1

FREDERIKSSUND FJORD LINK

1. Project overview
2. High Bridge
   - Dimensions/Planning
   - Geotechnic
   - Subestructure (Piles / Pile caps / Piers)
   - Superstructure
     - *Segments fabrication in Precast Yard*
     - *Deck erection and other works*

2

FREDERIKSSUND FJORD LINK

1. Project overview
2. High Bridge
   - Dimensions/Planning
   - Geotechnic
   - Subestructure (Piles / Pile caps / Piers)
   - Superstructure
     - *Segments fabrication in Precast Yard*
     - *Deck erection and other works*

Vejdirektoratet
Danish Road Directorate

RIZZANI DE ECCHER

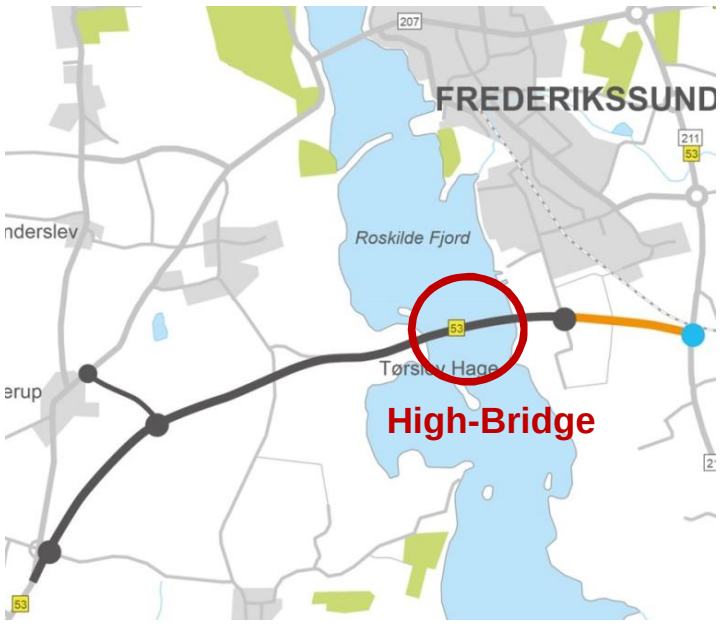
acciona Infraestructuras

BESIX

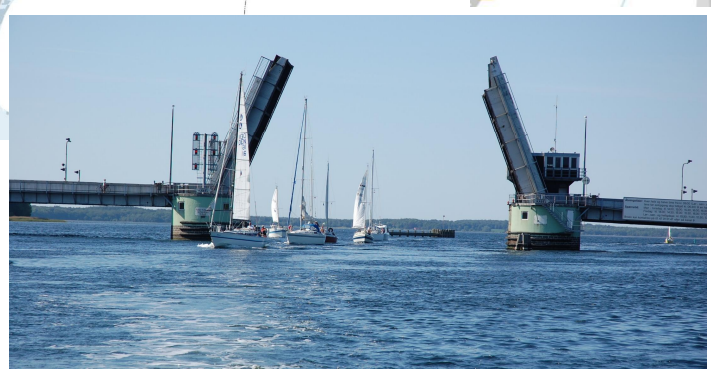
RBAI JV I/S

Contract : Design & Build
Value : 133 M€
Duration : 34 Months
Commencement : Oct 2016
Client : Vejdirektoratet
Engineer : ARUP
Contractor JV : 34% RdE , 33% Acciona , 33% Besix

Location



Existing Bascule Bridge at Frederikssund



5

Main data

- **8.2 km of express way (including 1.4 km High Bridge)**
- **11 Minor Structures**
- **1 km Retaining structure**
- **3 km Noise walls**

1.- Reinforcement:

High Bridge: 4.552 tn
Other Structures: 665 tn

2.- Earthworks

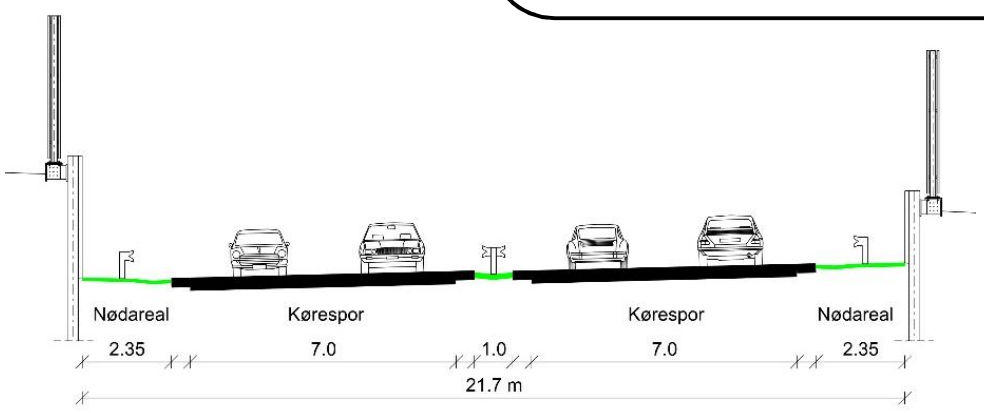
Cut: 400.000 m3
Fill: 350.000 m3

3.- Asphalt:

