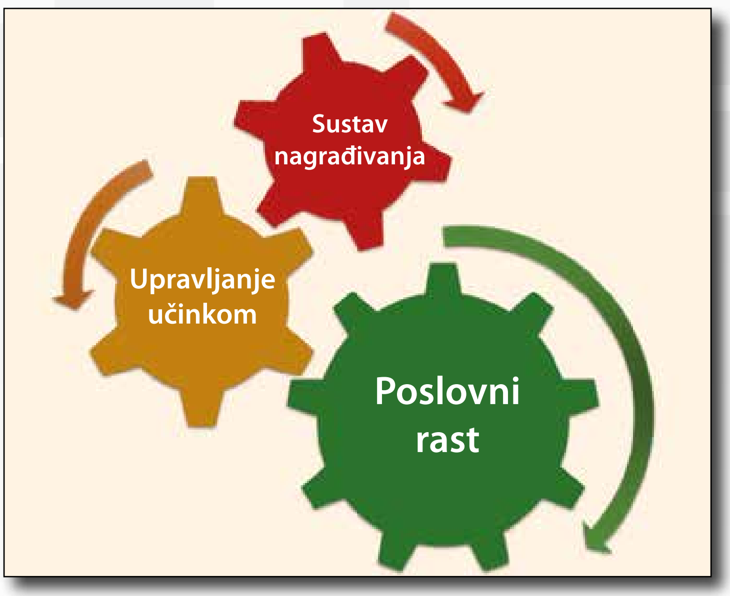
Thorsvik (2002) sugeriraju da sustav nagrađivanja treba sastojati od tri elementa oblikovana na najbolji mogući način.

Primatelj nagrada:	Oblici nagrada:	Što se nagrađuje?
• Individualac • Grupa • Sustav	• Unutarnji • Vanjski	• Orjentacija na ponašanje • Orjentacija na ishod

Slika 1. Pregled sustava nagrađivanja *(Jacobsen & Thorsvik, 2002)*

Kada organizacija donese odluku da će nagrađivati tada pristupa određivanju karakteristika sustava nagrađivanja. Na osnovu pregleda literature utvrđeno je da organizacija treba odlučiti koga će nagrađivati, što će biti nagrađeno, na koji način, koliko, kada i koliko često (*Beel, 2007*).

Važno je napomenuti da je prilikom pregleda literature utvrđeno je da se u sustavima nagrađivanja karakteristike i posebna obilježja projekta ne uzimaju u obzir, osim što se točke preokreta i završetak projekta predstavljaju kao potencijalni trenuci u vremenu za nagrađivanje timova (Beel, 2007). Na osnovu analiziranih istraživanja možemo konstatirati da rezultati projektnih timova za izvršenje projekta uvelike zavise o primjeni sustava nagrađivanja. Stoga možemo utvrditi da između sustava nagrađivanja, rezultata mjerenja uspješnosti te uspjeha cijele organizacije vlada čvrsta međuovisnost (Slika 2).



Slika 2. Povezanost nagrađivanja i rezultata mjerenja uspješnosti *(izvor: performancemagazine.org)*

Jacobsen and Thorsvik (*2002*) suggest that the reward system should consist of three elements shaped in the best possible way.

Recipients of revards:	Forms of reward:	What is rewarded?
• Individual • Group • System	• Intrinsic • Extrinsic	• Behaviour-oriented • Outcome-oriented

Figure 1. Overview of reward system (*Jacobsen & Thorsvik, 2002*)

When an organization makes a decision to reward then it approaches to determining the characteristics of the reward system. Based on the literature review, it was established that an organization should decide who will be rewarded, what will be rewarded, in which manner, to what extent, when and how often (*Beel, 2007*).

It is important to note that during the overview of the literature, it was found that in the reward systems, the characteristics and special features of the project are not taken into consideration, except that the turning points and the completion of the project are represented as potential moments in time for rewarding teams (*Beel, 2007*). Based on the analyzed researches we are able to claim that the results of project teams for execution of a project depend greatly on the application of the reward system. Therefore, we may conclude that there is a strong interdependence between the reward system, the results of performance measurement and the success of the whole organization (Figure 2).

Figure 2. Interrelation between reward systems and performance management *(source:performancemagazine.org)*

Literatura koja se odnosi na mjerenje izvršenja veoma je široka. Mjerenje izvršenja u građevinarstvu prvenstveno je usmjereno na vrijeme, troškove i kvalitetu (*Love i Holt, 2000; Kagioglou i dr., 2001*). Slučajevi korištenja najpoznatijih modela za mjerenje rezultata izvršenja u upravljanju projektima opisani su i u literaturi za građevinarstvo: Kagioglou i dr. (*2001*) opisali su izmijenjeni Balanced Scorecard za građevinarstvo; Watson i Seng (*2001*), te Beatham et al. (2002) pokazali su kako se EFQM može provesti u građevinarstvu; i Beatham i dr. (2003) identificirali i kritički vrednovali korištenje KPIs u građevinarstvu.

Na temelju pregleda literature Shaban (2008) je napravio prisustvo KPI u modelima za praćenje izvođenja građevinskih projekata (Slika 3).

Ključni pokazatelji uspješnosti	Okuwoga (1998)	Dissanayaka Anda Kumaraawamy (1999)	Reichelt and Lyneis (1999)	Karim and Marosszeky (1999)	Brown and Adams (2000)	DETR (2000)	Lehtonen (2001)	Chan (2001)	Samson and Lema (2002)	Kuprenas (2003)	Cheung (2004)	Navon (2005)	Iyer et al (2005)	Love et al (2005)	Ugvu and Haupt (2007)	Hovicht (2007)	Added Factors
Trošak	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Vrijeme	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Kvaliteta			✓			✓			✓	✓	✓	✓	✓		✓	✓	
Produktivnost		✓	✓						✓			✓	✓	✓	✓	✓	
Zadovoljstvo klijenta						✓			✓		✓		✓				
Opće i zadovoljstvo zajednice									✓				✓				✓
Ljudi									✓				✓			✓	✓
Zdravlje i sigurnost			✓		✓	✓			✓		✓				✓		✓
Inovacije i učenje									✓				✓				
Okoliš											✓		✓		✓		

Slika 3. Pregled osnovnih grupa ključnih pokazatelja izvršenja po istraživanjima *(izvor: Shaban; 2008)*

Prilikom provođenja istraživanja i definiranja modela koristit će se ključni pokazatelji izvršenja kao jedan od elemenata koji utječu na nagrađivanje članova projektnih timova.

Na osnovu obrađene literature možemo zaključiti da ne postoji sustav nagrađivanja projektnih timova za izvođenje građevinskih radova koji osim mjerenja uspješnosti projektnih timova u obzir na adekvatan način uzima i kompleksnost građevinskog projekta koji se izvodi. Kompeleksnost projekta

2.2 Kompleksnost projekta

Kompleksnost projekta sastoji se od mnogo različitih međusobno povezanih dijelova i može se operacionalizirati u terminima diferencijacije i međuzavisnosti. Primjena pojma kompleksnosti u građevinarstvu nije široko istražena, međutim, otkriveno je da se proces izgradnje može sam po sebi smatrati kompleksnim sustavom (*Wood, Gidado 2008*).

Literature related to performance measurement is quite comprehensive. Performance measurement in construction primarily focuses on time, cost and quality (*Love and Holt, 2000*; *Kagioglou et al., 2001*). The cases of the use of best-known models for measuring performance results in project management are also described in the literature for construction: Kagioglou et al. (*2001*) described the revised Balanced Scorecard for Construction; Watson and Seng (*2001*), and Beatham et al. (*2002*) showed that EFQM can be implemented in construction; Beatham et al. (*2003*) also identified and critically evaluated the use of KPIs in construction.

Based on the review of literature, Shaban (*2008*) made the KPI presence in models for monitoring construction projects (Figure 3).

Key Performance Indicators	Okuwoga (1998)	Dissanayaka Anda Kumaraawamy (1999)	Reichelt and Lyneis (1999)	Karim and Marosszeky (1999)	Brown and Adams (2000)	DETR (2000)	Lehtonen (2001)	Chan (2001)	Samson and Lema (2002)	Kuprenas (2003)	Cheung (2004)	Navon (2005)	Iyer et al (2005)	Love et al (2005)	Ugvu and Haupt (2007)	Hovicht (2007)	Added Factors
Cost	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Time	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Quality			✓			✓			✓	✓	✓	✓	✓		✓	✓	
Productivity		✓	✓						✓			✓	✓	✓	✓	✓	
Client satisfaction						✓			✓		✓		✓				
Regular and community satisfaction									✓				✓				✓
People									✓				✓			✓	✓
Safety and health			✓		✓	✓			✓		✓				✓		✓
Innovation and learning									✓				✓				
Enviroment											✓		✓		✓		

Figure 3. Summary of the main groups affecting the performance of construction projects (KPIs groups) and their references source; Shaban 2008)

When conducting research and defining the model, key performance indicators will be used as one of the elements that affect the rewarding of project team members.

