

# Immersed Tunnels Recent developments

*Kelprojektas seminar –  
Transport Infrastructure Innovations*



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10 June 2015



# Content

- General introduction Royal HaskoningDHV
- Principles immersed tunnels
- Main benefits
- Recent innovations

# Profile

- Global consultancy, design, engineering and project management service provider
- Leader in sustainability and innovation
- Top 10 of independently owned, non-listed companies
- Top 40 worldwide
- Turnover in excess of € 650 million
- Nearly 7,000 experienced and diverse team members
- Leading professionals in our fields



# Our markets

- Aviation
- Maritime & Waterways
- Transport & Asset Management
- Infrastructure
- Planning & Strategy
- Water Technology
- Rivers, Deltas & Coasts
- Industry, Energy & Mining
- Buildings



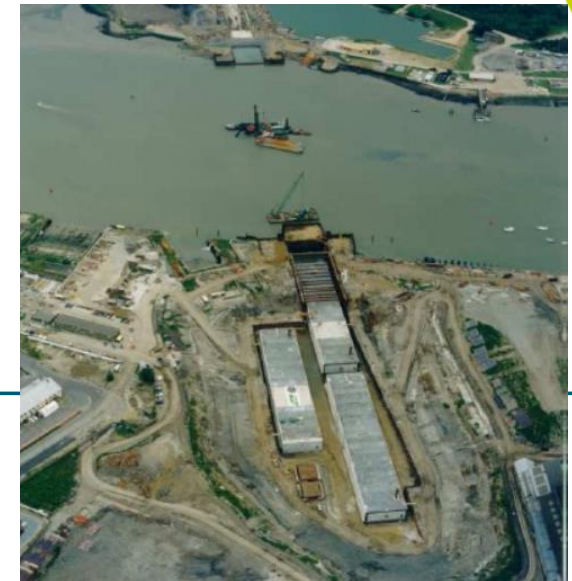


# Basic principle Immersed tunnels





# Production tunnel elements



# Busan Geoje IMT, South Korea





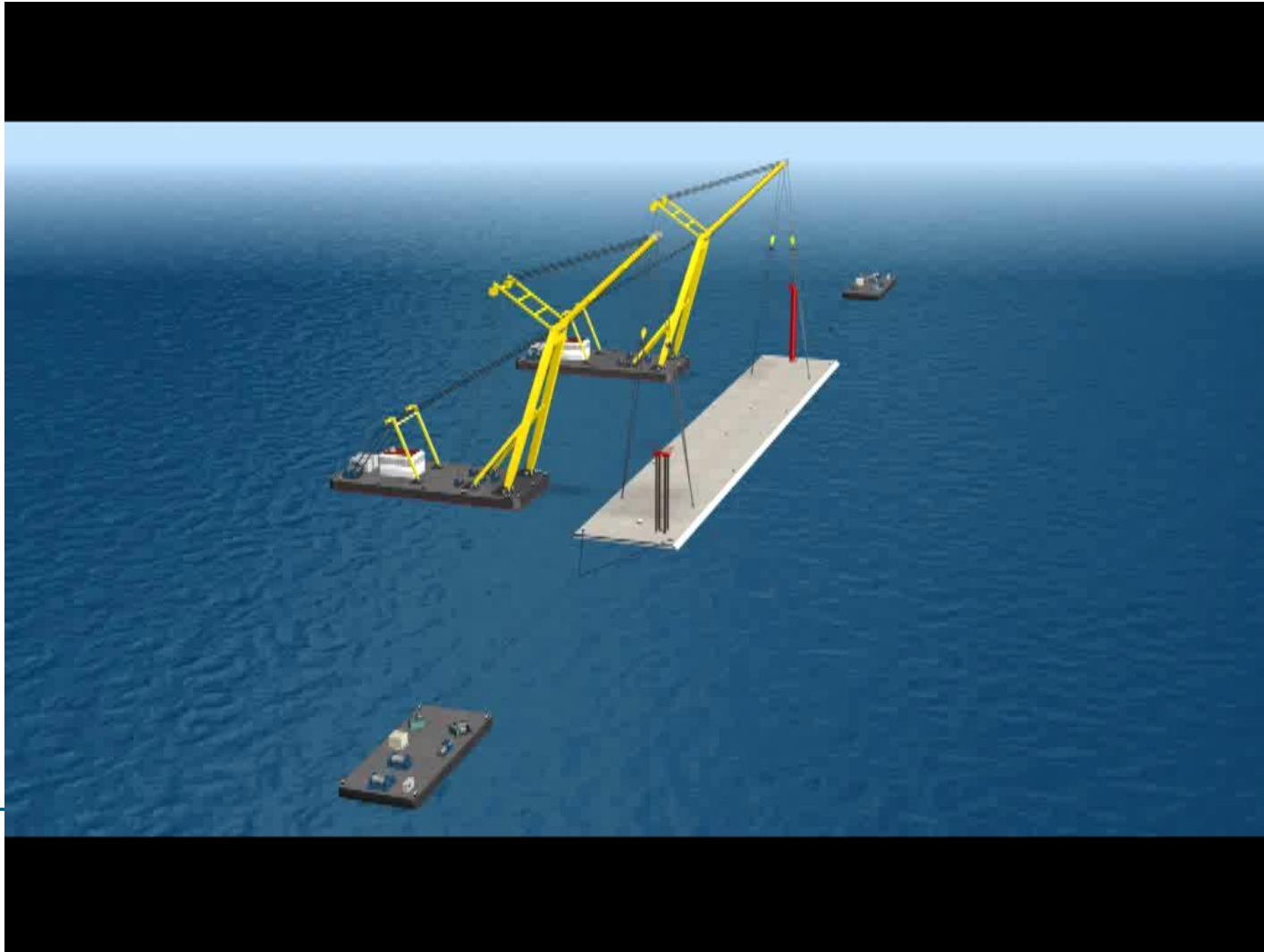
# Transport

- Wave conditions
- Limitations in transport route
  - Water depth
  - Locks
- Limitations at project site

