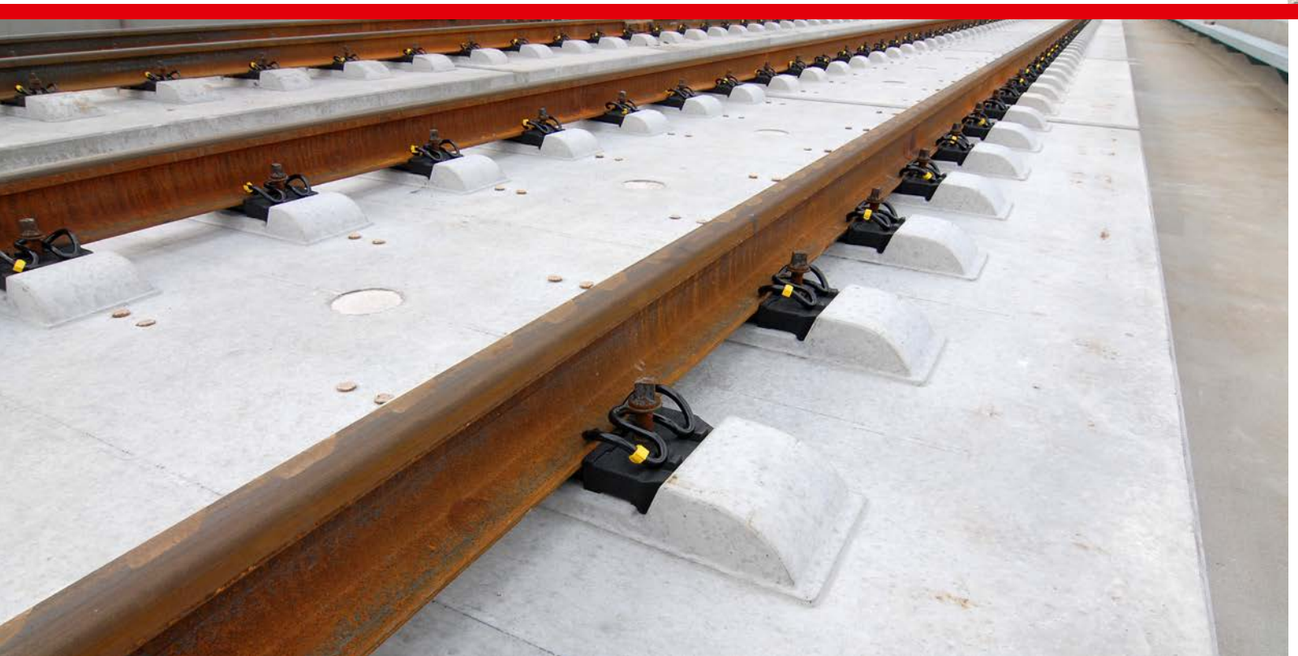
MAX BÖGL

Slab Track Bögl

Slab Track Bögl (FFB)



The FF Bögl slab track system is one of the internationally established track-bed systems for rail transport. High-speed trains travel at speeds of up to 350 km/h over more than 10,000 kilometres in Europe and China – on prestressed, longitudinally coupled track slabs made from precast elements, which offer high positional stability and require minimal maintenance.

For more than 30 years, Max Bögl has consistently advanced this technology, shaped by the practical experience of realised projects and the requirements of our customers. What began as a standard construction method, first used on the ICE line Nuremberg–Ingolstadt, has grown into a complete system covering almost every requirement of modern railway construction. Today, the range of individual solutions extends from underground and suburban railways to reconstruction routes and heavy-load traffic, as well as bridges, tunnels and high-speed switches – with additional noise and vibration protection available on request, for example through various mass-spring systems.

Planning, production, transport and installation all come from a single source. Efficient manufacturing, automated assembly processes and the use of more economical building materials shape the construction sequence and noticeably shorten construction time. The result is a track that stands for reliability, availability and safety throughout its entire service life.

Scope of services

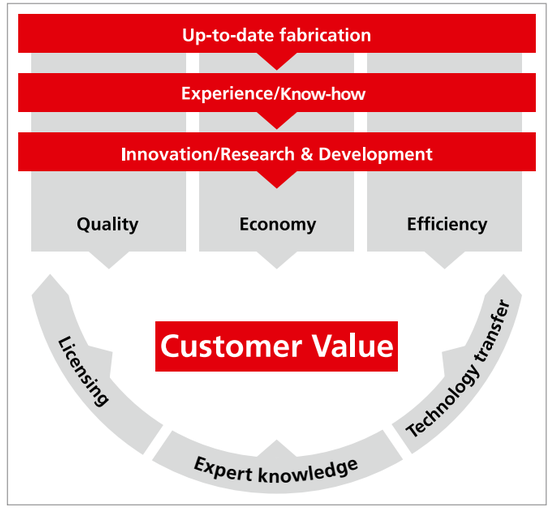
Due to its versatility, the Max Bögl Group is able to execute turnkey projects from slab tracks of underground/suburban railways to reconstruction routes to high-speed lines. For the manufacture of the FFB slab track we offer the following services:

Planning

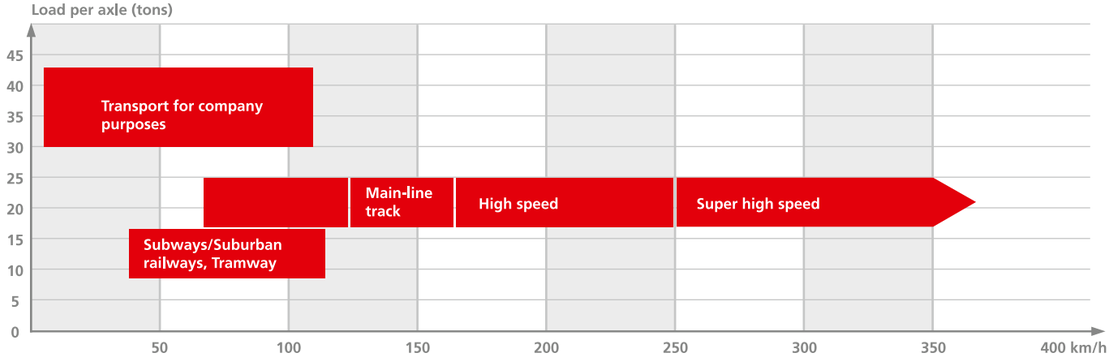
Max Bögl has developed planning software for the FF Bögl system which generates an installation plan from the track-geometric project containing all relevant data for the slab track. These are the basis for the entire logistics – that is production, stocking, transport and installation – as well as for quality assurance and inspection measurement. Adding to this, we also plan special solutions, such as transition areas or construction of prefabricated elements for various types of switches.

Manufacturing / machine technology

Our group of companies has decades of experience in advanced prefabricated construction. We plan, build and/or operate customer- and project-specific production facilities as well as plants and equipment for assembly. Out of our machinery, we are able to provide mobile production facilities and assembly-specific equipment for your projects on request. This includes CNC machines for FFB-typical processing of prefabricated elements.



The high degree of prefabrication of the panels at the factory enables short installation times.



