Dynamic behaviour of a retaining wall adjacent to a structure

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Background & Objectives

Due to increasingly congested areas in cities, the **construction of new infrastructure**, is unavoidably near existing buildings, requiring **retaining walls** to maintain **structural safety**. On the other hand, retaining walls are also needed to **prevent the damage** of the **increasing sea level** to the buildings in coastal areas.

The surcharge loading from the adjacent buildings results in **increased lateral earth pressure** on the retaining walls, posing **an increased risk** to both retaining walls and buildings, especially **during earthquakes**. However, limited research has been conducted to study the influence of the adjacent buildings on the dynamic behaviour of the retaining walls.

This research aims to study the influence of the structure on the **dynamic behaviour** and the **failure mechanism** of the retaining wall systems.

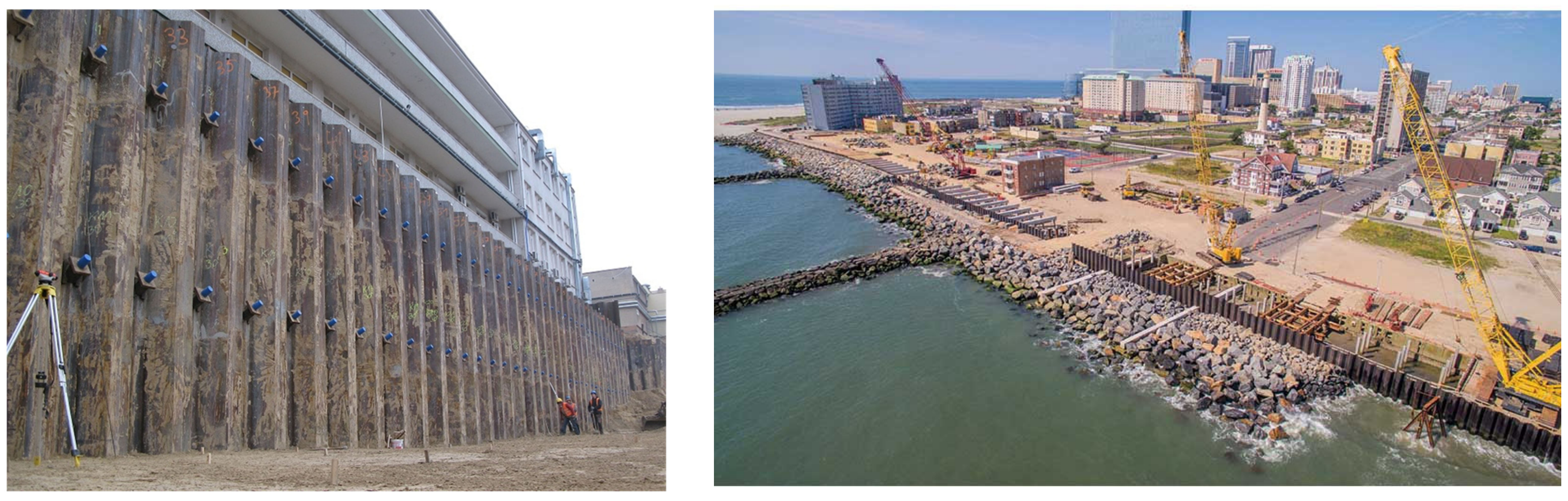


Figure 1. Applications of retaining walls near existing buildings (photo courtesy of Aarsleff Ground Engineering Ltd. and U.S. Army Corps of Engineers Philadelphia District respectively).

Methodology: centrifuge modelling

To investigate soil-structure interaction in retaining wall problems, four dynamic centrifuge tests have been conducted **at 60 g level**, on a retaining wall **with and without a structure** placed behind respectively.

- Two dry sand models and two saturated sand models were prepared with **Hostun sand** with a target relative density of **40%**.
- Some blocks made of **Duxseal** were used **to reduce wave reflection**.
- The transparent Perspex of the container allowed for adopting the **Particle Image Velocimetry (PIV)** technique in the analysis**.**