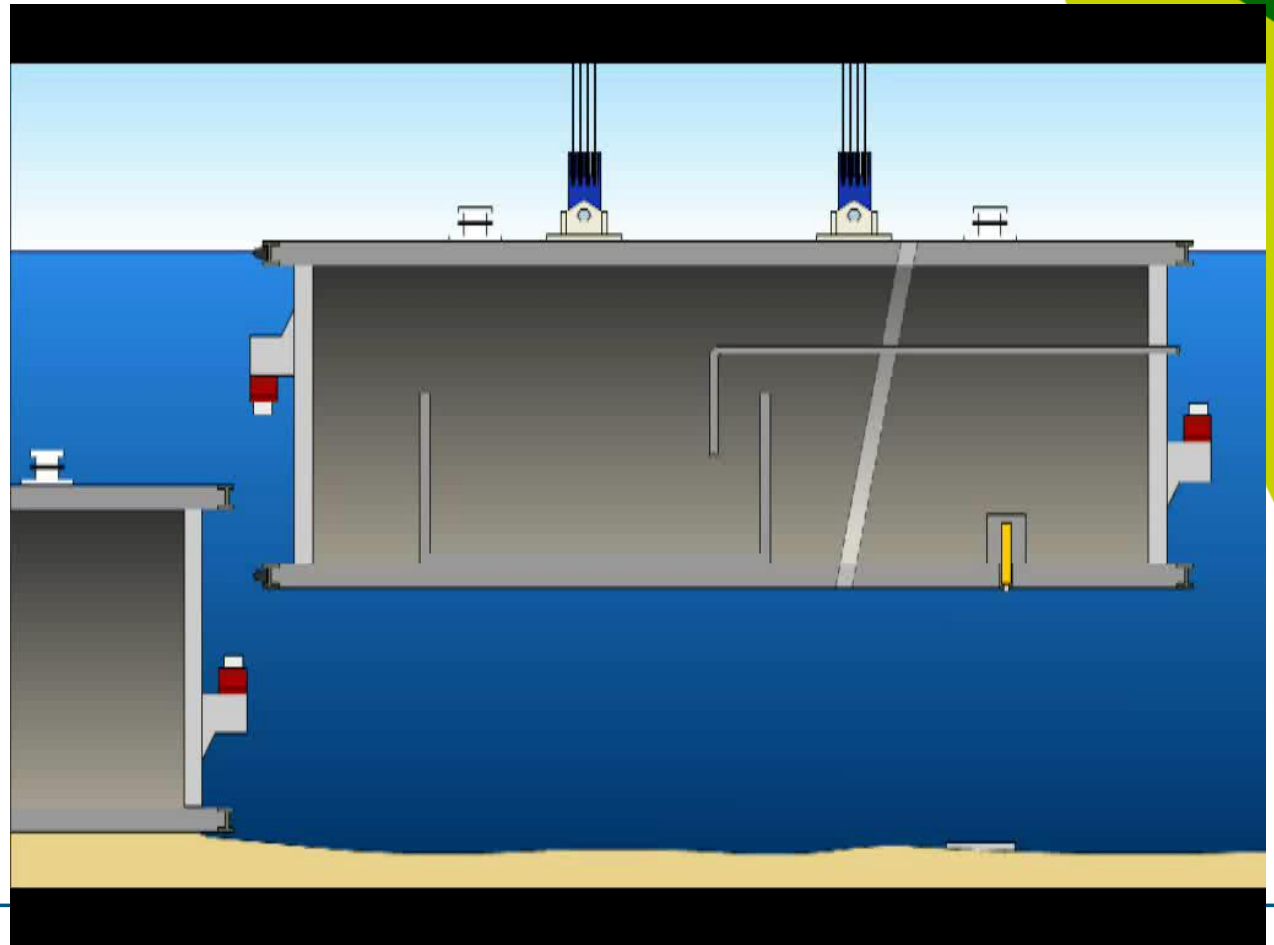




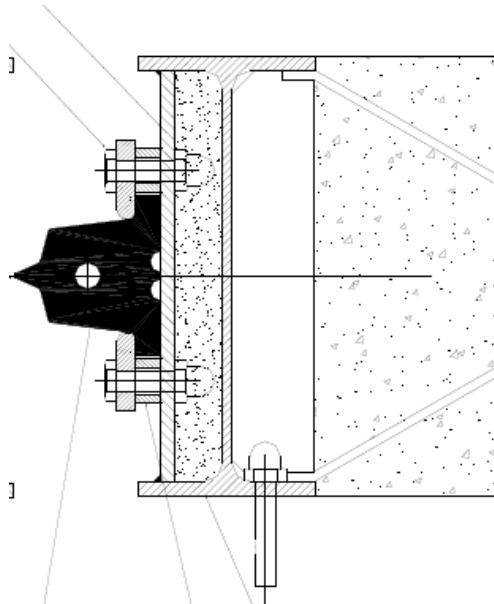
# Principle of immersion



# Principle immersed tunnels

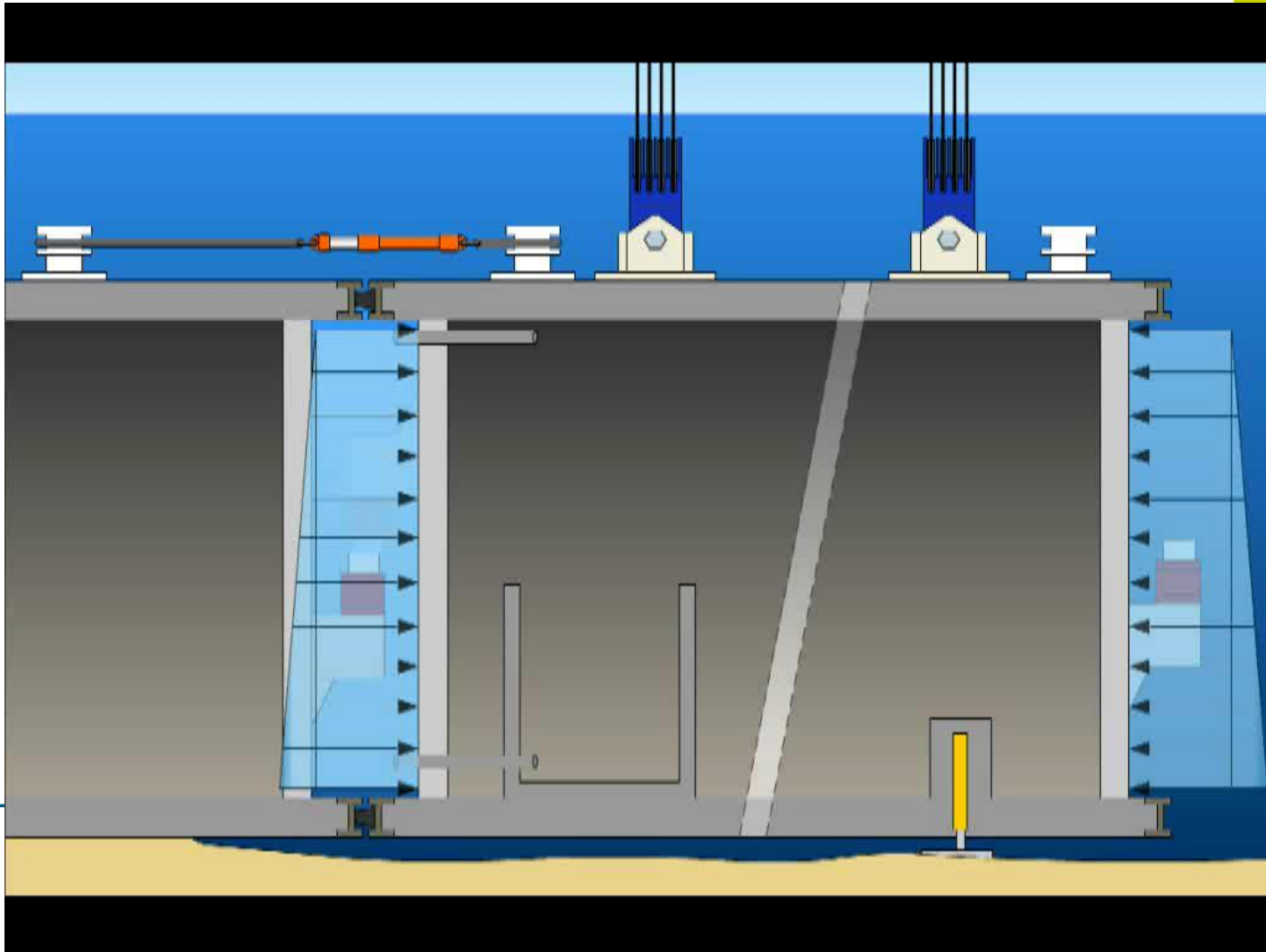


# Principle of joining / Gina gasket



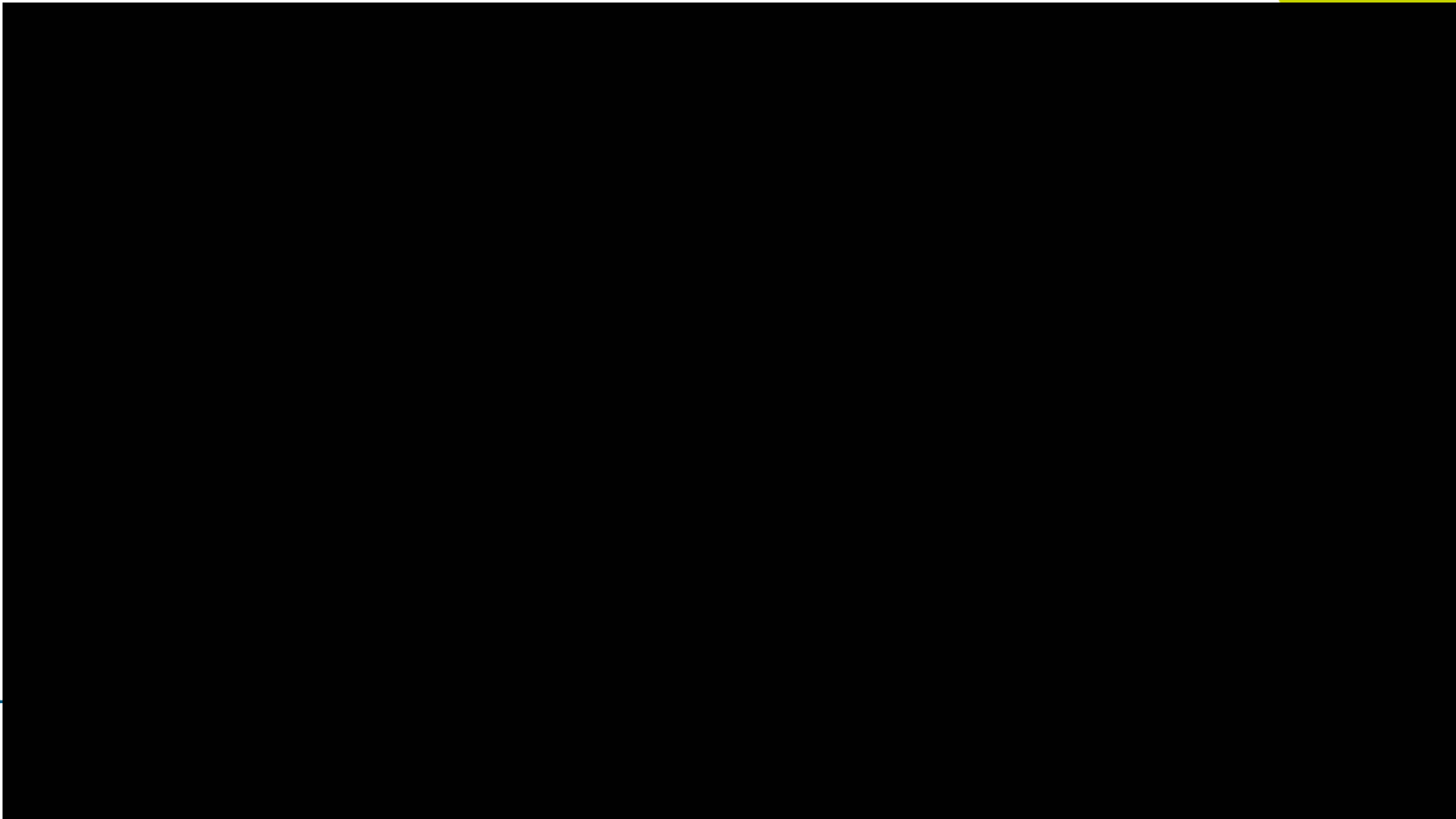


# Principle of joining



# Immersed tunnel Busan-Geoje South Korea

## Video Strukton Immersion Projects



# Potential advantages in alignment design - especially river crossings

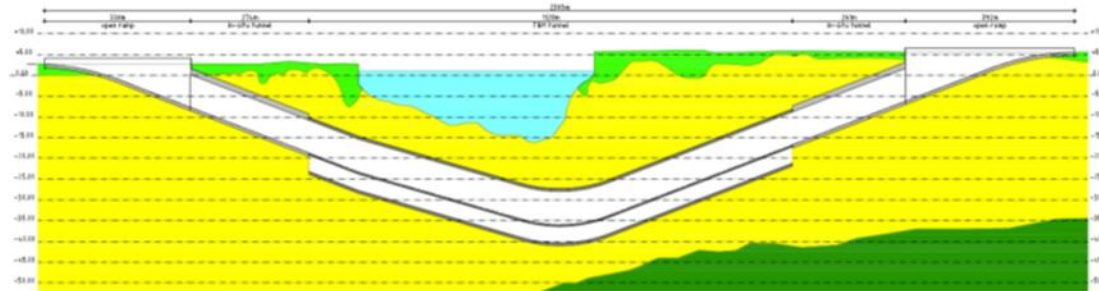




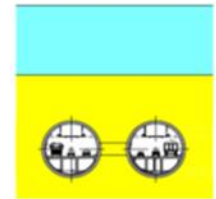
