The New Gänstor Bridge

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DOI: https://doi.org/10.14459/icbdb24.33

Abstract The new Gänstor Bridge is a single-span integral composite rigid frame structure over the Danube that will replace the old bridge designed by Ulrich Finsterwalder. With a span of 86.50 m, it is one of the longest rigid frame structures in Germany. It connects the cities of Ulm and Neu-Ulm and will be able to accommodate not only car, bicycle and pedestrian traffic, but also a tram.

The design is the result of a design competition announced in 2019/2020. Based on the old prestressed concrete bridge, which is an outstanding example of engineering from the early 1950s, the design impresses with its slim appearance. This slenderness is achieved, among other things, by the tapering of the superstructure from the frame corner to the middle of the bridge and by the cross-sectional height decreasing from the middle of the roadway to the outer edge. The bridge consists of two substructures. The superstructure of each substructure consists of a 5-cell hollow box made of steel and a 25 cm thick reinforced concrete slab. The superstructure is fixed into the deep-founded abutments. Both the dismantling of the existing structure and the construction of the new structure are very demanding due to the inner-city and environmental constraints. In the spirit of sustainability, the existing pillar foundations of a previous structure from 1912 will be used to demolish the existing structure and assemble the new superstructure.

1 Introduction

The Gänstor Bridge spans the Danube, connecting not only the cities of Ulm and Neu-Ulm, but also the states of Baden-Württemberg and Bavaria (Figure 1). It was built in 1950 as one of the first prestressed concrete bridges in Germany based on a design by Ulrich Finsterwalder [1].

With a span of 82.40 m and a height of 1.20 m at the mid-span and 4.28 m at the abutment, the structure was the slimmest of its kind at this time, see Figure 2. This was achieved by designing a hingeless frame for the first time and dissolving the abutments as slender bar systems. Overall, the structure consists of two substructures. The cross-section of each substructure is a double – webbed T-beam with a deck slab on top. The prestressing and the normative increase in the permissible

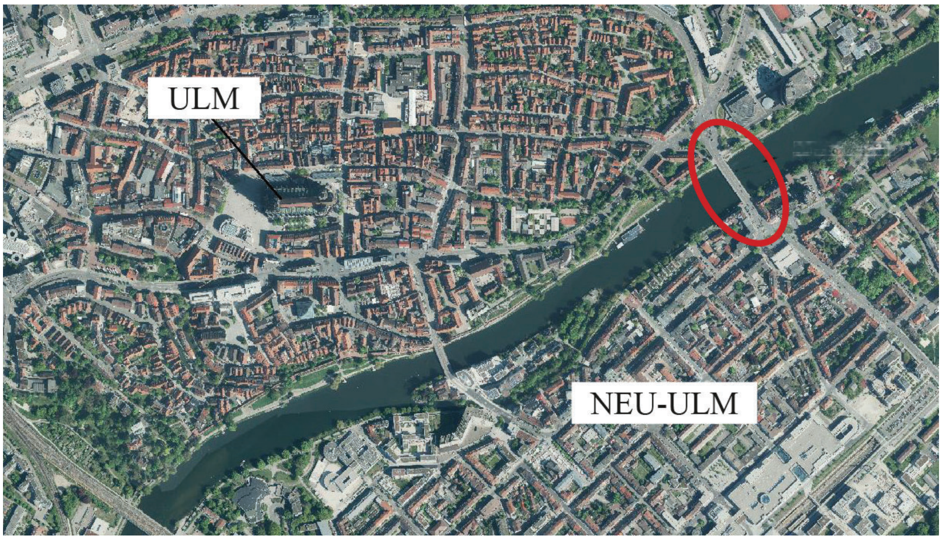

Figure 1: Location of the Gänstorbrücke, source: google maps

compressive stresses were essential for the possible slenderness in the middle of the bridge. The two plate girders were prestressed in the longitudinal direction and the deck slab in the transverse direction with tendons made of prestressing reinforcement St 60/90 d = 26 mm (ultimate strength 90 kg/mm2; yield strength 60 kg/mm2). The tendons were distributed relatively evenly across the width. A characteristic of this prestressing is that tensile stresses in the concrete are permitted up to the crack limit stress. Slack reinforcement was used hardly in either the longitudinal or transverse direction - only to ensure the load-bearing capacity in the still unstressed state and to ensure the geometry for the cladding tubes.
At the beginning of the 1980s, cracks were detected for the first time and renovation was required. Despite extensive renovation measures, the condition of the structure deteriorated noticeably in the following years. In 2018 additional damages were discovered in the course of in-depth investigations [2]. These are essentially grouting faults in the longitudinal and transverse prestressing and the tension members of the bar systems within the abutments and corrosion damage to the tension rod couplers and tensioning heads. As the damage could no longer be repaired and permanent reinforcement was not possible, the decision was made to build a new replacement.

