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Tunnelling-induced ground settlement risk assessment based on the integration of BIM with 3D Geospatial modelling tools

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3DGEOINFO 2018, Delft

Outline of the presentation

1. Introduction
2. 3D Geospatial modelling
3. Ground settlement risk assessment
4. Integration with BIM
5. Building risk assessment
6. BIM visualisations
7. Conclusions

Introduction

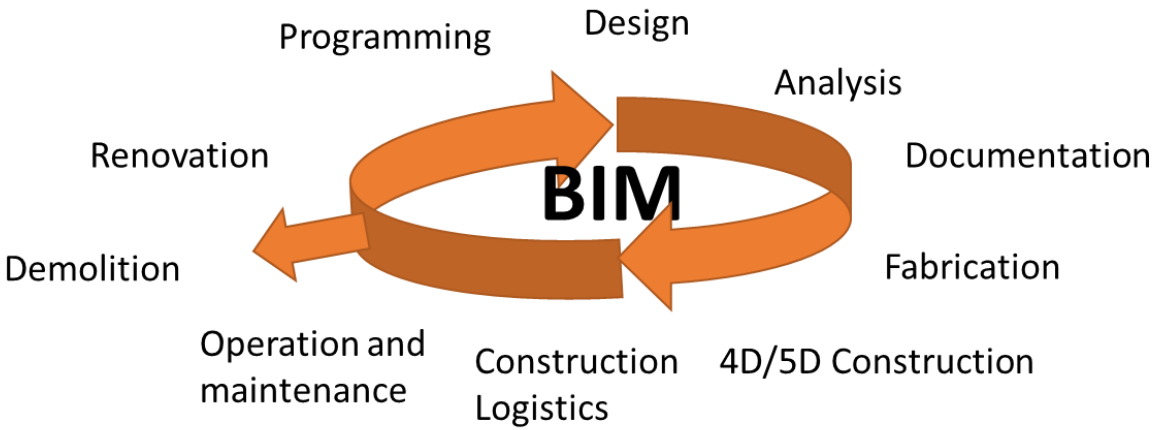
An integrated tool for assessing the ground settlement risk to the adjacent buildings will be presented, involving:

- Ground settlement hazard prediction in urban areas.
- Multi-dimensional visualisations using BIM.
- Ground investigation enhancement through
  - 3D visualisations
  - Advanced risk assessment

BIM

Building Information Modelling (BIM) is an advanced platform where all the information of a structure can be stored, shared and visualised in 3D, for the overall life of this structure.

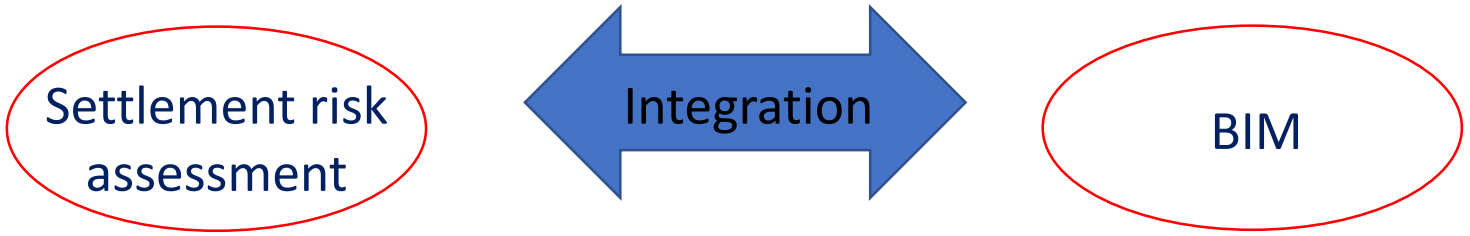
→ Possible geotechnical application.



Methodology of the study

Tunnelling-induced settlement risk assessment integration with BIM:

1. Ground settlement vulnerability analysis
   - Building damage risk.
2. 3D BIM visualisations
   - Geology and tunnel.
   - Settlement vulnerability assessment.
   - Settlement impact on buildings.