# High bridges with long approaches ?



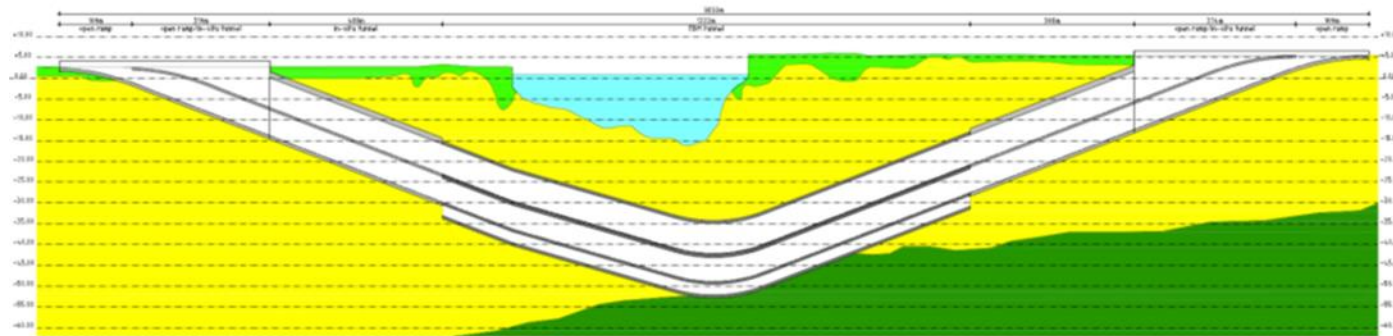
# Bored tunnel – deep level, long approaches



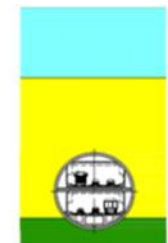
TBM-Original



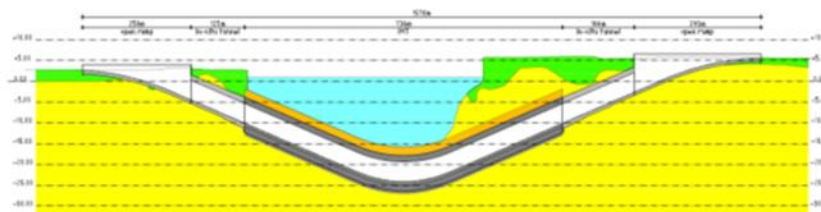
TBM-Original



TBM-Selected



TBM-Selected



IMT-Alternative



IMT-Alternative

# Practically every shape

→ rectangular, circular etc

→ cost effective for wide tunnels

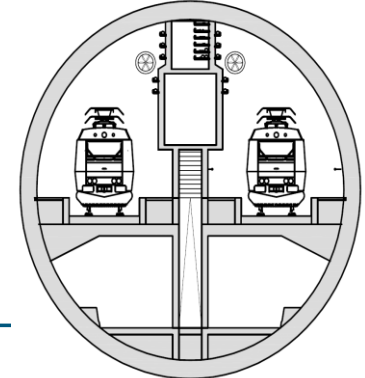
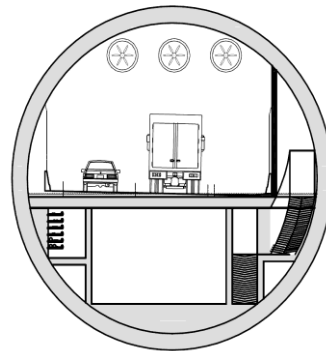
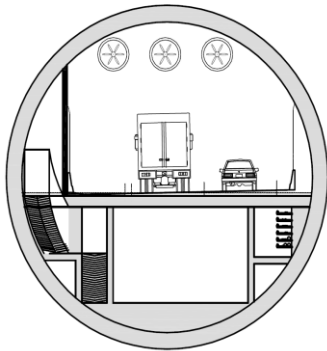
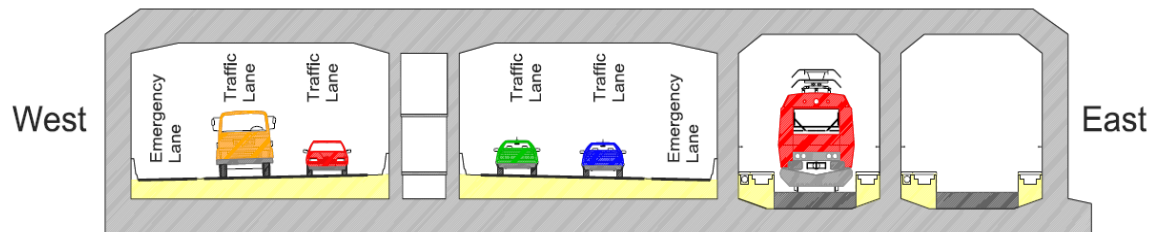




