

Third Bosphorus Bridge



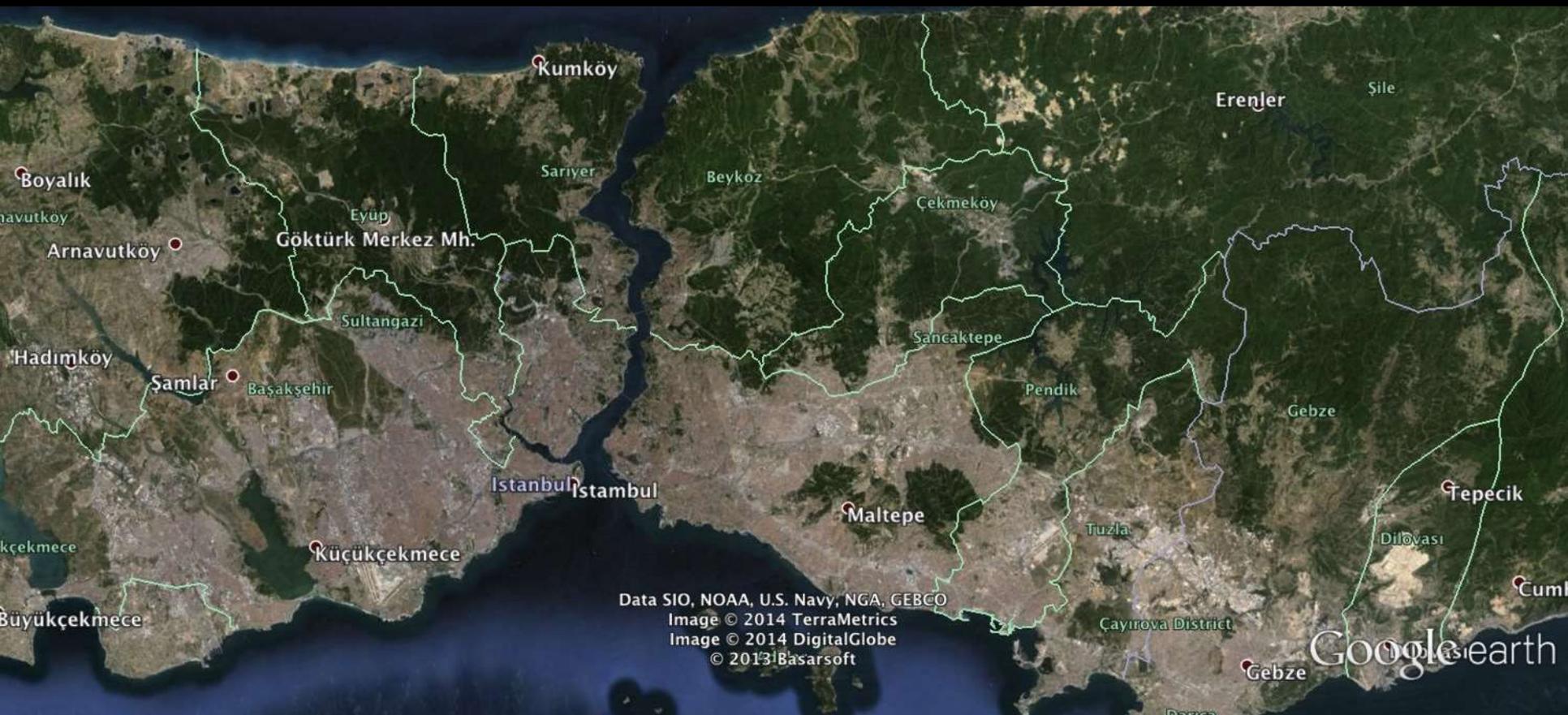
Jean-Yves Del Forno

greisch

3rd Bosphorus Bridge



3rd Bosphorus Bridge



Istanbul

NORTHERN MARMARA MOTORWAY PROJECT (INCLUDING 3rd BOSPHORUS BRIDGE)



Istanbul

Conceptual design

The requirements insisted on the architectural quality of the design to be developed, underlying a familiarity with the lines and shapes of the two previous suspension bridges across the strait.



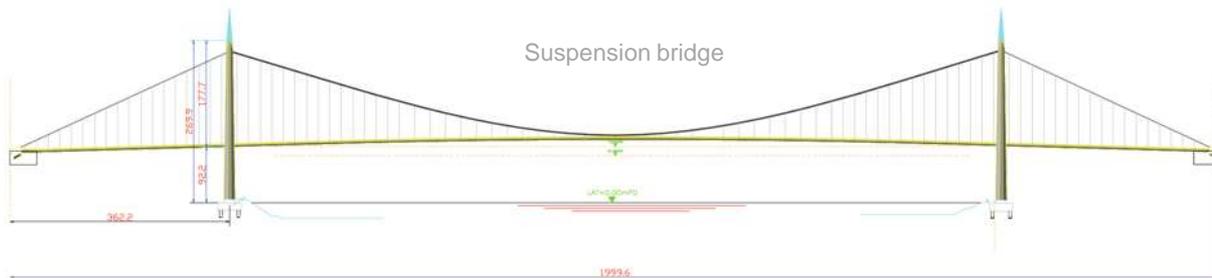
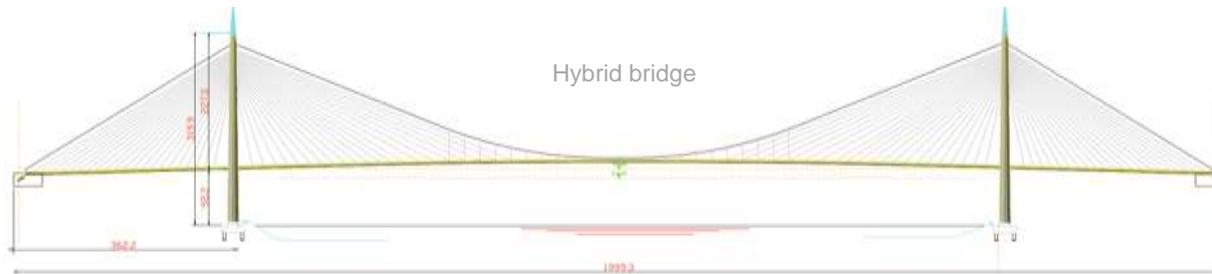
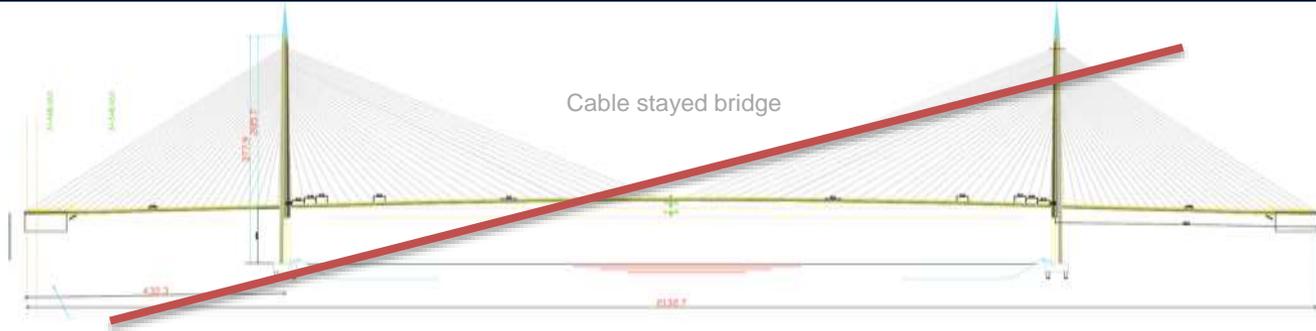
1. The bridge must be a suspension bridge
2. It must be in line with the architecture of the two existing bridges
3. The new suspension bridge should carry:
 - a roadway with four lanes in each direction
 - **two railways tracks.**
4. **The bridge must be completed in 36 months !**





Conceptual design

The minimal span was 1275 m



Stays: 15'900 to.
Main cable: 0 to.
Hangers: 0 to.
Total HP steel: 15'900 to.
Concrete pylon: 30'400 m³
Total length: 2145 m

Stays: 7'600 to.
Main cable: 14'600 to.
Hangers: 100 to.
Total HP steel: 22'300 to.
Concrete pylon: 23'700 m³
Tptal length: 2'000 m

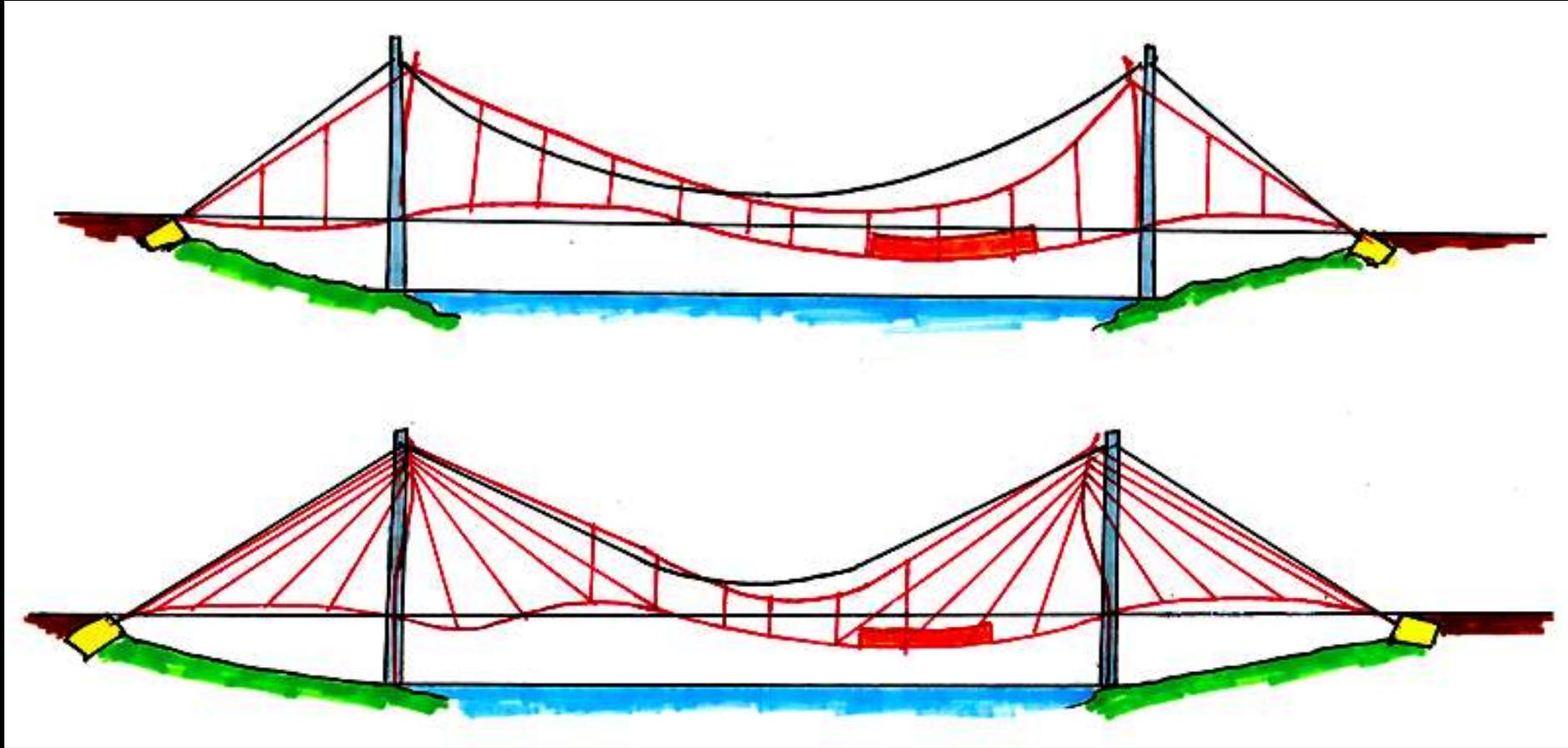
Stays: 0 to.
Main cable: 27'400 to.
Hangers: 1'300 to.
Total HP steel: 28'700 to.
Concrete pylon: 20'600 m³
Tptal length: 2'000 m

* Values with DW of 600 kN/m !

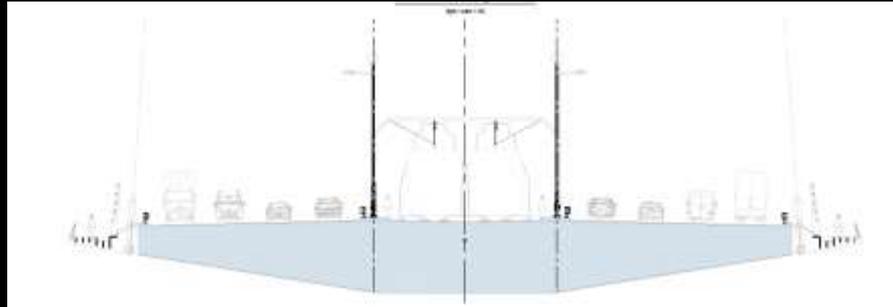
Conceptual design



Conceptual design



Conceptual design

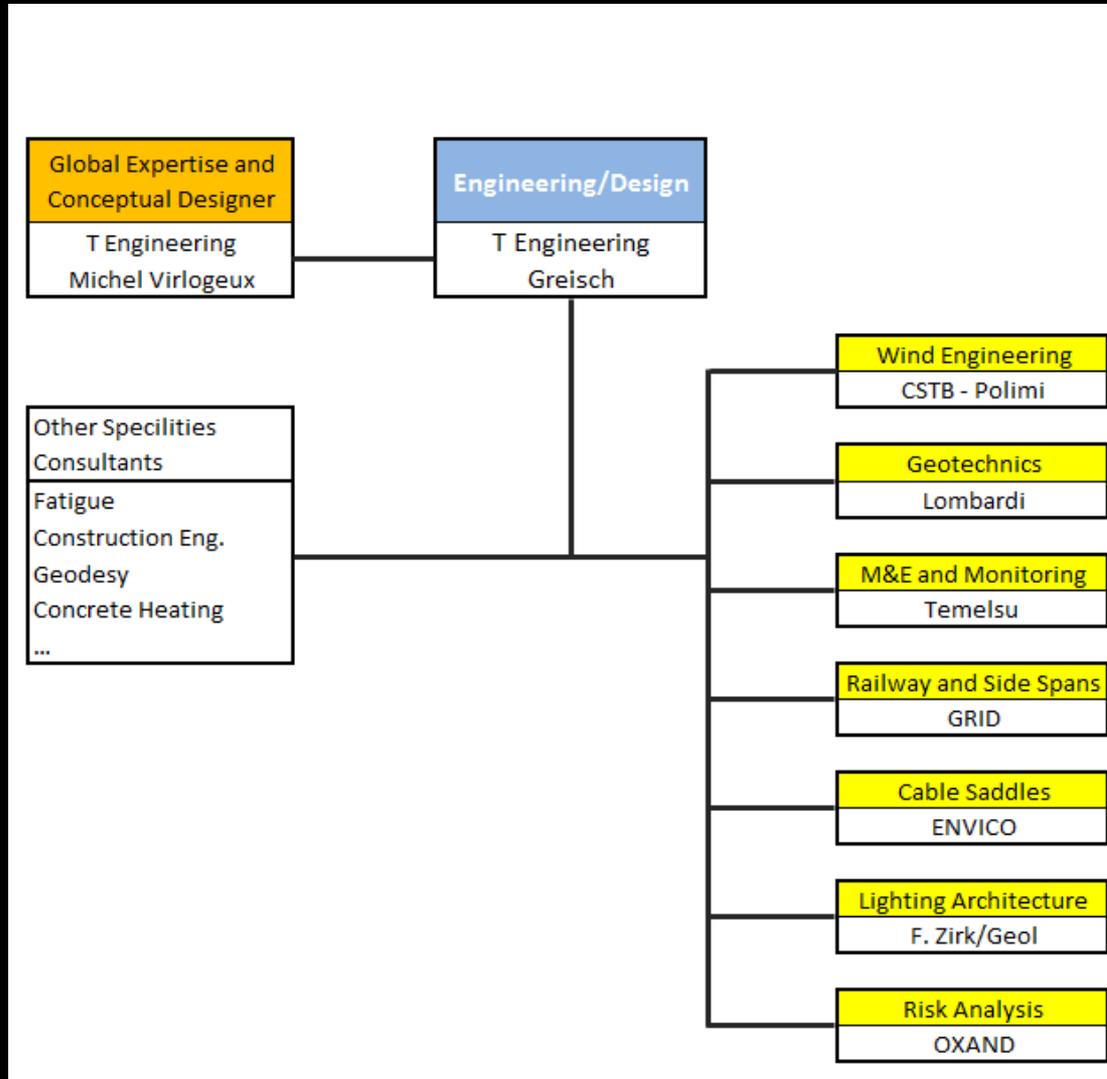




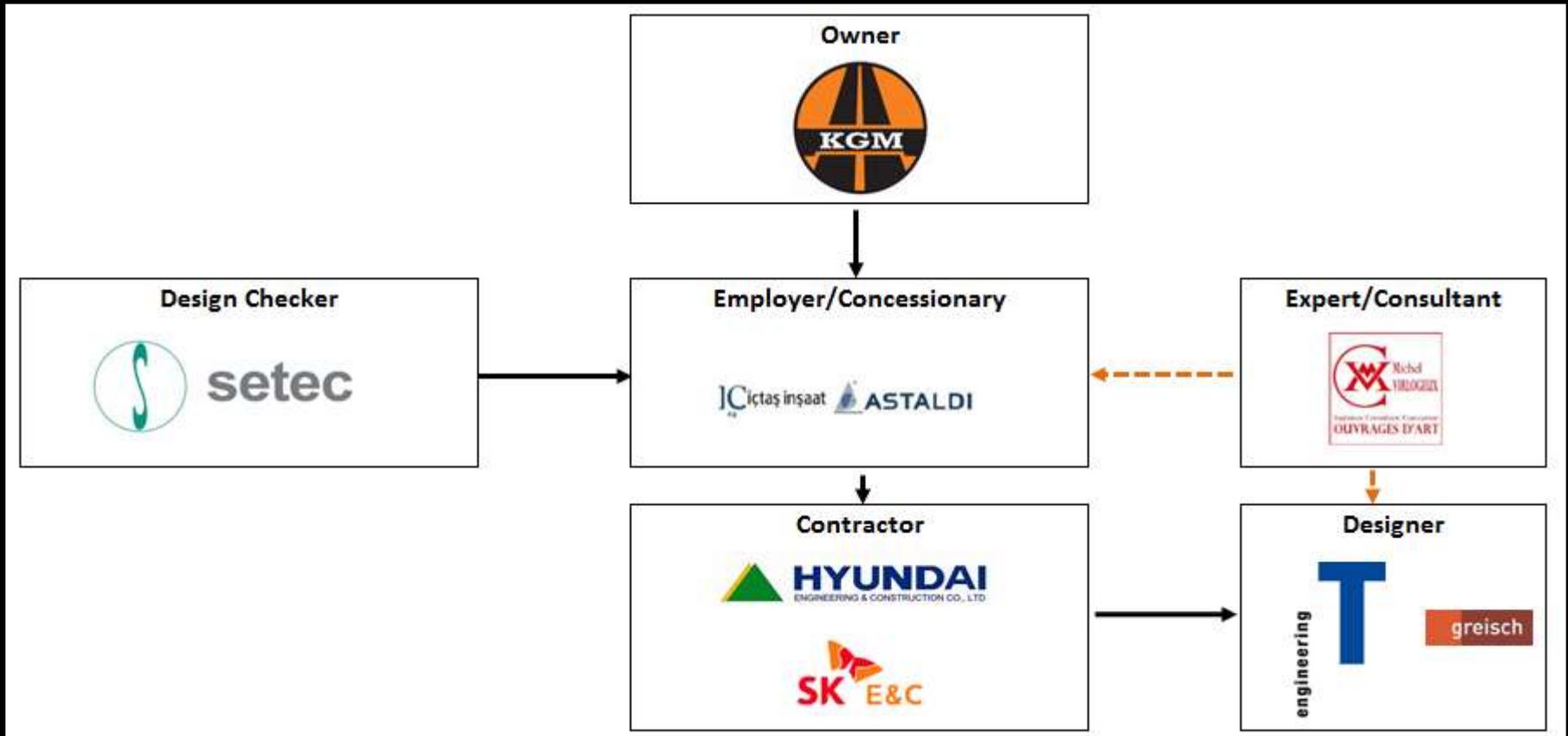
It is a BOT type contract, awarded to “ICA”, that includes:

- Odayeri – Paşaköy 60 km (Motorway + BB3)
- İstoç – Odayeri 22 km (Connection road)
- Reşadiye – Çamlık 13 km (Connection road)

