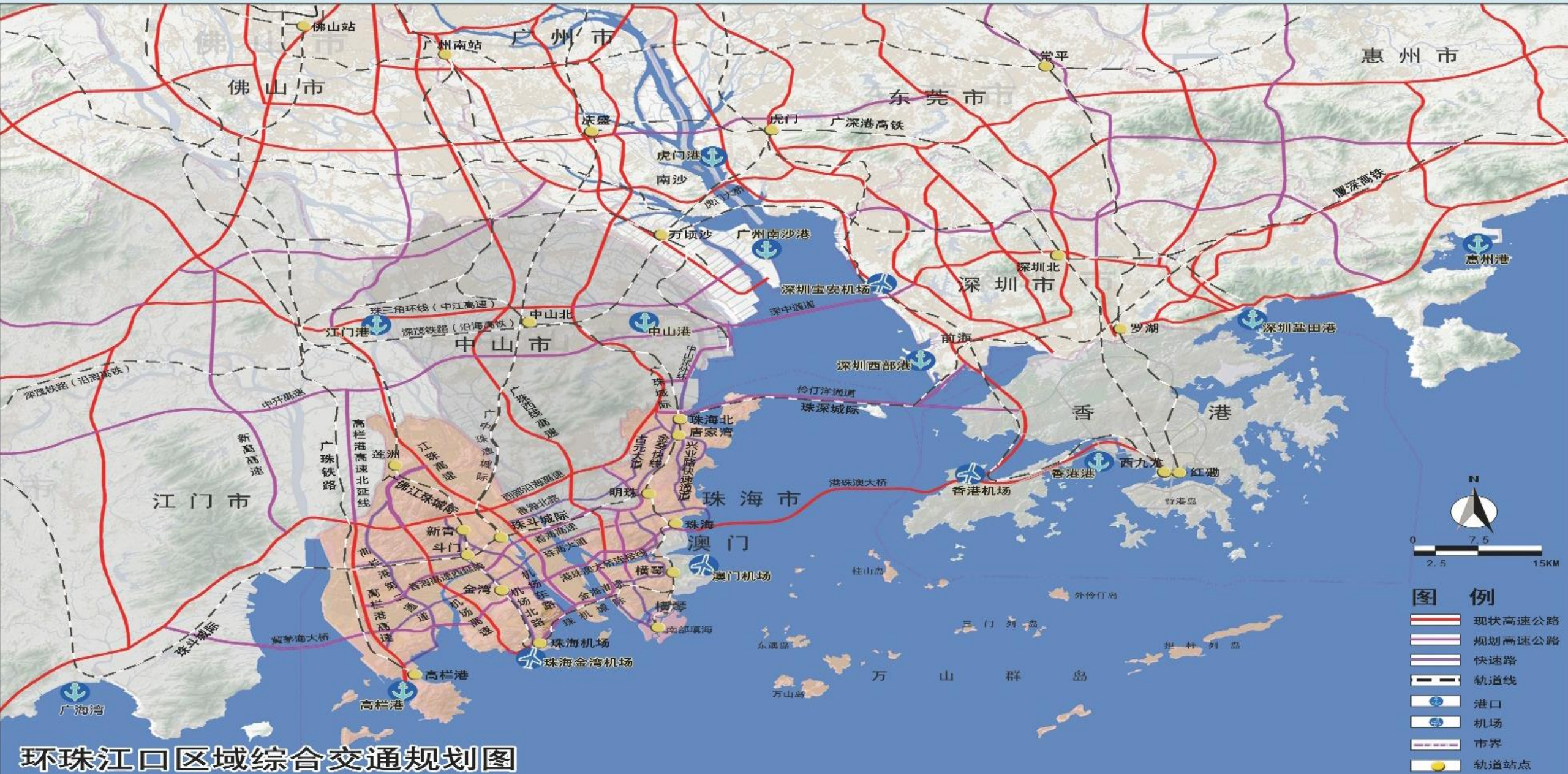
Hongkong-Zhuhai-Macao Bridge

Project Description

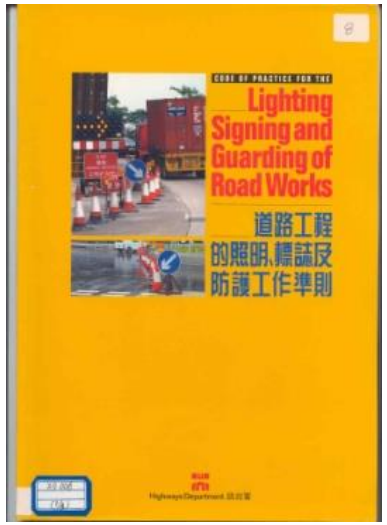
环珠江口区域综合交通规划图

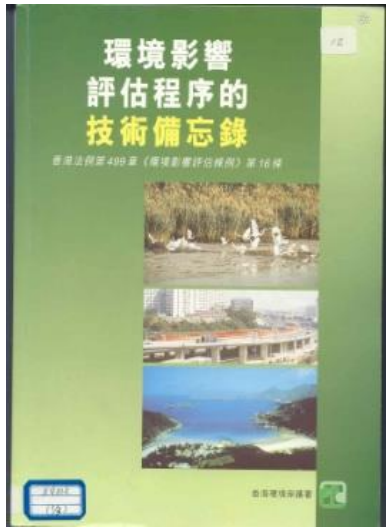


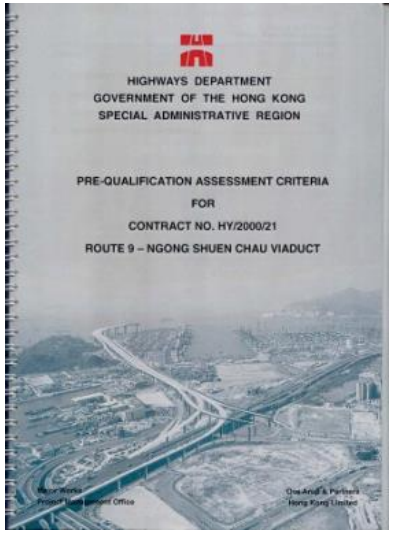
环珠江口区域综合交通规划图

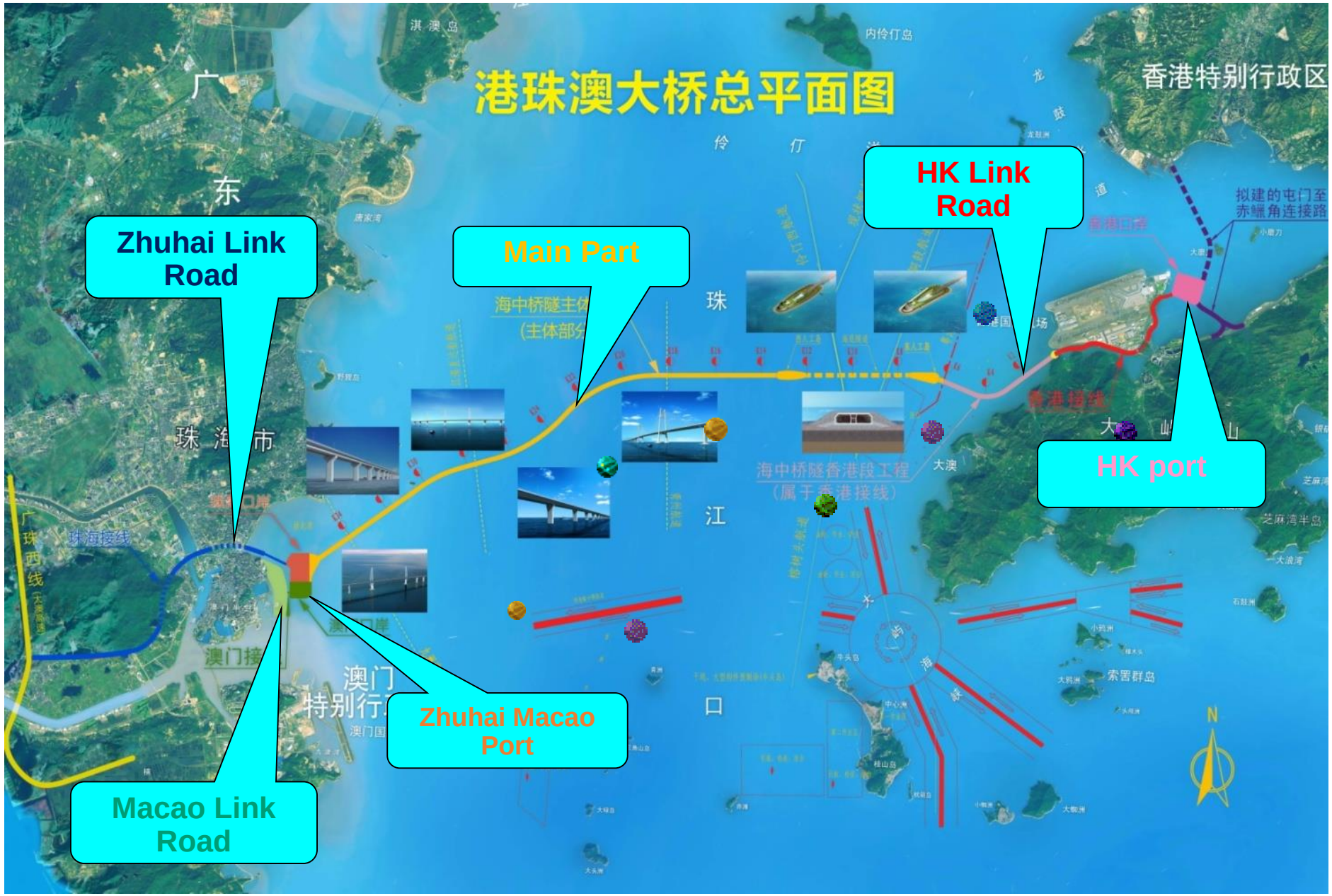
- Mega infrastructure project
- Political significance
- Economy significance
- Technical challenges
- 126.9 billions RMB (18.9billions USD)
- 98 months

Guangdong, Hong Kong and Macao









Co-Construction Section

Main Part:30Km

Hong Kong section

Link Road:12Km

Port:130 Ha

Zhuhai section

Link road:14Km

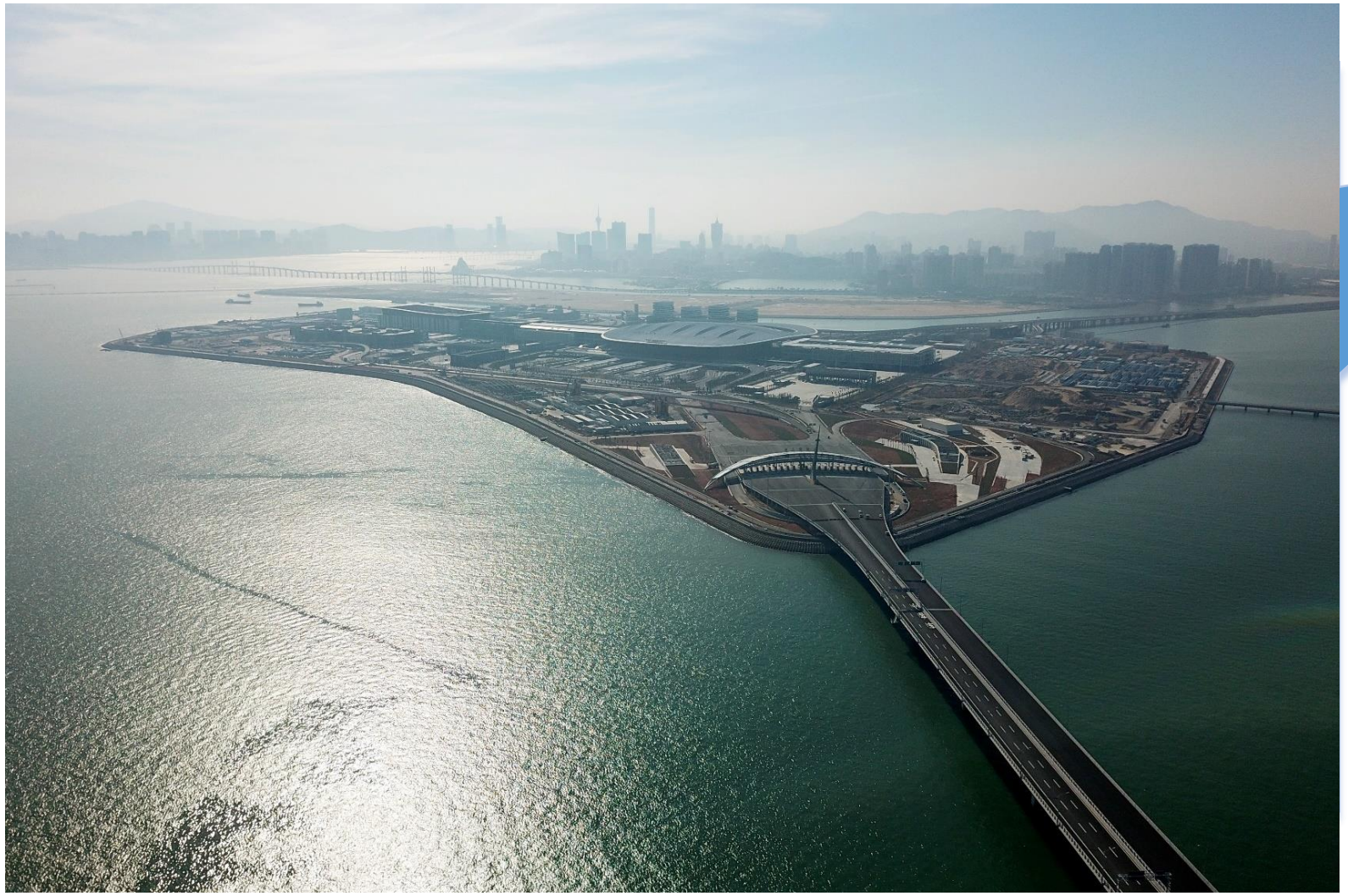
Port:136 Ha

Macao section

Link road:0.3Km

Port: 74 Ha

Zhuhai-Macao Port



Reclamation area 208.87ha

Shallow zone 85 meters span non navigable bridge (Viaduct)

Jiuzhou Navigable Channel Bridge

Two steel towers single column cable-stayed bridge with steel box girder
Bridge span
85+150+298+150+85=768m

River-Sea-Through Navigable Channel Bridge

Three steel towers single column cable-stayed bridge with steel box girder
Bridge Span
129 + 258 + 258 + 129 = 774m

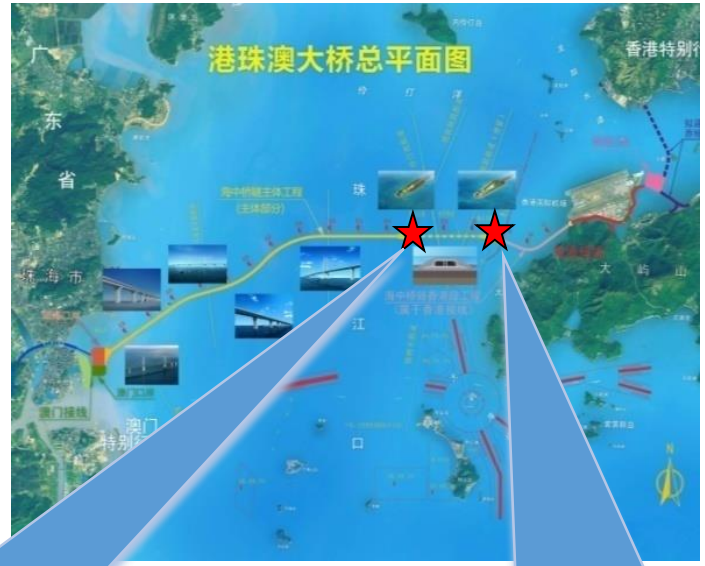
Deep zone 110 meters span non navigable bridge (Viaduct)

