2014 ESSS CONFERENCE & ANSYS USERS MEETING
Caesar Business Faria Lima - São Paulo, SP - Brasil
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Finite Element Analysis for Structural Reinforcements in Concrete Railway Bridges

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2014 REGIONAL CONFERENCES

PRESENTATION TOPICS

- Company Overview
- Problem Description
- Methodology
- Results
- Conclusion

Company Overview

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- M.Sc., Civil Engineer.

- Current: Professor of Mechanical and Civil Engineering at University of Mogi das Cruzes.
- Previous: Senior structural engineer at ACCIONA, 2012-2013.
- Previous : Senior civil engineer at Vale Competence Center of Engineering (CCEV) / PROGEN , 2012-2013.
- Previous : Structural engineer at EGT, 2011-2012.
- Previous : Senior engineer at ALSTOM Transport, 2005-2011.
- Previous : Senior research engineer at MAHLE, 2003-2005.
- Previous : Structural engineer at AKAER/EMBRAER, 2000-2003.

Problem Description

- Brazilian logistics operators intend to increase the transport of iron ore in the São Paulo railway mesh and the operating speeds to meet deadlines and volume of goods.

- To increase the volume of iron ore should adopt the train-type TB-360, but the existing bridges along the São Paulo railway mesh were originally designed for train-type TB-20 (Based on old standard ABNT NB 7:43).

- Thus, new bridges must be designed and constructed or should seek to strengthen existing bridges in order to meet this new load configuration.

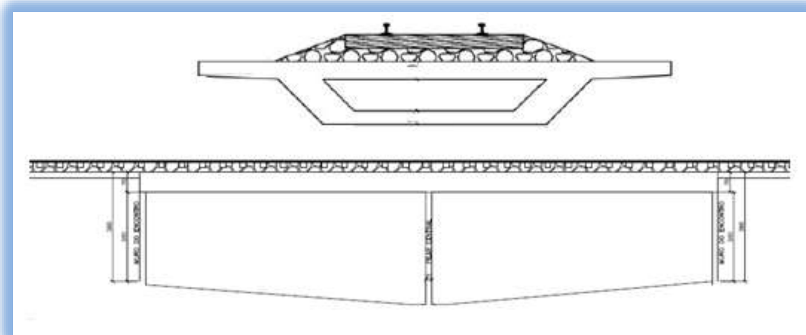
Problem Description

- Another requirement to be met is that the run-off of goods along this railway mesh must be preserved, i.e., is not allowed long periods of interruption in the operation of the railway track.

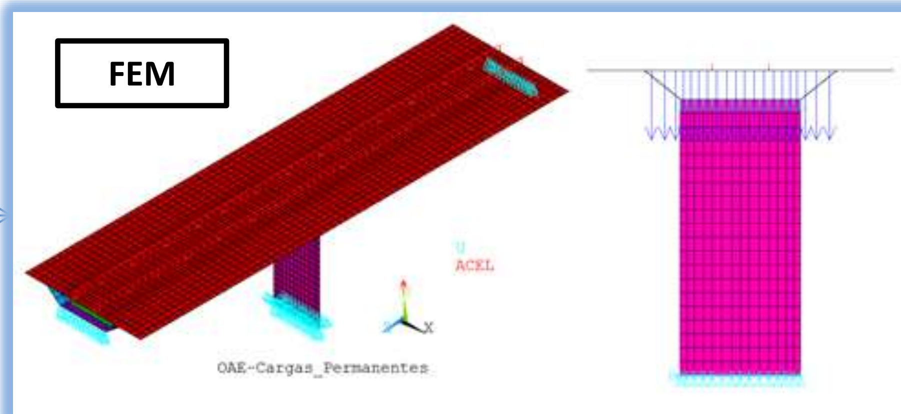
- A finite element analysis is presented for a railway concrete bridge that will be strengthened to ensure the future use of the train-type TB-360 and that during the execution of bridge structural reinforcements with a consideration of a train-type TB-20 does not cause impacts of interruption of the railway track operation.

Methodology

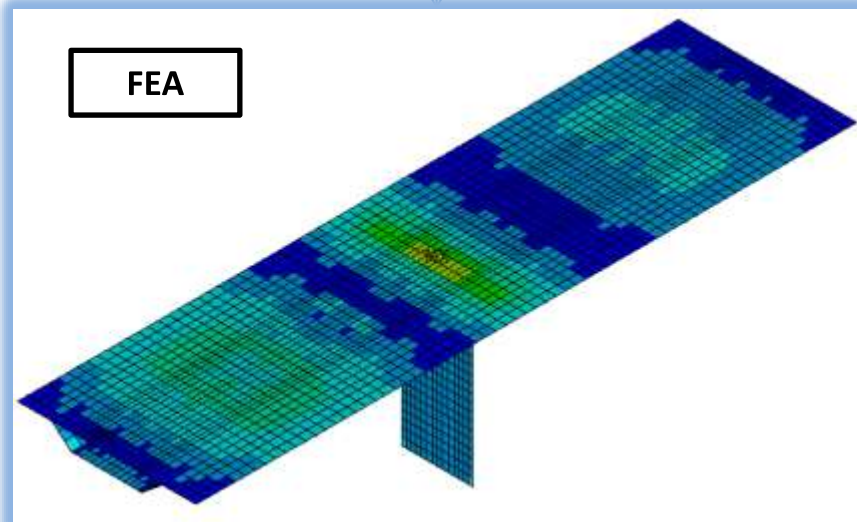
Bridge Structure



FEM



FEA



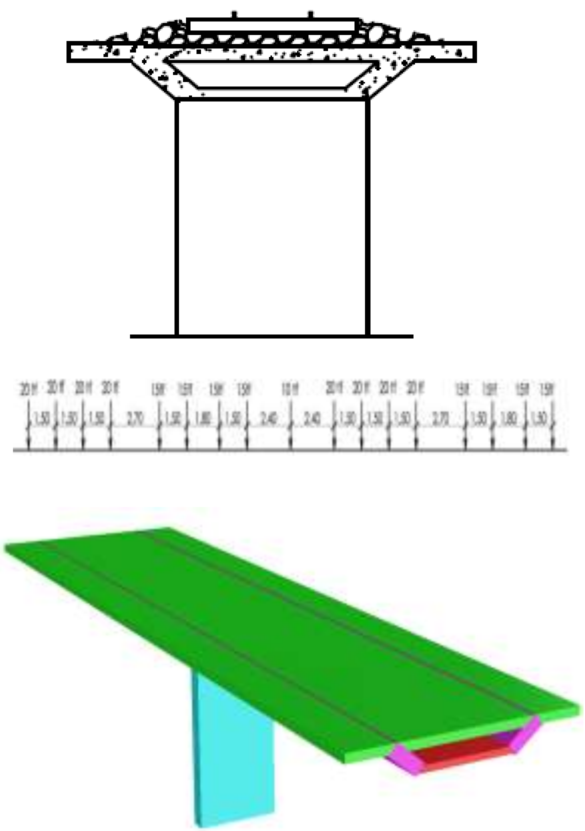
$FEA_i \leq FEA_O$

- **FEA_o: Current Bridge and TB-20**
- **FEA_1: Bridge with formworks and TB-20**
- **FEA_2: Bridge with reinforcements and TB-360**