Technology transfer

We have a team of skilled experts who will assist and advise you in the implementation of your projects by means of our technology. Within the task of a technology transfer we supply for our FFB product a complete compendium with work and test instructions for the manufacture of track slabs and their assembly. In especially adjusted training courses, our customers get all information which they need for the planning, execution and quality control of the FFB. Our practice-oriented experts are glad to accompany and advise you during the execution. In addition we also offer the technical overall responsibility for our system and quality monitoring.

Quality management

Our complete quality management system sets standards for the entire process flow. Defined work steps and tests which are adjusted to the national circumstances ensure constant and high quality. Due to our support in selecting national building materials we contribute to unerringly achieve the required quality of the final product.

FFB – Slab Track Bögl system description

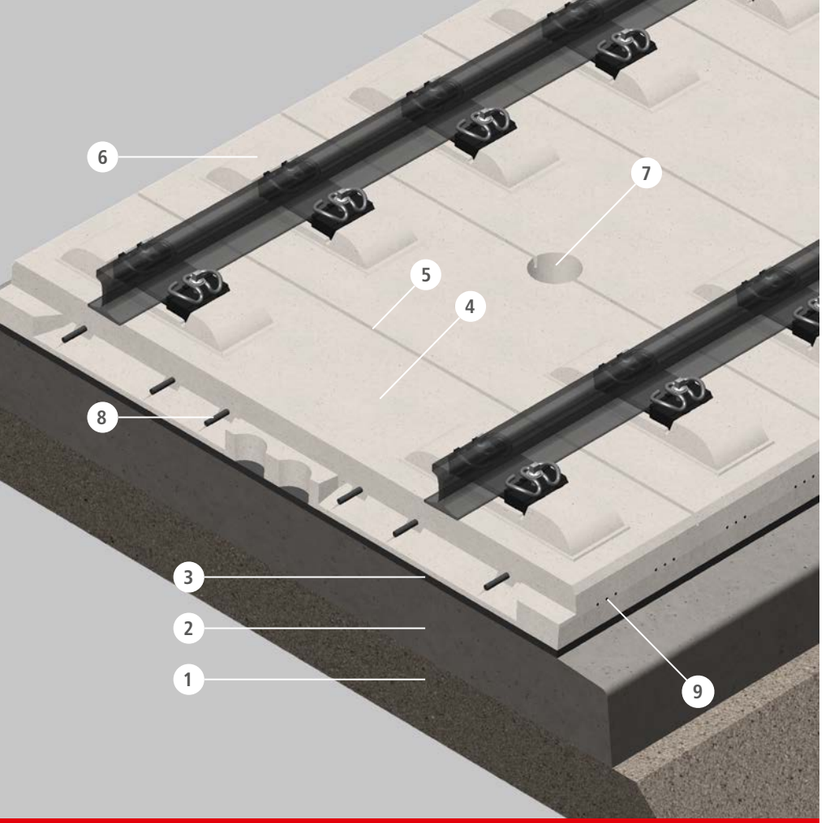
The FF Bögl system consists of prefabricated, prestressed slab tracks which are coupled in longitudinal direction. This construction method results in a homogeneous trackway designed to ensure long-term track stability. The system can be used on earth structures, in tunnels and troughs as well as on bridges.

Earth structures are stabilised in such a way that the requirements for tolerable remaining settlements are met with. The earth subgrade is covered with an anti-frost layer for protection against climatic impacts (frost heavings). The slab tracks are placed on a hydraulically bound layer (THB) or alternatively on a reinforced concrete base layer (BTS). In tunnels and troughs, these requirements are already fulfilled without further action. Standard slabs lie on bridges on a gliding, reinforced concrete base layer (BTS) which are anchored with the bridge superstructure in defined spaces (Bögl integral). Alternatively, it is also possible to design individual slabs, which are not prestressed, according to the instructions of the German Railway to install the slab track on bridges.

The THB or BTS base layers provide continuously decreased stiffness and load transfer. At the same time, they are blinding layers and support for the slab tracks. In trough and tunnel structures, the existing blinding concrete replaces the HGT/BTS.

The slab tracks are installed with a standard spacing of 5 cm. Vertical and horizontal adjustment takes place using spindle devices and a computer-aided surveying system. The vertical gap between slab and base layer is sealed and subsequently fully filled using a specially developed grout. Then the longitudinal coupling process of the slabs follows so that a monolithic, continuous band is created with a high resistance to longitudinal and transverse displacement. The longitudinal coupling counteracts the so-called “whipping effect”, which is a warping of the slab ends due to thermal differences. A characteristic feature of the slab tracks are the predetermined breaking points that are arranged between the rail support points. This will prevent an uncontrolled crack development.

In order to drain the surface water, every slab is manufactured with a transverse slope of 0.5% by default.



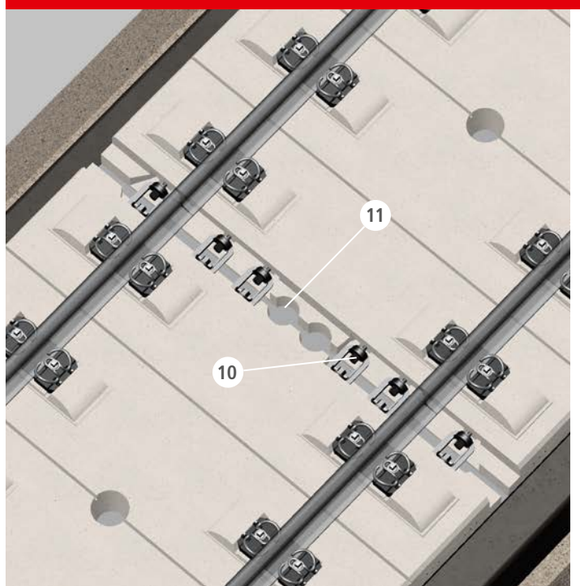
1 Frost protection layer (FSS)
2 Hydraulically bound layer (THB), d = 30 cm
3 Grouting mass
4 Slab Track
5 Design cracking joint
6 Rail support point
7 Opening for grouting mass
8 GEWI steel
9 Prestressed steel

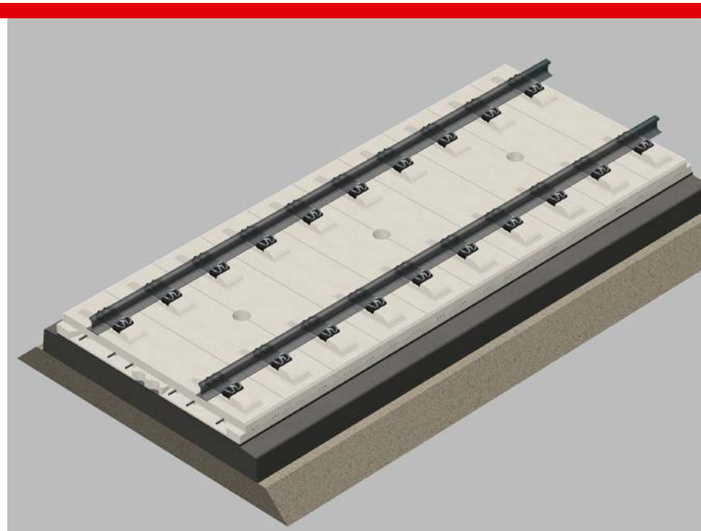
Pictured on page 9:
10 Turnbuckles and nuts
11 Construction joints

The rail support points can be mechanically processed via a computer-controlled grinding machine. This ensures a high degree of accuracy in the track alignment (tolerance values in the track support slab < 0.1 mm, achieved by grinding the track geometry). The slab production is finished with the assembly of the rail fastenings. All rail fastenings systems which are approved and suitable for ballastless tracks can be used according to the track requirements.