Based on the covered literature we can conclude that there is no system for rewarding project teams for performing construction works that takes into account the complexity of the construction project being executed besides measuring the performance of project teams, in an adequate manner.

2.2 Project complexity

The Project complexity consists of many different interconnected parts and may be operationalized in terms of differentiation and interdependence. The use of the term 'complexity' in construction is not thoroughly examined; however, it has been established that the process of construction by itself can be considered as a complex system (*Wood, Gidado 2008*).

Hertogh i Westerveld (2009) su u svome istraživanju ''Playing with complexity'' definirali šest elemenata kompleksnosti: tehnička, socijalna, financijska, pravna, organizacijska te vremenska kompleksnost.

Prilikom utvrđivanja utjecaja kompleksnosti projekta na nagrađivanje i stvaranja modela nagrađivanja koristit ćemo se kvantitativnom analizom utjecaja ovih elemenata na kompleksnost projekta izvođenja građevinskih radova.

3. Ciljevi i hipoteze

Predmet rada je na osnovu istraživanja utvrditi pravedan model nagrađivanja članova projektnih timova za izvođenje građevinskih projekata koje će u sebi sadržavati utjecaj rezultata mjerenja izvršenja, kompleksnosti projekta te načina upravljanja izvođenjem projekta. Za razvoj modela nagrađivanja postavit će se sljedeće hipoteze:

- **H0**: Moguće je formirati pošten sustav nagrađivanja članova projektnih timova za izvođenje građevinskih projekata koji će uključivati rezultate mjerenja uspješnosti izvršenja, utjecaj kompleksnosti projekta koji se izvodi te načina kojim njime upravlja projektni tim.
- **H1**: Postojeći sustavi nagrađivanja članova projektnih timova za izvođenje građevinskih radova oslanjaju se samo na rezultate mjerenja uspješnosti izvršenja bez uzimanja u obzir utjecaja kompleksnosti projekta na konačne rezultate projektnih timova.
- **H2**: Kompleksnost građevinskih projekata ima veliki utjecaj na rezultate mjerenja uspješnosti projektnih timova za njihovo izvođenje.

Cilj rada je detaljno istražiti postoji li definiran model nagrađivanja u kojemu je na adekvatan način uključen utjecaj kompleksnost građevinskih projekata te analizirati pojam kompleksnosti projekata. Anketom će se utvrditi što za voditelje projekata te članove projektnih timova predstavlja pojam kompleksnosti. Prilikom uključivanja kompleksnosti u model nagrađivanja koristit će se kvalitativna analiza elemenata kompleksnosti projekta. Na temelju pregleda literature i rezultata podataka prikupljenih kroz ankete potvrdit će se glavna te pomoćne znanstvene hipoteze.

4. Metodologija

Istraživanje će se započeti s detaljnim pregledom literature vezane za nagrađivanje, mjerenje izvršenja te kompleksnost projekta kod projekata za izvođenje građevinskih radova. Na osnovu pregleda literature formirat će se upitnik za anketiranje voditelja projekata te članova projektnih timova za izvođenje građevinskih projekata. U trećem koraku definirat će se model nagrađivanja. Na osnovu pregleda rezultata dosadašnjih istraživanja te na osnovu rezultata istraživanja rezultata upitnika kroz ankete koja će se provesti među članovima projektnih timova za upravljanje izvođenjem građevinskih projekata utvrdit će se utjecaj rezultata mjerenja pokazatelja izvršenja na ukupnu uspješnost

In their study “Playing with complexity” Hertogh and Westerveld (2009) defined six elements of complexity: technical, social, financial, legal, organizational and time complexity.

When determining the impact of the complexity of the project on rewarding and creating a reward model, we will use a quantitative analysis of the impact of these elements on the complexity of the construction project.

3. Objectives and hypotheses

The subject matter of this paper is to determine the equitable model of rewarding members of project teams for executing construction projects, which will include the impact of performance measurement results, complexity of the project and of the mode of project management execution. In order to develop a reward model, the following hypotheses will be set:

- **H0**: It is possible to form an honest system of rewarding members of project teams for executing construction projects, which will include the results of execution efficacy measurement, the impact of the complexity of the project being executed and the way the project team manages it.
- **H1**: Existing reward systems for project team members for construction work rely only on the results of measuring execution efficacy without taking into consideration the impact of project complexity on the final results of project teams.
- **H2**: Complexity of construction projects has a major impact on the results of the measurement of the efficacy of project teams for their performance.

The aim of the paper is to examine in detail whether there is a defined reward model that adequately incorporates the impact of complexity of construction projects and analyze the concept of project complexity. The survey will determine what the concept of complexity represents for project managers and members of project teams. When integrating complexity into the reward model, qualitative analysis of the elements of project complexity will be used. The main and supporting scientific hypotheses will be confirmed based on the literature review and the results of the data obtained through the survey.

4. Methodology

The research will begin with a detailed review of literature related to rewarding, performance measurement and complexity of projects in construction projects. Based on a review of the literature, a survey questionnaire will be developed for project managers and project team members for construction projects. In the third step, the reward model will be defined. The impact of the results of measuring the performance indicators on the overall efficacy of project teams for the execution of construction works and the extent of influence of the elements of project complexity on the overall complexity of the project being executed and, accordingly, on the model of rewarding members of projektnih timova za izvršenje građevinskih radova te stupanj utjecaja elemenata kompleksnosti projekta na ukupnu kompleksnost projekata koji se izvodi te shodno tome na model nagrađivanja članova projektnih timova za izvođenje projekata. Model nagrađivanja članova projektnih timova za izvođenje građevinskih projekata osim navedenih rezultata mjerenja izvršenja pomoću pokazatelja izvršenja te utjecaja stupnja kompleksnosti građevinskog projekta koji se izvodi sadržavat će i element koji će biti ovisan o načinu primjene znanja i tehnika od strane projektnih timova prilikom izvođenja samog projekta.

5. Očekivani doprinosi

Osnovni očekivani doprinos ovog rada je formiranje pravednog modela nagrađivanja članova projektnih timova za izvođenje građevinskih projekata na osnovu analize literature te rezultata ankete proveden u organizacijama za izvođenje građevinskih radova. Primjenom ovog modela nagrađivanja bit će omogućen daljnji napredak u povećanju uspješnosti projektnih timova te cijelih organizacija za izvođenje građevinskih projekata.

6. Literatura

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project teams for project execution will be determined based on the review of the results of previous research and on the basis of the results of the survey of the questionnaire results through surveys to be carried out among the project team members for the management of construction projects. Besides the mentioned results of performance measurement with performance indicators and impact of the degree of complexity of the construction project being executed, the model of rewarding members of project teams to execute construction projects will also include an element that will depend on how the project teams apply knowledge and techniques when executing the project.

5. Expected Contributions

The basic expected contribution of this paper is the formation of an equitable model for rewarding members of project teams for executing construction projects on the basis of literature analysis and the results of the survey conducted in construction organizations. The application of this reward model will enable further progress in increasing the efficacy of project teams and entire organizations for executing construction projects.

6. Literature

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HERING

Prof dr. sc. Alen Harapin, dipl. ing. građ
Sveučilište u Splitu, Građevinski i arhitektonski fakultet

Doc.dr.sc. Dragan Ćubela, dipl.ing.građ.
Sveučilište u Mostaru, Građevinski fakultet

Mr.Sc.Ladislav Bevanda, dipl.ing. građ.
Mario Jurišić, dipl.ing.građ.
HERING d.d. Široki Brijeg

Ivo Rako, dipl.ing. građ.,
Ronald Rejo, dipl.ing.građ.
LAVČEVIĆ-inženjering d.o.o

TEHNOLOGIJA GRADNJE ARMIRANO-BETONSKE KUPOLE SPORTSKE DVORANE VIŠNJIK U ZADRU

BUILDING TECHNOLOGY FOR REINFORCED CONCRETE DOME OF VIŠNJIK SPORTS HALL IN ZADAR

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Prof dr. sc. Alen Harapin, dipl. ing. građ
Sveučilište u Splitu, Građevinski i arhitektonski fakultet

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Sveučilište u Mostaru, Građevinski fakultet

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HERING d.d. Široki Brijeg

Ivo Rako, dipl.ing. građ.,
Ronald Rejo, dipl.ing.građ.
LAVČEVIĆ-inženjering d.o.o

Sažetak

U ovom radu se ukratko opisuje tehnologija gradnje armirano-betonske kupole sportske dvorane Višnjik u Zadru. Izabrana tehnologija je monolitna gradnja, betoniranje na licu mjesta na fiksiranu oplatu i skelu. Budući da je struktura dvostruko zakrivljena, postavljanje oplate i skele je izuzuetno složeno jer je svaki dio oplate i skele jedinstven. Nadalje, veličina i složenost strukture zahtijeva dodatnu analizu i pripremu detaljnog vremenskog plana za postavljanje i uklanjanje oplate i skele, kao i za betoniranje, u cilju optimalnog iskorištavanja rabljene opreme i ljudskih resursa. Štoviše, neki arhitektonski i funkcionalni zahtjevi uzrokuju dodatne poteškoće u projektu veza, betoniranju sastava i ostalim detaljima izgradnje, koje se sve moraju riješiti putem projektirane tehnologije.