High Bridge: 7.000 tn
Other Roadworks: 96.000 tn

4.- Concrete

High Bridge: 31.363 m3
Other Structures: 3.939 m3



6

Road layout

7

Road layout

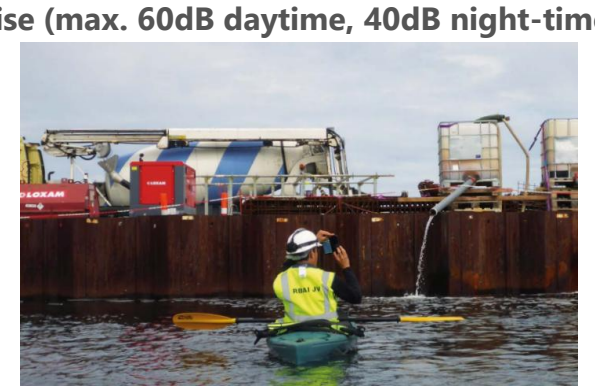
8

Road layout

Environmental

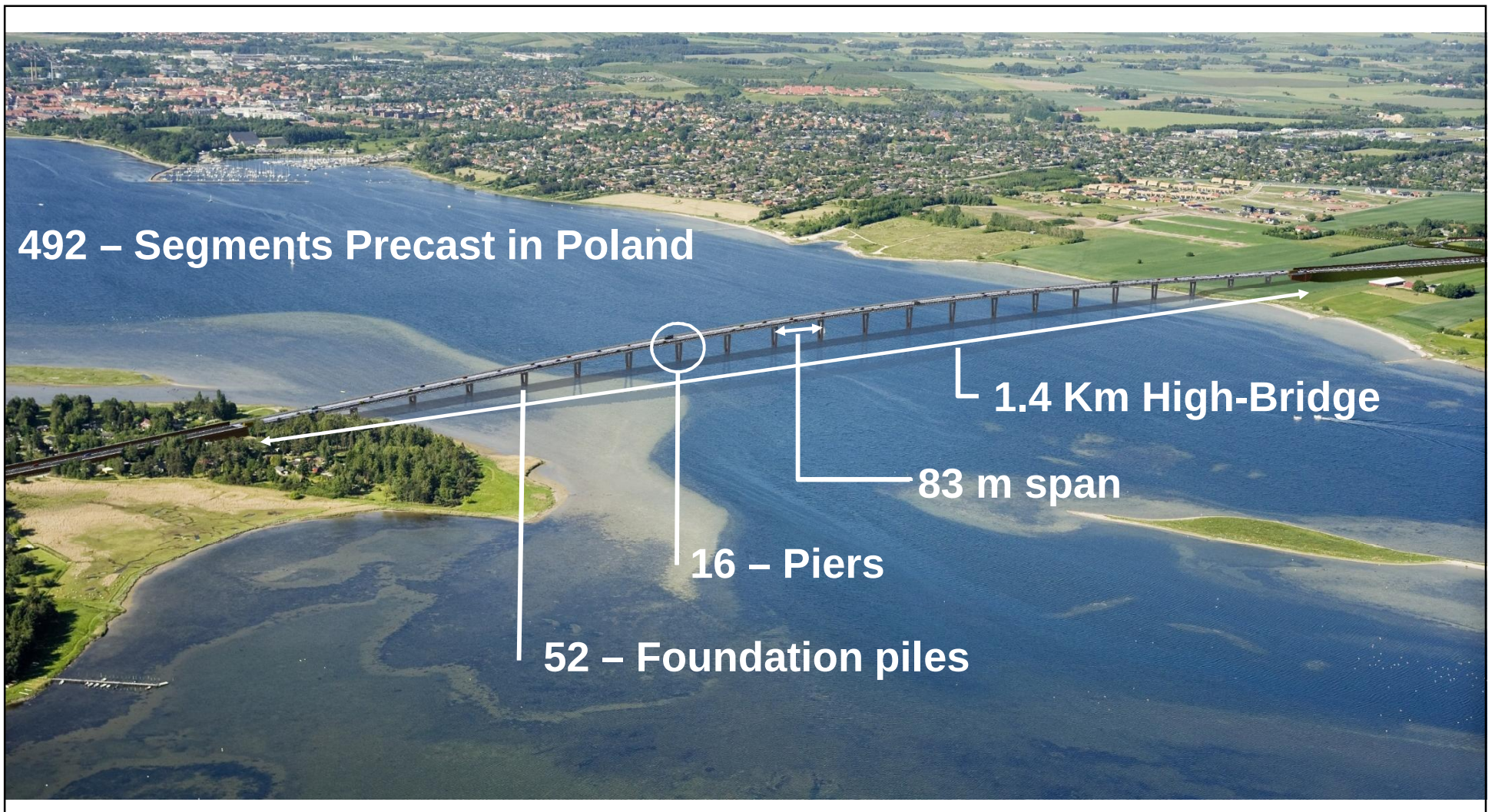
- **Natura 2000**

- **Strict control of sedimentation and water quality in the Fjord ; Fencing**
- **Strict control of dust, vibrations and noise (max. 60dB daytime, 40dB night-time)**

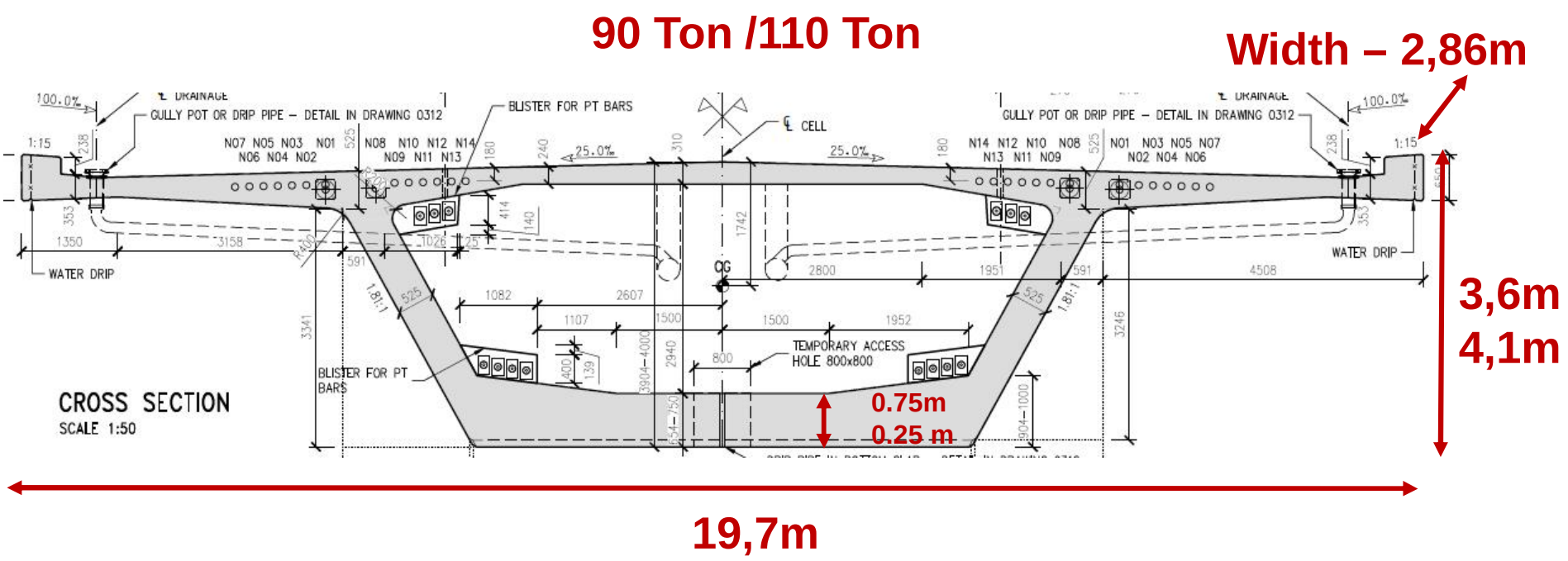


FREDERIKSSUND FJORD LINK

1. Project overview
2. High Bridge
    - Design/Planning
    - Geotechnic
    - Subestructure (Piles / Pile caps / Piers)
    - Superstructure
        - *Segments fabrication in Precast Yard*
        - *Deck erection and other works*