Design Team



BB3 Overall Organization



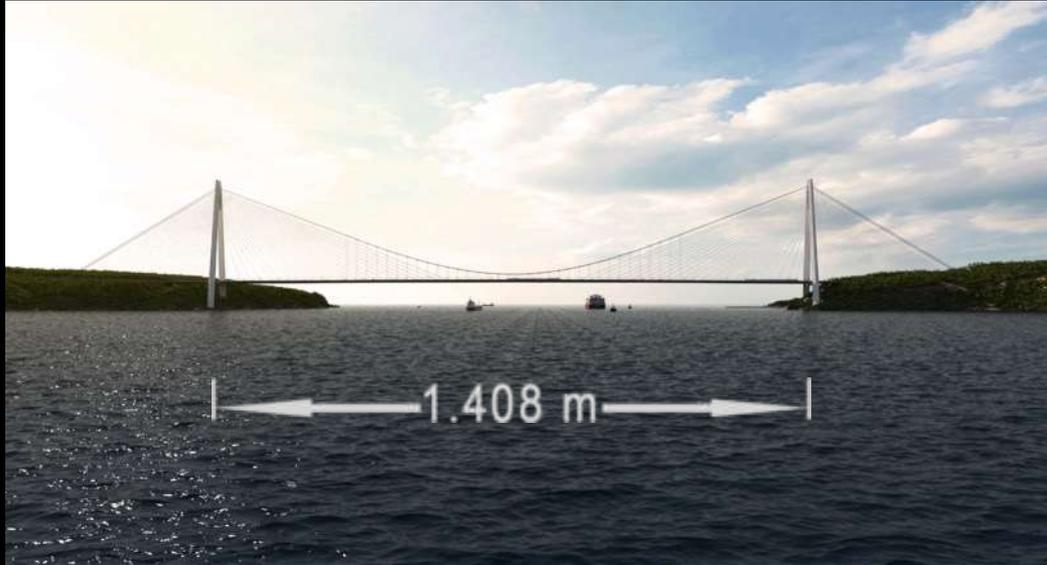
Conceptual design



Geometry

Third Bosphorus Bridge

A High Rigidity Suspension Bridge concept



The main span has been extended to avoid towers in water

No water pollution

No interaction with navigation channel

No interaction with fishing zones

Secure the foundation concept and timeframe

A shape towers

Height of tower from ground level

EUROPE 321,90 m

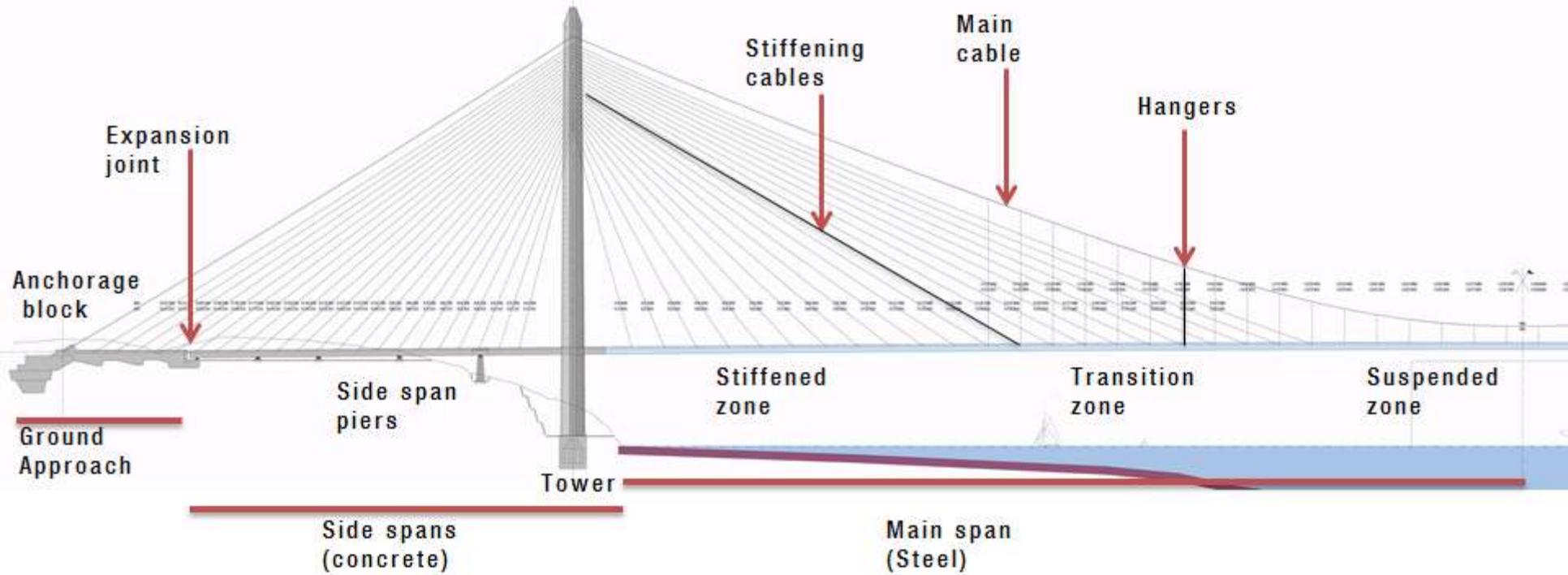
ASIA 317,90 m



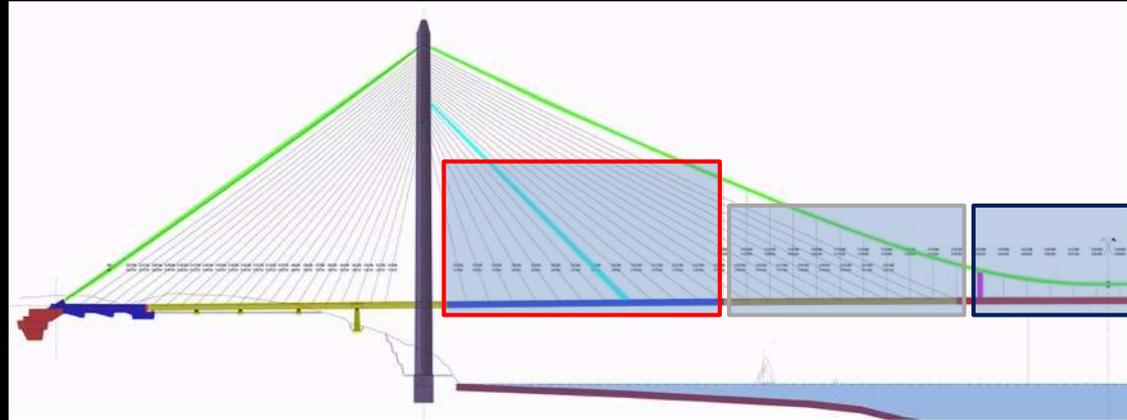
Functional Cross Section



Terminology and Geometry



Main Span



Stiffening zone

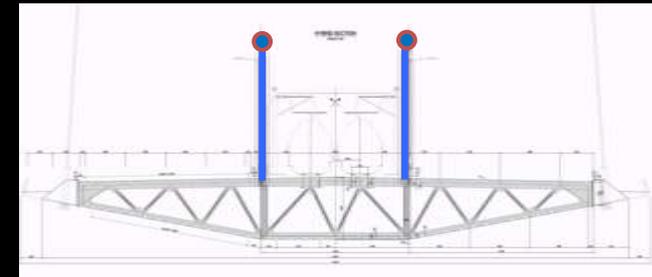
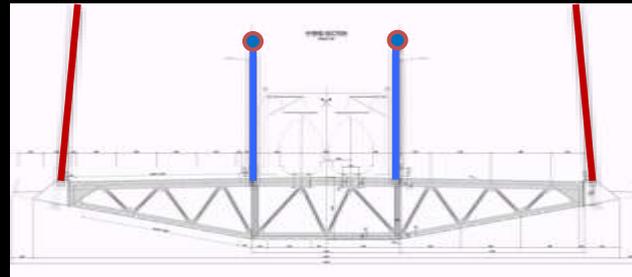
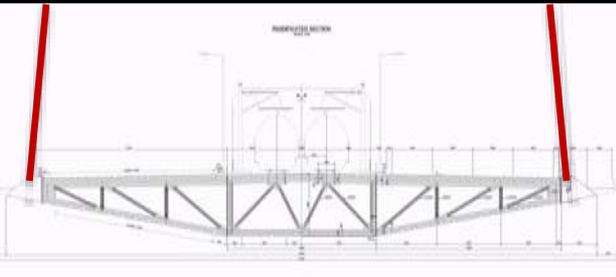
Stiffening cables in extreme sides

Transition zone

Stiffening cables in extreme sides
Hangers in the middle

Suspended zone

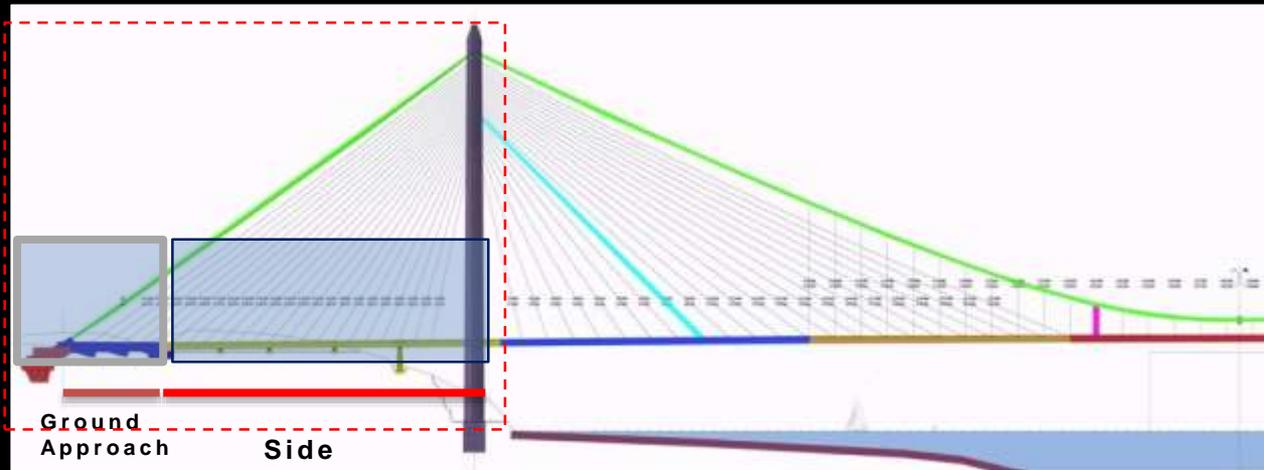
Main cables hangers in central zone
near railway



Main Span



Side Spans and ground approach

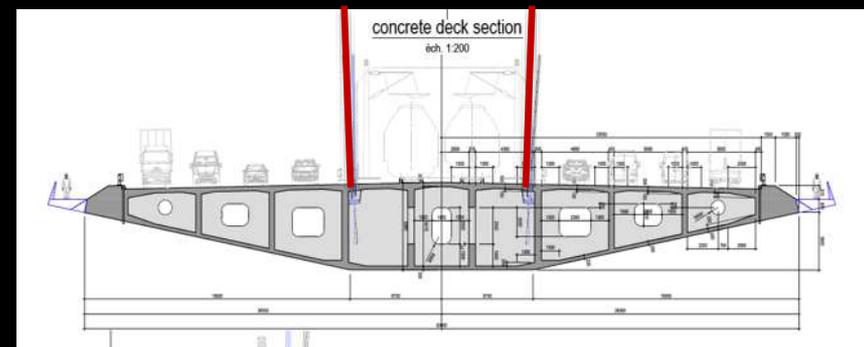
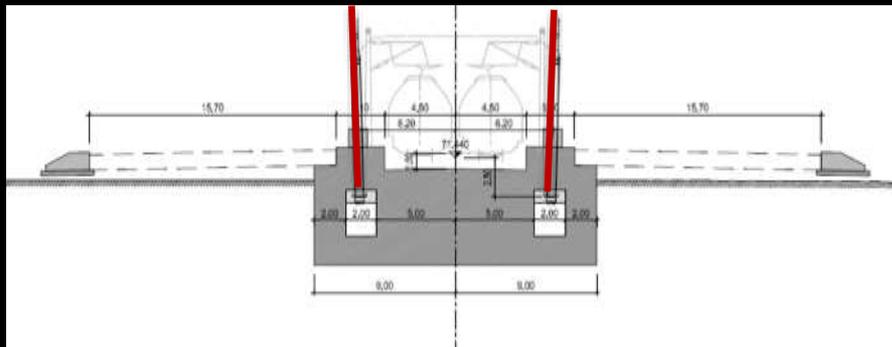


Ground approach zone

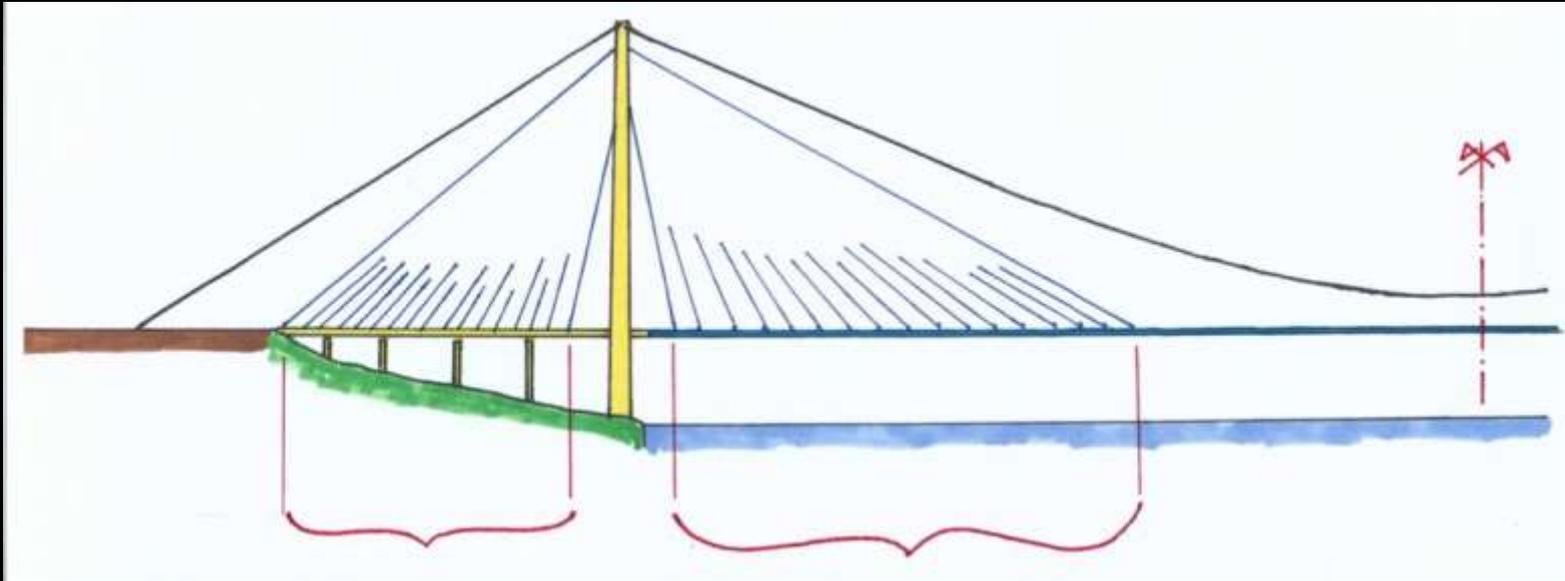
Stiffening cable in the internal zone, near the railway

