PROJECT REPORTS

ten project reports
from SSF Ingenieure AG
at the occasion of the Project Day
on July 13th, 2013
at BMW Welt Munich

Content

1

»Design and Build«
on the Example of Two Bridges in the Netherlands

Lecturer: Dipl.- Ing. Hans-Joachim Casper

With contract award by design and build the client puts design and executing services for a project in the hands of one contactor.
The tender documents are limited to the description of functional, technical, economic and ecologic project requirements. Other conditions are so-called RAMS requirements, which describe the period of unrestricted Reliability, the life cycle with accepted closure times and renovation works (Availability), required Maintenance measures and necessary Safety installations.
Together with project requirements, the client stipulates maximum admissible construction costs.
The focus of design is defined by the indicated evaluation criteria that assess public interests of function, visual appearance and economic efficiency.

Before handing over tender documents, a prequalification of bidders takes place in the context of which the client chooses a limited number of efficient and reliable companies or joint ventures.
For the projects presented below the number of bidders was limited to four or five joint ventures comprising executing companies, engineers and, because of the aesthetical design requirements, also architects. The limitation of companies invited to bid also takes into account the effort of the client to regularly meet and discuss with all bidders as well as the in general elevated costs of the bidding process.

During meetings the state of the design was presented to the client and the bidders had the chance to ask questions and clarify the construction task. Questions were answered in written by the client. The client thoroughly analysed static-structural aspects as well as maintenance aspects of the design as the same importance was attached to a guaranteed technical and financial feasibility, to a construction process according to schedule and based on partnership, to functionality and durability as well as to the desire to obtain an architecturally appealing design. To fulfil this task, the client sought the support of external architects, engineering offices and universities.

The contract award process 'Design and Build' transfers in the bidding phase the essential design work to the companies. At the same time, the client claims, in view of a safe evaluation of offers, comprehensive and transparent tender documents comprising technical descriptions, structural analyses, detailed draft plans, schedules, exact indications of maintenance efforts and calculation bases as well as models of the structure. For these services the bidders are appropriately reimbursed; in the case of the bridge over the Ijssel with 0.75 % of the maximum construction cost, or 375,000 € per bidder.

Fig.1, Bridge over the IJssel, front view

Fig.2, Bridge over the IJssel, view on the main opening over the River IJssel with a span width of 150 m; total bridge length approx. 926 m

The bridge over the IJssel required in particular an architecturally demanding structure. Public protests against a bridge and strong supporters of a tunnel solution for the infrastructurally necessary railway line, forced the client to gain the public's acceptance by a unique design of the bridge.

Fig.3/4, Bridge over the IJssel, bottom view of footpath

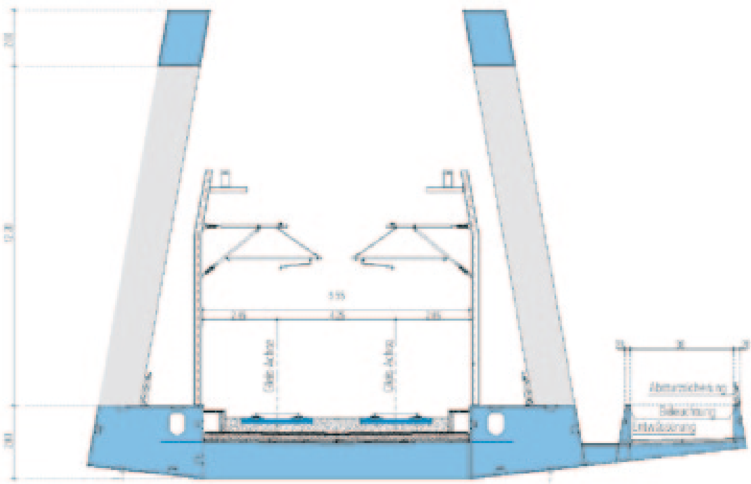


Fig.5, Bridge over the IJssel, cross section

So the call for tenders demanded an architect to be part of each bidding joint venture. Awarding criteria were with 65 % the architectural design and with only 35 % the construction costs that were limited to 50 m € net.

The winning design, a slender continuous arch truss, demonstrates impressively that it is achievable to unite seemingly contradictory aspects like architectural standards and fixed construction costs as well as dimensioning of a highly loaded and heavy railway bridge and at the same time modest integration into the flat landscape and rural nature.

The foot and cycle bridge Plofsluis over the Amsterdam-Rhine Canal is intended to complete the ensemble consisting of the Plofsluis, a sand bunker built during the war to close the canal, and an arch bridge existing on one side, and should adapt itself harmoniously to the sensitive fluvial landscape. Construction costs were predefined by the client, the municipality Nieuwegein, at 6.1 m € net and maintenance works for 15 years at 300,000 € net. Awarding criteria were with 50 % the design and adaptation to the environment, with 20 % potential cost reductions for the 15-year maintenance period, with 20 % the detailed description of maintenance works and with 10 % risk analysis of schedule reliability, technical quality and unrestricted functionality.
The winning design is an exceptionally designed foot and cycle bridge that remarkably was selected by the jury because of its details in view of function and maintenance.
The winning designs of both mentioned structures were created together with the architects Quist Wintermans and SSF Ingenieure AG as part of the bidding joint venture.

Fig.6, Footbridge Plofsluis, visualization

Fig.7, Footbridge Plofsluis, visualization

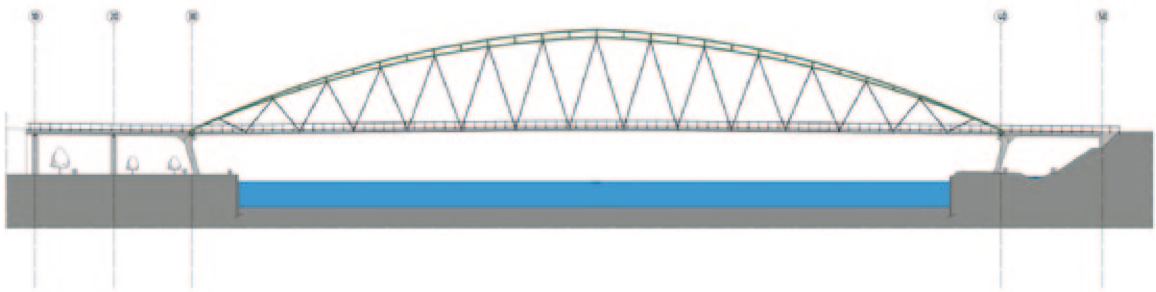


Fig.8, Footbridge Plofsluis with span widths of 20 m + 160 m + 15.50 m + 15.50 m; total bridge length 211 m

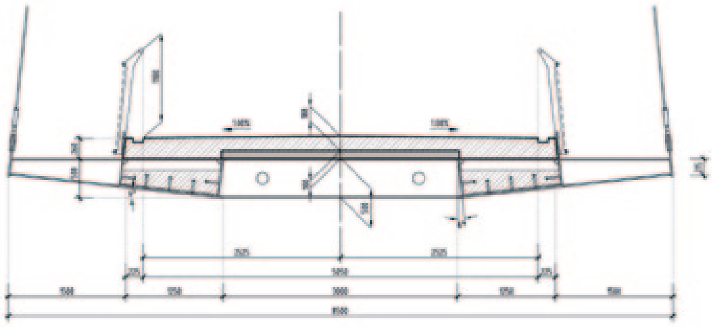


Fig.9, Footbridge Plofsluis, regular cross section

The fundamental characteristic of the award procedure of construction services in Germany is the separation of draft design and the following executing phase. The only decision criterion is in reality the lowest price. Even if the draft design itself can be subjected to a competition or alternative offers by the companies are allowed in the course of the bidding process, the design and price competition are separated from each other.

The award of draft and executing services of a construction project by design and build to one and the same contractor allows for an optimum solution reflecting individual evaluation of the requirements in the framework of the defined cost frame, and incorporates the construction companies' know-how during a very early (design) phase in view of work preparations and construction execution (best practice). An advantage for the client that should not be underestimated.

The bidding companies, designers and architects are given the opportunity to concentrate not on the price but on an idea competition in view of highest functionality, economic efficiency and sustainability. Yet, the winning bidder takes on every discernible risk that the call for tenders suggests.

Design and build means that the client is not the interface between designer and contractor of the construction services with all the well-known risks in terms of time and finances.

The awarding procedure gives the client the opportunity to hand over, in the framework of the competition, the overall responsibility for design, cost calculation and construction execution to the contractor and provides him, alongside highest possible cost reliability, with a structure optimized to the requirements and tailored to the client's wishes. In other words: the client does not build a bridge, he buys the desired bridge.

2

Report on a Selection of Interesting Projects Abroad

Lecturer: Dipl.-Ing. Matthias Scholz

Design and construction in an international network / international project management of SSF Ingenieure AG

Distant lands with foreign (construction) cultures, but mostly different construction and design traditions as well as often diverging normative frameworks that, just like in Germany, provide their own regulations and local standards, present a huge challenge when designing and implementing international projects.
Numerous projects realized abroad document that a good, integral and sustainable design can only be successful with profound and wide-spread knowledge and competence in project management and with intensive dialogue with the client and project participants.
SSF Ingenieure AG participates abroad together with the engineers of the SSF Group especially at projects of inner urban special engineering of traffic tunnels and metros, at railway infrastructure projects for local traffic, long-distance and high-speed railways, at highly specialized engineering of bridges and industrial buildings as well as at integral design of event arenas, stadiums and exposition buildings.

Examples of successfully implemented international projects:

- Baku Crystal Hall – event arena built for the ESC
- new metro network in Doha, Qatar – Qatar Integrated Railway Project (QIRP)
- road bridges in Tiflis, Georgia
- metro expansion line L1C, Algeria

Fig. 1, Baku Crystal Hall – event arena built for the Eurovision Song Contest (ESC)

Baku Crystal Hall – event arena built for the Eurovision Song Contest (ESC)

After Azerbaijan won the Eurovision Song Contest in spring 2011 and became the organizer of the following song contest in 2012, it faced the challenge to find or build an appropriate event location until May 2012.
At the end of July 2011, the Committee of Property Issues in Baku mandated the company Alpine Bau Germany in cooperation with the Swiss trade fair constructor Nüsssli International AG as general contractor for the construction of a new multifunctional hall based on the design of the architects GMP Gerkan, Marg und Partner.

The event arena initially planned was to be build uniquely for the ESC, for one single concert, and would have had the character of a temporary hall. However, it became soon clear that the new Baku Crystal Hall – a multifunctional hall at National Flag Square, at the seaside promenade of Baku, the »Dövlət Bayrağı Meydanı« – was to be erected for durable use. So the design of GMP architects, an arena in form of a crystal covered with a silver shining membrane, was realized under the general contractors Alpine Bau and Nüssli.
The multifunctional hall with an area of around 135 x 100 m (13,500 m²) consists essentially of three more or less independent load-bearing structures, the circular stands with cantilever roofs (around 5,500 t of steel), the hall's centre roof (around 2,500 t of steel) and the exterior façade (1,500 t of steel) with an approximately 20,000 m² spanning membrane cover.
The arena is situated in one of the world's most critical earthquake zones (with earthquakes of intensities of 9 on the Richter scale) and is in addition exposed to strong winds occurring at the Caspian Sea (wind speeds of up to 45 m/s).
The arena including all stages and broadcasting technology had to be ready for operation for the 1st semi-final of the ESC on May 22nd, 2012, and of course for the final on May 26th.
After a design and construction phase of only eight month, during which a concept for a provisional solution was transferred into a fully adequate arena, the multifunctional hall with a capacity of 25,000 people (reduced to 16,000 during the ESC event due to the stage arrangement) was inaugurated on time on April 1st, 2012 already.

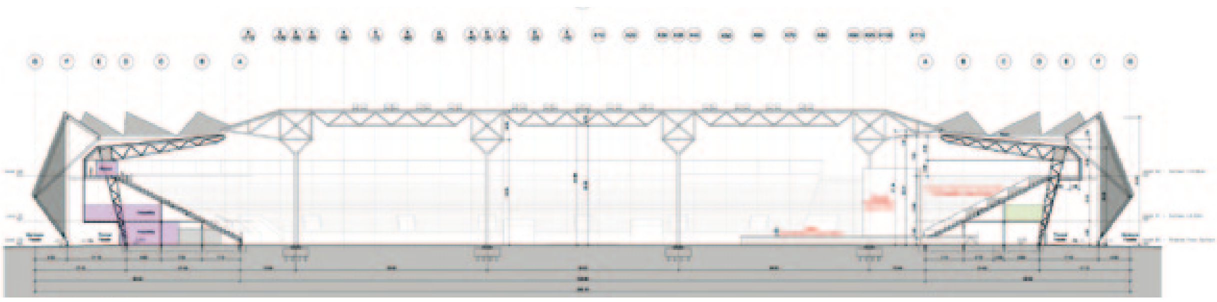


Fig.2, Longitudinal sectiont

SSF Ingenieure AG's department for international projects took on draft design and structural engineering of the stands and the stadium roof, the interface coordination as well as the analysis of design and workshop drawings. The SSF Group with Baugeologisches Büro Bauer was charged with the assessment of the construction ground, the foundation concept and the construction supervision of the driven pile foundation.

The very tight schedule did not allow examining in every detail the design and the structure in a chronological order. For the design, for example, load assumption were stipulated by the general contractor together with SSF Ingenieure AG on their own authority and presented to the client for coordination and approval.
In particular in case of critical stresses such as earthquakes and wind, a redundant procedure was applied. For example wind loads were defined in a wind report and verified by modified load assumptions in analogy to Eurocode. Only several months after the ESC event the design documents and the structure were examined and approved by the client.
To meet the very tight schedule, the individual load-bearing structures, roof and stands, were dimensioned separately. Later, everything was reproduced in an overall model in order to verify the total stability with the critical actions 'earthquake' and 'strong winds'.
At the beginning of August 2011, structural engineering started. Already in September 2011, pile driving for the foundation started and the first materials for steel profiles and steel sheets were ordered. In December 2011, large parts of the steel structure were already assembled. In March 2012 the multifunctional hall underwent last fitting works.

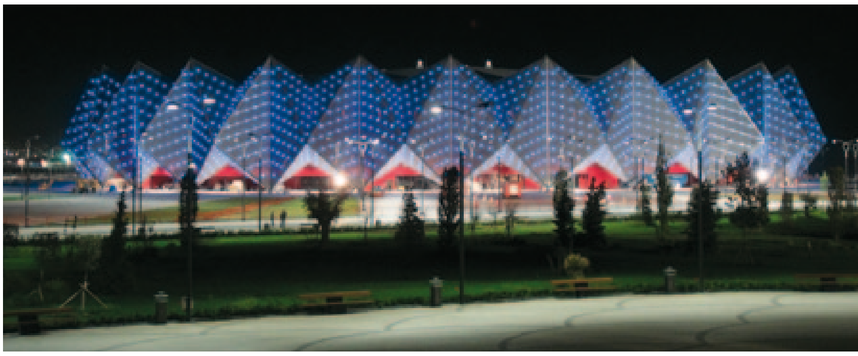


Fig.3, Illuminated arena in the evening

New metro network in Doha, Qatar Integrated Railway Project (QIRP)

A totally different, much larger project is the construction of a completely new metro system in Doha, Qatar; a project in the field of inner-urban infrastructure worth billions and observed all around the world.

At the occasion of the FIFA World Cup 2022, a modern metro network comprising four main lines within the City of Doha with connections to twelve football stadiums and to the new airport is planned. The network comprises around 90 km of metro line with a tunnel portion of 50 % and about 30 stations, of which 24 are underground. Connecting to the metro, the local transport system is planned to be expanded by 300 km regional train line (light rail system) in order take into account the rapidly growing urban density. What is more, a 300 km long distance railway network for freight traffic and a high-speed line to the neighbouring countries Saudi Arabia and Bahrain is envisaged, which will be linked to the urban network by transfer traffic hubs.

Fig.4, Doha Metro Phase I – network plan

The metro network constructed during phase 1 consists of four lines (yellow, red north/south, green and blue), to be implemented until 2022. In the underground area there are in total 24 stations, 7 emergency exits (shaft structures), 5 underground track switching systems and 4 ramps installations as well as a tunnel of an overall length of 45.6 km. Estimated construction costs amount to around 7 bn €.

Work Order 1

The so-called work order 1 entailed the elaboration of tender documents for the first part of the inner-urban network according to FIDIC Yello Book procedure.
SSF Ingenieure AG was mandated by Deutsche Bahn International (DBI) to elaborate design services for the QUATAR INTEGRATED RAIL PROJECT (QIRP) for the client Qatar Rail Cooperation in Doha. The design period for preliminary studies extended from 10/2011 to 01/2012 and from 02/2012 to 08/2012 for draft design.
With publication of the so-called tender design and kick-off of the FIDIC bidding procedure in August 2012, the design was completed on time for Ramadan festivities.
At the moment, award of the different lots to prequalified joint ventures as design and build packages is being carried out. Construction works are to be started this year and in 2018/2020 the stations are to be handed over for immediate use, including a completed infrastructure and equipped railway lines, on time for the FIFA World Cup.

Green Line	Msheireb – Ramp Education City
Red Line North	Msheireb – Trough M10
Red Line South	NDIA Station - Msheireb
Golden Line	Airport City North – Al Sadd
Major Station	Msheireb
Major Station	Education City

Tender design is founded on the design bases for the underground line established by SSF Ingenieure AG in the framework of preliminary design and following draft design. In total, SSF Ingenieure AG was responsible for the design of 11 underground stations, 5 track switching systems and 3 ramp installations.

The stations were conceptualized as through stations or crossing stations with underground aisles to create near surface connections. Further expansion of the network is intended by advance measures within the transfer stations that later allow annexing further tracks of metro or long distance trains.
Due to the large depth of the stations (up to 39 m underneath ground level), the high, very salty and chlorinated groundwater and the dense urban buildings, design requirements were high in terms of concept, design, construction site logistics, temporary traffic management, urban planning, architecture, building trades and structures interfaces.

Fig.5, Animation of transfer station Al Diwan

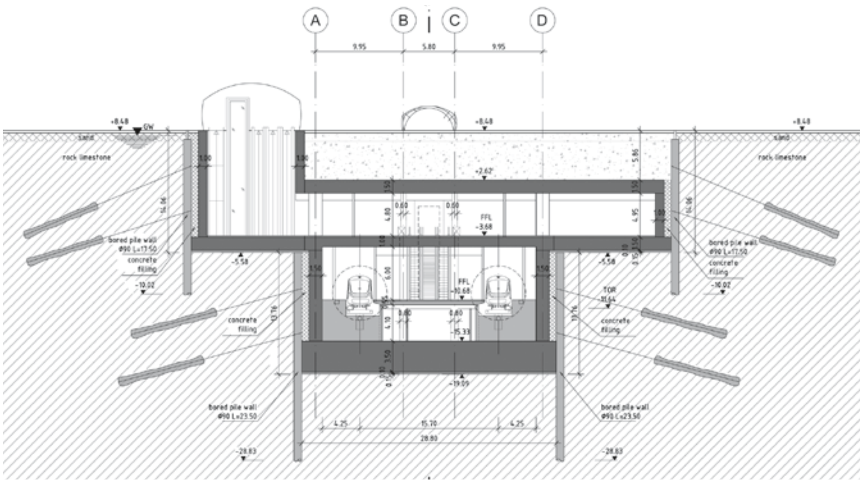


Fig.6, A typical station of this line is the so-called 'Silver I-Type underground station' with a central platform (120 m length, 15.70 m platform width, < 10,000 passengers/d) with a track system of around 17 m underneath the surface.

Fig.7, Urban Integration Plan of station Al Sadd - C – Ring

The roads are Doha's life lines. The entire traffic, individual traffic with cars and freight transport by lorries, runs day and night over the very spacious, sometimes more than 6-lane roads. The installation of inner-urban metro construction sites with the necessary traffic limitations, as we know it from Germany and Europe, was only tolerated by ASGHAL, the road construction authority, in some exceptional cases. This resulted in considerable traffic diversions as well as comprehensive temporary measures such as partial top-down construction method or huge temporary bridges.

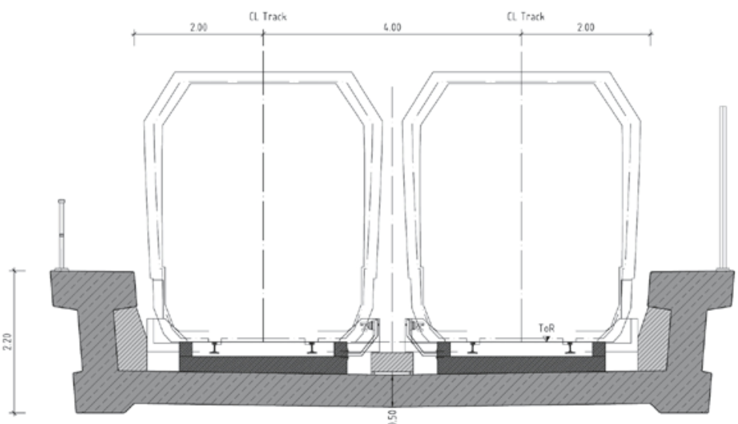


Fig.8, Selected trough cross section for the elevated track of Doha Metro

As the architectural branding, that is the major characteristic feature of the line and the stations, has not yet been defined – a separate architectural competition was launched for this purpose – the stations were designed according to a determined architectural standardized concept. Building technology (HVAC, MEP), but also the typical technological building equipment, has already been integrated in the draft design. Urban planning requirements and interfaces to railway equipment trades were also coordinated by SSF Ingenieure AG.

Work Order 4

After having completed the tender of the underground network sections, the next phase encompassed the basic design of overground lines. SSF Ingenieure AG was charged with the development of a standard girder for metro bridges for a so-called elevated track, comprising foundation, substructure and superstructure. After discussing different variants in view of possible cross sections, the client considered a trough cross section instead of a hollow box section or T-beam to be a suitable standard superstructure for Doha; this trough cross section has a regular length of 32 m. Aspects such as slenderness, integrated noise protection and additionally arranged visual barriers and noise barriers were regarded as particularly advantageous. Moreover, this superstructure allows a continuous girder system along the line without changing the cross section in the elevated stations as well as sufficient space in view of the external web design for architectural branding. Material orders, prefabrication in field factories, production type (full girder, segment type, in situ or prefabricated) as well as logistics for delivery and assembly were supplementary important criteria, which led to the choice of the most adequate standard girder.

For special areas, a solution differing from the standard girder had to be found in order to be able to realize larger span widths, e. g. to cross road intersections or branch-offs to the depots and sidings.

Therefore, SSF Ingenieure AG set up a so-called tool box, a track girder catalogue, which serves as guideline for bridge design and can be consulted by the route designers to demonstrated different situations in the alignment.

Design documents for the metro bridge standard girder as well as the concept for the modular construction system were submitted on time in August 2012 and are part of the current tender documents for the overground lines.

Road Bridges in Tiflis, Georgia

In the middle of the city of Tbilisi, traffic is newly regulated and guided over four new bridges. Continuing the traffic flow was one of the main priorities. The task of SSF Ingenieure AG consisted of finding an adequate bridge construction systems that could be implemented without influencing traffic too much and in consideration of very small radii and large slendernesses together with high earthquake risks.

A hybrid construction type was selected as combination of different construction methods in longitudinal bridge direction. In the areas where in situ concrete could be used, a conventional formwork method was applied, and in the areas of continued traffic a composite method with high degree of prefabrication.

The following structures were designed and built between 02/2012 and 09/2012:

Hybrid structures

Baratashvili Bridge:	99 m total length, 4 spans (16 m+30 m+30 m+23 m) approx. 1.7 m €
Laguna Bridge 02:	151 m total length, 6 spans (22 m+26 m+33 m+28 m+24 m+18 m), approx. 2.6 m €
Laguna Bridge 01:	258 m total length, 9 spans (2 x 24 m+3 x 27 m+30 m+3 x 33 m), approx. 4.5 m €

Reinforced concrete bridge

Kostava Bridge:	190 m total length, 8 spans (18 m+25 m+27 m+26 m+18 m+2 x 27,5 m+21 m), approx. 3.3 m €

total construction costs: approx. 12.1 m €

Client was a Georgian construction company from Tbilisi, which stipulated very tight design deadlines in the framework of the CRP (Caucasus Road Project). SSF Ingenieure AG's scope of services comprised the elaboration of a concept, draft design, stability verifications and final design of two superstructures 'by German standards'. For the other superstructures, final design was awarded to a local engineering office and examined by SSF Ingenieure AG. The design of the substructures and construction were executed by local design offices and construction companies.

