IZMIT BAY BRIDGE

› **Kent Fuglsang**
› **COWI, Bridges - International**

IZMIT BAY BRIDGE

› World no. 4 - 1550m main span suspension bridge
› High seismic load
› Short construction period - 38 months

General

- Major infrastructure project in Turkey. New highway from Gebze to Izmir – 420 km.
- Approx. $11 billion construction cost – bridge cost $1.2 billion
- Bridge site location approx. 50 km East of Istanbul
- BOT project

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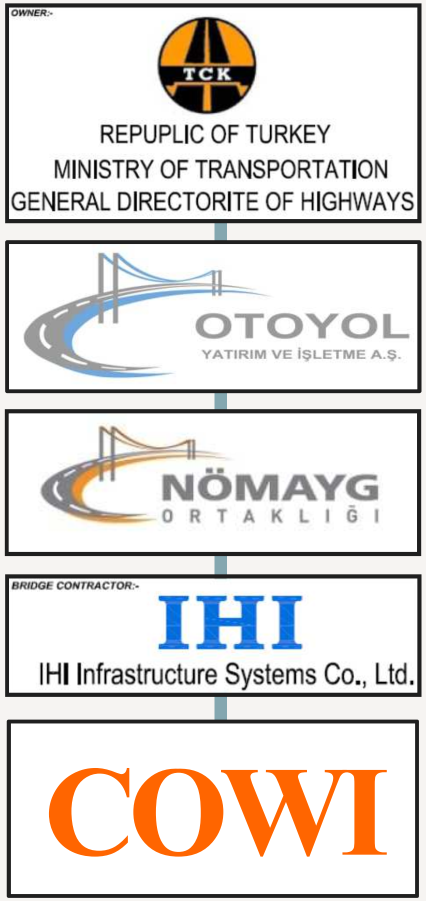
Brief history

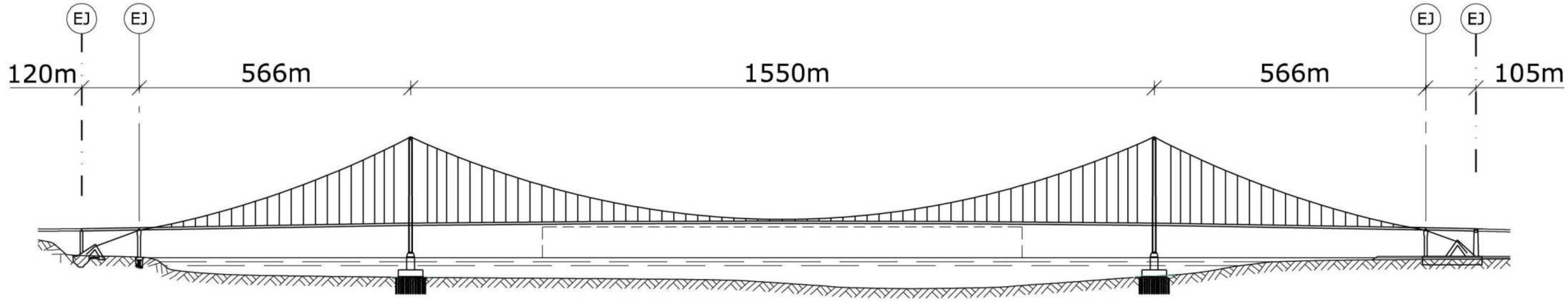
- Project under preparation since 90's
- **May 2010: invitation to tender**
- **Sep 2010: tender submission**
- Three bidding contractor groups – Japan (IHI), China, Korea
- Jan–Sep 2011: contract negotiations
- **Sep 2011: start detailed design**
- Sep 2012: start preparatory site works
- **Jan 2013: start permanent site works**
- **Mar 2016: completion**

Project Organisation

- Owner: KGM – Turkish Ministry of Traffic
- Employer: OTOYOL / **NÖMAYG** Joint Venture
- Bridge contractor: IHI, Japan
- Bridge designer: COWI



General layout



- Navigational clearance profile 64.3x1000m
- Tower foundations at approx. 40m water depth with base isolation
- Steel towers
- Bridge deck continuous at towers with no vertical support
- South piers supported on South anchor block (integrated structure)

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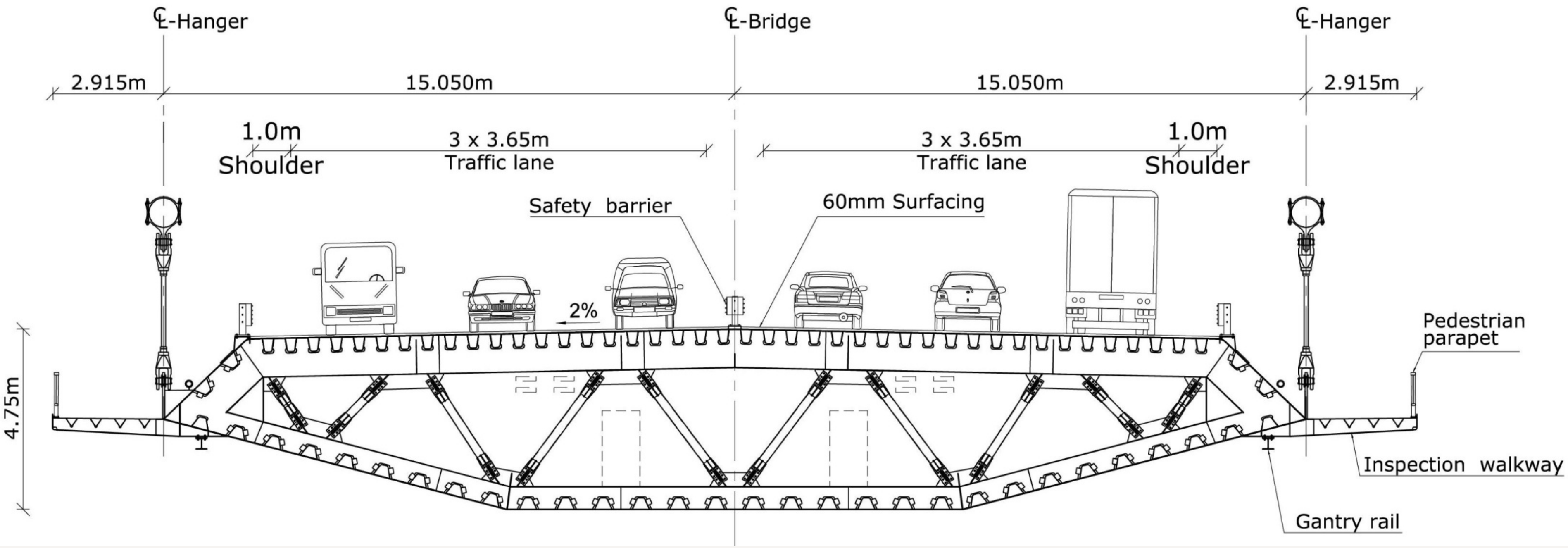
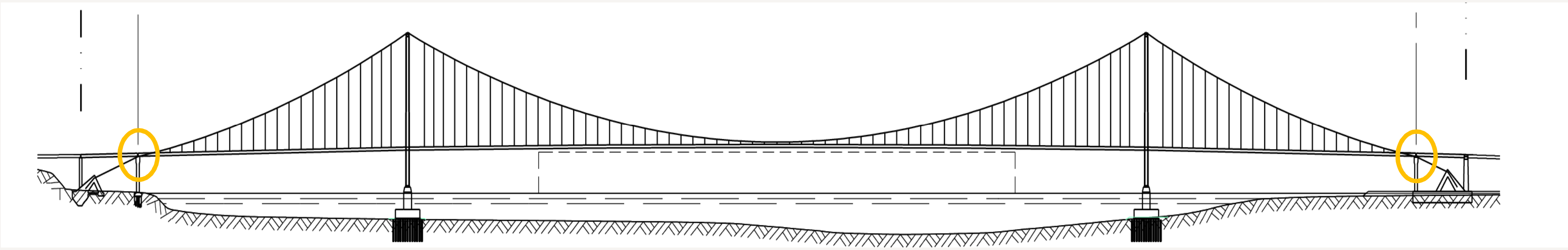
General arrangement - Bridge deck

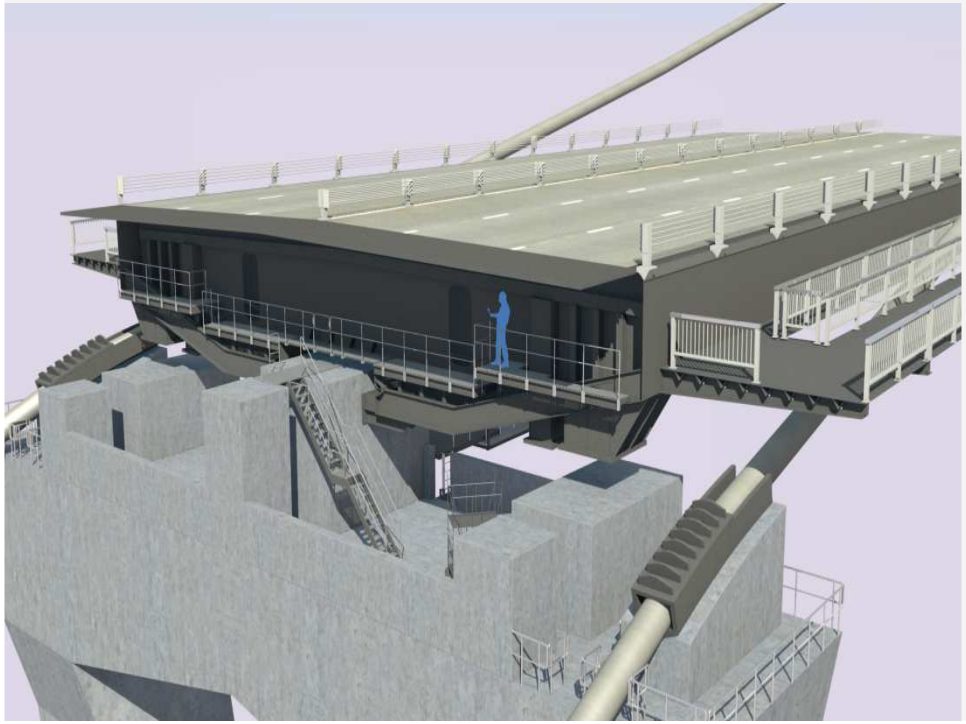


- Closed steel box girder - depth 4.75m - truss diaphragms at 5m spacing
- 14mm deck plate - trough depth 360mm - 60mm roadway surfacing
- Corrosion protection of box interior by dehumidification

