
A New Landmark in the Making: The 4th Danube Bridge in Linz

*Mathias Widmayer*¹ ✉, *Andreas Keil*¹, *Thomas Fackler*¹

✉ e-mail: m.widmayer@sbp.de

¹ Schlaich Bergermann Partner, Stuttgart, Germany

DOI: <https://doi.org/10.14459/icbdb24.01>

Abstract The 4th Danube Bridge in Linz is part of a significant infrastructure project aimed at enhancing traffic flow within the city and its surrounding suburbs. This strategic development promises substantial benefits for residents by reducing local traffic congestion and providing commuters from the western region with more direct routes. The bridge, a slender suspension structure spanning over 300 meters across the river Danube, is to become both a functional and aesthetic landmark for Linz. Upon its completion in 2024, it will be the only suspension bridge of this type over the Danube in Austria. The construction process, detailed in this presentation, involved complex engineering tasks, including the installation of suspension cables weighing over 65 tons each and the assembly of seven steel deck girder sections, each weighing up to 280 tons. This paper explains the design features, the construction process and the technical challenges faced. The completion of the 4th Danube Bridge is expected to significantly improve regional connectivity and serve as an outstanding example of modern bridge engineering in Austria.

1 Introduction

The so-called “A26 Linz Highway” is an important infrastructure project to improve the traffic situation in the city of Linz and the surrounding area of Austria’s state capital. Residents of the city will benefit from less traffic, while commuters from the western part of the region will profit from shorter routes. The major infrastructure project A26 is divided into three phases. The first Phase of this major infrastructure development includes the construction of the New Danube Bridge Linz. With a span of over 300 m, the slender suspension bridge over the river will be an elegant and functional landmark for the city of Linz. To date, the structure is the only suspension bridge over the Danube in Austria. Construction of the 4th Danube Bridge Linz started in January 2019. Almost six years later, the suspension bridge is entirely assembled. Suspension cables weighing 65 tons were pulled across the Danube and the seven sections of the steel deck girder weighing up to 280 tons were installed.



Figure 1: Bridge View / ASFINAG

2 Bridge Design

The 4th Danube Bridge in Linz is a simple suspension bridge and consists of:

- The superstructure is a steel composite structure with a central hollow steel box girder and tapered steel cross girders matching the spacing of the hangers.
- The cable support structure with 145 mm thick suspension cable bundles that consist of twelve parallel, fully locked cables. The hangers are also planned as fully locked cables and have a diameter of 95 mm.
- The anchoring structures, four cable anchorages (north and south) and two abutment structures at the tunnel portals.

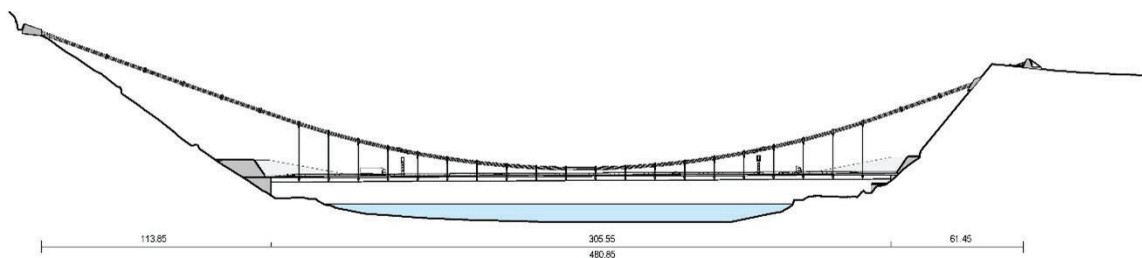


Figure 2: Bridge View / Schlaich Bergermann Partner

2.1 Deck

The superstructure of the bridge is suspended from the main cables with vertical suspension cables. The main girder is a hollow steel box girder with a composite concrete deck slab. It ensures the bending and torsional rigidity required for suspension bridges. In addition, the high dead weight of the steel structure, concrete slab and deck including edge beams also ensures that the deformations and fatigue loads from traffic remain within a permissible range. The central position of the box girder blends visually into the void of the cantilevered deck, creating a slender and elegant appearance of the bridge.

