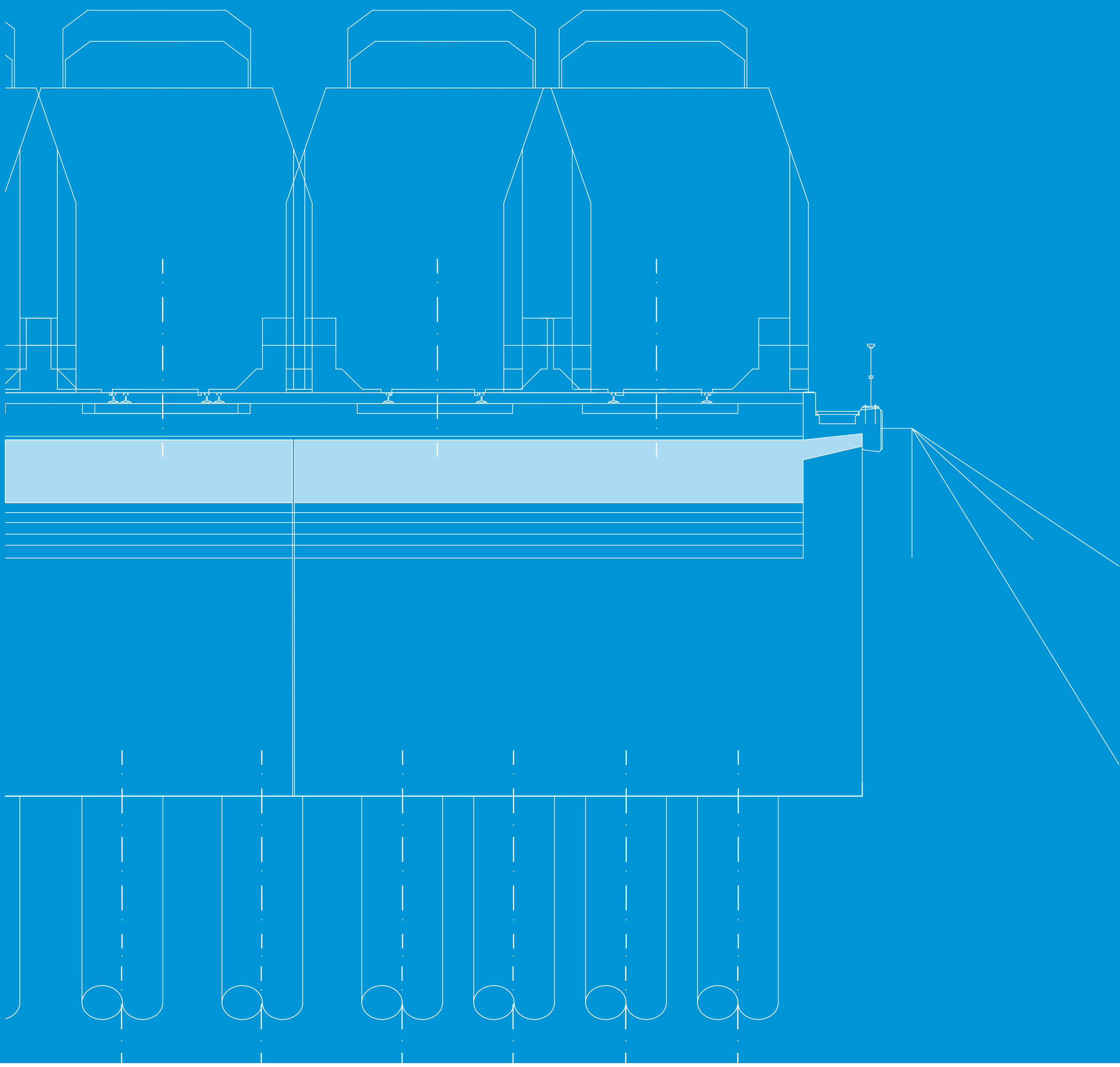
SSF Ingenieure

service

REPLACEMENT OF EXISTING RAILWAY BRIDGES

MINIMIZATION OF INTERVENTIONS AND INCREASE OF OPERATIONAL AVAILABILITY



The replacement of railway bridges in the existing railway network is always a significant interference in the line's operation. In addition to replacing superstructures due to age or damage, replacement bridges become necessary when tracks are modernized or expanded or – which is often the case – converted underneath crossing traffic installations. Important long-distance traffic routes or highly frequented urban train routes can in general not be closed off during these constructional interventions.

A reduced availability of the railway network and disturbed operation, hinder directly the economic efficiency of railway traffic. Longer journeys, additional connection times and delays have a negative effect on riding comfort and transport quality and reduce the number of passengers on the concerned lines. Especially, in competition with other transport systems the utmost importance is to design bridge replacements in such way that interventions in the operation are reduced to a minimum. Fabrication and construction processes have to be carried out underneath temporary bridges. Ideally, the construction and fabrication processes should take place in areas off track.

Construction during operation entails a huge amount of temporary constructions, which, naturally, have an effect on construction costs. Frequently, 70 percent of the construction sum is spent on pit sheeting, makeshift bridges, construction during nighttime shifts and other measures to maintain traffic. In addition to these increased construction costs, the German railway company charges so called operational hindrance costs resulting from slow-speed periods, energy costs, rail substitution traffic (bus transport) and a higher number of personnel to maintain traffic operation.

Railway bridge over the highway A8 near Gersthofen/Augsburg

One example: On a major German railway line, the average speed is 200 km/h. A speed reduction to 90 km/h because of bridge construction, costs 5,000 Euros per day being caused by energy costs from reacceleration especially of heavy freight trains. With a construction period of 6 month, this sums up to supplementary costs of 0.9 million Euros which have to be added to the pure construction costs.

Similar problems occur for bridge construction of highly frequented motorways and highways. Speed and lane limitations lead to time delays and dangerous traffic congestions which also are to be economically evaluated and lead to hindrance costs of around 10,000 Euros per day.

During replacements if existing bridges, highways in extra-urban areas are often relived by parallel deviation routes with makeshift bridges. The efforts for these deviations are enormous and reach sometimes almost the construction costs of the new bridge.
In densely built urban area, this kind of measure is impossible anyhow because of the confined space. In general, the erection of a new bridge at the same site as the old bridge is carried out underneath makeshift bridges.