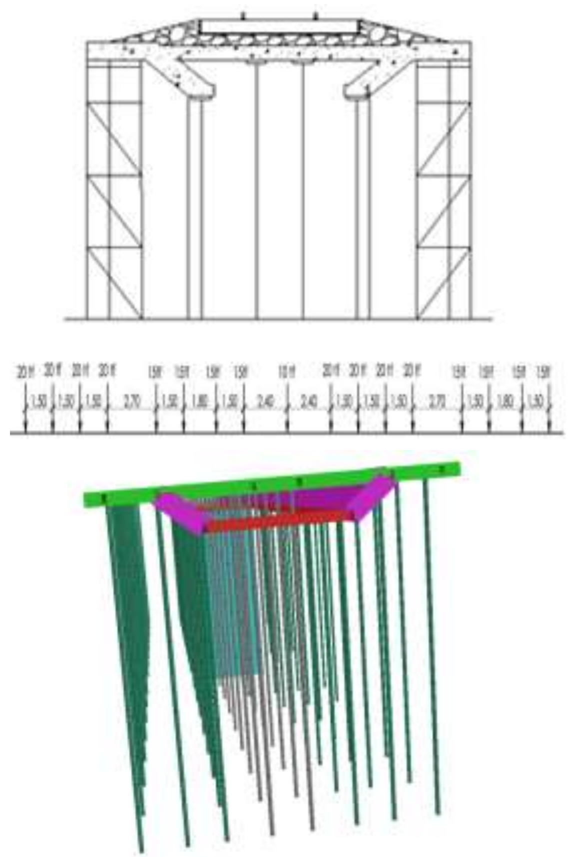
Methodology

- Bridge Structure and Traffic Scenarios

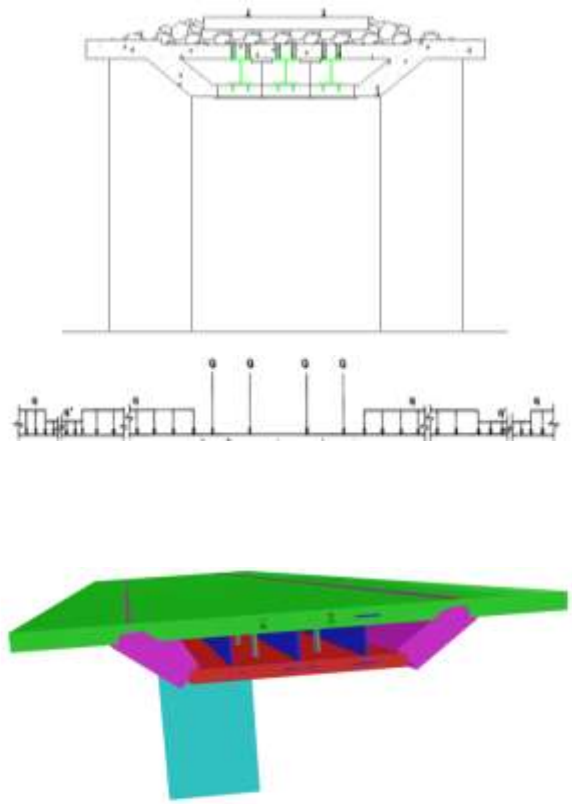
Current Bridge and TB-20



Bridge with formworks and TB-20



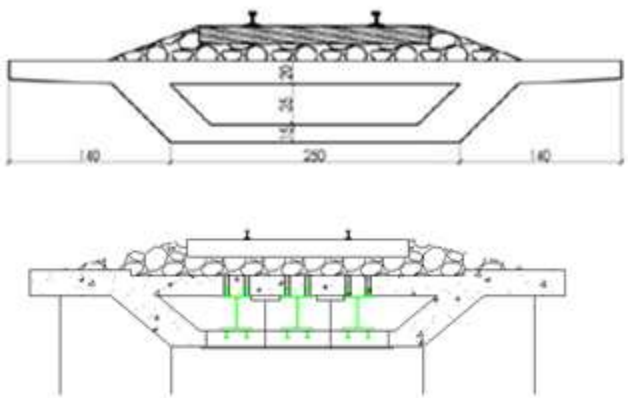
Bridge with reinforcements and TB-360

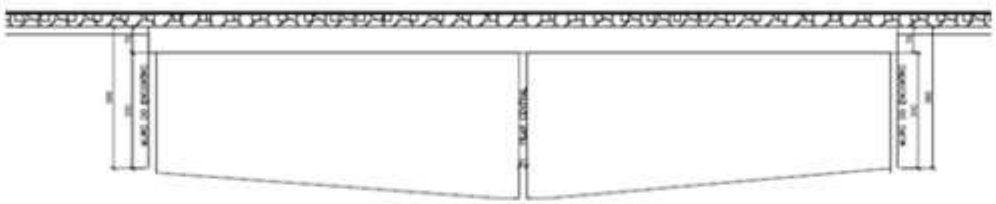


Methodology

Bridge Structure Characteristics

- Geometric





- Material Properties

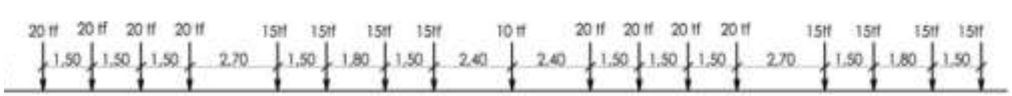
  – Structural concrete: *Fc* > 25MPa
  – Structural Steel reinforcements: *1.0* inches thickness I-shaped cross-section.
  – Poisson coefficient: Concrete μ=0.20 and Steel μ = 0.30
  – Specific weight: Concrete = 25kN/m^3, Steel = 78,50kN/m^3 and Ballast = 18kN/m^3

Methodology

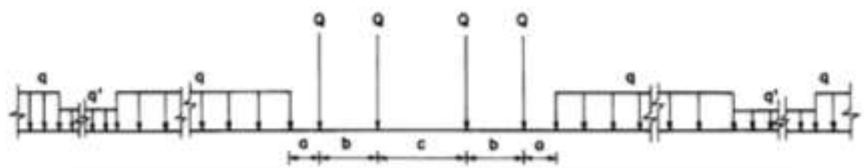
Bridge Loading Conditions

- Dead loads
  - Dead loads consist of weight of concrete structures, track rails, ballast, ties and structural reinforcements.