Side span zone

Stiffening cable in the internal zone, near the railway

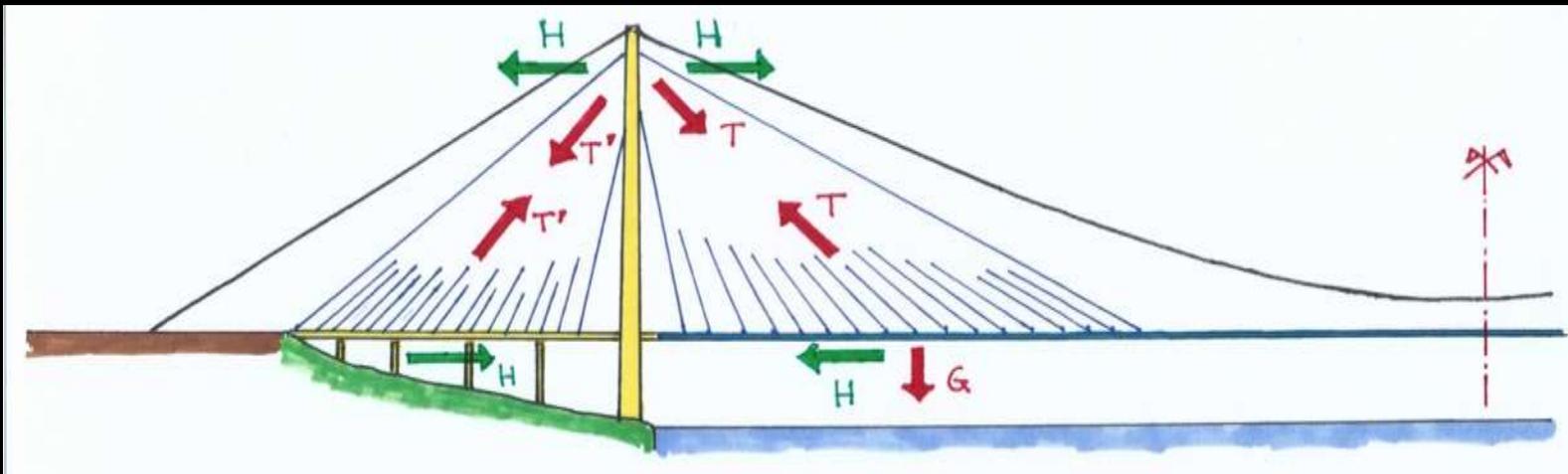


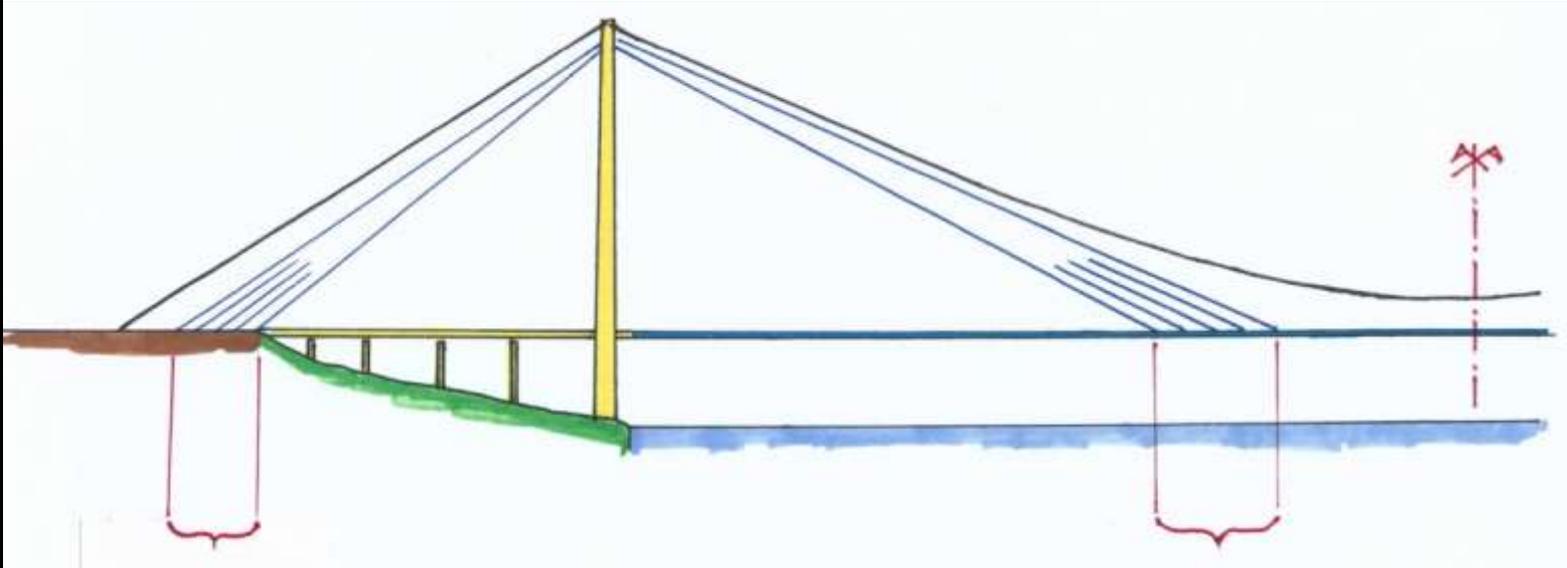
Balance of longitudinal forces



17 stiffening cables

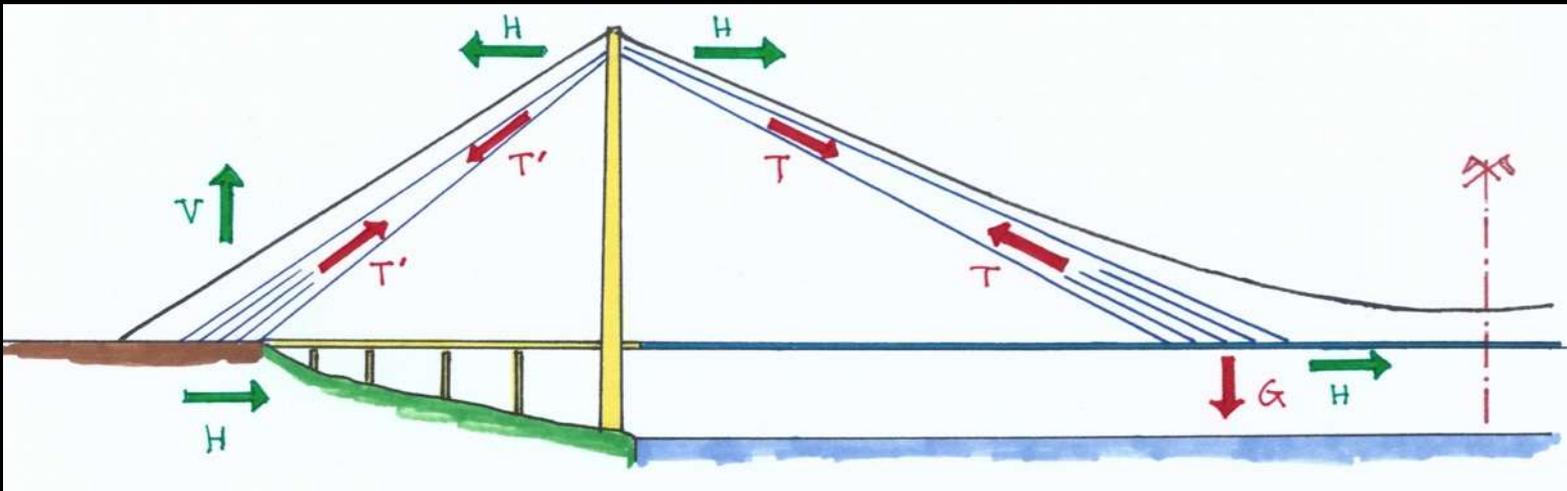
17 stiffening cables

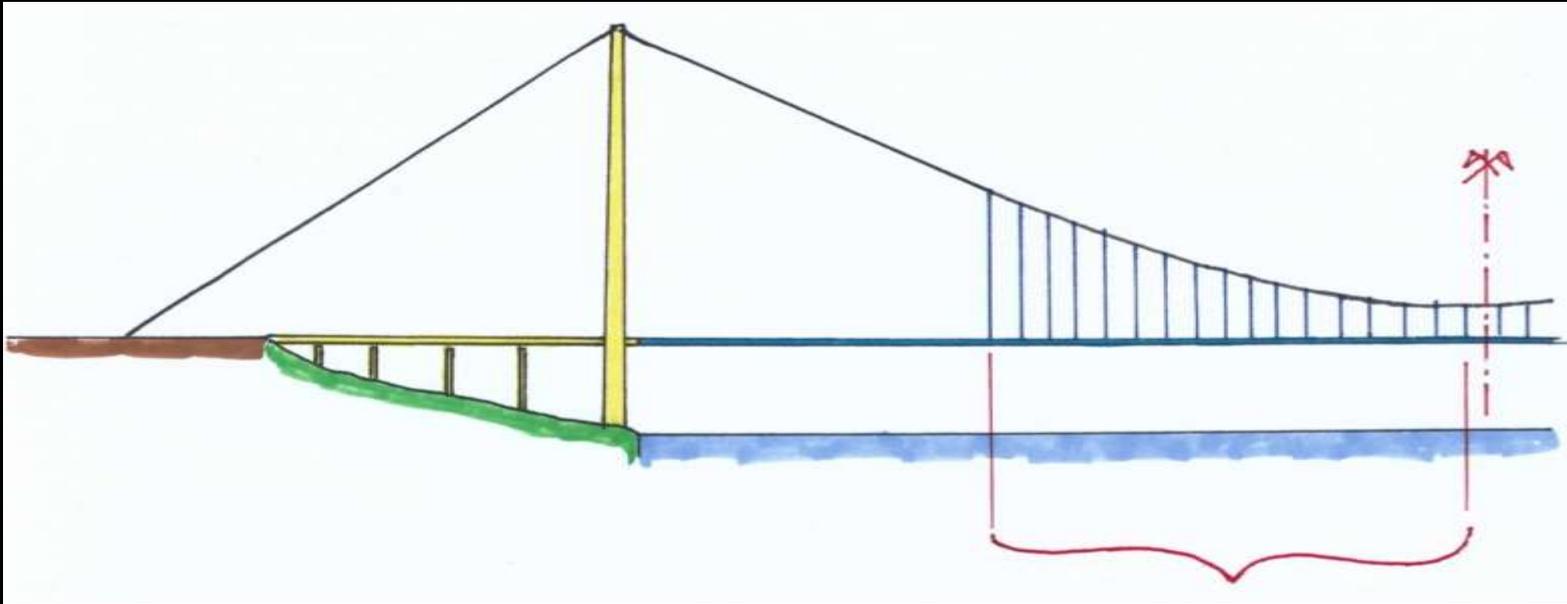




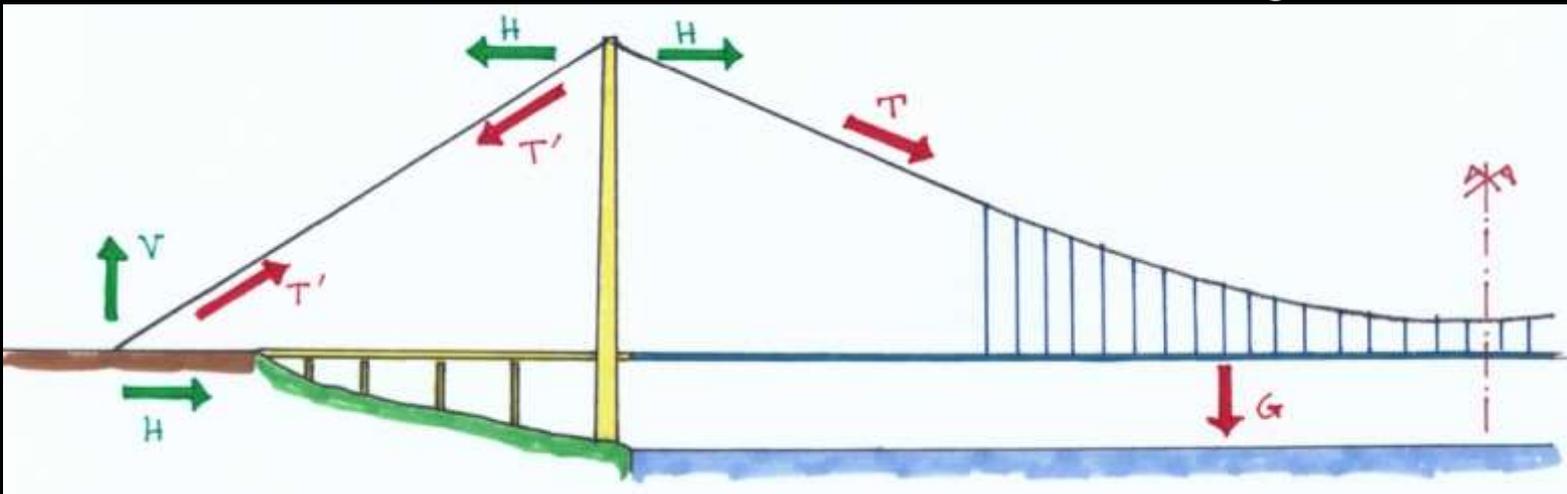
5 stiffening cables

5 stiffening cables

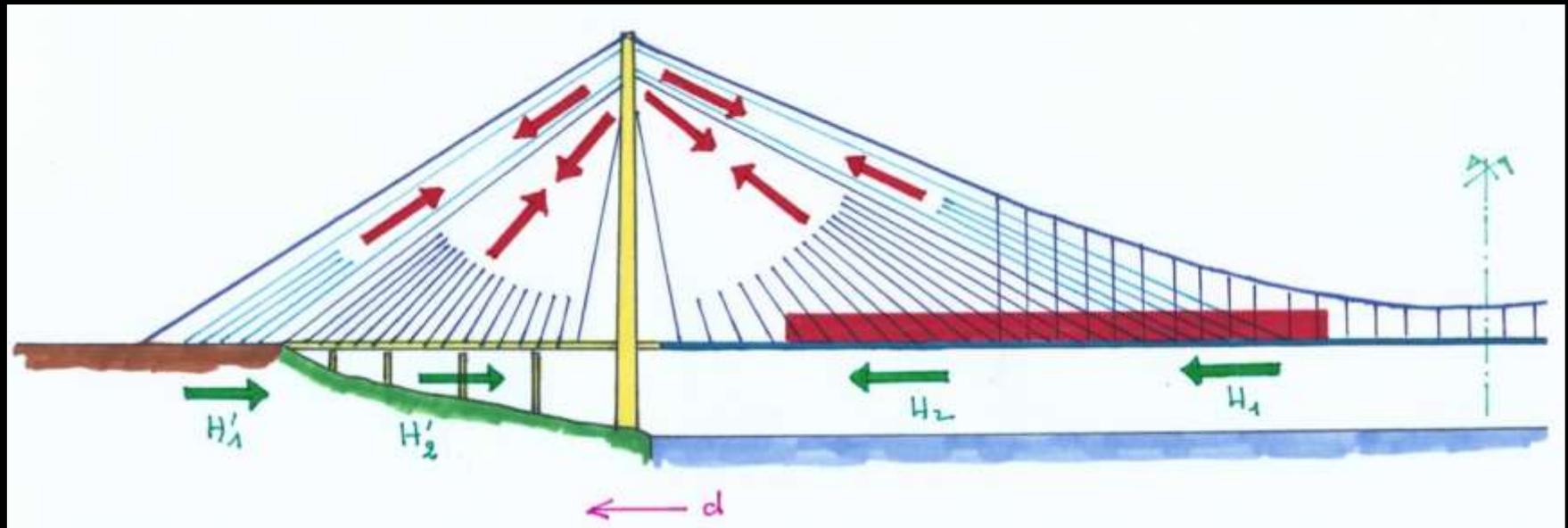
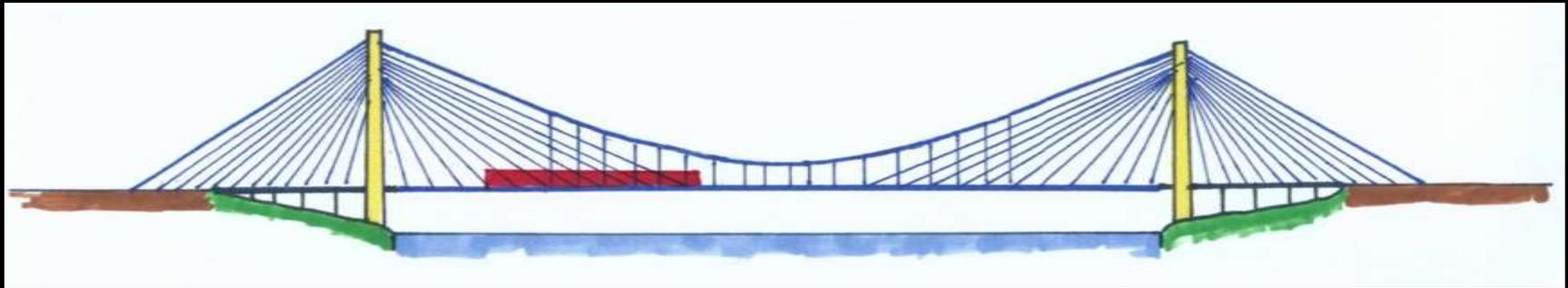




17 hangers

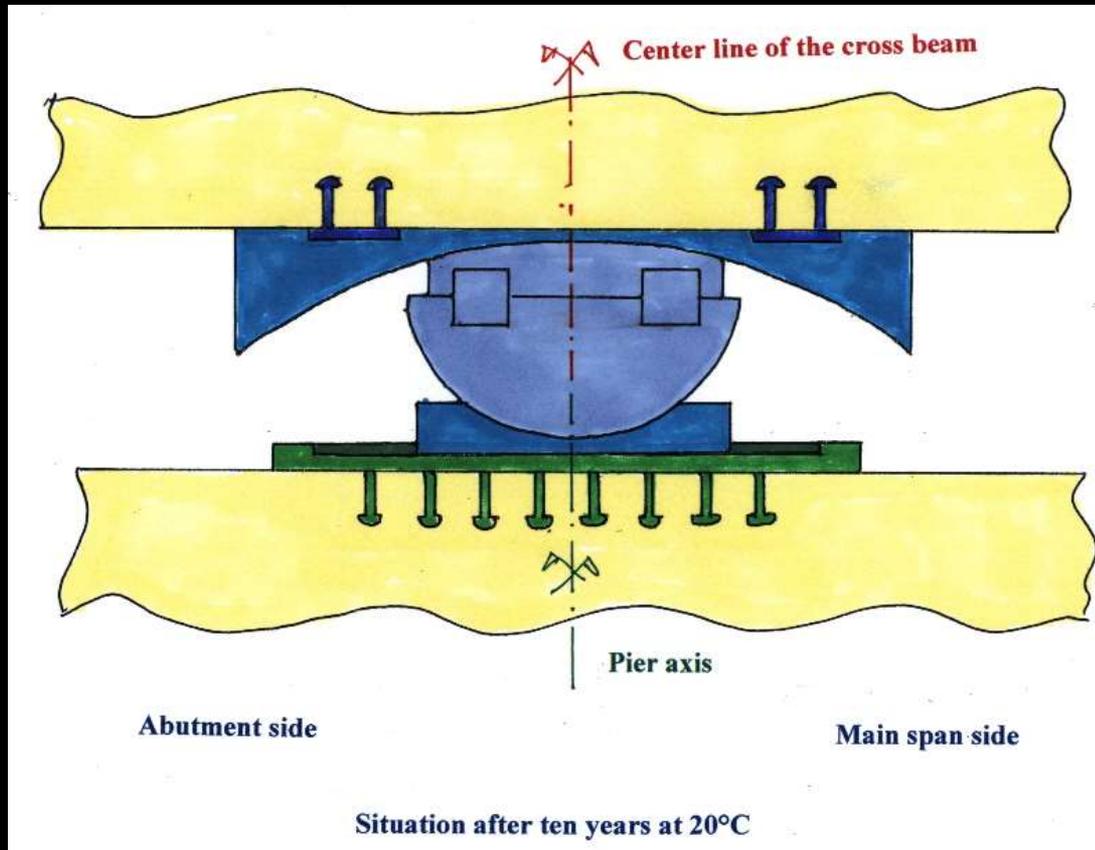


Effects of unsymmetrical train loads



Longitudinal displacement

Pendular bearings

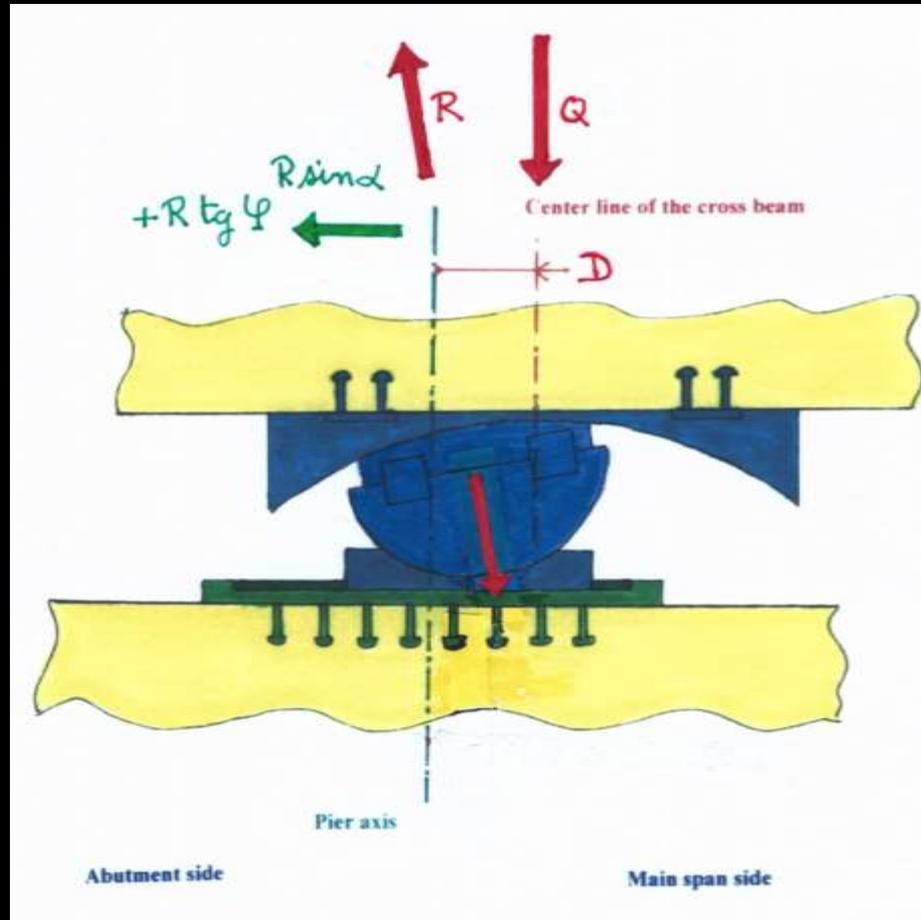


Pendular bearings have been chosen in order to control longitudinal displacements and seismic behaviour.

The design of the vertical radius optimised the following 4 effects:

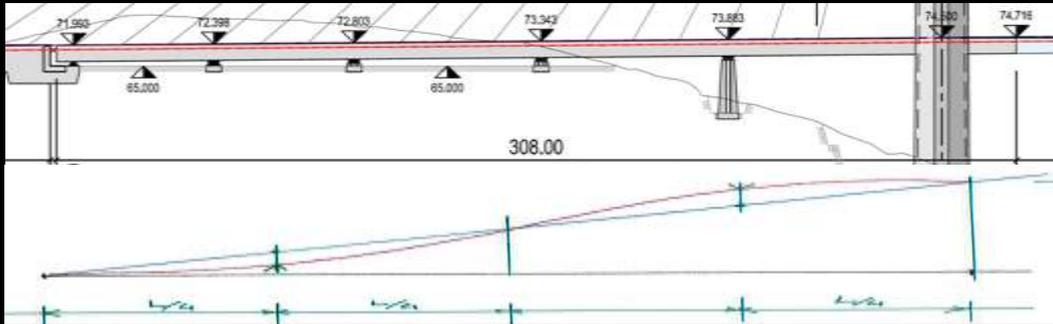
- Temperature effects
- Train stopping on the bridge
- Dynamic train
- Earthquake

Pendular bearings



Concrete deck side spans

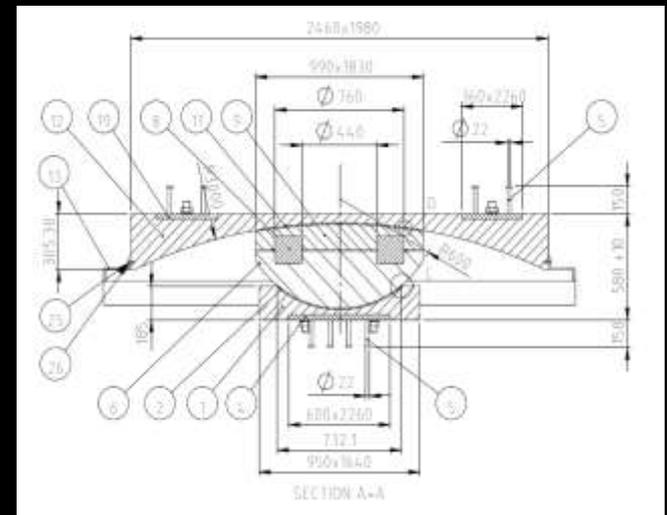
Pendular bearings



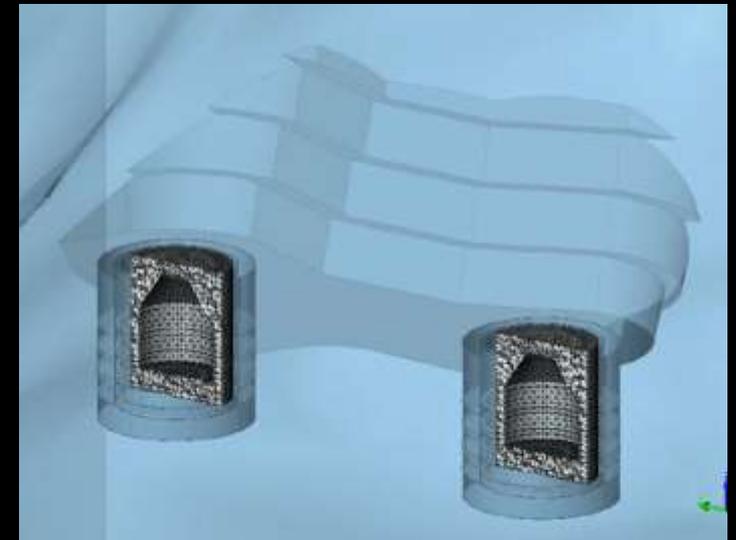
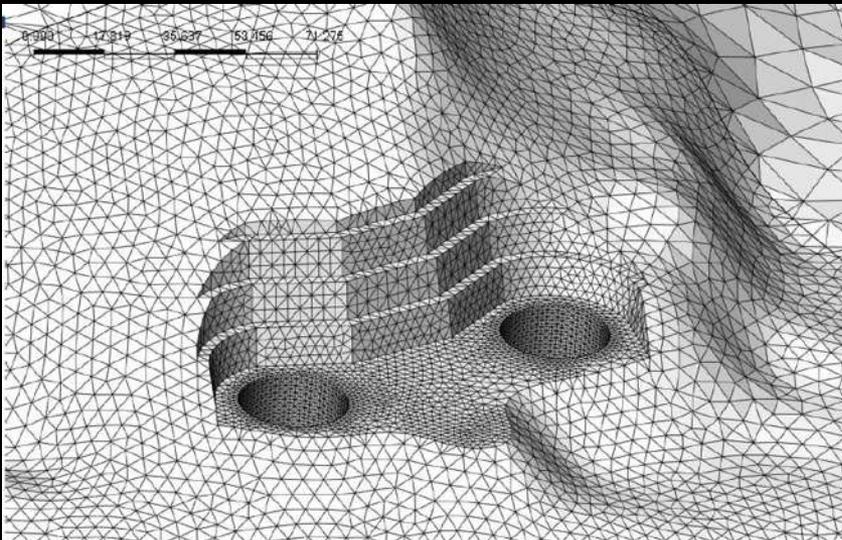
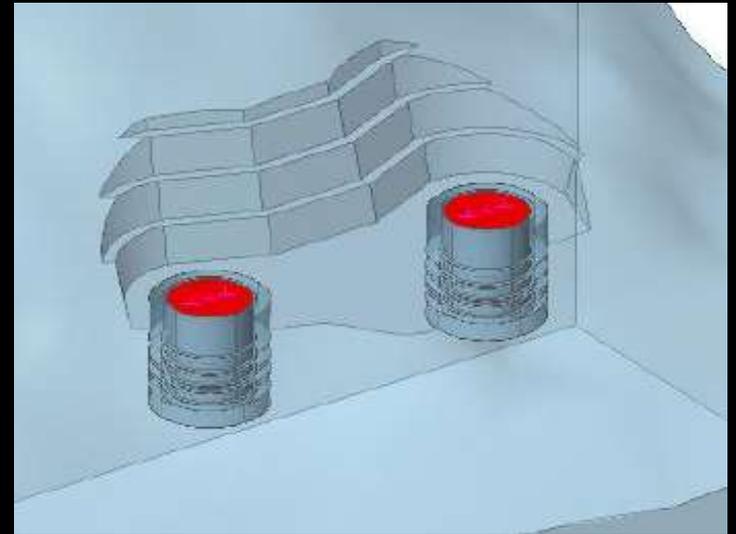
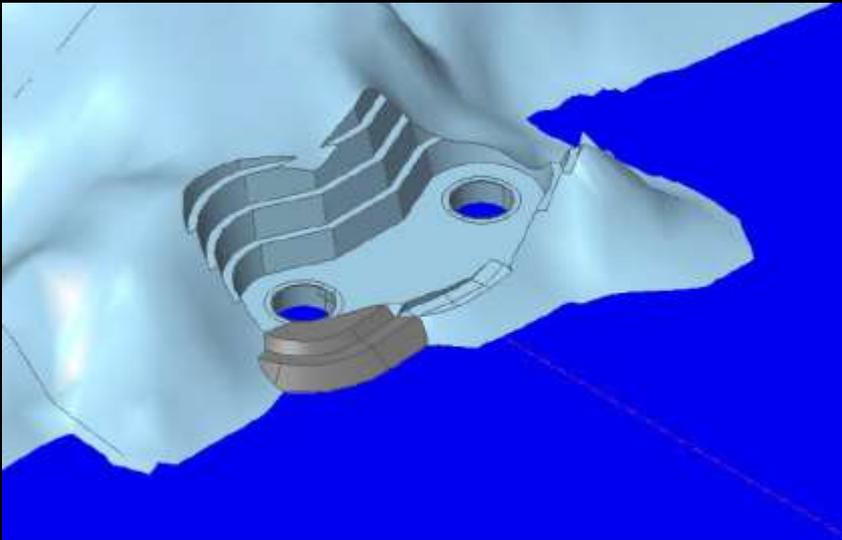
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The design of the vertical radius optimised the following 4 effects:

- Temperature effects
- Train stopping on the bridge
- Dynamic train
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Geotechnical analyses – tower shaft

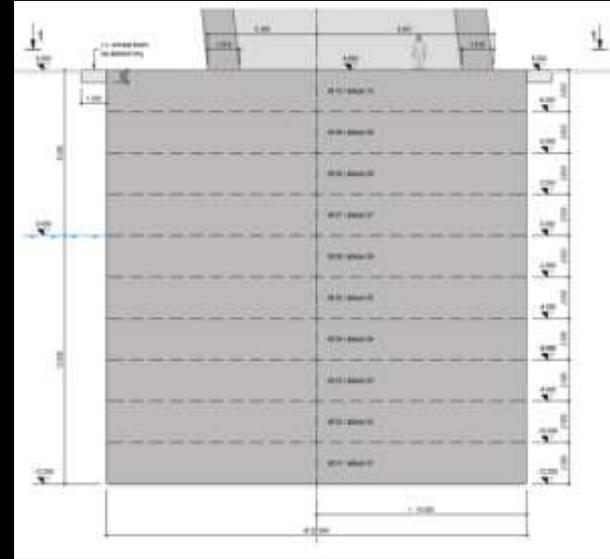




Tower Shafts – Diameter 20 m / depth 20 m

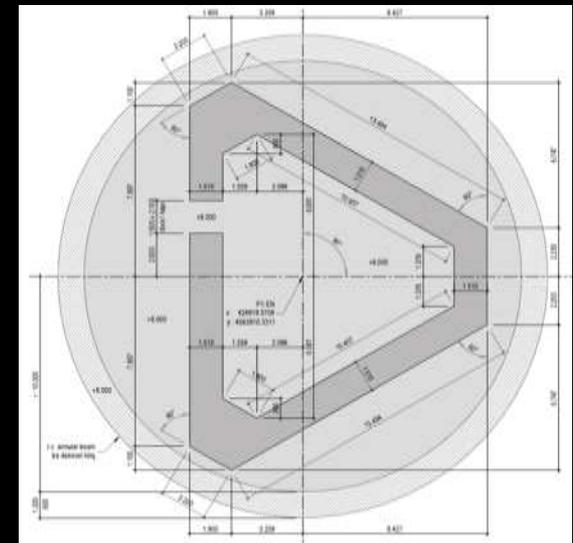


Europe North – Phase 8

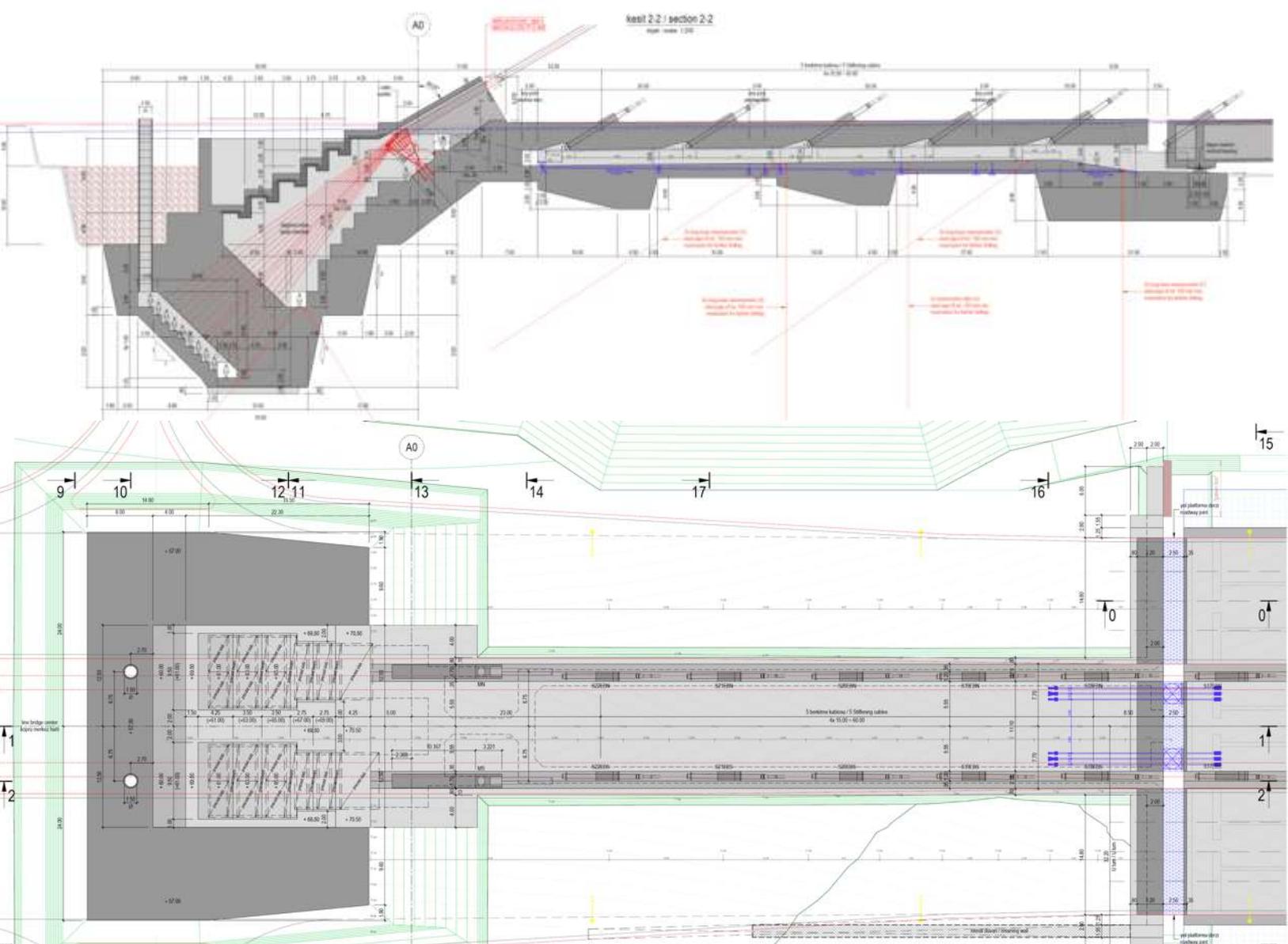
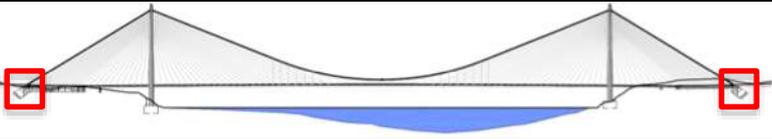