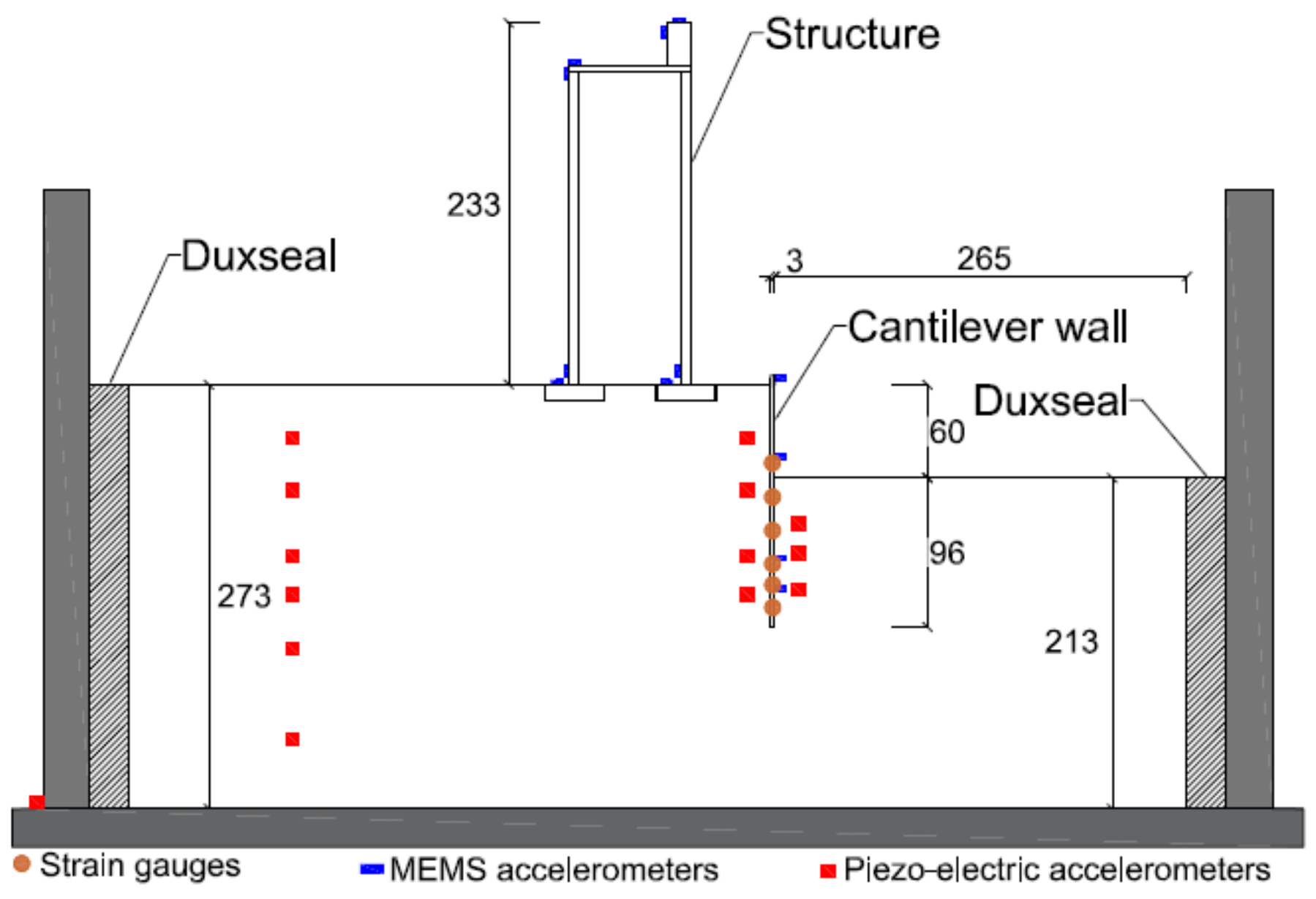


Figure 2. The centrifuge model for the 'structure' test with the dry backfill (in mm).

