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## RISK ASSESSMENT FOR CONSTRUCTION OF BRIDGE ON MOTORWAY

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**Abstract:** In this paper, risk assessment for the activities associated with construction of bridge as part of the risk assessment for the project comprising building of new motorway section from Demir Kapija to the village of Smokvica, Republic of Macedonia is presented. After identified risks and hazards, during activities related with bridge works and after performed risk assessment, control measures are proposed.

**Keywords:** risk assessment, motorway, bridge, control measures

### 1. INTRODUCTION

Branch of AKTOR ADT Greece in the Republic of Macedonia is the main contractor building the rest of the highway A-1 (E-75) from the town of Demir Kapija to the village Smokvica as part of the Pan-European Corridor X. The challenge on this project is to develop 28 km of new motorway section through difficult and environmentally sensitive terrain. Construction of the highway section, among other things will include construction-drilling of 2 twin tunnels with a total length of 4.5 km, 6 major river bridges/viaducts, 2 interchanges and 12 overpasses/underpasses. The works that will be performed in the section Demir Kapija – Smokvica are comprised of: road works, tunnel civil works, bridge works, overpasses, underpasses, junctions, associated auxiliary and temporary works including service roads, access roads, landscaping.

In this paper, the methodology of risk assessment, risk assessment and control measures for activities associated with construction of bridge on the motorway section Demir Kapija - Smokvica are presented.

### 2. THE RISK ASSESSMENT METHODOLOGY

Team of professionals in the field of safety of work from the Faculty of Technical Sciences Bitola prepared risk assessment for the whole project, [1]. The risk assessment is made in accordance with the Law on safety and health at work, [3] and Rulebook on minimal requirements related to safety and health at work for temporary or mobile construction sites [4]. The recognition and identification of risks and hazards in the workplace is made on the basis of data gathered from documents available to the Employer, observation and monitoring of the process at work in the workplace, gathering the necessary information and staff information and other sources. The Risk Assessment methodology presented in this paper is comprised of four levels

#### □ HAZARD IDENTIFICATION

At the first level, for each construction activity, a method statement has to be developed. Based on the method statement potential hazards are identified.

#### □ RISK ASSESSMENT

After having identified the hazards we calculate the risk per hazard. This calculation can be a qualitative or quantitative or both, if practicable. It is proposed that the occupational risk assessment is calculated qualitative, but without excluding other forms of similar competence.

According to the Risk Assessment methodology each activity is broken down to tasks, it considers the hazards associated with each task and assesses the risk by assessing the likelihood of an event of a particular severity to occur and multiplies this likelihood with the corresponding severity (see sample risk assessment in the next page). Always the worst case scenario is considered.

The Severity is specified qualitatively by setting classification criteria which determine how serious the impact of a hazard is. Severity is rated into five levels as shown in Table 1. The assessment of the likelihood of a risk is made by using Table 2. Table 3 is the Risk Matrix which incorporates the criteria for assessing the severity and the likelihood, and is an effective tool for assessing and presenting the risk that can be understood at all levels

#### □ SAFETY MEASURES EVALUATION

Completing a risk assessment with safety measures proposed, it is expected that the residual risk is trivial or minor. If this is not the case, then further measures are proposed.

#### □ SAFETY MEASURES REVALUATION – REVISION

The final stage of the Risk Assessment is about reevaluating and revising the assessment depending on the nature of the Hazards and the various changes in the method statements.

Table 1. Rating Severity

Rating	Severity
1	Trivial, minor first aid treatment. Back to work same day
2	Minor woods, first aid treatment. Back to work within three days from incident
3	Moderate First aid treatment. Hospital treatment. Back to work after 3 days from incident. No operation
4	Major Hospital treatment. Operation is required. Back to work after 60 days from incident or requirement for changing post due to injury
5	Severe Change work, Death

Table 2. Rating Likelihood

Rating	Likelihood
1	Almost zero Impossible or almost impossible to happen
2	Low The likelihood is very low
3	Possible It is possible to happen
4	High It is very likely to happen
5	Almost certain It is almost certain or certain

$$\text{RISK} = \text{SEVERITY} \times \text{LIKELIHOOD}$$

Table 3. Rating Risk Summary (see table 4)

Assessment	Risk	Rating (Quantification)
Acceptable risk. No additional safety measures required.	Trivial	1 (1-2)
Acceptable risk. No additional safety measures required apart. A more close supervision and safety measures implementation might be required.	Minor	2 (3-5)
Not acceptable risk. Action is required. Measures should be fully implemented within a month.	Moderate	3 (6-8)
Not acceptable risk. Action is required. Measures should be fully implemented within a week.	Major	4 (9-14)
Not acceptable risk. Action is required. Works must be stopped Immediately Measures should be fully implemented immediately.	Severe	5 (15-25)

Table 4. Risk classification

Risk = Likelihood X Severity			Severity				
			Trivial	Minor	Moderate	Major	Severe
Likelihood	Almost zero	1	1	2	3	4	5
	Low	2	2	4	6	8	10
	Possible	3	3	6	9	12	15
	High	4	4	8	12	16	20
	Almost certain	5	5	10	15	20	25

### 3. RISK ASSESSMENT FOR THE BRIDGE B6

Before analyzing the major risks associated with bridge construction, the main bridge construction methods should be known. The main bridge construction methods are: flasework method,

incremental launching method and cantilever method, [6]. Because the activities related to constructing of high motorway bridges include many different civil works, activities on the identification of hazard and risk are relatively difficult. Generic risks during construction of a highway bridge can be found in the literature related to this area. Due to pages limitations, in this article only an excerpt from the detailed risks assessment for the construction of bridge B6 is given in Table 5.