Fig.9, Laguna Bridge 02, bottom view

Fig.10, Laguna Bridge 01, lifting of steel girder

Bridge concept hybrid construction/composite construction method

Focus was given to the design and execution of the steel composite superstructures with a slenderness of 1/25 and very strong curves with radii of up to 33 m.
The main load-bearing system consists of two steel hollow box girders prefabricated at the plant, which are stiffened by cross girders and which were rapidly lifted during nightly road closures by two mobile tandem cranes onto dampening elastomeric bearings. Then prefabricated concrete slabs were placed onto them and connected by grouting within the composite dowel pockets to the tightly welded steel boxes.
Arrangement of the reinforcement, construction of the in situ deck slab and fitting and final works on the bridge were carried out later on whilst traffic was continued.
Due to the extremely tight schedule, design, call for tenders and construction of all bridges were conducted in parallel within 6 months. After a short period during which bearing axes and abutments were defined, in February 2012 pile driving works started. All works were completed in September 2012.

Fig.11, Metro Algiers, network plan with expansions designed by SSF Ingenieure AG; L1B: blue, L1C: yellow

Metro Algiers Line 1, expansion C

After having successfully completed final design of the line expansion L1B, for which at the moment fitting works are carried out, SSF Ingenieure AG was charged in February 2012 with the line expansion L1C between Hai el Badr and Ain Naadja by the same construction company, Cosider TP; the design will probably last until the end of 2013.

Part of the design contract is an around 210-m-long necessary tunnel by cut-and-cover method at the beginning of the line, the adjoining overground station Halt des Ateliers, the underground terminus Ain Naadja 2 as well as retaining walls and two ventilation structures.

Basis is once again a tender design presented by the client. SSF Ingenieure AG's scope of services comprises the design of construction pits and shell works in analogy to service phases approval design and final design as per HOAI German fees order and based on Eurocodes. Communication is handled entirely in French. The design depth is adapted to German standards. Additionally, for some areas, draft design of final variants and alternative offers were required in advance.
Construction of some sections started already in the middle of 2012. At the moment the terminus, the tunnel and the ventilation structures are erected; the overground station is still in the design phase due to several modifications.

Contrary to the first lot (L1B), where at the beginning of the design several construction methods proposed by us led to intensive discussions and could only be introduced after detailed explanations and presentation of

references, the coordination process is handled now with mutual confidence, founded on technically and economically proven solutions and much faster and more targeted.
The cooperation with the construction company Cosider is on the whole very cooperative and constructive, even more so as Cosider is familiar with the German way of thinking due to its long-time experience with German construction companies.

Summary

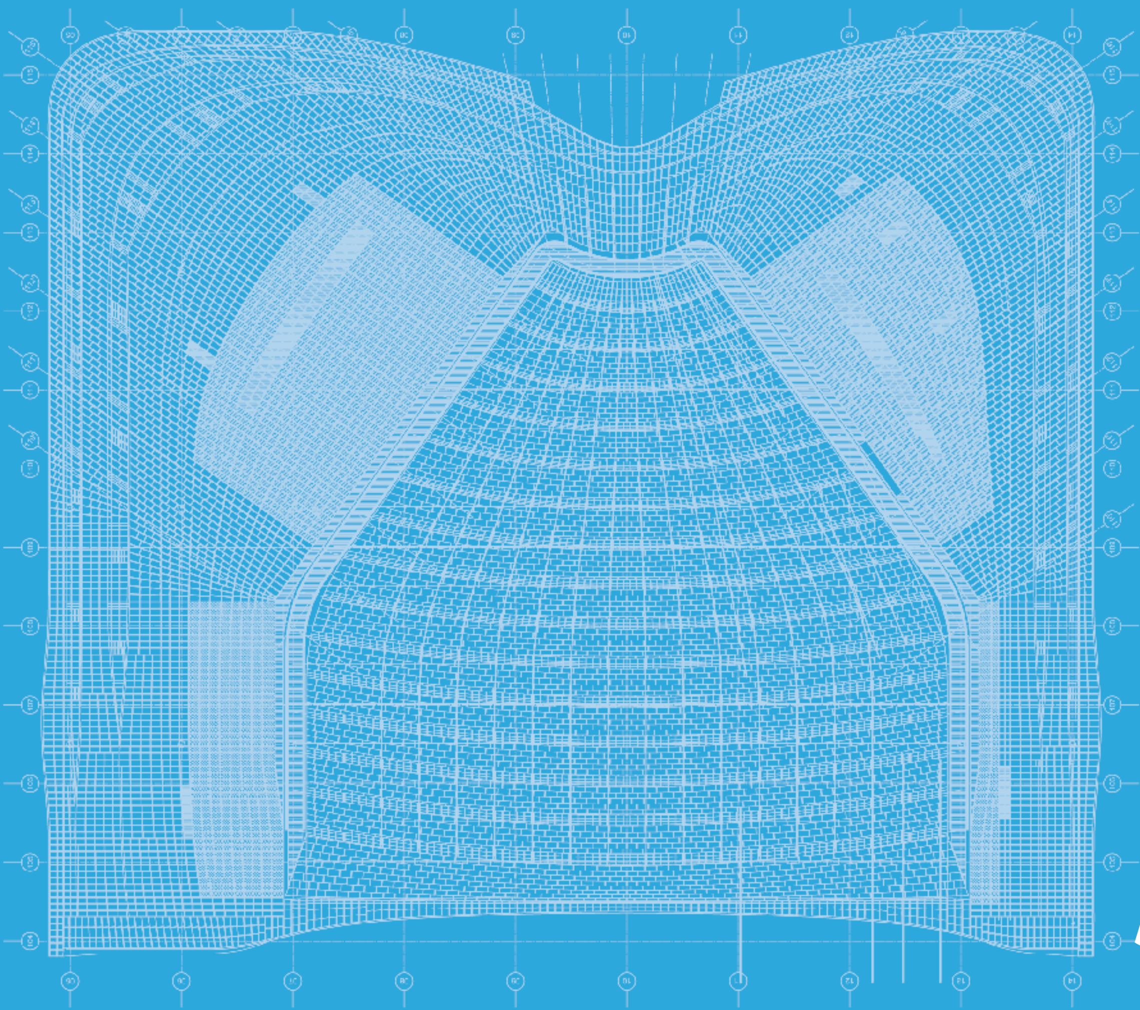
In particular abroad our engineering services have to be questioned constantly and design processes have to be adapted. Often intensive coordination processes are required in a culture and mentality that is foreign to German designers, and to which they have to adapt. Design, examination and approval often diverge considerably from well-known and habitual procedures.

Particular attention should be paid to local construction methods and local quality requirements that can have a restrictive effect on design approaches customary to us.

In summary, each project abroad presents a challenge that can only be mastered successfully with the vast experience from SSF Ingenieure AG's core business, by team work in dialogue with the back office and assignments on location, personal commitment to travel as well as a high willingness to adapt to foreign culture and design. In general, individual solutions are required for each market that differ from a standard design. But this is what makes working abroad so exciting and interesting.

Fig. 12, Terminus Ain Naadja 2 area west, concreting of floor slab

Fig. 13, Terminus Ain Naadja 2 area east, concreting of floor slab



3

From Visualization to Realization – Les Halles Paris

Lecturer: Dipl.- Ing. Ferdinand Tremmel

More than 30 years ago, Les Halles have been inaugurated in Paris. Due to the yearly increasing volume of passengers, a combined conversion and new construction was needed. The old forum Les Halles did no longer correspond to requirements. With around 800,000 passengers daily, Les Halles is the largest transport hub of metros, regional train lines and pedestrians in Europe.

The building ensemble is used in various ways. In addition to its function as transportation hub, Les Halles is the largest culture, leisure and shopping centre with more than 160 shops, 26 cinemas, the largest swimming pool in Paris, libraries, theatres and concert halls as well as numerous restaurants. The conversion can only be implemented gradually and under ongoing operation. The conversion costs amount to over 800 m € net.

Fig.1, Les Halles in Paris, La Canopée, visualization

Three clients sign responsible for the project:

- City of Paris (developer of the Canopée)
- RATP (Régie autonome des transports Parisiens), the Parisian transport operator, responsible for all metro and regional train construction projects in Paris
- shop operators association Société Civile du Forum des Halles de Paris

In 2006 an independent architectural competition was launched. The key project was to design a building that exceeds the tree line, merges with the adjoining park, guarantees traffic flow and provides a culture of space with the mix of shopping arcade and public building. On June 29th, 2007, the French architects Patrick Berger and Jacques Anziutti were selected as winners by the jury. The futuristic architecture of the building envelope is a new milestone in the heart of Paris, similar to the Eiffel Tower in 1889.
The overground part of Les Halles 'La Canopée' is formed by a curved building of which the shape arises from nature. 'La Canopée' means canopy; the roof melts, at a height of around 15 m over the ground with the crowns of the trees in the adjacent park. The structure's overground parts offer on three floors (levels L1, L2 and TT) a usable area of around 14,000 m², and are divided into three essential sections: the south wing (bâtiment sud), the north wing (bâtiment nord) and a roof spanning up to 95 m over the inner courtyard (patio).

Each floor has at its borders a cantilever roof as sun protection, called awnings. These awnings project up to 8.5 m and are supported by compression struts.

Fig.2, Les Halles in Paris, La Canopée, visualization

The glass and façade manufacturer Seele from Augsburg, Germany, won with its branch in Schorfling, Austria, the contract for construction of the multidimensional bended building envelope. Part of this order are the secondary steel works with a total volume of around 1,000 t of steel as well as the around 11,000 m² coloured and partially highly bended, walkable special glazing, which has been developed by Seele especially for this project.
SSF Ingenieure AG was charged as engineering office with the design by company Seele. The design comprised draft and approval design as well as final design and workshop drawings of the secondary steel works of roof and façade.

Fig.4, Perspective with view from diagonally above, on the left the south wing, right the north wing and the roof over the courtyard

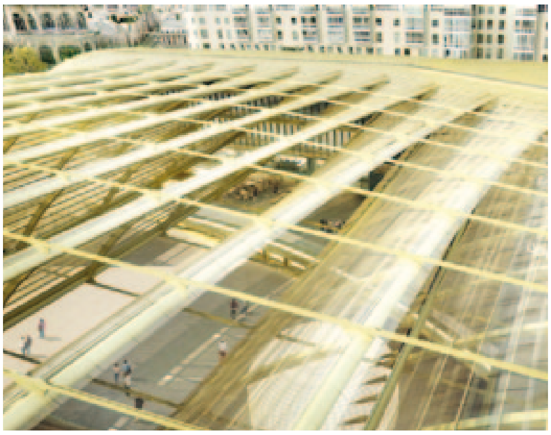


Fig.3, Perspective with view from the top on the 95-m-wide spanning roof

Fig.5, Perspective with view from below onto the roof and the courtyard's façade

On the basis of spatial 'rhino models' of the free-form roof, SSF Ingenieure AG established all structural stability analyses as well as all plans and lists, based on steel works overviews and complete workshop drawings, including all connection details, by means of most modern software in 3D. Structural analysis and the completed design were handed over via CNC interface to the steel construction company for manufacturing.
In order to better estimate surfaces and colours of the structure, individual parts of the building are planned in detail as master object, so-called mock-ups, and implemented on location.
The entire project was submitted in accordance with French national application documents of EC3. All documents were written and handed over to the inspecting engineer in French. Furthermore, SSF Ingenieure AG, as international engineering company, supported the company Seele during project meetings and project processing in Paris.

Fig.6, The implemented mock-up

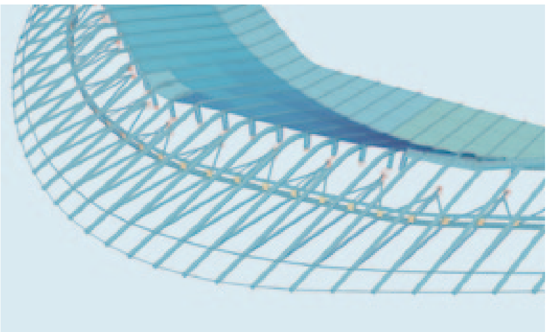


Fig.9, Section of rhino 3D overall model

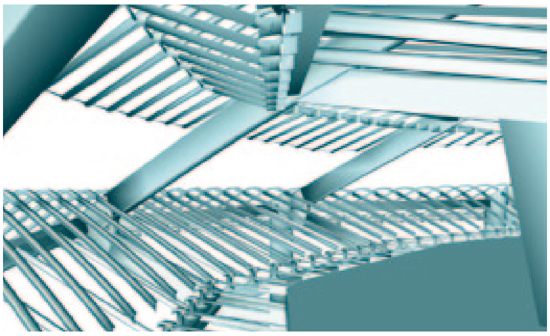


Fig.10, Structural system category 1, Sofistik

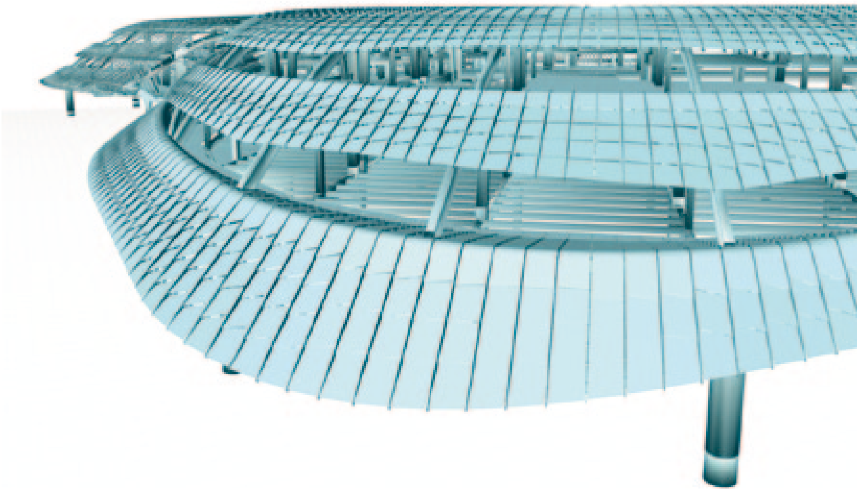


Fig.8, Section of rhino 3D overall model

SSF Ingenieure AG's scope of services entailed:

1. Definition of design criteria
2. Pre-dimensioning/quantities forecast
3. Frame statics of secondary steel works/interaction with primary structure/optimization of material and dimensioning
4. Detailed structural analysis/detail development/ regular detail concept for manufacturing and assembly optimization
5. Load take down plans/system design load insertion
6. Participation at assembly planning/assessment of all temporary actions and structural implementation

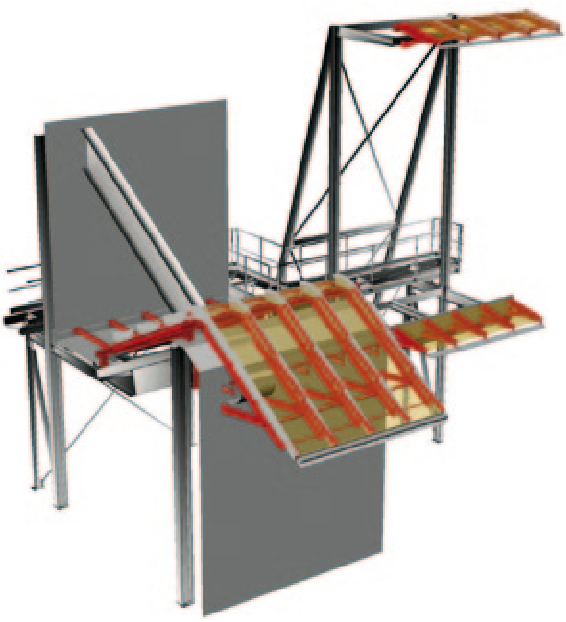


Fig.7, Perspective with view from the top on the mock-up

Structure's Data:

- Largest inner-urban transportation hub in Europe
- New construction and conversion under continued operation
- Construction costs over 800 m € net
- Usable area La Canopée on 3 floors around 14,000 m²
- LxWxH La Canopée approx. 135 m x 155 m x 15 m
- Steel of roof envelope approx. 1,000 t
- Over 11,000 m² partially bended, mostly walkable and coloured glazing developed by company Seele with individual case approval
- Workshop drawings completely in 3D with Thekla

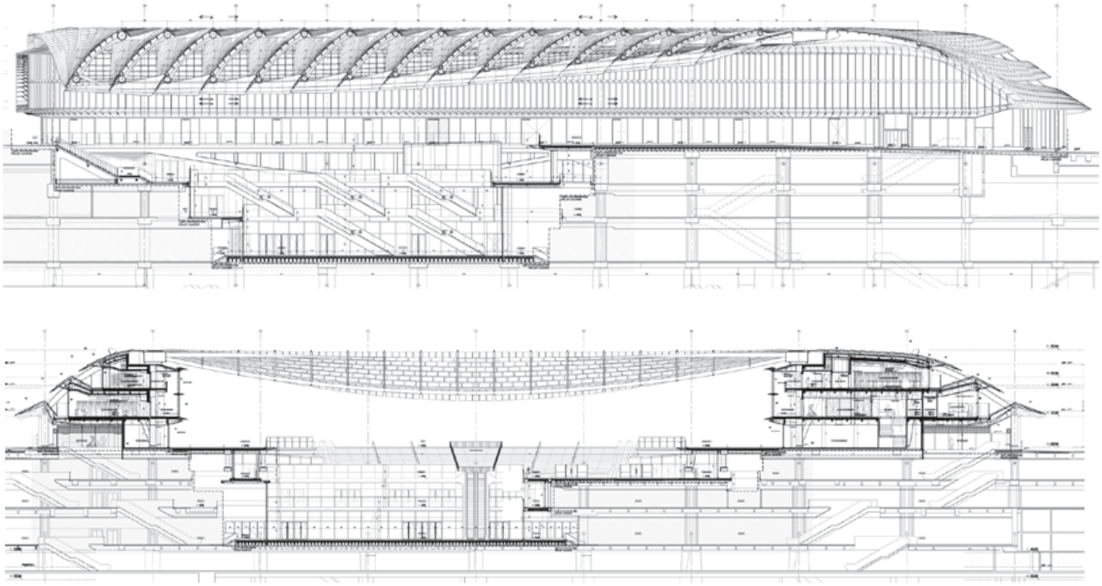


Fig.11, Section of the building in east-west (top) and north-south direction (bottom)

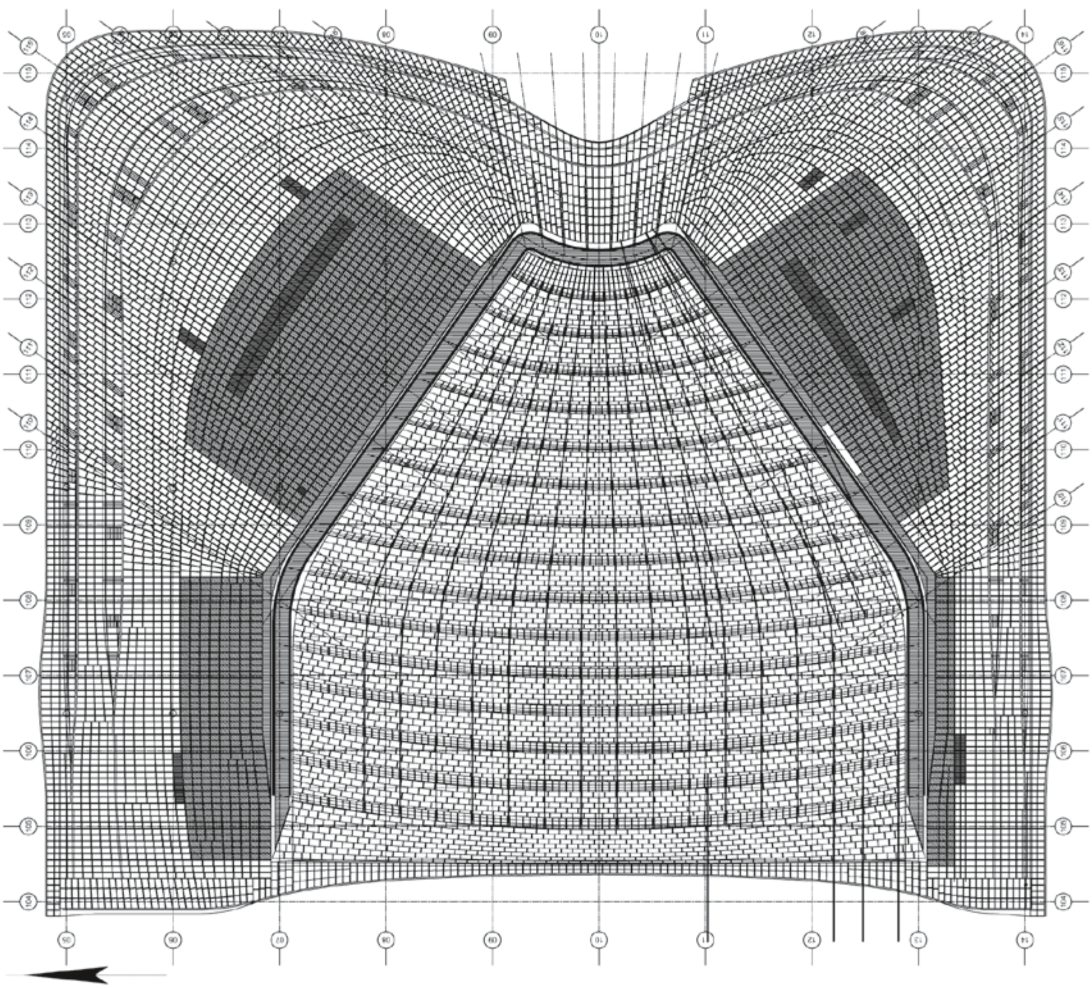


Fig.12, Ground plan

Motorway A9 – Hard Shoulder Release between Access Allershausen and Interchange Neufahrn

14 km of motorway in four month

Lecturer: Dipl.-Ing. (FH) Thomas Wolf / Dipl.-Ing. Stephan Lindner

General information

Because of the high traffic volume of over 100,000 vehicles per day between interchange Neufahrn and interchange Holledau, a temporary hard shoulder release and a traffic guidance system are arranged as quick interim solutions so that during times of high traffic frequency, the capacity of motorway A9can be considerably increased.
In the two previous construction sections between access Allershausen and interchange Neufahrn, the hard shoulder has already been released in one direction so that the third section comprised the release of the opposite lanes.

Fig. 1, Overview map of the entire project 3rd construction section: direction Nuremberg: section north approx. 9 km; direction Munich: section south approx. 5 km

The total project of the 3rd section was divided in sections north and south:
- direction Nuremberg: section north, from structures BW 93 to BW 109 (approx. 9 km)
- direction Munich: section south, from structures 110 to 120 (approx. 5 km)

Construction phase 1 comprised the renovation and widening in the areas of the 2nd and 3rd lane within a central construction site. Afterwards, during phase 2 the external areas of lane 1 and the hard shoulder were renewed.