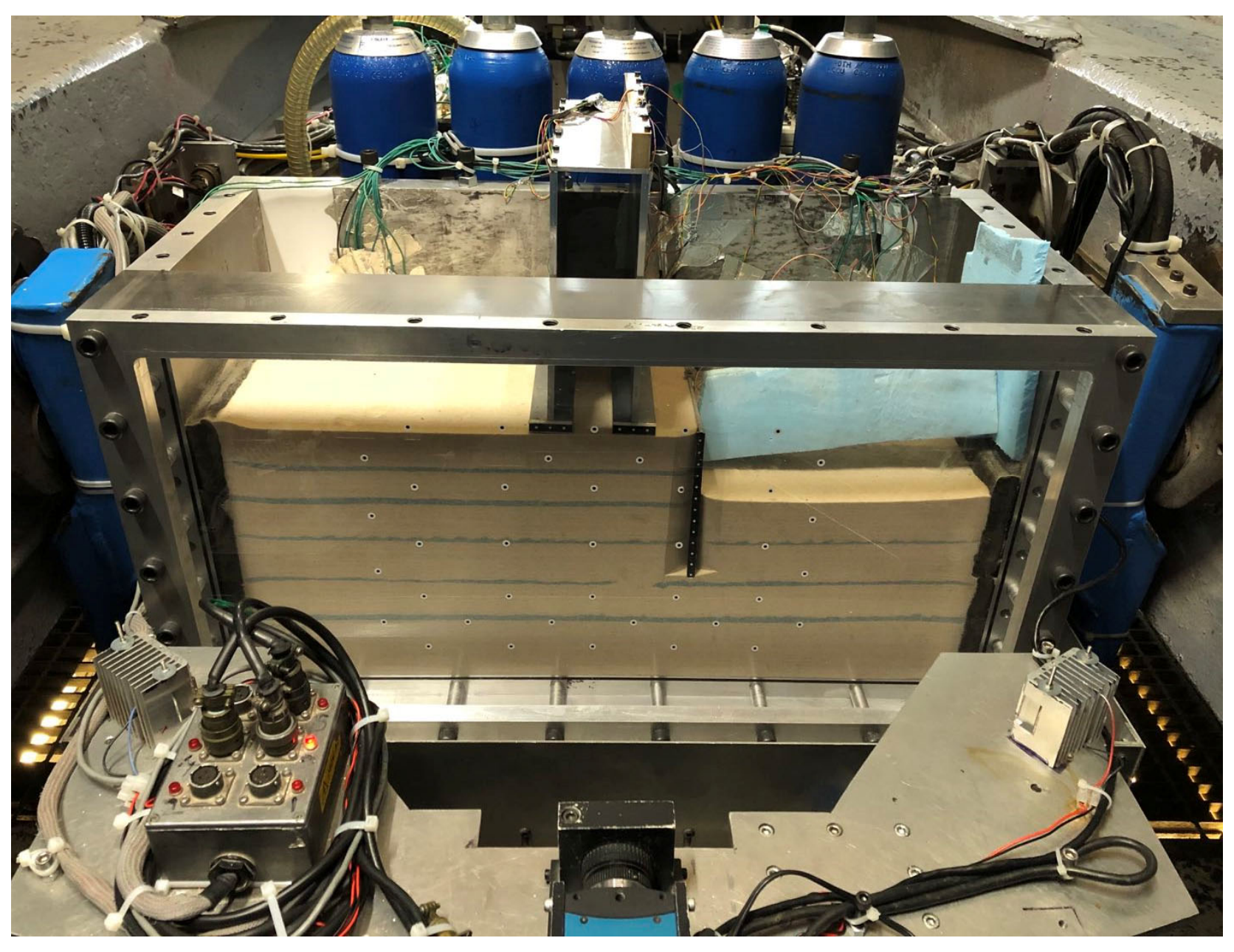


Figure 3. Set-up of a centrifuge model.

Methodology: numerical modelling

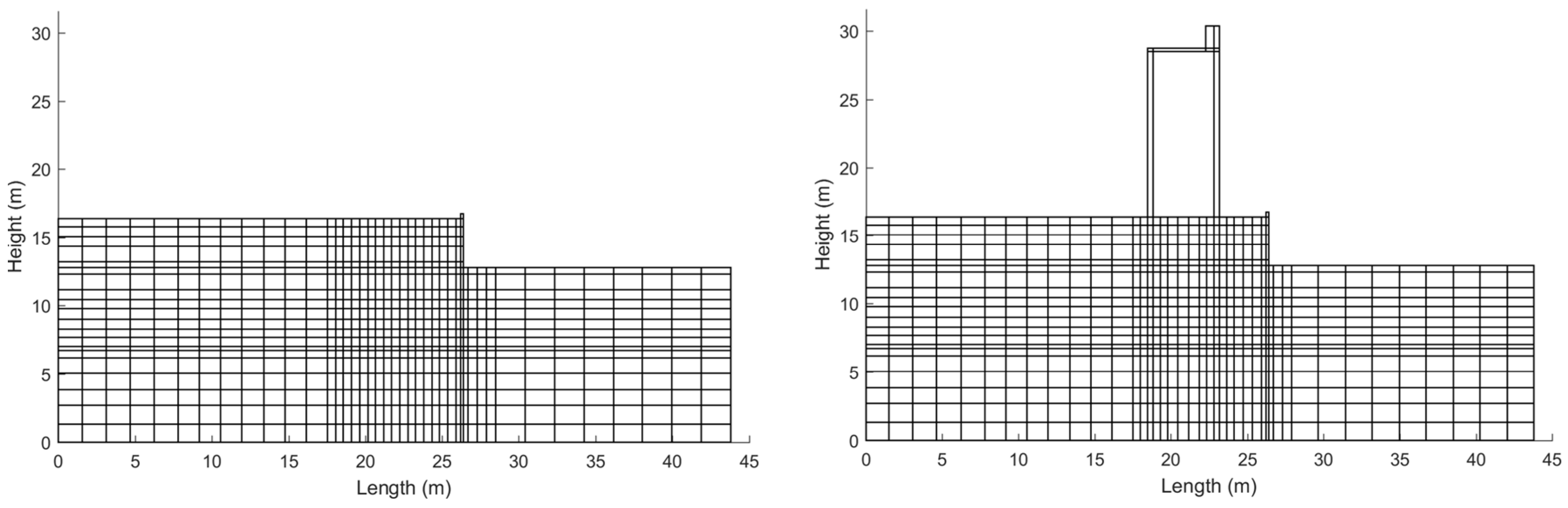
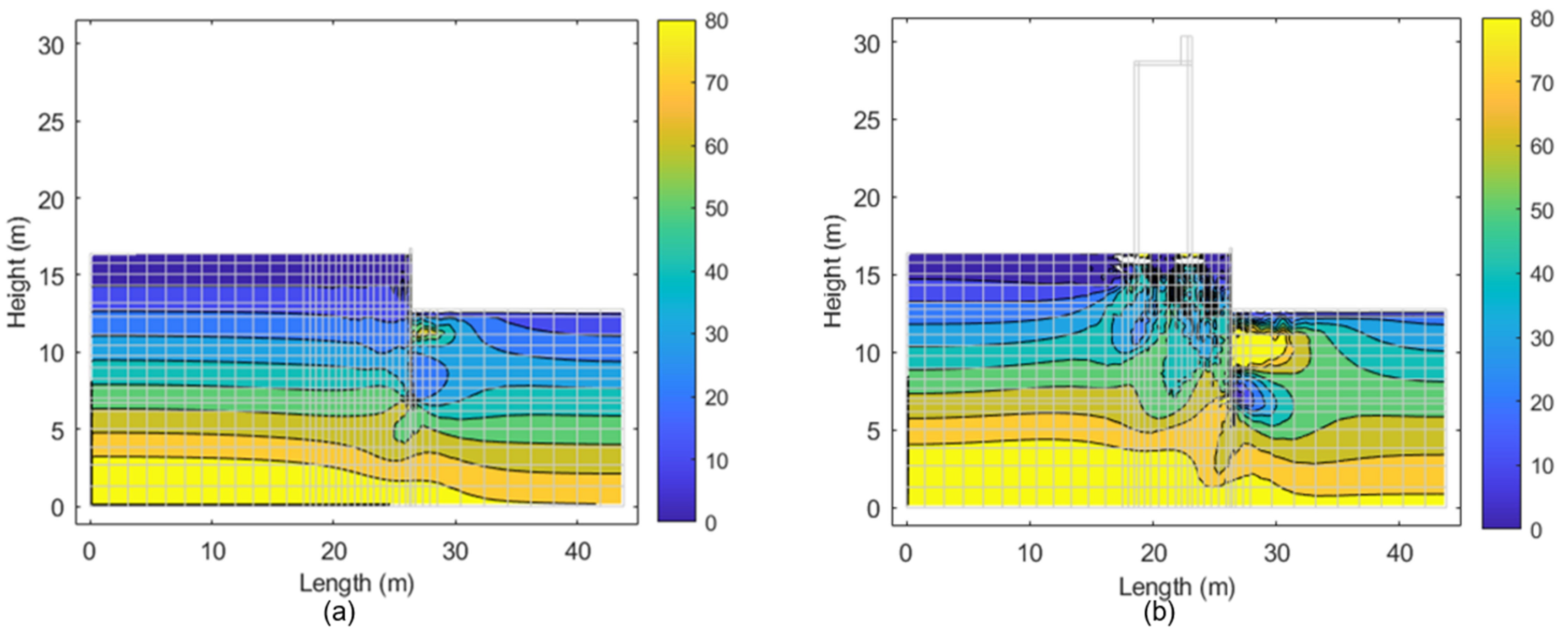


