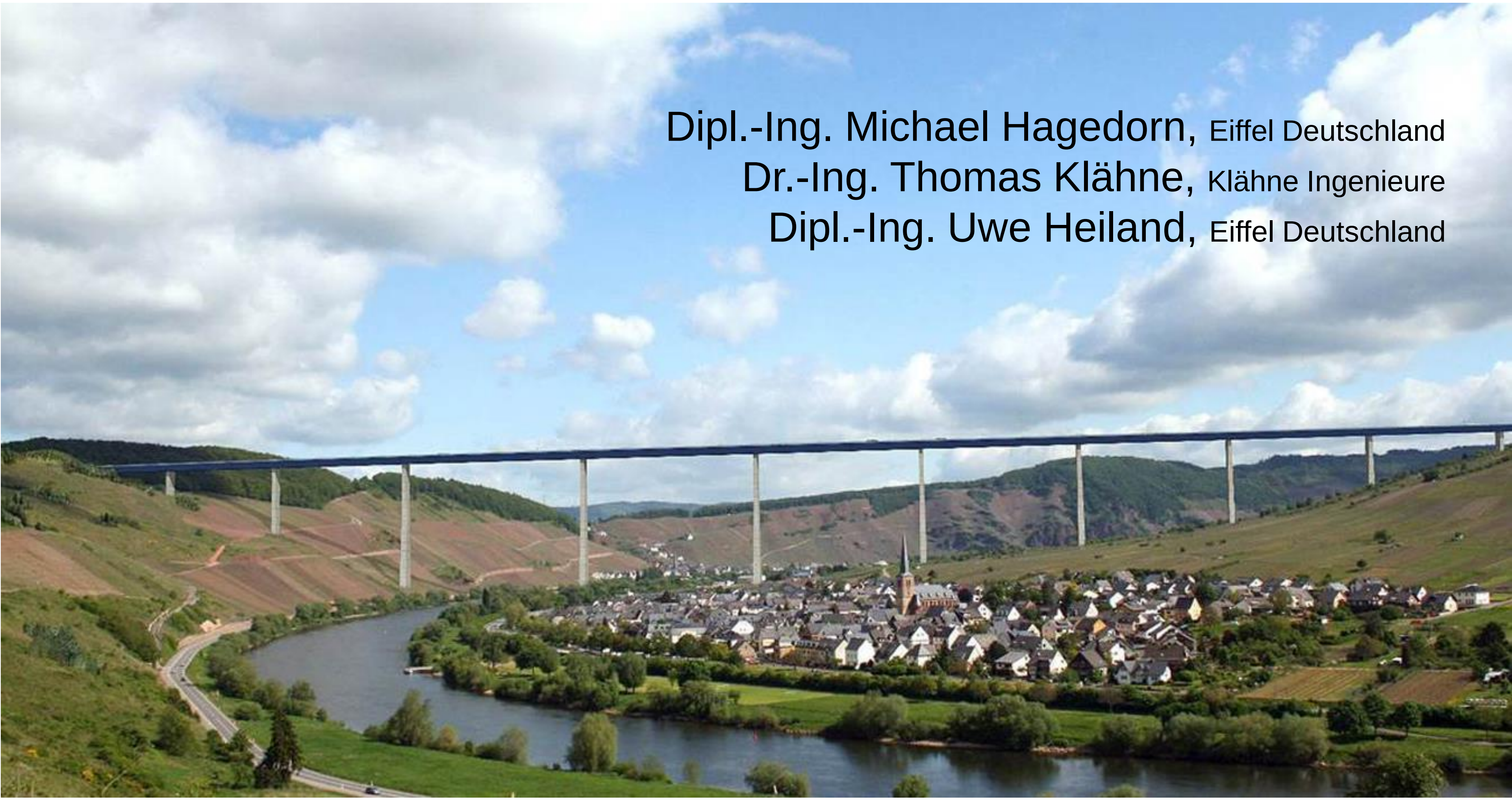
Solutions for the Construction of steel bridges using the example of the Hochmoselübergang

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure



Dipl.-Ing. Michael Hagedorn, Eiffel Deutschland
Dr.-Ing. Thomas Klähne, Klähne Ingenieure
Dipl.-Ing. Uwe Heiland, Eiffel Deutschland

Content

General Overview

Tender Project

Construction of the Superstructure

Preassembly

Sliding Technology

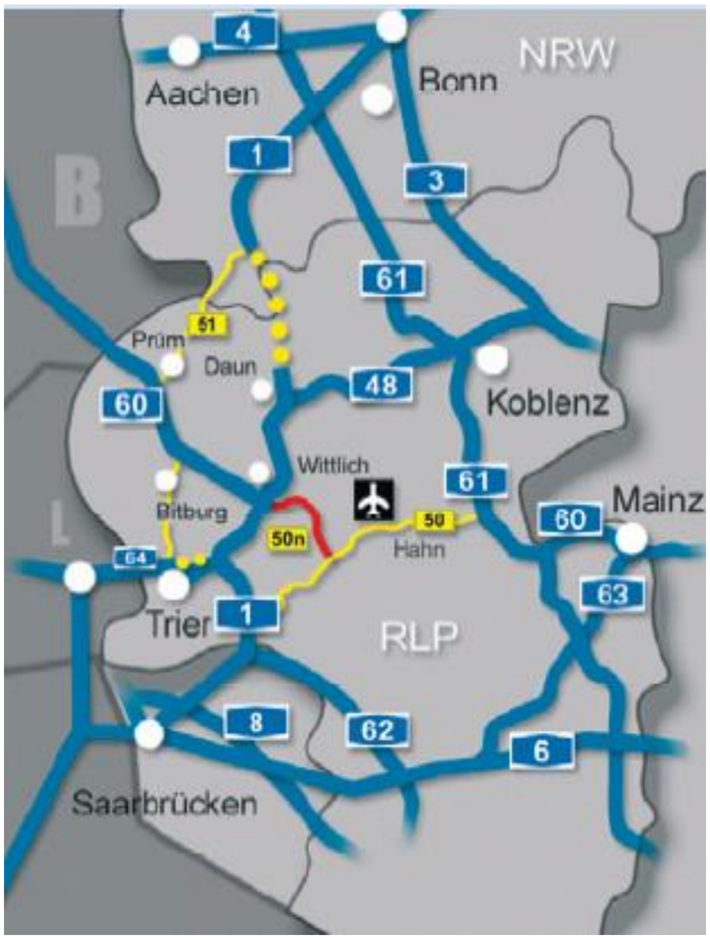
Statical Calculations

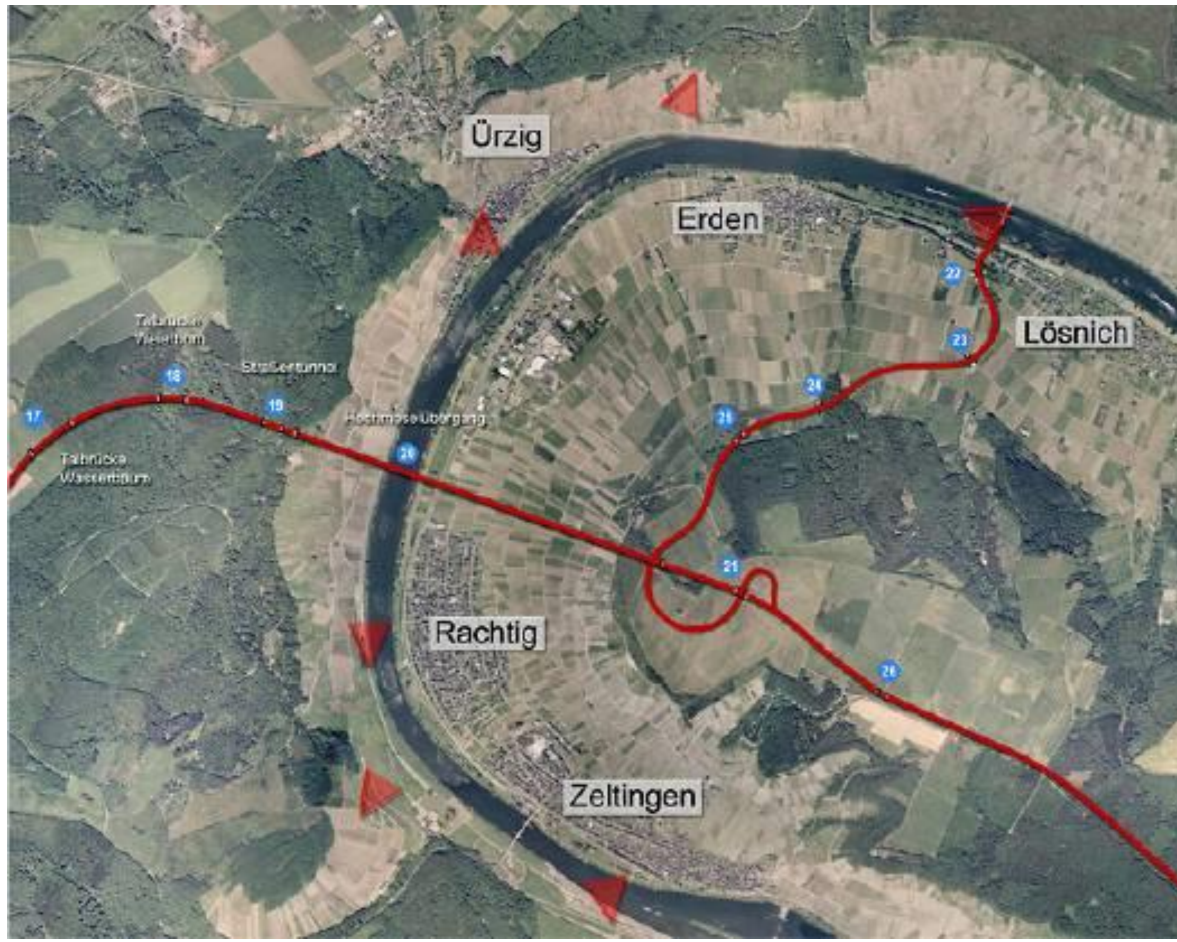
Conclusions

Overwiew – Integration of the Hochmoselbridge in the existing road network

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure





Overview – Visualisation of the bridge

Overview – Building consortium and volumina

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

Construction Joint Venture:

Eiffel Deutschland Stahltechnologie GmbH

Porr Deutschland GmbH

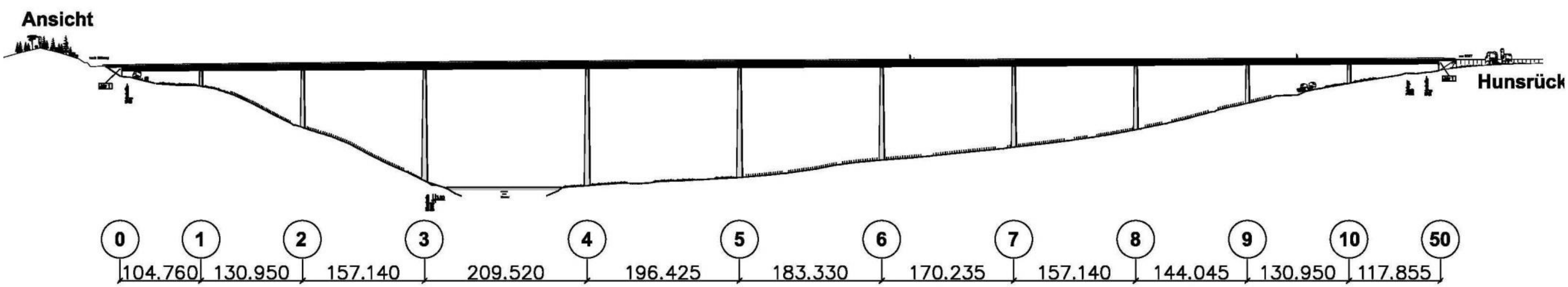
Eiffage Construction Metallique Frankreich

Contracted Services (net)	
Steel Construction:	85,4 Mio.€
Reinforced Concrete:	22,7 Mio.€
Contracted Amount:	108,1 Mio.€

Tendered Quantities:	
Superstructure:	
Steel Structure:	24.950 to (S 355)
Coating Area:	130.000 m² (outer surface),
	115.000 m² (inner surface)
Total Area:	51.000 m²
Substructures	
Piles Ø 1,80 m:	2.550 lfd. m mit 325 to BSt 500 S
Concrete Volume:	29.540 m³
Reinforcing Steel:	3.758 to BSt 500 S

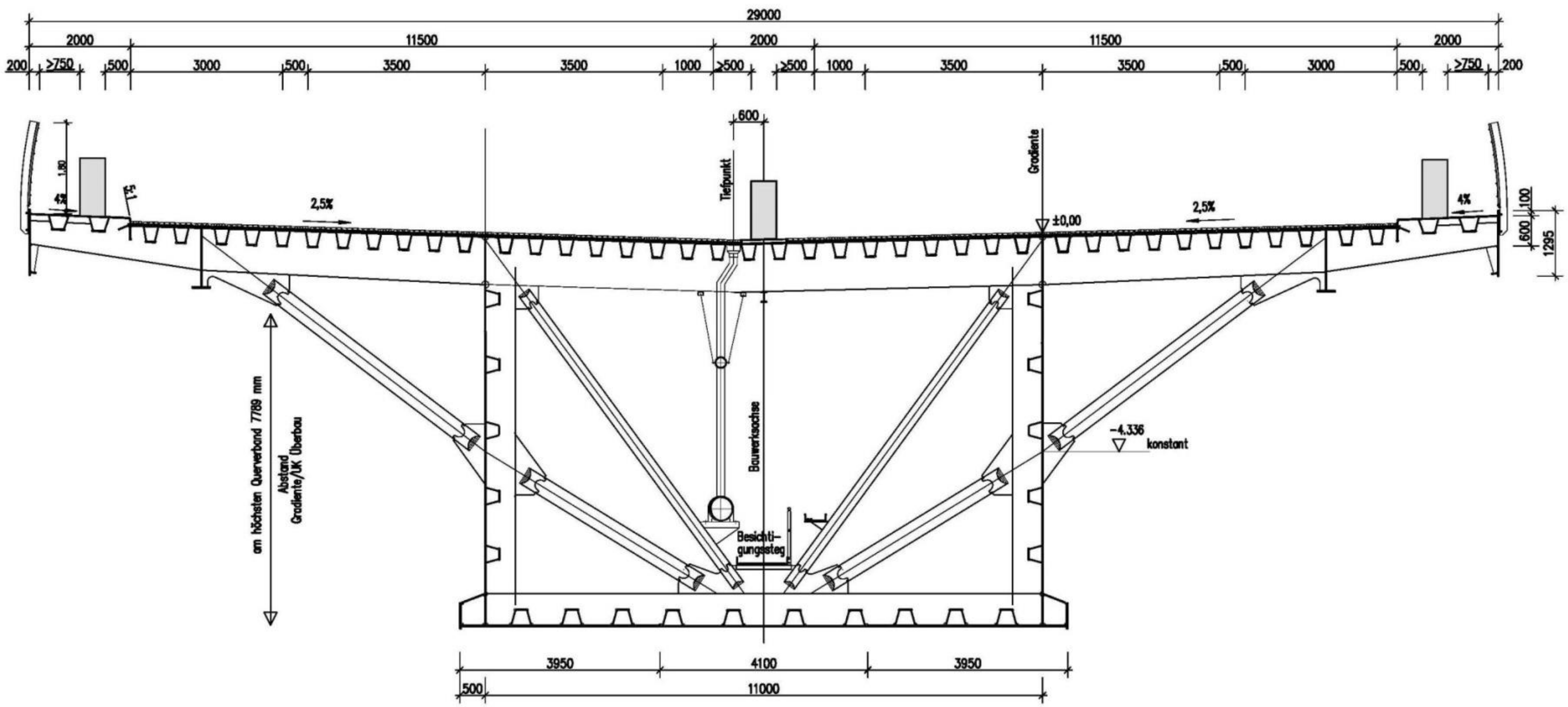
Tender project – View of the Hochmoselbridge