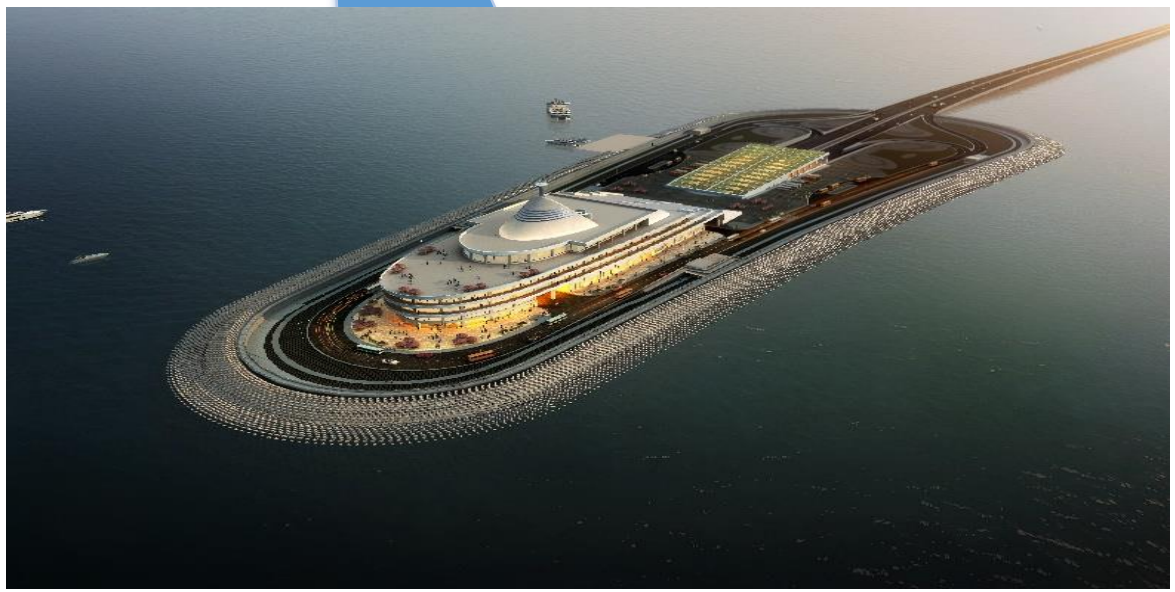
Qingzhou Navigable Channel Bridge

Two concrete towers single column cable-stayed bridge with steel box girder

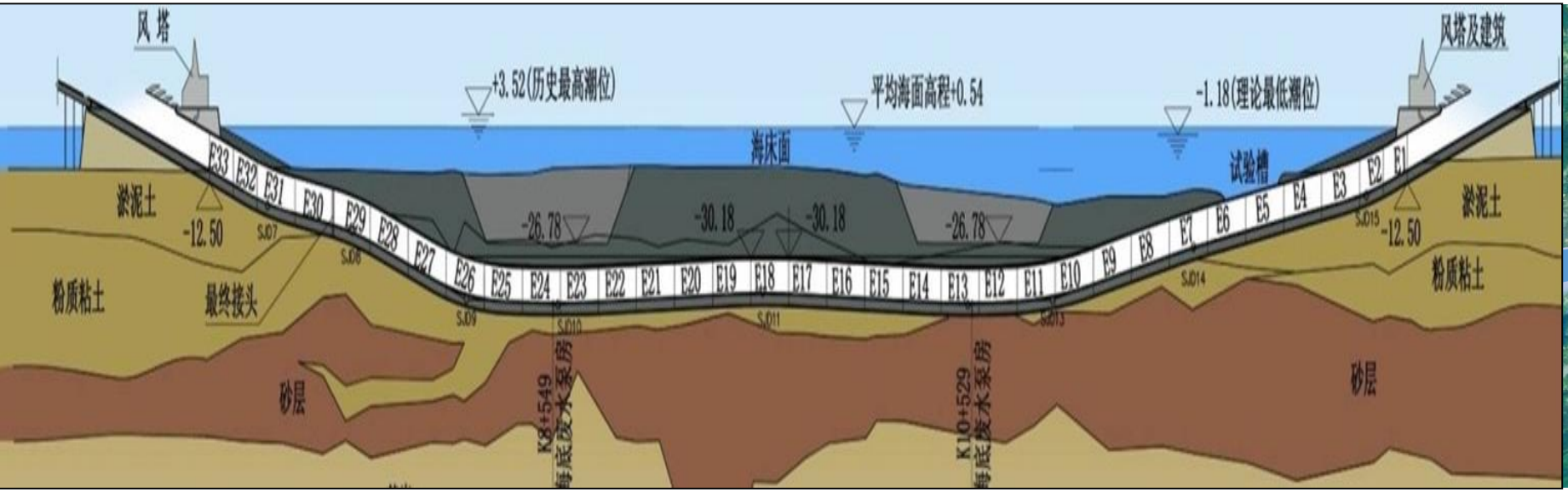
Bridge Span
110+126+458+126+110=930m

East & West Artificial Island

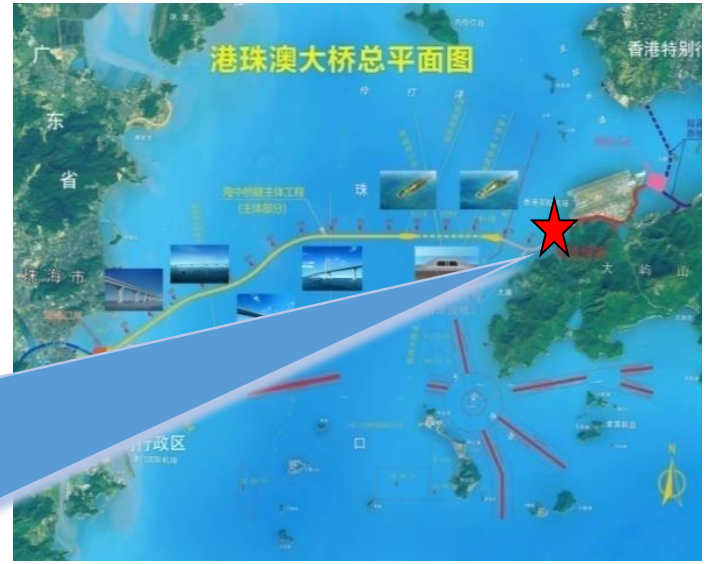




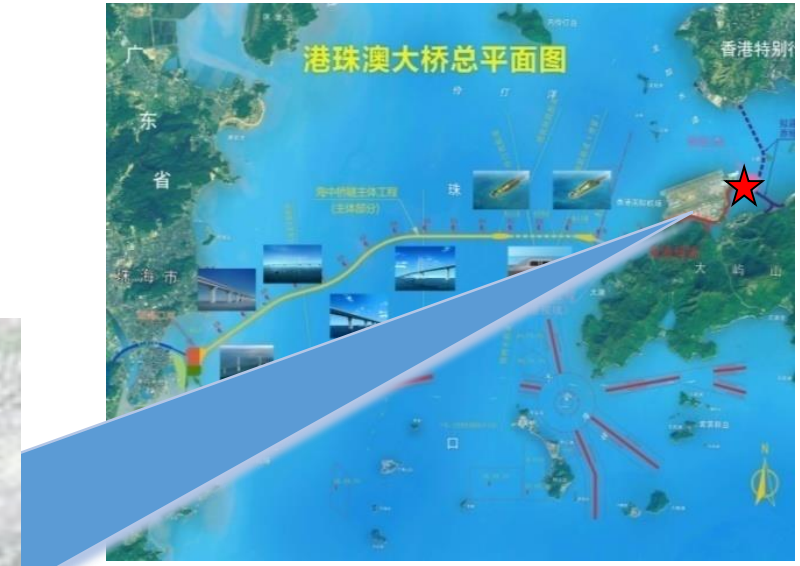
Immersed Tunnel



Hong Kong side link bridge (Viaduct)



Hong Kong Port



Reclamation area 130Ha


55KM
The longest Sea-Crossing Link Road

Hypercomplex project in china highway construction history included bridge, artificial island and tunnel on the sea

420000 tons

The largest scale steel box girders in the world

Equal to 60 Eiffel towers

The philosophy of construction
large-scale component , industrialization, standardization, assemblage

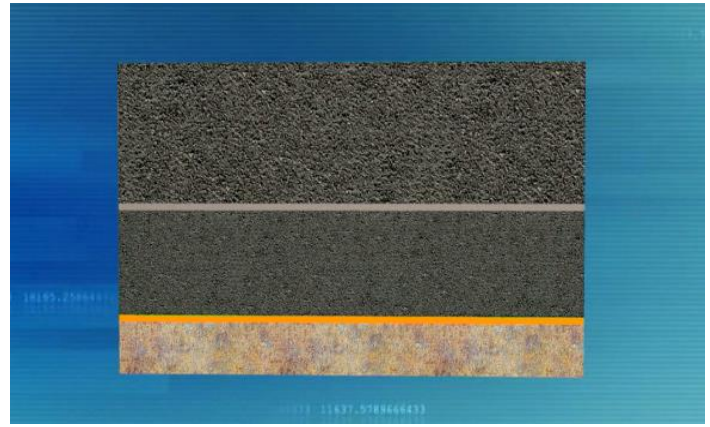
Bridge Pile foundation construction

Bridge tower construction

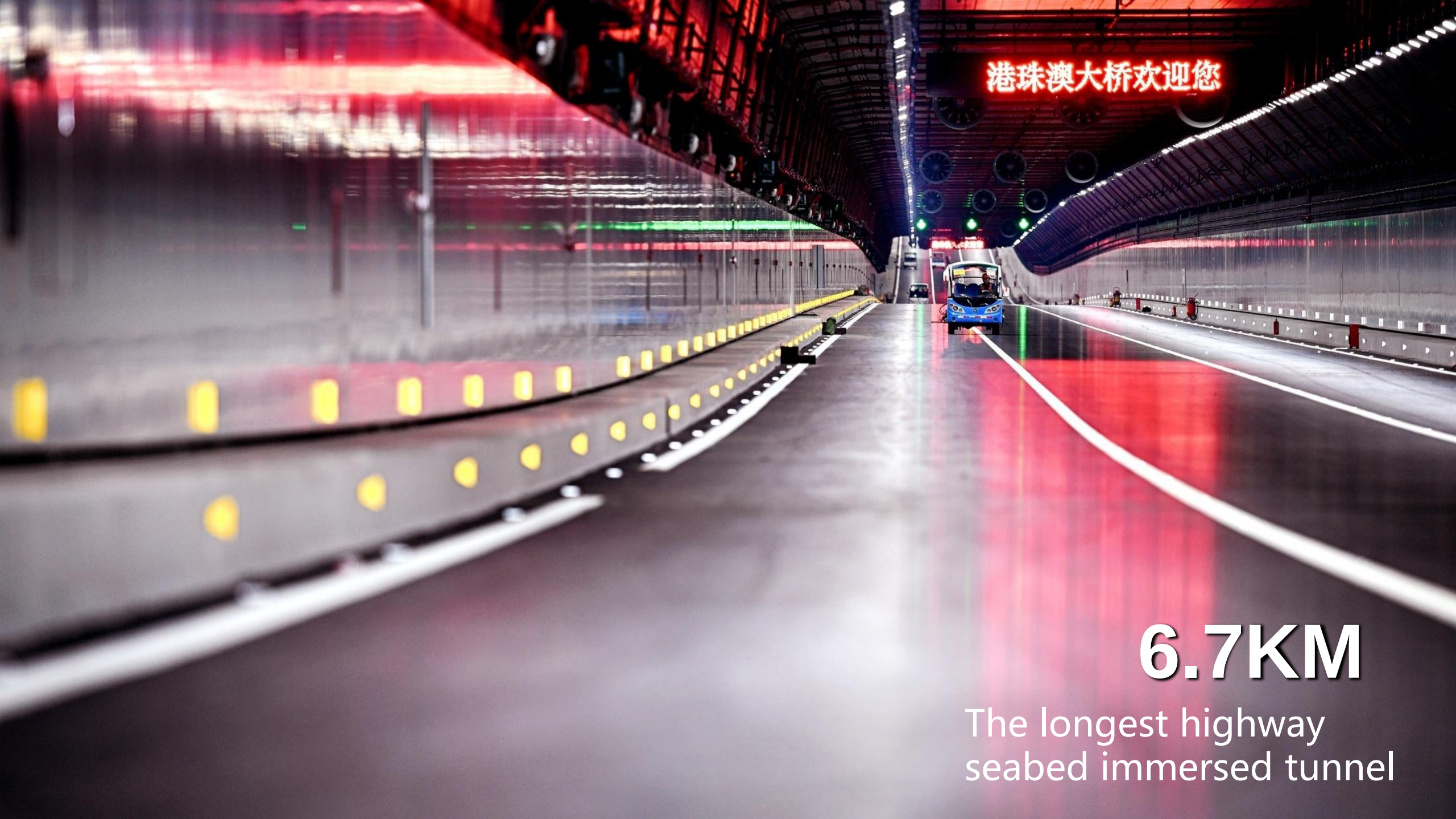
Steel box girder manufacturing in the workshop

Hoisting and installing a whole assemblied steel box girder 130m length ,3200 tons

500000 square meter bituminous pavement on surface of steel box girder which is the largest scale in the world




It is first time to build two artificial
island to connect bridge and tunnel

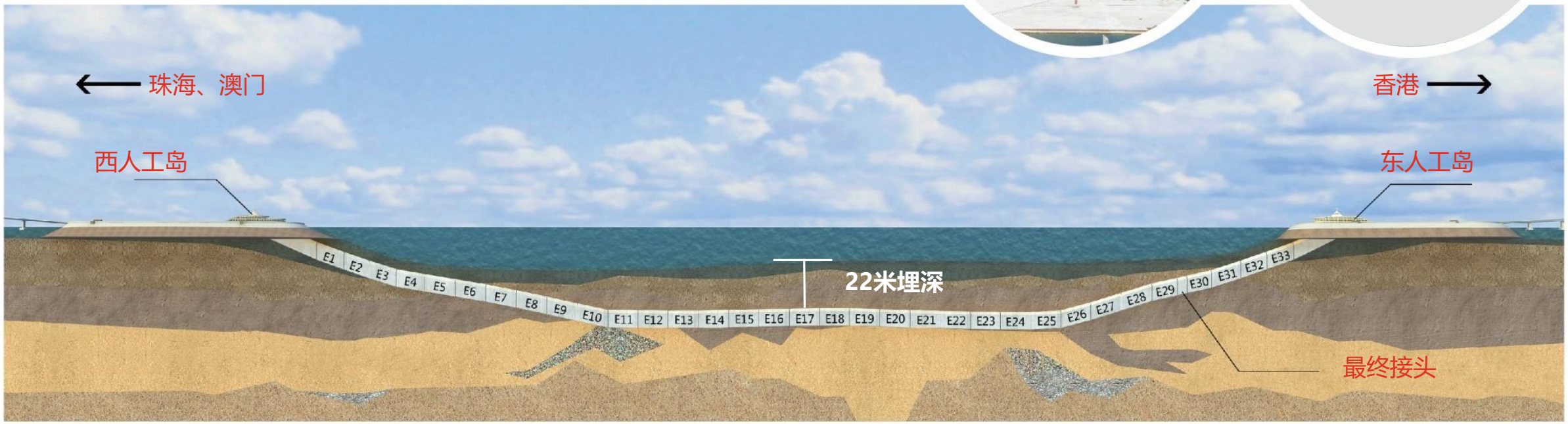


6.7KM

The longest highway
seabed immersed tunnel

78000tons for each element, total 33 elements

The roof of Elements should be buried deeply at 22 m below the seabed, in order to accommodate of 300000 oil tank navigation in future



Challenges

120 years service life
Design and construction criterions to meet Hongkong, Macao, China synchronously

Natural habitat of Chinese White dolphin

High Traffic Volume >4000 ships per day

Typhoon and monsoon happened frequently
38 times typhoon assaulted

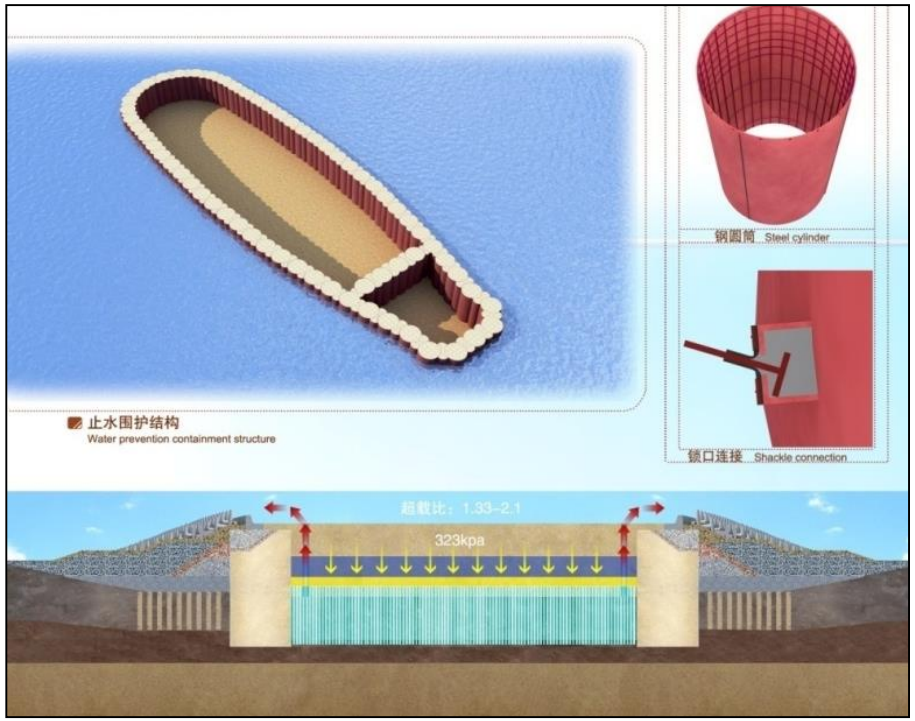
30m-40m thickness soft layer below seabed

An immensely difficult
for coordination and management

key Technology of Tunnel Engineering

Speediness Method for Artificial Island construction

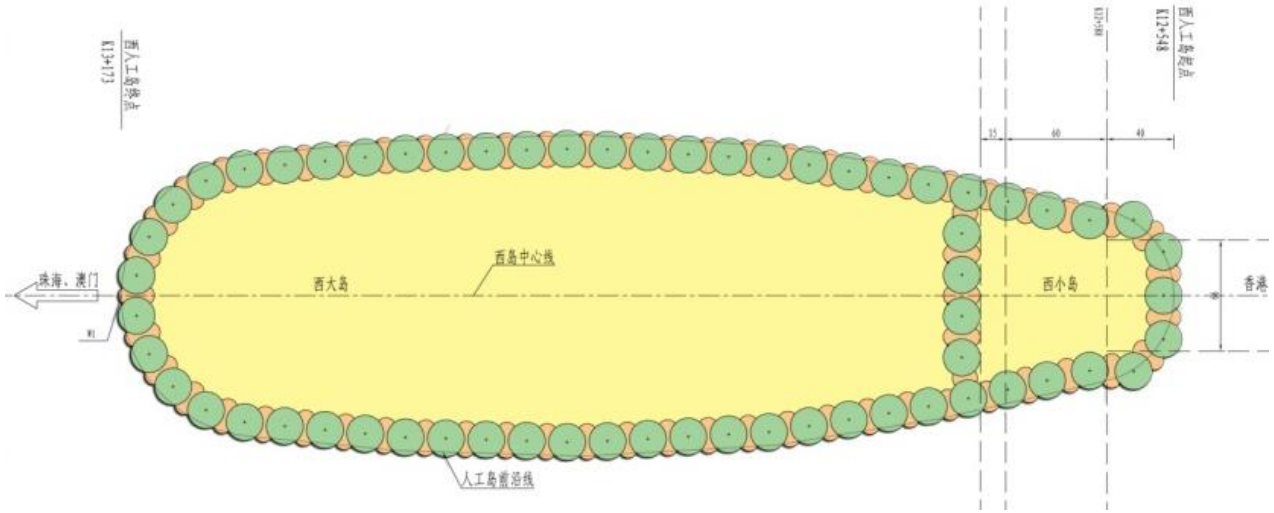
Inserted steel cylinders with 22 meters diameter into claypan to form sealing wall structure; backfill sand to form land formation; set up SCP piles around the island to reinforce the foundation.