# Cost effective for wide tunnels

(multiple road lanes or combined road – rail tunnels)

→ example multiple traffic lay out



# Practically every waterway



# Characteristics / Advantages

- Suitable for various and relatively poor soil conditions
- Parallel construction processes
- Relatively low and manageable risk profile
- Capable of dealing with (severe) seismic events
- 80-90% of all design and construction works can be done by local companies (limited input from international specialists)

# Disadvantages / Prejudices ?

- Environmental impact of dredging
  - Contaminated soils
  - But also opportunities ? → Land reclamations
- Construction impact on shipping
  - Limited and manageable impact
  - In practice often an issue that can be addressed properly by good communication



# Innovations

1. **Caland tunnel, The Netherlands**
2. **Øresund Link, Denmark**
3. **Busan Geoje, South Korea**
4. **HZMB, China**
5. **Fehmernbelt Link, Denmark**

# Caland tunnel – The Netherlands

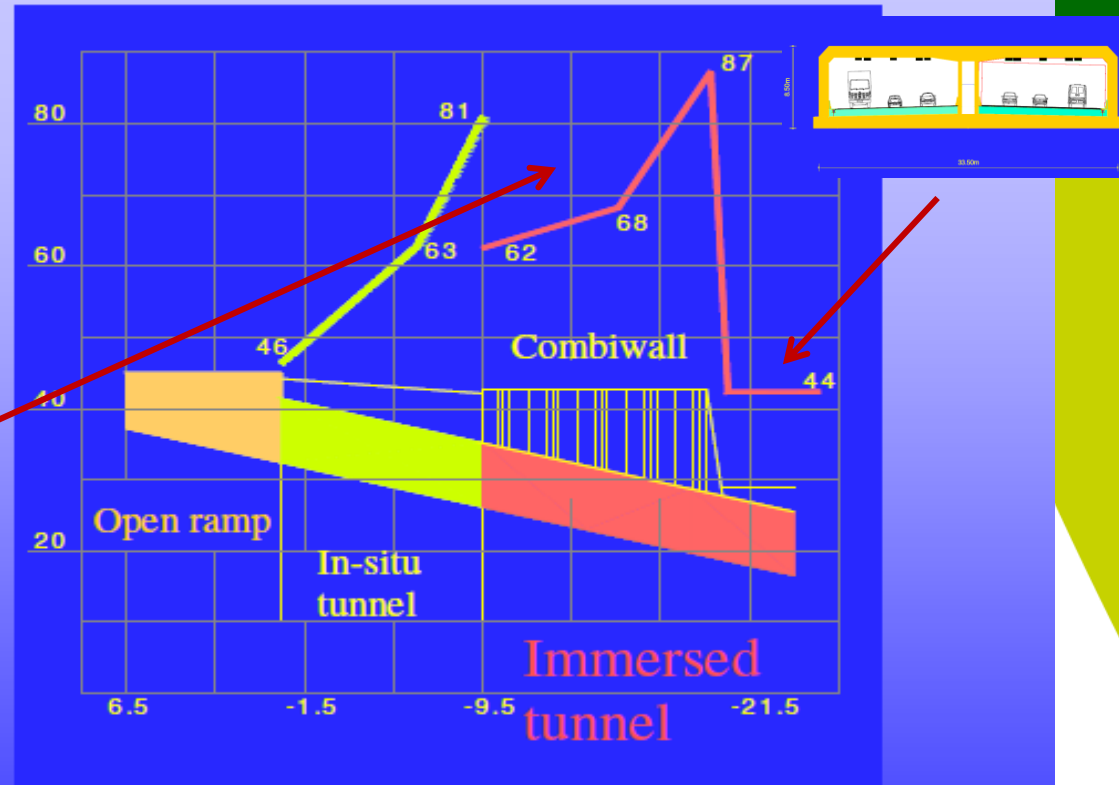
## Extension immersed section





# Cost Comparison

Costs in euro per meter (x1000)



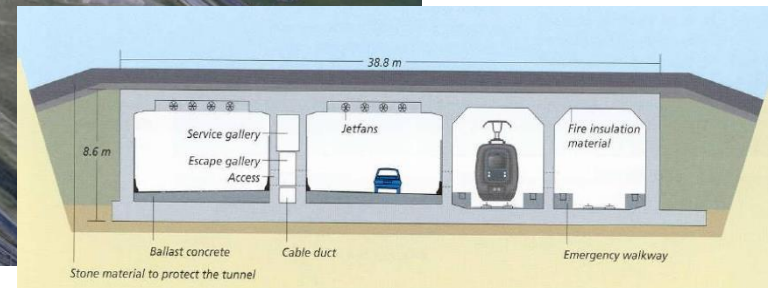
Road level in meters relative to N.A.P.

