UDK 624.2

MAINTENANCE PROBLEMS IN THE CASE OF HISTORICAL BRIDGES IN BIALSKI POVIAT IN EASTERN POLAND

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1. Introduction

Historical heritage provides the basis for future. We can draw on the wisdom, technology and earlier concepts which support our contemporary efforts and challenges. All this concerns old bridges, even if their structure condition is not sufficiently adequate to current needs. Additionally, it happens that these old bridges seem be nicely looking comparing to contemporary architecture. Sometimes is possible to arrange a park museum, where old bridges create the nostalgic mood, remembering the past glory. As an example we can recall the Ironbridge Gorge as a World Heritage Site which has the status of UNESCO; [1].

Fig. 1-2. Iron Bridge at Coalbrookdale, England (by the courtesy of Ironbridge Gorge Museum Trust)

The strengthened and renewed structures are monuments of the Industrial Revolution which had place here in XVIII centaury.

As a second example, the Thullie's foot bridge in Lvov can be recalled. The small plate-arc, erected in the earl period of reinforced concrete age, is now renewed and decorates the park area surrounding Lvov Polytechnic Main Building. This bridge has a deep meaning, being a common engineering monument. It is a hinge which connects Polish and Ukrainians bridge constructors.

Fig. 3-4. The Thullie's foot bridge in Lvov, Ukraine

These positive examples cannot bring the full satisfaction. Many historically worth bridges are still waiting for renovation. Probably a whole class of wooden bridges sunk completely from our contemporary landscapes and only old photos remind us about them.

Fig. 5-7. One of the lasts wooden bridges, Werbkowice, Poland

In the case of old bridges all the time we have to answer the questions: whether they are important enough to preserve them and as pay extra for their maintenance, whether are they enough serviceable. And the most important question is about the social and historical price of disappearing them. Mostly the answer is obvious; due to this, the concrete and steel materials replaced the wood in bridge structures. But when the discussion starts the answers are not clear anymore. Such a case has taken place in Leśna Podlaska, where in a fact small culvert is located on a secondary local road.

2. Historical bridges in Bialski Poviat

In the Fig. 8., the map shows localization of historical bridges or culverts in the Bialski Poviat (County) laying in eastern part of Poland. Let us now survey those historical bridges.

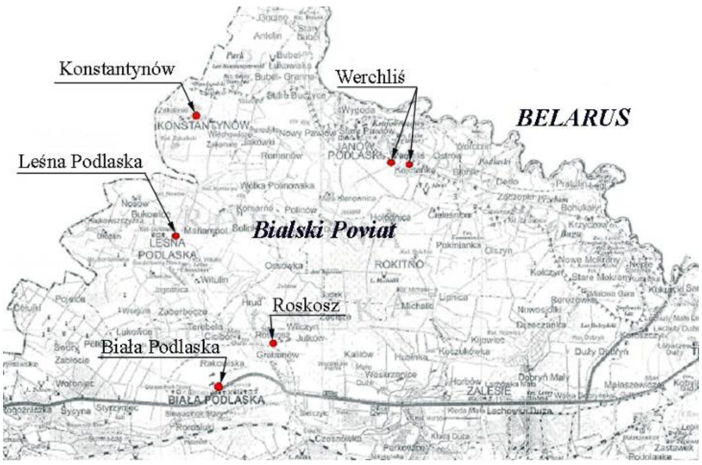

Fig. 8. The localization of historical bridges in Bialski Poviat region

The first in the survey is the arc stone bridge in Konstantynów. The massive structure emphasizes its role in the village landscape and supports the feeling of its safety construction. Indeed the technical condition of this object is almost excellent.

Fig. 9-11. XIX's c. stone pony type bridge over Czyżówka River in Konstantynów village

The used glacial stone material bounded by cement mortar guaranties the bridge serviceability till today and even the pavement has not been changed, Fig. 9-11. The line of arc is underlined by added red brick elevation. Different epoch i.e. the period of industrial revolution gave the steel bridge in Roskosz near Biała Podlaska. Previously it was a railway bridge with the span 24 m and breadth 7,5 m for narrow gauge railway, erected by Germans in 1916-1917 as a *feldbahn* and was in use till 1971 [2]. The bridge was rebuilt into pedestrian one, but this thoughtless works made that probably nobody could be proud of the final effect. The lacks of any conservation and maintenance works are observed in the Fig. 12-14.

