

## STRENGTHENING OF THE CONCRETE BRIDGE

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**Abstract:** The summary covers inspection, assessment and recommendations of repair and strengthening works for bridge no. 35 on N2 Road, Pristina - Blace section.

Load capacity calculations have been carried out based on the results from Desk Study and Detailed Inspection and have shown that the capacity is slightly insufficient.

Special load capacity assessment has been carried out considering loads representing the present traffic. Results have shown that no traffic restrictions need to be established.

The findings of this detailed inspection are that the condition is very poor due to poor workmanship and lack of routine maintenance.

**Keywords:** Methods of bridge reinforcement, duration of the Bridge, inspection of the Bridge, upgrade, substructure, assessment of the Bridge.

### 1. INTRODUCTION

The bridge is located in the central plain of Pristina in arable land. The bridge carries M2 road in 2 lanes over a small stream from Bandulic to Dobrotin. The location is shown on the map below:



From the existing drawings and static calculations, the bridge is assumed constructed in 1962 and consists of a single span of approx. 14 metres. Clearance in the span is 4.9 m. The overall length of the bridge is approx. 26 metres and width is 9.5 metres.

Wing walls parallel to the bridge longitudinal axis are constructed from reinforced concrete.

The bridge is constructed without visible expansion joints in the superstructure and without crash barriers.

Railings are provided on both side of the bridge fasted in the edge beams [1].

### 2. DETALIED INSPECTION

The waterproofing was not inspected, but leakage of water through the concrete deck slab is observed. The waterproofing is assumed to be at the age of the bridge construction. No information of maintenance, overhaul or major repair works of the bridge has been possible to retrieve from existing documentation or employees from concerned organisations.

The bridge asphalt-wearing course has been applied recently. Deformation of a few millimetres from rutting is observed in only few places. Small holes appear in the wearing course because of lost aggregates. No visible cracks appear, but the certainty of a uniform acceptable quality of the pavement on the bridge is unsure due to the recently applied asphalt-wearing course, which cover possible defects. The pavement applied at the time of construction probably still exists and causes adverse effect on the recently applied layers.

The soffit of the superstructure has been patch repaired with cement mortar. Not all honeycombs have been repaired. The quality of the patch repairs with cement mortar is doubtful and the function as well.

On the lower surface of the superstructure wet spots appear. Especially along the southern edge of the slag a large area is discoloured of water leaches. In few patch repairs leaches appear caused of penetrating water.

Horizontal cracks appear mostly on the southern the concrete slab fronts. It is probably caused by load deflections in combination with poor concrete aggregates and a constant high humidity of the concrete.

Cracks of medium size appear on the lower surface of the superstructure. The cracks are probably caused by load deflections.

Concrete covers to the reinforcement various from 0 mm to approx. 30 mm.

In calculation of the utility ratios, the load bearing capacity is reduced according to the actual condition of the bridge, please refer Section 4.2. for additional information.

Based on the damages observed and consequently the condition evaluated for the superstructure it is estimated that the load capacity is reduced by approximately 10 % compared to the capacity for a not damaged structure.

No significant damages were observed on the substructure parts of the bridge.

The foundations could not be inspected. As no signs of foundation failure in the form of settlements or related cracking in the abutments/supports were observed, it was considered that no further special inspections of the foundations are needed [2].

### 3. LOAD CAPACITY ASSESSMENT

The Euro code specifies among other things characteristic values for vertical traffic load in the ultimate limit state. In specific Load Model 1 covers the effects of the traffic of lorries and cars and is intended for both general and local verifications [3].

Load Model 1 consists of two parts:

a). Double-axle concentrated loads (tandem system), each axle having a weight:  $\alpha_Q Q_k$ . No more than one tandem system should be considered per lane; only complete tandem systems shall be considered. Each tandem system should be located in the most adverse position in its lane, see Figure 4.1. Each axle of the tandem model has two identical wheels, the load per wheel being therefore equal to  $0.5\alpha_Q Q_k$ . The contact surface of each wheel is to be taken as square and of side 0.40 m. Only three lanes shall be loaded with tandem systems [4].

b). Uniformly distributed loads (UDL system) having a weight density per square metre:  $\alpha_q q_k$ . These loads should be applied only in the unfavourable parts of the influence surface, longitudinally and transversally.  $q_k = 9 \text{ km/m}^2$  is related to lane number 1 while  $q_k = 2.5 \text{ km/m}^2$  in the remaining lanes. The adjustment factors  $\alpha$  are taken as equal to one. Dynamic amplification is included in the values for  $Q_{ik}$  and  $q_{ik}$  [5].