During several close-off periods, the sheet piling and soldier piles walls are built for the pit of the new substructures (abutments, piers), which also serve as foundation and supporting structure for the makeshift bridge. During following close-off periods, to temporary bridge the construction pits, so called makeshift bridges are placed on the piles. The rail is then operable with reduced speed. The substructures – foundations and vertical elements – can be built underneath these pit sheetings and the makeshift bridge on top. The demolition of old substructures is often carried out underneath these sheetings and makeshift bridges, too. New superstructures made of steel, completely prefabricated, are mounted during close-off periods. Solid superstructures are generally constructed in-situ next to the line then launched. Foundation works are, if necessary, accomplished from the existing track during the first close-off.

1 **Construction of bridge** parts on both sides of the railway line
2 **weekend close-off of the first track,** removal of track, excavation, placing of prefabricated elements of foundation, launching of first bridge half, backfill, commissioning of track
3 **weekend close-off of the second track**, removal of track, excavation, placing of prefabricated elements of foundation, launching of second bridge half, backfill, commissioning of track
4 **final stage**

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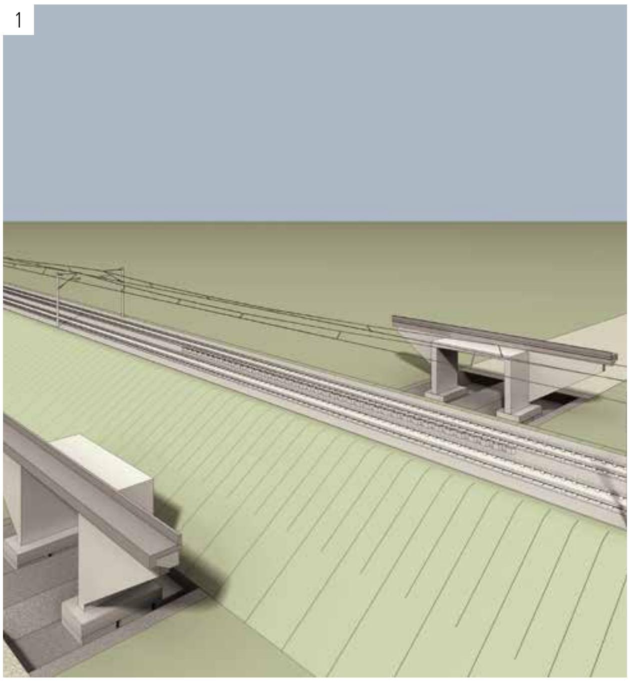

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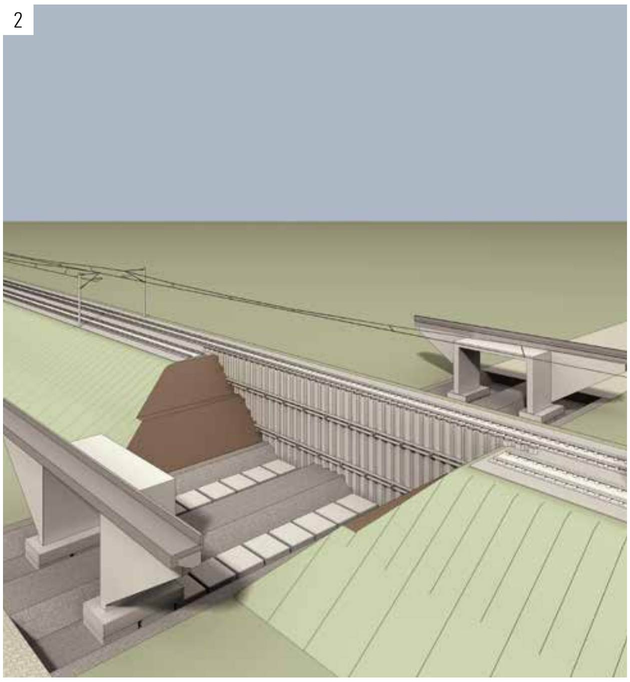
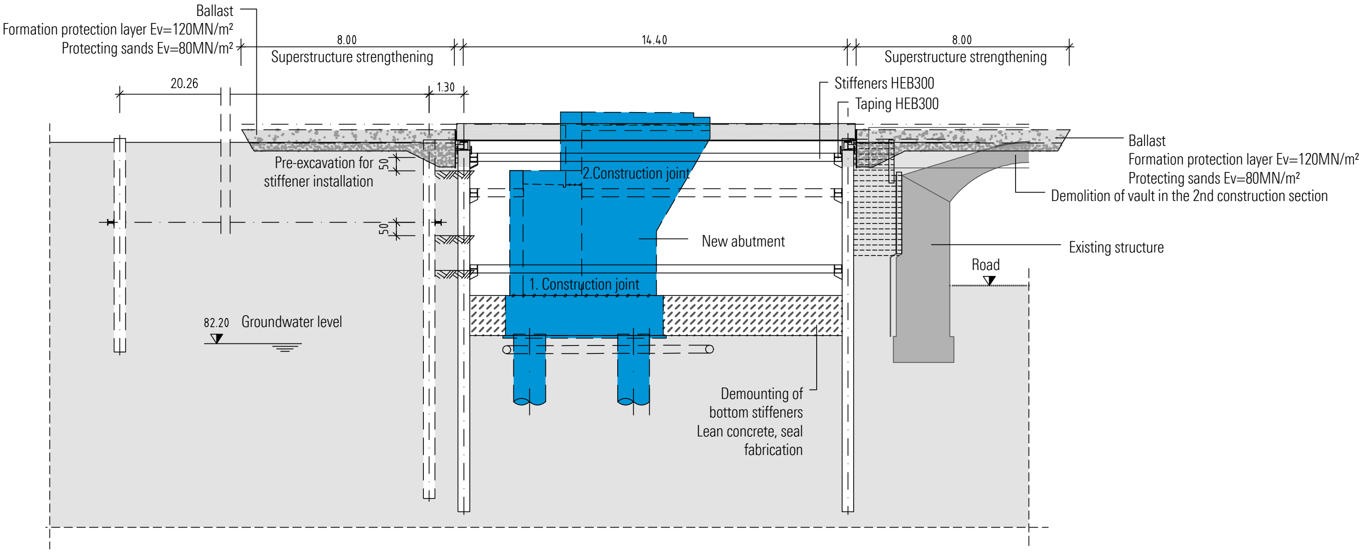
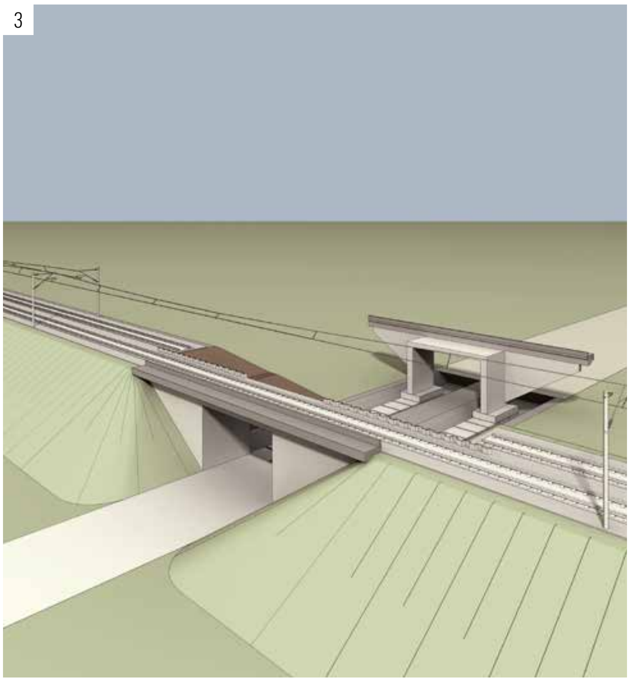
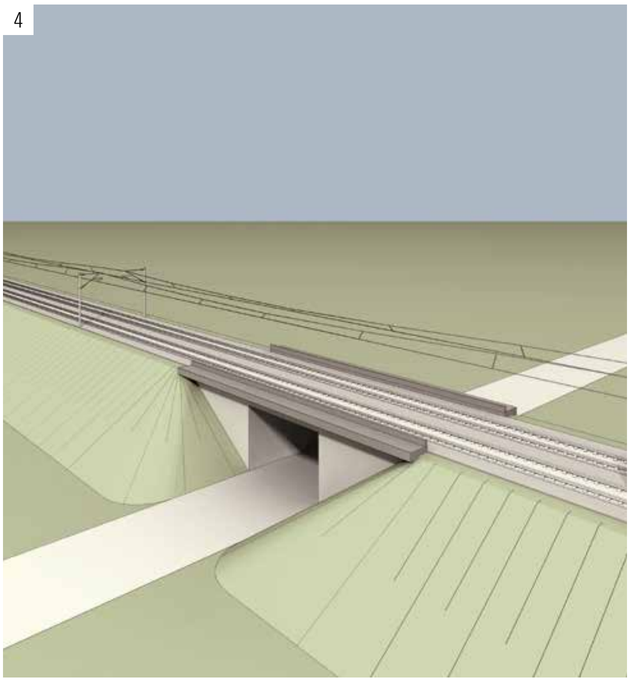