Ključne riječi: betonska kupola, tehnologija gradnje

BUILDING TECHNOLOGY FOR REINFORCED CONCRETE DOME VIŠNJIK SPORTS HALL IN ZADAR

Prof. Alen Harapin, Phd BCE*
University of Split, Faculty of Civil Engineering and Architecture

Assistant Prof. Dragan Ćubela, Phd BCE *
University of Mostar, Faculty of Civil Engineering

M.Sc.Ladislav Bevanda BCE*
Mario Jurišić BCE*
HERING d.d. Široki Brijeg

Ivo Rako BCE*
Ronald Rejo BCE*
LAVČEVIĆ-inženjering d.o.o

Abstract

The paper shortly describes the building technology of reinforced concrete dome of sports hall Višnjik in Zadar. Chosen technology is monolithic construction, on spot concreted on fixed formwork and scaffold. Since the structure is double curved, placing of formwork and scaffold is extremely complex because each part of formwork and scaffold is unique. Furthermore, the size and complexity of the structure require additional analyzing and detail time plan diagram preparing for setting and removing formwork and scaffold, as well as for concreting, aiming to optimally use exploit equipment and human resources. Moreover, some architectural and functional requests cause additional difficulties in connections design, concreting joints and other constructions details which all must be resolved through designed technology.

Keywords: concrete dome, building technology

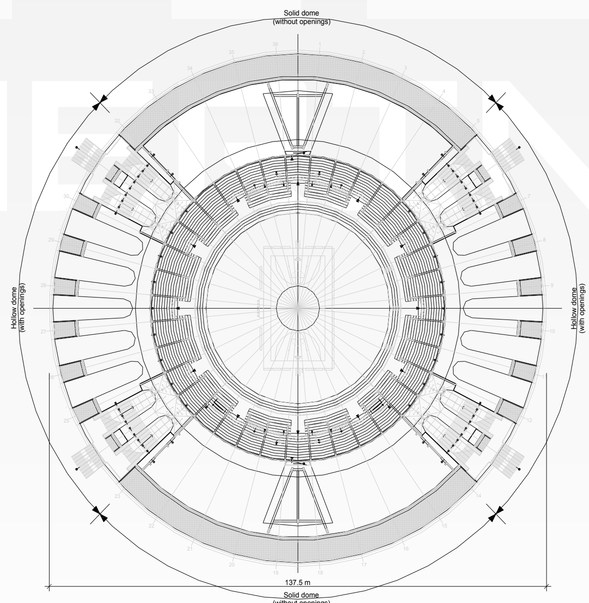
Uvod

Sportska dvorana Višnjik u Zadru vjerojatno je najveća građevina koja se trenutno gradi u Hrvatskoj. Na slikama 1, 2 i 3 prikazani su neki crteži s dimenzijama ove zgrade, kao i kompjuterska vizualizacija završenog projekta. Također se može naznačiti da će gotova građevina biti izrađena od 14.000 m^3 betona i 1.400 t armature, kao i sa 60.000 m^3 skele i 20.000 m^2 oplate.

Ova građevina bi se mogla koristiti u mnoge svrhe. Pored glavne dvorane s auditorijem, koja može primiti oko 8.100 posjetitelja, građevina ima dvije manje dodatne dvorane za različite sportske treninge, kao i mnoge druge prateće sadržaje poput teretane, kafića, restorana i uredskih prostorija.

Investitor ovog velikog projekta je: Ministarstvo znanosti, obrazovanja i športa Republike Hrvatske i Grad Zadar. Procijenjeni troškovi građevinskih radova iznose oko 65 milijuna kuna.

Slika 1. Kompjuterska vizualizacija sportske dvorane Višnjik



Slika 2. Tlocrt sportske dvorane Višnjik

Introduction

Sports hall Višnjik in Zadar is probably the biggest building currently under construction in Croatia. Some drawings with dimensions of this building, as well as computer visualization of completed project, are shown in figures 1, 2 & 3. Also, it can be specified that the finished building will be made of: 14.000 m^3 of concrete and 1.400 t of reinforcement, as well as: 60.000 m^3 of scaffold and 20.000 m^2 of formwork.

The Building could be used for many purposes. Except main hall with auditorium, which can take about 8.100 visitors, building has additional two smaller halls for different sports trainings as well as many other accompanying contents like fitness room, café bar, restaurant and office rooms.

Investor of this big project is: Ministry of science, education and sport of Republic of Croatia and City of Zadar. Estimated costs for civil engineering works ore about 65 million HRK.

Figure 1. Computer visualization of sports hall Višnjik

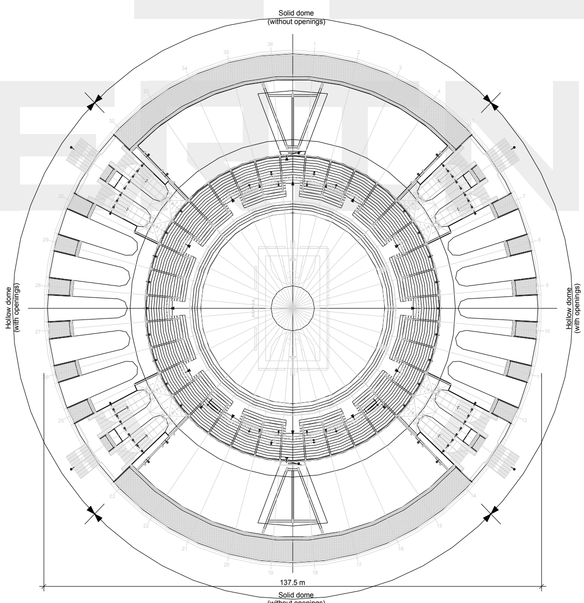
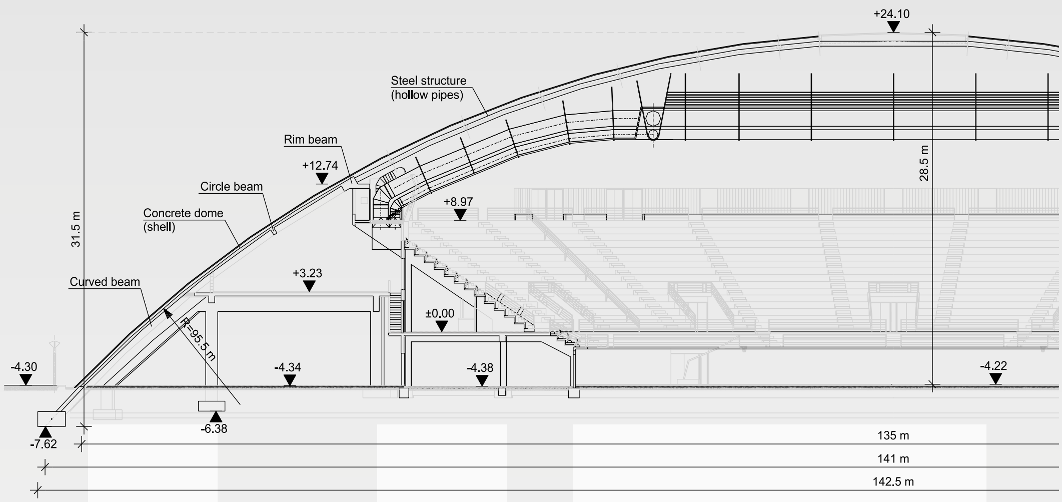


Figure 2. Plan of sports hall Višnjik



Slika 3. Poprečni presijek sportske dvorane Višnjik

O strukturi i tehnologiji građenja

Glavna nosiva struktura zgrade je armirano-betonska kupola, od temelja do vrha dvorane (19,16 m), a iznad toga je rešetkasta struktura čeličnih šupljih profila. Ova kupola je dio površine kugle sa polumjerom R = 95,46 m, tj. kalota R = 70,05 m s visinom h = 30,52 m. Ova ljuska, u strukturnom smislu, oslabljena je slijedom ulaznih otvora koji suprotne strane kupole čine slabijima. Ljuska se temelji na prednapregnutom betonskom prstenu.