Figure 4. Two numerical models established with Swandyne (Chan, 1988) for dry backfill cases (Guan & Madabhushi, 2020).

Table 1. Details of constitutive parameters for preliminary analysis with numerical modelling (Guan & Madabhushi, 2020).

Parameter	Value			Definition
	Dry sand	Interface elements	Structure/Retaining wall	
Constitutive model	Mohr-Coulomb V	Slip	Elastic	Type of constitutive model used
Young's modulus	50 MPa	50 MPa	70 GPa	Soil stiffness for static equilibrium
Young's modulus (dynamic)	50 MPa	50 MPa	70 GPa	Soil stiffness for damping in dynamic analyses
Poisson's ratio	0.3	0.3	0.15	Links strains in horizontal and vertical directions
Uniaxial yield stress	100 Pa	-	-	Cohesion
Friction angle (critical state)	30º	16.4º	-	To obtain critical state failure line
Dilatancy angle	2º	-	-	To obtain the peak friction angle
Work-hardening modulus	100	-	-	The slope of the stress vs yield strain
Void ratio	0.8	-	-	For the calculation of material density

Results: static analysis (numerical)



(a)　(b)

Figure 5. Horizontal stresses in the dry sand for: (a) the 'no structure' case; (b) the 'structure' case (Guan & Madabhushi, 2020).