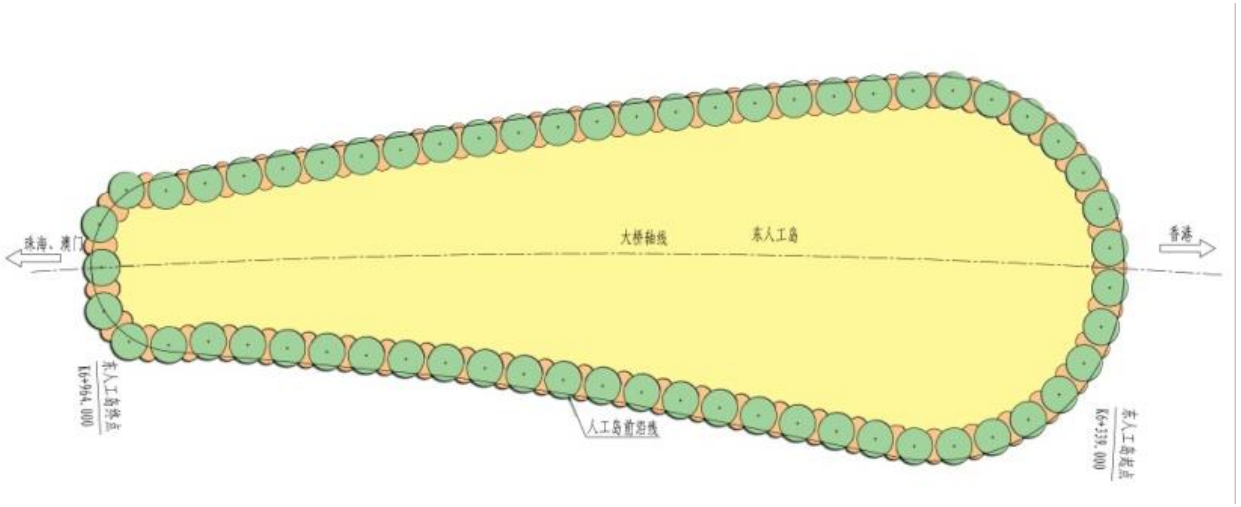


West Island 61 steel cylinders

- Diameters 22m
- Height 40.5m~50m
- Deepest penetration depth 29m
- Largest steel cylinders structure

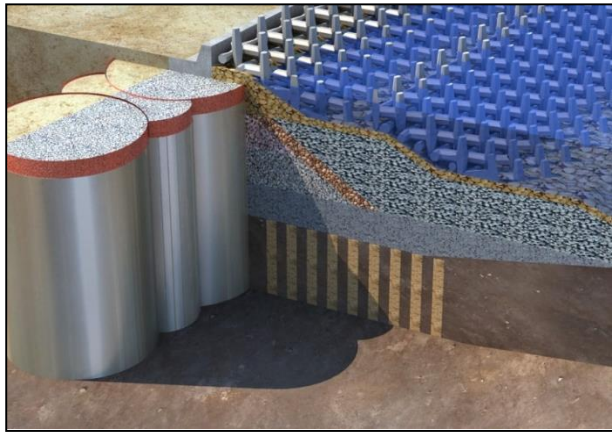
East Island 59 steel cylinders

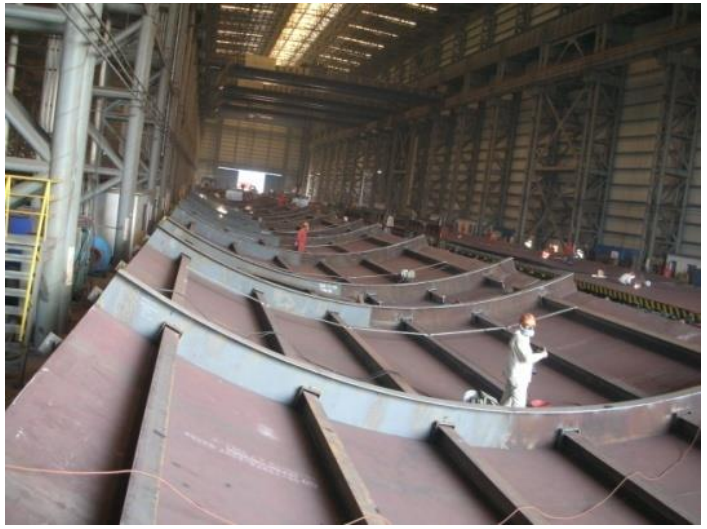




Steel cylinder is connected by using arc steel plate for waterproofness

Cylinder and steel plate

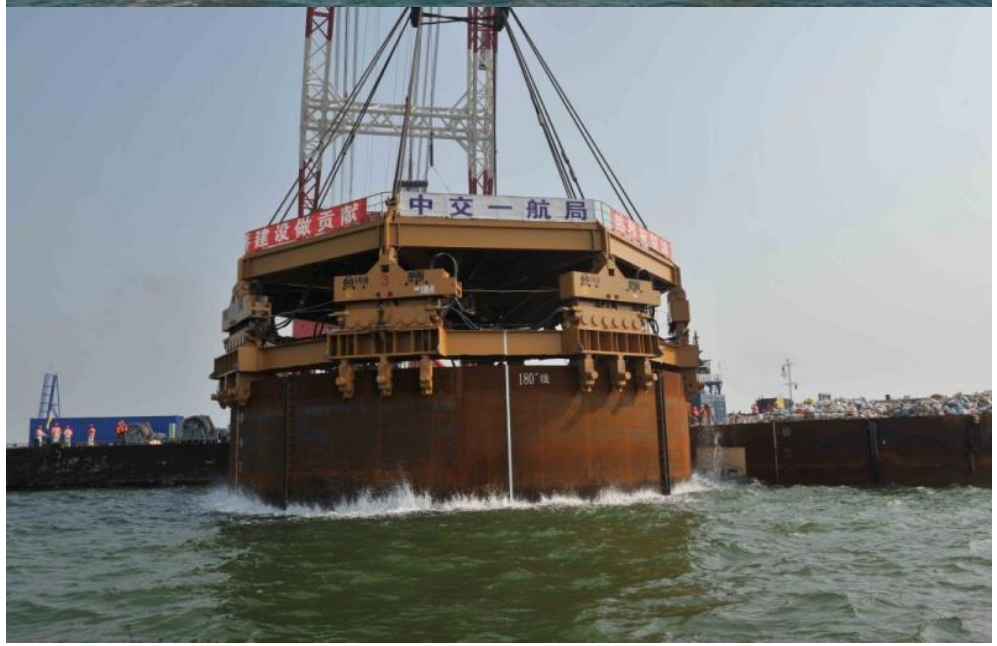




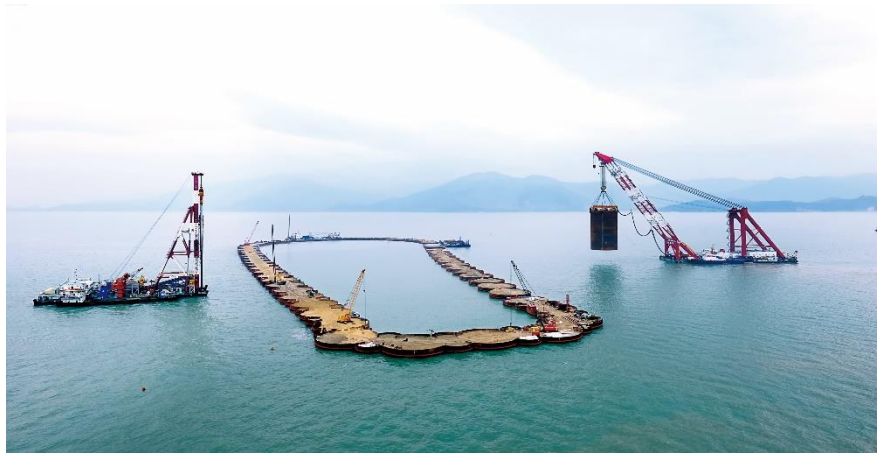
steel cylinders manufactured from shanghai

70,000-ton shipping vessel transporting steel cylinder

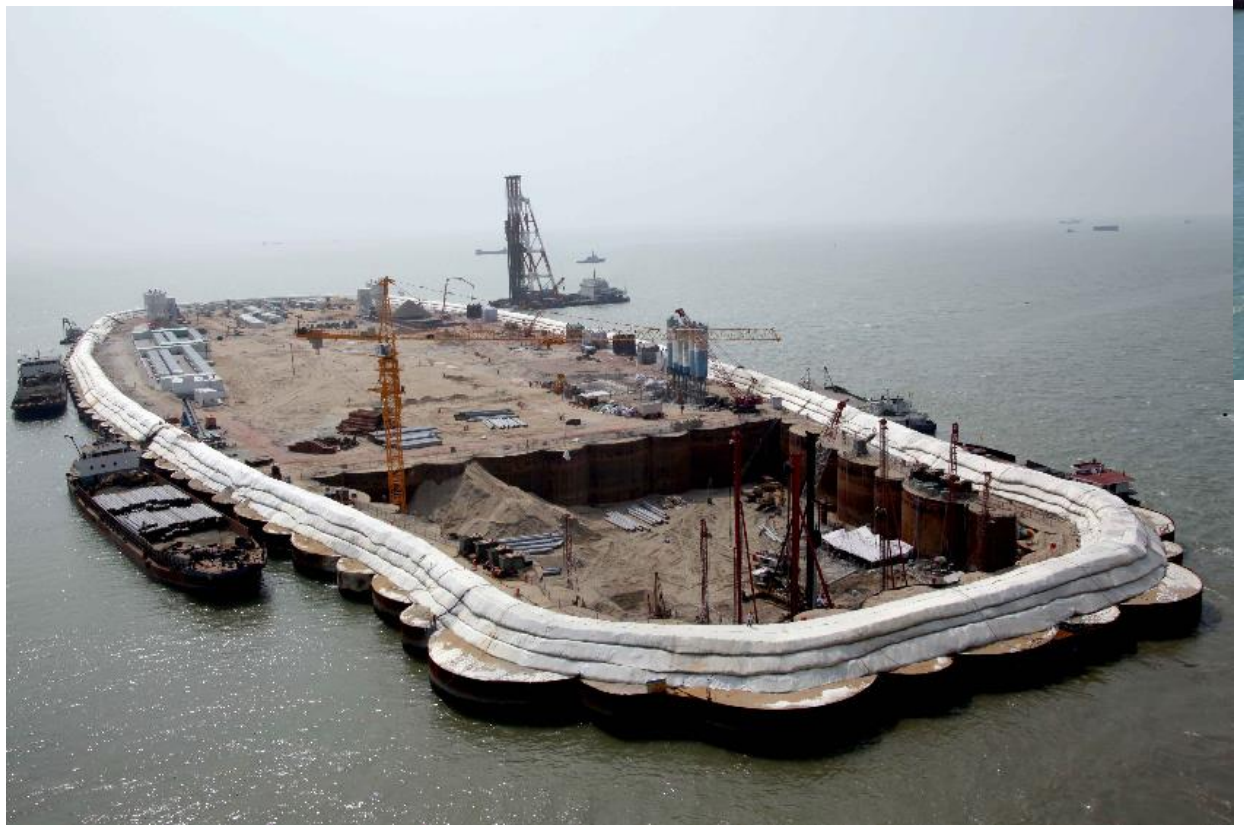
8 sets of APE600 hydraulic vibratory hammer



Driven down all 120 steel cylinders within 215days



West island

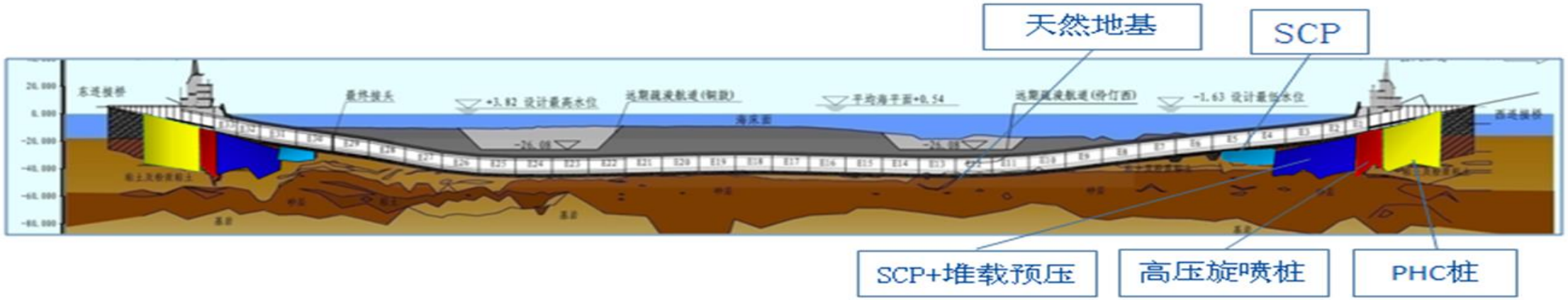


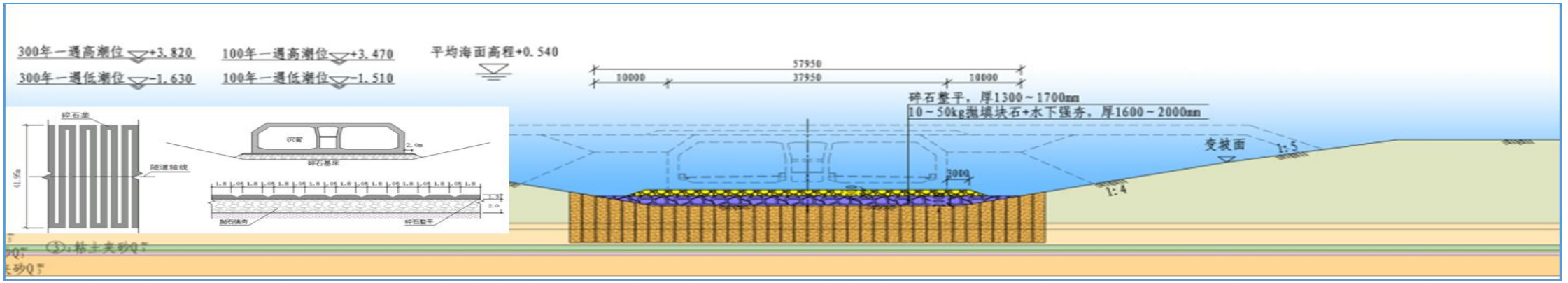
East Island

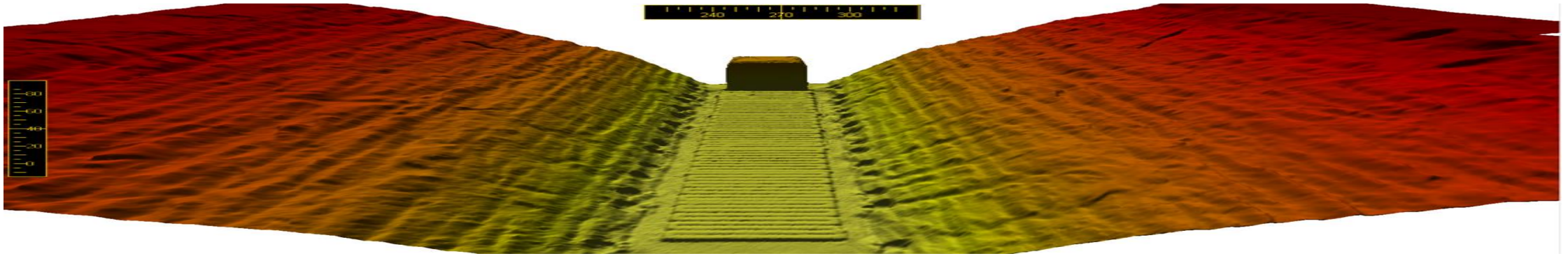
100days completed foundation treatment，post-construction settlement less than 20cm

Reduce by 10 millions m³ of excavated materials
construction period decrease by 2.5 years

