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PERIODIC MAINTENANCE OF ROAD BRIDGES TO ENSURE A SUSTAINABLE INFRASTRUCTURE – CASE STUDY

BY

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Abstract. Bridge maintenance work represents one of the main activities dedicated to the maintenance and repair of roads in operation. It plays a primary role within the activities undertaken by public administrators. Periodic maintenance work are large-scale works that are executed with a certain specific periodicity. They are planned in advance and aim to partially or fully compensate for the degradation and wear of the road infrastructure. This article aims to briefly present the periodic maintenance works designed to bring the bridge located on the Romanian national road DN 28 at km 6+957 to an optimal state of normal operation. The structure in question was built in 1963, with a total length of 236.90 meters. It consists of two metal I-type girders, continuous next to the piles, arranged at an interaxial distance of 7.10 meters. Before the execution of periodic maintenance works, the reinforced concrete decking, which supports the carriageway and sidewalks, rested directly on the upped soles of the stringers and main girders, without any intermediate element to ensure cooperation. The planned periodic maintenance works aim to bring the structure to normal parameters necessary for safe exploitation and also to increase the comfort of traffic by increasing the total width of the entire structure, including the pedestrian sidewalks. This modification of the constructive parameters is based on calculation of strength and stability, taking into account the new operating time provided to the structure by the execution of periodic maintenance works.

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1. Introduction

With the passage of time, constructions in operation suffer various degradations, mainly due to the physical wear and the phenomenon of aging of the materials from which they are executed. At the same time, their administrators are responsible for satisfying the requirements of the beneficiaries in terms of the buildings use, respectively the conduct of road traffic in safe and comfortable conditions, when we talk about the civil constructions dedicated to road transport (Scutaru et al., 2019).

In order to maintain the constructions, and specifically the bridges in the present case, at optimal parameters necessary for a good flow of traffic, the administrators carry out works of different scope, depending on the degradation degree of the construction in question.

The decision to implement different categories of works (current repairs, periodic maintenance, capital repairs or new bridge) is taken by a whole team of specialists. First of all, the technical expertise of the construction, respectively of the bridge concerned, takes place, after which the authorized technical expert propose at least 2 intervention solutions. Following the design stage of the Intervention Works Approval Documentation (DALI in Romanian) phase, together with the administrator's representatives, the optimal intervention solution is decided, which will satisfy the most requirements, while also fitting into its budget.

One of the categories of planned maintenance works currently applied to bridges in operation is represented by the design and execution of periodic maintenance works. According to the profile standard, namely AND 554 (2002), periodic maintenance works are defined as those works performed with the aim of partial or total compensation of the load-bearing capacity and the wear produced by the bridges, in order to restore them to normal operating and safety conditions of road traffic.

This article describes the main periodic maintenance works designed with the aim of bringing the Șcheia Bridge to optimal operating parameters, at the same time increasing the life of the structure. Thus, the second chapter provides a brief description of the bridge in question, its technical condition and the main degradations and defects identified, which are described in chapter 3. In the following three chapters, the authors focus their attention on the main planned periodic maintenance works, along with the stages of their realization.

2. Presentation of the Șcheia bridge structure

The case study focuses on the bridge that serves the Romanian national road DN 28 at kilometre 6+957, in Iasi country, near Șcheia, ensuring the continuity of the road when crossing the Siret River.

In the longitudinal section, the bridge has 4 spans of different lengths (50.35 m + 60.00 m + 60.00 m + 50.35 m), resulting in a superstructure length of 220.70 m and a total length of 236.90 m (figure 1). The static scheme of the structure is a continuous girder with 4 openings, a scheme that strongly influences its behavior in operation.



Fig. 1 – Longitudinal view of Șcheia Bridge

The superstructure consists of two continuous steel girders having a double T section (figure 2). The metal beam is made of laminated steel profiles, thick sheet metal and corner profiles, solidarized with rivets.



Fig. 2 – The metal bridge superstructure

The main girders have a constant height of 2.40 m, being arranged at an inter-axle distance of 7.10 m. They are solidarized in the transverse direction by means of short transvers beams resting at each end on metal reinforcements. The transverse beams are arranged at equal distances between the axes, having a constant height of 1.00 m. A riveted vertical bracing is arranged next to each support reinforcement, made of corner profiles with equal wings.

