WORKS ON STRENGTHENING BRIDGE

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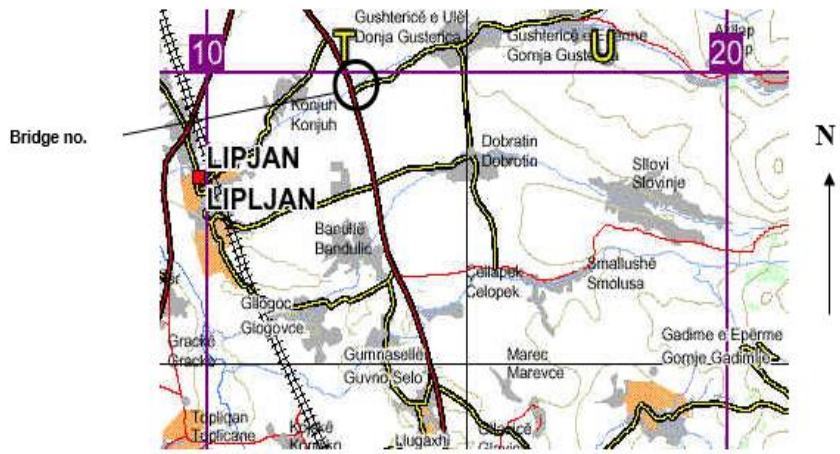
Abstract: The summary covers inspection, assessment and recommendations of repair and strengthening works for bridge no. 34 on N2 Road, Pristina - Blace section.
Load capacity calculations have been carried out based on the results from Desk Study and Detailed Inspection.
Special load capacity assessments have been carried out in order to define the necessary traffic restrictions to be established in the period until the strengthening of the bridge has been completed.
The findings of the detailed inspection are that the condition of the bridge is poor and rehabilitation is needed.
Further the load capacity of the bridge, related to Euro codes for design of bridges, is estimated to be insufficient.
Keywords: Methods of bridge reinforcement, duration of the Bridge, inspection of the Bridge, upgrade, substructure, assessment of the Bridge

INTRODUCTION

The bridge is located in the central plain of Pristina in arable land. The bridge carries N2 road in 2 lanes over a narrow stream parallel to a gravel track from Lipljan. The location is shown on the map below [1]:



From the existing drawings and static calculations the bridge is assumed constructed in 1961 with the superstructure in level above the natural ground level with road embankments adjoining the bridge.
The bridge consists of a single span and with length at approx. 9 metres and width at approx. 9.5 metres. The overall length of the bridge is approx. 18 metres. The bridge is constructed without visible expansion joints in the superstructure and without crash barriers.
The substructure is protected with cement mortar plaster, which makes it difficult to spot cracks and other defects. The cement mortar plaster is probably applied at a later stage as a maintenance precaution. Railings are provided on both side of the bridge fixed into the edge beams [1].

DETALIED INSPECTION

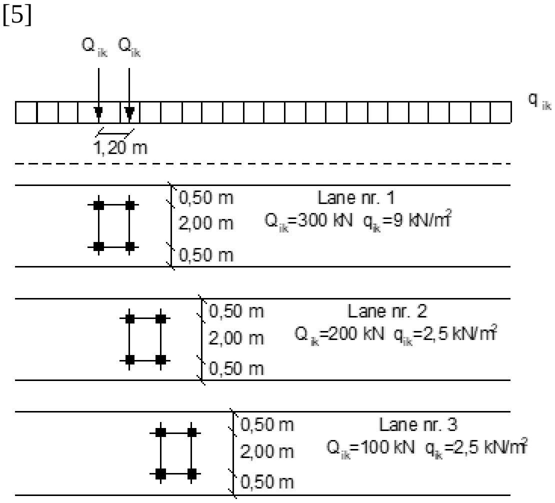
The concrete edge beams are deteriorated and visible reinforcement occurs. The defects specially occur around the fixations of the railing posts. The defects are caused of a combination of poor workmanship, unsuitable concrete aggregates for structural concrete exposed to weathering, temperature effect, freeze-thaw, etc.
The waterproofing was not inspected, but leakage of water through the deck slab is observed in few places. 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 from interview with 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. 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 is thick, in level with the top of the kerbstones, which indicates several asphalt-wearing course layers applied during time. The pavement applied at the time of construction probably still exists and causes adverse effect on the recently applied layers.
The bridge railing is of the pipe type commonly seen along the bridges on the N2-road section. Several of the bridges railing sections are extremely deformed due to dynamics impacts. Around several posts the concrete is deteriorated completely and does not fix the posts to the edge beams. The railing does not provide normal safety for the road users, pedestrians or vehicles even the kerbstone design form a kind of crash barrier effect for the vehicles [2].
Water leakage, insufficient concrete cover and poor concrete quality and construction causing spalling and deterioration of concrete, exposure of reinforcement and other defects are noted on the soft of the deck slab. Further the heavy spalling of concrete has lead to corrosion on both the stirrups and main reinforcement. The condition of the bridge is generally poor especially due to poor workmanship, such as the main reinforcement is embedded underneath the stirrups and many honeycombs.
Freeze-thaw action of the concrete has been noted on the edge beams and on the edge of the deck slab. The concrete in these areas is in general very porous and weak. There is a single wet spot on the soffit of the deck slab.
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 [2].

