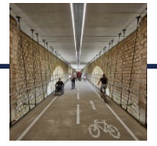
OA14: DESIGN CHOICES AND CHALLENGES

PRESENTATION STEEL BRIDGES SYMPOSIUM PRAGUE

Septembre 2024

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INNOVATIVE ENGINEERING

WHO WE ARE AND WHAT WE DO

ABOUT INCA

INCA Ingénieurs Conseils Associés S.à r.l.

- Established in 1991 (Gehl Jacoby & Associés)
- Rebranded INCA Ingénieurs Conseils Associés in 2006
- Team INCA : 8 partners, 140 multilingual experienced professionals

Our office in Niederanven (LU)

SUPERSTRUCTURES

- Residential, commercial, schools, leisure and industrial construction

INFRASTRUCTURES

- Bridge design
- Road and Railway engineering
- Flood risk management

PROJET MAGEMENT

- Planning
- Construction Management
- Quantity surveying

WORKS MANAGEMENT AND SUPERVISION

BUILDING PHYSICS

- Acoustics
- Thermal
- Fire safety

ENVIRONNEMENT

- Biotope studies
- Compensation measures






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EXEMPLES OF BRIDGES

REPLACING ROAD DECK OA498 & OA499
Insenborn - Lultzhausen

FOOTBRIDGE « PA1 »
Bettembourg station

FOOTBRIDGE
Bissen

FOOTBRIDGE + PLATFORM CANOPY
Luxembourg station

FOOTBRIDGE UNDER ADOLPHE'S BRIDGE
Luxembourg-Centre

RAILVIADUC FOR HIGH SPEED TRAIN
Rohrbach (France) – LGV Est

RAILBRIDGE « OA14 » OVER A3
Bettembourg - Luxembourg

OA401 – BORDER BRIDGE OVER MOSEL
Grevenmacher

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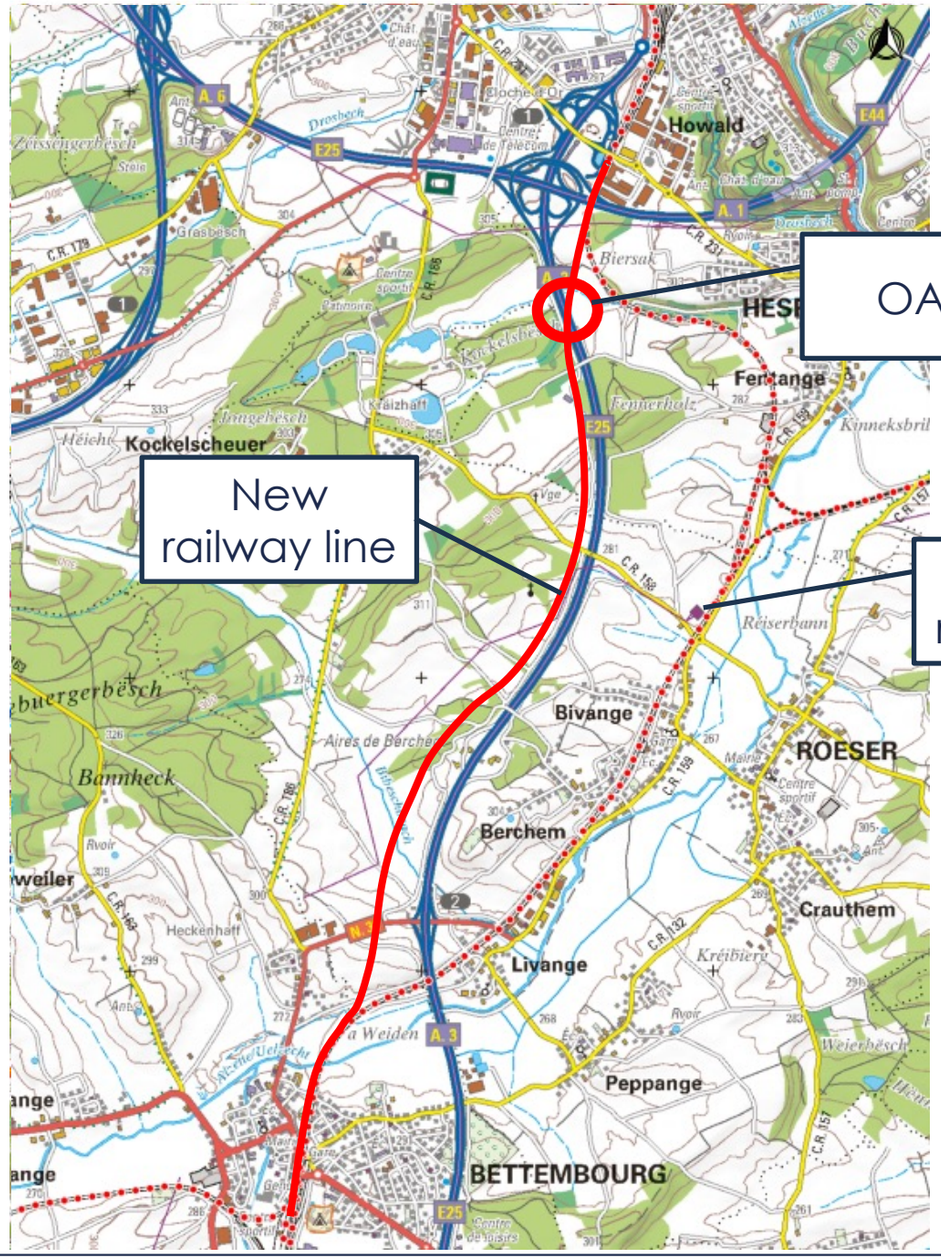
PATH OF NBS (NEUBAUSTRECKEN – NEW RAILWAY LINE)



OA 14

New railway line

Existing railway line

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GEOMETRIC CONSTRAINS AND CONSIDERATION

BASIC INPUTS

CONSTRAIN OF THE MOTORWAY:

- Free span of the motorway: 46,0 m
- Clearance height: 5,0 m
- No closure of the highway during construction (except a single weekend for installation)