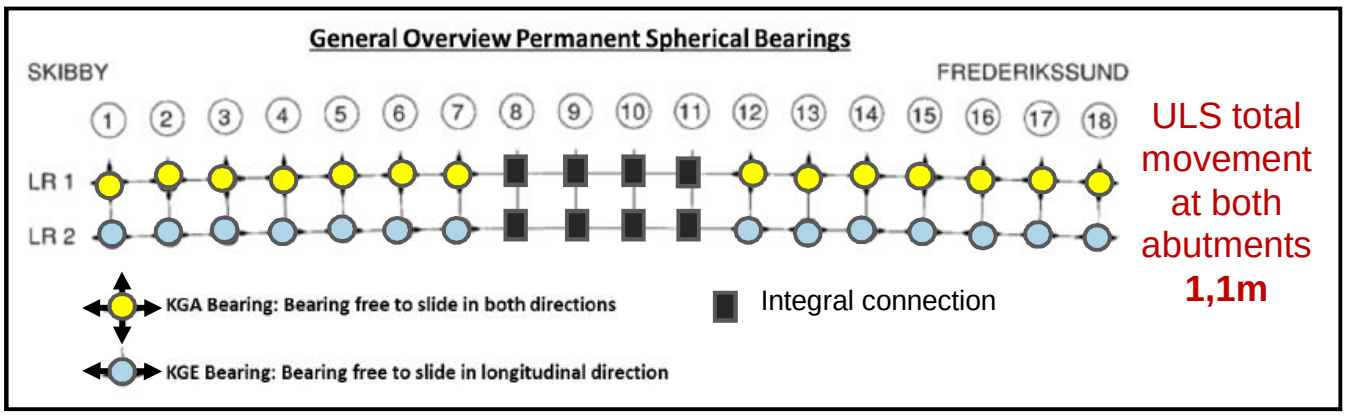


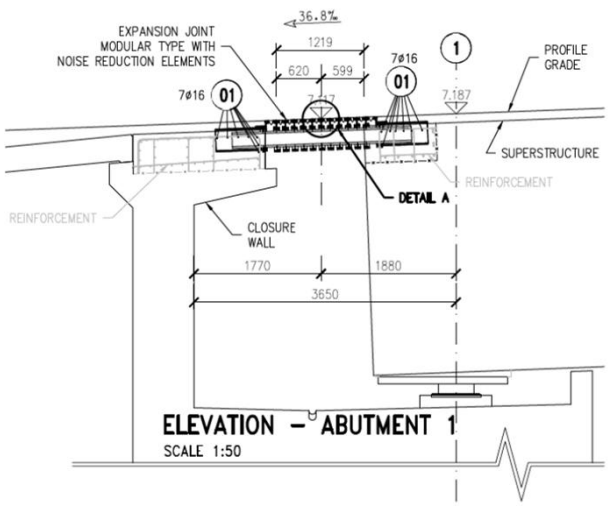
Typical Segments dimensions



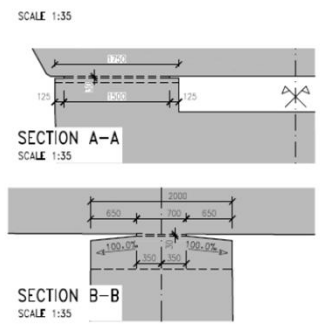
13

Bearings and expansion joints

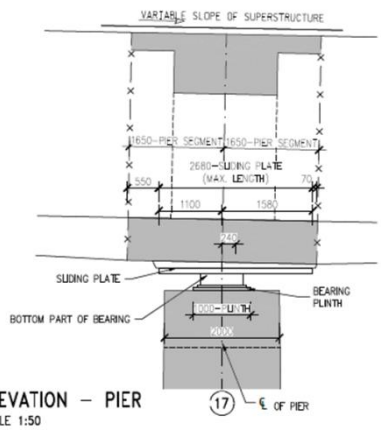




Integral connection



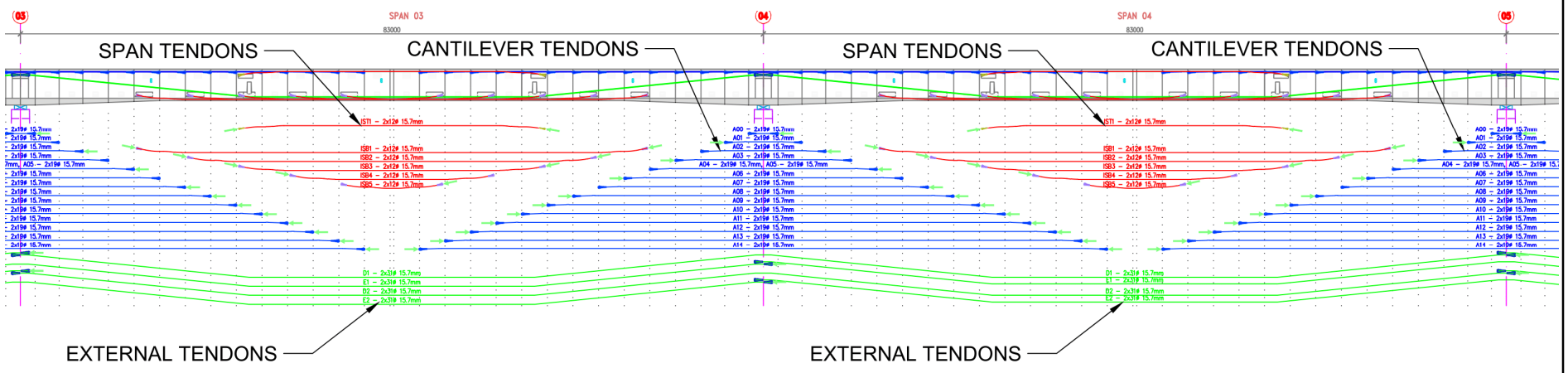
Bearings



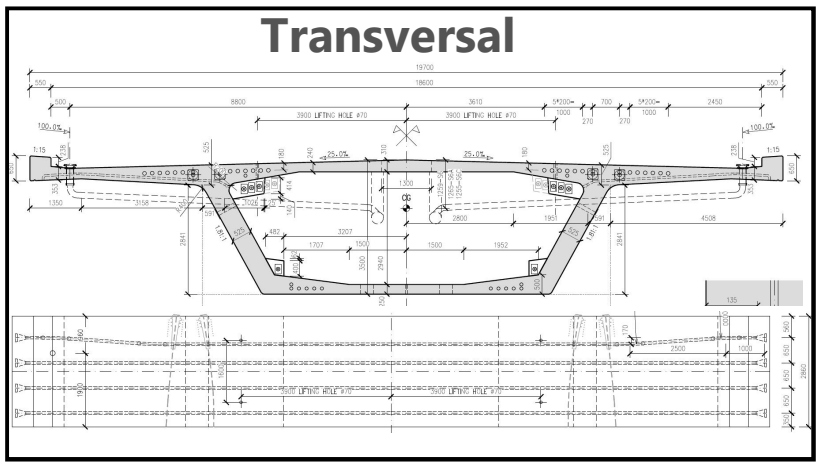
14

Post-tensioning

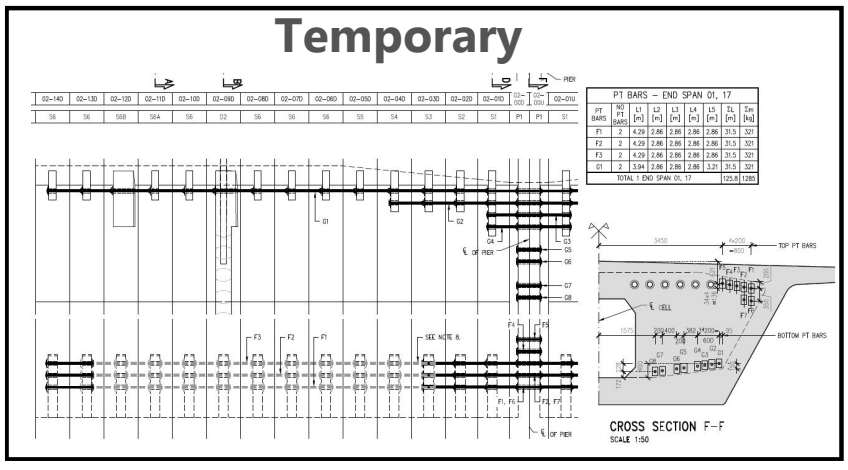
Longitudinal



Transversal

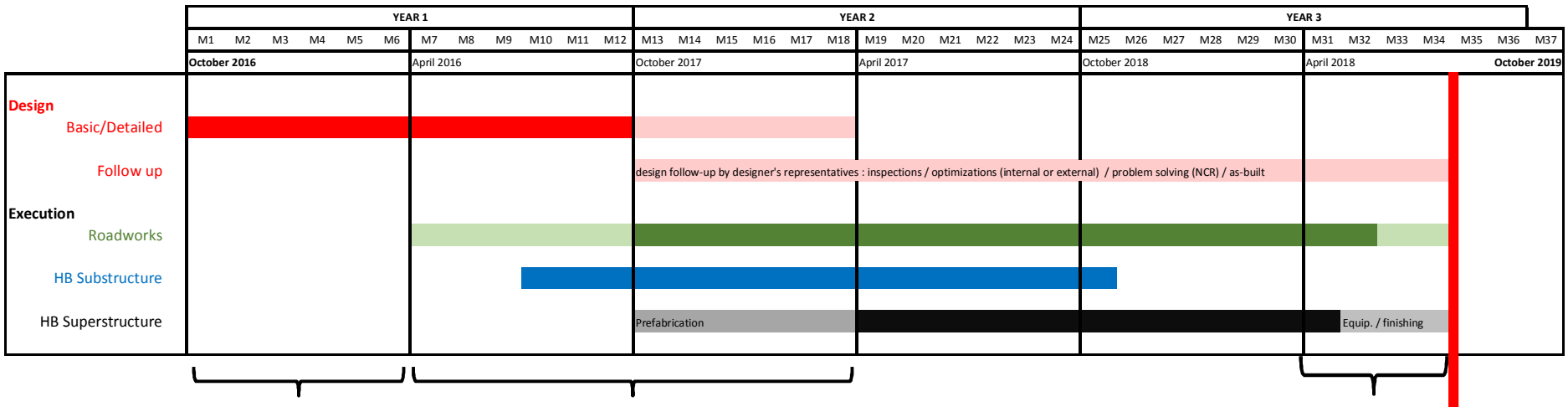


Temporary



15

Planning



1st challenge: Efficient start

- Mobilization and Communication (Different nationalities)
- Optimization (methods/procurement)
- Internal review (constructability / interphases)

2nd challenge: overlap design and construction

↓

priorities / risks management

- Review and approval by Client
- Requirements management
- Basic Design (30%) – Detailed Design (70% and 100%)
- Deliverables list and design packages

3rd challenge: Coordination finishing works

- Space in High bridge = High level coordination for logistics.
- Limited time to complete roadworks after winter period.