3D Geospatial modelling

Georeferencing of the 3D model:

- Interpolation of the 3D points from the borehole records data.
- Real position of the buildings (University of Birmingham campus buildings).

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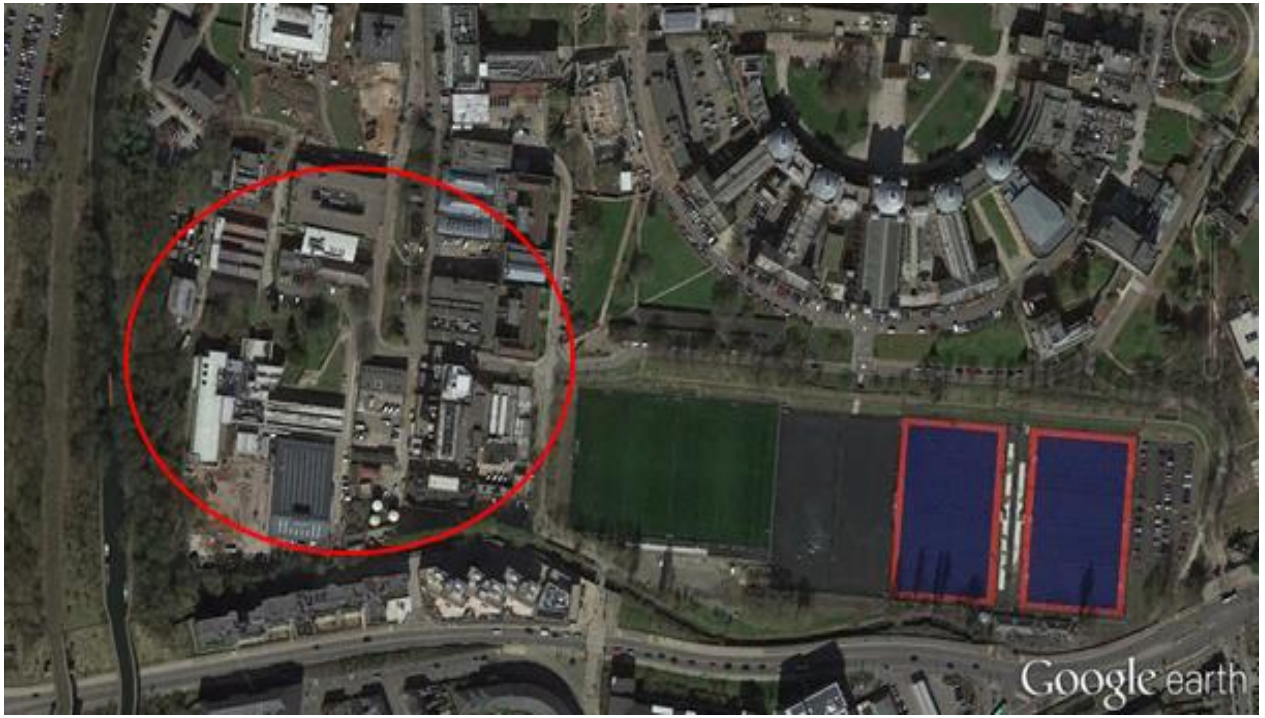
Case Study

University of Birmingham campus, UK.

- Real borehole records used from the ground investigations conducted in the area.