Odabrana tehnologija je monolitna gradnja, betoniranje u oplati na licu mjesta.

Zbog veličine građevine i potrebne količine oplate i skele, nemoguće je izraditi svu skelu i oplatu odjednom, tako da se oplata i skela moraju praviti u dijelovima tijekom napredovanja izgradnje i betoniranja.

Skela i oplata

Podupiranje oplatne strukture je izvedeno STAXO skelom za visoku potporu. Iznimka je napravljena na onim dijelovima strukture sa niskom elevacijom gdje se STAXO tornjevi ne mogu rabiti, pa se koriste drveni podupirači dimenzija 12/16 cm na punim dijelovima kupole (dijelovima bez šupljina) i 16/16 cm ispod zakrivljenih greda (otvori) (Slike 4 i 5).

STAXO skela je sačinjena od tornjeva (dva STAXO okvira zajedno povezana i učvršćena) koji se vežu sa dijagonalnim i vodoravnim pričvršćivačima – čeličnim cijevima ili dvostrukim cijevma na nekim

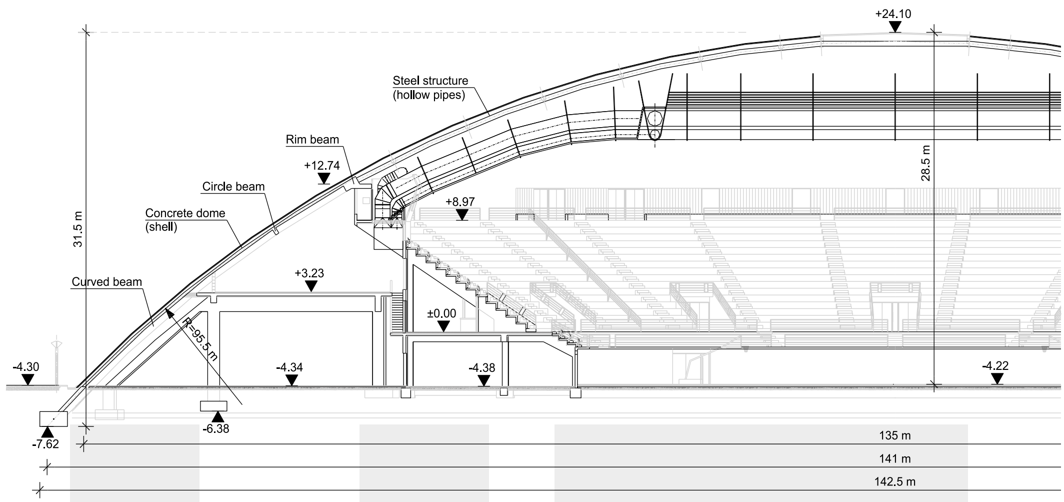


Figure 3. Cross-section of sports hall Višnjik

About the structure and construction technology

The main bearing structure of building is reinforced concrete dome – shell, from foundations to the top of auditorium (19.16 m), and above that is the truss structure of steel hollow profiles. This dome is part of sphere surface with radius of R=95.46 m, i.e. calotte of R=70.05 m with height of h=30.52 m. This shell, in structural sense, is softened with sequence of entrance openings which weaken opposite sides of dome. Shell is based on prestressed concrete ring.

Chosen technology is monolithic construction, concreted in formwork on the site. Because of building size and required quantity of formwork and scaffold, it is impossible to make whole scaffold and formwork at once, so formwork and scaffold must be made in sequences during construction and concreting progress.

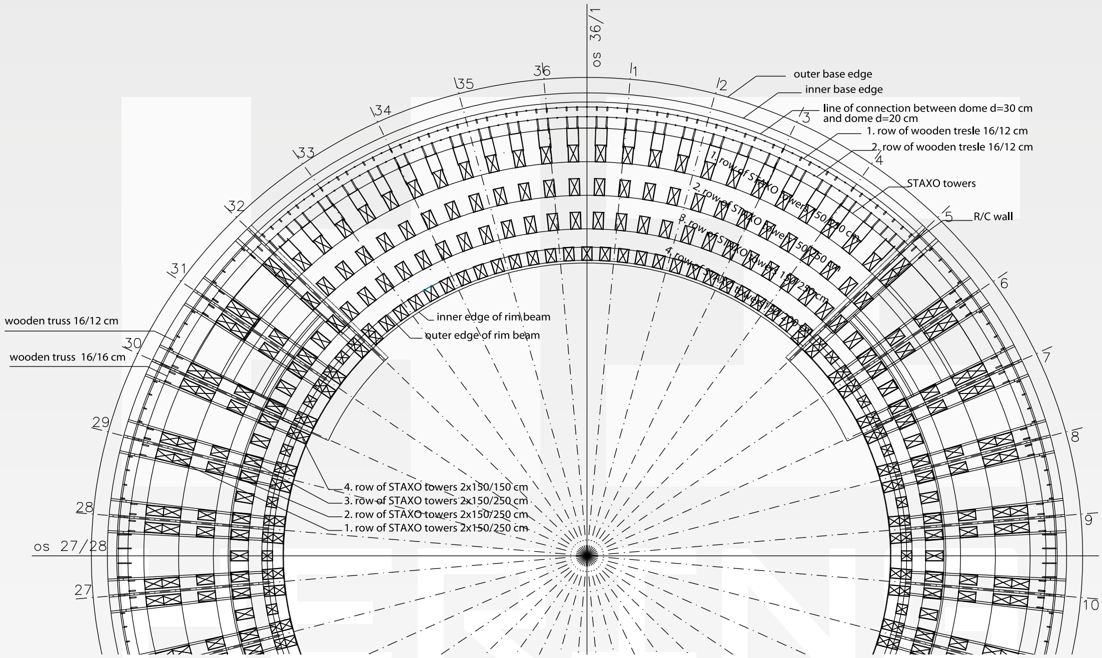
Scaffold and formwork

Shoring of formwork structure is performed with STAXO scaffold for high support. Exceptions are parts of structure with low elevation where STAXO towers cannot be used, so wooden trusses are used with dimensions: 12/16 cm on solid parts of the dome and 16/16 cm under curved beams (openings) (Figure 4 & 5).

STAXO scaffold is constituted of the towers (two STAXO frames together connected and stiffened) which are bound with diagonal and horizontal stiffeners – steel pipes, or twin pipes on some parts of scaffold. Scaffold towers are placed according to the scaffold static calculation. Stiffeners pipes placement is performed according to demands and requirements for global stability assurance.

dijelovima skele. Tornjevi skele se postavljaju prema statičkom izračunu skele. Postavljenje cijevi za pričvršćivanje se izvodi prema zahtjevima i potrebama globalnog osiguranja stabilnosti.

Svaki drugi toranj je povezan (osiguran) sa spojnim cijevima u tangencijalnim pravcima, a sa drugim parom povezanih tornjeva su spojeni sa vodoravnim cijevima. Radijalno su svi tornjevi povezani spojnim cijevima. Na oslabljenim mjestima strukture (dio sa zakrivljenim gredama/stupovima), svi tornjevi su povezani sa cijevima radi čvrstine. Na dijelu kupole sa zakrivljenim gredama (šuplji dijelovi), dva tornja su povezana u tangencijalnom pravcu i sa vodoravnim cijevima sa drugim dvostrukim tornjevima. Radijalno su svi tornjevi povezani sa cijevima zbog čvrstoće skele (Slika 6).



Slika 4. Tlocrt tornjeva skele

Prostorno osiguranje drvenih podupirača na dijelu kupole bez šupljina je izvedeno drvenim dijagonalnim učvršćivačima (10/12 cm) u radijalnom smjeru i sa drvenim poprečnim dijagonalama (2x2.4/12 cm) i horizontalama (2x2.4/12 cm) u tangencijalnom pravcu. Na šupljem dijelu kupole, prostorno osiguranje je prilično slično i izvodi se drvenim dijagonalnim učvršćivačima (10/12 cm) u radijalnom smjeru, a u tangencijalnom pravcu sa drvenim poprečnim dijagonalama (10/12 cm) i horizontalama (2x2.4/12 cm). Veza između drvenih podupirača i STAXO tornjeva nije izvedena direktno nego ispod remenata i drvene oplate na punim dijelovima kupole i ispod nosivih drvenih greda (nosači H20) – transverzalne grede) i drvene oplate na šupljem dijelu kupole.