2 The competition design

In 2019, the cities of Ulm and Neu-Ulm launched a design competition for the renovation of the Gänstor Bridge, which was followed by a planner selection procedure in 2020. The awarding authority expected a design that - based on the history and location in the urban area - would meet the "special requirements for design and integration into the surroundings" [3], fulfill the usage requirements and be economical and sustainable. All traffic relationships (road, tramway, pedestrian and bicycle traffic on and under the bridge, shipping traffic) were to be optimally taken into account.
Of the ten engineering firms and bidding consortia invited to tender, a design for a fixed frame

Figure 2: Bridge by Finsterwalder, source: author

structure, which is very reminiscent of the "Finsterwalder Bridge" [4], prevailed.

Figure 3: Winning design for the Gänstor Bridge, source: KRP

The guiding principle of the winning design was the continuation of history, i.e. the incorporation of Finsterwalder's ideas with regard to the construction principle, the adoption of the silhouette and also the reuse of structural relics. In contrast to the "Finsterwalder Bridge", modern construction and manufacturing principles were pursued, high-performance materials were used and modern planning methods were taken into account in the calculation and construction (Figure 3).
The planning of the replacement construction and the dismantling of the existing bridge was then carried out in the years 2020 - 2023 until it was ready for tendering. No design changes were necessary during the detail planning process compared to the competition design. Only design details and construction sequences were changed in the further planning.

3 Implementation planning of the new replacement structure

3.1 Planning boundary conditions

The main technical boundary conditions for the planning are listed below:

Urban planning and alignment
As one of three Danube crossings, the Gänstor Bridge connects the cities of Ulm and Neu-Ulm and is therefore of paramount importance for regional traffic. The Neu-Ulm side is characterized by a development structure very close to the banks, which has an influence on the geometry, design and construction of the new replacement structure. On both sides of the Danube, cycle paths pass under the bridge, which should be upgraded in the bridge area. The alignment and gradient of the existing structure can therefore only be changed insignificantly for the new replacement structure.

Construction ground
Both towns are located on the edge of the Swabian Alb, a low mountain range. On both sides of the Danube, rocky strata are found under artificial fillings and gravel layers. These are marls, which are still clayey and silty in the upper area and are referred to as "yellow Letten", but then change into limestone marlstone and red marl (bolustine). In addition, karst zones on the Ulm side were identified in a later construction-related subsoil survey.

Existing conduits
There are a number of conduits behind both abutments that need to be relocated for construction purposes. For the new construction, empty conduits for electricity, gas pipes as well as drinking water and district heating pipes must be taken into account.

Waters
The Gänstor Bridge is located in the flood zone of the Danube and is subject to regular flooding. Therefore, no permanent installations in the Danube are permitted - only temporary ones for construction aids, which must be flood-proof and secured against being washed away. This means that a single-span structure is required for the replacement construction.
Only small excursion boats and rowing boats sail on the Danube in Ulm. There is no industrial commercial shipping due to the upstream and downstream weirs. The clearance profile under the bridge is determined by the discharge profile of the HQ100 with corresponding freeboard.

Condition of the existing structure
The deficits of the prestressed concrete structure in terms of grouting condition and susceptibility to corrosion have led to necessary partial closures in the past and the load-bearing capacity has been reduced. The upstream partial superstructure is estimated to be less load-bearing.

Traffic and impacts
In addition to car traffic with more than 26,000 vehicles per 24 hours [3], cyclist and pedestrian traffic will become increasingly important in the future. In addition, the possibility of running the tramway over the bridge in the future is to be created. The requirement for a total of 4 lanes and separate cycle paths and footpaths results in a minimum width of 23.50 m, which is to be spread

over two structurally separate superstructures. For the construction stage, it must be ensured that two lanes remain and that bicycle and pedestrian traffic is possible. In addition to the usual traffic impacts for road bridges in accordance with DIN EN 1991-2, the load pattern for the tramway ("Combino" load pattern) is therefore also a significant impact. In addition, the usual effects of dead loads, wind and temperature must be taken into account. In addition, earthquake loads in accordance with the new DIN EN 1998 were taken into account in consultation with the client.