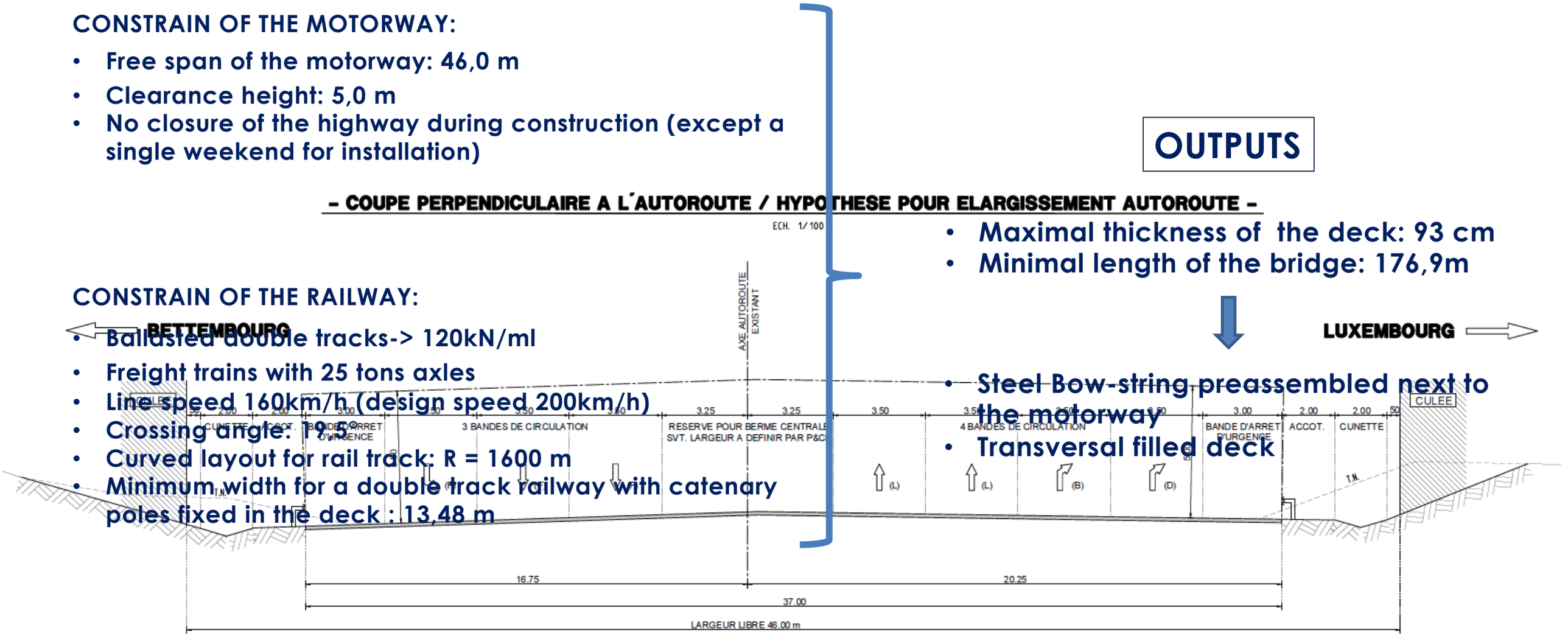
CONSTRAIN OF THE RAILWAY:

- Ballasted double tracks-> 120kN/ml
- Freight trains with 25 tons axles
- Line speed 160km/h (design speed 200km/h)
- Crossing angle: 79,5°
- Curved layout for rail track: R = 1600 m
- Minimum width for a double track railway with catenary poles fixed in the deck : 13,48 m