Each two towers are connected (assured) with bond pipes in tangential directions, and with other couple of connected towers are linked with horizontal pipes. In radial directions all towers are connected with bond pipes. On weakening parts of structure (part with curved beams/columns), all towers are connected with pipes for stiffening. On dome part with curved beams (hollow part), two towers are connected in tangential direction and with horizontal pipes with other twin towers. In radial direction all towers are connected with pipes for scaffold stiffening (Figure 6).

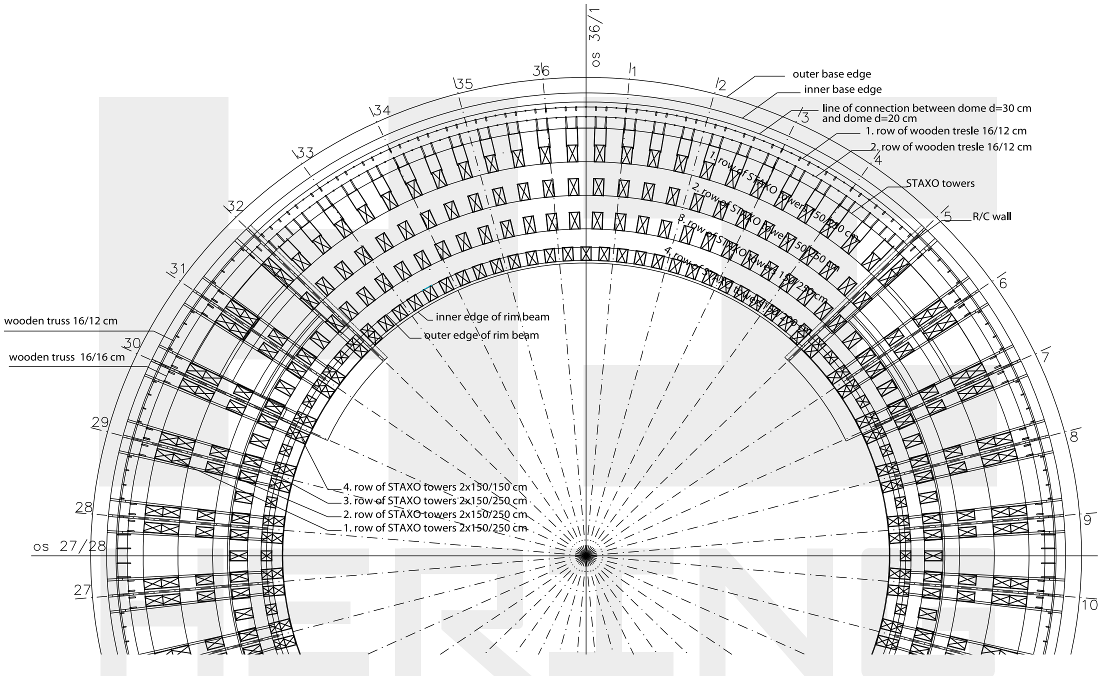
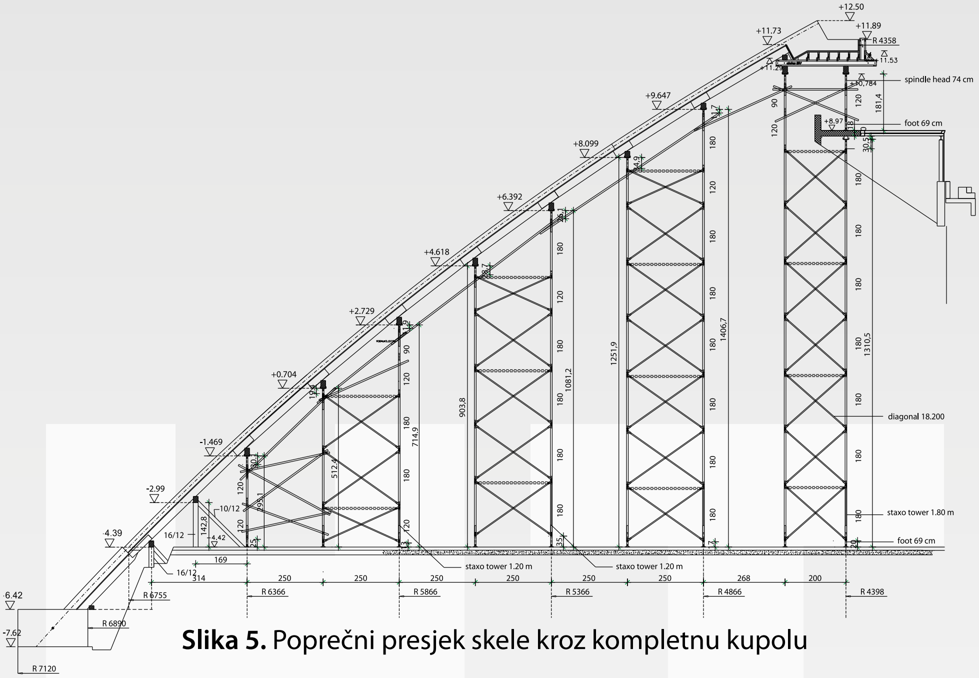


Figure 4. Plan of scaffold towers

Spatial assurance of wooden truss on solid part of dome is made by wooden diagonal bracing (10/12 cm) in radial direction and with wooden crossing diagonals (2x2.4/12 cm) and horizontals (2x2.4/12 cm) in tangential direction. On hollow part of dome, spatial assurance is quite similar, and made by wooden diagonal bracing (10/12 cm) in radial direction, and in tangential direction with wooden crossing diagonals (10/12 cm) and horizontals (2x2.4/12 cm). Connection of wooden trusses with STAXO towers is not done directly, but under centrings and wooden formwork on solid part of dome and under bearing wooden beams (girders H20 – transversal beams) and wooden formwork on hollow part of dome.



Slika 5. Poprečni presjek skele kroz kompletnu kupolu

Skela ispod rubne grede leži na armirano-betonskoj ploči iznad tribina, sa jednim svojim dijelom, te je spojena i pričvršćena za nju. Na potpornim mjestima armirano-betonska ploča je poduprta sa toranjskom konstrukcijom iz podruma.

Skela leži direktno na podnoj ploči ukoliko je već betonirana. Na mjestima gdje podna ploča ne postoji, podupirači skele leže na dobro zbijenoj zemlji na drvenim podmetačima debljine d=4,8 cm i dimenzija 20/20 ispod stopa STAXO tornjeva, te na drvenim podmetačima dimenzija 16/16 i 20/15 ispod drvenog nosača.

U nekim fazama postavljanja oplate, skela ima dodatnu stabilizaciju sa prostornim zategama na punim dijelovima kupole i rubne grede, te sa zategama i drvenim dijagonalnim učvršćivačima na šupljim dijelovima. Ovi dijelovi se uklanjaju kada više nisu potrebni (Slika 6).

S aspekta osiguranja stabilnosti skele i smanjenja utjecaja vjetra na neopterećenu oplatu, predviđeno je postavljanje skele i oplate u fazama.

Četiri faze postavljanja oplate su planirana na punim dijelovima kupole. U prvoj fazi se postavljaju dva reda drvenih nogara sa neovisnim okvirom skele i prvi toranj (sve zajedno prvih pet redova nosivih greda). Slijedi postavljanje remenate i oplate i betoniranje prema izabranom dinamičkom planu (vidi naprijed – faze betoniranja). U drugoj fazi postavljanja oplate, postavljaju se sljedeća dva tornja skele (6., 7., 8. i 9. red greda) i betoniraju se zajedno sa 8. fazom betoniranja. Treća faza se sastoji od postavljanja preostalih tornjeva i oplate do rubne grede. Četvrta faza je postavljanje oplate i betoniranje rubne grede.

