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TECHNICAL PROJECT INNOVATION - OF THE YEAR -

Mechanized Tunnelling with Large Section Horseshoe Shape EPB-TBM First Applied in Loess Mountain Tunnel at Mengxi Huazhong Railway Line Baicheng Tunnel

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Stakeholders

Name	Company
Owner	Mengxi -Huazhong railway co., Ltd.
Contractor	China Tiesiju Civil Engineering Group
Design	China Railway Design Corporation
Supervisor	Siyuan Hubei Engineering Supervision & Consultant Co., Ltd
TBM Fabricator	China Railway Engineering Equipment Group Co., Ltd
Research	Southwest Jiaotong University/Chengdu Tunnelkey Co., Ltd
Tech-assist	China Railway Engineering Services Co., Ltd

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01 Introduction

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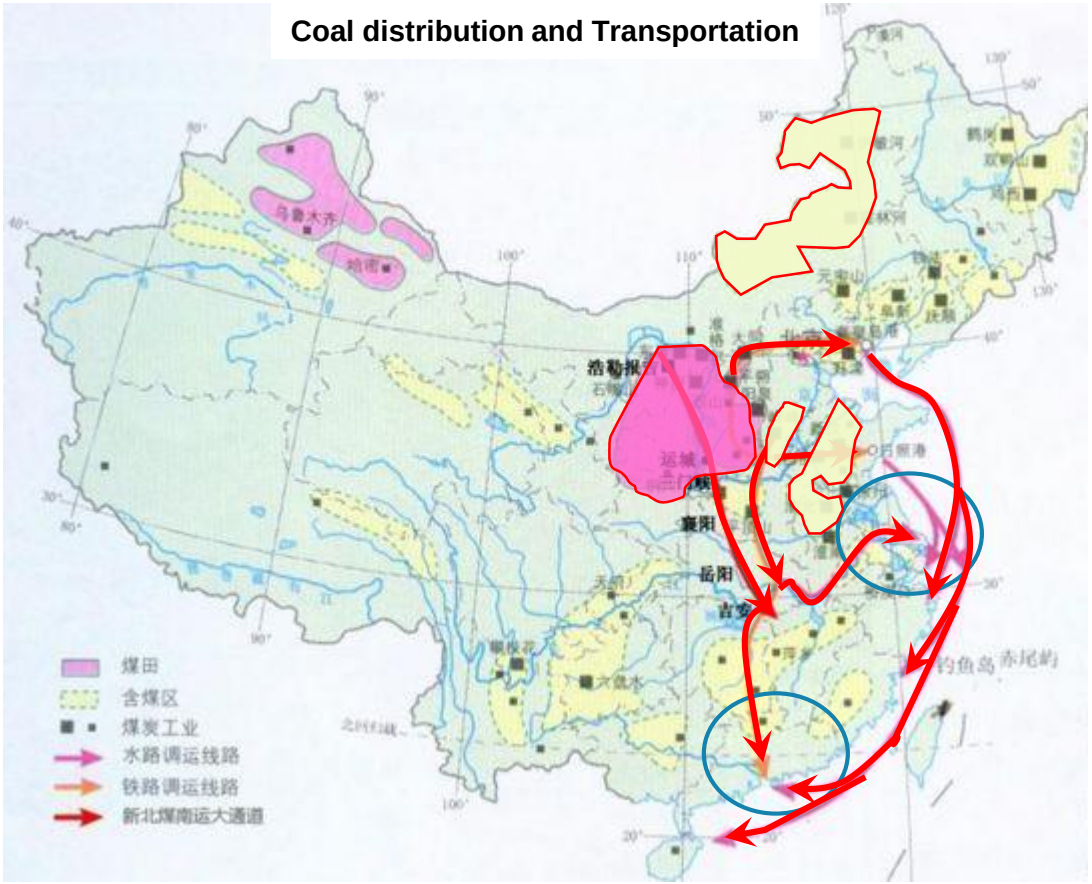
Coal mine distribuition in China and “the North coal to the south”



- The coal is mainly distributed in the north China. The need of coal is in the east China and south China.
- The current coal transportation route is consisted of “the west coal to the east” coal railway lines, river transportation and sea transportation.
- One north to south coal transportation railway is needed.

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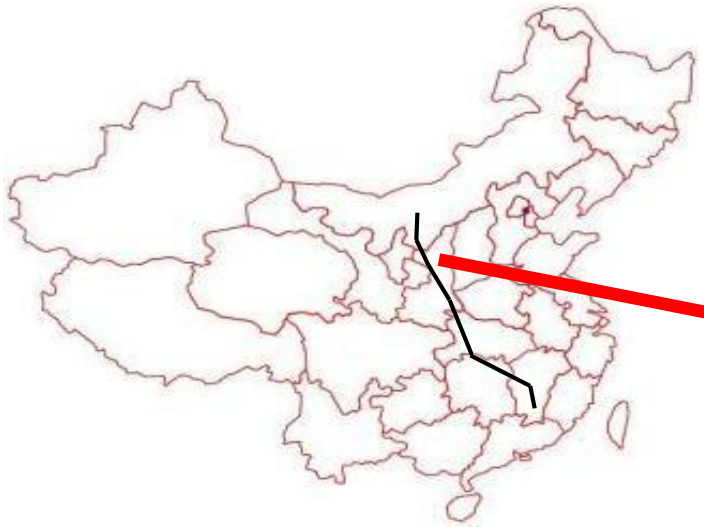
TECHNICAL PROJECT INNOVATION - OF THE YEAR -

Mengxi Huazhong Coal Transportation Railway Line



- Total length: 1814 kilometers
- Total investment: 24.2 billion euro
- Designed transportation capacity: 0.2 billion ton/annual