- Live loads
  - Live loads consist of the train traffic load models
    - Load model TB-20 (ABNT NB 7:43)
    - Load model TB-360 (ABNT NBR 7189)
    - Dynamic magnification factor φ= 1.434



TB-20



TB	Q (kN)	Q (kN/m)	q' (kN/m)	a (m)	b (m)	c (m)
360	360	120	20	1,00	2,00	2,00

TB-360

Methodology

- Bridge Structure - Design Strength
  - According standard NBR 6118 for Ultimate Limit States (ULS):

$$F_d = \gamma_g F_{gk} + \gamma_q F_{qk}$$

γ_g Major factor for Dead Loads. $\gamma_g = 1.40$

F_{gk} Dead Loads

γ_q Minor factor for Live Loads $\gamma_q = 1.40$

F_{qk} Live Loads

Methodology

- Bridge Structure - Design Validation and Goals
  - von Mises stress results from FEAs shall be:

$FEA_i \leq FEA_O$

FEA_O: Current Bridge and TB-20

FEA_1: Bridge with formworks and TB-20

FEA_2: Bridge with reinforcements and TB-360

The railway concrete bridge meets:

(i) The bridge's structural reinforcements ensure the future use of the train-type TB-360.

(ii) The bridge's executive steps for the implementation of structural reinforcements and with the consideration of the train-type TB-20 does not cause impacts of interruption of the railway track operation.

Methodology

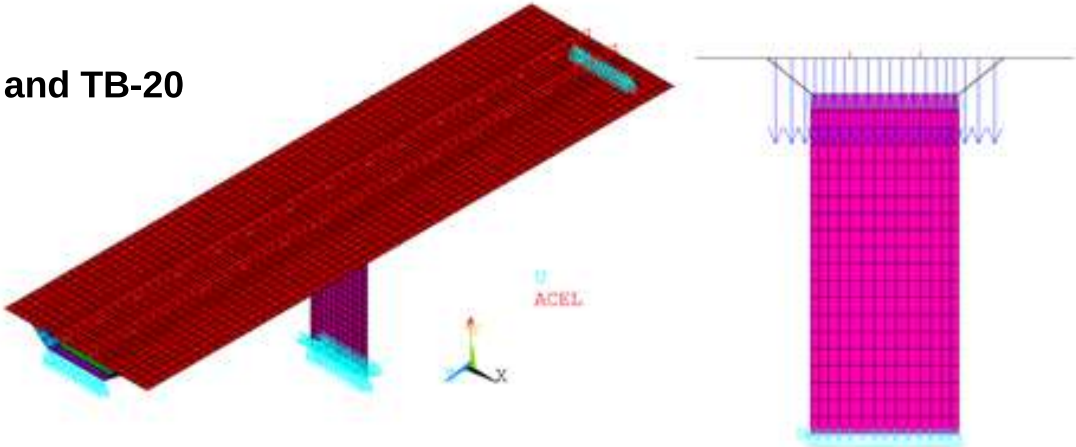
Finite Element Modeling

- Concrete structures and structural steel reinforcements modeled by ANSYS SHELL181 element.
- Formwork structures modeled by ANSYS BEAM188 element.
- Track rails modeled by fictitious beam elements to apply the live loads (bridge traffic loading).
- Boundary conditions: Soil-structure interaction represented by restriction all translation for the bridge's foundation and the basis of formwork structures.
- Dead loading applied as gravitational load and the weight of track rails represented by beam pressure loads.
- Live loads (traffic load models: TB-20 and TB-360) simulated by concentrated loads and beam pressure loads applied on the track rails.
- Materials linear elastic isotropic.