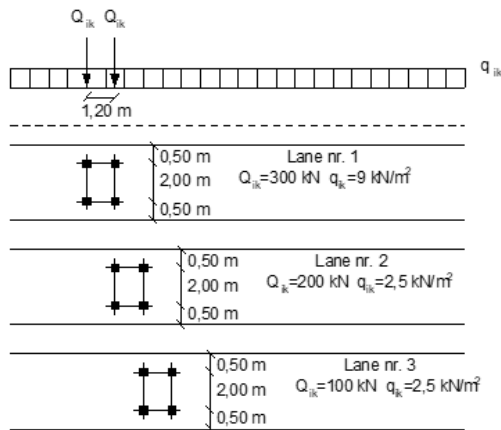


Figure - 3.1 Load Model 1 according to Euro code.

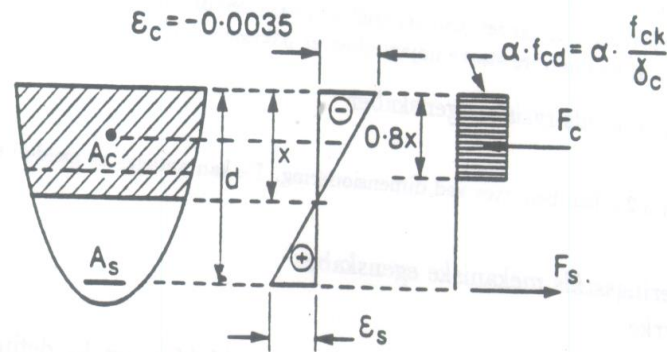
Location	Tandem system	UDL system
	Axle loads $Q_{ik}$ (kN)	$q_{ik}$ (kN/m <sup>2</sup> )
Lane number 1	300	9
Lane number 2	200	2.5
Lane number 3	100	2.5
Other lanes	0	2.5
Remaining area	0	2.5

Table - 3.1. Basic values.

According to Euro code 2, Part 2, Concrete Bridges the following material safety factors shall be used:

- Concrete: 1.50
- Reinforcement: 1.15

A factor  $\alpha$  for sustained compression shall also be taken into account. Generally  $\alpha$  may be assumed to be 0.85 [6].



**Figure - 3.2. Rectangular diagram showing  $\alpha$**

The superstructure is modelled as a simply supported “rigid frame” with walls and deck-plate. Geometry and reinforcement data are taken from drawings.

- Span length: 12.5 m
- Deck width: 8.9 m
- Carriageway width: 7.5 m
- Number of notional lanes: 2
- Deck height: 0.50 m in mid-span and 0.70 m near the walls
- Reinforcement diameter: 20 mm
- Distance between reinforcement bars: 90 mm for tension in mid-span and 60 mm for tension at fixation to walls.

The concrete strength is based on information from drawings while the reinforcement strength is based on information from the design calculations.

- Cubic strength of concrete equal to 22 MPa corresponding to a characteristic concrete cylinder strength of 18 MPa
- Reinforcement equal to St. 37, which is used for main reinforcement on most of the bridges. The characteristic yield tensile strength of St. 37 is assumed equal to 225 MPa

#### 4. SPECIAL INSPECTION AND LOAD TEXT

The bridge design is documented through available drawings and statically calculations as described in section 2. Moreover, the construction period is known, which means that the type and the origin of the construction materials are well known.

As described in section 3 the load capacity is determined not to be acceptable. It is also considered that an acceptable load capacity cannot be documented even if high material strengths could be documented based on carried out special inspections. As moreover the most relevant strengthening design as described in section 5 is rather independent of the actual condition and material strengths related to the existing structures it is estimated that no special inspections should be carried out for the bridge. The availability of sufficient documentation for the bridge in relation to the recommended strengthening method was not foreseen in the Inception Report [7].

The load capacity of the bridge as determined and described in section 5 is considered to represent the true capacity with sufficient accuracy as:

- Drawings and statically calculations from design are available, which means that all dimensions and material data are known
- The visual inspection carried out in October/November 2001 has verified that the load capacity is only reduced by a small amount due to damages
- The static behaviour of the bridge is simple and the analysis model used for the load bearing capacity calculations is therefore considered accurate.

Based on these items, the information for the load capacity assessment is considered adequate to determine a reliable load capacity. This was not foreseen in the Inception Report.

It is therefore not expected that a loading test for bridge no. 35 would benefit the assessment of the load bearing capacity and consequently no loading tests have been carried out for the bridge [7].

