Assessment of a steel bridge corrosion degree

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Abstract. The subject of this analysis is connected with the verification of the load capacity of the span structure taking into account the degree of corrosion of the railway viaduct components located at 41.446 km, on the railway line no. 301 of "Kotlarnia" SA Sand Mine built over the national road DK88 and railway tracks PKP-PLK near T. Kościuszki street in Zabrze The general condition of the structure with regard to the corrosion assessment of structural steel is presented in the paper. Static and strength calculations were carried out to determine the load capacity class, and as a result of the analysis it was found that the technical condition of the facility steel girders is suitable for repair.

1 General description of the facility

The railway viaduct runs a single-track railway line over the national road No. 88 and railway tracks of PKP-PLK. The tracks on the object are placed in a horizontal curve. The building consists of two spans in a mixed-wall full-blown steel structure - riveted and welded with the bridge open on bridge sleepers. In the cross-section, two main girders with intermediate steel plates were used. The railway line crosses the road diagonally. Supports parallel to the obstacle were used - the object is diagonal. In order to complete the object and level the bevel, additional short spans were used perpendicularly to the axis of the abutment track. The girders were built in kinked curve shape adapt to the pillar track arc. The northern span of the riveted structure has a theoretical span of 28.40 m, plus a support with a projection of 3.90 m, on which the welded structure of the southern span is based. The theoretical span of the eastern span is 19.50 m, and the western span is 19.90 m. On the bridgehead, on the western beam, a short span is used to level the structure bevel. The bridge supports [13, 19] consist of two bridgeheads and a pillar with a circular, massive concrete structure. At the western girders, the sidewalk is made on the outside on brackets attached to the girder. Figures 1 ÷ 3 describe the analyzed object.

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Fig. 1. Railway viaduct view.

Fig. 2. Span no 1.

Fig. 3. Span no 2.

2 Evaluation of the structural steel corrosion degree

According to the source [23], we can point out six corrosiveness categories: very low (C1), low (C2), medium (C3), high (C4), very high (C5) and extreme (CX). On the basis of macroscopic evaluation [1, 4, 6, 11], general corrosion was found on the steel components of the load-bearing structure, according to the source [23] this is category C4. The largest corrosion points [17, 18, 21] occur mainly at the contact point between the web and the lower crossbars.

The current degree of corrosion [5, 7] lowered locally the bearing capacity of the viaduct, the loss of load capacity is estimated at 5%. For stringers, corrosion mainly appears in the sheets fixed to the stringers and nodes on the northern span. It was estimated that, taking into account the riveted metal sheet, the bearing capacity of HEB sections did not decrease in the middle part. At the nodes of the stringers sections, it was estimated that corrosion caused a 20% reduction in load capacity. In the crossbars of the northern span significant losses of web material and angles connecting the lower belt were found, in addition, the corrosion of the upper belt causes a reduction of the load capacity by approx. 20%. At the southern span, it was estimated that the steel cross-sections do not exceed 5%, with the exception of the end crossbars on the bridgehead, which's load loss is estimated at 20%

3 Static and strength calculations

Static-strength calculations were performed [2, 8–10] to determine the class of the object bearing capacity.

In the calculations carried out, the load capacity for bending and shearing of steel girders of the load-bearing structure, crossbars and stringers was checked by limit states. The facility uses standard bridge spacers with standard spacing.

For the longitudinal beams and transverse beams, the static scheme of the free-standing beam was adopted. For southern span girders, a static scheme of a free-standing beam was also used. On the other hand, for the northern span a static scheme of a free-standing beam with a bracket to with loads from the southern span transferred was assumed. The calculations were made assuming the construction steel grade [20, 22] as "historical", as a welded steel or early cast steel.

Material parameters adopted in the calculations it structural steel of the load-bearing structure:

- R=56.5 MPa,
- Rt=93.6 MPa.

Static and strength calculations have shown that the bearing capacity of the viaduct corresponds to the load classes in [8] without taking into account corrosion damage.

The bar system of the crossbars and stringers is shown in Fig. 4.

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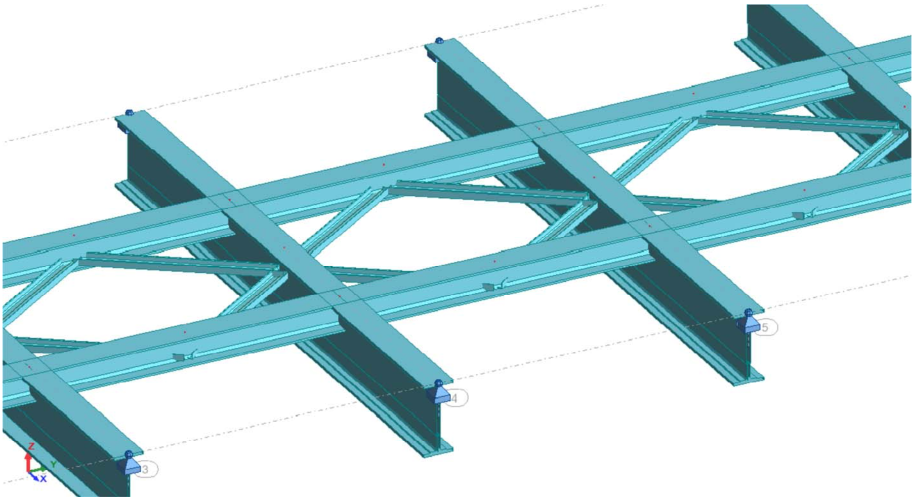

Fig. 4. Bar system of crossbars and stringers.