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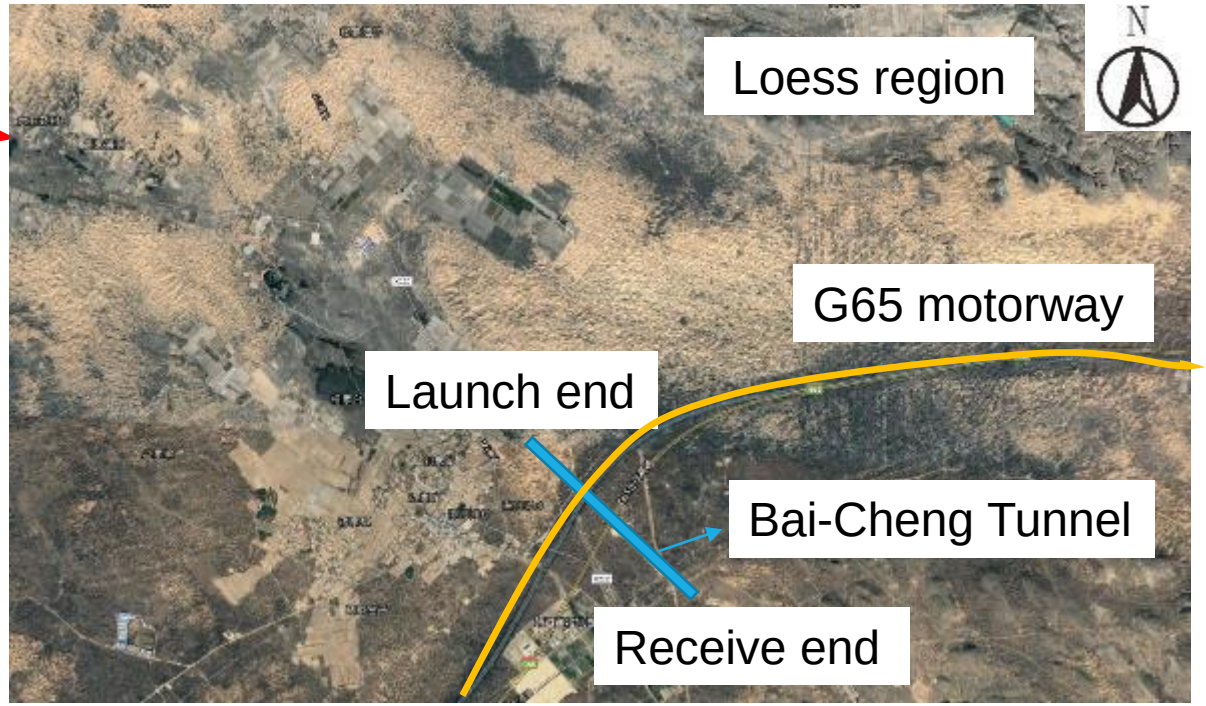
TECHNICAL PROJECT INNOVATION - OF THE YEAR -

Bai-Cheng Tunnel

- Located in Loess plateau, a.k.a. the Huangtu plateau
- Length: 3345m
- Dimensions: 11.9m×10.95m horseshoe shape
- Overburden: 7m~81m



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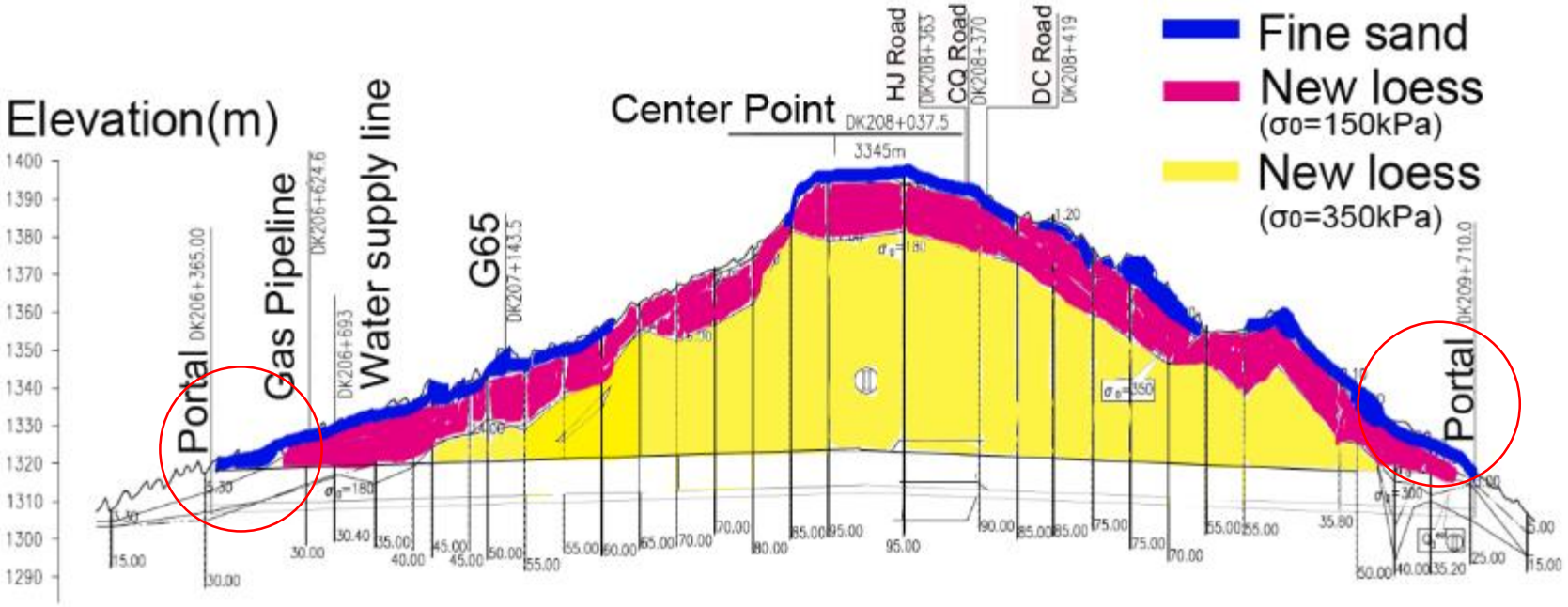
Basic information of the Bai-cheng tunnel