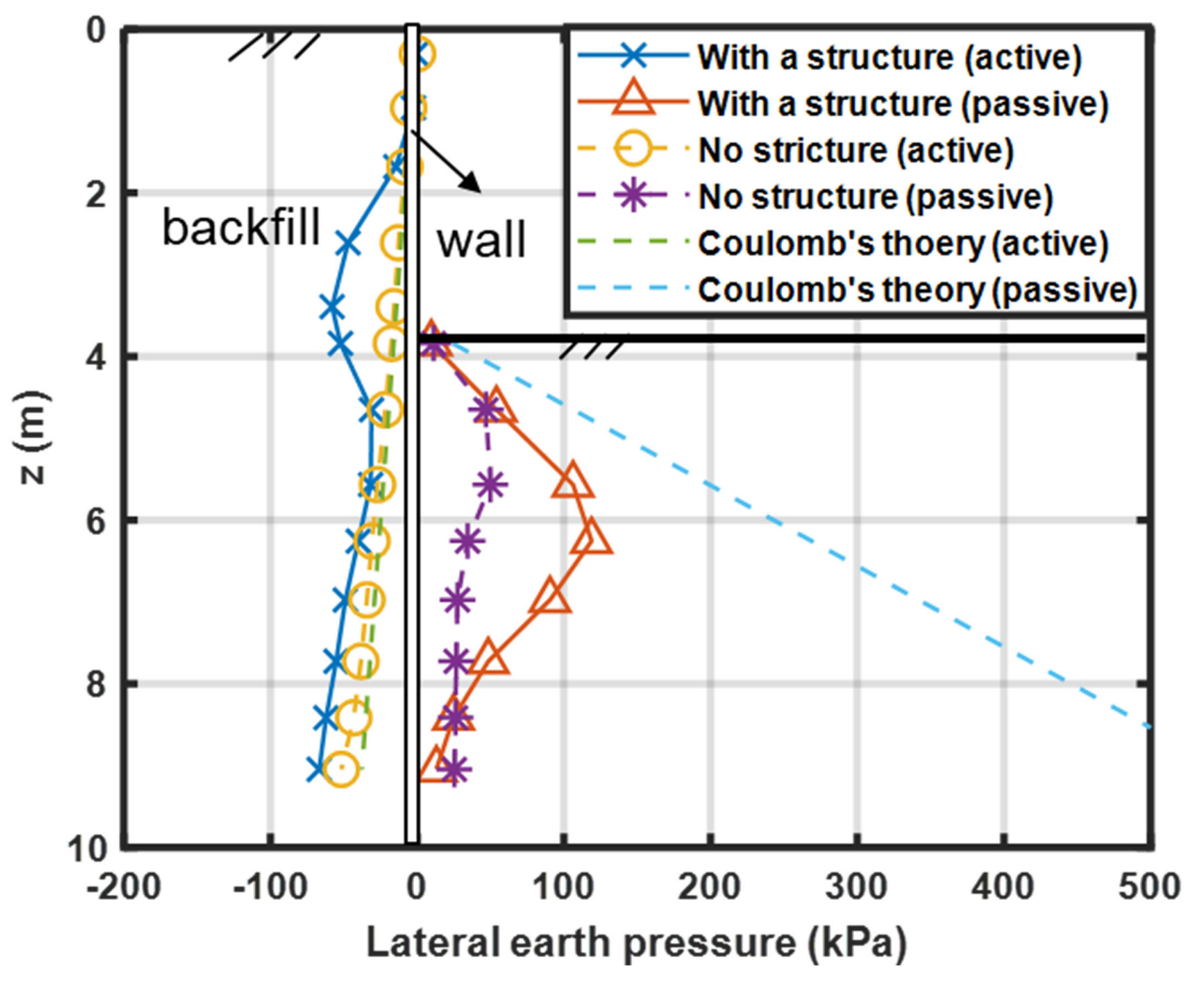


Figure 6. Lateral earth pressures on the wall.