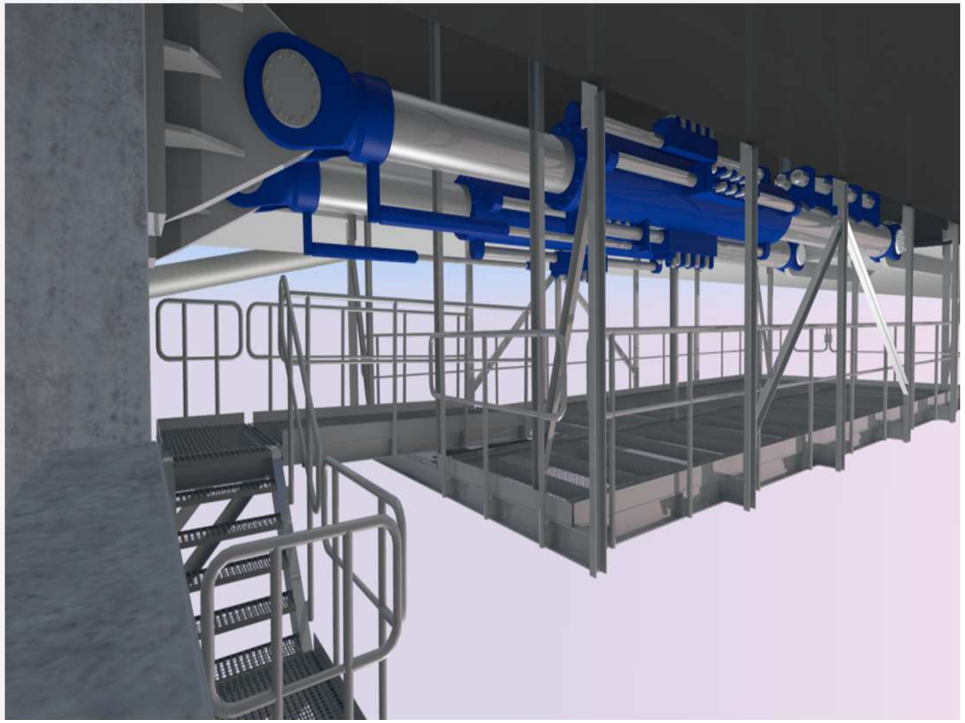
General layout



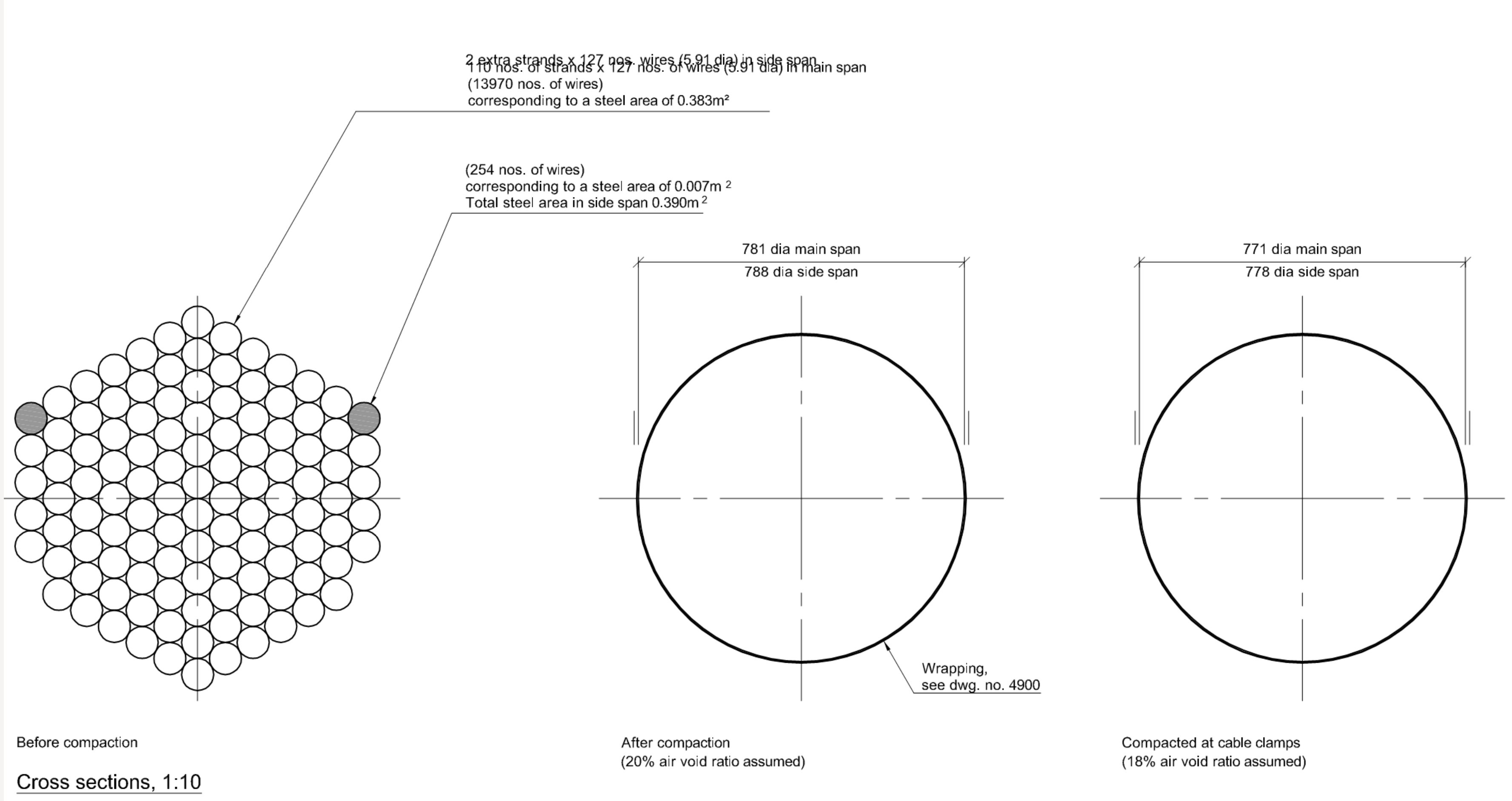
Main cable support at side span piers



Hydraulic buffers at side span piers



General arrangement – Cable structures



- Sag-to-span-ratio 1:9
- Prefabricated strands
- 110 strands each with 127 nos. 5.91 mm diameter wires, 1760 MPa
- 781 mm diameter

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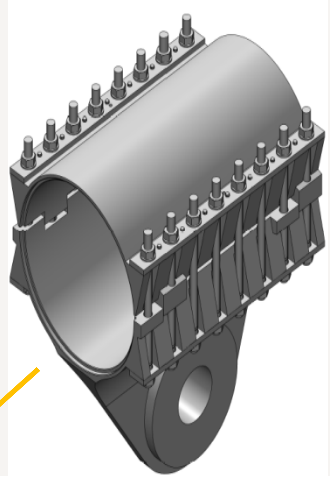
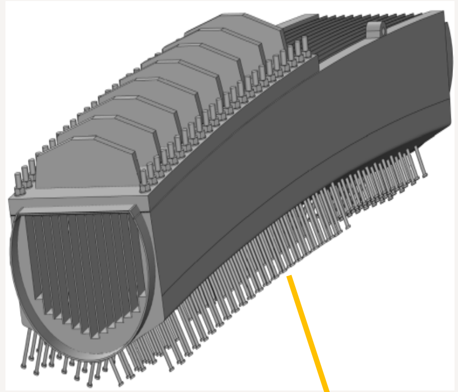
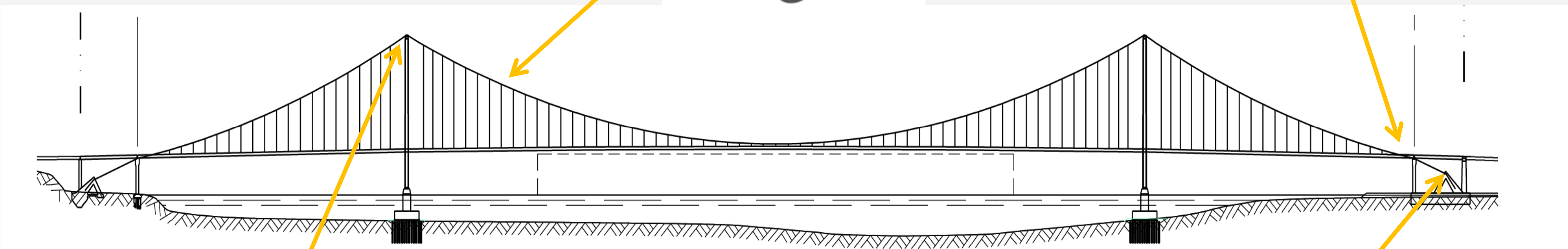
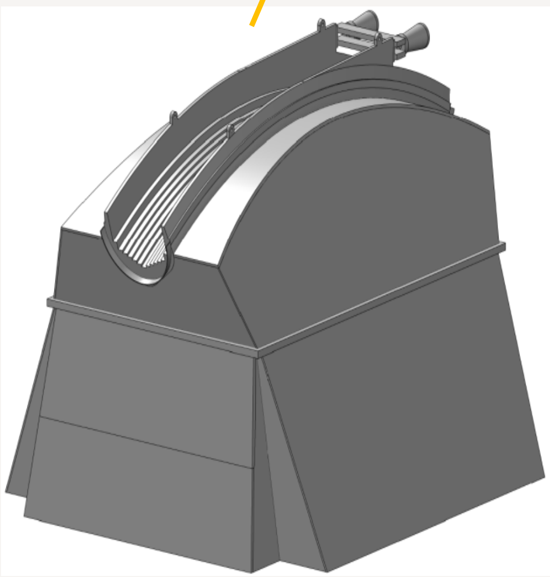
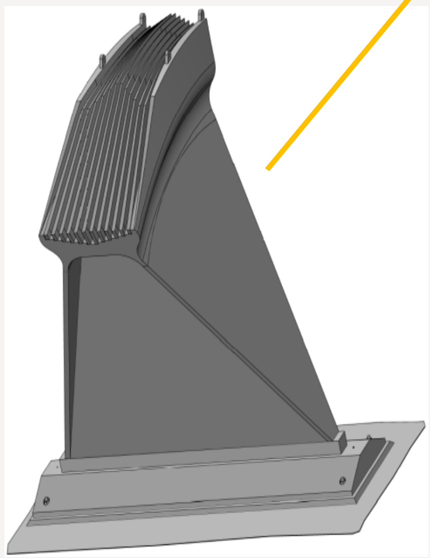
Clamps and saddles