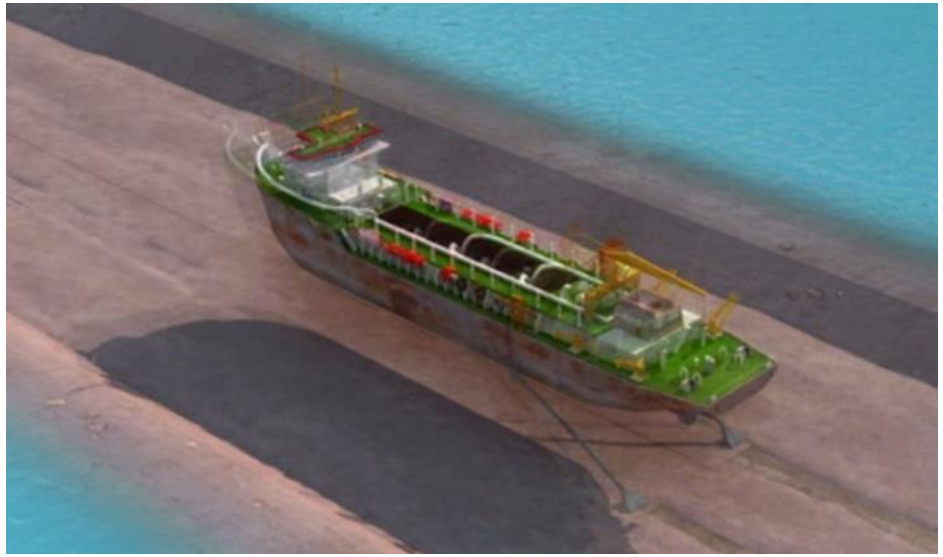
Combined Gravel Bed + Composite Foundation

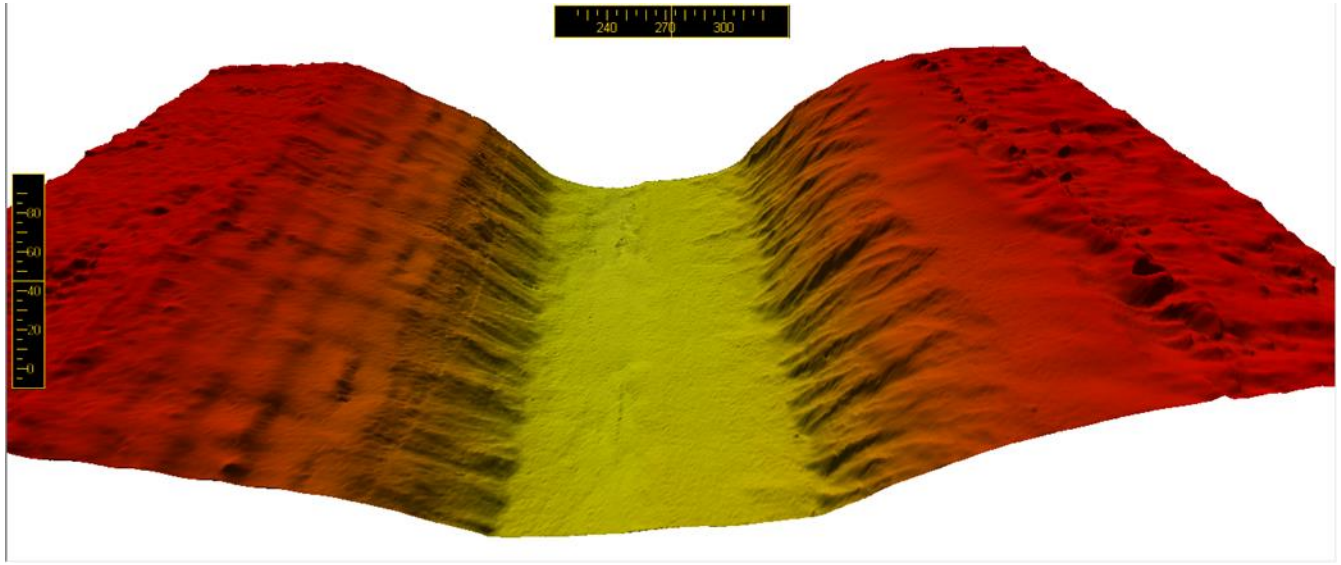




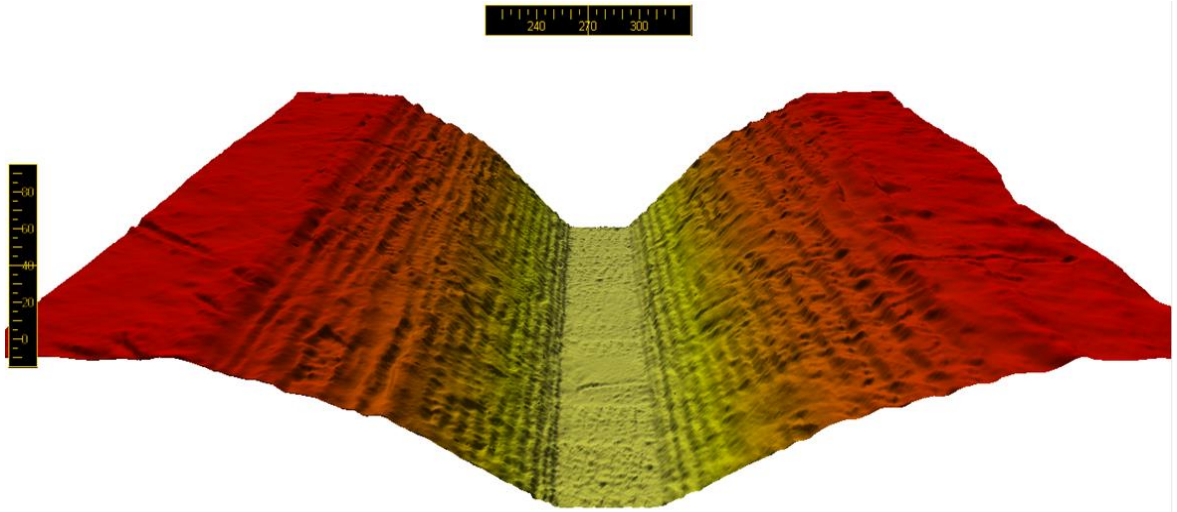


Trailing Suction Hopper Dredger for extensive dredging



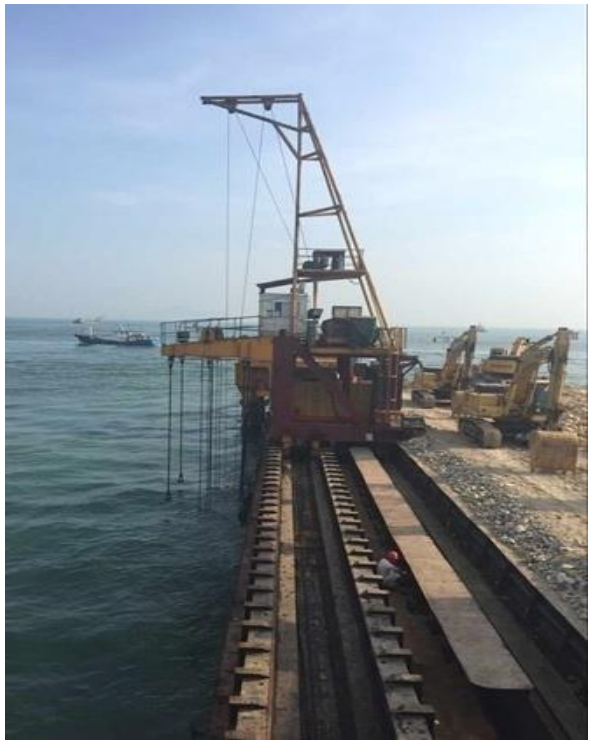


Grab Dredger with deep fixed controlling function for precise dredging



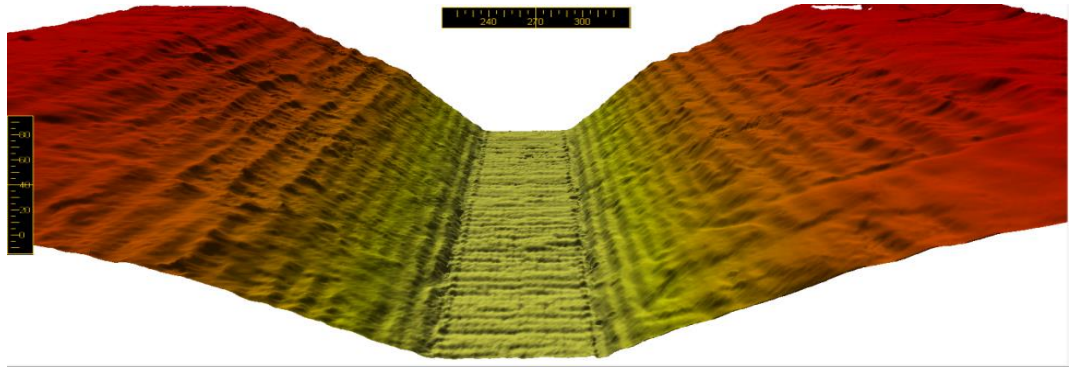
Excavating water depth more than 50m，tolerance within-60~+40cm

Riprap dumping and tamping for a rock block cushion



Water depth >46m,

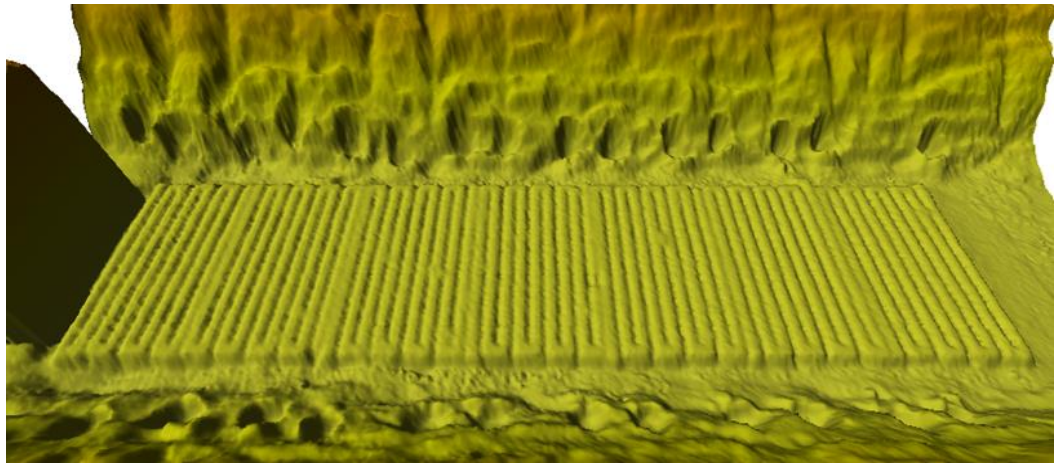
tolerance 0cm-30cm

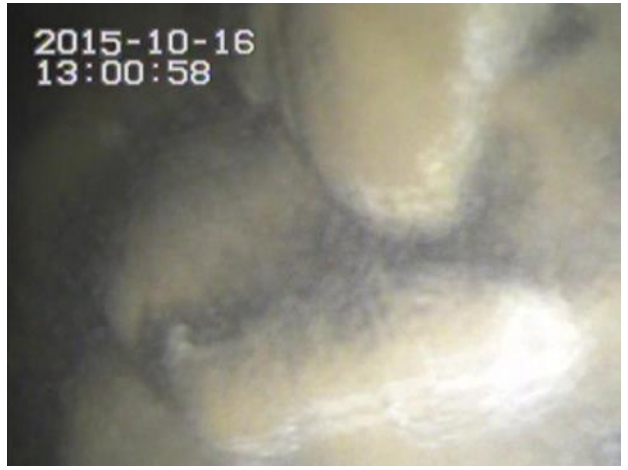


Trailing Suction Hopper Dredger for desilting

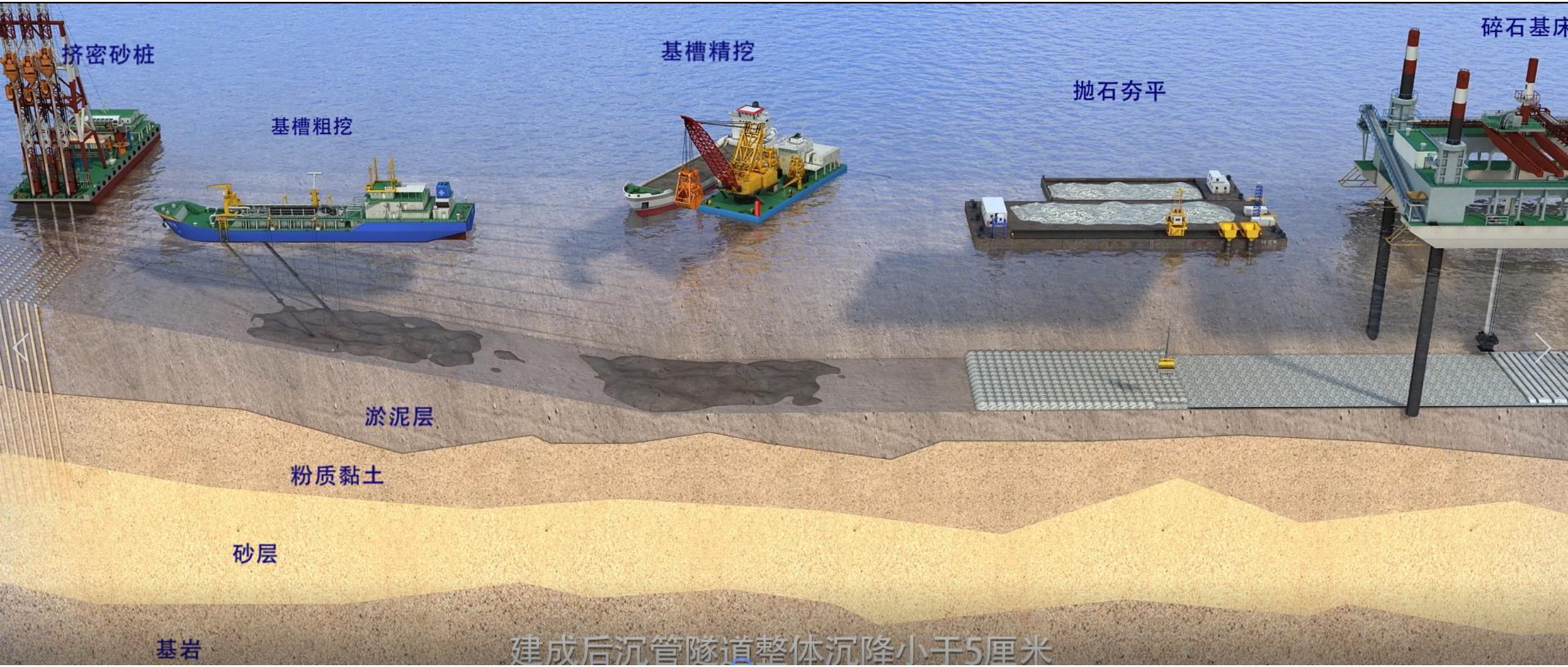
Gravel bed paving with a Plateform

Leveling depth of maximum 45 meters
Accuracy of flatness within 4cm





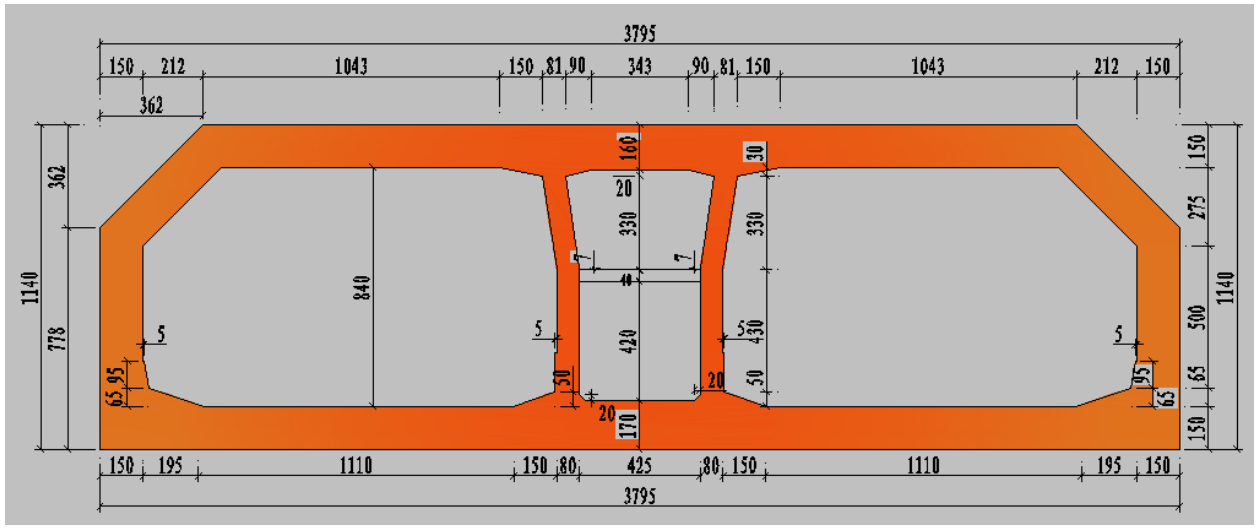
Trench foundation post-construction uneven settlement <5cm, more better than design criterion 20cm

