Mihail Naumovski
BSc, Teaching Associate
University “Ss. Cyril and Methodius”
Faculty of Civil Engineering – Skopje
naumovskimgf@outlook.com

Marijana Lazarevska
PhD, Associate Professor
University “Ss. Cyril and Methodius”
Faculty of Civil Engineering – Skopje
marijana@gf.ukim.edu.mk

RISK ASSESSMENT OF ROAD CONSTRUCTION PROJECTS USING EXPECTED VALUE MODEL

Risks can occur during any phase of road construction project, they cannot be completely avoided, but with proper risk management model they can be put to minimum. Risk assessment enables proper project management and helps the road construction managers in the decision-making process in order to avoid or decrease the negative effects and/or outcomes of any possible negative risks.

The Expected Value Model refers to risk assessment by determining the severity of the consequences caused by the risk itself. This paper presents the benefits of risk assessment for achieving a quality realization of road construction projects. The main goal is to show the application of The Expected Value Model (EVM) and its implementation on a road construction project.

Keywords: risk assessment, expected value model, road construction project

1. INTRODUCTION

Road construction projects are affected not only by minor risks, but also by risks which can cause a scenario that can be critical in terms of creating a negative impact onto any project objective. Therefore, it is necessary to assess the risk, regardless of when, how and in which form or phase it occurs. Risk assessment enables proper project management and helps the road construction managers in the decision-making process in order to avoid or decrease the negative effects and/or outcomes of any possible negative risks. It is highly important to understand that proper risk management is based on an adequate risk assessment, especially during the first phases of the project life-cycle, and it is essentially the most important component for a successful realization of a any road construction project.

1.1 RISK ASSESSMENT AS PART OF THE RISK MANAGEMENT PROCESS

Risk management is mostly defined as a cycle process with a returning character. This means that regardless of the phase in which the risk can happen, it has to be analyzed with a

simultaneous consideration of all other phases of the project life-cycle. The returning character clearly expresses the cyclicality, in sense that no phase of the risk management process can be passed without re-analyzing a previous one or without perceiving the effects and impacts on a subsequent one. And this is because the risk usually comes suddenly and incidentally, so it is necessary to take into consideration the road construction phase during which the risk can occur. Such a vigilant monitoring requires abilitis and skills in order to find an appropriate way to assess the risk properly and manage it after, correctly.

When it comes to a risk management of road construction projects, the cycle process is based on a platform that consists of several phases. The size of the platform depends on the extent of the risk that is subject of interest in for a certain road construction projects. So, it is always said that the greater the risk, the bigger the platform. This means, that the risk can affect on the platform size by developing phases more and more. The phases are generally independent of each other in terms of what they are intended to address in risk management. But, in some cases they are tightly connected to each other, in terms of its smooth reduction. Such a platform, based not only on a few phases, helps road construction managers to correctly solve the risk, by reducing its negative consequences in terms of creating a minimum harmful impact.

Figure 1. Cycle character of the risk management process

Figure 1 shows the cyclical risk management process which can be related to a road construction project [1]. It mainly consists of five phases, depending on the severity of the risk and its influence to the project. In order to properly manage the risk, the first step is to properly identify all possible risks that can occur during the road project life-cycle. The risk assessment, as a next phase of the risk management process, depends on the type and nature of the risk, the probability of occurrence, the extent of the consequences on the project objectives and the way it affects the road construction project as a whole. Risk assessment is crucial for planning of the management decisions regarding the further risk responses. It is quite important that risk assessment gives a distinctive note in the complete annulment of the risk, especially in finding a model for its management. And the importance of the management model is that it helps fulfilling the project objectives, effectively and efficiently. Risks can occur during any phase of road construction project, they cannot be completely avoided, but with proper risk management model they can be put to minimum.

1.2 OBJECTIVES OF RISK ASSESSMENT

To define the objectives of the risk assessment the sources that can cause future risks must be identified. Examples of some risk sources that are typical for road construction projects are:

- complexity of the project and its uniqueness;
- numerous participants and various project stakeholders;
- capacity and ability to respond to a wide range of project activities;
- high project costs;
- environmental impact;
- location conditions (geomechanical, hydrological, climate, meteorological etc.);
- safety and health at work, as an inevitable concept for successful execution of the road construction project;
- expropriation;
- cultural, socio and economical level of development of the area in which the road is being constructed;
- political situation;
- poor designs;
- not sufficient or not correct geotechnical investigations;
- lack of qualified staff in both design and construction stage etc.

