Gongbei Tunnel
of the Hong Kong-Zhuhai-Macau Bridge
China

Presented by
Peixin Shi
CONTENTS

Part 1 / Project Description

Part 2 / Design

Part 3 / Construction

Part 4 / Management

Part 5 / Innovations
PROJECT DESCRIPTION

Key Stakeholders

- Client
- Designer
- Constructor
- Value Engineer
- Inspector

PROJECT OF THE YEAR - BETWEEN €50 M AND €500 M

- Total Length: 2.74 km
- Design Speed: 80 km/h
- Total Duration: 62 months
- Construction Cost: €223 million

Part One

Client: Peixin Shi, Professor, PhD, PE

Chuzhou-Nanjing 7th November 2018
PROJECT DESCRIPTION

Plane & Profile View of Gongbei Tunnel

Lingding Ocean

Open-cut & Cut-and-cover Section in Ocean

Hong Kong

Macau

Open-cut & Cut-and-cover Section on Land

Gongbei Port

Zhuhai City

Conventional Tunneling Section

Sand  Clay  Muddy Silt  Gravel  Muddy Silty Clay  Sandy & Gravelly Clay  Mud  Silt  Muddy clay  Fill  Granite

1200 m  255 m  1285 m

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Conventional Section of Gongbei Tunnel

- **Length:** 255 m
- **Cross-section Area:** 336.8 m²
- **Minimum Burial Depth:** 4.5 m
- **Complicated Site Conditions:**
  - Poor ground condition
  - High groundwater level
  - Dense adjacent structures
  - Politic sensitivity

**Construction Method:**
Pipe roof + Artificial ground Freezing
PART TWO

DESIGN

Hydro-filling Manmade Island

- Length: 1.3 km
- Width: 70 m
- Land Area: 9.27 hm²
- Height: 7-16 m

Deep Excavation Supported by Concrete Diaphragm Wall

- Max Excavation Depth: 26.9 m
- Max Width: 32.7 m
- Max Wall Depth: 52 m
- Max Wall Thickness: 1.2 m

Sand Blowing

Deep Excavation

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### Part Two

#### Design

**Pipe Roof**

<table>
<thead>
<tr>
<th><strong>Length</strong></th>
<th>225 m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number</strong></td>
<td>36+1 Pieces</td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>1620 mm</td>
</tr>
<tr>
<td><strong>Net Spacing</strong></td>
<td>35.5 cm</td>
</tr>
<tr>
<td><strong>Wall Thickness</strong></td>
<td>20×24 mm</td>
</tr>
<tr>
<td><strong>Section Size</strong></td>
<td>22×23.8 m</td>
</tr>
<tr>
<td><strong>Burial Depth</strong></td>
<td>4.5-28.3 m</td>
</tr>
</tbody>
</table>

- **Manufacturer**: Herrenk Necht AG
- **Type**: AVN1200TC
- **Max. Jacking Load**: 6000 kN
- **Diameter**: 1667 mm
- **Cutter Opening Ratio**: 35%
- **Cutter Head**: 6 Hobs & 16 Scrapers
Pipe Jacking

Gongbei Port

Herrenk Necht AVN1200TC Slurry Shield Machine

West Shaft

East Shaft

Control Room

Launch Device

Water Tightness

Launch Device

3 Line Guidance

F-shape Joint

SLS Guidance

Manual Check

Slurry Lubrication

Rubber Gasket Ring

Slurry Circulation

Pressurized Cabin

Launching Device

Water Tightness

Receiving

Jacking

Launching

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Artificial Ground Freezing

- **Freezing Zones**
  - 5 zones in cross-section
  - 3 freezing loops

- **Frozen Ring Thickness**
  - Min.: 2 m
  - Max.: 2.3 ~ 2.6 m

- **Freezer Pipe Design**
  - Circular Freezer Pipe + Irregular Shape Freezer Pipe + Heating Pipe

Design

- **Frozen Ring**
- **Roof Pipe**
- **Heating Pipe**
- **Frozen Zone 1**
- **Frozen Zone 2**
- **Frozen Zone 3**
- **Zone A**
- **Zone B1**
- **Zone B2**
- **Zone B3**
- **Zone C**

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Artificial Ground Freezing

Freezing Station

Freezing within Roof Pipe

Brain Circulation System

- 24 Refrigerators
- 44 Cooling Towers
- 36 Centrifugal Pumps

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PART TWO
DESIGN

Grouting

- Grouting before freezing
- Grouting before excavation
- Thaw-settlement grouting

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Excavation

- **Excavation Stages:** 5 Benches 14 Headings
- **Excavation Sequences:**
  A1 → A2 → B1 → B2 → C1 → C2 → D1 → D2 → E1 → E2
- **Bench Height:** 3.8-5.1 m
- **Initial Support:** I-beam + C25 Shotcrete
- **2nd Liner:** Lattices Girders + C35 CIP Concrete
- **Final Liner:** C45 Steel Reinforced Concrete
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PART FOUR

MANAGEMENT

♦ ITA Criteria

◼ Design-bid-build Mode & Unit Price Contracts
◼ Site Inspection Team for Environmental Protection
◼ Clear Regulation on Differing Site Conditions Clauses (DSCs)
◼ Detailed Claim Management System & Standard Insurance Policy
Safety Management

- Implement Strict Safety Regulations
- Form a Safety Management Department
- Organize Regular Safety Meetings
- Develop Task Specific Risk Management Plans
- Prepare for Comprehensive Emergency Plans
Safety Management

- **LTIF (Lost Time Injury Frequency):** 1.29
- **FTIR (Fatality Incident Rate):** 0
- **TLWR (Total Lost Working Rate):** 67.1
- **FTLR (Fatality Rate):** 0
- **TRCF (Total Recordable Case Frequency):** 4.50

**Zero Causality & 24 Injuries**
- 3 MTCs (Medical Treatment Case)
- 4 LTCs (Lost Time Case)
- 7 RWCs (Restricted Work Case)
- 10 FAs (First Aid)
PART FIVE
INNOVATIONS

01 Gongbei tunnel represents the largest single tunnel excavation in the world.

02 The pipe roof system represents the largest one in the world ever used.

03 The pipe roof in combination with artificial ground freezing pre-support technique is the first attempt in China.

04 The in-pipe artificial ground freezing technique is the first attempt in China.

05 The alignment error of 5 cm during jacking φ1600 mm steel pipes along 257 m curved alignment sets of a world record.

06 The full-face grouting within a frozen ring is the first attempt in China.
The construction experience of Gongbei tunnel was published in more than 50 technical papers (journals, conference proceedings, and monographs) and won over 20 patents.

Dozens of TV channels including CCTV-1, -2, -4, -10 & -13, more than 100 websites, and many newspaper agencies tracked the construction process of Gongbei tunnel in the past five years.

Based on the evaluation from tunneling experts from both domestic and abroad, the technology involved in Gongbei tunnel construction is innovative and cutting edge.
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THANKS