The slabs are adjusted only on defined measuring points on the rail supporting points without the use of a mounting rail. Therefore the main disadvantage due to deformation of a mounting rail as a result of temperature changes during fine adjustment of the slab tracks is solved. Complicated measuring work as well as correction of the track geometry after installation of the rails are unnecessary.

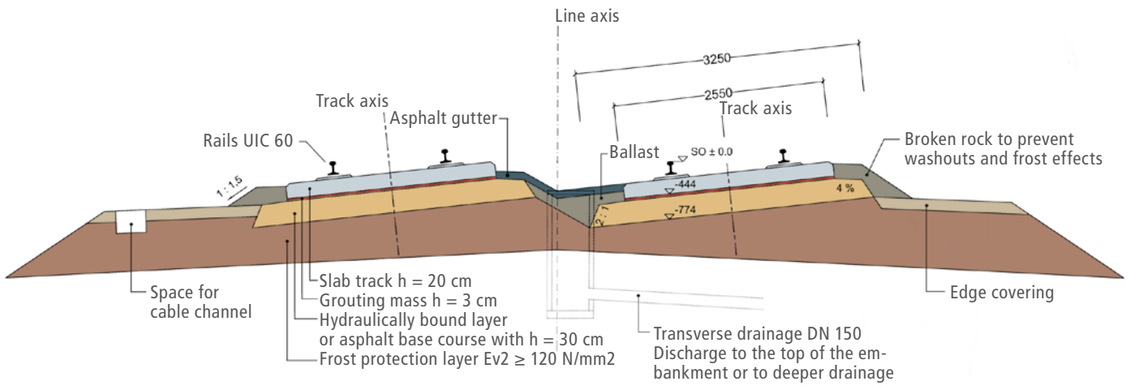
Technical data of the FF Bögl System:	
Construction height (from OK THB to OK rails):	474 mm
Slab length (System length: nominal 6.5 m):	6.45 m
Slab width:	2.55 m
Slab height:	0.20 m
Rail supports:	10 pairs per slab; spacing 650 mm
Prestressing:	transversal
Longitudinal coupling:	GEWI steel



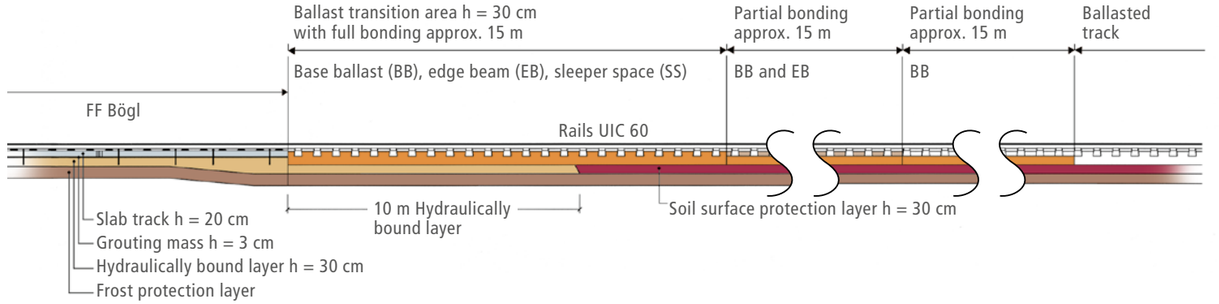


System cross-sections

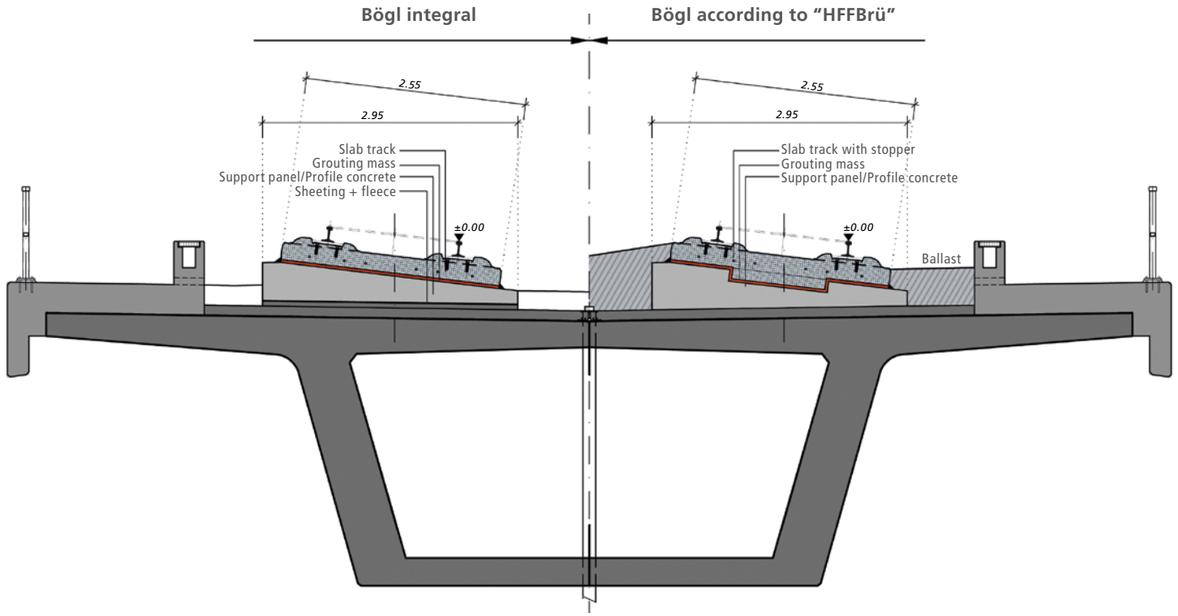
Typical cross-section for FF Bögl on an earth structure