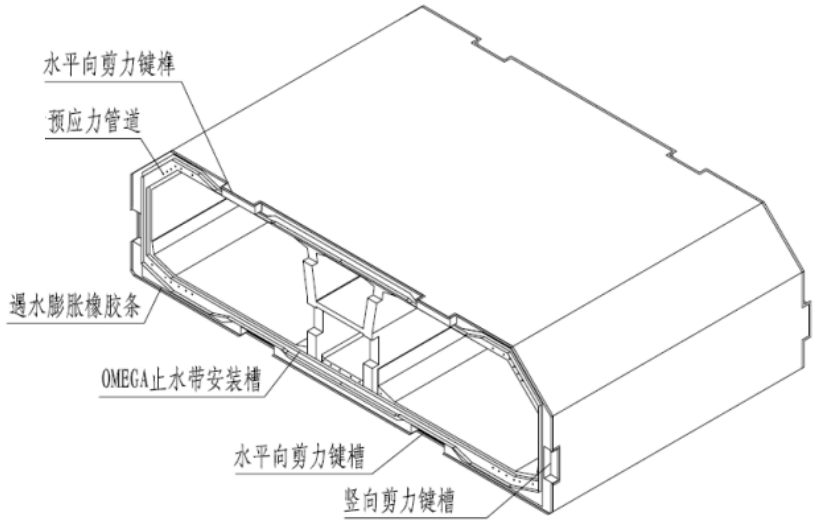


Elements precasting

Prefabrication using industrialized method (factory-like)

Precast yard located in Guishan Island, about 12km away from immersion location



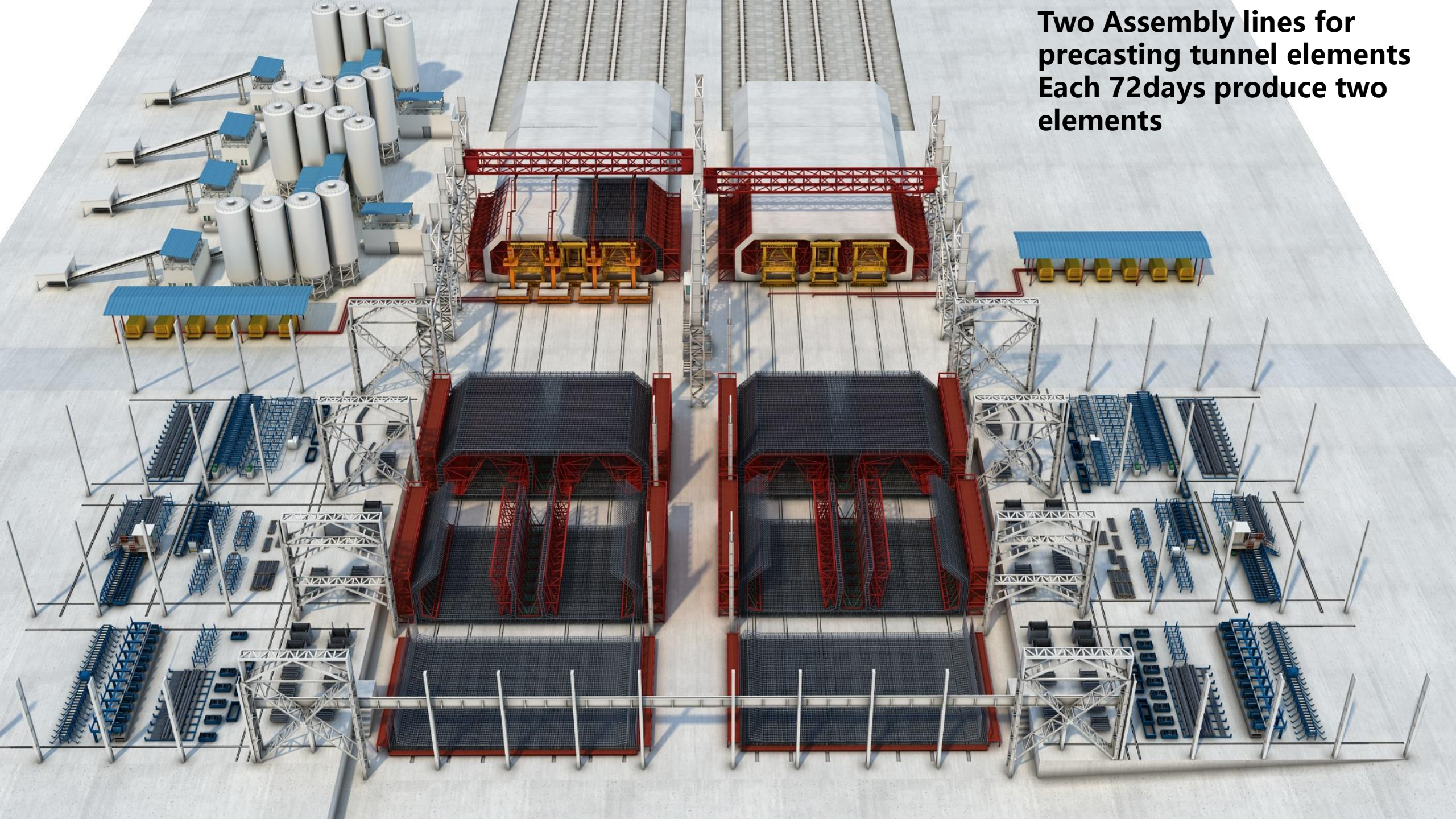


Standard element 180×37.95×11.4m

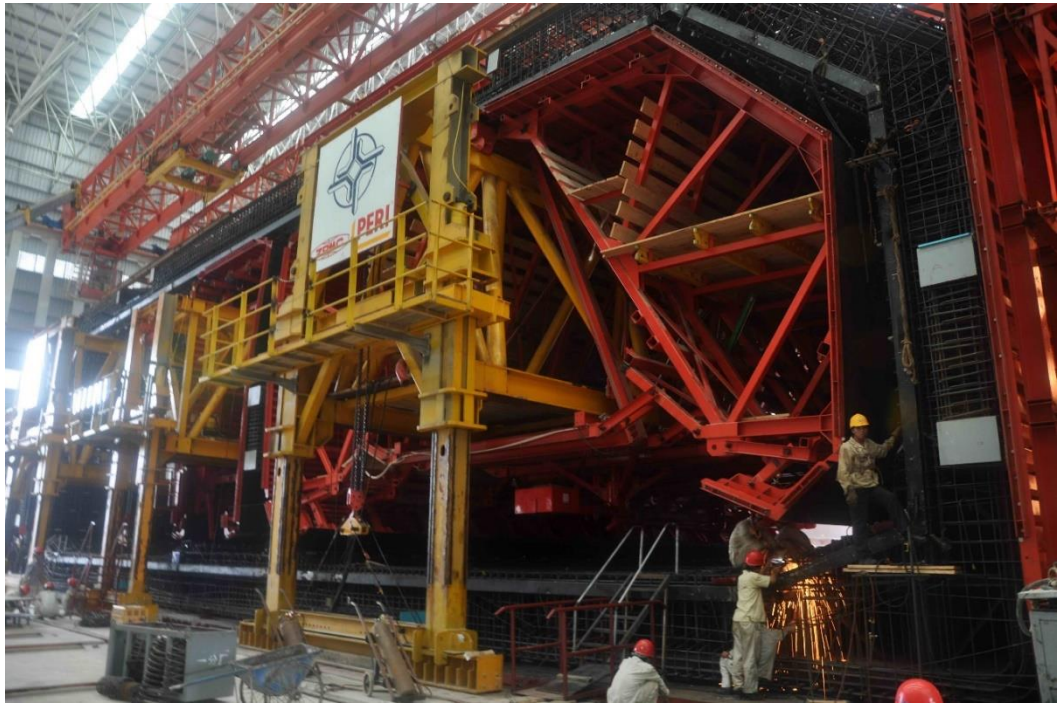
weight about 78,000 tons

8 segments constituted one element

22.5m length for each segment


Two Assembly lines for precasting tunnel elements
Each 72days produce two elements

Full Section Hydraulic Formwork erected



Fully whole section concrete placing continuously

Concrete pouring temperature must be controlled within 22～25℃ through a monitoring system

C45 self water proof concrete, anti-permeability level P12

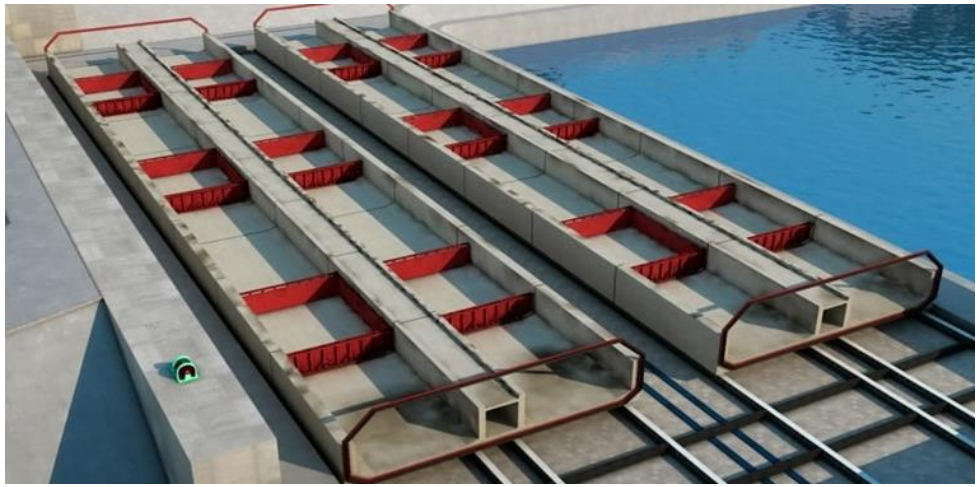
Element incremental launching

Moving distance >200m

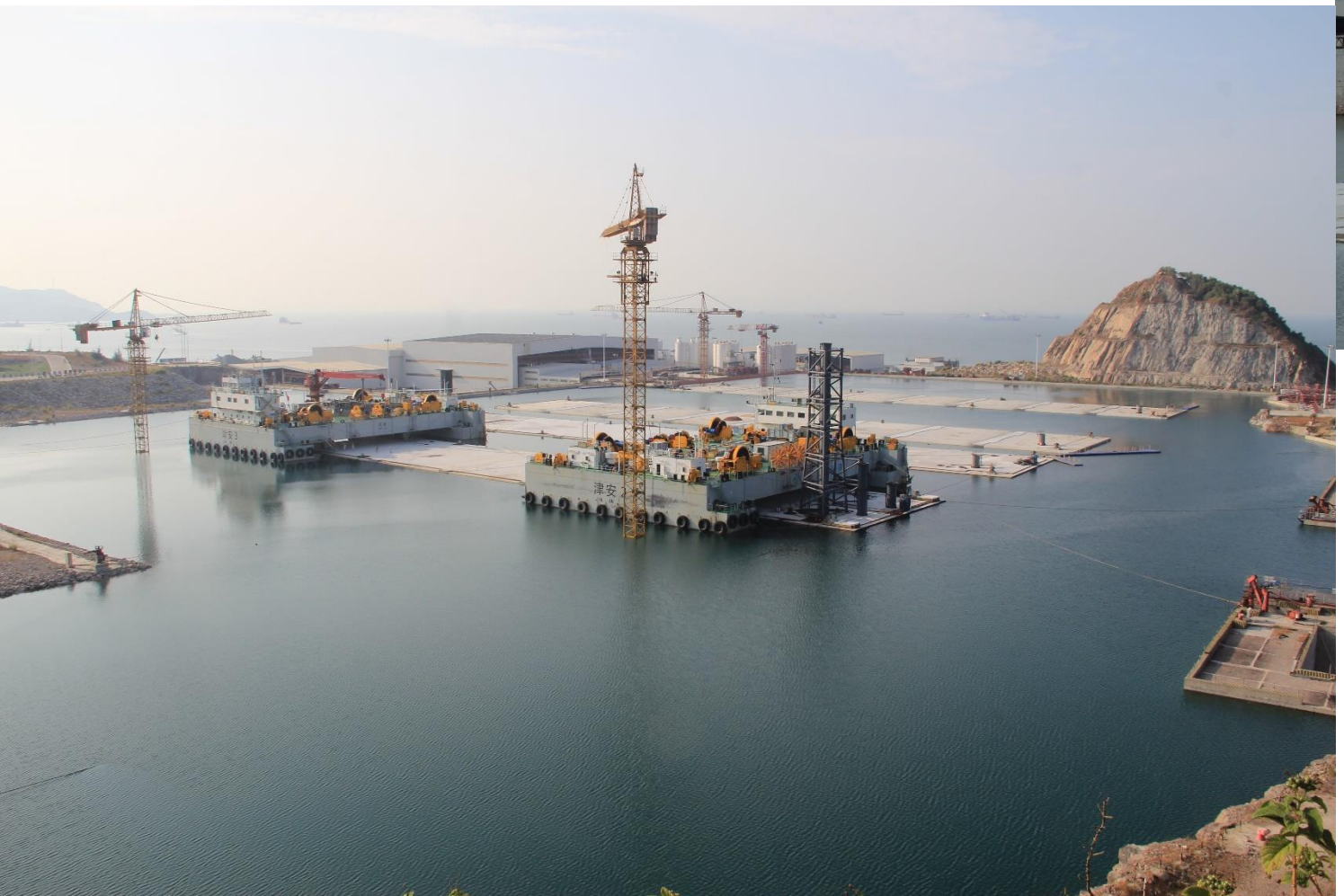
Axis deviation<5mm

Element Outfitting

Ballast water tank, Bulkhead, GINA gasket



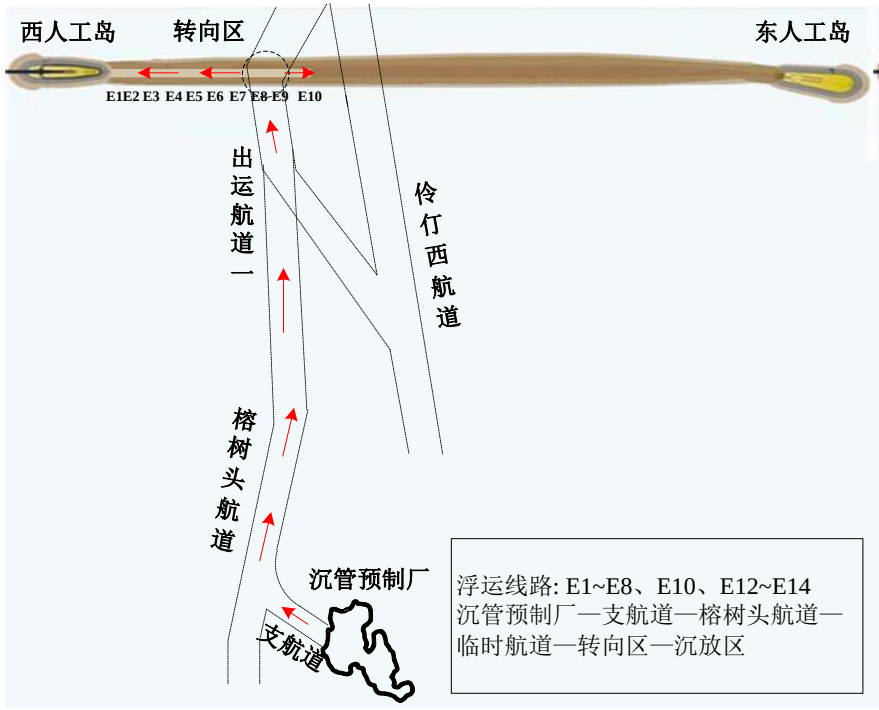
Element floating shift



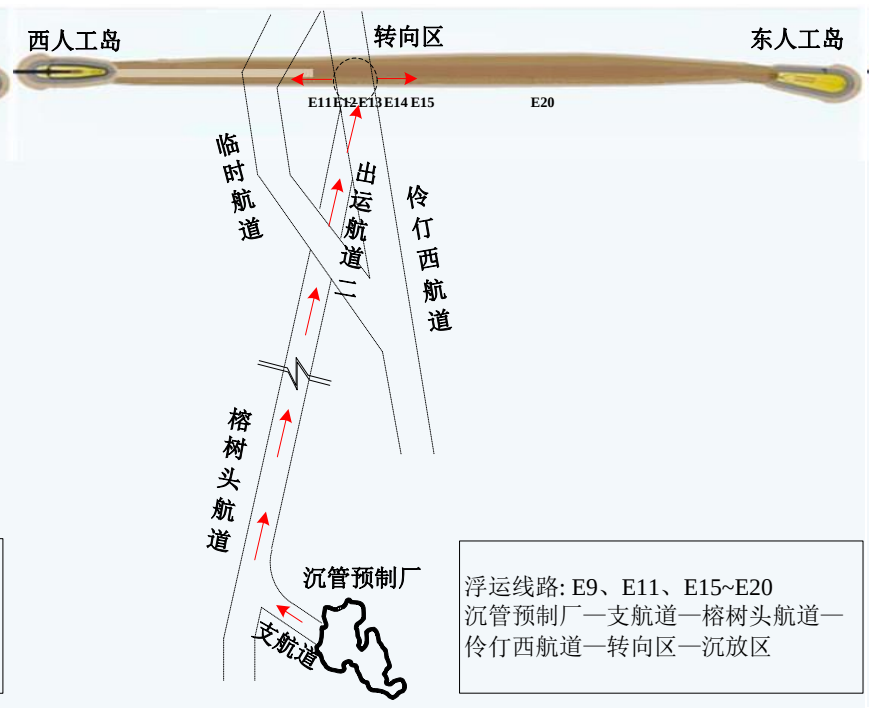
Producing to 33 tunnel elements with a high quality