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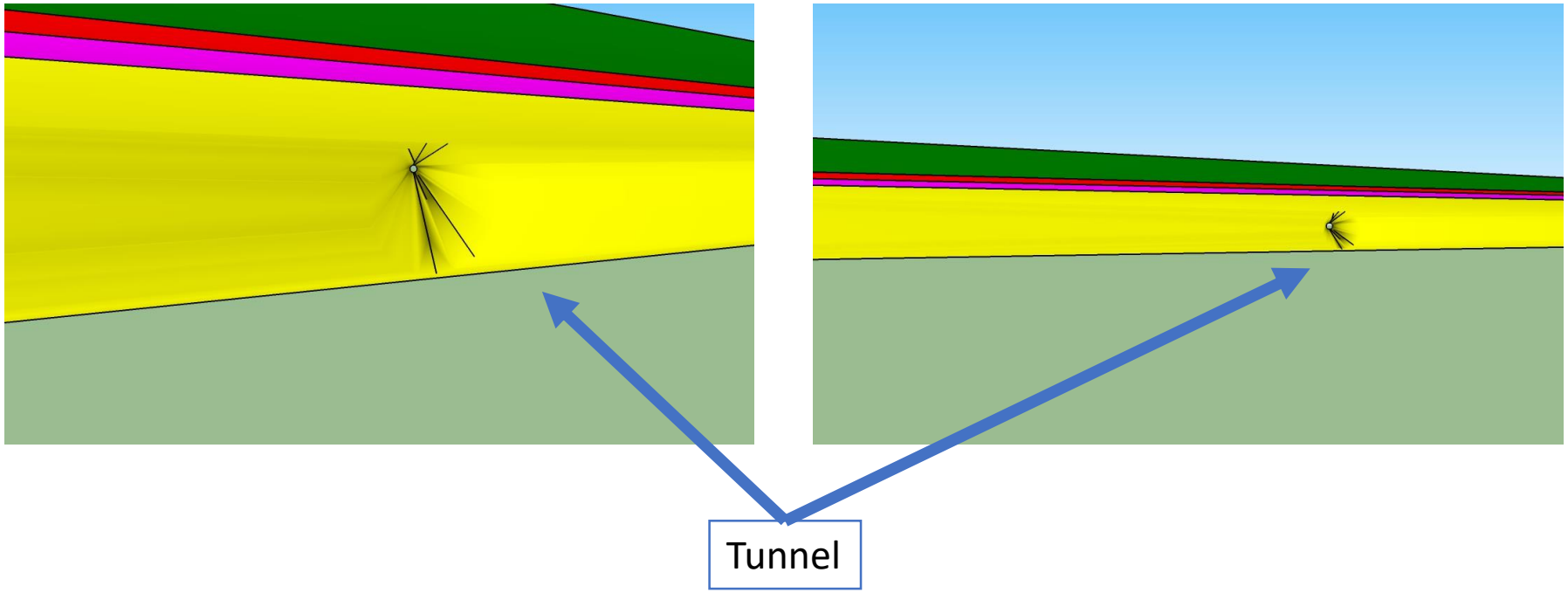
BIM visualisations



Visualisations of the 3D geology and the tunnel adopted in the BIM framework.

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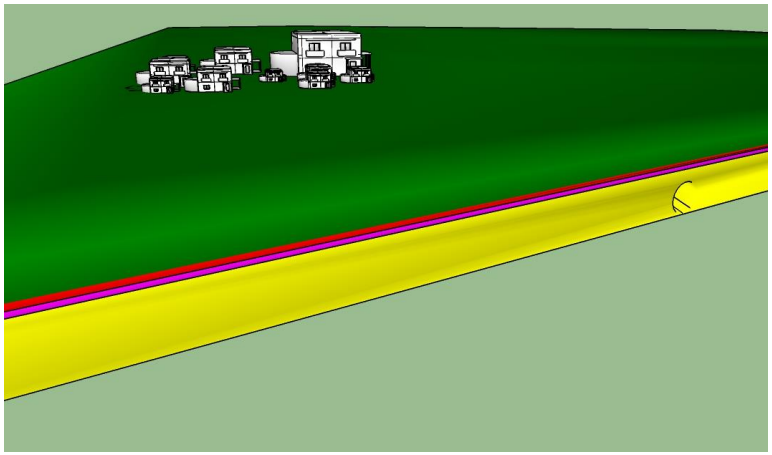
Integration with BIM