In the course of the road and bridge construction project, mainly the following services were delivered:

- upgrading of the hard shoulder and the 1st lane – fundamental renewal (2nd phase)
- renewal of the bituminous superstructure of the 2nd and 3rd lane (1st phase 'central construction site')
- installation of a noise reducing thin asphalt layer paved 'hot on hot' (DSH-V layer)
- construction of emergency bays (approx. every 500 m)
- conversion of access with acceleration and deceleration lanes relocated to the outside
- general renovation of underpasses (within two construction phases)
- renovation of bridges (within two construction phases)
- renovation and new construction of drainage installations
- new construction of passive safety devices (vehicle restraint systems)
- construction of in total 9 sedimentation installations
- traffic management and traffic safety (two traffic guidance phases)

From as-built surveying to geometrical road surface data

A detailed and exact as-built surveying together with the elaboration of a levelled fix point network are indispensable bases for each road and structure design. To guarantee a flawless elevation grid for this very long

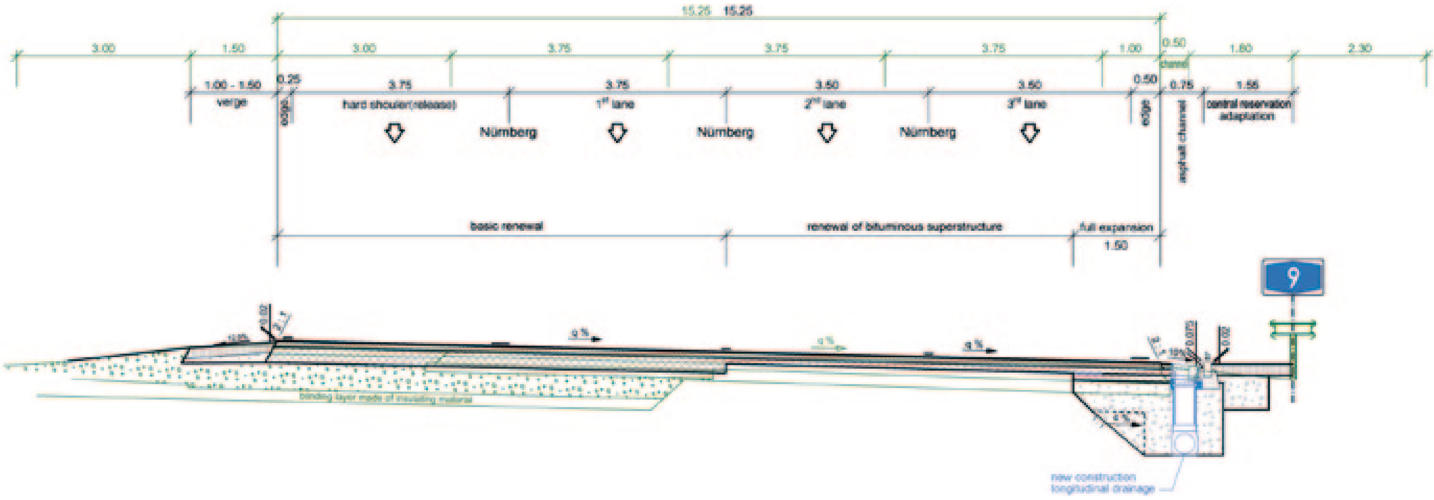


Fig.2, Regular cross section of hard shoulder release

construction site, on both sides of motorway A 9 on a length of 36 km, double levellings were conducted for the entire project, which were marked with in total around 250 fix points.

This net of fix points, adapted by situation and height to the Bavarian system, was given to the executing companies as basis for construction surveying.

When constructing in the existing network, it is especially important that the fix point system of construction surveying corresponds exactly to the fix point system of as-built surveying.

With a total traffic area of 250,000 m^2 of the 3rd section, the exact as-built surveying served to precisely determine quantities in the framework of tender design and later on to control calculations of the construction companies.

Deviations of the two fix point systems lead inevitably to interruptions of the construction process with construction delays and supplementary contract claims.

The calculations of geometrical road surface data for the hard shoulder release required a new indispensable terrestrial surveying of the existing carriageway edges as the already existing surveying data were an incomprehensible mix of tachymeter and GPS surveying resulting in elevation inaccuracies of up to 8 cm.

The two carriageway edges were surveyed with a point distance of around 50 cm in a straight line and around 20 cm in radii (curves, crests, sags), were interpolated in a point sequence with 5 m distance and the inner edge of A 9 was calculated as longitudinal profile.

As the thickness of the existing superstructure did mostly not correspond to construction class SV, in the framework of the renovation around 12 cm of the surface were milled off and a 20-cm-thick asphalt layer was applied so that the road surface is 8 to 10 cm above the existing road. This means that the upgrade was carried out with an overlay of 8 cm.

On the basis of the elaborated longitudinal profile, a compensation gradient with an elevation of 7 to 11 cm, on average 8 cm, was calculated. Deviations of all basic points were verified at a distance of 5 m by a constraint point diagnosis and if required corrections of the gradient were adopted.

Additionally, every 5 m the profile of the newly constructed areas was compared to the existing profiles and an optimum course of the transverse incline similar to the existing one was defined so that deviations remained within an acceptable margin

Structure renovations with continued traffic

Existing Situation

The underpasses in the central area, corresponding to lanes 2 and 3, are partially structures from the years between 1937 and 1939 with 2+2 lanes without hard shoulder. In the years 1975 to 1977 the structures were expanded at the outer edge by one lane each plus one hard shoulder. The 'old' structures mostly remained. The superstructures of the underpasses were partially widened (annexes) or completely renewed.

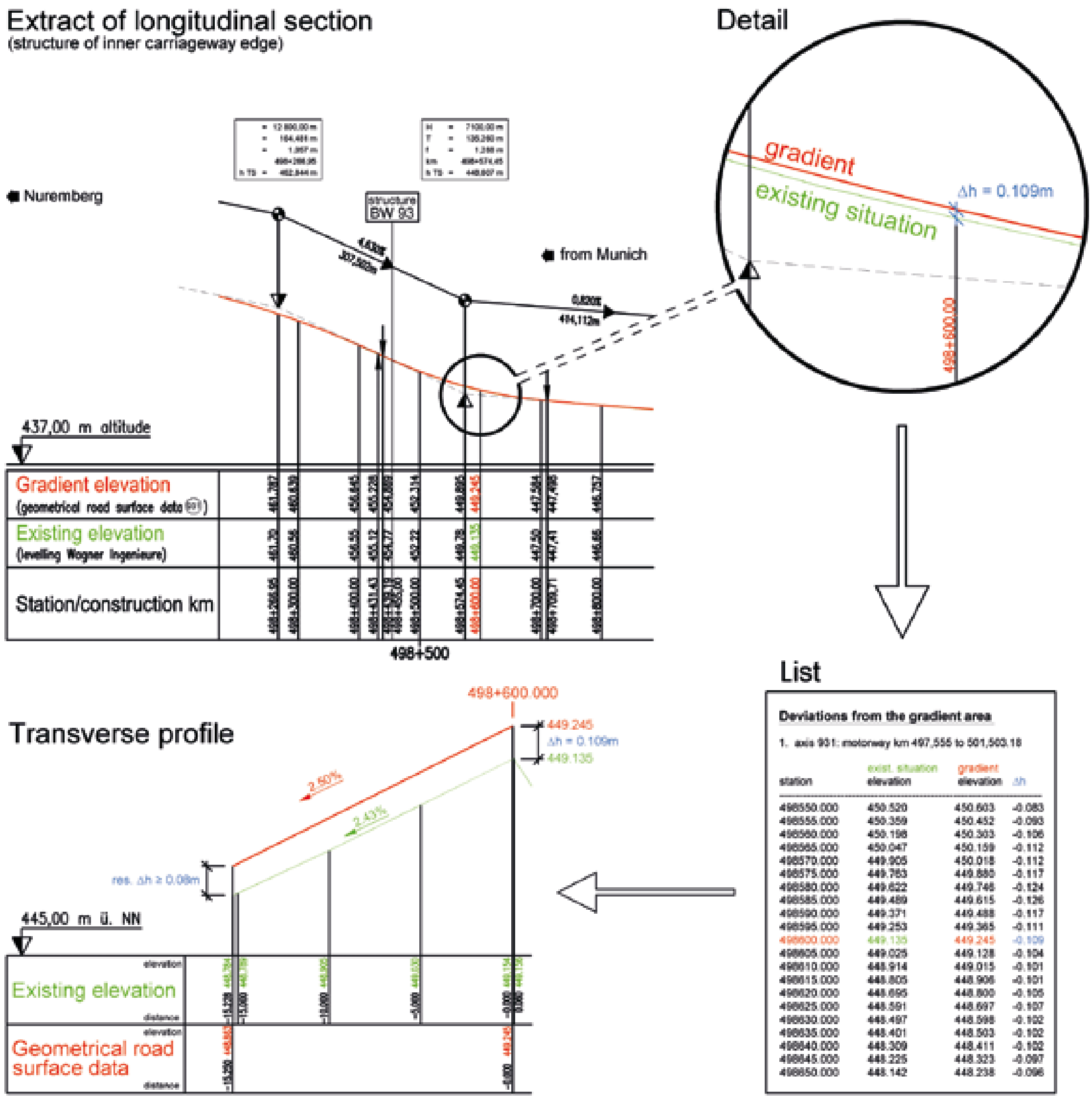


Fig.3, Elevation plan, transverse profile, deviations

Renovation of engineering structures

- Asphalt, caps and sealing at the underpasses were demolished (see Fig. 6 and 7).
- Due to the thick asphalt layers on the structures, it was decided in advance to keep the regular road structure together with a strengthening concrete on the existing superstructure's concrete.
- After the installation of composite dowels and reinforcement on the uncovered superstructure, the strengthening concrete was applied (see Fig. 9 to 11).
- Afterwards, the new sealing was applied and the new caps were concreted. The caps' front edge on the side of the lane was shifted by around 0.5 m to the outside (cap width thus 0.5 m narrower). Finally, new railings and protective devices were assembled (see Fig. 12).

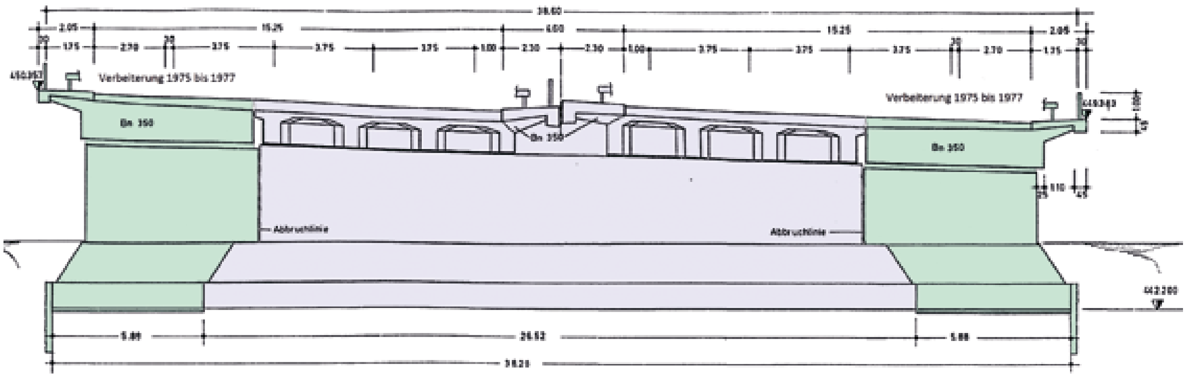


Fig.4, Cross section structure BW 107; initial structures from the years 1937-1939 and lateral widening areas from the 70s

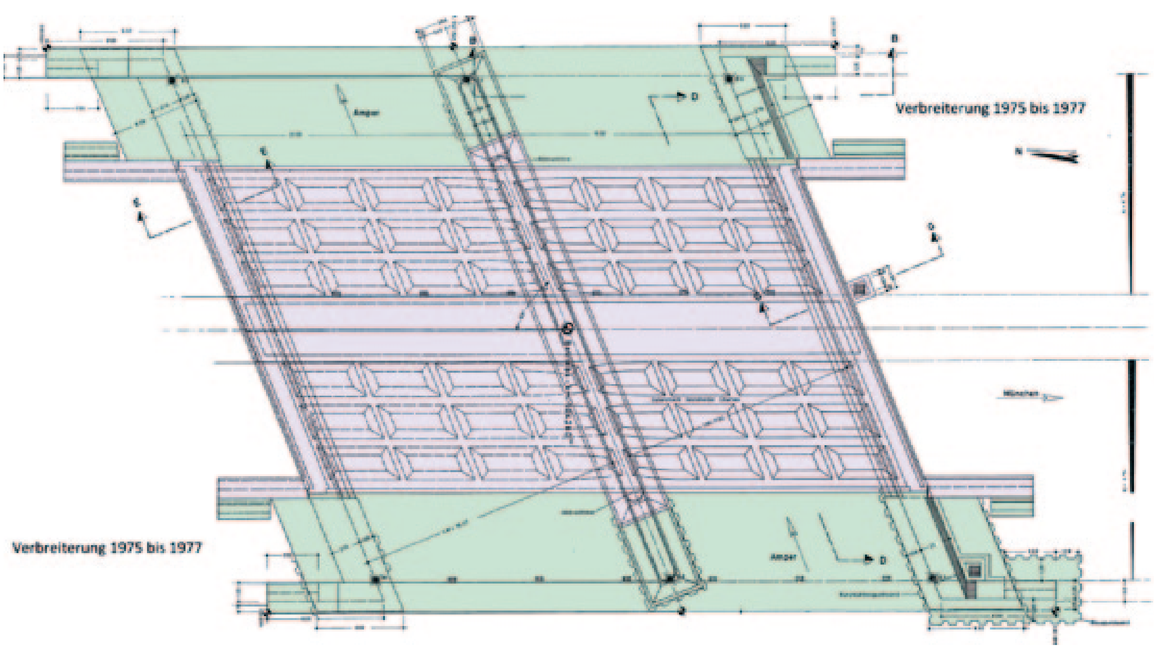


Fig.5, Top view BW 107

Fig.6, Demolition of caps and sealing

Fig.7, Demolition of asphalt, caps and sealing

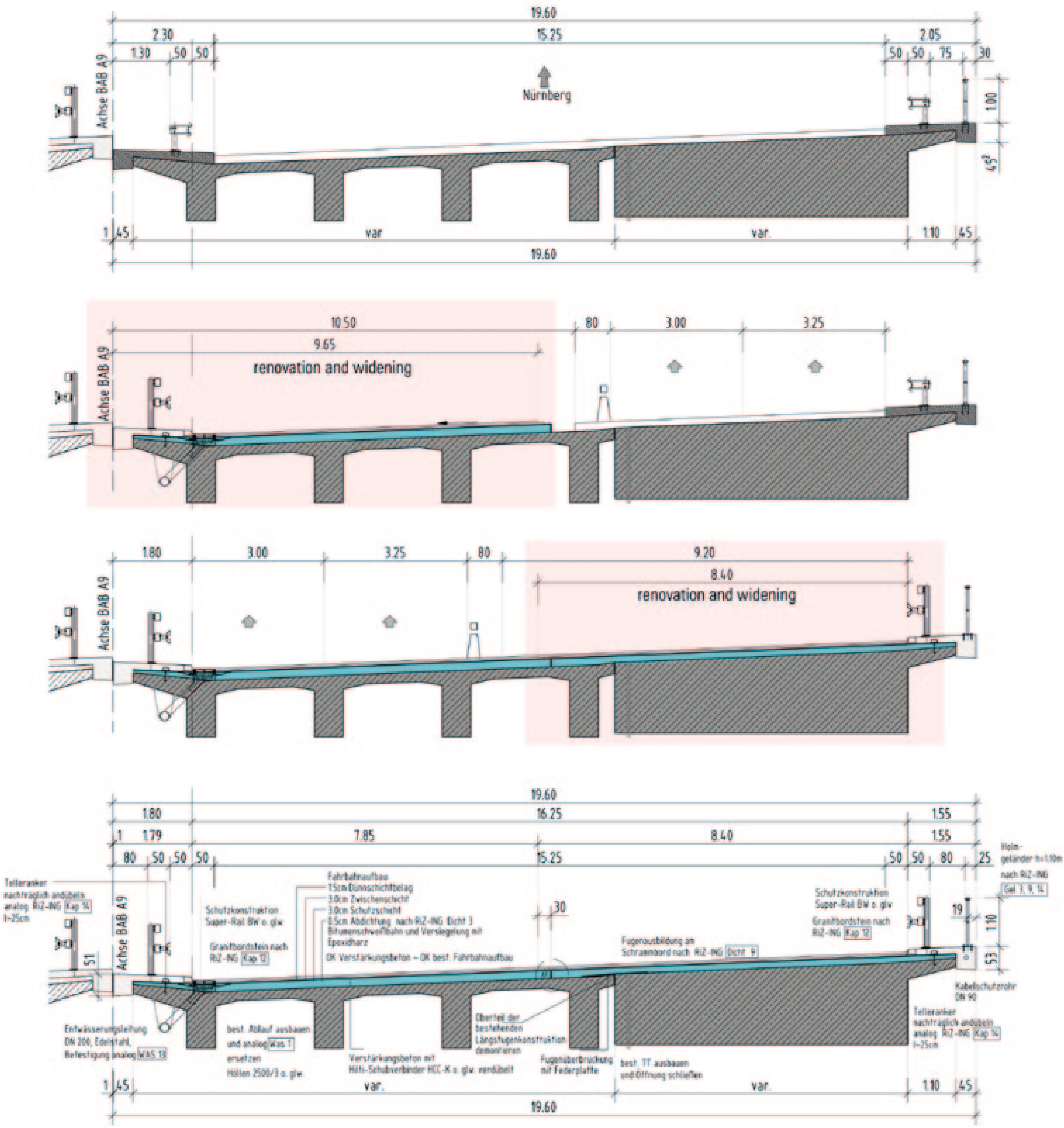


Fig.8, Regular cross section structure BW 107
top: as-built
centre top: construction phase I
centre bottom: construction phase II
bottom: final stage

Fig.9, Installation of composite dowels and reinforcement on the uncovered superstructure

Fig.10, Installation of new transitions at two structures

Fig.11, Installation of strengthening concrete

Fig.12, Completion of the structure

Challenges during the execution of the construction project

The contractual construction time, including installation and demounting of traffic guidance systems on the motorway, was less than four month. Within this period in the framework of two traffic phases (central construction site with 2nd and 3rd lane and the external area with hard shoulder and 1st lane), all road construction and bridge renovations had to be completed.

To make things even more complicated, after construction started but before demolition works began, the as-built heights of the structures had to be assessed and then integrated into the final design.

Due to the minimum construction time of only four month and a cost range of in total 28 m € net, of which 5.5 m € for bridge construction, works took place on the road and all structures mostly simultaneously and around the clock by 24-hour operation on seven days per week.

In particular, the central construction site (1st construction phase) had to be logistically precisely planned by the construction company and the construction supervision, and was nonetheless very time consuming as the central situation of the construction site was only accessible via the motorway. The structure further back was accessible by going over the individual lane to the next access (Schweitenkirchen), then back to the construction beginning (interchange Neufahrn) and back to the construction site of the structure itself. This resulted in one-way routes of up to 56 km.

Scope of services Wagner Ingenieure GmbH

1. As-built survey of carriageway
2. Project planning of traffic installations
3. Traffic management design during construction

Scope of services SSF Ingenieure AG

1. Partial project planning and structural engineering
2. Plan verification
3. Construction supervision and partial construction management of engineering structures

Project overview

- length	14 km
- emergency bays	17
- renovated underpasses	17
- renovated bridges	9
- renovated culverts	2
- newly constructed retaining walls	2
- relocated acceleration and deceleration lanes to the outside	6

Danube Upgrading Straubing – Vilshofen

25 Years Consolidated Study by GIS of Ecological and Environmental Planning Facts

Lecturer: Dipl.- Ing. landscape architect Prof. Dr. Jörg Schaller

The Federal Republic of Germany, represented by the Ministry of Transport, Building and Urban Development as owner and operator of the German waterway Danube, and the Free State of Bavaria, represented by the Bavarian Ministry of Economy, Infrastructure, Transport and Technology, have been planning for decades several hydraulic engineering projects to improve navigation on the Danube between Straubing and Vilshofen. Both bodies are supported and represented by the Rhein-Main-Donau AG and its subsidiary RMD Wasserstraßen GmbH, Munich, during the design and its implementation.

Fig. 1, Do-GIS as methodical support of environmental balancing and forecast

The expected environmental effects of the planned Danube upgrading between Straubing and Vislhofen have been analysed for the last 25 years by means of GIS (geographic information system) and evaluated in terms of nature protection, and the future situations (forecasts) have been compared to the current state of the Danube and its marshes. The GIS models also provide an important basis for prognosis (calculation of location potential, chain of effects, risk maps of existing situation).
In the context of this GIS-based environmental planning, the planning office Prof. Dr. Jörg Schaller (PbS) and its legal successor Prof. Schaller UmweltConsult GmbH, Munich, have been supporting the federal waterways authority for the last 25 years.

The Ecological Study 2001 established by PbS serves as basis for the environmental impact assessments, also written by PbS, for the regional planning procedure successfully completed between 2004 and 2006 of the upgrading variant C 2.80.
Already in 2000, the Do-GIS was set up as geo-database for the project and was permanently further developed.
Do-GIS serves since then as methodical support for:

- as-built assessment
- attribution
- balancing
- comprehensible evaluation of balancing results
- forecast and variant study
- planning optimization
- presentation (cartography)
- documentation and filing

Fig. 2, Situation of the study area, approx. 25,000 ha

In the mean time, on this section of the Danube waterway of around 69 km length and encompassing a study area of around 25,000 ha, different upgrading variants have been analyzed (fluvial regulations with groynes and longitudinal dykes, damming stages with different retention levels and with or without drainage cuts or side canals).

After the regional planning procedure, the German and Bavarian governments have agreed on the examination of variant A, a pure fluvial variant comprising the construction of a navigation channel 2.35 m deep at regulated low water level, as well as variant C 2.80 with an inflatable dam with lock channel and a navigation channel of 2.80 m depth at regulated low water level. Since 2009 the effects of only these two variants on shipping and the environment have been studied, forecast and evaluated. To assess the intensity of those two upgrading variants, the current environmental state in the planning area serves as basis for comparison.

Fig.3, Principle of fluvial regulations of variant A

Fig.4, 'Mühlhamer loop' – not only a nautical challenge!

This study determines – independently from the variant – technological and ecological details of the Danube upgrading. Of the estimated costs of around 33 m €, 50% are supported by the TEN financing of the European Commission. The remaining 16.5 m € are financed by the federal government and the Free State of Bavaria in the ratio of

Fig.5, A barrage near Aicha is the essential difference between variant C 2.80 and variant A.
Exemplary visualization during mean tide.
An inflatable dam with four openings and temporary water level support is being evaluated.

2 to 1. The grant information of the European Commission was published on Nov. 20th, 2008 (source: WSD Süd 3/2012). The study was completed on time at the end of 2012.

The environmental planning analyses has already been developed to an extent necessary for plan approval procedures so that with a political consent plan approval can start immediately.
Therefore, during the processing of environmental requirements, all current legal regulations applicable to plan approval procedures, especially EU nature protection guidelines, were taken into consideration.

The establishing of environmental planning contributions was awarded to the joint venture Danubia, an equal union of the three planning offices Prof. Schaller UmweltConsult, Bosch & Partner and Jestaedt + Partner. Moreover, the ichthyo-ecological sections of the environmental planning were processed by the joint venture Donauplan, another union of three companies. For each of the two upgrading variants, the joint venture Danubia elaborated the following contributions:

- environmental impact study as per German environmental compatibility act, incl. German waterways general guideline (WRRL)

- FFH compatibility study as per flora-fauna-habitat guideline, incl. coherence measures concept
- species conservation report (special conservation assessment)
- landscape conservation plan

In addition to independent expert activities and cartography of the above listed areas, Prof. Schaller UmweltConsult GmbH elaborated the GIS-technological bases with ArcGIS 10.1 (full version), such as:

- digital ground model (DGM) from 1x1 m airborne laser data (ALS) for the entire area of around 200 km^2 as terrain, grid and vector data (actual state and variants)
- water impact line of seven different stationary Danube and Isar flows, by means of water levels provided by the client (actual state and variants), map of the flood areas and their duration as 1x1 m grid and vector data
- depth to the groundwater table for several stationary water levels (actual state and variants) provided by the client as 1x1 m grid and vector data
- calculation of the clay layers' thickness in the marshlands on 69 km by means of provided data of around 15,000 soil core samplings and several thousands of exploration drillings and dynamic probings as well as laser DGM
- location potential maps, based on model regulations and pre-calculations of the German Institute of Hydrology as 1x1 m grid and vector data
- habitat backdrop for indicatory particularly significant characteristic species of FFH habitat types
- technical overall control, coordination and quality control of the fieldworks conducted in 2011 (GISPad supported) for the overall recoding of plant associations, FFH habitat types, all biotope types incl. § 30 of German nature protection act and article 63 of Bavarian nature protection act as well as forest structuring maps (tree type composition, age class proportions, dead wood proportions, etc.); around 500 differentiated polygons
- technical overall control, coordination and quality control and partially implementation of digitalization, evaluation and documentation (e.g. meta data) of results of the above indicated ground assessments

Parallel to the study of environmental requirements relevant for approval of the planned Danube upgrading, the joint venture Danubia assessed the environmental impacts in the section between Straubing und Vilshofen of a comprehensive flood protection concept, also to the extent required for approval procedures; this assessment was then integrated into the corresponding environmental sections for the later following approval procedures.