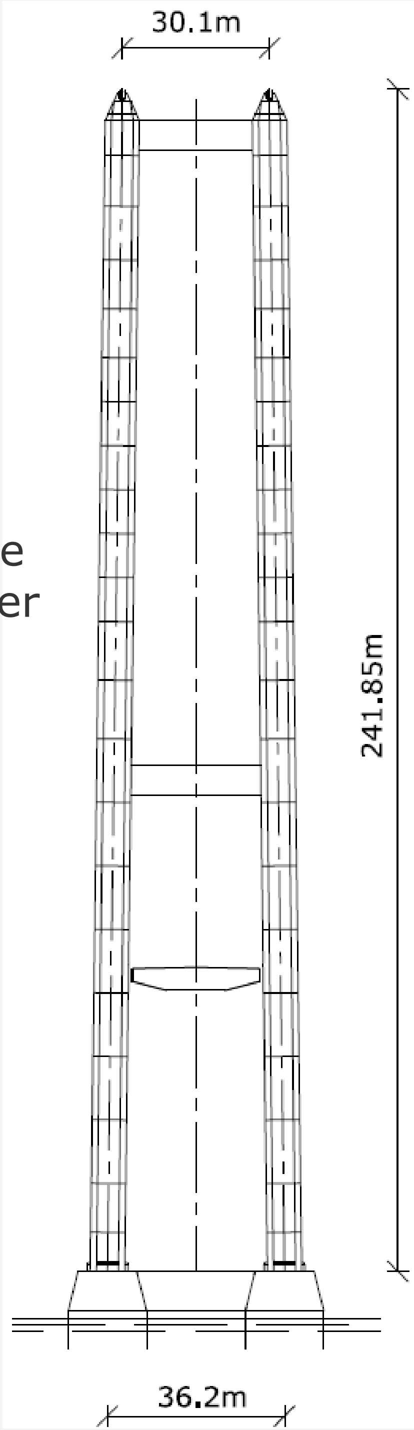


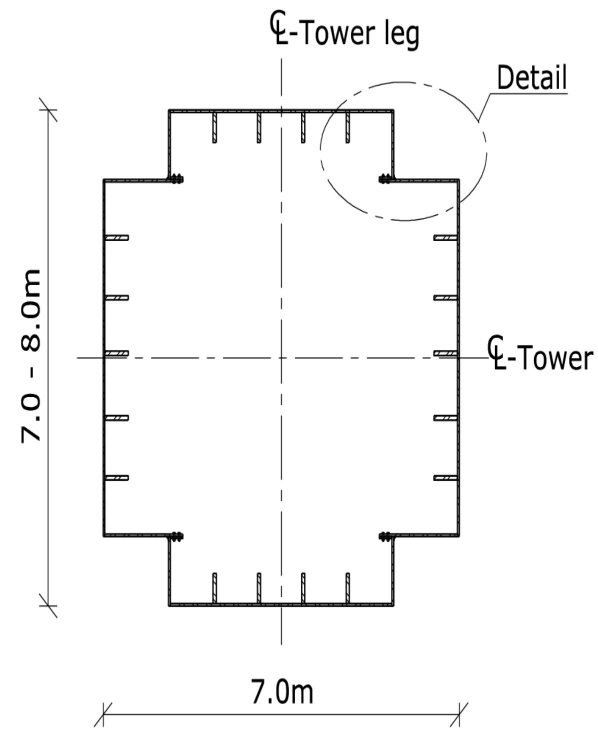


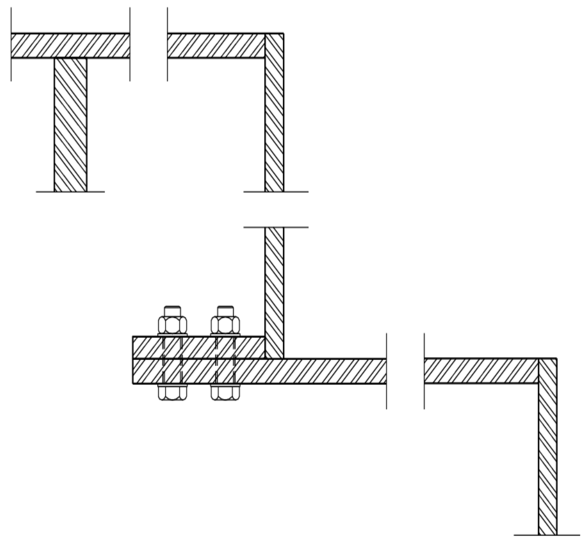


Towers

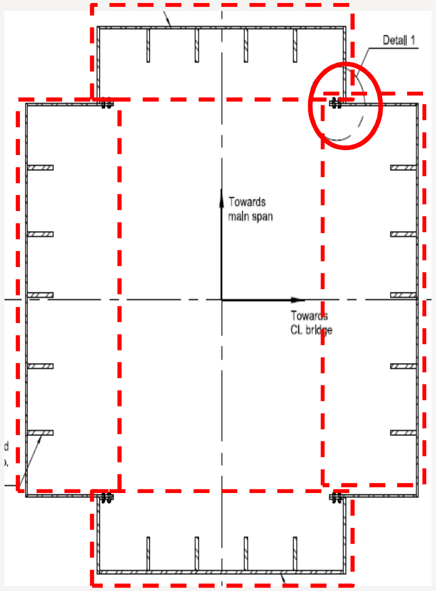
- Steel towers / low weight / increased flexibility / fast construction
- Seismic load combinations and normal ULS combinations are more or less equal in governing the tower design
- Constructed by prefabricated elements – 22 blocks
- Horizontal joints by combined welding and bolting

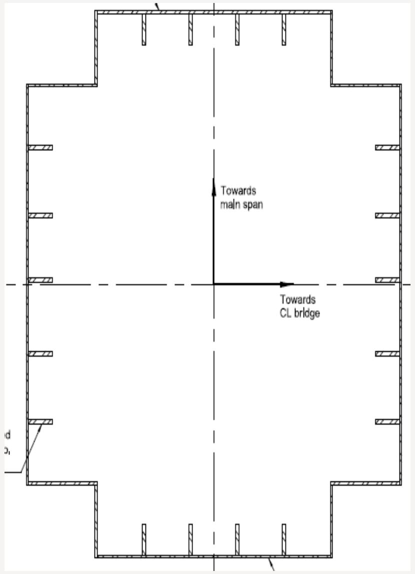


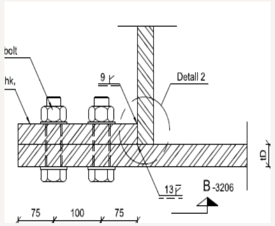


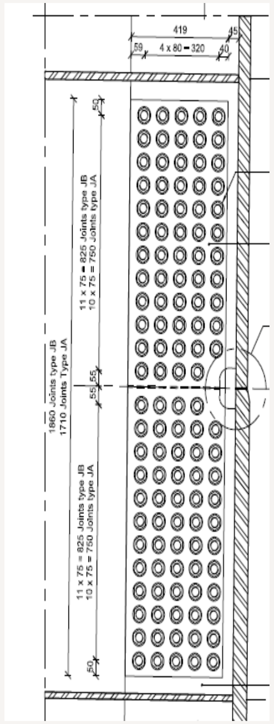


Block erection of towers





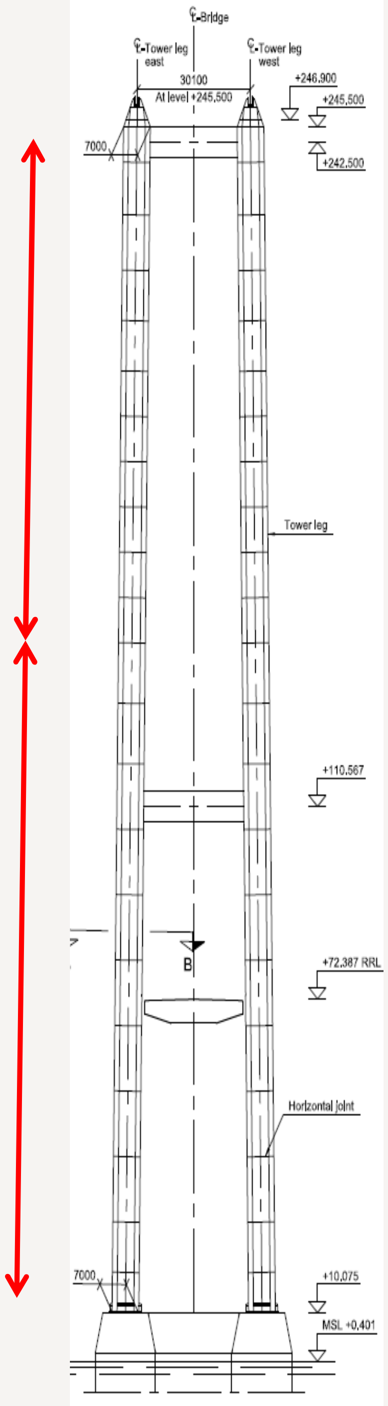




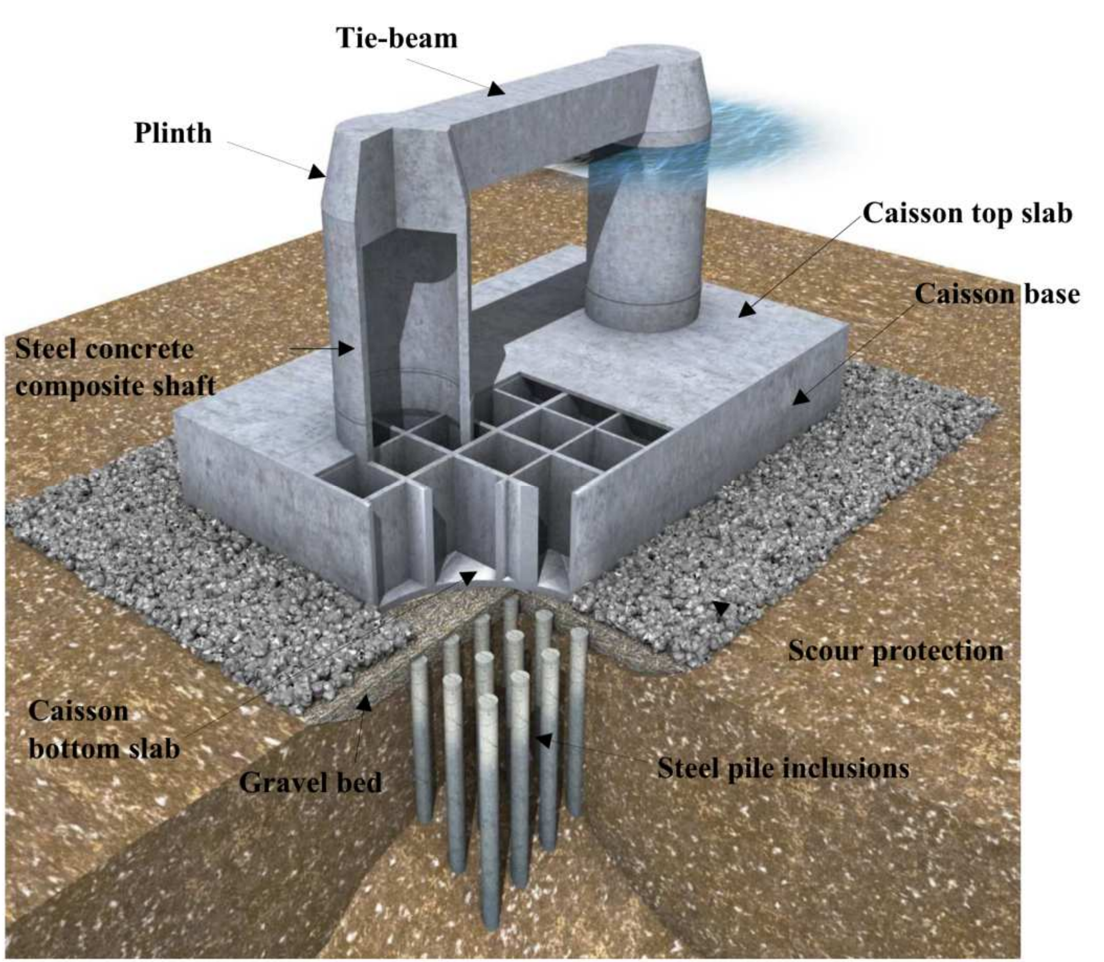
Bolt friction connection in stiffeners

Panel erection
Block no. 12-22
Tower crane, 40t

Block erection
Block no. 1-11
Floating crane, 300t



Tower foundations



- Reinforced soil with steel inclusion piles (195 nos. ø2m dia. per foundation)
- Gravel bed (3m thick) allowing caisson to slide during earthquake
- Pre-fabricated caisson (54x67x15m)
- Composite steel/concrete shafts (16m dia, t = 1.2m) with high robustness against ship impact
- Solid plinths with anchor bolts for fixing of the steel tower


