Miami Tunnel Project

IMIA
24/09/2014
I GENERAL RISK MANAGEMENT TOOL WITHIN BYTP IN TUNNELING PROJECTS

- MOBYDIC
- TELEMAC
- BYDAS
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Mobydic : « Monitored Bouygues Disc Cutter »

- Wear measurement (real time)
- Adhesion follow-up
- Cave detection / flat disc detection

TMB in board real time view, based on data transmitted by the disc cutter sensors
Mobydic : « Monitored Bouygues Disc Cutter »

- Mobydic system allows optimizing of the TBM advancement by real time knowledge of:
  - Front geology
  - Disc cutter state (temperature, rotation, wearing statut, load)
  - Cutter head plugging area (by interpretation of disc cutters temperatur)
  - Prevents cutter head structure deep damage
  - This system is especially powerful in heterogeneous condition, by avoiding disc cutter overload and brake away
  - It reduces also hyperbaric intervention
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BOUYGUES DATA ACQUISITION SYSTEM FOR TBM SITE

From instantaneous to final recordings, all data are recorded and can be treated for any type of following View are specially developed for TBM supervision (instantaneous) in order to help the pilot (here slurry system supervision)
BOUYGUES DATA ACQUISITION SYSTEM FOR TBM SITE

GraphShop, CSVShop and Trends

Powerful tools adapted to TBM for real time and historical trends and usable for any tendency analysis (sampling from second to days), here TBM pushing force and cutter head speed.
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BOUYGUES DATA ACQUISITION SYSTEM FOR TBM SITE

Weekly and Monthly Report, for management reporting, and recording
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**BOUYGUES DATA ACQUISITION SYSTEM FOR TBM SITE**

Smartphone Application
Real Time and historical pages are available from smartphones
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II RISK ANALYSIS LAYER 7

EXAMPLES OF CORAL

- Layer 6 “Coquina"
- Coral head – Layer 7
- Key Largo highly dissolved layer 7
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SURVEY

- **WATSON**
  - 19 CONE PENETRATION TEST (CPT) FOR THE TUNNEL (INCLUDING 6 SHALLOW ONES CLOSE TO BI/BO)
  - 7 CPT FOR LINE ANALYSIS
  - 13 SPT CORES
  - 10 SONIC CORES
  - 2 SHAFTS LARGE DIAMETER
  - **TOTAL NUMBER OF DRILLS : 51 (+49)**

- **CHANNEL**
  - 5 SONIC CORES
  - 18 CPT
  - **TOTAL NUMBER OF DRILLS : 23 (+13)**

- **DODGE**
  - 23 CPT (INCLUDING 2 SHALLOW ONES CLOSE TO BI/BO)
  - 12 SPT CORES
  - 5 SONIC CORES
  - 1 INVESTIGATION SHAFT
  - **TOTAL NUMBER OF DRILLS : 41 (+25)**
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GEOLOGICAL PROFILE - EAST BOUND
Above is the geological profile of layers S1 to S8 as confirmed by the survey.

- Significant reduction of grains <2mm in layer S7 with respect to “GDR/GBR” confirmation by sonic core, large diameter test shaft and the response of the terrain during the “compaction grouting” test phase.
- Unstable zones identified in layer 7 – red hatched area.
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**GEOLOGY – IMPACT ON TUNNELING**

**CALL FOR TENDER**

- The granulometry reported in the "gbr" has led Bouygues to use the EPB method (Earth Pressure Balance) for excavations.

- The zones of layer 7 have led Bouygues to design a TBM that can inject the lower part of the tunnel to avoid the TBM burying itself.

**AFTER SURVEY**

- The geological survey has shown there is no sand or fine material in layer 7.

- The "cpt" tests have shown there are unstable zones in layer 7.
**IMPACT ON THE EXCAVATION METHOD**

- It is not possible to excavate by the EPB method when there is no sand.
- The instability of the front cannot be compensated without confinement.
- The EPB method and the production of the paste are not possible [the permeability of the terrain is too high, 10-2 to 10-4 m/s].
- The unstable parts of layer 7 must be consolidated and a new system must be implemented to excavate and remove high porosity terrains (strong water inflow to be handled by the TBM).
III SOLUTION DESIGN AND IMPLEMENTATION

EXCAVATION - EPB METHODE

**IMPORTANT** - the use of the WCP process requires that the excavation face be self-stable.

The Key Largo limestone layer was determined to be meta-stable leading to a significant risk of face instability, over-excavation and the inability to construct and grout the segmental lining in place.

Ground treatment was therefore required to provide stability prior to excavation.
The solution was the Water Control Process (WCP) which was adopted where the alignment encountered the Key Largo:

- the plenum is maintained full of water at hydrostatic pressure and the excavated rock is evacuated via the screw conveyor, through an inline crusher and into a hydraulic circuit to the surface.
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Soil instability – Risk of excessive excavation
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GEOLICAL LAYERS – EXCAVATION MODES
Injections were necessary to consolidate the unstable zones of layer 7 (wcp) and add fine material (Ep+wcp)

Nombre total de forages = 824 (hors cross passages)
Treatment target Layer S7

Objective – to prevent instability of the excavation face so enabling the use of the WCP excavation process
IV TOOL DEVELOPPED DURING MIAMI PROJECT

SNAKE IS USED ON MOST OF OUR NEW TUNNELING PROJECTS

TBM Jet Inspection arm « SNAKE »

- Inspection arm for Compressed TBM cutting chamber:
  - Visual inspection and record
  - Cutting tools Wear measurement & damage detection

Un-plugging of cutter head, prior important damage as:

- hard plugging and over heating
- main bearing sealing system damage due to plugging
Cutter head adjusted position on arm 6
10H 18 VIEW OF CUTTER DISC 63.65 (FROM REAR) AND SUPERVISION SCREEN
V. ORGANISATION DESIGNED TO CONCENTRATE AND SHARE EXPERIENCES

- Department of « Tunnel Expertise »
  - Analyse of the past projects problems (use of End of Site Report)
  - Benchmark
  - Intelligence

- R/D Committee
  - Validation of products we intend to develop
  - Priorisation of the need on short/middle/long time
  - Validation of budget/time for each product

- Innovation Approach
  - Revisit of the impacting components of bored tunnel
  - Use of a « method of creativity »
  - Goal to improve the execution while decreasing risks factors

- One exemple
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**TELE-OPERATED MAINTENANCE OF CUTTER HEAD: «TELEMACH»**

- Special disc cutter implemented to be changed with robot arm:
  - Avoid human hyperbaric works
  - Help human being for heavy lifting
  - Decrease cutting chamber human intervention time
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DON’T ONLY QUOTE THE RISK
QUOTE WHO IS TAKING IT
Construction is living a revolution

Construction is moving to industrialization
- more and more components are pre-built outside the construction site
- New products
- Incorporated across many projects

This is moving fast and embracing all types of works

QA/QC improving efficiency
- Improving claim experience
- More and more problems are identified very early in the process
- Quite often well before any damage
A contractor is now an integrator

Find solutions for these risks generated by new methods of construction

No one else but the Construction / Engineering branch of insurance can manage this
Existing Solutions

- Construction / Engineering Insurance Solutions / Risk Transfer Solutions: have not yet evolved
- The gap between the need for transfer and transfer solutions is increasing
- We still very much need the existing solutions (CAR, TPL, machinery breakdown, DSU, etc…)
- But we also need new solutions
Creating New Solutions

- This is an opportunity for the market to propose new solutions including with very substantial retention.
- We are looking for a Construction Product Liability type solution:
  - Covering the works prior to handover
  - Pure defect cover