COMPLETION

3 MONTHS AHEAD

16

FREDERIKSSUND FJORD LINK

1. Project overview
2. High Bridge
   - Design/Planning
   - Geotechnic
   - Subestructure (Piles / Pile caps / Piers)
   - Superstructure
     - *Segments fabrication in Precast Yard*
     - *Deck erection and other works*

Geotechnical Design – Soil Investigations

- **Foundation concept**
  - Large diameter bored piles (diameter 1,5 to 2,0 m)
  - Resistance nearly entirely mobilised in limestone (50% shaft + 50% tip)

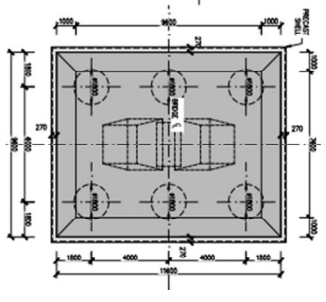
- **Available information for foundation design**
  - Reference projects in Copenhagen area: Metro, Oresund
  - Geotechnical investigations:

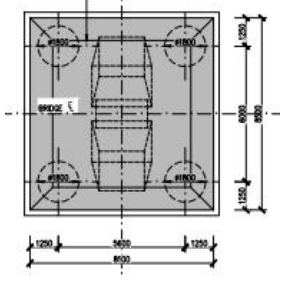
    TENDER STAGE: 15 Boreholes (≈ 150 m in limestone)

    ADDITIONAL INVESTIGATION: + 25 boreholes (≈ 725 m in limestone)

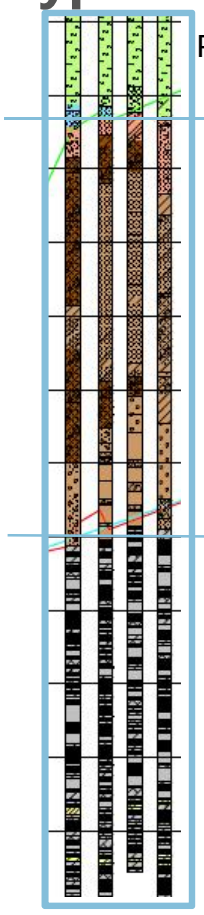
    Extensive Investigation of Local Limestone ⟶ Statistical approach - pier by pier assesment

TENDER	OPTIMIZATION	DETAILED DESIGN
Onshore : 4 piles D1800mm/pier	➔	4 piles D1500mm/pier
Offshore : 6 piles D1800mm/pier	➔	4 piles D2000mm/pier





Typical borehole profiles (P12)



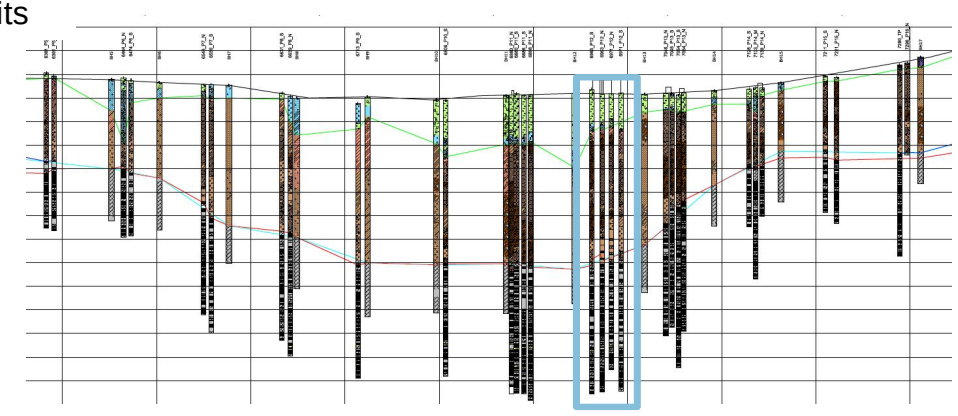
Post glacial deposits

~-10m DVR

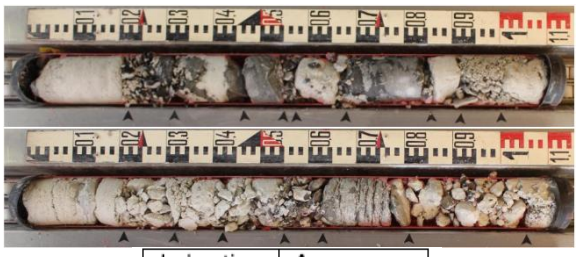
Glacial deposits and clay till

~-40m DVR

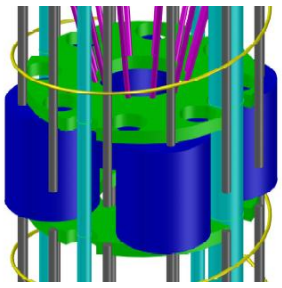
Limestone



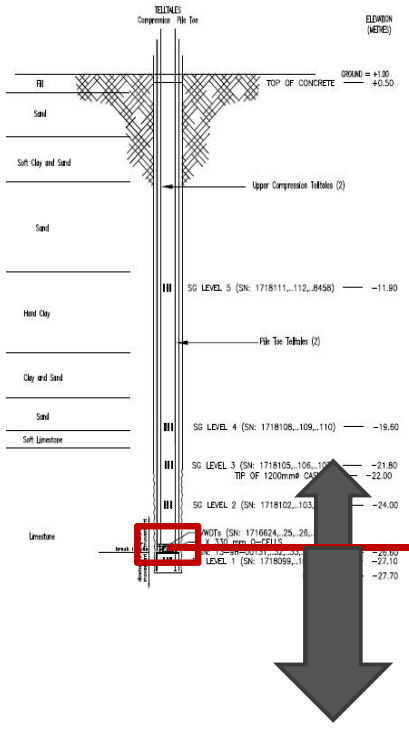
High variability in hardness classes



Induration	Average q_{uc} (MPa)
H1	1.3
H2	6.4
H3	19.5
H4	27.7
H5	27.7 (73.6)



Pile Test by O-cell method (2 test piles 1m diameter)



19

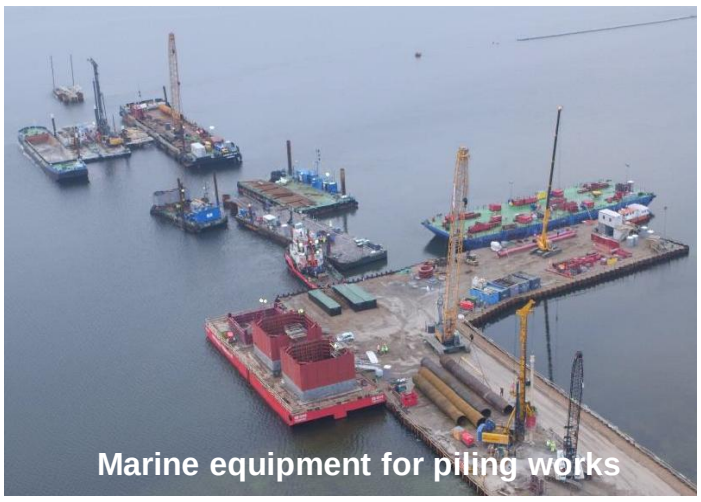
FREDERIKSSUND FJORD LINK

1. Project overview
2. High Bridge
   - Design/Planning
   - Geotechnic
   - Subestructure (Piles / Pile caps / Piers)
   - Superstructure
     - *Segments fabrication in Precast Yard*
     - *Deck erection and other works*

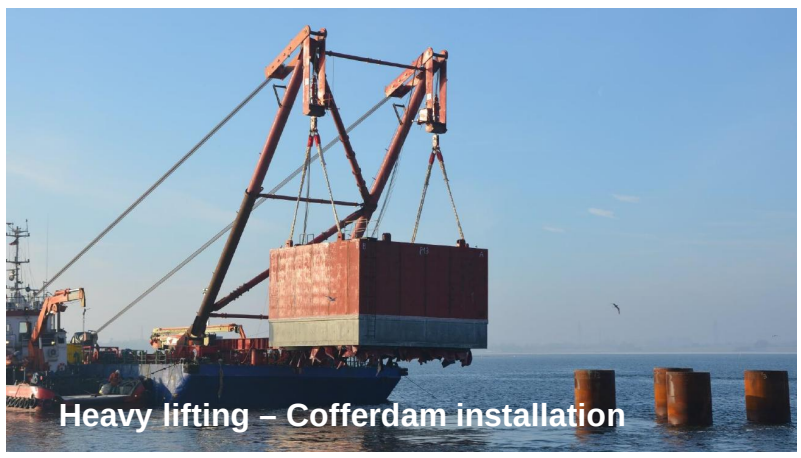
20

Major Challenges

- Weather conditions.
  - Strong wind (lifting operations)
  - Fjord frozen (marine works)
- Working in Natura 2000 area.
- Marine works
  - Navigation channel.
  - Diving works
- Piles execution. Soil stratigraphy.
- Precast shell.
  - Fabrication on a barge.
  - Heavy lifting.



