Dynamic behaviour of a shallow cut-and-cover tunnel adjacent to a nearby building in liquefiable ground

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Background & Objectives

The development of underground tunnelling in urban areas has become more frequent, due to the growth of demand of space for utility and railway transportation in congested urban spaces. **Shallow cut-and-cover tunnels** are preferred as these are cheaper to build and technologically more straight forward to construct. However, these shallow tunnels can be close to the **foundations of existing structures** in an complicated urban environment.

This research aims to investigate the **floatation mechanism** of a shallow cut-and-cover rectangular tunnel, and the **dynamic interaction** between the tunnel, soil, and nearby building foundation under the **liquefiable sandy ground** during a **strong earthquake**

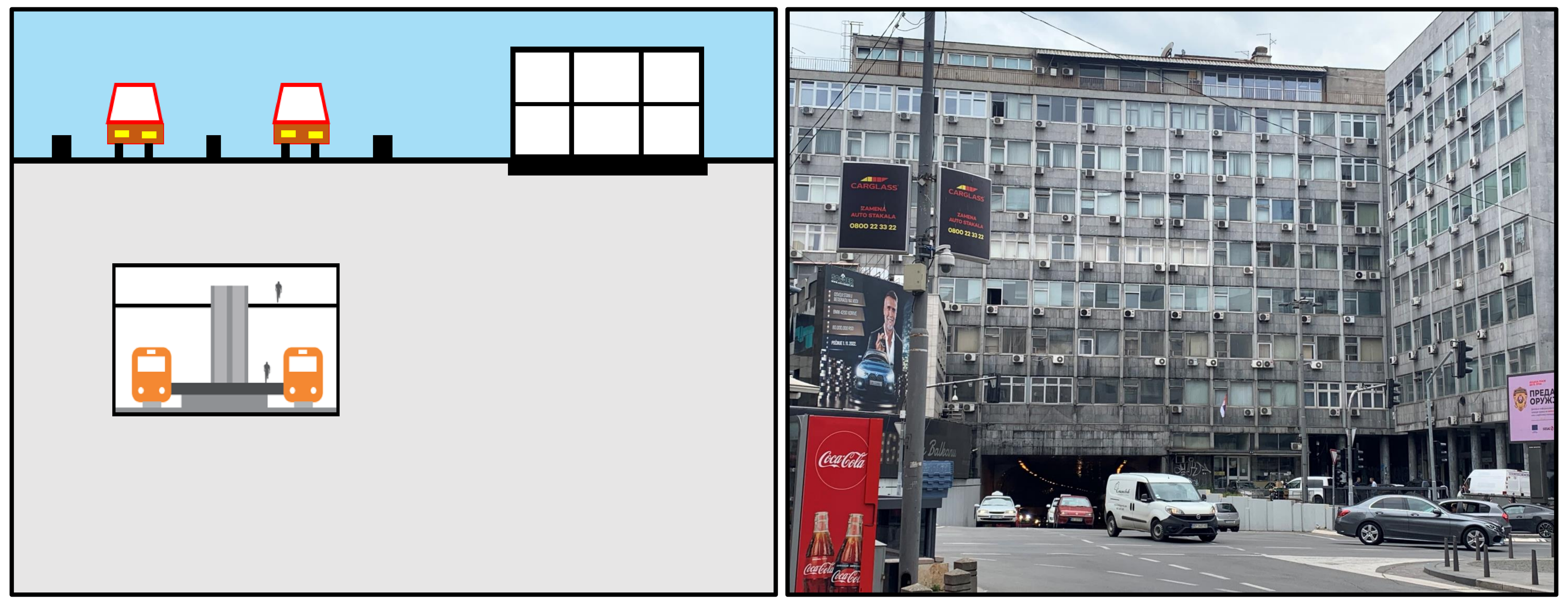

Figure 1. a) Typical geometry of the tunnel – structural interaction problem; b) A rectangular motorway tunnel under a wide residential building at Belgrade, Serbia

Methodology: Centrifuge Modelling

Geotechnical centrifuge modelling is a well-established tool to simulate similar prototype **soil non-linear stress and strain** conditions. Two dynamic centrifuge tests have been conducted at **60 g level**, on a buried rectangular tunnel **with and without a nearby building**

