Lomost: engineering heritage in the heart of Croatia

The oldest reinforced concrete bridge in Croatia showed serious signs of deterioration and needed extensive repairs. Among the solutions was a corrosion-inhibiting admixture to protect the steel reinforcement in the concrete.

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Lomost Bridge in the Ogulin City is the oldest reinforced concrete bridge in Croatia. It was constructed by the Austrian Company Eduard Ast & Co from Vienna. The bridge structure is the patented single-span Hennebique system. In the ribbed span assembly with 10m free span, smooth reinforcement with 25 and 27mm diameters was built-in. The longitudinal reinforcement was built-in following the rules of covering the moment diagram with cross reinforcement made from narrow steel sheets. Lower body elements of abutments were constructed as gravity concrete elements with no reinforcement.

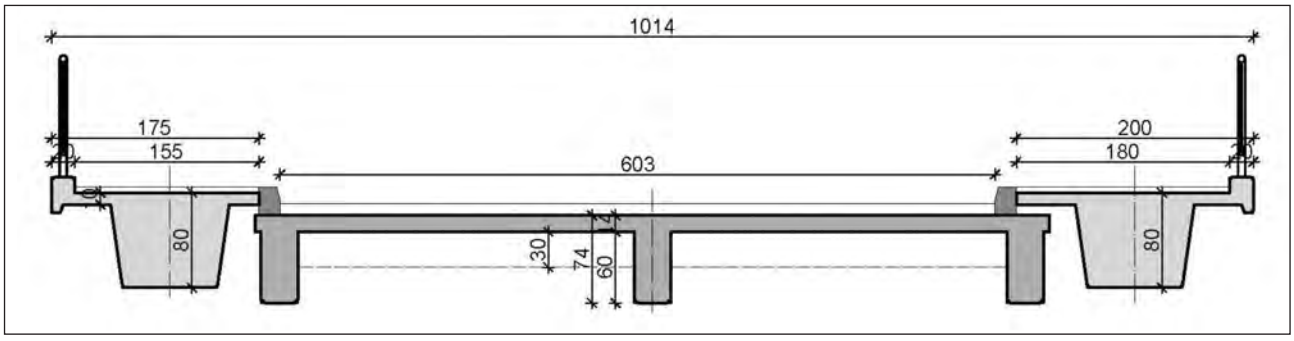
The ribbed span comprises three main longitudinal girders (600/310mm) spaced at 3150mm with two cross girders (300/210mm) in thirds of the span. The superstructure is firmly fixed to the abutments. Upper flanges of the side longitudinal girders were built with decorative elements typical for the time. The 140mm slab is fixed with main longitudinal and cross girders, and together they comprise a monolithic ribbed span.

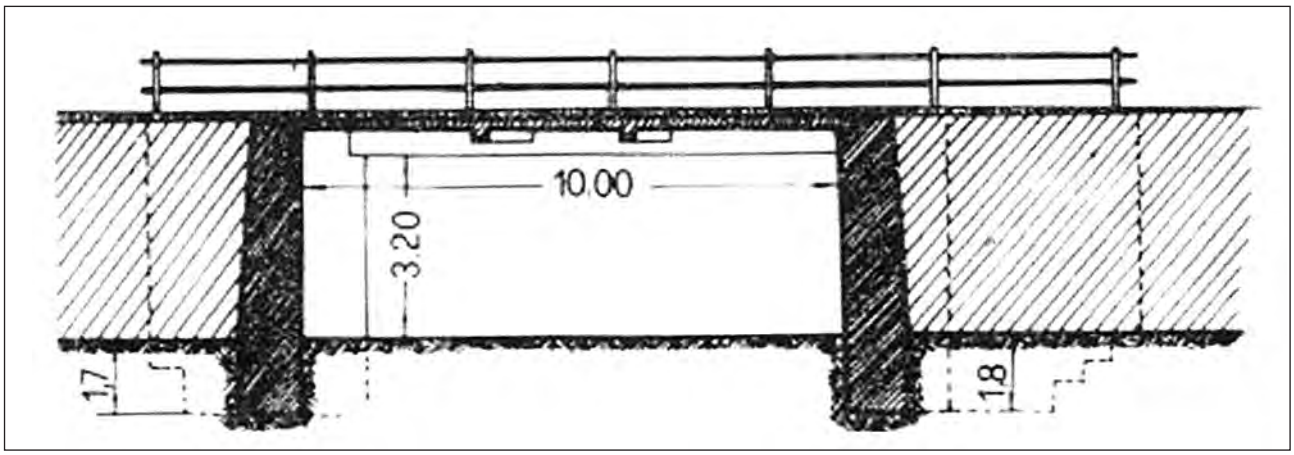
Over the historic bridge, a 6030mm pavement was conducted (two traffic lanes). Over time, the main cross-section was rarely repaired and during the late 1980s or early 1990s, two separate and independent pedestrian bridges were constructed on each side of the main historic bridge.

