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DETECTION OF CORROSION IN RAILWAY BRIDGES AND ITS IMPACT ON THEIR TECHNICAL CONDITION

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Abstract. This article examines corrosion in railway bridges and its impact on strength and service life. Corrosion reduces structural cross-section, lowers load capacity, and increases failure risk. Types, causes, and assessment methods are discussed. Protection measures, such as coatings, improved concrete, cathodic protection, and drainage, help extend service life and ensure safety.

Key words: railway bridges, corrosion, metal structures, reinforced concrete, load-bearing capacity, structural strength, environmental factors, protective measures, cathodic protection, coatings.

Introduction. Railway bridges are among the most important engineering structures in transport infrastructure. Trains run across them, and their technical condition directly affects the safety of train operations. Railway bridges are constructed from metal, reinforced concrete and composite materials. These structures undergo various degradation processes under the influence of the external environment. Of these, corrosion is the most dangerous. Corrosion is the deterioration of metal and reinforced concrete structures under the influence of the environment (moisture, salts, CO_2, aggressive gases), which reduces the structure's strength and load-bearing capacity and increases the risk of an accident. Therefore, it is crucial to detect corrosion in railway bridges in a timely manner, assess its impact on the structural integrity, and implement protective measures.

Corrosion is the process of deterioration of a metal as a result of its chemical or electrochemical reaction with the external environment. In railway bridges, corrosion manifests itself as rusting of metal structures and, in reinforced concrete structures, as corrosion of the reinforcement and cracking of the concrete.

Corrosion damage to metal bridges. The most common principal types of damage to metal intermediate structures are corrosion, failure of riveted and bolted joints, fatigue and mechanical damage.

Fig. 1. Corrosion of metal structures

The extent of corrosion damage depends on the quality of the metal, the anti-corrosion coating of the bridge's intermediate structures and the current maintenance. Metal corrosion occurs as a result of the metal's chemical interaction with its environment and is the product of galvanic cell interactions on its surface. Electrochemical corrosion is more characteristic of steel bridges. In the process of diagnosing the technical condition of corroded metal bridge elements, the type of corrosion is usually determined first. This makes it possible to more accurately determine the effect of corrosion damage on the load-bearing properties and load-bearing capacity of these elements, and to develop more well-founded repair and restoration measures. Corrosive damage to metal bridges is classified into various types of corrosion. (Table 1)

Metal corrosion	Total (per unit)	Corrosion resistance is characteristic of metals or protective coatings that are not particularly durable – they are sealed by a visible layer of corrosion products	
	Local	Pitted	It appears as some small, deep ulcers
		Among the crystals	Characterised by the uniform distribution of numerous cracks
	Wounded	It is associated with the metal's unfavourable (negative) structure (high sulphide content). Over time, the formation of a thick layer of corrosion products that develop into whitish cracks is observed	
	Coating with corrosion cracks	A type of quasi-brittle fracture in steel characterised by the simultaneous action of tensile stress and an aggressive environment, resulting in the formation of single and multiple cracks	
	Corrosion fatigue	A quasi-brittle fracture mode in steel, characterised by the appearance of fine cracks under the simultaneous action of cyclic loading and an aggressive environment	
	Connectivity	Overall corrosion is characterised by a localised increase in the depth of penetration to the interface between dissimilar metals	

During operation, the full range of corrosion observed in metal interconnect devices occurs (Figure 2). Corrosive damage reduces the cross-sectional area of the elements, lowering their load-bearing capacity and fatigue resistance. The rate of corrosion development depends on the chemical composition of the metal, the type of aggressiveness of the environment, its moisture content, temperature, anti-corrosion protection and stress conditions. The corrosion rate by mass loss is determined as follows:

$$V_k = \frac{m_1 - m_2}{S \cdot t};$$

this determines how much mass a metal surface has lost to corrosion.

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Corrosion is most prevalent in full-wall spacer devices, the upper chords of the main beam and the wing-type main-truss section—particularly at the bearing points of the bridge girder—as well as in elements and nodes that have become heavily soiled (Figure 2).

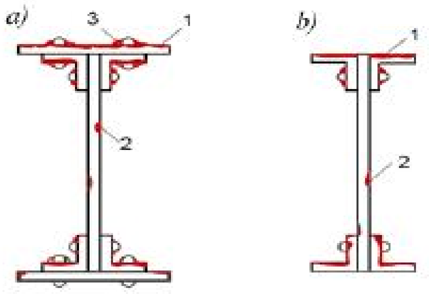

Fig. 2. Corrosion damage of full-wall spacer devices and main beam bearings: a - with horizontal chords; b - without horizontal chords; 1 – surface corrosion; 2 - local corrosion; 3-rivet in the rivet zone

Corrosion damage to reinforced concrete bridges. The strength of reinforced concrete bridge structures is based on the combined action of the concrete and the reinforcement. However, over time, processes of rusting and corrosion develop in these structures, which can significantly shorten their service life. In reinforced concrete structures, it is primarily the reinforcement (steel) that rusts. The factors that cause reinforcement corrosion are as follows:

• Insufficient concrete cover. If the concrete cover over the reinforcement is too thin, moisture and aggressive substances will quickly reach the reinforcement.

