

## Broen over Inderhavnen



**Ian Firth**, Director, Flint & Neill Limited

# Project Team

## Client

**Københavns Kommune, Teknik- og Miljøforvaltningen**

## Design Team

**Flint & Neill Ltd**

**London, UK**

**COWI A/S**

**Copenhagen**

**Studio Bednarski Ltd** (*Architect*)

**London, UK**

**Hardesty & Hanover** (*Mechanical & Electrical*)

**New York, USA**

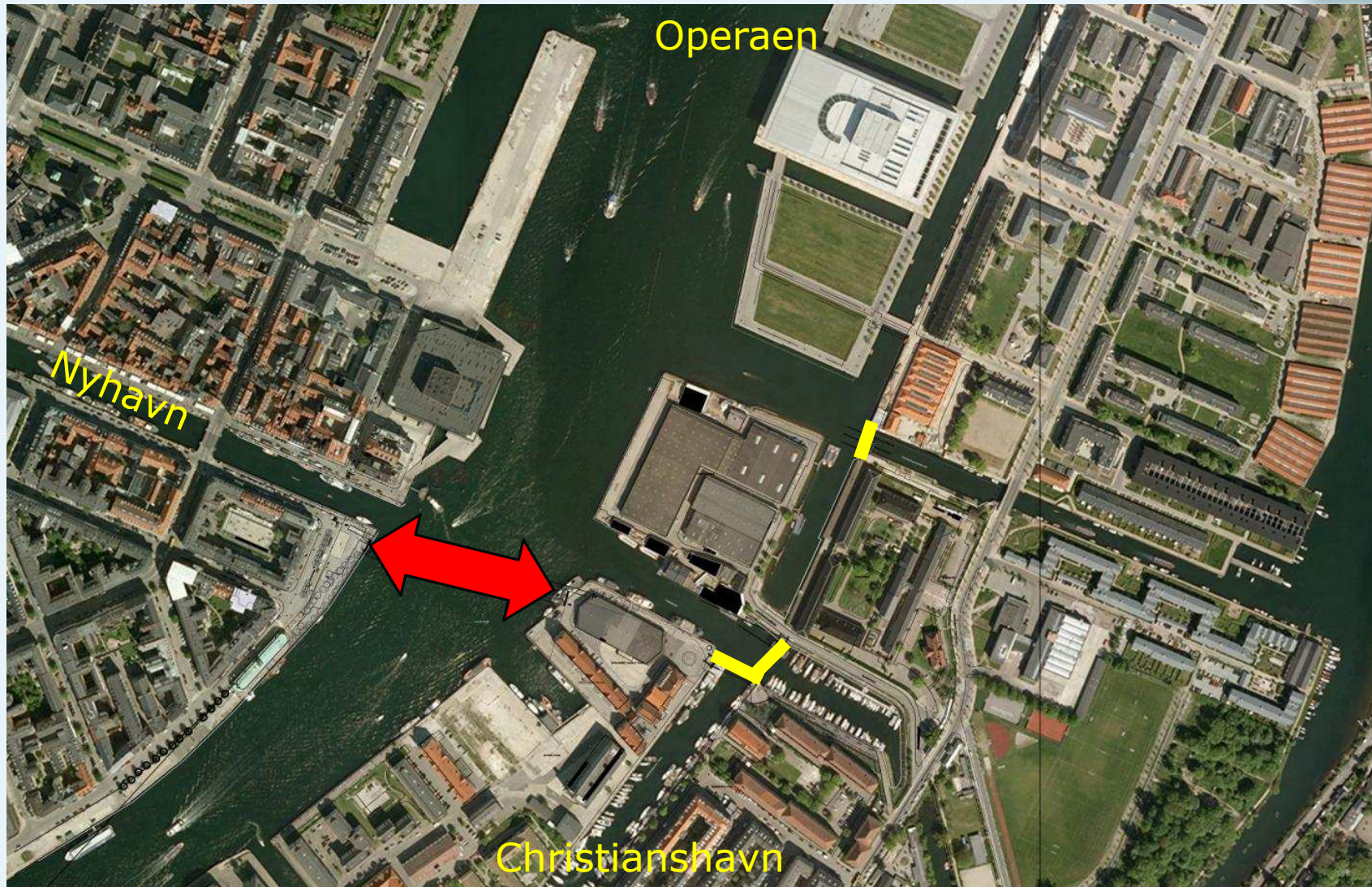
**Speirs & Major Associates** (*Lighting Design*)

**London, UK**

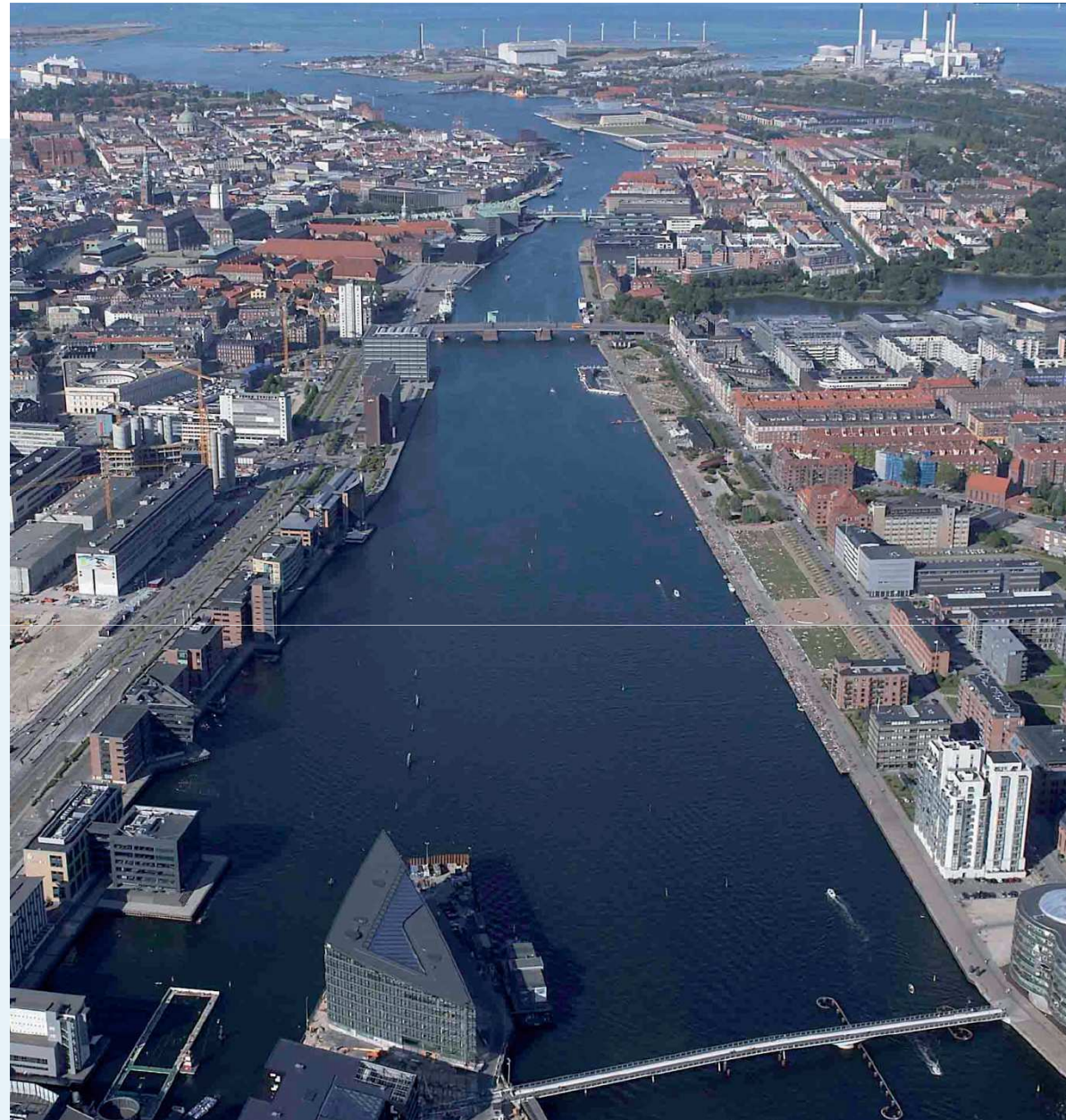
# Outline

- Introduction
- The design competition
- The main technical challenges
- Current status
- Questions / discussion

# Aerial view of site



# Context



# Context



# Context



# Context





# Context



# Context



# Design Competition

## Shortlist:

10 international teams

## Competition:

Mar – Aug 2009

## Negotiation:

Sept – Oct 2009

## Winners announced:

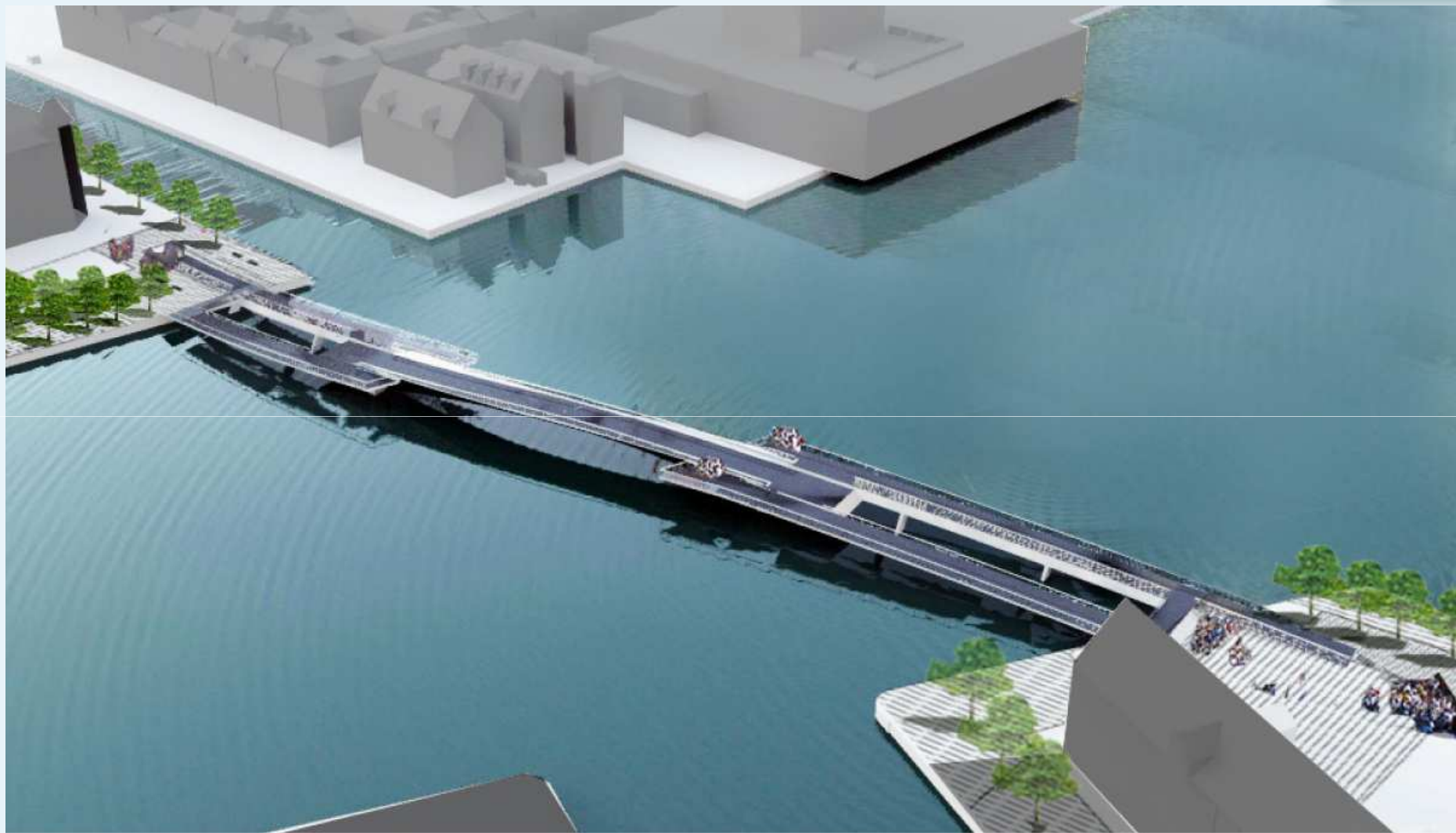
October 2009

Dietmar Feichtinger - Kanaler

**Flint & Neill - Inderhavnen**

- **Lundgaard & Tranberg Arkitekter A/S, Copenhagen**  
Ove Arup & Partners, Danmark A/S, Brøndby  
Alectia A/S, Virum
- **Leonhardt, Andrä und Partner Consulting Engineers VBI, GmbH, Stuttgart**  
Georg K. S. Rotne, arkitekt MAA, Copenhagen  
ES-Consult A/S, Hørsholm
- **Grontmij | Carl Bro A/S, Glostrup**  
Schlaich Bergermann und Partner GmbH, Berlin  
GMP Architects and Engineers GmbH, Berlin
- **ISC Rådgivende Ingeniører A/S, Copenhagen**  
Bystrup Arkitekter MAA MDD, Copenhagen
- **Zaha Hadid Architects Ltd, London**  
Buro Happold Ltd., London
- **Dissing + Weitling arkitektfirma a/s, Copenhagen**  
Cowi a/s, Lyngby  
Polyform arkitekter Aps, Copenhagen  
Ulrike Brandi Licht, Hamburg
- **DFA | Dietmar Feichtinger Architects, Paris Wien**  
WTM Engineers GmbH, Hamburg
- **Henning Larsen Architects A/S, Copenhagen**  
Ove Arup & Partners International Ltd., London
- **Flint & Neill Ltd., London**  
Studio Bednarski Ltd. Architecture, London  
Hardesty & Hanover International LLC, New York  
Speirs & Major Associates, London
- **Rambøll Danmark A/S, Virum**  
3XN A/S, Århus