### 5. REPAIR AND INSPECTION

The existing concrete edge beam and steel railing is in a very poor and deteriorated condition.

It is proposed to replace the edge beam and walkway to a new integral structural concrete part of the bridge edge reinforced to obtain vertical and horizontal loads from the traffic. It is proposed to introduce a combined steel railing and crash barrier system, which meet international standard for bridge safety crash barriers.

It is proposed to carry out a standard polymer modified bituminous-based waterproofing membrane in two layers without concrete protection layer. The system is commonly used in Europe.

It is proposed to replace the existing asphalt pavement with new asphalt pavement based on a bearing course layer and a wearing course layer.

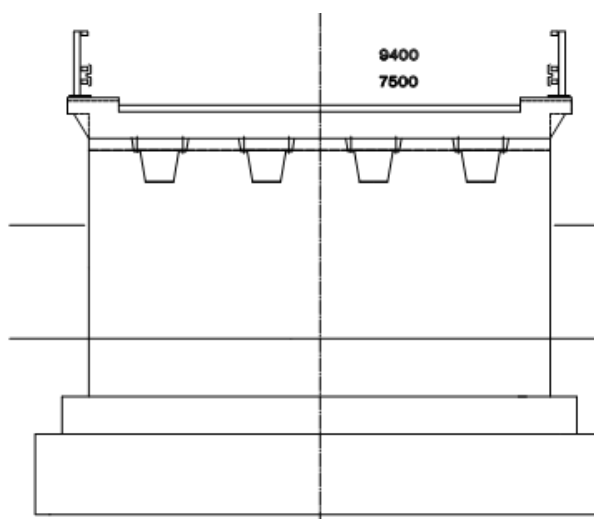


Figure - 5.3. Cross section - Strengthened superstructure RC/Steel composite

### Report from previous bridge 35 Inspection

<b>Category:</b>	<b>Road bridge</b>	
Coordinates:	42°31.75...21°09,76	
Road location	L.selo - Ferizaj - Main Road N-2	
Superstructure type	Mono-span, continual concrete structural slab	
Total spans:	1	
Length (m):	20,5	
Total Width (m):	9,4	
Road Width (m):	7,2	

### DESCRIPTION

<b>Approaches:</b>	<i>level 0 (good) to 3 (high severity)</i>	
Asphalt pavement	YES	1
Embankment	YES	2
Guard rail	NO	
<b>Abutments:</b>	<i>level 0 (good) to 3 (high severity)</i>	
Type	Full height	

Joint with deck	NO	
Bearings and pedestal	NO	
Back wall	YES, reinforced concrete beams	0
Wing walls	YES, reinforced concrete beams	0

<b>Pier:</b>	<i>level 0 (good) to 3 (high severity)</i>	
Pier columns	NO	
Cap beam	NO	
Pedestals	NO	
Bearings	NO	

<b>Superstructure:</b>	<i>level 0 (good) to 3 (high severity)</i>	
Primary member	NO	
Deck structural	Reinforced concrete plate cast in situ	0
Joints	NO	

<b>Deck elements:</b>	<i>level 0 (good) to 3 (high severity)</i>	
Wearing surface	Asphalt	1
Sidewalk	YES	1
Guard rails	NO	
Parapets	YES	0

Figure - 5.2 Selected documentation

## 6. CONCLUSION

First, it is necessary to define the scope of work and perform a complete remediation or just eliminate the causes of damage, and report all necessary remediation works later, when all conditions are met (funds, time and temporary traffic regulations, ...).

Success in the repair of bridges depends primarily on a good and complete knowledge of the structure being repaired, the nature and extent of damage, quality and condition of materials and the experience of the designer, especially in the application of modern materials and technology. The rehabilitation of this bridge proved to be very good even after 15 years, without damaging parts of the reinforcement that was performed in the period 2005-2008 from the EU. The research conducted so far has shown which factor crucially influences the durability of bridges in operation. The lifespan of concrete bridges has received increasing attention, as in the world and here in Kosovo.

In order to achieve quality and cost-effective solutions, appropriate calculation and analysis methods should be applied. Unfortunately, in our practice, very approximate calculations are still often applied, which leads to inadequate and expensive solutions, both in the design of bridges and during the rehabilitation.

Concrete bridges are built in extremely unfavourable conditions, where they are exposed to various influences and unfavourable factors of damage and degradation of the structure

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The "Bridge Assessment" project was carried out after the program described in the Initial Report, Report  
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