IZMIT BAY CROSSING BRIDGE PROJECT
CROSSING BRIDGE PROJECT
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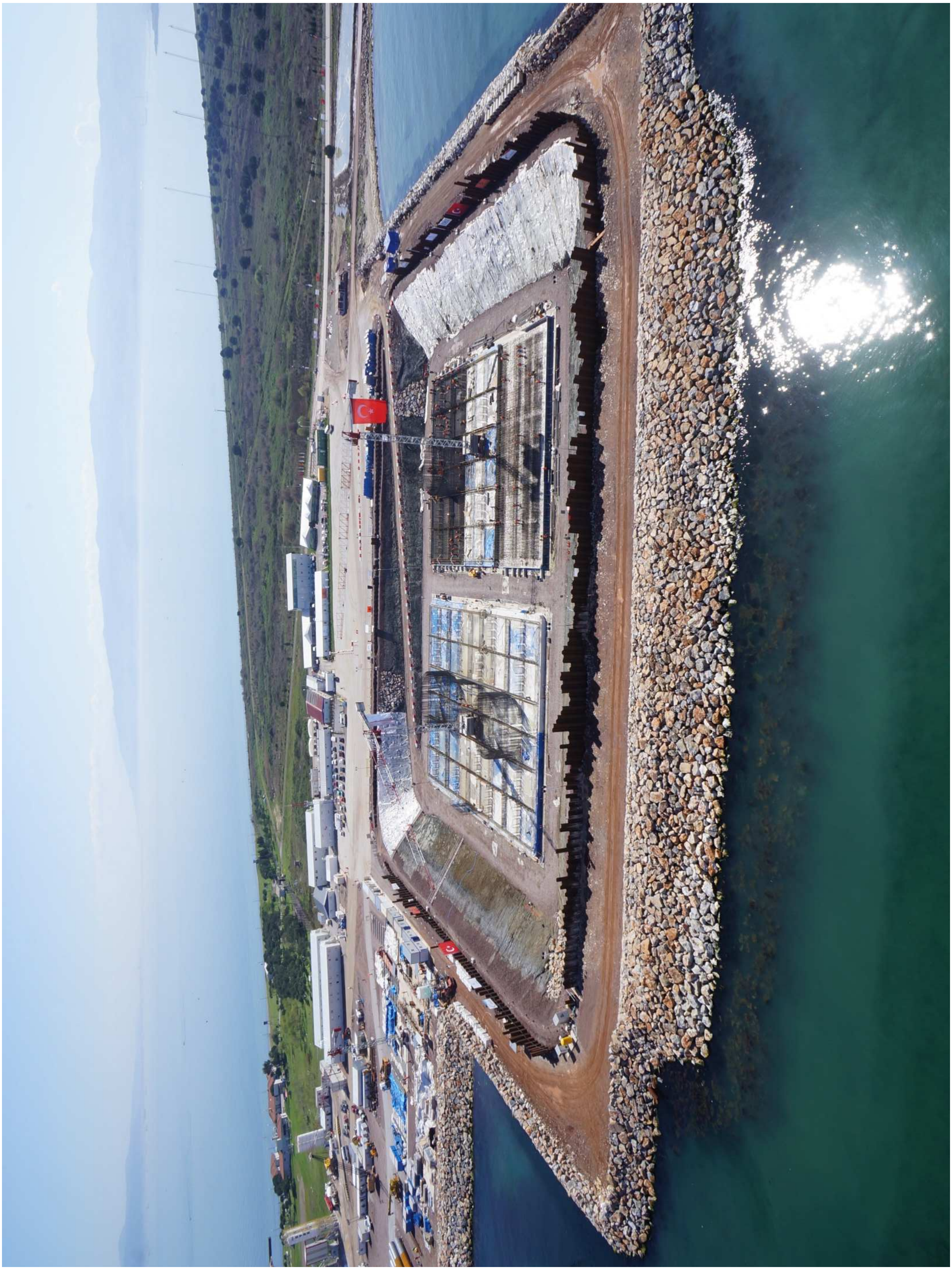
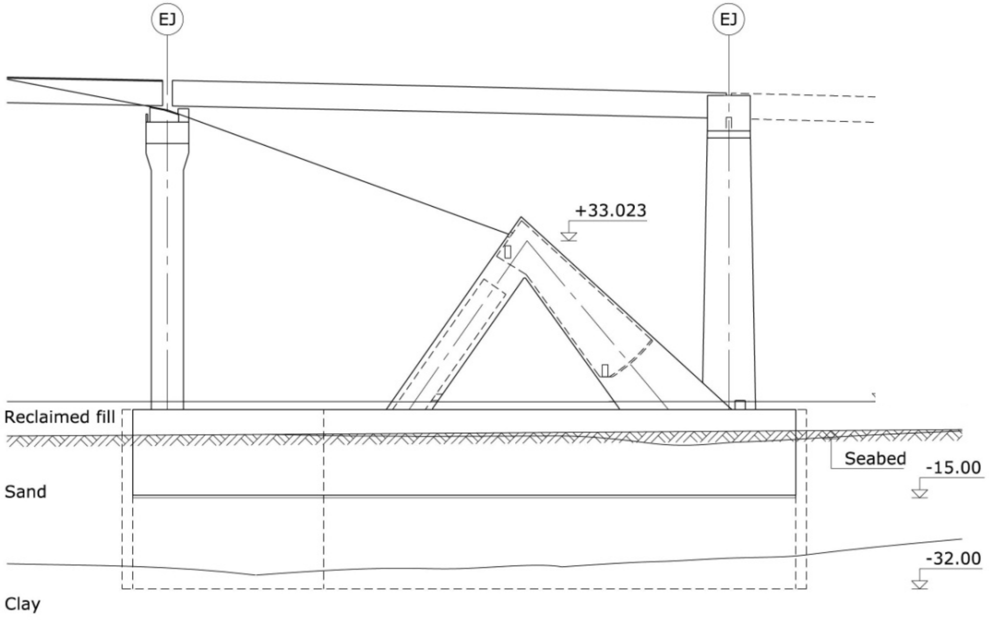
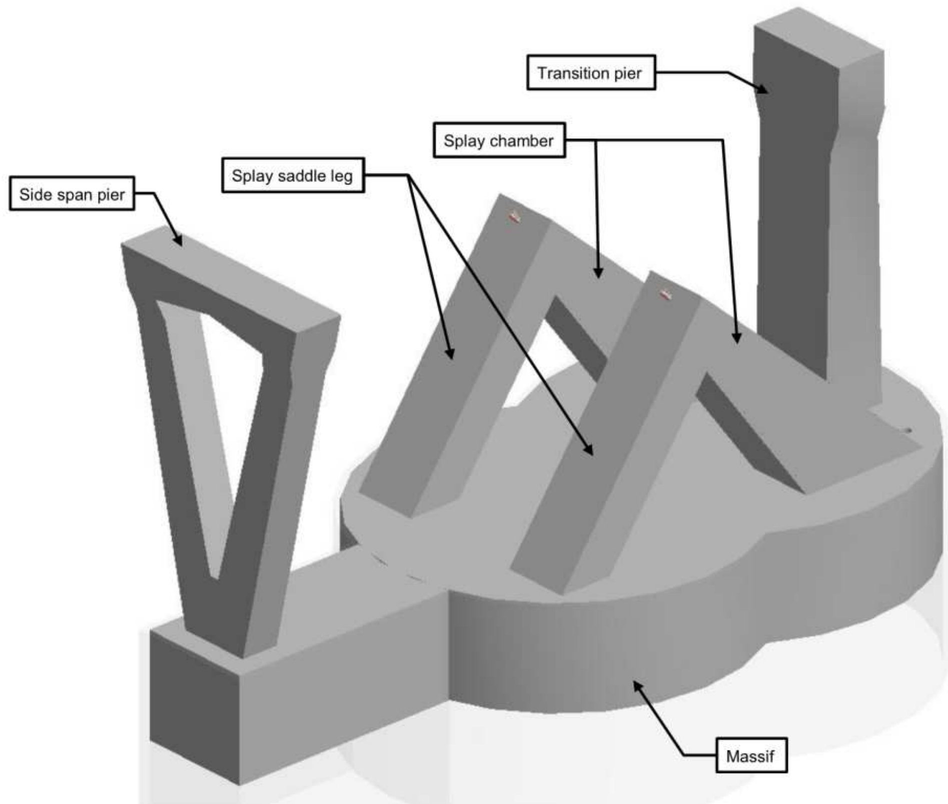


South Anchor Block

- Gravity based solution founded on dense sand
- Foundation massif 124x58x16m
- Circular diaphragms walls due to construction preferences