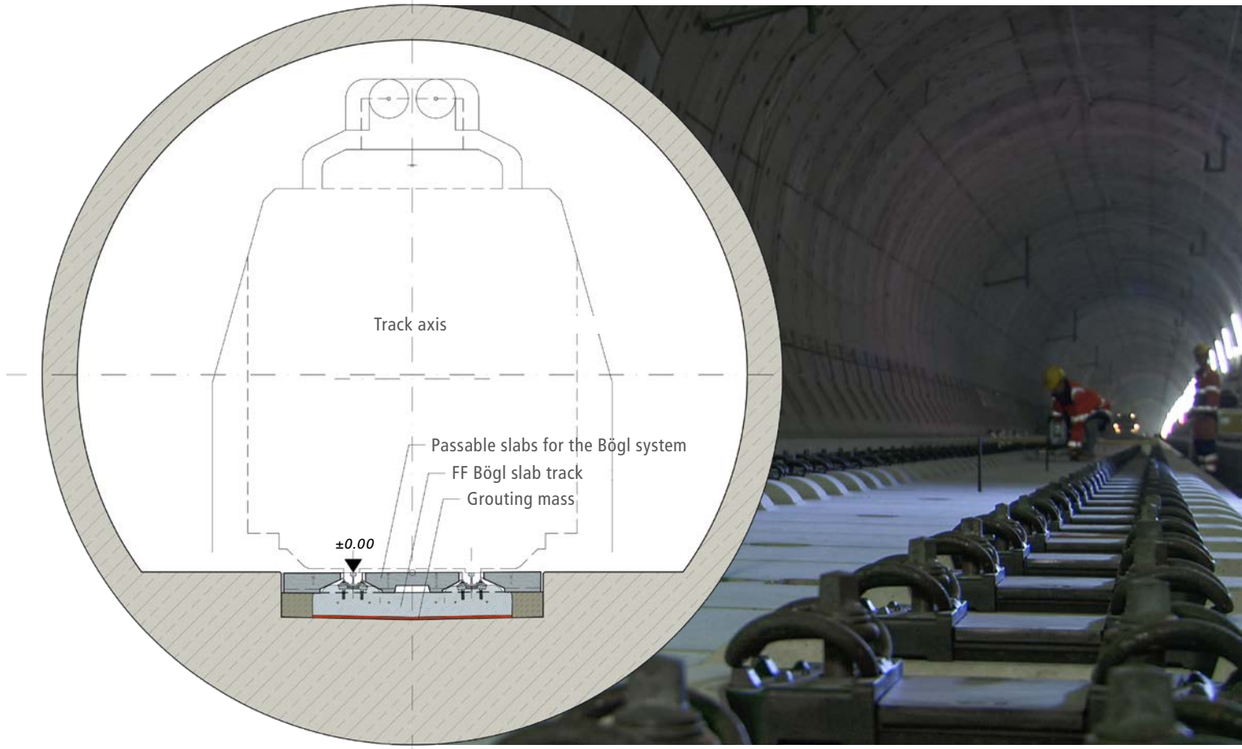
Transition of the FF Bögl to a ballast roadbed and track

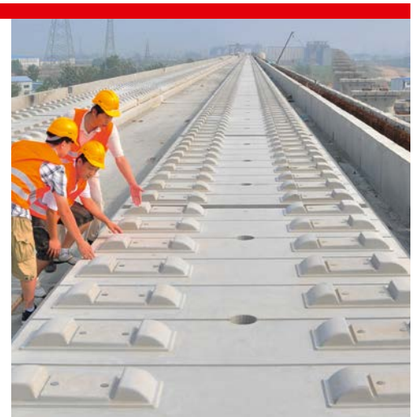


Typical cross-section for FF Bögl on bridges



Typical cross-section for FF Bögl in tunnels

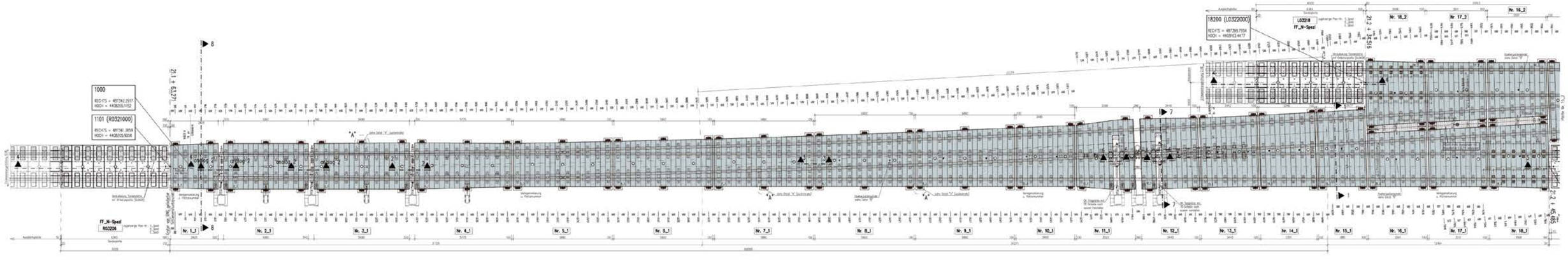


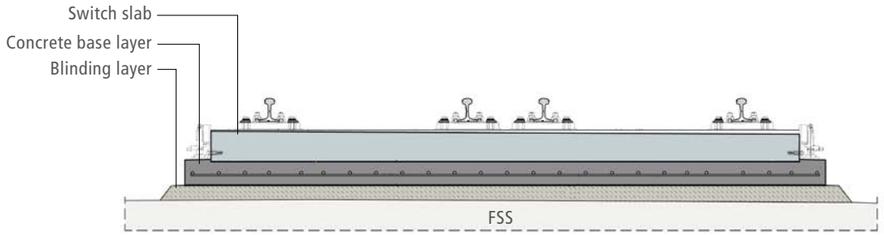


FF Bögl Switches and Turnouts

Based on the idea to implement railway lines without using a cast-in track panel, but rather by means of prefabricated slabs, the Max Bögl Group has developed a system for gauge change devices. From the conventional turnout sleeper plan of the switch manufacturer, a slab installation plan is generated. The slab dimensions are, on the one hand, dependent on economic transport sizes and weights, and mechanical and electrical facilities have to be taken into consideration on the other hand. Due to the switch geometry, the precast slabs for switches and turnouts have different dimensions and most various arrangements of rail fastenings.

However, there is one thing that all precast slabs for switches and turnouts have in common: In longitudinal direction, plain benchings and transversely inclined areas change in turn with unchanging widths. The inclined areas serve for surface drainage. The rail fastenings are mounted on the benchings. In order to be able to ensure the precise position of the benchings, the fastening holes are drilled using a CNC drilling station. Already in the prefabricated parts plant, the precast slabs for switches and turnouts are equipped with through-bolted connections which are required for fastening the rails. At the place of installation, the precast slabs for switches and turnouts are put down one after another in the planned order and aligned and undercast. The grouting mass consist of self-compacting concrete and is reinforced. Reinforcement stirrups at the bottom side of the precast slabs for switches and turnouts, which are anchored with the undercast concrete, ensure that their position is secured.



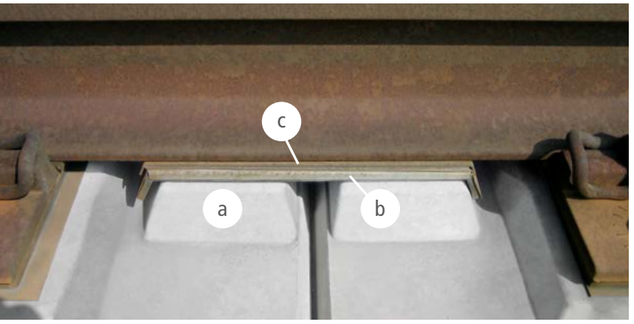


Assembly of the precast slabs for switches and turnouts takes place without turnout rails and accessory. Exact fit of the rail fastenings requires no adjustment later on. The complete switch, including all accessory parts, is only mounted after the precast slabs for switches and turnouts have been undercast. That way, no switch components are soiled or damaged. In contrast to conventional assembly, considerably smaller and lighter components can be delivered, reducing costs for transport and assembly cranes. Construction times are considerably shortened.