- Two saturated sand models were prepared with **Hostun sand** with a target relative density of **40 %**
- Input motion**: 1 Hz, 10 cycle** with **PGA** of **0.2 g**
- **Duxseal** blocks were placed on both boundary to **reduce wave reflection**
- The transparent Perspex of the container allowed for adopting the **Particle Image Velocimetry (PIV)** technique in the analysis**.**

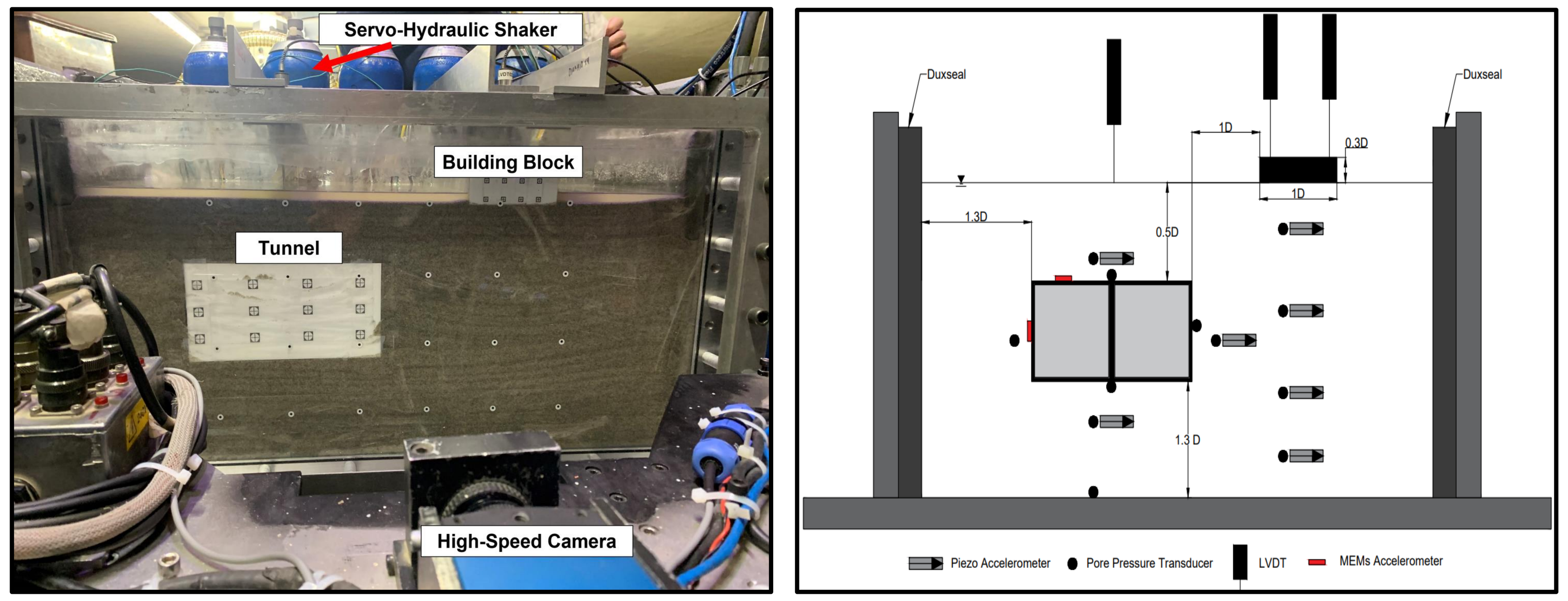

Figure 2. a) Completed model of test with building before spinning; b) Typical centrifuge model layouts