The above-mentioned risk sources do not always act separately. They usually act as combination of two or more in case of creating the risk that affects the road construction project in its own specific way. Such an issue abounds in having a complex background, according to what the risk assessment itself should be performed.

The risk assessment can be simply defined as: *"The process of quantifying events that affect the formation of risk, based on previous documentation that primarily provides information about the origin of the risk, and the origin is nothing but the source of which arose from the risk itself."* [2] This approach to defining risk assessment offers the possibility of distinctively separating the assessment phase from the risk identification phase. Therefore, the basic objectives of risk assessment can be considered from two most important aspects:

1. ***Determining the probability of occurrence of the risk.***

The occurrence of the risk can be interpreted as the probability of occurrence of an adverse event that causes negative effects on the road construction project. According to this, from the aspect of probability and statistics, the risk can be quantified in the continuum, so that it can get values from 0 to 1. Of course, when assessing the risk, there should always be a tendency to reach 0, which is theoretically achieved, but practically in almost no case can it be achieved at all.

2. ***Determining the impact of risk.***

If the value of the frequency of the risk exceeds the limit value 0.5, then the risk has a significant impact on the construction project. The impact of risk, as an aspect, treats risk in a way that gives a quantitative and qualitative assessment of the severity of the consequences caused by the risk itself. The term definition of severity assessment implies whether the risk can or must be treated in the further management process. For that purpose, a risk assessment model is developed, ie. a model that assesses the severity of the consequences caused by the risk itself. Depending on the results of the analysis, an appropriate conclusion is further drawn as to whether the risk can be reversed or it should be treated, by defining a management model, as the next phase or even a next step in the whole process of risk management.

2. RISK ASSESSMENT MODEL – EVM (EXPECTED VALUE MODEL)

2.1 DESCRIPTION OF EVM

The Expected Value Model (EVM) refers to risk assessment by determining the severity of the consequences caused by the risk itself. Target consequences that are being considered in this model are: **time** and **cost**. Of course, road construction projects can be affected by many other risk consequences, but these two have the most significant contribution in defining the severity assessment. In order to define the severity assessment, a separate assessment should be given for the quantitative and the qualitative aspect of the risk on the project as a whole. Finally, depending on these two assessments, a description is given of the complete condition of the road construction project, affected by the effects caused by the risk. All this provides an answer for the extent of the negative consequences that risk can cause during the road construction project.

EVM must be based on a previously developed and resolved network plan. The need to solve a network plan is due to determining the total time period from the start of the construction project until its implementation. It is common knowledge that every network plan must have at least one critical path, ie. a path that is composed of critical activities. The critical path always starts with the first and ends with the last project activity, which are always critical indeed. And critical project activity means that the activity has an equal earliest and lowest start or end. After determining the critical path, EVM can be applied for risk assessment. If there are more than one critical paths in the network, the EVM should be applied separately on each of the critical paths.

2.2 METHODOLOGY OF EVM

After completing of the network plan composed of all project activities and determining the critical paths, critical activities (N_j) should be marked. Each critical activity is marked as a $j-$activity, where $j=1,2,...,n$. The sources (M_i), that cause the risk, which in turn directly affect the critical activities, are marked as $i-$ sources, where $i=1,2,...,m$.

Variables in EVM are:

$L_{ij}-$ probability of occurrence of the $i-$ source, on the $j-$ activity;

$I_{ij}-$ probability of impact of the $i-$ source, on the $j-$ activity;

$W_{ij}-$ weight coefficient of probability of the $i-$ source, on the $j-$ activity;

Variables are quantities which are determined empirically in the analysis or they are based on a current survey or research. Namely, if it is a matter of experiential definition of the values of the variables, it means that a the range in which

they move should be defined. This method, although is a quite skeptical, still offers a great accuracy in terms of end results. Defining the values of the variables with a currently conducted survey or research can lead to inaccurate data, due to inaccuracy and unpreparedness of the surveyed or inappropriately located sources in the research. In that case, it is proposed that the respondents should be experts and professionals who have participated in similar or the same road construction projects. With their experience, the survey turns into an empirical definition of the values of the variables, which also offers certainty in the analysis.