No	Soil Type	Overburden (m)	γ (kN/m3)	Φ (°)	Cohesion (kpa)
1	Fine sand	3.8	19.4	34	3
2	New loess Ⅰ	11.4	16.0	27.1	22.0
3	New loess Ⅱ	29.8	18.0	27.5	20.7

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Original scheme for the Bai-Cheng Tunnel

Issue to Concern Using Conventional Sequential Excavation Method (SEM)

1. Soft ground: Fine sand and Loess, especially at the portal region
2. Underpass nearby infrastructures, i.e., motorways, roads, and pipelines for gas and water supply

Result in

1. Instability of surrounding soil at the portal region
2. Instability of tunnel face
3. Heavy support
4. Hard to control ground settlement under across the nearby infrastructures
5. Extra support and protection under across the nearby infrastructures
6. Noise and dust
7. Long construction period

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02 The Large Section Horseshoe EPB-TBM

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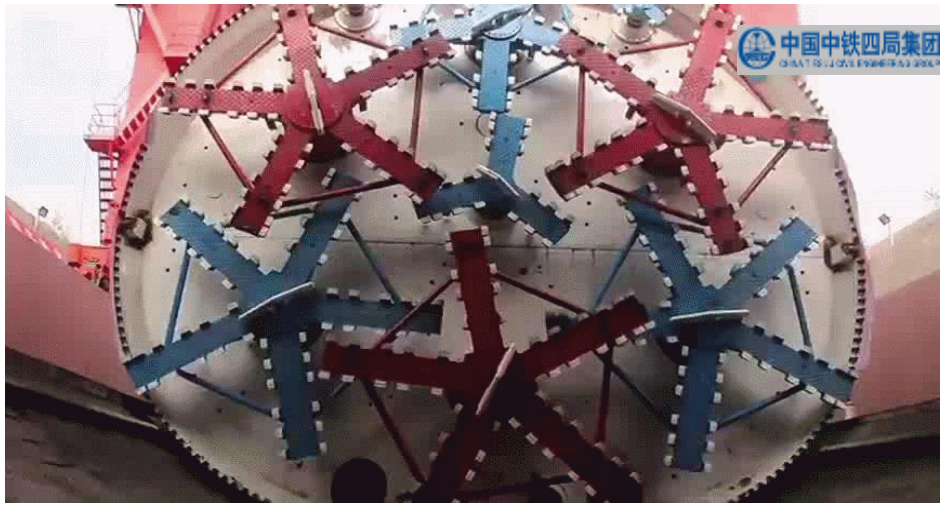
TECHNICAL PROJECT INNOVATION - OF THE YEAR -

Pilot project: World's First-Ever Large Section Horseshoe Shape EPB-TBM



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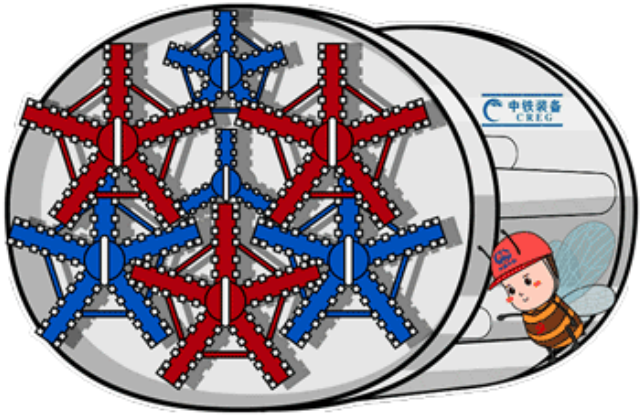
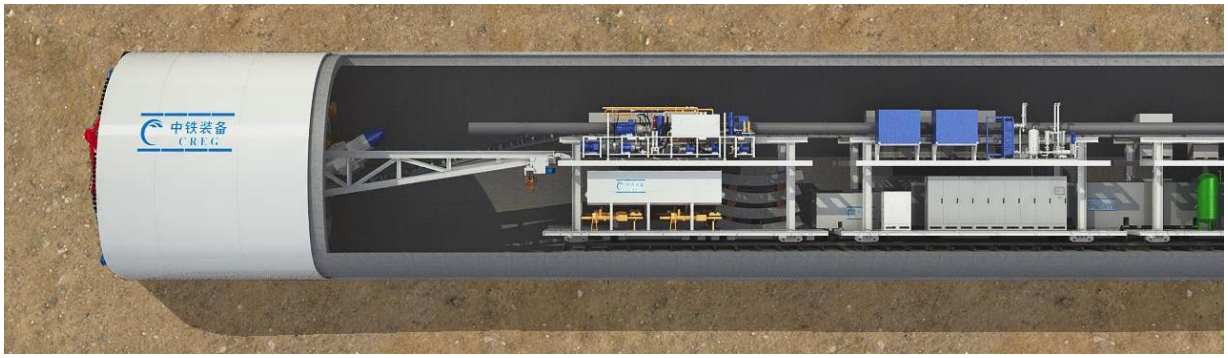
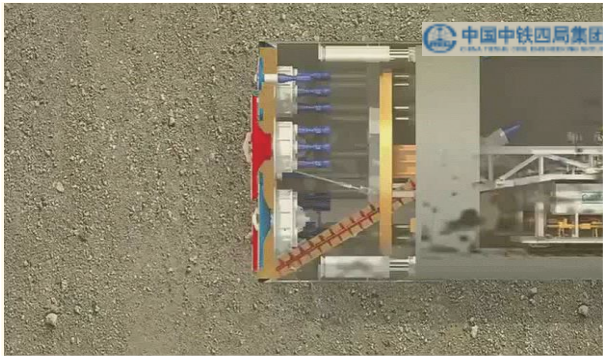
Key Components of the Horseshoe EPB-TBM