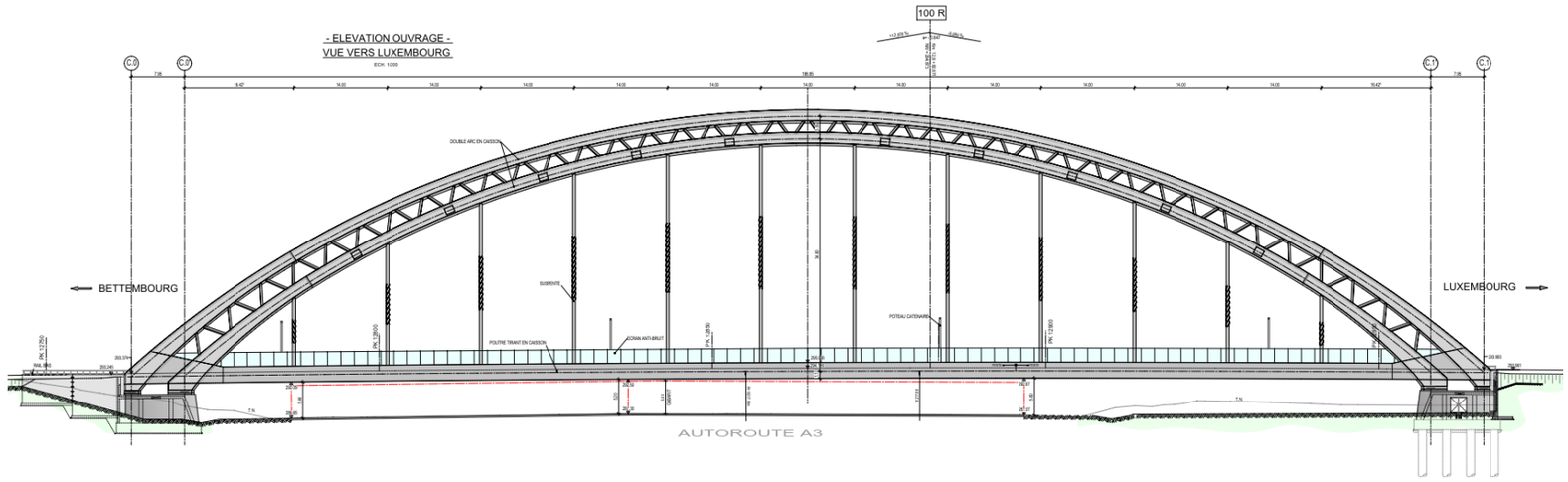
OUTPUTS

- Maximal thickness of the deck: 93 cm
- Minimal length of the bridge: 176,9m

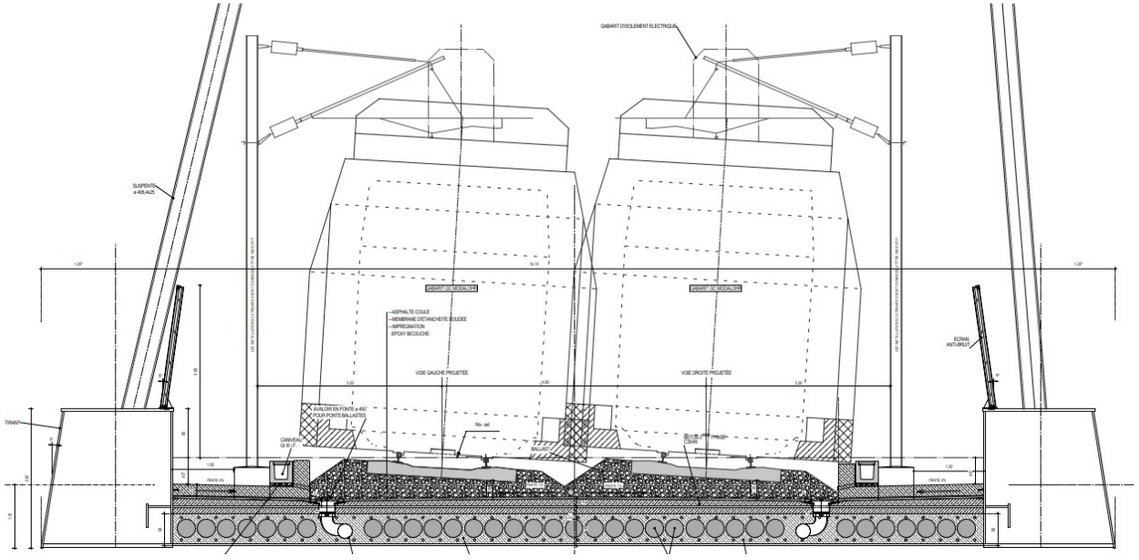
- Steel Bow-string preassembled next to the motorway
- Transversal filled deck



KEYS FEATURES OF OA14



Total lenght:	207,1 m
Spans	8,0 – 187,0 – 8,0
Width of the deck	14,11 (net) -18,7 (total)
Quantity of steel:	5600 ton
Deck surface:	2900 m^2
Quantity of concrete	2200 m^3 (deck) - 1900 m^3 (abutments)



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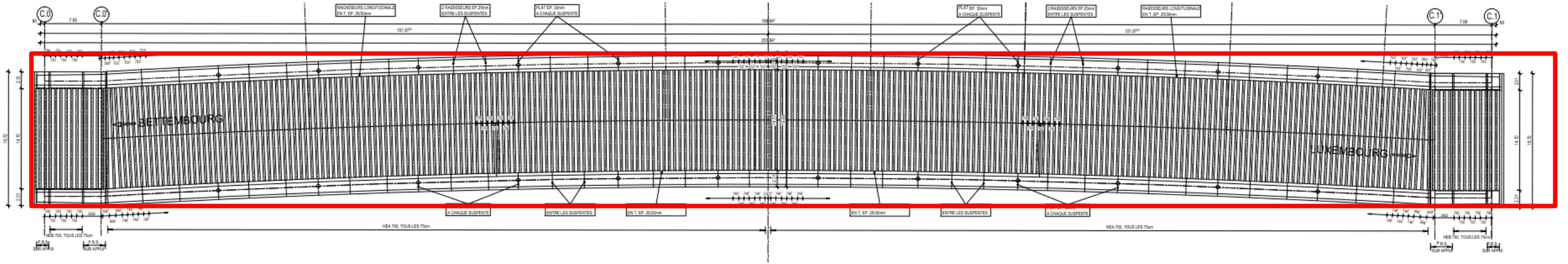
OA14: DESIGN CHOICES AND CHALLENGES

1) Straight deck or curved deck?

1. Straight deck or curved deck?



- **With a straight deck, the surface area of the deck increases from 2900m2 to 3600m2 -> +24% and the feld moment then increases by 35%**

-> CURVED DECK

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OA14: DESIGN CHOICES AND CHALLENGES

1) ~~Straight deck or~~ Curved deck

2) Hangers:
   - Solid bars?
   - Cables?
   - Hollow Tubes?

2. Hangers

- Solid bar hangers type DIN-Fachbericht 103 §II-H.2 -> Nrd,max= limit to 7440 kN and problem for butt welds

- Cable hangers -> at least 37strand, Need to re-tension them after concreting the slab, Motorway gauge to be respected, Consequence of creep to be controlled