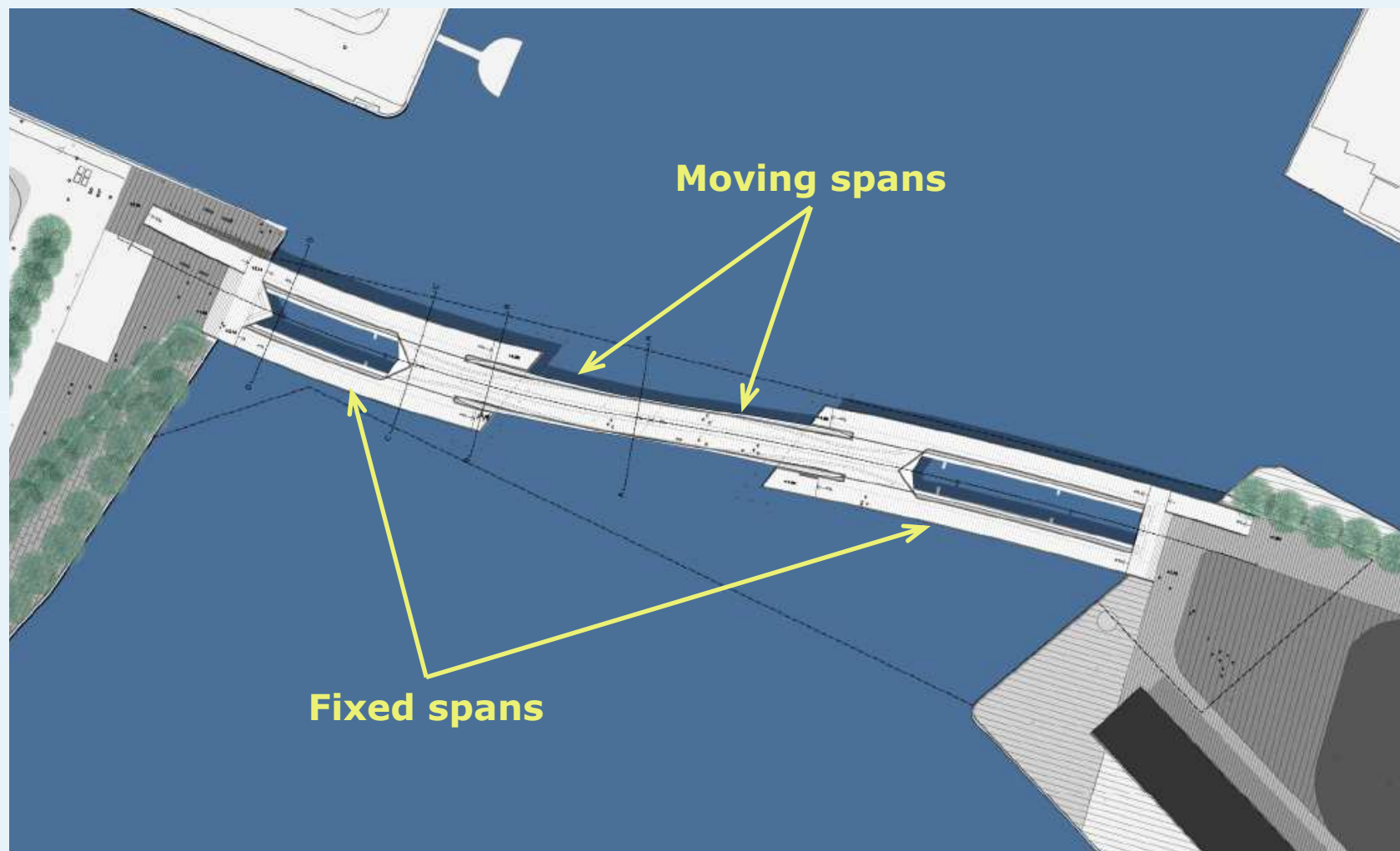
# Bridge Closed



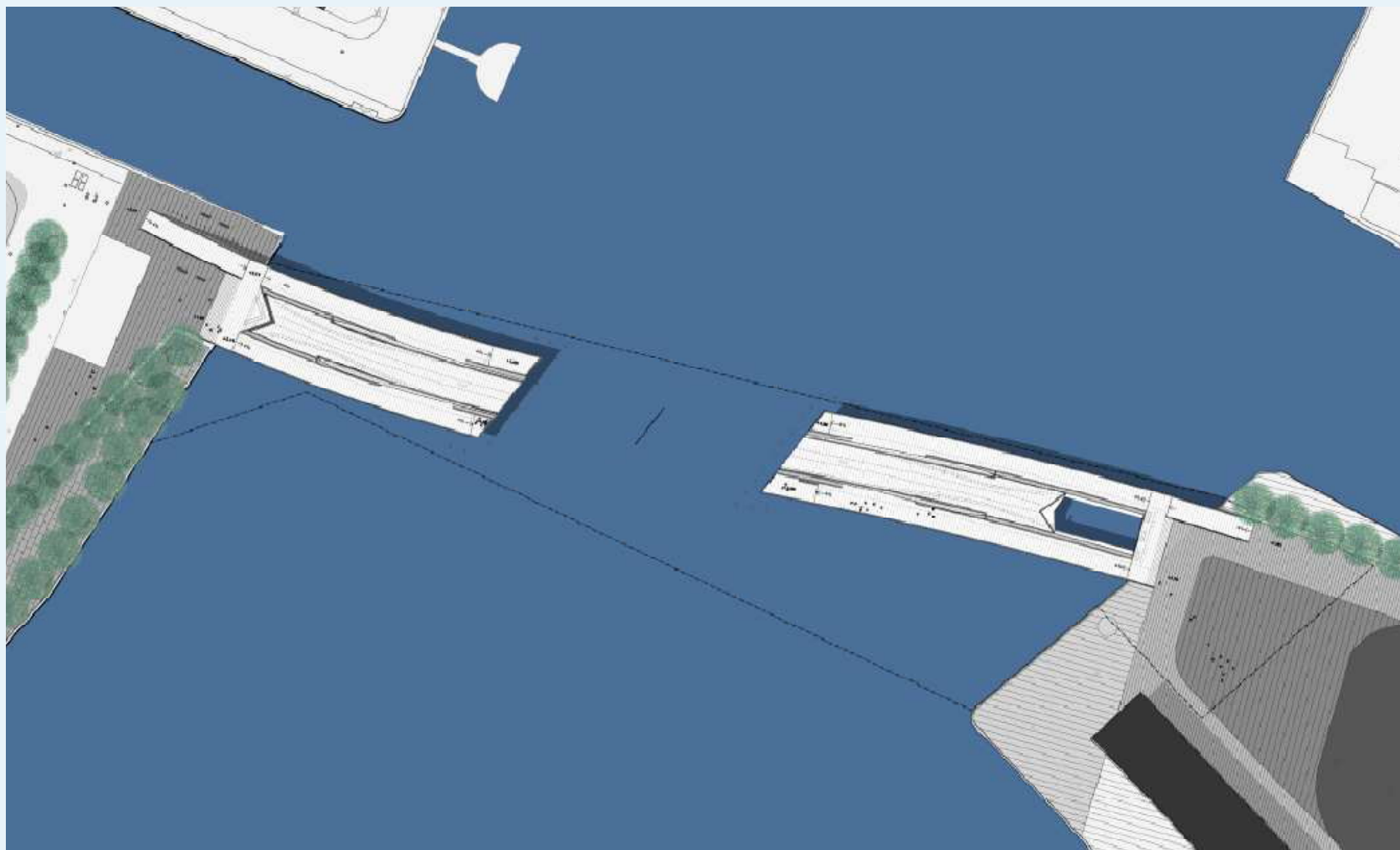
# Bridge Open



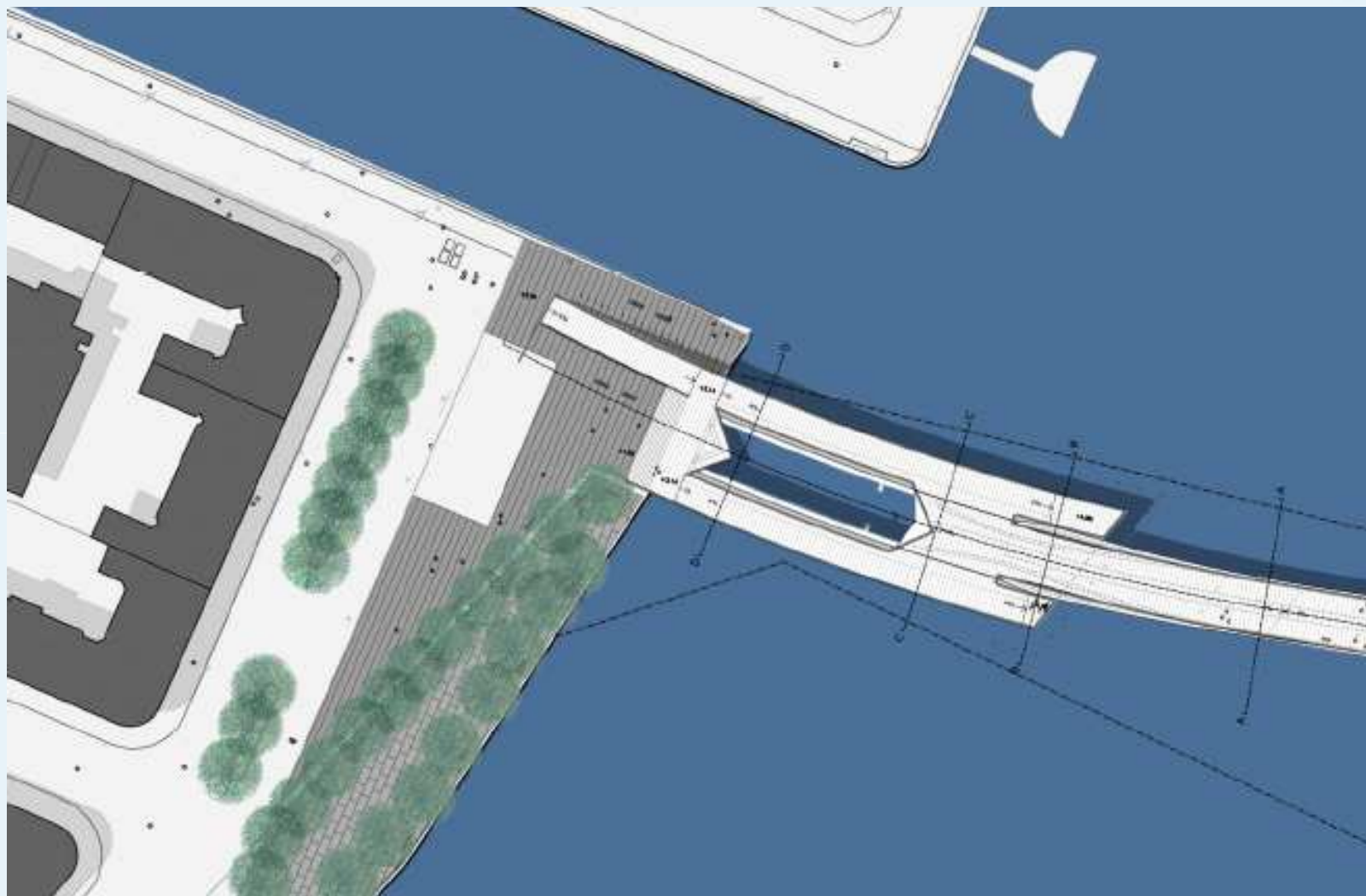
# Bridge Closed



# Bridge Open



# Havnegade end – Bridge Closed

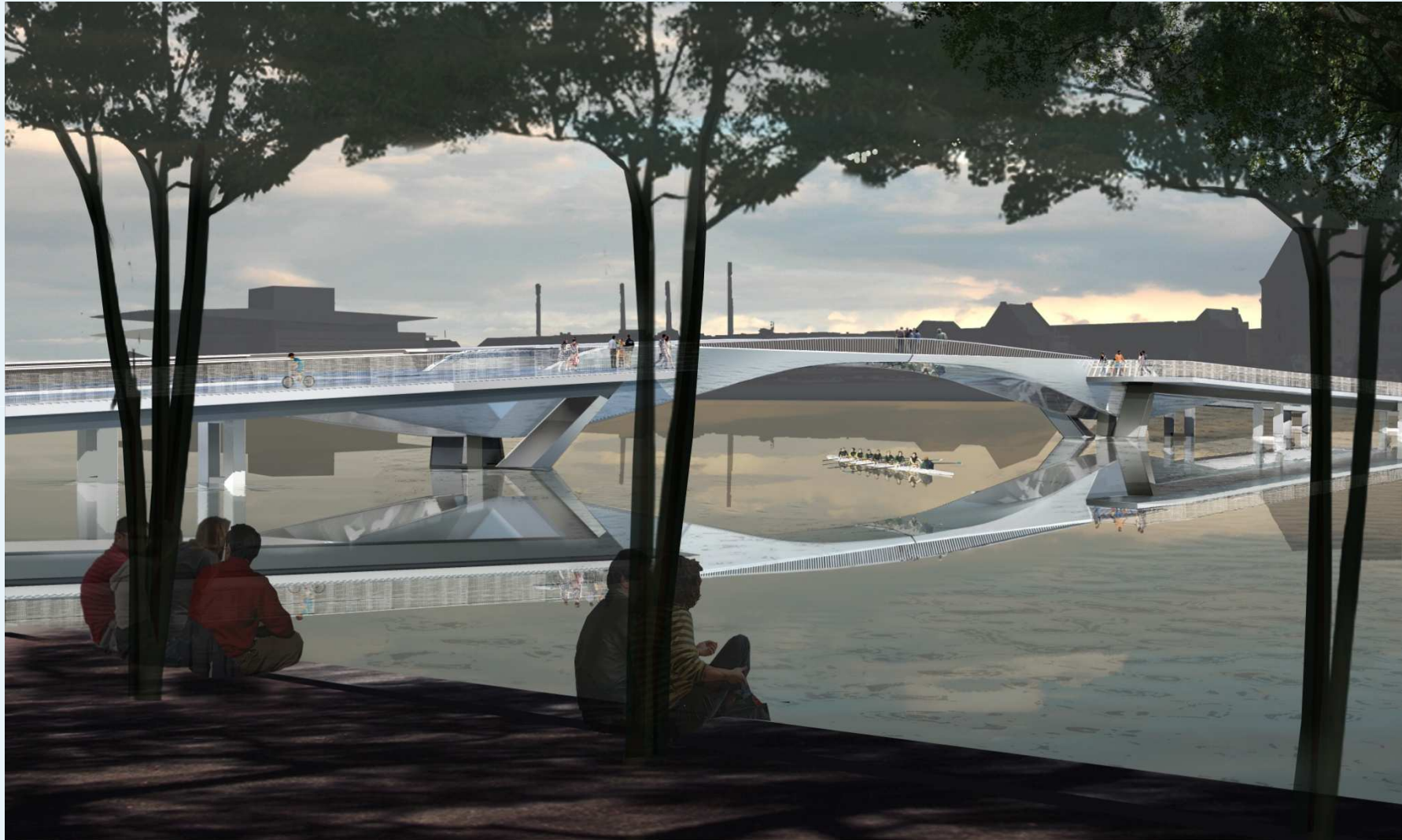




# Havnegade end – Bridge Open



# Ideas for softening the harbour edge



# Elevations



**Bridge Closed**



**Bridge Open**

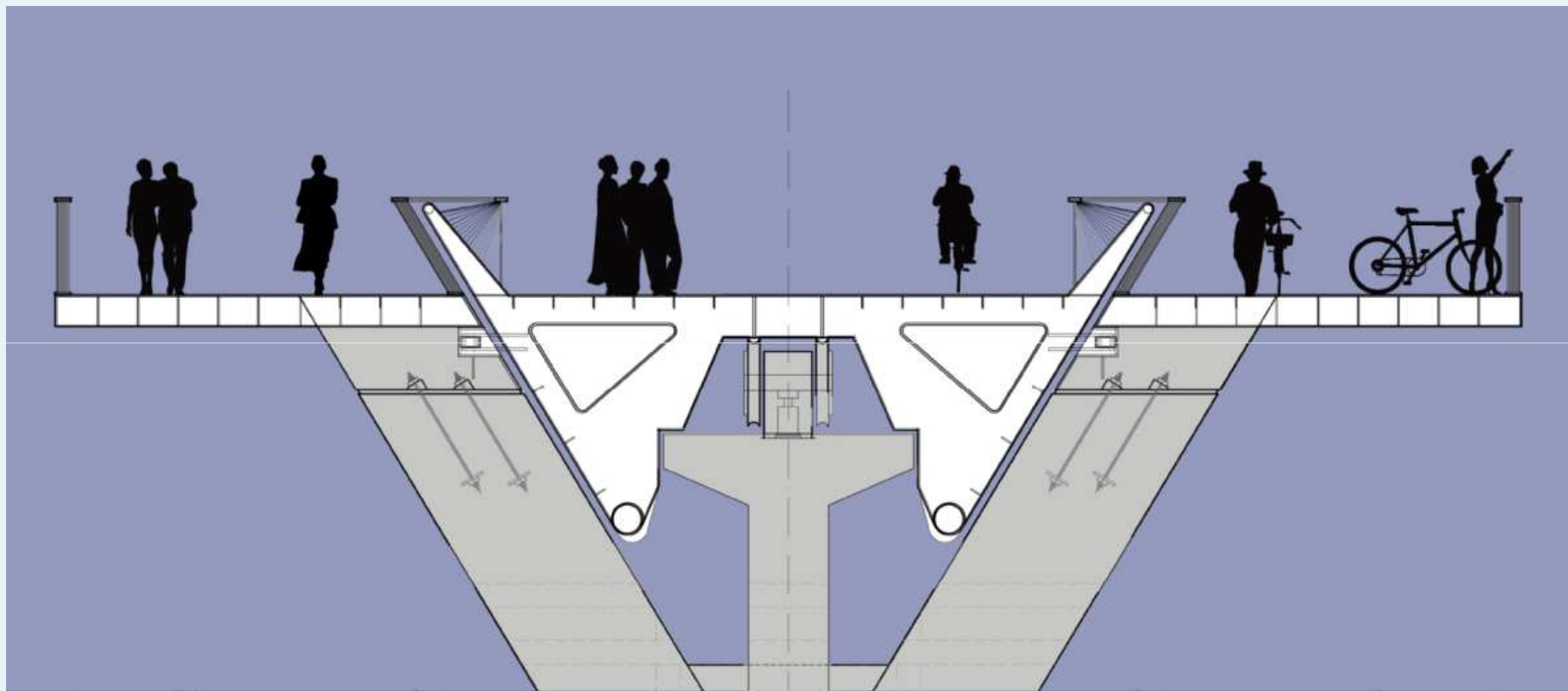
# Long Section – Closed



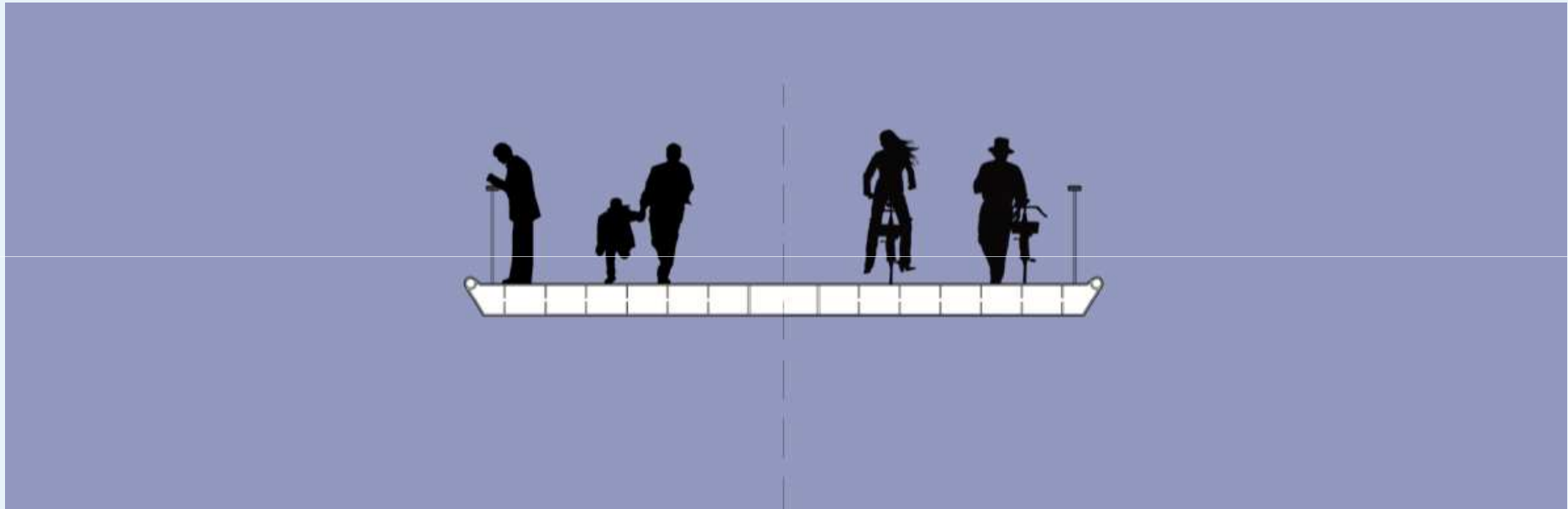
# Long Section - Closed



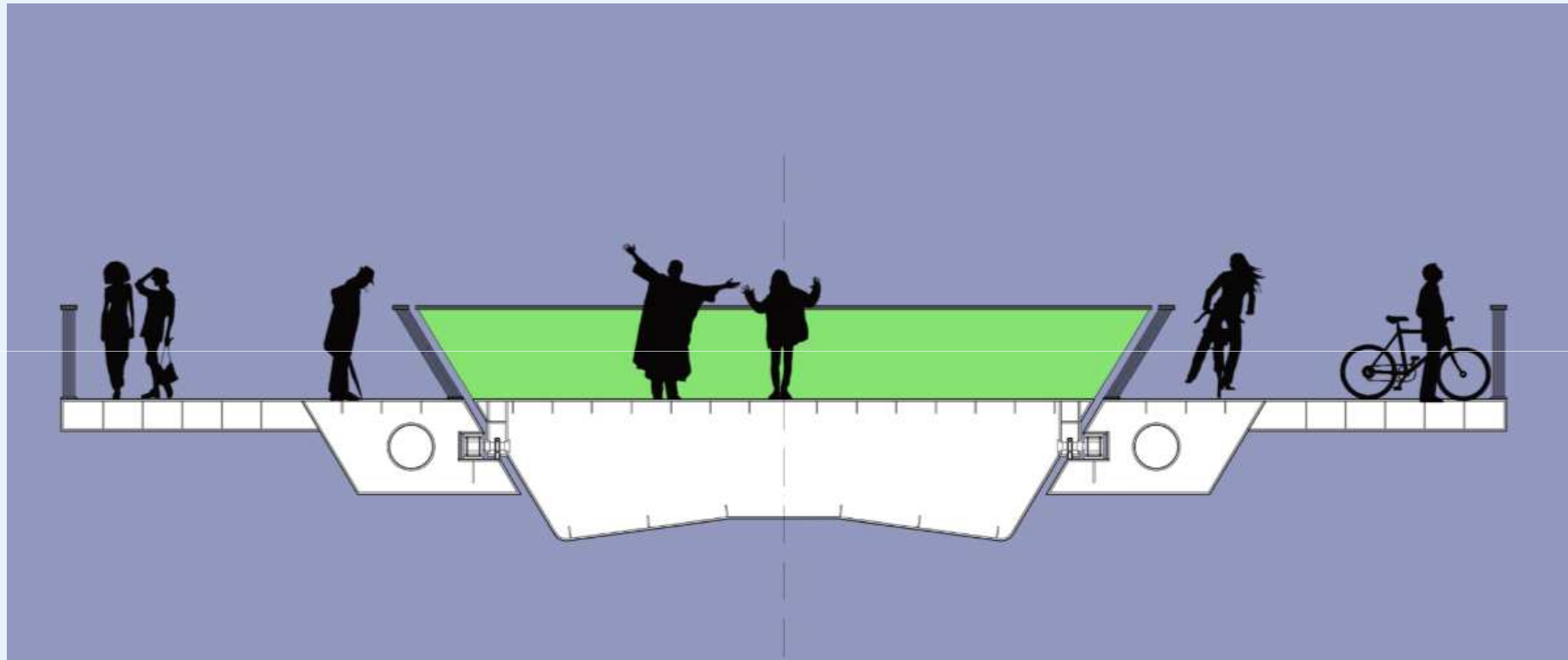