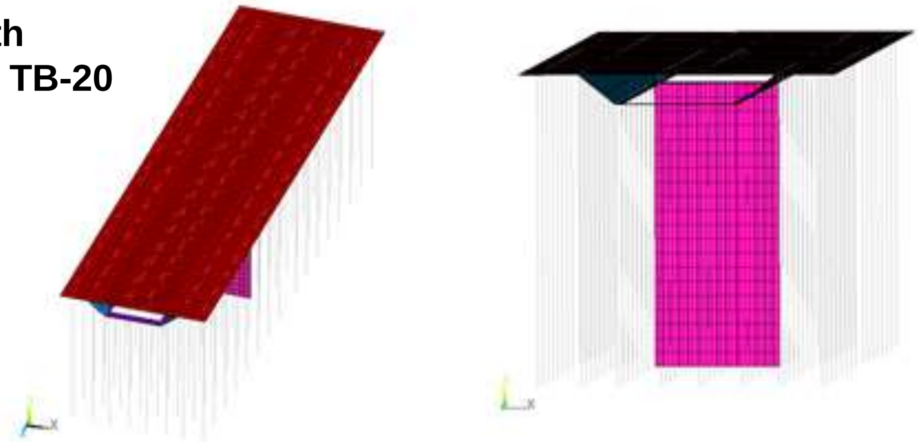
Methodology

Finite Element Models

Current Bridge and TB-20



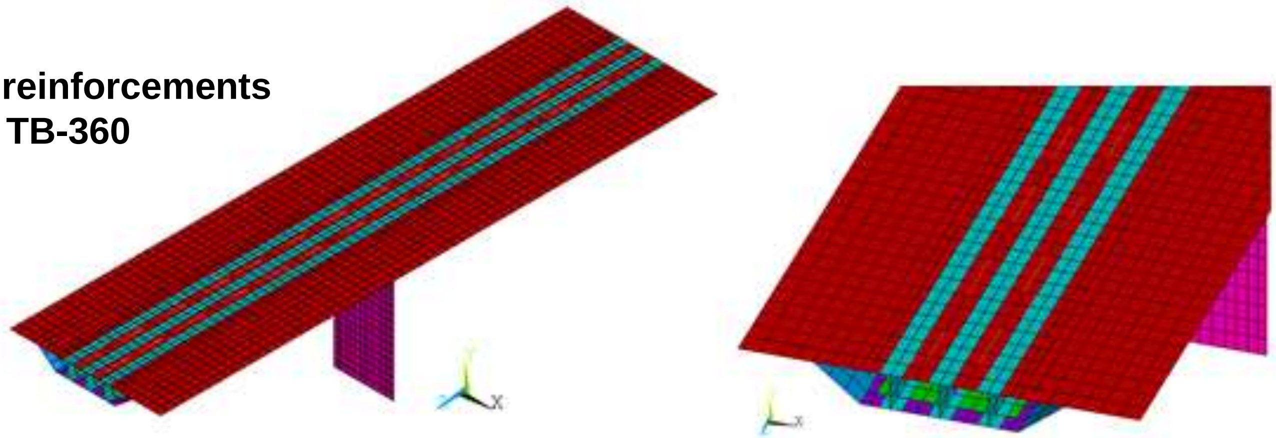
Bridge with formworks and TB-20

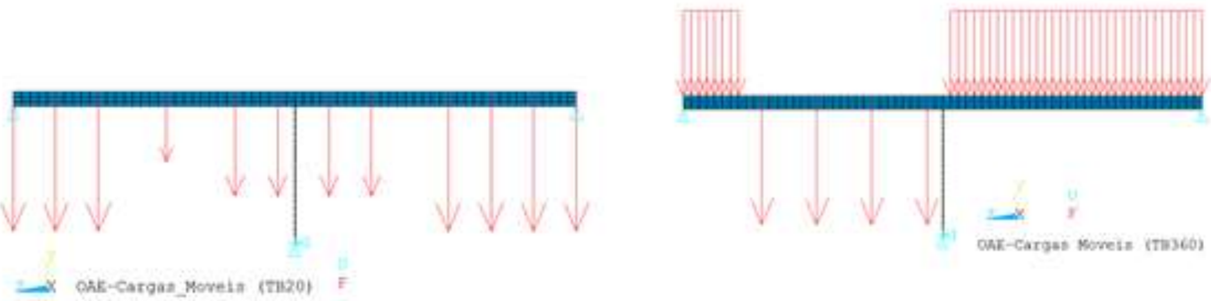


Methodology

Finite Element Models and Traffic Load Models

Bridge with reinforcements and TB-360





Traffic load models: TB-20 and TB-360

Results

- Finite Element Analysis

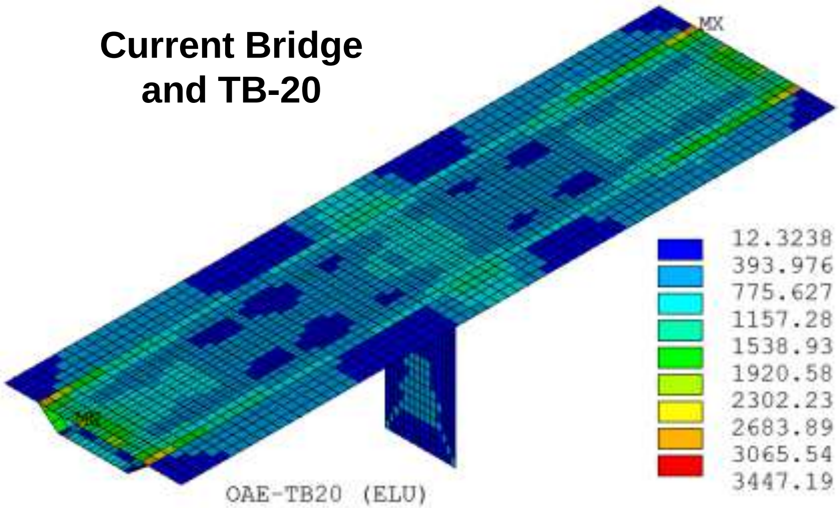
Summary of results – Maximum von Mises stress - ULS

Bridge scenarios	Maximum von Mises Stress (MPa) - ULS									
	Superior Slab			Inferior Slab			Longitudinal Beams			Central Support
	Middle Span	Central Support	End Supports	Middle Span	Central Support	End Supports	Middle Span	Central Support	End Supports	
Current Bridge and TB-20	10,7	10,8	22,2	10,3	28,7	10,8	11,2	22,0	13,6	3,9
Bridge with formworks and TB-20	3,9	2,7	12,0	0,0	0,9	1,5	1,2	1,7	2,5	0,3
Bridge with reinforcements and TB-360	8,1	10,8	2,1	10,1	19,0	5,6	6,0	13,3	4,7	4,1