Caland Tunnel

## Caland tunnel – The Netherlands

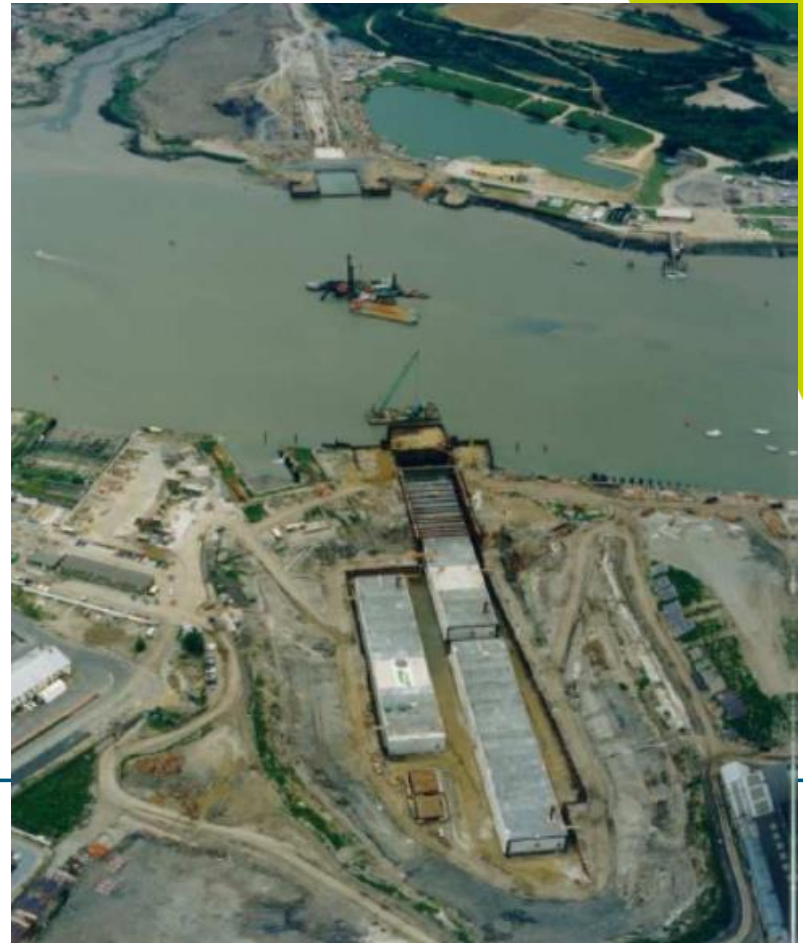
### Extension immersed section

# Øresund Link, Denmark

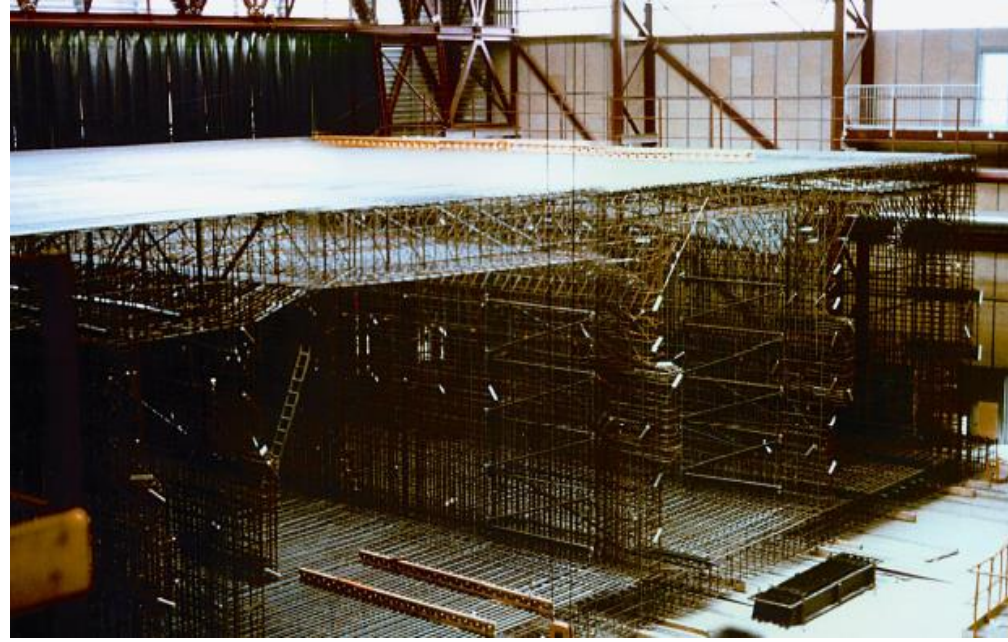




# Traditional production tunnel elements



# Øresund Link, Denmark – new developments



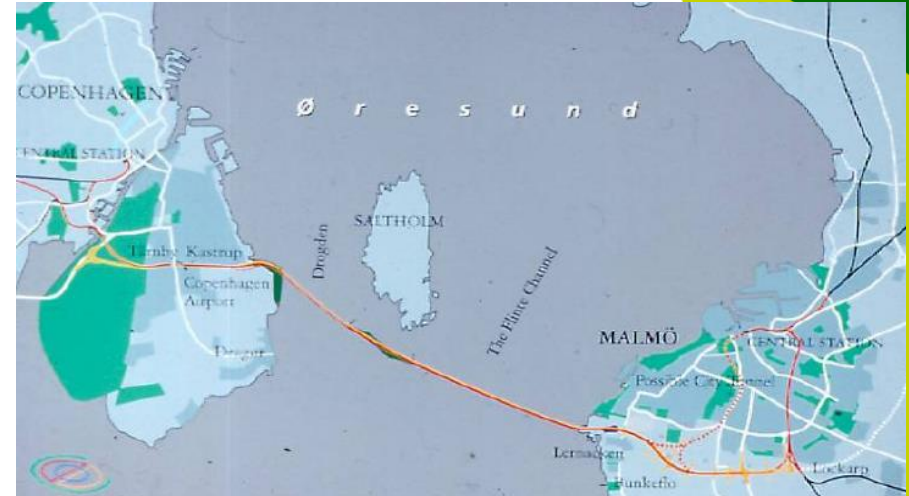
Factory Production / Full Section Casting





# Production Factory Principle

# Øresund Link, Denmark



Dredging & Environmental issues

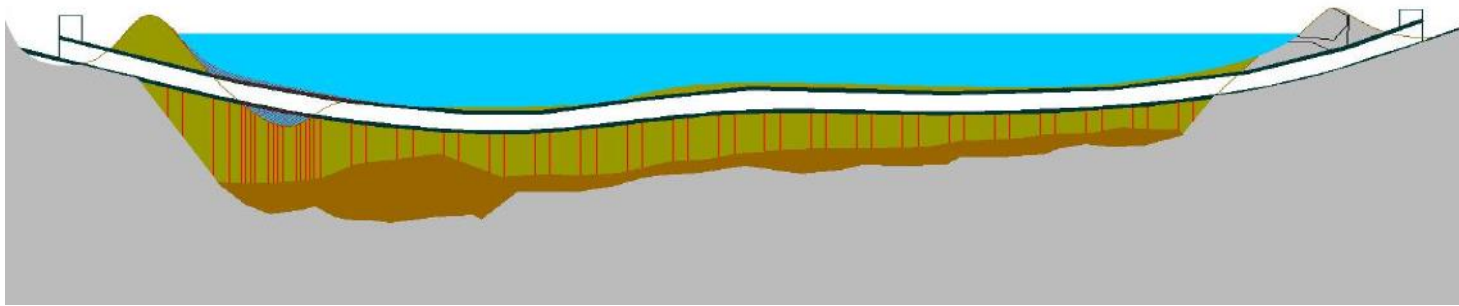


# Busan Geoje Fixed Link, South Korea



# Busan Geoje Fixed Link, Challenges

- Deep level
- Poor soil conditions



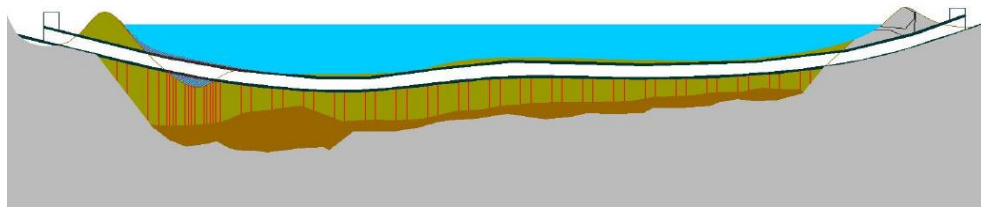
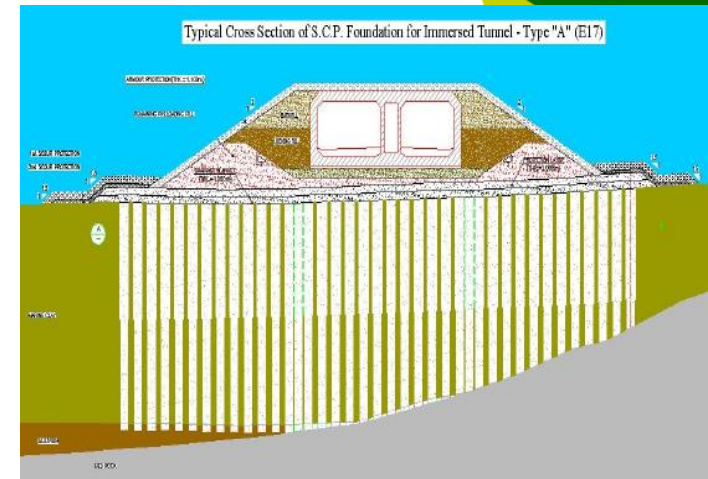
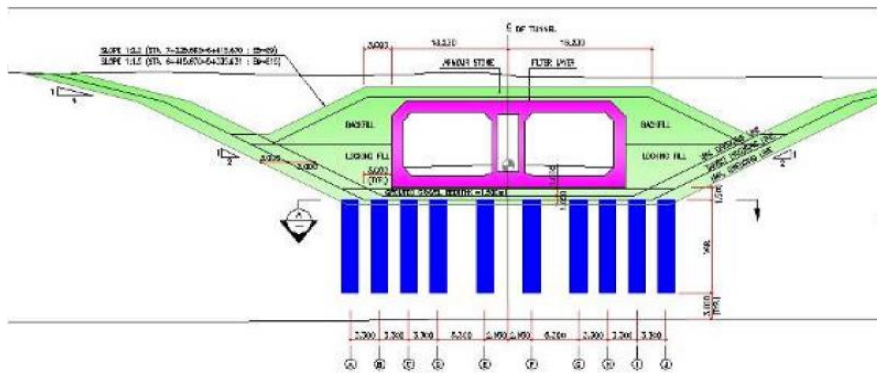
- Adverse marine conditions (off shore)
- Seismic events and exceptional wave conditions due to typhoons