Results: Dynamic Soil Response

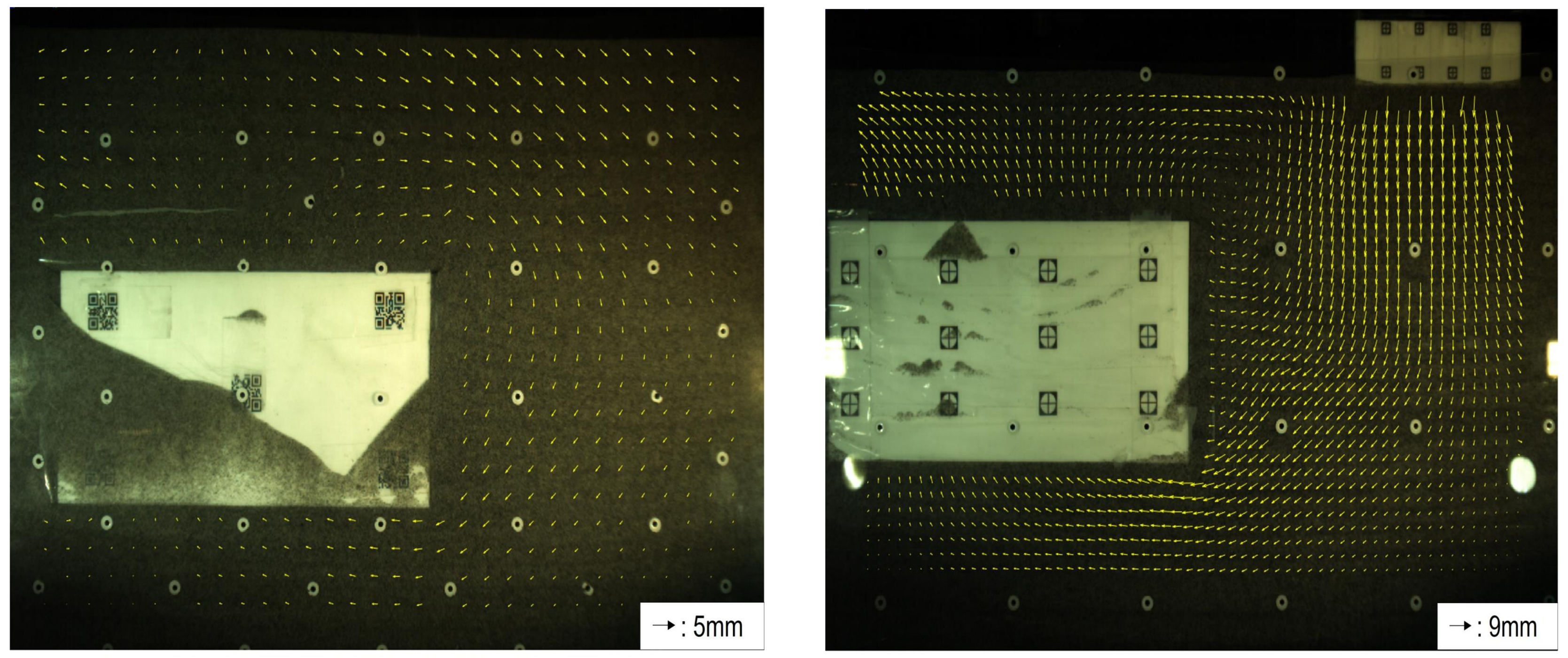

Figure 3. Traces of soil displacements vector in the saturated soil (Model scale), a) without building, b) with building