Main body

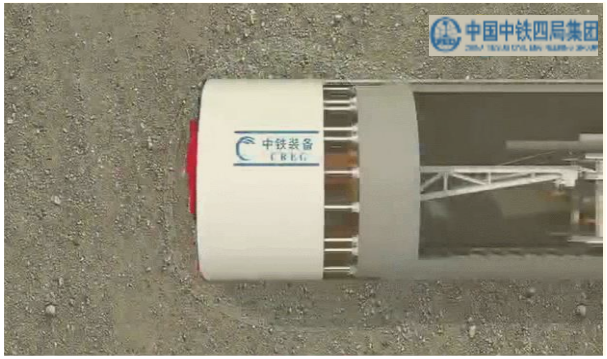




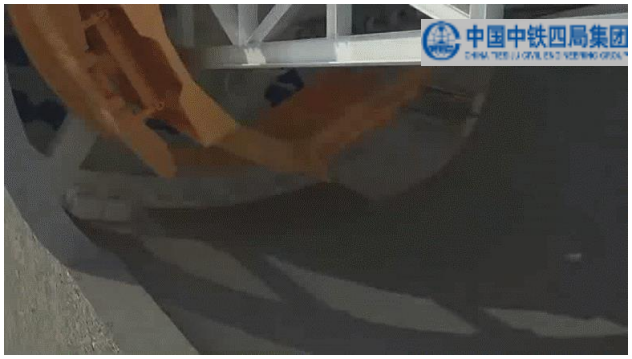
Face support



Jacking system



Lining installation system



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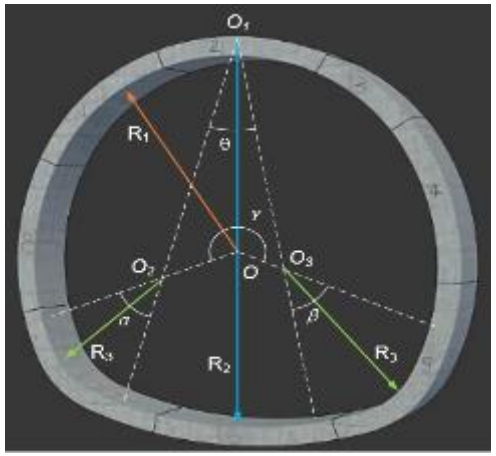
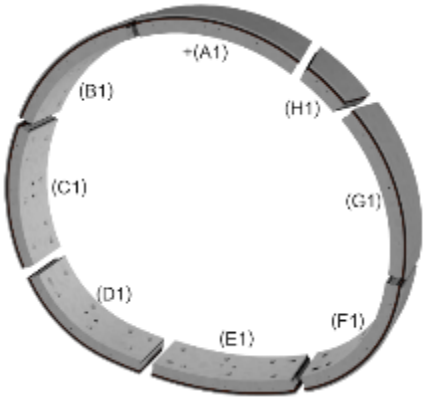
Lining and Lining Installation System





Longitudinal:44 RD30 Bolts
Transverse:
16 RD30 Bolts

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TECHNICAL PROJECT INNOVATION - OF THE YEAR -

Launch the TBM in the Cut and Cover Section

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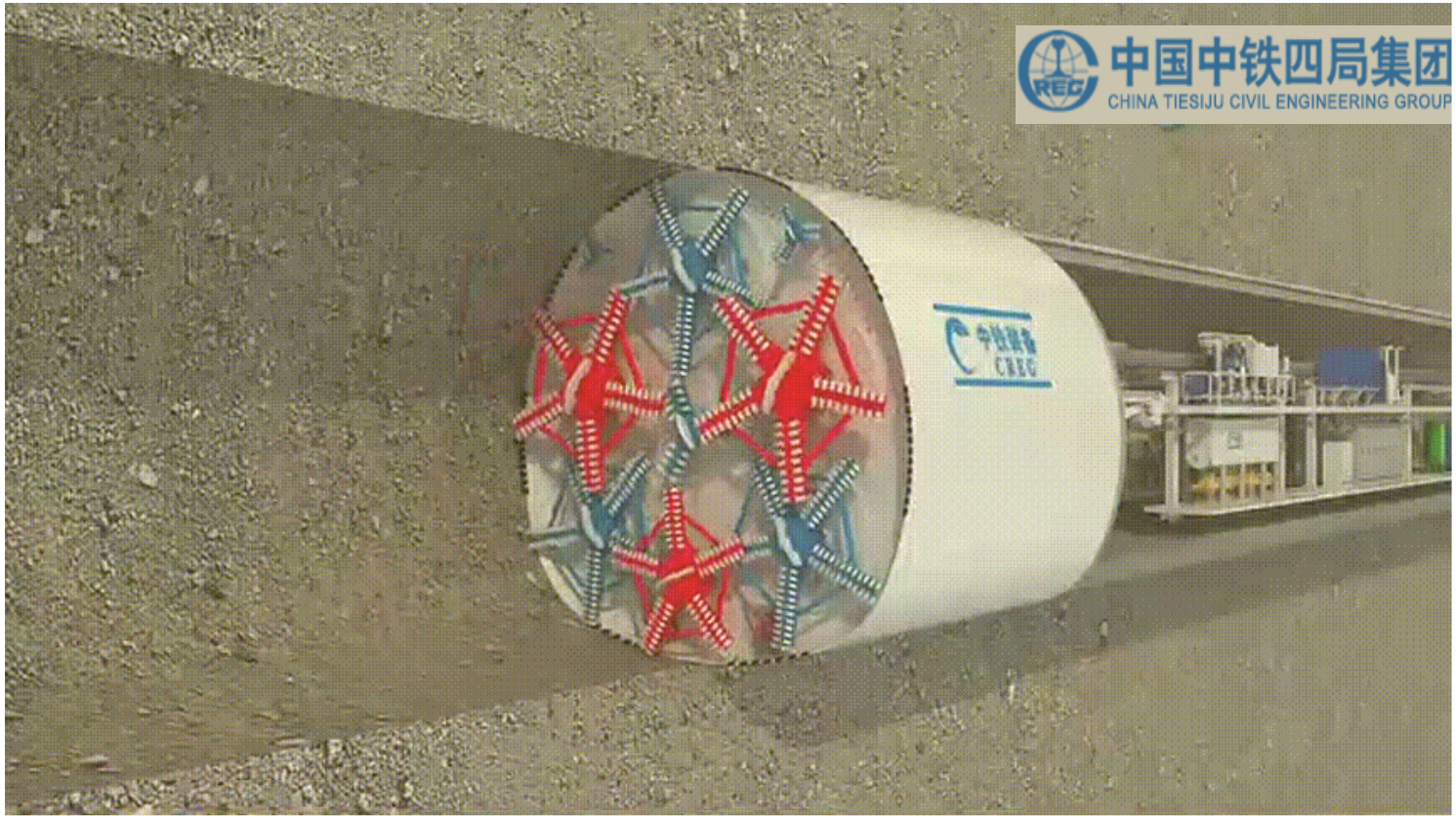
Excavation