Erection of a new bridge carried out underneath makeshift bridges







Picture credits: bit-better visualisierungen / SSF Ingenieure GmbH

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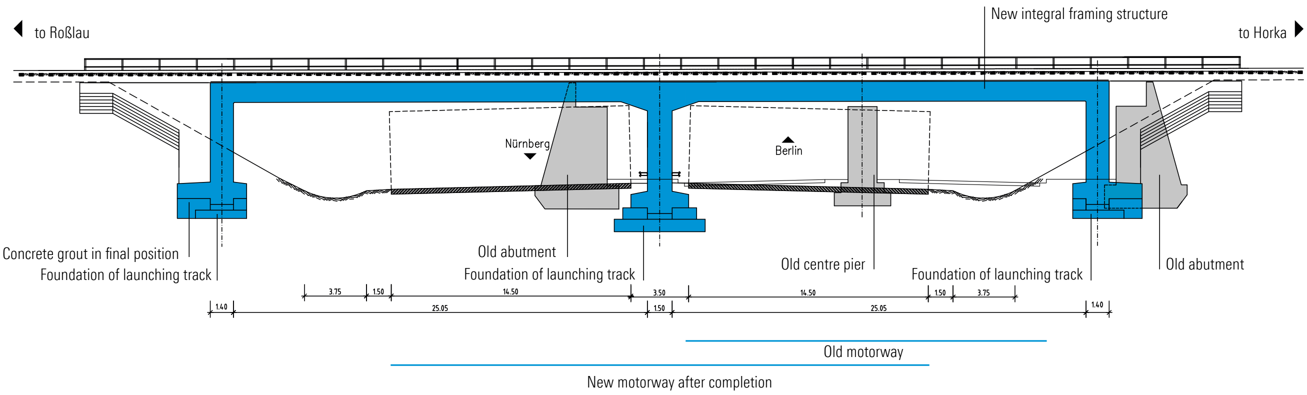

Disadvantages of this construction method are, in addition to the many close-offs, the reduced speed on the makeshift bridge during the whole construction time and the hindrances to production of the new constructional elements in confined and covered pits. This has regularly negative effects on the construction time and thus on the whole operation of railway traffic.

1 **Structure 23Ü5** over motorway A9 near Coswig
2 **Construction of the new bridge** next to the existing line
3 **Bridge launching** – construction method whilst maintaining traffic
4 **"Pulling" Procedure** patented by SSF/with prefabricated foundation and height-adjustable launching bearings
5 **Completed structure** after a close-off period of 110 hours

General problem solving

To reduce influences of bridge construction on railway traffic routes, two possibilities are probable:

- Reduction of the overall construction time by round-the-clock site operation.

Disadvantage: There are limits to a three-shift operation due to the hardening time of concrete, so that no extensive advantages for the construction time are deduced. Financial resources, that are applied for a round-the-clock site operation, make the construction more expensive. Moreover, experience shows that round-the-clock construction leads to quality problems.

- Construction of the structure or large parts of it next to the railway line, launching and completion during as few close-off periods as possible.