# Section at Main Pier



# Section at Midspan

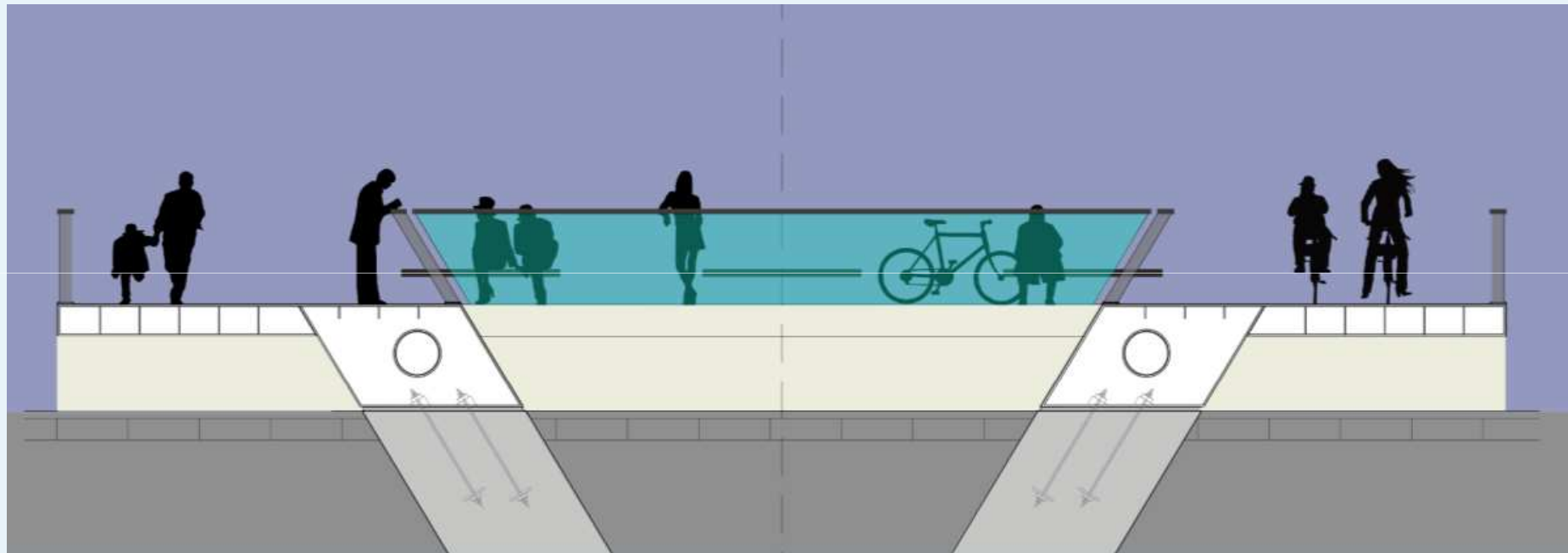


# Section at Rear of Moving Section

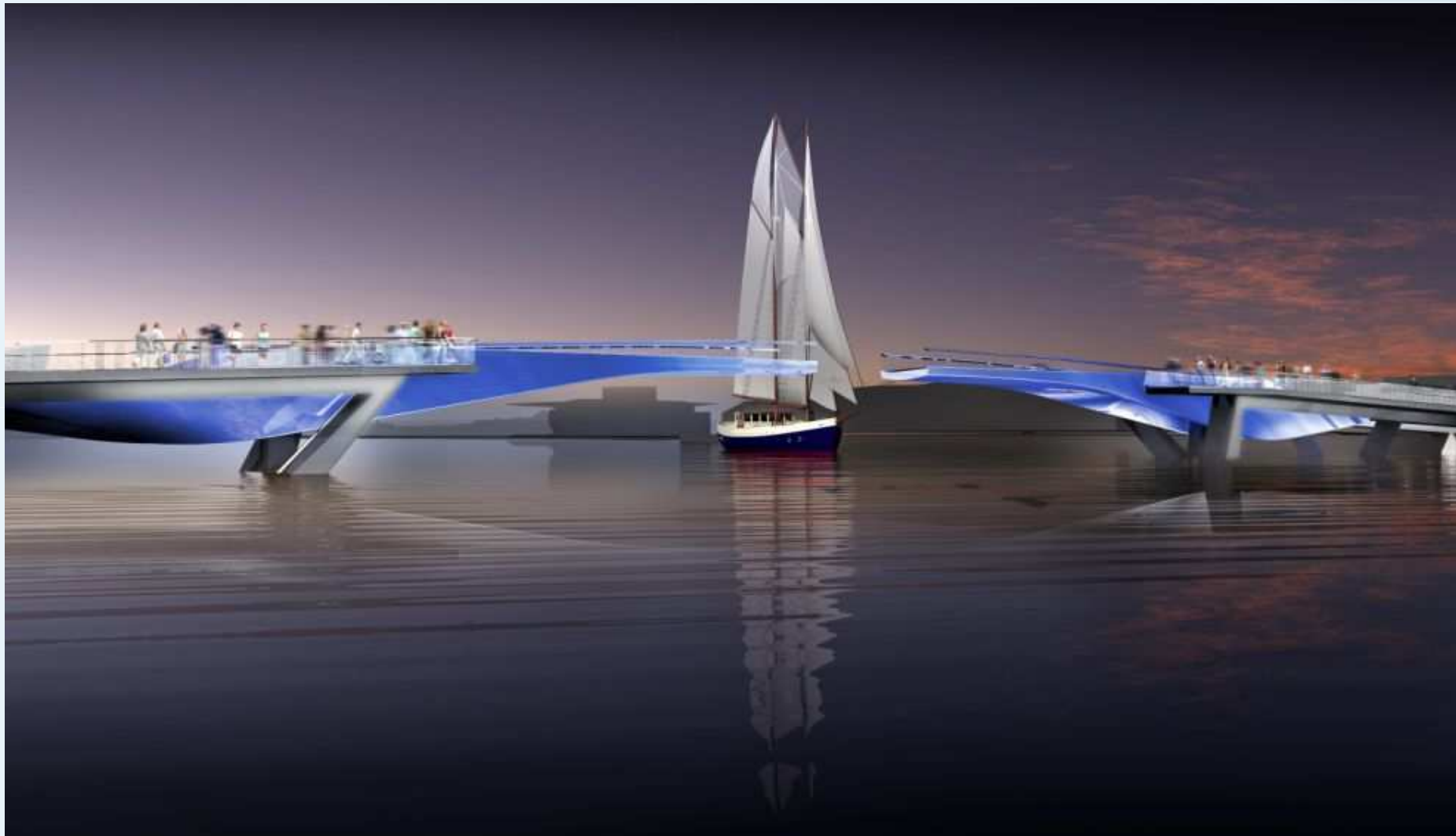




# Section at end of approach spans



# Competition image



# Competition image



# Competition image



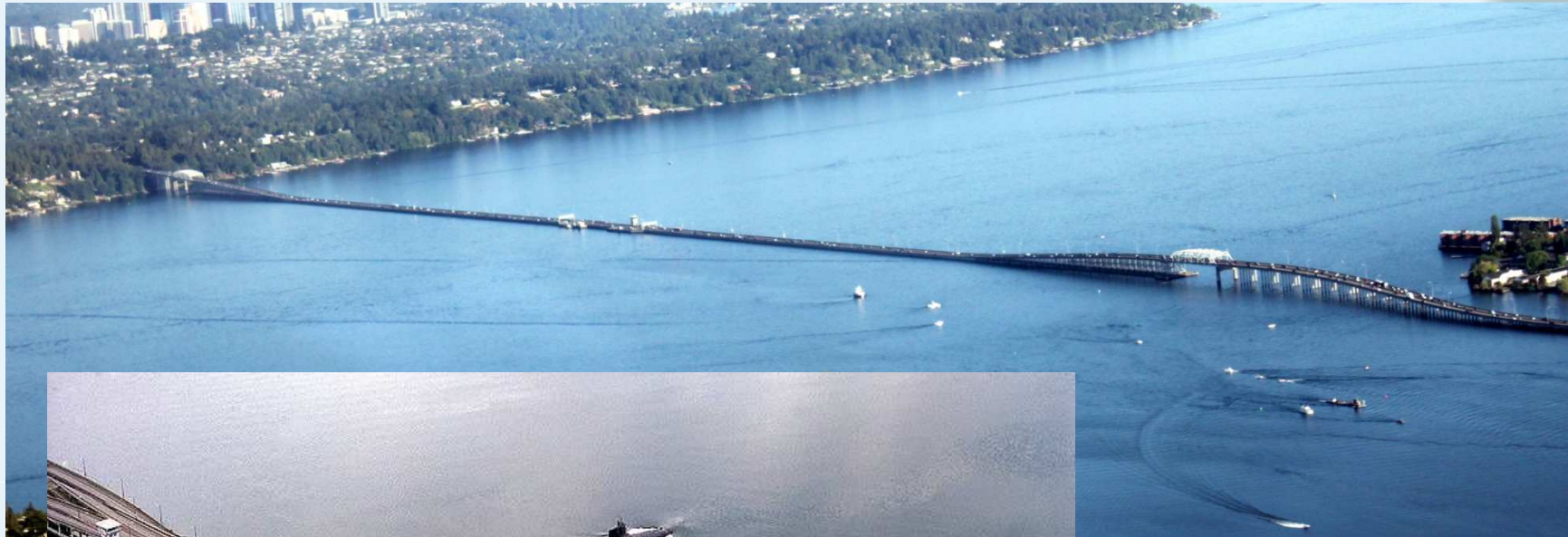
# Competition image



# Competition image

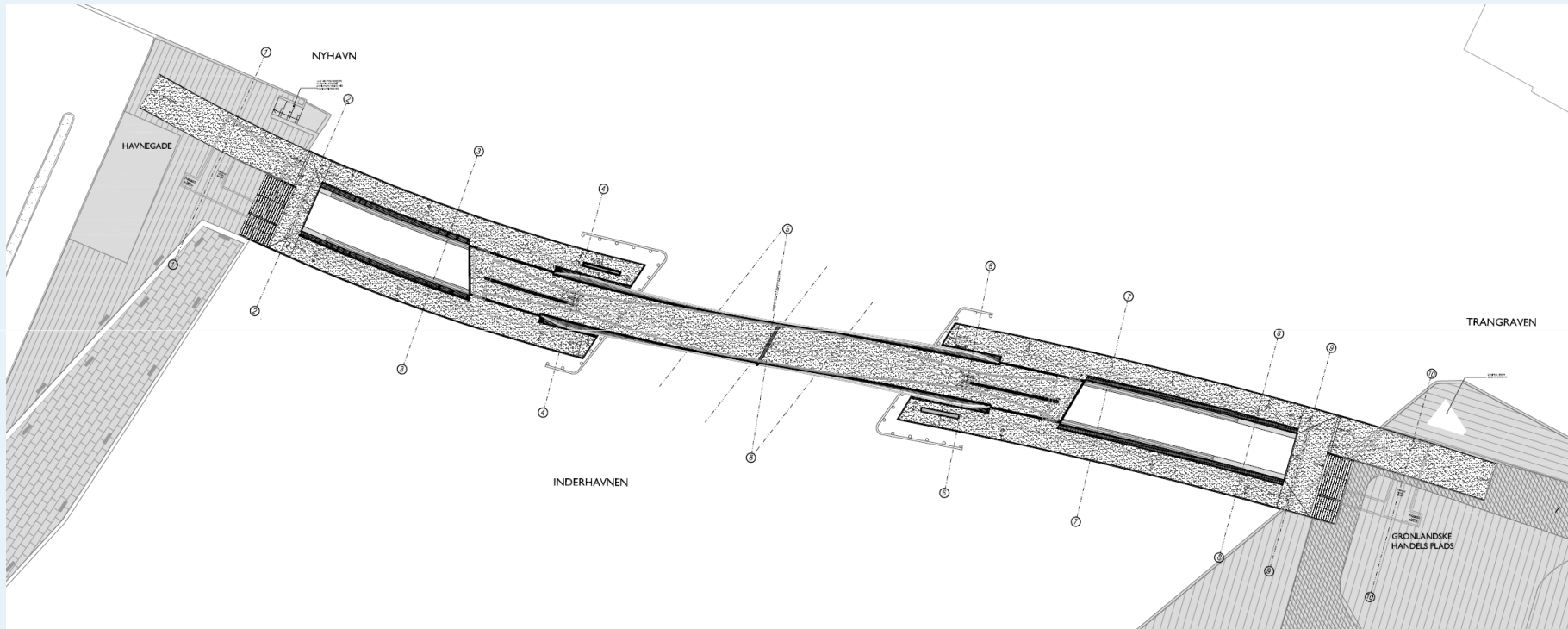


# Precedents



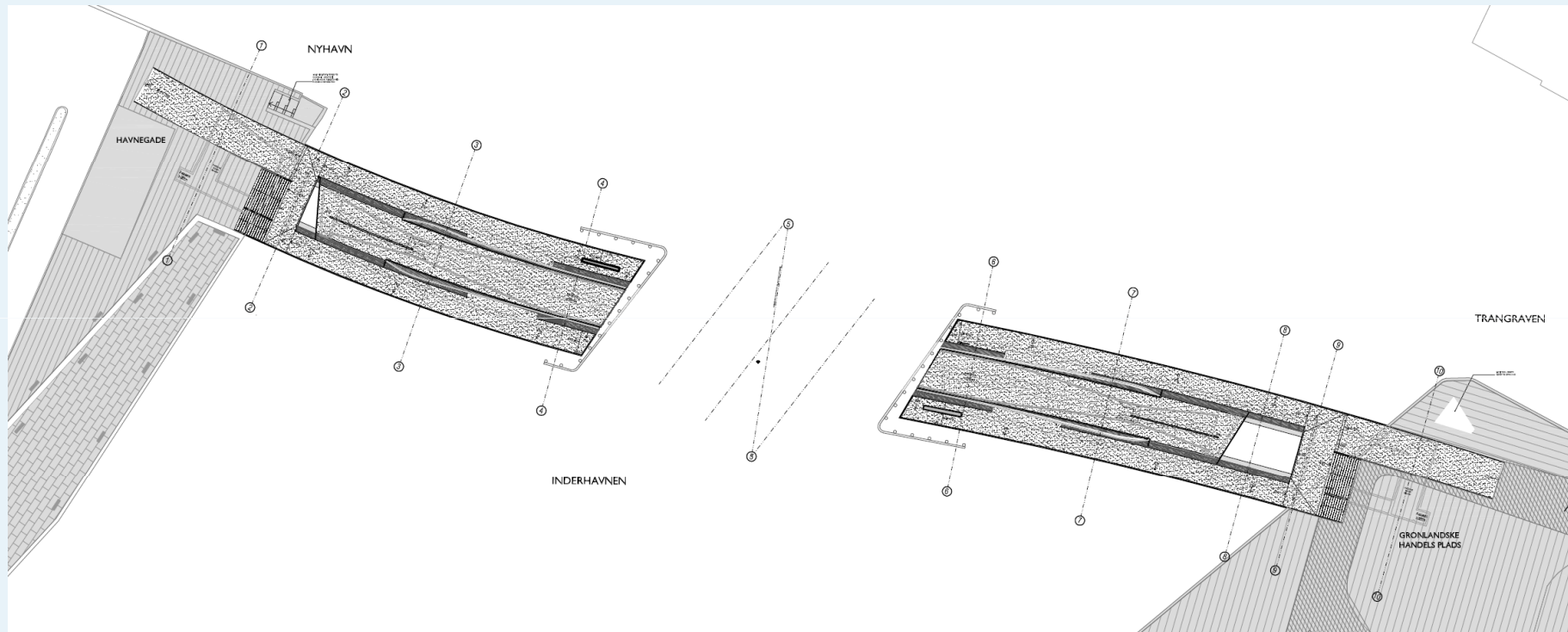
Hood Canal Bridge, USA

# Plan – Bridge closed

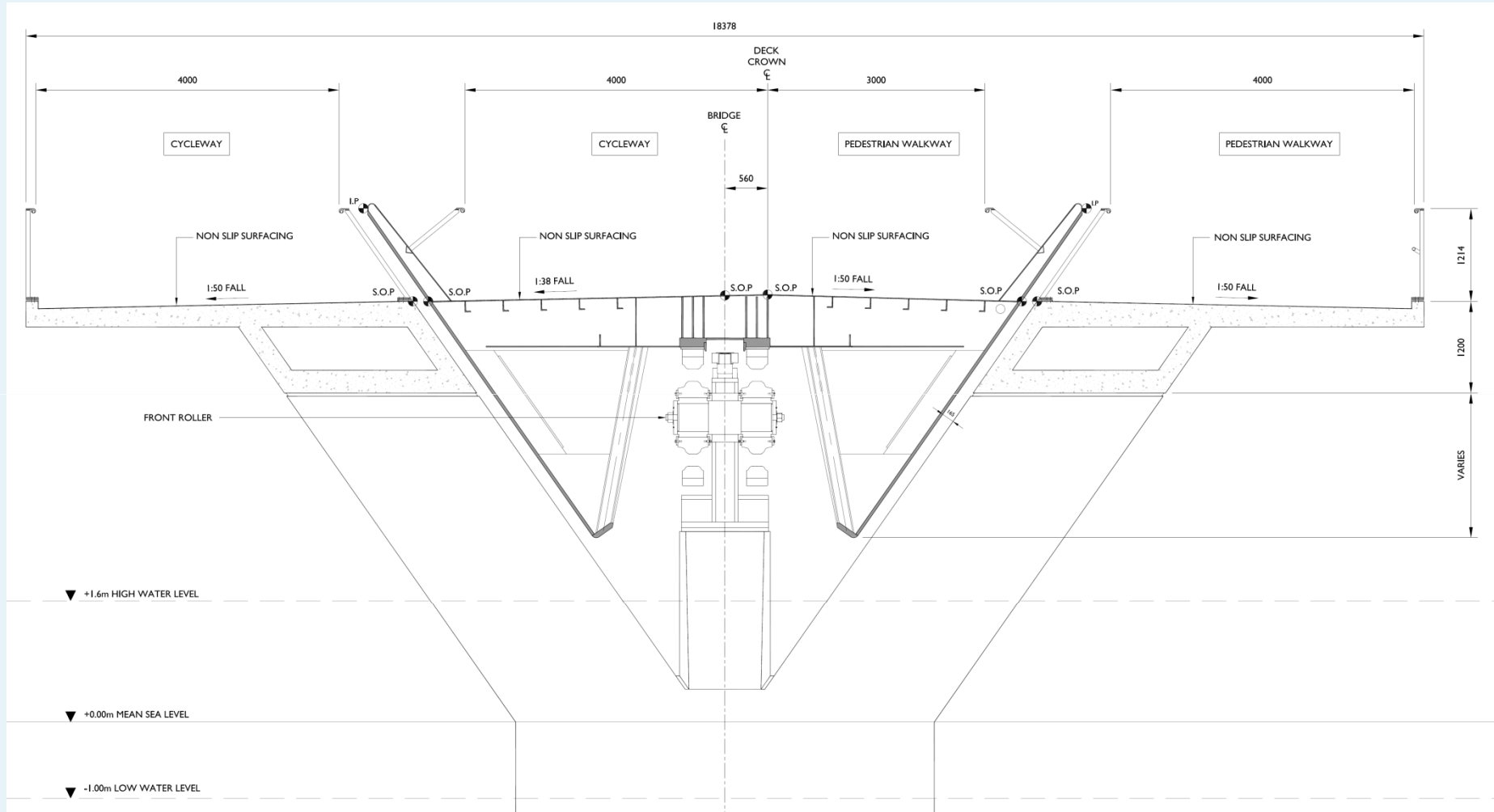




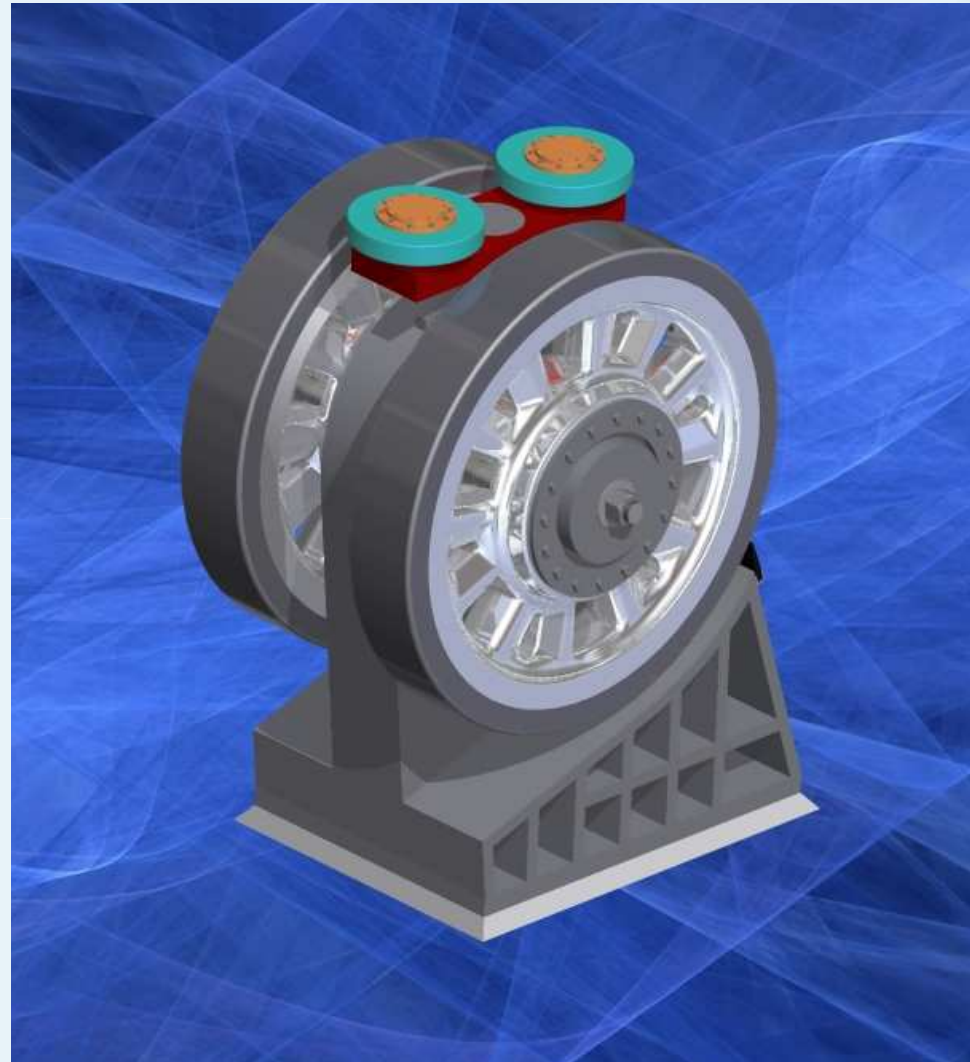
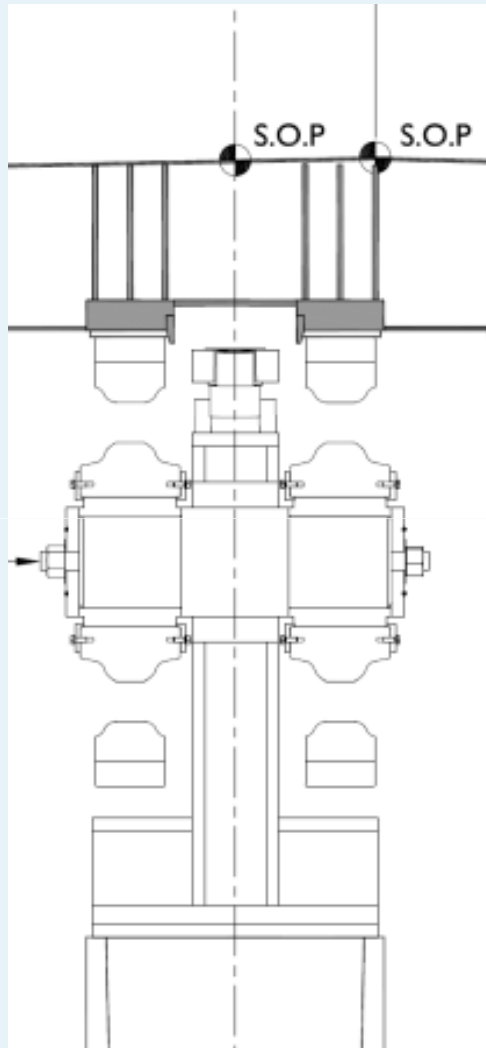
# Plan – Bridge open