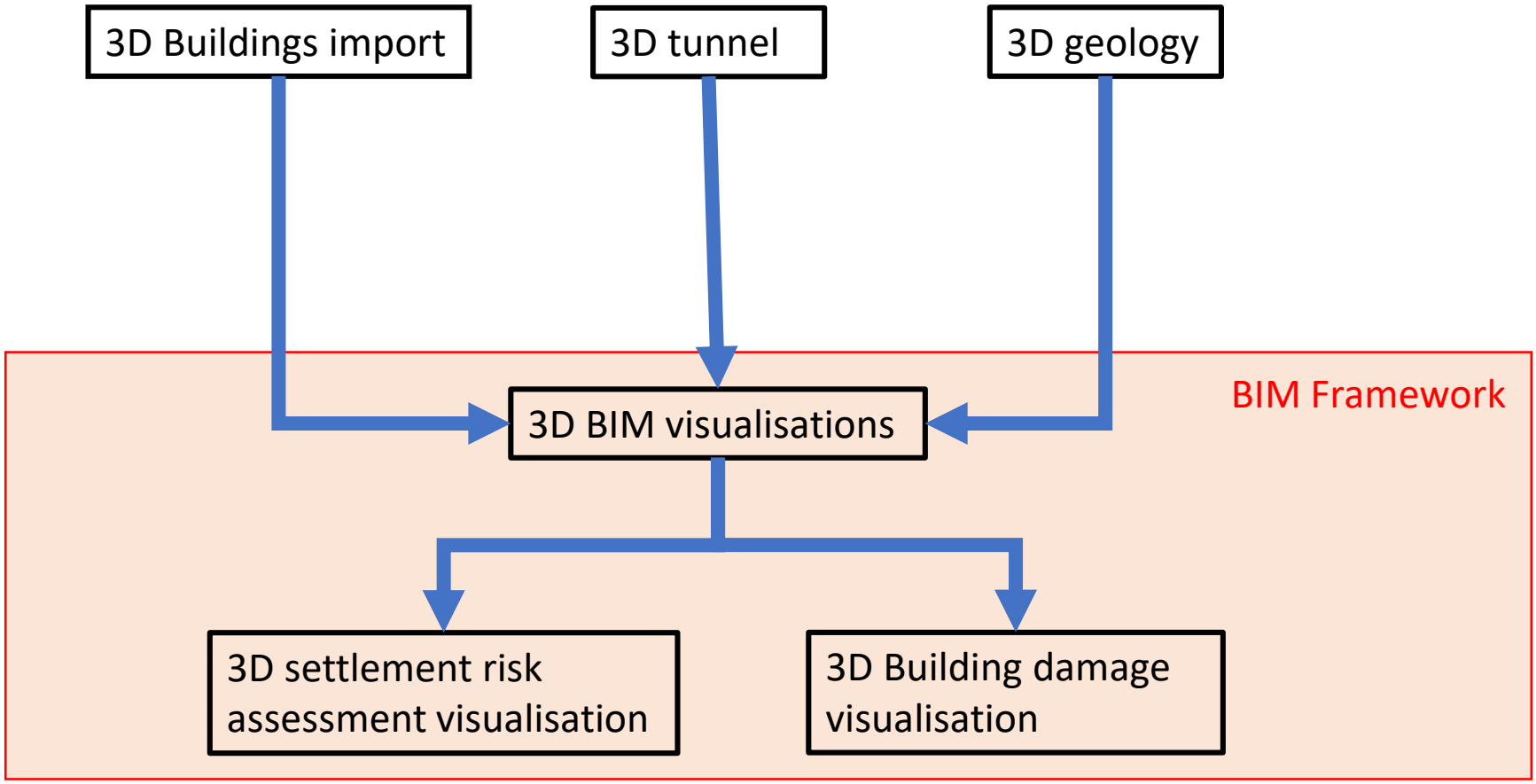
Case Study: Southwest part of the University of Birmingham campus, UK.

1) Building additions.



2) The georeferenced buildings added to the BIM model (including the 3D geology and the tunnel).