• Low concrete density. Poorly compacted concrete contains many voids. Water and air can penetrate through these voids, accelerating the corrosion process.

• The process of carbonation. The alkalinity of the concrete decreases over time. As a result, the passive layer protecting the reinforcement is broken down, and corrosion begins.

• The effect of chloride salts. Road salts or salts in a marine environment can penetrate the concrete, causing the reinforcement to corrode rapidly.

• Water permeability and waterproofing defects. Water ingress creates a moist environment within the concrete, which accelerates corrosion.

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In reinforced concrete structures, when the reinforcement corrodes, longitudinal cracks appear (the concrete cracks along the reinforcement), concrete spalling (otval – the volume of corroded structures increases, pushing the concrete from within), a reduction in strength (the cross-section of the reinforcement is diminished) and a decrease in load-bearing capacity are observed:

$R = \sigma \cdot A$;

- σ – permitted stress (MPa);
- A – cross-sectional area (mm^2);
- R – lifting capacity.

Because the cross-sectional area of the reinforcement has been reduced, its stress resistance decreases, which undermines the safety of the bridge. Therefore, corrosion inspections must be carried out regularly.

The effect of the environment on the corrosion process. Air humidity, precipitation, temperature fluctuations, wind, atmospheric oxygen, carbon dioxide ($CO2$), sulphur compounds in industrial areas, salts and chlorides, river and canal waters, ice and snow have a significant impact on the corrosion process of structures. The more aggressive the external environment, the faster corrosion develops. In high-humidity areas, industrial zones and on bridges over water, corrosion develops particularly rapidly. Salts break down the protective layer on reinforcement and metal structures, accelerating the corrosion process.

Methods of corrosion protection. Protecting bridges from corrosion increases their service life several times over. There are several types of corrosion protection for bridge structures:

Paints and coatings. Metal surfaces are coated with special anti-corrosion paints, lacquers and zinc coatings. This protects the metal from air and moisture. In this case, the effectiveness of the protective coating:

$$\eta = \frac{V_0 - V}{V_0} \cdot 100\%$$

- V_0 – unprotected corrosion rate;
- V_1 – corrosion rate with coating;
- η – coating efficiency (%).

Metal coatings. The surface of a metal can be protected by coating it with zinc, aluminium or chromium.

Improving the quality of concrete. In reinforced concrete structures, adding waterproofing admixtures, thickening the protective layer and using dense concrete reduces corrosion.

Electrochemical protection. Using cathodic protection systems, the reinforcement is protected from corrosion. This method is particularly used in underwater structures.

Moisture barriers and drainage. To reduce the structure's direct contact with water, drainage systems, waterproofing and moisture barrier layers are used.

Regular maintenance. Removing rust, repainting, replacing damaged elements and sealing cracks ensures the bridge's long-term service life.

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Conclusion. Corrosion is one of the main causes of deterioration of metal and reinforced concrete structures in railway bridges. As a result of corrosion, the cross-section of the structure is reduced, its strength decreases and its load-bearing capacity is reduced. This worsens the bridge's technical condition and increases the risk of an accident. Visual inspections, ultrasonic, electrochemical, and other non-destructive testing methods are used for the timely detection of corrosion. Environmental factors, particularly moisture, salts, and aggressive gases, accelerate the corrosion process. To protect bridges from corrosion, paint coatings, metal coatings, concrete quality improvement, cathodic protection, and waterproofing methods are used. These measures extend the service life of the bridges and ensure traffic safety.

References

1. Transport inshootlarining ekspluatatsiyasi: darslik / Ch.S. Raupov, U.Z. Shermuxamedov, X.Q. Umarov. – Tashkent: OOO “Complex Print”, 2020 y. – 488 b.
2. QMQ 2.03.11-96. Qurilish konstruksiyalarini korroziyadan himoya qilish. O‘zbekiston Respublikasi Davlat arxitektura va qurilish qo‘mitasi. Toshkent, 1996.
3. Transport inshootlarining ekspluatatsiyasi, sinovi va reabilitatsiyasi. Darslik. O’RO va O’MTV, 2017. I va II tomlar.
4. Normurodov Sh.U. – “Temir yo’llar ko’priklari va tonellari ekspluatatsiyasi” nomli 60730800 – “Yo’l muhandisligi” (temir yo’llar ekspluatatsiyasi) bakalavr ta’lim yo’nalishi 4-kurs talabalari va professor-o’qituvchilar uchun o’quv qo’llanma. – Jizzax: “Ilm nuri print” MCHJ nashriyoti, 2025-287 b.
5. ShNQ 2.05.03-12 “Ko’priklar va quvurlar”.
6. ShNQ 3.06.07-23 “Ko’priklar va quvurlar. Tekshirish, sinash va diagnostika qoidalar”.
7. GOST 33161-2014 “Avtomobil yo’llaridagi sun’iy inshootlarda diagnostika va pasportlashtirishdan o’tkazishga qo’yiladigan talablar’’.