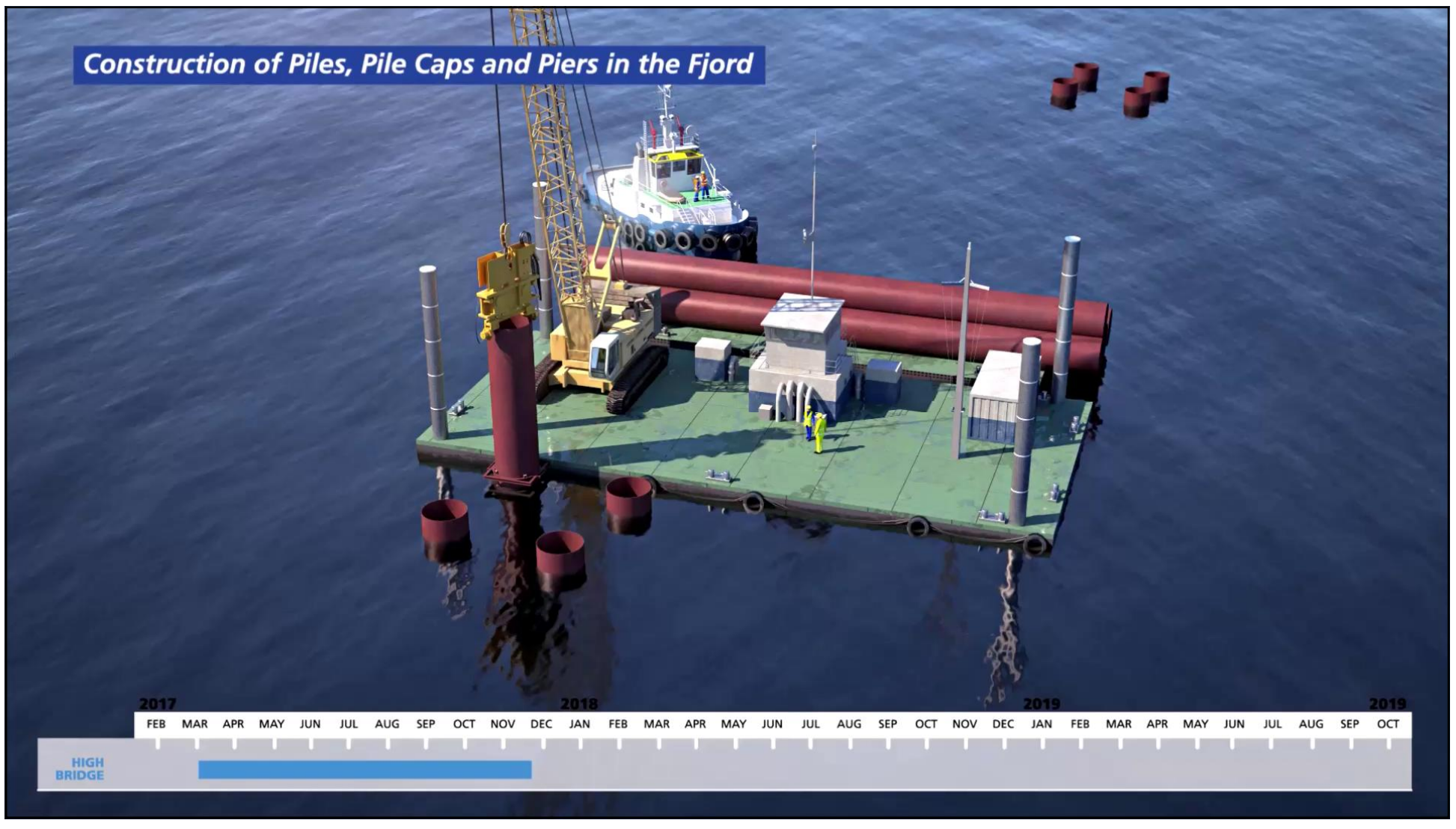
Marine equipment for piling works



Heavy lifting – Cofferdam installation

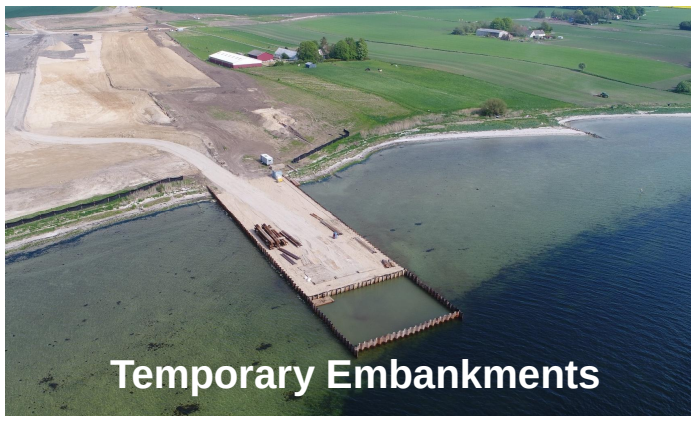
Weather Conditions

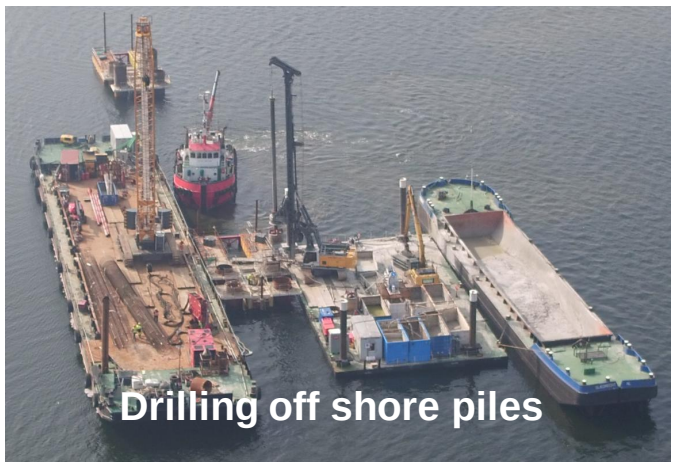
21



22

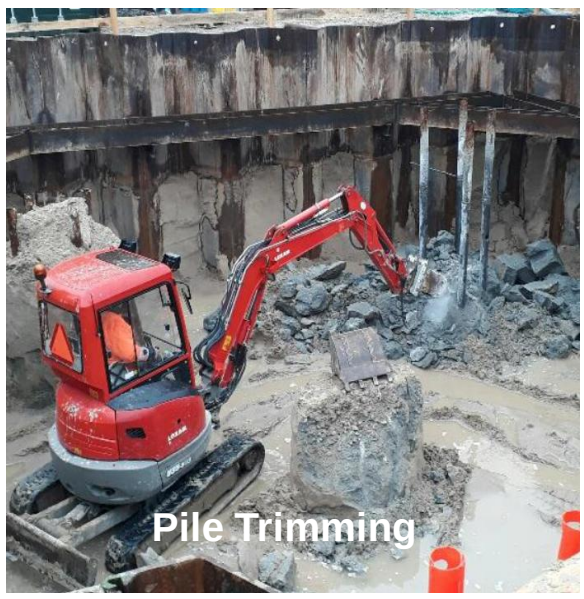
Foundations

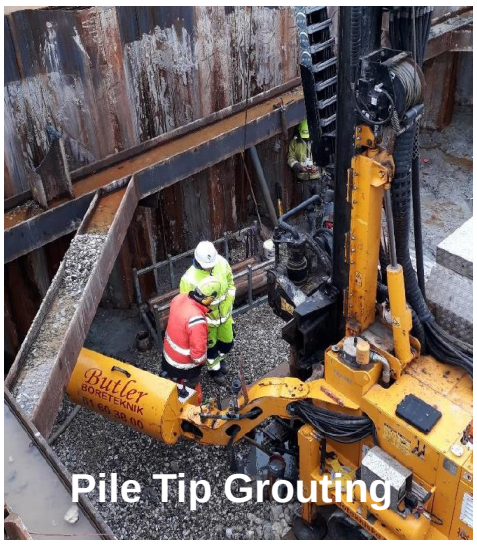




23

Foundations

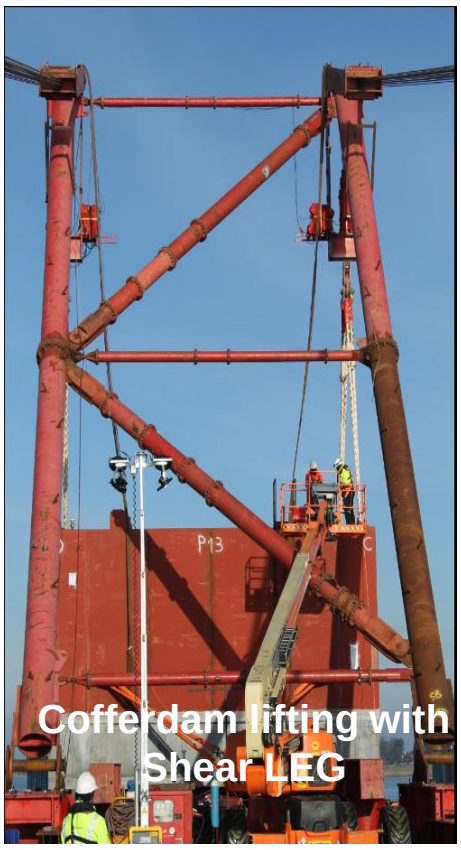




24

Cofferdam & Precast Shell


Installation of bottom collars



Cofferdam lifting with Shear LEG


Underwater heating system for grout

25

Pile caps


COFFERDAM DEWATERING

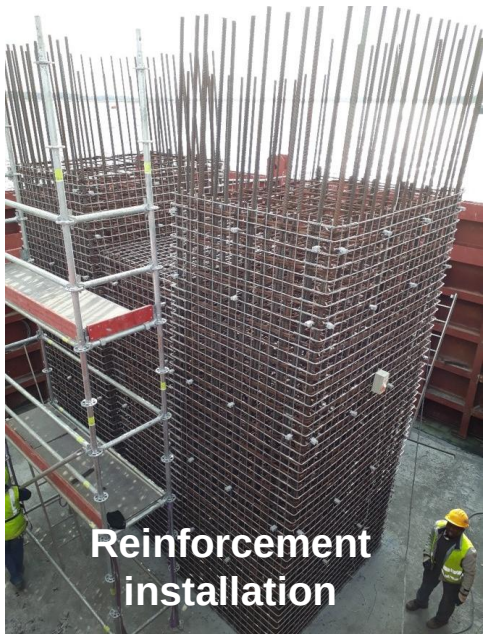
COFFERDAM	AS BUILT	
Cofferdam Fabrication	17	days/PS fabrication
Cofferdam Installation	3	days/PS installation

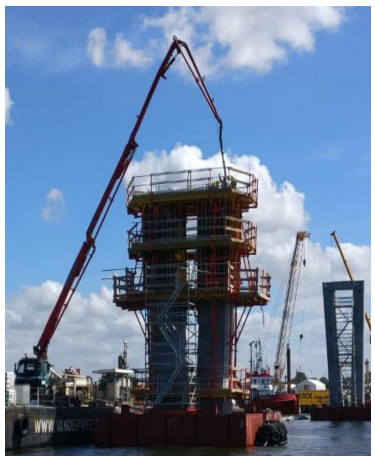

START OF ON SHORE PILE CAP