Between the main girders, in the longitudinal direction of the bridge, there are 4 metal struts with a double T section, located at a distance of 1.85 m center-to-center. The height of the stringers is lower than that of the transverse beams, having the upper soles mounted at the same level as the upper soled of the main beams (figure 3).



Fig. 3 – The “collaboration” between the metal structure and the reinforced concrete deck

The reinforced concrete pavement, having the role of supporting the carriageway and the sidewalks, rests directly on the upped soled of the main beams, the stringers and of the intermediate beams, this being the most important defect of the structure, with a repercussions on its behavior in operation (figure 3).

The foundations are direct, deep, made of caissons with compressed air. The support of the superstructure is done by means of mobile support devices on abutments and piers P1 and P3 and fixed on piers P2 (figure 4).



Fig. 4 – Transmission of loads from the superstructure to the infrastructures

3. The main degradation identified within the technical expertise

In 2018, the Technical Expertise of the bridge on DN 28 km 6+957 was carried out by an authorized Technical Expert at the request of the administrator of the structure, namely National Company for Road Infrastructure Administration, through DRDP Iasi. At that time, an IST technical condition index of 22 points was calculated, which leads to the classification of the structure in IV Technical Class, presenting an unsatisfactory technical condition.

Some of the most important identified degradations were:

- A. At the level of the main resistance elements of the superstructure, the identified degradations were:
 - The lack of elements necessary to ensure the cooperation between the metal superstructure and the reinforced concrete decking, the support and transmission of loads being done exclusively by gravity and by means of frictional forces
 - The absence of major maintenance, repair or rehabilitation works during the entire duration of the bridge operation
 - Advanced corrosion of the entire metal structure, i.e. main girders, transverse beams, struts and braces
- B. At the level of the structural members supporting the bridge path (reinforced concrete slab and pavement brackets), the degradations identified were:
 - Concrete degraded by carbonation, with a friable appearance
 - Exposed, heavily corroded fittings, rust spots and cracks
 - Surface defects of the visible face of the tiled superstructure: uneven colour, rust spots, black spots, impurities, geometric imperfections
 - Infiltrations, efflorescence
 - Cracks, fissures and exfoliation of concrete at the soffit of the superstructure and pavement brackets neat the joint covering devices
- C. At the infrastructure level:
 - Surface defects of the visible face of the infrastructure (uneven colour, black spots, impurities, rust spots, etc.)
 - Shrinkage cracks, concrete tiling at the elevation level and the support bench
 - Advanced rusting of the support devices and their fastening elements
 - Lack of anti-seismic protection devices
- D. At the level of the bridge path and related elements:
 - Degraded asphalt concrete, with cracks and unevenness, especially near the devices covering the joints and drain holes

- Advanced degradation of joint covering devices
- Strong infiltrations at the soffit of the superstructure, which indicated degradation on large areas of the waterproofing
- Excessive thickness of road layers, as a result of poor maintenance, buried drains, no extensions

Considering the degradation degree, the Technical Expert recommended the urgent traffic restrictions, namely the low speed (30 km/h) traffic of vehicles on the bridge and the reduction of the maximum weight allowed on the axle to 11.7 t.

With the aim of bringing the bridge to the appropriate constructive and functional parameters according to the norms, two intervention solutions were recommended, namely the execution of periodic maintenance works (code 112 according to the codification provided by the AND 554 standard) and the execution of current repair works (code 118 according to the AND 554 standard).

4. Periodic maintenance work designed at the superstructure and track level on the bridge

The approved Technical Project includes extensive periodic maintenance works to be performed on the structure covered by this case study. Thus, the designed works will ensure safe and comfortable traffic, at the same time maintaining the current technical characteristics, i.e. load class E for which the structure and development of road traffic was checked on 2 traffic lanes, one for each direction.