To meet requirement of 120 years design service life
Nearly 1 millions cube meter concrete without thermal crack

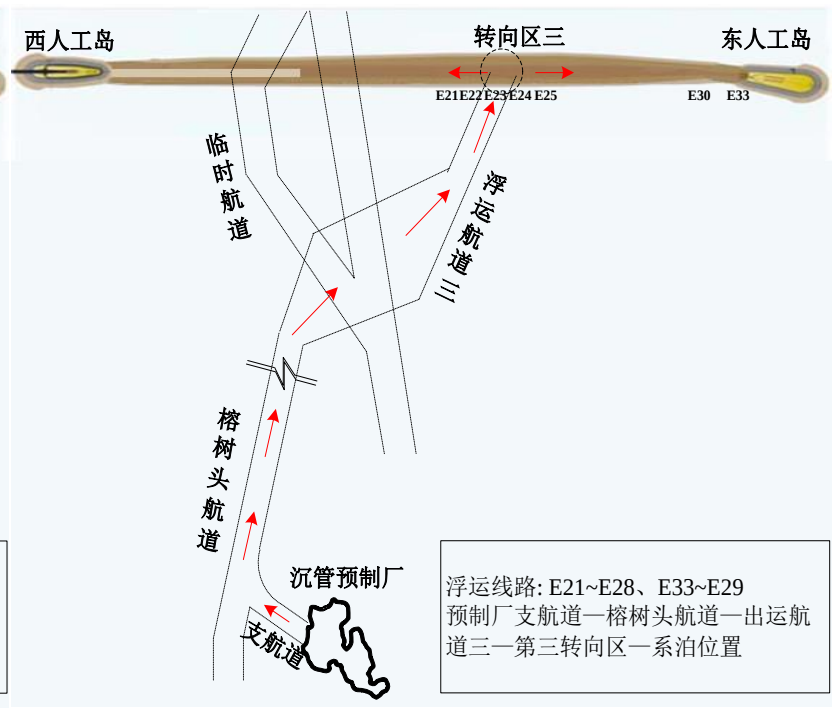

Elements Towing Transport
Elements Immersion and Placement



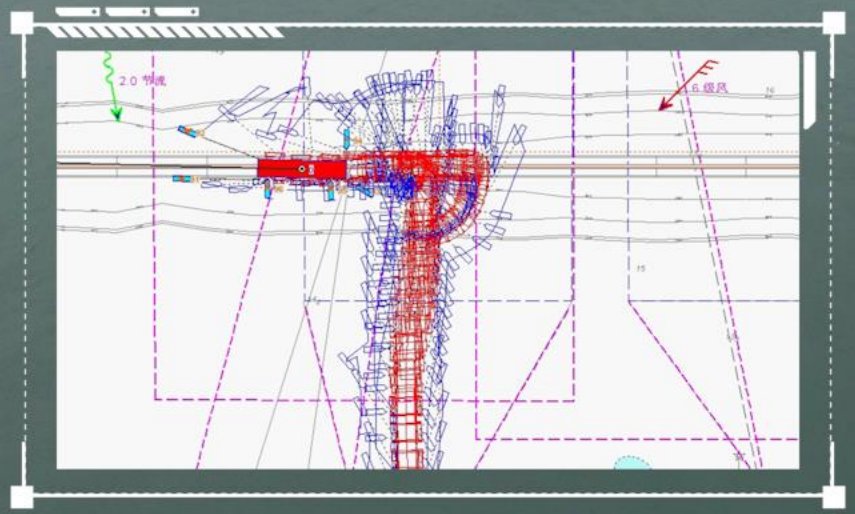
浮运线路: E1~E8、E10、E12~E14
沉管预制厂—支航道—榕树头航道—临时航道—转向区—沉放区



浮运线路: E9、E11、E15~E20
沉管预制厂—支航道—榕树头航道—伶仃西航道—转向区—沉放区



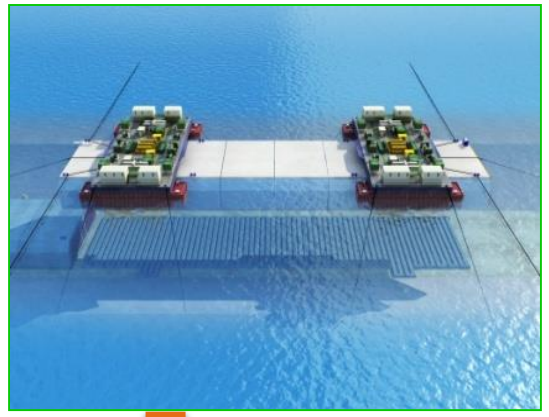
浮运线路: E21~E28、E33~E29
预制厂支航道—榕树头航道—出运航道三—第三转向区—系泊位置



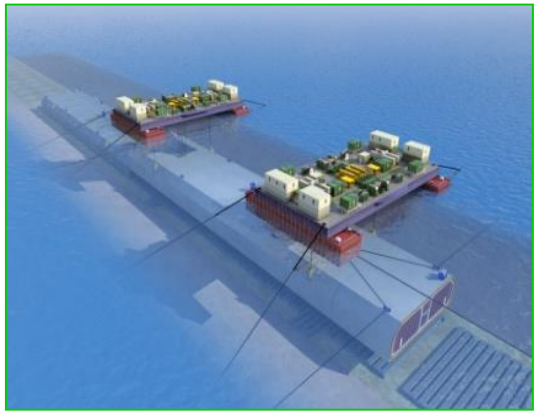
	持续时间	海流	气象	海浪
支航道	3-4小时	上层平均流速<0.4m/s	风力≤5级 能见度≥3km	有效波高<0.8m
浮运航道	2-3小时	上层平均流速<0.8m/s		
横移	1-2小时	上层平均流速<0.6m/s		
转向	0.5-1小时	上层平均流速<0.4m/s		
系泊	4-5小时	上层平均流速<0.8m/s		
沉放	6-10小时	整层流速<0.4m/s	风力≤5级	有效波高<0.6m
对接	4-10小时			

Undocking

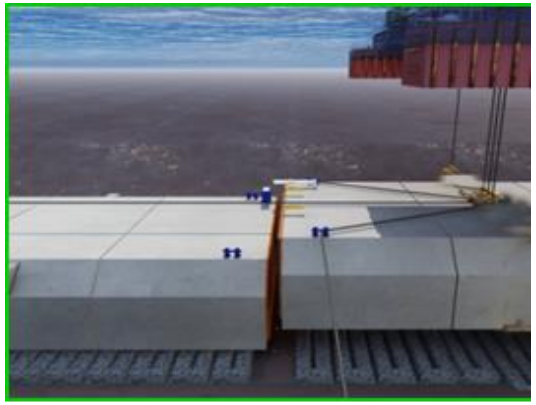
Floating transportation



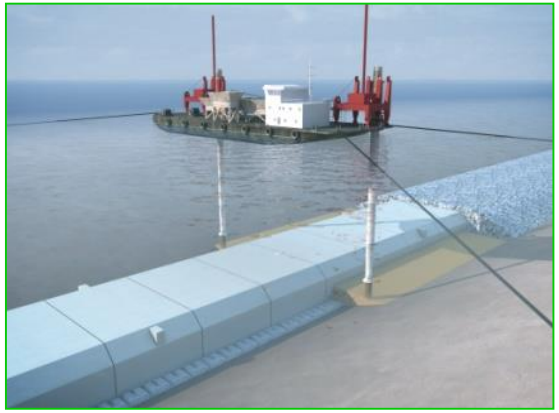
anchoring



immersing



Butt joint

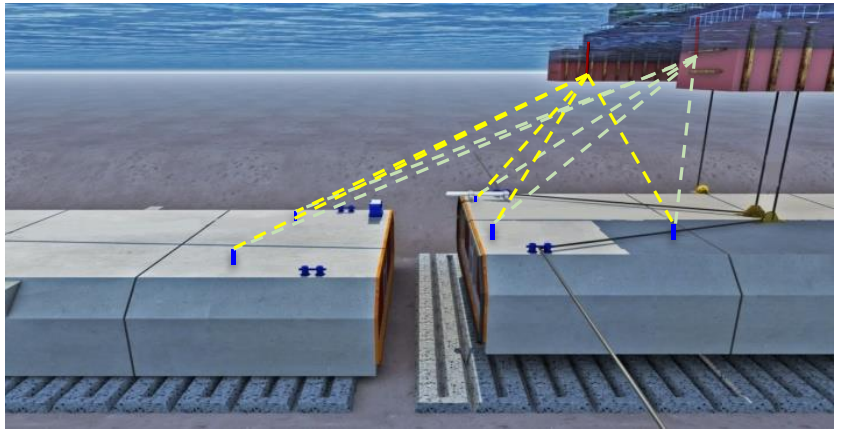


Lock backfilling

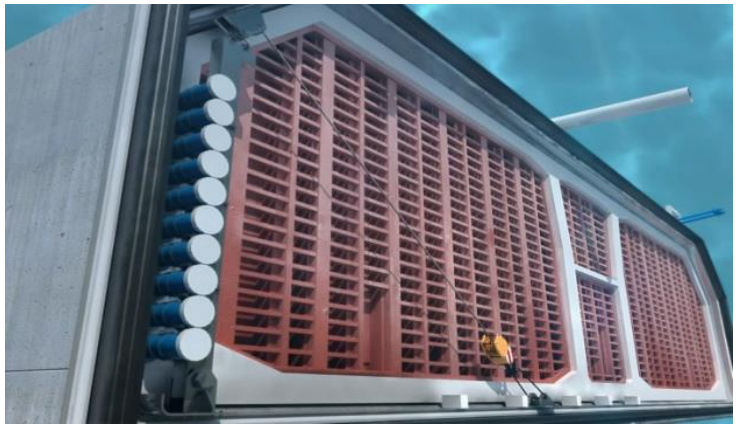
Purposed equipment for immersion

Ballast water tank

Pulling jack



Surveying system

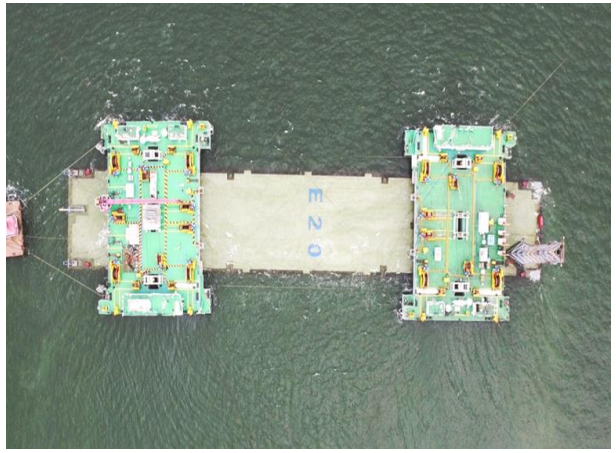


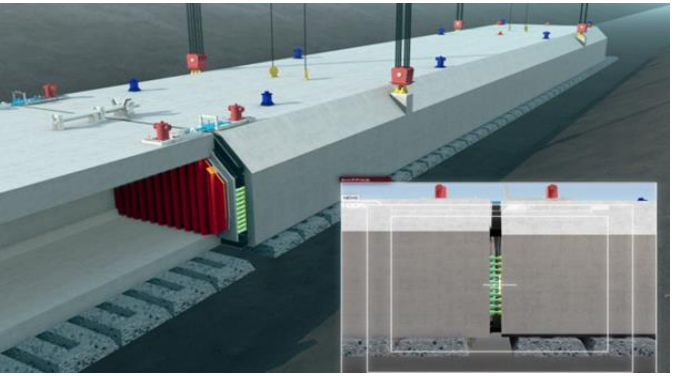
Fine adjustment device

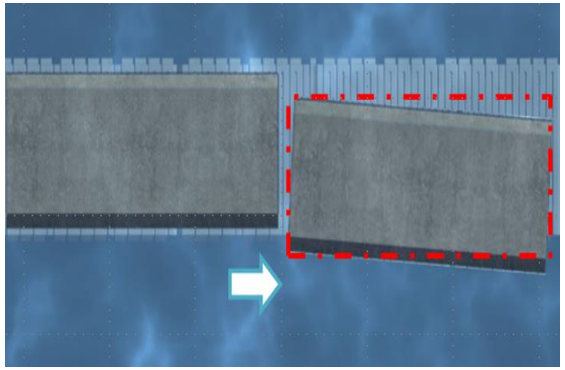
Tugboats

Anchor Boat

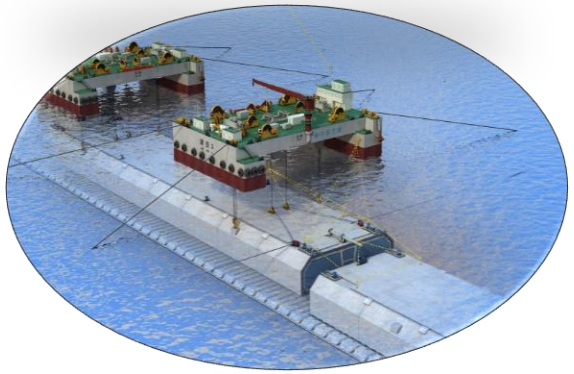
Pontoons for element immersion







Process Technology



Security System

Operation windows forecasting

Butt joint position management

Siltation volume pre-warning

Abnormal wave early warning

Element position observe and control

Element structure safety monitoring

Operation for Immersion and placement

Immersion Equipment

Anchoring & positioning

Ballast water tank control

Butt joint Hydraulic Transmission

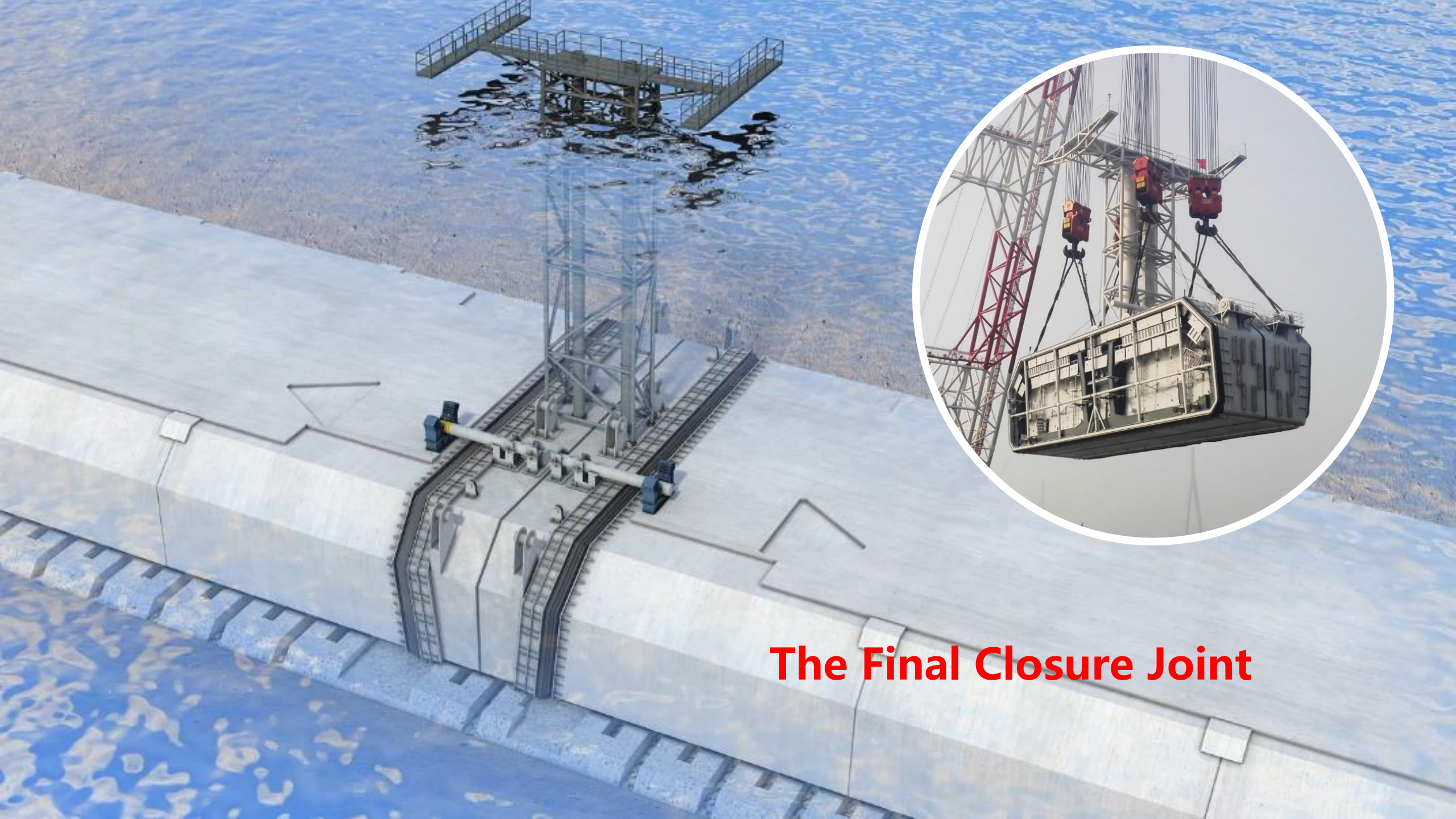
Water pressure compaction for GINA

Deep water Surveying and Positioning

Fine adjustment device

Navigational system for element towing transport

容重1.26	回淤≤4cm
容重1.15	回淤≤8cm



The Final Closure Joint

Steel shell and concrete filling inside, sandwich structure.