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:

1. 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 3.1. 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].
2. 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 km/m² is related to lane number 1 while q_k = 2.5 km/m² in the remaining lanes.

The adjustment factors α are taken as equal to one. Dynamic amplification is included in the values for Q_{ik} and q_{ik}. [5]



Location	Tandem system	UDL system
	Axle loads Q_{ik} (kN)	q_{ik} (kN/m²)
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

Figure 3.1 Load Model 1 according to Euro code.

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 α for sustained compression shall also be taken into account. Generally α may be assumed to be 0.85. [6]

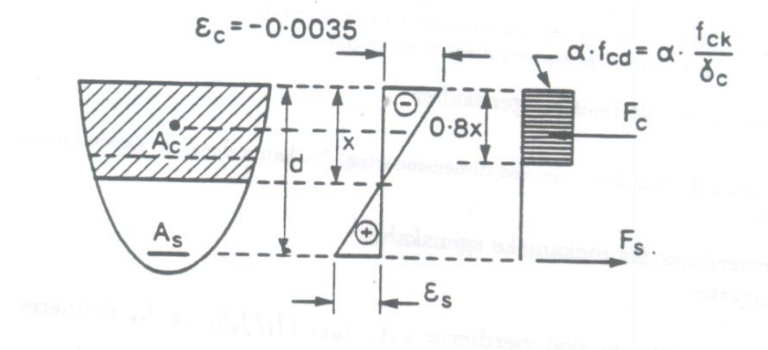


Figure 3.2. Rectangular diagram showing α.

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: 9.6 m
- Deck width: 8.6 m
- Carriageway width: 7.5 m
- Number of notional lanes: 2
- Deck height: 0.38 m in mid-span and 0.60 m near the walls
- Reinforcement diameter: 20 mm
- Distance between reinforcement bars: 120 mm for tension in mid-span and 90 mm for tension at fixation to walls .

The concrete strength is based on test results from inspections and information from the other bridges while the reinforcement strength is taken from design calculations.

- Cubic strength of concrete equal to 30 MPa corresponding to a characteristic concrete cylinder strength of 24 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.

SPECIAL INSPECTION AND LOAD TEXT

The bridge design is documented through available drawings and statically calculations as described in section 1.. Moreover the construction period is known, which means that the type and the origin of the construction materials are well known.

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 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 4 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 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 accu-rate.

Based on these items, the information for the load capacity assessment is con-sidered 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. 34 would benefit the assessment of the load bearing capacity and consequently no loading tests have been carried out for the bridge [7].

REPAIR AND INSPECTION

The existing concrete edge beam and steel railing is in a very poor and deteriorated condition. Depending on whether strengthening of the superstructure or replacement of the bridge is selected, the following solutions are proposed:

1) Strengthening of the superstructure
   For the strengthening solution it is proposed to replace the edge beam and walkway to a new integral structural concrete part of the bridge edge reinforced to sustain 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.
   It is proposed to replace the existing asphalt pavement with new asphalt pavement based on a bearing course layer and a wearing course layer[8].
2) Replacement of the bridge
   For the corrugated steel pipe solution it is proposed to remove the existing concrete edge beams and railings and instead install a normal road crash barrier on top of the road embankment across the bridge.
   No works concerning waterproofing and pavement is recommended [9].