The comprehensive flood protection concept for the entire section of 69 km length is currently further elaborated for variant A. The Bavarian Government provides another 315 m € of special funds until 2024 for implementation of flood protection. Already in 2013, construction of another flood protection project will be started for which an initial

Fig.6, Today's dams offer protection against flood occurrences as they happen every 20 or 30 years.
Based on landscape development programmes, it is intended to install protections against these flood events for settlement areas and important infrastructure installations.

funding of over 100 m € is made available. At 35 advanced flood protection projects with a total value of around 200 m €, works are in full swing since 1999. Until know 24 projects were completed, two more projects were finished in 2012 and 6 measures are in the design phase. Prof. Schaller UmweltConsult GmbH is directly, and through the joint venture Danubia charged with the development of environmental planning documents and success control of compensation and replacement projects of some of the advanced flood protection projects.
In the run-up of the regional planning procedures suc-

cessfully completed for variant C 2.80, the planning office Prof. Dr. Schaller, Kranzberg, established by ArcGIS different visualizations of the upgrading design, which has been optimized in the mean time. The then ground model, vegetation and surface use maps as well as ortho-aerial images were superimposed by 3D geometry. The technical design was also converted to 3D geometry. The future vegetation and the planned buildings were represented as 3D structures.

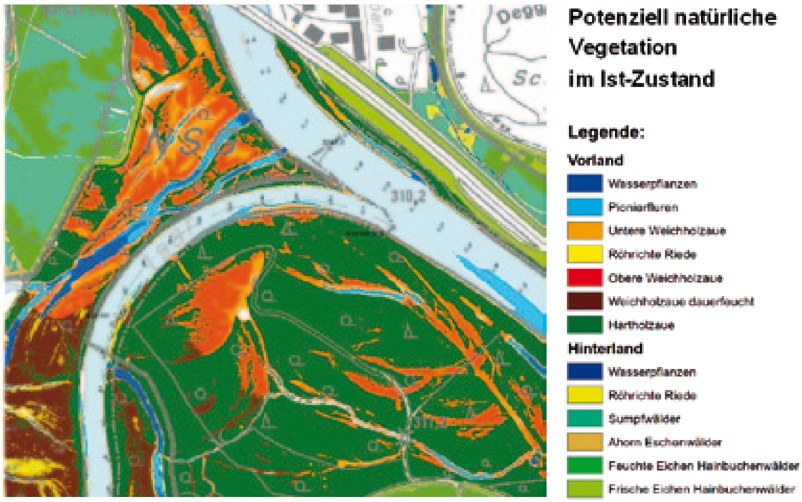


Fig.9, Location potential map (1x1m grid) as result of the model calculations of the German Institute of Hydrology

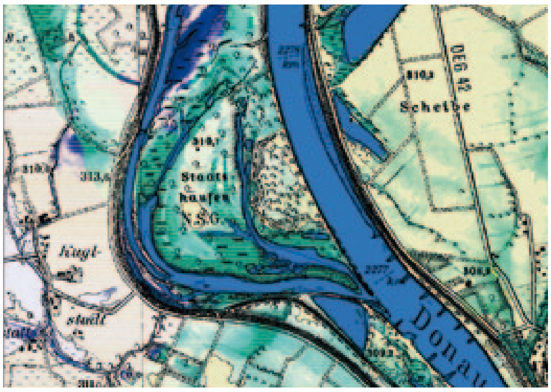


Fig.7, Map of the groundwater level height for the regional planning procedure

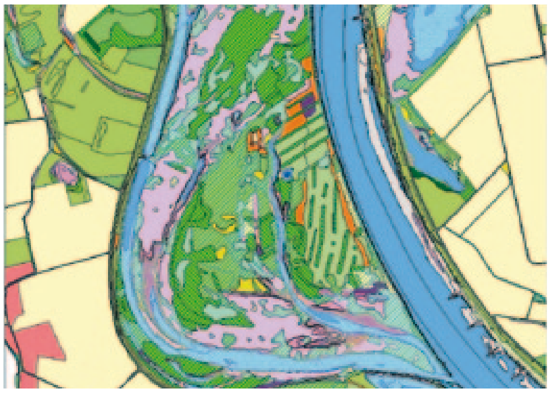


Fig.10, Mapping of plant associations 2011

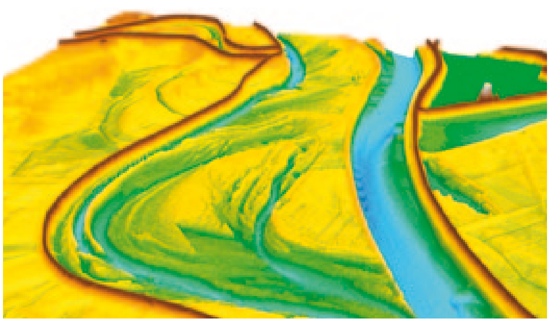


Fig.8, Laser DGM 2011 (1x1m), combined with sonar data DGM in the Danube from 2011

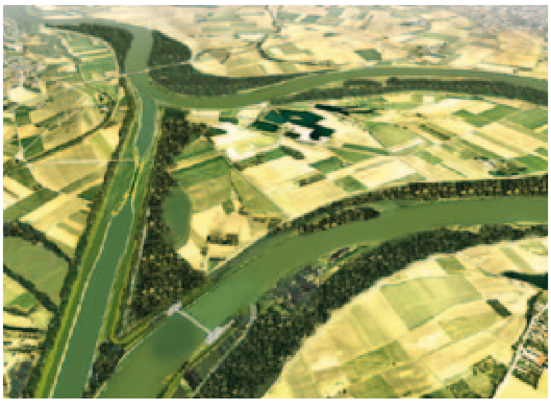


Fig.11, Visualization for regional planning procedure of the lock channel planned in variant C2.80 and the overground barrage near Aicha

6

Overview Infrastructure Projects of Railway Facilities

Lecturer: Dipl.- Ing. (FH) Holger Knippschild

Introduction

The railway infrastructure in Germany and all around the world is faced with constantly changing requirements, which demand regular adaptations of the existing railway and construction of new lines and belonging installations.

In addition to upgrades and new construction of infrastructure, the replacement of existing parts of the network that have come to the end of their life cycle plays an important role in order to guarantee the availability and optimum use of track installations for railway companies.

Independently from the commissioned building trade, a railway installation is not to be considered solely as part of a transportation installation or engineering structure. There are, moreover, many boundary conditions and influences of the system, which is as a whole very complex, especially in view of high operational availability requirements, to be taken into account. The designing engineer faces the challenge to coordinate the interaction of structural installation, railway technical equipment and operation in consideration of construction with continued railway traffic; all this through intensive exchange with his colleagues from other trades and as an integral process to form the entire system to one functioning unit.
This very interesting field of action with the alignment and design of railway superstructure, belonging civil works as well as project planning of engineering structures, from feasibility studies, draft design and call for tenders to final design, is the area of responsibility of SSF Ingenieure AG's department 'Civil engineering/Railway transportation installations'.

A huge advantage for the comprehensive interdisciplinary and integral consideration of each project is that with the geologists from Baugeologisches Büro Bauer GmbH, the environmental planners from Prof. Schaller Um–weltConsult GmbH and the transportation planners from Wagner Ingenieure GmbH three specialist planners are in direct vicinity, integrated into the organization of the SSF Group, and with whom an intensive interdisciplinary exchange has become natural.

The following short project descriptions represent an overview of SSF Ingenieure AG's expertise and of portfolio of design services:

- railway transportation facilities, ballasted track and ballastless track
- Bridges- and civil enggineering
- civil works and earthworks
- passenger transport installations

Fig. 1/2, New railway line Nuremberg – Ingolstadt, ballastless track, station tracks with ballasted superstructure, civil works on the line, railway bridge, earthworks and embankments, passenger transport installations, cable engineering, noise barriers, retaining structures

Due to the high number and variety of projects of the department Civil engineering/Railway transportation installations the following summary is limited to a small part of our references. The focus is on railway alignment projects and the design of track superstructure and civil works.

Ballastless track Roitzsch - Hohenthurm: Line 6132, Bitterfeld - Halle/Saale

This project was executed under enormous time pressure. From February to April 2013, final design comprised the renewal of the superstructure of the double-tracked, electrified line from km 136.0+00 to km 150.9+00, part of the line 6132 Berlin Südkreuz to Halle Central station, including the continuous main tracks at station Roitzsch, stop point Brehna and station Landsberg as well as the therein integrated switch connection and crossovers. Realization was to be completed until June 2013.

The tracks on the line were implemented as ballastless track system Bögl (prefabricated system). The switches and crossovers are of type Rheda 2000. The tracks in the stations are ballasted and are connected to the ballastless track by transition joints.

The dismantling of the old ballastless track FFYS (Y steel switches on asphalt layer) requires the adaptation of the central drainage and in the stations' areas its complete renewal.
The line is also equipped on a length of 8.7 km with light concrete noise absorbers of type Briest System Liakustik.

SSF Ingenieure AG's scope of services included the final design of transportation facilities and engineering structures. Structural engineering comprised approval and final design.

The ballastless track superstructure of the main track on the open line, station tracks and bridges were designed with transitions from ballastless track type Bögle to ballasted track, from ballastless track type Bögle to ballastless track type Walter (existing line) and from ballastless track type Bögle to ballastless track type Rheda 2000 (switches).
Furthermore, SSF delivered the designs for the adaptation of the drainage installations on the open line, the renewal of drainage installations at stations Roitzsch and Landsberg and the installation of noise absorbers type Briest System Liakustik with the corresponding environmental information act applications for ballastless track, switches and noise absorbers.

Design parameters resulted in the following ballastless track system requirements:

- continuous main tracks are to be driven on with a design speed of 200 km/h; on the station tracks the speed is 60 km/h; crossovers are planned for 100 km/h
- the tracks will be used for mixed passenger and freight traffic, resulting in the decisive load model LM71 as per DIN Fachbericht 101, classification factor is 1.0 (corresponding to 100% of LM 71)

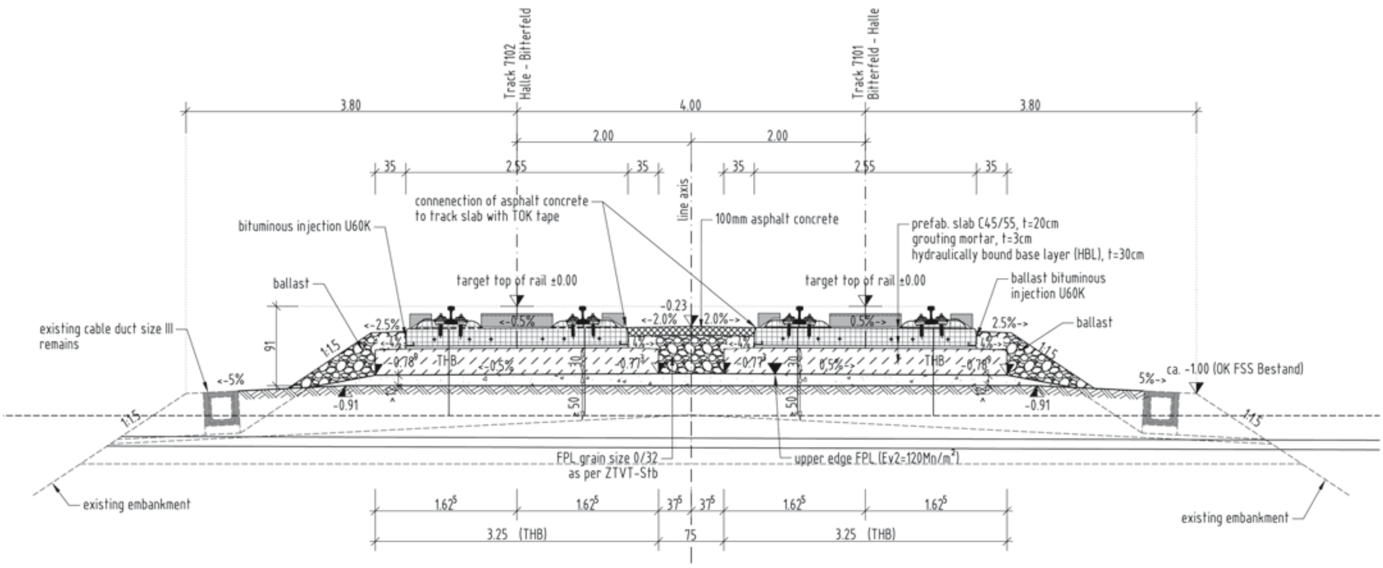


Fig.3, Ballastless track Roitsch – Hohenturm, regular cross section ballastless track Bögl on the open line

Ballastless track Ilmenau – Erfurt: Line 5919, Ebensfeld – Erfurt

This 32.34 km long section of the double-tracked new railway line between Ilmenau and Erfurt is implemented as ballastless track system Bögl (prefabricated construction method) including all main track switches in the two overtaking stations Ilmenau – Wolfsberg and Eischleben. In total, more than ten thousand slabs are placed. The overtaking tracks and the therein comprised catch points are of ballasted type. Switches of types -2500-1:26,5 fb and 60-1200-1:18,5 fb are installed on the ballastless track. The catch points in the ballasted track are ABWs 54-190-1:9. In total around 28 switches are installed. The shell works of the artificial structures in this section, 6 viaducts with total lengths between 120 m and 1,121 m, 3 long bridges between 40 m and 90 m total span width, 3 short bridges, tunnel Augustaburg with 1,404 m of length, tunnel Behringen with 463 m of length, tunnel Sandberg with 1,320 m of length and parts of the drainage system, were already part of advanced construction projects between 2000 and 2005.

Especially the viaducts and the long bridges had to be examined in view of updated requirements for ballastless track (ballastless track requirements catalogue) and to be structurally adapted. Moreover, renovation, completions and partial strengthening works were conducted at the existing structures.

Part of the project is also the erection of noise barriers on the open line and on bridges as well as wind barriers. In total 16 noise and wind barrier sections were to be built.

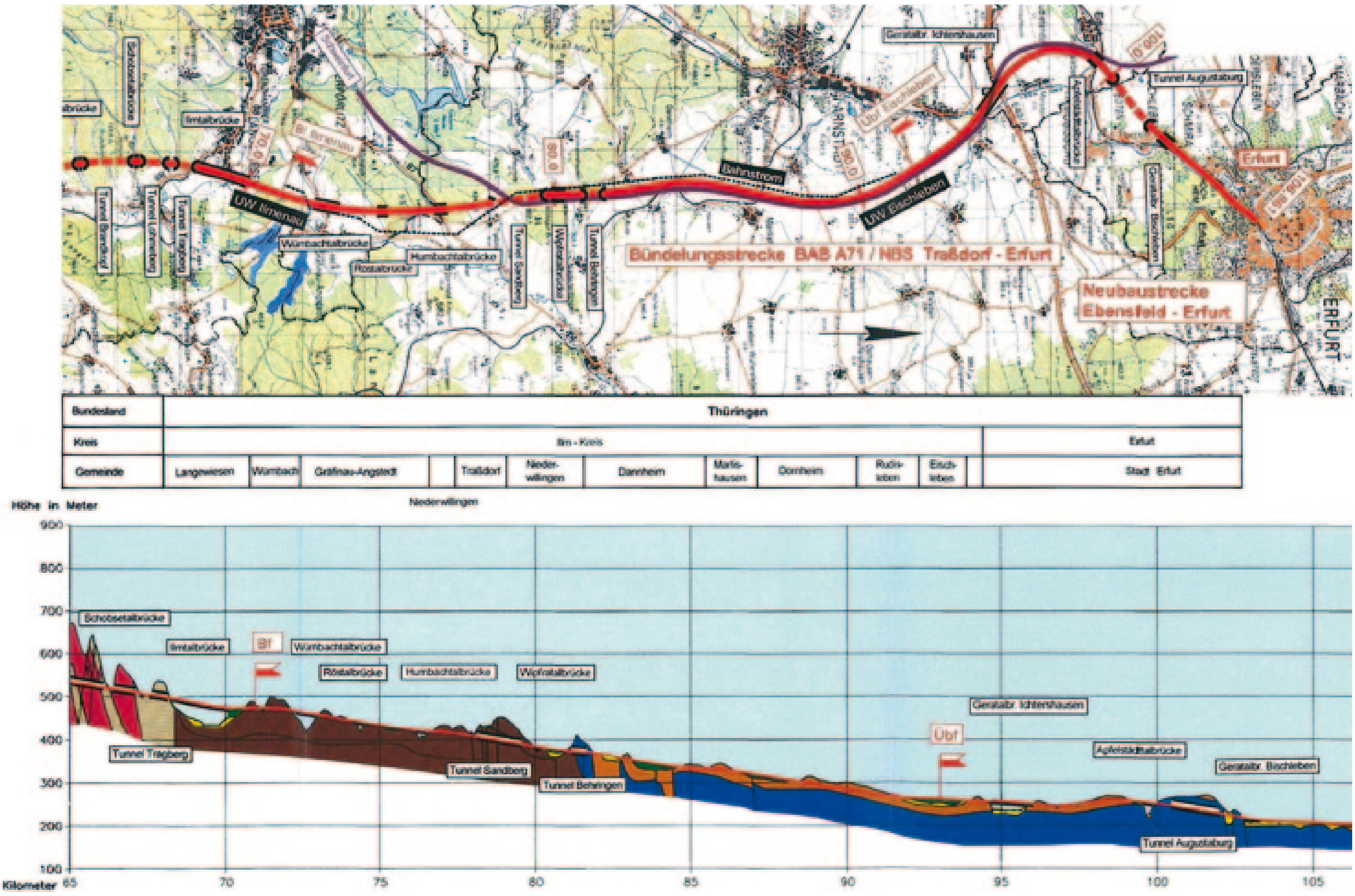


Fig.4, Ballastless track Ilmenau – Erfurt, line overview, situation plan and longitudinal section; around 32 km long newly built section

Resulting from the design parameters are the following ballastless track requirements:

- continuous main tracks are to be driven on with a design speed of max. 300 km/h; on the overtaking tracks in the stations Ilmenau – Wolfsberg und Eischleben the speed is 100 km/h; crossovers are planned for 130 km/h
- the tracks will be used for mixed passenger and freight traffic, resulting in the decisive load model LM71 as per DIN Fachbericht 101, classification factor is 1.0 (corresponding to 100% of LM 71)

Fig.5, Ballastless track Ilmenau – Erfurt, switch connections during construction; crossovers; in the background one of two overtaking stations, track structure station in ballasted track

SSF Ingenieure AG's scope of services comprises the following designs:

- superstructure (ballastless track) of main tracks (including switches, crossovers and branch-off switches) on the open line, on bridges and in tunnels
- underground cabling (cable troughs, cable shafts, cable crossings)
- completion of drainage systems on the open line
- superstructure (ballasted track) in the area of overtaking stations incl. catch points
- track cover slabs in tunnels and on the open line in front of tunnel portals (rescue areas) to make the track passable for emergency vehicles
- embankment completion/earthworks
- slope nailing
- noise barriers on the open line and on bridges, wind barriers on bridges
- pgrade of a short bridge in view of resonance risks
- upgrade of noise barriers' anchoring on bridges

In view of the bridges' suitability to install ballastless track, SSF Ingenieure AG delivers the following verifications:

- calculation of rail stresses
- calculation of uplifting forces in the rail fasteners; verification of position stability of superstructure elements
- verification of maximum subsidences in the rail fasteners
- verification of maximum rail fastener distances at bridge joints
- calculation of lateral displacements (vertical/ horizontal) due to bearing clearances and temperature

Railway link Erding: Line 5601, Markt Schwaben – Munich Airport Terminal

The project 'Erdinger Ringschluss – improvement of the railway connection to Munich Airport' aims at improving railway links to Munich Airport and to add to the currently existing regional train line some more regional train-like connections to the airport. It is intended that the airport is reachable directly by railway from North and South Bavaria.

To facilitate the project objectives, comprehensive infrastructure measures are necessary. The entire project comprises three construction stages as well as further expansions required in the long run.

The area modified during construction stage II consists of station Munich Airport Terminal, the stop point Schwaigerloh, the new turning system and sidings Schwaigerloh, the closing of the gap between the airport and the city of Erding, the double-tracked expansion of the line between Erding and Altenerding and the relocation of station Erding to the area of the air base.

In the framework of construction stage II SSF Ingenieure AG is currently planning the new construction of the double-tracked line section Munich Airport – Altenerding (gap closure Erding), and the draft and approval design of the installations between the Airport and the municipal borders Erding (Fig. 7).