# Busan Geoje Fixed Link, South Korea



Full section casting in traditional casting basin

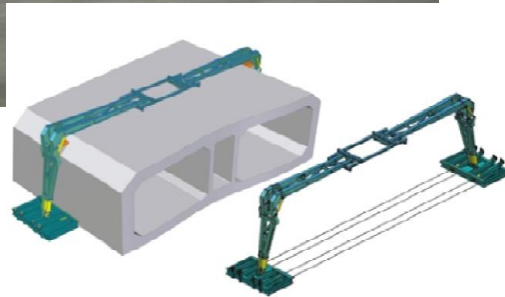
# Busan Geoje Fixed Link, South Korea



Soil treatment of poor soils

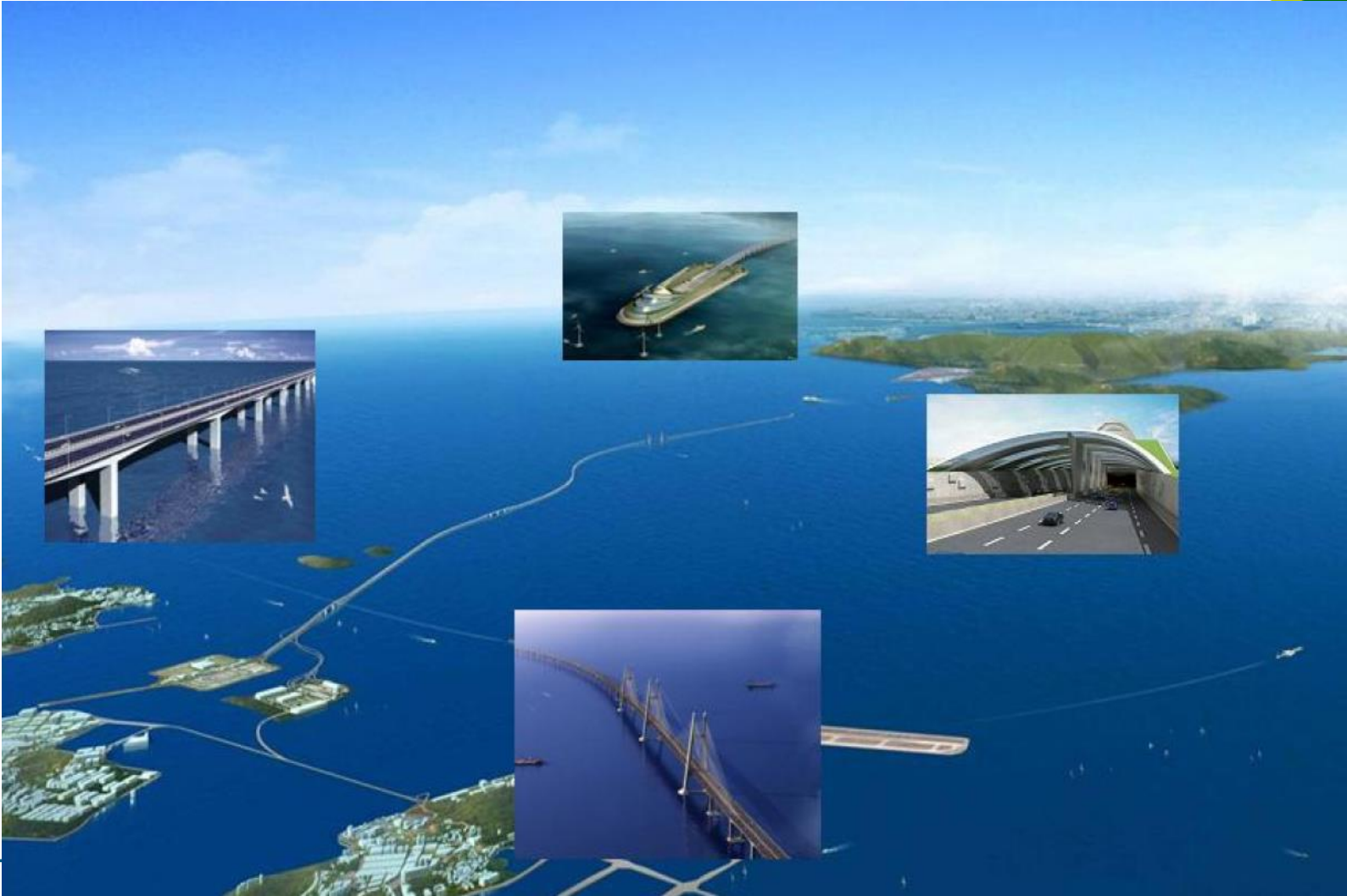


# Busan Geoje Fixed Link, South Korea



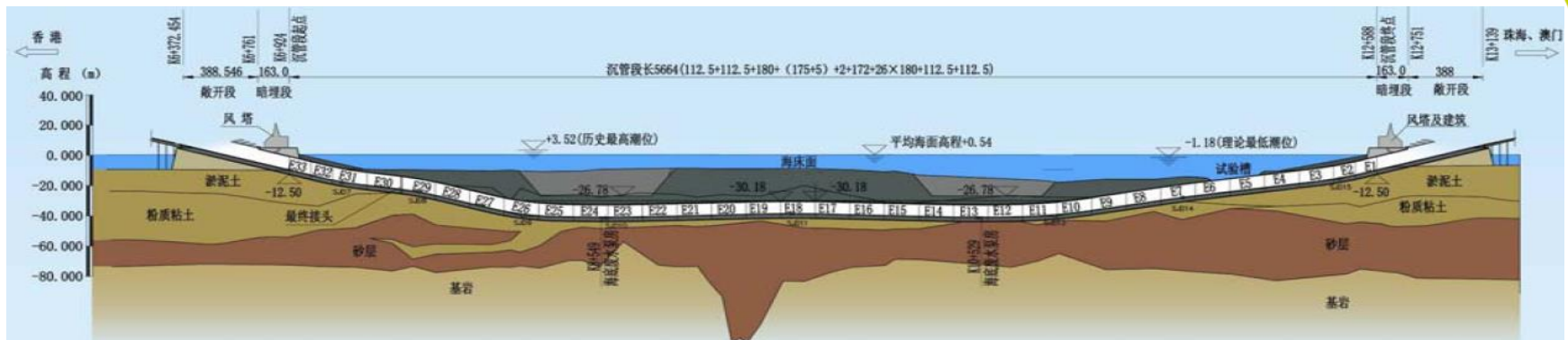
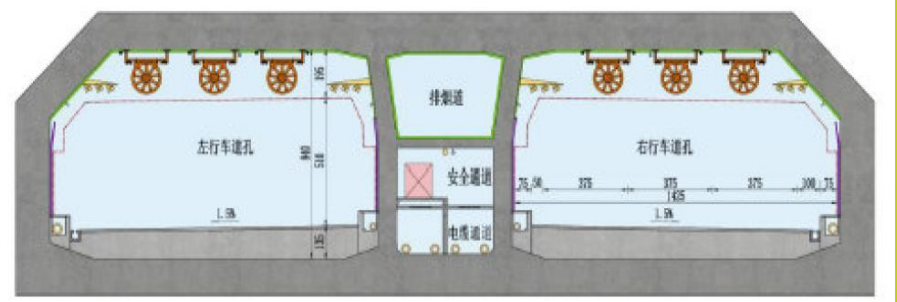
Special equipment for transport and immersion

# Hongkong Zhuhai Macao Link, China



# Hongkong Zhuhai Macao Link, Challenges

- Geotechnical conditions
- Depth
- Geometrical (span + length)
- Off shore conditions
- Design life of 150 years