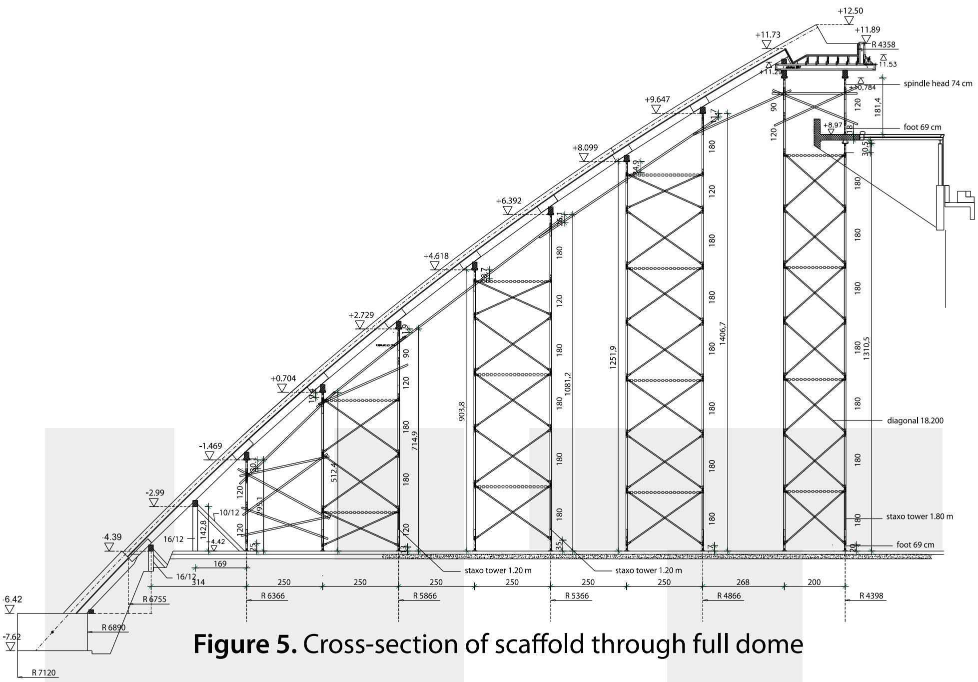


Figure 5. Cross-section of scaffold through full dome

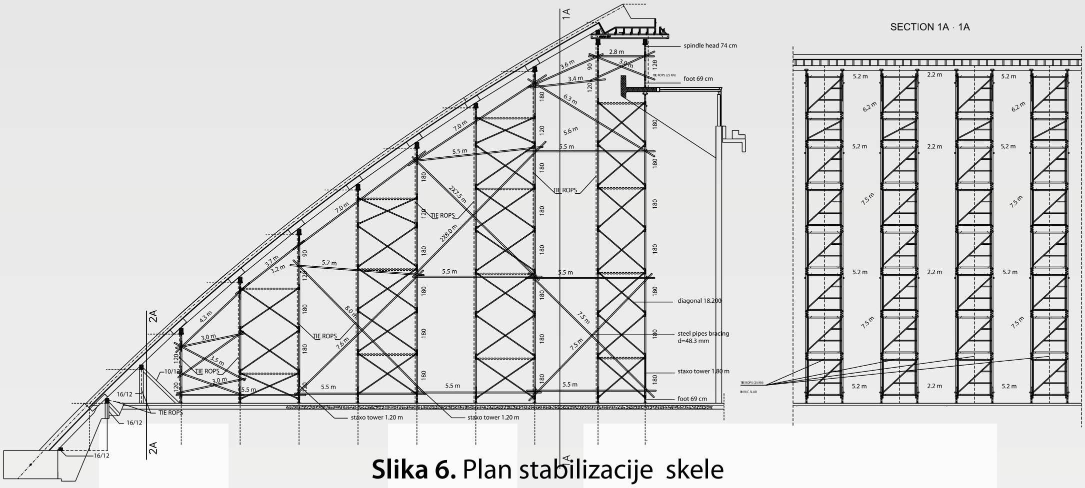
Scaffold under rim beam lies on reinforced concrete slab above grandstand, with its one part, and it is connected and stiffens to it. On support places reinforced concrete slab is shored with tower construction from basement.

Scaffold lies directly on floor slab, if it is already concerted. On parts where floor slab does not exist, scaffold supports lie on well compact ground through wooden washers d=4.8 cm thick and dimensions of 20/20, under footings of STAXO towers as well as wooden washers of dimensions of 16/16 and 20/15, under wooden truss.

In some phases of formwork placing, scaffold has additional stabilization with tie rods on solid parts of dome and rim beam, and with tie rods and wooden diagonal bracing on hollow parts. These parts are removed when no longer necessary (Figure 6).

From the aspect of scaffold stability assurance and decrease of the wind influence on unloaded formwork, the placement of scaffold and formwork is planned in phases.

On solid dome parts, four phases of formwork placing are planned. In the first phase two rows of wooden trestle are placed with independent scaffold frame and the first tower (all together first five rows of bearing beams). Next come placing of centring and formwork and concreting according to chosen dynamic plan (see forward – concreting phases). In the second phase of formworking next two towers of scaffold are placed (6., 7., 8. and 9. beam row) and concreted together with 8. phase of concreting. The third phase consists of placing remaining towers and formworking to rim beam. The fourth phase is formworking and concreting of rim beam.



Slika 6. Plan stabilizacije skele

Slika 7. Pogled na gradilište prije početka radova na kupoli

Slika 8. Postavljanje oplate i skele

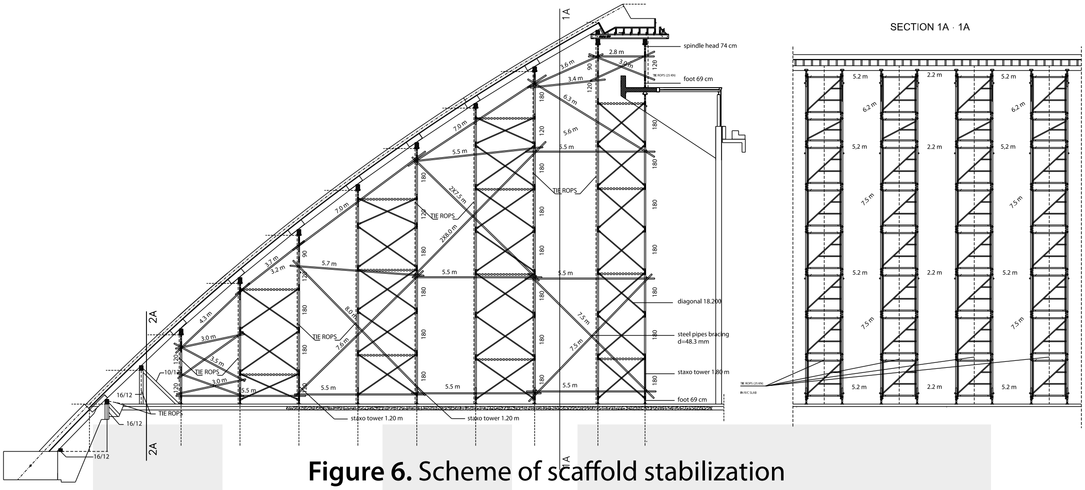


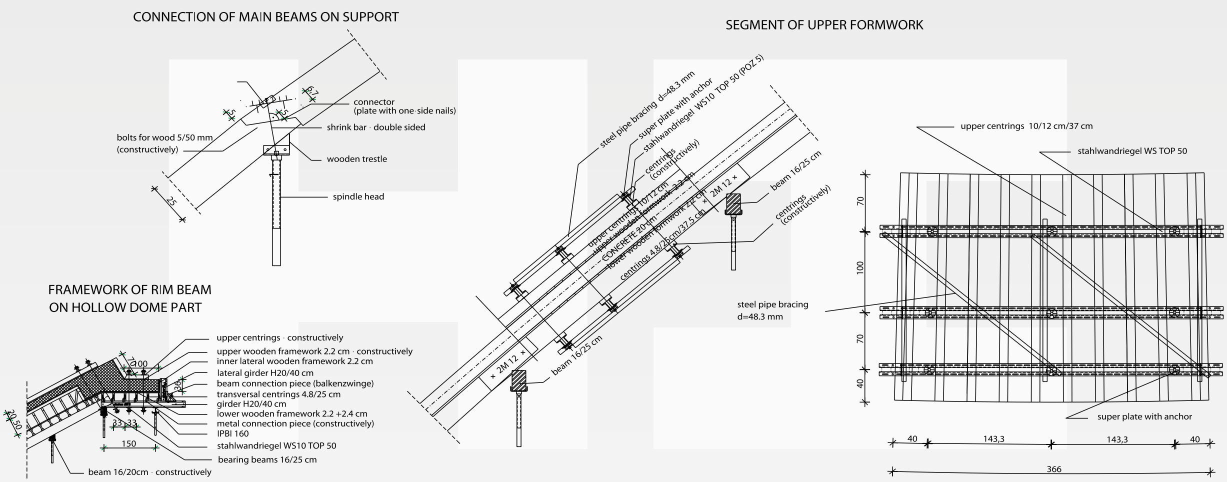
Figure 6. Scheme of scaffold stabilization

Figure 7. Site view before starting works on dome

Figure 8. Placing of formwork and scaffold

Na šupljim dijelovima kupole, planirane su također četiri faze postavljanja oplate. U prvoj fazi se postavlja jedan red drvenih nogara sa dva tornja skele, što predstavlja dva reda nosivih greda. U isto vrijeme se vrši postavljanje oplate i betoniranje dijelova kupole pod zemljom (između zakrivljenih greda). U drugoj fazi postavljanja oplate postavljaju se dva sljedeća tornja skele i betoniraju se zajedno sa kružnom gredom. Treća faza se sastoji od postavljanja preostalih tornjeva i oplate iznad kružne grede do rubne grede, uz betoniranje rubne grede. Četvrta faza je postavljanje oplate i betoniranje rubne grede.