Overview of measures planned by SSF Ingenieure AG:

- 6.257 km transportation installations, track superstructure and civil works (new constructions)
- 15 individual measures of road transportation installations (new constructions and conversions)
- 9 railway bridges
- 4 road bridges
- 1 stop point with 2 platforms, ramps and weather protection systems
- 1 operational station with 7 switches
- 326 m railway trough
- 4 pipe culverts (underneath rail and road)
- 2 rain water retention basin

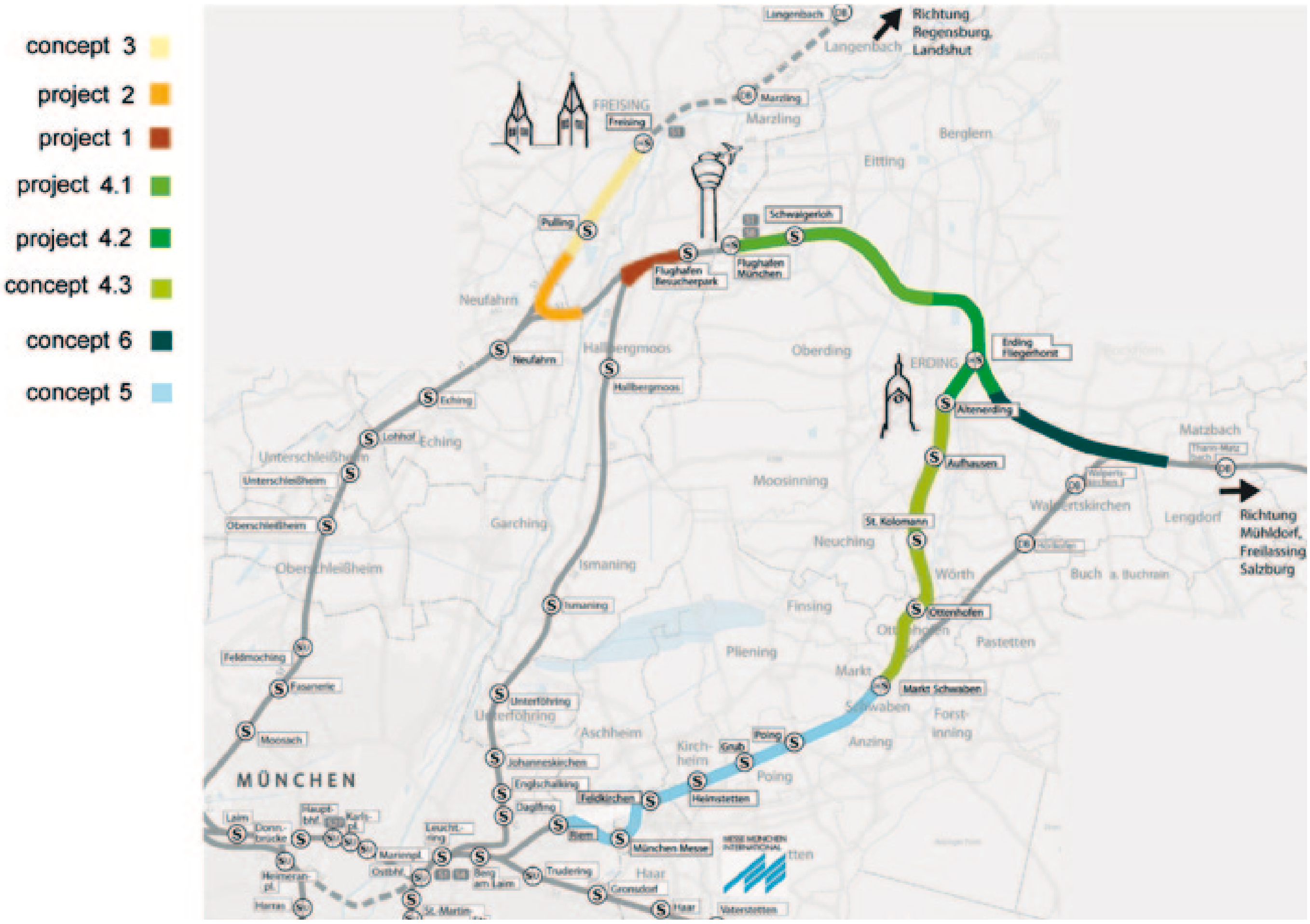


Fig.6, Airport connection, overview map of construction stages

Fig.7, Gap closure Erding, construction stage II, overview of measures planned by SSF Ingenieure AG

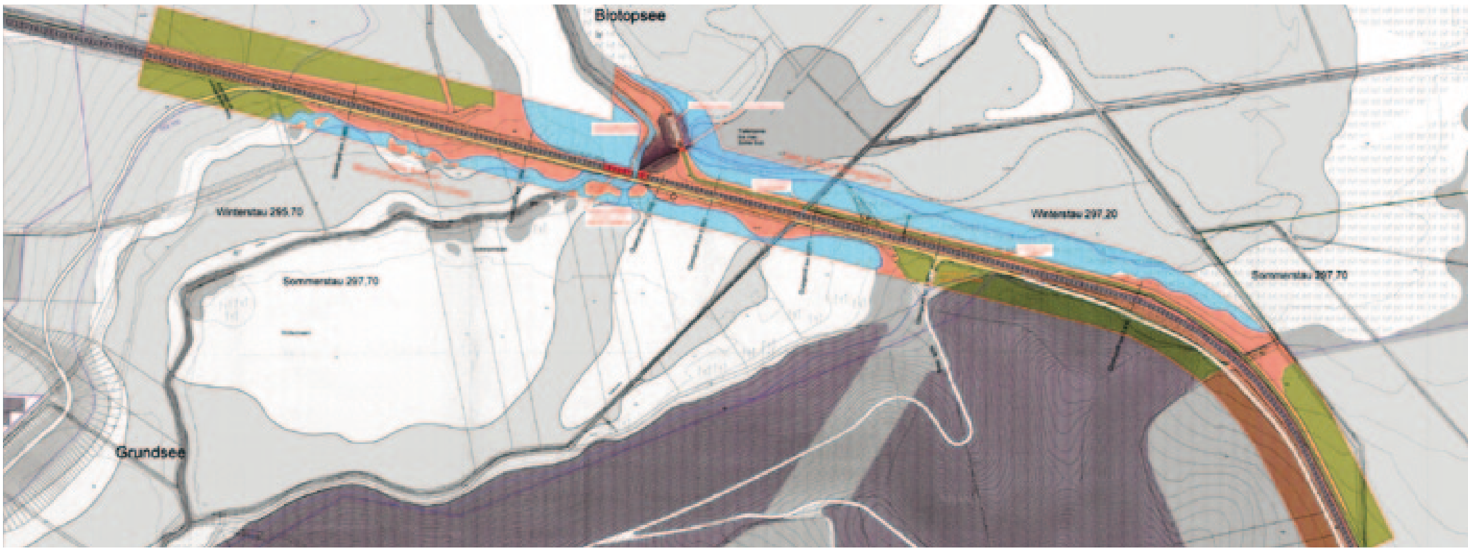


Fig.8, Floodwater retention basin Goldbergsee, overview plan

Floodwater retention basin Goldbergsee: Line 5122, Coburg – Bad Rodach

In the framework of floodwater protection of the City of Coburg, the department of hydrology Kronach is planning to build a floodwater retention basin of lake Goldbergsee within the area of the railway line Coburg – Bad Rodach. The installation consists of two water areas, the Goldbergsee with differences of 2.00 m (295.70 m NN – 297.70 m NN) of the dammed up water, and the so-called biotope lake with differences of 0.50 m (297.20 m NN – 297.70 m NN). The railway line Coburg – Bad Rodach runs on an embankment of around 2m height between Golbergsee on the left side of the tracks and the biotope lake on the right side.

In the section to be adapted of around 700 m length are 2 railway bridges, 3 private level crossings as well as several roads and paths.

The targeted alignment of the track could not be retraced due to damaged markings in this area. In the construction site's area it was recreated by the actual situation and the local conditions, was then newly planned and finally rebuilt on this basis. For impounding of Goldbergsee, the railway embankment was equipped with a bank protection. Moreover, for water exchange between the two lakes as well as the stream Sulzbach, a sufficiently wide opening in the embankment was designed. This opening was realized by a new, four-span railway bridge, constructed by launching method and built on deep foundations. The existing railway bridge was demolished and not replaced.

As foot and cycle paths, for inspection and maintenance works as well as for rescue operations, a network of paths was arranged parallel to the railway line. To transfer one of these paths over the water, a bridge is available analogous and parallel to the new railway bridge.

The protection of the existing railway embankment was to be planned in such a way that the stability and the serviceability of the embankment was not endangered in consideration of the different damming objectives as well as the thereof resulting dam lifting and settlement as well as of the loads from impounding and outlet.

The essential planned and executed measures were:

- construction of bank protection on both sides of the existing embankment
- removal of railway bridge at km 3.019, km 3.207 and km 3.512
- removal of path bridge north of the railway line at approx. km 3.218
- removal of railway bridge over Weidengraben at approx. km 3.084
- relocation of the bed of the Sulzbach in the area of the new railway bridge
- removal of railway bridge over Sulzbach approx. km 3.218
- new construction of railway bridge over Sulzbach approx. km 3.223
- new construction of road bridge – foot and cycle path south of the railway line at km 3.223 incl. dam construction
- construction of foot and cycle path south of the railway line between km 2.900 and 3.543 incl. dam construction
- construction of the new track position

Fig.9/10, Floodwater retention basin Goldbergsee, view on the newly aligned railway line and the parallel paths, in the foreground the two bridges

SSF Ingenieure AG's scope of services comprised:

- design of transportation facilities (rail and road)
- project planning and structural engineering for new construction of engineering structures, railway and road embankments and dam strengthening
- geological evaluation and foundation consulting
- surveying
- local construction supervision and railway construction supervision
- construction documents for the German railway administration EBA and the department of hydrology for all building trades.

Fig.11, New stop point Hirschgarten in Munich,
design of passenger transportation facility, tracks, railway embankment adaptation and connection by stairs and elevators from Friedenheimer Brücke

Passenger transportation facilities

The design of passenger transportation facilities of railway traffic is one of our favourite tasks. In the last few years we have been planning the final design of many railway platforms.

The challenge lies in the optimized design of structures adapted to the needs of the travellers as well as the wishes of the client and in the integration of the different sectoral plannings, especially whilst operation is continued.

Final remark

We thank our clients for their trust in us and the pleasant cooperation. We are happy to be your qualified and motivated partner when it comes to question of railway design. We are looking forward to new challenges.

7

Selected Bridge Designs of the Last Years

Lecturer: Dipl.-Ing. Peter Radl

The following summary out of hundreds of projects of our project planning department represents just a small number of technically challenging, sometimes innovative and individually designed bridges.

Integral frame structures

From their visual character, wide spanning frame structures with an arched haunch of the superstructure are the closest equivalent to vault bridges or stone arches. They resemble even with their flat arch the original form of concrete bridges and appear harmonious and pleasant. They are modern structures embedded into the earth without joints and should be considered as structural integrity. The condition of the ground has an influence – although small – on the dimensioning of the frame.

Fig.1, ABD South Bavaria: motorway A 99, structure BW 5 near Allach

A new design guideline, RE-ING, stipulates to examine and document the interaction of the ground in a geotechnical design report. Especially in case of difficult ground conditions our partner office Baugeologisches Büro Bauer supports us to verify the geological report.

Frames are very suitable as pile-less bridges over motorways or water. Span widths of up to 50 m can be realized with prestressed concrete as well as by composite construction. These wide spanning structures distinguish themselves by their very high sustainable quality. There are no mechanical construction elements such as bearings and transitional structures.
Moreover, the elimination of intermediate supports offers advantages in view of sustainability considerations of socio-economic aspects: no economic disadvantages by traffic congestions during construction and maintenance, hence minimization of CO_2 emissions.

Fig.2, ABD North Bavaria: motorway A 73, structure BW 42-2 near Lichtenfels

Fig.3, ABD North Bavaria: motorway A 73, structure BW 46-2 near Coburg

A prestressed concrete frame, built already 22 years ago for the Authority of Motorways (ABD) South Bavaria, over motorway A 99 Munich-North near Allach, under construction at that time, proves the maintenance-low and aesthetically qualitative construction method (Fig. 1). With a clear width of 51.50 m at the centre of the span, it only has a construction height of 1.00 m.

Other prestressed concrete bridges are designed for the Authority of Motorways North Bavaria in the course of new construction of A73 section Suhl – Lichtenfels as reference structures (Fig. 2/3). All bridges in this 35-km-long section are pile-less frame structures. In addition to prestressed concrete bridges, composite structures were implemented.

Integral tube truss bridges with welded nodes

For the first bridge near Lichtenfels of the above mentioned section of A 73, the ABD North Bavaria demanded a technically and aesthetically high quality structure, which led to the design of a tube truss bridge in steel composite frame construction method. The bridge spans with a clear width of 91 m over the new motorway section at the north side of the Main, which is visible from far (Fig. 4)
A frame structure was designed despite the enormous total length of 122.62 m. The two truss girders, inclined towards each other in the cross section, and the reinforced concrete carriageway slab merge within the embankment with the abutments, founded on large bored piles.

Fig.4/5, ABD North Bavaria: motorway A 73, structure BW 67-1 near Lichtenfels

For the truss girders of this bridge, for the first time in Germany, large tubes were directly welded to each other, made possible on the basis of the structural durability verification procedure proposed by SSF Ingenieure AG, which has been known and applied for a long time in offshore engineering. The durability of the tube nodes was verified by tests carried out at Bundeswehrhochschule Munich. This construction type required an individual case approval.

Initiation of a new bridge construction method

The direct welding of truss nodes was unknown territory in German bridge engineering. The verification procedure is not explicitly regulated in the standards of DIN Fachbericht. Therefore, several universities and research institutes took on this new construction method with the aim to create a calculation basis and to publish it in a DASt guideline (German steel construction committee). The introduction of this guideline is expected in 2013.
The structure won the 3rd prize in the category 'Steel components and systems for construction' in the framework of the steel innovation prize 2009.

Pedestrian and cycle bridge over motorway A 9 in Bayreuth

The tube truss bridge over motorway A 9 was in some ways the inspiration behind the above described road bridge. The particularity of this design, also for ADB North Bavaria, is the separation of the orthotropic footpath slab and the lower chords level. The motorway's trench in the

Fig.6, ABD North Bavaria: motorway A 9, structure BW 307b near Bayreuth

bridge area has different heights and the gradient of the path is inclined correspondingly. To create a certain 'arc of tension', a structure was selected that is asymmetrical in the front view. The truss upper chord and the parallel

suspended deck span the motorway with one large sweep to the west. The lower chord bridges the motorway with one symmetrical curve. The structural height decreases from east to west. In the east, the bridge is connected to an invisible concrete abutment on bored piles; in the west, there is a bearing on an abutment integrated into the embankment. The tube dimensions were deliberately not thinned out to highlight the structure's contour, which led by the way to a rather robust dimensioning.
Compared to road bridges, pedestrian bridges do not require a durability verification. The weld seams are subjected to fewer stresses. An individual case approval for direct welding of the tubes was not required.

Cast in situ reinforced concrete and prestressed concrete bridges

Especially economic and attractively shaped concrete structures allow cast in situ construction with a formwork on scaffoldings.

Bridge of road Lochhauser Straße over motorway A 8 West in Munich

Bei der Überführung der Lochhauser Straße über die The bridge leading Lochhauser Straße over motorway A8 west of Munich is planned as a rather exceptional structure because of its position – it is the last visible bridge before entering the city of Munich. The very large central reservation allows V-shaped spread supports that were implemented as thin steel tubes, with dominant red coating (Fig. 7). The slender superstructure as well as the low abutments in the embankments react to the incline of the supports in the central reservation.

In the further course of A 8 West the abutments' inclines towards the carriageway are repeated, first in combination with frame structures, then as bearings of two-span bridges with superstructures haunched towards the support. The design convinced the construction department of Munich as well as the Motorway Authority South Bavaria responsible for construction.

Fig.7, ABD South Bavaria, motorway A 8 West, bridge of Lochhauser Straße in Munich

Fig.8, ABD South Bavaria, motorway A 9/A 92, direct ramp at interchange Neufahrn

Flyover at interchange Neufahrn part of motorways A 9 / A 92

Cast in situ construction method is an exception for ramp bridges, so called flyovers, over motorway interchanges. However, it was chosen for the construction of a direct ramp of motorway A 92 onto A 9 at Neufahrn near Munich (Fig. 8).

Already during design, detailed construction stages and numerous traffic management phases were planned and subjected to a call for tenders, which entailed an execution without any remarkable influences on the traffic flow. The selected double-web prestressed concrete T-beam, of which the webs have very different span widths due to the substructures arranged parallel to the motorway and the bridge's curve in the ground plan, could be dimensioned very slender and robust compared to incrementally launched bridges with accessible hollow boxes. The ABD South Bavaria made a bold move by deviating from the habitual incremental launching, and was rewarded with a flawless implementation of this slender and extremely economic efficient and sustainable structure.

Railway bridge over motorway A 8 West near Gersthofen

West of Augsburg near Gershofen the highly frequented railway line Augsburg – Donauwörth crosses motorway A 8 West. Due to the motorway expansion the old railway bridge had to be replaced.
The elevation of both transport routes remained nearly unchanged. For construction of a common deck bridge over two spans the available construction height was insufficient. The combination of a frame structure over two spans, stiffened with edge covers (Fig. 9) made however the required stiffness possible and avoided a truss bridge twice as expensive. Another advantage of the frame is its robustness and easy ability to be moved. The structure was built next to the railway line and launched into its final position during a railway line closure on a weekend, motorway traffic was partially continued. The railway operator chose this very economic construction type as an alternative construction in the final position would have entailed a makeshift deviation and speed limits, thus much larger restrictions on railway operation. The construction next to the location took place on a scaffolding in elevated position. Only after removal of the scaffolding, the frame was lowered into its launching track along the motorway. DB AG received with this design a sustainable, extremely economic yet robust reinforced concrete structure.

Fig.9, ABD South Bavaria, motorway A8 West, railway bridge near Gersthofen

River Bridges

Danube Bridge Günzburg

Tied-arch bridges count amongst typical river bridges spanning bodies of water with one step without disturbing installations.

In Günzburg, in cooperation with the construction department Krumbach, a modern and compact arch bridge was designed with crossing prestressed hangers and arch slabs inclined towards each other. The two upper cross

Fig.10, Danube Bridge Günzburg

Fig. 11, Danube Bridge Günzburg
Fig. 12, Danube Bridge Günzburg in the evening – with changing coloured illumination

girders complete the structure to the top and create a gate effect into the town of Günzburg. The steel profiles merge calm and harmoniously into each other. The piles, designed as low and clear arch bearings, are elliptically rounded and taper to the top corresponding to the arch incline. Slender reinforced concrete slabs span the short foreland spans and connect to abutments placed high in the embankment. The arch incline continues in the incline of the wing walls.

The design convinced the city of Günzburg, who equipped the structure with multicoloured illumination effects, and also the association bauforumstahl e.V., who awarded it in 2013 the engineering prize of the German steel construction association Deutscher Stahlbau.

Fig. 13, ABD South Bavaria, motorway A 8 East, bridge over the river Tiroler Arche, front view

Bridge over the river Tiroler Ache part of motorway A 8 East

Not only the execution as tied-arch bridge, oblique in the ground plan, over Tiroler Ache as part of motorway A 8 East, but also the foundation of the load-bearing structure in the colour of lake Chiemsee are a particularity of the bridge over the river.

The structure of ABD South Bavaria stands on 57-m-long, telescope-like large bored piles on a conglomerate of clay and silt. The former steel composite bridge at this location that was placed on a floating foundation with short wood piles on the upper gravel layers and the lacustrine clay underneath, settled together with the motorway embankment more than 1 m. Thanks to the large bored piles, the new bridge is fixed in its targeted position. Only the height of the adjoining motorway embankment has still to be adapted in regular intervals.

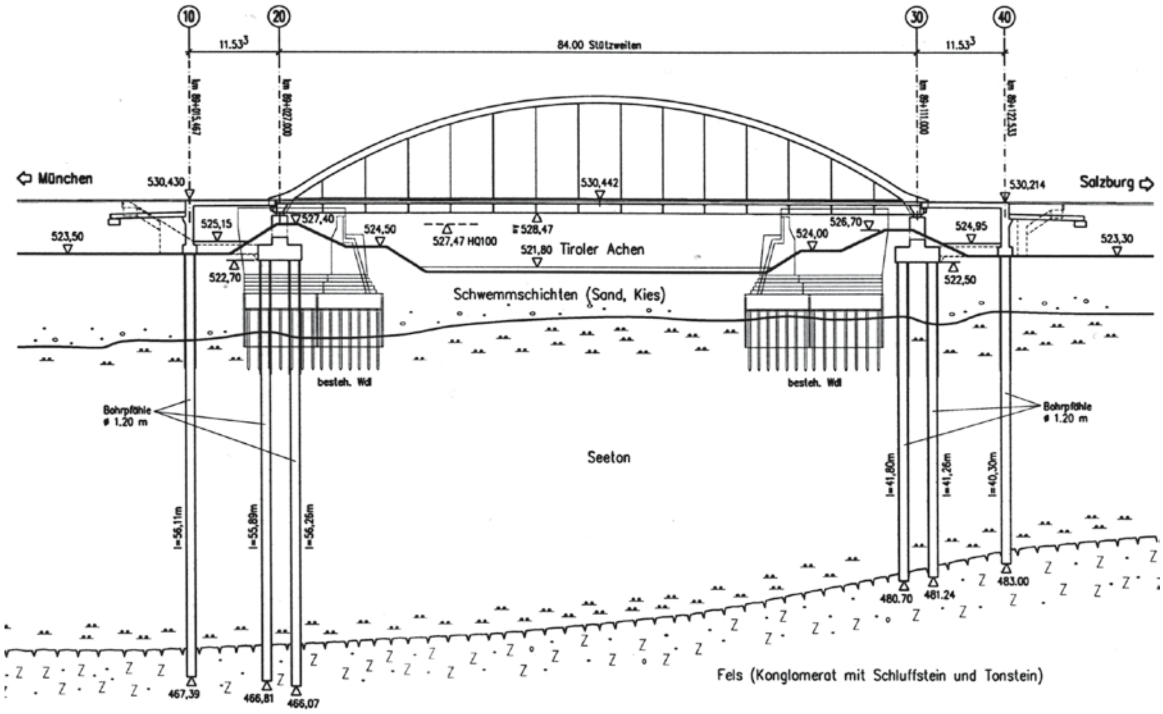


Fig.14, ABD South Bavaria, motorway A 8 East, bridge over the river Tiroler Arche, longitudinal section with representation of the foundation and difficult geological situation

More pedestrian and cycle bridges

Pedestrian and cycle bridge Neustadt/Aisch

In 1993, the city Neustadt/Aisch, consulted by the road construction department Ansbach, launched a realization competition for a pedestrian and cycle bridge over the valley Aischtal and national road B 479 in Neustadt/Aisch; SSF Ingenieure AG together with the architects Rudolf und Sohn, Munich, won the competition.

The design planned a S-curved, tightly welded and very slender steel box with orthotropic slab. The load-bearing structure stretches with seven spans over a length of 144 m. The slender steel columns are designed with point rocker bearings and at the abutments with fork bearings required for stabilization.
Because of the small bearing spread, tensile stresses could not be excluded so that despite the enormous total length a connection of the superstructure to the abutment was implemented. The curve in the ground plan and the slender columns allow this semi-integral construction method.

Fig.15, City Neustadt/Aisch, pedestrian and cycle bridge over national road B 479 and river Aisch

Bridge at Arnulfpark Munich

The city of Munich held a bridge design competition in 2012/2013 for a pedestrian and cycle bridge over the central railway axis at regional train station Donnersbergerbrücke. Together with the architectural office Lang Hugger Rampp, Munich, SSF Ingenieure AG won the first prize with its concept of a discrete Vierendeel bridge. The orthotropic slab held on both side by the two girders spans the 37 tracks of the railway installation with a total length of 242 m. For the busy railway environment, a calm structure with parallel chord girders and vertical struts was selected. Only the detail reveals dynamic elements such as a nearly horizontal bend of the girder, which starts at the abutments due to the crest-like course of the bridge and moves downwards backwards. Above this line, the girder has openings. The area is covered by a closed glass surface. Underneath the line, metal sheet walls remain visible. The changing actions of light during the day on the different materials create constantly varying light reflections and different moods.

A structural particularity is the launching of the superstructure from the north without temporary supports by temporary pylons over the three spans with a span width of up to 93 m.