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Solutions developed by SSF Ingenieure

Launching of integral frame bridges

The answer that SSF Ingenieure found to the necessity of economically efficient optimization of interference into railway traffic, is the concept of integral, joint-less and bearing-less frame structures, completely built next to railway line and then launched into their final position during a line close-off.

The main advantage compared to other construction methods is the minimization of construction time for the substructures and the resulting reduction of hindrances to railway operation.

Already in 1989, in cooperation with the company Komm, SSF Ingenieure had a procedure patented. This construction method, according to which already around 300 bridges have been built, allows the launching of bridges with dimensions up to 70 x 40 m and weights of 7,500 tons.

Procedure

With a speed of around 10 meters per hour, hydraulic jacks move the bridge, pre-built beforehand next to the railway line, on specially designed launching tracks into its final position.

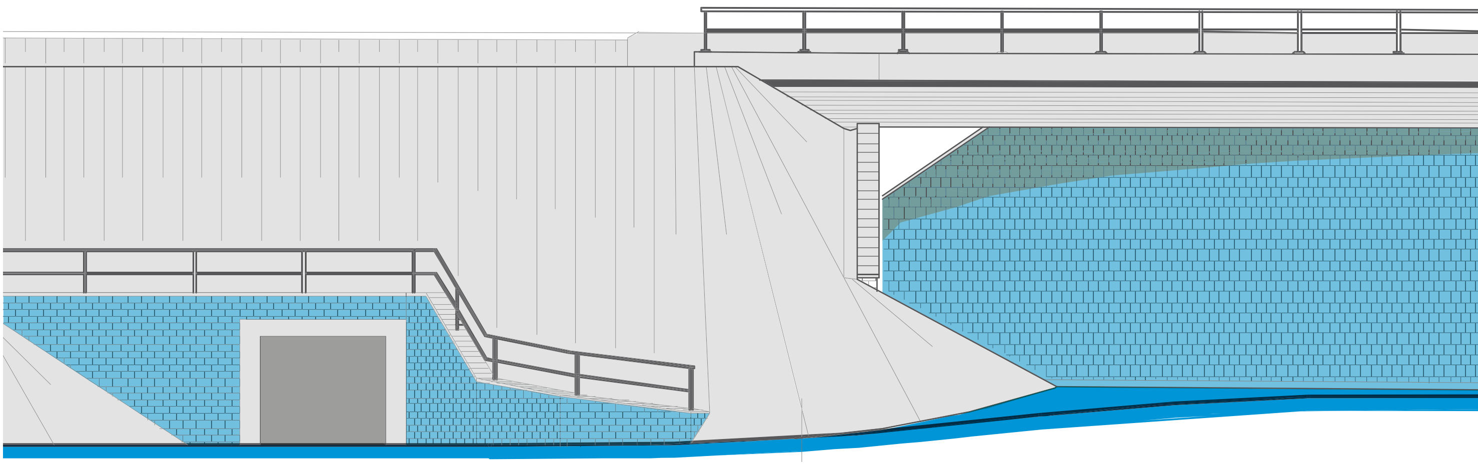
The Teflon coated bearings, gliding plates or air cushions with hydraulic fluid technology reduce friction so that the horizontal launching force reaches only 3 to 5 percent of the structures weight. The bridges can be moved with exactness in height and position by the utilized hydraulic jacks which are individually movable.

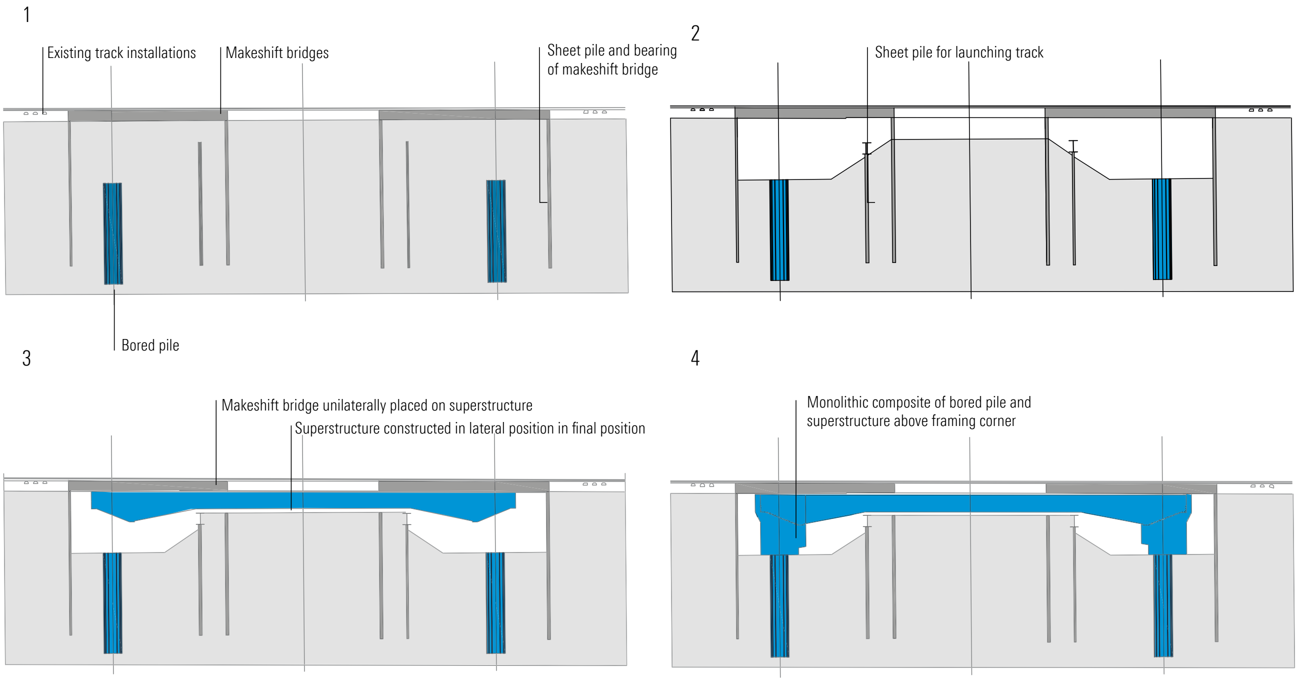
above: "Pushing" Launching on HEB girders and height-adjustable launching bearings
below "Floating" Launching on steel launching tracks and sliding bearings (e.g. „Hydraulic Fluid Technique")