3.2 General construction sequence

The main construction phases had already been worked out in the competition design and were not changed in the subsequent planning process. The fact that the foundations of the previous bridge from 1912 (three-span stone arch bridge) were still present The main construction phases had already been worked out in the competition design and were not changed in the subsequent planning process. The fact that the foundations of the previous bridge from 1912 (three-span stone arch bridge) were still present in the Danube was a major help in planning the construction sequence for dismantling the existing bridge and installing the new superstructure. These foundations could be used as foundations for auxiliary piers. In order to verify the stability of these foundations, static investigations were carried out with the help of existing documents. Extensive investigations by divers were necessary with regard to the material properties and the existing geometry. The auxiliary piers were then planned and have since been constructed, see Figure 4.

Figure 4: Auxiliary support, source: author

The overall construction process consisted of first erecting the auxiliary piers on the existing arched foundations of the 1912 bridge - this has already been carried out as an early measure (Figure 4). From 2024, the western bridge structure will then be dismantled and the western replacement structure built, followed by dismantling and new construction on the eastern side. Traffic will be routed on the existing superstructure, i.e. not interrupted, see Figure 5.

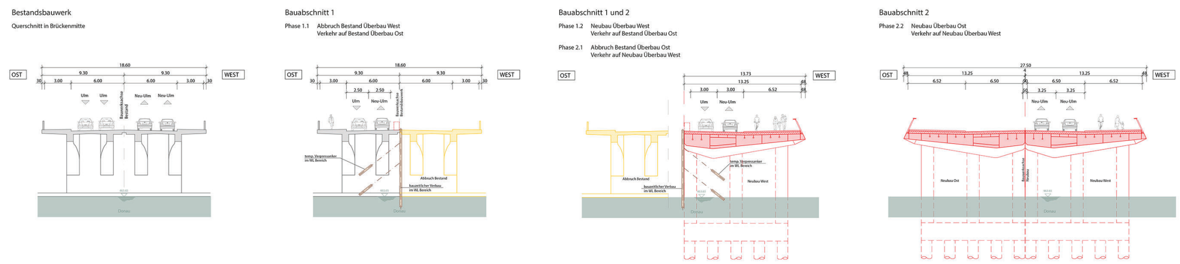

Figure 5: Main phases

3.3 Dismantling the existing structure

The decisive boundary conditions for the dismantling were the prohibition of blasting demolition, the impossibility of navigating the Danube with large pontoons and finally the basic static concept of the structure itself. This led to the development of a very complex and also relatively expensive dismantling concept. The concept for the dismantling of one superstructure is shown in Figure 6. Both superstructures are dismantled in the same way.

The dismantling itself is carried out using a movable scaffolding system for the central area between the auxiliary supports and the Ulm side; on the New Ulm side, a banking is backfilled on which conventional demolition can then take place. This backfill will be completely covered and - to prevent soil from being washed out from under possible supports for the conventional demolition - provided with a concrete slab.

It is planned that the scaffolding will be erected on the Ulm side and then pushed in lengthwise, resting on the auxiliary supports. The push-in scaffolding essentially consists of the two skidding girders and an internal transport unit. The superstructure is secured to the scaffolding and then sawn into segments. These segments are then transported to the Ulm side via trolley girders and crushed there. As can be seen from the construction sequence, the middle section is dismantled first, followed by the remaining edge section.