Constants in EVM are:

$(BTE)_j -$ basic parameter for estimating the time of the $j-$ activity;

$(BCE)_j -$ basic parameter for estimating the cost of the $j-$ activity;

The parameter for estimating the time of the the $j-$ activity $(BTE)_j$ is determined from the beginning with the solution of the network plan. It clearly shows the duration of each critical activity, necessary for its full execution. The value of this parameter is constant and unique for each road construction project separately.

The parameter for estimating the cost of the $j-$ activity $(BCE)_j$, is determined depending on the budget available for the road construction project management. This parameter varies greatly due to unforeseen costs that can arise during project implementation. However, it is due to the unity in defining the seriousness of the consequences. This means that the risk assessment should define an average value which, like the previous parameter, will have a constant character.

Results in EVM are:

The results are the essential part of the risk management model. They are usually interpreted as an amount of the assessment, whether it is a quantitative or a qualitative one. The interpretation of the results is based on three different characteristics, which are shown below. Precisely, they are two composite factors and a factor which can not be define as a quantity of something, so it is the quality of the risk assessment, at all.

$(CLF)_j -$ composite factor of probability of occurrence on the $j-$ activity;

$$(CLF)_j = \sum_{i=1}^{m} L_{ij} \cdot W_{ij} \qquad (1)$$

where: $0 \le L_{ij} \le 1$ and the sum of all weight coefficients is 1.

$(CIF)_j -$ composite factor of probability of impact on the $j-$ activity;

$$(CIF)_j = \sum_{i=1}^{m} I_{ij} \cdot W_{ij} \qquad (2)$$

where: $0 \le I_{ij} \le 1$ and the sum of all weight coefficients is 1.

$(RS)_j -$ severity of consequences (risk assessment)

QUANTITATIVE ASSESSMENT:

$$(RS)_j = (CLF)_j \cdot (CIF)_j \qquad (3)$$

QUALITATIVE ASSESSMENT: (Table 1.)

Table 1. Risk quality assessment

No.	Values	Severity of consequences
1	$0.00 \le (RS)_j \le 0.10$	**low**
2	$0.11 \le (RS)_j \le 0.20$	**medium**
3	$0.21 \le (RS)_j \le 0.25$	**high**
4	$0.26 \le (RS)_j \le 1.00$	**dangerous**

2.3 APPLICATION OF THE EVM

The application of the EVM requires a specific database that meets the requirements of the model itself. By specific database, it means subsets whose values are obtained according to the methodology of the model itself. In this paper, the model is implemented on a road construction project, for which, depending on the results obtained, appropriate conclusions are made. Table 2. gives the basic characteristics of the road, ie. the road construction project that is subject to elaboration [3].

During the implementation of the EVM, there are separated twelve (12) most significant risks that affect the road construction project. For a clearer presentation, they are divided into three groups which refer to the different phases that the construction project goes through. They are presented in Table 3 with an appropriate explanation.

Table 2. Base char acteristics of the road construction project

No.	Base characteristics	
1	Category	A
2	Length	80 km
3	Construction period	24 months
4	Cost	10 milions €
5	Assessment model	EVM

Table 4 shows the calculation model, made of mathematical relations between the data base [3]. The final results are obtained for the three basic characteristics in defining the severity of the consequences, caused by the risks that affected the road construction project. These parameters, previously defined in the methodology of the EVM, can only receive values from 0 to 1. The first two parameters are only an opportunity to define the third, which in turn is considered from two aspects: **quantitative** and **qualitative**. This way of defining offers the possibility of risk assessment with a high degree of accuracy. Errors of course exist, but they are negligibly small compared to the accuracy of the obtained results, so it can be conclude that the EVM represents the risk assessment at all.

Table 3. Risk classification

No.	Risk Classification Nomenclature	Risk Description
1	**FPR**	Feasibility Project Risk
2	**DPR**	Design Project Risk
3	**TPR**	Technology Project Risk