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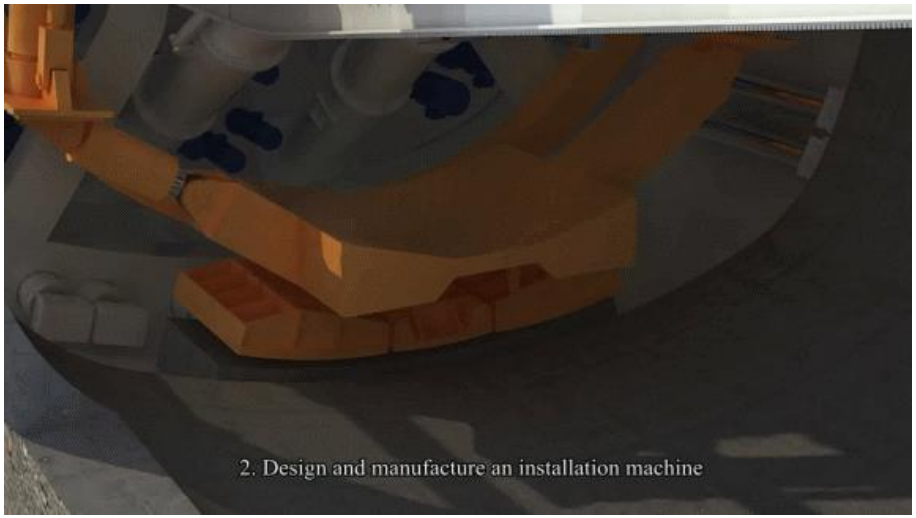
TECHNICAL PROJECT INNOVATION - OF THE YEAR -

Lining



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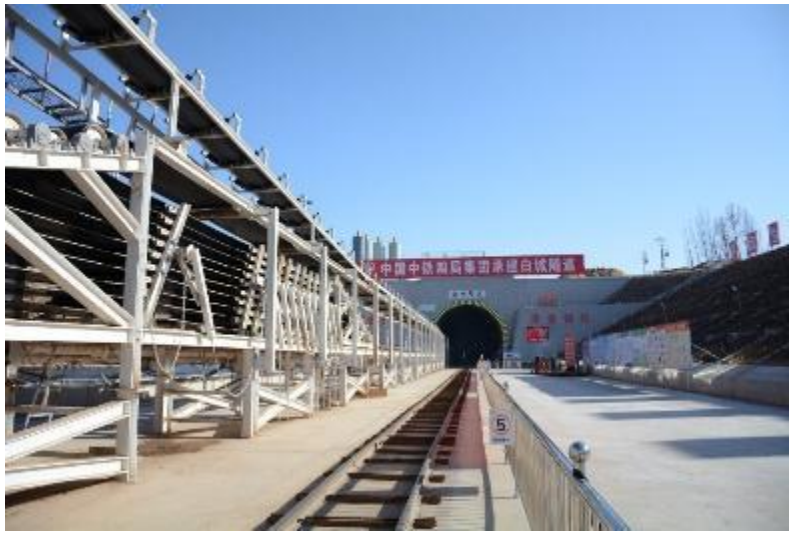
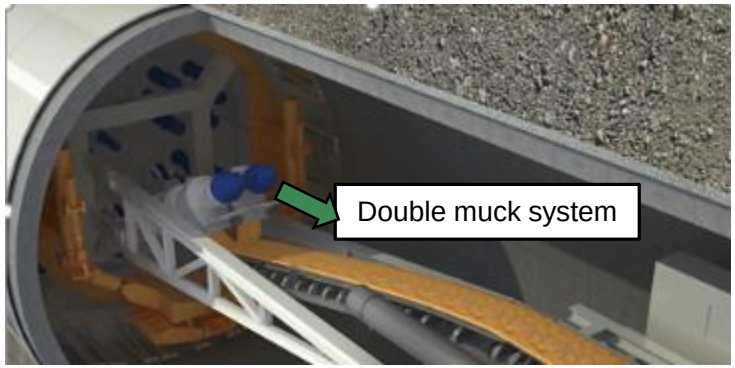
TECHNICAL PROJECT INNOVATION - OF THE YEAR -

Belt conveyor for muck transport



Double muck system



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TECHNICAL PROJECT INNOVATION - OF THE YEAR -

Segment accomplish

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TECHNICAL PROJECT INNOVATION - OF THE YEAR -

World's First-Ever Horseshoe Shape EPB-TBM is arrived!

