# Conditional assessment of Kiri Bridge in Shkoder, Albania

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## ABSTRACT

The Kiri bridge is located 1 km in north-west of Shkoder city and it is the only connection for the city of Shkoder and the Vau i Dejes hydropower station. It is a reinforced concrete bridge with 8 spans, 2 sidewalks and steels parapets on both sides.

In this paper general evaluation of the bridge's current structural conditions and the ability of the bridge to withstand loads from the vehicular traffic are examined. The methodology used in this study consists of the proper definition of the bridge's structural elements and field inspection of each of them. Deterioration of the structural elements, damage of the paving, parapets and expansion joints are observed at a great extent. The other identified defects are recorded in an inspection form. As a result, the overall conditions were rated 6/10.

In this paper some precautions and further measures to be taken are suggested.

## INTRODUCTION

After the declaration of the Albanian state in 1912, there have been built many new roads and bridges. The construction of these structures has been carried out during different time periods and different construction codes such as the Soviet code, Albanian Standard and Code (KTP 23-78) as well as AASHTO, BS Standards and Eurocodes have been used [1].

In the Albanian National Road Network there are found 562 bridges that span a length of 19295 meters across the country, many of them being in service for more than 35 years [12].

This bridge is called Kiri Bridge, is located 1 km in north-west of Shkoder city and connects Shkodra city and Vau i Dejes hydropower station (Figure 1,2).

Figure 1. Aerial view of the bridge

Figure 2. Entrance of the bridge

It is a reinforced concrete bridge with 8 (eight) spans, 2 sidewalks and steels parapets on both sides, important to notice is in this bridge are passing railway and road vehicles two lines. Each pier has 4 piles with diameter 100 cm (Figure 3, 4).

Figure 3. Railway

Figure 4. Piers of the bridge

The scope of this study is to prepare a general evaluation of the bridge's present ability to withstand loads from light vehicular traffic.

## INSPECTION PROCEDURE

The purposes of the bridge inspection are [3]:

a) to ensure public safety and confidence in bridge structural capacity
b) to protect public investment and allow efficient allocation of resources
c) to effectively schedule maintenance and rehabilitation operations
d) to provide a basis for repair, replacement, or other improvements such as retrofit railings
e) to ensure that national funding will remain available for bridge rehabilitation and replacement.

According to US Bridge Inspection Manual, bridges should be inspected every two years but the frequency may be increased depending on the structural conditions of the considered bridge [3].

Bridge inspection consists of defining the elements (structural parts of the bridge) and total quantities that exist at each bridge. The condition of each element is determined by performing a field inspection and recording quantities of the element that have identified defects that correlate to the severity of the defects. The condition assessment is complete when the appropriate portion of the total quantity is stratified over the defined condition states [4-9] For agencies utilizing bridge management systems, the appropriate element Smart Flags and environment shall be recorded for use in deterioration modelling.

## INSPECTION RESULTS

The bridge is an eight-span bridge, having two concrete abutments on each side of the river and a four group pile foundation, superstructure composed by 80 beams and the deck slab. The deck slab in the area between the beams has variable thickness, being thicker adjacent to the beams and thinner at the central axis parallel to the beam axes.

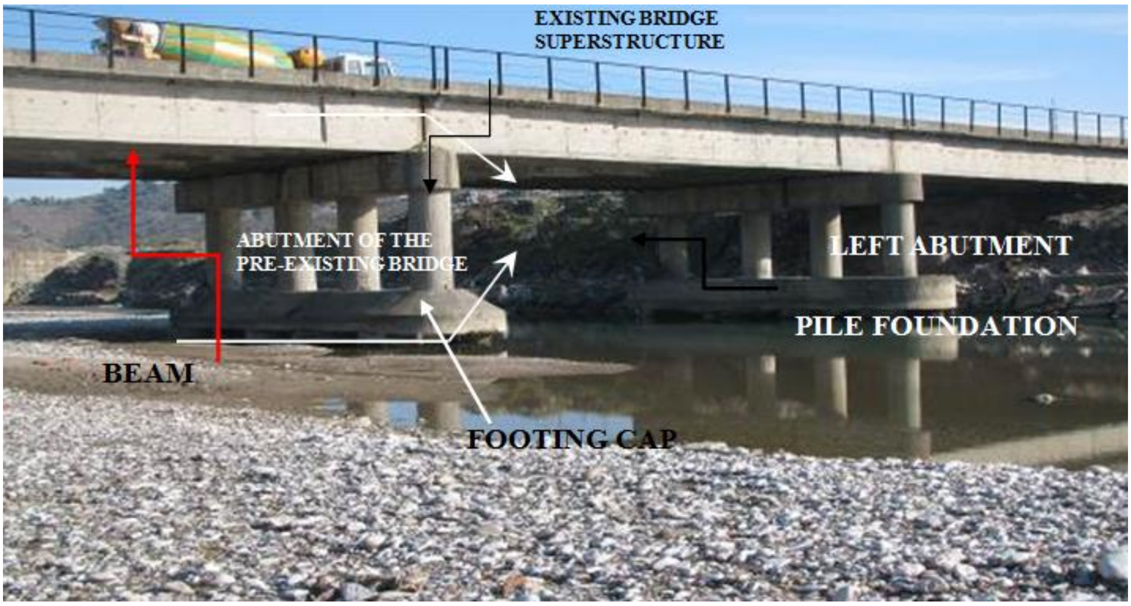


Figure 5. Description of the elements of the bridge.