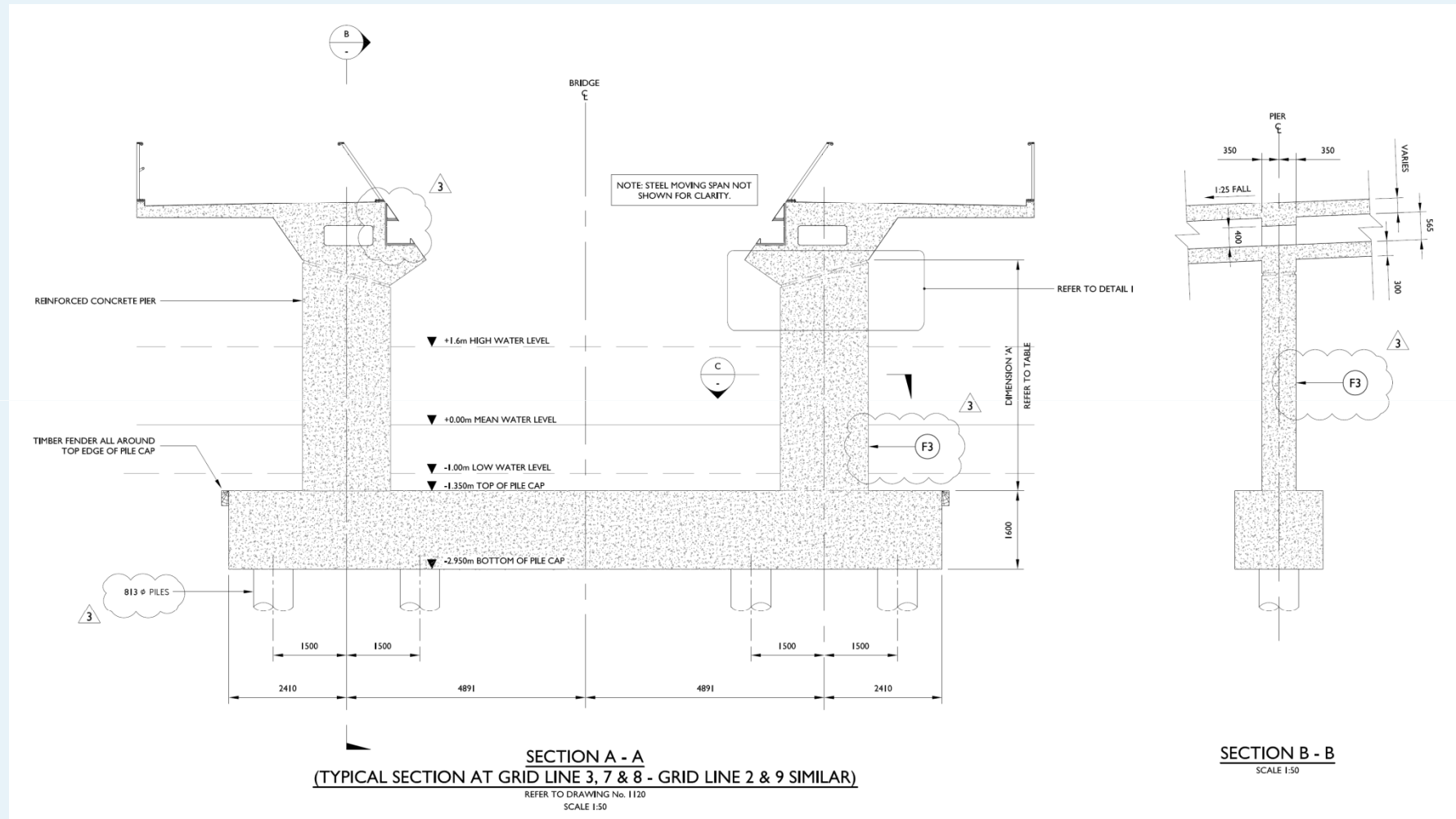
# Section at front roller support



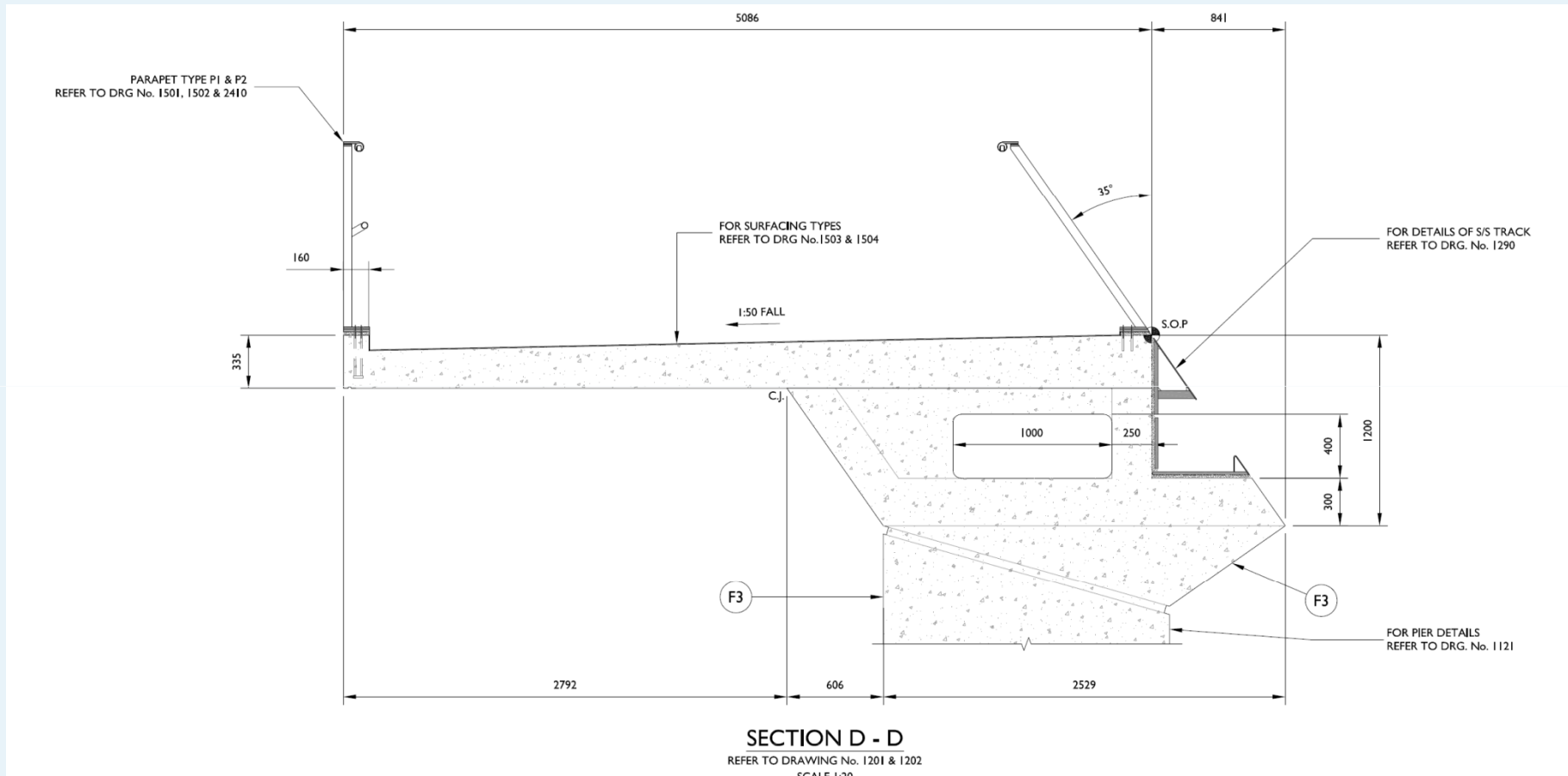
# Front roller support assembly



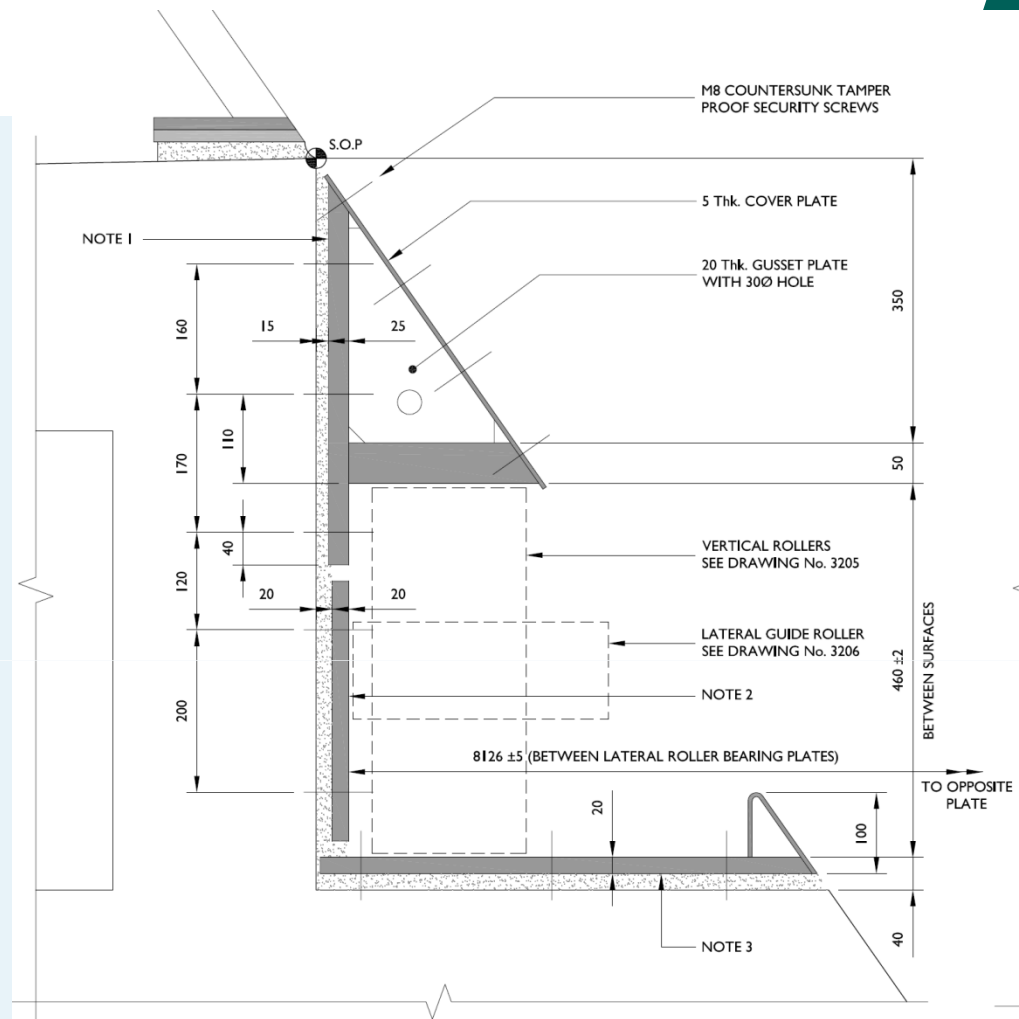
# Section at approach bridge pier



# Concrete deck typical section



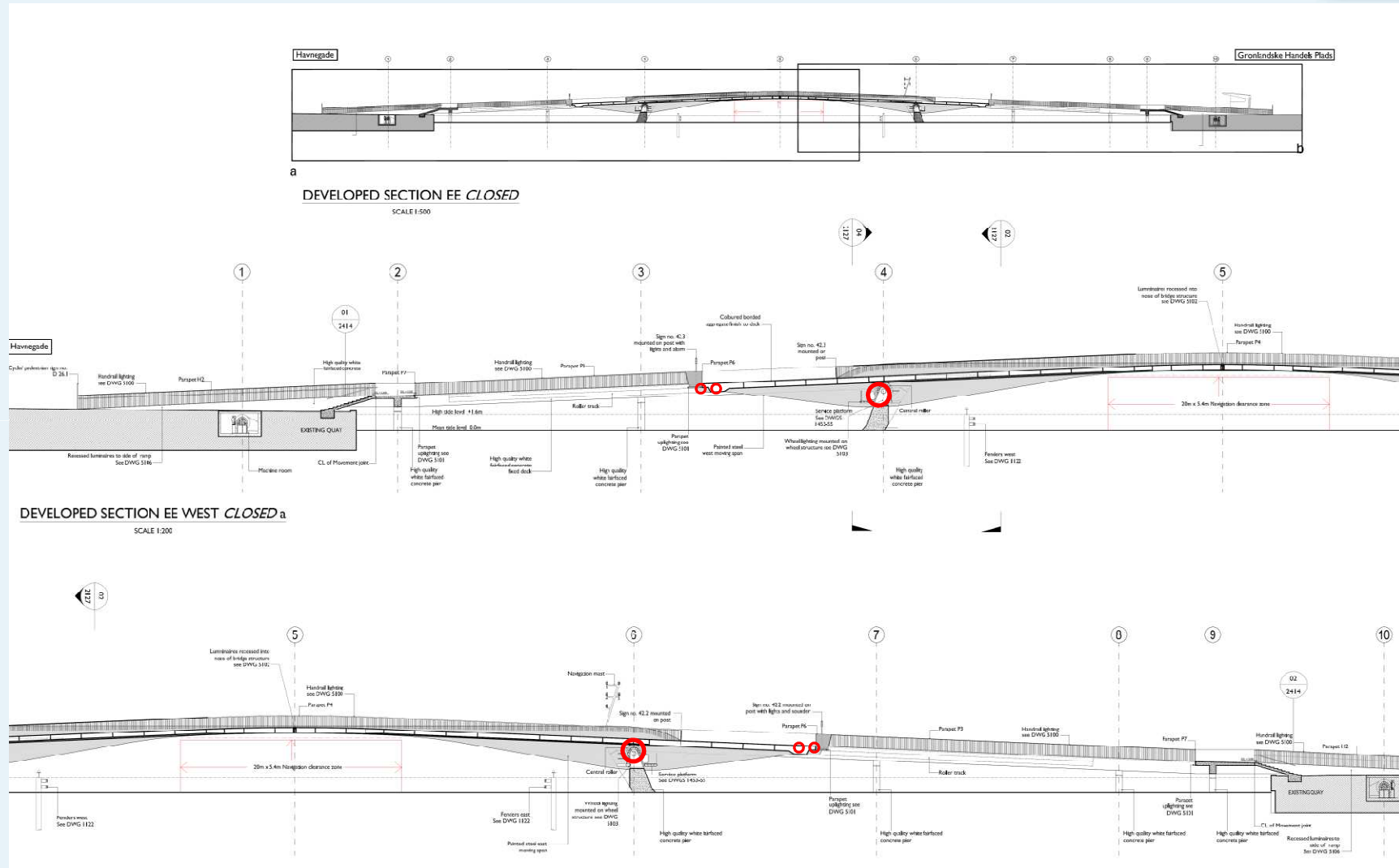
# Rear roller tracks



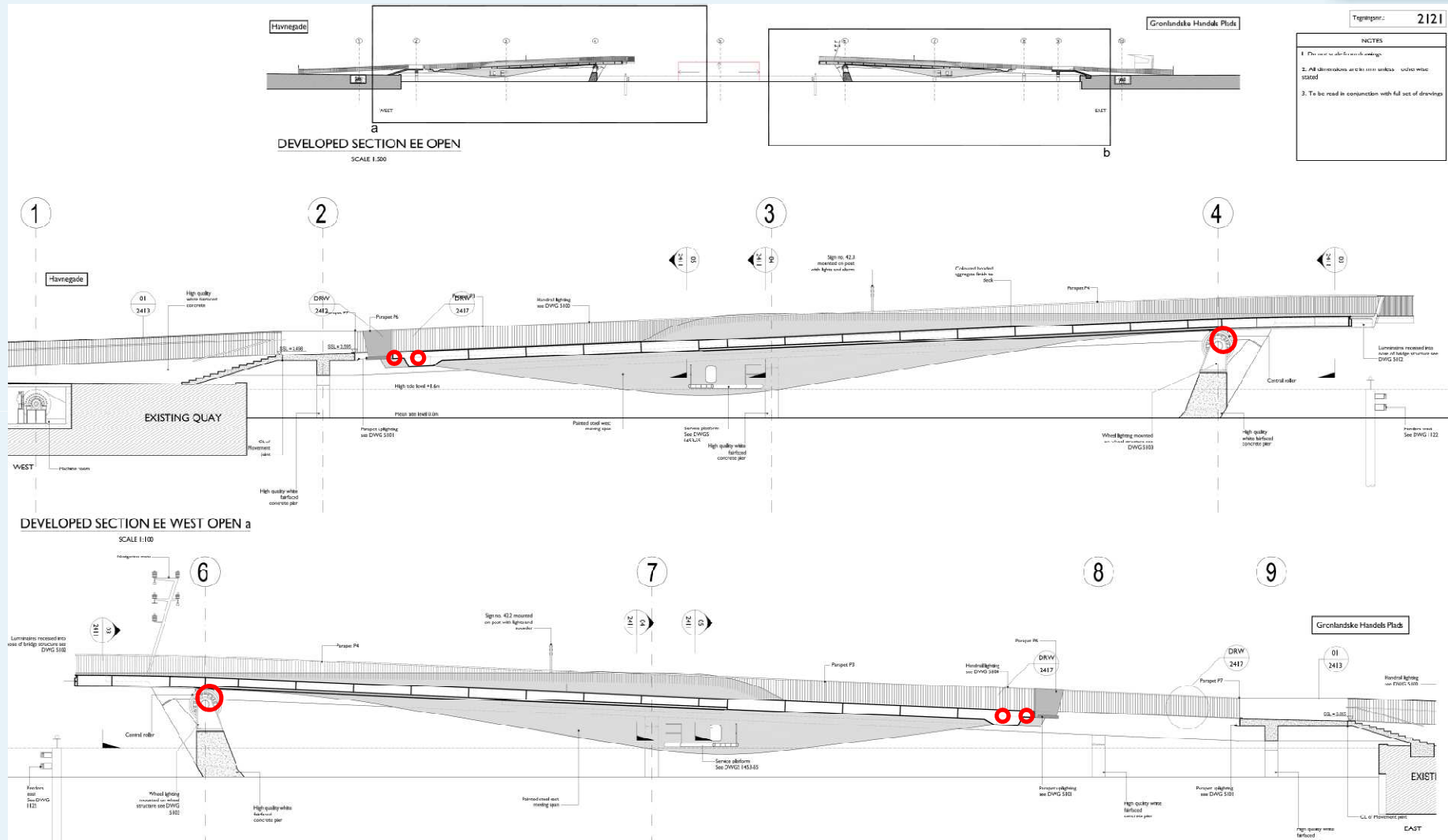
## NOTES FOR STRUCTURAL TRACK SECTION

1. UPPER TRACK SECTION SCREWED TO CONCRETE WEB WITH M24 HILTI ANCHORS.
2. BEARING PLATE FOR LATERAL ROLLERS SCREWED TO CONCRETE WITH COUNTERSUNK M20 HILTI FIXINGS. GROUT LAYER ADJUSTED TO ACHIEVE ALIGNMENT TOLERANCE WITH OPPOSITE TRACK.
3. BASE PLATE FOR ROLLER SUPPORT IN ROLLING BACK POSITION, SCREWED TO CONCRETE CORBEL USING COUNTERSINK M20 HILTI FIXINGS. LEVEL ADJUSTED TO ACHIEVE VERTICAL ALIGNMENT TOLERANCE.