Europe South – Phase 5

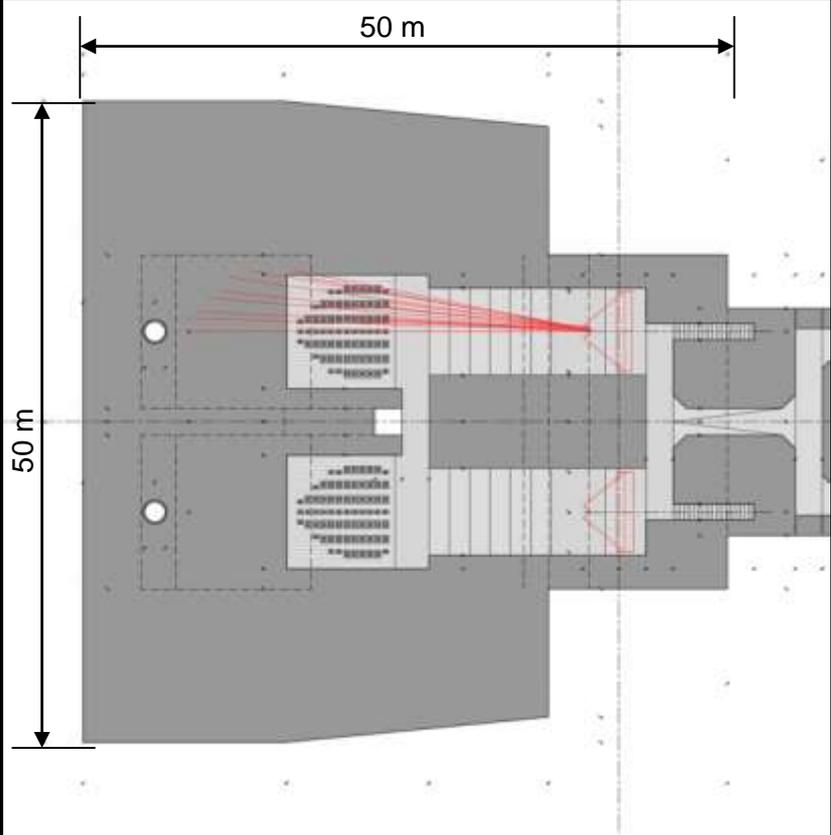
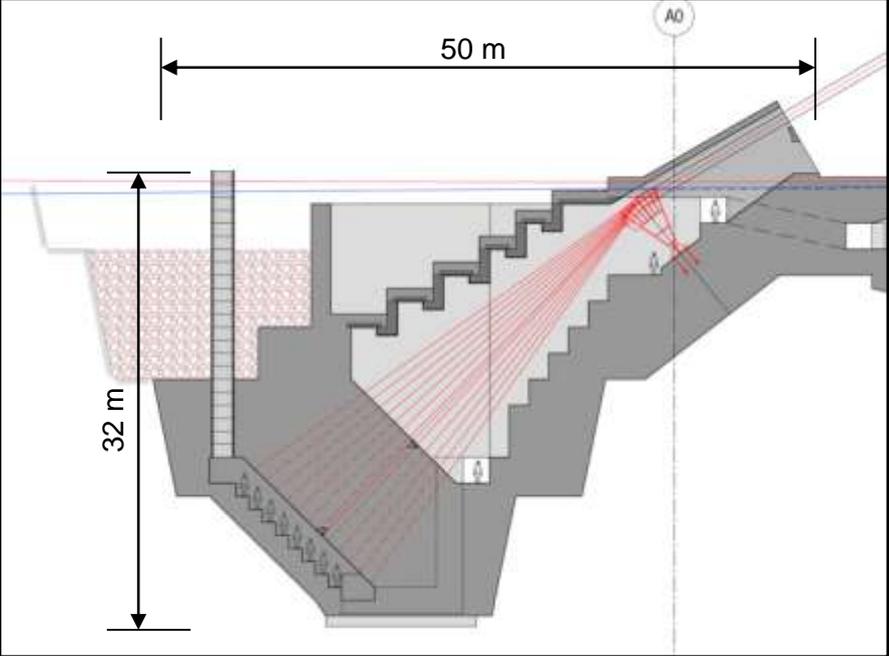
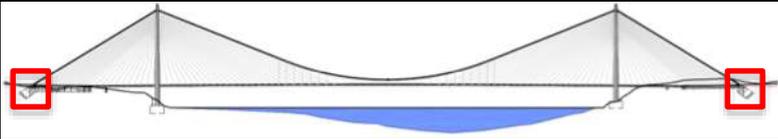
Designed by the tower free standing situation and by minimal reinforcement against shrinkage thermal effects during construction



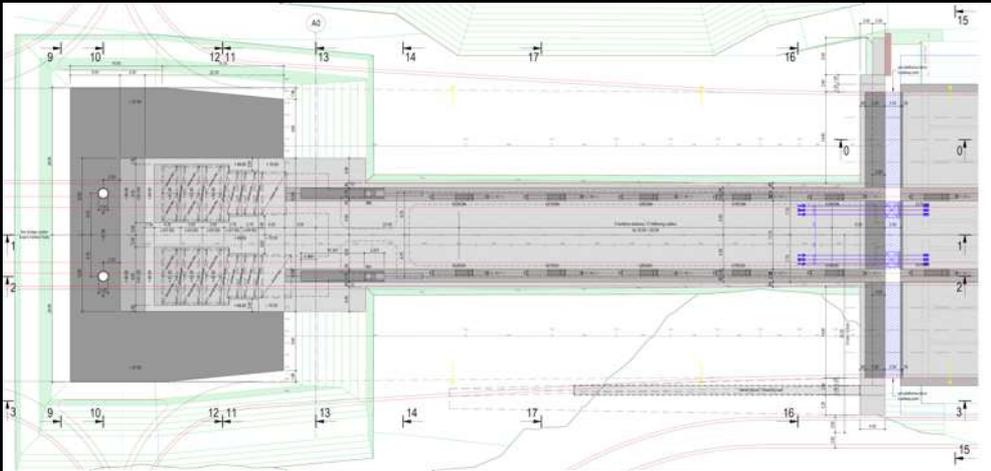
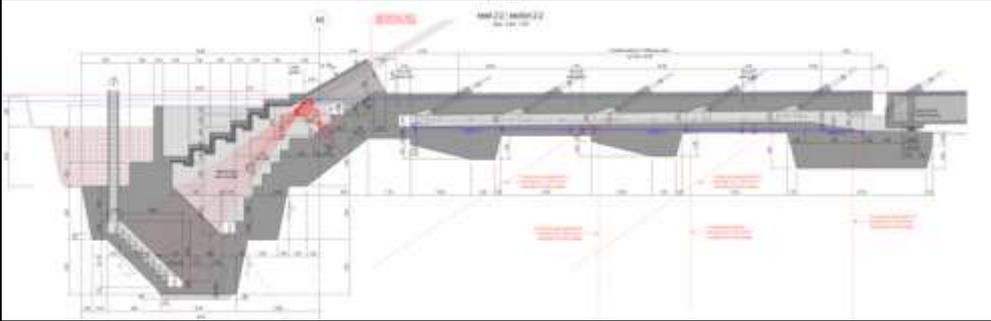
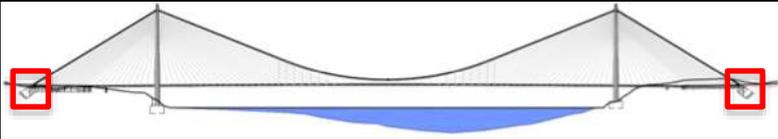
Anchorage Blocks



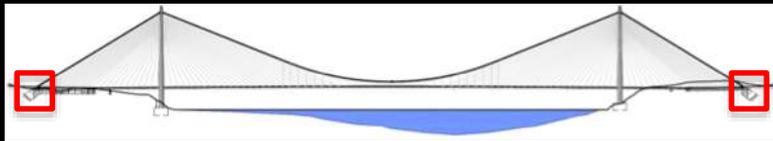
Anchorage Blocks



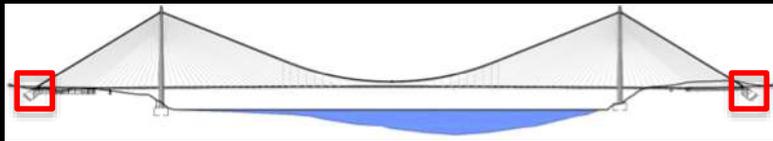
Anchorage Blocks



Anchorage Blocks



Anchorage Blocks



Anchorage Blocks

- March 2014

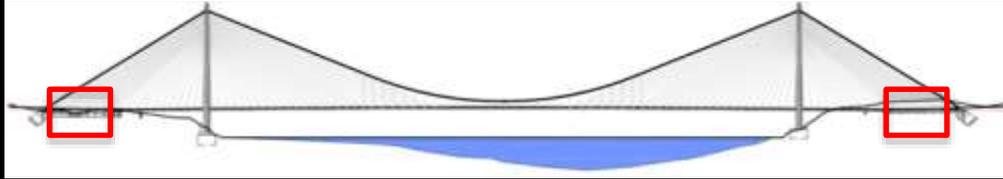


Anchorage Blocks

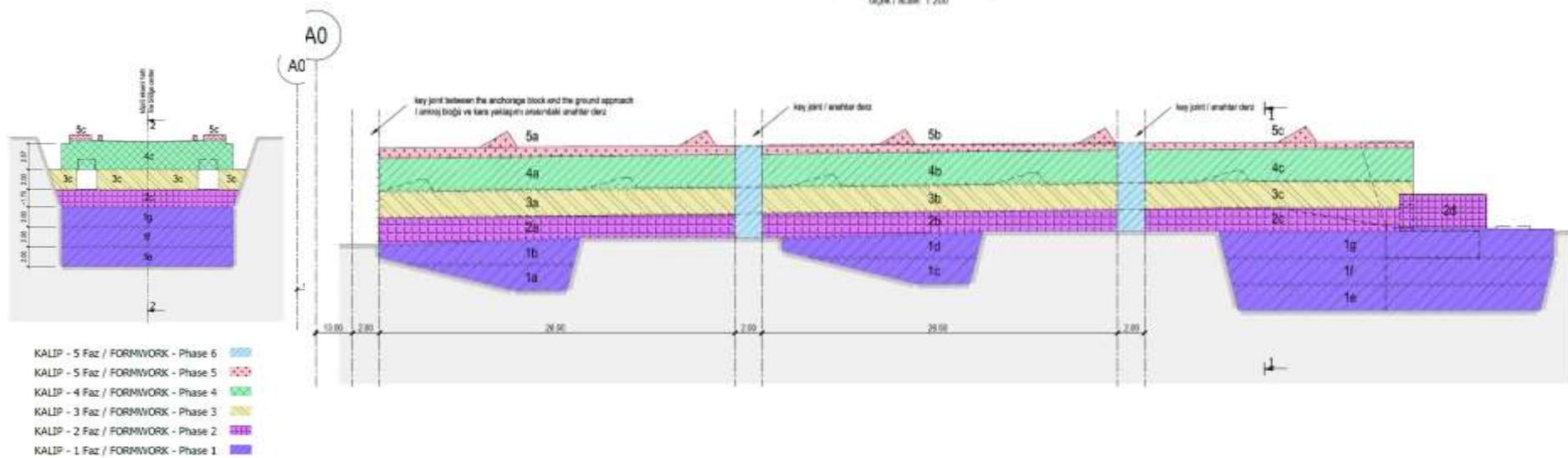
- May 2014



ground approach



kesit 2-2 / section 2-2
ölçek / scale: 1/200

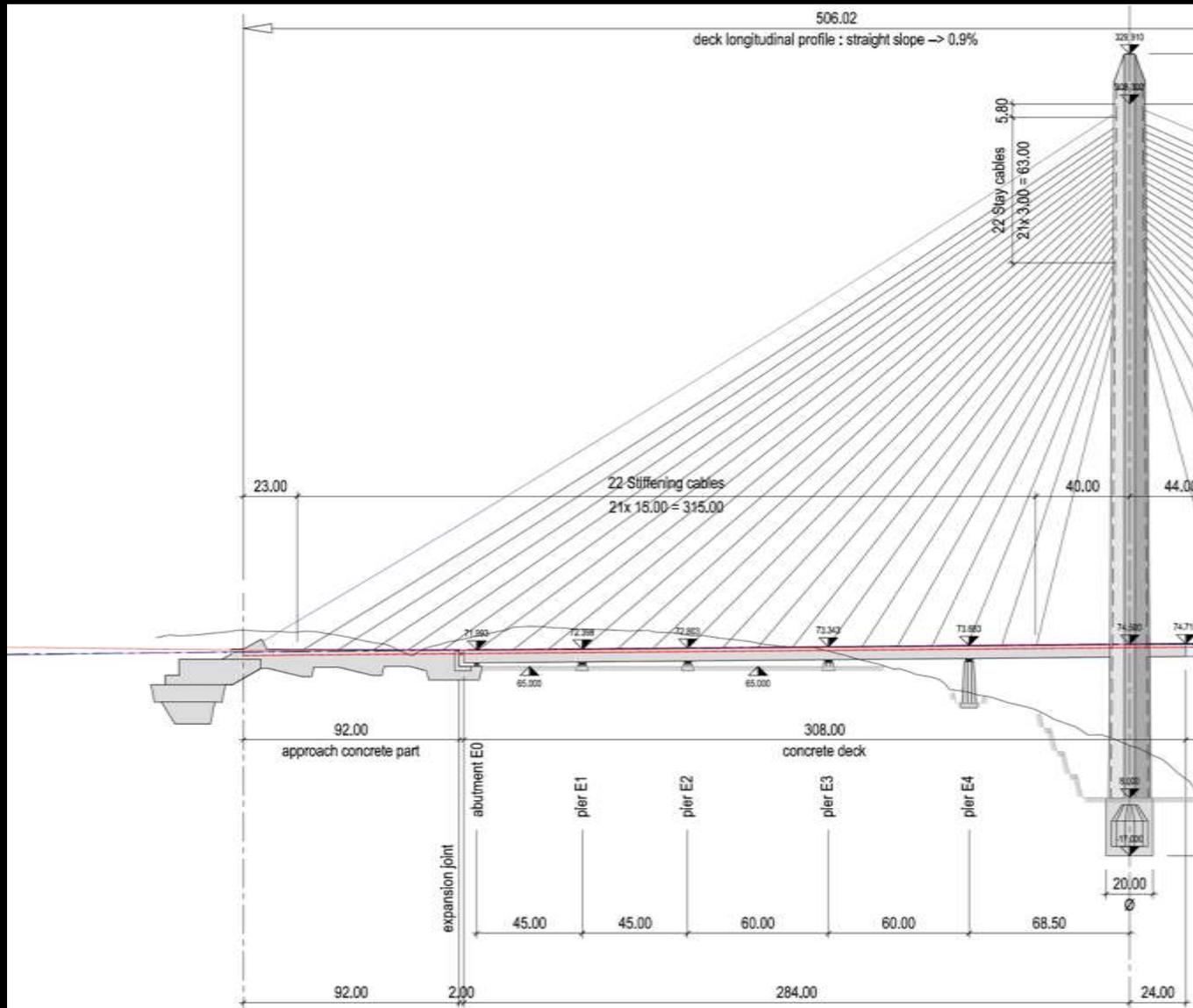


ground approach

- March 2014



Concrete side spans

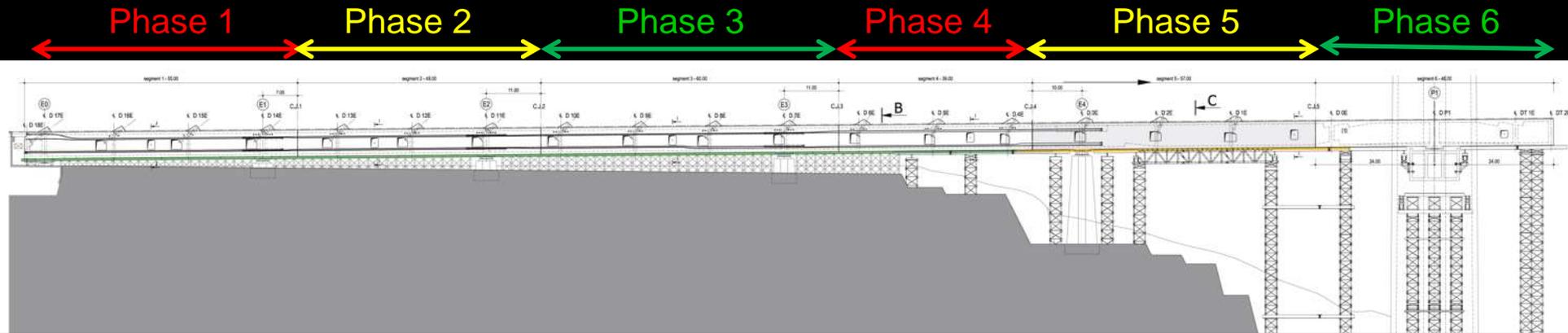


Side Spans – global design

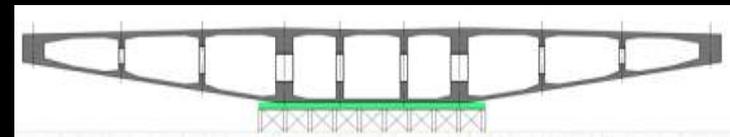
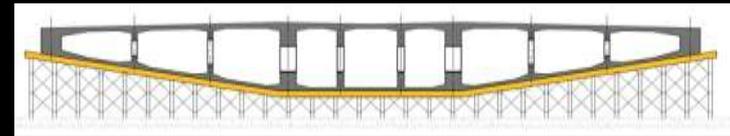


Side Spans – global design

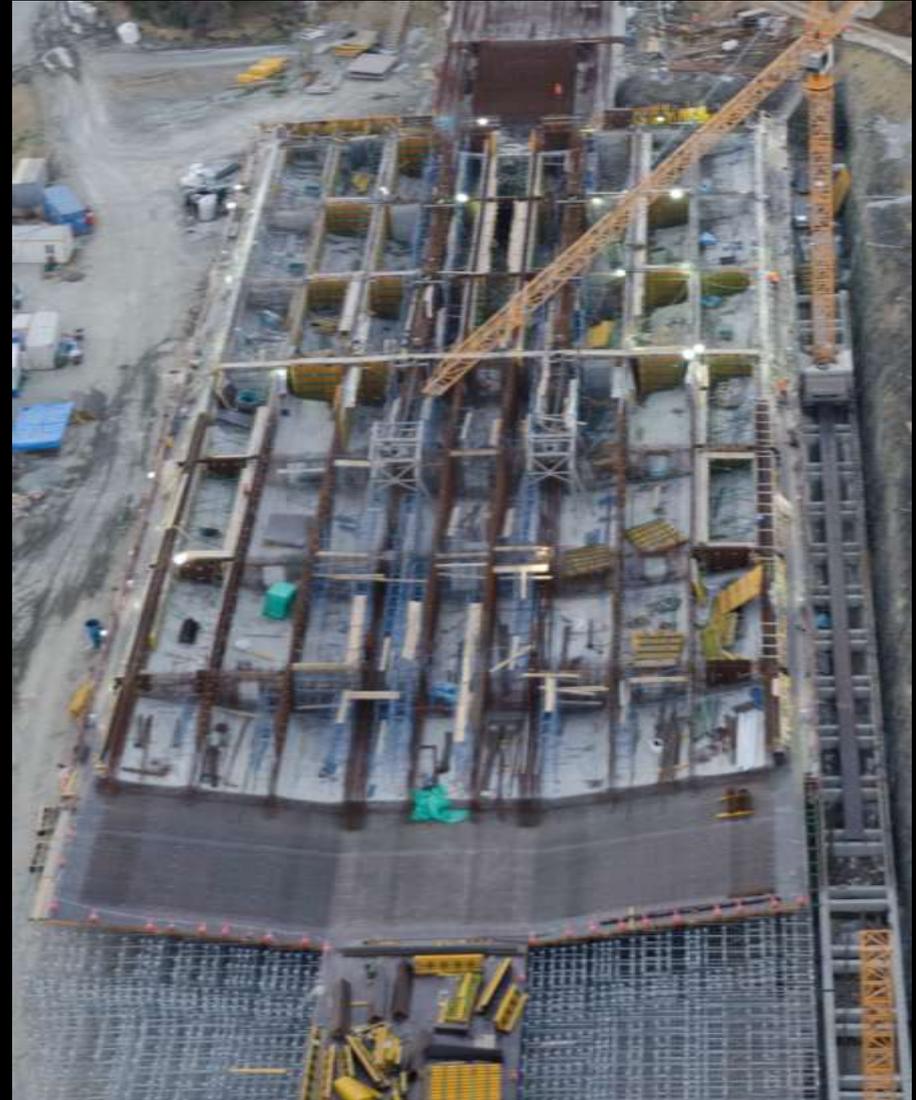
Construction stages (phases 1 to 6)



1. Concreting in 3 phases
 - a. bottom slab
 - b. Walls (girders + diaphragms)
 - c. top slab
2. 100% Transversal prestressing tensioning (diaphragms and slab)
3. Removal of side scaffolding (to re-use 2 phases later), exception: ph. 5 & 6
4. 100% Longitudinal prestressing tensioning, exception: ph. 5 and 6