All beams are supported on the flat bearing steel plates on both ends, joined with the bearing shelf on the left side abutment. The bridge has two lanes. One line has width of 4 m. There are parapets on both sides of the bridge for safety of people.

The overall inspection process of Kiri Bridge consists of four stages. The first stage is the identification bridges elements. These elements are divided in superstructure and in sub-structure:

***a) Superstructure Inspection.***

Superstructure Inspection is focused on beams, gears, cable, sidewalks, parapets, wearing course and expansion joints.

***b) Sub-structure Inspection.***

Sub-structure Inspection is focused on piles, cap, piers, piers cap, columns, and abutments.

During the second stage the quantity of the elements are collected. In the third stage to description of the defects is conducted, and in the fourth stage ranking of the defects noticed during inspection is performed.

After the condition assessment of the Kiri Bridge, the following problems were observed:

*Cracking of the concrete:*

Accurate inspection was undertaken to detect cracking on the concrete surface of the beams and deck slab.

The inspection team looked for cracks all over the superstructure of the bridge. Apart from some cracks at the end parts of the beams and of the slab resulting from additional compression stresses in the concrete elements due to additional forces being induced by earth pressure produced by the landslide, there are no cracks in the superstructure reinforced concrete elements, such as beams and deck slab.

The superstructure seems to be in good condition, with the exception of some minor damages at the ends of the beams caused by overstressing from the contact stresses during the landslide.

Spall of concrete

The results from the inspection showed that spalling has occurred in some parts of the concrete as a due to slipping of the structure from its supports. As it can be seen from the figures (Figure 6,7), this phenomenon is more emphasized at the ends of the beams, where the beams have slipped over the bearing shelves or over the abutments. No spalling of the structural elements was detected to have been caused by overstressed compressed concrete or by the corrosion expansion.


Figure 6. Spall of concrete


Figure 7. Spall of concrete.

However, there was something that attracted the attention of the inspection team that was worth remarking. The spaces between the main longitudinal tensile steel bars reinforcements did not fulfill the required parameters set according to the standard. [4] This space was way too small, and thus preventing the concrete layer from filling the bottom part of the beams. The concrete cover layer of the main reinforcement bars at the bottom of the beam is damaged in some parts of the beam facilitating the corrosion of steel bars. As it can be seen, the lack of concrete cover layer is not a result of spalling of concrete.

Corrosion of reinforcement

No corrosion was detected except from those parts of steel reinforcement bars exposed to the environment due to lack of concrete cover layer as a result of inappropriate spacing of the bars.

Quality of the concrete

Not possessing the original detailed drawings and technical specifications, the analogy has been made with all the other existing bridges for which detailed drawings and technical specifications were found. Based on this analogy, the concrete for the superstructure should have been M-200 for the supports (bearing shelves) and M-150 for the abutments and M-100 for the wing walls.

Non destructive tests were conducted to roughly establish the concrete cubic compression strength of different structural elements of the bridge. The cubic compression strength was measured by non destructive tests made by using KRS-D845 instrument [5].
Based on the results of the tests, there is no doubt about the concrete quality of the superstructure. Despite the fact that the concrete for the superstructure has been cast in place (no prefabricated structure is used), the compression strength of the concrete seems a little bit higher than that usually used for this kind of structure. It exceeds the prescribed value of the project which is M-200, which corresponds to the cubic compression strength equal to 200 $Kg/cm^2$ after 28 days. This probably is due to the hardening of the concrete during the years.
The concrete material in the beams and deck slab is well compacted and some small parts at the bottom of the slab have been plastered with cement mortar to cover the steel reinforcement bars, which probably remained uncovered when the wooden scaffolding had been taken off.

<u>Chemical attack</u>

Chemical attack on the concrete has been detected on structure. There exists on all air pollutant in the region and the environmental conditions are very good for preserving the concrete quality.

**Abutment, abutment foundation and wing walls inspection**

The vertical supporting structural elements of the bridge, i.e. the abutment foundations, the abutments, pile foundation, footing cap and the wing walls of the bridge were checked. After the inspection, the following problems were observed:

<u>Cracking of the concrete</u>

The inspection team searched for cracks all over the superstructure of the bridge. There were detected different cracks in the upper part of the abutments as well as the presence of some horizontal cracks related to additional normal end shear stresses in the concrete elements caused by horizontal forces applied on the top of the abutments due to friction between superstructure and the support and, later on, applied also on the ballast wall by beam’s ends when the ballast wall blocked the displacements of free ends of the superstructure preventing further slipping of them over the bearing shelves. The horizontal forces were result of additional earth pressure produced by the landslide.
There are two other major wide cracks on the left abutment (Figure 8,9). Both of them are a consequence of the forces induced to the bearing shelf by the beams during the rotation of the superstructure around its central vertical axis as the result of the direction of the earth pressure caused by the landslide.