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE
klähne ingenieure



- Number of superstructure fields: 11
- Total length: 1702,35 m
- Max. height above valley: about 158 m

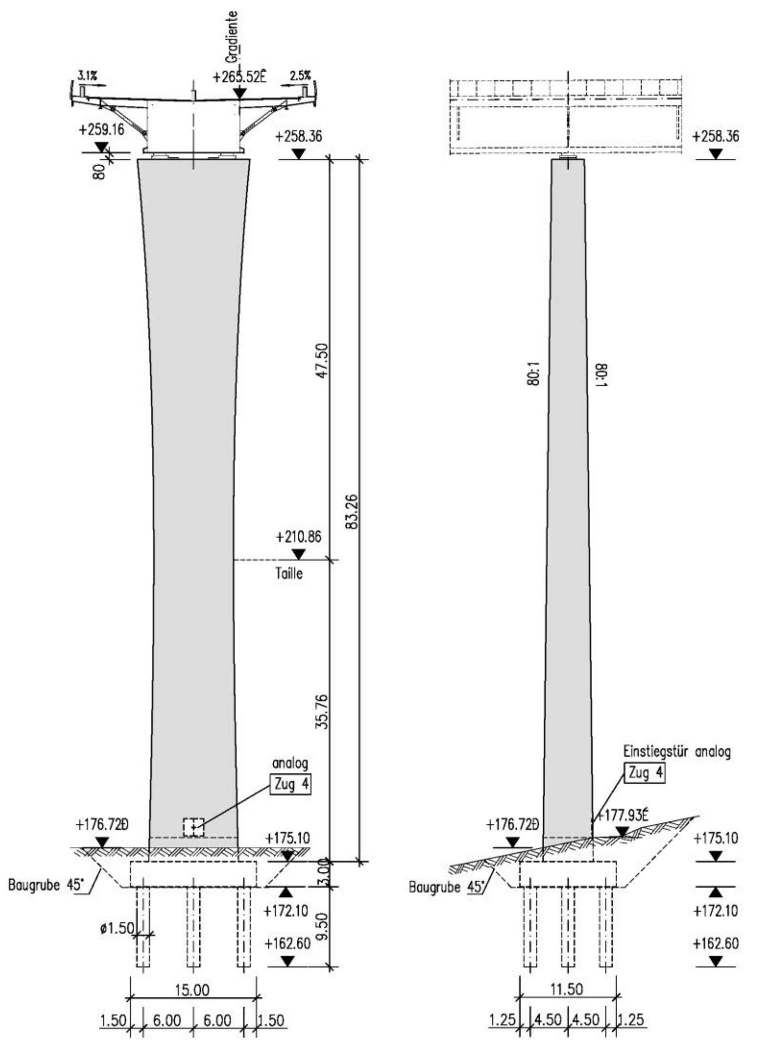
Tender project – Normal cross section



- Cross section: 2 x footway – 2 x road – median strip
- Nominal width: 28,50 m
- Bridge deck area: 48517 m²

Tender project – Substructures – Pier 8

Ansicht Querrichtung Ansicht Längsrichtung



Substructures

- 2 box shaped abutments
- 10 piers

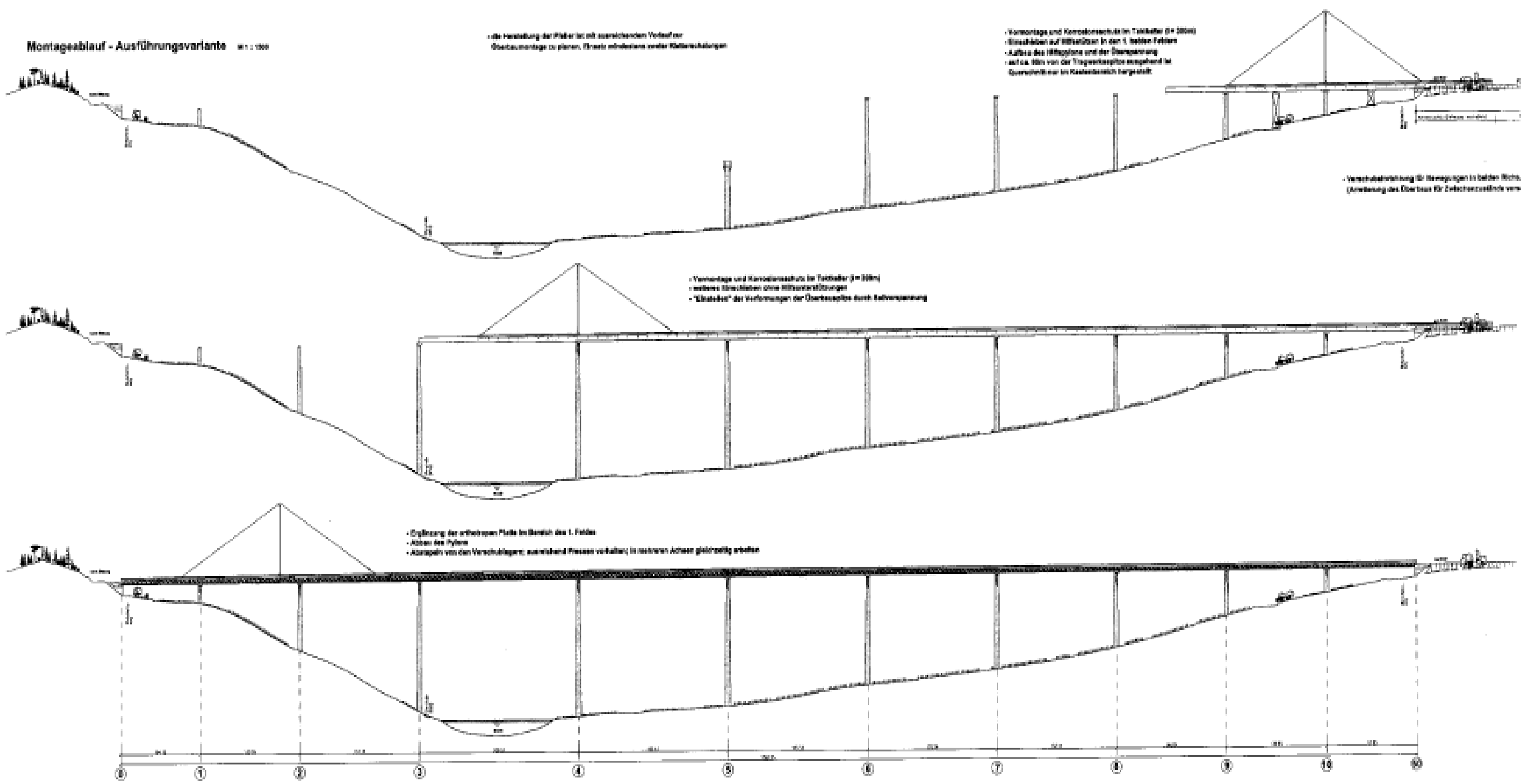
Piers

- foundations with bored piles (diameters of 1,50 m to 2,00 m)
- single-celled hollow cross section
- pier head from 20,78 m up to 150,72 m
- shape defined by tapering

Tender project – Construction method

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

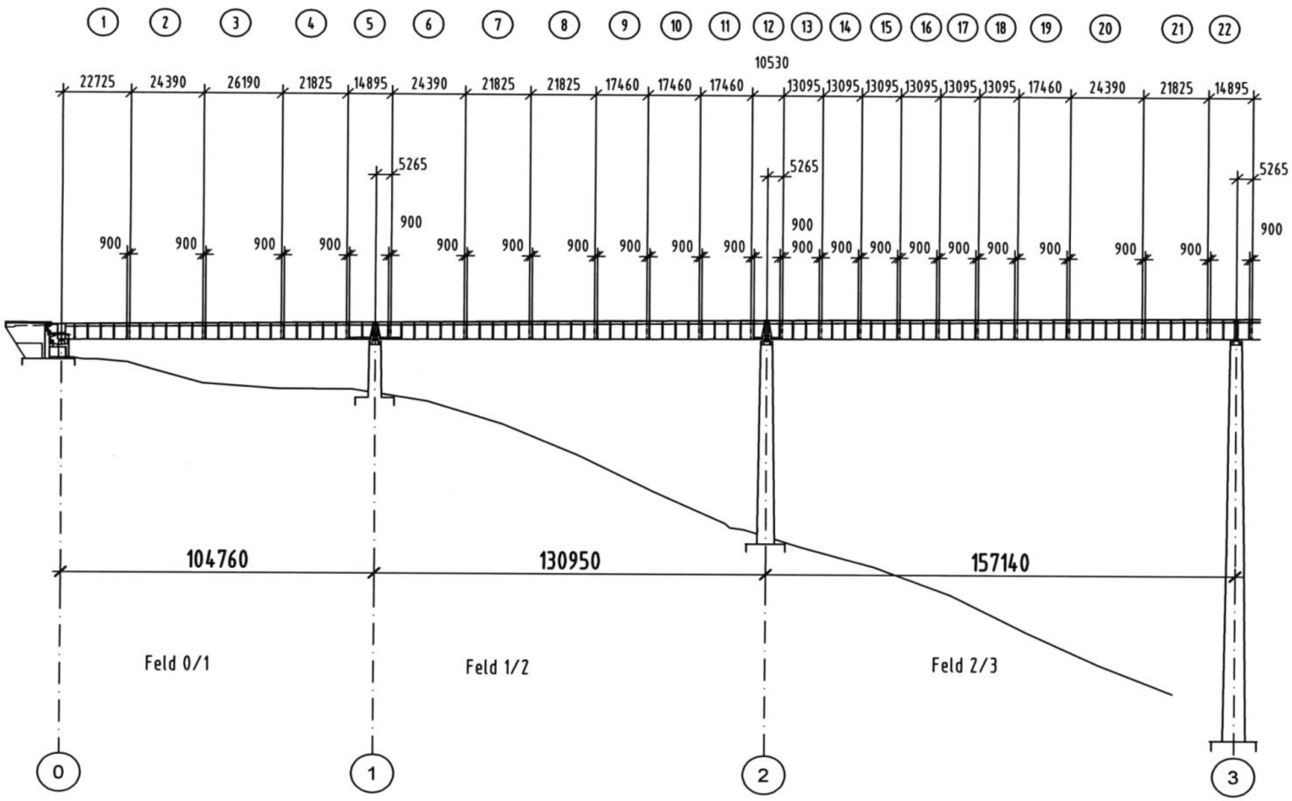


- Construction method: incremental launching method
- Steel construction is premounted behind the eastern abutment
- Use of pylon cables and an 80 m high pylon for reduction of bending moments

Construction project – Arrangement into shots

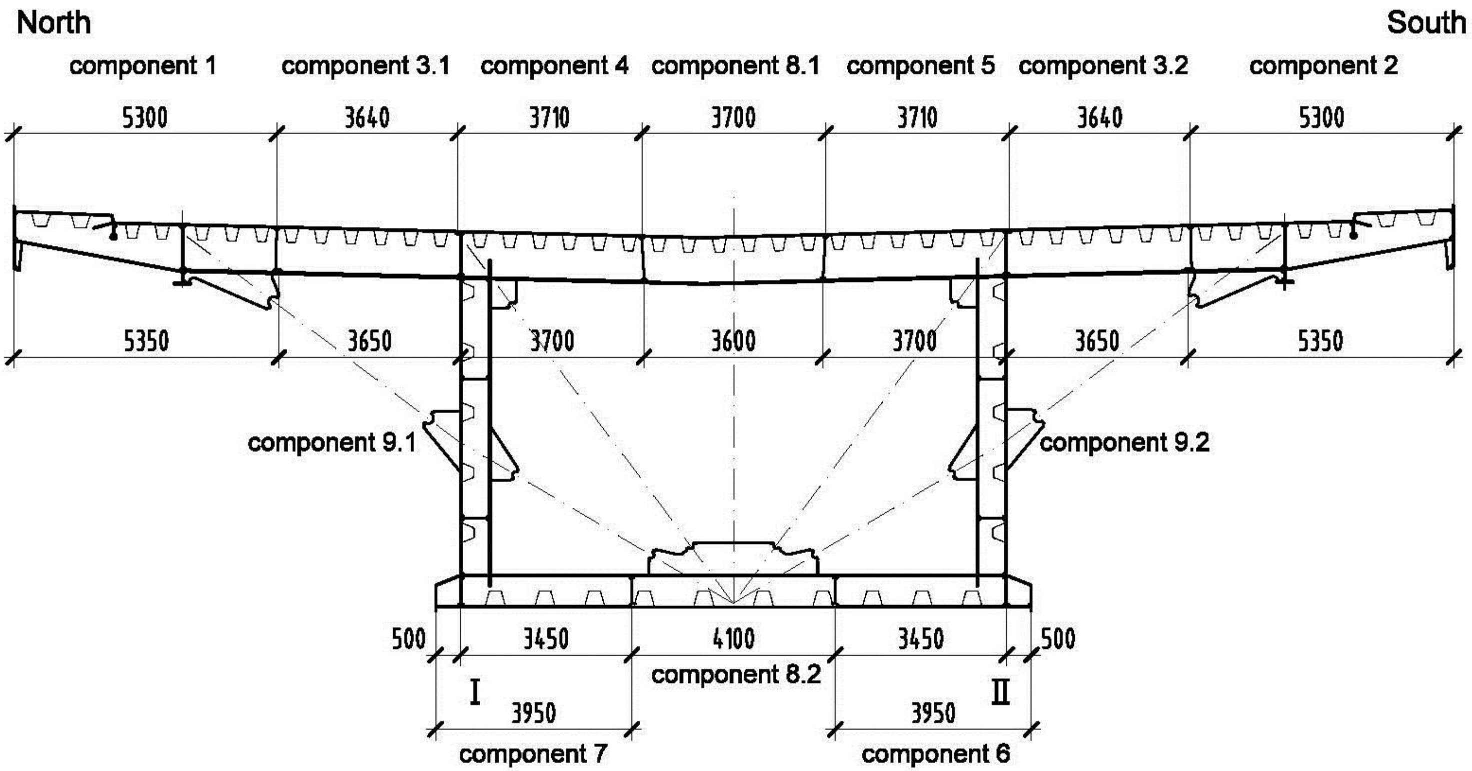
EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure



- Superstructure is divided into 82 shots
- Length of the shots: appr. 10 up to 25 m
- Below: example of arrangement for the first 3 fields

Construction project – Arrangement of components



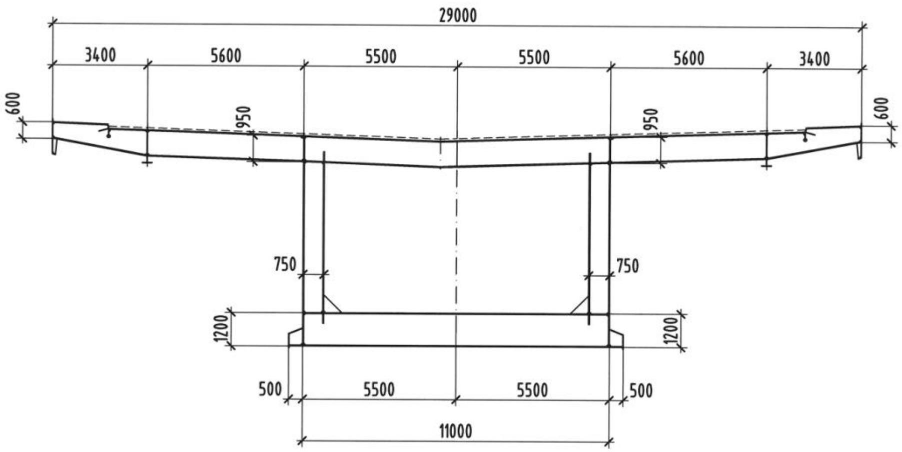
- Superstructure is divided into 12 components (height exceeds 6,00 m)
- Height variation is realised by components 9.1 and 9.2
- Components weights varies between 20 and 100 tons

Construction project – Different systems of transversal elements

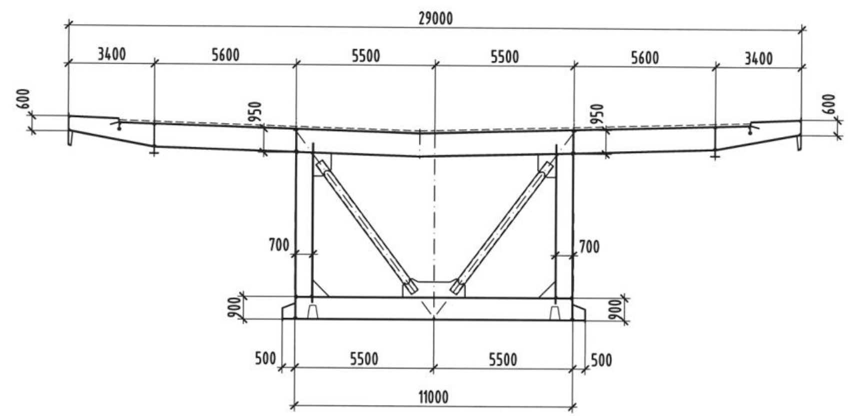
EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

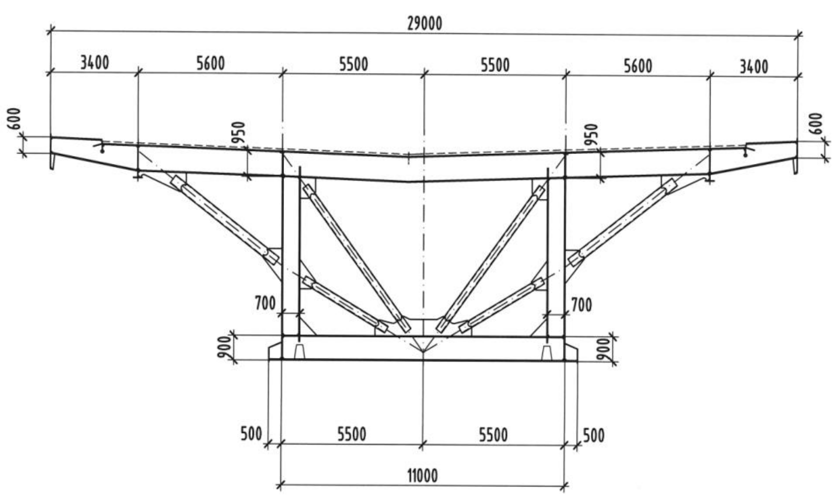
Cross frames (QR)



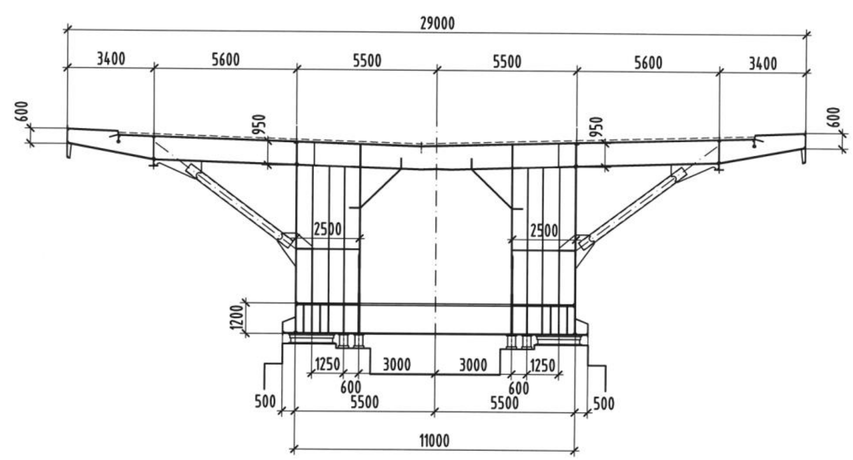
Cross frames bracings (QRV)



Transverse bracing (QV)



Pier transverse system (PS)



Assembly – Preassembly shots 1-3 and transport

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

Preassembly of orthotropic plate with web (component 4) in the manufacturing plant of EDS

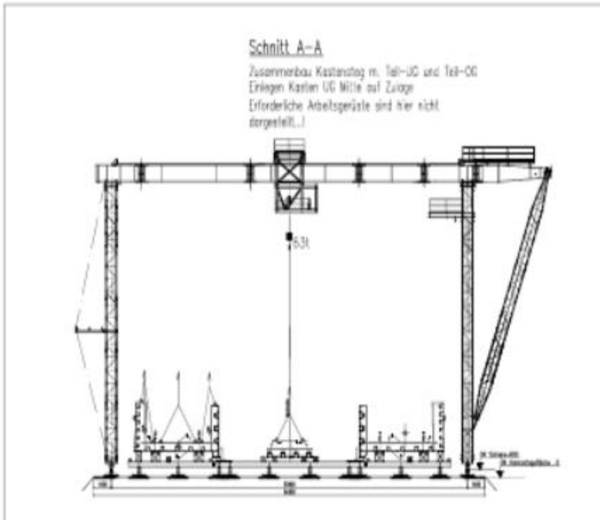
Transport to the building site (component 6)

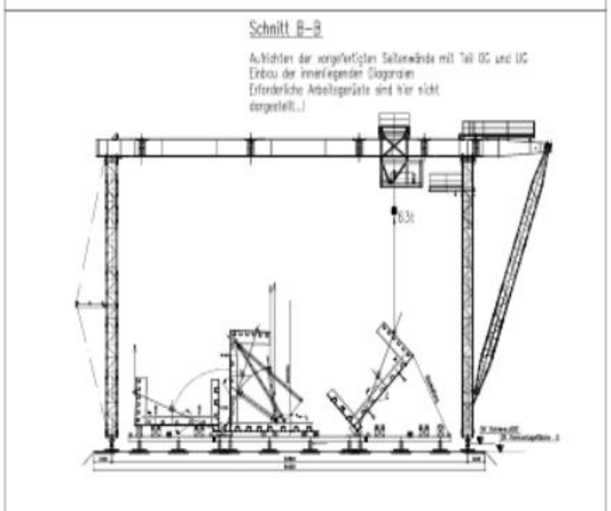
Assembly – Preassembly yard 2011 and 2014

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

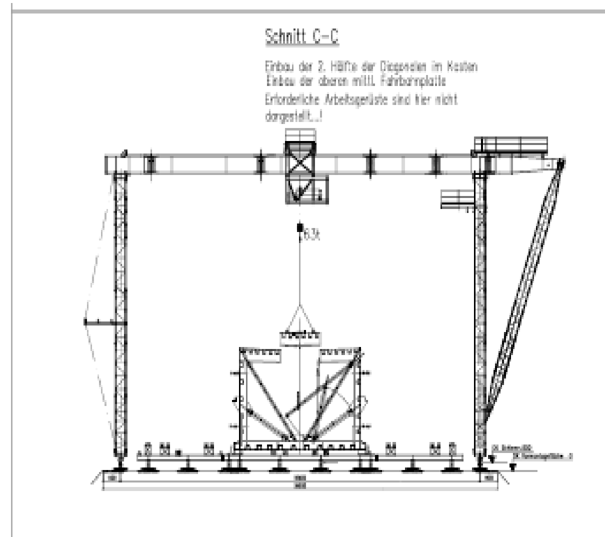
klähne ingenieure

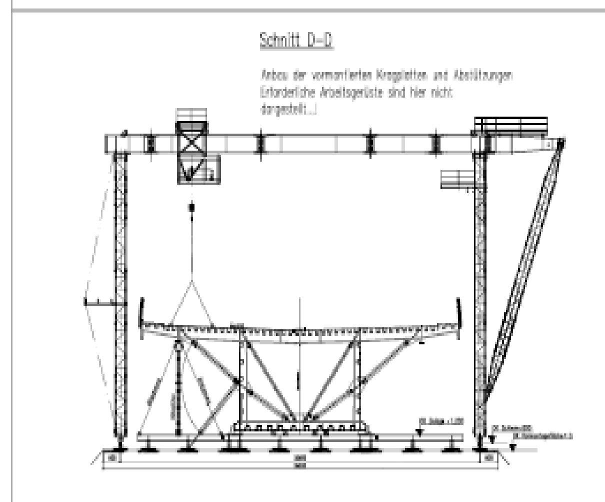
Assembly – Preassembly of superstructure