After the execution of periodic maintenance work, the following changes will occur on the bridge gauge:

- the total width of the structure will increase from 9.10 m to 11.00 m
- the carriageway width will increase from 7.50 m to 7.80 m
- the new sidewalks will have a width of 1.60 m each, being composed of 0.80 m pedestrian space, 0.55 m width of the safety parapet, H4b type, and 0.25 m width of the pedestrian parapet base, before the execution of the periodic maintenance works on the sidewalks measuring only 0.80 meters

Periodic maintenance work applied to the superstructure resistance structure will be carried out on half the width of the deck, alternatively, due to the high level of traffic in the area served by the bridge and the importance of the structure. A total closure of traffic during the works execution would have led to the creation of traffic jams on bypass routes, a significant increase in travel time and fuel consumption, and also, in air pollution.

The necessary works at the superstructure level to bring the structure to optimal parameters are:

- Diverting traffic onto one lane
- Demolition of roadway layers
- Demolition of the pedestrian parapet and the sidewalk console, together with the reinforced concrete decking, including the next one to the marginal metal struts (figure 5)



Fig. 5 – Demolition of reinforced concrete decking

- The most important stage is the metal connectors mounting on the upper sole of the main girders and the marginal metal struts (figure 6)

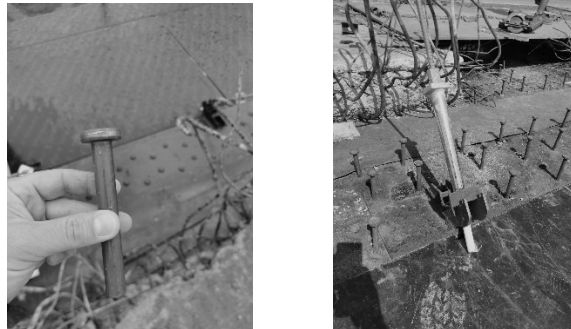


Fig. 6 – Metal connector

- The existing reinforcements, remaining after the demolition of the pavement console and the indicated part of the pavement, will be strengthened and completed, being used to work with the new ones that will be mounted next to the pavement and those in the new pavement console

- Execution of a slope concrete using a C35/45 class concrete, continuous next to the marginal metal struts
- The following works will be performed at the level of the deck made of reinforced concrete slab:
 - demolition of the reinforced concrete slab ends for 1.00 m, next to the joints
 - ensuring the continuation of the slab by introducing reinforcements that will be placed over the existing ones, the surface to be monolithic with a C35/45 class concrete
 - repairing the tiles after continuing with special fast-hardening mortars on degraded areas and treating them with special anti-corrosive paints
- At the level of the metal resistance structure, specific periodic maintenance works will be carried out, including a layer of anti-corrosive paint being applied

5. Designed periodic maintenance works at bridge deck level

The works designed to be carried out at the level of the deck on the bridge will also be carried out halfway through the deck, alternatively, in order to minimize the periodic of imposing traffic restrictions.

Considering the necessity of total decommissioning of the path on the bridge, the stages of its restoration are:

- Execution of slope concrete and high-performance waterproofing of polyurethane type, two-component, with an average thickness of 10 cm
- Replacing the drain holes and arranging some extensions in order to ensure the removal of water from precipitation below the metal superstructure level
- Replacement of expansion joint cover devices

The new path on the bridge will consist of 2 layers of asphalt mixture, respectively:

- MAS16 in thickness of 4 cm
- BA16 in thickness of 6 cm

For the proper execution of the asphalt mixture layers, the base layer will be primed (figure 7).



Fig. 7 – Priming the support layer

In the connection area between the deck and the sidewalk bracket, a continuous mastic cord with sealing properties will be placed, having the role of perfectly closing the contact area of two different construction materials (cement concrete and asphalt concrete).

Considering the beneficiary's requirement that the sidewalks be at the same level as the path on the bridge, the demarcation between the two component parts will be done by means of metal parapets with a high level of protection, type H4b, which will be mounted on isolated concrete plinth armed. The slope of the pavement will be 2%, being directed towards the drains located in the pavement bracket.

In order to provide increased protection for pedestrians, the sidewalks will be delimited on the outside of the console with a parapet made of open galvanized profile.