Fig.16, City of Munich, pedestrian and cycle bridge Arnulfpark, front view

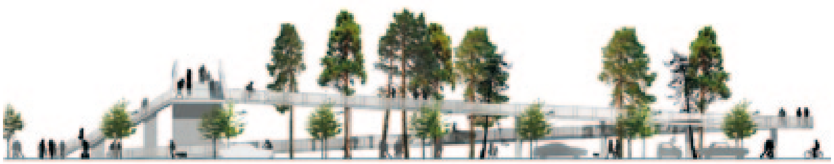


Fig.17, Detailed view, bridge head north side

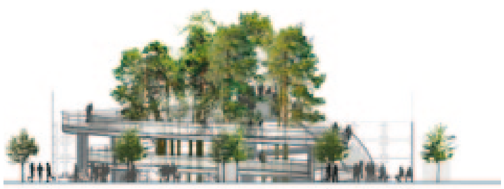


Fig.18, Detailed view, bridge head south side

Fig.19, Situation plan

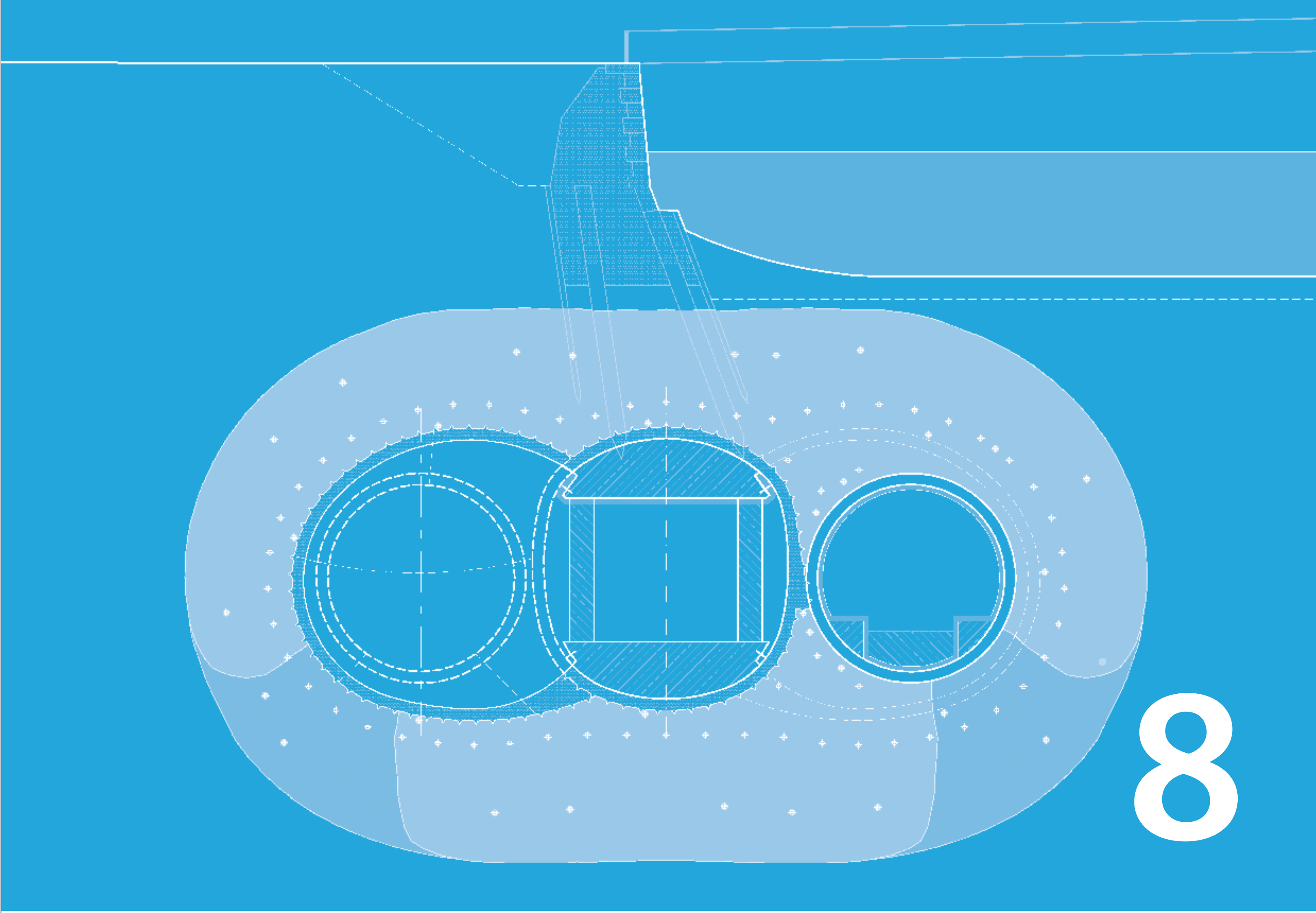
Bridge of stadium connection Augsburg

The pedestrian connection to the new football stadium in Augsburg was conceptualized together with the architects of Lang Hugger Rampp GmbH, Munich, and comprises three bridges in very economic and integral prestressed concrete construction method. The bridges cross a road with only one span each of a span width of 44.50 m and a usable surface of up to 7.00 m. In the ground plan, they are bended, which creates a certain tension and an optimized route design. The superstructures merge directly into the planted embankment and are connected to invisible abutments on large bored piles. The very slender superstructures are only slightly higher towards the abutments, creating maximum transparency.

Final remark

We thank our clients for their trust in us and their willingness to strive, together with the designer, in special situation for the design of exceptional structures. We are looking forward to new challenges.

Fig.20-22, City of Augsburg, bridge for the new stadium connection



8

The U5. For Greater togetherness

Design for Gap Closing of Underground U5 in Berlin

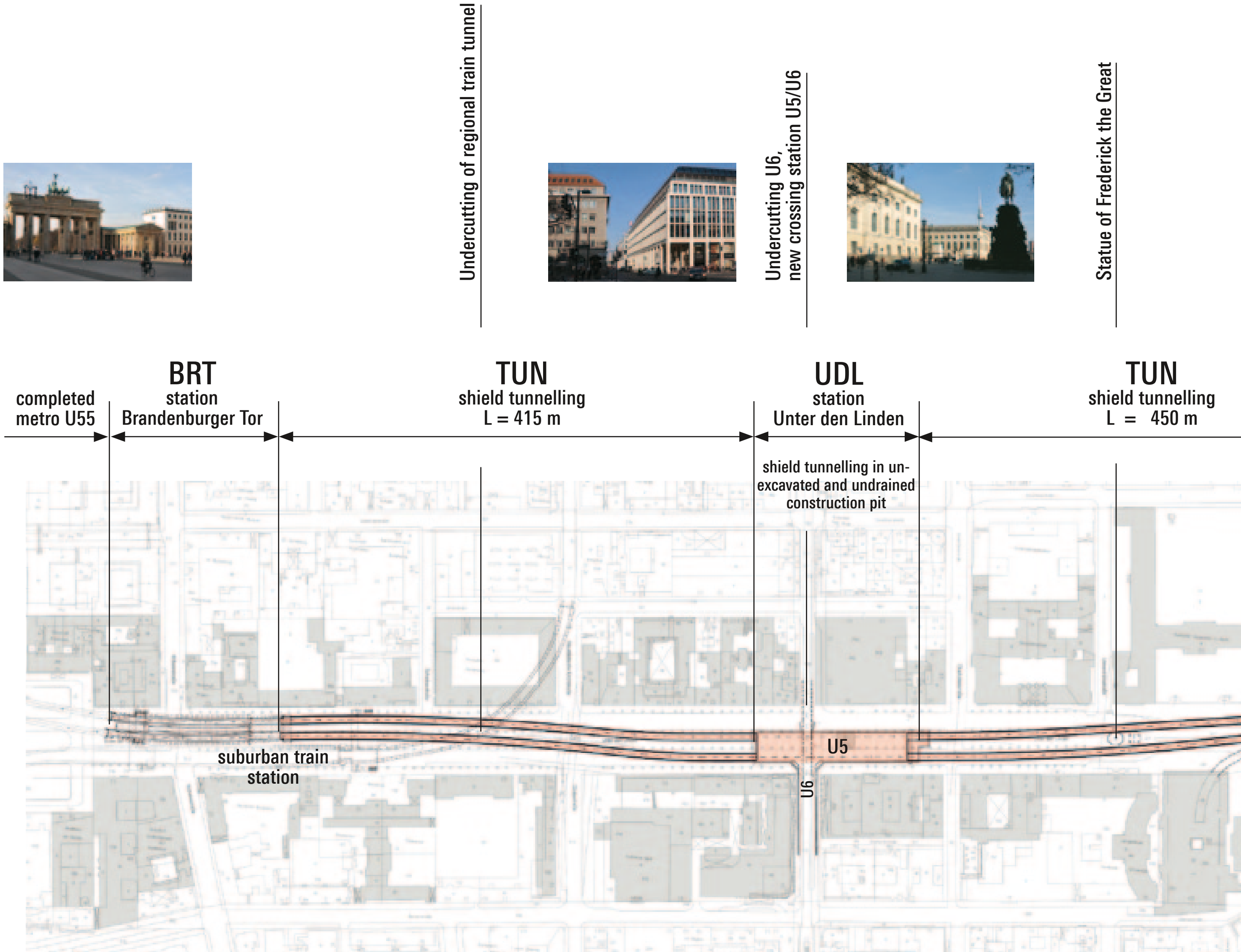
Lecturer: Dipl.-Ing. Michael Weizenegger

For the missing connection between underground lines U5 and U55 between stations Alexanderplatz and Brandenburger Tor, it is planned to close the gap with a tunnel at Berliner Rathaus linked to the existing station Brandenburger Tor. Berlin is thus provided a direct connection of U5 to the central station and the residential areas in the east of the city.

The project comprises the new construction of three stations and a connecting double-tracked tunnel line to be built by shield tunnelling method. The line consists of the link to the existing sidings at Berliner Rathaus, station Berliner Rathaus (BRH) and the adjoining track switching system (TSS), station Museumsinsel (MUI), station Unter den Linden (UDL), the connection to station Brandenburger Tor (BRT) and line sections in-between.

The new underground line runs in two single-tracked tunnels starting at the new station BRH underneath river Spree, underneath the new Berlin Palace (Humboldtforum) currently under reconstruction, underneath Spree Canal and road Unter den Linden leading to the existing station BRT.

The total construction length is around 1.9 km.



Geology

The district Berlin-Mitte is marked by a glacial valley traversing Berlin from east to west, consisting of thick sand and gravel sediments as aquifer. At some points above these layers are organically interspersed sands and peats as well as partially very thick organic silt, partially expanding to the excavation cross section of shield tunnelling. Large stones and rocks are likely to be encountered during construction.

In the area of station MUI the foundation has to be built reaching into the marlstone layers underneath the sands.

Shield tunneling

Tunnelling starts in the launching shaft at the TSS and ends at station BRT. The tunnels, each 1.6 m long, are built by shield tunnelling method with a tunnel boring machine (TBM) with heading face support by means of a supporting fluid. The inner diameter of the tunnel galleries is 5.70 m.

The tunnel galleries are lined with reinforced concrete tubbings of 35 cm thickness. The conic width of the rings is on average 1.5 m. The tubbing joints are sealed with closed elastomeric frames embedded in a groove and designed for a maximum water pressure of 3.0 bar.

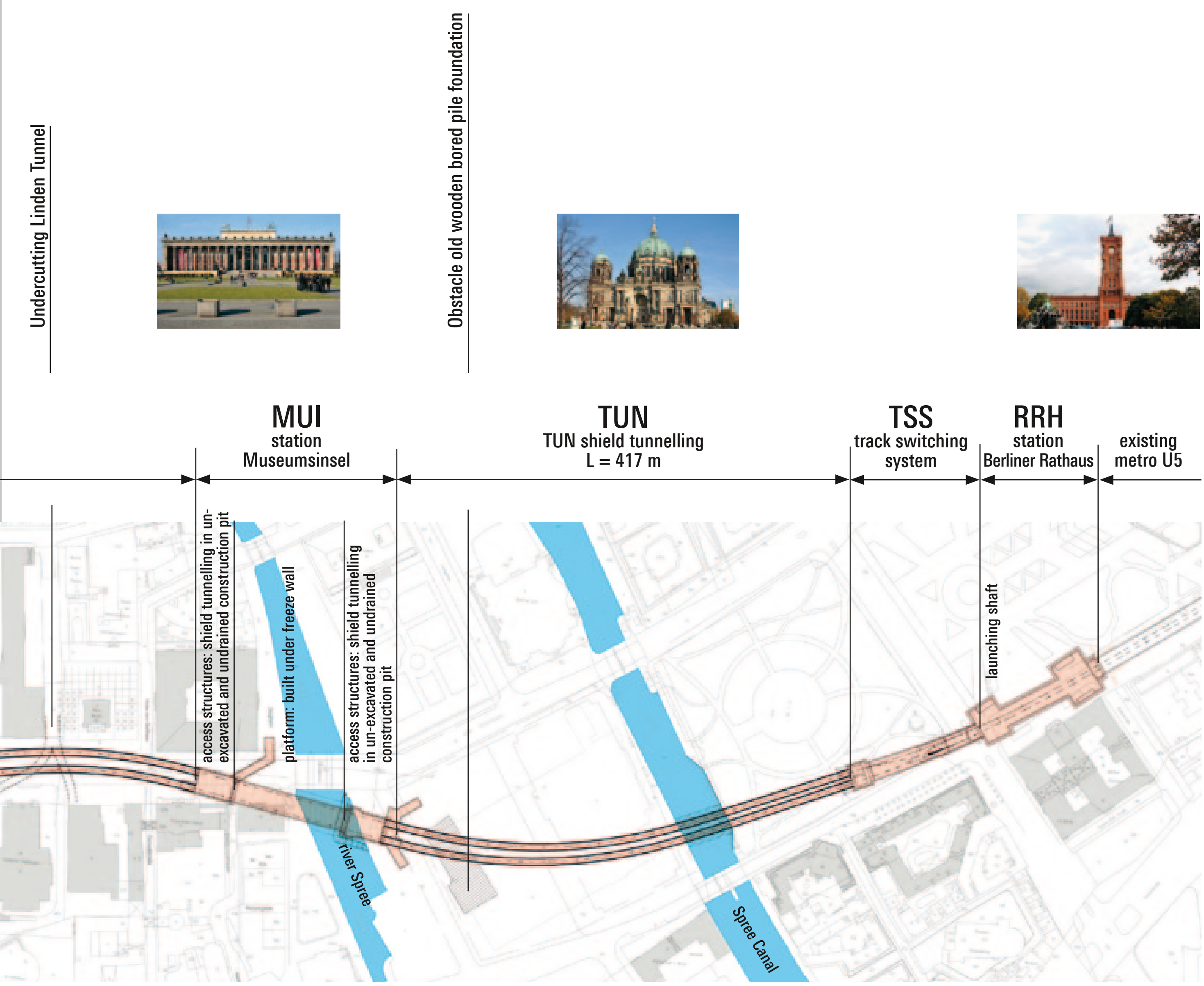


Fig.1, Situation plan

Construction of the excavation pit for the launching shaft at the TSS is executed by diaphragm wall method with underwater concrete bottom. The pit wall to be cut through during launching is built with glass fibre reinforcement in the area of the excavation cross section.
The connecting areas are planned with a redundant sealing system consisting of a launching cap with lip sealing rings, inflatable emergency sealing and a sealing block (jet grouted) at the earth side of the diaphragm wall.
Tunnelling is carried out after construction of the excavation pit enclosure at the ends of stations MUI and UDL before drainage and excavation of the pits.
Shield tunnelling will take place underneath the Spree, the future Berlin Palace, the Spree Canal and the Bertelsmann buildings, the Linden Tunnel, the statute of Frederick the Great and the regional train tunnel near road Unter den Linden. Undercutting the river and canal requires a ballasting of the water bottom because of the small distance between water bottom and excavation cross section of only around 6 m; for ballasting steel slabs or heavy concrete prefabricated elements are used; ship traffic will be maintained throughout.

Connection Brandenburger Tor

The tunnel galleries join the eastern pit walls at station Brandenburger Tor. At the eastern end wall of the station, joint tapes have already been installed and preserved. Together with a transitional block they allow the water-tight connection of the tunnel lining to the existing end wall.

The TBM cuts into the jet grouted body and the unreinforced diaphragm wall to a point where a secure waterproofing of the TBM is possible. All around the shield skin, under pressurised air, the gap in the cutting area and the shield skin, and, atmospherically, the gap between shield tail and last tubbing ring are sealed.

Before decreasing the pressurised air, a freeze wall has to be built from the ground surface, enabling to seal the water-loaded joint between end wall and reinforced diaphragm wall, the joints of the diaphragm wall's ribs caused by construction and the joint between reinforced and unreinforced diaphragm wall. Freezing and

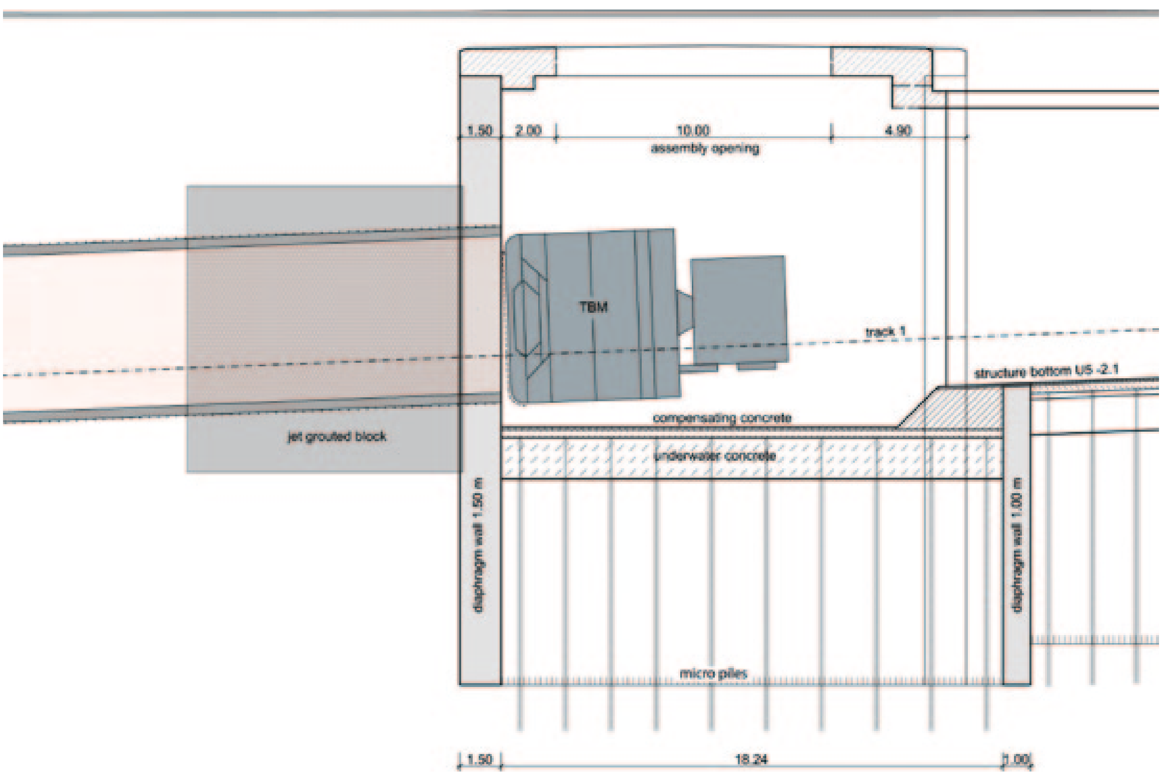


Fig.2, Longitudinal section launching pit TSS

Fig.3, Construction pit TSS

Fig.4, Home wall

Fig.5, TSS underneath road Spandauer Straße

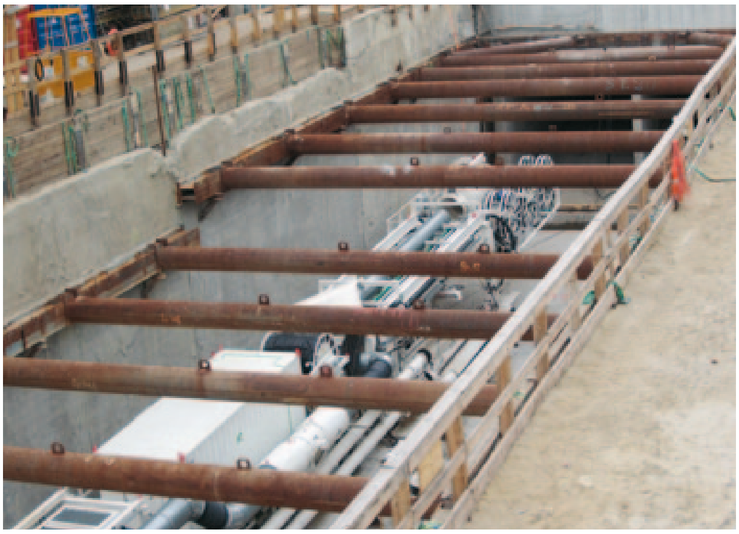


Fig.6, TBM under stiffened TSS

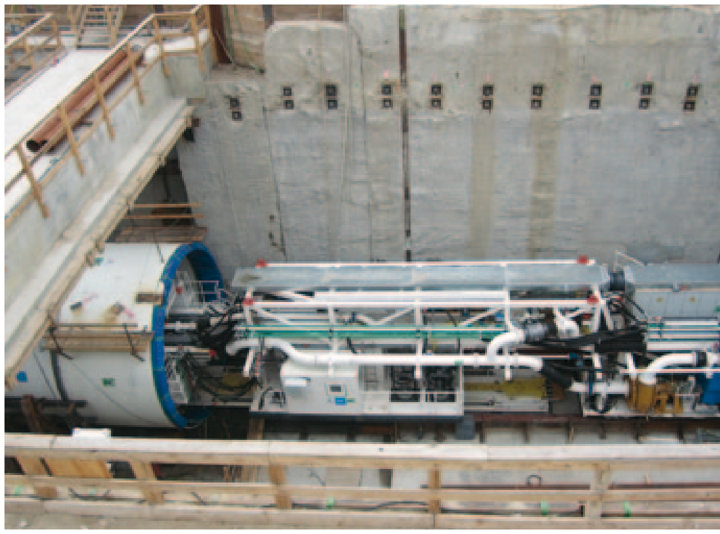


Fig.7, Tunnel boring machine

temperature measurement bore holes are drilled in two consecutive rows in the reinforced diaphragm wall as core drillings. Only when all joints are sealed, the TBM can be dismantled.

The remaining tunnelling step to break through the diaphragm wall is done manually under a freeze wall; its temperature has to be maintained by arranging freezing pipes at the excavation's edges. The joint tapes kept in the end wall are uncovered and concreted into the transitional block of the tunnel's inner shell. Afterwards the tunnel is broken through to the existing station.

Construction in inner urban area

New construction of underground U5 in the centre of Berlin requires, in addition to structural and technological particularities of undercutting bodies of water and the proximity to existing buildings, supplementary measures, especially in terms of construction site clearing and traffic management during construction as well as logistics planning.
Examples are the area of the new crossing station Unter den Linden and the crossing of the Spree including a port of transhipment for construction materials.

To maintain individual traffic on road Unter den Linden and to guarantee unrestricted accessibility to surrounding buildings, construction has to be accomplished section-wise by construction lots.

Station Berliner Rathaus

Station BRH is situated in direct vicinity to Berlin's Red City Hall. It comprises the connection to the sidings in the currently operated tunnel of the existing parts of U5. In the following course of the line in direction west, the TSS is planned.

As it is necessary to maintain individual traffic on Spandauer Straße construction is planned in two sections.

The first section consists mainly of the TSS, the second one of station BRH.

Track switching system

At the west end of the TSS, a gate will be arranged in a weir chamber during construction works, so that in case of an accident in the area where the underground tunnel crosses river Spree, the eastern parts of the installation are protected from flooding. In the area of the weir chamber and the adjoining blocks, the launching shaft for tunnelling is arranged.

The partially two-storey TSS is built in cut-and-cover method with diaphragm walls and an underwater concrete bottom anchored with injection piles.

The Station

The station consists of three levels:

- The lower level of the station is connected to the lower level of the existing tunnel. Four tracks of the old tunnel are led into the new station and will there be used as sidings.