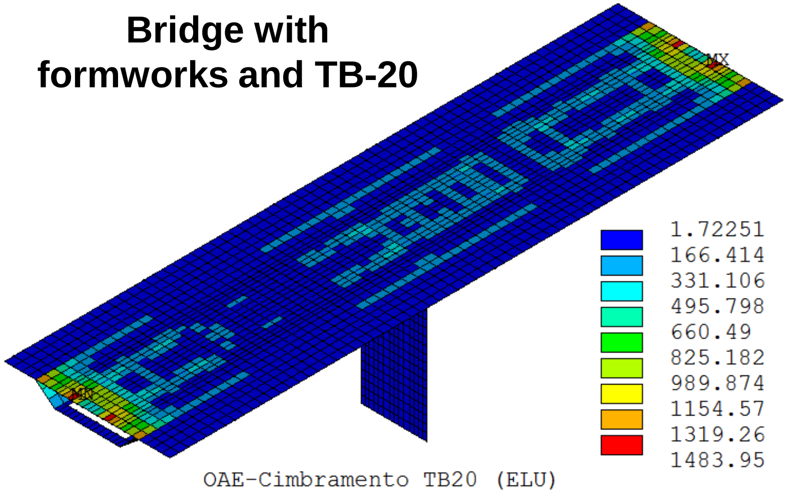
Results

Bridge Structure - Maximum von Mises stress results (ton/m^2) - ULS

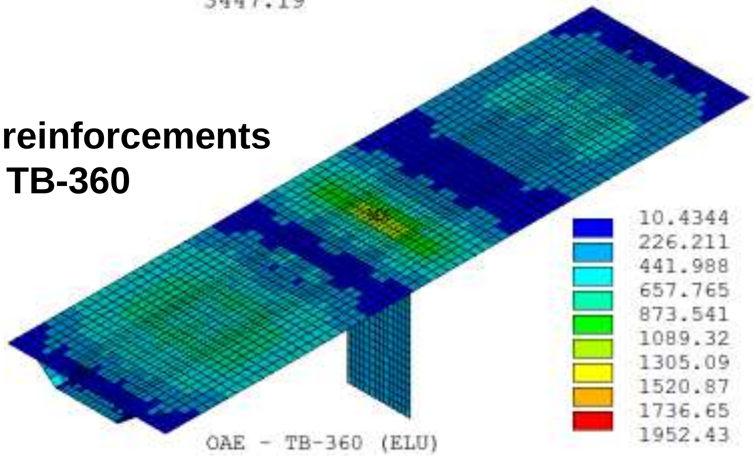
Current Bridge and TB-20



Bridge with formworks and TB-20



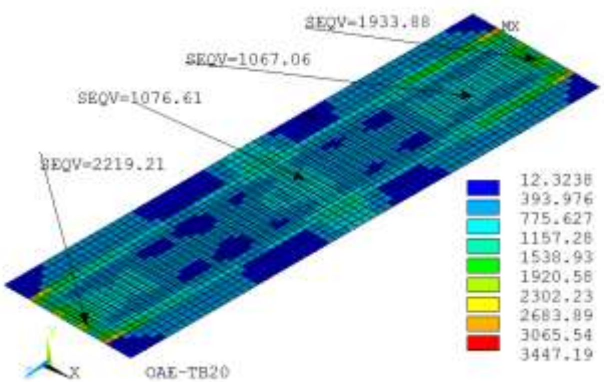
Bridge with reinforcements and TB-360

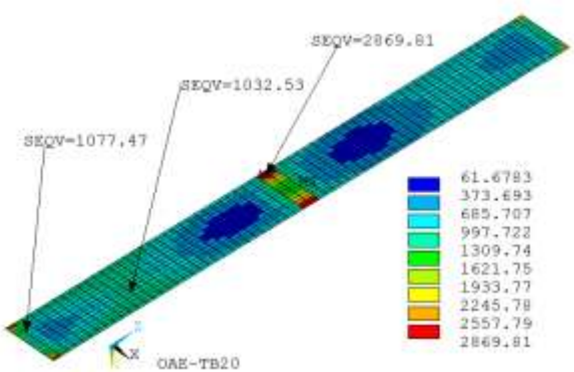


Results

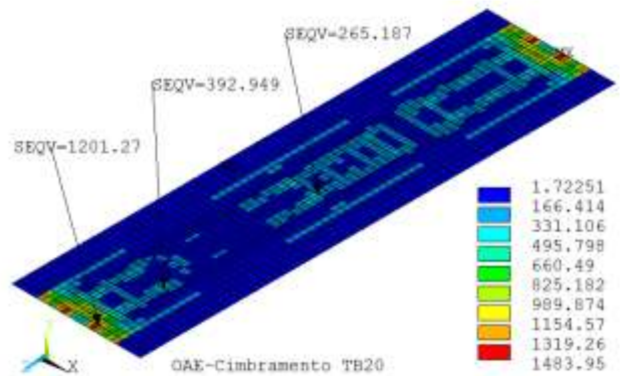
Superior and Inferior Slabs - Maximum von Mises stress results (ton/m^2) - ULS

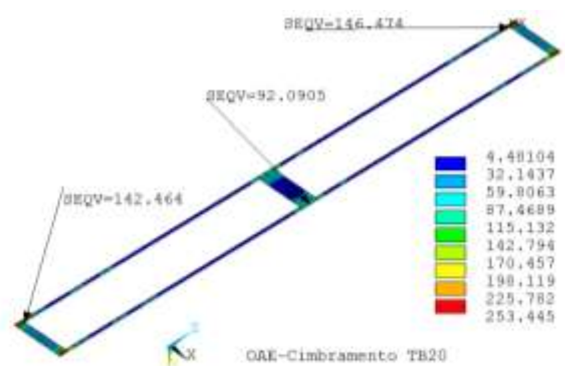
Current Bridge and TB-20



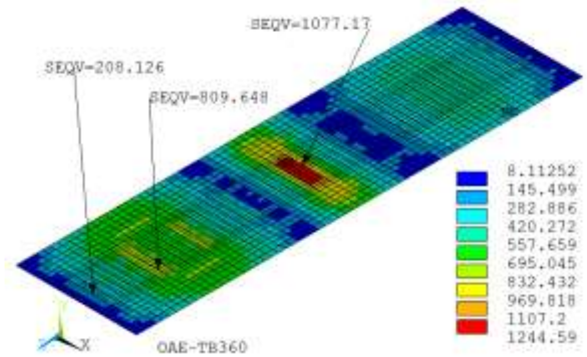


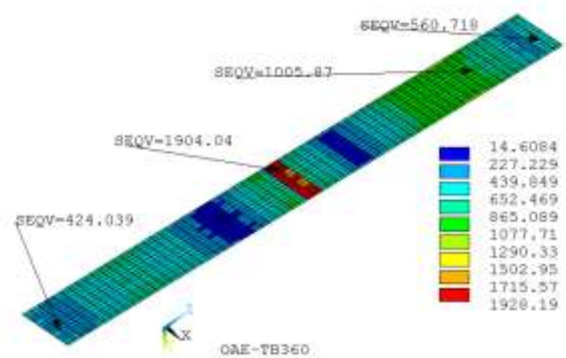
Bridge with formworks and TB-20





Bridge with reinforcements and TB-360





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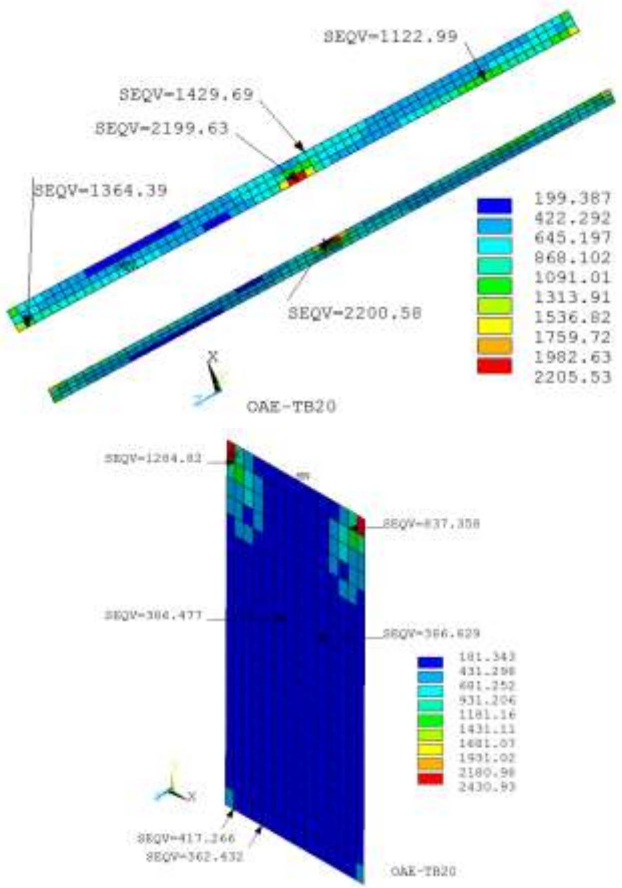
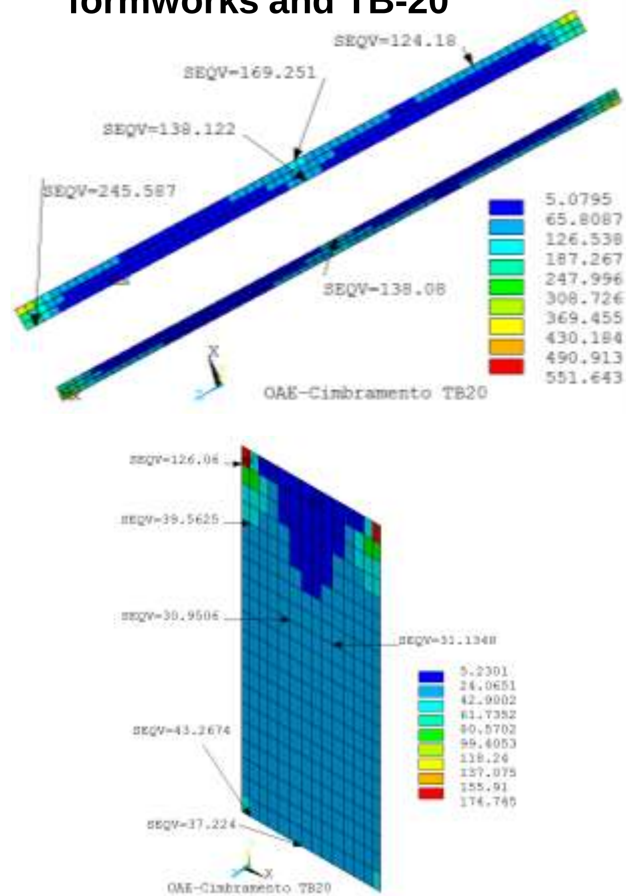
Results