Side Spans



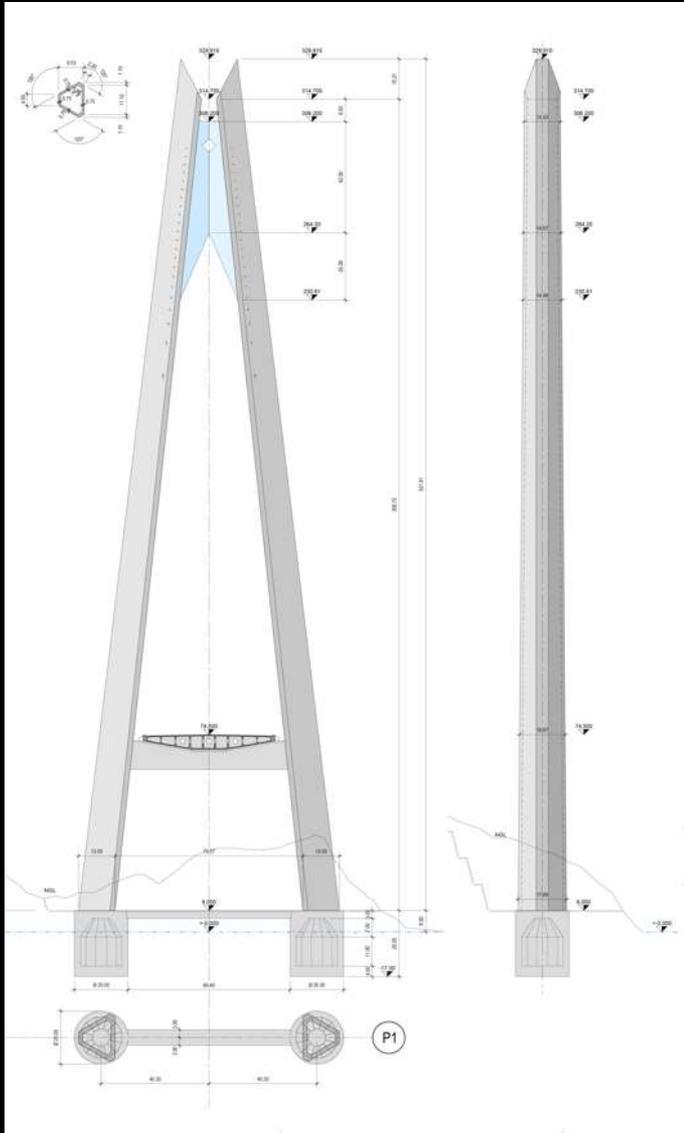
Side Spans



Side Spans

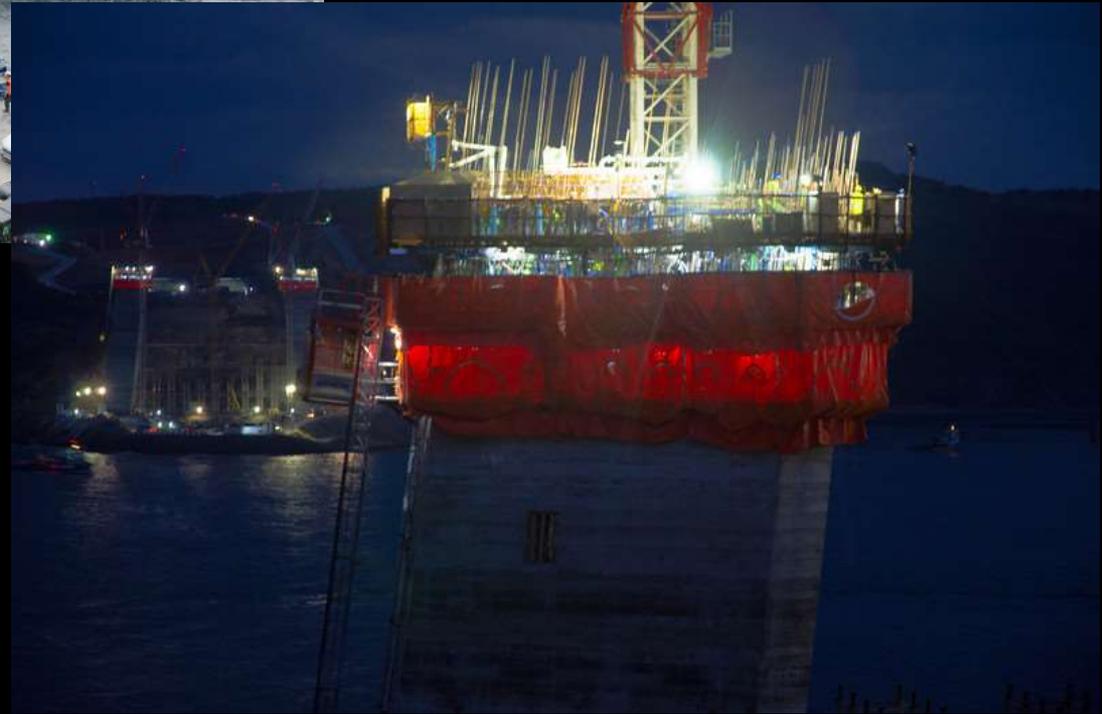


Towers



Tower – construction

Construction of the tower



Tower – construction

Construction of the tower



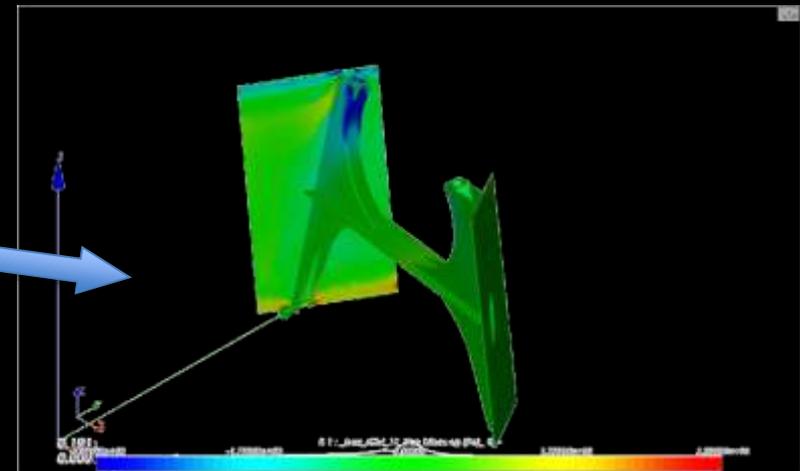
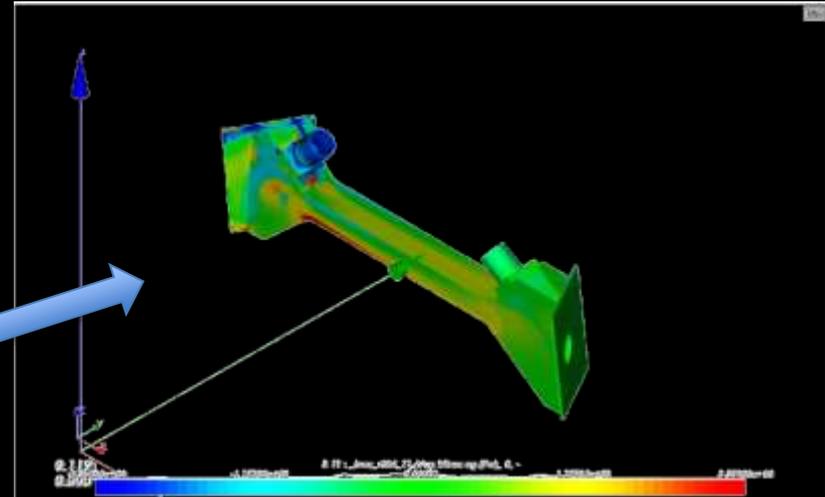
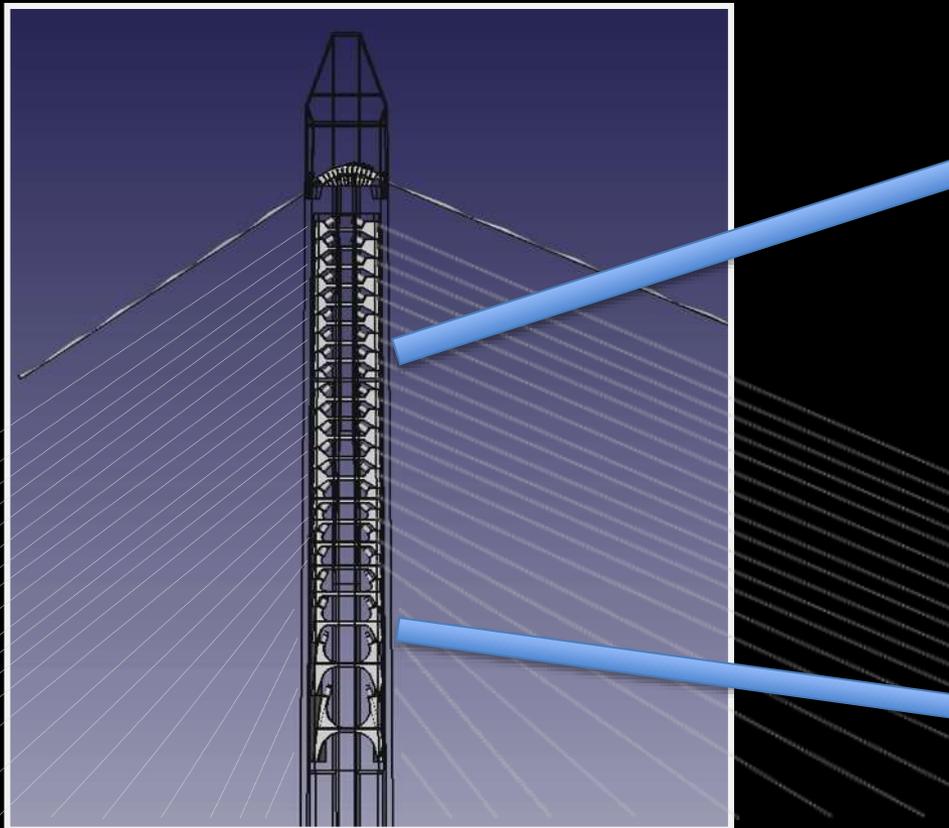
Tower – construction

Construction of the tower

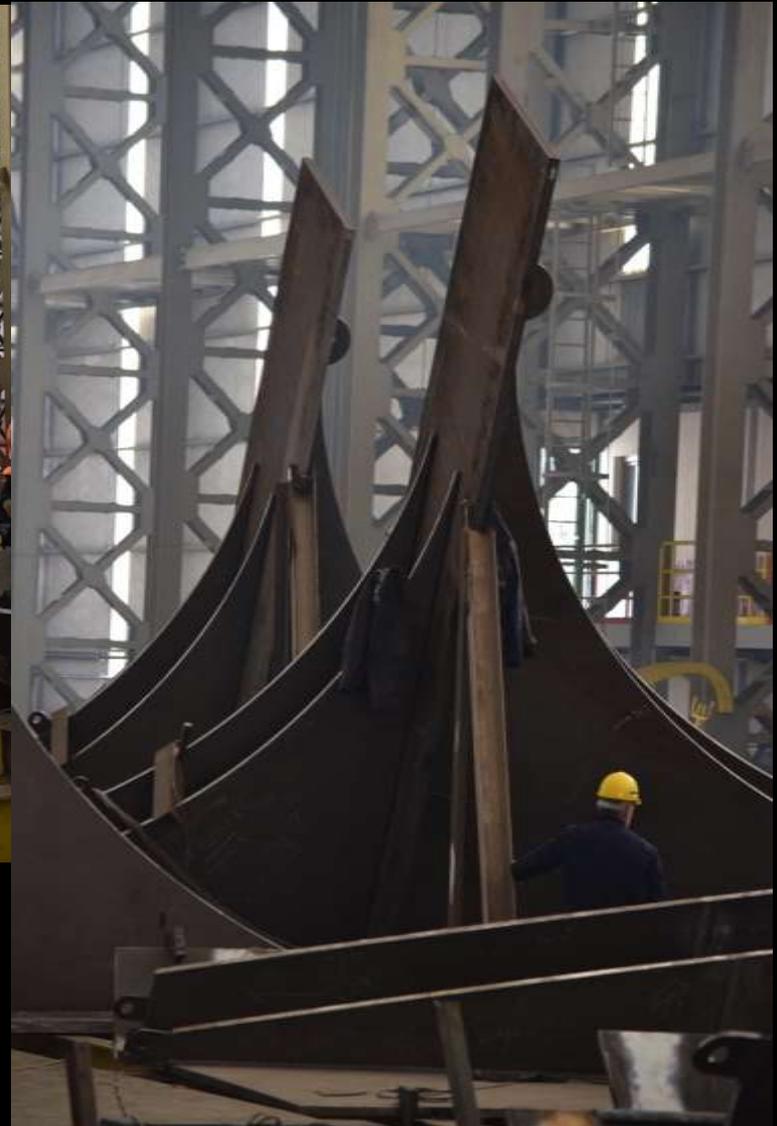


Tower Anchorage boxes

Number of Anchorage boxes	22 X 4 = 88
Total weight	2.820 t



Tower Anchorage boxes



Tower construction

March 2014



Tower construction



Tower construction

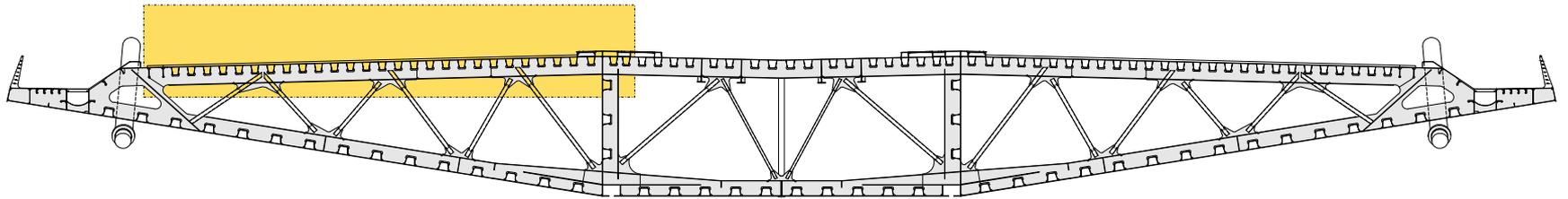
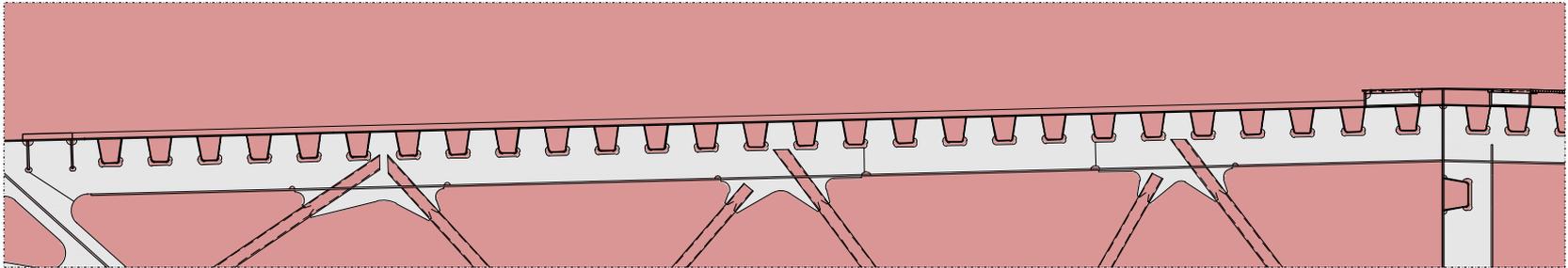
Anchor boxes



Main span – steel deck



Dalle orthotrope



Dalle orthotrope "classique"

Tôle : ép. 14 mm et 12 mm

Augets : 300 x 300, ép. 8 et 7 mm

Acier S460

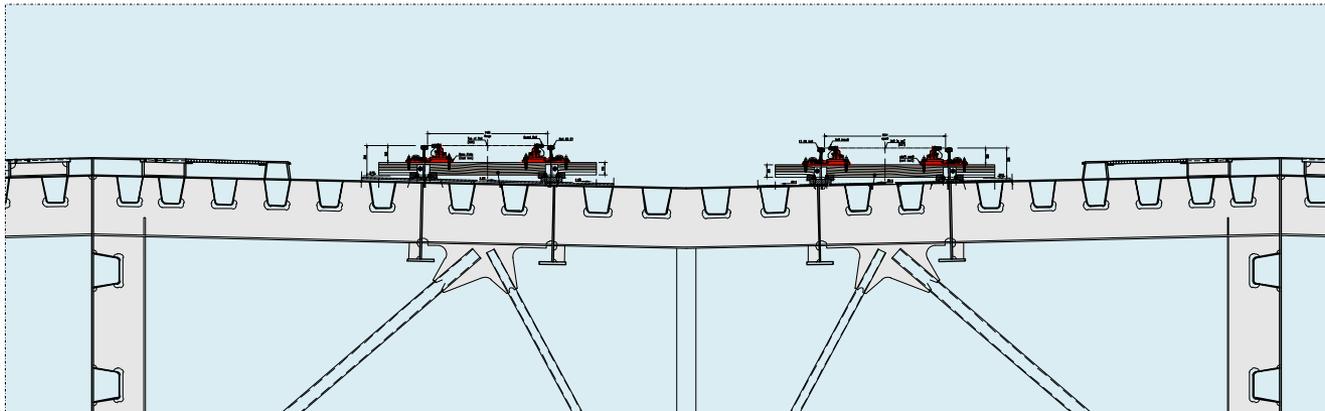
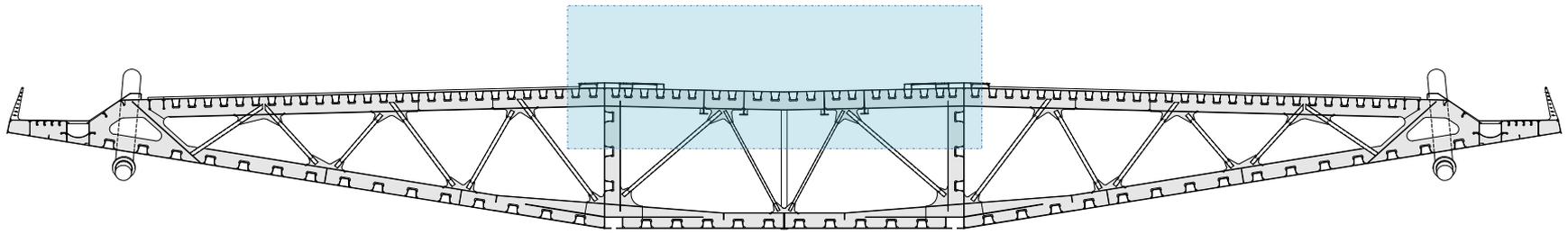
Dalle orthotrope

Dalle orthotrope "classique" + Supports des futures voies

Tôle : ép. 14 mm et 12 mm

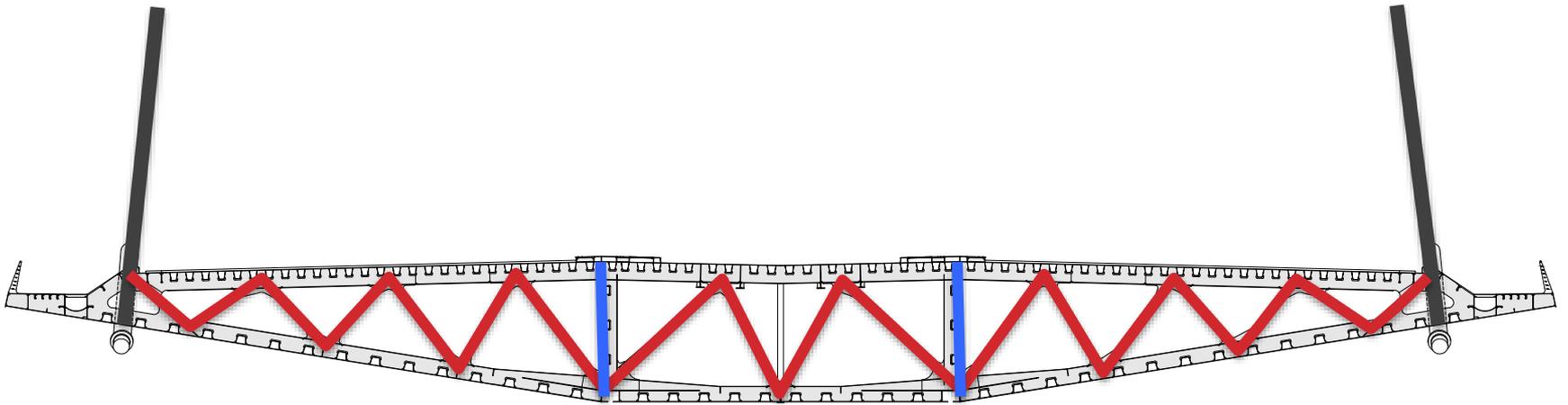
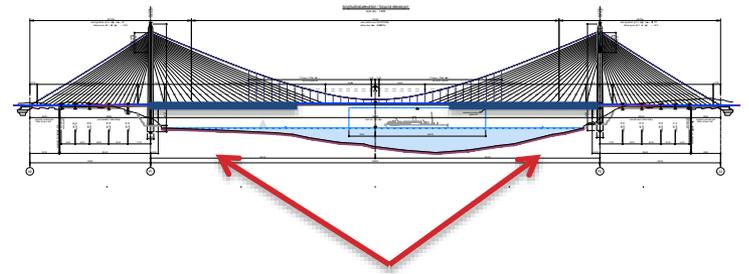
Profils reconstitués