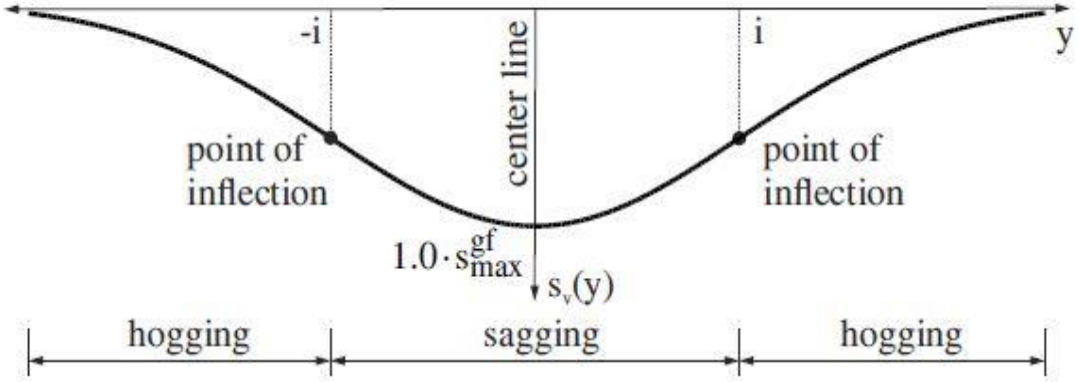
Integration with the BIM Framework



Ground settlement risk assessment

Risk Assessment method:

- Tunnelling-induced ground settlement vulnerability of adjacent buildings.
- Focus of this study on the integrated 3D visualisations.



The transversal ground settlement trough profile (adapted by Attewell et al. (1986) and Mair et al. (1996)).

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Example building risk assessment

Building damage classification After Burland (1995), and Mair et al (1996)					Approximately equivalent ground settlement and slopes (after Rankin 1988)	
1	2	3	4	5	6	7
Risk Cat	**Description of degree of damage**	**Description of typical and likely forms of repair for typical masonry buildings**	**Approx. crack width (mm)[1]**	**Max. tensile strain %[2]**	**Max. slope of ground[3]**	**Max. settl. of building (mm)[3]**
3	Moderate	Cracks may require cutting out and patching. Recurrent cracks can be masked by suitable linings. Brick pointing and possible replacement of a small amount of exterior brickwork may be required. Doors and windows sticking. Utility services may be interrupted. Weather tightness often impaired.	5 to 15 or a number if cracks greater than 3	0.15 to 0.3	1:200 to 1:50	50 to 75

Building risk assessment

Stage 1: Settlement and slope assessment risk classification from the table:

- 0 (negligible) – 5 (severe)

Stage 2: Damage assessment for the buildings of "moderate" to "high" risk rating from Stage 1:

- From horizontal, bending and shear strains on the building.
- Hogging – sagging footprint from the settlement trough.