Receiving

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03 Project Challenges

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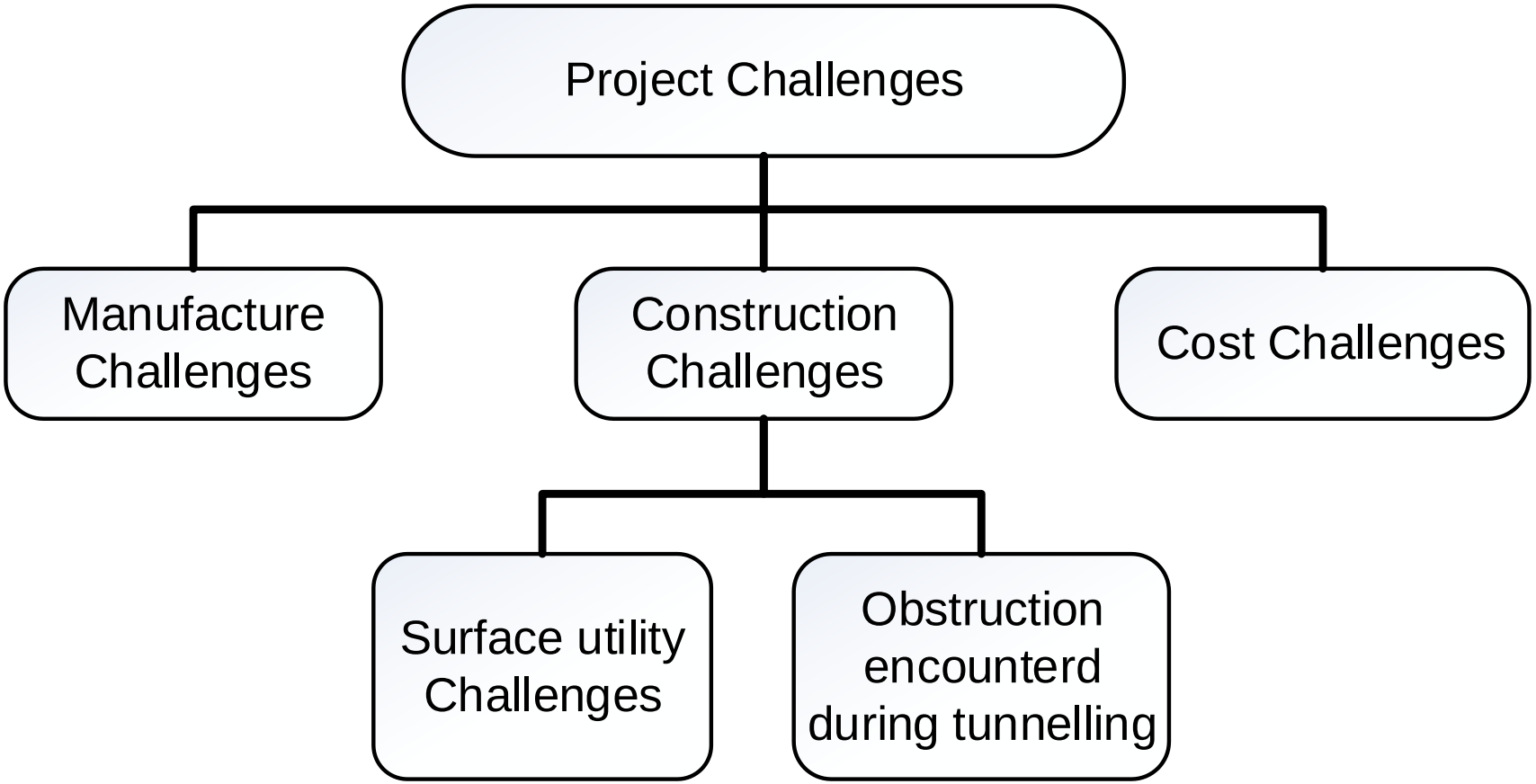

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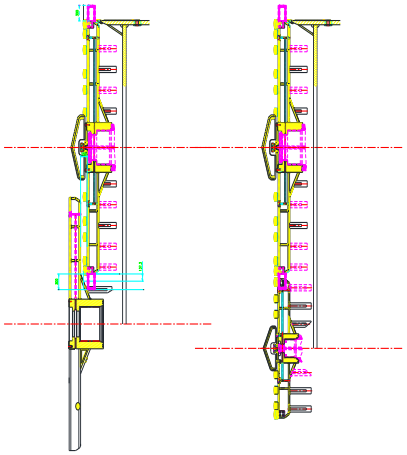
TECHNICAL PROJECT INNOVATION - OF THE YEAR -