Table 5. Excerpt from the detailed risk assessment for construction of bridge B6

Activities/ work phases	Hazards	Risk	Risk severity	Safety Measures
General excavation of foundations	Earthworks	Collision / crushing / fall (at deep excavations)	High	Operator / Personnel experienced Trained personnel Use of PPE The entry or exit from the pit must become with the use of appropriate ladder Remotion of personnel out of load path where it is possible The operator must have the proper licence The equipment must be equipped with reverse alarm that is working Assistance by an operator for the equipment movements
				Confined space
	Unstable seat Lack of adequate space Pre-existing aerial networks Scroll bunding Flood / flooding project	Proper mounting of the machinery  Safe distance the boom from overhead networks	Low  High	Presence Geotechnical / Geologists during manufacture qualified staff Appropriate equipment
	Use of electrical tools	Workers electrocution	High	The tools shall be insulated, earthed and with undamaged wire Working floor without water
	Exposure to harmful factors	Solar radiation	Medium	Use of up to date and well maintained equipment for reduced noise production Shock – absorbing handles Continuous impregnation treatment for dust Controlled operations during frost and heat Personal Protection
		Noise / vibration / shocks Dust	High Medium	
		Outdoor /work-frost Outdoor work-heat	High Medium	
	Manual load handling	Musculoskeletal conditions	Medium	25 kg of load per worker training for the safe load lift and transportation mechanical load handling

Table 5. Excerpt from the detailed risk assessment for construction of bridge B6 (continuing)

Activities/ work phases	Hazards	Risk	Risk severity	Safety Measures
Assembling - disassembly scaffolding / formwork Assembling - disassembly metal body bridging	Dangers of construction equipment /lifting works	Load lift / collision	High	Operator / Personnel experienced and careful Trained personnel Use of PPE Remotion of personnel out of load path where it is possible Optic contact during transport or guide help Safety load binding The operator must have the proper licence Before starting works with heavy equipment ensure the soil condition is good Personal Protection
		Hand tools	Low	
	Falls from height	Gaps in scaffolds Subversion. failure assembly Subversion. bearing failure Collapse	High High High High	Tying tools Avoid storing materials in floor scaffolding Safe tying to transfer items Personal Protection Use certified scaffolding Applicability - Compliance studies scaffolding (if required) Adequate support (fixed seating etc) - complete flooring work Measures against overturning
	Exposure to harmful factors	Solar radiation Noise / vibration Dust Outdoor work - frost Outdoor work - heat	Medium Low Medium Low Medium	Continuous wetting the road to avoid The dust Controlled operations during frost and heat Personal Protection
Concrete works (concreting piers / walls /abutments / retaining walls)	Dangers of construction equipment	Vehicle crash Vehicle collisions - people Vehicle crashes - fixed obstacle Crush between vehicle - machine Crush between vehicle - fixed obstacle Uncontrolled movement. system failures Uncontrolled movement. incomplete immobilization unstable seat Lack of space Construction Tools	Medium High Medium Medium Medium Low Low Low Low	Check fencing Fixed seating machine appropriate signage Accompanying documents (licenses & insurances operator / machine, authorization) Prohibition overload vehicles - machinery The machines will be equipped with beacon and reversing beep keeping driving code Proper maintenance machinery (Technical Manual) Personal Protection
		Falls from height	Gaps on floors Lack of ends on the flooring Elevated paths and footbridges Mobiles Ladders Suspended floors. Failure suspension Gaps in scaffolds Subversion. Failure assembly Subversion. Bearing failure Collapse. Failure material of the scaffold	High High High High High High High High

The conducted risk assessment is part of the total H&S plan implemented by the Contractor which also involves permanent health and safety related campaigns, on-site trainings and education of the staff, [2].

**CONCLUSION**

Construction of high motorway bridge is one of the activities with highest hazards. In order to reduce the hazards, emergency procedures are developed and workers are advised to strictly follow these procedures accompanied by control measures. Some of these control measures are [5]:

- All work surfaces should be properly installed in order to prevent their collapse/breakage, and to prevent people or objects falling out of them; they as well as all cavities and openings, must be securely fenced safe and stable positioning of ladders is a must; all open pits, in the field and in the work areas must be safely fenced;
- Wearing of safety-shoes with non-slip soles; it is also possible to roughen (by various techniques) all or some of the work surfaces;
- All means for preventing worker injury should be applied prior to and during excavation, as well as before carrying out demolition works, if required; compliance with the specific regulations dealing with excavation is a must;
- Usage of personal protection equipment fit for protecting the whole body, inc. crashhelmets, safety shoes and goggles;
- Work surfaces, floors, footpaths and similar passages must be free from protruding nails, binding wires, and all other obstacles;
- Work clothes have to be fitted to the climatic conditions; in order to prevent dehydration, all workers should drink enough water; use gloves and safety clothes according to need;
- Wear safety shoes that have inherent isolation, and do not work with detective tools
- Use appropriate clothing and head covers, for protection against inconvenient climatic conditions, inc. solar radiation;
- When necessary, consult with an ergonomist and/or environmental engineer and
- When working over water, the employer is required to provide employees with approved life jackets.

Handling and storing materials involves diverse operations such as hoisting tons of steel or concrete with a crane. It is important to know the rated capacity of cranes and rigging equipment to prevent overloading conditions.

- Cranes must be inspected frequently by people thoroughly familiar with the crane.
- If slings are used, they must be visually inspected before use and during operation. Defective equipment must be removed from service.
- Hoisting routes that minimize the exposure of employees to hoisted loads must be used.
- Materials must be rigged by a qualified rigger.
- Materials being hoisted must be rigged to prevent unintentional displacement.
- A tag or restrain line must be used if necessary to prevent rotation of the load that would be hazardous.
- Where a signal person is required, the type of signals must be established and understood by the crane operator, signal person and lift supervisor.

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