Approval of field testing by Germany's Federal Railway Office (EBA) was the condition for the implementation within the first FFB high-speed line in China. In 2007, two switches were manufactured as cross-over in the new line between Beijing–Tianjin. In follow-up projects, more than 1,250 high-speed switches were installed in the new high-speed-lines in China until 2015. After numerous successful operations in China, this technology was also implemented for the German Railway at the new line Ebensfeld–Erfurt.

System complements / extensions

1 Derailment protection



2 Continuous support

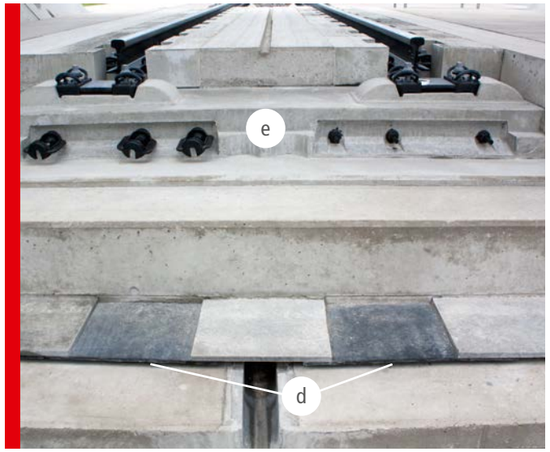
Derailment protection (1)

The Max Bögl group offers solutions to protect derailment for new tracks as well as up grading the system FF Bögl. Prefabricated parts are fixed by dowels between the rails of the slab track.

Noise protection / vibration protection

■ **Continuous support** (2)
In 2004 the promoted project "Hipertrack" (High Performance Track) was tested near the station of Foggia, south Italy. A solution developed for the Slab Track Bögl. For this research project, standard FFB slabs were manufactured with additional support points between two neighbouring rail fasteners each. On top of these integrated rail seats (a) an elastic layer (b) and steel plates (c) for height adjustment and fixation are arranged. These flexible supports, which are adjusted to the track stiffness, absorb rail vibration and noise emission. The results achieved by means of this continuous support were positive. The air-borne sound could be reduced by 2–3 dB(A), and the structure-borne sound could be reduced by up to 5.5 dB(A). This reduces the perceived volume to the human ear by around half, as shown by the results of noise measurements carried out on the NBS Nuremberg–Ingolstadt line (noise assessment report 024901).

■ **Mass-spring system**
Vibrations generated by wheelrail contact can be reduced by means of so-called mass-spring-systems in a targeted way. Depending on the relevant degree of efficiency, it is distinguished between light and heavy mass-spring systems.



3 Heavy mass-spring system

4 Noise-protection walls

■ **Heavy mass-spring system** (3)
By means of linear supports (d), the slab track is decoupled from its constructional environment in a targeted way, thus enabling free swinging. This ensures a cushioning effect up to very low frequencies. The linear supports have the function of springs. The FFB slab (e) is integrated into a trough forming together with it the mass element. The mass and spring stiffness of the linear support are dimensioned in such a way that the system achieves the intended cushioning effect.

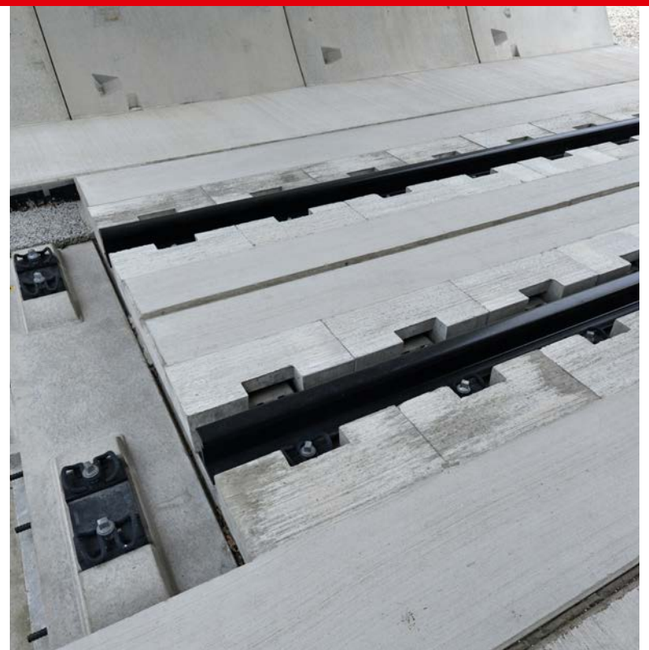
■ **Light mass-spring system**
In case of low demands on the vibration protection, the FFB system is decoupled via a spatial support from the constructional environment. The mass is only generated by the self weight. Flexible mats are glued underneath the slabs. Using variable slab thicknesses and defined spring coefficients of the mats, the system can be adjusted to the relevant situation.

Noise-protection walls (4)

In 2010, the German Railway put into effect the revised Guideline 804 5501 on "Noise-protection Installations on Railway Lines". The dimensioning takes into consideration the static and dynamic stress changes owing to pressure and suction impacts from train service. Based on this guideline, the Max Bögl Group was granted type approval by the German railway authority (EBA) for a noise-protection system made of prefabricated concrete elements for high-speed traffic up to 350 km/h. The noise-protection elements can be designed both as absorbing on one and on two sides. They are modularly designed and can be combined to wall heights of up to 5 m. This system will be used for the first time on the new line Ebensfeld–Erfurt.

Trafficability in tunnels

Modern rescue concepts demand, among other things, trafficability of the tunnel by means of rescue vehicles linked to wheels. For this purpose, the Max Bögl Group offers a prefabricated element which also offers a high degree of safety during construction works. Prefabricated parts are installed on the slab track between and next to the rails and fastened. Their geometry is adjusted to the slab track system in such a way that the gap between rail and prefabricated part becomes as narrow as possible. Inspection and maintenance of the safety-relevant parts of the slab track, such as the rail fasteners, are possible without dismounting these prefabricated parts, however. Assembly is integrated into the process of the general trackway works without any problems.