PILE CAP REINFORCEMENT OFF SHORE

26

Piers





PIER	AS BUILT
Each Phase	6 days/Phase Pier

FREDERIKSSUND FJORD LINK

1. Project overview
2. High Bridge
   - Design/Planning
   - Geotechnic
   - Subestructure (Piles / Pile caps / Piers)
   - Superstructure
     - *Segments fabrication in Precast Yard*
     - *Deck erection and other works*

Precast yard - Layout

29

Precast yard – Rebar cages, casting and post-tensioning

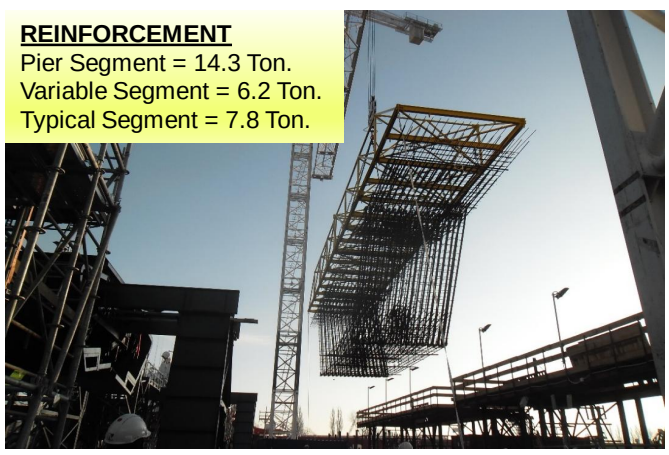
REBAR CAGES ASSEMBLY

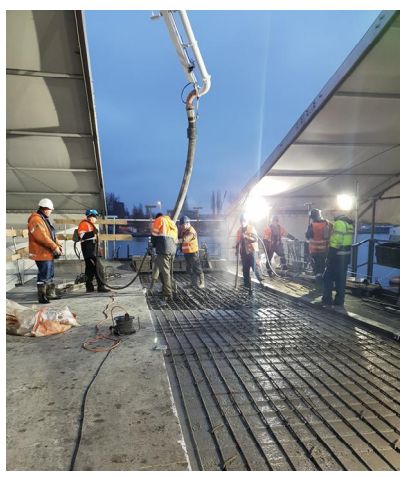
CASTING

POST-TENSIONING IN TWO STAGES

- **40% PT:** After concrete reaches 15 MPa
- **100% PT:** After concrete reaches 25 MPa

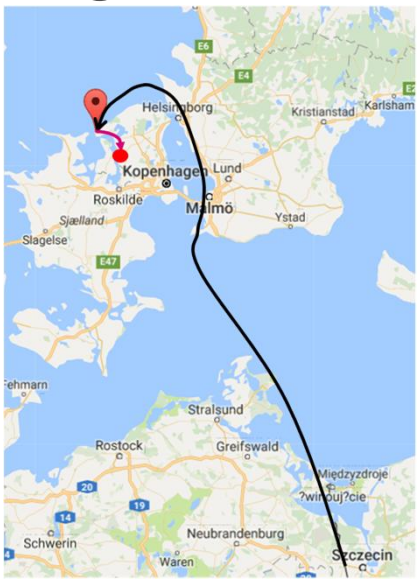
REINFORCEMENT
Pier Segment = 14.3 Ton.
Variable Segment = 6.2 Ton.
Typical Segment = 7.8 Ton.