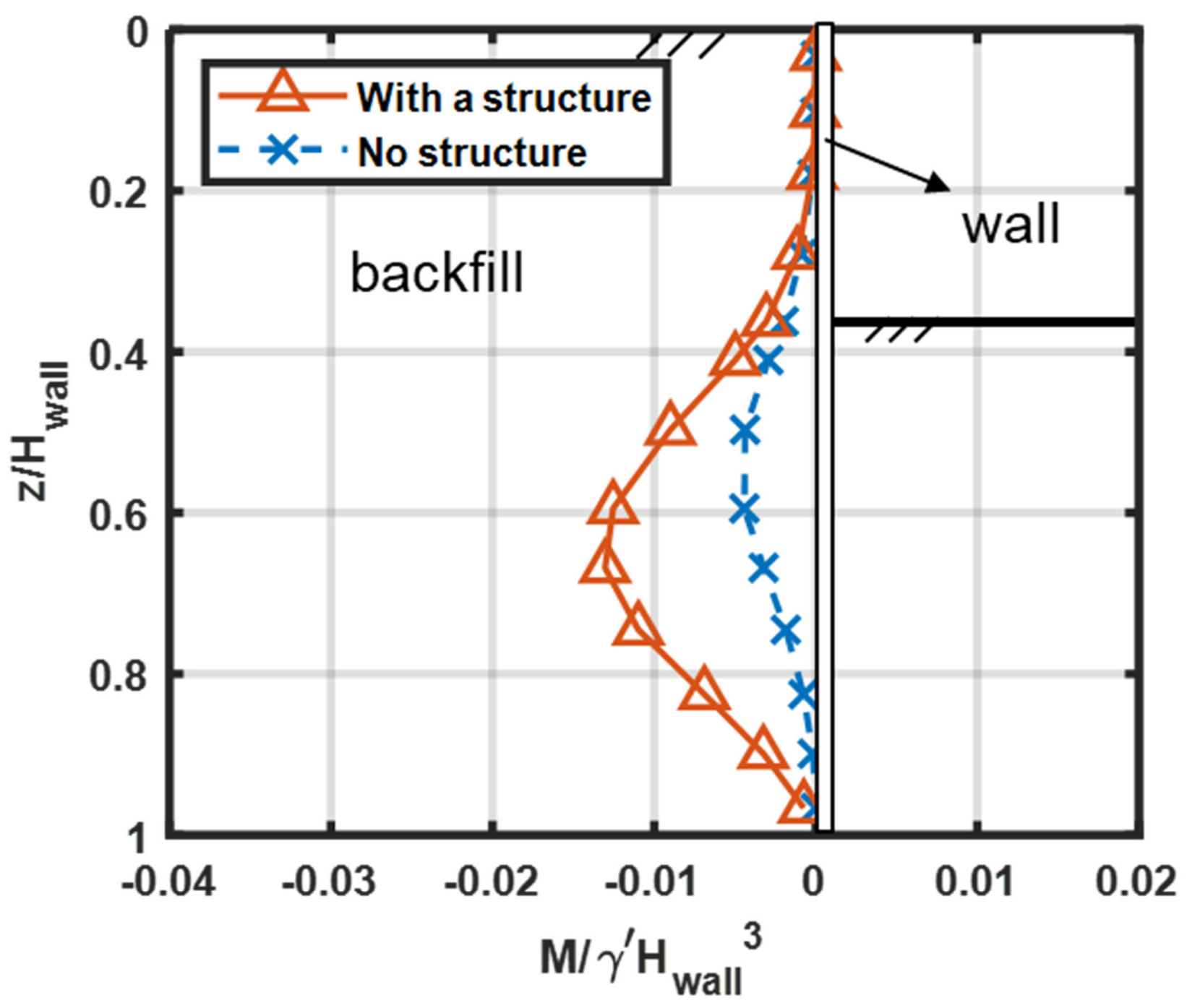
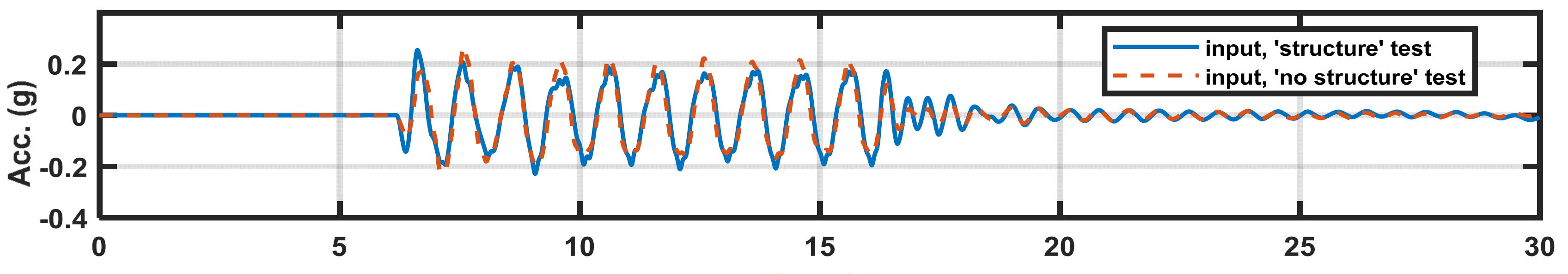
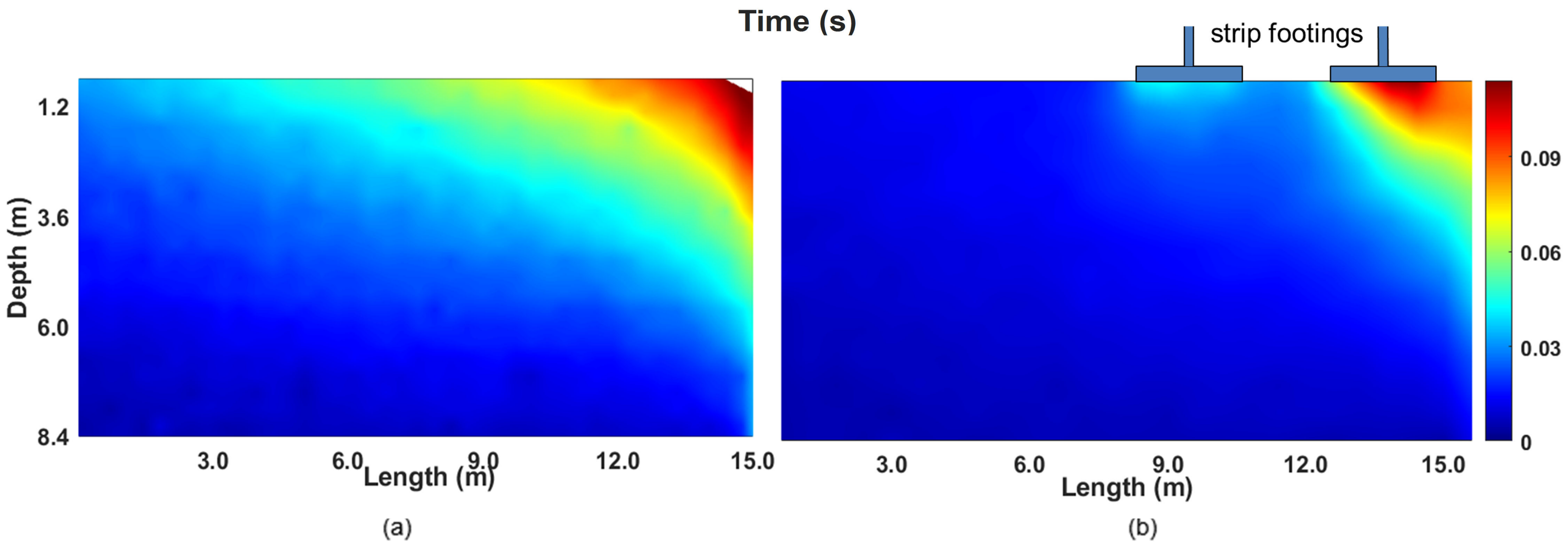