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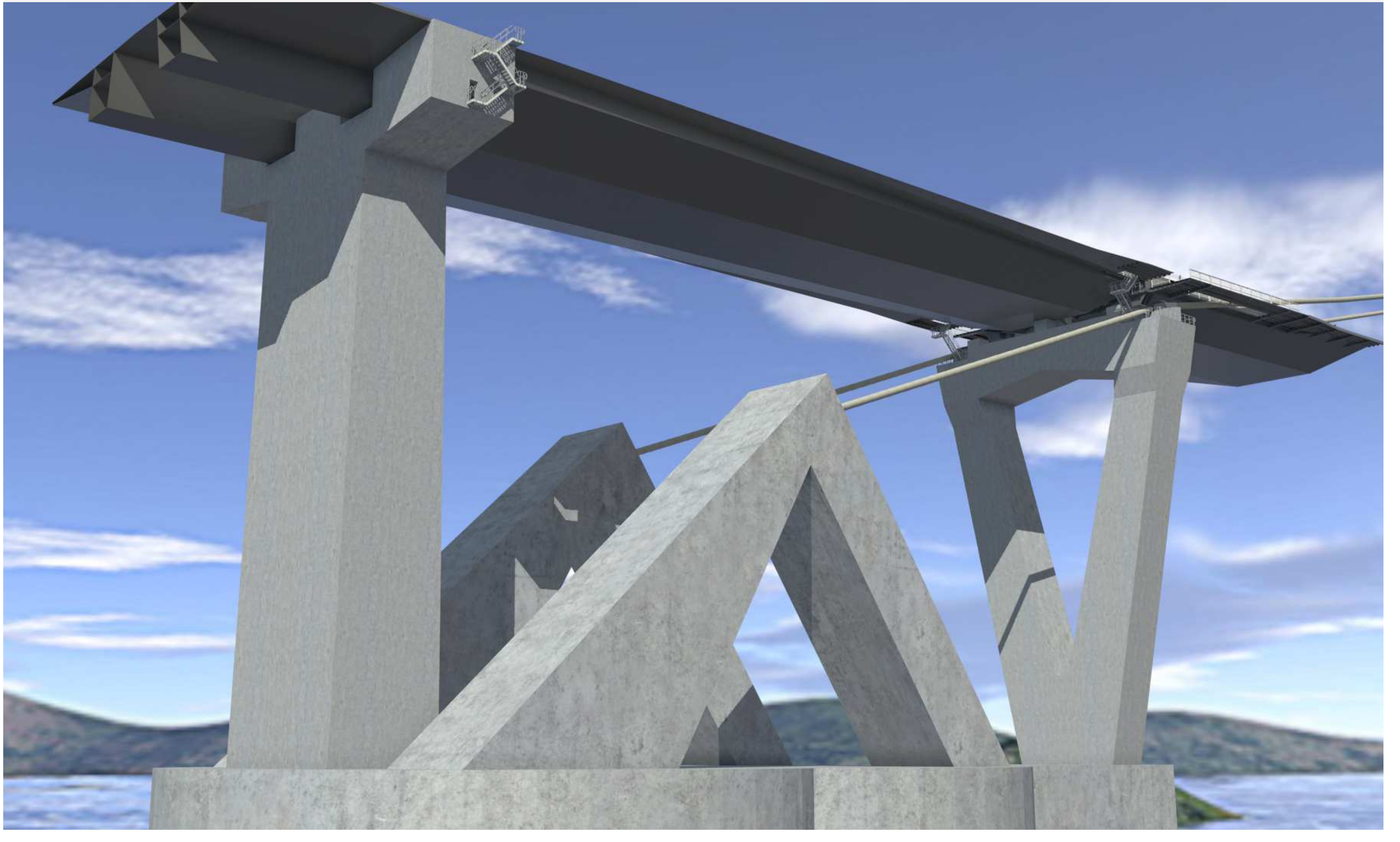
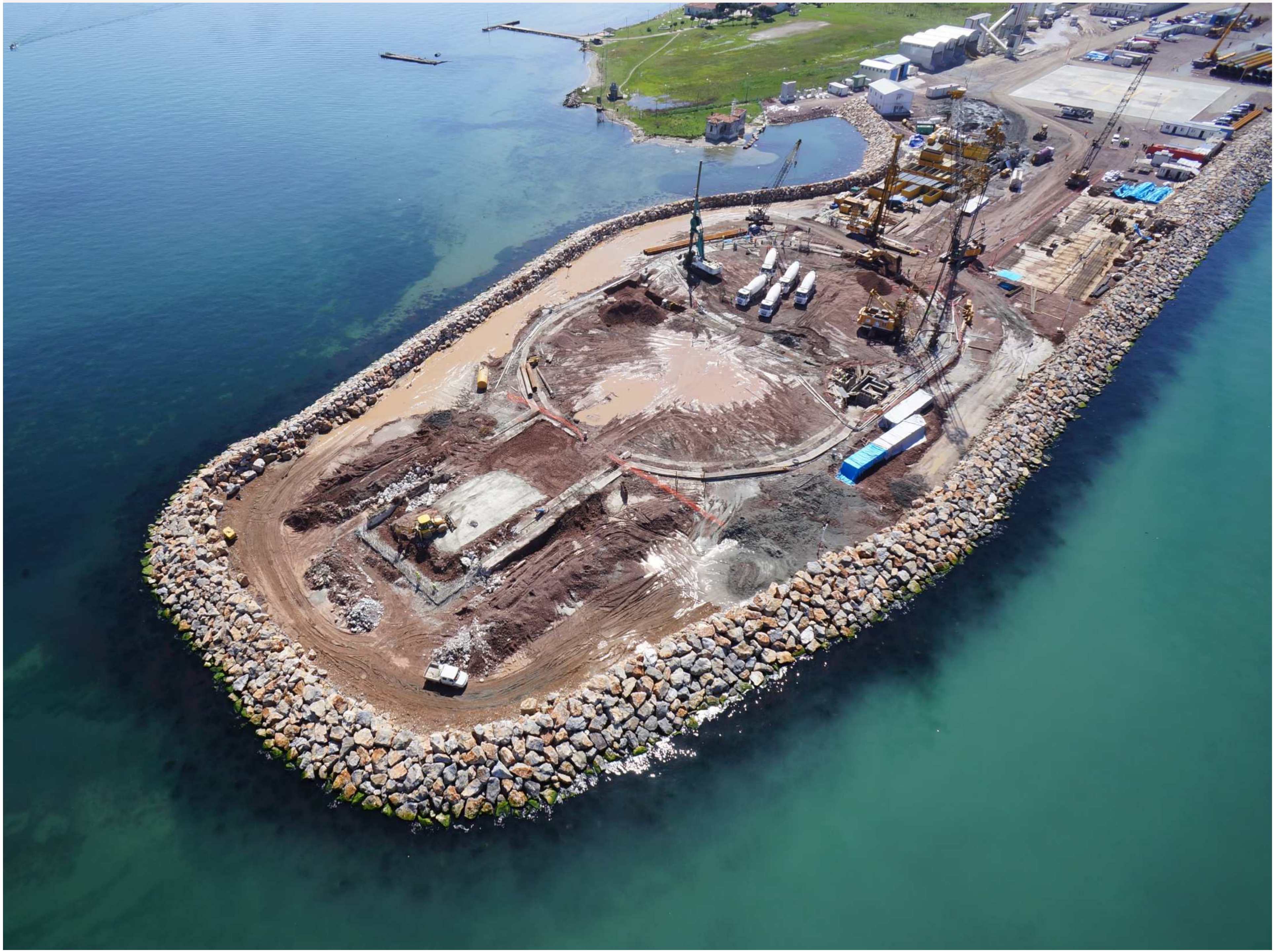
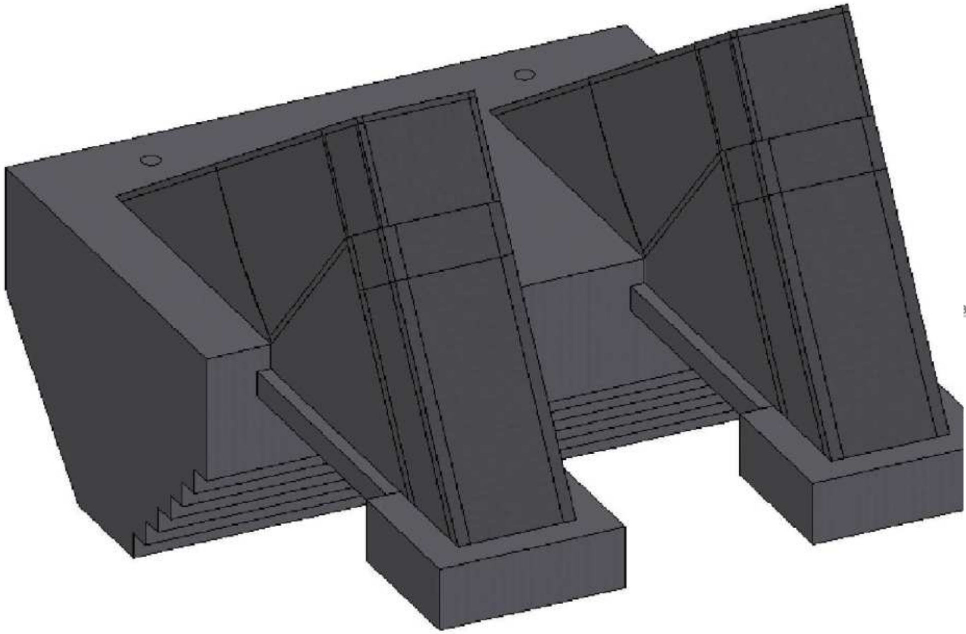
General arrangement – South Anchor Block

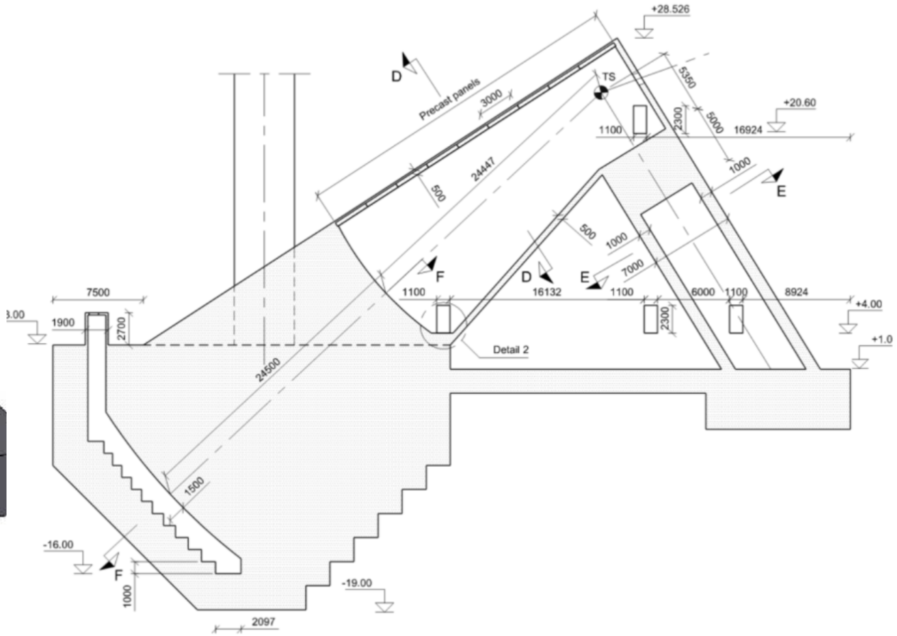




General arrangement – North Anchor Block

- Traditional gravity based structure deeply embedded in rock
- Foundation massif 66x50x22m





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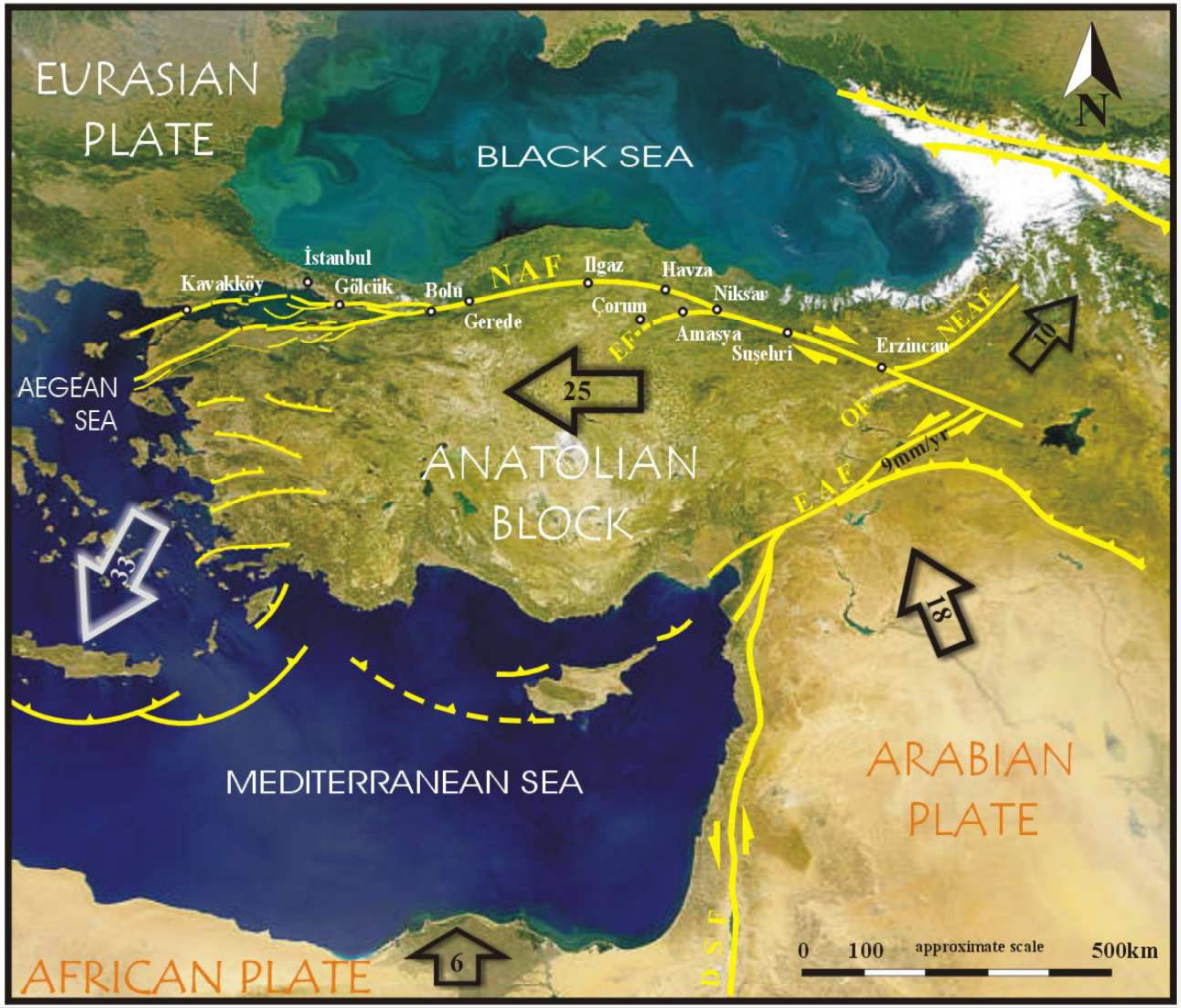
Summary of Main Quantities

Structure	Material	Unit	Quantity
Anchor blocks	Concrete	m^3	130000
Tower foundations	Concrete	m^3	45000
Steel inclusions	Steel	ton	16000
Towers	Steel	ton	17000
Main cable	Steel	ton	18000
Bridge deck	Steel	ton	33000