Augets : 300 x 300, ép. 7 mm

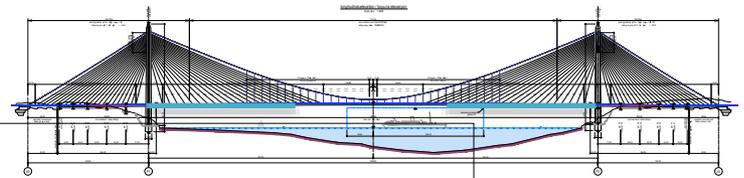


Fonctionnement transversal

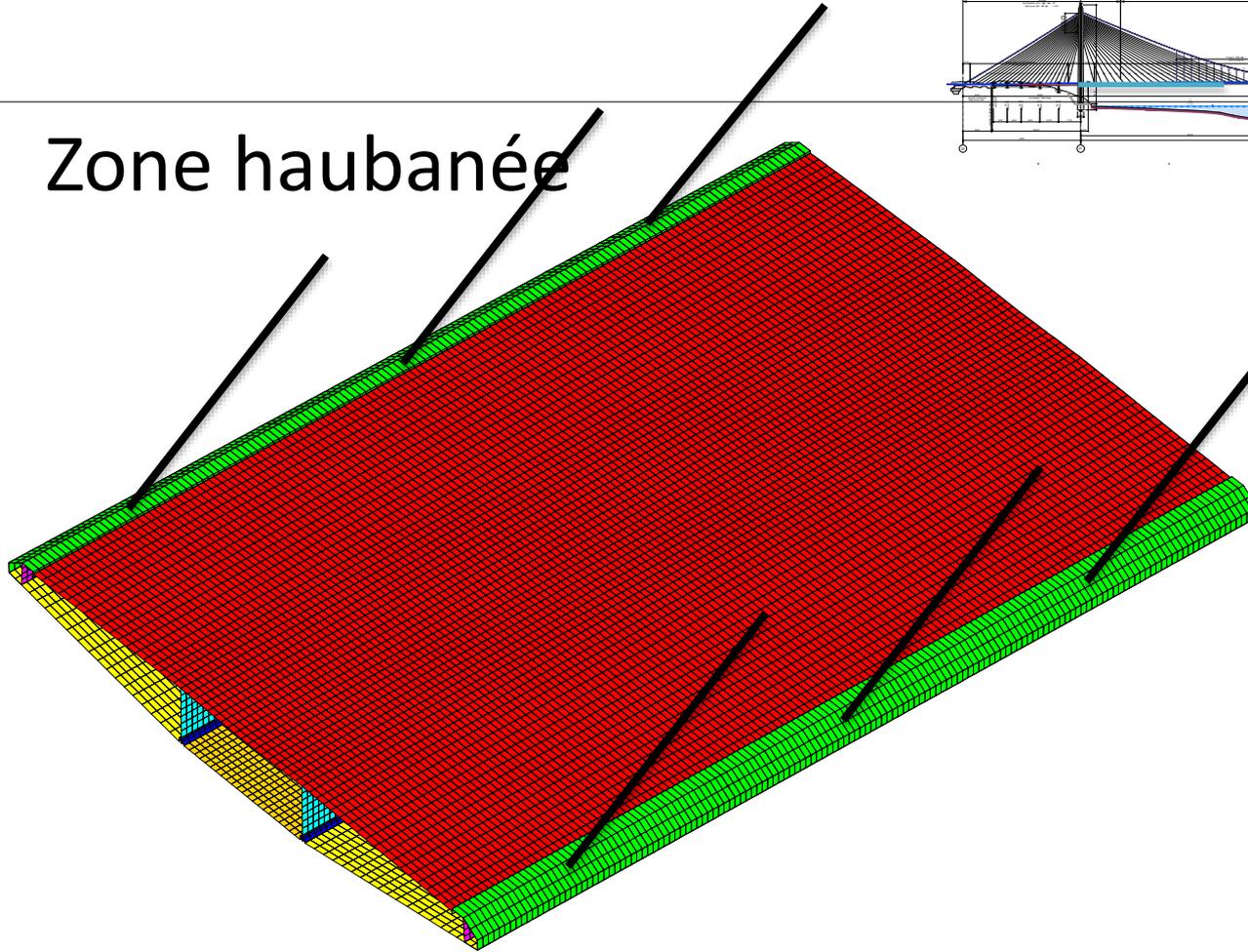
- Zone haubanée



Fonctionnement transversal

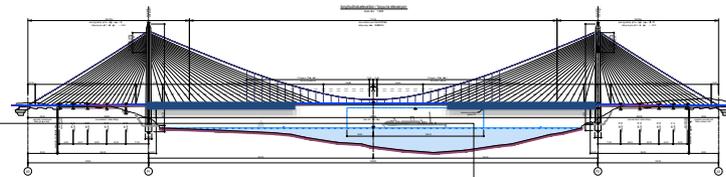


- Zone haubanée

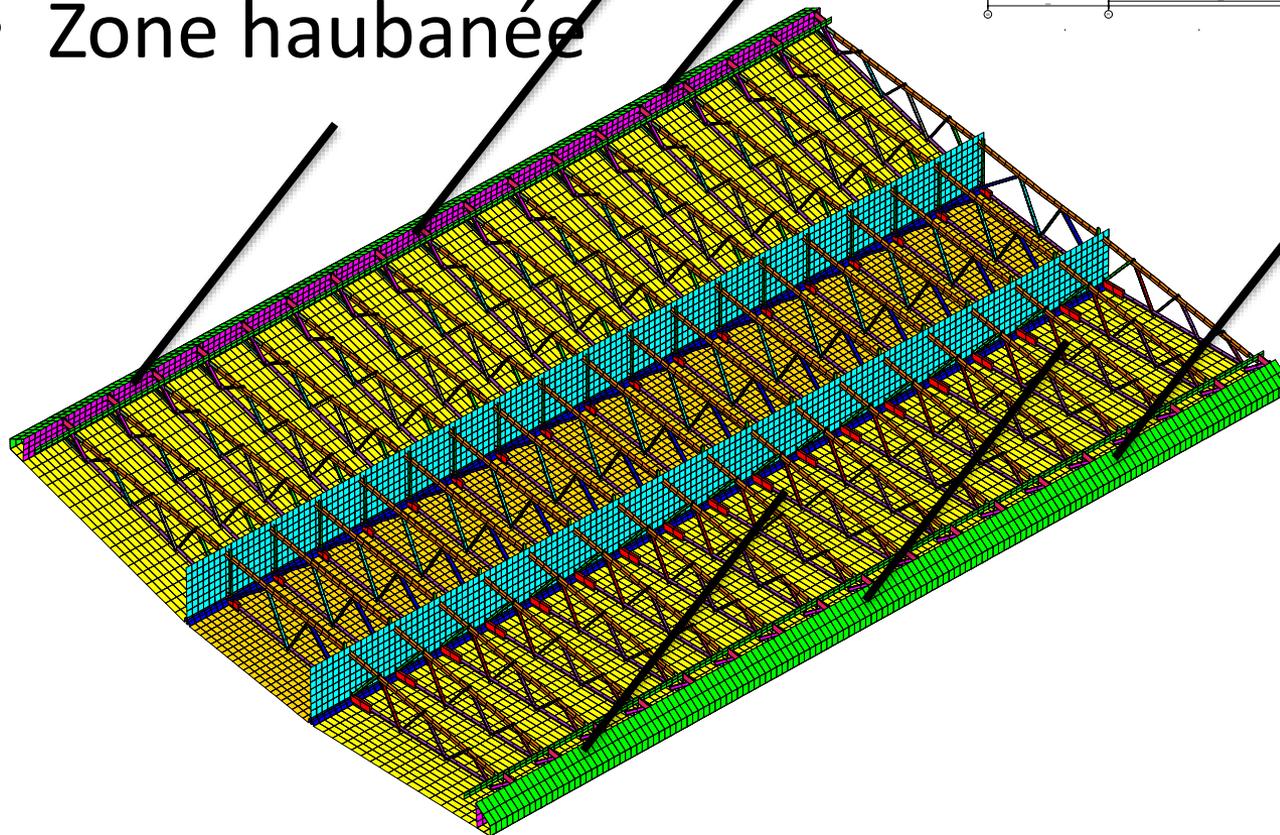


<p>STRUCTURE INITIALE UNITES: KN, M</p> <p>NO ELEMENTS : GEOMETRIE</p> <p>TOUTES LES ARETES</p>	<p>PERSPECTIVE (PV, PF, PO)</p> <table border="1"> <thead> <tr> <th>X</th> <th>Y</th> <th>Z</th> </tr> </thead> <tbody> <tr> <td>993.78</td> <td>1149.33</td> <td>1338.19</td> </tr> <tr> <td>36.00</td> <td>0.00</td> <td>-2.70</td> </tr> <tr> <td>36.00</td> <td>0.00</td> <td>93.08</td> </tr> </tbody> </table>	X	Y	Z	993.78	1149.33	1338.19	36.00	0.00	-2.70	36.00	0.00	93.08	<table border="1"> <thead> <tr> <th></th> <th>MIN</th> <th>MAX</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>-1.715</td> <td>73.715</td> </tr> <tr> <td>Y</td> <td>-29.250</td> <td>29.250</td> </tr> <tr> <td>Z</td> <td>-6.621</td> <td>1.222</td> </tr> </tbody> </table>		MIN	MAX	X	-1.715	73.715	Y	-29.250	29.250	Z	-6.621	1.222	<p>SELECTION DES ELEMENTS T,M-2,G-41A50</p>	 <p>DESFIN 9.4 20/03/14</p>
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Y	-29.250	29.250																										
Z	-6.621	1.222																										
BB3-troncon de tablier-mzh04		4678-F-MZH04-V01-CAS_UNITAIRESS		Andre																								

Fonctionnement transversal



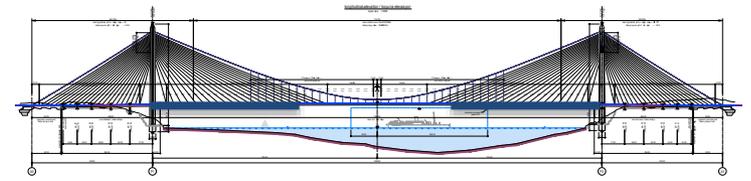
- Zone haubanée



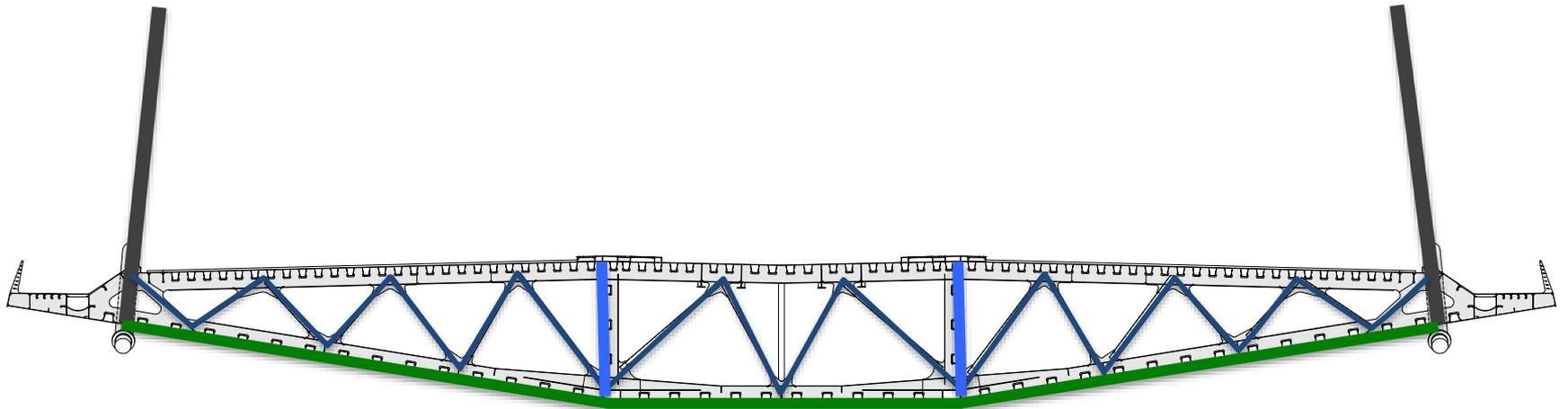
STRUCTURE INITIALE UNITES: KN, M	NO ELEMENTS : GEOMETRIE	PERSPECTIVE (PV, PF, PO)	MIN MAX	SELECTION DES ELEMENTS																							
TOUTES LES ARETES	<table border="1"> <thead> <tr> <th>X</th> <th>Y</th> <th>Z</th> </tr> </thead> <tbody> <tr> <td>993.78</td> <td>1149.33</td> <td>1338.19</td> </tr> <tr> <td>36.00</td> <td>0.00</td> <td>-2.70</td> </tr> <tr> <td>36.00</td> <td>0.00</td> <td>93.08</td> </tr> </tbody> </table>	X	Y	Z		993.78	1149.33	1338.19	36.00	0.00	-2.70	36.00	0.00	93.08	<table border="1"> <thead> <tr> <th>X</th> <th>Y</th> <th>Z</th> </tr> </thead> <tbody> <tr> <td>-1.715</td> <td>73.715</td> <td></td> </tr> <tr> <td>-29.250</td> <td>29.250</td> <td></td> </tr> <tr> <td>-6.621</td> <td>1.222</td> <td></td> </tr> </tbody> </table>	X	Y	Z	-1.715	73.715		-29.250	29.250		-6.621	1.222	
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DESFIN 9.4 20/03/14