Assembly of the hollow box in the preassembly yard and lying on edge



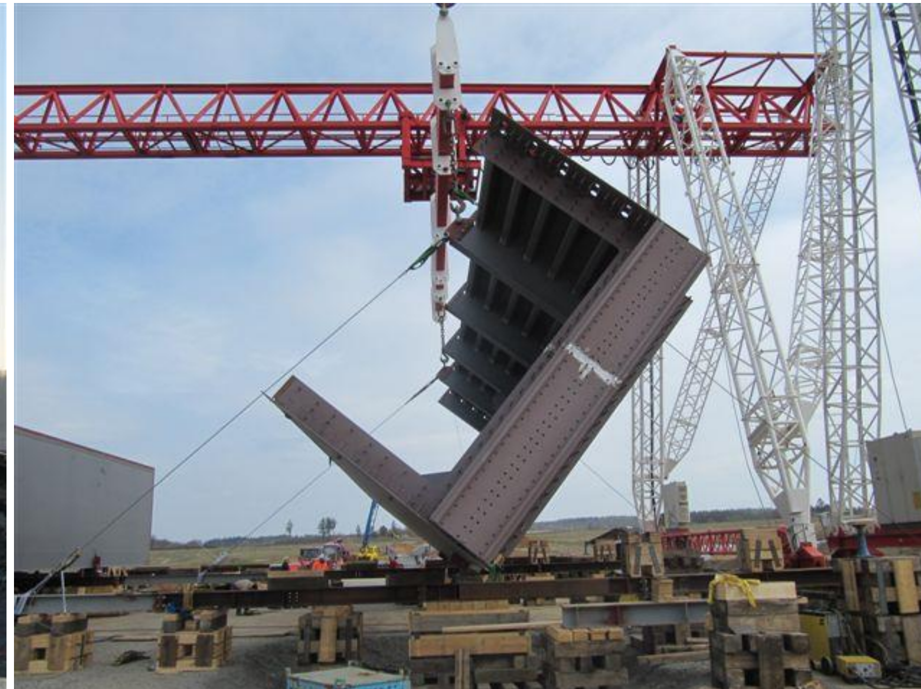


Assembly – Preassembly of components

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

Assembly of box web and parts of bottom and orthotropic plate



Erection of preassembled side walls with parts of bottom and ortotropic plate

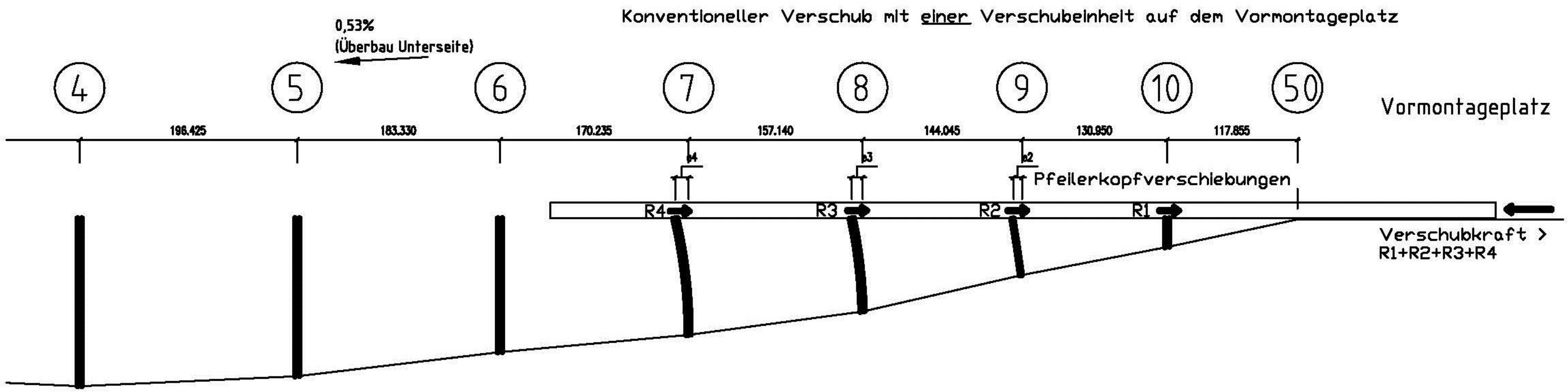
Assembly – Preassembly of bottom part

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

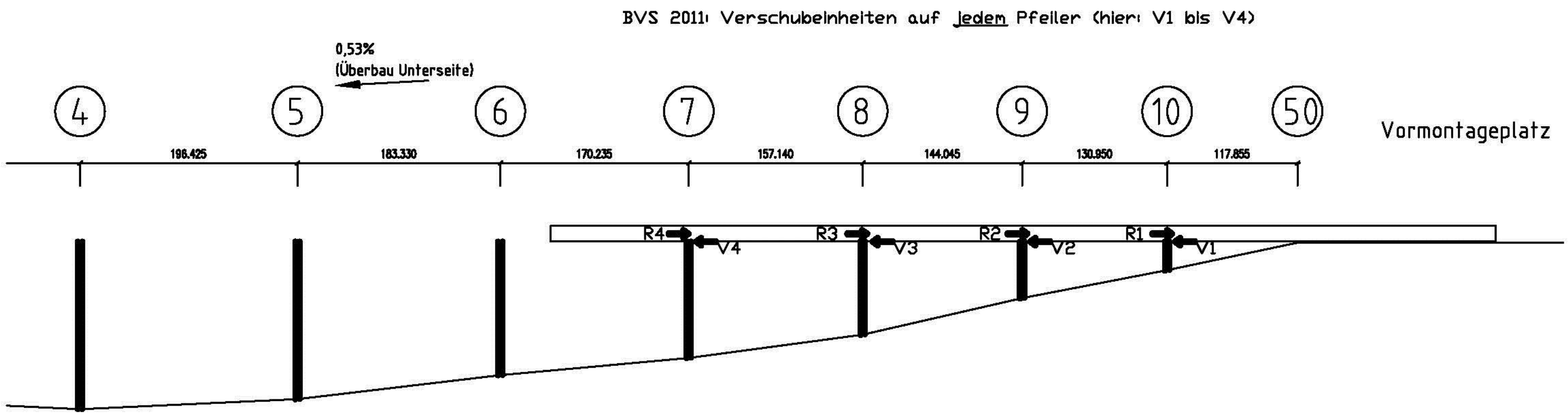
Assembly of the bottom plate shot 3 in 2012

Assembly – Sliding of superstructure using an stationary, central drive



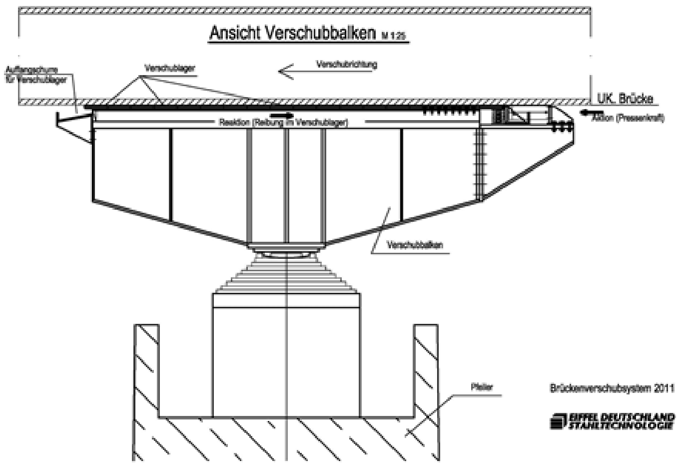
Horizontal forces due to friction on the sliding bearings on the piers →
Stability of the piers cannot be realised

Assembly – Sliding of superstructure with decentralised drive



Horizontal forces are „shorted“:
action force (by hydraulic press) = reaction force (friction on the sliding bearings)