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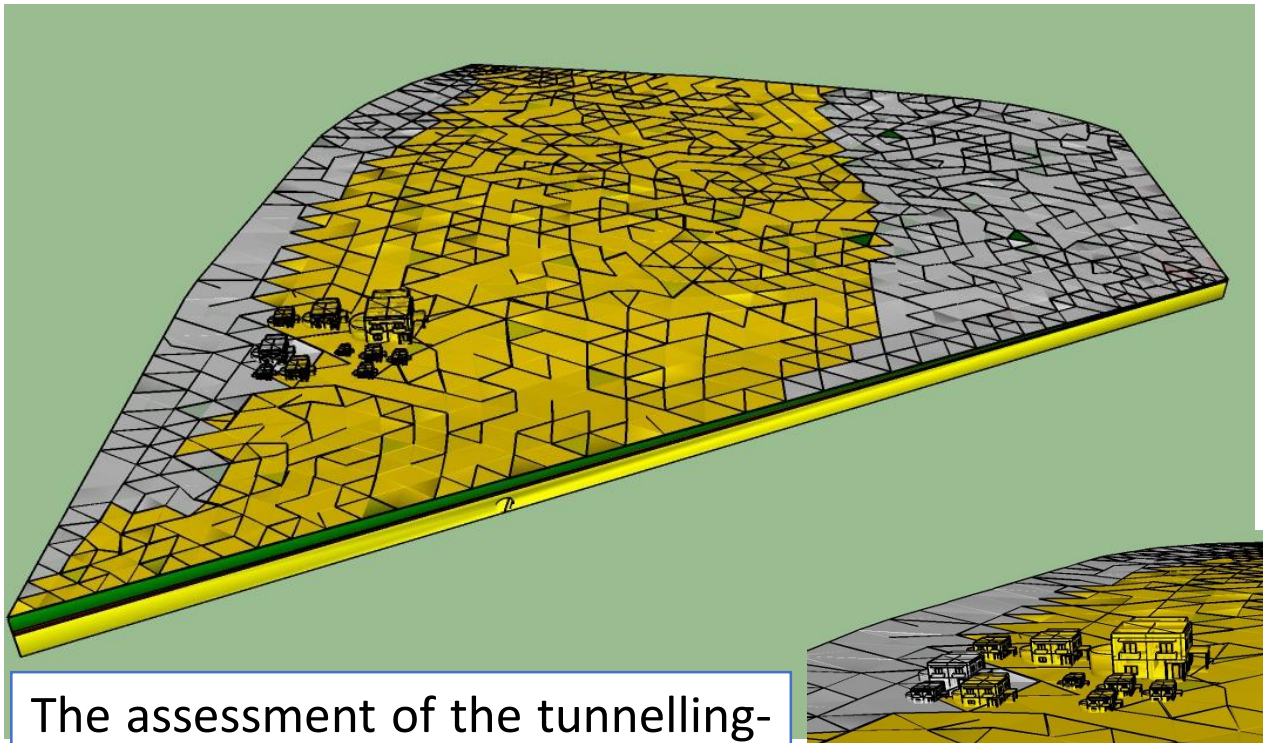
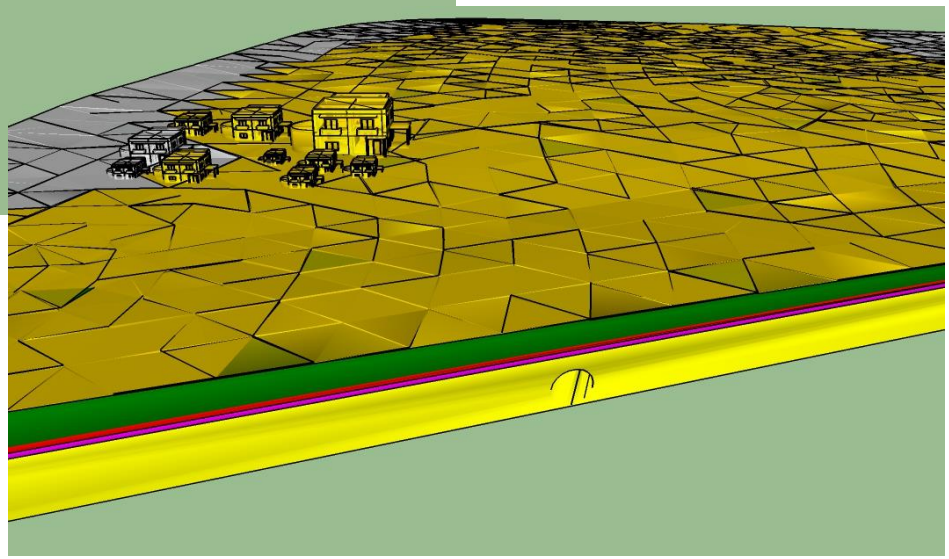
BIM visualisations – Risk assessment



RISK	COLOUR
1. Low	Grey
2. Moderate	Yellow
3. High	Red



The assessment of the tunnelling-induced settlement susceptibility on adjacent buildings using the settlement trough method is presented in BIM. The 3D geology and buildings are also presented.