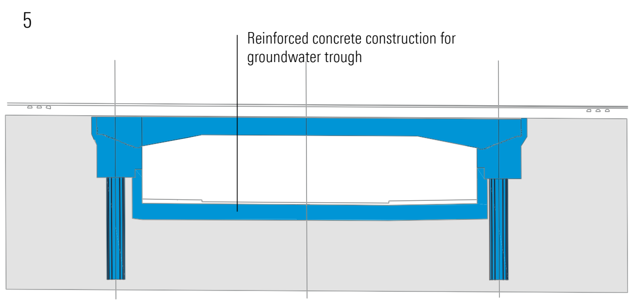
Advantages of this construction method are evident: The bridge is already completed at the moment of launching as pre-stressed concrete frame that is with wings, sealing and railings as well as the superstructure's equipment. Until this moment there are nearly no influences on railway traffic. During a relatively short close-off period of 60 to 100 hours, the old bridge is demolished, the launching track built and the new bridge launched into its final position and backfilled. Then the tracks are connected and all railway relevant works are completed. Double-tracked railway traffic can be led over one track under protection of temporary walls along the tracks. In the case of multi-tracked railway lines, the same procedure is repeated for the other tracks. In principle, bridges with two or more tracks can also be launched in one piece. In addition to single-span frame bridges, multi-span structures can also be launched. Bridges with large individual span widths, with steel truss or steel tied-arch superstructures on solid abutments, can also be produced completely next to the line and then be launched.

Impact on railway and road traffic is clearly minimized, costs are reduced considerably compared to other construction methods. Moreover, the concept of frame structures allows slender well-proportioned superstructures with small rotation angle of the final tangent, and diminishes maintenance costs on a large scale due to its lack of bearings, bridge and expansion joints.

Railway bridge over federal road B39 near Neidenfels, extremely oblique crossing angle

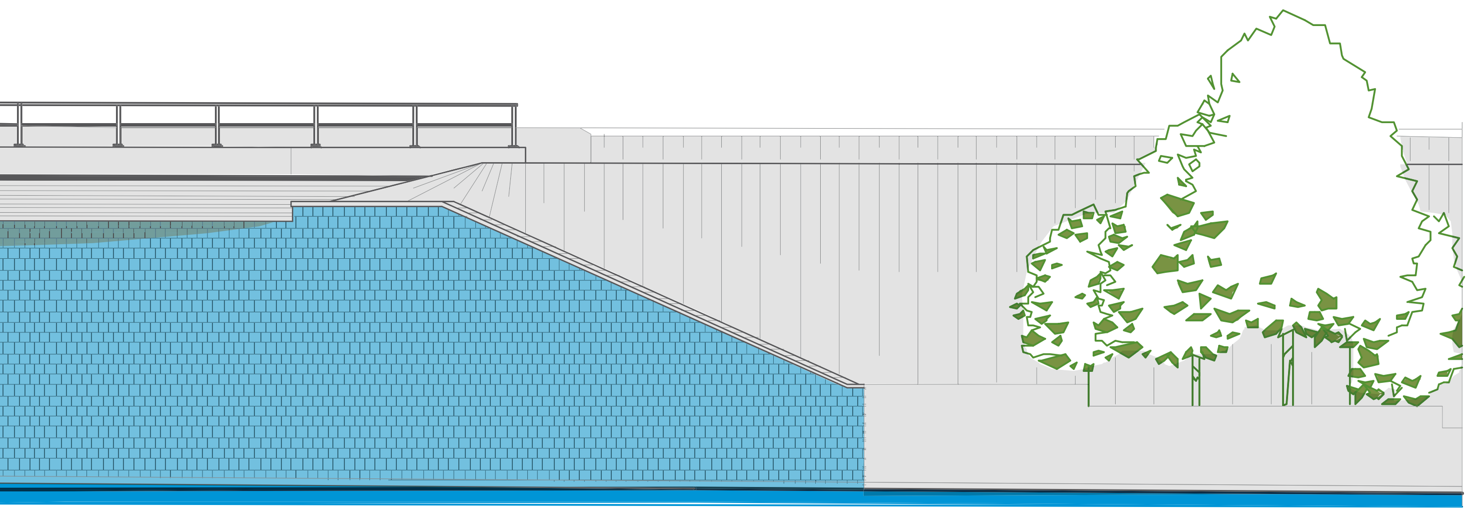






1 **Sheeting and bored piles near the tracks** – construction of temporary bridges
2 **Excavation and extension** of launching tracks
3 **Launching** of prefabricated superstructure
4 **Construction** of pile caps/framing corner
5 **Demounting of temporary bridges** – backfill – construction of regular superstructure – construction of under passing road

Picture credits: SSF Ingenieure GmbH



Railway bridge Siemensstraße in Frankfurt Construction of bored piles in track area

Top down construction

A further development of the construction underneath makeshift bridges is the top down construction method for railway bridges. The technique developed by SSF Ingenieure meets all requirements in terms of construction efficiency and minimization of interferences.

At the basis of top down construction is the concept of integral frame structures, constructed as monolithic frame in two separated sections – frame stanchions (abutment/foundation) and frame transom (superstructure).