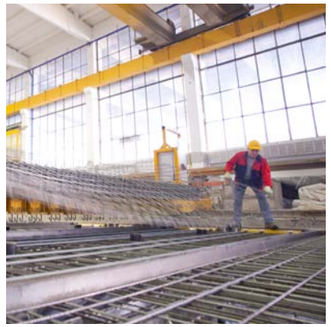
BÜB – Level Crossing Bögl

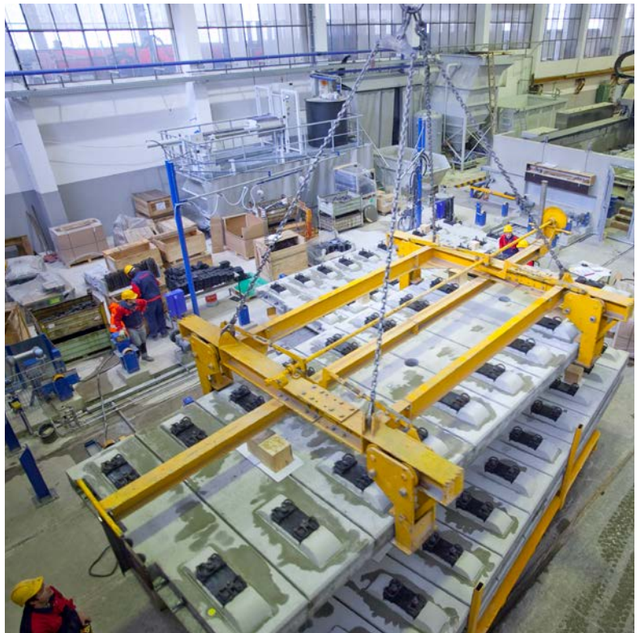
With the directly passable prefabricated concrete slab for level crossings with inserted rail, Max Bögl delivers a carriageway slab which can be used right away without an additional cover, such as mastic asphalt. In combination with the inserted rail, the carriageway can be made available within a very short time both for rail vehicles and wheeled vehicles. The rail is embedded in a prefabricated polyurethane jacket and elastically anchored in the concrete channel. The slab can be used as level crossing for mainline railways, as tram slab and as passable slab for emergency vehicles in tunnels. Apart from the directly passable slab with level crossings, the inserted rail can also be used on the FFB – Slab Track Bögl and is thus suitable for the high-speed range.

Production

Production process

- Cleaning and preparing the formwork
- Installation of the reinforcement and dowels for the rail fasteners
- Prestressing
- Concreting and aftertreating
- Cutting through the prestressing wires
- Lifting and storage of the slabs
- Mechanical processing of the rail support points
- Assembly of the rail fastenings
- Intermediate storage of the final product or delivery “just in time“

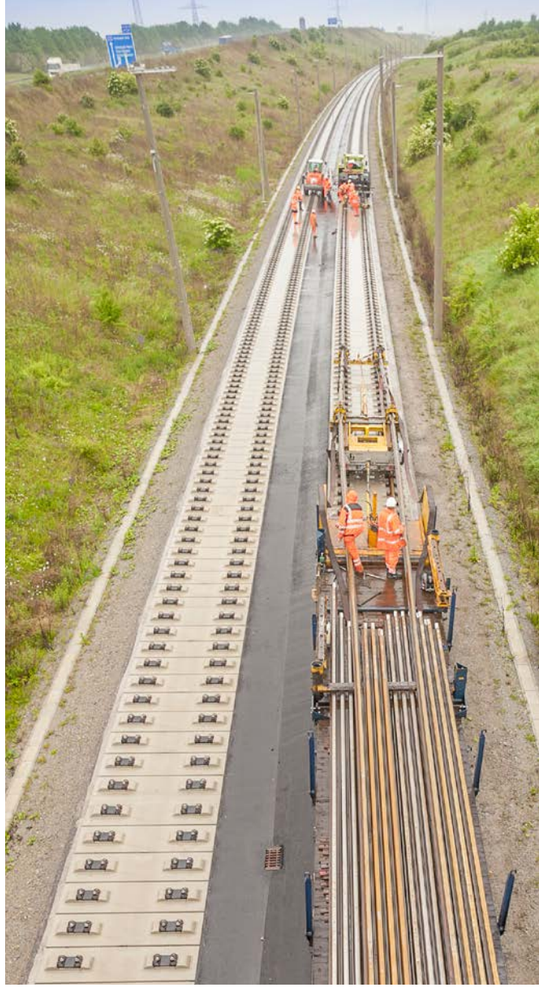


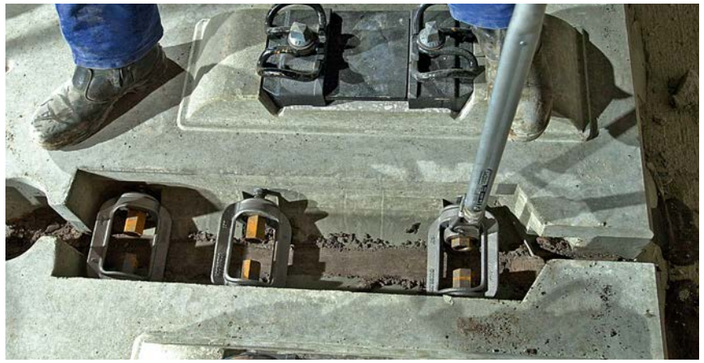


Installation

Installation process – for example on earthworks with a frost-protection layer

- Installation of the hydraulically bound layer (THB) or reinforced concrete base layer (BTS)
- Anticipatory pegging out of the track axles and slab joints
- Transport of the slabs to the building site
- Depositing and aligning the slab tracks
- Adjusting and fixing
- Sealing the longitudinal and transverse joints
- Underpouring the slab
- Coupling in longitudinal direction
- Filling the transverse joints
- Assembly of the rails