3.4 New replacement Structure

The main intention of the design - based on the urban significance and the design considerations - was to take up the form of the previous Finsterwalder construction and to achieve the greatest possible slenderness of the superstructure. This was achieved through the following design measures:

- Selection of the supporting structure as a rigid frame, which allows for greater slenderness compared to a single-span structure
- Selection of steel grade S 460 where required

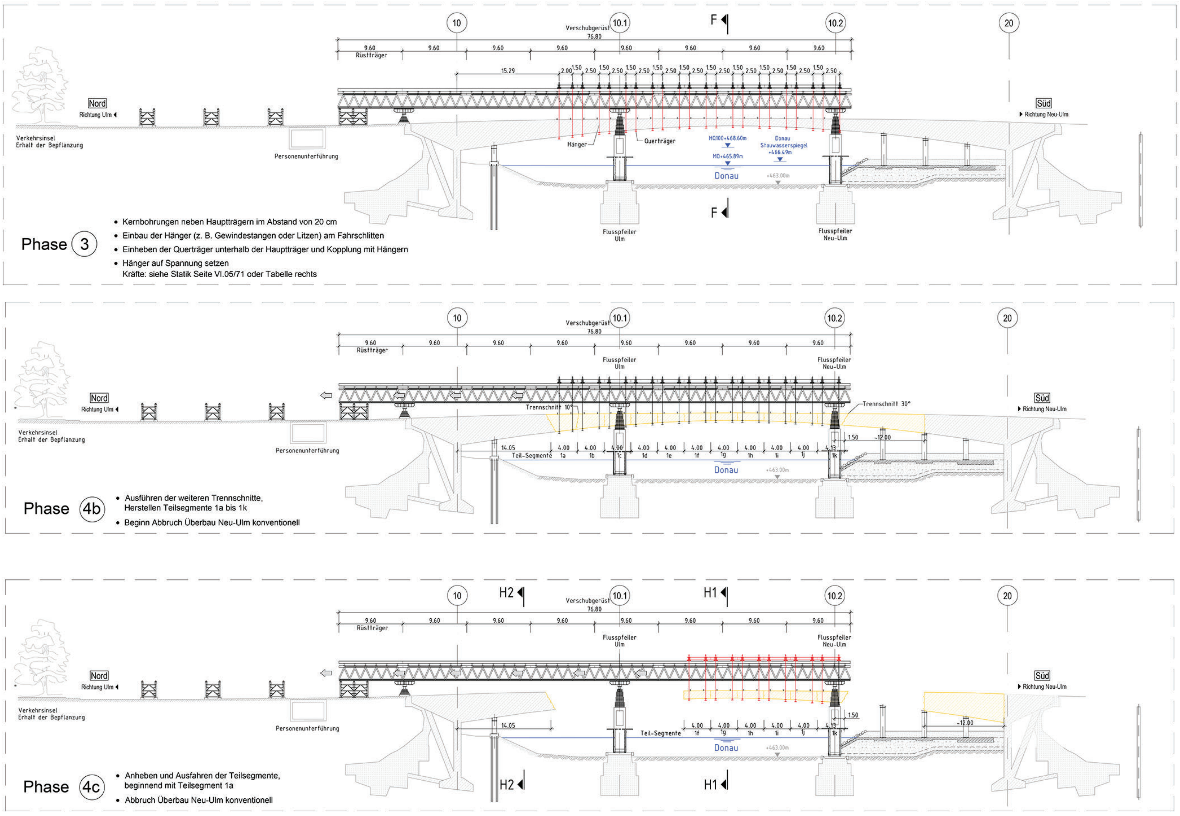

Figure 6: Deconstruction phase concept

- Selection of a torsionally rigid cross-section to achieve sufficient stiffness for deflection restrictions to l/650 and sufficient torsional stiffness to prevent excessive torsion under one-sided traffic loads
- Selection of a 5-cell cross-section to generate a fully contributing cross-section (no reduction due to effective width)
- Selection of a assembly sequence with assembly of the rigid frame corners with roadway slab concrete at the beginning in order to reduce the span moments and thus the construction height in the middle of the span

The load-bearing behavior of rigid frame bridges is well known. The frame structures known as integral bridges are characterized by the jointless frame design, in which the entire supporting structure forms a monolithic unit [5]. In addition to a series of tasks that need to be clarified, this type of bridge repeatedly poses the task of considering the interaction between the supporting structure and the subsoil as well as the control of the frame corner in terms of structural design.