The choice of a combined steel and concrete supporting structure simplifies assembly by lifting the lightweight steel construction segments from the Danube and, with the concrete slab subsequently concreted on, provides the necessary robustness and durability for a road bridge with heavy traffic. The 2.05 m high, 7 m wide at the top and 5 m wide at the bottom, accessible steel main girder in combination with the edge girder and a 28 cm thick, lightly reinforced concrete slab form the bending and torsion-resistant longitudinal girder of the bridge. Longitudinal and transverse stiffeners (T-profile frames) in the main girder prevent the web and chord plates from buckling under compression and shear loads.

Steel cross girders (80 cm wide / 0.9 m to 2.05 m high), which are also connected to the concrete slab, transfer the forces from the main girder to the anchorage points of the suspension cables. The cross girders as well as the longitudinal girders arranged at the edge (65 cm wide / 90 cm high) are designed as tightly welded hollow sections. The transverse and longitudinal beams also support the concrete slab. The concrete deck slab spans mainly in the transverse direction with supports on the beams of the main girder and the edge girders. At the edges, the concrete slab cantilevers approx. 1.2 m, thus relieving the span between the edge girder and the main girder. The slab is also supported at the cross girders, resulting in a biaxially tensioned slab in these areas. To ease the construction, the composite slab was constructed with semi-prefabricated parts (8 cm filigree slabs tensioned in the transverse direction with an intermediate yoke support and an additional 20 cm of concrete).

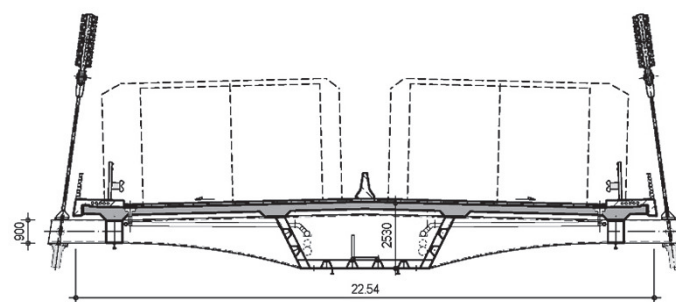


Figure 3: Cross Section / Schlaich Bergermann Partner

2.2 Cables

The main suspension cables across the Danube, which carry a weight of 13,000 tons, are around 500 m long. They are arranged in two bundles, each consisting of twelve individual fully locked

cables with a diameter of 145 mm. The vertical suspension cables, which connect the main cables to the bridge deck, have a diameter of 95 millimeters and are spaced 14.55 m apart from each other. The two sets of cables reunite at the steep banks of the Danube and are secured in two steel anchor blocks in the massive, guyed structures, each with 100 anchors in the rock of the Freinberg and the Urfahr walls.

This layout not only allows the cables to be installed easily but also ensures that individual cables can be replaced at any time, a requirement for a long service life of the structure. By choosing two levels per cable, it is possible to anchor them simply and efficiently to a strong, upright plate (anchor sword). Shim plates are included to adjust the length of the suspension cables.

The main cables are anchored to the cast steel suspension cable clamps, which also fix the cables in their geometry, using a clevis. The cables are held in the grooves of the suspension cable clamps with clamping shells. The tangential forces can be transmitted via friction due to the pre-tensioning of the HV bolts. The length of the suspension cable clamps depends on the permissible lateral pressure and the required “run-out trumpets” for the cable deflection. The suspension cables are also fully locked cables with a diameter of 95 mm and individual lengths of approx. 4.5 - 27 m. They are 14.55 m apart in the longitudinal direction of the bridge.

