USING 3D GEOLOGICAL MODELLING IN CIVIL INDUSTRY

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INTRODUCTION

• Technological breakthrough has been successful in civil design using BIM (Building Information Modelling) technology, but not yet in traditional oriented Engineering Geology

• Using emerging new technologies for data acquisition, processing and analysis in 3D environment, we have developed a set of procedures and techniques to combine them to manage large data sets and BIM modelling techniques

• To demonstrate the concept, the Markovec tunnel and the forthcoming Karavanke tunnel project in Slovenia have been chosen for testing techniques with the possibility of digitising geological data while communicating with Leapfrog Geo 3D modelling algorithms
Using 3D geological modelling in Civil Industry

STATE OF THE ART IN ENGINEERING GEOLOGY

- Disadvantages
  - Subjective logs of outcrops and excavated faces due to difficult or dangerous access
  - Insufficient data acquired for further statistical evaluation and computation analysis
  - Several data digitalisation
  - Mostly 2D working environment

- Conventional geological data acquisition
  - Geological compass, pencil & paper
  - Manual data acquisition
  - Remote data estimation

↓ time
↓ budget
EMERGING NEW TECHNOLOGIES

**Data Acquisition**

- Satellite & Aerial Imagery
- UAV (drones)
- Ground-based technology
  - Photogrammetry
  - Terrestrial Laser Scanning (TLS)
  - Hyperspectral Imagery
  - GB InSAR
- Devices and applications (GeoLIDAR)
  - GIS-based geological data acquisition
  - On-site digital logging (surface outcrops, excavated faces, boreholes)

**Processing**

**Analysis & Visualisation**
EMERGING NEW TECHNOLOGIES

Data Acquisition

- SW for processing and analysis of geological data from remote sensed acquisition
- 3D geological modelling

Processing

Analysis & Visualisation

Geological analysis of photogrammetric images
Using ShapeMetriX3D (3GSM GmbH)

Geological analysis as 3D geological modelling
using Leapfrog Geo (Aranz Geo Ltd.)

Geological analysis of point clouds from TLS (Riegl VZ-400)
using RiSCAN Pro (Riegl LMS GmbH)
EMERGING NEW TECHNOLOGIES

- Presentation of geological structures in space
- Fast in big data processing
- Understands properties of predefined geological features (i.e., faults, intrusion, veins, deposits) for data evaluation
- Basis for further analysis (i.e., hydrogeological simulation, geotechnical calculations)

Importance of building 3D geological model for underground constructions in urban areas (Markovec tunnel, Slovenia)
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EMERGING NEW TECHNOLOGIES

Data Acquisition  ➔  Processing  ➔  Analysis & Visualisation

- 3D geological modelling
- 3D hydrogeological simulations
- Calculations (Analytical & Numerical Methods)
- Visualisation of 3D geological model using augmented reality on site

3D block model in Leapfrog Geo for further analyses

Numerical simulation of soil and rock mechanics for tunnel excavation using Zsoil (courtesy of V. Selan, Elea iC)
EMERGING NEW TECHNOLOGIES

BIM in tunnelling

- BIM (Building Information Modelling)
- Information modelling in tunnelling still in its early stages of development
- Data analysis and visualisation inside a virtual tunnel
- Reduces the risk of information loss
- Provides more extensive information for tunnel designers, contractors, owners, managers
PILOT PROJECT: MARKOVEC TUNNEL

General

- Koper, Slovenia
- Investor: DARS d.d.
- Double-tube, two-lane motorway tunnel
- 2,3 km length
- Construction: 2009 – 2015
- Ground conditions: Flysch rock mass (Eocene age)
PILOT PROJECT: MARKOVEC TUNNEL

Building 3D geological model

- Integration of digitised geological features from face logs, acquired during tunnel excavation into a 3D geological model
- Testing GeoLIDAR – GIS based geological application prototype
  
  **Macro level:** GIS based for data upload and geological mapping of the investigated area
  
  **Micro level:** geological mapping combined with outcrop and face logging
  
  **Third level:** data download, analysis and interpretation
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PILOT PROJECT: MARKOVEC TUNNEL

- 3D geological model built on borehole data
- implementation of the model using digitised geological features with attributes from GeoLIDAR spacing roughness aperture
CASE STUDY: KARAVANKE TUNNEL

General

- Jesenice, Slovenia
- Investor: DARS d.d.
- Double-tube, two-lane motorway tunnel
- 7,8 km length
- Construction:
  - Left tube: 1986 – 1989
  - Right tube: Building permit design
- Ground conditions: complex, imbricate fan like structure with Carboniferous, Permian, Triassic and Quaternary rock mass
CASE STUDY: KARAVANKE TUNNEL

Geological profile along the Karavanke tunnel (after Budkovič, 1993)
CASE STUDY: KARAVANKE TUNNEL

Building 3D geological model

• Extensive geological data from previous investigation and construction phases

• Lack of borehole data

• 3D geological model along the tunnel alignment built on the basis of understanding the complex fault system

• 3D geological model built in Leapfrog Geo (ARANZ Geo Ltd.)

  comparison of ground conditions
database

  implementation of new technologies

  implementation with BIM tunnel model for further numerical analysis
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CASE STUDY: KARAVANKE TUNNEL

Ortophoto images

Digitalization of maps, drawings

Digitalization of cross sections

3D geological model

Combined geological model

Extrapolation of geological structures

Investigation planning

Rock mass characterization
DISCUSSION & FURTHER RESEARCH

• Replacing conventional geological investigations with collection and interpretation using new technology
  – Faster and more accurate data acquisition in the field
  – Improved quality of measurements and results
  – Greater efficiency, costs reduction and more time for data analysis and interpretation of the 3D geological model
  – Reduction of construction time

• Benefits for everyone involved in tunnelling and geotechnics: Engineering Geologist, Designer, Client and Contractor

• Further research and development:
  – Integrating acquired data in unified data format
  – Implementing 3D geological model with data from remote sensing techniques
  – Implementing 3D geological model with geometrical features of geotechnical constructions from BIM
  – Implementing the communication between different tools for numerical calculations, design, analysis, monitoring and management would result in building and upgrading the 3D geological model on site and in real time
Thank you!