B15 Bridge Over the Mangfall River and Canal

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Abstract Federal Highway B15 is an important Bavarian north–south connection east of Munich's metropolitan area. The construction of the western section of the Rosenheim ring road (Westtangente Rosenheim) reduces traffic in the town and increases the residents' quality of life. The heart of the construction is the 192.50 m Aicherpark Bridge crossing both the Mangfall River and the Mangfall Canal.

The flexible cable-stayed bridge was the best design for the difficult subsoil conditions. The subsoil, consisting of basin deposits, is a leftover from the ice age and prone to excessive settlement that had to be taken into account. The superstructure counters this problem by means of pylons clamped into the structure and traditional supports. Intelligent move. The entire construction can be lifted if required. The 50 m foundation elements are not visible yet crucial. Bored piles, drainage columns and displacement piles transfer the loads to the marine clay soil.

The extradosed bridge with short pylons and shallow cables blends harmoniously into its environment. The structure does not steal the limelight from the tall trees nor from the buildings of the adjacent Aicherpark. The exterior longitudinal girders form a continuous visual band with the pylons. The cables are not anchored into consoles but into the inside of the girders, which creates a structurally, economically and visually durable construction.

1 Local Conditions and Tight Constraints for the Structure

The Mangfall Bridge of the B15 West Bypass Rosenheim is an outstanding structure that spans the Mangfall River, the Mangfall Canal, and parts of the Aicherpark industrial area. The construction of the West Bypass Rosenheim relieves the independent city in particular and increases the quality of life for the residents of Rosenheim.
The constraints from the local conditions and tight constraints lead to a gradient running very close to the ground and a transition curve on the structure. A foundation on the central embankment between the Mangfall and Mangfall Canal is not possible due to the crossing culvert for the main

water and high-pressure gas pipeline. This results in a required main span of about 100 meters and two side spans of just under 45 meters to keep the flood discharge cross-section and areas of the companies in the industrial area clear.

Figure 1: Oblique View of the Bridge Structure (©Ingenieurbüro Grassl GmbH, photography Stefan Kuhn)

2 Rosenheim Clay – A Relic from the Ice Age

The subsoil in Rosenheim is characterized by substantial basin deposits, known as "clay": clays, silts, and fine sands, which make foundations particularly susceptible to settlements and thus represent a significant constraint for the new construction project. The clays, which extend almost to the surface, are extremely sensitive and liquefy under the unavoidable construction vibrations.Additionally, due to the load concentration in the limited construction area, significant settlements were expected not only during construction but also after completion, i.e., during operation.

Therefore, stiff continuous girder bridges are not a suitable option. Instead, the following alternatives remain: overhead truss arches in the form of Langer beams as single-span chains or with continuous action, trough bridges as single-span chains, and cable-stayed bridges as continuous systems.

Figure 2: Low pylon blend harmoniously into the landscape und urban environment (©Ingenieurbüro Grassl GmbH, photography Stefan Kuhn)

3 Perfect Structure for the Complex Constraints

The optimal solution is to use an overhead structure that provides maximum clearance under the bridge. The low pylons blend harmoniously into the landscape and urban environment, and the flexible superstructure shows excellent compatibility with the expected settlements. The continuous girder system also minimizes the required transition constructions and maximizes durability.

The cleverly integrated pylons in the superstructure and the traditional bearings not only offer an aesthetic solution but also allow for the adjustment or elevation of the entire structure if needed. The superstructure can be raised by 2 centimeters in one axis, and shim plates can be inserted between the bearings and the superstructure similar to a bearing replacement. The expected settlements are in the decimeter range, and the superstructure is designed for differential settlements between the axes of 3 centimeters each.

A further reduction in foundation loads results from the use of main and cross girders as well as pylons made of steel. Only the roadway slab is made of reinforced concrete with regard to traffic safety and winter operating costs.

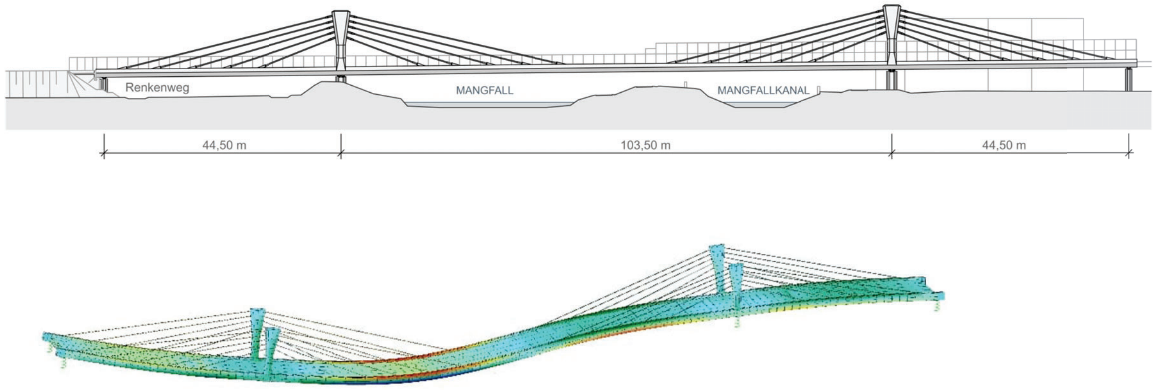

Figure 3: Side View of the Bridge and Calculation Model in one Settlement Load Case (©Ingenieurbüro Grassl GmbH)