Seismic environment



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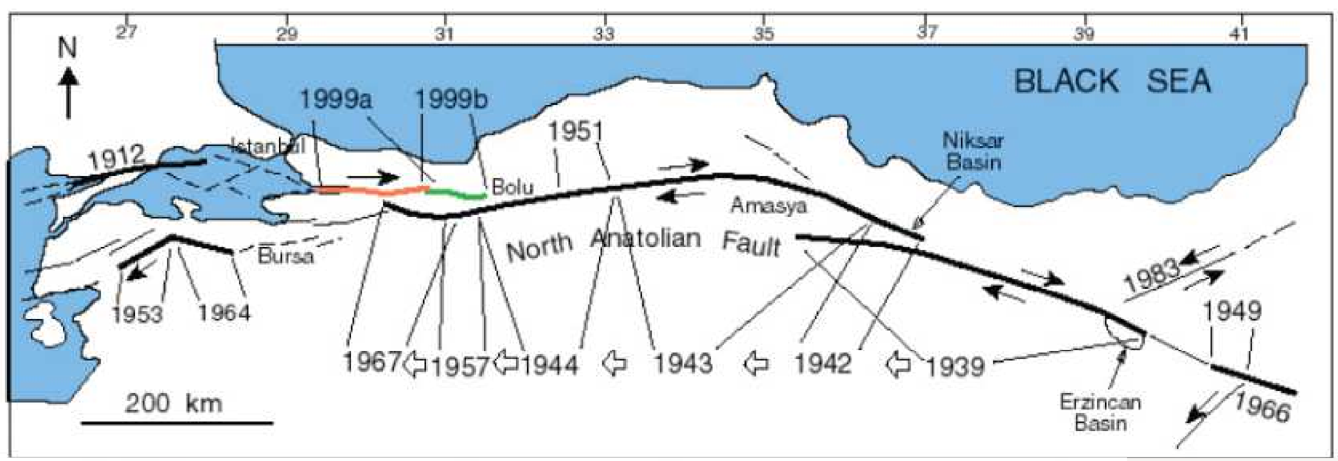
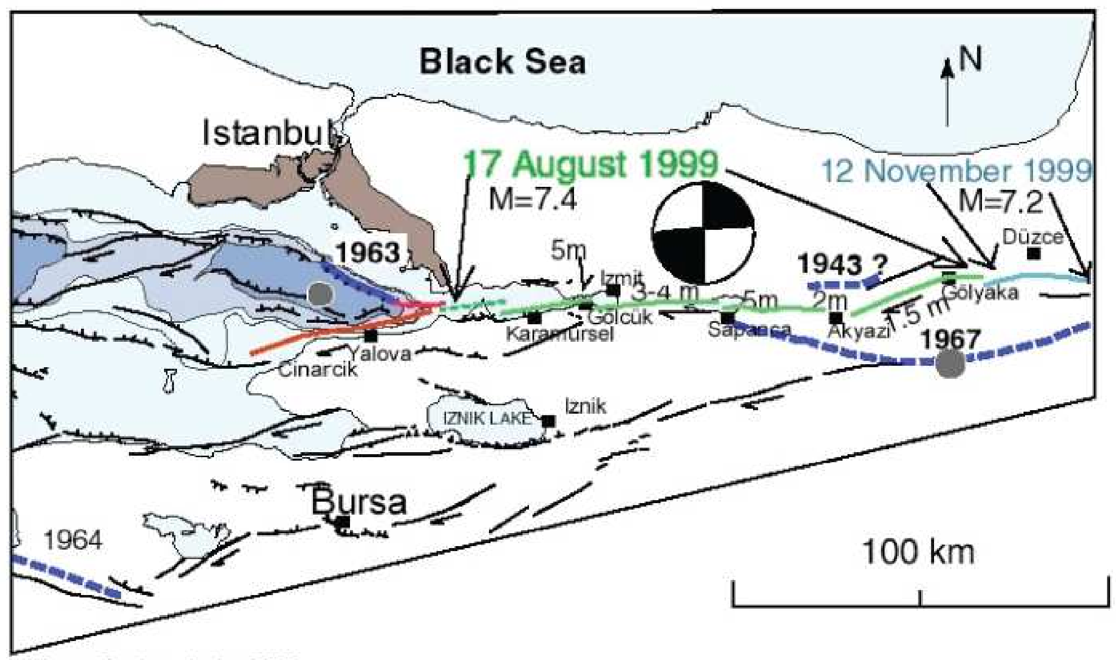
North Anatolian Fault Rupture History

- Gölcük 1999 EQ – 7.5 magnitude
- Progression of 20th Century EQs along the NAF
- 1999 EQs Surface Ruptures Map





From Barka et al., 2002

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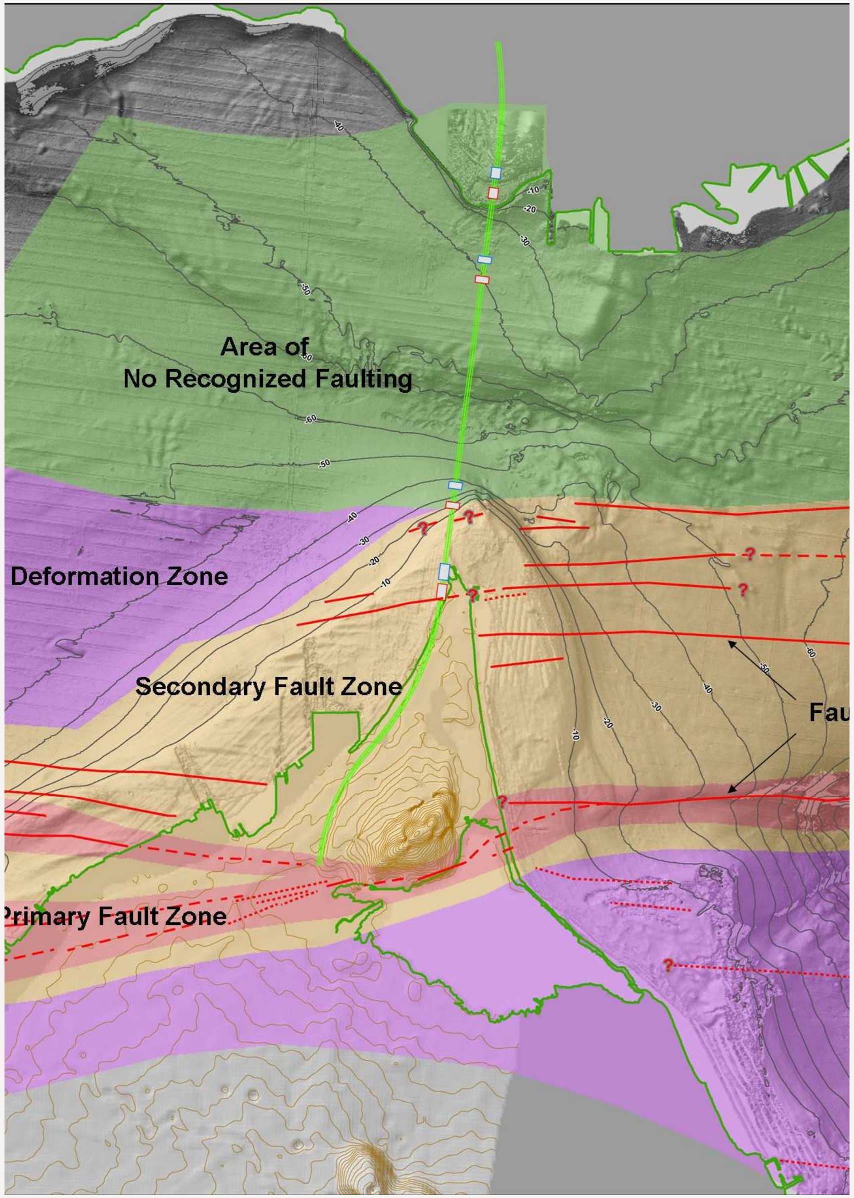
Faulting at bridge site

- Geophysical survey
- Secondary faults in southern part of the bridge
- Revised general arrangement
- Modified South Anchor Block design
  - South Anchor block moved North approx. 160m
  - Both towers moved 80m North
  - Modified support arrangement at bridge ends



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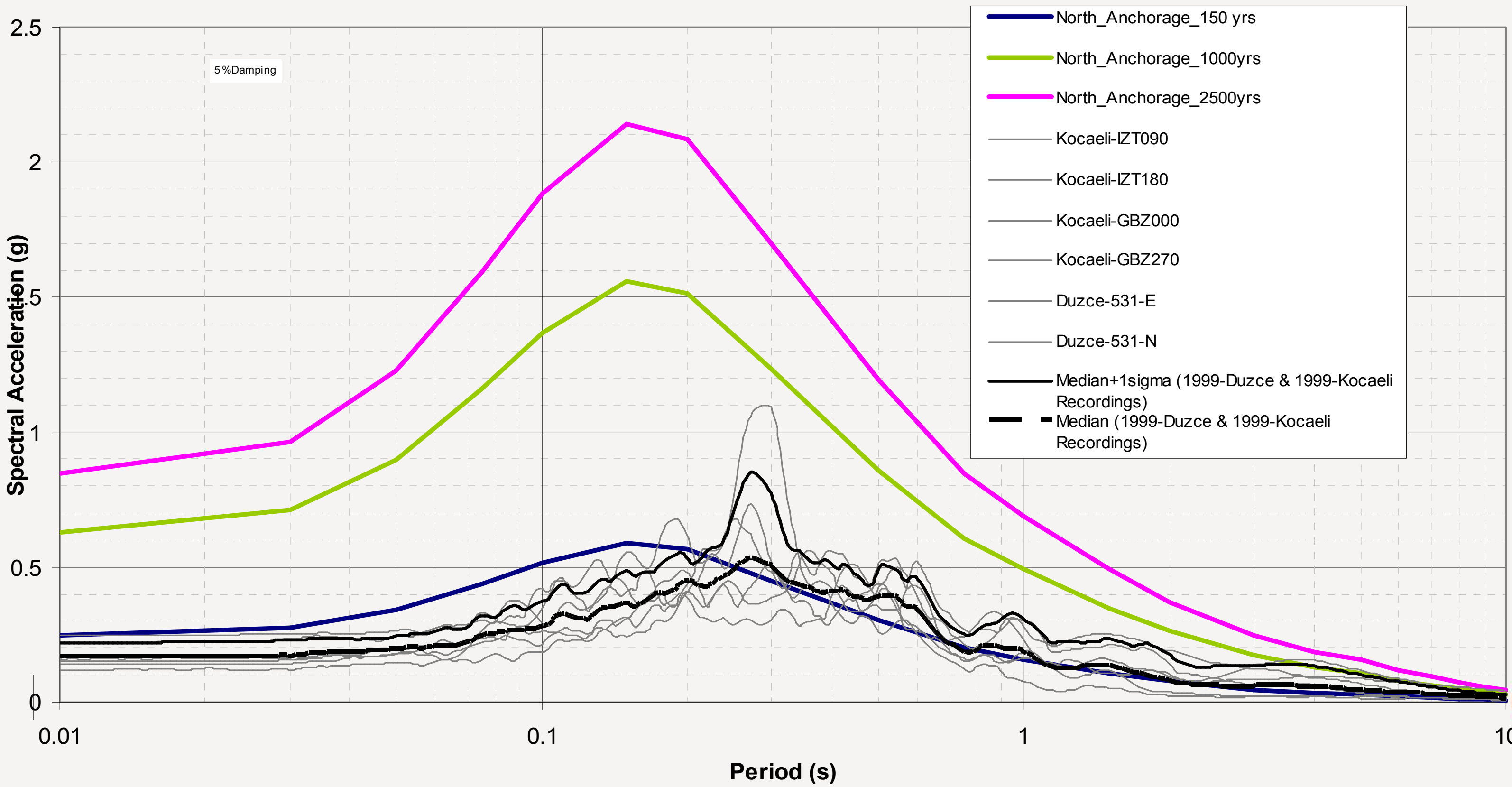
Seismic performance criteria