Fig. 12-14. The previously railway bridge truss girders, now used for pedestrian bridge in Roskosz

Fig. 15-17. Steel railway bridge in Biała Podlaska over the Krzna River

The steel bridge which has been lying on the same railway tract is in Biała Podlaska. The solid structure and good standard of constructional works made that the bridge, after some conservational works, would be ready to carry the next train.

In the village Werchliś on the 698 Road Siedlce – Terespol there are two bridges made of reinforced concrete. They were erected before the Second World War. In 2003 the road was rebuilt and as a result of this the bridges are now excluded from traffic use. In those cases we can also observe the changes in the water system. The previous rivers water volume has been considerably reduced due to numerous meliorations in recent 30 years, Fig. 18-20.

Fig. 18-20. The 70 years old reinforced concrete bridges in Werchliś

3. The arc stone culvert in Leśna Podlaska

In the flatten landscape, in Leśna Podlaska we meet the Pauline's Closter surrounded by parkas trees and old defence walls equipped with moat along them. The church building is stated in the main place. The old XIX c. postcard shows the church and additionally the objective small bridge.

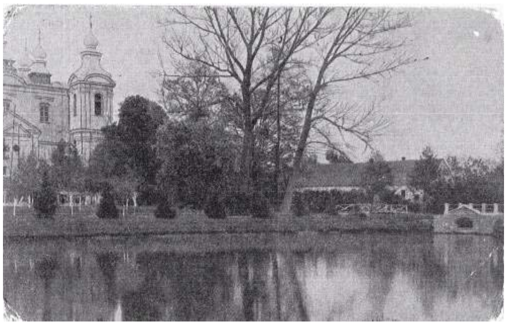

Fig. 21-22. The postcard with Pauline's Closter and the bridge in the left part of the photo

Fig. 23-26. The church and the bridges in its neighbourhood

The road runs close to monastery and is crossing several rivulets. During the time of monastery prosperity all roads led to the church hill, crossing water springs by stone bridges. Most of them are now renovated and nowadays play the same role for the faithful as it was in the past.

From time to time the ponds occur near the road, which together with rivulets form retention water system.

One of the small bridges located there is the aim of the consideration. The object lies in the road marked with the number 1081 from Leśna Podlaska to Ludwinów.

The date of foundation was approximately 1780, but no one knows for sure when it really happened. The road 6.5 m in breadth needs to be modernized and some concepts of planed rebuilding are being analyzed. Among them the one, herein has been presented to the local government. The basic assumption is to remain the existing culvert unchanged and additionally to expose this historical structure to tourists and inhabitants. Moreover, it is important to strengthen the structure in an appropriate way to contemporary transport loads. All this is possible, if we adopt modern concepts and technology.

The plan is as follows:

(i). to use a corrugated steel culvert over the existing arc as a strengthening element, and

(ii). to fork the road traffic into two isolated paths, where each of the paths will carry the separated traffic in the opposite directions.

Let us start the analysis with the strengthening of the structure.

3.1. The Ultimate and Serviceability Limit States

The current view of the culvert and the longitudinal cross-section of designing variant are shown in the Fig. 27-29. We assume the culvert parameters according to typical element known as ViaCon A17, [3].