Assembly – Sliding rocker with bridge sliding system 2011

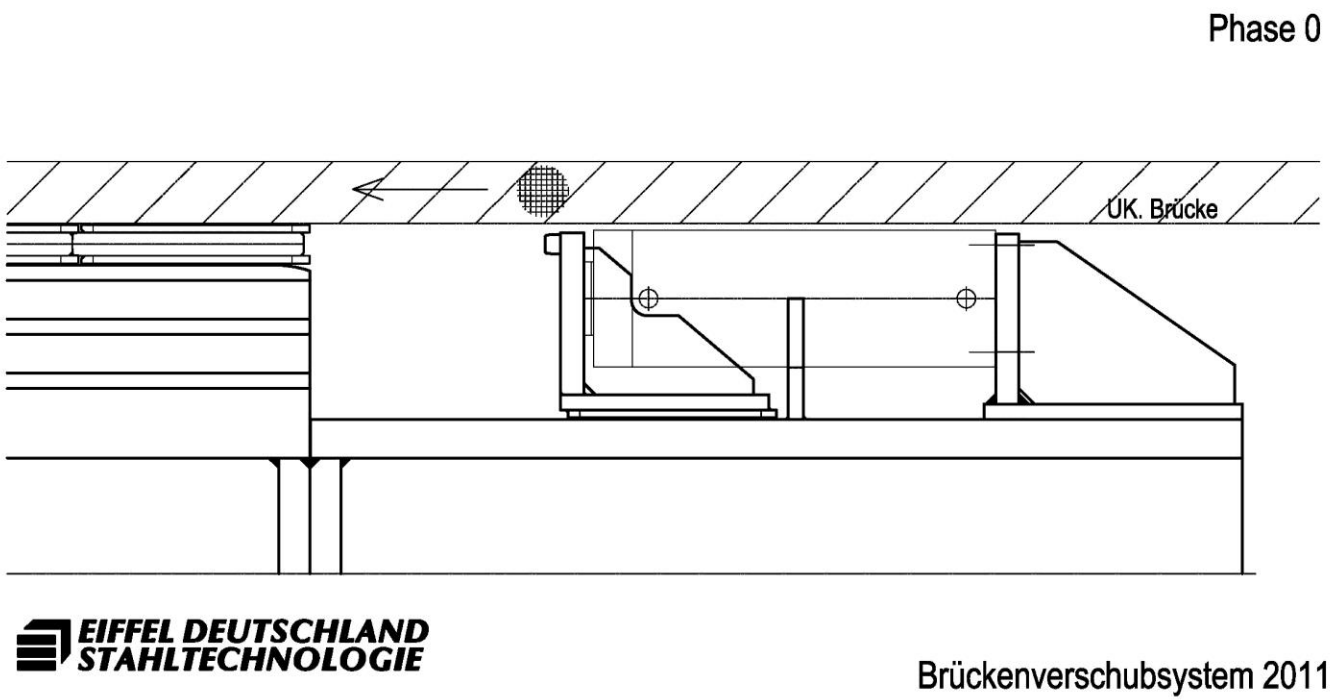


Hydraulic presses

Sliding layer

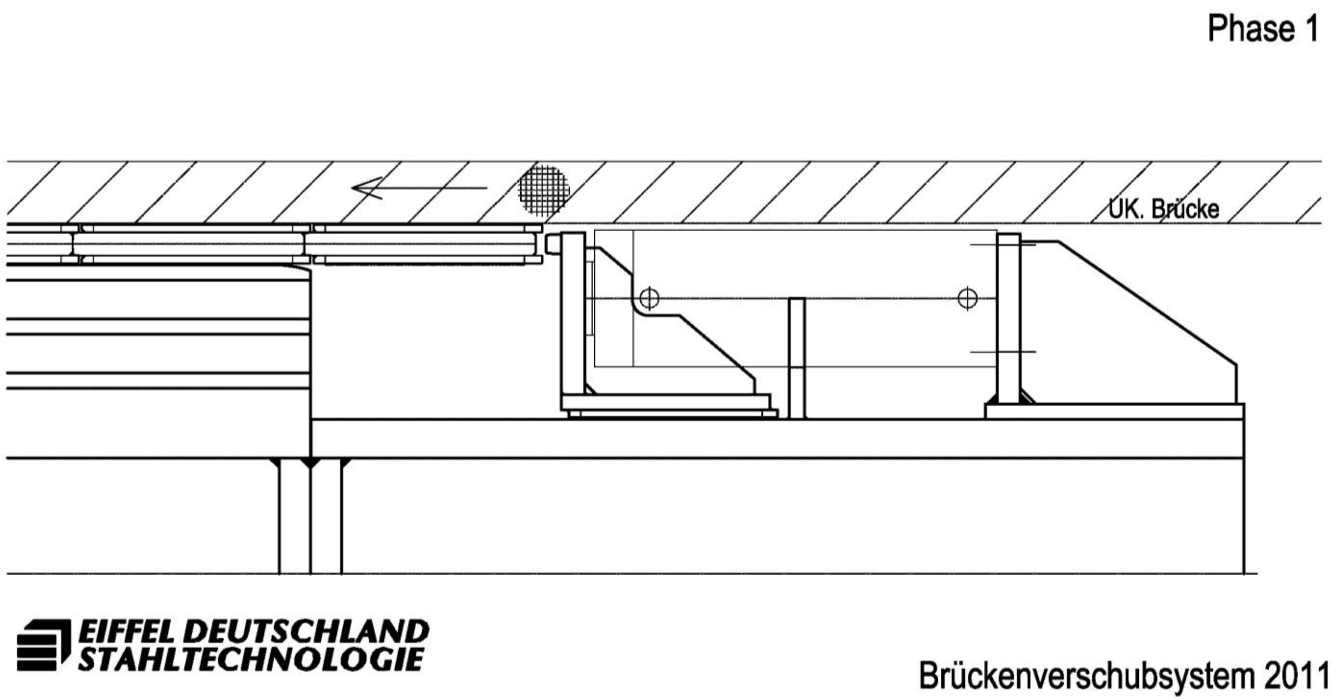
Bridge Sliding System 2011

mode of operation BVS 2011



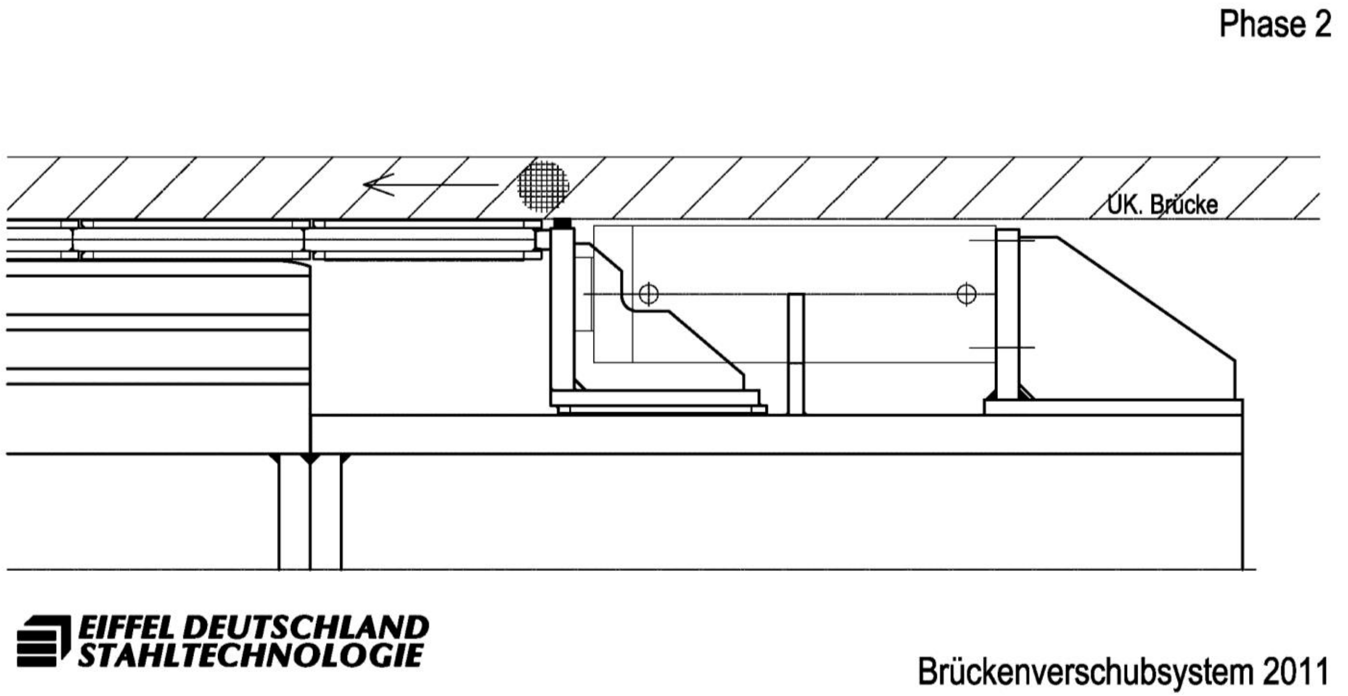
Bridge Sliding System 2011

mode of operation BVS 2011



Bridge Sliding System 2011

mode of operation BVS 2011

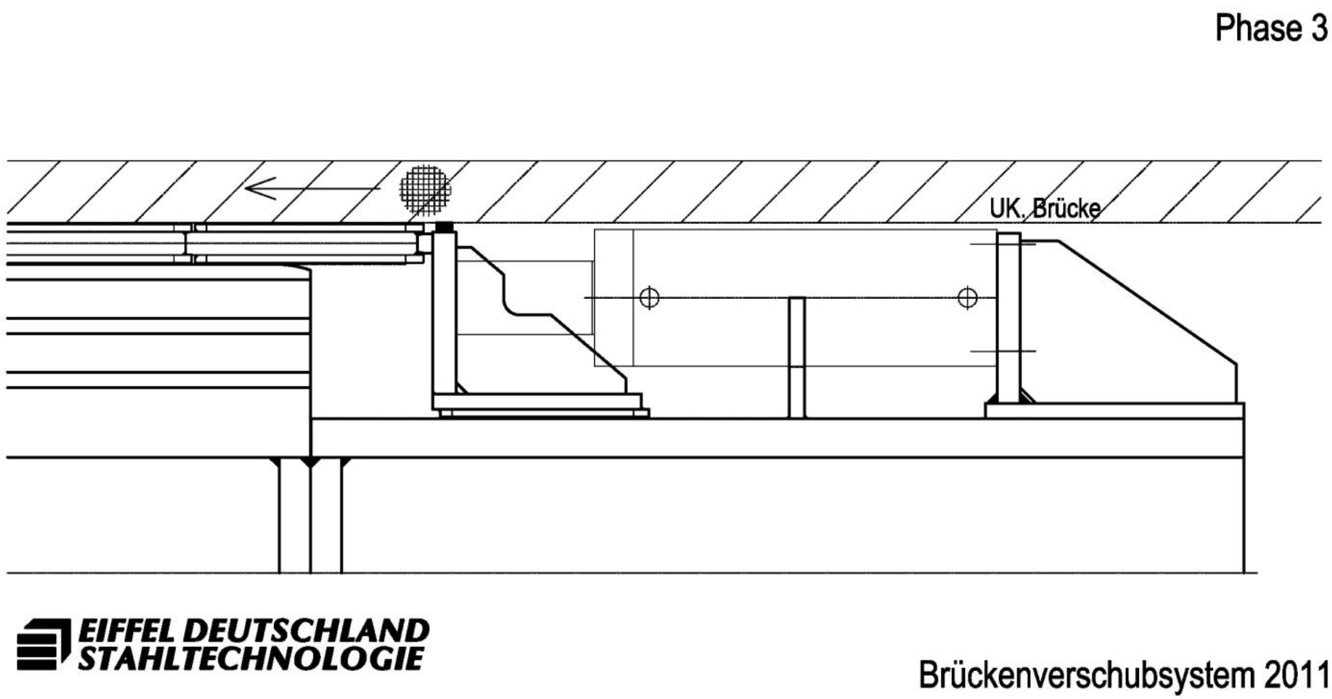


Bridge Sliding System 2011

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

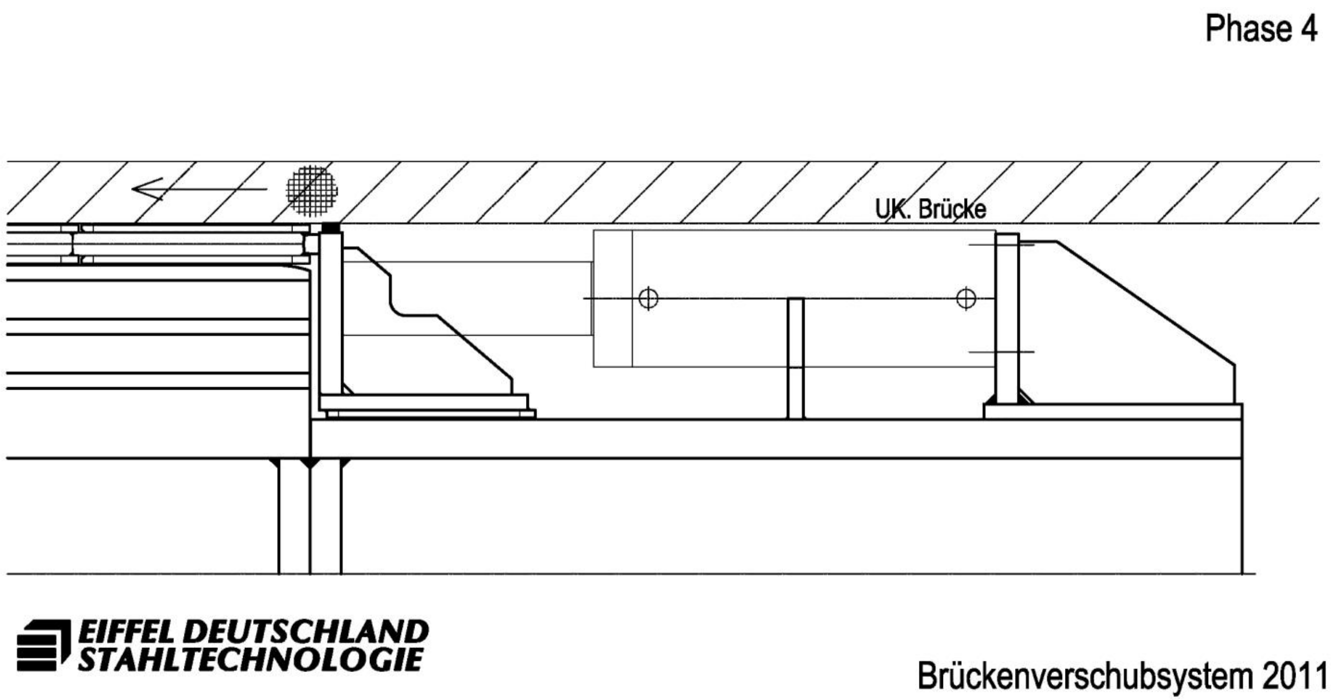
mode of operation BVS 2011



EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

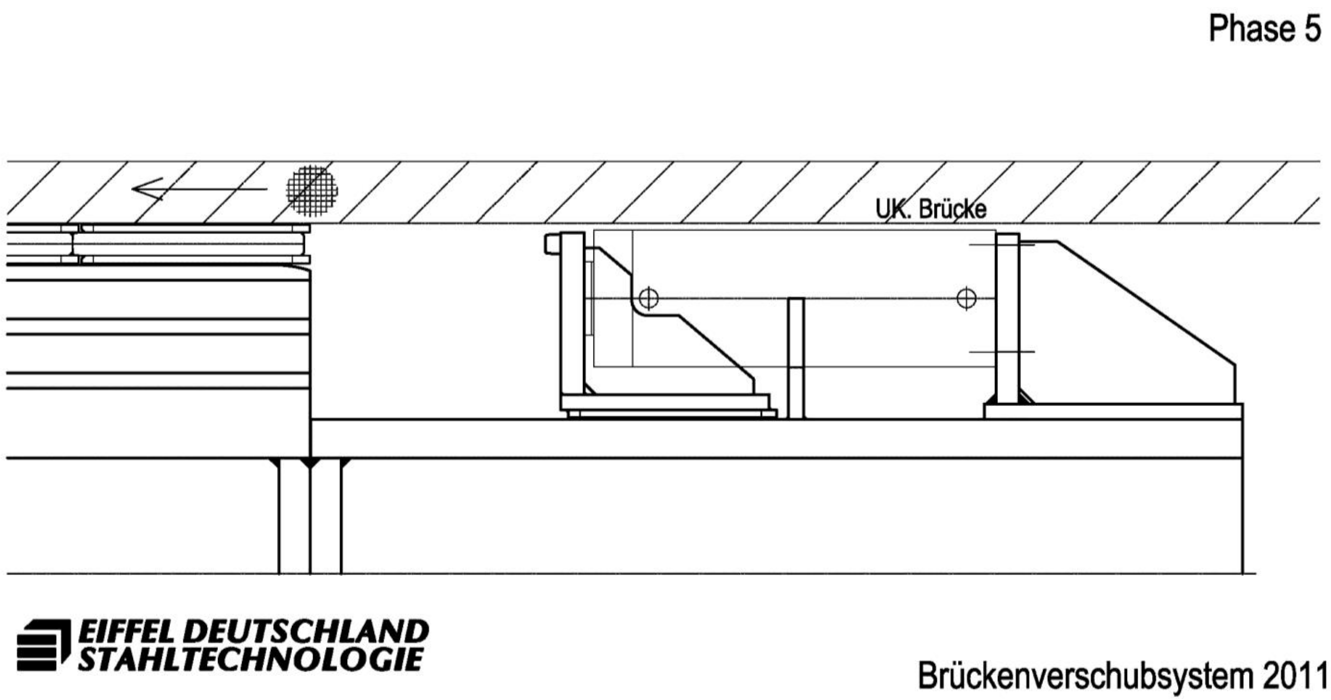
klähne ingenieure

mode of operation BVS 2011



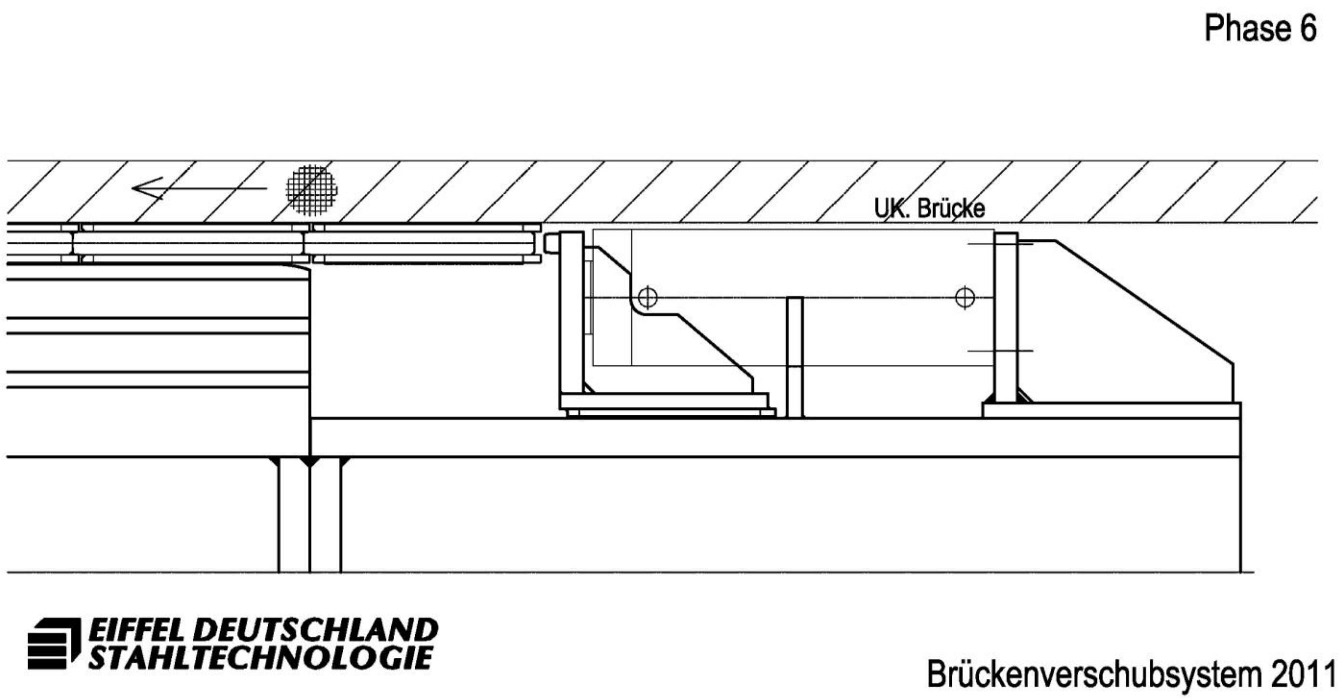
Bridge Sliding System 2011

mode of operation BVS 2011



Bridge Sliding System 2011

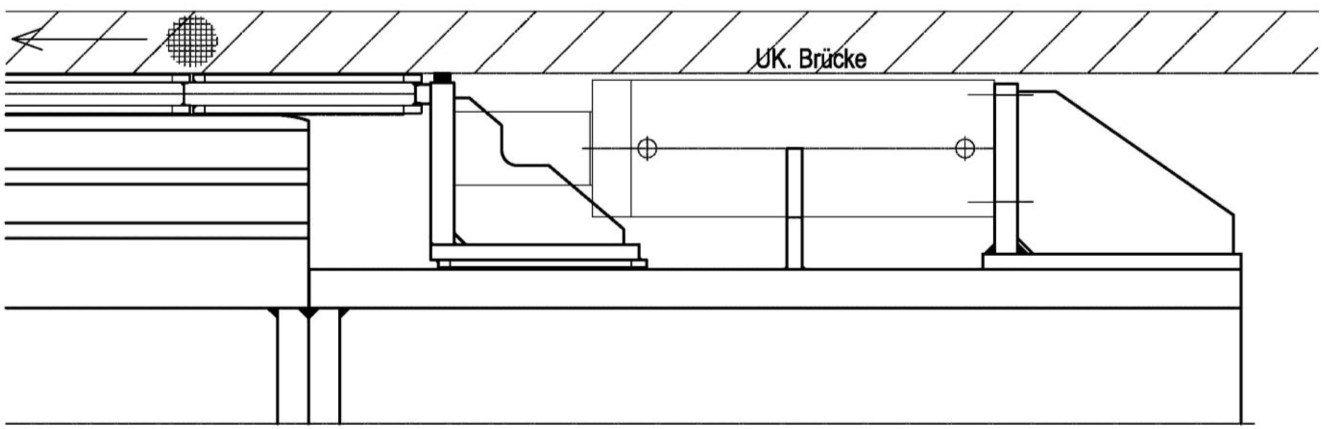
mode of operation BVS 2011



Bridge Sliding System 2011

mode of operation BVS 2011

Phase 7

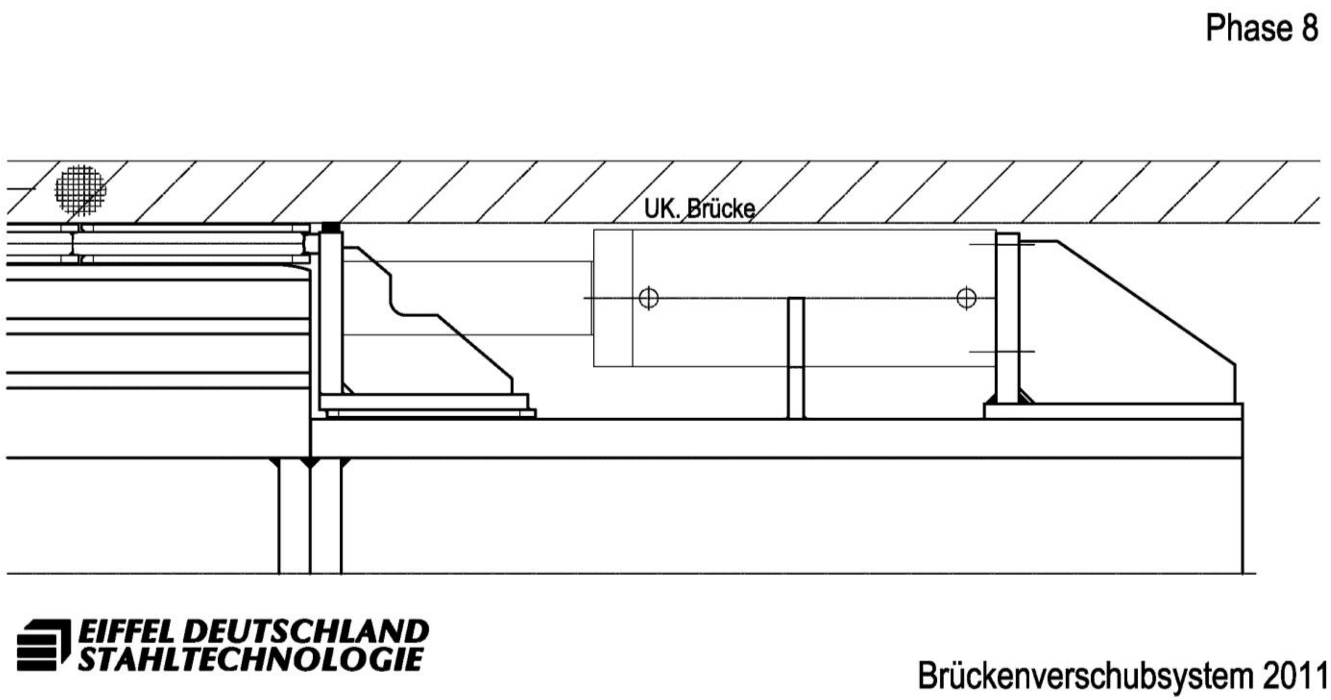


EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

Brückenverschubsystem 2011

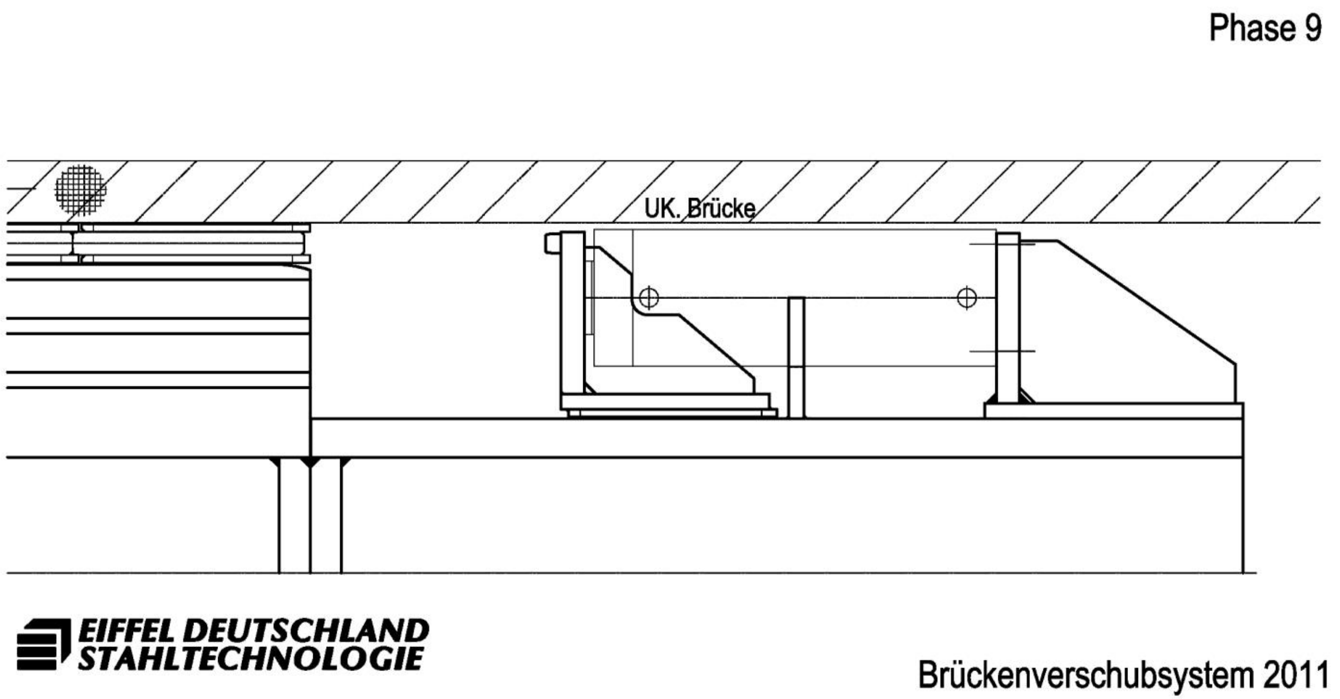
Bridge Sliding System 2011

mode of operation BVS 2011



Bridge Sliding System 2011

mode of operation BVS 2011



Bridge Sliding system 2011