Seismic Event	Ground Motion Return Period	Service Performance Level	Damage Performance Level
Functional Evaluation Earthquake (FEE)	150 years (50% in 100 years)	Immediate Access	No Damage
Safety Evaluation Earthquake (SEE)	1000 years (10% in 100 years)	Limited Access	Repairable Damage
No Collapse Earthquake (NCE)	2500 years (4% in 1000 years)	-	No collapse, life safety Damage

Seismic load response spectra at rock level

- FEE – 150 years: Functional Evaluation Earthquake = 1999 earthquake
- SEE – 1000 years: Safety Evaluation Earthquake
- NCE – 2500 years: Non collapse Earthquake



Global IBDAS model

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Global IBDAS model including local models

Local models integrated into the global model:

- Anchor Blocks (shell and solid elements) – verify concrete in IBDAS
- Side Span Piers (solid elements) – verify concrete in IBDAS
- Tower caissons (shell elements) – verify concrete in IBDAS
- Tower leg to lower cross beam connection (shell elements) – stress output
- Tower leg to upper cross beam connection (shell elements) – stress output
- Bridge deck (shell elements) – stress output

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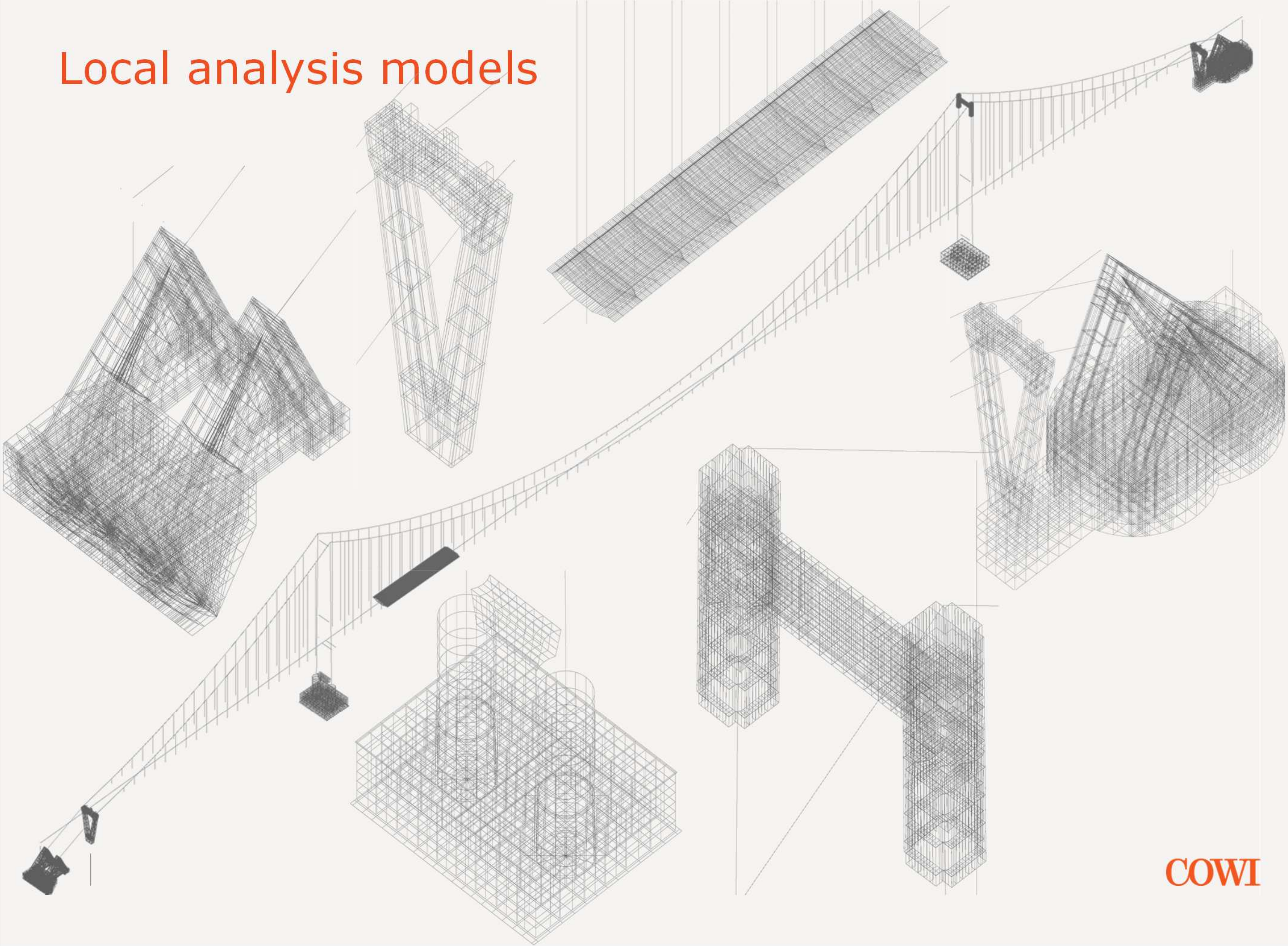
Local analysis models



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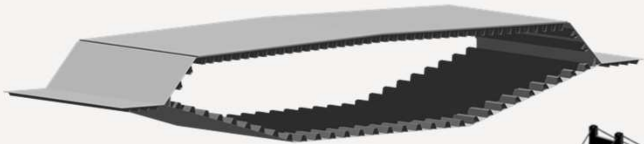
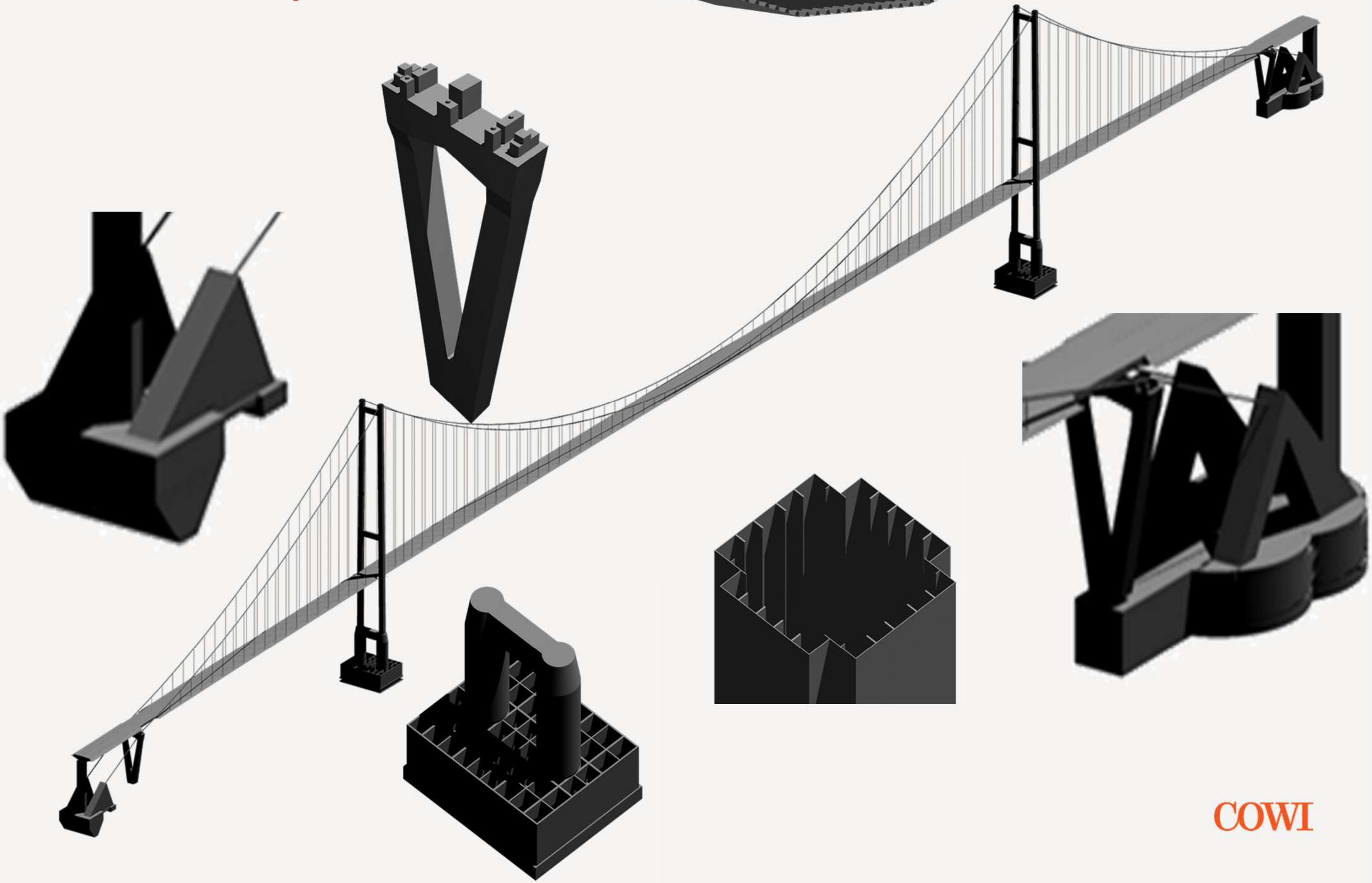
Local analysis models





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Global IBDAS model including local models

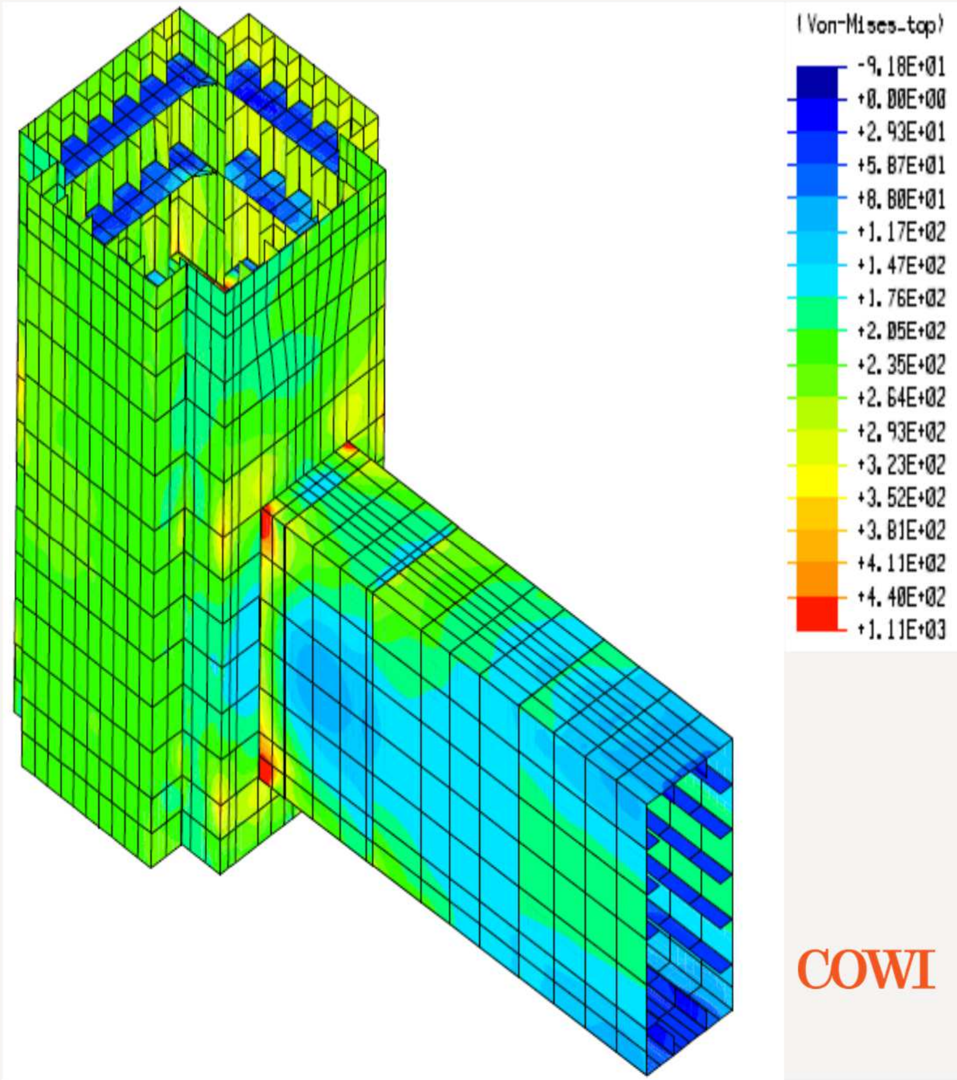
Advantages of incorporating local models in the global model:

- Boundary conditions are automatically correct as there is no manual transfer of forces from the global to the local model
- Geometrical changes made to the global model is automatically included in the local model
- Loads and load combinations are defined in the global model
- Design verification can be completed directly, without moving data
- Non-linearities in the global model are automatically included
- Full non-linear time history analyses can be performed on the local model when it is included in the global model

Include local tower leg and cross beam model

Example for ULS:

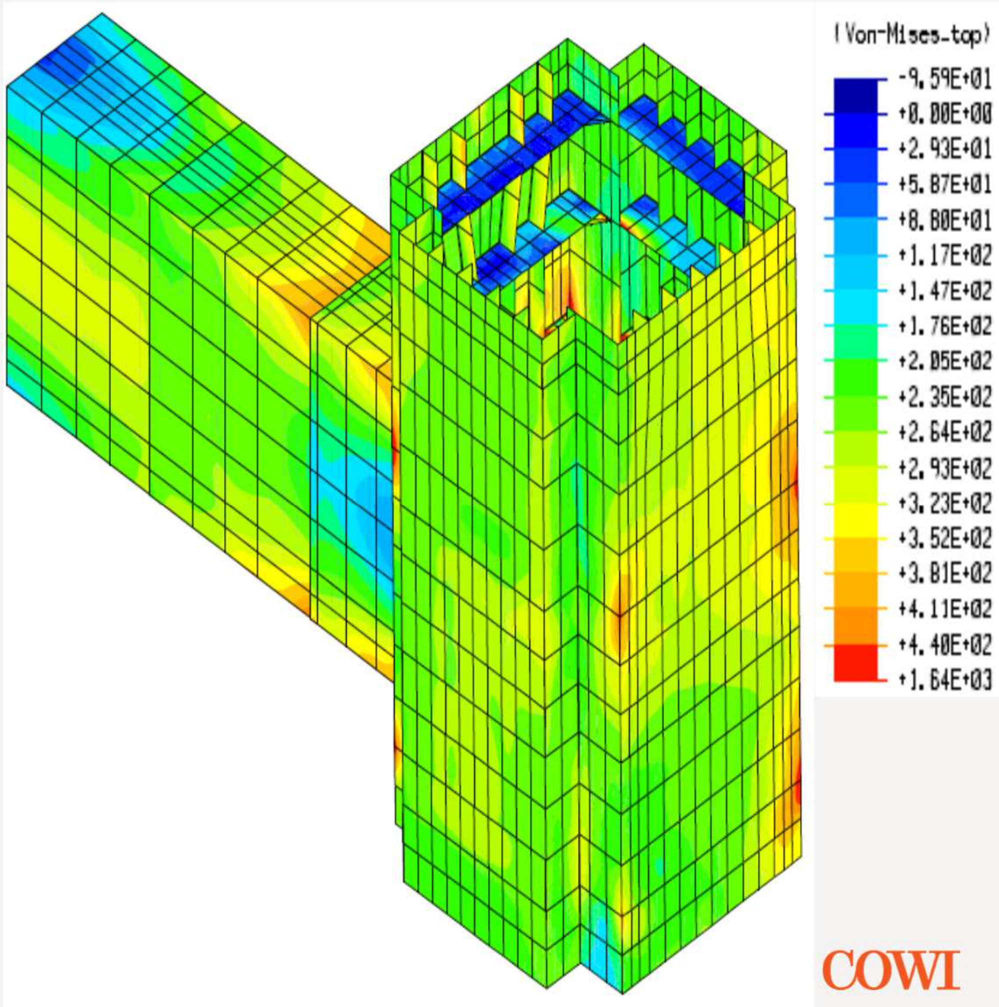
- Apply variable loads to obtain max von Mieses stress in a gauss point
- Repeat for all gauss points in local model
- Show all max stresses in one plot (envelope plot) – all max stresses are calculated from coexisting values of σ_s, σ_y, and τ
- Max stresses in gauss points on plot are not coexisting



Include local tower leg and cross beam model

Example for NCE seismic:

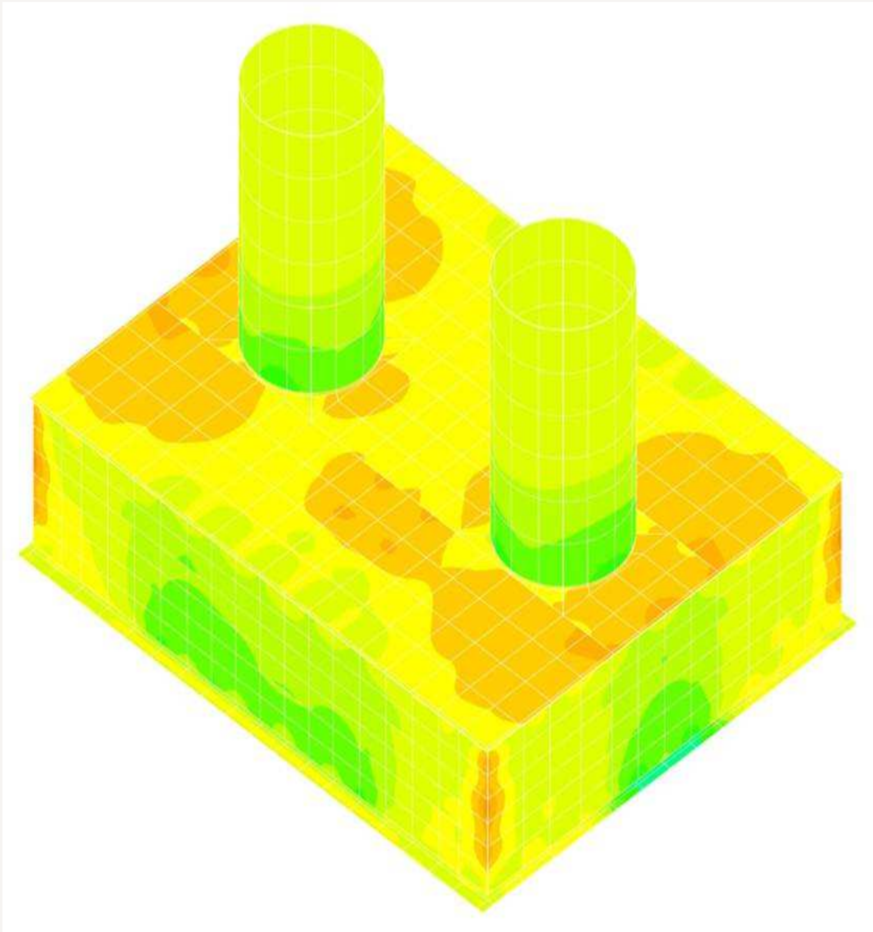
- Calculate max von Mieses stresses in all gauss points for 7 TH's
- Make average of 7 values of max von Mieses stresses in all gauss points
- Show average max von Mieses stresses in one plot (envelope plot)

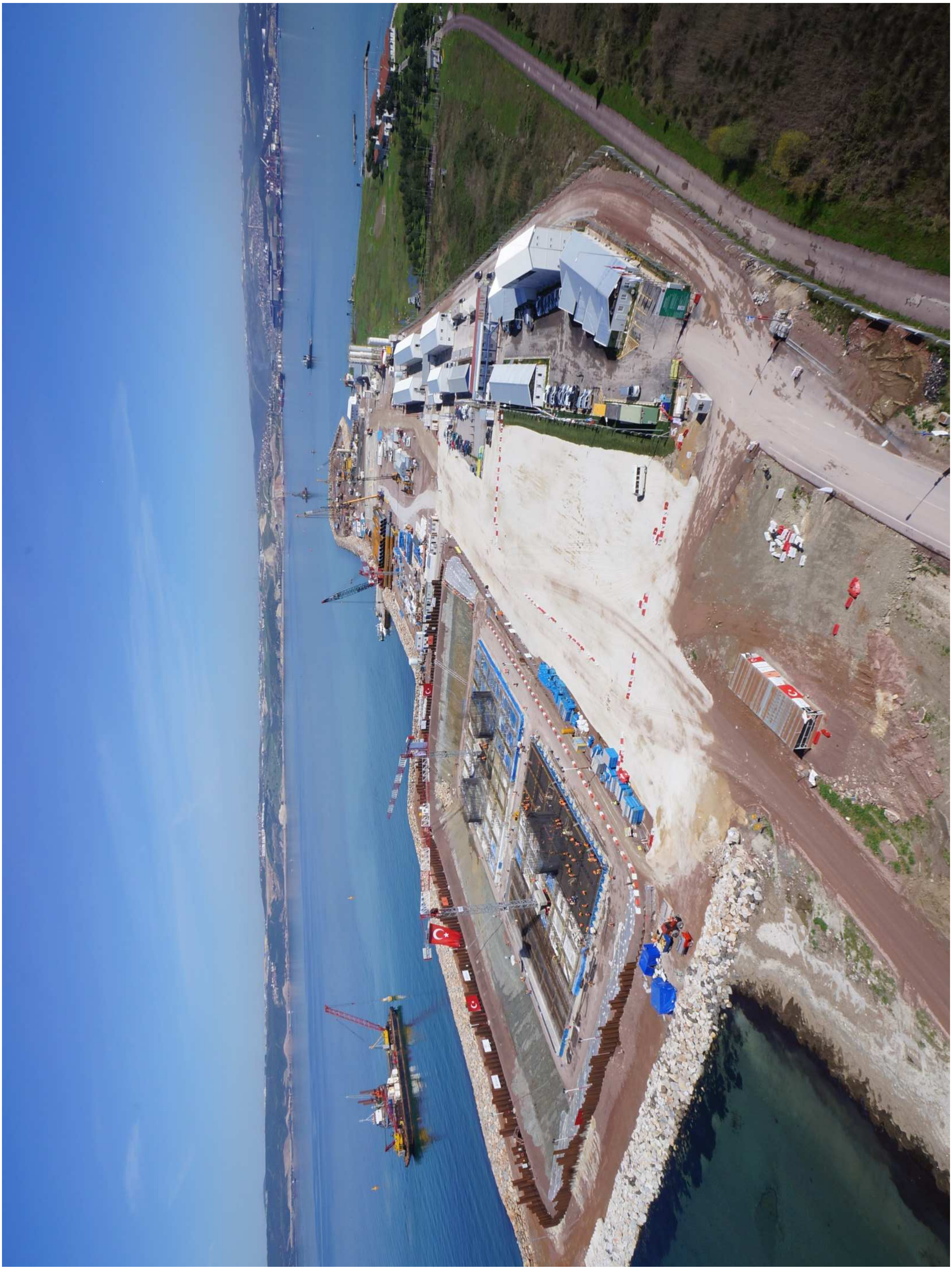


Include local tower caisson model

Example for SLS crack width:

- Calculate combinations of sectional forces in all gauss points
- Define reinforcement in the post-processing module
- Calculate crack widths for all combinations of sectional forces in all gauss points and determine max values
- Show all max values in one plot (envelope plot) – all max values are calculated from coexisting sectional forces





Thank you for your attention!

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