# Long section – Bridge closed

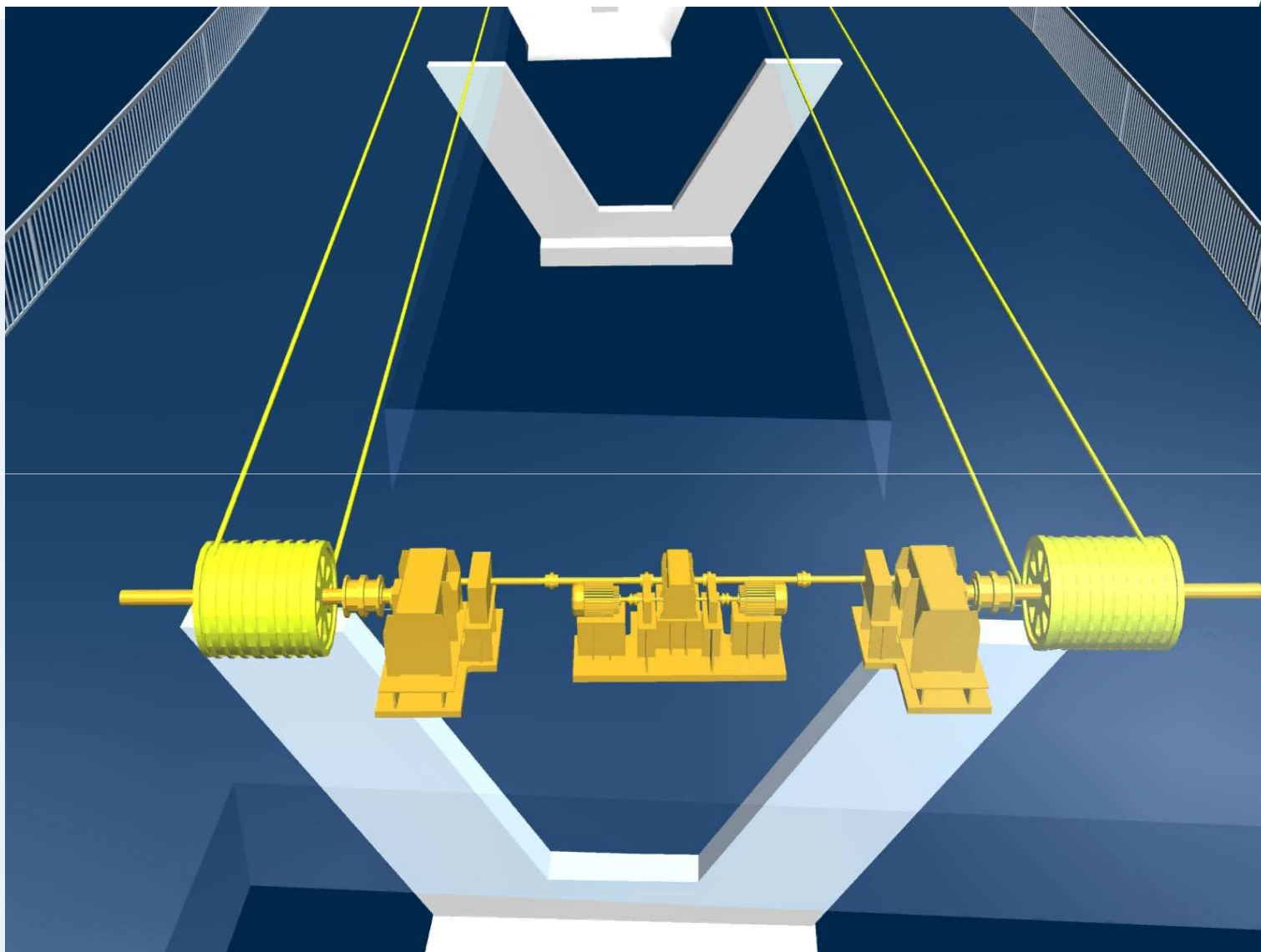


# Long section – Bridge open

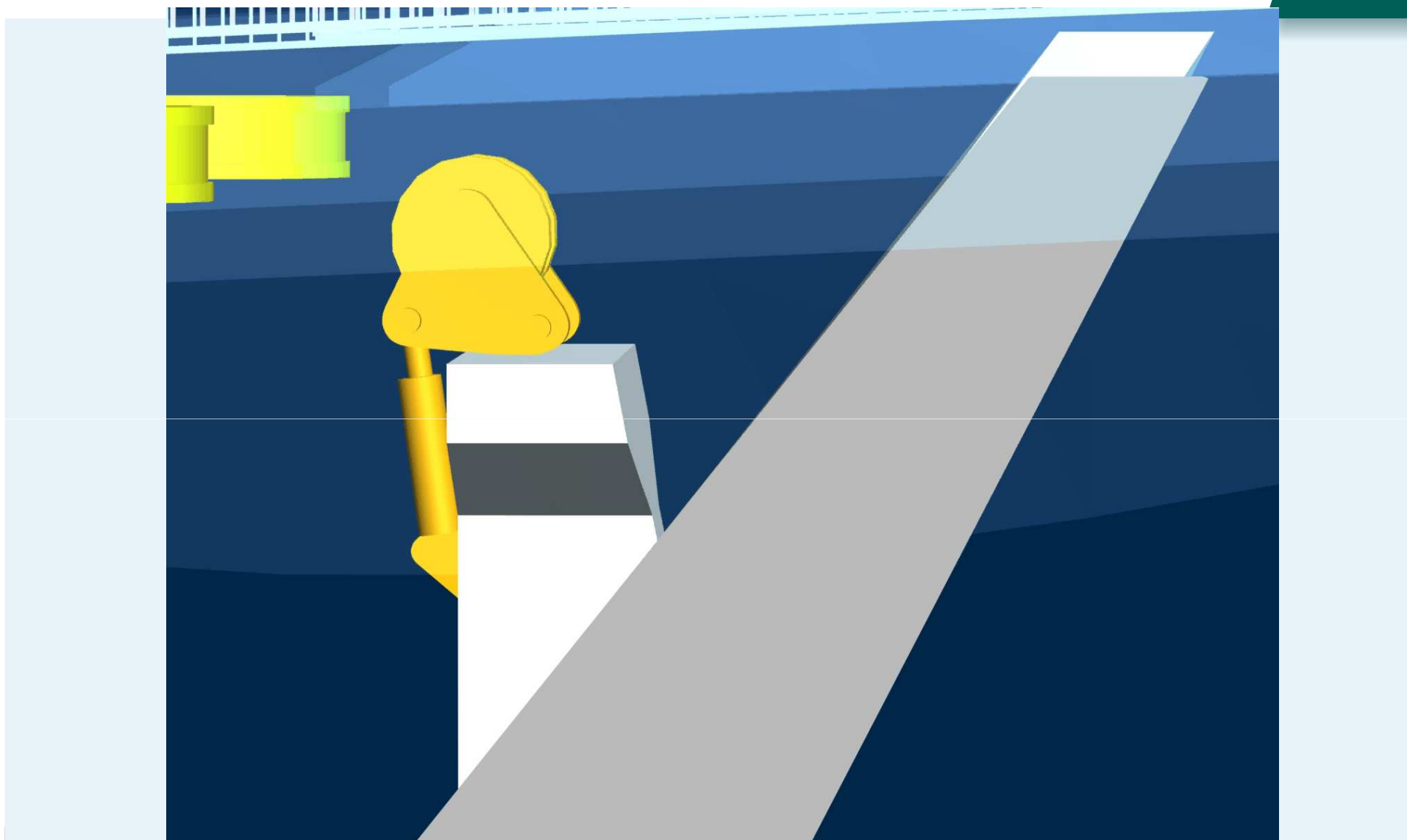




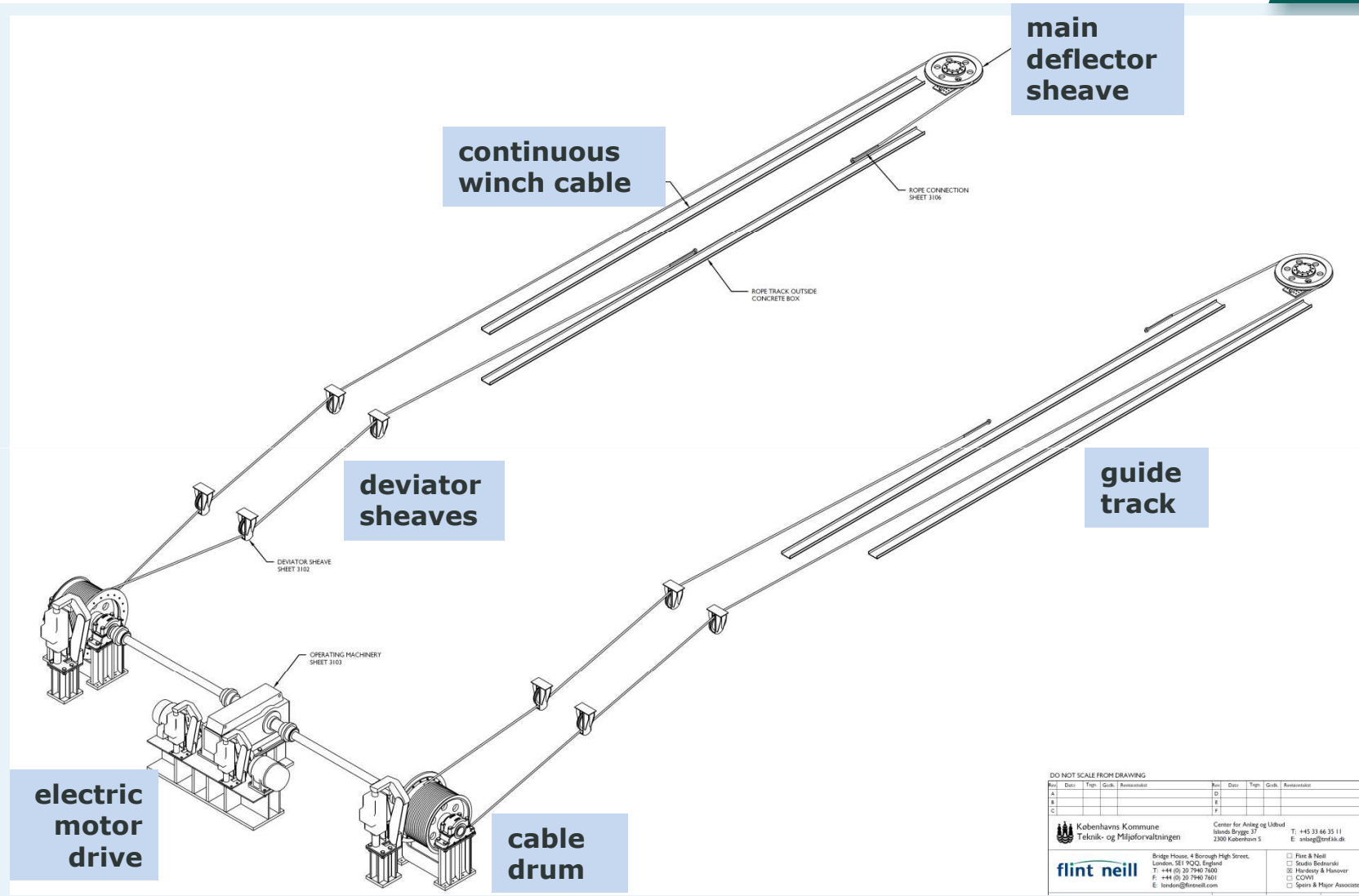
# Moving mechanism (competition stage)



## Moving mechanism (competition stage)



# Mechanical principle



DO NOT SCALE FROM DRAWING

Rev.	Date	Typ.	Grsk.	Revisjonst.	Rev.	Date	Typ.	Grsk.	Revisjonst.
A					D				
B					E				
C					F				

Københavns Kommune  
Teknik- og Miljøforvaltningen

Center for Anlæg og Udbud  
Blånds Brygge 37  
2300 København S

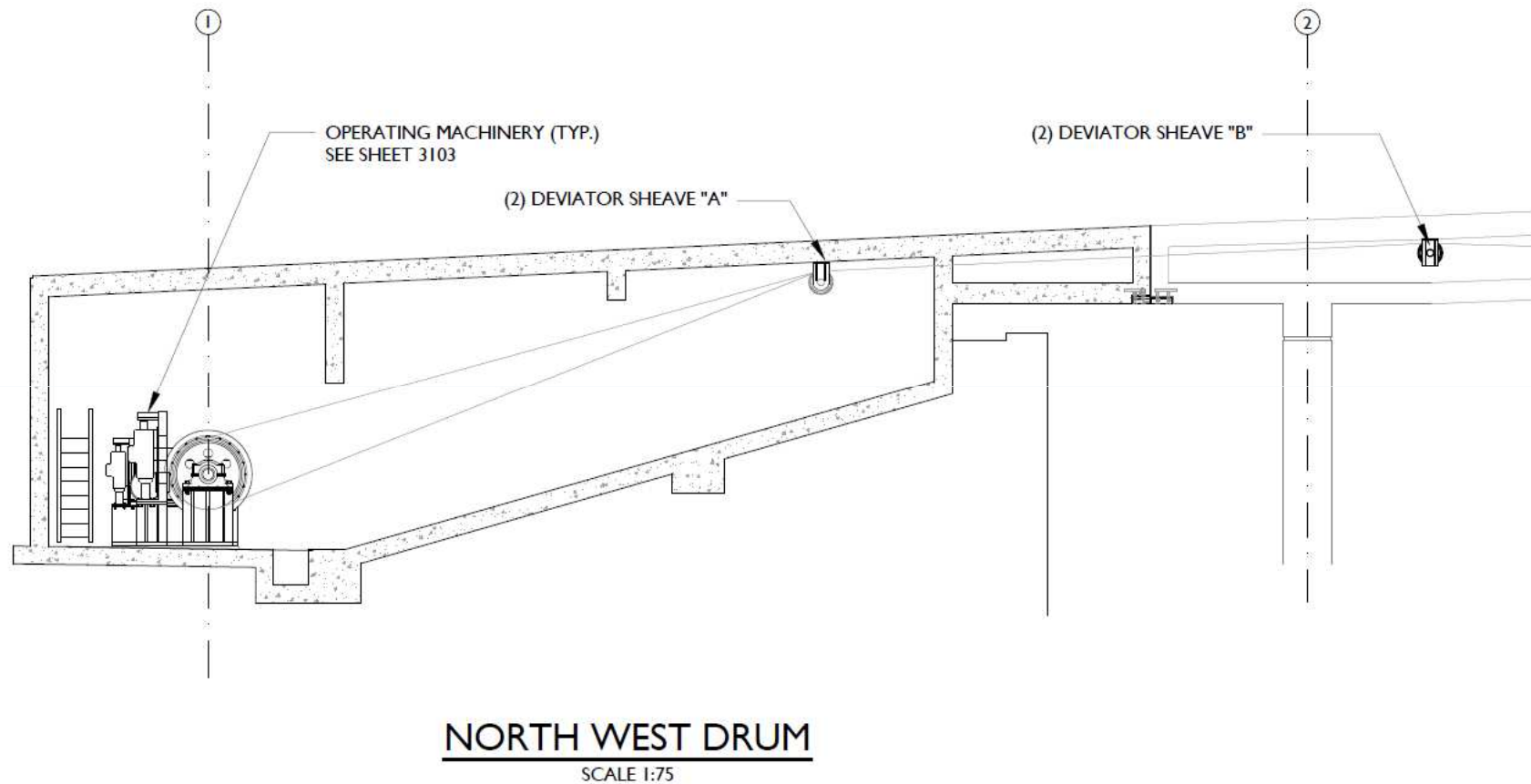
T: +45 33 46 35 11  
E: anlæg@tmf.kk.dk

flint neill

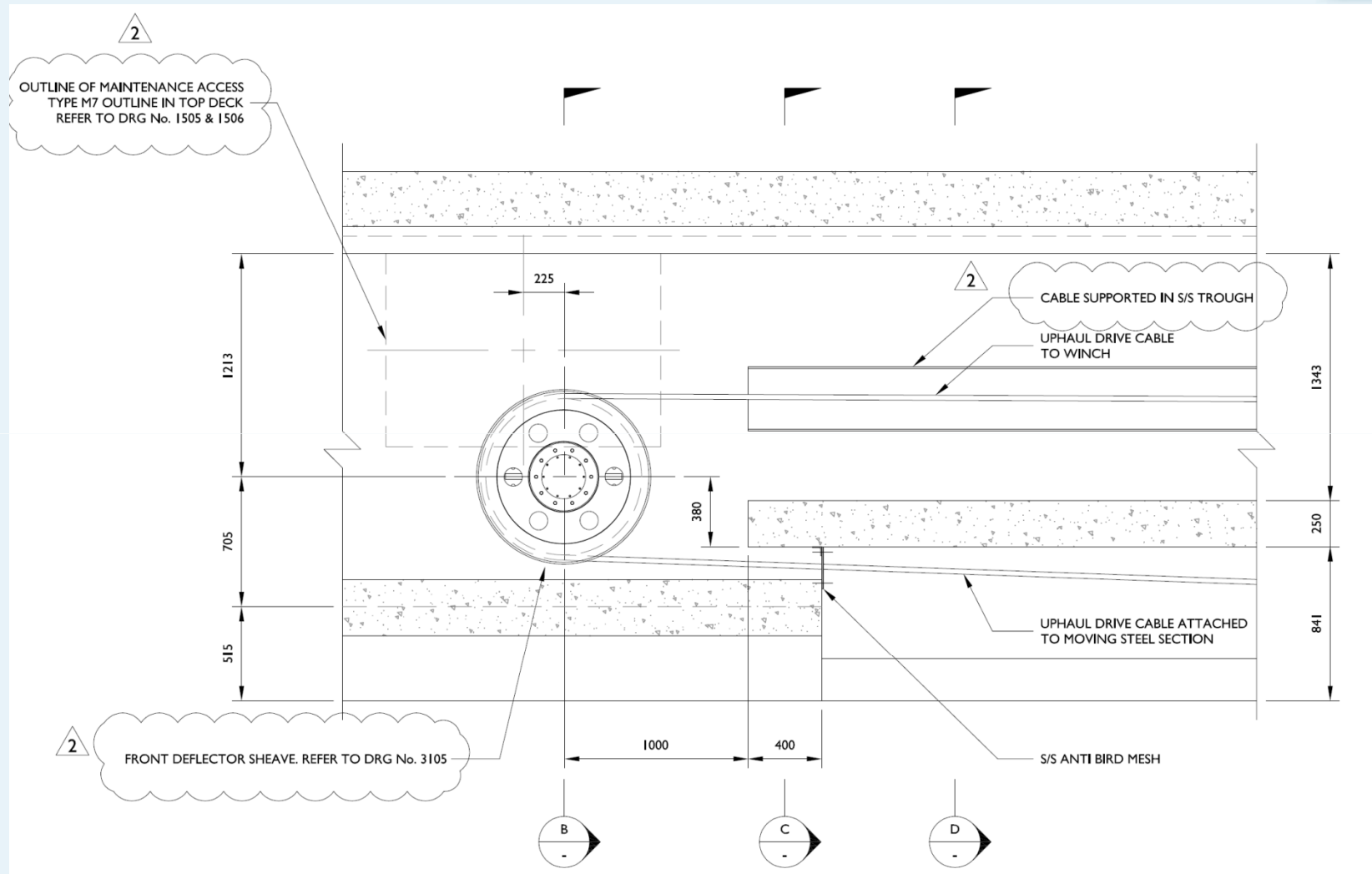
Bridge House, 4 Borough High Street,  
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F: +44 (0) 20 7940 7601  
E: london@flintneill.com

Fire & Neill  
 Skidde Bøderne  
 Hardisty & Hauser  
 COWI  
 Spinks & Major Associates

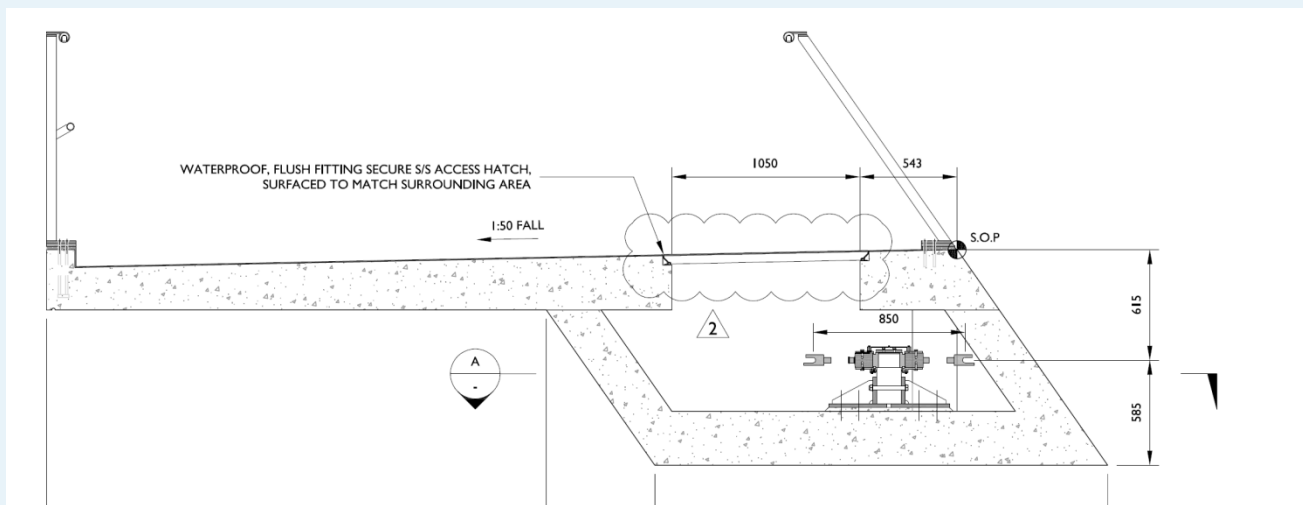
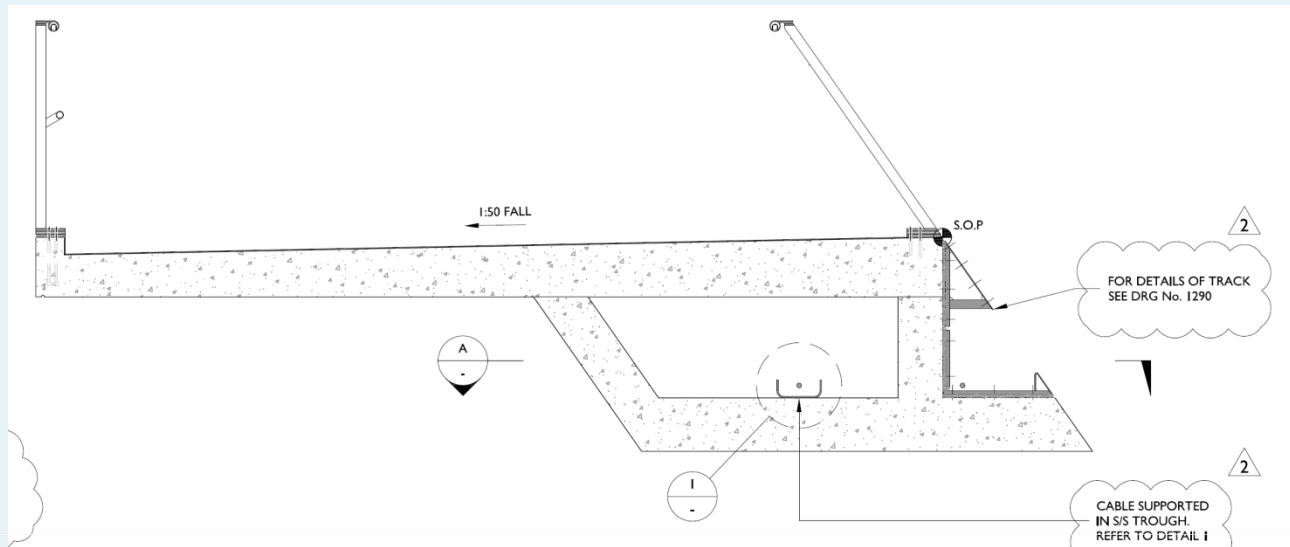
# Typical buried chamber arrangement



# Plan at main deviator sheave

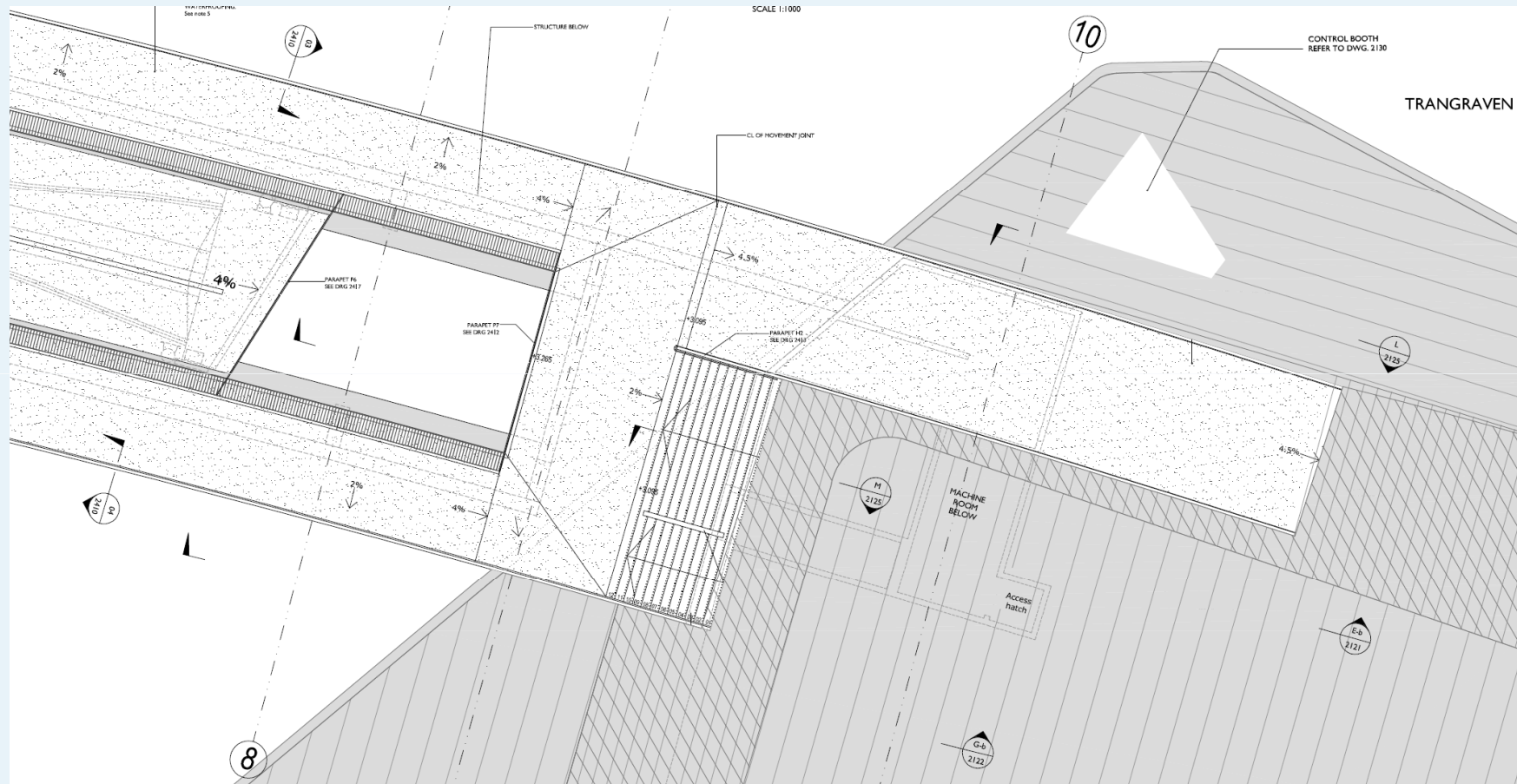


# Sections at main deviator sheave





# Grønlandske Handels Plads abutment

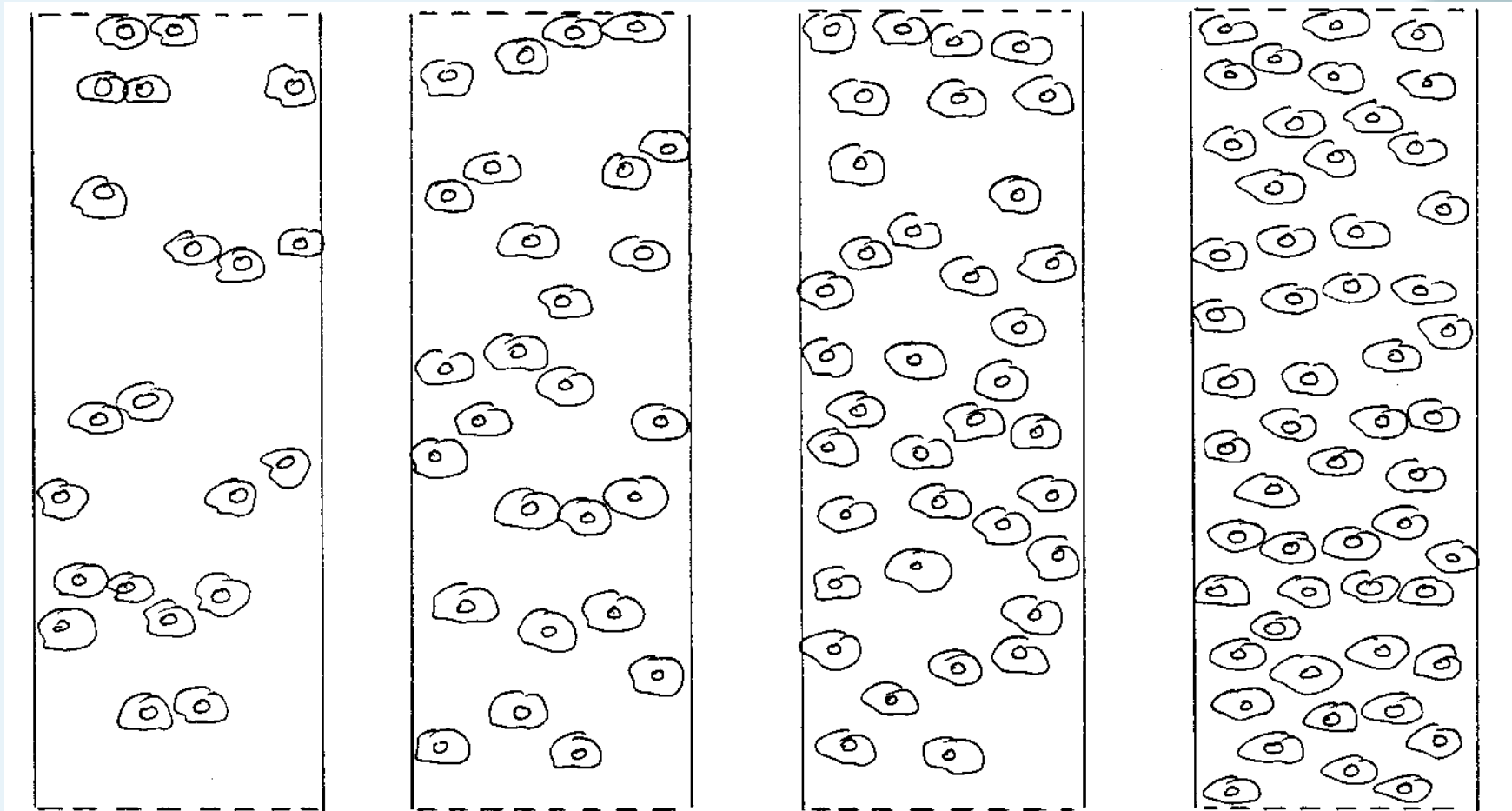




# The challenge of large crowds



# Pedestrian intensity



**0.6 P/m<sup>2</sup>**  
**0.5 kPa**

**0.8 P/m<sup>2</sup>**  
**0.6 kPa**

**1.0 P/m<sup>2</sup>**  
**0.8 kPa**

**1.5 P/m<sup>2</sup>**  
**1.2 kPa**

# Natural vibration modes

Mode	Frequency (Hz)	Generalised Mass (kg)
1 <sup>st</sup> Vertical	1.51	41,000
2 <sup>nd</sup> Vertical	3.36	125,000
1 <sup>st</sup> Torsional	3.45	66,000