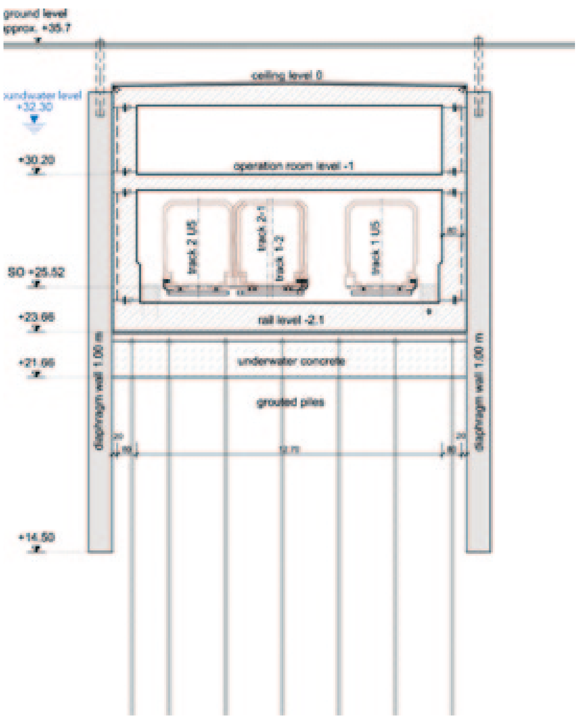


Fig.8, Track switching system at station Berliner Rathaus

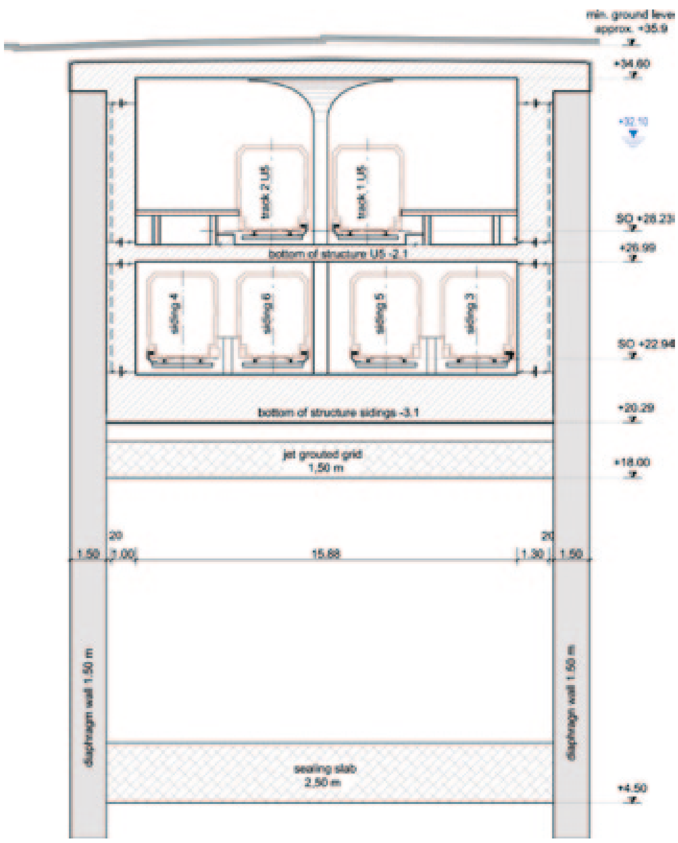


Fig.9, Cross section of station Berliner Rathaus

- The lateral platforms of U5 are at a depth of around 7 m underneath ground level. With aisles and escalators the connection of the mezzanine floor and station exits is guaranteed.
- The mezzanine floor spans the platforms of the east and west areas of the station and links the lateral platforms of U5 to each other.

Construction is executed partially in cut-and-cover method with diaphragm wall enclosure, a deep jet grouted bottom and stiffening grid just underneath the excavation pit bottom. Levels of stiffeners and anchors support the diaphragm walls.
To minimise emissions at the city hall, top-down construction is used by applying diaphragm walls and primary supports.
The tight and at the same time electronically insulating connection of station BRH to the existing tunnel is accomplished by means of underground injections. The bituminous sealing tapes of the existing tunnel are connected with great care.

Station Museumsinsel

The station starts at the east bank of the Spree Canal and finishes in the area of Kronprinzenpalais. The structure comprises two station ends of a maximum length of 43 m with accesses and mezzanine floors as well as the platform areas.

The station ends are built in top-down method with enclosing diaphragm walls and a deep jet grouted bottom. In addition, a jet grouted stiffening grid is planned underneath the excavation bottom. Intermediate stiffeners are implemented as steel constructions.
Tunnelling with the TBM is done analogous to tunnelling in the area TSS.

The platform hall is in the area of Spree Canal and is constructed under a freeze wall by shotcrete method after breakthrough of the tunnel boring machine. The minimum cover between freeze wall and bottom of the Spree Canal is around 4.50 m. The freeze wall is created from

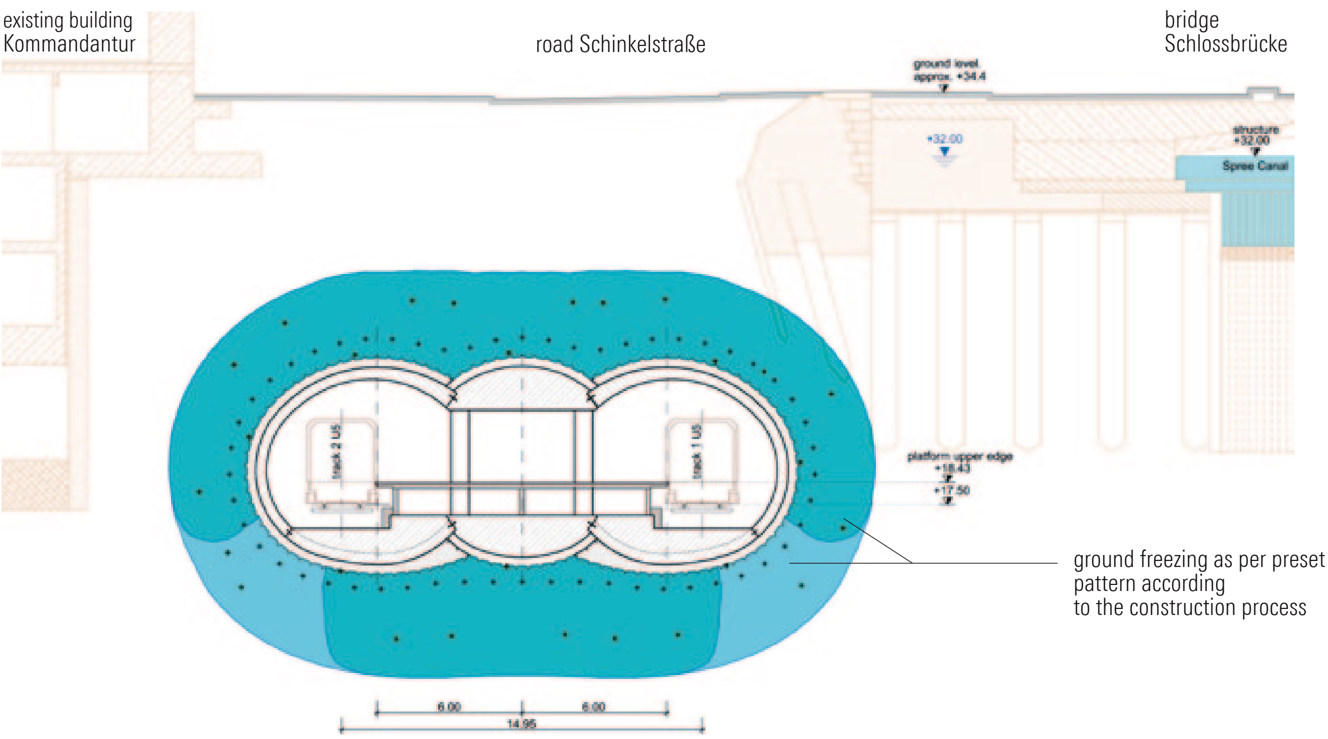


Fig.10, Cross section station area and freezing area of station Museumsinsel

Fig. 11, Construction site station Museumsinsel

both station ends by drillings of 85 m length (controlled) and 25 m (uncontrolled). The designed structural thickness of the freeze wall is 2.0 m.

The platform hall is excavated in a three-cell cross section, consisting of one centre and two lateral galleries. First, the centre gallery is excavated by graded full-face cutting with rapidly following bottom closure by shotcrete grouting.

The structure is then completed in the area of the centre gallery. Afterwards, the lateral galleries are built in the same way. Tunnelling of the lateral galleries is implemented during a cross section widening of the already built shield tunnelling area, whilst parts of the tubbing tubes are continually demolished. The reinforced inner shells are then built in the lateral galleries and connected force-fit to the shell of the centre gallery.

Station Unter den Linden

At station UDL the new line U5 crosses the existing U6. To construct the new crossing station, the existing tunnel of line U6 has to be demolished in some areas and be rebuilt together with one of the platform areas and the new interchange situation between U6 and U5.
The T-shaped crossing station runs from east to west underneath road Unter den Linden (U5) and from north to south underneath road Friedrichstraße (U6).
The new part of U6 is built in top-down method with diaphragm wall enclosure and deep jet grouted bottom as well as a jet grouted stiffening grid underneath the excavation bottom. Due to simultaneous demolition of the existing underground tunnel, construction has to be divided in stages.

Fig. 12-14, Construction site station Unter den Linden

The station of U5 is also constructed in top-down method with diaphragm walls and a deep jet grouted bottom as well as a jet grouted stiffening grid underneath the excavation bottom. The depth of the diaphragm walls of up to 35 m is quite remarkable. The structure of the station required the arrangement of individual blocks, which are joint-less on a length of up to 80 m.

To maintain individual road traffic on Unter den Linden and to ensure accessibility to adjacent buildings, a section-wise realisation in the above mentioned lots is necessary.

The TBM runs through the station after construction of the pit enclosure and the cover of U5, and after construction of the new section of U6. Underground operation of U6 will then already have been resumed.

The excavation pits are not excavated or drained at this moment. To securely seal the joints, jet grouted columns are built at the outside of the final diaphragm walls; the joint between diaphragm wall and tubbing ring is grouted afterwards. On track 2, the TBM cuts through an area where there are anchors and grout bodies in old construction pits of surrounding buildings. They are drilled through and the anchor parts are removed before shield tunnelling.

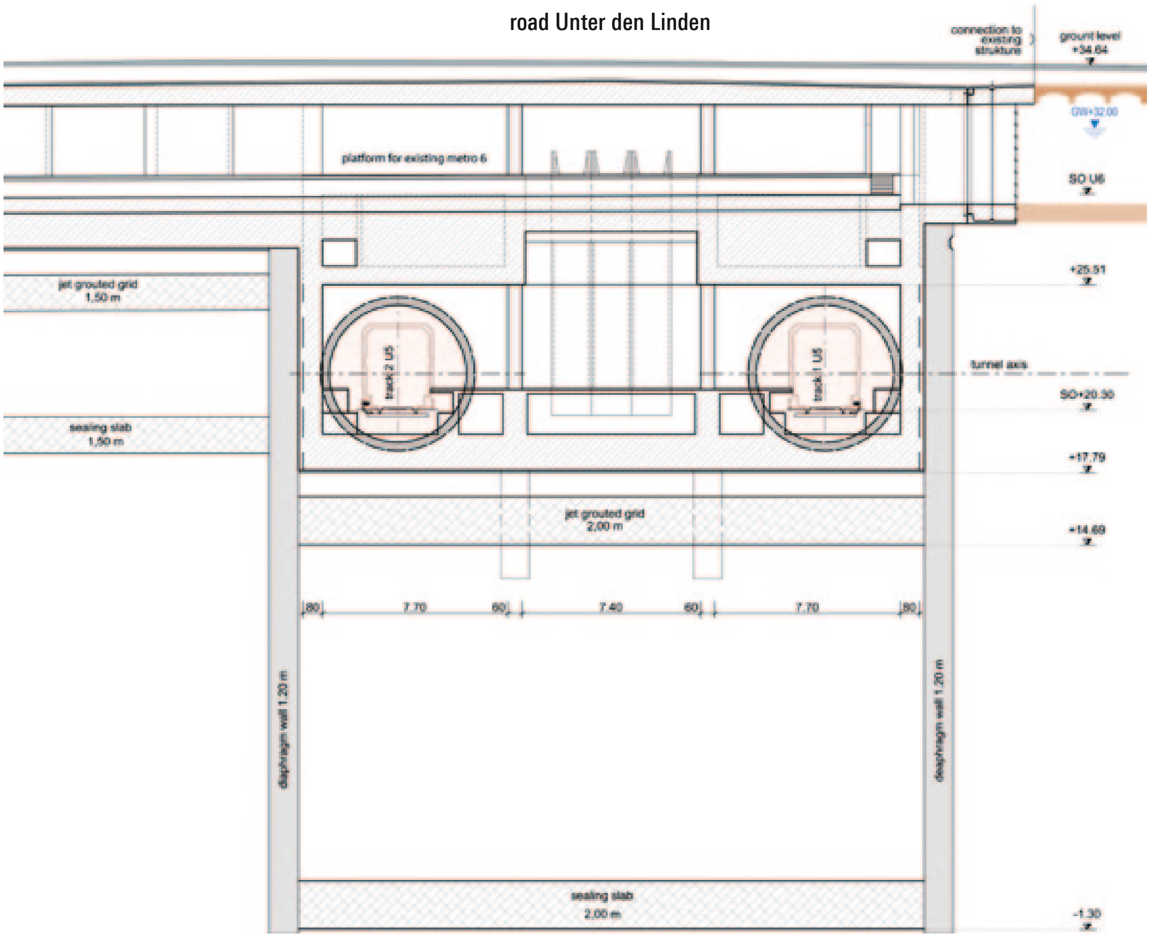
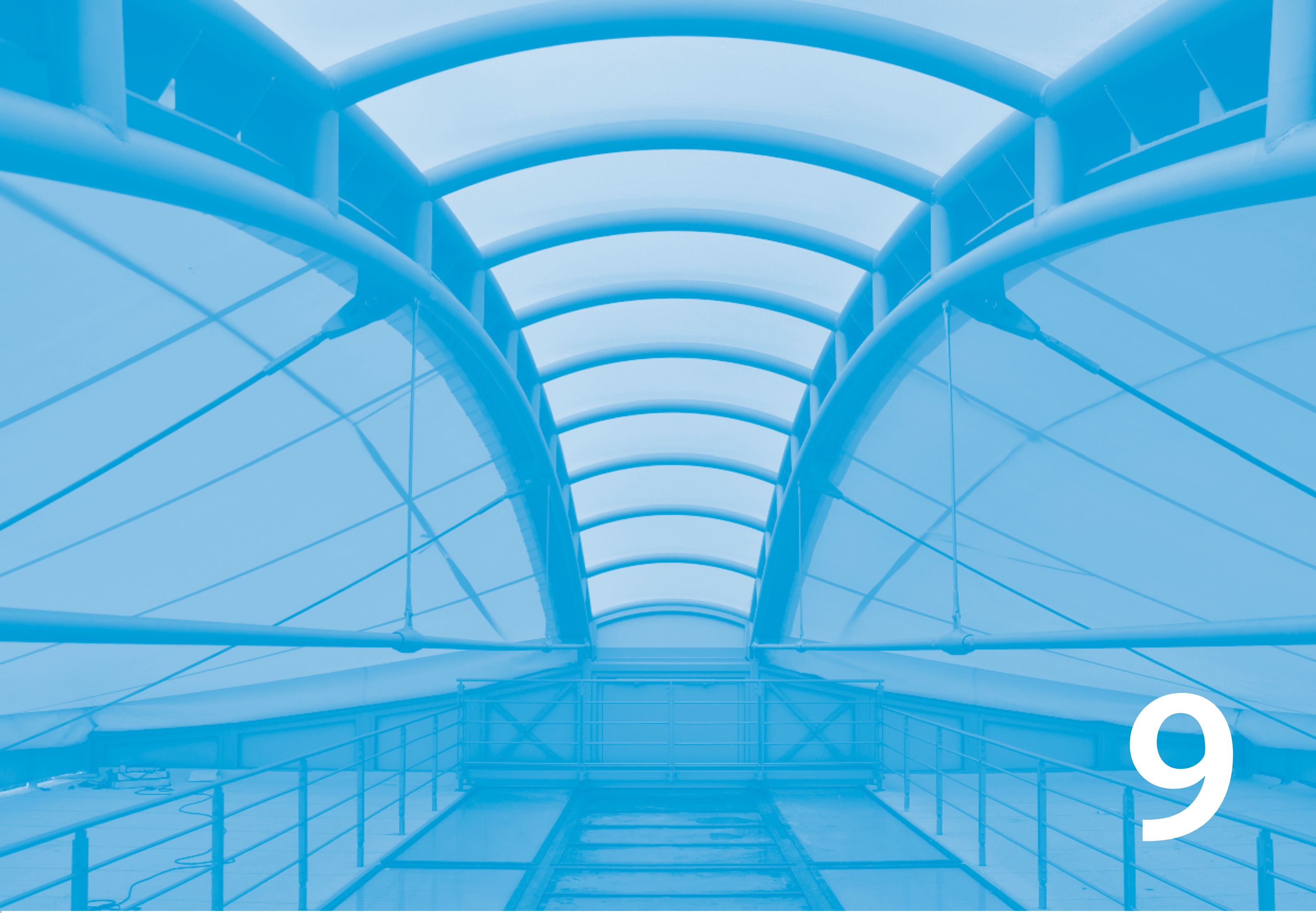


Fig.15, Cross section of crossing area



New Construction of ZAE Energy Efficiency Centre Bavaria

Lecturer: Dipl.-Ing. Peter Voland

The awareness of the increasing greenhouse effect and the related ecological consequences lead to ambitious CO_2 reduction objectives in the framework of internatio-nal and national climate protection. The planned ZAE re-search building in Wurzburg is to be built with innovative, prototypical and efficient construction materials, con-struction systems and technologies in order to verify by means of example their application in the sense of re-source-friendly construction methods within the building stock as well as on new buildings, to demonstrate them and to subject them to monitoring.

Fig.1, Energy Efficiency Centre, visualization

The building is erected on a 135 ha large converted area of the old US military base Leighton Barracks. The plan-ned main area of use of the new building is around 3,200 m^2 on two floors. The property comprises around 10,000 m^2.
The building's use is envisaged as experimental centre where various new developments from the field of buil-ding are tested under laboratory conditions. The intention to build only a demonstration building for zero or plus en-ergy (values were 40 % below the requirements stipula-ted in the German Energy Savings Act EnEV) or a refe-rence object of maximum sustainability (DGNB silver status) was not put in the foreground. Moreover, it was strived at showing how efficient technologies of the buil-ding envelop and technologies of building services engi-neering can be harmonized intelligently in the context of integral design so as to obtain high primary energy effici-ency.
In the building are offices, laboratories and technical room as well as the infrastructure for research activities of the ZAE Bavaria in Wurzburg.

The building's design with its complexity and the system-immanent interactions of the components building de-sign/structural engineering, building envelop, technolo-gical building equipment, building automation and energy storage is the product of a design integrally imple-mented from the beginning between architects, building services engineers and structural engineers.

Objective of the technological concept was the lightness of the envelop with soft technologies to support the buil-ding. The use of naturally available resources of the out-side space – light, air, sun and night's cold – to cover energy demands in connection with elevated interior comfort was an essential part of the energy and climate concept. Heating and cooling concept are based on a low-energy approach to optimize efficiency of regional energy generation systems; in this approach the systems are design with temperature differences as low as possi-ble compared to the room temperature. Especially the comprehensive use of daylight from the outside by opti-mized transparent surfaces in the façade and the roof membrane structure is one of the core aspects of the de-sign. The planned textile construction contributes essen-tially to the increase of energy efficiency of the new buil-ding. Designed as multi-shell building envelop, the roof creates an intermediate climate zone, reducing heat loss as well as decreasing the weather resistance require-ments of thermally effective layers at the building's exter-nal façade. Moreover, energy input and supply of the area by daylight can be influenced by a customized adjustment of transmission properties of the utilized membranes.

Technological building equipment

The technological building concept comprises:

- the use of surface heating and cooling systems made of graphite slabs with thermally coupled phase change materials PCM
- sorptive air-conditioning systems of open and closed construction type
- as well as nightly radiative cooling via the roof surfaces

Especially the interdisciplinary networking of building functions creates synergies in view of energy efficient use of systems and of best possible harnessing of envi-ronmental energy.

Load-bearing structure

The building's ground floor is a reinforced concrete skeleton construction. The heating, cooling and ventilation technologies to be integrated and their extensive distribution lines require a reduction of the wall areas to a minimum in terms of structural and fire-technological requirements. The implementation of the load-bearing structure of the upper floor is, with the exception of the reinforced concrete intermediate structures, a lightweight construction made of steel and adapts perfectly to

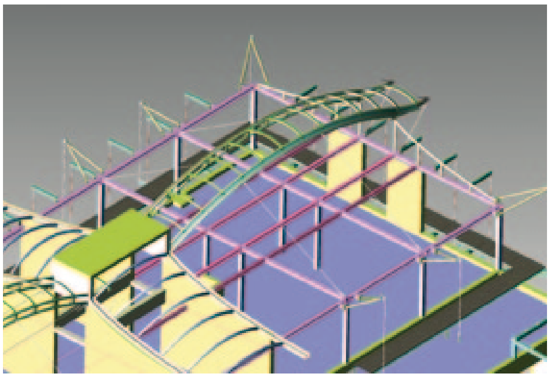


Fig.2, 3D steel structure

Fig.3, Intermediate roof structure with ETFE and PTFE membrane spans

the innovative multi-shell roof design and the thereof resulting structural and physical demands. The lower roof shell, acting at the same time as upper floor roof, is supported by a girder grid and closed in some areas with different materials. To these materials belong common trapezoidal steel sheets, also serving as lower structure of the prototypical cooling surface system with use of phase change material, as well as horizontal insulating glazing with aerogel filling in the translucent areas.
Membranes of three different construction types form the upper roof shell (PTFE roofing, ETFE foils of the intermediate roof, two layers PVC foil as innovative pneumatic cushion with integrated heat insulation as lower structure in the single-floor building area). The thereof resulting different requirements are optimally met by the lower steel structures through their spatial interaction from a structural and aesthetic point of view.

Due to the high detailing of the design, assembly was possible without further adaptations on location.