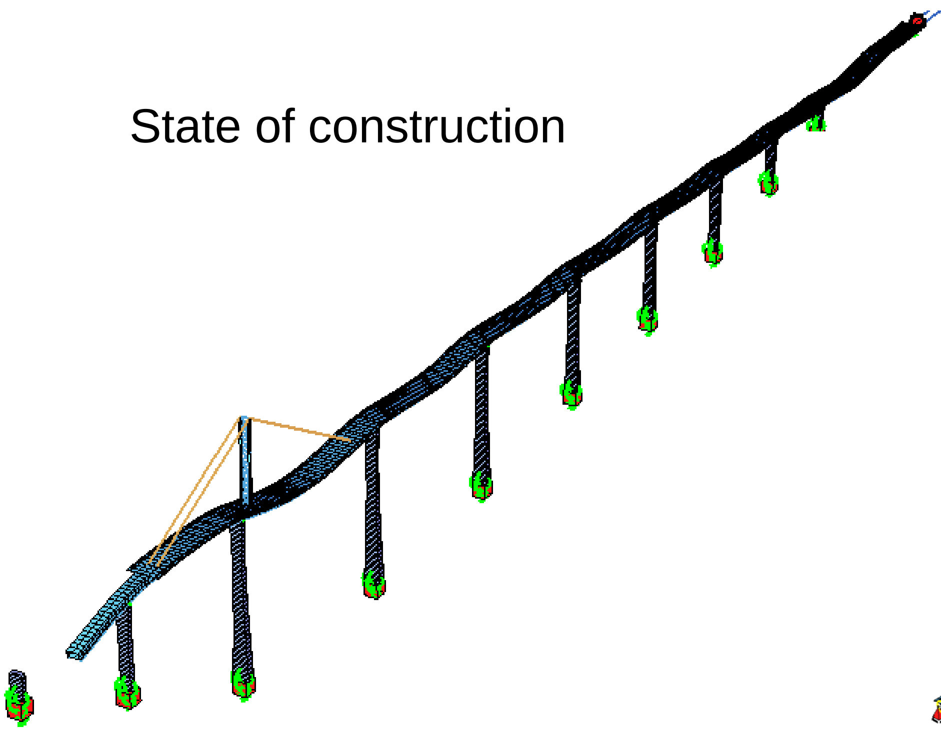
EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

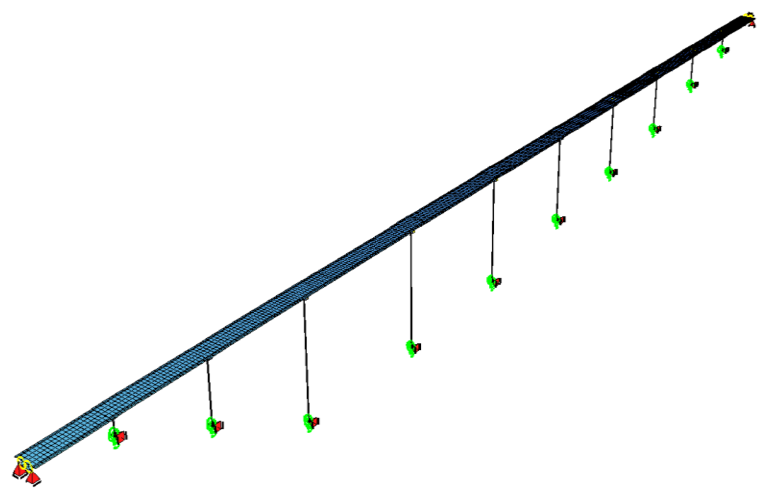
Calculation – Modelling of overall system in final state and state of construction

- Superstructure and piers were modelled in the overall modell
- One-beam 3 D model with corresponding section properties in all directions
- This modelling has been chosen to meat the acceptabel calculation duration

State of construction



Final state

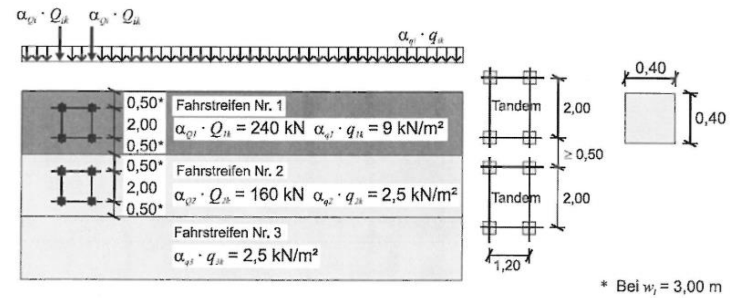


Calculation – Load assumptions – General

The following effects are considered for calculation:

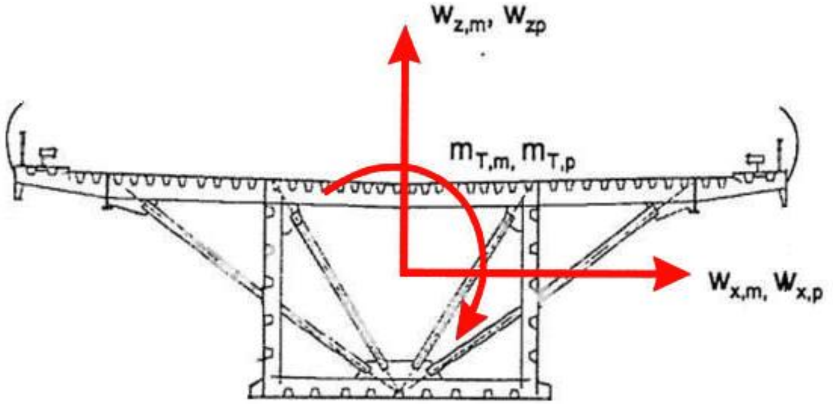
- Permanent influences (dead loads and additional loads) according to DIN Technical Report 101
- Traffic influences (LM 1, LM 2, LM 3 according to DIN Technical Report 101)
- Subsoil movements
- Drifting loads as a result of the tilted position of the piers
- Wind effects
- Bearing friction and bearing replacement
- Subsequent removal and installation of asphalt
- Military traffic loads (MLC)
- Earthquake loads

Load Model 1 (DIN Fachbericht 1)

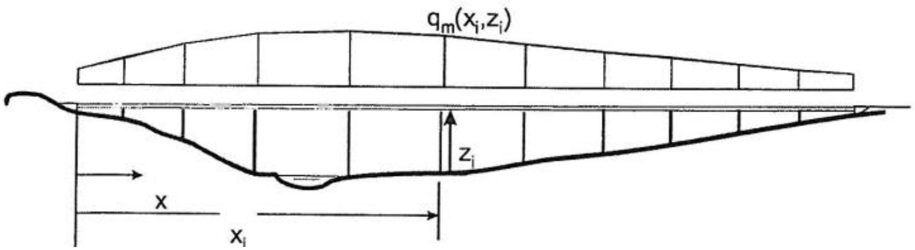


Calculation – Wind load assumptions

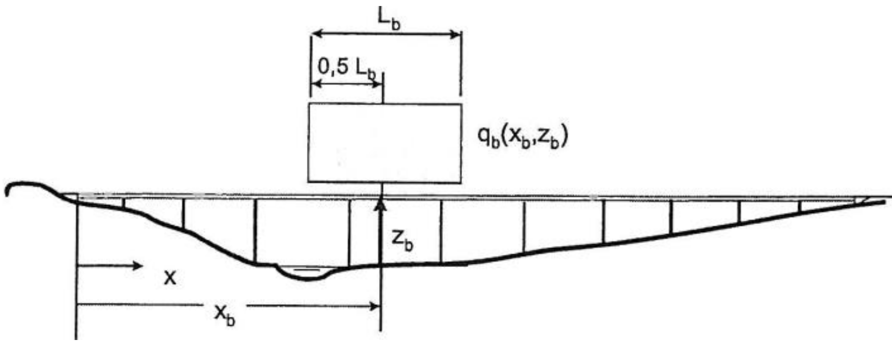
The wind load on the superstructure consists of a horizontal, vertical and a torsional component.