# London Millennium Bridge, July 2000



# London Millennium Bridge, July 2000



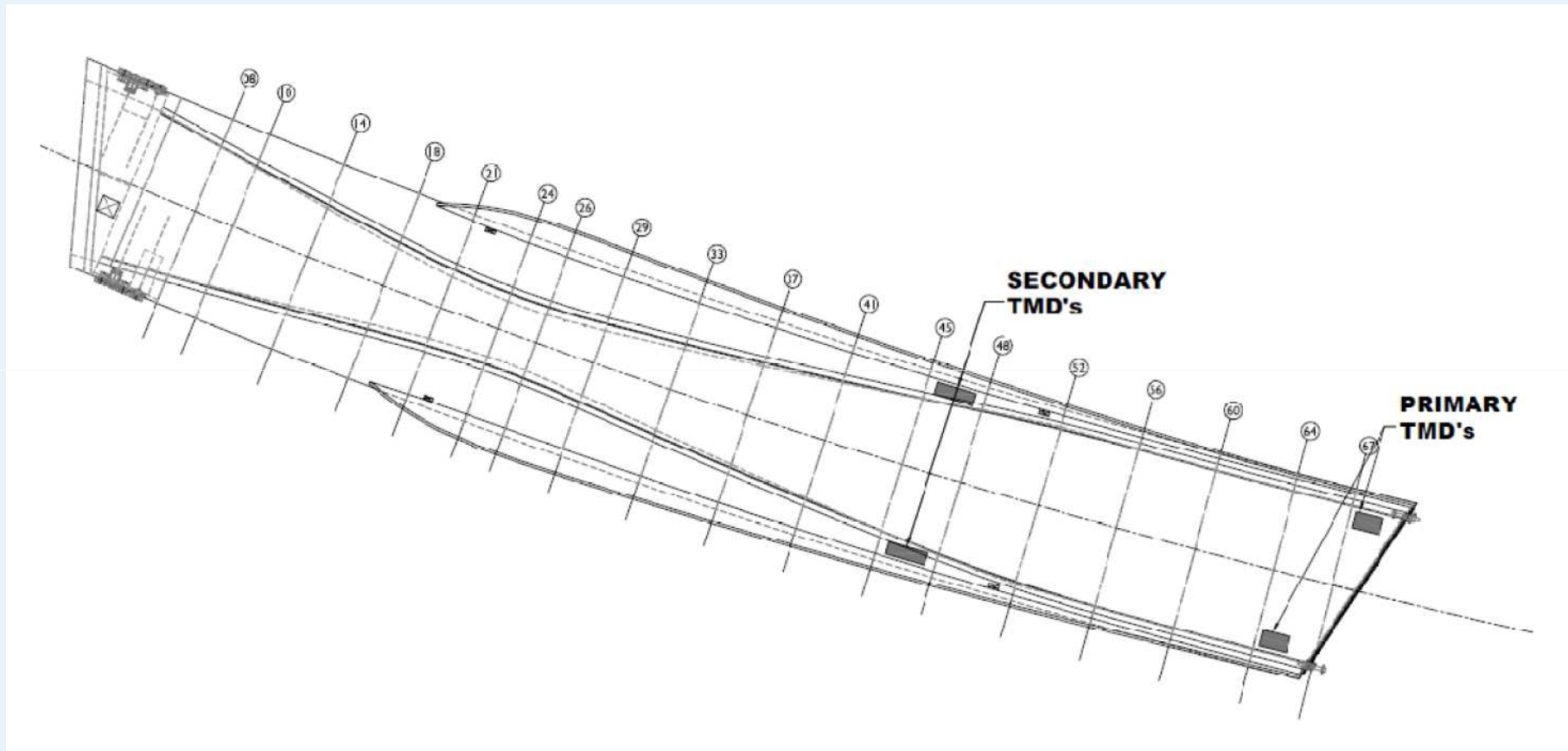
# Tuned Mass Damper, Swansea Sail Bridge



# Mill on the Exe bridge damper retrofit



# Locations of Tuned Mass Dampers

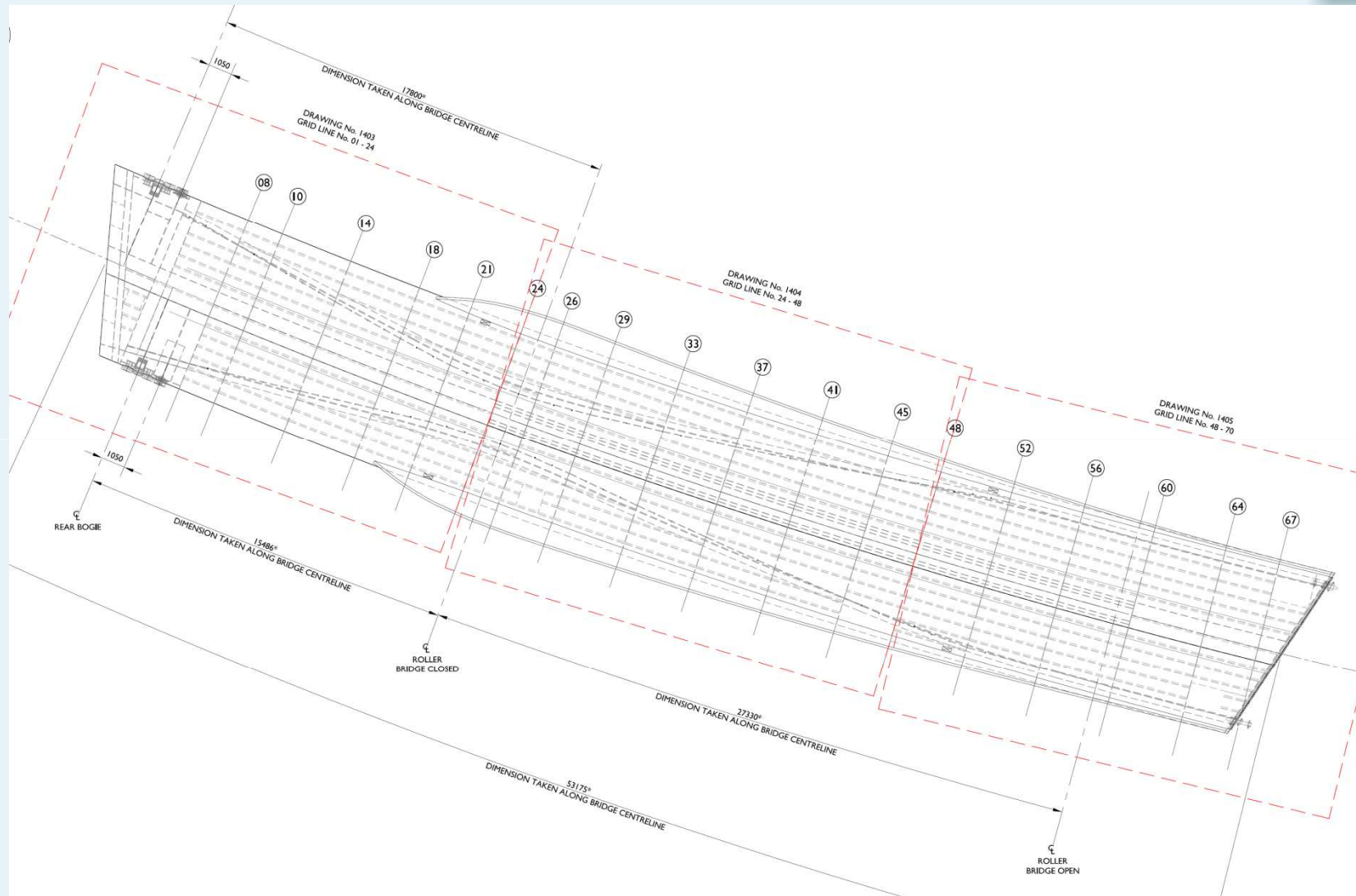




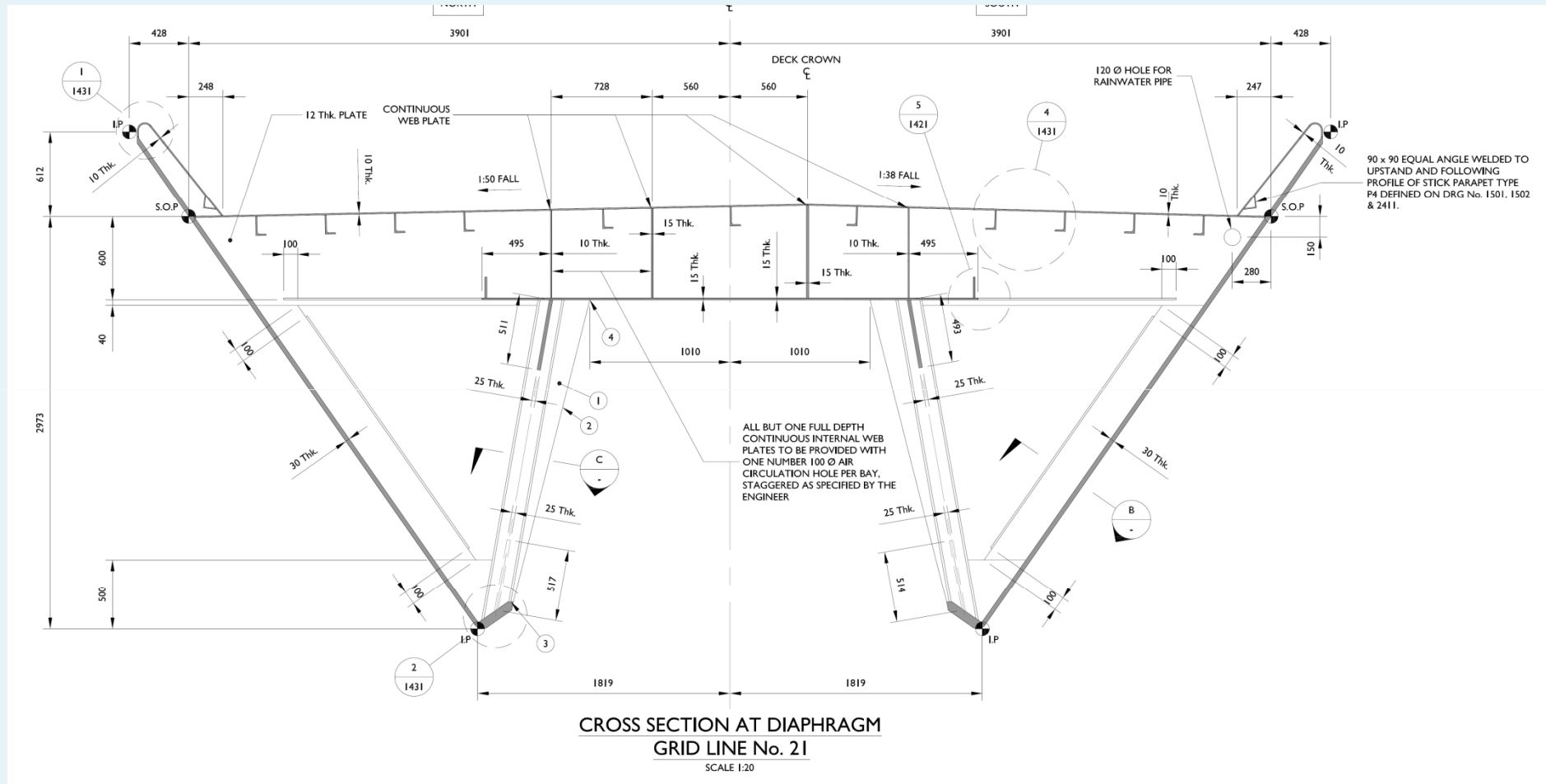
# Dynamic loading cases

- Walking group
- Running group
- Deliberate excitation (vandalism)
- Rhythmic crowd (dancing)

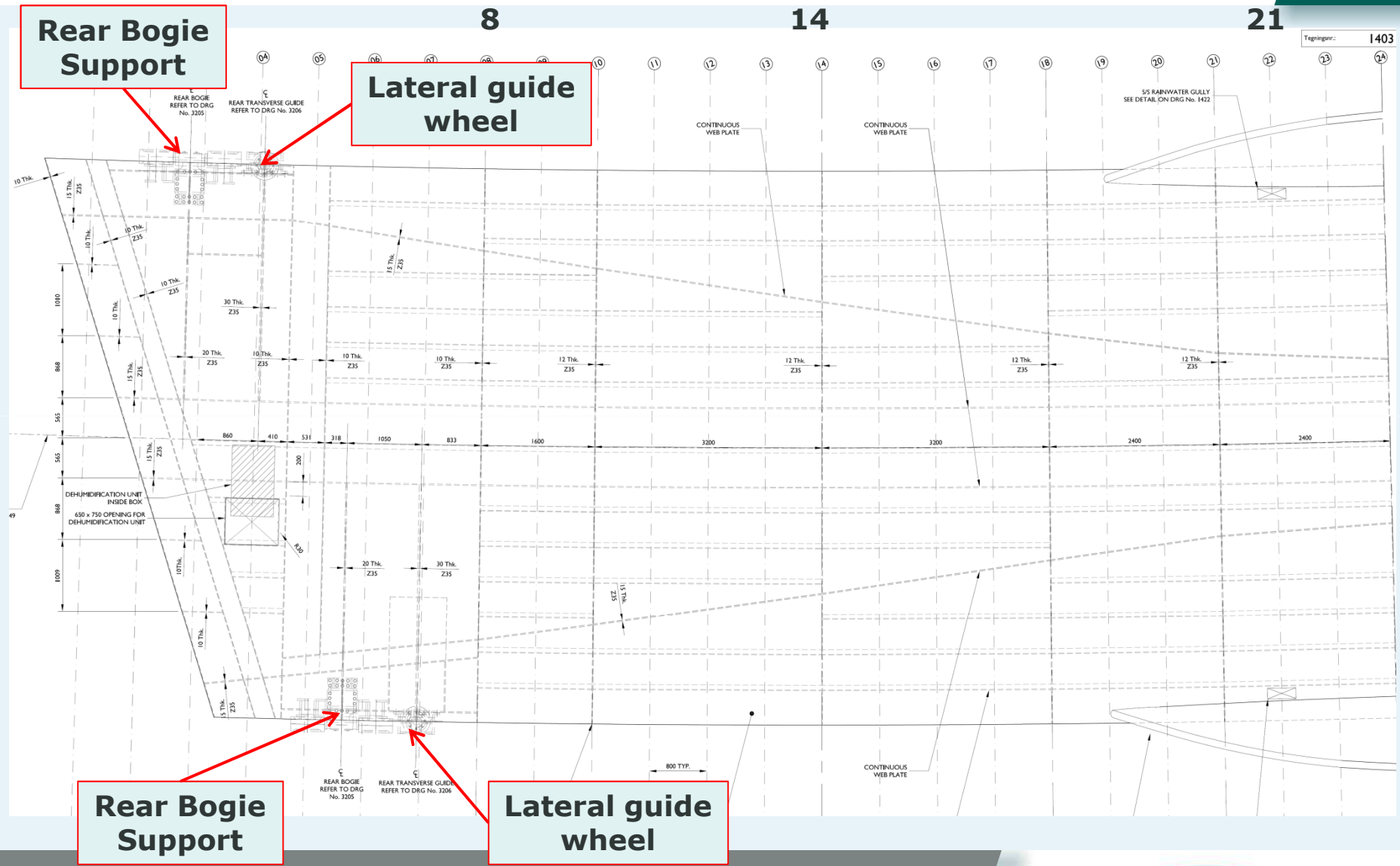
# Plan on west steel section



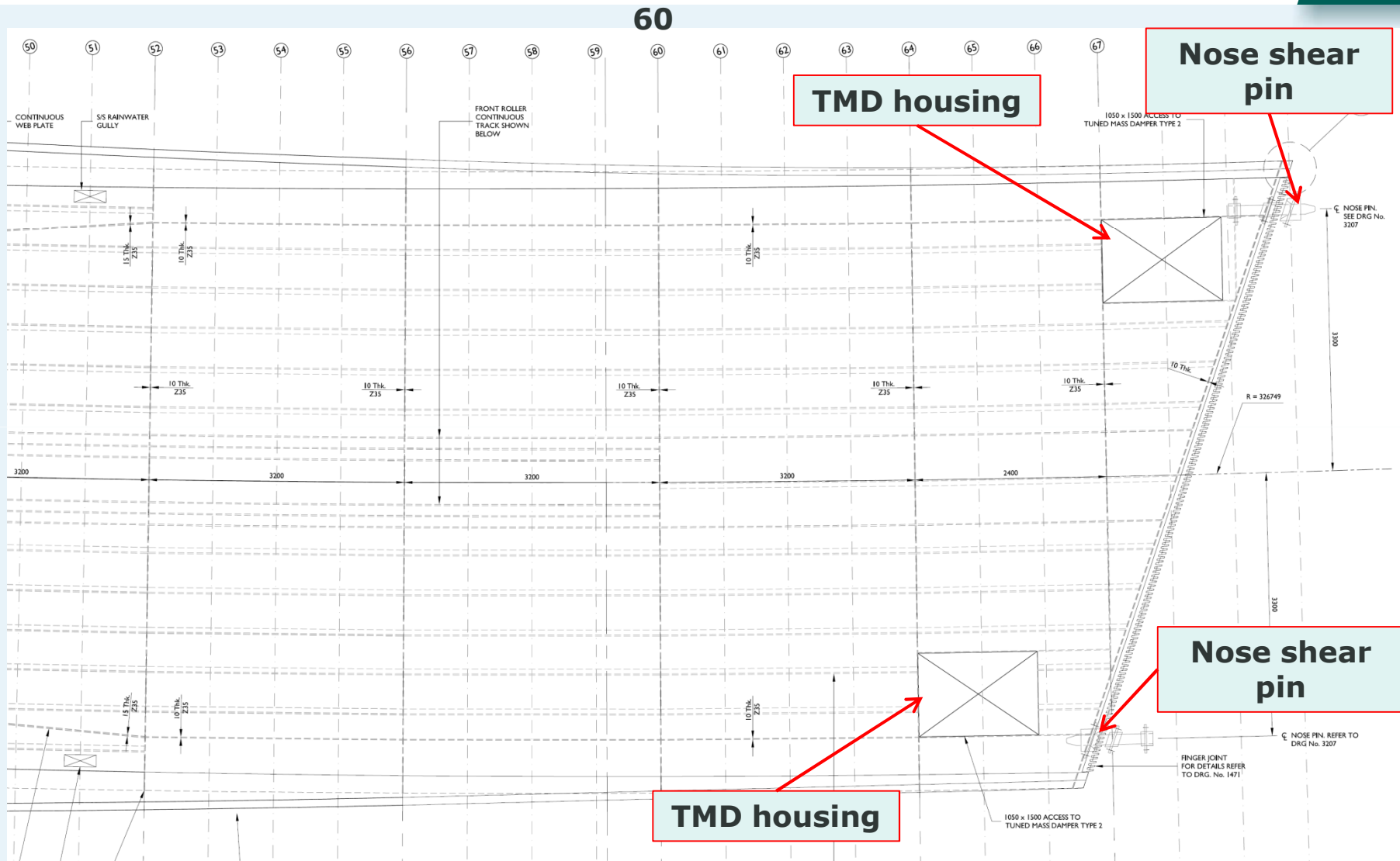
# Typical section through steel span (grid 21)