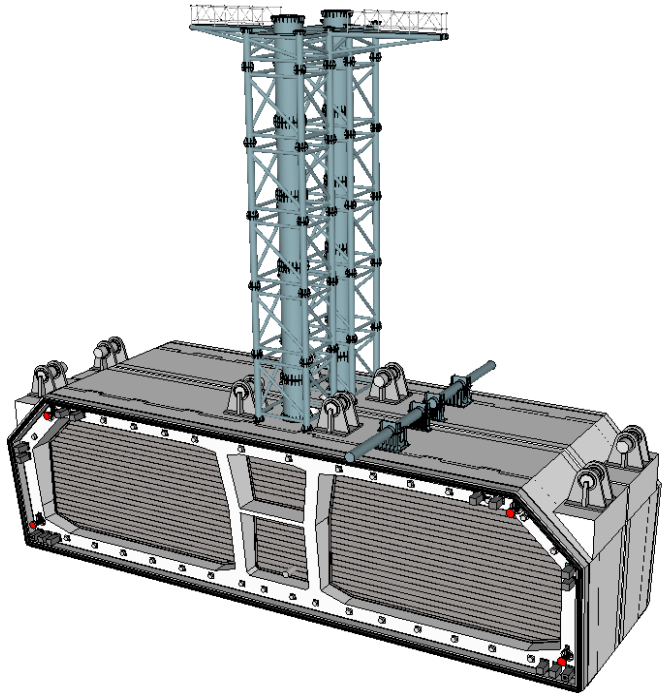
lenth12M（9.6M），

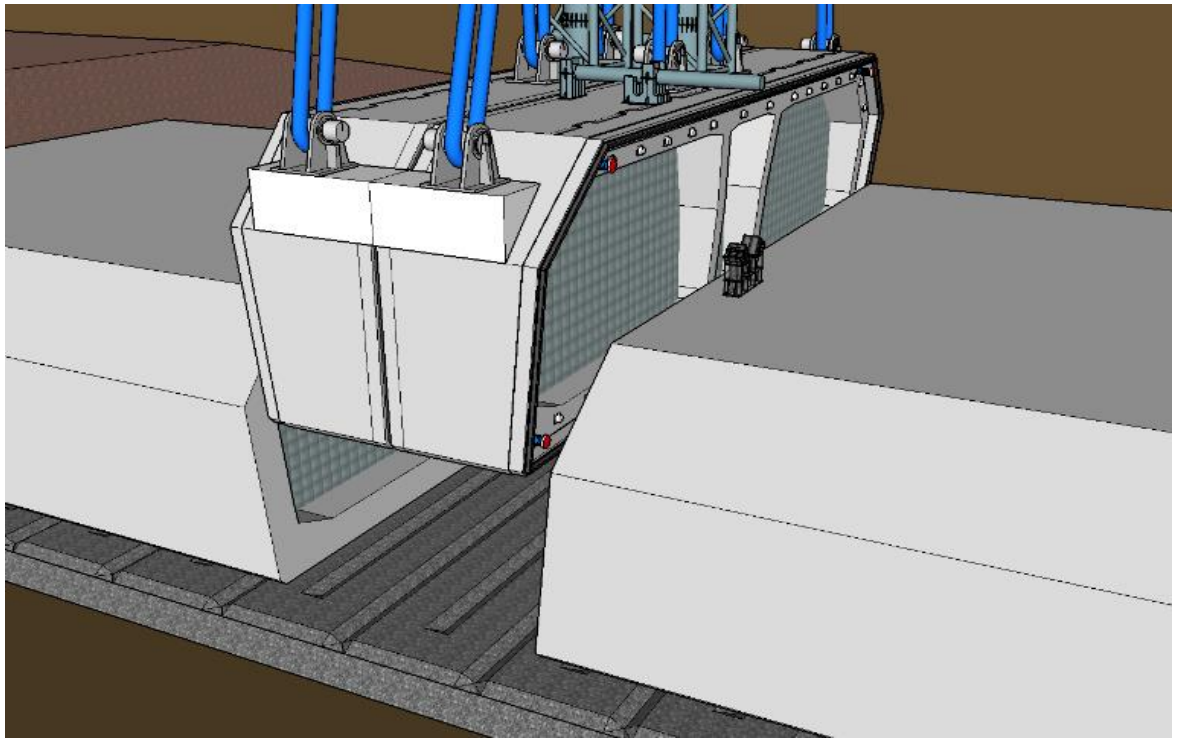
wideth37.95M,

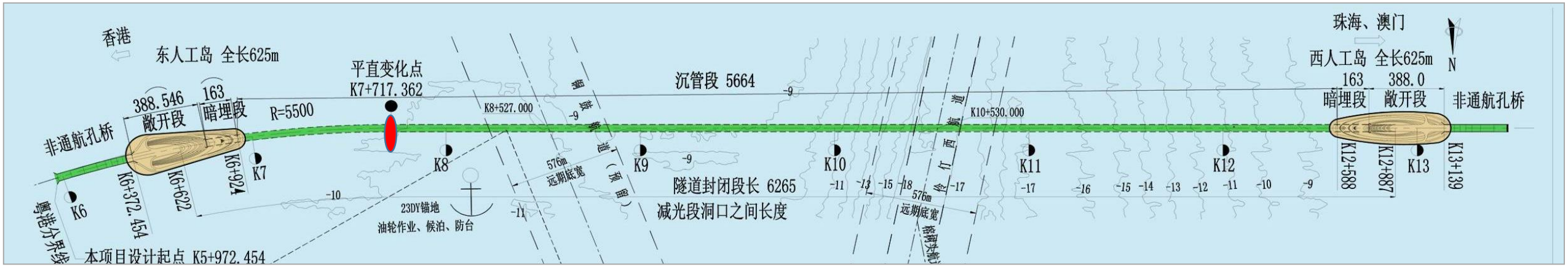
heigth11.5M,

weight 6000tons.

Located on between E29 and E30.





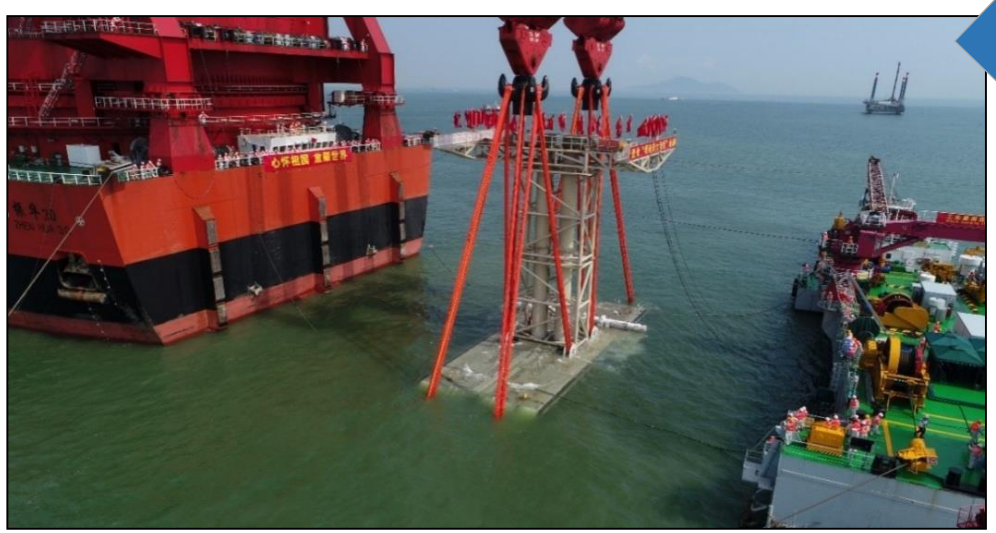



Genie S-125


S000T


Genie S-125

Capacity 12000T Floating crane was used



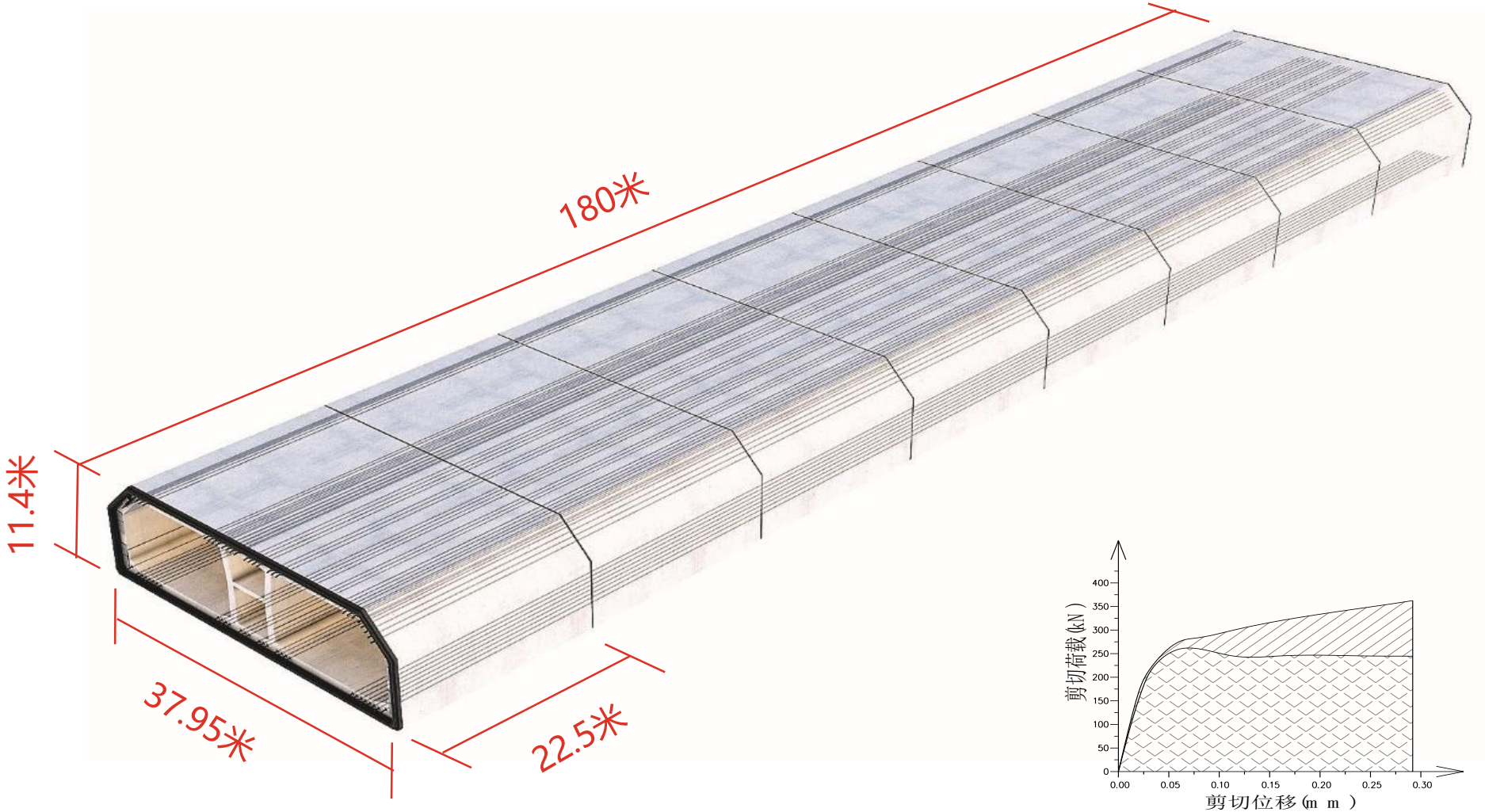
Hoisting

Immersing

Rotating

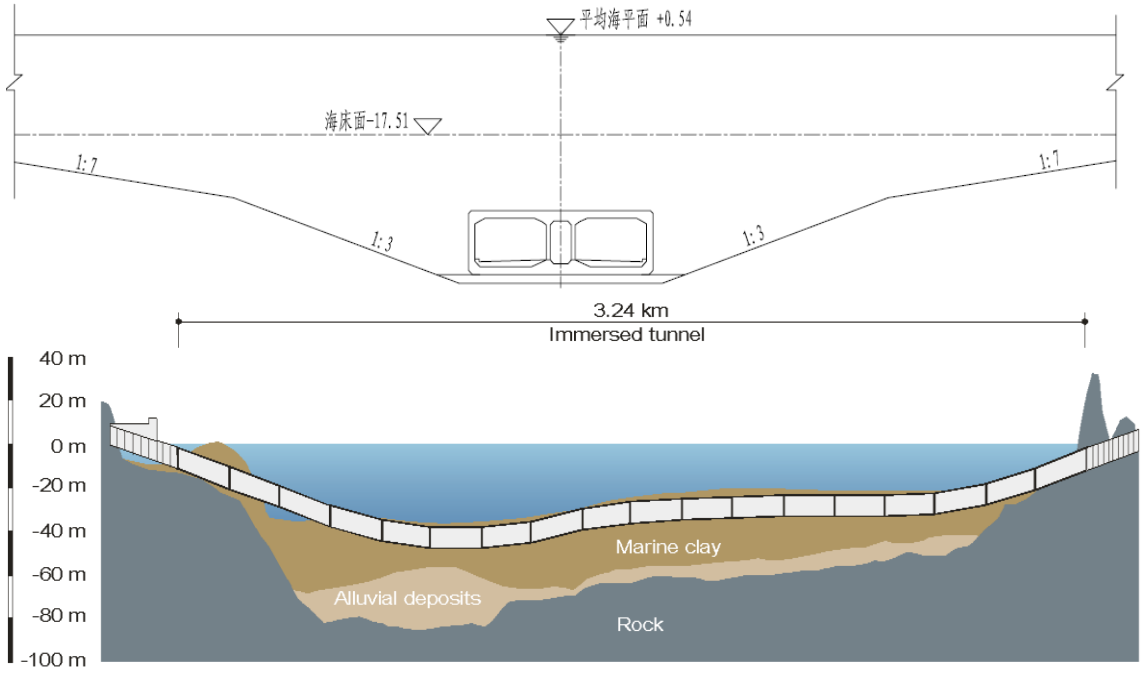
The 12000t full circle swinging Floating Crane for operation, This technique enables reverse operation during closure joint placement, which is the first time to be applied in the world. That is after the closure joint is placed, in case accurate measure data measured inside the tunnel by surveyor is unacceptable, the closure joint can be detached, floated up, and placed again. In this way, placement of closure joint is more accurate and the alignment at this connection is more controllable. The overall alignment of the tunnel and quality of the joint are more guaranteed.(we realized tunnel axis alignment deviation <2.6mm)

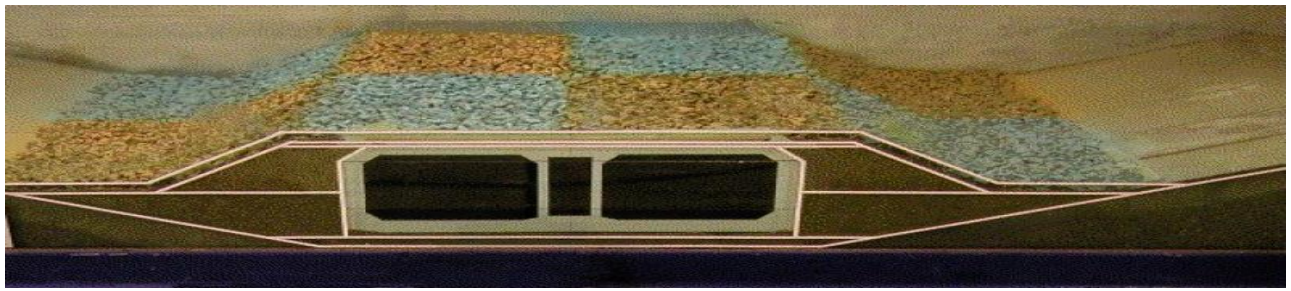
Semi-rigid Tunnel Element Structure & Memory Bearing

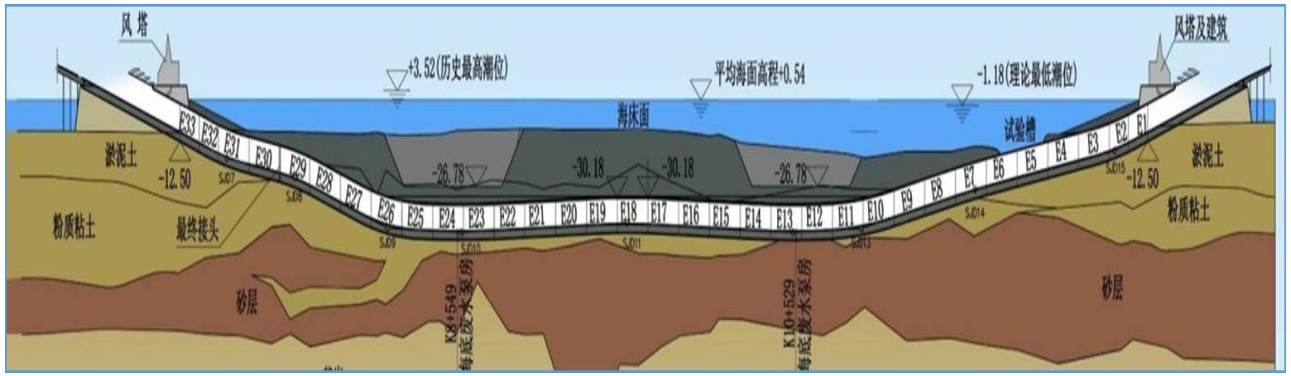


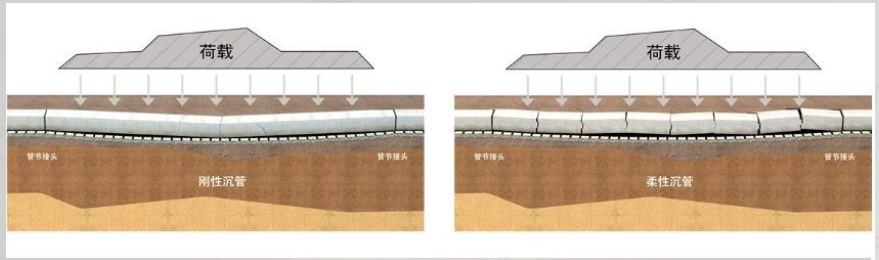
The difference between deep buried immersed tunnel and normal immersed tunnel