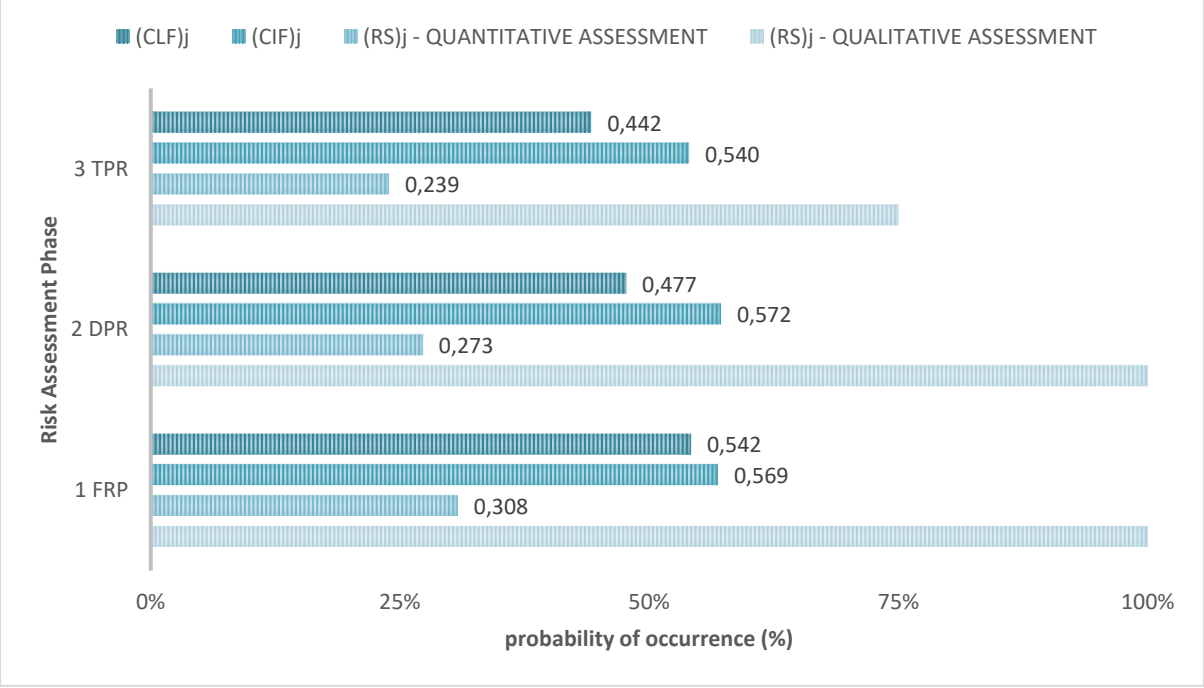

Figure 2. Results of the EVM

Table 4. EVM calculations for Risk Assessment

No.		Risk Classification Nomenclature	Risk Description	SEVERITY Risk Assessment			
				$(CLF)_j$	$(CIF)_j$	**QUANTITATIVE ASSESSMENT**	**QUALITATIVE ASSESSMENT**
						$(RS)_j = (CLF)_j \cdot (CIF)_j$	
1	1.1	**FPR**	Political interference	0.050	0.065	**0.308**	**dangerous**
	1.2		Interference of the environment	0.085	0.085		
	1.3		Delay due to interdepartmental issues	0.058	0.058		
	1.4		Delay in clearance from environmental and forest departments	0.170	0.164		
	1.5		Lenders not comfortable with project viability	0.047	0.044		
	1.6		Cancellation of project after bidding	0.041	0.058		
	1.7		Review of technical specification and Bill of quantities	0.090	0.094		
	Σ			**0.542**	**0.569**		
2	2.1	**DPR**	Design error and omissions	0.128	0.159	**0.273**	**dangerous**
	2.2		Design process takes longer than anticipated	0.113	0.144		
	2.3		Failure to carry out work in accordance with contract	0.117	0.159		
	2.4		Request late changes	0.118	0.112		
	Σ			**0.477**	**0.572**		
3	3.1	**TPR**	Unqualified staff for managing risks	0.160	0.225	**0.239**	**high**
	3.2		Unqualified staff for using mechanization	0.282	0.325		
	Σ			**0.442**	**0.540**		

3. CONCLUSION

During the risk management process, when it comes to a road construction projects, there are undoubtedly a number of risks that affect the project itself. But it is not the number of risks that matters, but the severity of the consequences, which are caused by the risks. For that purpose, in this paper is shown the importance of determining the seriousness, ie. the risk assessment itself. And all this leads to the process of defining a model for further risk management in the risk management process. Best interpretation of the EVM results is a graphical representation of the severity – risk assessment both quantitative and qualitative assessment. So, it can be concluded that regardless of the phase of the road construction project, the risk is involved, it is quite important to act quickly and correctly. In order to avoid many possible risks that can cause a negative impact, it is necessary to hire a professional staff, led by a road construction manager, who will both strive for the most efficient and better implementation of the road construction project as a whole.

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