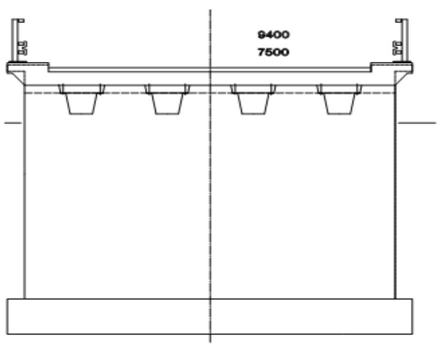


Figure 6.3. Cross section - Strengthened superstructure RC/Steel composite

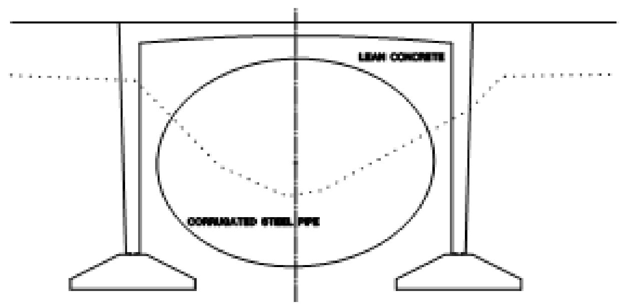


Figure 6.4. Longitudinal section - Corrugated steel pipe

Report from previous bridge 34 Inspection

Category:	**Road bridge**	
Coordinates:	42°31.75…21°09,75	
Road location	L.selo - Ferizaj - Main Road N-2	
Superstructure type	Mono-span, continual concrete structural slab	
Total spans:	1	
Length (m):	7,4	
Total Width (m):	9,4	
Road Width (m):	7	

DESCRIPTION

Approaches:	***level 0 (good) to 3 (high severity)***	
Asphalt pavement	YES	2
Embankment	YES	1
Guard rail	NO	

Abutments:	***level 0 (good) to 3 (high severity)***	
Type	Full height	
Joint with deck	NO	
Bearings and pedestal	NO	
Back wall	Cost in situ r. concrete	1
Wing walls	Cost in situ r. concrete	1
Pier:	***level 0 (good) to 3 (high severity)***	
Pier columns	NO	
Cap beam	NO	
Pedestals	NO	
Bearings	NO	
Superstructure:	***level 0 (good) to 3 (high severity)***	
Primary member	NO	
Deck structural	Reinforced concrete plate cost in situ	2
Joints	NO	
Deck elements:	***level 0 (good) to 3 (high severity)***	
Wearing surface	Asphalt	2
Sidewalk	YES (both sides 1.20)	1
Guard rails	NO	
Parapets	YES	2

Figure - 4: Selected dokumentation

CONCLUSION

Success in the rehabilitation of bridges depends primarily on good and complete knowledge of the structure being rehabilitated, from knowledge of the character and extent of damage, quality and condition of the material and from the experience of the designer, especially in the application of modern materials and technologies.
It is necessary to define the scope of the work and carry out a complete rehabilitation or just eliminate the causes for the occurrence of the damage, and all necessary rehabilitation works should be carried out later, when all the conditions (means, time and temporary regulation of traffic, ...) are established.
The lifetime of concrete bridges is gaining increasing attention to building science and practice as in the world at a later time in a new state such as the Republic of Kosovo. Rehabilitation of this bridge proved very good and after 15 years, without damage to parts of the reinforcement that was carried out in the period 2005-2008 from the EU. So far, the research carried out showed the number and importance of the factors that have a decisive influence on the durability of the bridges in exploitation. Concrete bridges are built in extremely unfavorable conditions, whereby they are exposed to various influences and unfavorable factors of damage and degradation of the structure.
In order to achieve quality and economical favorable solutions, appropriate methods of calculation and analysis should be applied. Unfortunately, in our practice, very approximative calculations are still often applied, which leads to inadequate and costly solutions, both in the design of bridges and in its rehabilitation.

LITERATURE

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