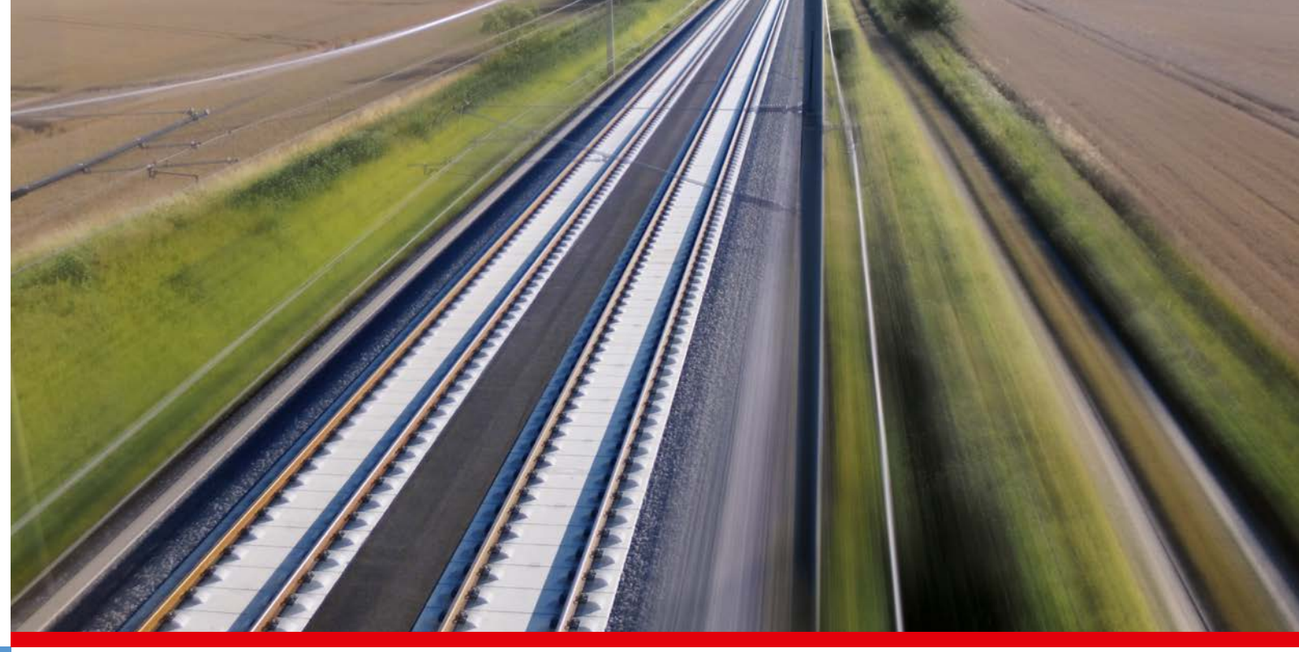




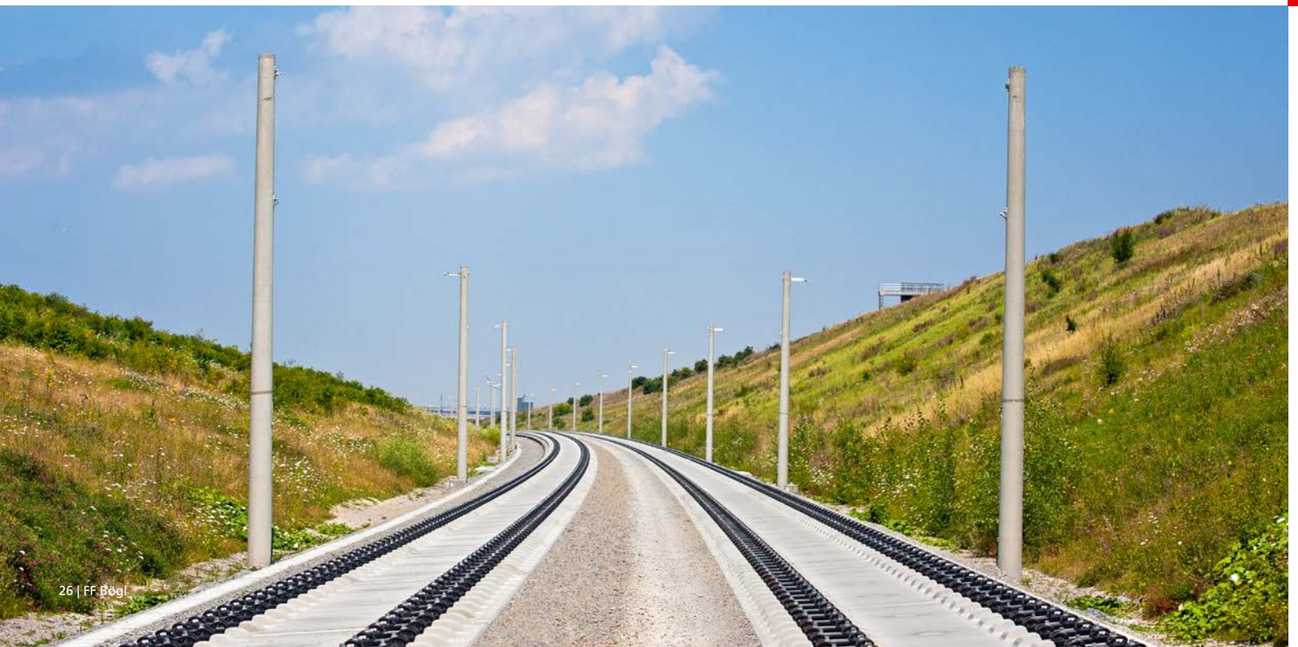
Projects

New line Erfurt–Ilmenau

As part of the traffic project “Deutsche Einheit Schiene Nr. 8”, the new line runs from Ebensfeld–Erfurt from the connection cross Erfurt to the newly erected Ilmtal bridge at Langewiesen. For the two-track extension of the 32 km long section, of which the track work is designed for high speeds of 300 km/h, roughly 8,800 slab tracks of the FF Bögl system have been installed. The three double-tube tunnels of Sandberg, Behringen and Augustaburg were equipped with a special rescue/trafficability cover. In the two overtaking stations of Eischleben and Ilmenau-Wolfsberg, precast slabs for switches and turnouts of the FF Bögl slab track system were applied for the first time in Germany. Out of the total of 12 bridge constructions, nine were equipped with circa 1,200 special slabs.



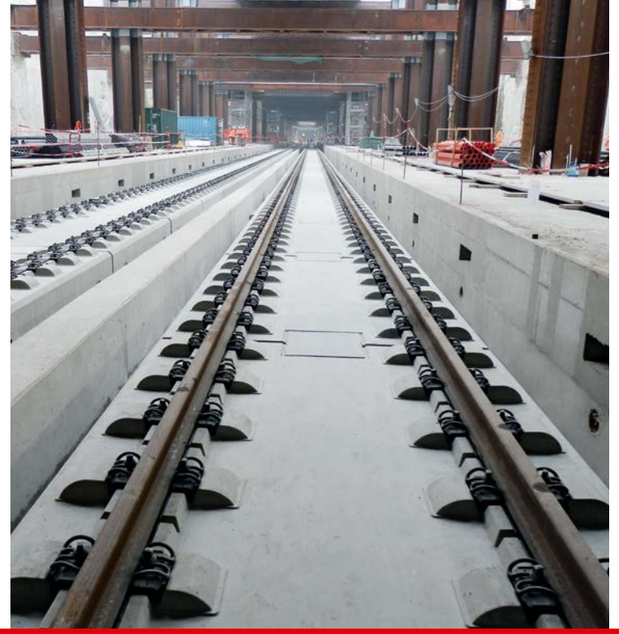
Construction of the 32 km high-speed line between Erfurt and Ebensfeld:
FF Bögl ensures precise track alignment and a high level of ride comfort at speeds of up to 300 km/h.



Track renewal of Roitzsch–Hohenthurm section

Originally constructed for a speed of 160 km/h the just under 15 km long Roitzsch–Hohenthurm double track section on the Halle–Bitterfeld railway line was modernised as a result of instability on the track. To renew the electrified section the existing carriageway was replaced by the FF Bögl system with roughly 4,400 slabs, 18 switches, and sound absorbers in some sections. The special challenges for Max Bögl were the extremely short construction time of just four months and construction within an existing structure with the overhead lines switched off. A specially equipped assembly crane took the slab tracks delivered by train/HGV and from the adjacent track positioned them accurately for final installation on the base course. The speed on the line is to be increased to 200 km/h in a second development phase when more noise protection will be provided.

This project was distinguished by the “Supplier Award” from DB AG.



Katzenbergtunnel

The roughly 9.4 km long Katzenbergtunnel, Germany's third longest tunnel, with its two one-track tubes is the heart of the extended and new line between Karlsruhe and Basel. To enable speeds of up to 250 km/h in the tunnel, the FF Bögl slab track system is being used, with track support slabs having tolerance values of < 0.1 mm. This provides the basis for precise track alignment and a high level of ride comfort. As a protection against vibrations and secondary sound, a 500 m long section of the FF Bögl slab track was built as mass-spring system. A considerable novelty for the superstructure in one-track tunnel tubes is the required drivability of the track area by rescue vehicles linked to wheels. The safety concept provides for the installation of special superstructure elements made of prefabricated concrete components in the areas next to the rails and an addition made of in-situ concrete between the rails.