The application of the wind load on the bridge is as follows:



Average velocity pressure q_m



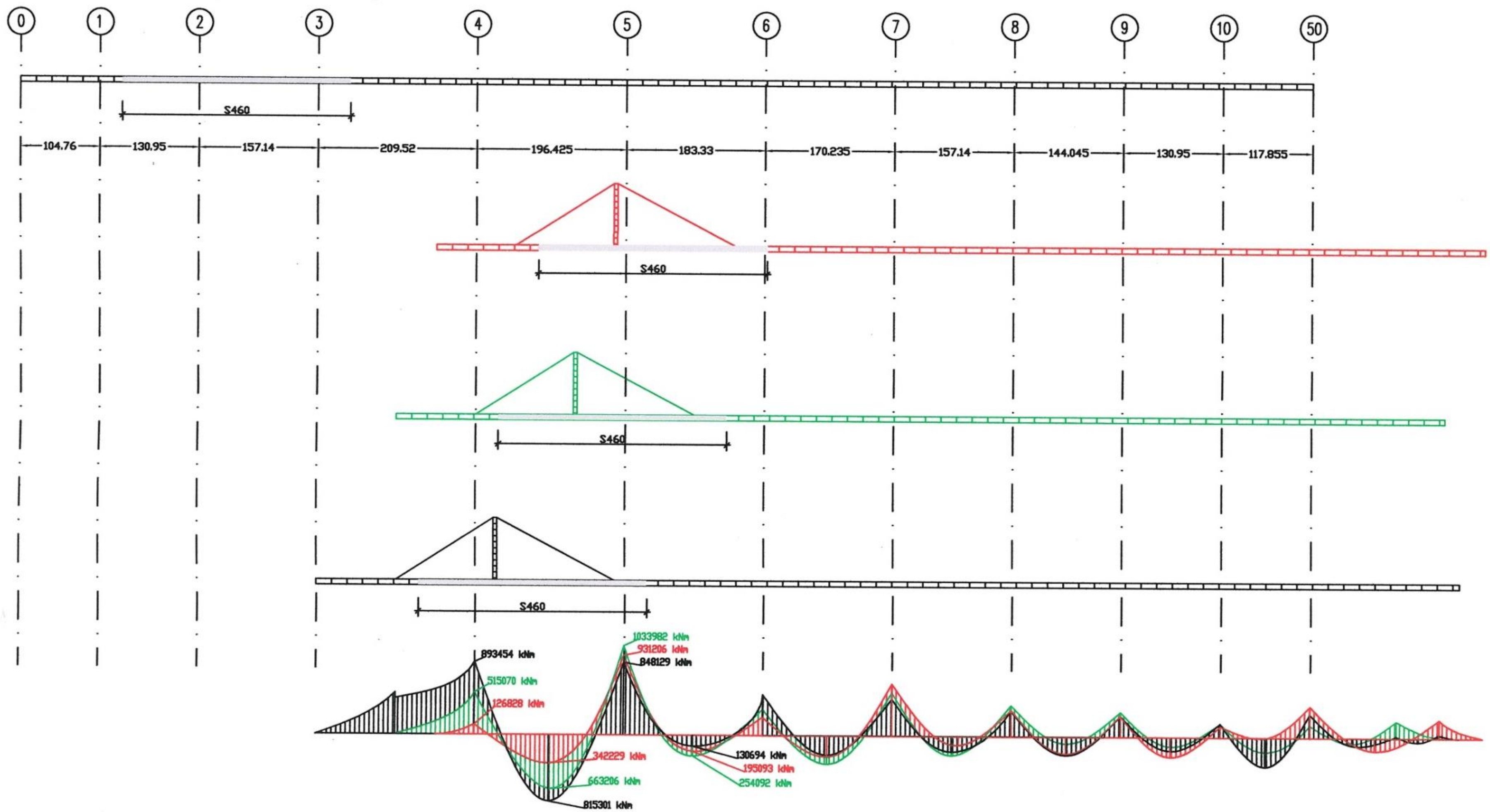
Peak velocity pressure q_b

Calculation – Wind cover in shots 1 to 4

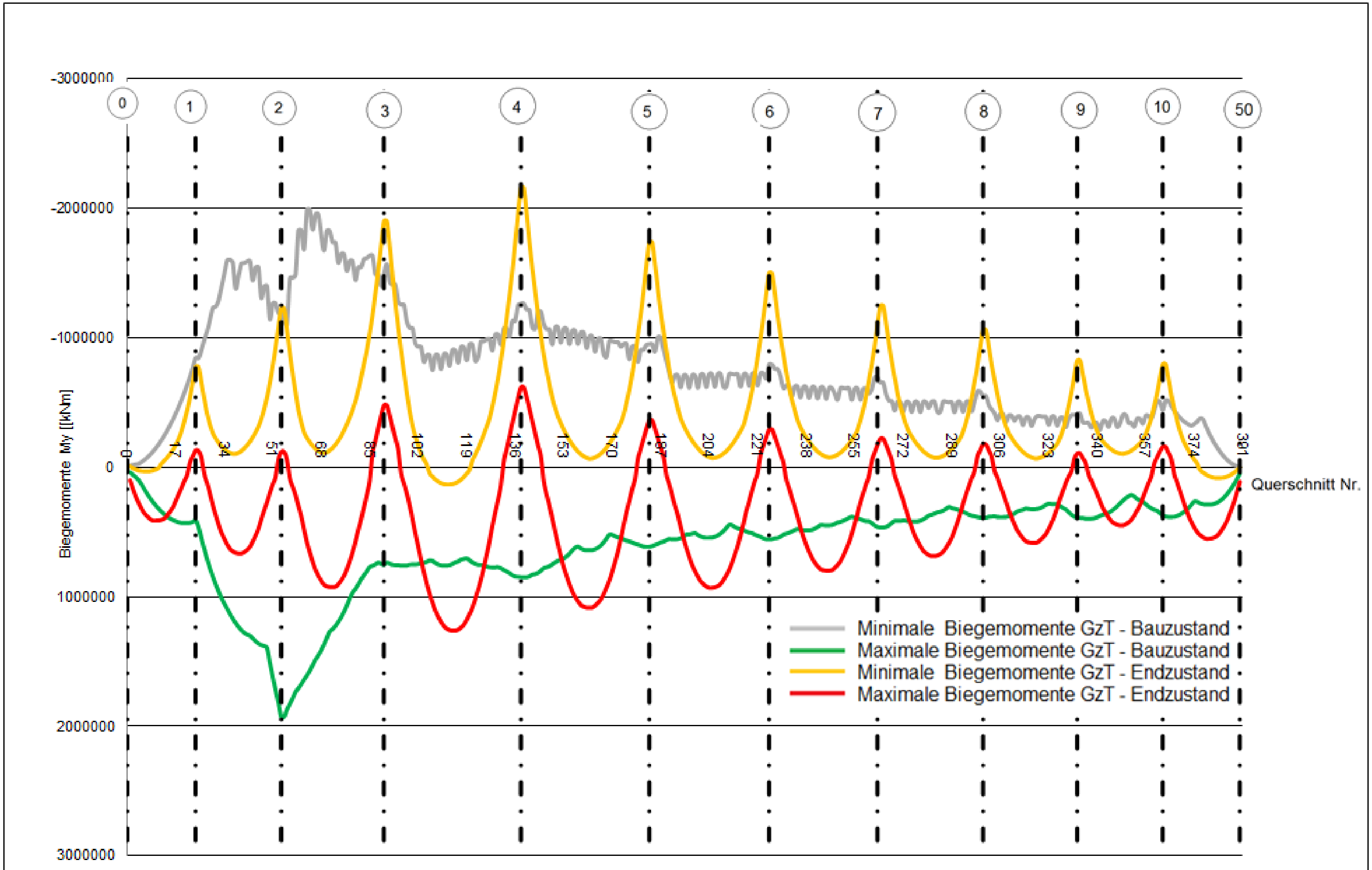
Due to the high wind load assumptions the stability is not given for
- superstructure in different sliding states and
- some free piers in intermediate construction conditions

Therefore must be arranged
- „cubes“ on the respective piers
- triangular wedges covered with sheet metal in the first 90 m of the cantilever end

Calculation – Distribution of bending moments during construction



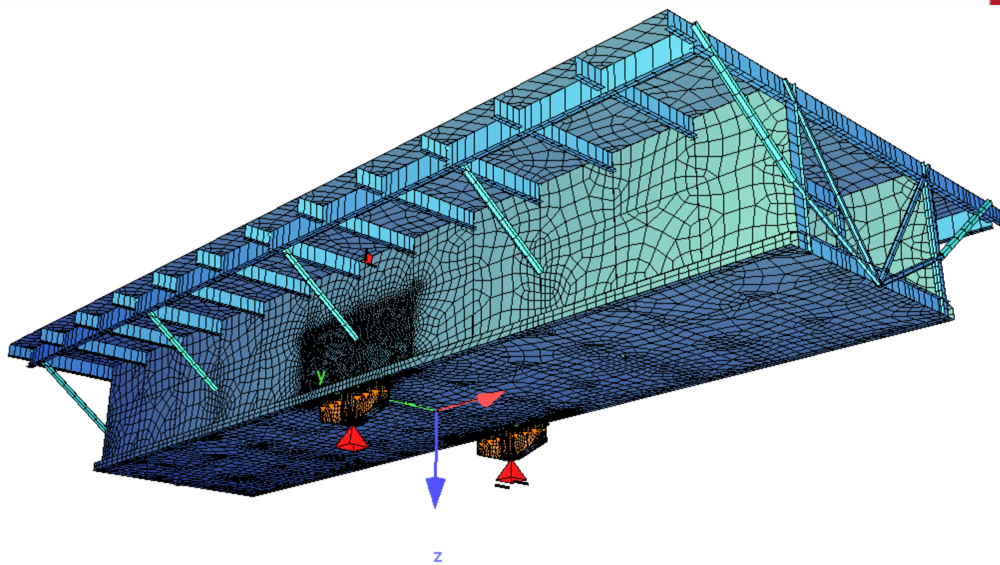
Calculation – Maximum bending moments in the state of construction and final state



Calculation – Interaction of sliding rockers and superstructure

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure



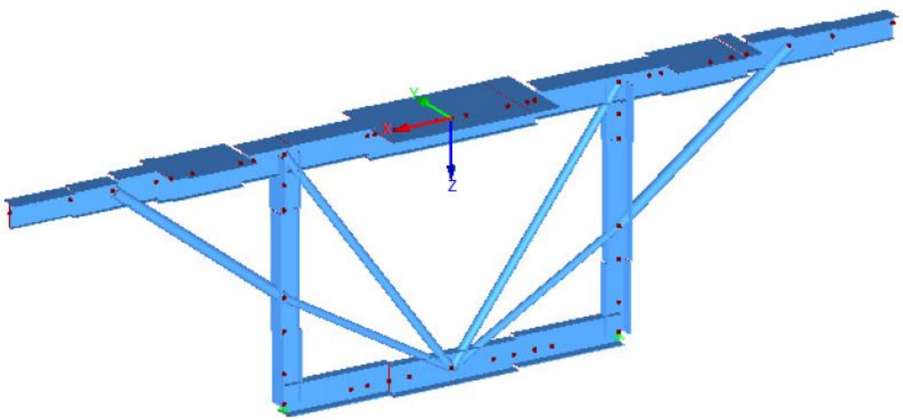
	Spannung unter Gleichlast	Laststeigerungsfaktor (SF) neu		anzunehmende Bemessungsspannung in Prozent inkl. Sicherheitsfaktor	
		$t_{Blech}\geq$ 40 mm	t_{Blech}<40 mm	$t_{Blech}\geq$ 40 mm	t_{Blech}<40 mm
	%	-	-	%	%
Steife 3	35	1,00	1,00	35	35
Feld IV	50	1,00	1,00	50	50
Steife 2	60	1,05	1,00	63	60
Feld III	80	1,10	1,05	88	84
Steife 1	85	1,15	1,10	98	94
Feld II	95	1,20	1,15	114	109
Feld I	100	1,30	1,20	130	120

Calculation – Modelling of the transverse bracing and frames

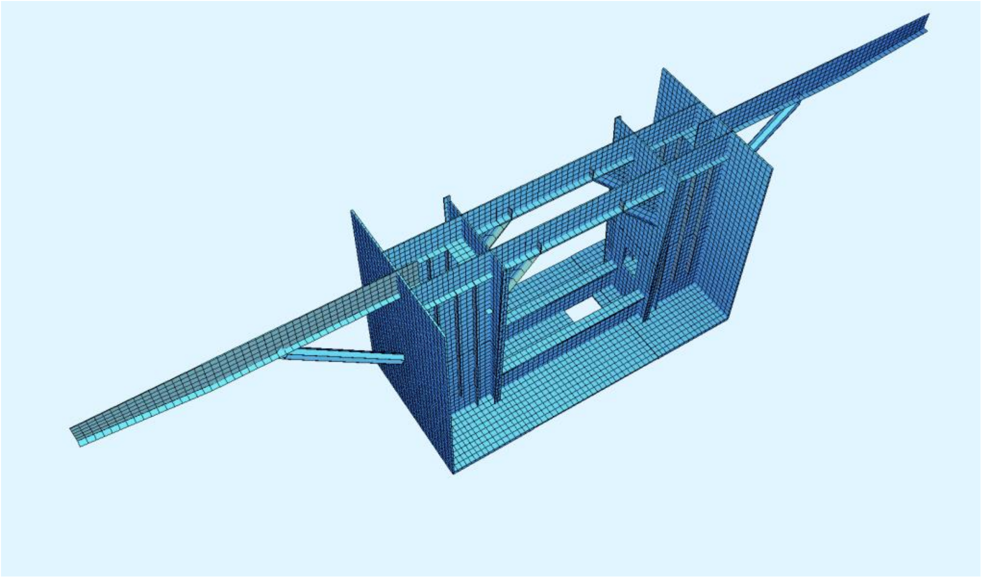
EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

Modeling Transverse bracing (QV)



Modeling Pier transverse system (PS)



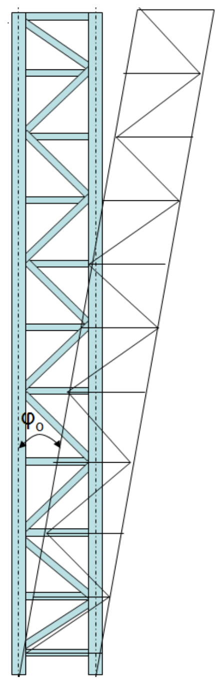
Calculation – Modelling of the pylon

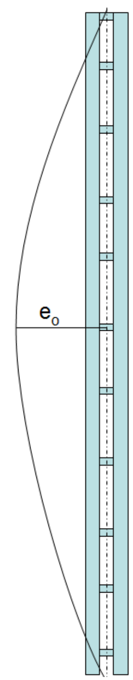
EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

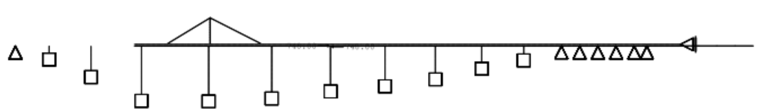
klähne ingenieure

Main Assumptions

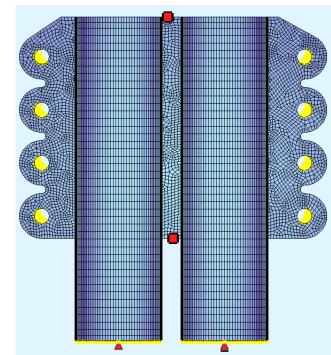
- Calculation according to II. order theory with use of global imperfections H/500
- Load and boundary conditions according to global calculations of whole structure
- Submodelling used to detailed calculations of main parts of structure of pylon i.e. pylon head, pylon foot, joints, etc.
- Material: S235 (Pylon), S355 (pylon head, pylon foot, etc.)