Figure 4: Oblique Top View of the Bridge (©Ingenieurbüro Grassl GmbH, photography Stefan Kuhn)

4 Unique Foundation – Interdisciplinary Collaboration Leads to Success

Invisible but crucial are the foundation elements reaching depths of up to 50 meters, consisting of bored piles for load transfer, drainage columns for faster dewatering, and displacement piles for improving the clay, which successfully transfer the loads into the clay. A standard foundation on bored piles was not possible after the results of pile load tests due to the required pile lengths. In the soft, structure-sensitive clays, bored piles alone showed low load-bearing capacity due to the unavoidable construction disturbances – only in combination with the subsequently installed

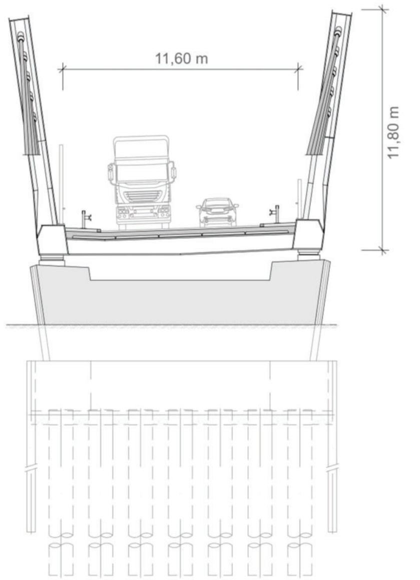

Figure 5: Cross-Section of the Bridge with View of the Pylon (©Ingenieurbüro Grassl GmbH)

Figure 6: Driver's Perspective (©Ingenieurbüro Grassl GmbH, photography Stefan Kuhn)

displacement columns could the required load-bearing capacities be demonstrated at economical depths.

This pioneering foundation – now also called the Rosenheim mixed foundation – owes its realization to the constructive work between the object and structural planners of the engineering firm GRASSL and the geotechnicians of the Geotechnical Center at the Technical University of Munich. Without this interdisciplinary engineering effort, the realization of this crossing and the relief of Rosenheim's city center from traffic would have been a distant prospect.

As a result, the mixed foundation as a whole represents a robust foundation element that does not

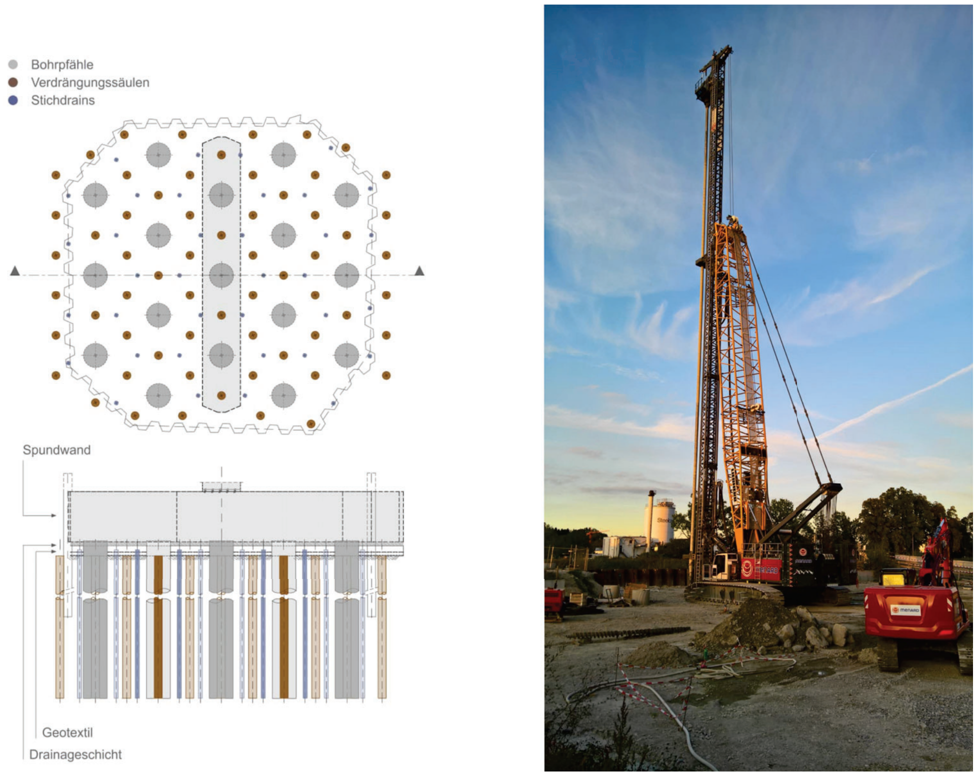

Figure 7: Rosenheimer mixed foundation and Unique Large Device on a Large Crane (©Ingenieurbüro Grassl GmbH and Geotechnical Center, Technical University of Munich)