4 Conclusion

The static and strength calculations showed that the bridge bearing capacity does not correspond to the load classes in [8] due to the stringers and cross-members. The object is non-classified. After strengthening the cross members and stringers, the bearing capacity will correspond to the load class k-2 in [8].

It should be stated that the technical condition of individual parts of the facility is diverse and its overall assessment is influenced by the condition of the most damaged elements.

The scale of technical condition assessment was adopted on the basis of the respective Regulation [3, 12, 14–16].

Damage to the load carrying structure locally causes a reduction in the effective cross-section of the structural elements, which significantly reduces its load capacity.

Inspection of the bridge showed that the technical condition of the steel girders is acceptable and no damage was found that could indicate their overload. The corrosion of general steel beams has been found. Stronger corrosion occurs mainly near the crossbars. The current degree of corrosion does not significantly affect the load carrying capacity of the load-bearing structure girder structures, except for local places at some of the nodes, where material loss has occurred, which reduces the strength of the girder by 5%. The condition of the steel beams of the supporting structure is to a large extent a consequence of the age of the structure, the lack of adequate protection, and the contamination of the nodes. On the entire surface of the load-bearing structure, the paint coating is destroyed which leaves no proper protection of the steel structure.

The technical condition of the stringers is assessed as insufficient due to corrosion damage and the related low carrying capacity. As in the case of stringers, the technical condition of crossbars is assessed as a pre-emergency state.

Visual inspection of the object supports showed on the surfaces small moisture, efflorescence, biological corrosion, local scratches not affecting the work of the structure. Therefore, summarizing as a result of the analysis carried out, the general technical condition of the load-bearing structure as a whole is assessed as insufficient. In connection with this, it is necessary to take actions related to carrying out renovation work as soon as possible.

References

1. A. Madaj, W. Wołowicki, (*Budowa i utrzymanie mostów*, WKŁ, Warszawa, 2013)
2. PN-85/S-10030. *Obiekty mostowe. Obciążenia*
3. J. Cholewo, M. Sznurowski, (*Mosty kolejowe*, WK, Warszawa, 1966)
4. F. Szelągowski, (*Mosty metalowe*, WKŁ, Warszawa, 1966)
5. PN-88/B-01808. *Antykorozyjne zabezpieczenia w budownictwie. Zasady określania uszkodzeń powłok zabezpieczających konstrukcje stalowe i żelbetowe*
6. D. Strożecki, (*Mosty drewniane*, WK, Warszawa, 1959)
7. A. Pszenicki, (*Mosty stalowe,* WK, Warszawa, 1954)
8. PN-82/S-10052. *Obiekty mostowe. Konstrukcje stalowe. Projektowanie*
9. PN-89/S-10050. *Obiekty mostowe. Konstrukcje stalowe. Wymagania i badania*
10. PN-92/S-l 0082. *Obiekty mostowe. Konstrukcje drewniane. Projektowanie*
11. A. Ryżyński, (*Mosty stalowe*, PWN, Warszawa, 1984)
12. *Rozporządzenie Ministra Transportu i Gospodarki Morskiej z dnia 30 maja 2000 r. w sprawie warunków technicznych, jakim powinny odpowiadać drogowe obiekty inżynierskie i ich usytuowanie* (2000)
13. J. Biliszczuk, J. Bień, P. Maliszkiewicz, Cz. Machelski, M. Mistewicz, J. Onysyk, J. Rabiega, (*Podręcznik inspektora mostowego. Politechnika Wrocławska, Instytut Inżynierii Lądowej*, Zakład Mostów, Wrocław, 1995)
14. *Rozporządzenie Ministra Transportu i Gospodarki Morskiej z dnia 28 lutego 2000 r. w sprawie numeracji i ewidencji dróg oraz obiektów mostowych* (2000)
15. *Rozporządzenie Ministra Transportu i Gospodarki Morskiej z dnia 10.09.1998 r. w sprawie warunków technicznych jakim powinny odpowiadać budowle kolejowe i ich usytuowanie* (1998)
16. M.S. Nelson, A.Z. Fam, J.P. Busel, C.E. Bakis, A. Nanni, L.C. Bank, M. Henderson, J. Hanus, Structural Journal **111,** 1069 (2014)
17. T. Lipinski, (*Corrosion effect of 20% NaCl solution on basic carbon structural S235JR steel*, in *16th International Scientific Conference Engineering for Rural Development*, 1069, 2017)
18. I. Pliszka, N. Radek, Procedia Engineering **192,** 707 (2017)
19. D.W. Johnston, (*Design and Construction of Concrete Formwork*, in: E.G. Nawy (Ed.) *Concrete Construction Engineering Handbook*, CRC Press, Boca Raton, 2008).
20. R. Ulewicz, (*Quality management system operation in the woodworking industry*, in *Path Forward For Wood Products: A Global perspective, proceedings of scientific papers*, **51**, 2016)
21. J. Selejdak, R. Ulewicz, M. Ingaldi, (*The evaluation of the use of a device for producing metal elements applied in civil engineering*, in 23rd International Conference on Metallurgy and Materials 1882–1888, 2014)
22. P. Szataniak, R. Ulewicz, F. Novy, HSLA steels – *comparison of cutting techniques, in Metal* 2014. 23rd International Conference on Metallurgy and Materials, 778, 2014)