Description of the new replacement structure

The new replacement structure consists of two partial structures that are separated by a structural joint. It is a frame structure with a total length of 120.50 m between the two abutment rear edges and a clear span of 86.50 m as well as a total width between the outer edges of the structure of 27.64 m at mid-span and 25.42 m at the abutment. The superstructure is designed as a steel composite

superstructure, which consists of a 5-cell steel torsionally rigid cross-section with a 25 cm thick in-situ concrete slab for each substructure. The cross-section is variable both in its height of 1.85 m in the middle of the bridge and 2.94 m at the abutment section and in its width of 13.77 m in the middle of the bridge and 12.66 m at the abutment section. The superstructure is fixed into the abutments, which are deeply founded with piles d = 1.50 m and pile lengths of 23 m at the Ulm abutment and 18 m at the New Ulm abutment. The abutments themselves are designed as box abutments for each substructure, whereby, in contrast to classic box abutments, an additional middle wall is formed between the two wing walls and the 50 cm thicker slab in the end area of the superstructure is extended over the entire length of the abutment. The structure is shown in Figure 7, Figure 8 and Figure 9.
The steel composite superstructure is formed by the 5-cell box cross-section and the shear-resistant connected roadway slab. Additional transverse bulkheads are provided at 4 m intervals in the transverse direction. The construction consists largely of S355 J2. Due to the great slenderness and the high stresses in the frame corner, segments 1 and 5 directly adjacent to the abutments, i.e. approx. 13 m each, are made of S460N.
The deck slab above the abutments up to 12 m beyond the abutment front edge - i.e. above the segments made of S460N - is made of C50/60. In the middle of the bridge, C40/50 concrete is used. The concrete slab is connected over its entire surface using shear studs. At the ends of the superstructure, the rows of shear studs are continued into the abutment via approx. 3.5 m long dowel bars.

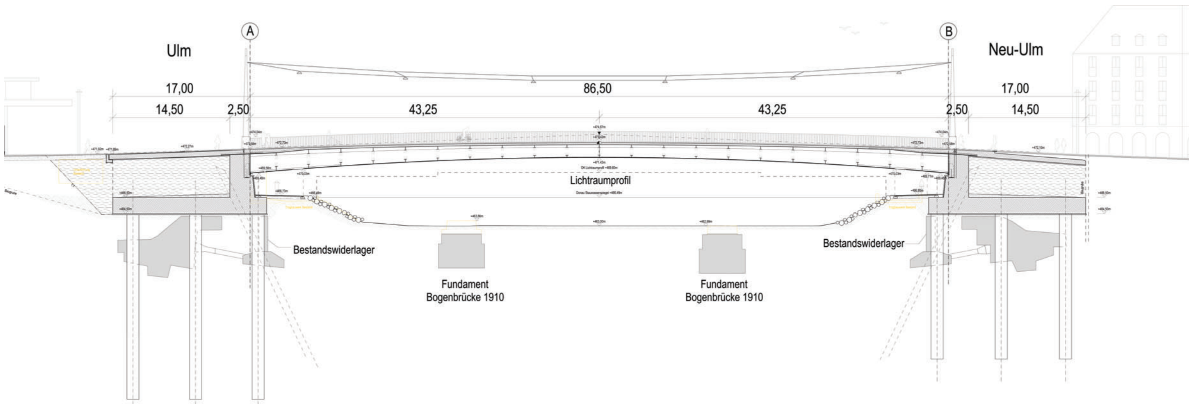

Figure 7: Longitudinal section

Assembling the superstructure
Once the abutments have been constructed, the superstructure is assembled. The steel structure is assembled in 5 segments per substructure. Segments 1 and 5 are 13 m long, segments 2 and 4 are 17 m long and segment 3 in the middle of the bridge is 26.50 m long. The assembly process is shown in Figure 10. The steel superstructure is assembled in five steps. First, the sections of segments 1 and 5 are assembled directly on site, i.e. on the abutment wall and a row of auxiliary supports in front of the abutment. Once segments 1 and 5 have been completed, the frame corner is concreted first. Segments 2 and 4 are then placed on top and locked and welded to segments 1 and 5. The segments are lifted to their destination by crane. The keystone, segment 3, is moved to the installation site using pontoons and lifted into place using strand jacks. Once the segment has

