CUTTERHEAD DISC ROBOTIC CHANGING SYSTEM « TELEMACH »

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Introduction

LIANTANG TBM CUTTERHEAD

TELEMACH ROBOT
PARIS– 15 November 2017

FRANCE - Paris

RESEARCH & DEVELOPMENT

Follow up & improvement

HONG-KONG

IMPLEMENTATION ON SITE (3 TBM)

Feedback

TELEMACH DEVELOPMENT

Stakeholders
1. Dragages HK & Liantang Contract 2 Project information

2. TBM Description

3. Cutterhead Disc Changing System innovation
1. DHK & Liantang Contract 2 information

Dragages Hong Kong & Liantang Contract 2 project information
1. DHK & Liantang Contract 2 information

Dragages Hong Kong in 2017

1/ SCL 1128
- Rail tunnel
- Tunnel TBM diam 7.1m
- Length: 2 x 570m
  - 2 x 650m

2/ TMCLK Link
- Road
- Bored Tunnel diam: 17.63m & 14m
- Total length: 2 x 5480m

Hong Kong

Hong Kong Airport

Dragages Hong Kong in 2017
Liantang / Heung Yuen Wai Boundary Control Point Project (2013-2018)

- 11km long project
- Client CEDD & Engineer AECOM
- Contract 2 – Lung Shan Tunnel to Dragages HK
- Contract 2 - 1.3 Billion US$
1. DHK & Liantang Contract 2 information

**Contract 2:**
- 5.4km long duel, 2 lane highway
- Twin, two lane, 4.8 km long tunnels
- 49 cross passages (every 100m)
- 4 Buildings
1. DHK & Liantang Contract 2 information

Geological Context

- Geology – Volcanic Ash Tuff rock
- Ground conditions vary from very strong rock (max ~200MPa) to completely decomposed with sections of faulted ground and low ground cover
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Northern Tunnels

North Bound - 2404m
South Bound - 2428m
24 Cross passages

TBM U-Turn in Mid – Vent Cavern

TBM Tunnels – 14.1m dia. EPB machine

North Bound Tradi-tunnel ~472m
South Bound Tradi-tunnel – 204m

Cross passage
Technical challenges

1. DHK & Liantang Contract 2 information

TBM U TURN IN CAVERNS

- Cavern dimension (22m span, 23m Height)
- Overall schedule improvement by turning the TBM underground rather than dismantling and relaunching from the north
2  TBM Description
2. TBM Description

Princess Xianglong TBM

- 14.1m dia. EPB TBM (Supplier NHI / NFM Technologies)
- Shield 12.27m long with 4 back-up gantries
- Screw 1.4m diam.
- Total installed power - 7700 KW
2. TBM Description

- All TBM parts on site June’15
- Commence boring 5th November’15
77 disc cutters mounted on the cutter head.
Cutterhead Disc Changing System Innovation
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When town density increases, networks go deeper

Scarce resources

Increased maintenance

Programme and cost impact

Deepening of underground works

Health, Safety and Wellbeing

- 10m
- 20m
- 50m => 5 bars
3. CUTTERHEAD DISC CHANGING SYSTEM INNOVATION

TBM tasks split

Overall

- Excavation: 54.4 h, 32%
- Ring building: 37.1 h, 22%
- Stops: 76.4 h, 46%

Saturatio

Stops

- Unavoidable tasks: 15.8 h, 21%
- TBM Breakdowns: 6.9 h, 9%
- Hyperbaric Maintenance: 8.5 h, 11%
- Daily maintenance: 8.5 h, 11%
- Other breakdowns: 2.6 h, 3%
- Timeouts: 0.8 h, 1%
- 41.9 h, 55%
3. CUTTERHEAD DISC CHANGING SYSTEM INNOVATION

TELEMACH general definition

✓ New technology for safe maintenance of tunnel boring machine cutter heads in hyperbaric conditions, which lead to develop:

- A new disc-cutter supporting system called “Muquet”, patented by BOUYGUES TP.
- A Robot arm and its tools able to manipulate this new disc-cutter assembly in Hyperbaric condition without any human helps.
3. CUTTERHEAD DISC CHANGING SYSTEM INNOVATION

Telemach in Liantang TBM

TBM Cutterhead equipped with Telemach robot

TBM Shield without cutterhead-excavation chamber

Cutter disc

Telemach
3. CUTTERHEAD DISC CHANGING SYSTEM INNOVATION

**TBM Cutter disc Muguet**

- 11 separated parts
- Best manual replacement time **45mn***

- Only 1 part – 300kg
- Only 25mn***

(* Manual exchange without logistical considerations)
3. CUTTERHEAD DISC CHANGING SYSTEM INNOVATION

An industrial robot
Payload 500kg

Modified by BYTP to withstand up to 7 bars
3. CUTTERHEAD DISC CHANGING SYSTEM INNOVATION

Stereoscopic laser vision driven

Force control i.e. active touch sense

Water cleaning jet 400 bar

Torque controlled screw driver device
### 3. CUTTERHEAD DISC CHANGING SYSTEM INNOVATION

<table>
<thead>
<tr>
<th></th>
<th>Human Intervention</th>
<th>TELEMACH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time taken per disc exchange</td>
<td>4 hours</td>
<td>1.5 hours</td>
</tr>
<tr>
<td>Avg no. of disc exchanges per TBM stop</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>No. operatives required per disc*</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Total man hours required per TBM stop*</td>
<td><strong>160 hours</strong></td>
<td><strong>24 hours</strong></td>
</tr>
<tr>
<td>Typical days required per TBM stop</td>
<td>6 days</td>
<td>3 days</td>
</tr>
<tr>
<td>Typical no. cutter head replacements per tunnelling year (in challenging geology)</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Total lost tunnelling time per year</td>
<td><strong>54 days (1,440 man/hrs)</strong></td>
<td><strong>27 days (246 man/hrs)</strong></td>
</tr>
</tbody>
</table>

* Operatives work no more than two hours on disc replacement operation due to hyperbaric conditions plus one safety officer per 8 hour shift.
3. CUTTERHEAD DISC CHANGING SYSTEM INNOVATION

- Performance => new possibilities
- Safety for workers => exposure reduction
- Less time for maintenance => cost efficiency
- Project planning reduction => earlier use

✓ Health and long term wellbeing
Dragages Liantang Contract 2 team has been honored to be awarded by its client the « Civil Engineering and Development Department (CEDD) Innovation Award for Site Safety 2016 –Merit Prize » for Telemach innovation.

We received the award at the 8th CEDD Construction Site Safety Award on 31st May 2017. The awards commended contractors with outstanding safety performance at its construction sites in 2016.
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DHK & LIANTANG CONTRACT 2
INNOVATIONS

Cutting Disc replacement
TELEMACH

TBM JET “SNAKE”
Cutterhead cleaning and
inspection device

“ROBY 850”
Concrete anchors installation robot
THANKS