Applying 3D Geological Modeling to Infrastructure Design

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SUMMARY

• 3D Geological Modeling at BGS
• Two Recent United Kingdom Infrastructure Applications
• Geotech-BIM Concepts
BGS Model Applications at Many Scales

National 3D UK Model

Regional 3D Model (London)

Site 3D Model (Farringdon Station)
Two Recent UK Infrastructure Applications

Farringdon Station

- Two 300 m (985 ft) platform tunnels plus multiple access tunnels
- 30 m (100 ft) below the surface

PRIOR INVESTIGATIONS IDENTIFIED ADVERSE GROUND CONDITIONS:
- Multiple faults,
- Buried valley of Fleet River
- Water-bearing sands within the tunneling medium (Lambeth Group)
- Potential surface settlement on old buildings and surface railway
Existing 3D Subsurface Information

BGS Regional 3D
London Model

7174 Borehole logs used to create Model

Framework Cross-sections used to create Model

Oblique View of Completed London Model

(From Mathers et al., 2014)
Initial 3D Geological Model of Farringdon Station Site

• By 2008 Crossrail had completed initial ground investigations, at least one fault has been identified but little confidence in the ground model.
• In 2009 Crossrail commissioned BGS to develop a 3D geological site model to guide future investigations.
• Model constructed using existing London regional model, historical & third-party data, and available Crossrail data.
Farringdon Station Design Modeling (2009-2013)

Initial 2009 BGS 3D geological model of Farringdon station was progressively updated as new Crossrail exploration data received.
Farringdon Station 3D Model

3D model display of sand and gravel (water-bearing) units and faults

(Aldiss et al., 2012)
In 2013, this model was handed over to the contractor and integrated into the site supervision workflow.
Farringdon Station
Predicted vs Observed locations of sand lenses and faults

(Gakis, 2014)
Farringdon Station
Success in Predicting Geological Conditions

Geological predictions at one section of Farringdon station

(Gakis, 2014)
Farringdon Station
Comparison of Estimated Risks to SCL Tunneling from Water-Charged Sand Units

(Gakis et al., 2014)
Consequences of Employing Farringdon Station 3D Model

Because the Ground Model was updated daily as station excavated:

- **Enabled geological predictions ahead of excavation**
- **Provided a geological database to collate and store all acquired data**
- **Confidence increased as tunneling progressed**
- **Key Element in reducing Geotechnical Risk**
- **70% reduction of in-tunnel probing compared to original plan**
- **Efficient SCL design and installation**
- **Station excavation completed 3 months early!**

- 28 km (17.5 miles) existing railway line is planned for electrification.
- Concern for foundations of support masts
  - Depth to bedrock, type of rock, weathering
  - Old mine workings, karst features, fault structures
- Long narrow 3D model created along railway
  - 28 km long; 80 m wide, 30 m deep
  - Outputs transferrable to Bentley Microstation
- BGS completed/delivered model in 1 month

- A 4 km long section of central portion of route
- Model consists of 3 parallel sections, and numerous short “rung” sections (25 shown in this portion of route)
- Model based on 1:10,000 BGS maps and 102 borehole logs
- Model contains 57 geological units, 11 coal seams, 29 faults

- Isometric view of 3D model (central 4 km section)
How Did Client Use the Model?

Combined geological model information with CAD infrastructure design files.

This illustrates the future of 3D model applications.
Building Information Modeling (BIM)

But Where is the Geology?

- Process involving the generation and management of digital representations of physical and functional characteristics of places.

- BIM files can be exchanged or networked to support decision-making about a place.

- Used by individuals, businesses and government agencies who plan, design, construct, operate and maintain diverse physical infrastructures.

Courtesy Mott Macdonald
“Geotech-BIM”

BIM and the Subsurface

• Extend/Integrate 3D Geological Modeling techniques to the BIM environment

Grice & Kessler, 2015
Current Capability:
City of London on 3D Geology Model

City model courtesy of ARUP
Available Now –
Direct access to BGS geological maps and boreholes through web map services
Current Research –
Integrating Digital Field Information with 3D Models

Working with the AGS
(equivalent too DIGGS in North America)

A new initiative to include interpreted data and the concept of layers in the next phase of the AGS data transfer format (AGSi)

Electronic Reporting

Site Exploration
Laboratory Testing
SI Presentation
Engineering Analysis
CAD Presentation, 3D modelling and GIS
Local or national Archive

Geological cross-section transmitted via xml and visualised in Excel
In The Future –

Ability to edit sections and surfaces and submit them back to the BGS to be incorporated in the national geological model

Early prototype section editor in Autodesk–HoleBase plug-in