Beams and Mesostructure - Maximum von Mises stress results (ton/m^2) - ULS

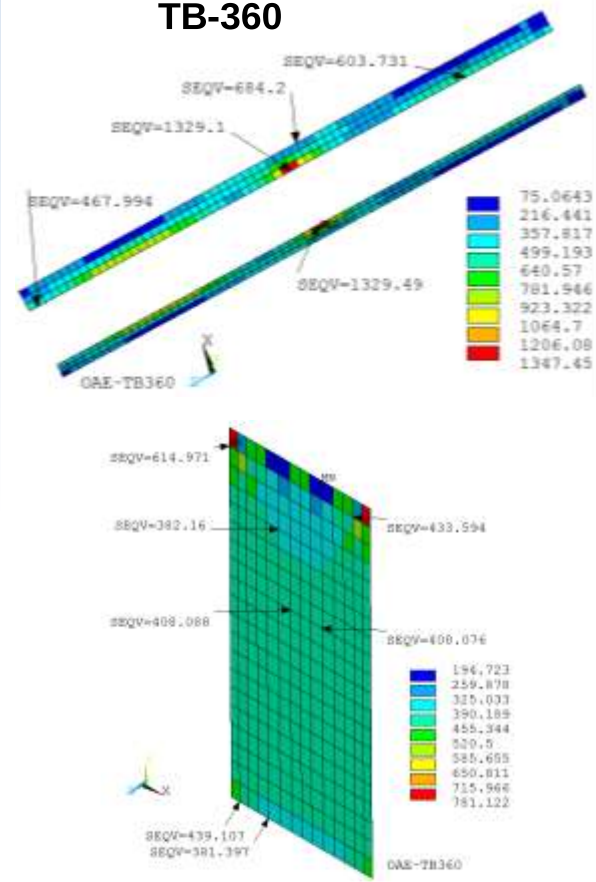
Current Bridge and TB-20



Bridge with formworks and TB-20



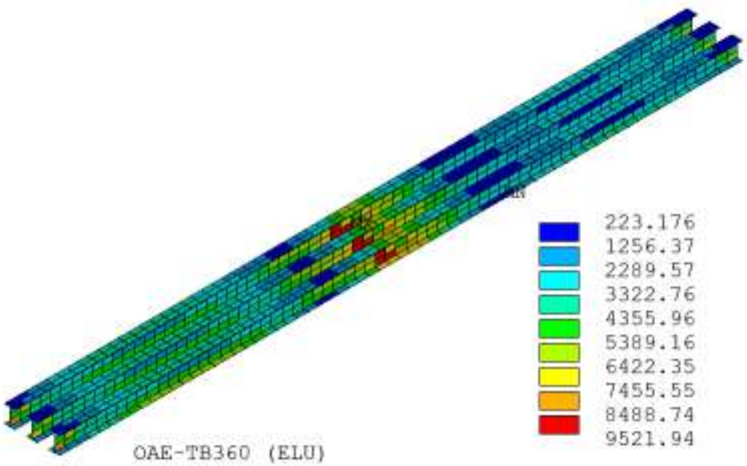
Bridge with reinforcements and TB-360



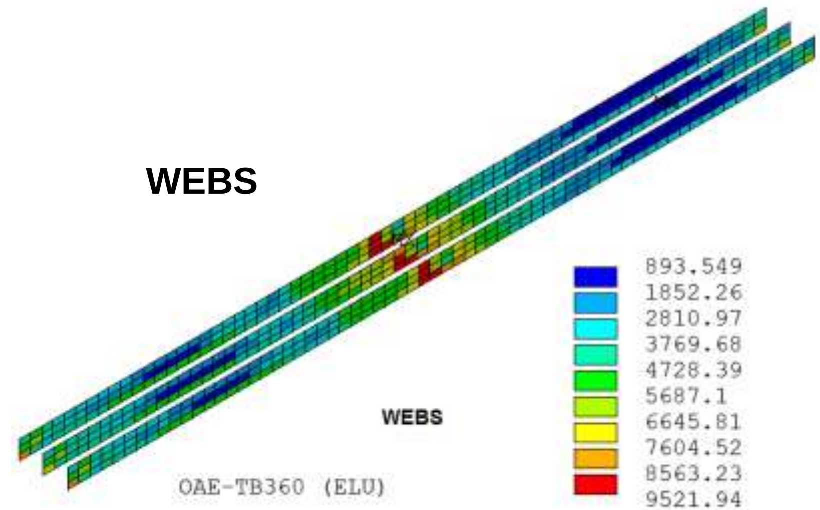
Results

Structural Reinforcements - Maximum von Mises stress results (ton/m²) - ULS

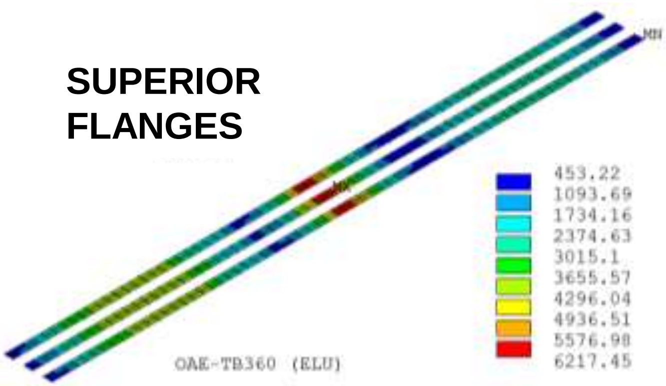
Bridge with reinforcements and TB-360