Figure 8.

Figure 9.

The crack openings are relatively wide (less than 1cm) and, apart from the possibility of damage of the concrete during the winter, there may be no further effects on the stability and bearing capacity of the structure. Because the abutment resists a compressive load, the cracks mentioned above will tend to close when they will be resisting bigger loads.

Quality of the concrete

As for the superstructure, in order to define the concrete grade, analogy has been made with all the other existing bridges for which drawings and technical specifications were found. Based on this analogy, the concrete for the superstructure should have been M-200 for the supports (bearing shelves) and M-150 for the abutments and M-100 for the wing walls, being 'M' for 'type' and 200 corresponding to the cubic compression strength expressed in $Kg/cm^2$ after 28 days from the day of preparation of the mix.

Despite the fact that the concrete for the structure has been cast in place and that coarse material has been used to prepare the mix, the compression strength of the concrete seems a little bit higher than the value prescribed in the project. This is probably due to the hardening of the concrete during the years.

Erosion

The water-flow mixed with the solid materials produced by the waterway of the bridge has caused the erosion of the concrete at the basement of the abutment and pile as well as the concrete of the abutment itself. Although this kind of damage does not appear to be seriously affecting the stability of the bridge, a long term solution should be found for the new bridge to be built.

Superstructure integrity and its bearing capacity

The superstructure does not bring serious visible signs of damage. Hence, from a structural point of view, the bearing capacity of the superstructure has remained the same as the one calculated by the designers at the time of the construction of the bridge. This means that the bridge can be crossed by trucks having a total weight of 25 tons and by crawler vehicles weighting not more than 80 tons.

Abutments integrity and their bearing capacity

Although the concrete quality is almost decent and, apart the lose material of the basement on left side abutment, as the result of serious damages caused by the erosion of the water flow to the abutment and to its foundation, the integrity of the structure is guaranteed. The bridge can be considered on use if we refer to the standard.
The foundation of the right side abutment is in good condition.
As a result, it can be said that there are no integrity problems for the superstructure. However, this is not the case for abutments.

The left side abutment lacks overall integrity and cannot be considered a bearing structure without appropriate rehabilitating intervention on basement.
The left abutment has a major cracks as a result of load on the superstructure and caused by lose of material on basement foundation.
Although the cracks are developing under the normal vertical loads (superstructure self weight and traffic loads).


Figure 9. Damage of the column


Figure 10. Damage of the piles

**CONCLUSIONS**

The inspection results have shown that the overall structural conditions of Kiri Bridge are below the average, a rate of 6 (six). In Table 1, the severity conditions of the structural elements are shown:

Table 1. Bridge rating elements (1= *best* condition, 10 = *worst* condition)

| No. | Element Name | Rating |
|---|---|---|
| 1 | Wearing surface | 3 |
| 2 | Expansion joints | 7 |
| 3 | Deck | 5 |
| 4 | Parapets | 7 |
| 5 | Paint | 6 |
| 6 | Bearings | 7 |
| 7 | Abutments | 6 |
| 8 | Abutment foundation | 5 |

| | | |
|---|---|---|
| 9 | Reinforced concrete beam | 7 |

The abovementioned problems should be resolved in order to improve the overall structural capacity of Kiri Bridge.

## REFERENCES


[1] Periku, E. (2012) Bridge Assessment in Albania, MSc Thesis, Epoka University.

[2] Delegation of the European Commision to Albania (2010) "Albanian Bridge Asset Management System Manual Introduction & Overview", Ref: EuropeAid/127796/C/SER/AL

[3] Bridge Inspection Manual (2002) Texas Department of Transportation

[4] Bridge Maintenance, Planning, and Repair Handbook - *Defines standard maintenance and repair details.*

[5] AASHTO Movable Bridge Inspection, Evaluation and Maintenance Manual - *Provides guidelines for the inspection, preventive maintenance, operation and repair of moveable bridges. This document is available from the American Association of State Highway and Transportation Officials (AASHTO), 444 North Capitol Street, N.W., Suite 249 Washington, D.C. 20001. This document is not available from the Department.*

[6] Bridge Work Order Handbook – *Provides instructions for the processing of data collected by Bridge Inspectors.*

[7] Bridge Inspectors Field Handbook – *Provides guidance for inspectors in selecting elements and assigning quantities to condition states for selected elements.*

[8] Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges – *Provides instructions for coding data items required by the Federal Highway Administration. This document is* available from the Federal Highway Administration and a link is provided from the State Maintenance Office Infonet site to an electronic version of this document.

[9] AASHTO Bridge Element Inspection Manual 1st Edition, 2010.