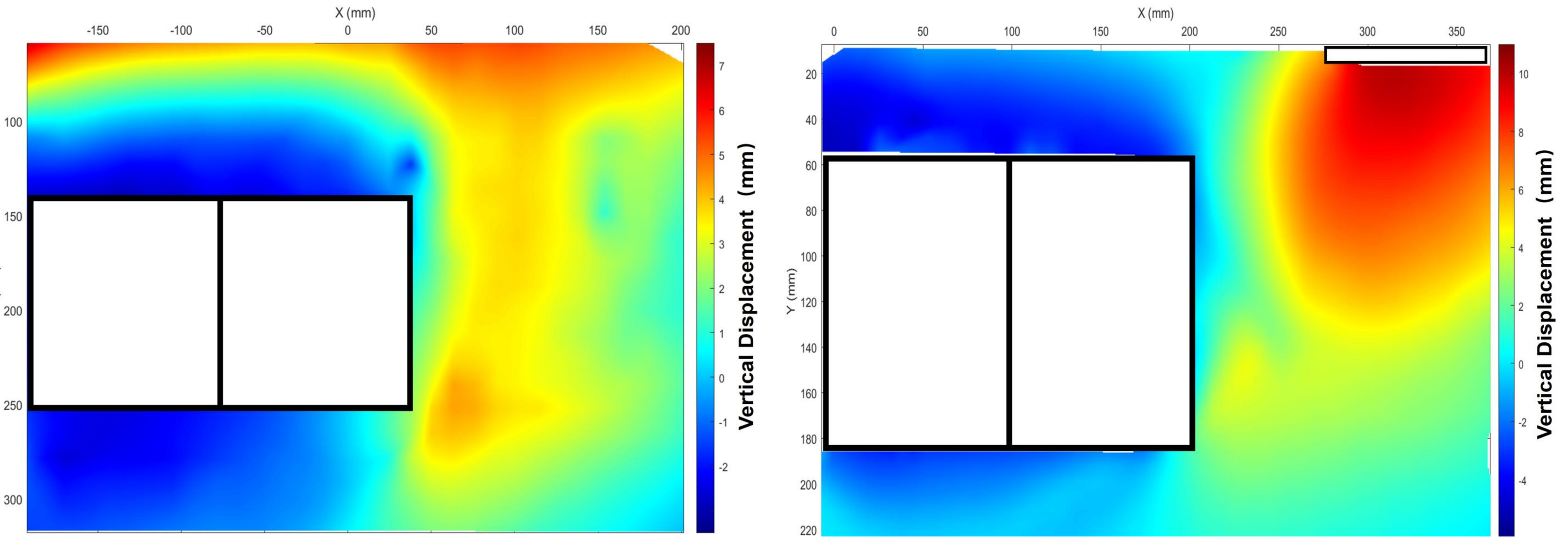

Figure 3. Vertical displacement in the saturated soil (Model scale, positive as settlement), a) without building, b) with building

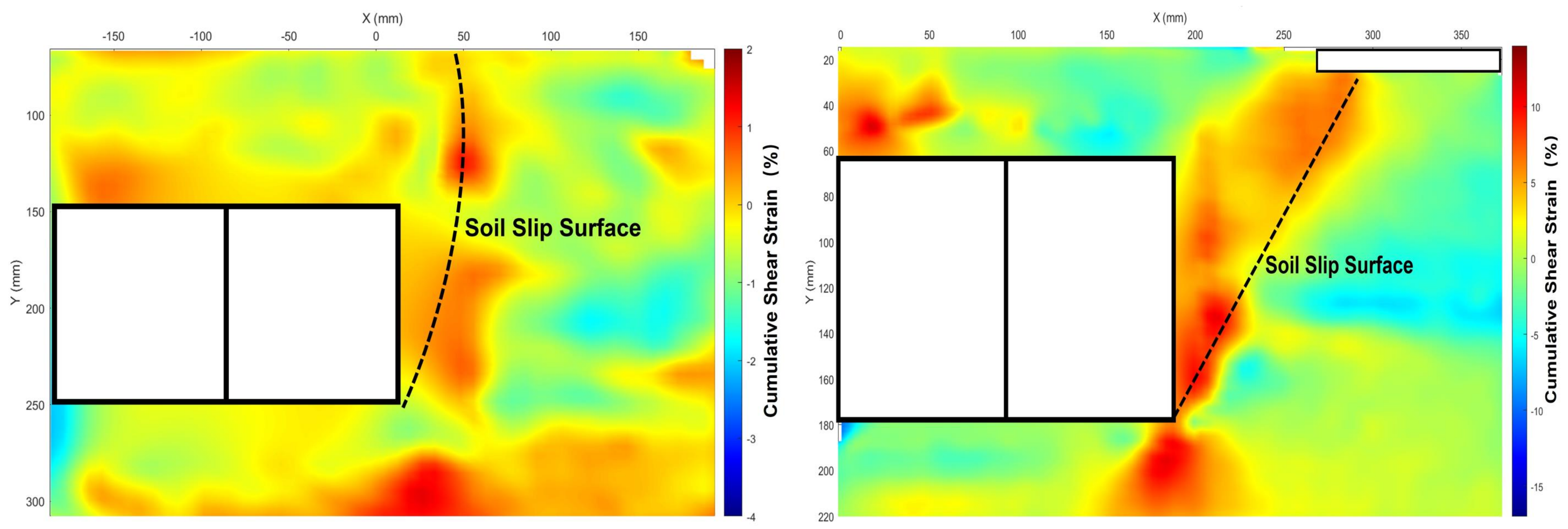

Figure 4. Cumulative shear strain contour in the saturated soil after 4 cycles of shaking (Positive as clockwise), a) without building, b) with building