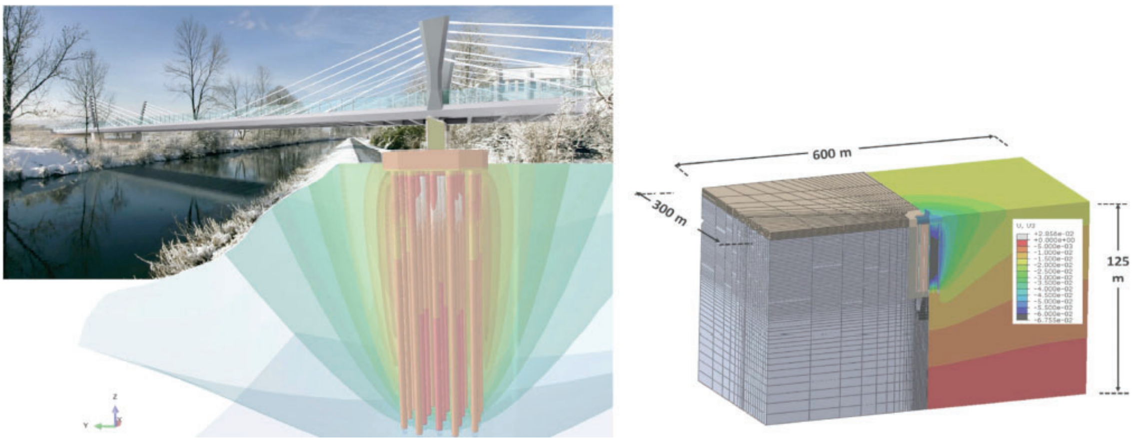

Figure 8: Visualization with Subsoil Model and 3D Model of the Pile Group (©Ingenieurbüro Grassl GmbH and Geotechnical Center, Technical University of Munich)

rely on the load-bearing behavior of individual bored piles. The displacement columns cause a compaction and tensioning of the soil, which increases the shear strength and stiffness of the clay as well as the activatable resistance of the bored piles. They also homogenize the subsoil and counteract unavoidable construction-related disturbances. With extensive geotechnical monitoring, the construction of the foundation – which was carried out with a unique large device with a leader height of about 60 meters on a large crane – the shell construction, and the commissioning were monitored in real-time. The currently ongoing measurements show very good performance of the foundation system, which was previously examined in detail using numerical analyses.

5 Slim Band – Optimal Integration into the Environment

The three-span superstructure consists of a steel girder grid with external, torsion- and bending-stiff longitudinal girders made of airtight welded steel box sections. A kink in the outer webs structures the visible surface, and the oppositely inclined web plates create different light reflections, enhancing the slim appearance.

Figure 9: Slim Band without Brackets (©Ingenieurbüro Grassl GmbH, photography Stefan Kuhn)

The extradosed bridge with its low pylons (approximately 10.70 meters from the top of the longitudinal girders) and flat cables blends seamlessly into the environment without overshadowing the treetops or buildings of the adjacent Aicherpark. The outer longitudinal girders together with the pylons form a continuous band that harmoniously integrates the bridge into the landscape. Anchoring the cables inside the girders instead of using brackets creates a structurally, economically, and visually durable construction that is not only functional but also aesthetically pleasing.

6 Complex Steel Construction – Three-Dimensional Modeling for Required Precision

The tight constraints for the alignment required the use of a transition curve on the structure. This change in cross slope leads to a variable superstructure cross-section over the entire length of the structure.
The cross girders, spaced 3.45 meters apart, adapt to the respective cross slope and are rigidly connected to the longitudinal girders, which follow the alignment. For the creation of the workshop

planning, this complex steel construction was captured using three-dimensional modeling methods and delivered in the form of plans and tables.