# Hongkong Zhuhai Macao Link, Challenges



- Controlled conditions for element production

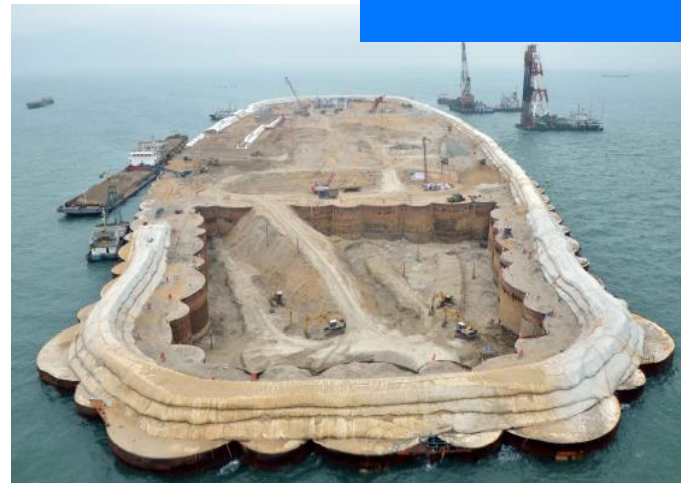
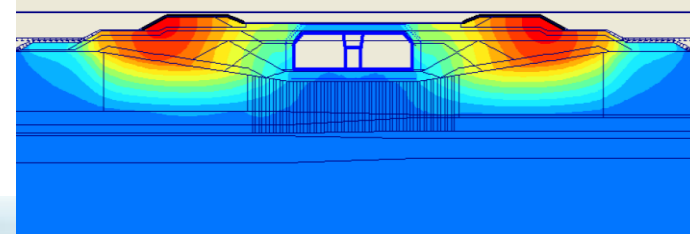
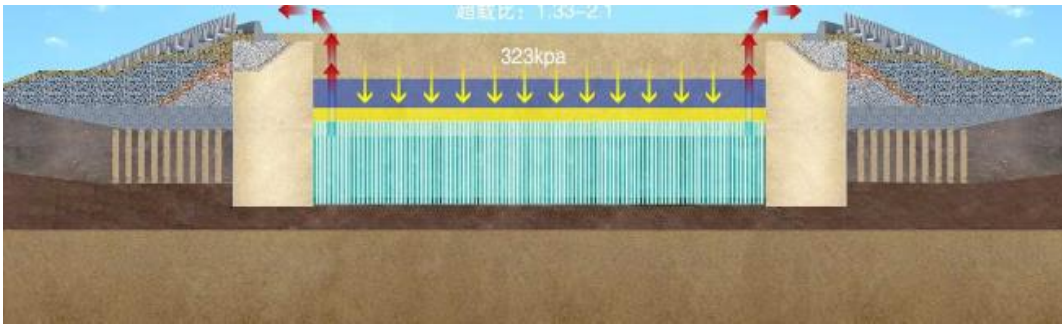