Central station Bologna

As an important hub of the Italian high-speed network between Milan and Florence, the central station of Bologna was extended as an underground station complex. In order to avoid or reduce structure-borne sound, all four station tracks on a length of 440 m were built as FF Bögl slab track system instead of conventional ballasted tracks. Based on positive results at the partial routed in the station of Incoronta near Foggia, installation in Bologna was carried out as mass-spring system with continuous rail support system. A total of 226 slab tracks in a width of 50 cm each were at first installed in the area of the two main tracks, with the auxiliary tracks being completed in a second step.

Rhine bridge Kehl

In the course of extending the high-speed route Paris-Eastern France-Southwest Germany, the new Rhine bridge Kehl will replace the existing old, one-track bridge structure, thus also allowing for higher speeds in the area of the bridge on the roughly 14 km long railway line between Kehl and Appenweier. As for the two-track extension of the Rhine bridge Kehl there was only a limited constructional depth, German Railway decided to install the FF Bögl slab track system made of non-coupled individual slabs. To minimize load transmission from the rail traffic, the slab tracks, by interconnecting an elastic mat, were directly deposited on the track plate of the steel superstructure. Installation of standard slabs and special slabs in the area of the abutments took place in two phases prior or after the crosswise insertion of the new Rhine bridge.

High-speed lines
Beijing–Tianjin and Beijing–Shanghai

Following the signing of the contract for the technology transfer of China's first high-speed route in 2005, 36,000 slab tracks were manufactured in only 15 months and installed in less than nine months on the 115 km long line between Beijing and Tianjin. With the exception of the regular passenger service for the Olympics in August 2008, the FF Bögl slab track system made speeds of up to 350 km/h at high comfort possible. To our group of companies it was a big challenge to not only accompany this prestige project in an advising function, but also to ensure the execution according to European quality standards as well as completion on schedule.

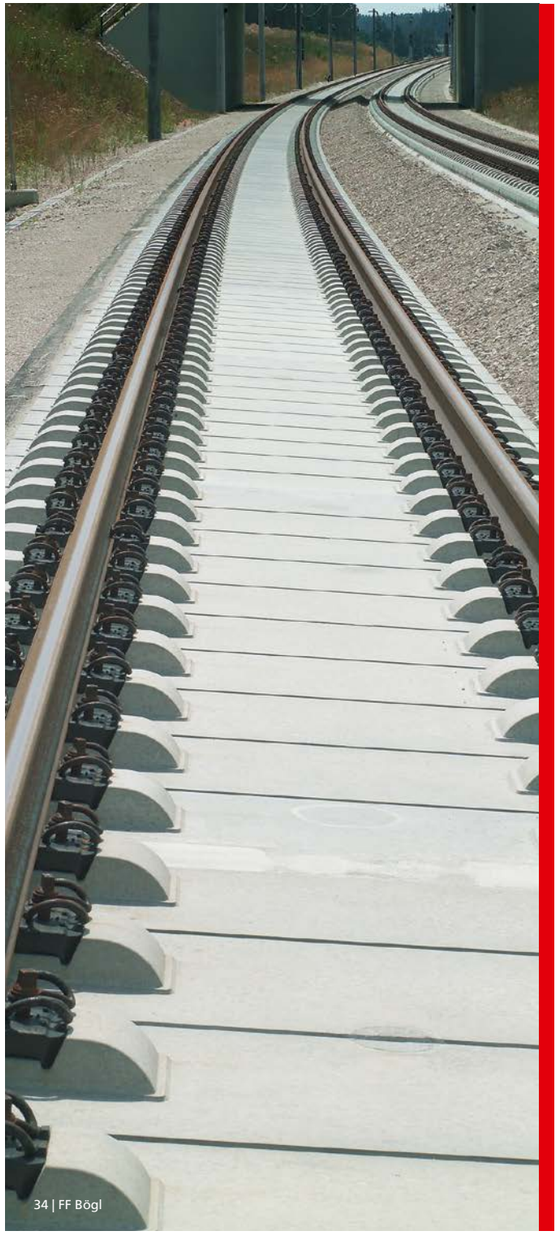
In time for the celebrations surrounding the 90th anniversary of the Communist Party, the world's longest high-speedline at the time, linking Beijing and Shanghai, was opened in China on 30th June 2011 – following a record construction time of just 38 months, including trial operation. The superstructure FF Bögl slab track system CRTS II ensures high comfort and high-speed conditions on the 1,318 km long line, reducing travel time from once ten hours to less than five hours from the capital to the eastern Chinese port city. Manufactured in 16 prefabricated component plants along the line, a total of nearly 400,000 slab tracks on a length of 1,270 km and approx. 7,500 switch slabs for more than 200 high-speed switches were installed mainly on bridge structures.

Already today, the nationalised system of FF Bögl is used on more than 10,000 km of high-speed lines in China.

ICE high speed line Nuremberg–Ingolstadt

The Max Bögl Group was commissioned by the DB AG as general contractor in a consortium to build the new railway track Nuremberg-Ingolstadt functionally, including the roadbed and track. As an innovative type of roadbed and track, the FFB – Slab Track Bögl was used commercially for the first time. The track was designed for a draft speed of 300 km/h and an axle load of 25 tons with a service life of 60 years. The 35 km long roadbed and double-track system with 10,600 standard, special and compensation slabs was installed in earth structures, frame bridges, tunnels and troughs as well as on long viaducts. For areas with very difficult geologic conditions, special earthwork measurements were developed and carried out.

World record on FF Bögl between Nuremberg and Ingolstadt: In a speed of 357 km/h, the "Taurus III" locomotive set a new speed record for electric locomotives on a non-prepared track.



Advantages

The FFB – Slab Track Bögl which is based on prefabricated slabs, is an internationally established system for high-speed tracks which in terms of reliability, availability, maintainability, and safety offers a number of advantages:

- Low maintenance and servicing requirements due to the high manufacturing precision of the track sleepers
- High resistance to transverse and longitudinal displacement
- Constantly high quality and accuracy of manufacture
- Durable and precise track bed without readjusting
- High driving comfort
- Low wear and tear on the rolling stock and the rails
- Correction options in case of settlements
- Quick re-commissioning after correction/repair measures

Max Bögl Group

With more than 7.500 highly qualified employees at 40 locations worldwide and an annual turnover in excess of 3 billion euros, Max Bögl is one of the largest construction companies in the German construction industry. Since its foundation in 1929, the company's history has been characterised by innovative strength in research and technology – ranging from custom products to comprehensive structural engineering solutions, all with the aim of ensuring the efficient use of resources.

With forward-looking in-house developments on topics of our time, such as renewable energies, urbanisation, mobility and infrastructure, the Max Bögl Group is already realising solutions for the megatrends of our globalised world. Based on many years of experience and competence in high-precision precast concrete construction, Max Bögl is also positioning itself as an important driving force in the development of innovative products, technologies and construction processes.

The wide range of services and the high level of vertical integration with our own steel construction, our own precast plants, the most modern fleet of vehicles and equipment as well as our own raw materials and building materials guarantee the highest quality. The use of BIM, lean management/ production and standardised project management ensures adherence to schedules and cost-effectiveness from the initial concept idea to the finished building product.

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