Procedure

During nightly line close-offs, bored piles are assembled in the area of the rails, which, in the final state, form the bridges foundation and at the same time the frame stanchions. Simultaneously, before and behind the bored piles, sheet piles are inserted to secure the small construction pits and to support the makeshift

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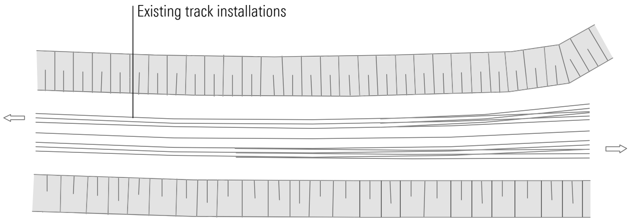

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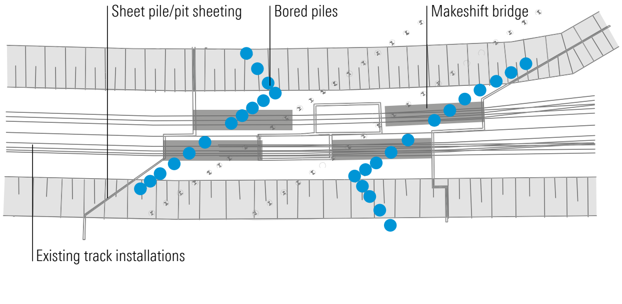

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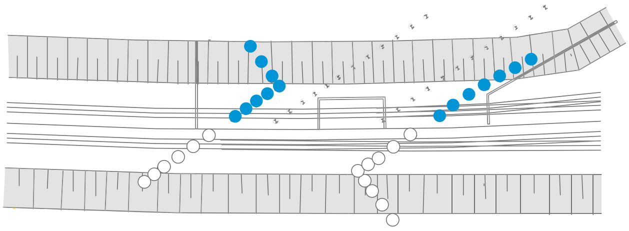

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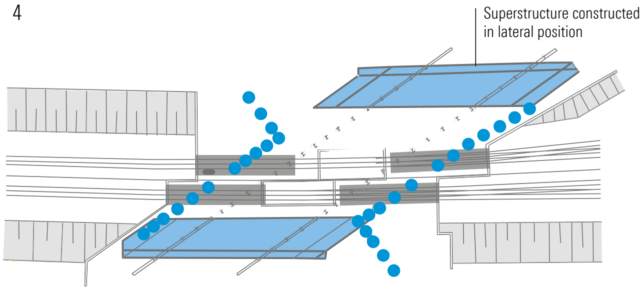

1 **Initial situation**
2 **Sheeting and bored piles** in track area 1
3 **Sheeting and bored piles** in track area 2
4 **Construction of superstructure** in lateral concreting direction on launching tracks – assembly of temporary bridges (during close-off period of one track) – demounting and extension of launching tracks
5 **Launching of prefabricated superstructure 1** into final position – integration of temporary bridges – commissioning
6 **Launching of prefabricated superstructure 2** into final position – integration of temporary bridges – commissioning
7 **Construction of pile cap/framing corner** of superstructure and temporary bridges (concreting during close-off of one track)
8 **Demounting of temporary bridge** – backfill – construction of regular superstructure – construction of under passing road

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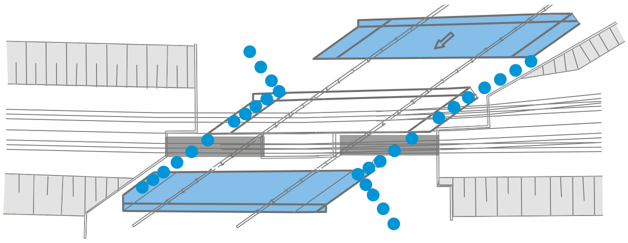

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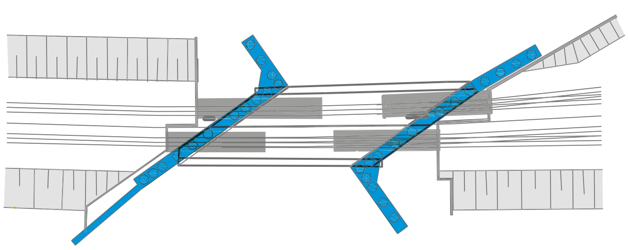

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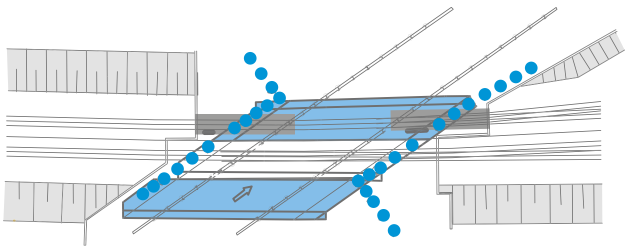

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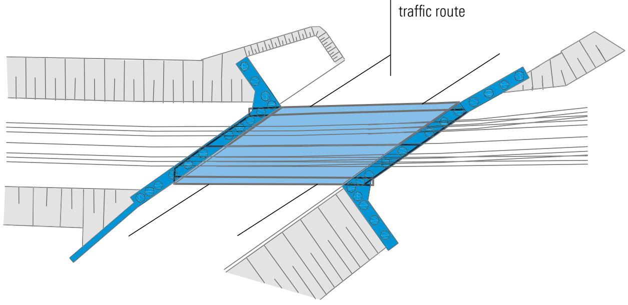

Picture credits: SSF Ingenieure GmbH

bridges. Until now the construction process corresponds nearly exactly to the habitual construction underneath makeshift bridges. The now following construction of two short makeshift bridges entails close-off of one track as well as reduced traffic speed, however, only taking a few weeks because of the small excavation and simple elongation of the launching track. Then, without influencing railway traffic, the superstructures, separated by track (generally double-tracked lines), are constructed off line in pre-stressed concrete method on falseworks/launching tracks. To launch the first superstructure (track 1) into the final position, including erection and demounting of the makeshift bridges, only a short close-off is required. Immediately after positioning of the superstructure– supported on one side of the newly launched superstructure – the makeshift bridges are re-erected to create operability.

Construction and launching processes are repeated for the superstructure with the second track. Once the superstructures of track 1 and 2 are in final position, framing corners or monolithic connections between large bored piles and superstructures are constructed underneath the makeshift bridges. Concreting the framing corner necessitates once again a short line close-off. After setting of the framing corner's concrete, the makeshift bridges are removed and the structure is backfilled. The regular superstructure and railway installations are completed.