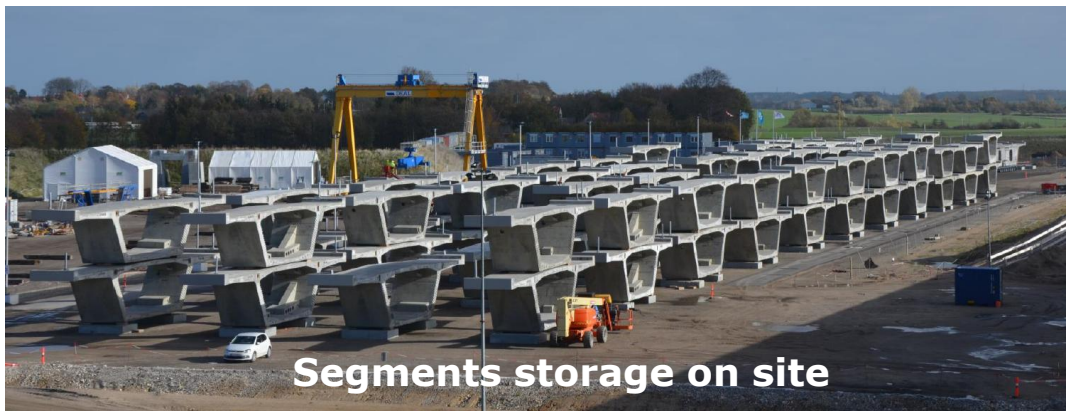




30

Segments tranportation and Storage





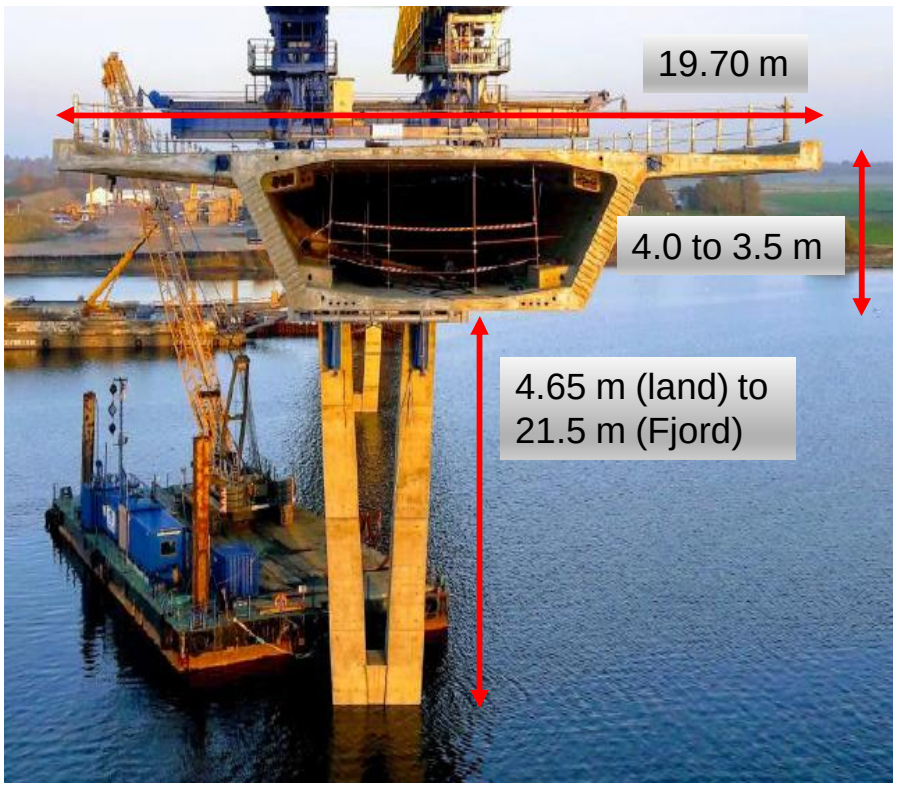
31

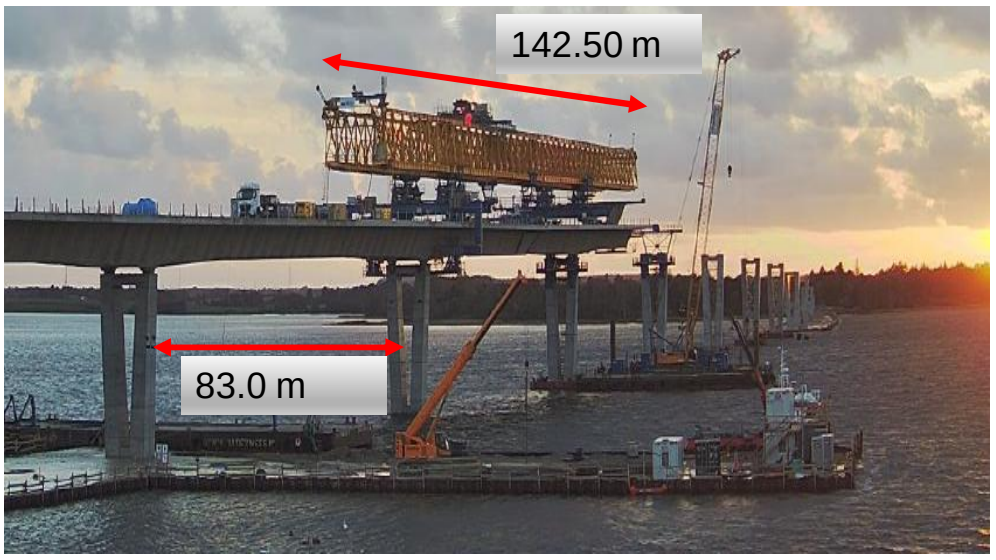
FREDERIKSSUND FJORD LINK

1. Project overview
2. High Bridge
   - Design/Planning
   - Geotechnic
   - Subestructure (Piles / Pile caps / Piers)
   - Superstructure
     - *Segments fabrication in Precast Yard*
     - *Deck erection and other works*

32

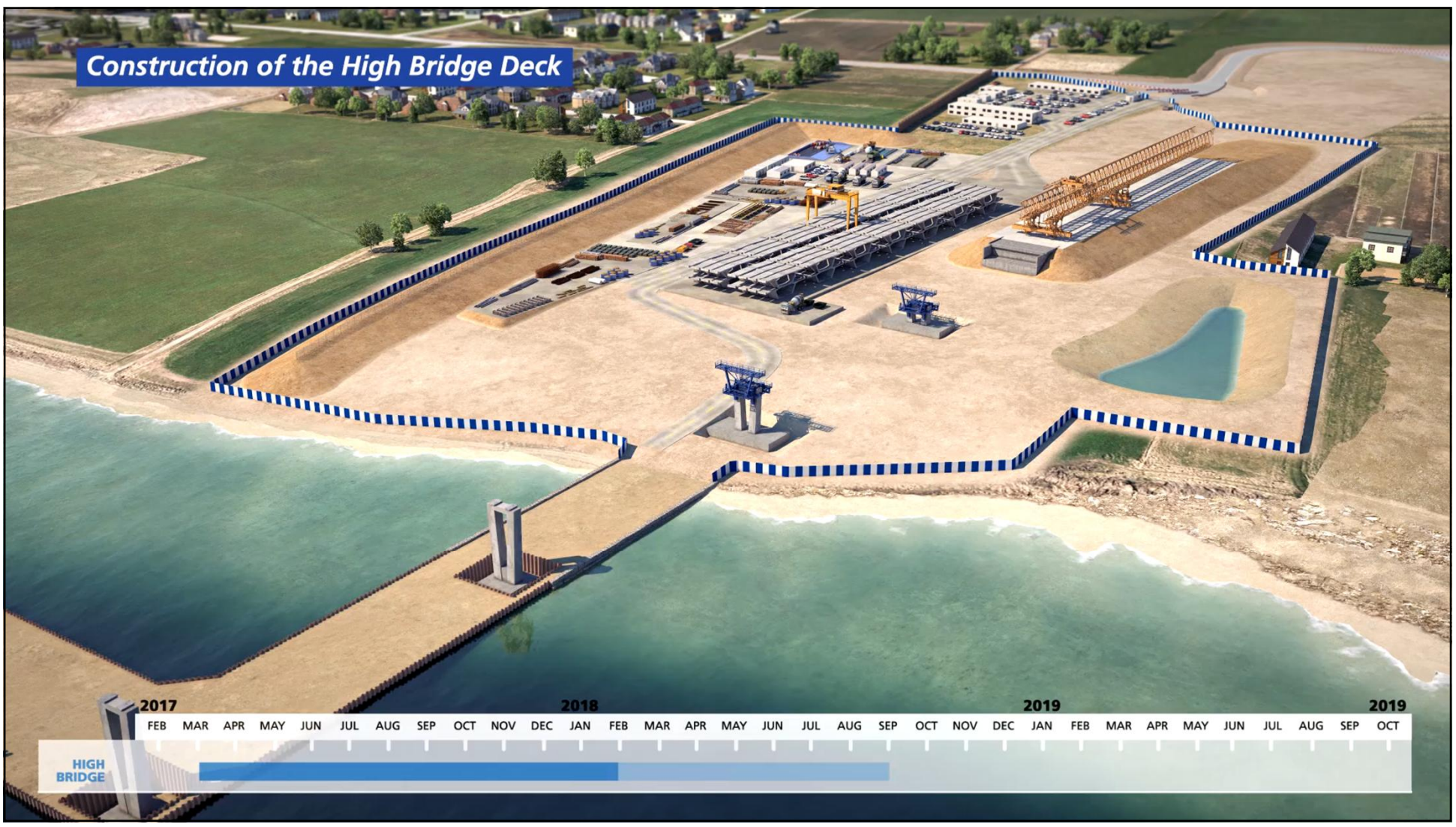
Deck erection





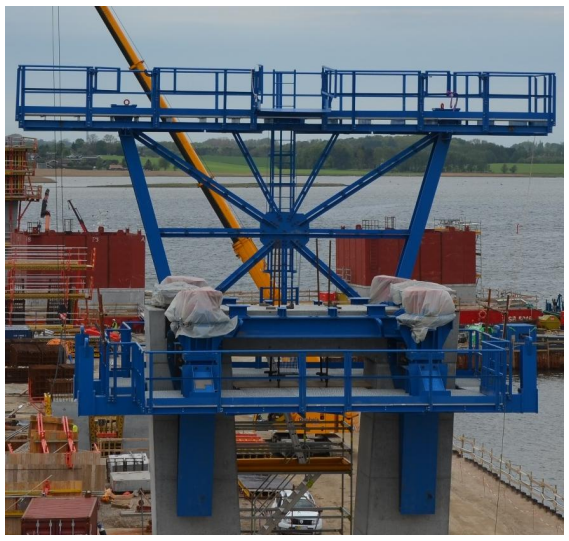
492 Precast Segments (21s/1 span + 30 s/15 span + 21/1 span)