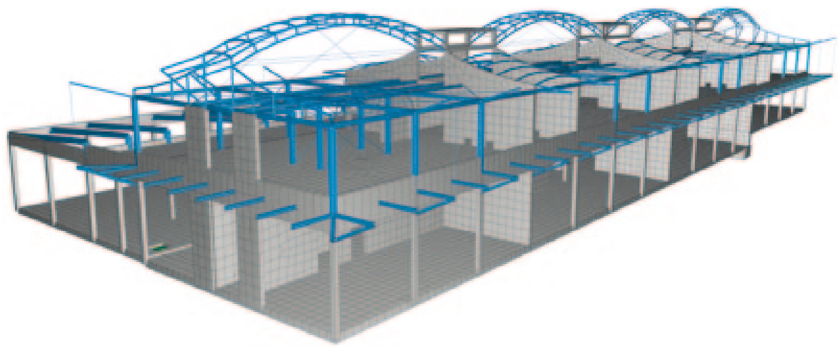
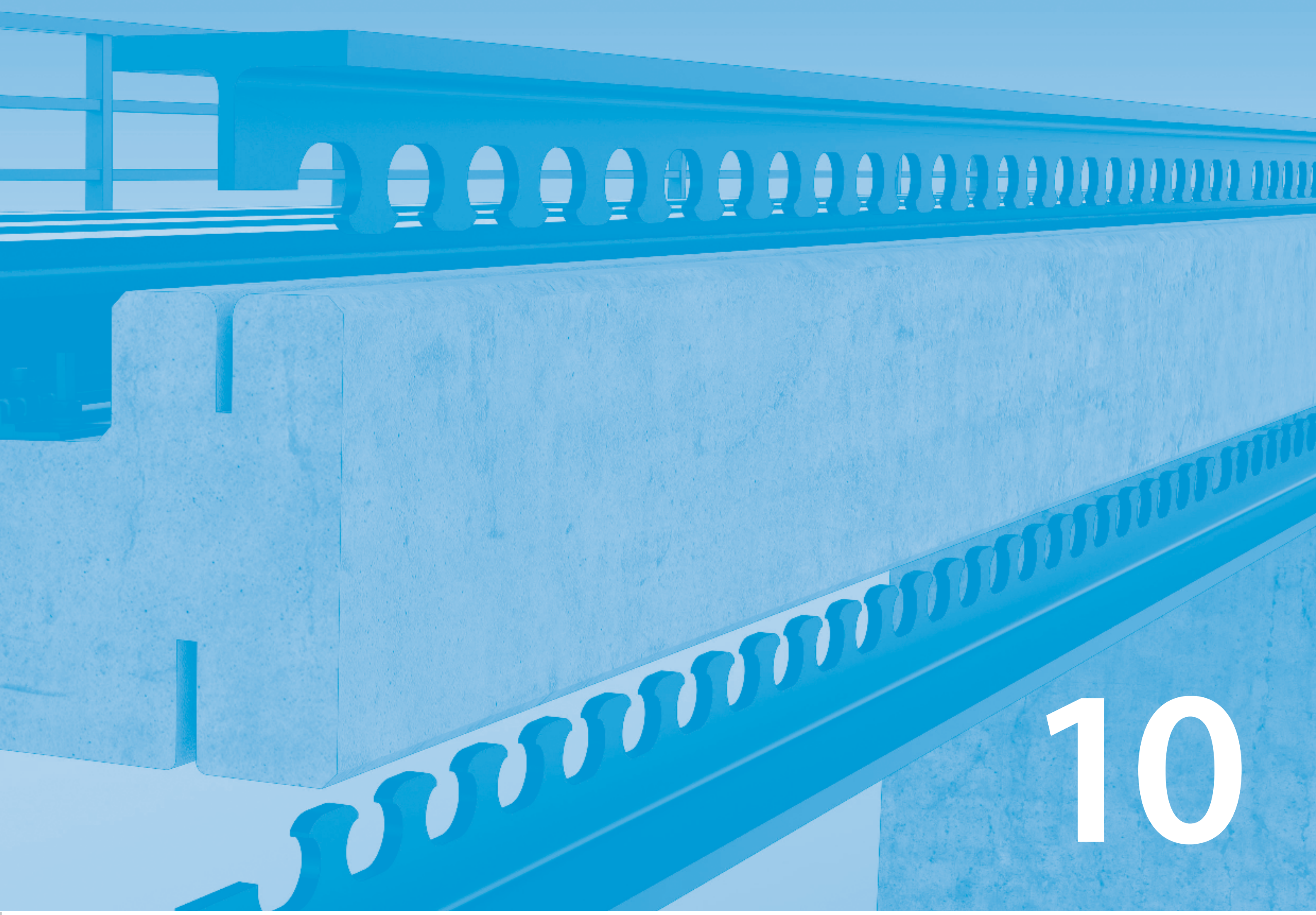


Fig.4, FE structural model

Project overview:

Architecture	Lang Hugger Rampp GmbH Architekten (LHR)
Building services engineering	EB-Partner GmbH & Co. KG
Project management/ Structural engineering	SSF Ingenieure AG

Gross building volume	approx. 18,600 m³
Gross floor area	approx. 4,500 m²
Design period	2010 – 2012
Construction execution	2011 – 2013
Construction costs	approx. 13.2 m €
of which DIN cost group 300:	6 m €
of which DIN cost group 400:	2.5 m €



10

Development of New Construction Systems
and Their Application in Bridge Engineering

Lecturer: Dr.-Ing. Günter Seidl

VFT-WIB copnstruction method / VFT copnstruction method with composite dowel bar

First bridges with rolled girders as load-bearing element were built for railways at the end of the 19th century. The concrete was not used as composite element; its function was a supporting element and durable corrosion protection. In the 1930s, very efficient systems with dished plates were constructed before prestressed concrete construction was established for small and medium span widths. The perfobond bar is the starting point of systematic examinations of load-bearing behaviour of composite dowel bars, which shows similar advantages in terms of construction, load-bearing behaviour and construction process:

- the cutting line is double symmetric and can be fabricated without producing waste
- rolled girders are cut in half at the centre by this cutting line and comprise the composite means
- the reinforcement can be built as cage and lifted from the top in the open steel dowels
- the dowel has a high load-bearing capacity and is fatigue resistant
- halved rolled girders and welded T-profiles with composite dowels are applicable as external reinforcement of new load-bearing systems

1. Cross section types of VFT/VFT-WIB girders with composite dowel bars

To consider composite dowels just as replacement for welded shear studs does not go far enough. Due to the different load-bearing behaviour and the modified structural form, new construction methods become feasible. When the composite dowel geometry is planned in the web of the steel girder, a steel girder's upper chord, serving only to hold shear studs, is no longer necessary.

Typified cross sections are shown below by means of example.

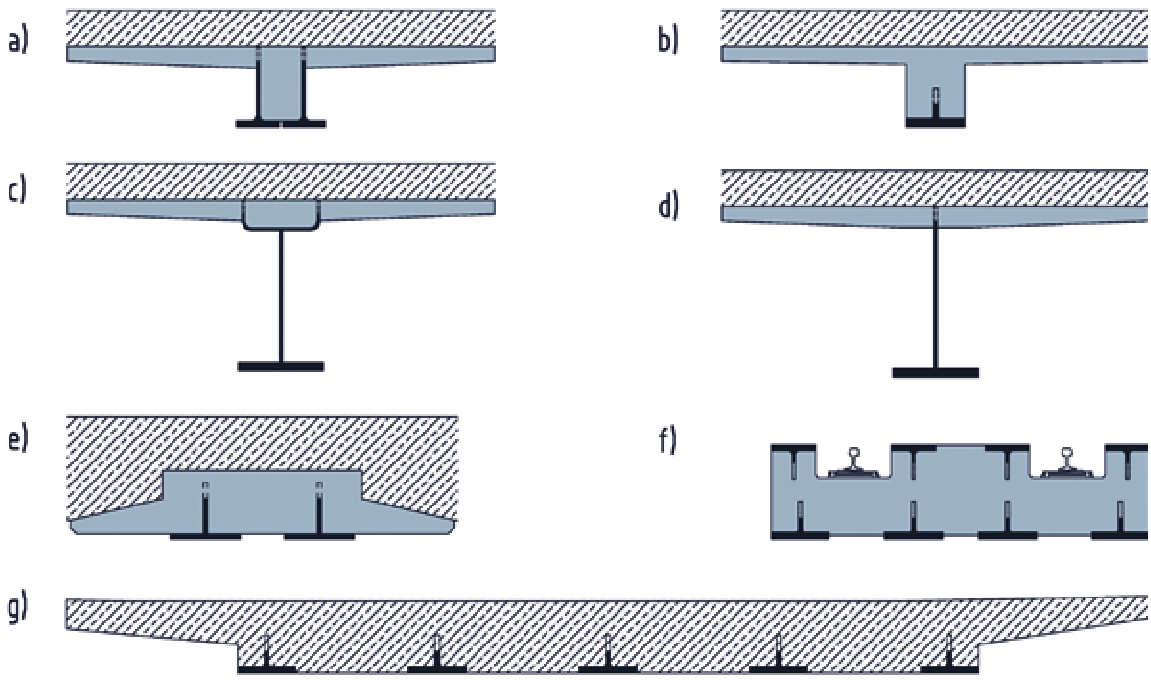


Fig.1, Typified cross section: VFT-WIB method as 'Duo-WIB' (a+e) and 'Mono-WIB' (b) and with welded profiles (c+d); special form as VFT-Rail (f) and external reinforcement in a cast in situ slab (g)

When a rolled girder is cut in half in the middle, tow equal girder parts are the result, which already comprise the composite dowel. They can form one composite girder by placing the halves next to each other. The area between the girders is completed by reinforced concrete. Advantages of this cross section (Fig. 1a) are:

- robust load-bearing behaviour due to concrete encasement in case of impact stresses
- slender load-bearing structure with two steel girders in the cross section
- good appearance due to the web surfaces at the outside
- low construction costs as fully welded girders

The usual rolling programme is designed for girder heights of 1.10 m. Heights of prefabricated elements are then at maximum 0.60 m in case of concrete flange thicknesses of 12 to 20 m. The field of application of Duo-WIB bridges is thus limited to span widths of 20 m. If only an external reinforcement is arranged at the centre of the concrete web of the prefabricated element, the height of the structure is independent of the steel girder's height. The essential benefits of this girder type (Fig. 1b), called Mono-WIB girders, are:

- economic fabrication of prefabricated elements, as ordinary installations for prefabricated prestressed concrete elements can be used
- efficient material use, as the steel distributes the tensile stresses, the concrete the compressive and shear stresses
- the girder height is independent of the steel profile due to the variable concrete web
- through a haunch the superstructure can be adapted to the force flow, and frame systems are easy to implement
- robust load-bearing behaviour due to concrete webs in case of impact stresses
- no horizontal surfaces (soiling by birds)

The assembly weights of both variants a) and b) are double as high as compared to prefabricated composite girders (VFT girders). For economic crane capacities and uncomplicated handling during transport and on site, the area of application of VFT-WIB girders is recommended just like for prestressed concrete girders of up to 35 m span widths. For larger span widths, especially of frame bridges, the VFT girder with welded steel girders is advantageous. When composite dowels are planned at the steel girder's web, the upper chord, which holds the shear studs on conventional VFT girders, is not necessary (Fig. 1d). In the area of negative moments and in case of large forces in the composite joint, an upper chord with composite dowels can be arranged (Fig. 1c).

In case of slabs, the arrangement of an external reinforcement leads to considerably more slender construction components. They are used for cast in situ method for road bridges or for railway bridges with extremely sturdy cross section forms such as the VFT-Rail method (Fig. 1e+f).

2. Road bridges

2.1 Bridges in the course of expressway S7 in VFT-WIB construction method

The largest projects with Duo-WIB girders were realized between 2009 and 2012 in Poland.

The new four-lane expressway S7 between Olsztynek and Nidzica and the bypass Olsztynek was subject of a design and build invitation to tenders. Twelve bridges were built as frame bridges by prefabricated composite (VFT)

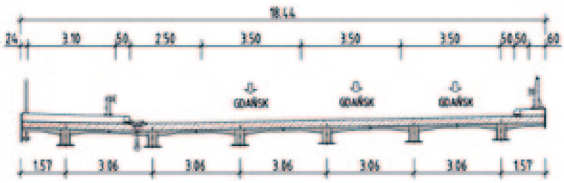


Fig.2, Carriageway in direction Gdansk of bridge MD-1 with six VFT-WIB girders in the cross section

Fig.3, Fabrication area for concreting of prefabricated elements directly next to the construction site method. The construction company selected the VFT-WIB construction method with two rolled girders per prefabricated element (Duo-WIB) for four road flyovers and two wildlife bridges.

A particularity is the bridge WD-4. Boundary conditions were very difficult with 42 gon and a slenderness of l/h = 34.66 / 0.85 = 42. Initially a mildly reinforced cast in situ slab was designed, of which the construction would have been very difficult above the ongoing traffic. For this reason an alternative proposal with prefabricated elements was implemented.

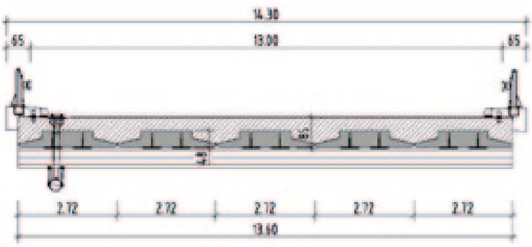


Fig.4, Cross section of frame bridge WD-4 with prefabricated elements

The alternative design consists of a frame with external reinforcement in the prefabricated elements. The planned bottom view was defined by the client and had to be maintained. Because of this, the prefabricated elements were designed with pulled down flanges. The four prefabricated elements span only the area of the railway line as they can be mounted easily and quickly during a line closure at night.

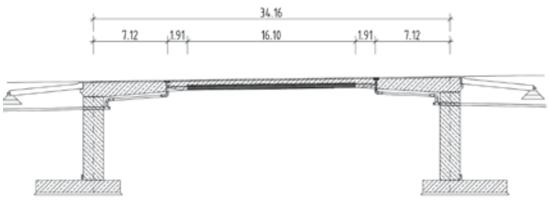


Fig.5, Longitudinal section of road bridge WD-4 with VFT-WIB prefabricated elements in the area of the 2-tracked railway line

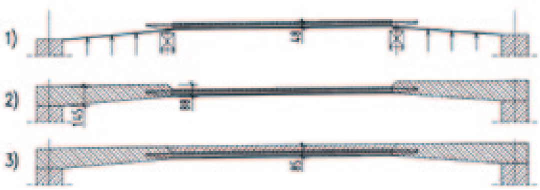


Fig.6, Construction section of bridge WD-4 longitudinal section

Just as in case of the VFT construction method, the whole framing corner including the haunch was concreted in one first section to connect the VFT-WIB girders to the substructures. After setting of the concrete, the second step consisted of concreting the deck slab in the span areas.

The transition of the prefabricated element to the haunch is formed according to the force flow. So the external reinforcement is arranged only in the area of the span moment. The web with composite dowels of MCL geometry continues into the haunch.

Fig.7, Bridge WD-4, bottom view with external reinforcement adapted to the force flow

2.2 Wildlife bridges in the course of expressway S 7

Another much more demanding solution was applied for wildlife bridges over the expressway. In the ground plan, the wildlife bridges PE-1 and PE-4 widen in the final spans from 40 m to around 60 m. Furthermore, the permanent loads are much higher than on road bridges due to the covering of at minimum 0.70 m.

The frame system bridges span over four spans with 17.00 + 2 x 22.00 + 17.00 = 78.00 m. The superstructures are founded on Ø 1.00 m piles. The implementation of a haunch is technically difficult for Duo-WIB girders and entails additional costs because a changeable height of WIB girders is very complicated to realize. Due to the large slenderness and loads, a haunch is however structurally advantageous. In this case, the prefabricated elements were designed with a larger superelevation to obtain a variably thick cast in situ slab.

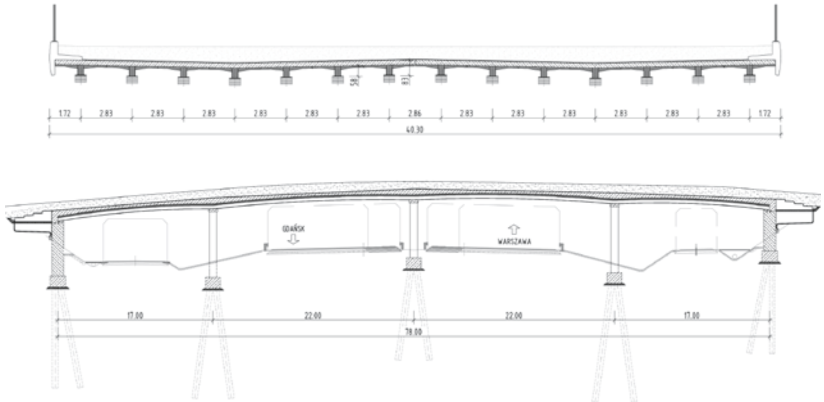


Fig.8, Longitudinal section and span cross section of wildlife bridge PE-4

2.3 VFT bridges with composite dowel bar as frame bridges in Romania

The design & build call for tenders for a section of the new Romanian east-west motorway A 1 as part of the pan-European corridor IV envisages for the majority of bridges integral construction with a life cycle of 120 years.

For some bridges the economically efficient alternative of VFT construction with composite dowel bars was suggested. To create the shear composite by composite dowel bars arranged in the web instead of shear studs (and the therefore required steel upper chord) is one major simplification of the steel structure's construction.

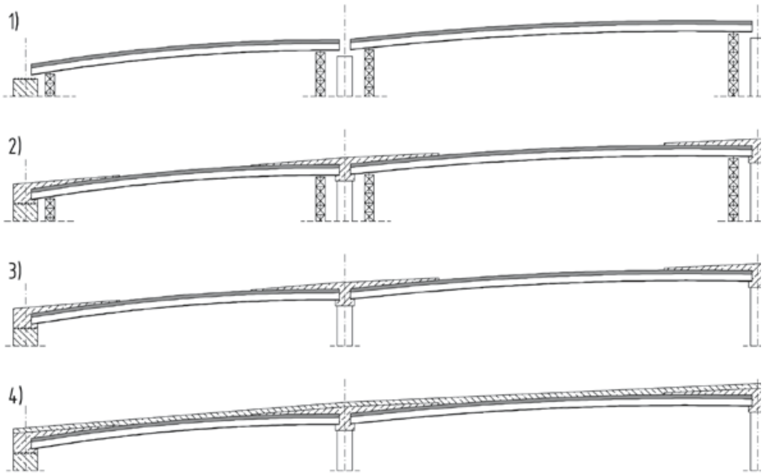


Fig.9, Exemplary construction process of wildlife bridge with pre-concreted framing corner

Structure P11 crosses the ring road with a span width of around 39 m. The structure crosses in an angle of 79 gon and is a slightly haunched frame, founded on bored piles, with short wings. The four 1.20 to 1.50 m high T-shaped steel girders were fabricated at the plant under protected conditions, and completed by a 0.15 m thick prefabricated slab. In the span areas, the composite dowel bars connect directly to the prefabricated element. At each end, an upper chord is arranged that holds two dowel bars at each outside edge. The metal sheets have been produced together with cutting of the composite dowel bars. This construction type resulted in a very economic use of steel of only around 130 kg/m² of superstructure area. As the long girders were difficult to transport via the existing access routes, the prefabricated elements were concrete on location on a formwork built for all five girders.

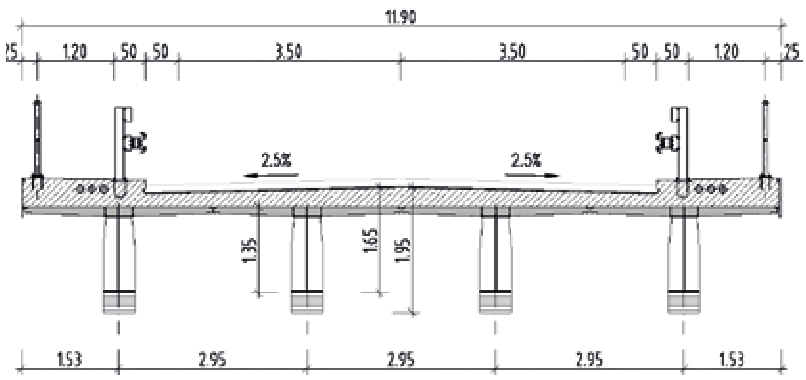


Fig.10, Regular cross section of bridge P11

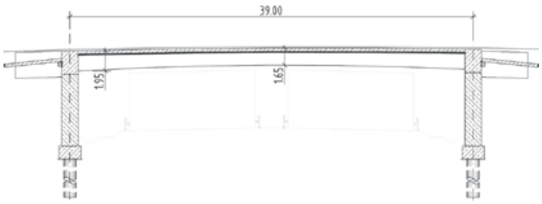


Fig. 11, Longitudinal section of bridge P11

Fig. 12, Steel girder on site; double-line dowel bar in the bearing/framing corner area

2.4 Road bridges over the railway line Salzburg – Wörgl near Vigaun and Kuchl

The Mono-WIB construction method is used for larger span widths or when haunches are needed in frame systems. What is more, this method is the most economic form for larger span widths. The use of steel is the lowest and fabrication at the prefabrication plant is easy to realize. As area of application for frame systems with large slenderness, span widths between 25 and 35 m came to light. A slender and at the same time haunched prefabricated prestressed concrete girder is difficult to dimensions, as the arrangement of prestressing tendons has to designed for the frame system with large span widths as well as for lifting out of the formwork and for the construction stage.

The first bridge built by Mono-WIB method was in 2008 the bridge of a resident road near Vigaun over the Austrian railway line Salzburg – Worgl at km 23.135. In 2010, because of the very reasonable construction costs of under 1,500 € net per m² of bridge area, this construction method was also planned for the adjoining bridge at km 26.993 near Kuchl. Contrary to the bridge Vigaun, the haunched frame over four spans with span widths of 19.50 + 2x19.70 + 19.50 = 78.40 m was designed with gabion abutments and a deep foundation (Fig. 15).

The superstructure holds two lanes of 3.00 m widths each with three VFT-WIB girders of variable height of 0.60 m at the span centre and 0.90 m at the abutments and piles. The cast in situ slab is 0.25 m thick (Fig. 13). Costs of this bridge were also under 1,500 € net per m² of bridge area.

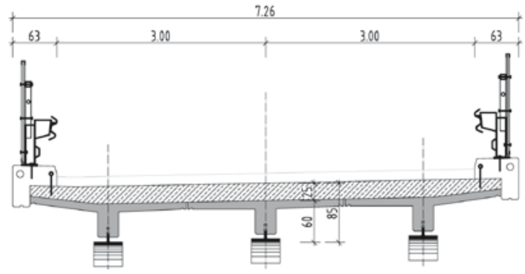


Fig. 13, Span cross section of bridge Kuchl (A)

Fig. 14, Front view of bridge Kuchl;
Fig. 15, Bottom view VFT-WIB girder of bridge Kuchl

2.5 Traffic connection over the river Wilde Saale in Halle to the ice skating rink

The bridge connecting to the ice skating rink in Halle/Saale is an ideal area of use for VFT-WIB construction as Mono-WIB. The span width is with 23.50 m between 20 and 30 m and the necessary opening cross section for one branch of the Saale requires a very slender structure (Fig. 16). The slenderness is with l/h = 23.50 / 0.85 = 27.6 m at the span and 23.50 / 1.00 = 23.50 at the abutment too large for a prefabricated prestressed concrete girder. VFT girders would have been too expensive with regard to fabrication costs of the fully welded girders compared to rolled profile girders of the applied Mono-WIB construction method.

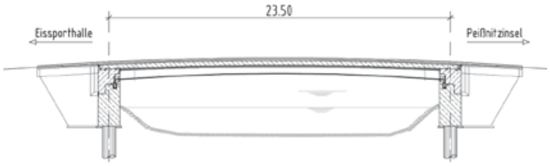


Fig. 16, Longitudinal section of Bridge over Wilde Saale (Saale loop) in Halle (D)

3. Railway bridges

The existing railway truss bridge in the course of the double-tracked line Kielca-Fosowskie over river Łososina was replaced by a bridge with prefabricated composite elements. The presented solution is an alternative offer with VFT-WIB girders of type Duo-WIB that competed successfully against a conventional composite bridge. The superstructures consist of two single-span girders

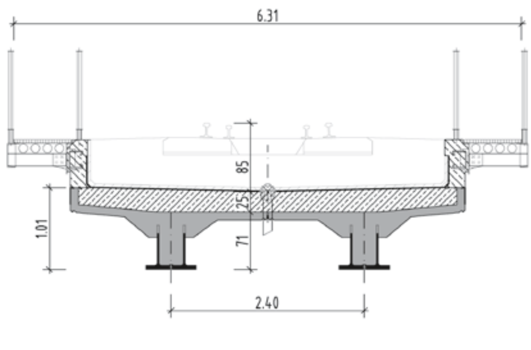


Fig. 17, Cross section of single-tracked bridge over Łososina

with 16.50 m span width. Per track one separate superstructure with accompanying path is designed. The steel girders are made of a rolled profile. They connect into a 0.30 m end piece of the prefabricated element in order to increase the structural height to 1.00 m and to be able to apply halved rolled girders.

For railway flyovers, fatigue plays an essential role during dimensioning of the structure. For the bridge over Łososina, for the first time the modified clothoid shape MCL 250/115 is used as composite means.

The railway bridge near Spergau for the infrastructure operator Infraleuna is a frame structure with external reinforcement in longitudinal direction and an externally reinforced slab in transverse direction (Fig. 18).

The frame with a trough cross section has a span width of 13.00 m. The external reinforcement lies at the top and bottom of the trough side. The upper slats run along the abutment axis into the wing and cover the framing moment. The lower slats distribute compressive forces via the front slab into the abutment. In the deck slab, forces are inserted into the trough sides by the external reinforcement in form of halved rolled profiles arranged every 0.50 m. The superstructure was lifted into place, connected to the substructures and launched laterally during a railway line closure on one weekend.

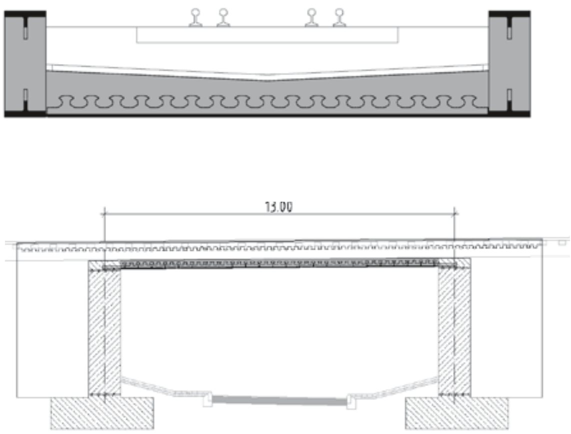


Fig. 18, Cross section and longitudinal section of frame bridge near Spergau with external reinforcement at the trough sides and in transverse direction of the deck slab

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