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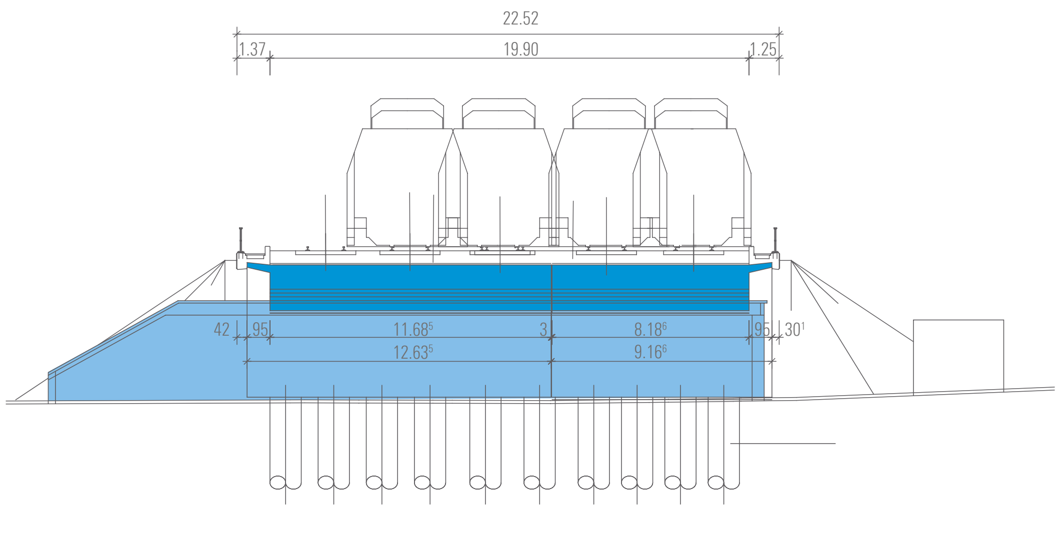

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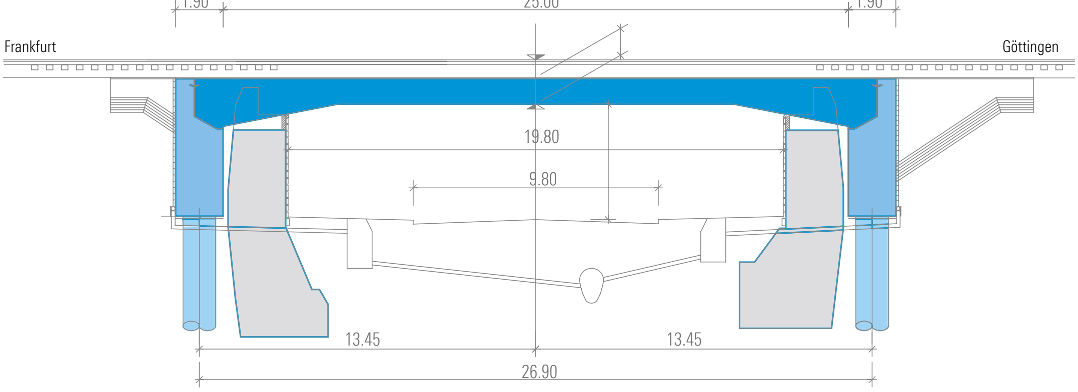

1 **Longitudinal section of railway bridge** Siemensstrasse in Frankfurt
2 **Cross-section of railway bridge** Siemensstrasse in Frankfurt
3 **Railway bridge Siemensstrasse in Frankfurt** – construction of bored piles in track area
4 **Railway bridge Siemensstrasse in Frankfurt** – launching of prefabricated superstructure
5 **Railway bridge in Dieburg** – prefabricated superstructure in final position
6 **Railway bridge at Schleifenstrasse in Augsburg** – structure with temporary bridge before launching
7 **Railway bridge Siemensstrasse in Frankfurt** – Completed structure

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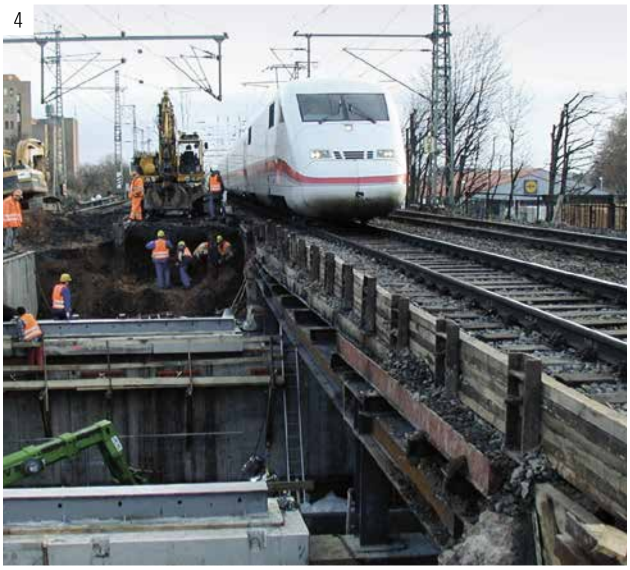

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Picture credits: **1 - 4 + 7** SSF Ingenieure GmbH / **5 + 6** Max Bögl Bauservice GmbH & Co. KG

Top down construction is especially suitable under the following boundary conditions:

- High groundwater level
- Limited construction field (construction within existing structures – densely built areas)
- Unsuitable ground for footings
- Extremely oblique crossing angle
- Crossing of flowing water
- Heavy traffic on the crossed roads
- Highly frequented railway lines with short close-off periods and high speed

Advantages of the construction method:

- Robust reinforced concrete frame structure
- No maintenance-intensive transverse and longitudinal joints
- Superstructure slender but deformation-low due to framing effect
- Rotation angle of final tangent negligibly small due to traffic
- No interference into the groundwater during construction

Economic advantage:

- Short construction time on the whole
- Minimized interference into rail traffic
- Shorter periods of reduced speed due to short use of makeshift bridges
- Savings in the provision of makeshift bridges
- Savings in superstructure maintenance
- Cost savings in site securing measures ("safety attendants")
- Savings in construction supervision