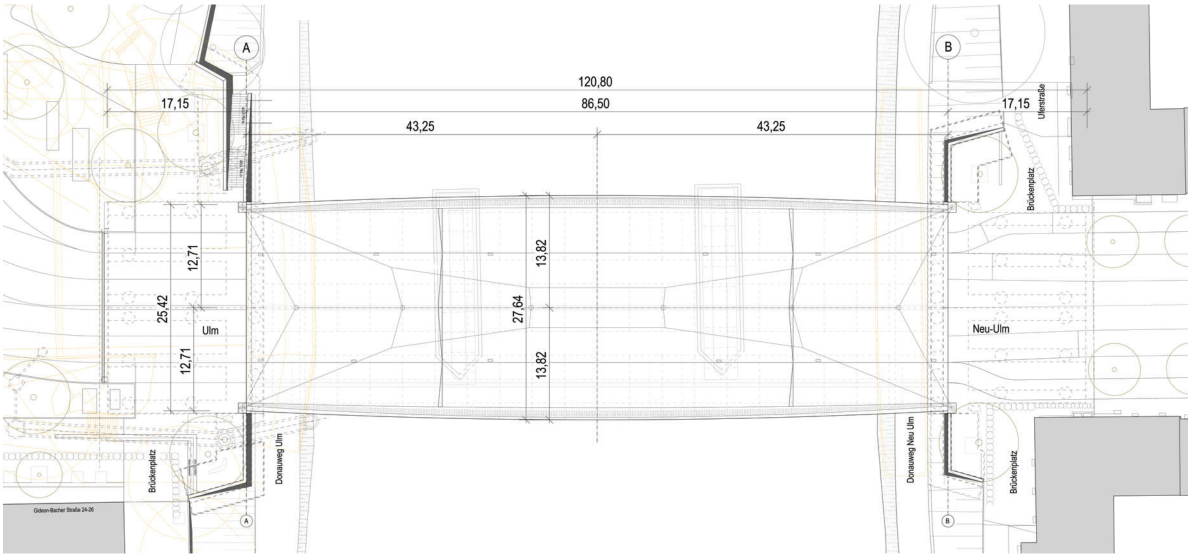

Figure 8: Plan view

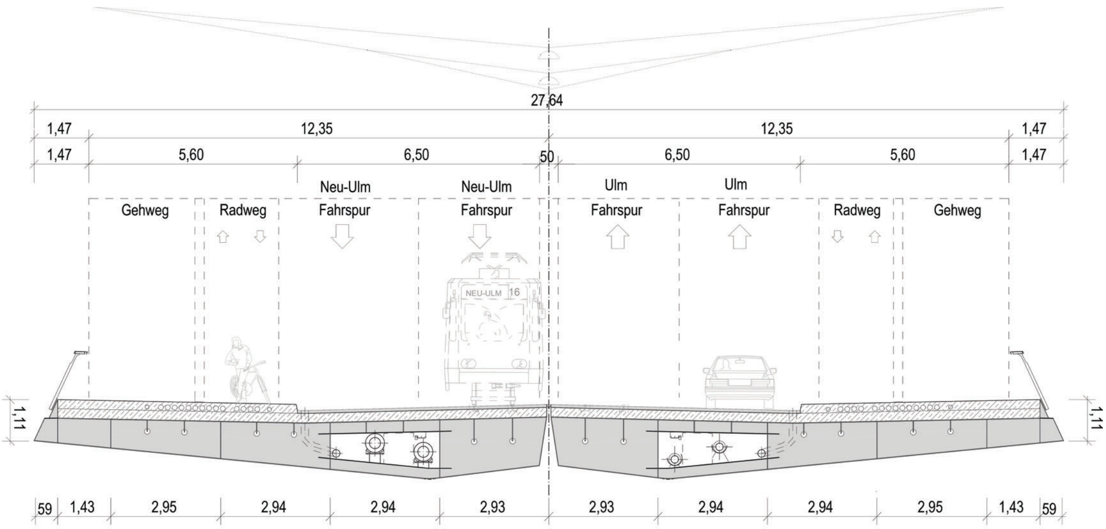

Figure 9: Cross section center of bridge

been aligned, it can be locked and welded to segments 2 and 4. Once the steel structure has been completed, the rest of the roadway slab can be concreted.

Welding windows must be provided in the construction to weld the segments together. For the installation of segment 3, the outside temperature must be taken into account; a corresponding temperature window was specified for this purpose. If this temperature window is deviated from, measures must be taken to adjust the length of the segment.