- Tube

  PRO: Significant vertical stiffness

  PRO: “Easy” Butt welds

  CONS: Fatigue detail to be studied

  CONS: Joint moments to master

  CONS: Resonance with the wind

→ Hollow tubes

- Diametre: 457mm
- Thickness: 40 mm
- Quality of steel: S450H

OA14: DESIGN CHOICES AND CHALLENGES

~~1) Straight deck or~~ Curved deck

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   - ~~Cables?~~
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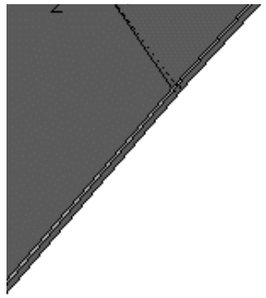
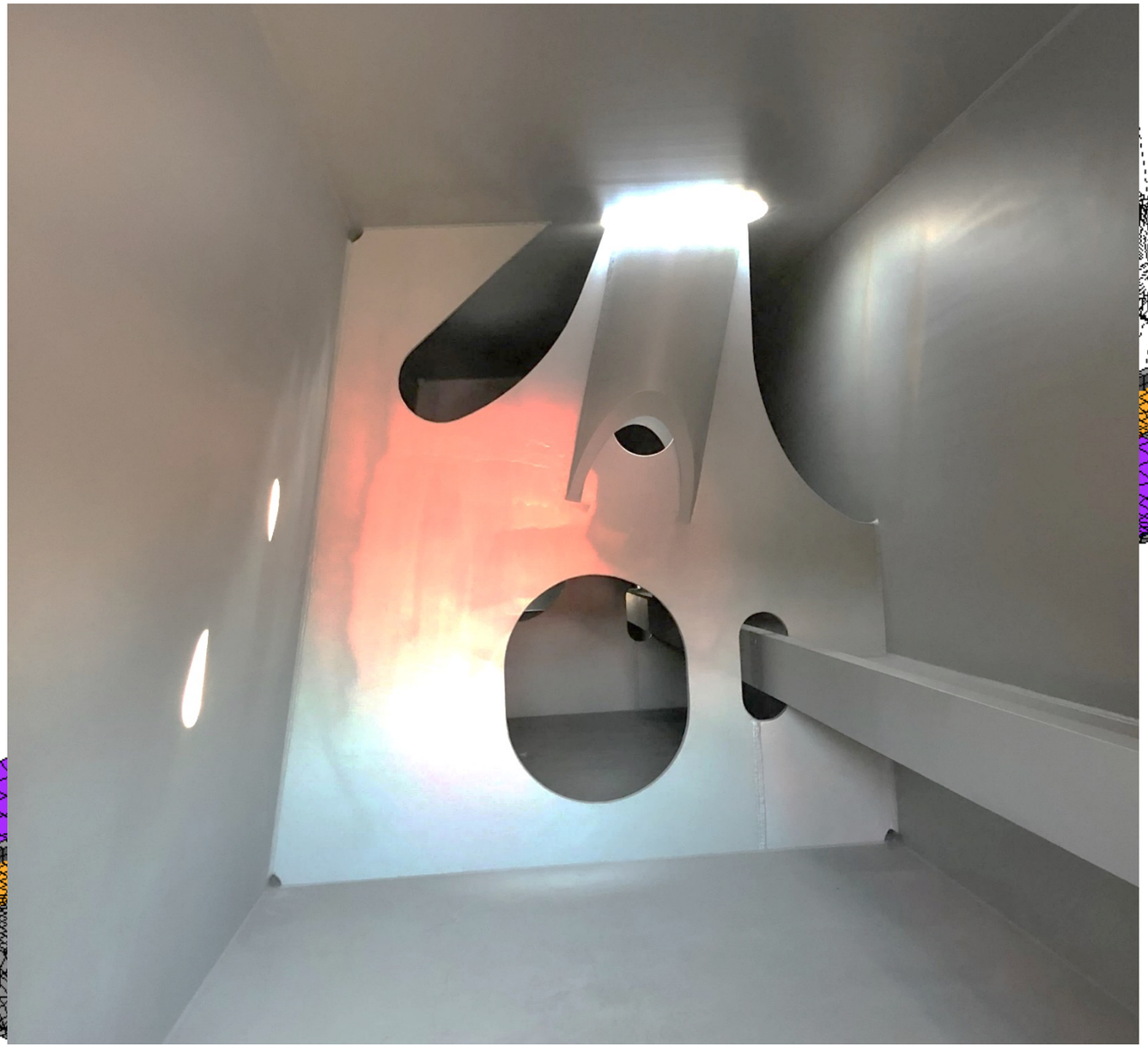
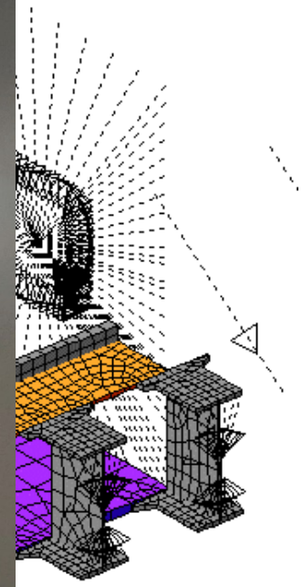
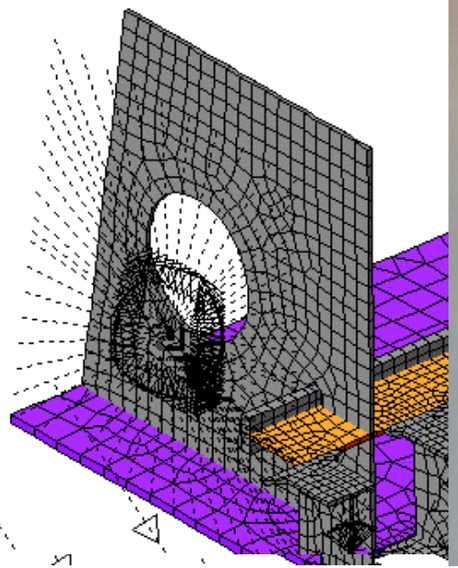
↳ Hanger – girder connection: design and fatigue study

Hangers: Fatigue Studies of type of joint









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Hanger – girder connection: design and fatigue study

Wind-induced vibrations

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Hangers: vibration with wind

OA14: DESIGN CHOICES AND CHALLENGES

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Hanger – girder connection: design and fatigue study

Wind-induced vibrations

3) Supports ?

3. Supports ?

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1990:2002/A1

December 2005

ICS 91.010.30

English Version

Eurocode - Basis of structural design

Eurocode - Bases de calcul des structures

Eurocode - Grundlagen der Tragwerksplanung

A2.4.4.2.4 Transverse deformation and vibration of the deck

(3) The first natural frequency of lateral vibration of a span should not be less than f_{h0}.

NOTE The value for f_{h0} may be defined in the National Annex. The recommended value is: f_{h0} = 1,2 Hz.

Eigenmode 2: Resonant frequency = 0,74 Hz, Eigenmode u [mm], Factor = 781,8
Value range (overall system, min/max): 0,00/26,32 [mm]

Model lateral bending frequency: 0.74Hz!