Stabilnost skele je dokazana statičkom kalkulacijom za sve faze postavljanja oplate i betoniranja, kao i svi relevantni utjecaji.



Slika 9. Detalji skele i oplate

Gradnja STAXO tornjeva u radijalnim smjerovima (tornjevi povezani čeličnim cijevima), te osiguranje drvenim podupiračima sa drvenim dijagonalnim učvršćivanjem su dovoljni za stabilnost skele kod svih utjecaja tijekom betoniranja, te utjecaje vjetra na oplatu sa ili bez betona. Tlačni utjecaj vjetra se uzima kao utjecaj na otvorenu strukturu krova sa jednom kosinom i koeficijent ovisi o strmini površine oplate.

Usisni utjecaj vjetra na praznu oplatu (bez betona i armature) je osobito opasan zato što može prouzrokovati odvajanje oplate od skele, ili podizanje i prevrtanje cijele skele. Na dijelovima gdje je kupola puna (bez otvora) skela se drži nosivim gredama koje su zahvaćene sa zategama tamo gdje se spajaju sa čeličnim pločama i klinovima. Projekt skele uključuje izračun maksimalne sile u zategi za svaku fazu oplate i betoniranja, kao i protokol skidanja zatega za spajanje nakon što više nisu korisne. Na ovom dijelu kupole zatege se mogu pričvrstiti u podnu ploču.

On hollow dome parts, four phases of formwork placing are planned too. In first phase one row of wooden trestle with two scaffold towers is placed, that is two rows of bearing beams. At the same time formworking and concreting of dome parts under ground is performed (between curved beams). In the second phase of formworking next two towers of scaffold are placed and concreted together with circle beam. The third phase consists of placing remaining towers and formworking above circle beam to rim beam, with concreting rim beam. The fourth phase is formworking and concreting of rim beam.

Stability of scaffold is proved by static calculation for all phases of formwork placing and concreting, as well as all relevant influences.

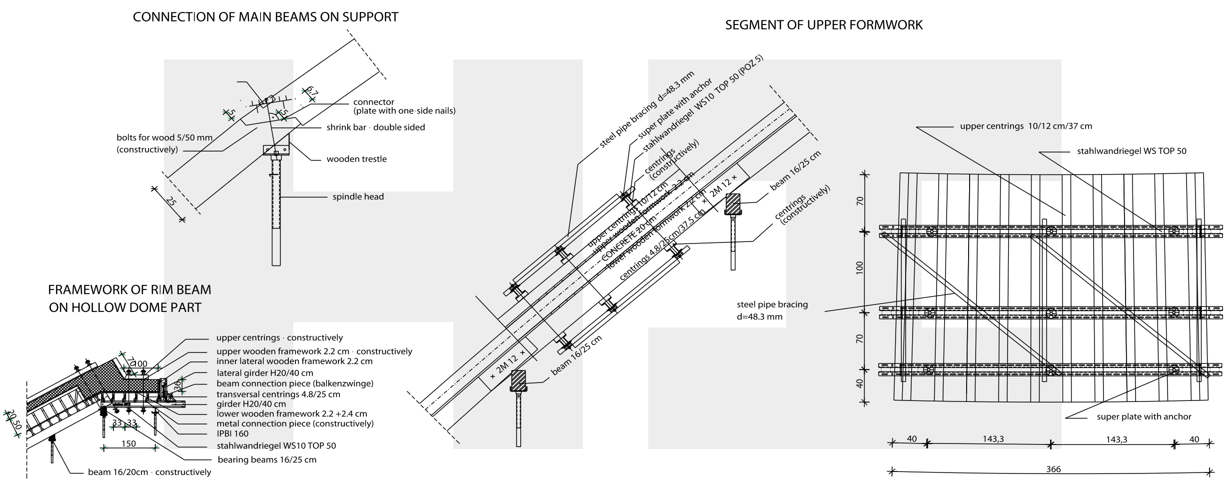


Figure 9. Details of scaffold and formwork

In radial directions STAXO tower construction (towers linked with steel pipes), and wooden truss assurance with wooden diagonal bracing is enough for scaffold stability for all influences during concreting and influences of wind on formwork with or without concrete. Pressure influence of wind is taken as influence on one slope roof open structure and coefficient depends on slope of formwork surface.

Sucking influence of wind on empty formwork (without concrete and reinforcement) is especially dangerous, because it can cause detachment of formwork from scaffold, or lifting up and tumbling of whole scaffold. On parts where dome is solid (without openings) scaffold is held-up with bearing beams which are caught with tie ropes where they are connected with steel plates and bolts. Scaffold design includes calculation of maximum force in rope for each phase of formworking and concreting, as well as protocol of tie ropes removing after its not useful anymore. On this part of dome tie ropes can be anchored in floor slab.

Na šupljim dijelovima kupole (dio kupole sa ulaznim otvorima), skela je osigurana od usisnog utjecaja vjetra sa nosivim gredama koje su pričvršćene preko dvostrukih nosača H20, i to: u radijalnom smjeru na sastav nosivih greda i u tangencijalnom pravcu na dvije pozicije (između nosivih greda). Pričvršćivanje zatega se mora izvesti u skladu sa aktiviranjem sile u zategama, a budući da ovaj dio kupole nema podnu ploču, pričvršćivanje se mora izvesti na zasebnim betonskim blokovima ili na neki drugi način. Zatege se mogu skloniti nakon što više ne budu potrebne (kada se otkloni usisni utjecaj vjetra na dijelove betonirane strukture) i premjestiti na druge dijelove skele.

Tangencijalni (bočni) utjecaj vjetra je također uzet u obzir sa svojim utjecajem na oplatu i skelu. Na punim dijelovima kupole, struktura skele s očvršćujućim cijevima je sasvim dostatna za podnošenje svih vrsta utjecaja.

Na šupljim dijelovima kupole vjetar u tangencijalnom pravcu ima povećan učinak na strukturu skele zbog veće izložene površine direktnom utjecaju vjetra, pa je potrebno dodatno osiguranje kako bi se spriječilo podizanje i prevrtanje.

U prvoj fazi postavljanja oplate, drugi red nosivih greda (bočne grede) u sredini je poduprt drvenim nakošenim potpornjima (16/16 cm), koji se mogu ukloniti nakon betoniranja. U drugoj fazi postavljanja oplate, skela se osigurava sa zategama (prostornim) na sastavima glavnih nosivih greda i nosača H20. Ove zatege služe za spriječavanje podizanja i prevrtanja pod utjecajem tangencijalnog (bočnog) vjetra kao i od utjecaja usisnog vjetra. Dodatno osiguranje nije potrebno iznad kružne grede.

Tehnologija gradnje i betoniranje

Kao što je već definirano, postavljanje oplate i skele se planira u fazama. Ove faze ovise o mogućnostima betoniranja svakog segmenta. Planirane su tri globalne faze u betoniranju kupole (Slika 10).

Prva faza se odnosi na betoniranje zakrivljenih greda u zemlji i iznad zemlje, kao i betoniranje dijela kupole između zakrivljenih greda do kružnih greda. Prvi segmenti betoniranja su počeli blizu osi 32 i 23 (I. faza 1a), visine 2,8 m. Sljedeći segmenti su 5,0 m visoki (2x2,5 m) do kružne grede (I.faza 1b-1e). Nakon toga, segmenti oko osi 32 i 24 se betoniraju (I. faza 2a-2e) i dio kupole između zakrivljenih greda u zemlji (I. faza 3). Zatim dolazi naizmjenično betoniranje zakrivljenih greda i dijela kupole između zakrivljenih greda u zemlji sa krajnjim segmentom (I. faza 10). Prva faza završava sa kružnim gredama (I. faza 11a – 11e) u segmentima s dužinom približno 8 m. Na suprotnoj strani kupole betoniranje je simetrično.

Druga faza se odnosi na betoniranje pune kupole ispod zemlje, iznad zemlje i dijela kupole iznad zakrivljenih greda. Prvi segmenti počinju s betoniranjem segmenata ispod zemlje d=30 cm (II. faza 1a), počevši s A/B zidom na osi 32 i osi 5 do sredine pune kupole, završavajući sa segmentom 2g (II. faza 1g). Dužina segmenta je približno 8 m, a visina je jednaka visini kupole ispod zemlje (2.8 m). Betoniranje se izvodi po metodi „šahovskog polja“, u segmentima od približno 8 m. Druga runda betoniranja (II. faza 2a-2g) slijedi s betoniranjem krugova (3-9) do kružne grede. Nakon toga betoniranje se nastavlja s betoniranjem kruga 10 (segmenti 10a-10e), koji se dovršavaju poslije sa segmentima (10f-10j).