4 Summary and outlook

The competition jury selected an unusual frame bridge whose design blends in perfectly with the cityscape, but which also tests the limits of what is feasible in terms of construction. The Gänstor Bridge is clearly restrained in its design and impresses with its simple form. Nevertheless, the many small details, such as the inclined railing, the launching masts and the design of the lighting, make it an unmistakable structure. For the cities of Ulm and Neu-Ulm, a new recreational area with a view of the Danube and the city skyline is being created in addition to a transport link.
The ceremonial start of construction of the Gänstor Bridge took place on 26.07.2024. The first section of the structure is expected to be completed by the beginning of 2026. Completion of th[illegible] ne in[illegible]

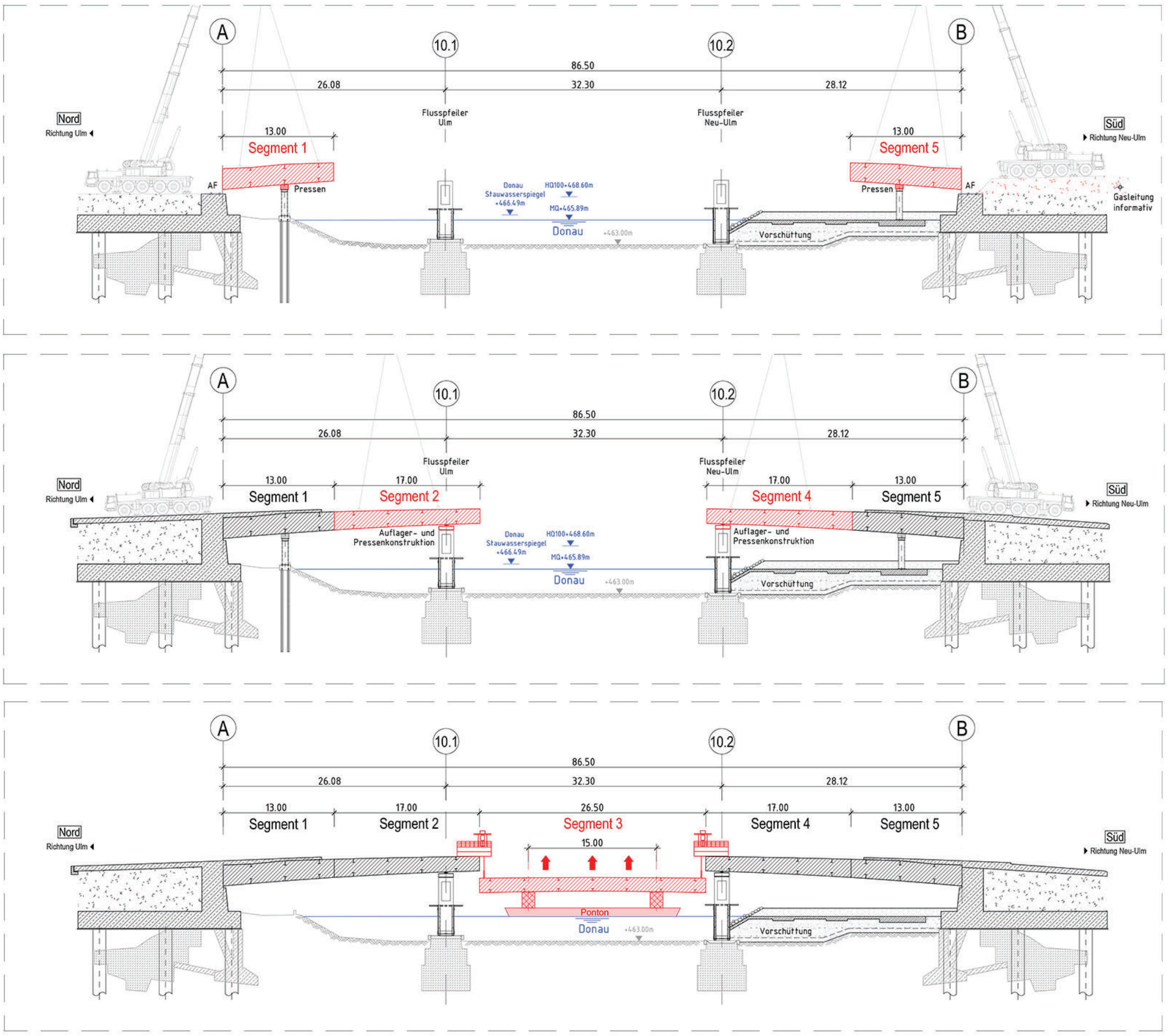

Figure 10: Construction phases

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