Bridge elements damage

Following a detail bridge inspection by Alex Kindij, senior designer at Kindijing, Croatia in October 2021 damage and deterioration of materials were found on

Below: Lomost bridge cross-section – main bridge and separate and independent pedestrian bridges on each side.
Bottom: Lomost Bridge historic drawing – longitudinal section.





Above: Temporary support of the Lomost Bridge edge girders from October 2021 until full bridge repair works started.

Above: Repair work was carried out for the City of Ogulin. The designer was Alex Kindij from Kindijing and the contractor MAR, Croatia.

all structural elements of the main historic bridge. The structure was riddled with cracks, visible traces of seepage and, in winter, freezing of chloride-contaminated water from the pavement level. Also, large areas showed signs of deteriorating and spalling from the basic concrete material. Due to seepage at the junction of the main bridge and the edges to the pedestrian bridges, the exposed surfaces of the reinforced concrete superstructure have been significantly damaged with visible and wide-band corroded longitudinal reinforcement, which was on large sections completely outside the concrete cross-section (no function), while simultaneously the transverse reinforcement on exposed parts has been completely severed.

Due to significant damage to the longitudinal rib's edges, the deformations of the superstructure increased under heavy vehicles traffic. Due to separate deformations of the different systems of the main bridge and the side pedestrian paths, the contact joint additionally opened, which increased the penetration of water from the roadway level towards the edge structural elements of the main bridge.

Bridge repair

The client, the City of Ogulin, Croatia, was looking for a design solution that would preserve this valuable architectural heritage, even though it was not under special conservation protection. In order to ensure its use during the design process and during the time until the financing was secured for the execution of the works, a limit of

Below: (left and right): Lomost Bridge – pavement level old (left) and after reconstruction (right).
Bottom: (left and right): Abutment A1, before reconstruction (left) and after (right).

Above: Abutment A2, before reconstruction (left) and after (right).

20 tons per vehicle was allowed to travel on the bridge, which, after inspection and assessment of the condition, was further limited to 3.5 tons per vehicle and a maximum vehicle speed of 10km/h with the obligation to support the edge girders.

The restoration of the bridge included hydro-demolition works of concrete and reinforced concrete surfaces of the structural elements of the bridge with the application of a liquid migrating inhibitor directly to the prepared structural elements surfaces and mixing it into repair mortar R4 (BS EN 1504-3[1]), and the reconstruction of the bridge included the construction of a concrete relief plate with mixed-in liquid migrating corrosion inhibitors (MCI); the construction of supporting cantilever protrusions for longitudinal supports and reinforcement of ribs with carbon-fibre-reinforced polymer (CFRP) lamellas and carbon sheets.

The use of MCI, a chemical substance based on the technology of organic amine alcohols and amine carbosilicates, ensured reduced metal corrosion without reducing the concentration of the corrosive substance that caused corrosion. After the analyses were carried out, the project defined the direct application of the inhibitor on vertical surfaces and undersurfaces of the slab and girders in a higher concentration and density (3.68l/m^2) to ensure the achievement of the goals.

MCI-2005 is a water-based, organic, corrosion-inhibiting admixture developed by Cortec for the long-term protection of metallic reinforcement in concrete structures. When integrated directly into the concrete during new construction, it forms a protective, monomolecular layer on the embedded reinforcement bar, significantly delaying the onset of corrosion caused by chlorides and carbonation. In addition – and unlike MCI-2005, which is an admixture for new concrete – MCI-2020 is a surface-applied product designed for existing concrete structures. It penetrates hardened concrete, mortar and limestone to protect embedded reinforcing steel from corrosion. Applied by spray, brush, or roller, it effectively migrates through the concrete's pore structure and significantly reduces the rate of existing corrosion caused by chlorides and carbonation.

By applying the above-described technological and structural solutions, the rehabilitation of the Lomost Bridge was carried out and its usability in the future was ensured while keeping the total costs at a minimum. Works were completed in December 2024. ■

Reference:

1. BRITISH STANDARDS INSTITUTION, BS EN 1504-3. *Products and systems for the protection and repair of concrete structures. Definitions, requirements, quality control and evaluation of conformity - Structural and non-structural repair.* BSI, London, 2005.

Below: Edge longitudinal girder – level of damage (left) and after (right).