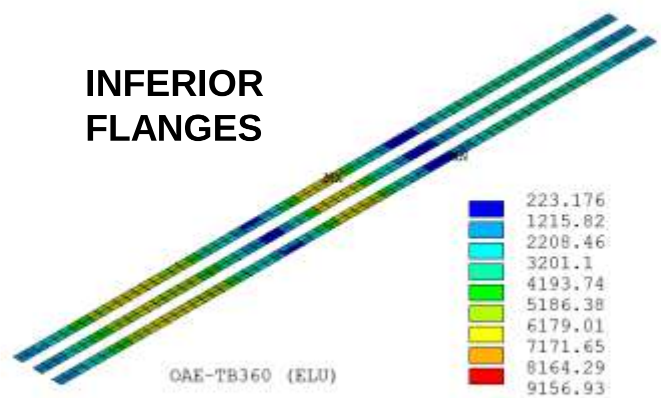
WEBS



SUPERIOR FLANGES



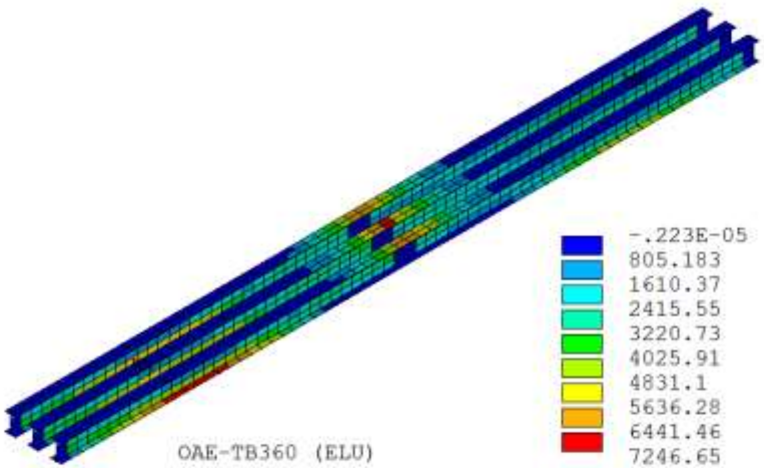
INFERIOR FLANGES



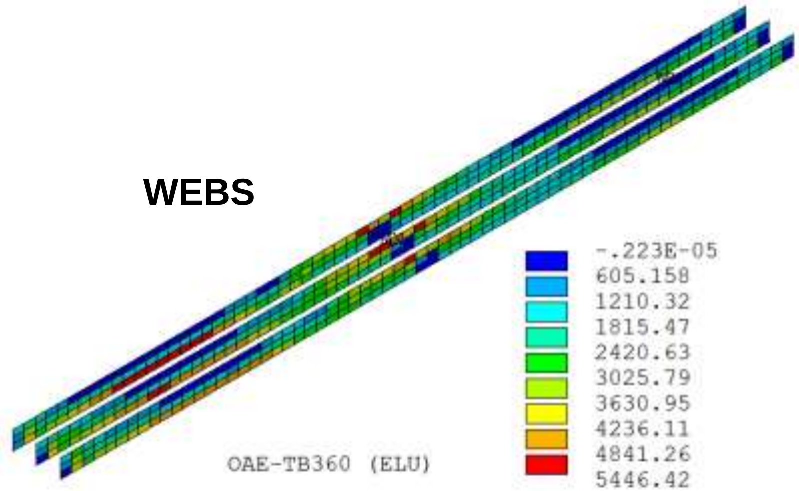
Results

Structural Reinforcements - Maximum Principal stress results (ton/m^2) - ULS

Bridge with reinforcements and TB-360



WEBS



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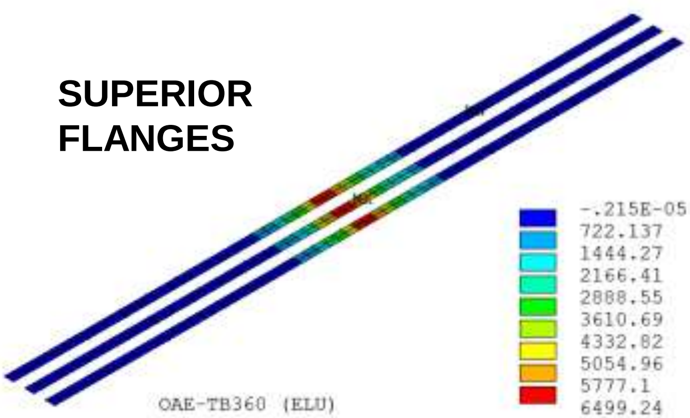
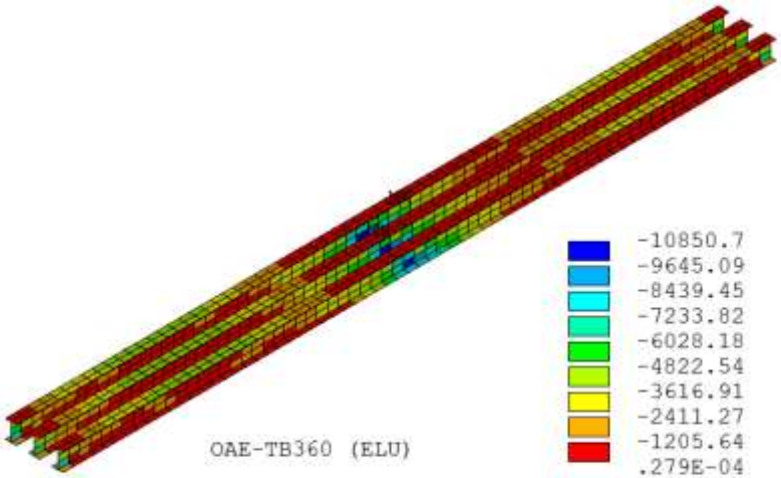