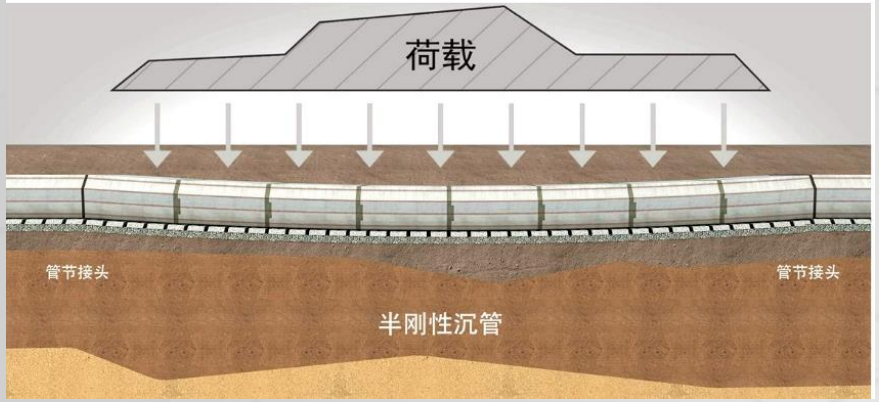
Item	Normal	Deep Buried
Backfill and cover Thickness	Around 2m	2m+21m（siltation）
Element Stress	40～50kPa	160kPa





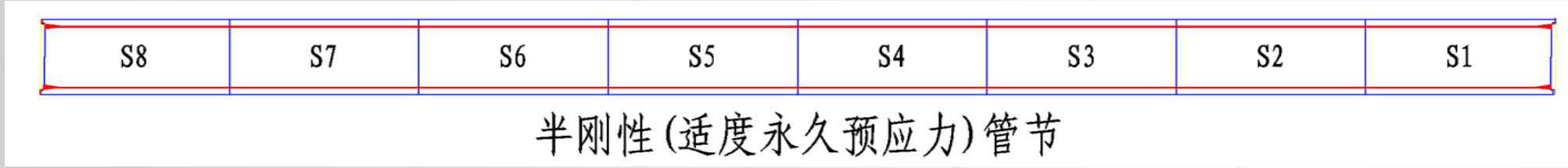




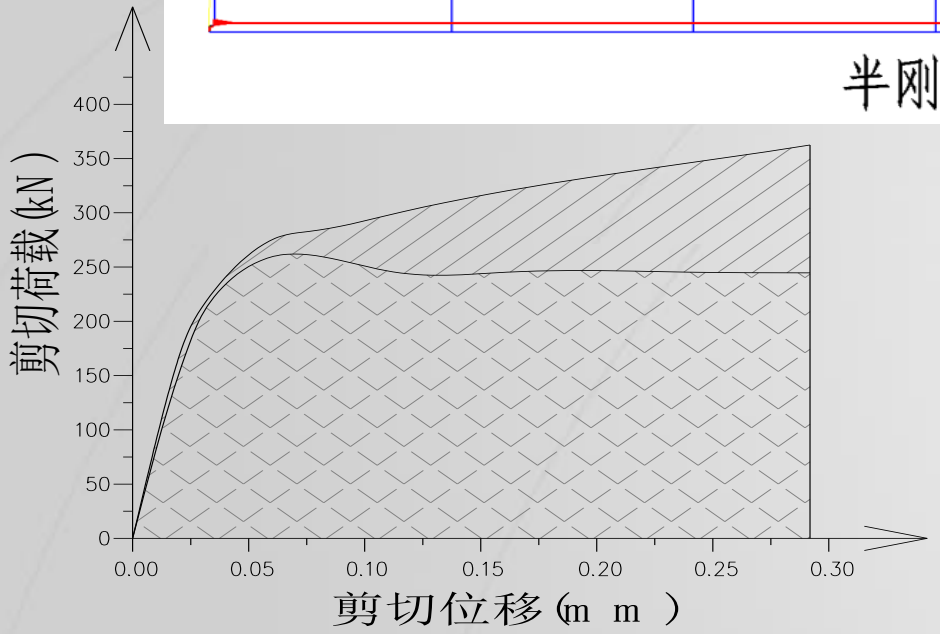


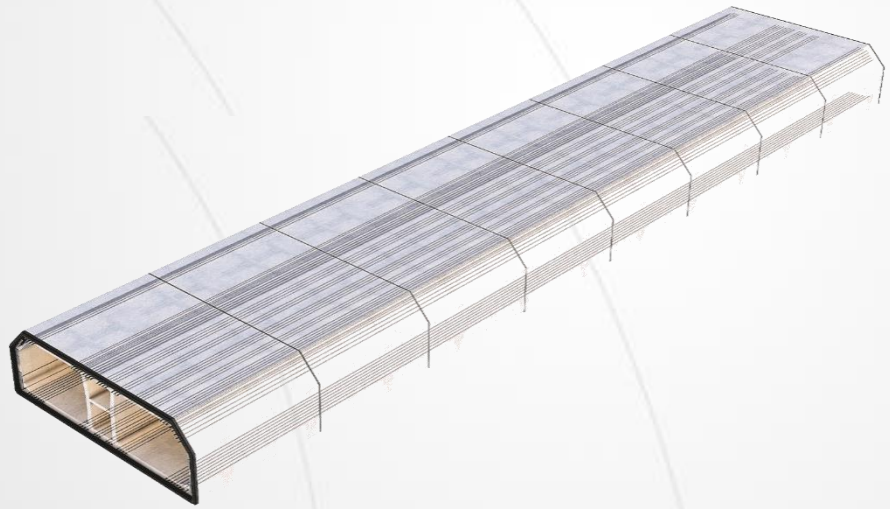
	整体式	半刚性	节段式
正常情况			
极端情况			
极端情况+	混凝土开裂		节段接头抗剪失效 节段接头张开漏水

注
1. 为方便理解，图中尺寸夸大。
2. 图例 为抵抗地基刚度或荷载不均匀，沿着纵向，结构的额外弯矩
为抵消地基刚度或荷载不均匀，地基提供的额外反力
3. 上述结果同样适用于局部荷载与地基的变异性。

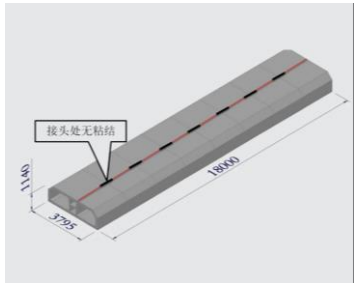


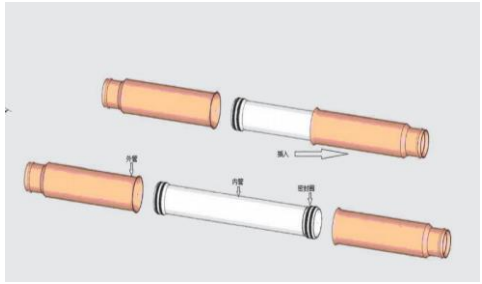
半刚性(适度永久预应力)管节

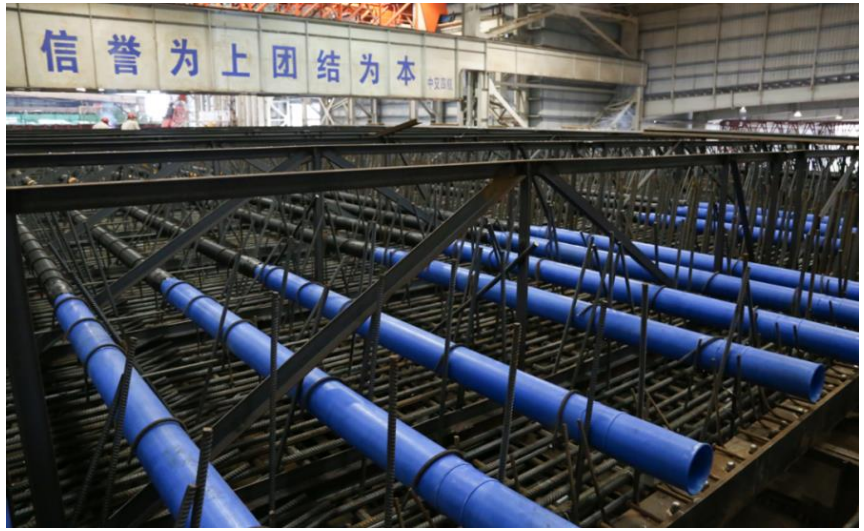




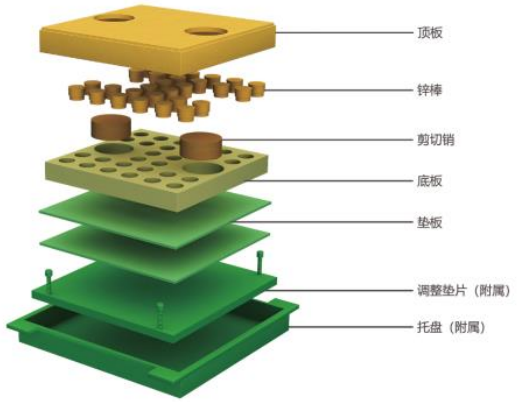
Permanent Prestress

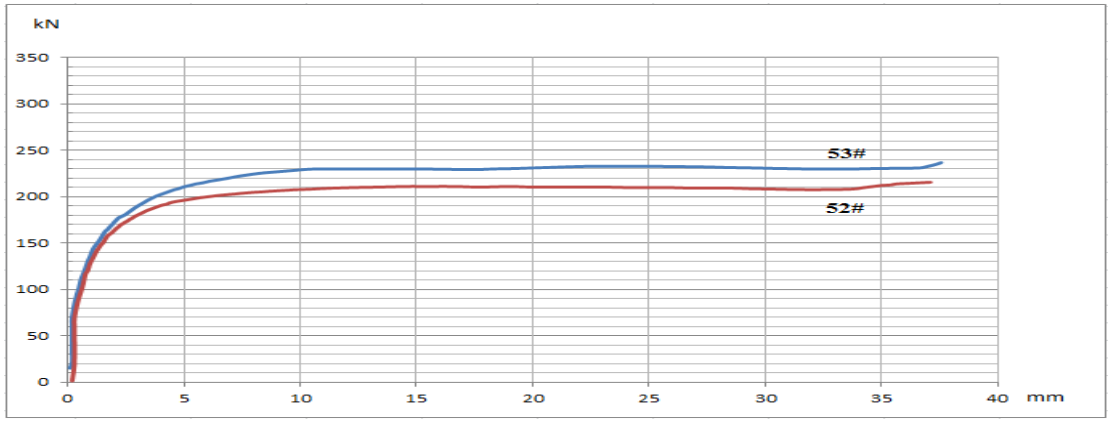






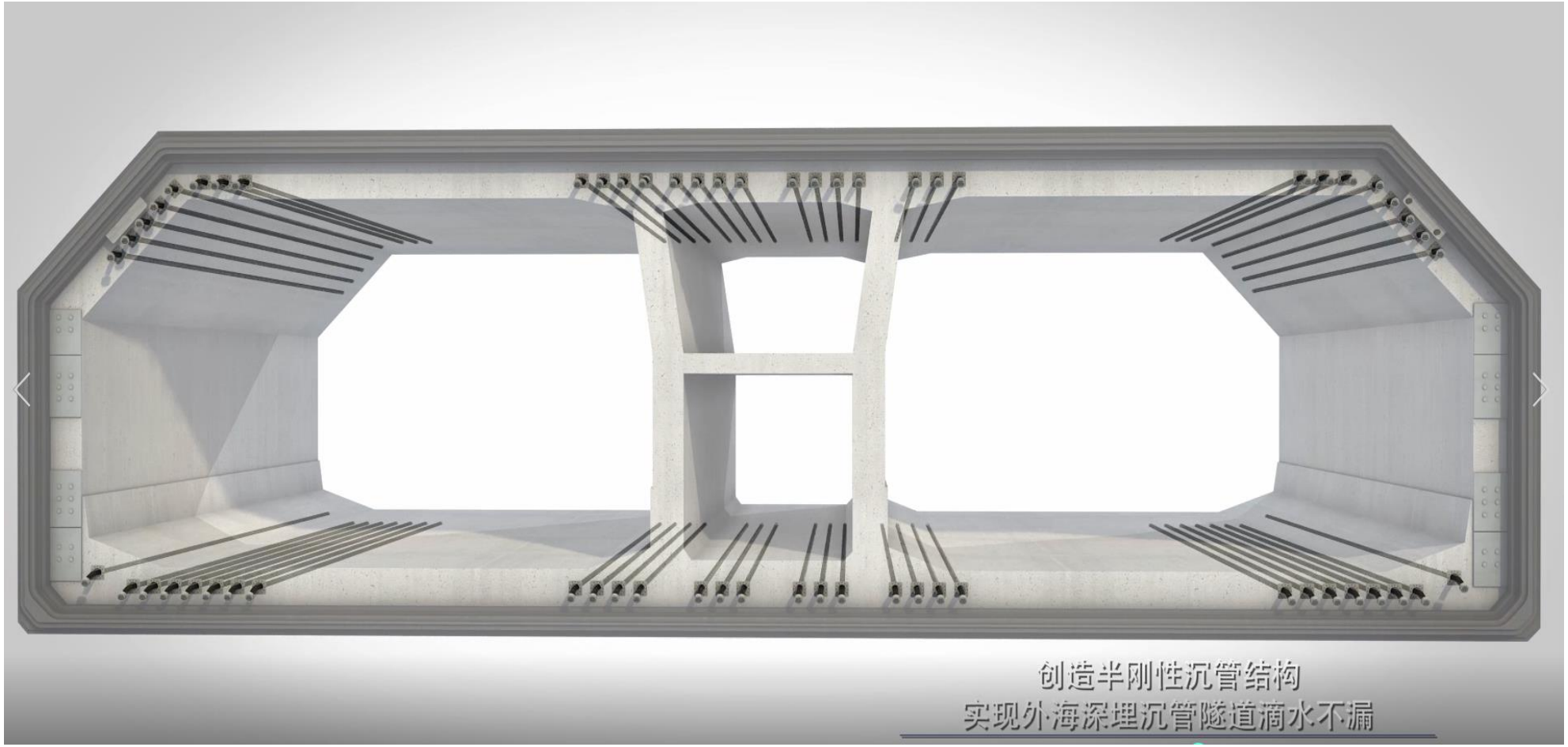
Memory Bearing





Design & Construction Innovation

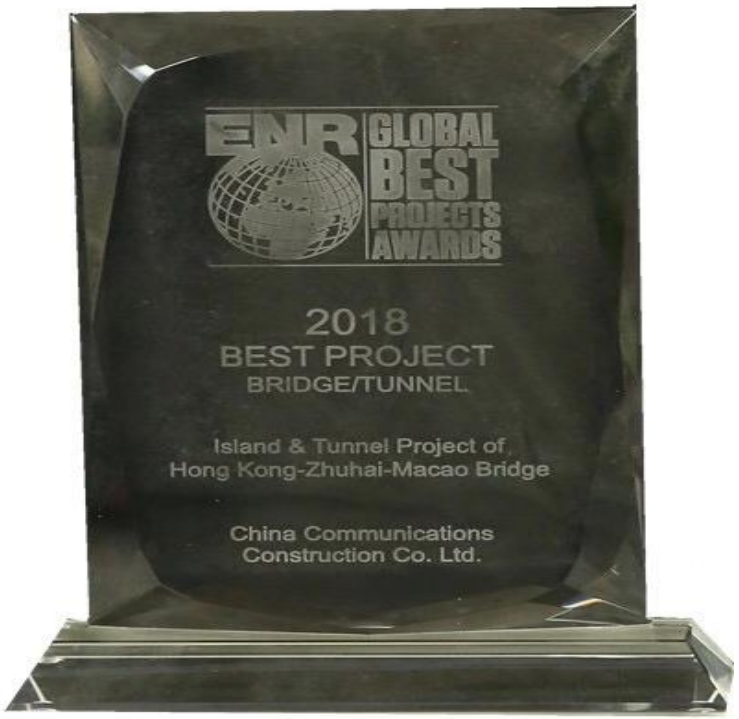
- Increased the robustness of the longitudinal structure of the element. Hence the tunnel can undertake higher overload
- Eliminated the need of maintenance dredging



Carry out more than 100 experimental tests and methodology studies
Registered 537 technical patents

International awards

“Major Project of the Year 2018” by International Tunnel Association (ITA)
“Global Best Projects 2018: Best Project, Bridge/ Tunnel” by Engineering News-Record (ENR) of the USA
“Tunneling project of the Year(over $1 bn)” by New Civil Engineer (NCE) of the UK



Thanks for Attention!