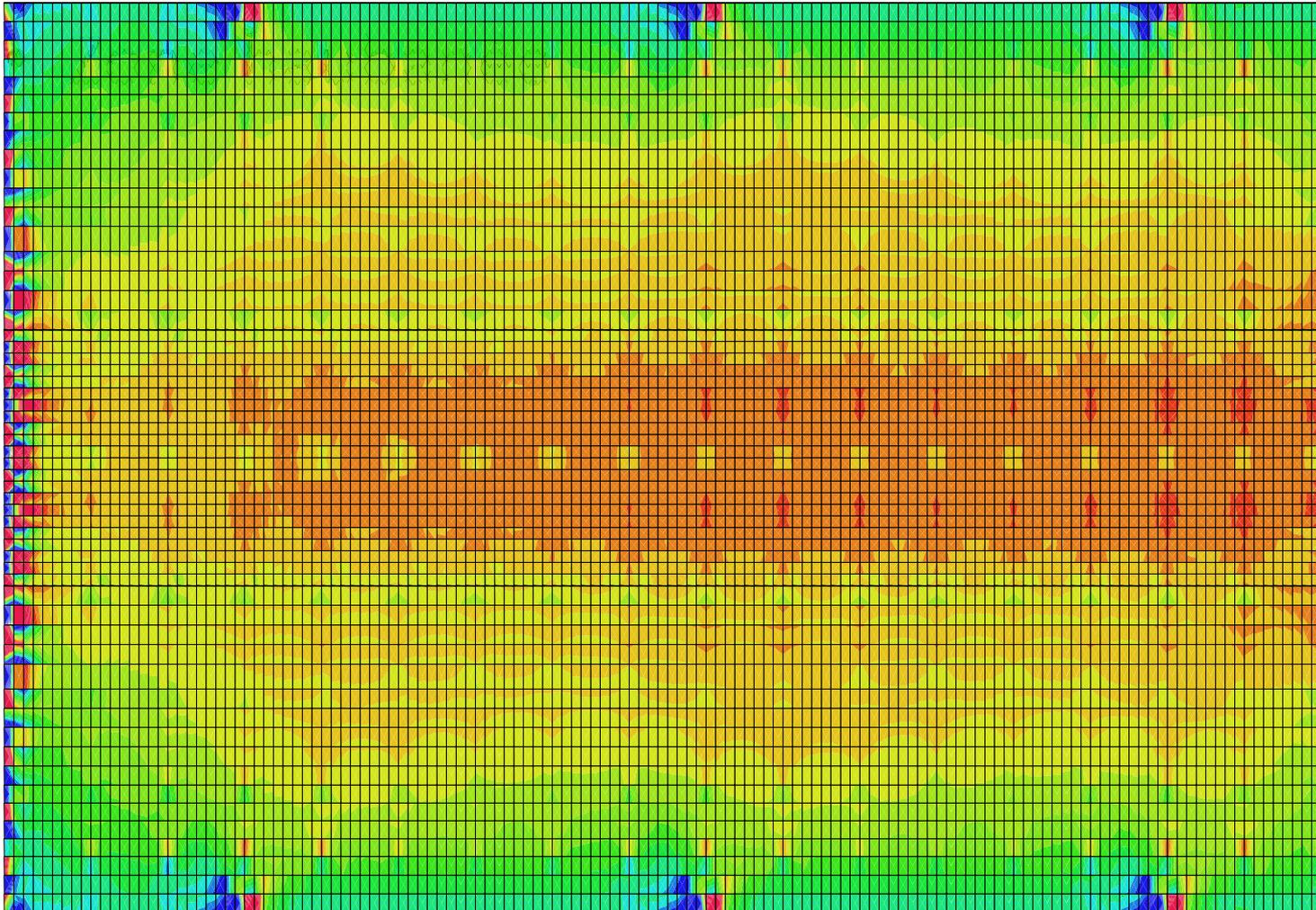
Fonctionnement transversal



- Zone haubanée

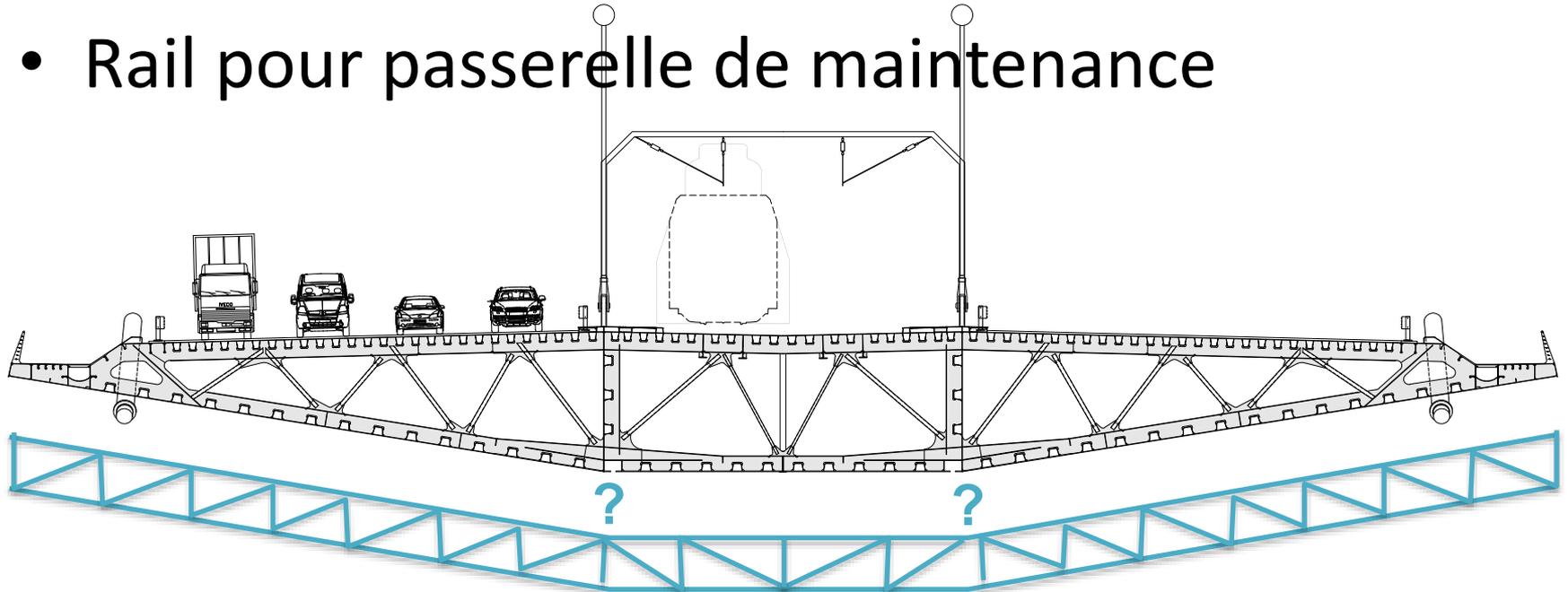


Fonctionnement transversal



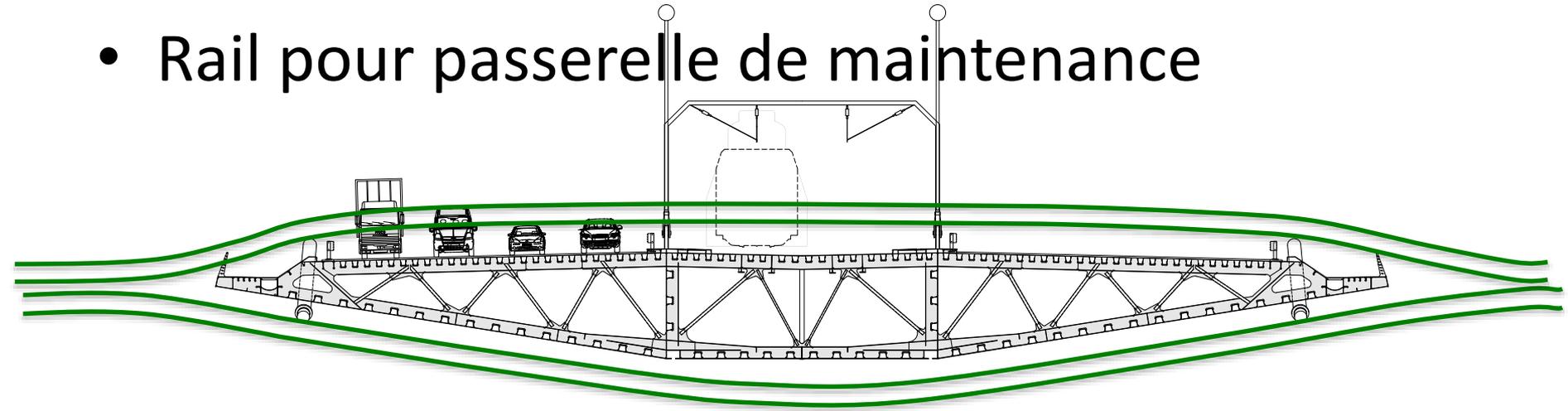
Fonctionnement transversal

- Rail pour passerelle de maintenance



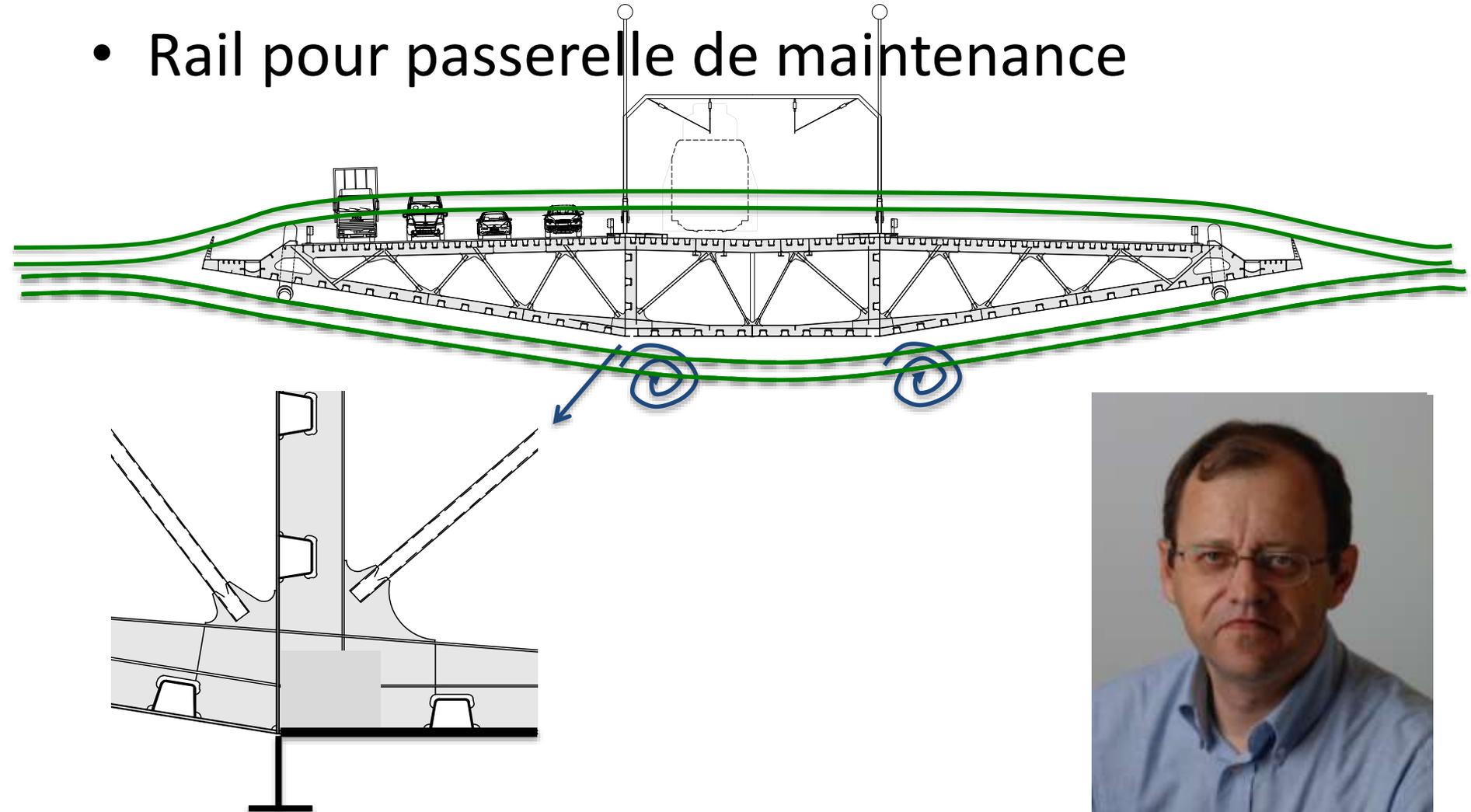
Fonctionnement transversal

- Rail pour passerelle de maintenance



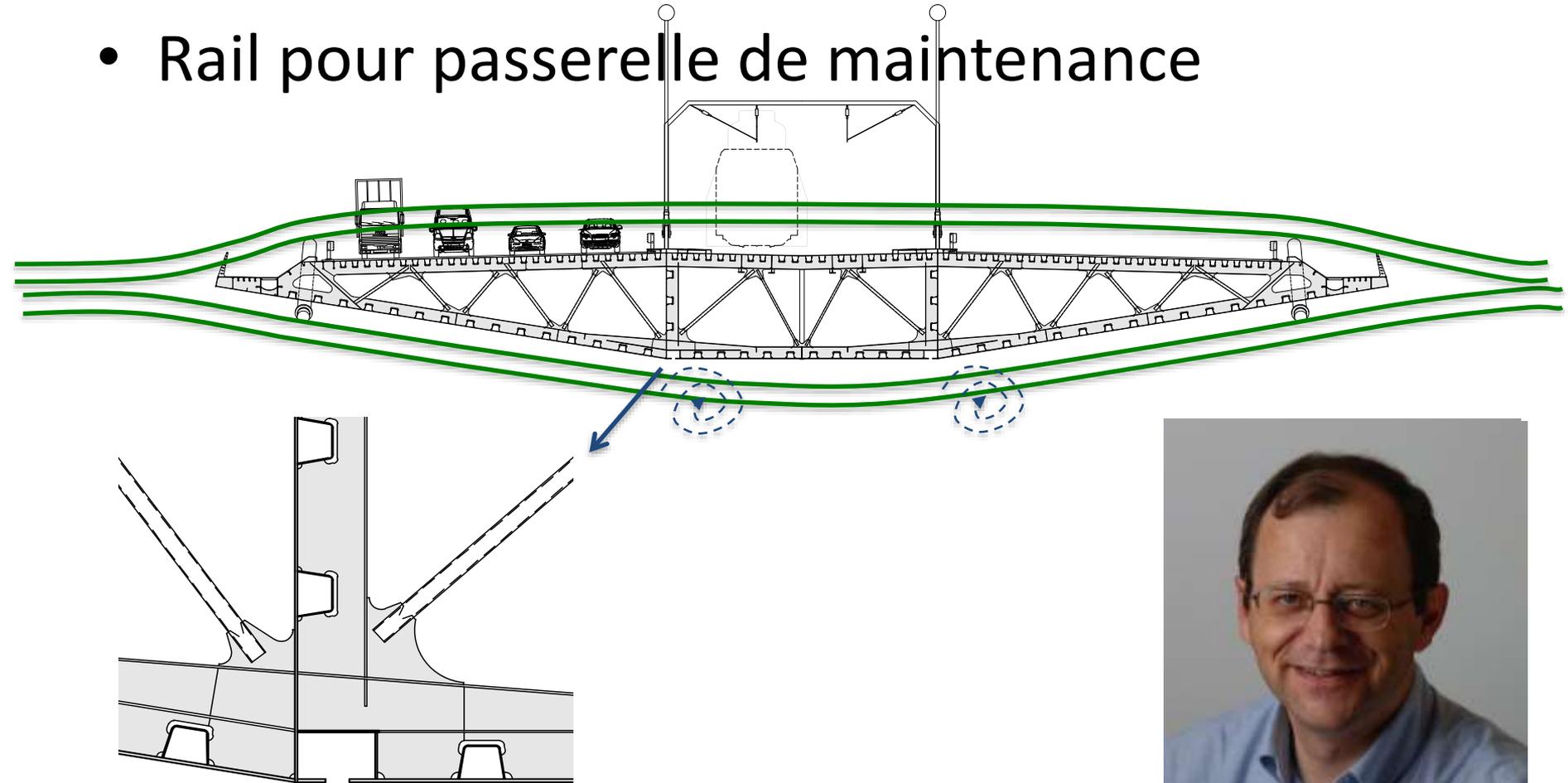
Fonctionnement transversal

- Rail pour passerelle de maintenance

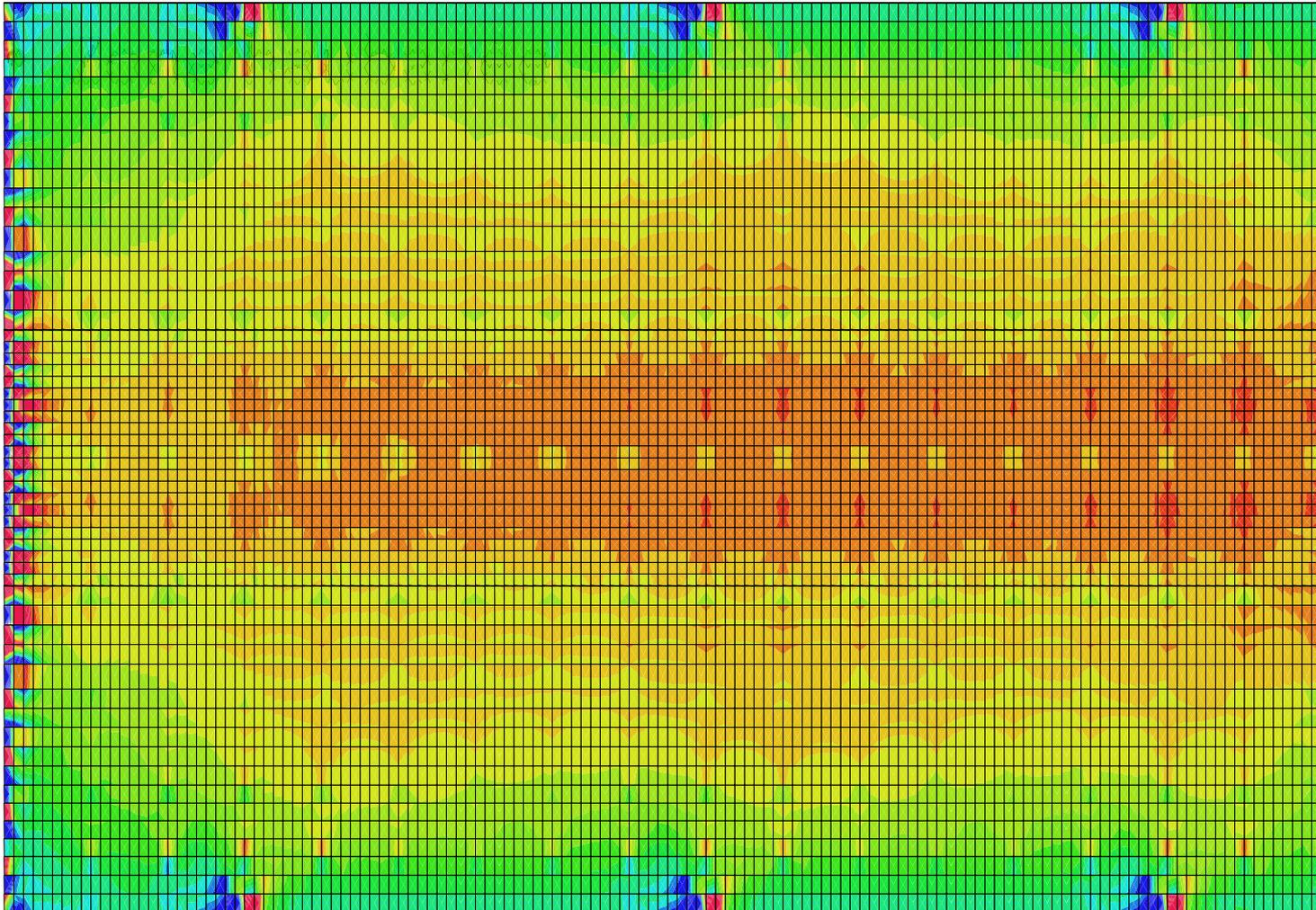


Fonctionnement transversal

- Rail pour passerelle de maintenance

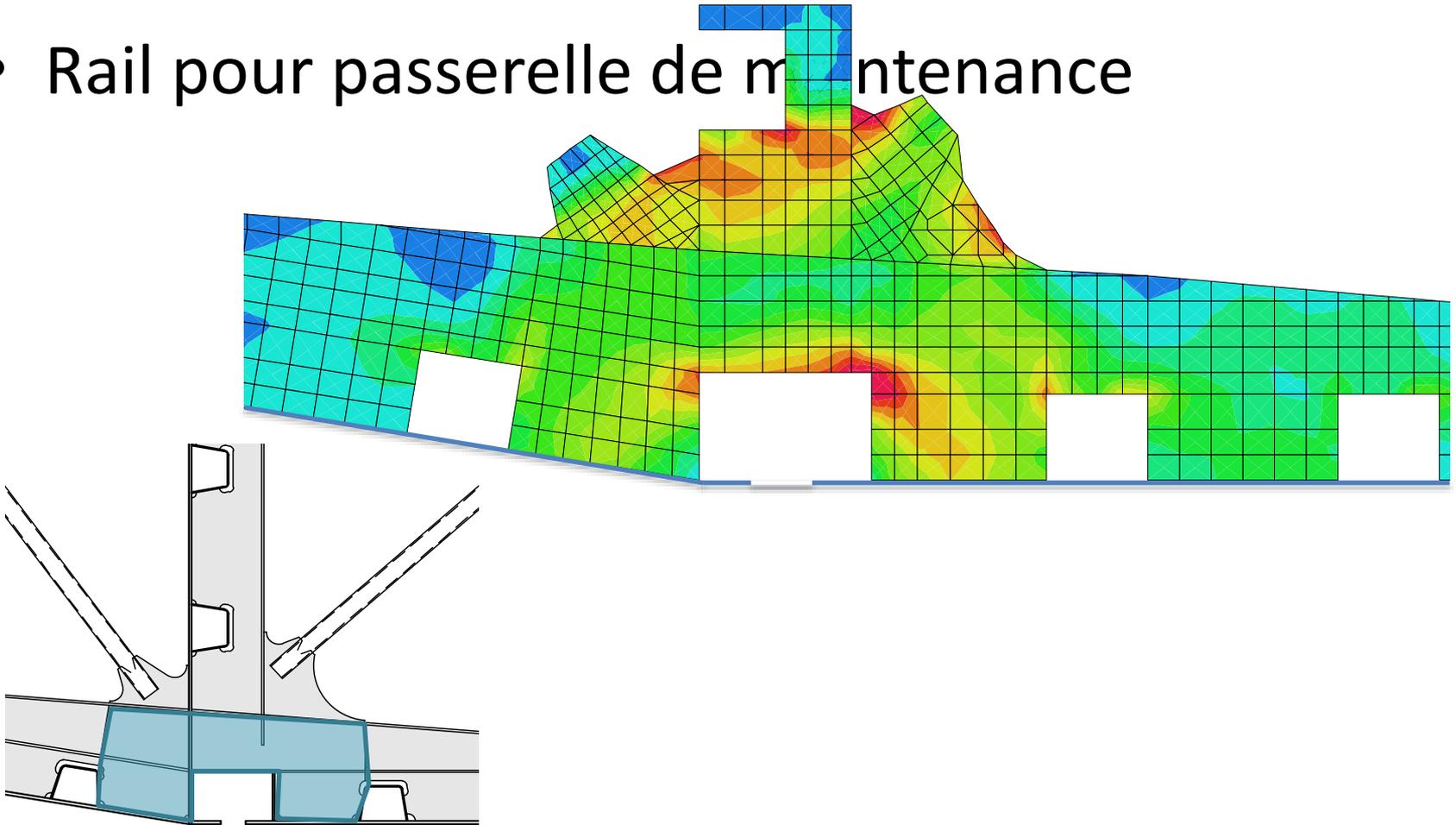


Fonctionnement transversal

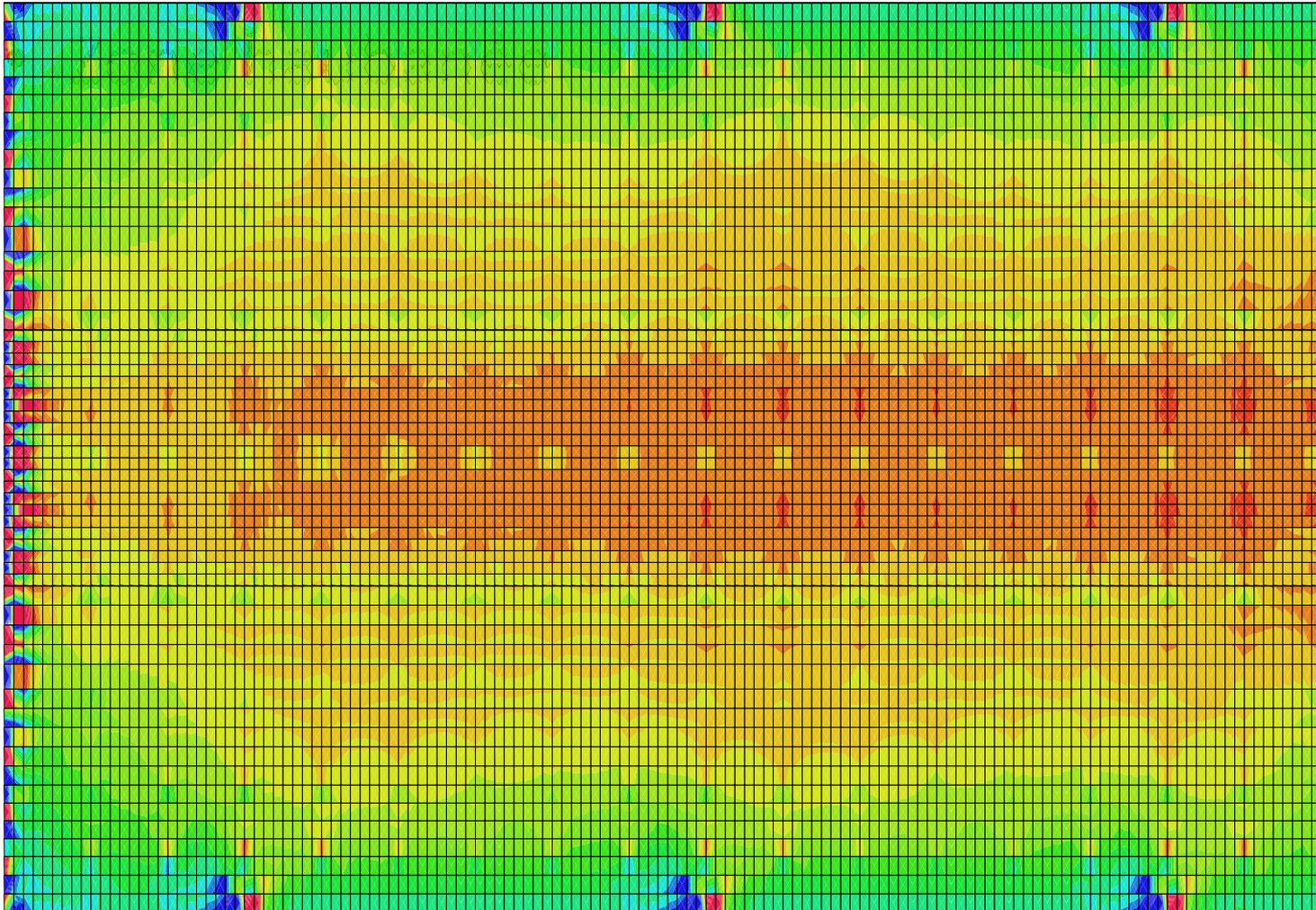


Fonctionnement transversal

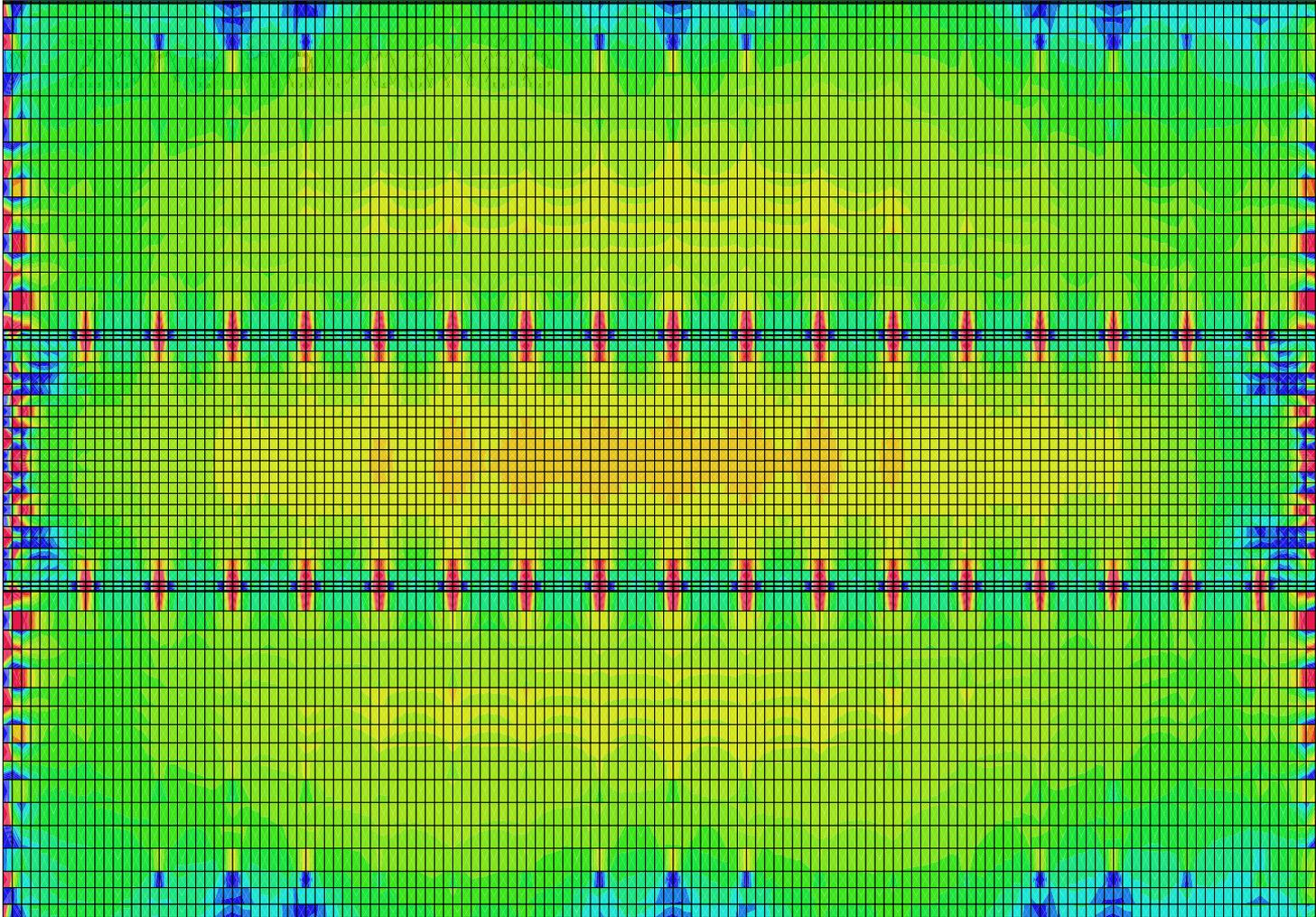
- Rail pour passerelle de maintenance



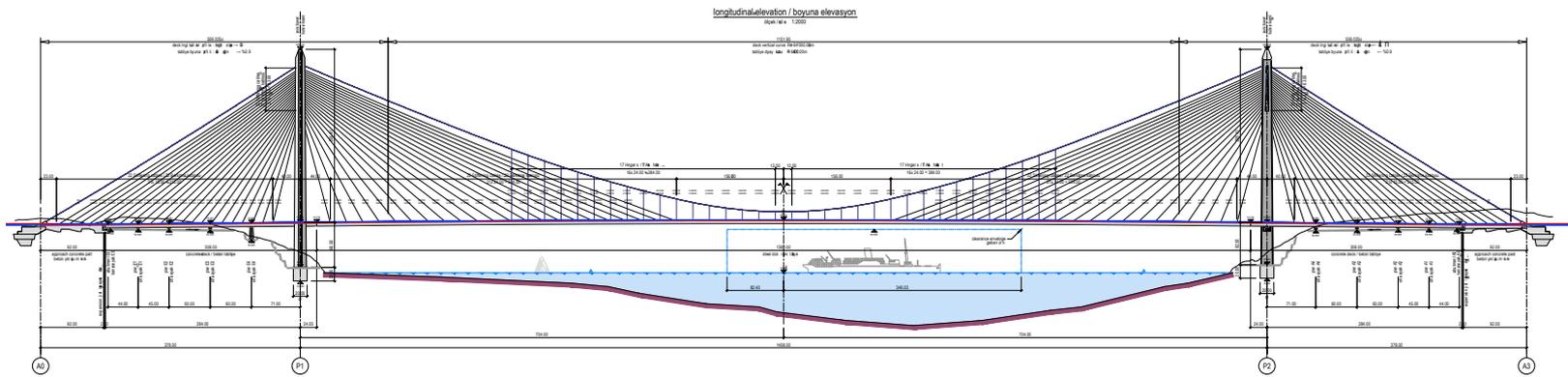
Fonctionnement transversal



Fonctionnement transversal

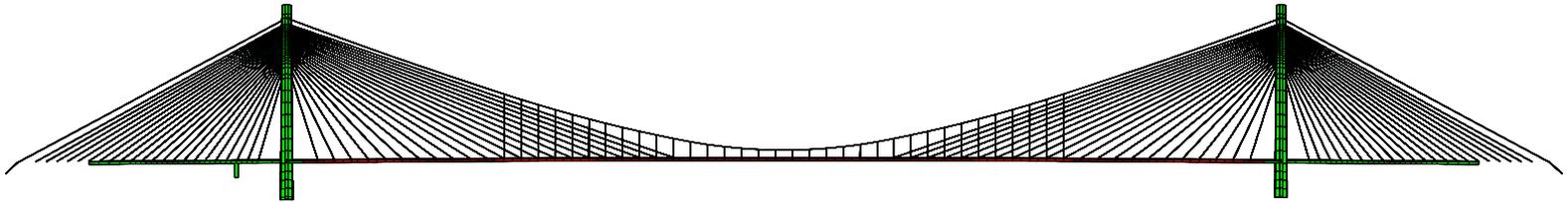


Fonctionnement longitudinal



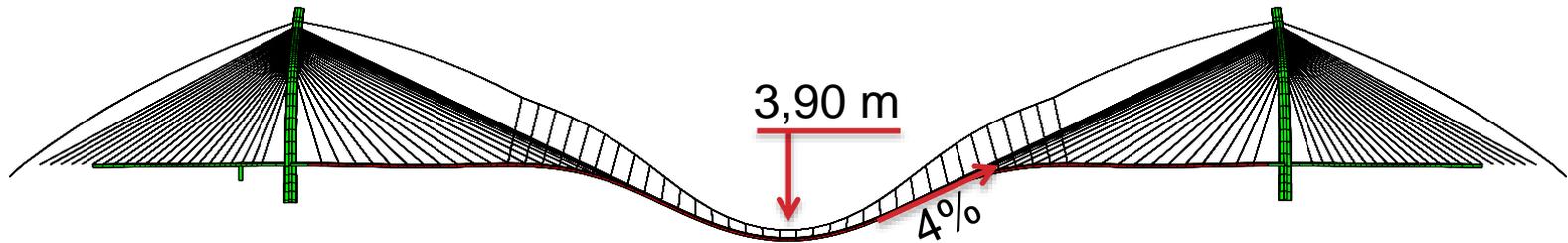
Fonctionnement longitudinal

Flexion générale



Fonctionnement longitudinal

Flexion générale



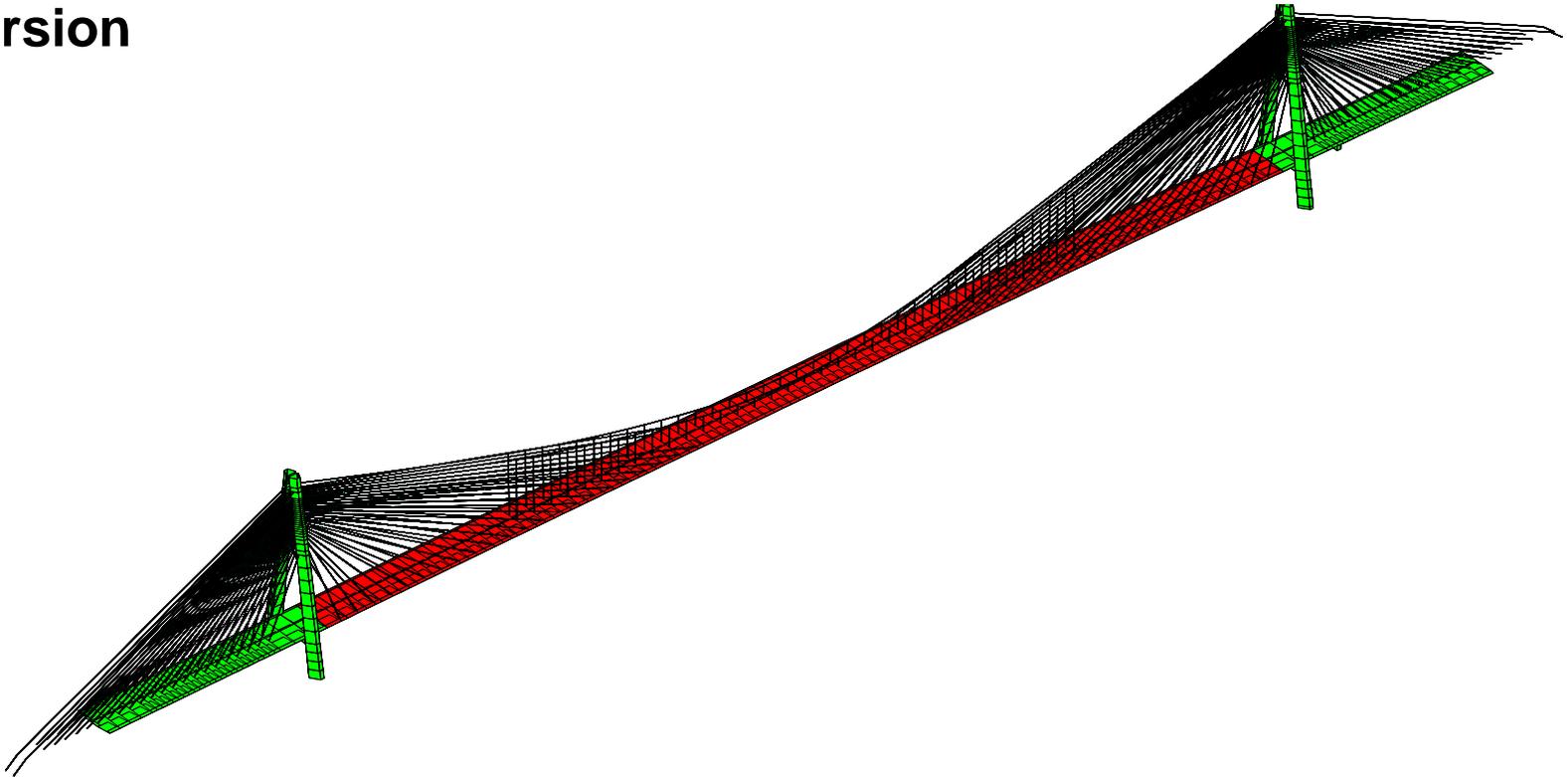
Déformation générale guidée par la section du **câble principal**.
Le dimensionnement global du tablier dépend de cette déformation.