Fig. 27-29. The historical culvert in Leśna Podlaska

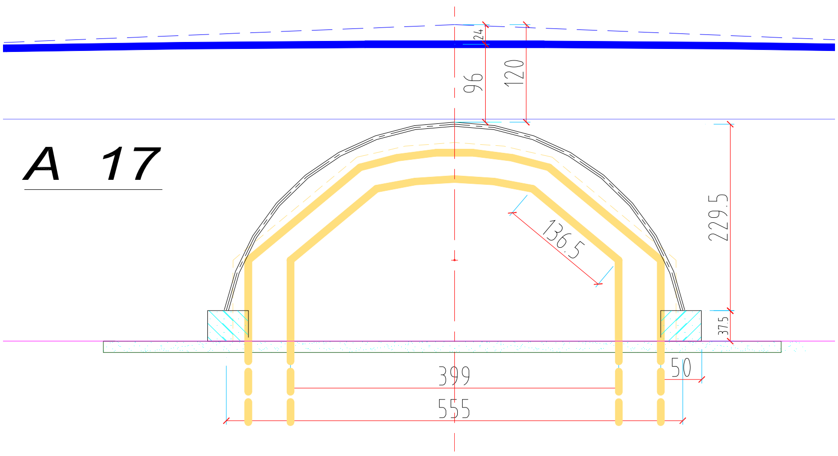

Fig. 30. The strengthening steel culvert element

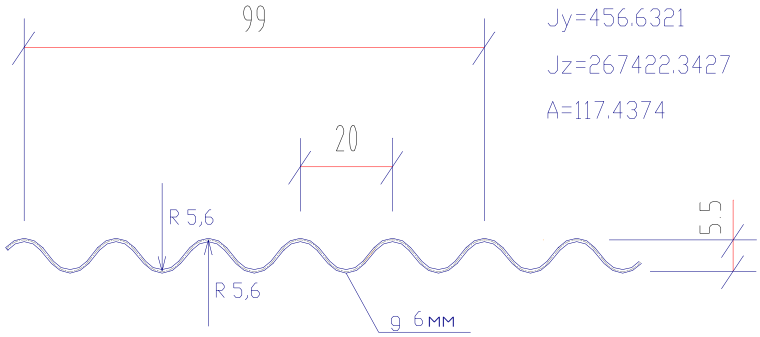

Fig. 31. Geometry of corrugating

The 2D FE model is used for estimating the deformation and stresses of designed structure. The two analyzed states of loads, i.e. symmetrical and non-symmetrical ones, are shown in Fig. 32.

The value of the loads concerns the case of class B, which means that the total caterpillar characteristic weight is 60 T. The class B allowed carrying the traffic with the maximum van weight of 40 T.

The ULS's partial safety multiplayer value is $\gamma_f = 1{,}5$ and the dynamical coefficient is neglected i.e. $\varphi = 1$; this is because of existing absorptive sand layer with height of 1 m. The sand parameters are: $\gamma_p = 18\,\mathrm{kN/m^3}$, $E_p = 90\,\mathrm{MPa}$ and Poisson's ratio $\nu_p = 0{,}22$. Respectively, for the asphalt pavement layers we have: $\gamma_n = 23\,\mathrm{kN/m^3}$, $E_n = 300\,\mathrm{MPa}$ and $\nu_n = 0{,}2$. Steel parameters are generally known.

Under the pavement layers and over the culvert the so called 'umbrella' is additionally placed, whose role is to carry the tension and to moderate occurring load concentration effects. As usual it is a high strength polymer or steel net with the closed loop of diameter ca 2 cm.