On hollow parts of dome (part of dome with entrance openings) scaffold is secured from sucking influence of wind by bearing beams which are fastened over twin girders H20 namely: in radial direction on bearing beams connections and in tangential direction on two positions (between bearing beams). Anchoring of tie ropes must be performed in accordance with activating force in ropes, and because this part of dome does not have floor slab, anchoring must be done on separate concrete blocks or in some other way. Tie ropes can be removed after they are not needed anymore (when parts of concreted structure eliminate sucking influence of wind) and dislocated on other parts of scaffold.

Tangential (lateral) wind influence is also considered with its influence on formwork and scaffold. On solid dome parts scaffold structure with stiffening pipes is quite enough for taking all those influences.

On hollow dome parts wind in tangential direction has enhanced effect on scaffold structure because of a greater exposed area to direct wind impact, so to prevent lifting up and tumbling, additional assurance is required.

In the first phase of formworking, second row of bearing beams (beams on sides) in the middle are supported with wooden inclined struts (16/16 cm), which can be removed after concreting. In the second phase of formworking, scaffold is assured with tie ropes (spatial) on connections of main bearing beams and girders H20. These tie ropes serve to prevent lifting up and tumbling under influence of tangential (lateral) wind as well as sucking wind influence. Additional assurance is not required above circle beam.

Building technology and concreting

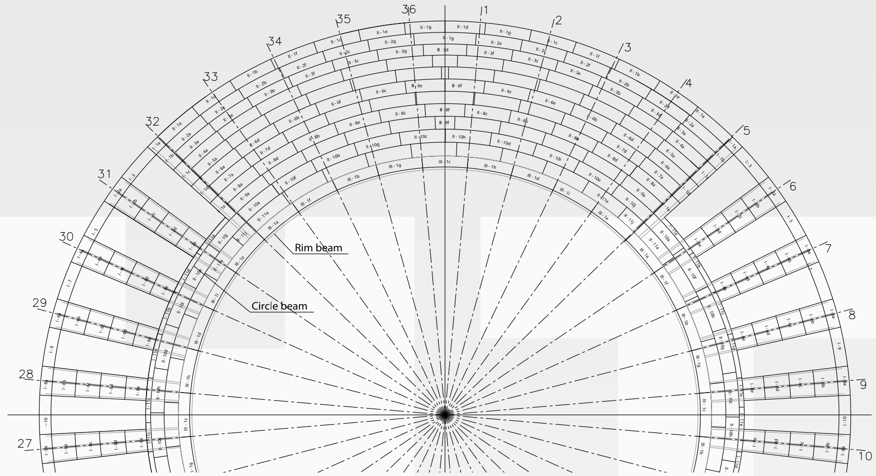
As it has already been defined, placing of formwork and scaffold is planed in phases. These phases are depended on concreting possibilities of each segment. Three global phases in concreting dome are planned (Figure 10).

First phase refers to concreting curved beams in ground and above ground, as well as concreting part of dome between curved beams up to circle beams. First segments of concreting started near axis 32 and 23 (I. phase 1a), with high 2.8 m. Next segments are 5.0 m high (2×2.5 m) to circle beam (I. phase 1b-1e). After that, segments around axis 32 and 24 are concreting (I. phase 2a-2e), and part of dome between curved beams in ground (I. phase 3). Next comes alternating concreting of curved beams and part of dome between curved beams in ground with final segment (I. phase 10). First phase finishes with circle beams (I. phase 11a-11e) in segments with length of approximately 8 m. On opposite part of dome concreting is executed symmetrically.

Second phase refers to concreting solid dome under ground, above ground and part of dome above curved beams. First segments start with concreting segments under ground d=30 cm (II. phase 1a), starting from R/C wall on axis 32 and axis 5 to the middle of solid dome, ending with 1g segment(II. phase 1g). Segment length is approximately 8 m, and high is equal to dome high under ground (2.8 m). Concreting is performed on “chess field” way, in segments of approximately 8 m. Second round of concreting (II. phase 2a-2g) follows with concreting circles (3-9) to the circle beam. After that concreting continues with concreting circle 10 (segments 10a-10e), which are completed afterwards

Betoniranje se istovremeno izvodi na sva četiri kvadranta kupole. Betoniranje kruga 11 se izvodi na isti način.

Treća faza betoniranja se odnosi na betoniranje rubne grede u segmentima približno 8 m dužine. Betoniranje se izvodi „preskakanjem“ (svako drugo polje - III. faza 1a-1e), a nakon toga betoniranje između završenih segmenata (III. faza 1f-1i). Betoniranje je istovremeno također na sva četiri kvadranta kupole.



Slika 10. Faze betoniranja

Nakon završetka betonskih radova, kada je zadnji postavljeni beton star 7 dana, skela se može ukloniti. Uklanjanje skele će se izvesti na način da se prvo oslobodi skela rubne grede, zatim ostala skela od vrha prema zemlji.

Reference

[1] Arhitektonski projekt: „Sportska dvorana Višnjik u Zadru”, Arhitektonski biro Hržić, Zagreb, 2003., projektant: Marijan Hržić (na hrvatskom)

[2] Strukturni projekt: „Sportska dvorana Višnjik u Zadru ”, D&Z, Zadar, 2003., projektant: Davorin Uglešić (na hrvatskom)

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[4] Radni projekt: „Sportska dvorana Višnjik u Zadru – projekt skele i oplate ”, Sveučilište u Splitu, Fakulter građevinarstva i arhitekture, 2005., projektanti: Alen Harapin, Ladislav Bevanda, Mario Jurišić i Dragan Ćubela (na hrvatskom)

[5] STAXO – projektantov priručnik (na njemačkom)

with segments (10f-10j). Concreting is simultaneous on all four quadrants of dome. Concreting circle 11 is done in the same way.

Third phase of concreting refers to concreting rim beam in segments approximately 8 m long. Concreting is performed "skipping" (every second field - III. phase 1a-1e), and afterwards concreting between finished segments (III. phase 1f-1i). Concreting is simultaneous on all four quadrants of dome, too.

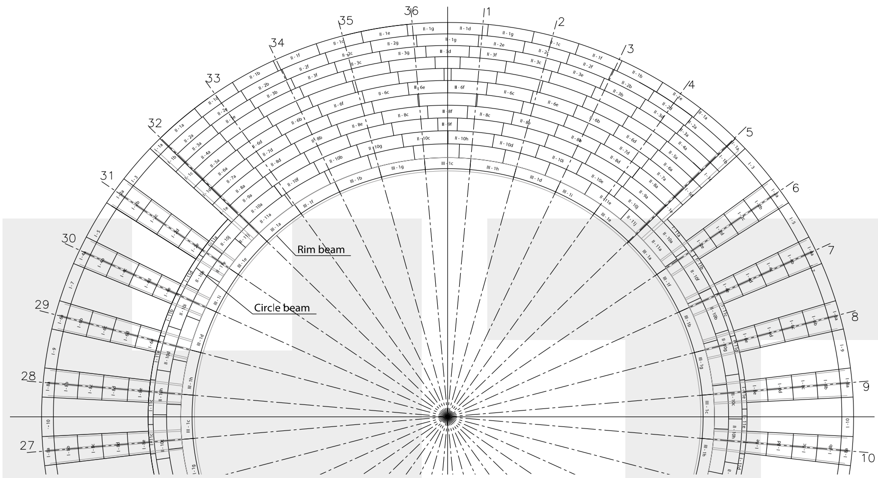

Figure 10. Concreting phases

After finishing concreting job, when the last concrete in the structure is 7 days old, scaffold can be removed. Removing of scaffold will be done by releasing rim beam scaffold first, then other scaffold from the top to the ground.

References

[1] Architectural design: "Sports hall Višnjik in Zadar", Arhitektonski biro Hržić, Zagreb, 2003., designer: Marijan Hržić (in Croatian)

[2] Structural design: "Sports hall Višnjik in Zadar", D&Z, Zadar, 2003., designer: Davorin Uglešić (in Croatian)

[3] Structural design: "Sports hall Višnjik in Zadar – calculation of scaffold and formwork", University of Zagreb, Faculty of Civil Engineering, Zagreb, 2004., designers: Milutin Anđelić and Damir Lazarević (in Croatian)

[4] Work design: "Sports hall Višnjik in Zadar – design of scaffold and formwork", University of Split, Faculty of Civil Engineering and Architecture, 2005., designers: Alen Harapin, Ladislav Bevanda, Mario Jurišić and Dragan Ćubela (in Croatian)

[5] STAXO –designer's manual (in German)

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