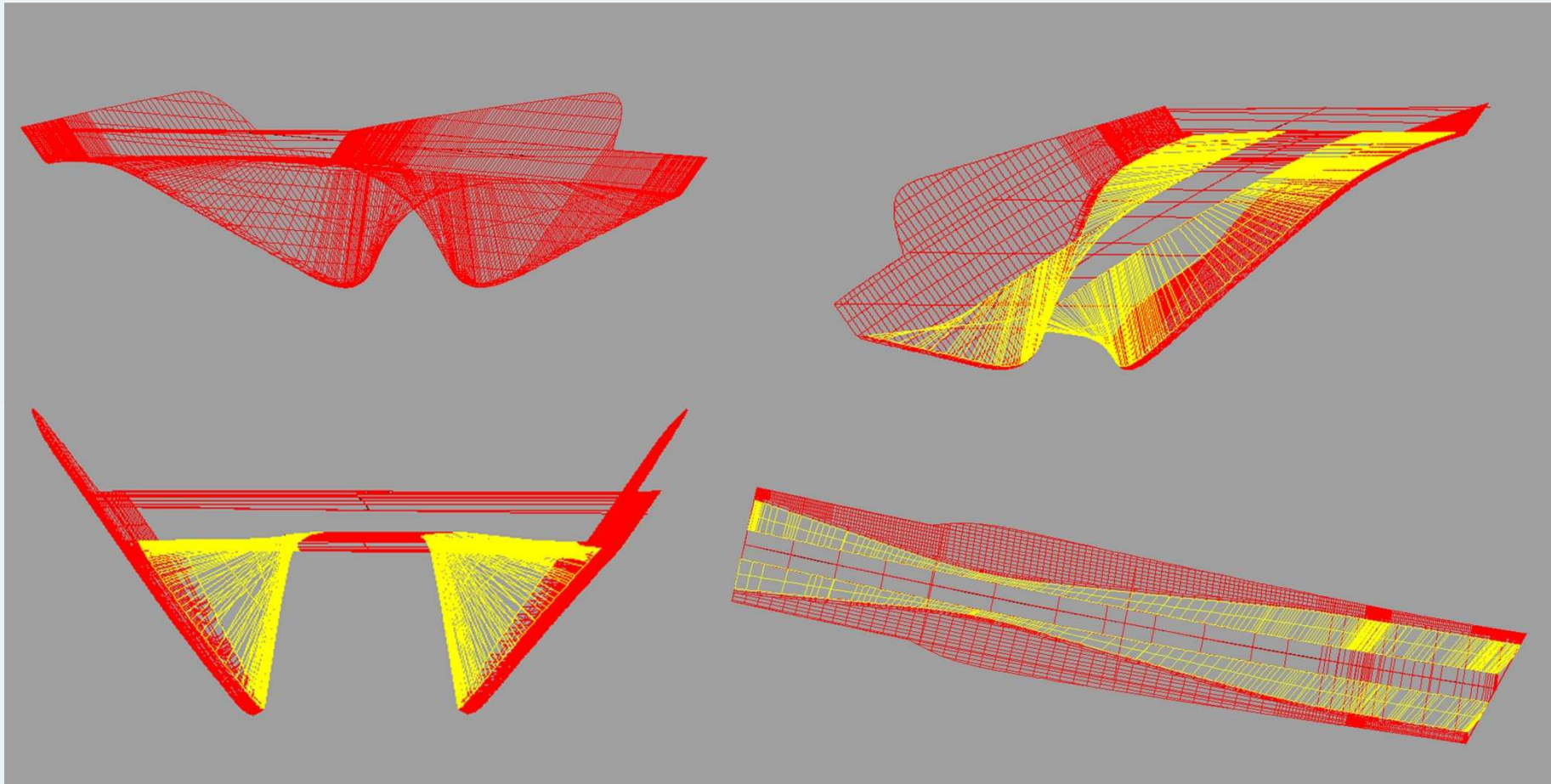
# Plan at rear of moving span



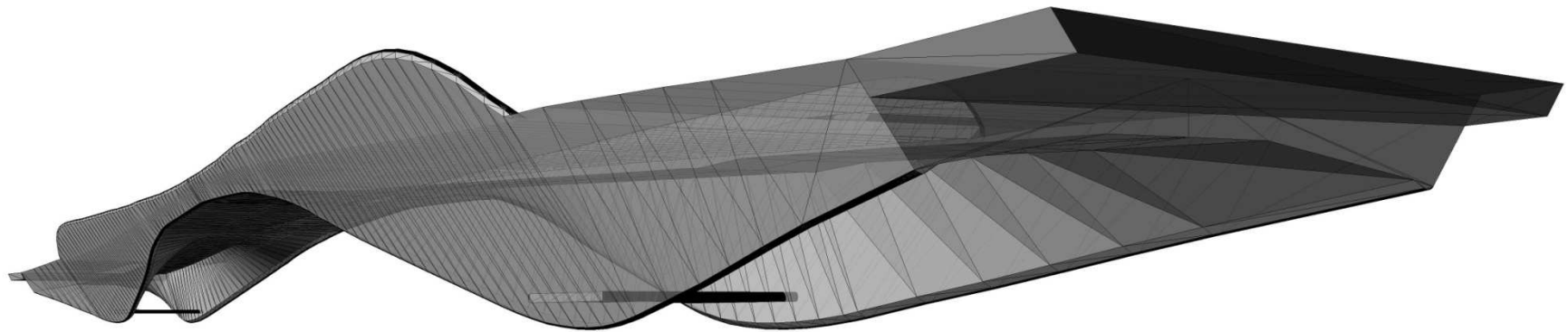
# Plan at front end of steel span



# 3-D geometry development



# 3-D Geometry



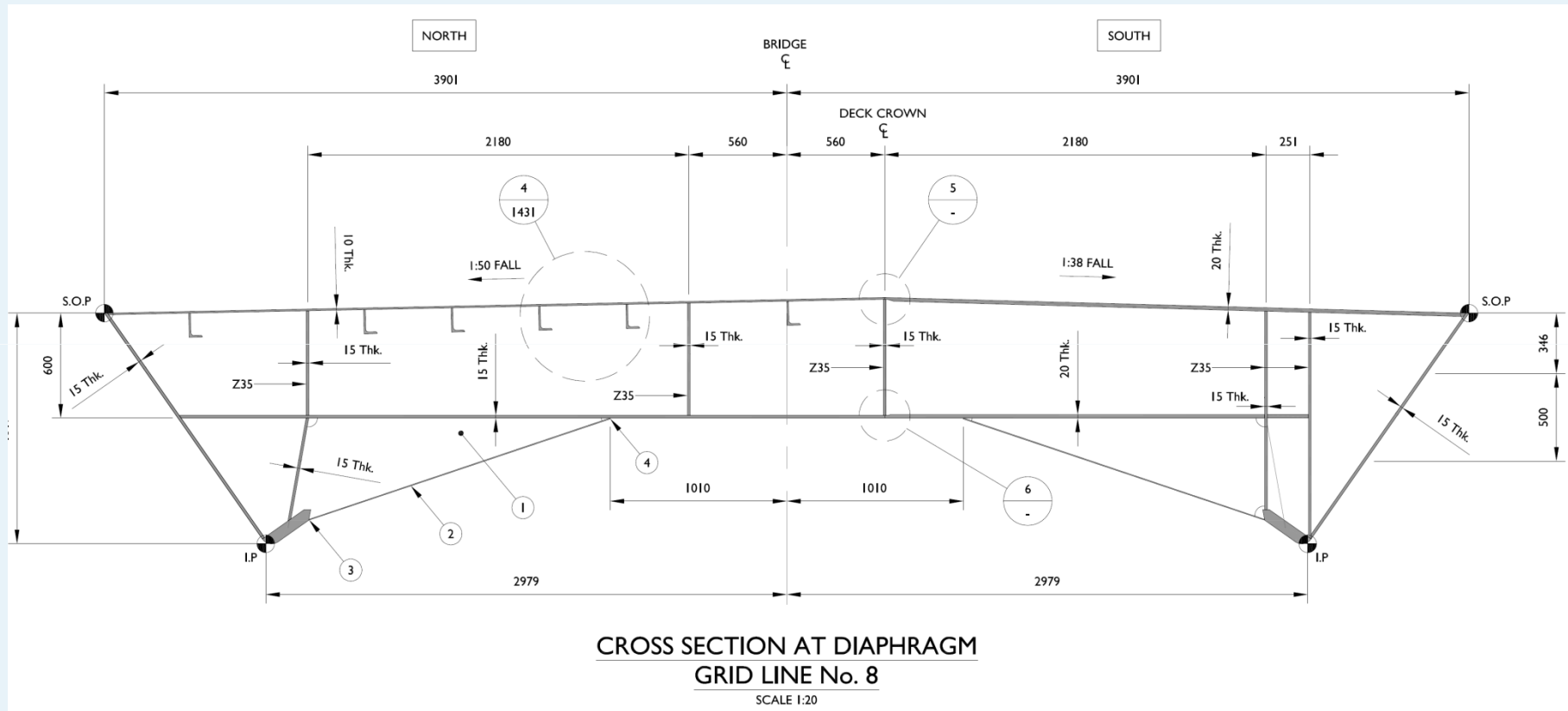
# 3-D Geometry



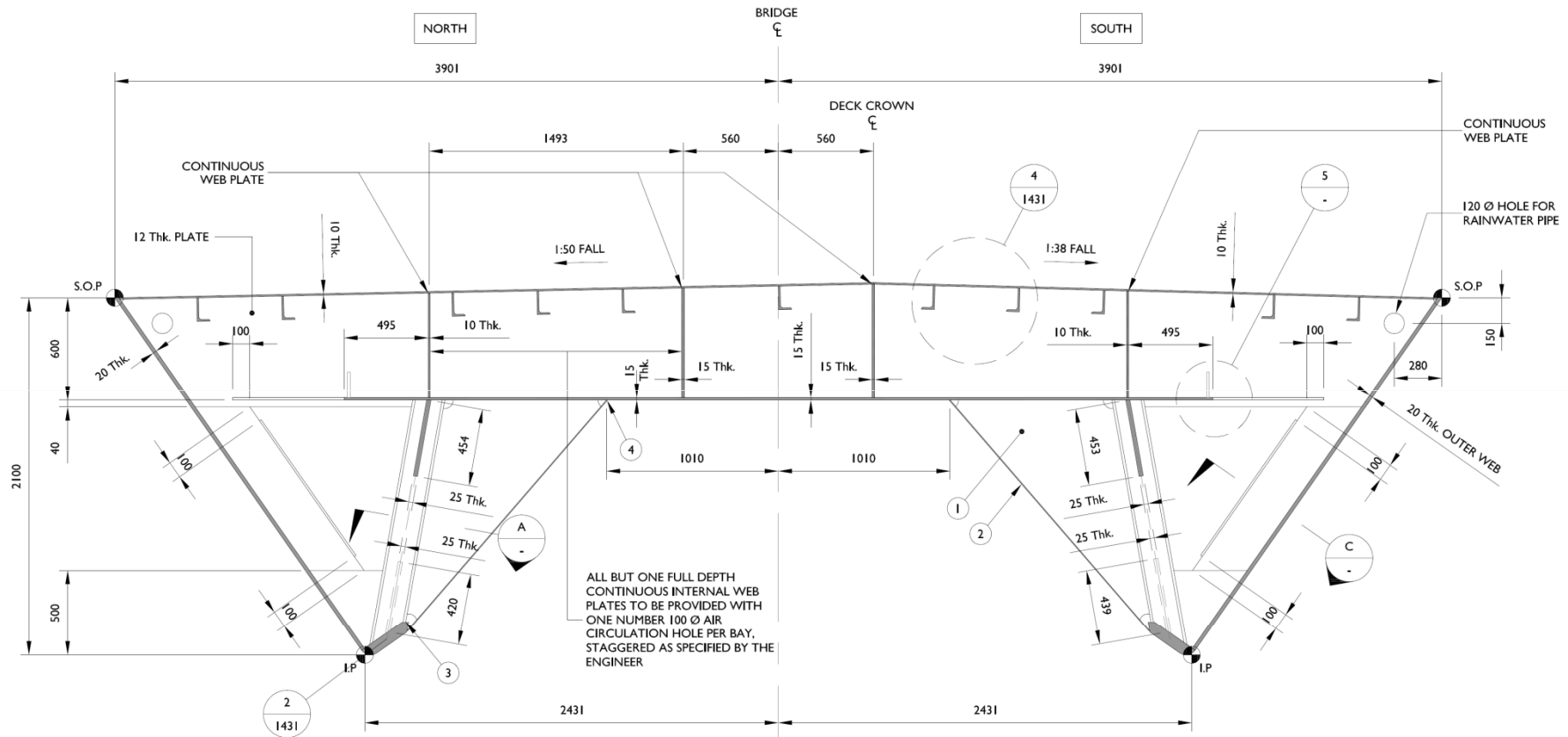




# Section at grid 8

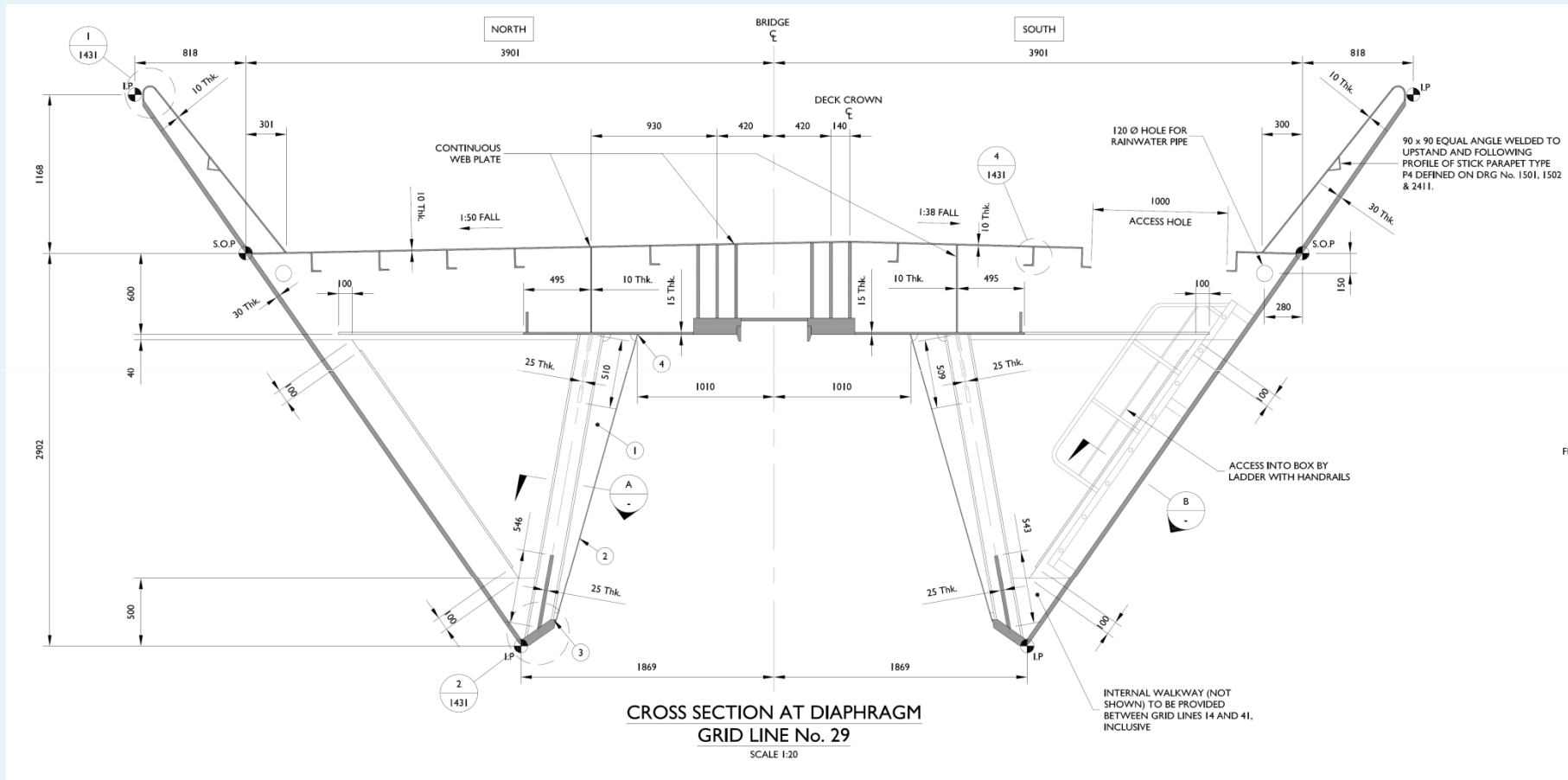


# Section at grid 14

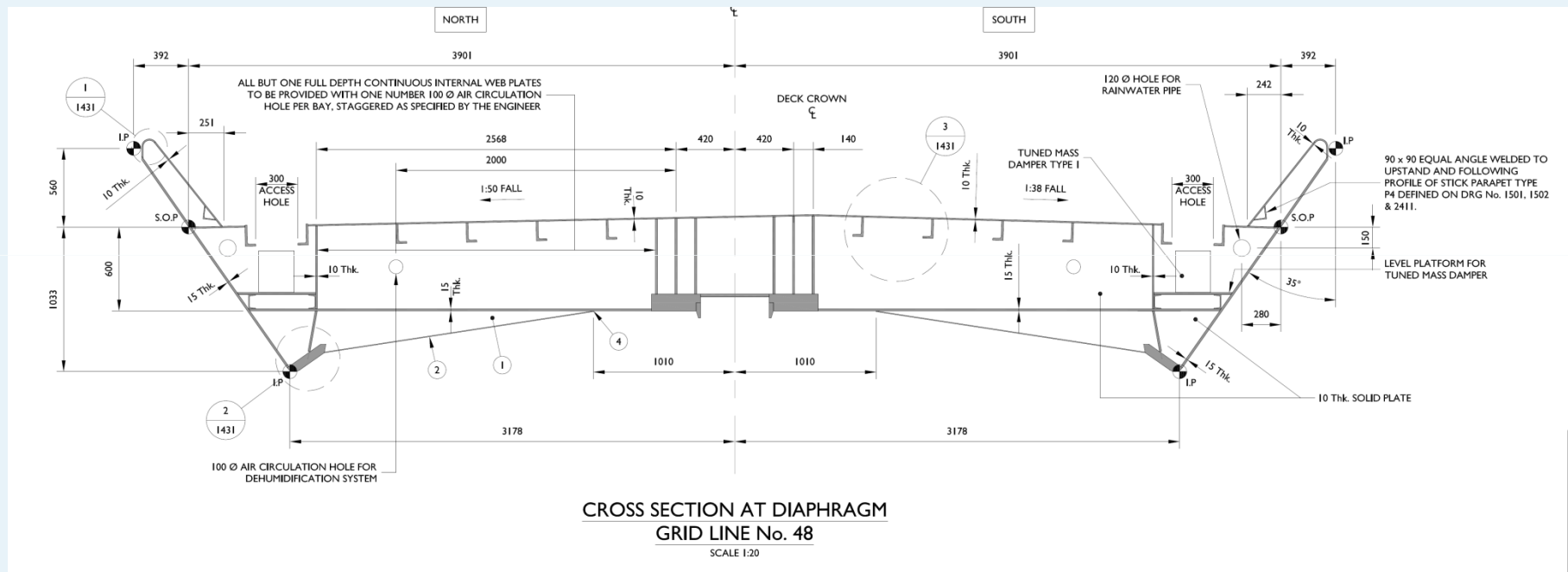


**CROSS SECTION AT DIAPHRAGM  
GRID LINE No. 14**  
SCALE 1:20

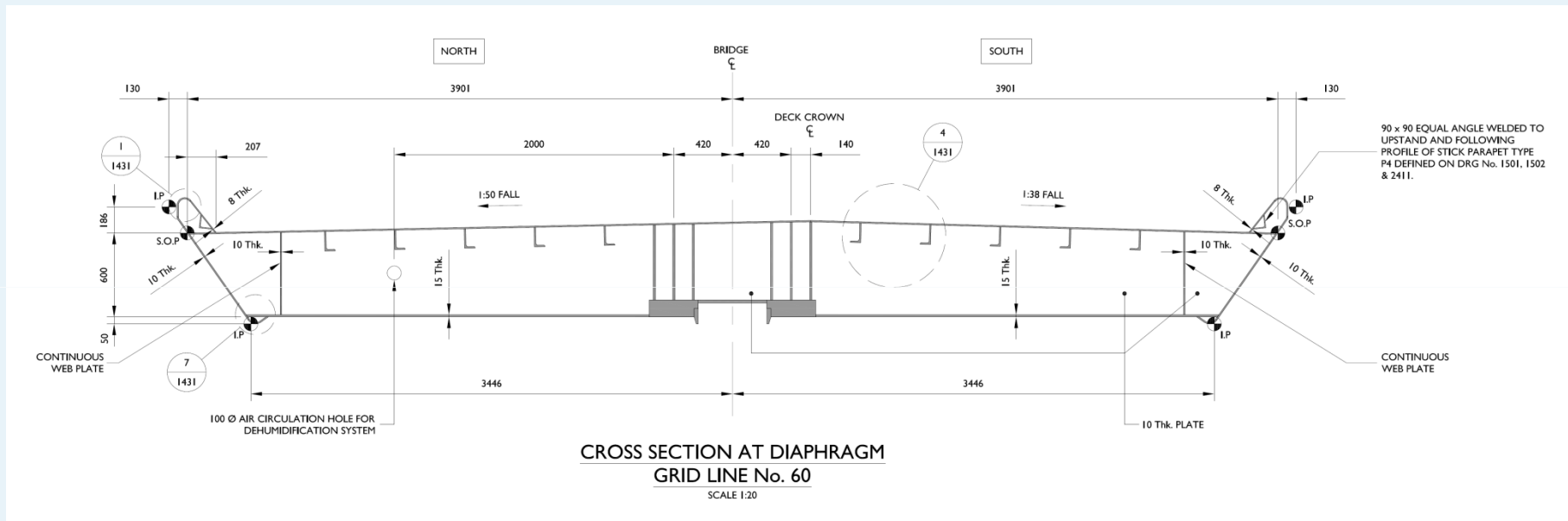
# Section at grid 29



# Section at grid 48

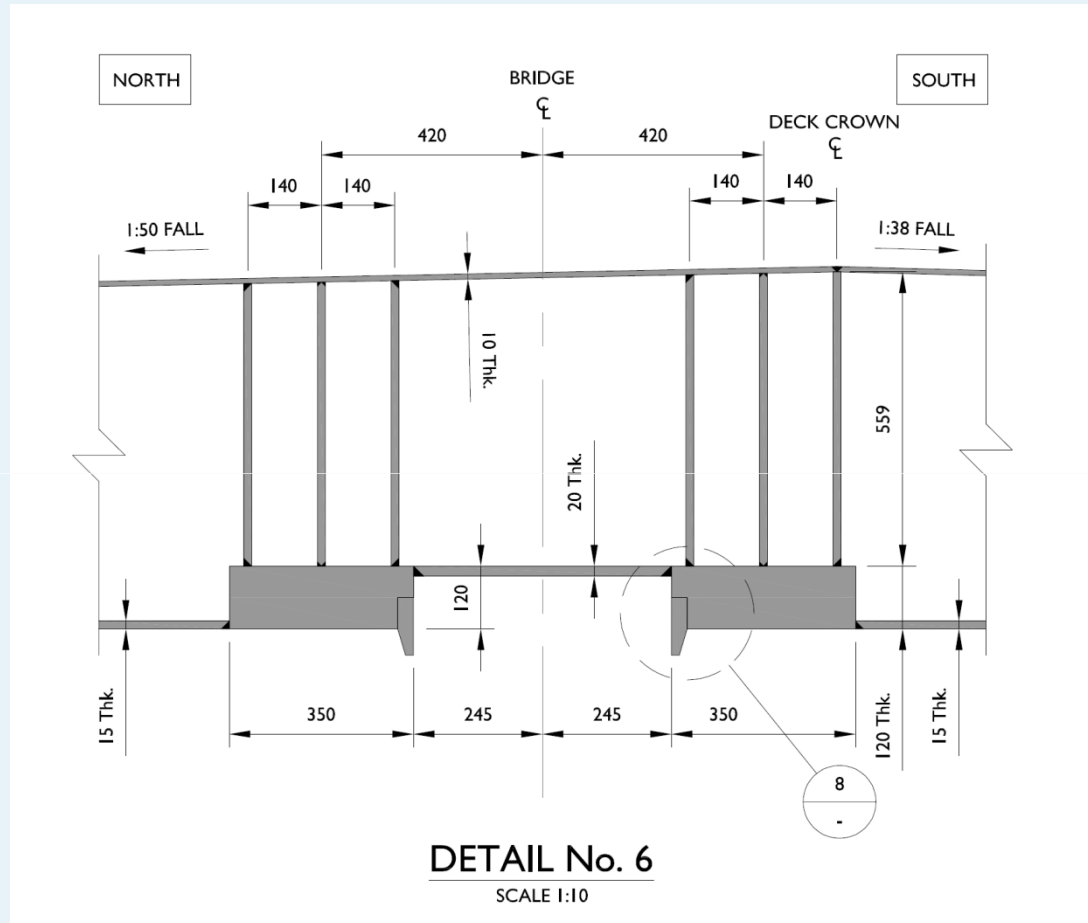


# Section at grid 60



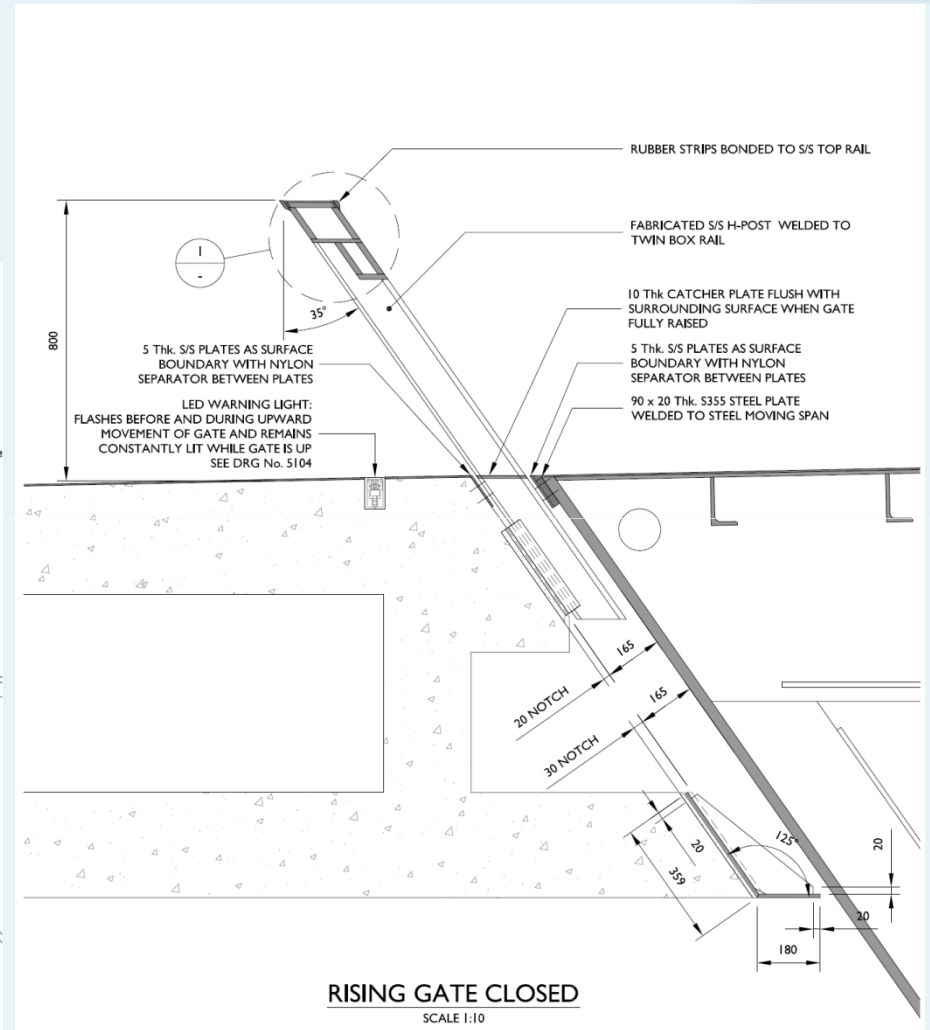
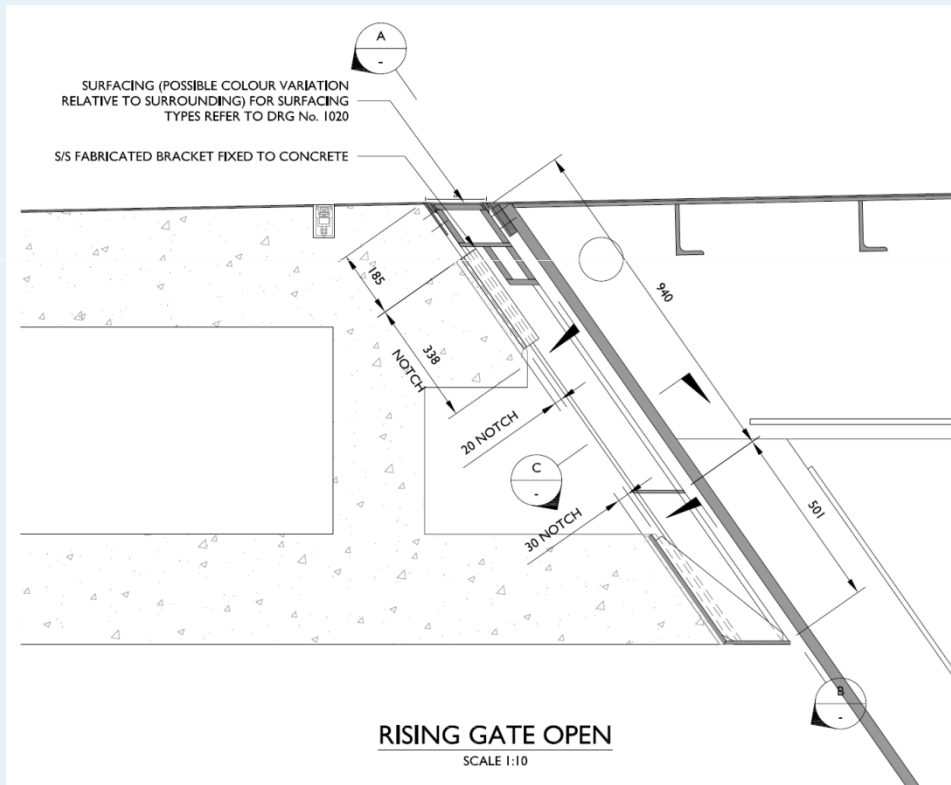