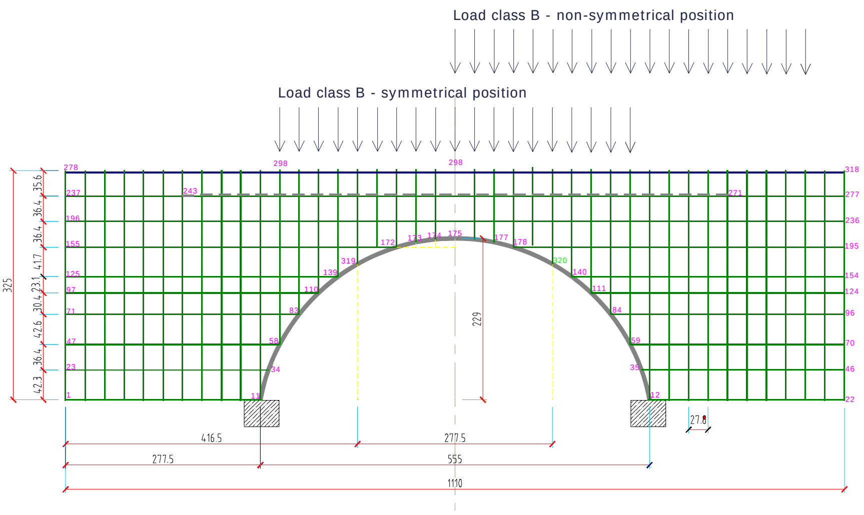

Fig. 32. FE model of analyzed culvert

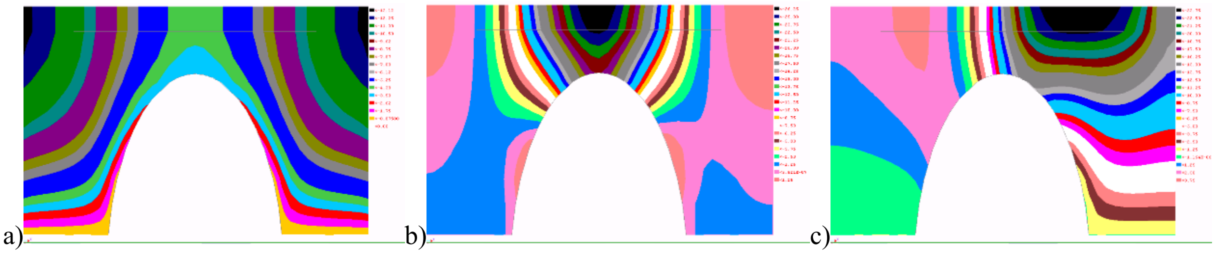

Fig 33. The displacement caused by:
a) own weight, b) symmetrical traffic load position, c) non-symmetrical one.

The cross-section of ground is modelled by shell elements, while the umbrella and culvert by ordinary one dimensional bar elements. The assumed breadth of both sorts of elements is 99 cm. The external traffic loads are transformed to this breadth too.

As it turned out [4], the corrugated steel shell was stiff enough as well as proposed sand and road pavement constructions. Analyzing the summarised displacements in the culvert neighbourhood, in both positions of caterpillar weight action, we obtain as a maximum displacements of the value: in vertical direction ~2,5 mm and in horizontal one 0,3 mm, as shown in Fig. 33.

On this basis, we assume that the free space, which is present between old arc structure and steel corrugated shell, could be filled with foam concrete or other foam on basis of polymers for example.

The extreme normal stresses are of secondary importance for this problem. The normal

forces are compressive all the time. For the steel culvert shell the stresses achieve the extreme values for the symmetrical load variant; as follows:

$$\sigma = \begin{Bmatrix} -147{,}62 \\ -75{,}08 \end{Bmatrix} \text{MPa} < 200\,\text{MPa}\,, \quad \delta = \frac{147{,}62}{200} \cong 0{,}74$$

in the restrain and

$$\sigma = \begin{Bmatrix} -6{,}16 \\ 29{,}77 \end{Bmatrix} \text{MPa} < 200\,\text{MPa}\,, \qquad \delta = \frac{29{,}77}{200} \cong 0{,}15$$

in crown, while the internal forces are showed in Fig. 26-27.

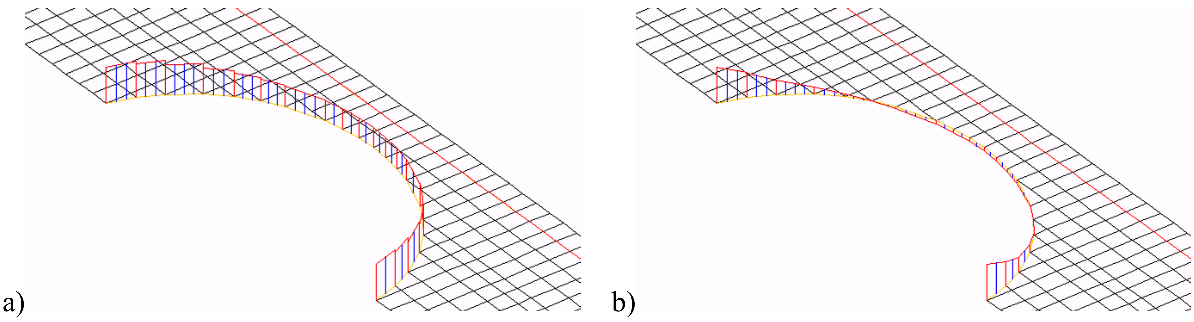

Fig. 34. Ground own weight: a) normal force [kN]: N_{max}=173,55, N_{min}=96,09;
b) bending moment [kNm]: M_{max}=-9.28, M_{min}=0.97