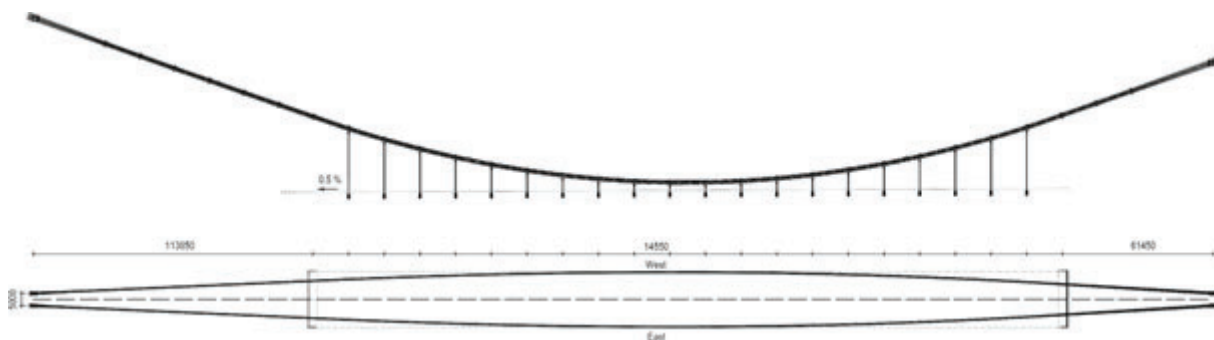


Figure 4: Cable support structure / Schlaich Bergemann Partner

2.3 Anchoring structures

Considering the special geographical location of the bridge in the Danube Valley with its steeply rising rocky slopes, the bridge’s main cables are anchored directly in the rock of these mountain slopes. As a result, the bridge visually “hover” above the Danube and blends into its surroundings in a visually weightless manner.

Only two cable anchorages and two abutments are required for the structure. The forces of the 2 x 12 main cables are each transferred to the northern and southern anchoring blocks via an anchor sword. Both blocks are anchored in the ground with over 100 permanent grouted anchors.

On both sides, the two end cross girders of the bridge deck are supported on abutments in the entrance area of the tunnels.

Vertical support is provided by spherical bearings that can move in all directions and are arranged on the outer sides of the bearing cross girders. In the horizontal direction, the main box girder is supported on separate horizontal bearings in the central axis of the bridge.

The fixed point is on the south abutment; on the north side, there is a transversely fixed, longitudi-

nally movable bearing. This bearing system at the north allows a rotation of the wide bridge deck and avoids any additional longitudinal forces due to lateral wind.

3 Construction Process

After various approval procedures, construction of the A26 Linz Highway began in January 2019. The centerpiece of the first development stage includes the approximately 300 m long earth-anchored suspension bridge over the Danube River. The unique topography and geological conditions in this area of the Danube Valley enable the forces to be diverted over the adjacent rock faces to the south and north side of the Danube, creating a genuine suspension bridge.

The suspension bridge was assembled in five main steps:

- Construction of anchor blocks north and south including the bridge anchoring and abutments.
- Erection of cable support structure (suspension cables, hanger clamps and hanger cables).
- Assembly and installation of the steel deck girder.
- Production of the roadway slab including the roadway structure.
- Bridge equipment and finishings.

3.1 Construction of anchor blocks north and south

Before construction of the anchor blocks and the bridge anchoring could begin, the rocky subsoil had to be prepared. This preparation included above-ground blasting work, the construction of rockfall protection walls and rock cross-linking, the excavation of the construction pits for the anchor blocks and cable tunnels, including excavation support and subsequent ground improvement. The soil was improved by removing the weathered rock, subsequent concrete backfilling, and additional grouting. These measures allow the anchor forces in the inverted joint to be transferred evenly to the underlying rock. Once the preparatory work had been completed, 217 permanent grouted anchors with a maximum anchor length of around 70 m were installed using a guided and controlled drilling process. With the installation of the bridge anchors complete, the anchor block was prepared for the upcoming concreting.

In addition to formwork and reinforcement work, the installation of the 45-ton anchor swords was carried out with an installation tolerance of ± 5 mm. In the final state, the force is transferred from the cable support structure to the anchor sword, via the reinforced concrete block to the bridge anchors and finally in the 15 m long bonding section of the bridge anchors to the rocky subsoil. In order to meet the high safety and engineering requirements of the structure, the anchor blocks were concreted in a single pour. The installation of the approx. 600 m³ of reinforced concrete was completed in one day, considering the proximity to the neighboring residents. Continuous monitoring of the concrete temperature was installed to prevent cracks. Cooling was achieved by introducing cooling water into the existing empty pipes of the bridge anchors.

3.2 Erection of cable support structure

A wide range of equipment and auxiliary constructions was required to assemble the cable support structure.

These include, among others:

- Two cable cranes over the Danube including Balloon rope to secure the airspace.
- Auxiliary ropeway for transferring the main carrying cable.
- Cable winches and hydraulic strand jacks.
- Uncoiling machine and braking machines for controlled uncoiling and retraction of the main suspension ropes.
- Various lifting equipment (rail crane lifting capacity > 80 tons, tower cranes, etc.) and safety equipment (work baskets for use over the Danube, working platforms, etc.)