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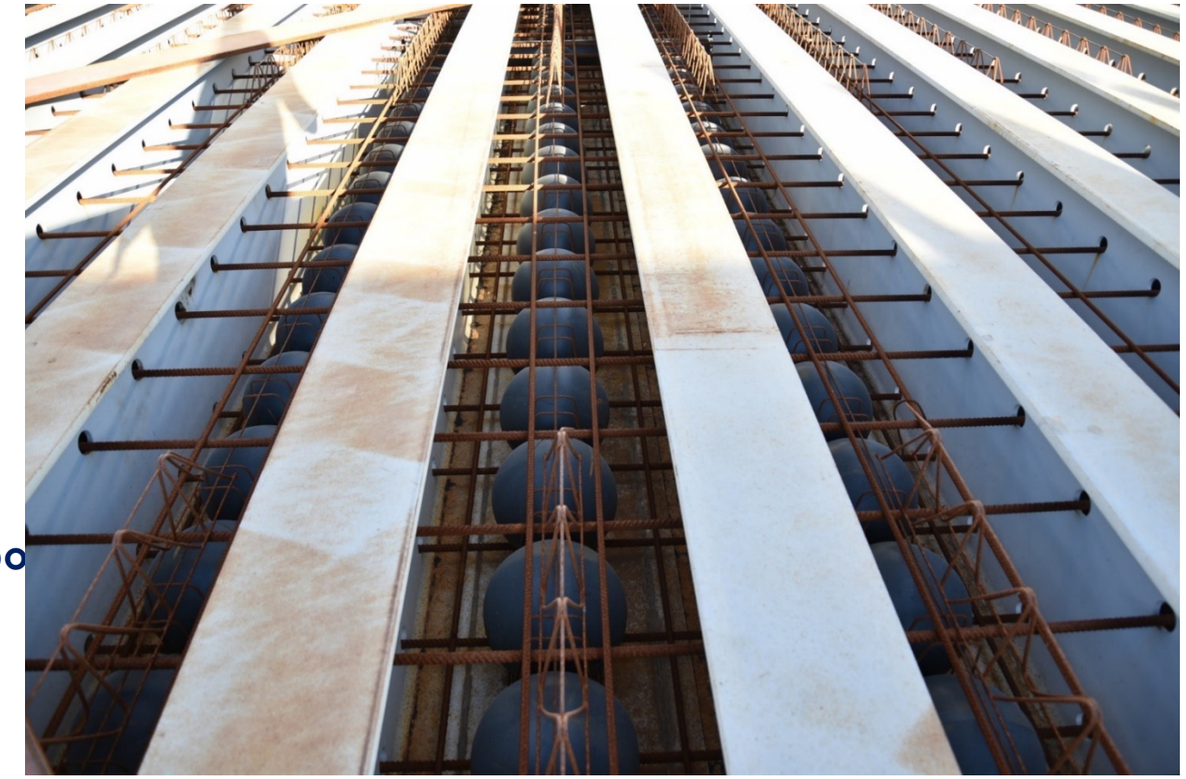
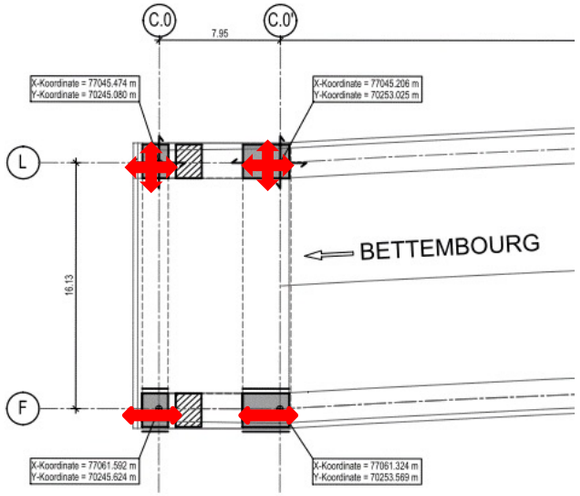
3. Supports ?

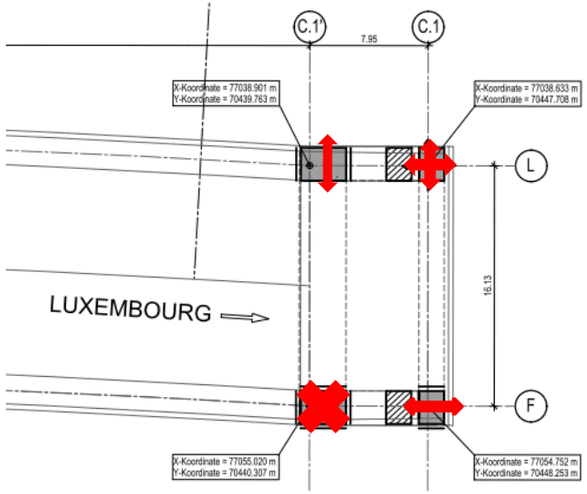
(5) The fundamental vertical bending frequency $n_{1,B}$ of a plate or box girder bridge may be approximately derived from Expression (F.6).

$$n_{1,B} = \frac{K^2}{2 \cdot \pi \cdot L^2} \cdot \sqrt{\frac{EI_b}{m}} \qquad \text{(F.6)}$$

- Increase stiffness -> Reinforce tie rods? Not sufficient
- Reduce mass -> - Steel deck? Problems with acceleration when trains crossing
  - Lightweight concrete + Cobiax®
- Reduce span -> Embedded abutments -> duplicate suppo







- Enormous clamping forces
- Problem of uplifting of external supports

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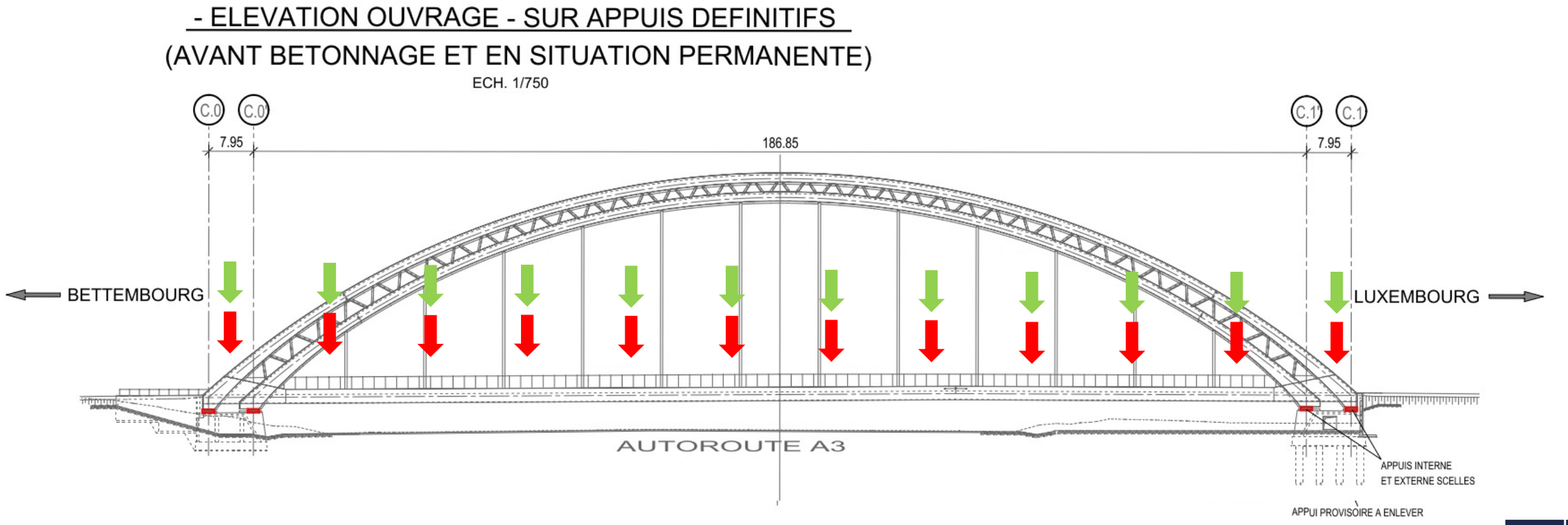
Sequencing of installation