6. Periodic maintenance work designed at the infrastructure level

Due to the fact that there were no degradations identified at the infrastructures level that could affect the operating behavior of the structure, the decision was made that the works to be executed at this level should not be of grater scope. When making this decision, it was also noted that in 2001, repair and consolidation works were carried out as a consequence of the Siret river bed outcrops, with the aim of bringing the infrastructures to optimal operating conditions.

Thus, the infrastructures will be subjected, during the work execution, to a process of identifying degraded surfaces and intervention on them. In this case, the geometric shapes will be restored using special concretes, and in the case of cracks and segregations, quick hardening mortars will be used.

The elevations of the infrastructures will be treated with special anti-corrosion paints in order to close the pores and microcracks, to prevent the water penetration and the element degradation over time.

At the support benches level, minimal work will be applied, represented by their cleaning of dust and debris deposits. At the same time, the landing gear will be cleaned and refurbished.

The retaining wall will be raised to adapt to the road level on the bridge and to ensure the necessary conditions for the proper installation of the expansion joints.

7. Conclusions

This article presents the periodic maintenance works designed to bring the bridge on DN 28 km 6+957 to optimal parameters to ensure operation under normal conditions for as long as possible.

The periodic maintenance works designed at that moment represent the most important intervention on the bridge structure in question since it was put into operation in 1958. Within them, perhaps, the most important defect identified over time was fixed, namely the lack of working elements arranged at the upper sole level of the main girders and marginal metal struts. These elements play a very important role in transmitting the loads from the reinforced concrete deck to the metal superstructure and, from there, to the infrastructures.

In the absence of these intervention works, the Șcheia bridge superstructure would become a real danger for the safety of road traffic in the area by aggravating the strong degradations, as it has been emphasized countless times over the years in various specialized works in the field, through numerical modeling and analysis of the operating behavior of the structure based on the recording of specific dynamic parameters.

This work is part of a complex research program developed by the Faculty of Civil Engineering and Building Services within the “Gheorghe Asachi” Technical University in Iasi, in collaboration with the Regional Directorate of Road and Bridges Iasi. The present research is channelled on the study of the ways of bridges maintenance, on the development of modern systems for tracking the behavior of bridges in operation and on their adaptation and application in the bridges in our country.

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ÎNȚREȚINEREA PERIODICĂ A PODURILOR RUTIERE PENTRU ASIGURAREA UNEI INFRASTRUCTURI SUSTENABILE – STUDIU DE CAZ

Lucrările de întreținere a podurilor reprezintă una dintre principalele activități dedicate întreținerii și reparării drumurilor aflate în exploatare, ocupând un rol primordial în cadrul activităților întreprinse de către administratorii publici. Lucrările de întreținere periodică sunt acele lucrări de anvergură ridicată, executate cu o anumită periodicitate specifică, fiind planificate din timp și având ca scop compensarea parțială sau totală a degradărilor și a uzurii infrastructurii rutiere. Articolul de față își propune să prezinte succint lucrările de întreținere periodică proiectate cu scopul aducerii podului amplasat pe drumul național DN 28 la km 6+957 la o stare optimă de exploatare normală. Structura vizată a fost construită în anul 1963, având o lungime totală de 236,90 m. Aceasta este alcătuită din două grinzi metalice cu inimă plină, continue în dreptul pilelor, cu secțiune dublu T, dispuse la o distanță interax de 7,10 m. Înaintea execuției lucrărilor de întreținere periodică, platelajul din beton armat, având rol de susținere a părții carosabile și a trotuarelor, rezema direct pe tăpile superioare ale lonjeronilor și a grinzilor principale, fără a exista niciun element intermediar, cu rol de asigurare a conlucrării. Lucrările de întreținere periodică proiectate au ca scop aducerea structurii la parametri optimi necesari unei exploatare în siguranță, vizând totodată și creșterea confortului circulației prin sporirea lățimii totale a întregii structuri, inclusiv a trotuarelor pietonale. Această modificare a parametrilor constructivi se bazează pe un calcul riguros de rezistență și stabilitate, avându-se în vedere și noua durată de exploatare asigurată structurii de execuția lucrărilor de întreținere periodică.