In addition to the availability of the auxiliary structures, the safety requirements for the interaction of the equipment posed a particular challenge. Another major challenge for the construction of the anchor blocks and the cable support structure were the cramped and alpine conditions. Two cable cranes with a load capacity of 2 x 5 tons were erected to serve the areas between the anchor blocks. To pull the large 70ton ropes across the Danube, an auxiliary cable bridge consisting of two 52 mm cables and 40 cable riders had to be erected in advance using the cranes. With this auxiliary cableway, the pulling force during the pulling operation was reduced significantly. The individual cables (diameter 145 mm with a breaking load of 2100 tons) were unrolled one after the other from a motorized reel and inserted into a cable tensioner unit which ensures controlled movement. The end of the cable was then connected to a 16ton winch on the south side using a 24 mm pulling cable. This allowed the cable to be pulled from north to south over the 40 riders in a force- controlled manner. Once the cable arrived at the south end, both cable ends were connected to a hydraulic strand hoist. The auxiliary cable bridge (52 mm diameter cables with 40 riders) was then lowered and moved transversely so that the main suspension cable could hang freely above the Danube in an elevated position. Afterwards, both centrally arranged strand jacks were successively lowered as the free cable sockets had to be inserted into the bearing pockets of the anchor sword. During the lowering process, the cable moved transversely to the bridge axis into its corresponding end position.

The installation of the main cables began at the end of 2021 and was completed in the first half of 2022. Once the main cable assembly was completed, the two vertical cable levels (12 / 2) of each main cable bundle were temporarily separated to create space for inserting and aligning the 3-ton hanger clamps. A total of 2 x 20 hanger cable clamps and further 2 x 10 distance holder clamps had to be installed. Following the cable clamp assembly, 40 hanger cables were installed. To get the two main suspension cables (west and east) into their final position for the deck assembly, seven temporary spreader beams had to be installed along the two main cables. For this operation, custom-designed lightweight spreading devices were created, facilitating the separation of the main cable by 18 m using two- strand jack systems. With the temporarily spread main cables approaching the final cable geometry, the steel deck installation could commence.

3.3 Installation of the steel deck, erecting the deck slab and remaining work

During the erection of the cable support structure, two out of nine steel deck segments were installed at the abutment area in front of the tunnel portals North and South on a temporary protective framework. The remaining seven steel deck segments were prepared at a pre-assembly area, 16 km downstream of the construction site.

After completing the cable assembly, the seven lifting segments of the steel deck girder, starting with the middle one, were transported across the Danube to their destination. To ensure a controlled assembly process in the face of the high flow velocity in this section of the Danube, a stilt pontoon was employed for transportation and as a foundation during the strand lifting process. The various assembly steps resulted in numerous intermediate assembly states, requiring careful planning and calculation. Beyond the planning of these erection stages, geometry control throughout the entire construction played an important role in the project's success for all parties involved. Crucial for the successful deck assembly was the stress-free trial assembly and the installation of temporary locking devices between the individual steel deck segments. This ensured that each segment could be effortlessly suspended and pinned to the cable structure. Subsequently, the corresponding segments above the Danube were progressively welded in place.



Figure 5: Bridge Deck / ASFINAG

Installation of the concrete deck slab began in the autumn 2022 after completion of the steel deck girder. The light semi-finished precast slabs could be laid over the entire bridge using the cable crane. However, the very thin semi-finished slabs had to be temporarily supported to accommodate the weight of fresh concrete. For this purpose, the 8 cm precast was suspended with a light scaffolding

system to achieve the required prechamber. After the entire bridge was equipped with all semi-finished precast slabs, concreting could begin according to a defined sequence. Ensuring a uniform load application/concreting is crucial for the still-soft, cable-supported steel deck. Therefore, the assembly process and a stage-wise concreting sequence were meticulously simulated in a detailed FE Model, encompassing all time- dependent shrinkage effects. After all concreting steps were completed, the edge beams were concreted in place, followed by sealing and mastic asphalt.

4 Outlook

The 4th Danube Bridge in Linz will be completed for the 2024 International Conference on Bridges in the Danube Basin. Apart from finalizing all bridge equipment such as functional street lighting, plumbing, joints, railings, etc., the main suspension cables will also be coated, and the architectural bridge lighting installed. Partial commissioning of the bridge is scheduled for the end-2024, accompanying the start of project phases 2 and 3 of the overall A26 project. Thanks to the very slender and transparent, minimalistic construction, which fits perfectly into the ecologically highly sensitive area and the beautiful landscape of the Danube Valley, the New Danube Bridge is already a unique landmark in Linz and the surrounding area.