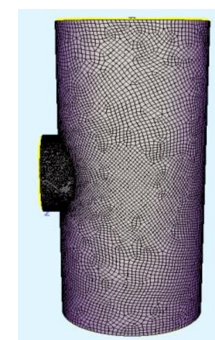




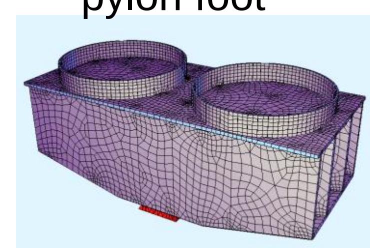
pylon head



pylon joint



pylon foot

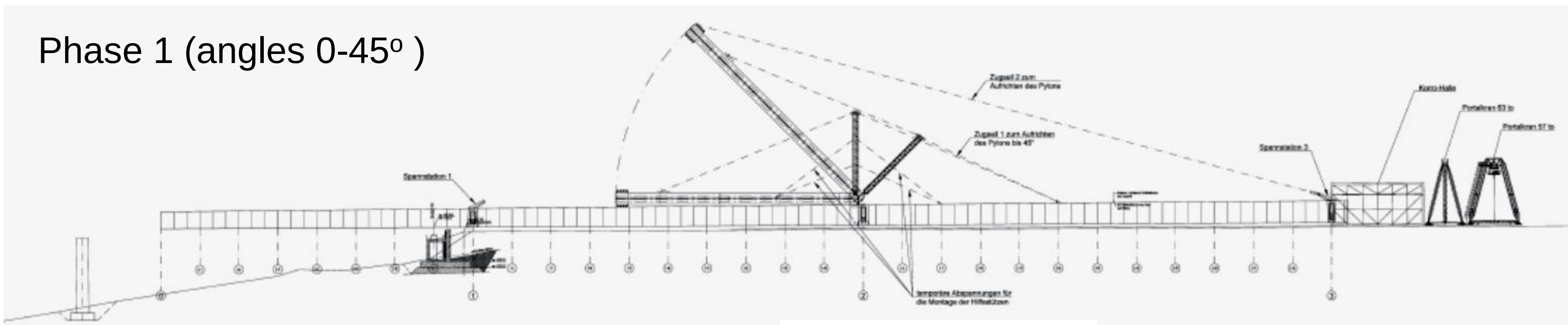


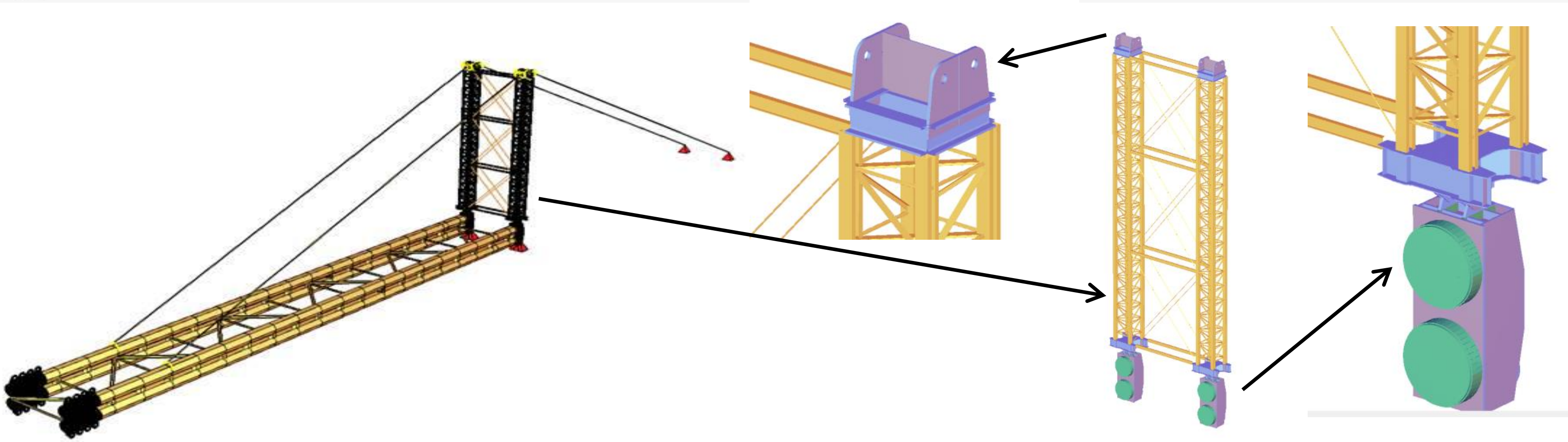
Calculation – Modelling the Erection processes of the pylon

The Erection process carried out in two phases:

Phase 1 (angles 0-45^{o}) – erection with use of additional pylon located at the foot of main pylon

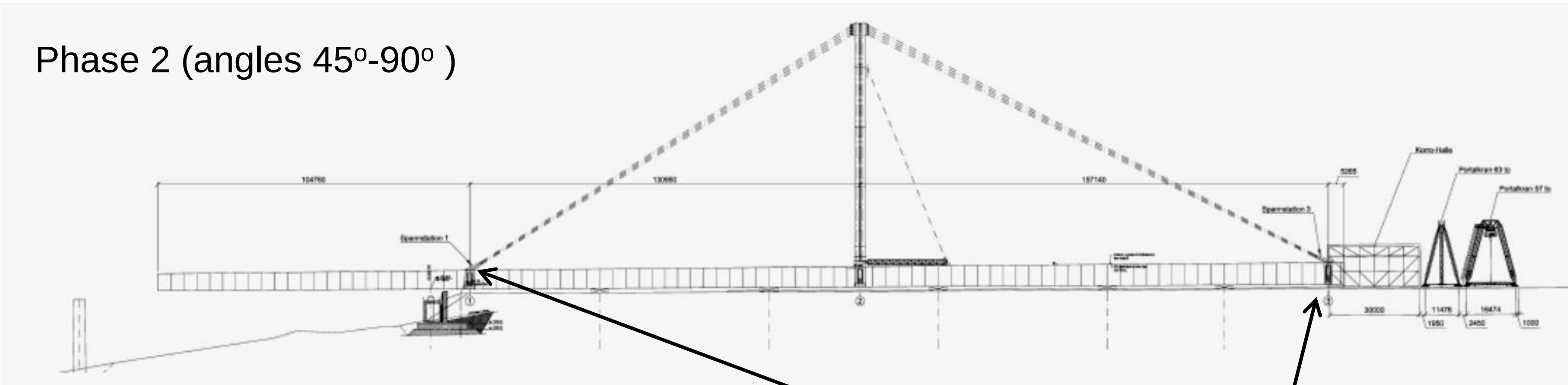
Phase 2 (angles 45^{o}-90^{o}) – erection with use of tensioning station located at the bridge deck

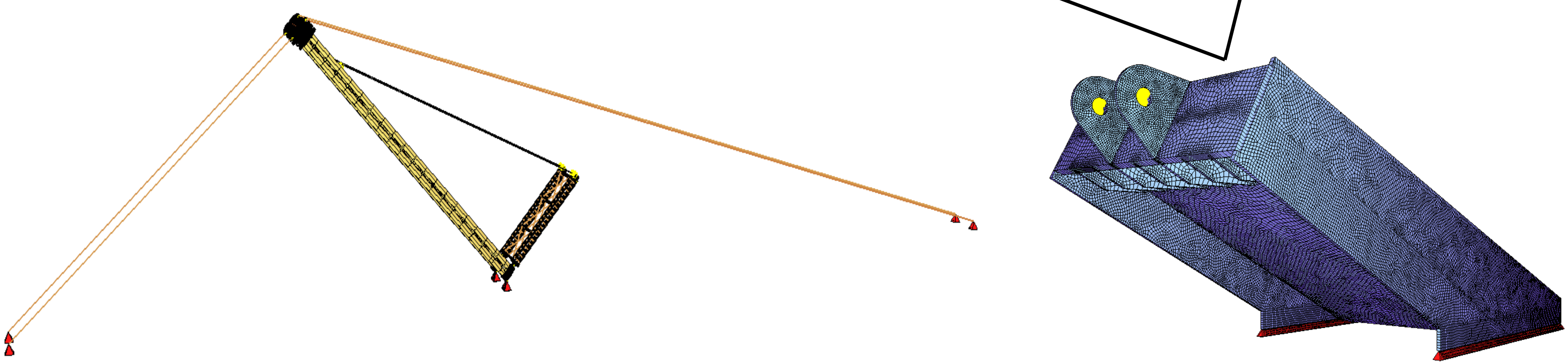




Calculation – Modelling the Erection processes of the pylon

Phase 2 (angles 45º-90º)





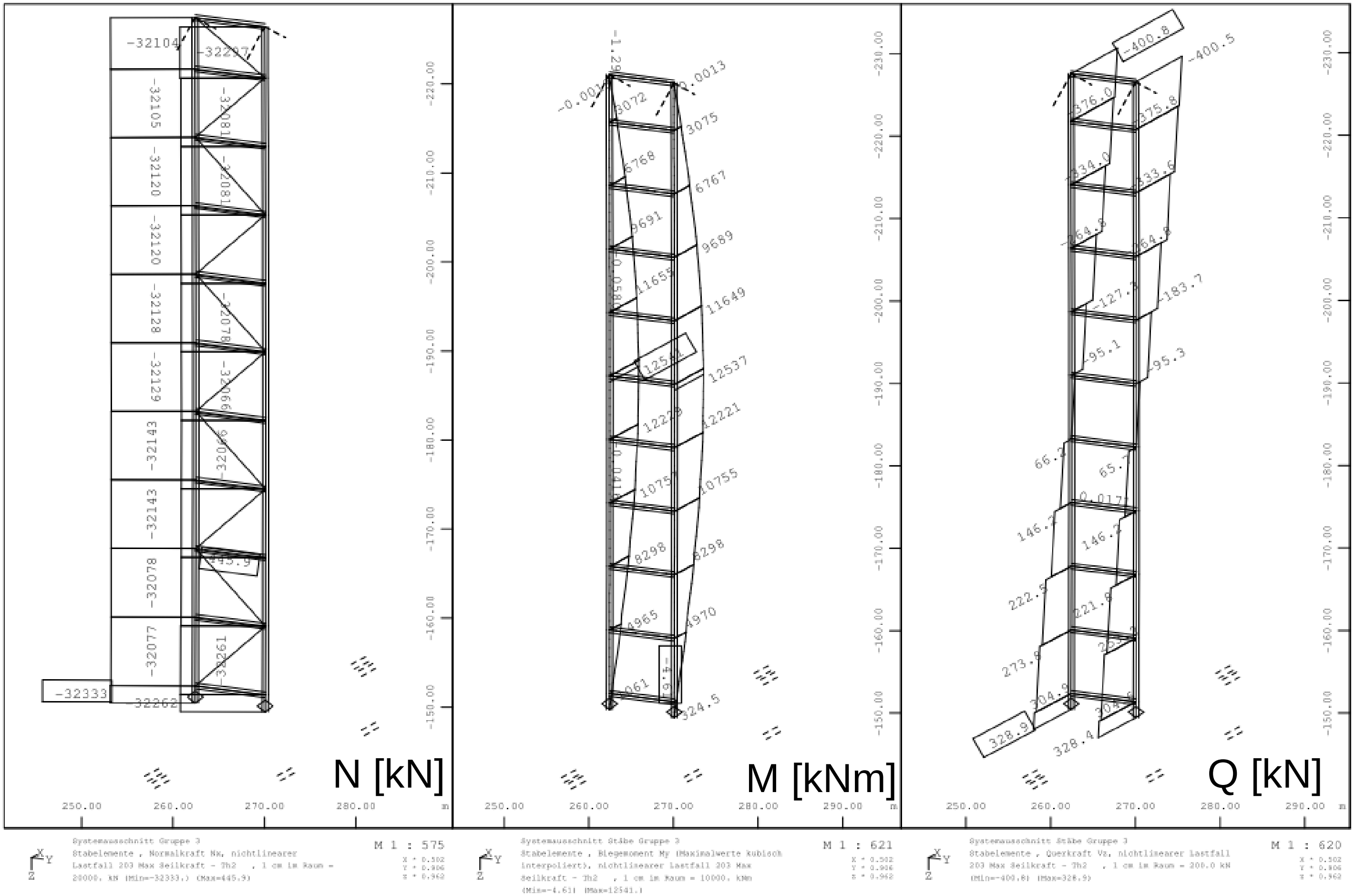
tensioning station

Calculation – Results for the pylon

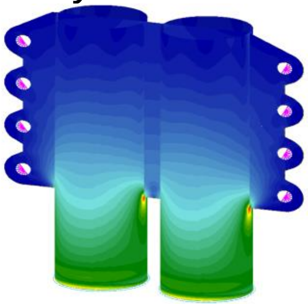
EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

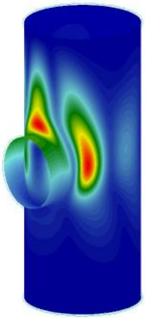
Main structure



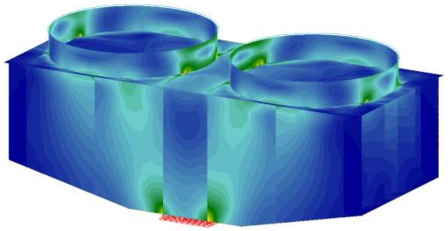
Pylon head



Pylon joint



Pylon foot



Conclusions

Construction of Hochmosel bridge is associated with further developments concerning the erection technology and static construction solutions

This includes

- the patented sliding system BVS 2011
- the vertical manipulation of the auxialary pylon for the variation of cable forces
- the shapes defined for the superstructure cantilever and pier heads as a result of wind tunnel investigations
- the concept of statical analysis for the global and functional subsystems

Sliding process

Sliding process

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

HOCHMOSELÜBERGANG

23.06.- 28.06.14

Verschub Nr. 2

EIFFEL DEUTSCHLAND STAHLTECHNOLOGIE

klähne ingenieure

Thank you for your attention