# Detail of front roller track

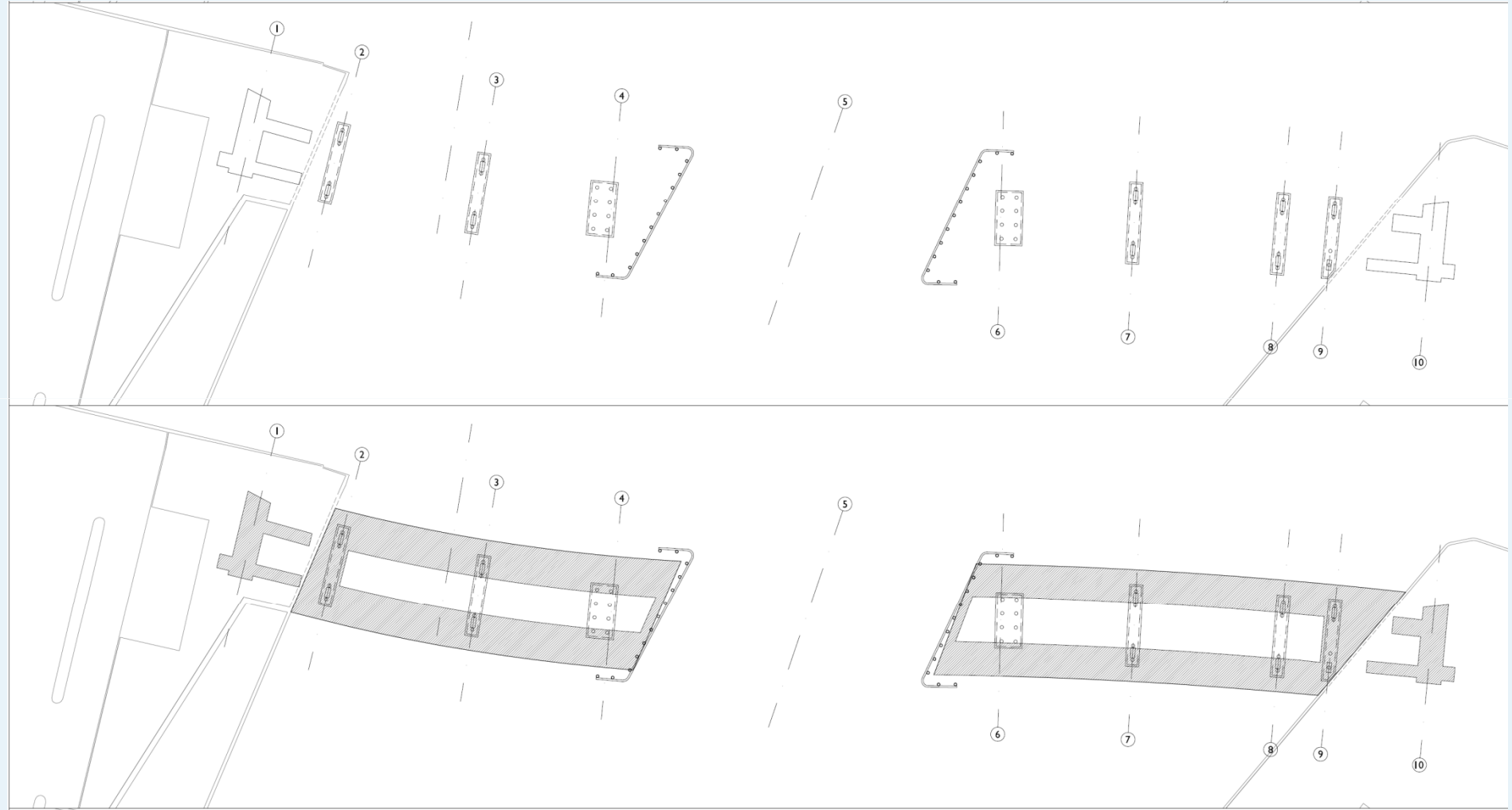




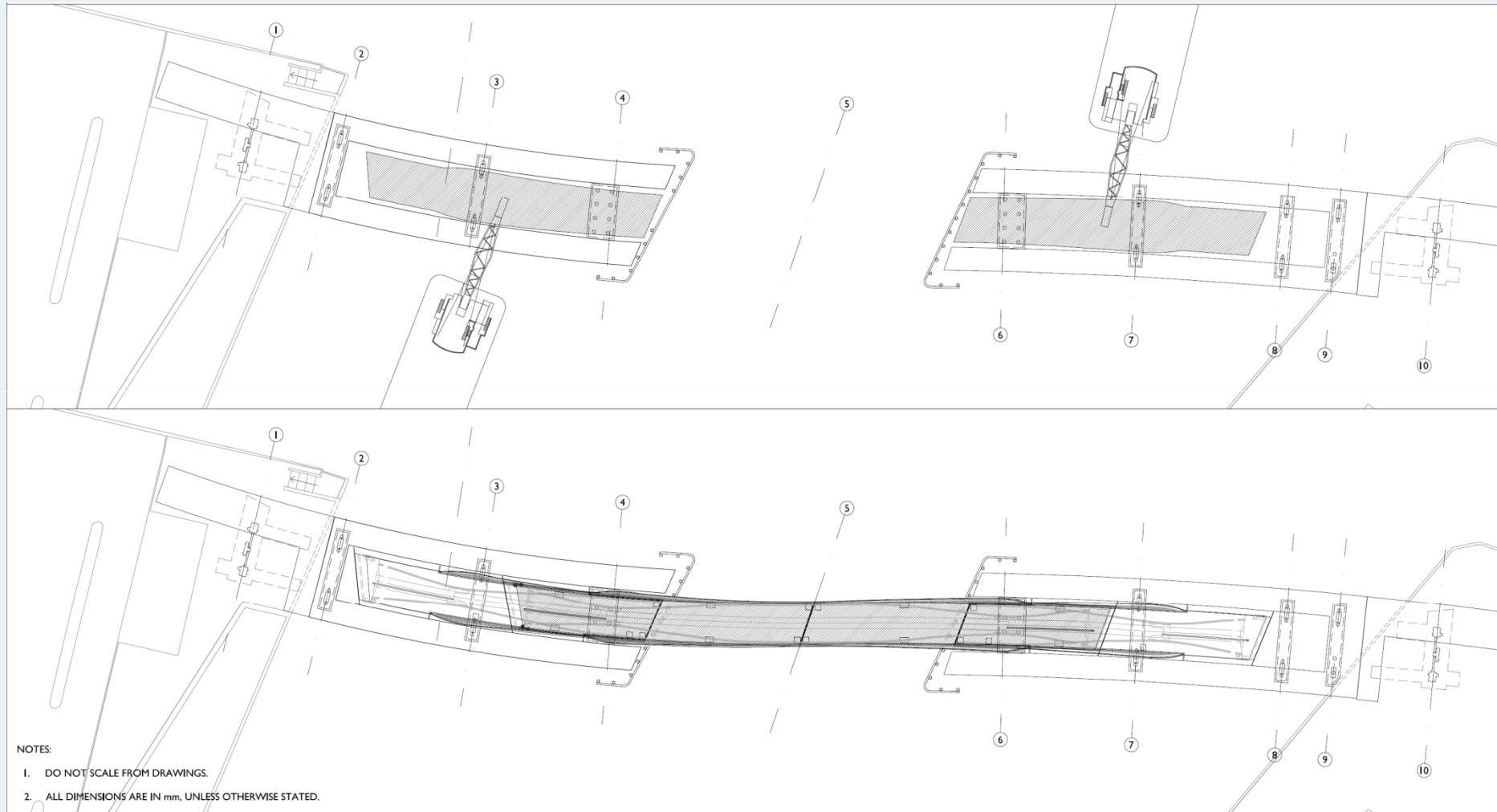
# Pedestrian Barrier



# Construction principles



# Construction principles



# Outline Programme and Budget

- Hovedprojekt (detailed design) complete: Dec. 2010
- Invite tenders: Mar. 2011
- Construction start: Aug. 2011
- Completion: Nov. 2012
  
- Budget: DKK 71 million

# Havnegade approach



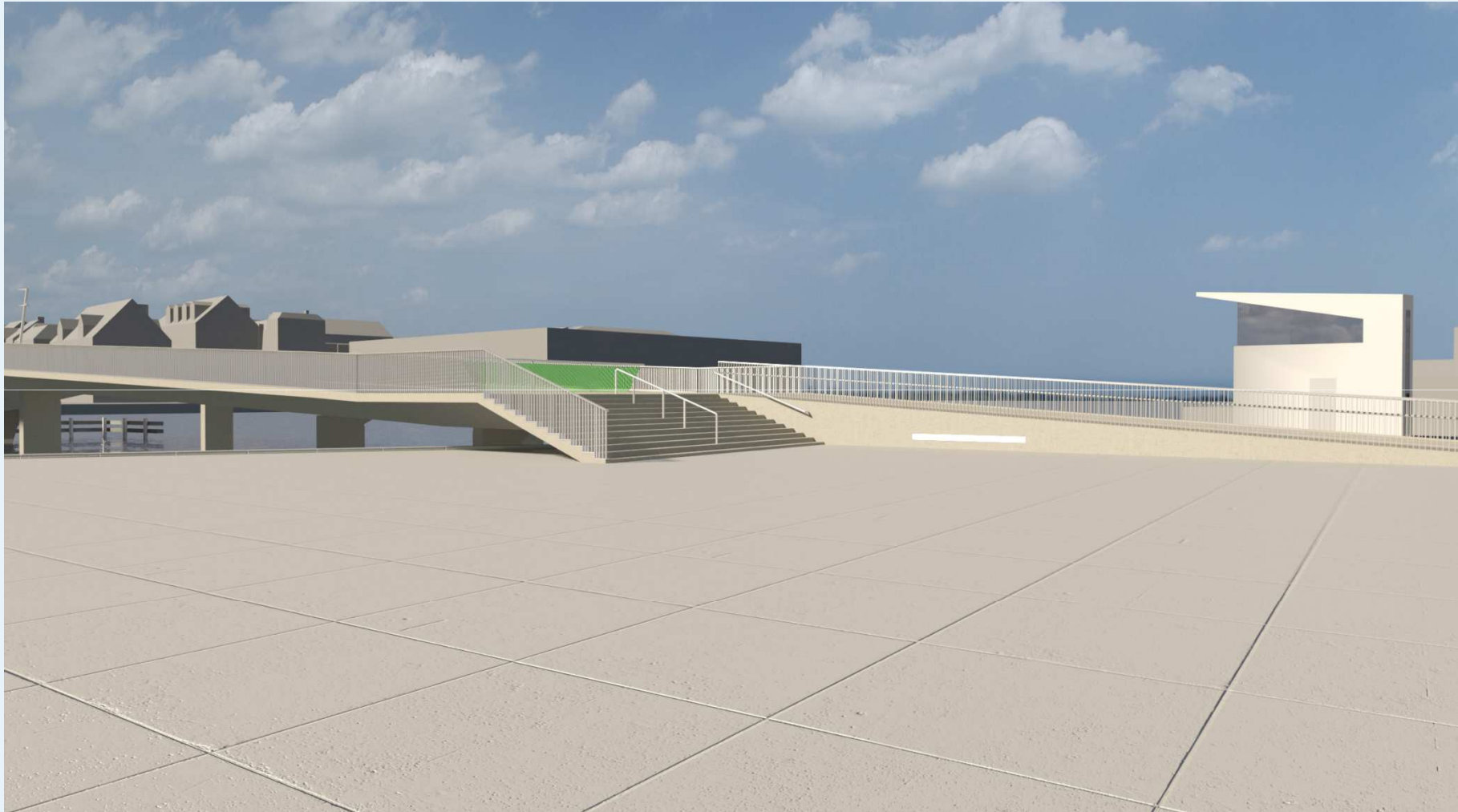
# Havnegade approach



# View across the end of Nyhavn



# Grønlandske Handels Plads approach

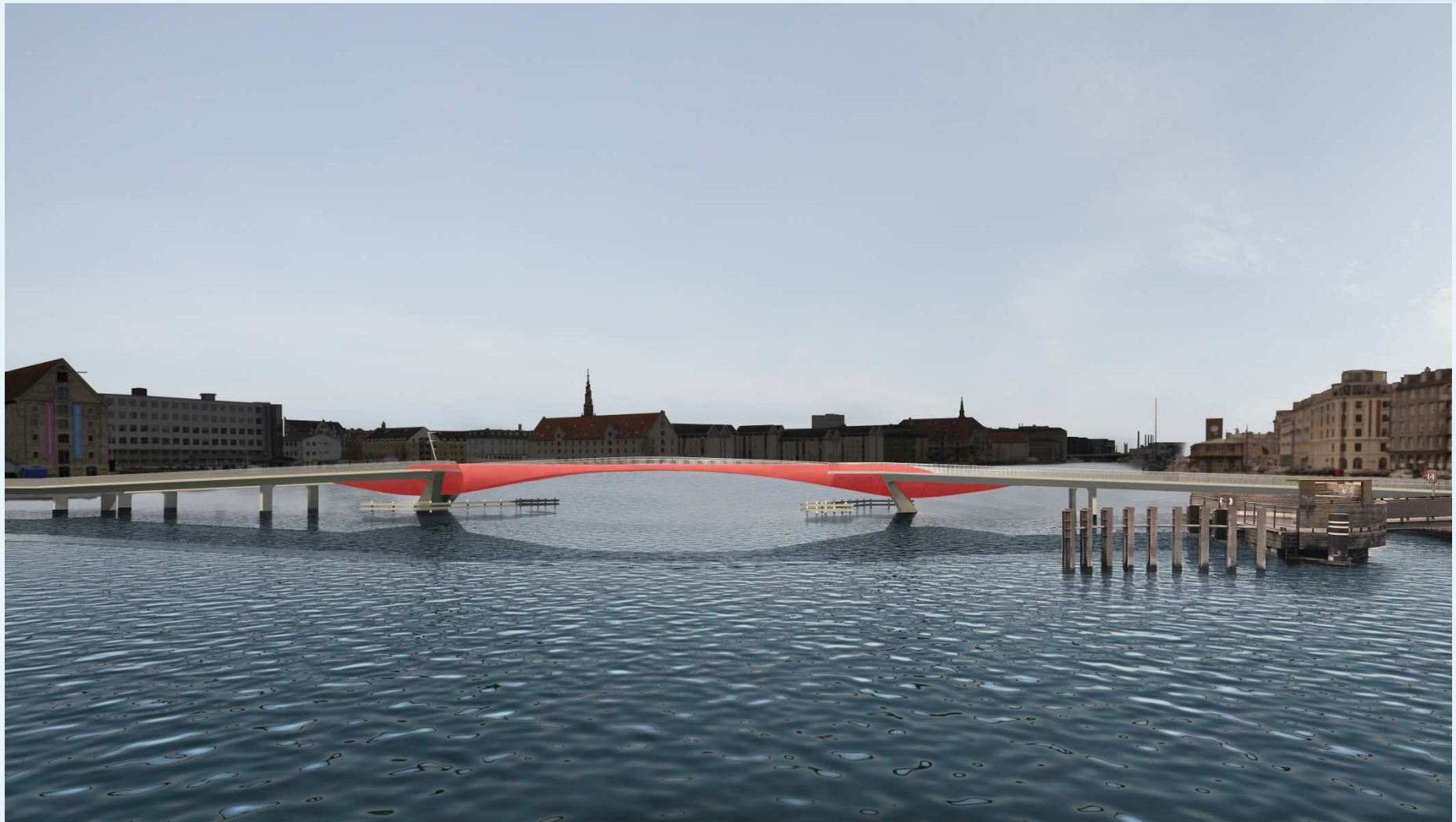




# View from Skuespilshuset



# View from Skuespilshuset ?



# Thank you



**Thank you**

**Questions / Discussion**