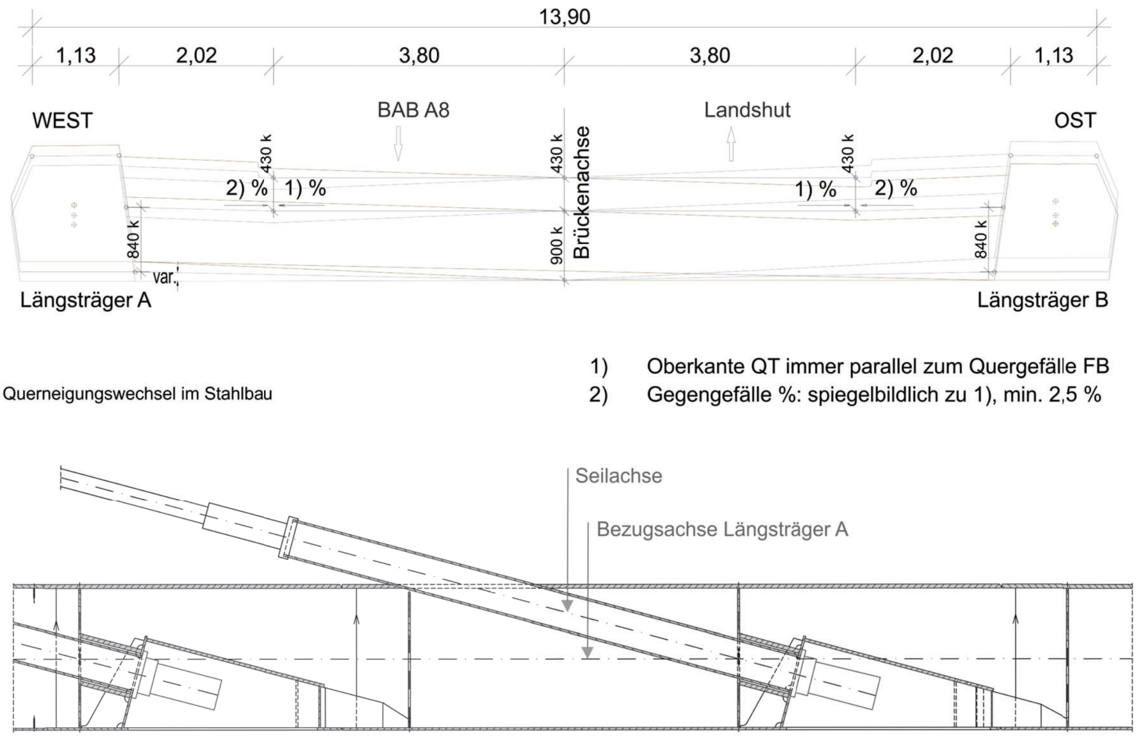

Figure 10: Change in Cross Slope in Steel Construction and Anchoring of the Cables Inside the Longitudinal Girders (©Ingenieurbüro Grassl GmbH)

7 Resource-Efficient and Durable Structure

The composite steel structure is resource-efficient and optimally adapted to the constraints. To further reduce material consumption, modern calculation methods were applied, and FE shell models were created for the critical detail points. These models were directly integrated into the overall model, enabling a highly realistic modeling of the structural behavior and constructive optimization of the details.

In terms of sustainability, durable and economical solutions were implemented in the design of all details. The number of required transition constructions was minimized by implementing a three-span structure. This led to the potential elimination of particularly costly and maintenance-intensive wear parts.

Through the innovative foundation using displacement columns for soil improvement and the load-bearing pile cap, the required pile lengths and quantities, and thus the concrete volume, were significantly reduced.

8 Sustainability – In the Final State and Construction Process

The economic efficiency and environmental compatibility of new constructions significantly depend on the selection of suitable bridge systems and their superstructure designs. Systems that enable efficient and direct load transfer and do not require elaborate and resource-intensive temporary structures during the construction phase are particularly advantageous. During the construction of the Mangfall Bridge, no auxiliary cables, temporary supports, or temporary pylons were needed, whose material and personnel use would not benefit the structure in its final state. Instead, the load-bearing elements of the final state could also be used for the sectional construction in the free cantilever method.

Figure 11: Free Cantilever Construction in Front of Mountain Scenery (©Ingenieurbüro Grassl GmbH)

9 Details about the Project and Participants:

PROJECT
Bridge over Renkenweg, Mangfall, and Mangfall Canal as part of the B 15n

LOCATION
Rosenheim

CONSTRUCTION PERIOD
2018–2023

CLIENT
Free State of Bavaria represented by the State Building Authority Rosenheim

ENGINEERS + ARCHITECTS
Object and Structural Planning:
Design, approval and execution planning, preparation and articipation in the award Ingenieurbüro Grassl GmbH, Munich

Local Construction Supervision and Site Management:
INGE Ingenieurbüro Grassl GmbH, Munich and SSF Ingenieure AG, Munich

Geotechnical Consulting:
Geotechnical Center, Technical University of Munich

CONSTRUCTION EXECUTION
Consortium – Habau, Perg and MCE, Linz, Austria