Figure 7. Wall bending moments before earthquakes.

Results: dynamic analysis (experimental)





(a)　(b)

Figure 7. Total displacements of dry backfill during a strong earthquake loading EQ4: (a) in the 'no structure' test; (b) in the 'structure' test.

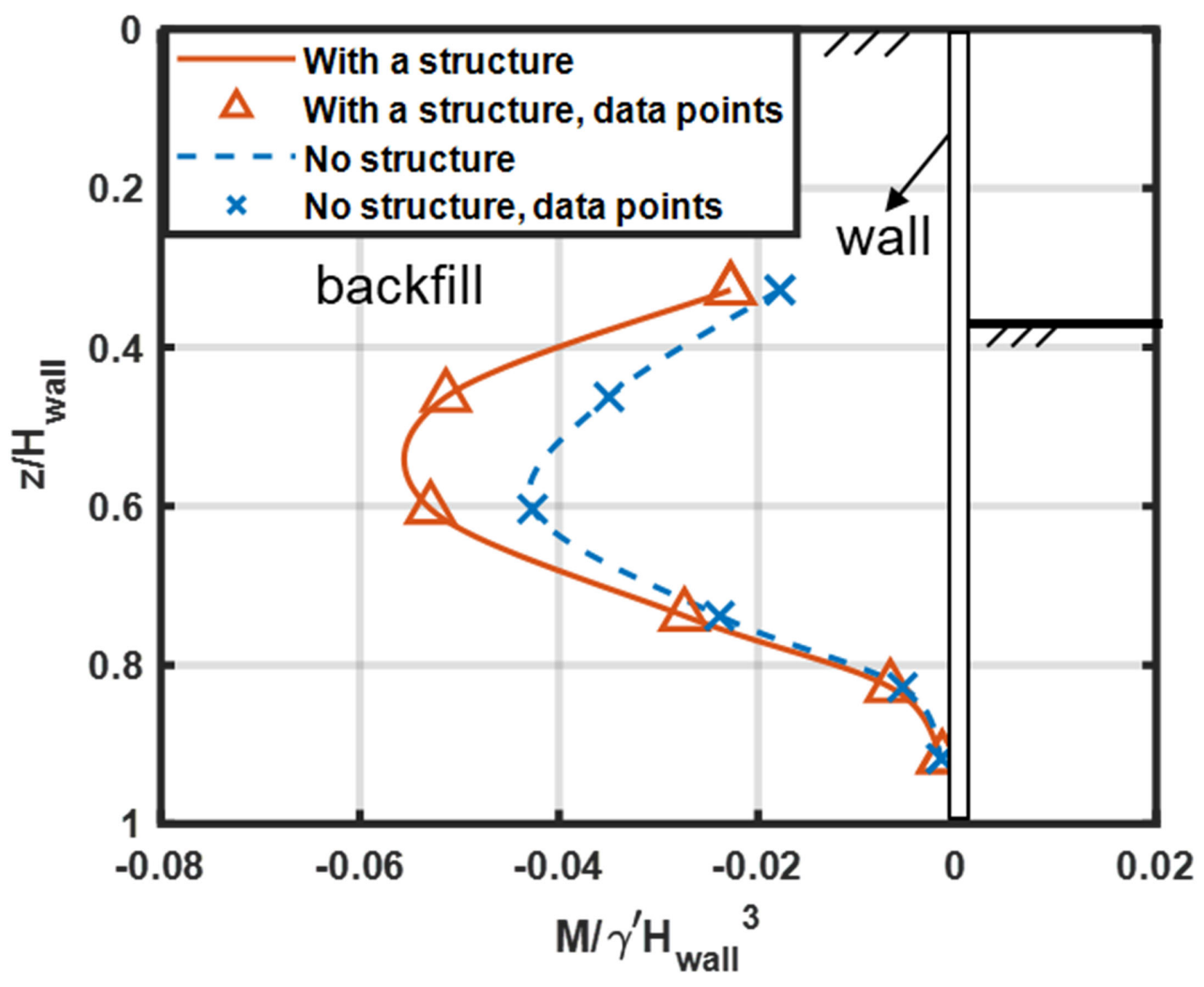


Figure 8. Bending moment envelopes during EQ4.