A selection of SSF projects constructed using the top down construction	
1993	Railway bridge Coswitzanger Schmölln on the line Görlitz – Gera
1994	Railway bridge over a road on the line Stuttgart – Bad Cannstadt (interurban train)
1995	Railway bridge Sandreuthstr. in Nuremberg on the line Treuchtlingen – Nuremberg
1996	Railway bridge over the federal road B26 in Laufach on the line Würzburg – Frankfurt
1997	Railway bridge over the federal road B260 in Bad Ems on the line Wetzlar – Koblenz
1998	Railway bridge over the federal road B39 in Neidenfels on the line Homburg - Ludwigshafen
1999	2 Railway bridges for a newly built groundwater trough in Schwandorf
2000	Railway bridge Siemensstraße in Frankfurt on the Main, on the line Frankfurt – Göttingen and Frankfurt – Würzburg
2000	Railway bridge over the bypass Rote-Tor in Augsburg on the line Munich – Augsburg
2002	Removal of a railroad crossing in Flörsheim on the line Frankfurt – Wiesbaden
2003	Railway bridge over the federal road B 236 n on the line Dortmund – Soest
2007	Railway bridge Schützenstraße in Werl on the line 2103 Dortmund – Kassel
2009	Railway bridge in Dieburg, on the line 3557 Darmstadt – Aschaffenburg

A selection of SSF projects constructed using the launching method	
1990	Railway bridge Neustadt Weinstraße on the line Mannheim – Saarbrücken
1992	Railway bridge over a federal road near Fürstenfeldbruck
1994	Railway bridge over the federal road B 101 near Berlin
1996	Railway bridge on the track Würzburg – Aschaffenburg over the federal road B 26
2000	Railway bridge Rotherstraße on the track Nuremberg – Roth
2002	Railway bridge on the line Roßlau – Wittenberg over the highway BAB A9 near Coswig
2002	Railway bridge on the line Schweinfurt – Meiningen over the highway BAB A71 near Kronungen
2010	Railway bridge on the line Pilsen – Furth im Wald over the federal road dB 20 near Furth im Wald
2010	Railway bridge on the line ABS 38 Mühldorf – Ampfing
2010	Railway bridge on the line Munich – Mittenwald near Uffing

Comparison of construction methods

Criteria	Top down construction	Construction underneath makeshift bridges	Bridge launching
structure concept	integral frame construction	traditional construction	integral frame construction
bearings, joints	no	yes	no
construction type – substructures	large bored piles as frame stanchions, construction in track area	traditional construction with joints and bearings, construction in track area within pit sheeting and under makeshift bridges	traditional construction, monolithic joints, construction off track on launching tracks underneath foundations
type of foundation	foundations	footings/foundations	footings
construction type – superstructure	off track, transverse launching into final position, construction of framing corner (connection superstructure – substructure) as individual work step	off track, transverse launching into final position; alternatively prefabrication of steel bridge with complete lifting	off track together with substructures, transverse launching into final position
makeshift bridges	number reduced to the small pit areas of large bored piles, use reduced to a few weeks, short use of makeshift bridges, short period with reduced speed	makeshift bridges in the area of new substructures (abutments, piers), series of makeshift bridges with temporary supports, construction time of substructures underneath makeshift bridges from 6 to 8 month relevant to railway operation, long-time employment of makeshift bridges, long period with reduced speed	in general no makeshift bridges required, no periods with reduced speed
close-off periods	reduced to construction of large bored piles and sheeting measures in the piles' area, for erection and demounting of makeshift bridges, for bridge completion	many close-off periods due to large pits and sheeting area as well as anchor or stiffener assembly; on some projects for construction of temporary supports and multi-part makeshift bridges, close-off for launching	close-offs only for pit sheeting and bridge launching, generally, one weekend per track
pits/sheeting/ excavation quantity	minimized pits only in the area of large bored piles, low pit depth, small pits, small sheeting areas and excavation quantities, few anchoring works for pit securing	large and deep pits acc. to abutment size and foundations, large sheeting area, many anchoring works for pit securing, large excavation quantities	large and deep pits acc. to abutment size and foundations
high groundwater level	construction above groundwater level, no water-tight pit sheeting, no groundwater drainage, small pits, small sheeting areas, small space required	construction within groundwater, water-tight pit sheeting, groundwater drainage, interference into the groundwater, deep pits, many anchoring/stiffening measures	construction within groundwater, water-tight pit sheeting, groundwater drainage, interference into the groundwater, deep pits, large pit sheeting area , many anchoring works
limited construction field/construction within existing strucutres	small space required as small pit dimensions	large space required as deep pits for foundation construction	large space required as deep pits through foundation construction
ground unsuitable for footings	unproblematic as foundation constructed from the track, support of abutments by superstructure in front of backfill	high effort for soil exchange, difficult bored pile construction, working height for special engineering works limited by makeshift bridges , backfill of abutment problematic without support by superstructure	problematic due to settlement risk during launching and in final position, high effort for soil exchange

Construction method

Criteria	Top down construction	Construction underneath makeshift bridges	Bridge launching
crossing angle	unproblematic as frame structure (no rectangular superstructure connection required), span width minimization and slender superstructure	difficult as orthogonal superstructure connection required, leading to larger span widths thus higher superstructures, difficult abutments and large pits required, difficult sheeting and large makeshift bridges or series of makeshift bridges with temporary supports, difficult joints and bearings	unproblematic as frame structure (see top down method)
flowing water	advantageous as no pits underneath groundwater level, new abutments built underneath old ones, small quantity of sheeting and excavation, no water-tight sheeting, no groundwater drainage	difficult as construction underneath groundwater level, first demolition of old abutment and installation of water-tight sheeting during close-offs, removal of existing superstructure at the beginning and replacement by makeshift bridges or series of makeshift bridges	difficult as construction underneath groundwater level, first demolition of old abutment and installation of water-tight sheeting during close-offs, large quantity of excavation
heavy traffic on crossed road	no deep construction pits along undercrossed traffic routes (roads), new construction under shelter of the old abutments, small interference in urban traffic, construction without influence on existing cables/pipings etc.	pits parallel to the road with large influences on traffic, hindrances by cables and ducts (in the pits), old abutments to be demolished before new construction	deep construction pit along undercrossed road with interference into the traffic; hindrances by cables and ducts (in the pits), existing abutments to be demolished during launching
highly frequented railway line	hindrance to operation very minimized superstructure construction completely off line, after launching of superstructure railway technical installations in only 7 to 10 weeks	high interference in railway operation, time for construction of substructures underneath makeshift bridges between 6 to 8 month	hindrance to operation very minimized, superstructure construction completely off line, sheeting and launching works within weekend close-offs (60 to 100 hours)

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