Results: Dynamic Tunnel Response

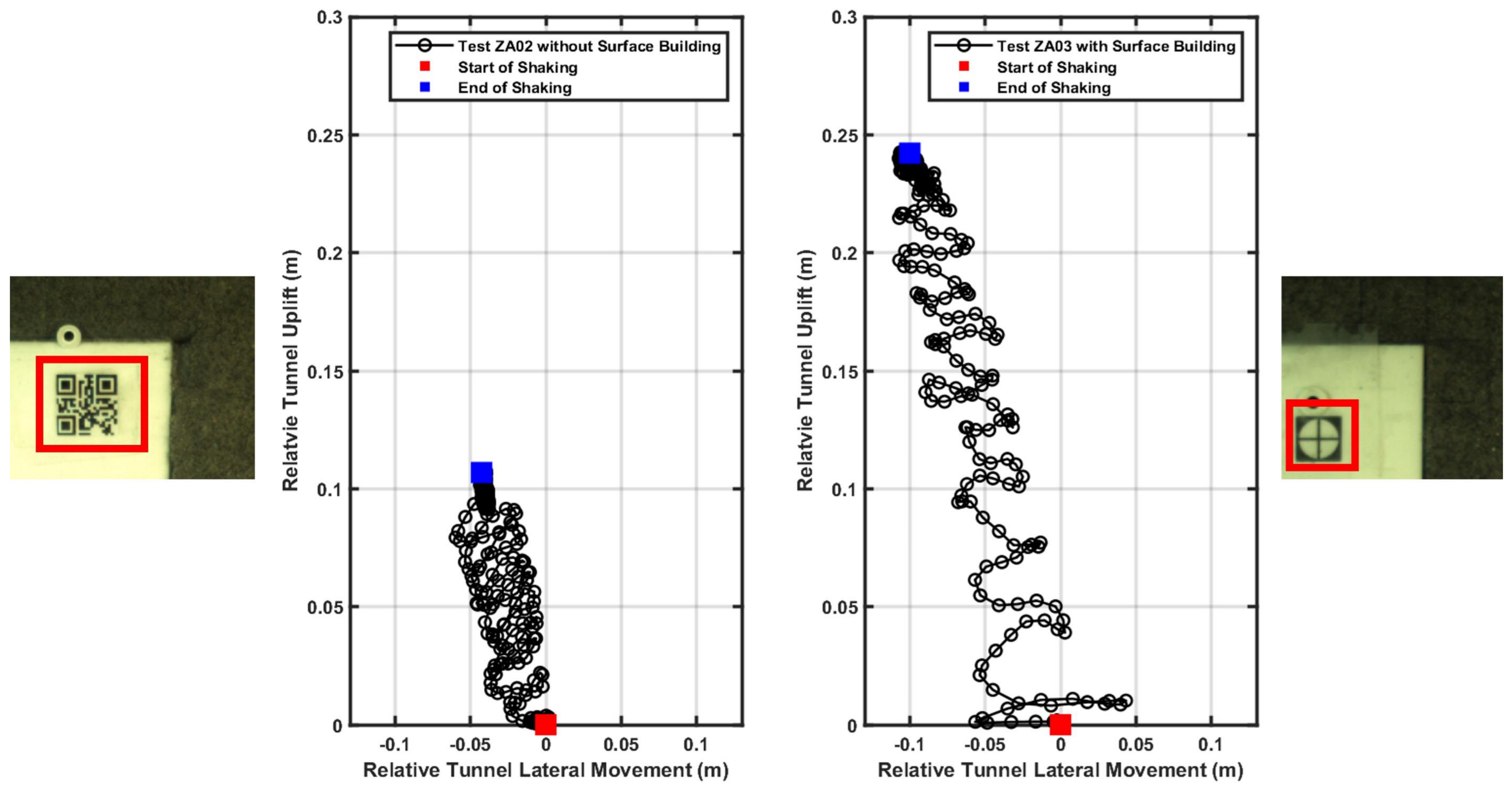

Figure 5. Relative tunnel movement captured with PIV method during the input motion (Prototype scale), a) without building, b) with building