- Steel frame weight: 5600 ton → On external supports
- Concrete weight: 4450 ton
- Weight of the railway structure: 2950 ton

} Largely on internal supports



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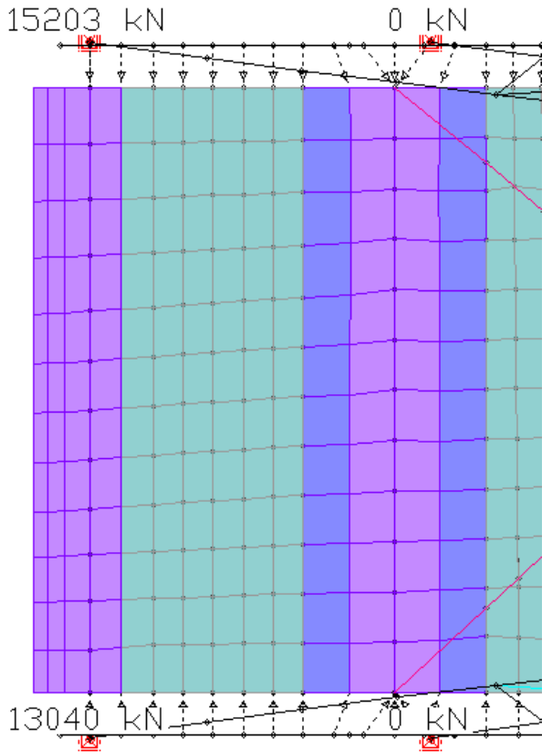
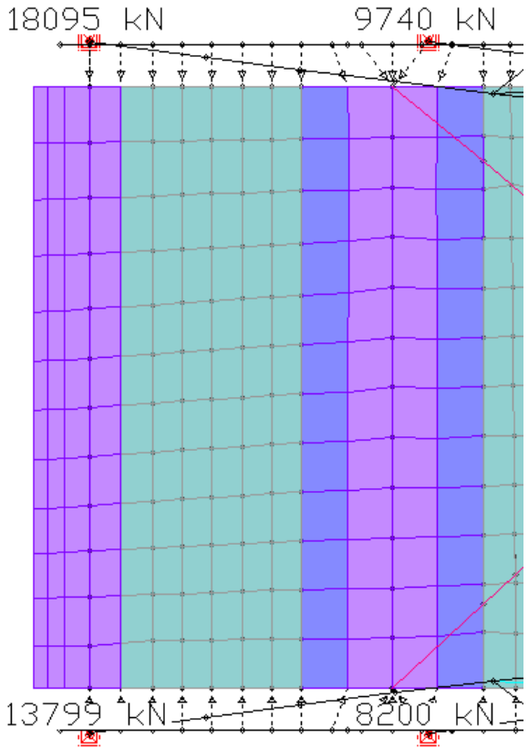
Sequencing of installation

After installation of the framework



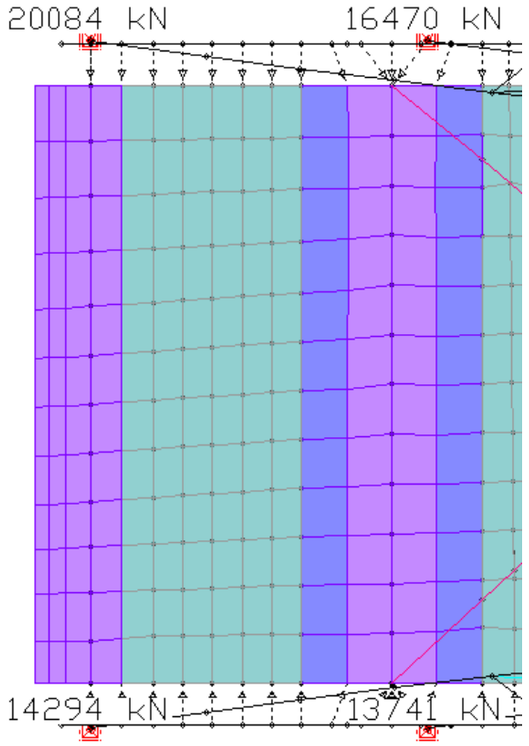
LC 4: redistribution acier + équipements
Support reactions in the system of the support lines Rz(l). 0,06 [kN/m] =
Sum in the global system Rz(g) = 56486,72 [kN]

After concreting



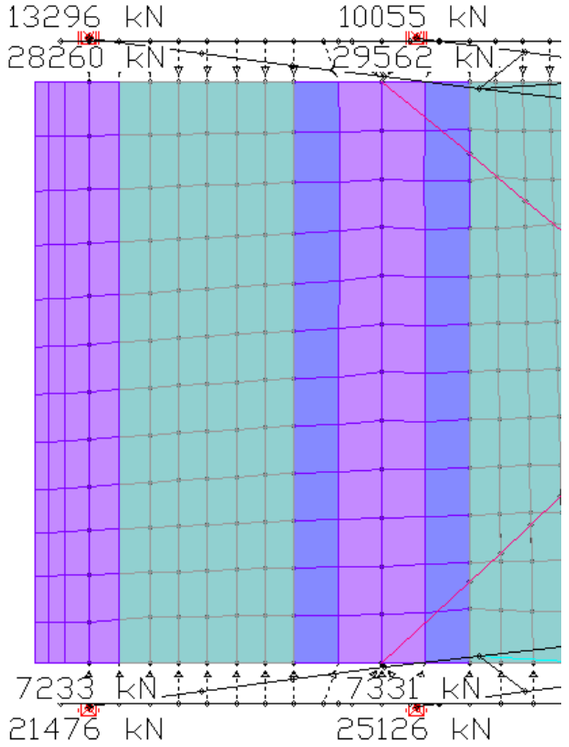
LC 2000: STRUCTURE
Support reactions in the system of the support lines Rz(l). 0,06 [kN/m] =
Sum in the global system Rz(g) = 99667,73 [kN]