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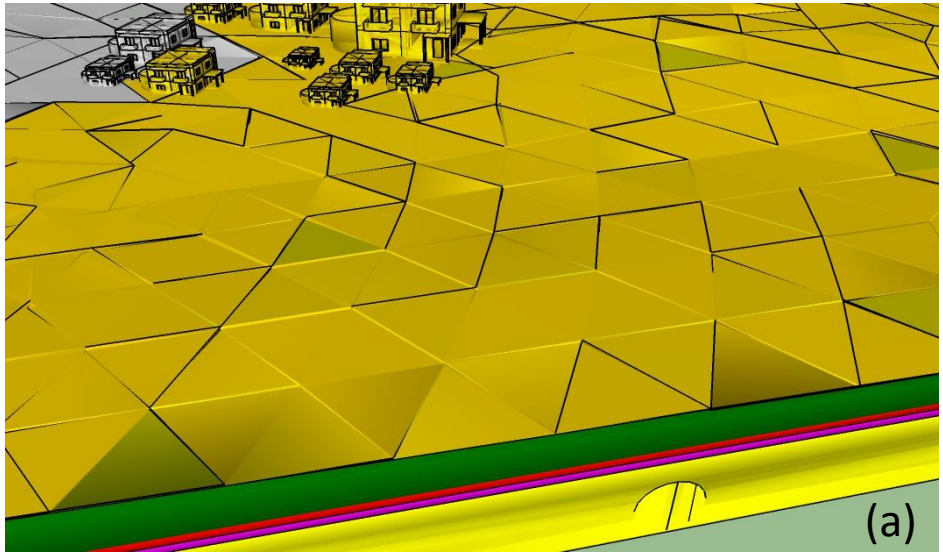
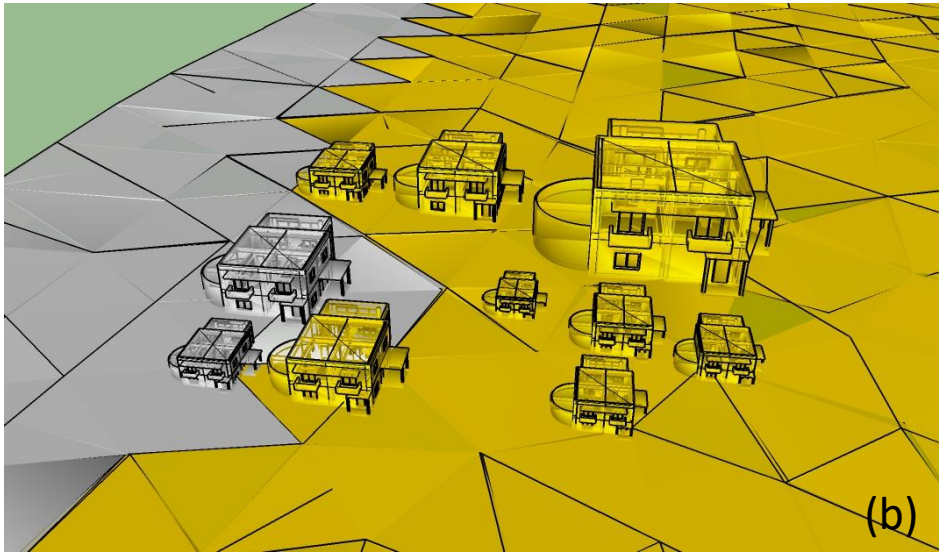
BIM visualisations – Risk assessment





RISK	COLOUR
1. Low	Grey
2. Moderate	Yellow
3. High	Red

Visualisations of the settlement effects on adjacent buildings, focusing on: (a) the tunnel and (b) the building damage assessment.

Conclusions

An integrated tool for assessing risk to adjacent buildings from tunnel induced ground settlement is presented. Key points:

- Integration with BIM to be used as an assessment tool.
- Ground information incorporated into BIM.
- Application of Georeferenced modelling and visualisations.
- 3D visualisations for better understanding of the risks associated with tunnelling in urban areas.
- Ground Investigations alignment.
- Leading to more sustainable urban planning and decision-making.

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Thank you for your attention!