INFERIOR FLANGES

Results

Structural Reinforcements - Minimum Principal stress results (ton/m^2) - ULS

Bridge with reinforcements and TB-360



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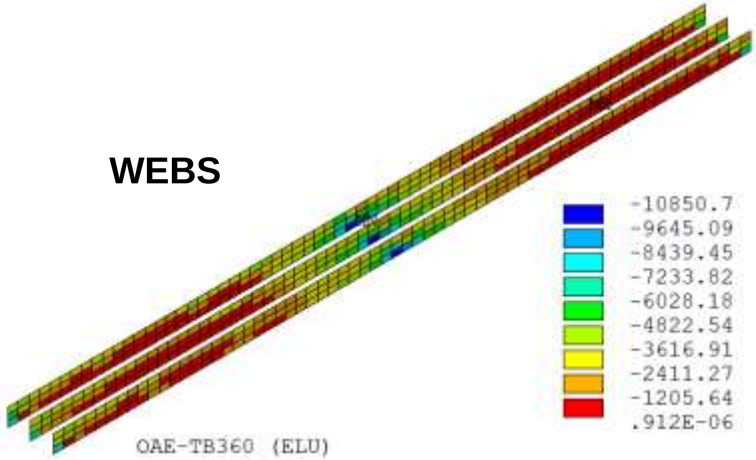

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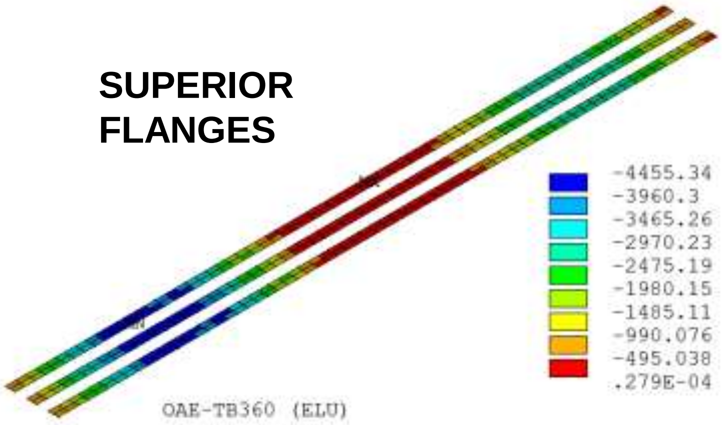


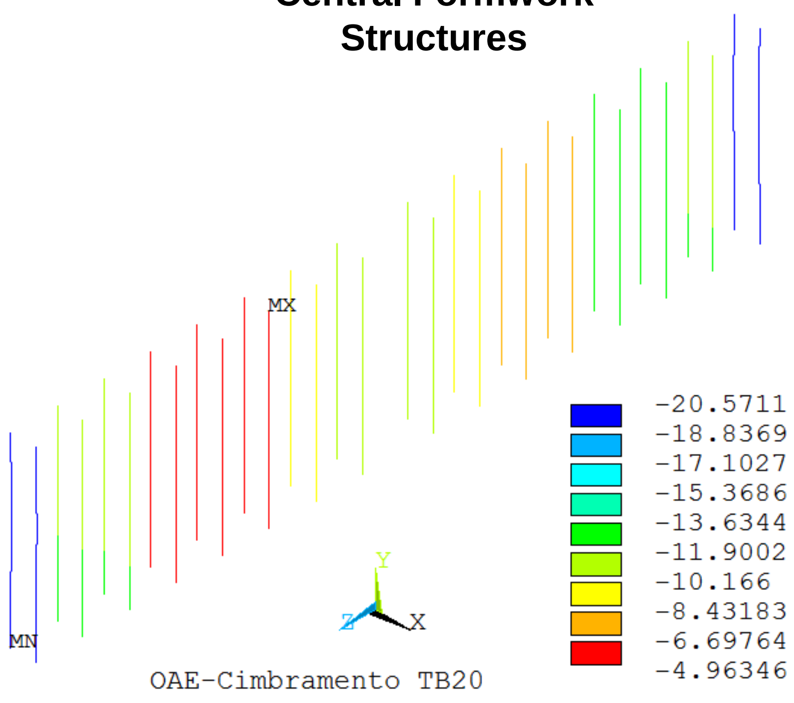
INFERIOR FLANGES

Results

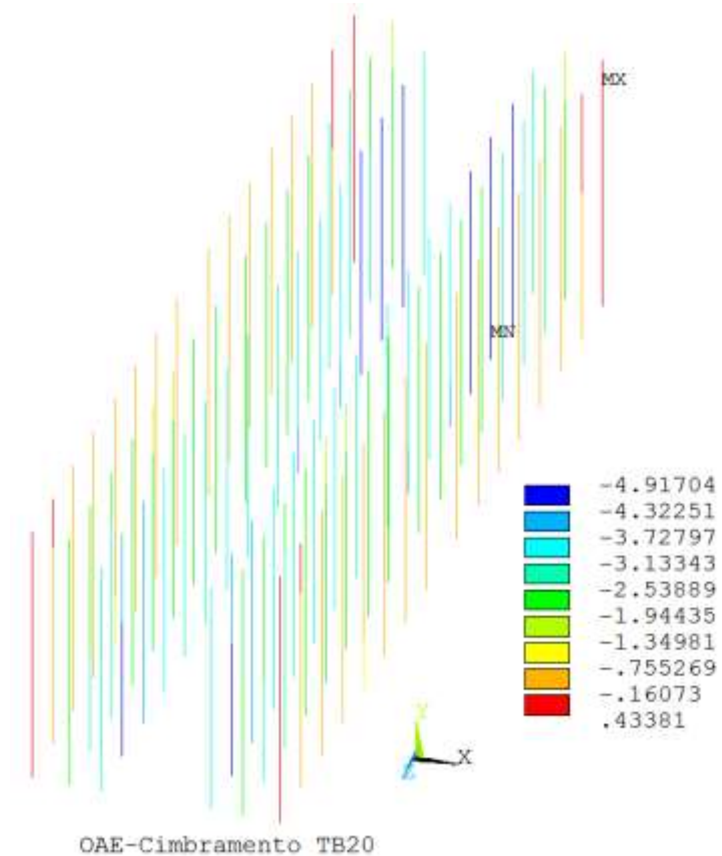
Formwork Structures – Compression forces results (ton) - ULS

Bridge with formworks and TB-20

Central Formwork Structures



Lateral Formwork Structures



Conclusion

By the results presented previously, it is noted that the values of von Mises stress obtained for scenarios (2) and (3) are smaller than those obtained from scenario (1).

Thus, it is concluded that the railway concrete bridge meets:

- The bridge's structural reinforcements ensure the future use of the train-type TB-360.

- The bridge's executive steps for the implementation of structural reinforcements and with the consideration of the train-type TB-20 does not cause impacts of interruption of the railway track operation.