# Hong Kong-Zhuhai-Macao Link China



# Hongkong Zhuhai Macao Link, Challenges

- Ground conditions





# Hongkong Zhuhai Macao Link, Challenges

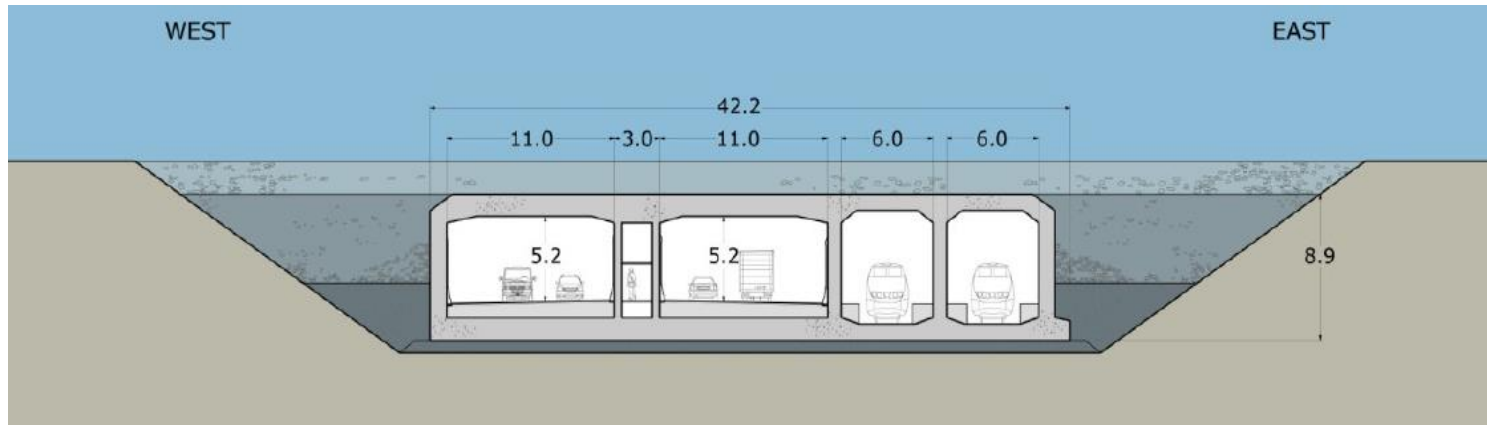


- Offshore conditions





# FehmernBelt Link, Denmark



Special elements for M&E and maintenance

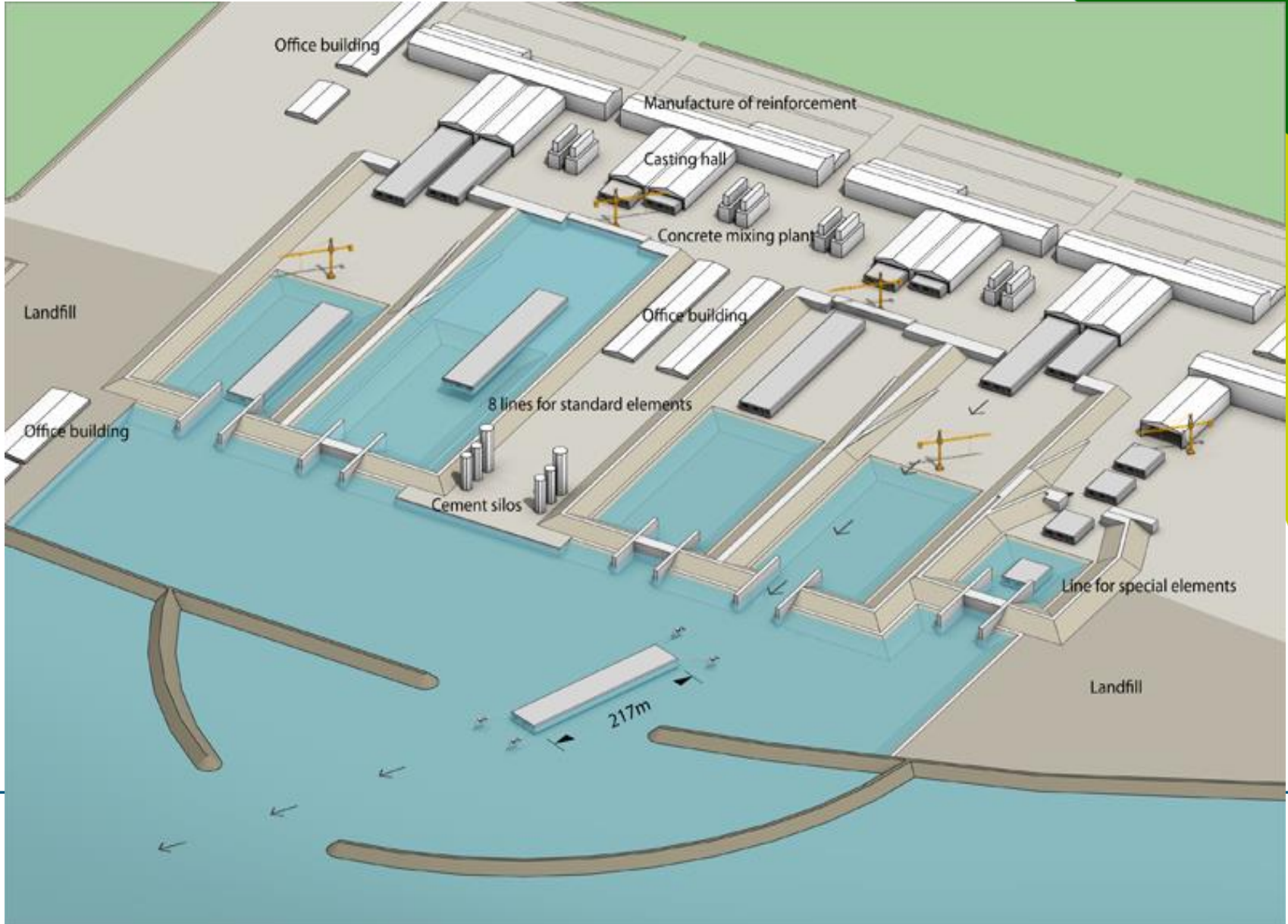
# FehmernBelt Link, Denmark

## Construction



4 x times Oresund







# FehmernBelt Link, Denmark



Environmental – re use of dredged material

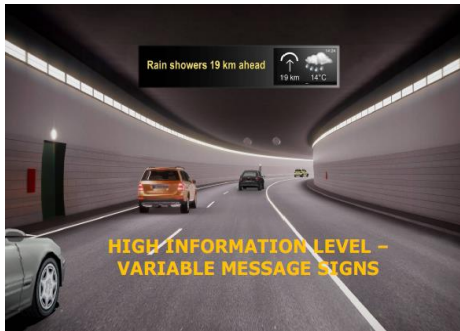


# FehmernBelt Link, Denmark

## Safety Concept ventilation

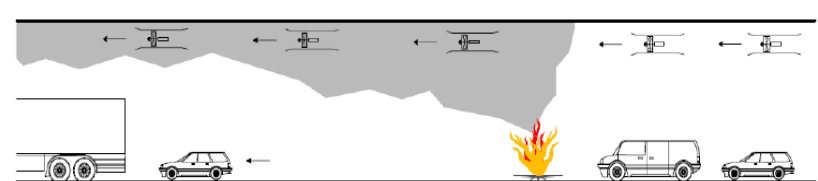
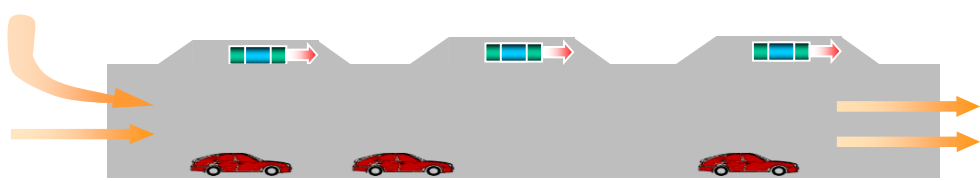
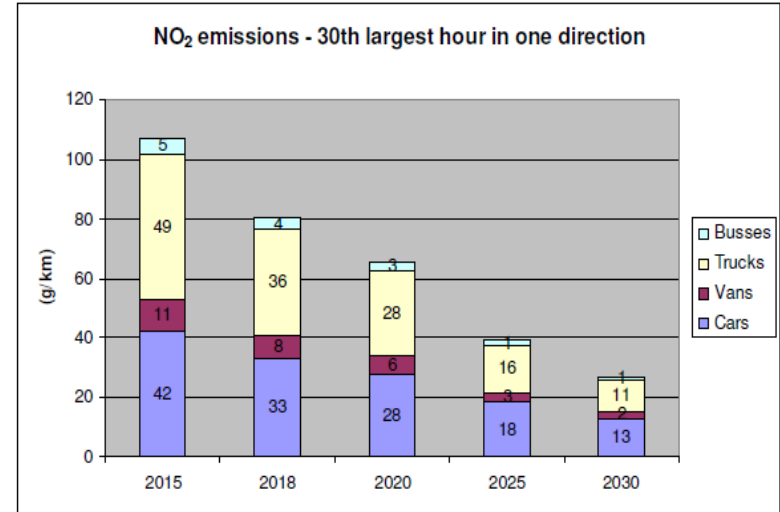
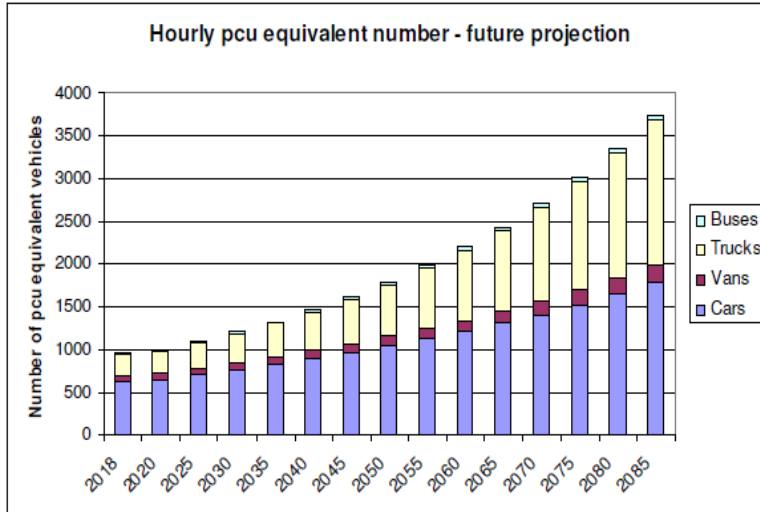
Safety Strategy based on three levels:

- Level 1 – prevention of accidents and fires through design and operation
- Level 2 – control of incidents, and self-rescue
- Level 3 – facilities for emergency services response and rescue

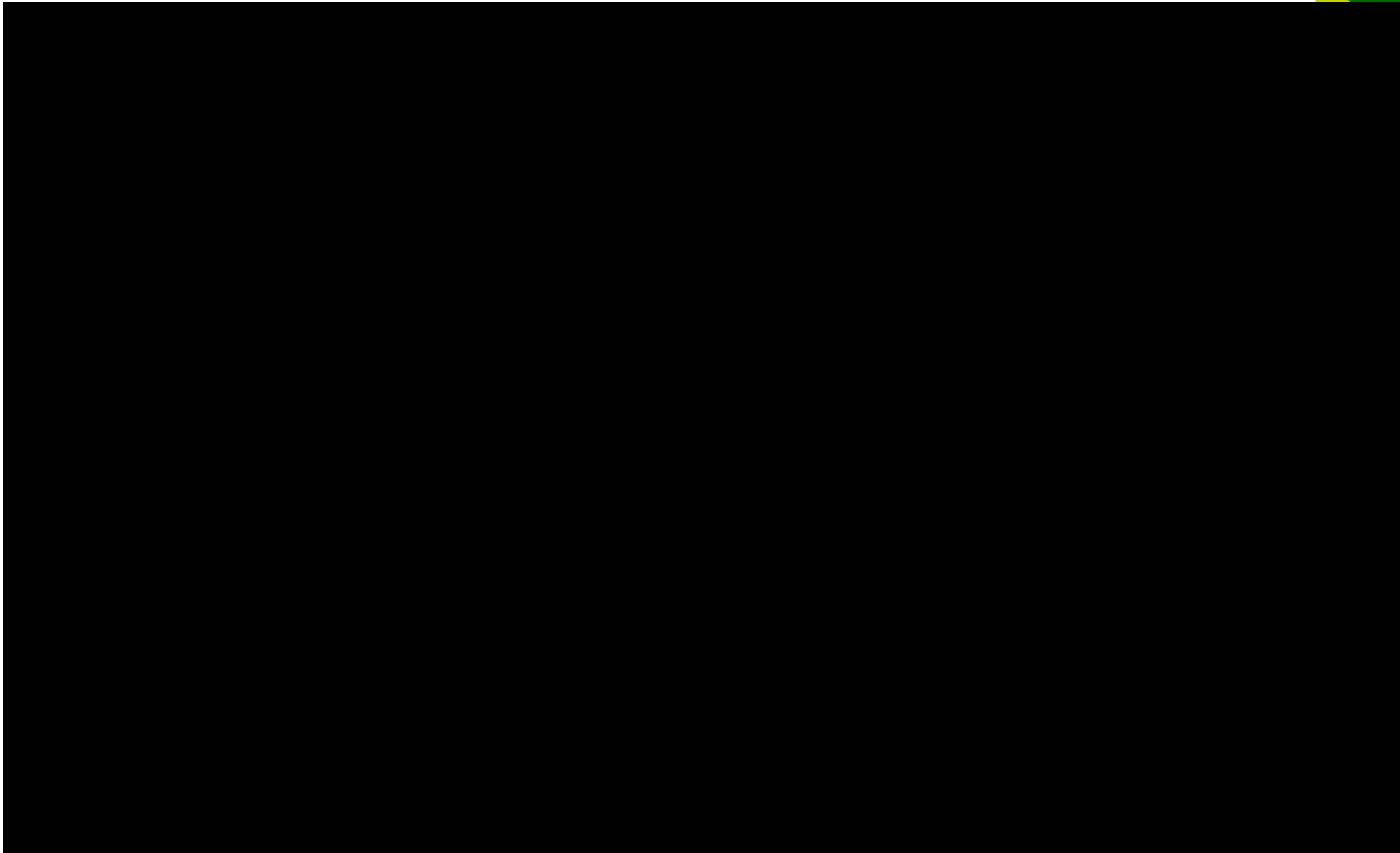


# FehmernBelt Link, Denmark

## Longitudinal ventilation for operation and fire



# FehmernBelt Link, Denmark -- Video



# *Ačiū už dėmesį*

[www.rhdhv.com](http://www.rhdhv.com)