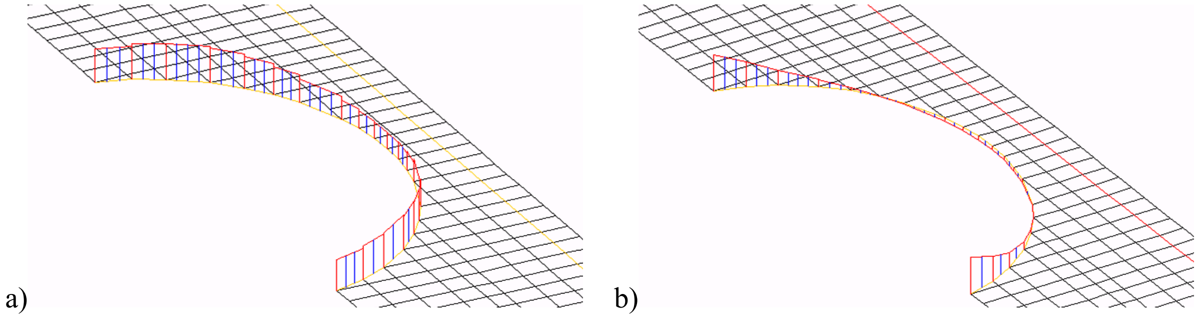

Fig. 35. Symmetrical load variant : a) normal force [kN]: N_{max}=252.49, N_{min}=114.92; b) bending moment [kNm]: M_{max}=-9.21, M_{min}=0.98

3.2. The proposal of traffic calming

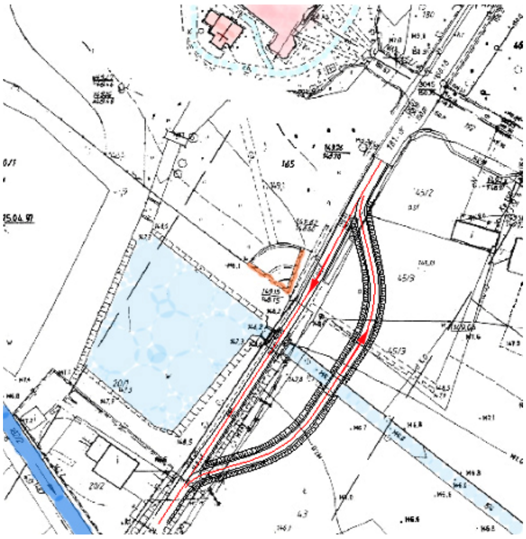

Fig. 36. Calming device proposal

'*The speed is a killer*' or '*50 km/h = be alive*' – these are the catchwords used in many assurance programs. This slogans touch upon the aspects road users' safety and this is parallel goal to the trial of current maintenance. Due to this the traffic engineering methods are taken into our consideration. Traffic calming refers to a variety of physical measures intended to reduce the effect of motorized vehicle traffic in urban and village areas. Poland has not a long history of traffic calming efforts, but this sort of thinking, step by step, comes privileging. In the analyzed problem the proposal is to divide the traffic into two one way roads with roadway breadths of 4 m and the velocity up to 50 km/h. To realize the concept the calming device showed in Fig. 36. should be used. Certainly, the speed bumpers at the beginning and in the end of the culming device should be assembled.

4. Conclusions

Applying the proposed solution we can achieve the effect of good exposition of the historical culvert and, which is the subject of these considerations, to maintain them for future. Additionally, we reach the traffic state safer than the existing one.

Fig. 37

Usually the corrugated culverts are used in rather different manner, see Fig. 37. The pipe or shell is slid into the existing bridge or culvert opening. Comparing this technology to herein discussed one, it is easier and cheaper, but in this case could not be effective.

The estimate cost price is about 140 thousands euros. The price is not low but on the other hand we can keep a piece of our past safe, which is indisputably priceless. The bridges showed in Fig. 1-4. are of greater importance for human heritage in general, but in this part of Poland the remained bridge structures have a certain worth as well. Nowadays it is difficult to estimate this worth, however, the loss these technical structures would be disgrace.

5. Bibliography

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