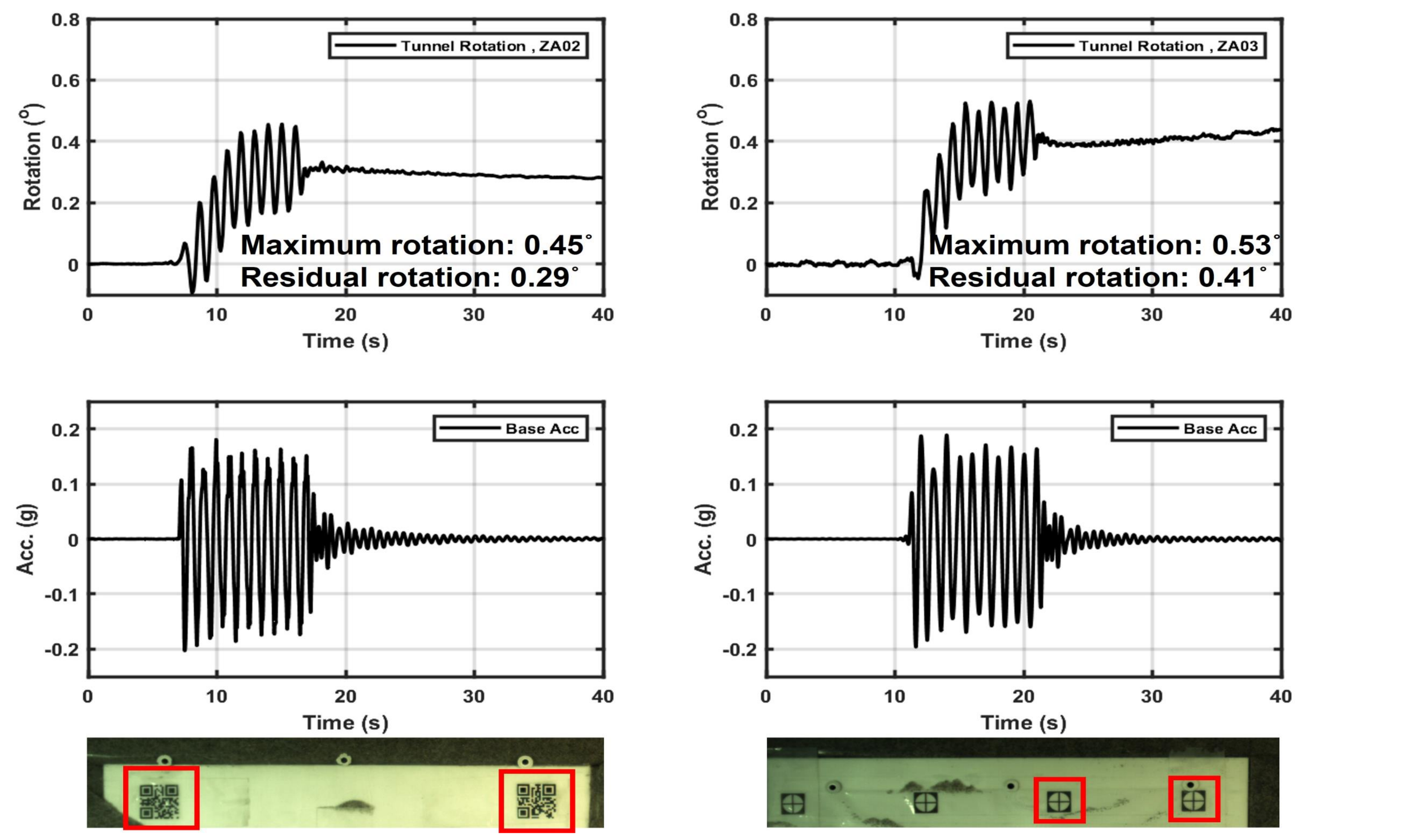

Figure 6. Tunnel rotation subjected to the input motion (clockwise as positive), a) without building, b) with building

Conclusion

- The presence of the nearby building significantly affects the soil **slip surface** during the tunnel floatation
- **More tunnel lateral movements** occurred due to the increase of the **lateral earth pressure** induced by the nearby building surcharge
- The presence of the nearby building also increases the **tunnel rotation** during and after the earthquake.

- Further research on the effect of tunnel **buried depth** and **relative tunnel-building distance** will be performed
- The numerical simulation will be validated with the centrifuge experimental results.