Permanent



LC 17: PERM
Support reactions in the system of the support lines Rz(l). 0,06 [kN/m] =
Sum in the global system Rz(g) = 129180,16 [kN]

SLS Fréquent



LCC 230: ELSf
Support reactions in the system of the support lines min,max Rz(l). 0,06 [kN/m] =

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Juin 2021 – Juillet 2022: ON-SITE ASSEMBLY

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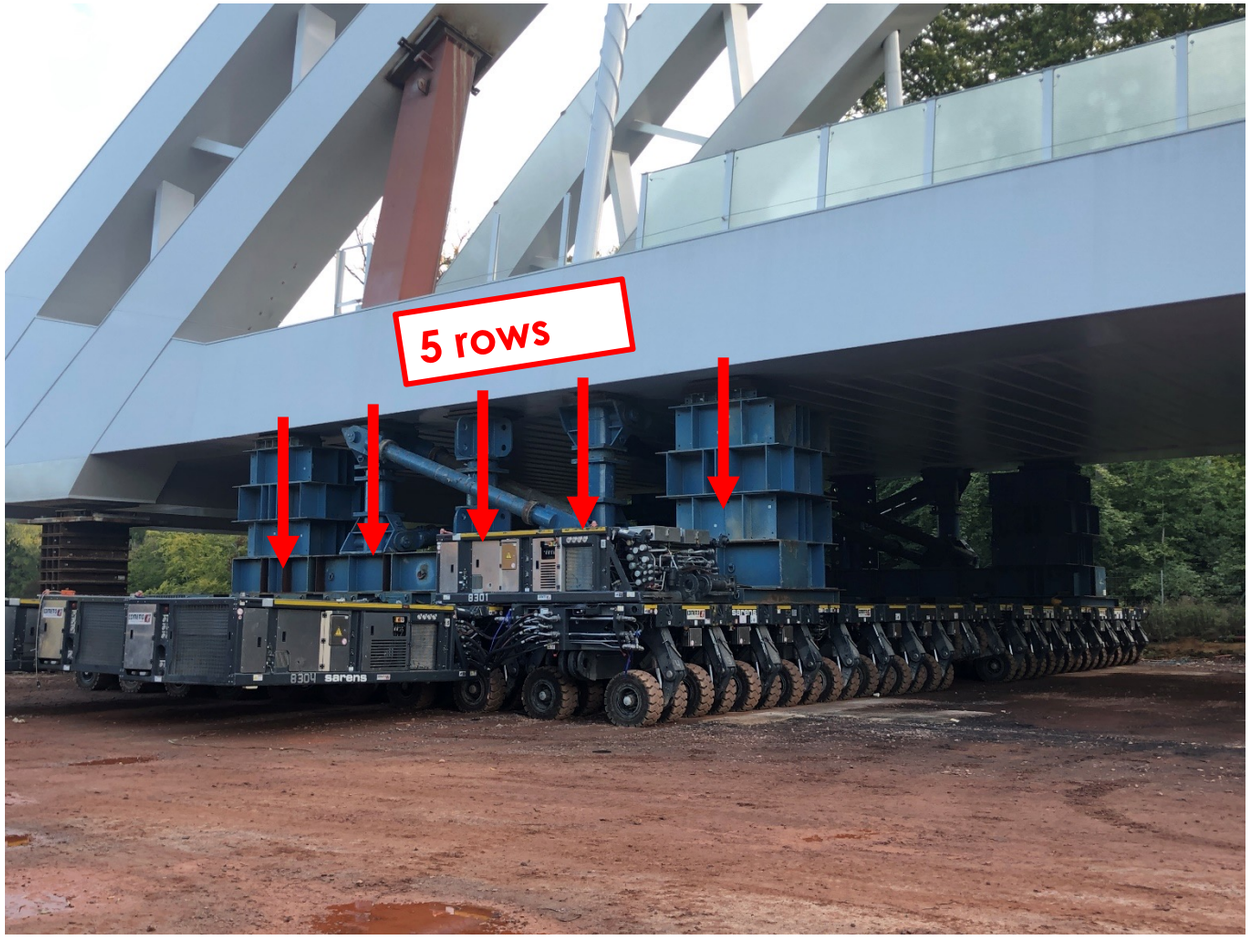
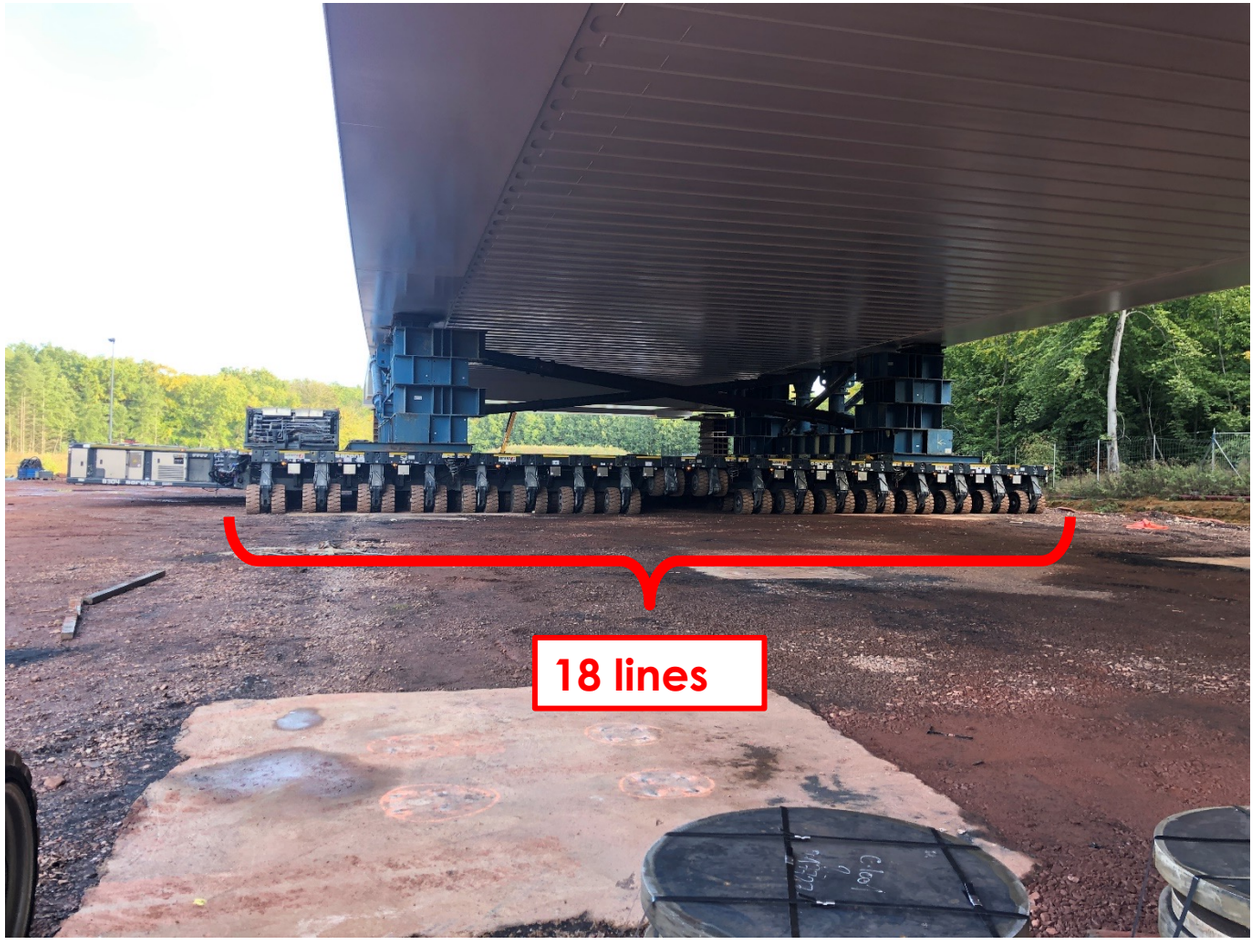
Lifting with SPMT