Impact technologique sur :

- Les pentes
- Le drainage

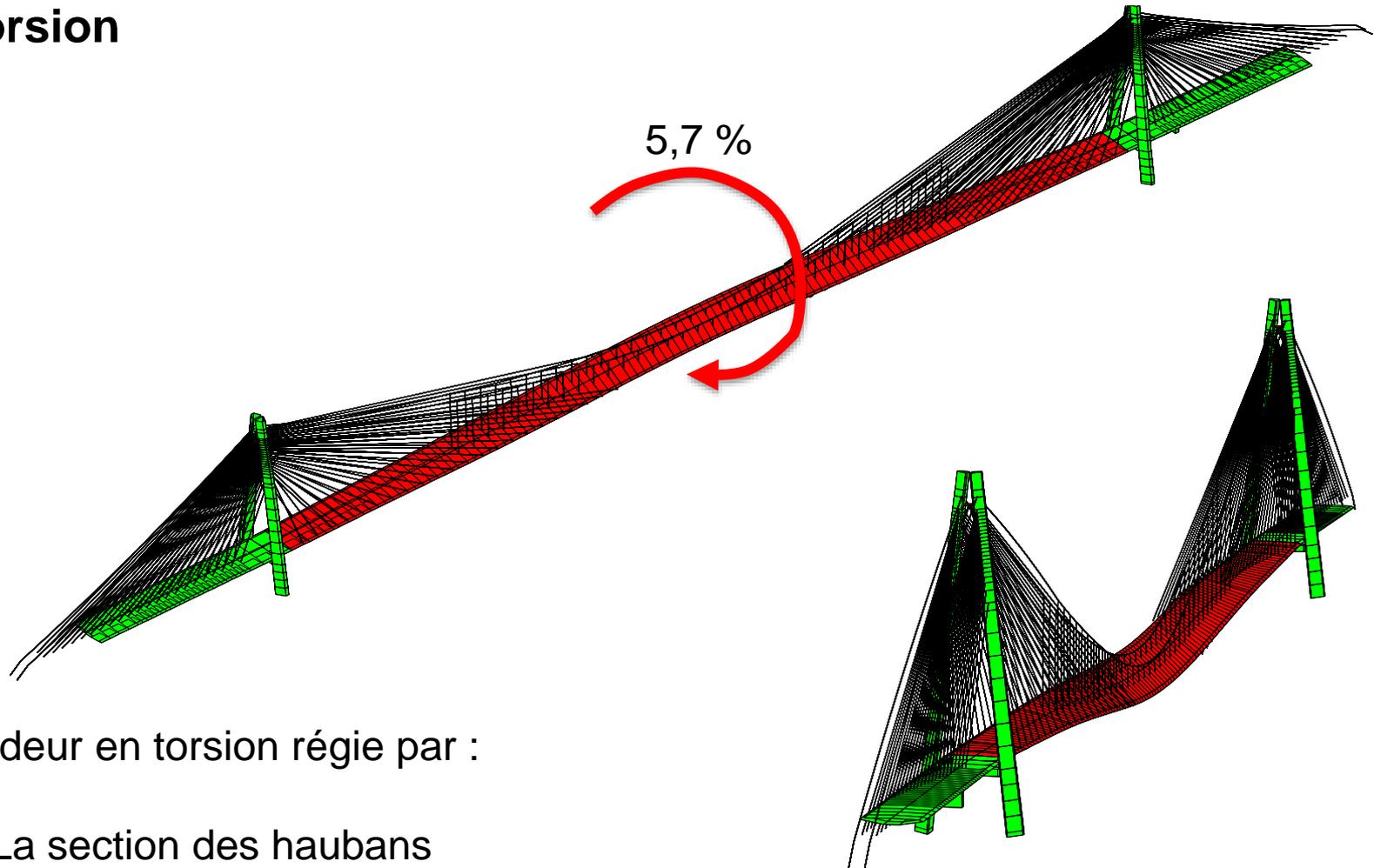
Fonctionnement longitudinal

Torsion



Fonctionnement longitudinal

Torsion

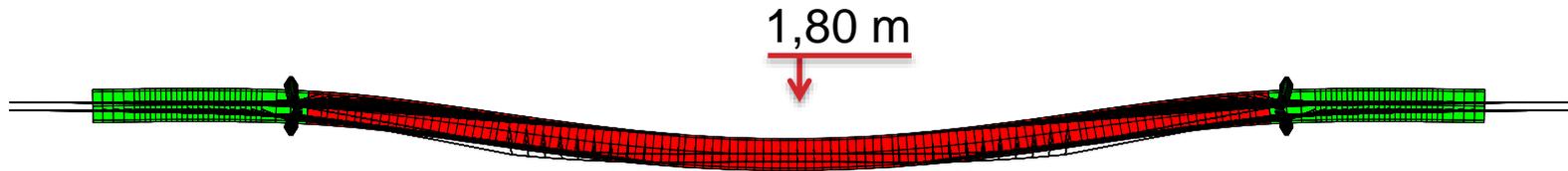


Raideur en torsion régie par :

- La section des haubans
- L'inertie en torsion du caisson

Fonctionnement longitudinal

Flexion transversale



Paramètre déterminant :

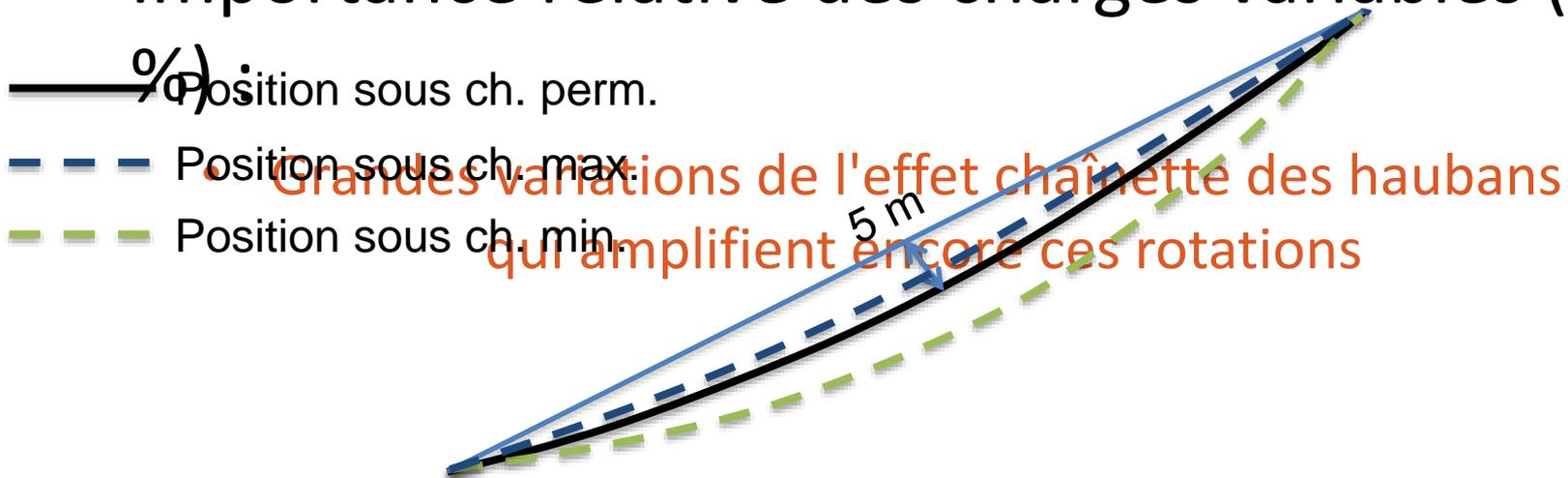
Raideur transversale du tablier

Fonctionnement longitudinal

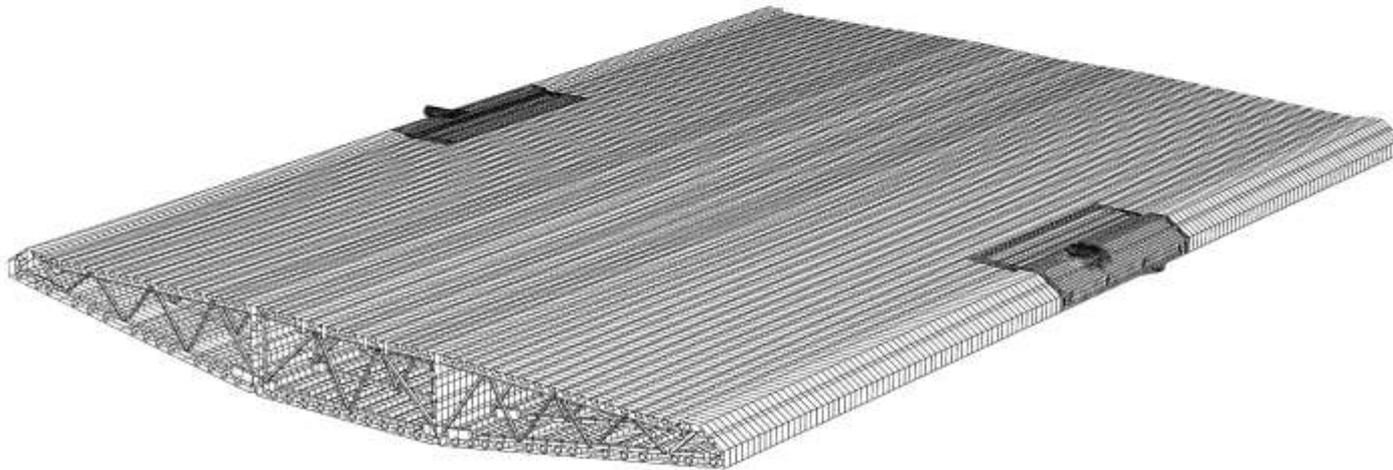
- Déformations régies par :
- La raideur du câble principal
- La raideur des haubans
- La raideur en torsion du tablier
- La raideur en flexion transversale du tablier

Fonctionnement longitudinal

- Impact inhabituel de ces déformations importantes :
 - Grandes valeurs de rotations imposées aux ancrages des haubans et des suspentes
 - +
- Importance relative des charges variables (42



Ancrages des haubans



STRUCTURE INITIALE
UNITES: kN, M

TOUTES LES ARÊTES

PERSPECTIVE (PV, PF, PD)

X	Y	Z
-150.00	-140.00	70.00
67.00	25.00	-19.00
67.00	25.00	-19.00

	MIN	MAX
X	-1.715	73.715
Y	-29.250	29.250
Z	-6.620	0.914

SELECTION DES ELEMENTS
MAS, M-28-4



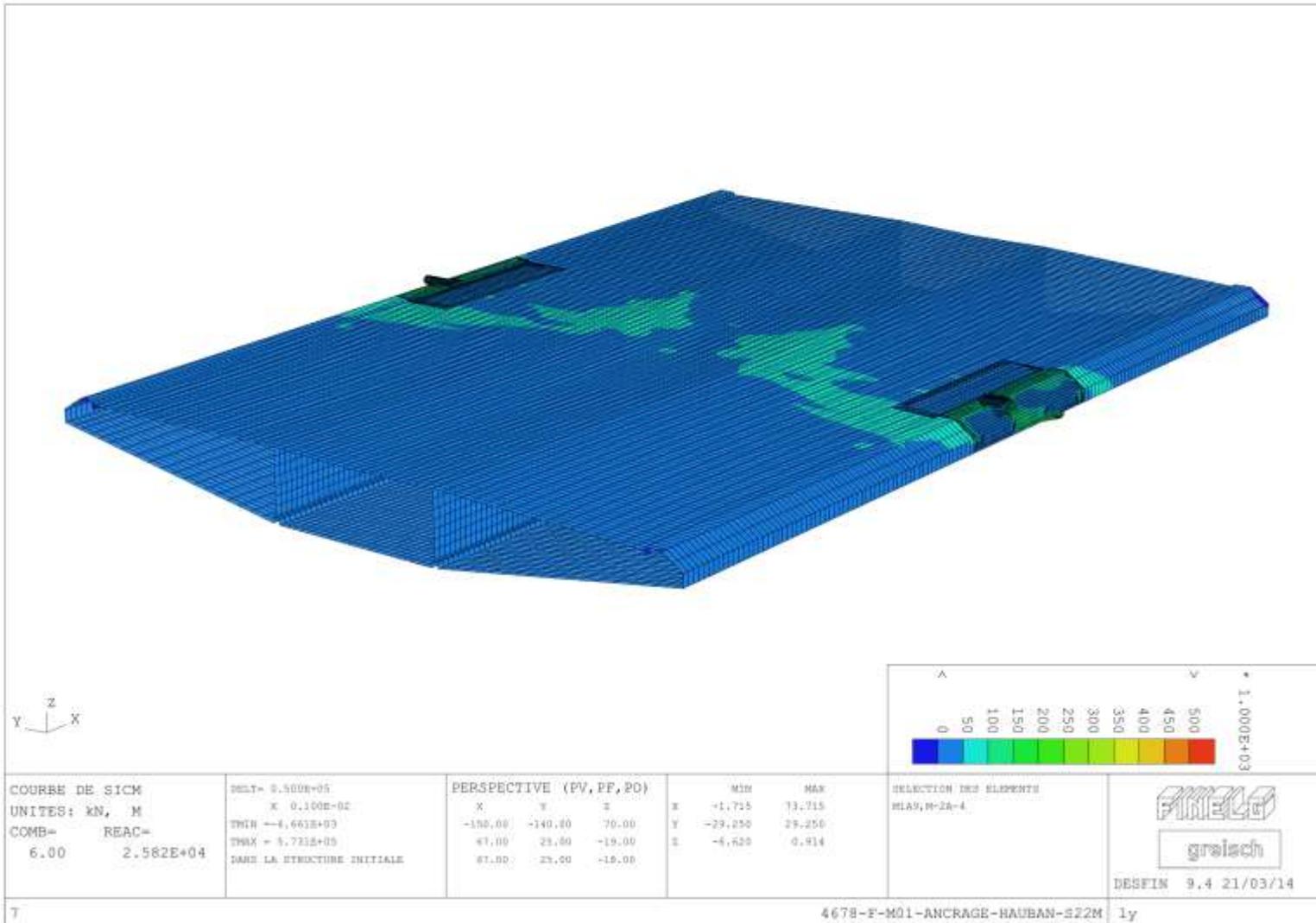
graisch

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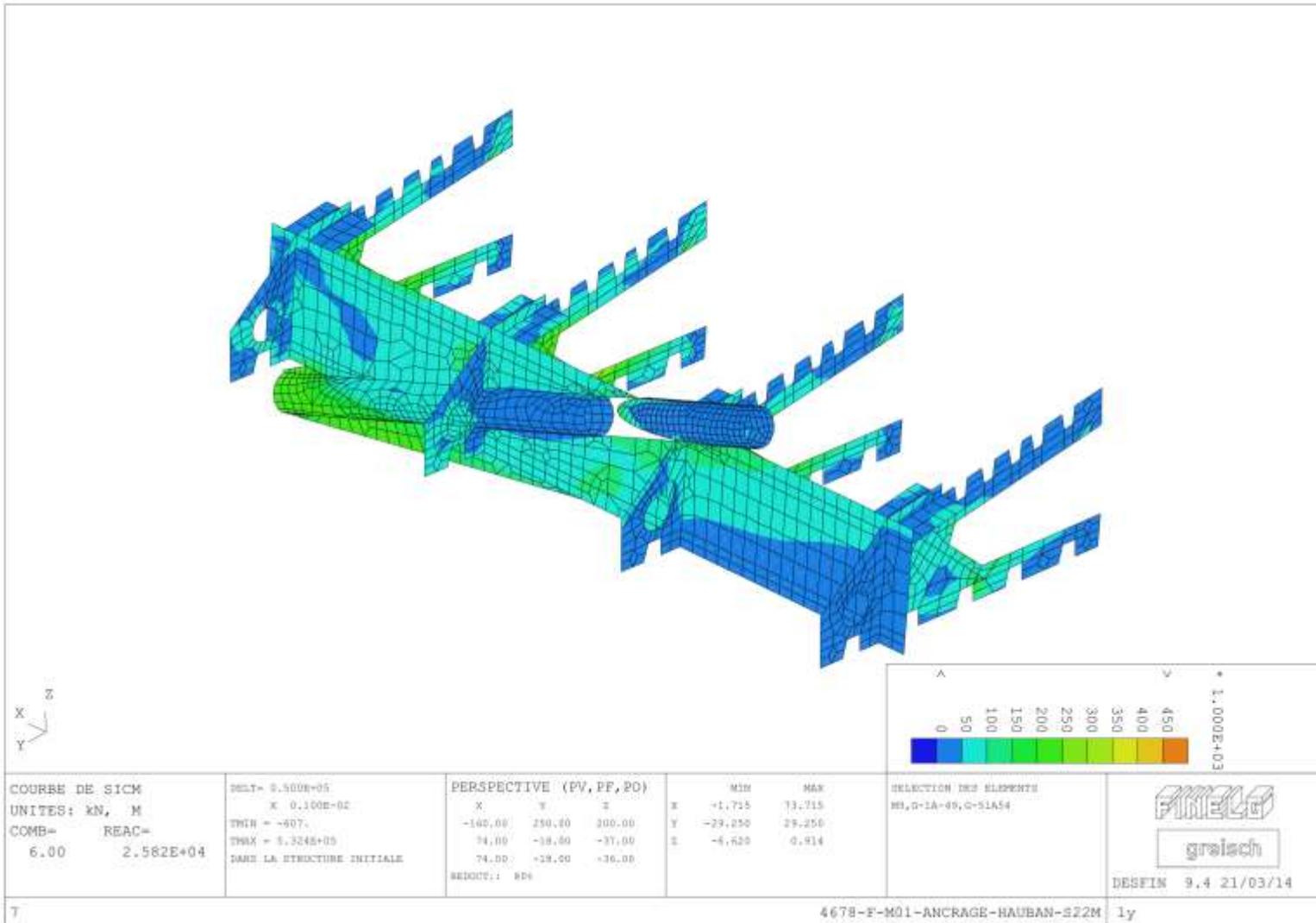
T

4678-F-M01-ANCRAGE-HAUBAN-S22M 1y

Ancrages des haubans

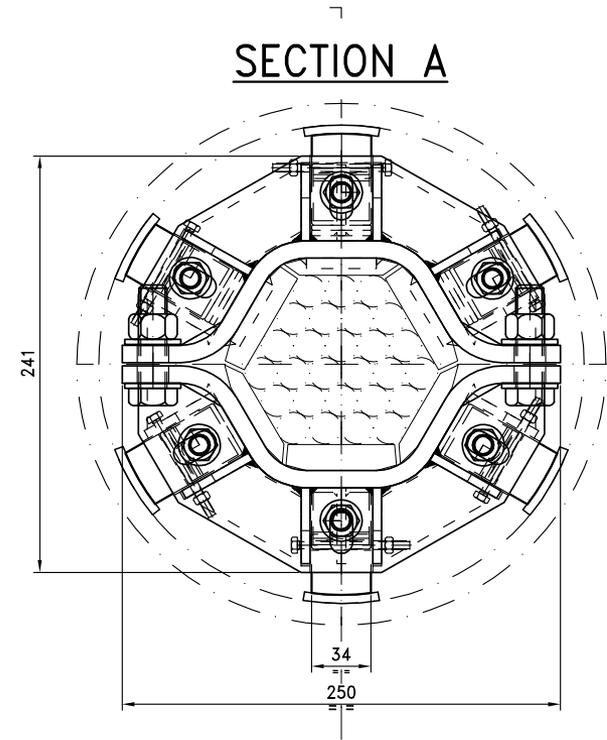
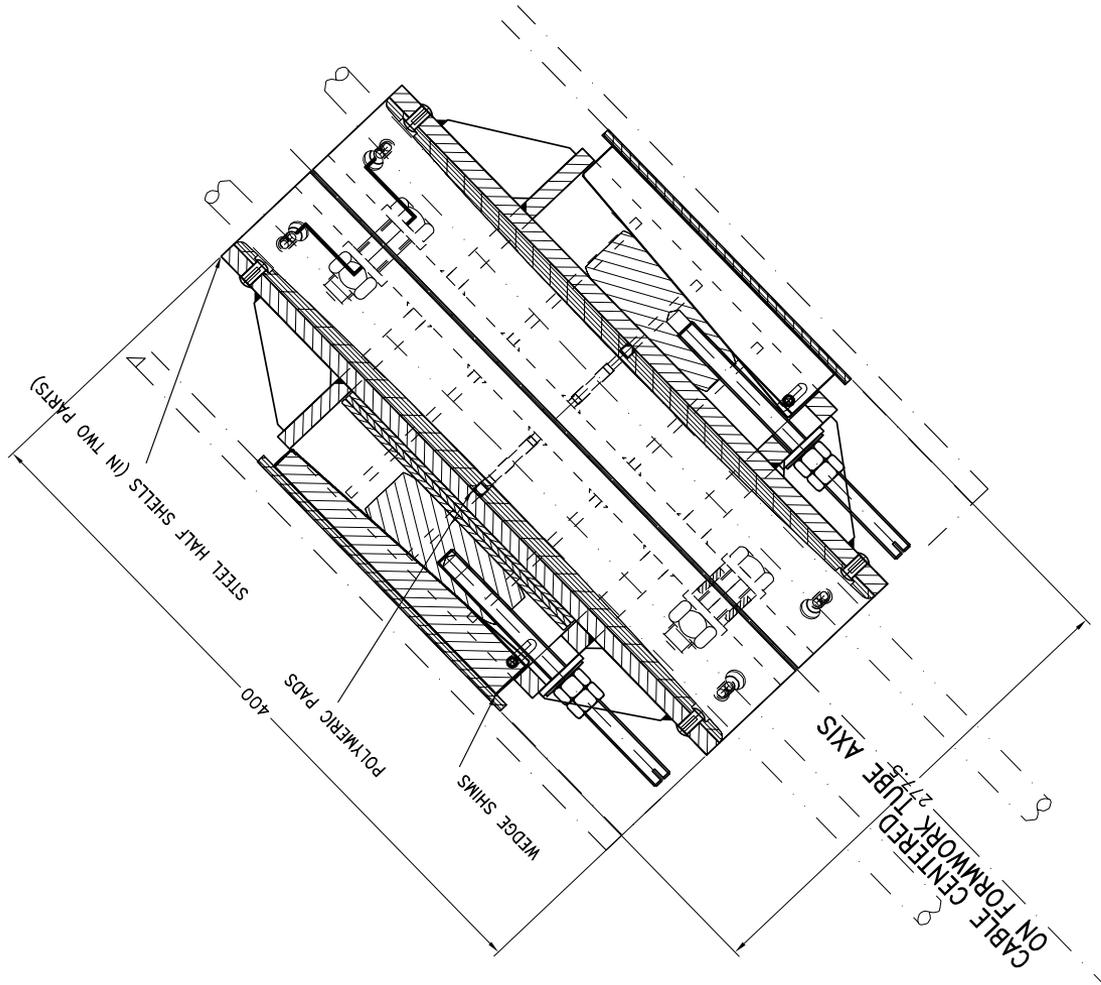


Ancrages des haubans



Ancrages des haubans

Déviateurs



Ancrages des haubans





Vent, Essais en soufflerie,
Aciers moulés des selles,
Comportement en fatigue,
Amortisseurs des haubans,
Montage en encorbellement,
Levage du tablier suspendu,
Clavage,

A dans deux ans ...