Manufacture Challenges

1. A single circular cutterhead

1. Main bearing with large power
2. Special design and manufacture period
3. Expensive

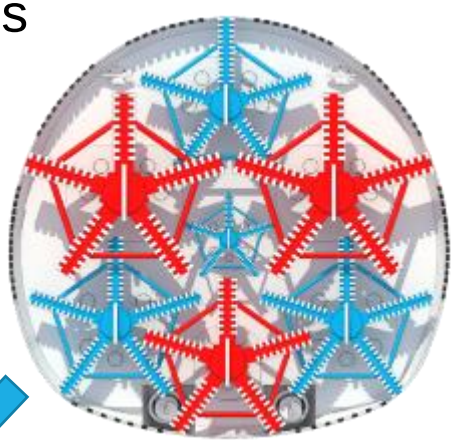
2. Multiple horseshoe cutterhead



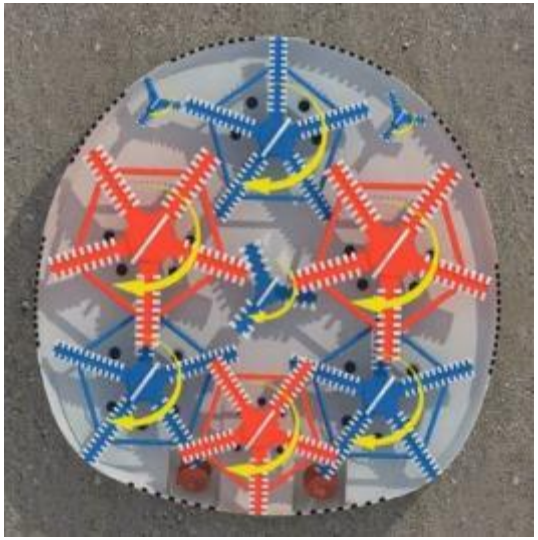
1. Smaller main bearing
2. Reduce 7.1 m^2 excavation area
3. Spatial distribution of cutterheads with little blind region
4. Lower cost

Manufacture Challenges

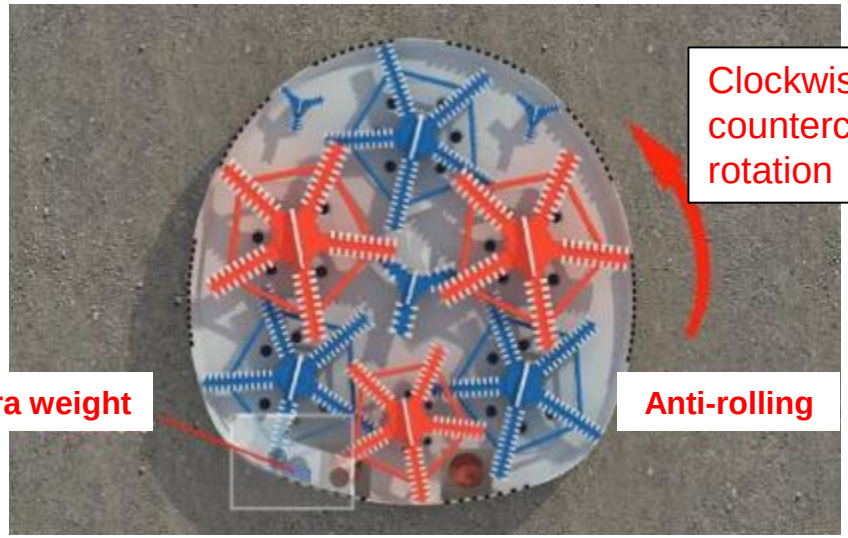
Uneven shape



Rolling



Countermeasures for anti-rolling



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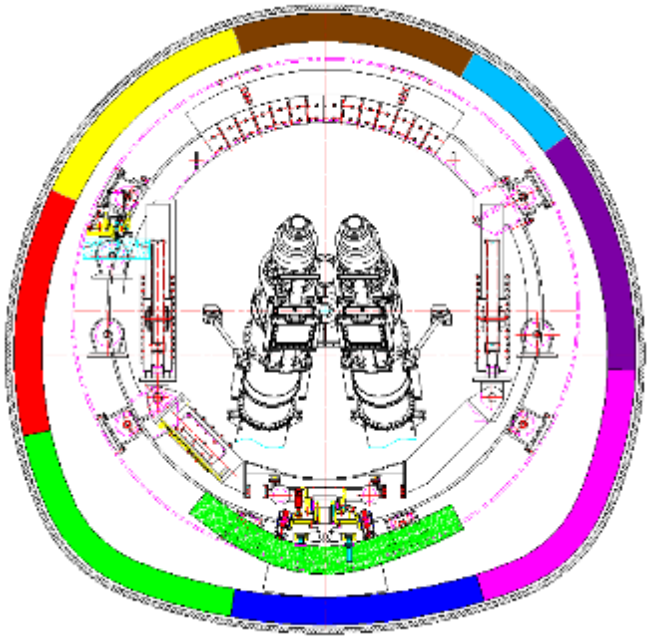
Manufacture Challenges

Lining Installation



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Construction Challenges

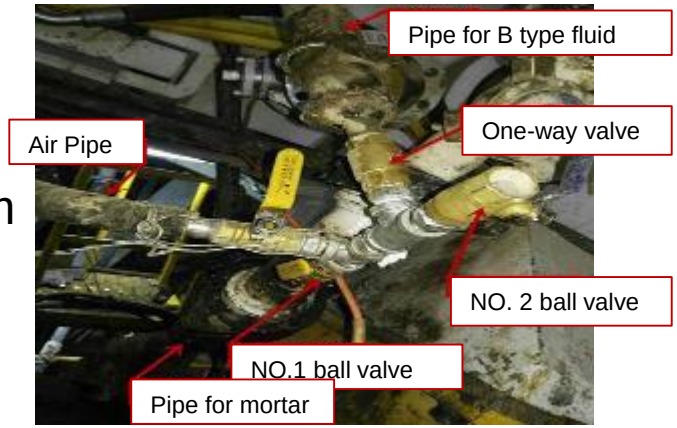
1. Instability of the surrounding soil

A. At the portal region, the surrounding soil is fine sand, which causes the instability of the tunnel face.
B. Due to the weight of lining and earth pressure, the segment would turn to oval shape.

Countermeasures:

A. Synchronous grouting combining polyester polyol and isocyanate
B. Fast hardening system of grouting
C. Muck improving to increase fluidity of the excavation soil

Fast Grouting System



Synchronous grouting field sampling

Construction Challenges

2. Obstruction encountered during tunneling

After 1064th Ring, hard and cohesive old loess encountered. It prevented excavation.

Countermeasures:

Conic soil breaker added at the front of the TBM

Conic soil breaker

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Cost Challenges

Cost comparison

A. Cost for SEM: 54.998 million euro

B. Cost for the horseshoe EPB-TBM: 60.198 million euro

More than SEM

Countermeasure:

In the near future, 560 kilometers mountain tunnel in loess region will be constructed. Reuse of the large section horseshoe EPB-TBM will be possible which would decrease the manufacture cost of the machine.