Total of 180 axle's lines

07-08 October 2022: INSTALLATION OF THE STRUCTURE

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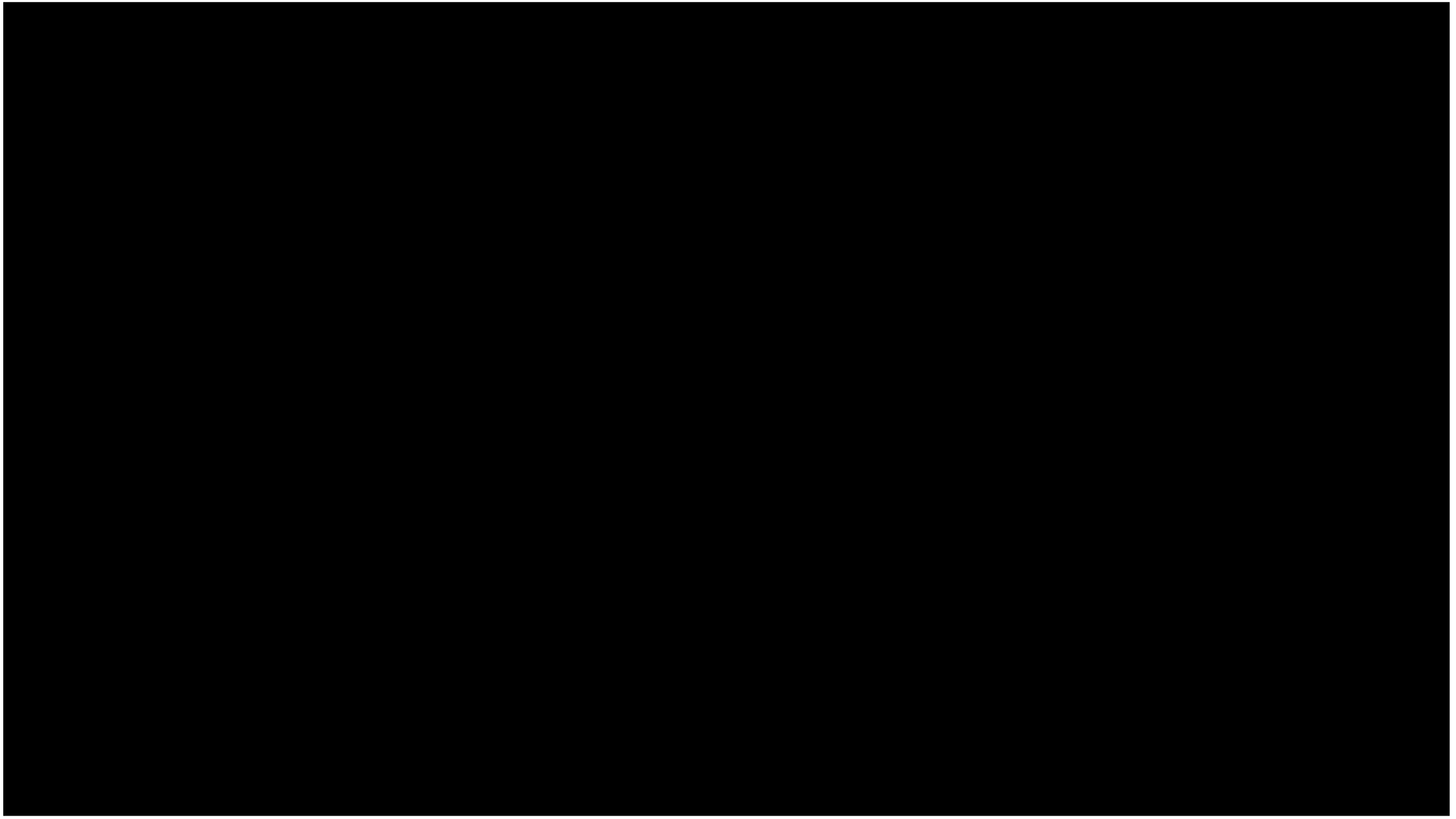
24 August 2023: STATIC LOAD TEST



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THANK YOU FOR YOUR ATTENTION

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