33

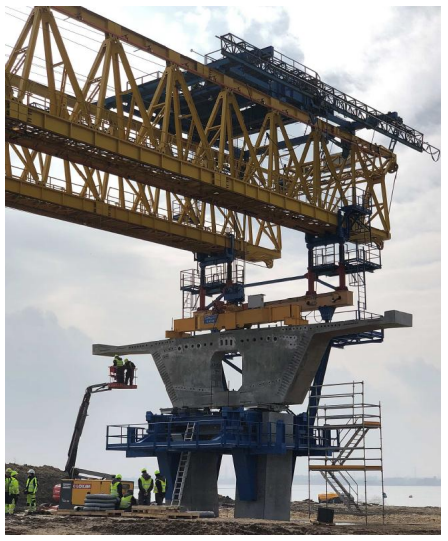


34

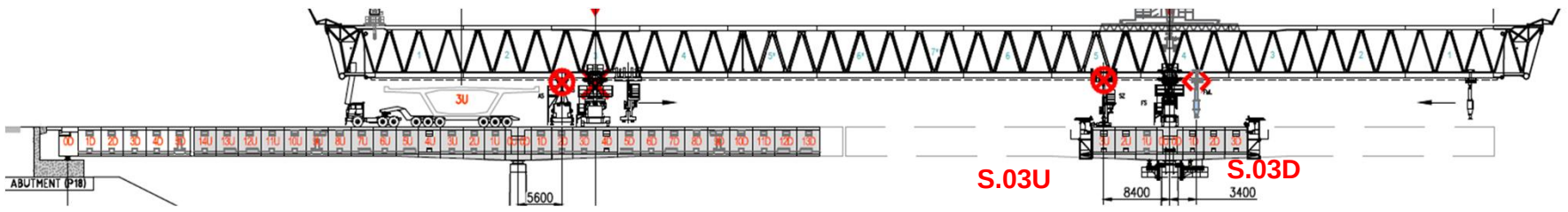
Deck erection



Installation of pier brackets before segments erection.

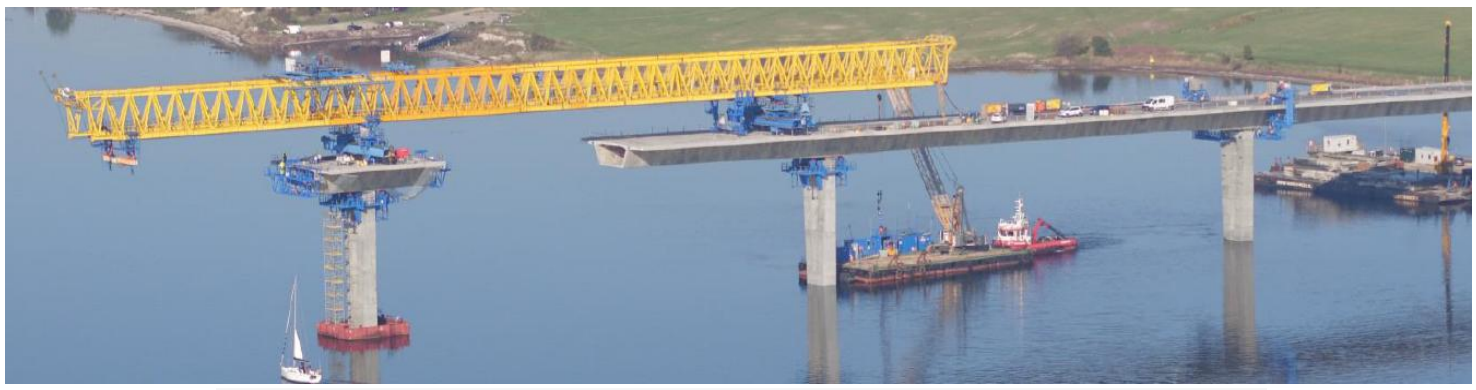


Erection of pier segments S00D and S00U on temporary jacks.



Launching of the main truss forward

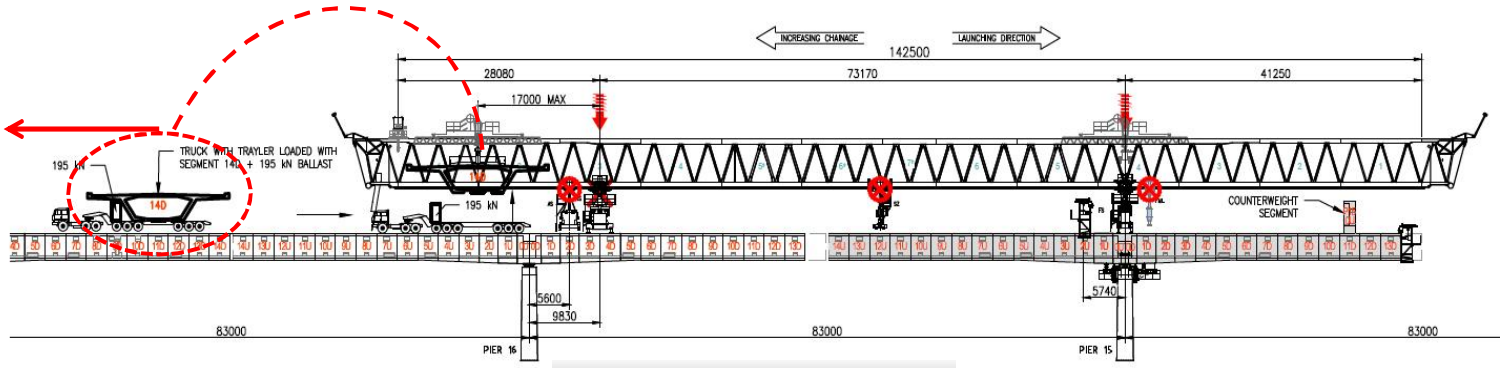
Deck erection



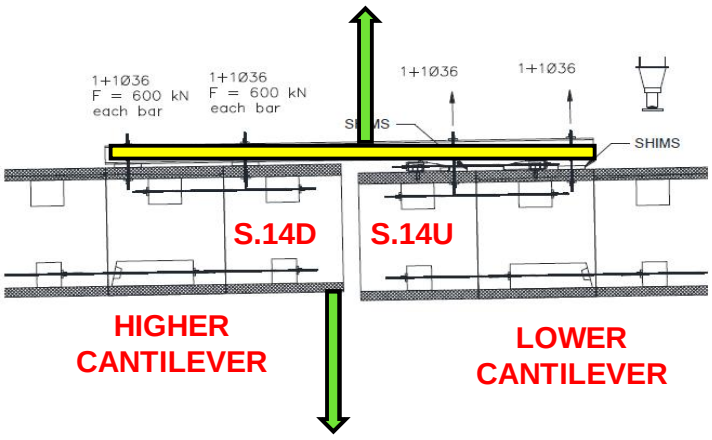
BALANCED CANTILEVER: UNTIL PAIR OF SEGMENT “03.D – 03.U”

BALANCED CANTILEVER: FROM SEGMENT “04D-U” TO “13D-U”

Deck erection



Erection segment “14D”



Installation of stitch beams connecting 2 cantilevers and Casting of closure pour.

37

Other works in High Bridge Superstructure

38

Thank you

RBAI JV I/S