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04 Benefits of the Horseshoe EPB-TBM

Benefits of the Horseshoe Shape EPB-TBM

- Simpler and safer construction method
- Faster construction speed than conventional SEM
- Smaller excavation: Horseshoe shape: 104.1 m^2 Circular shape: 111.2 m^2
- Less construction material used

NO.	Comparison Factors	Unit	SEM	Horseshoe shape EPB-TBM
1	Excavation area	m^3	121.91	104.10
2	Grouting volume	m^3	1.18	10.60
3	Grouting pile	m	71.74	19.1
4	Concrete soil mixing pile	m	28.75	2.45
5	pipe	m	65.46	0.00
6	bolts	m	56.73	0.00
7	Concrete	m^3	28.80	16.80
8	Reinforcement	t	3.96	2.80
9	Total	euro/meter	16442	17713

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Benefits of the Horseshoe Shape EPB-TBM

- Little influence to the surface building and infrastructures
- In winter, heat preservation ensure consistent construction
- Minimum dust and human-friendly working environment

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05 Conclusions

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Conclusions

- Horseshoe EPB-TBM proves to a feasible solution for mountain tunnels in soft ground (approximately 560 km mountain tunnels in loess region)
- Innovative alternative to the conventional SEM at a wide range of overburdens
- A further innovation from circular section to horseshoe section for EPB-TBM
- Faster construction speed than the conventional SEM
- Less excavation volume and construction material used
- Capable of winter construction to ensure construction consistency
- Human-friendly construction environment

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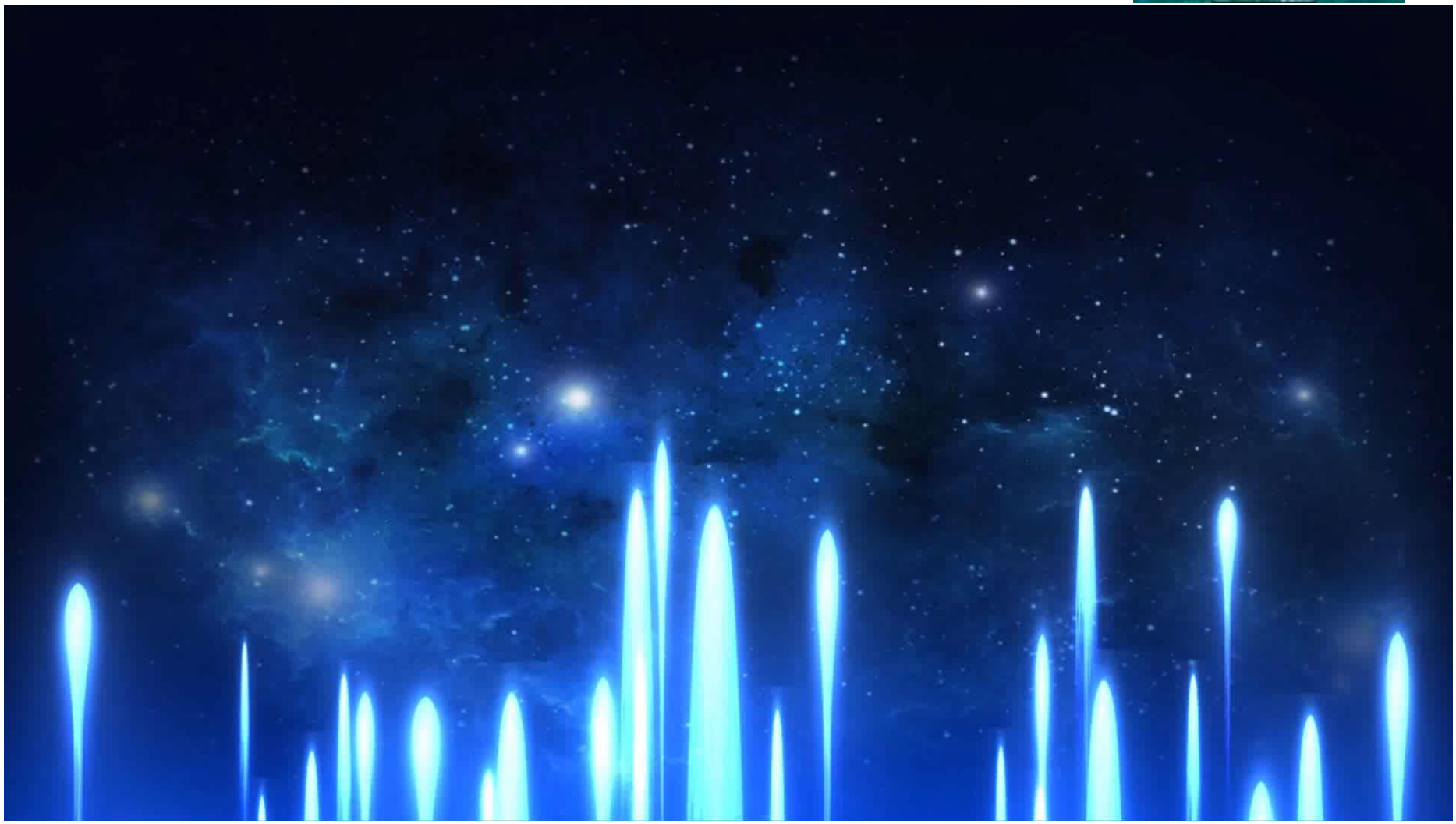

ITA AITES

Chuzhou-Nanjing 7th November 2018

Jianghong Wang
Wenge Qiu

Large Section Horseshoe Shape EPB-TBM in Loess Mountain Tunnel

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Thank you for your attention