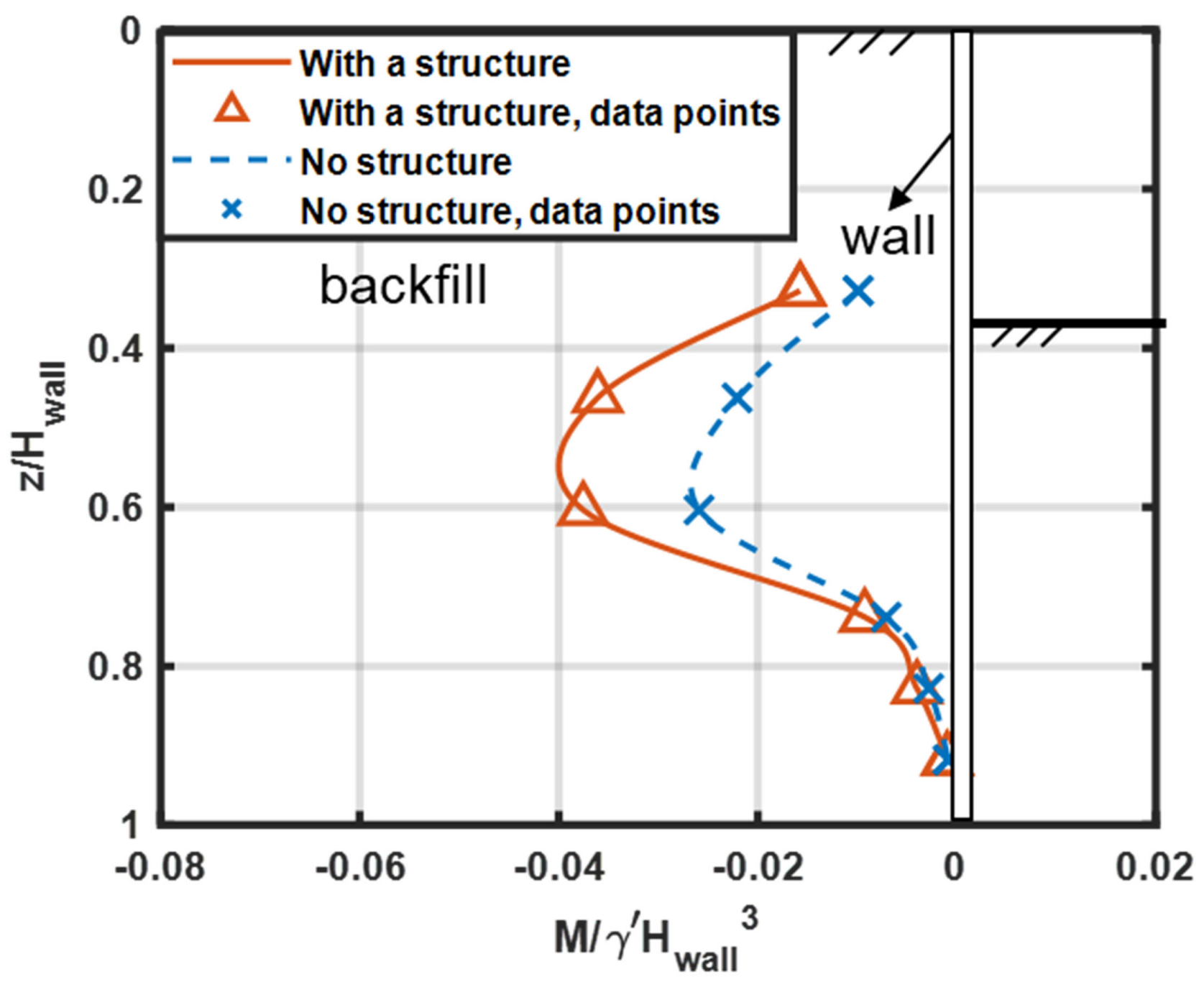


Figure 9. Residual bending moments after EQ4.

Conclusions & Future work

- The structure on the backfill increases both dynamic and residual bending moments and therefore results in a higher seismic vulnerability of the retaining wall.
- The difference in the displacement field of the backfill may indicate a significant influence of the structure on the failure mode of the retaining wall.

- Further research on the failure mechanism of the retaining wall systems will be performed.
- The numerical models will be validated with experimental results.

References

[1] Chan, A. H. C. (1988). A generalised fully coupled effective stress based computer procedure for problems in Geomechanics. SWANDYNE User Manual, Swansea, UK.

[2] Guan, X., & Madabhushi, G. S. (2020). Numerical Modelling of Structures Adjacent to Retaining Walls Subjected to Earthquake Loading. Geosciences, 10(12), 486.

Acknowledgements

The financial support from China Scholarship Council and Cambridge Trust is acknowledged.