Better Zsoil，

Better Geotechnical Analysis

Comparison of Bending Moments in Basement Beams: Differential Settlement due to Soil–Piled-Raft Interaction versus Rigid Foundation

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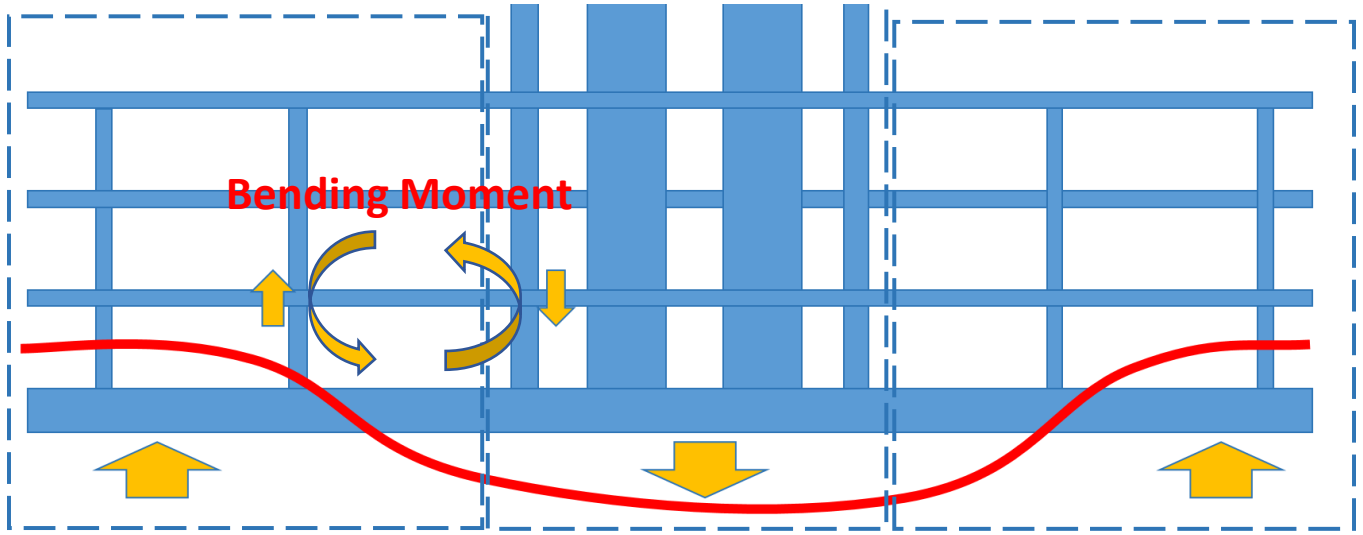
Feasibility Study on Removing Settlement Joints

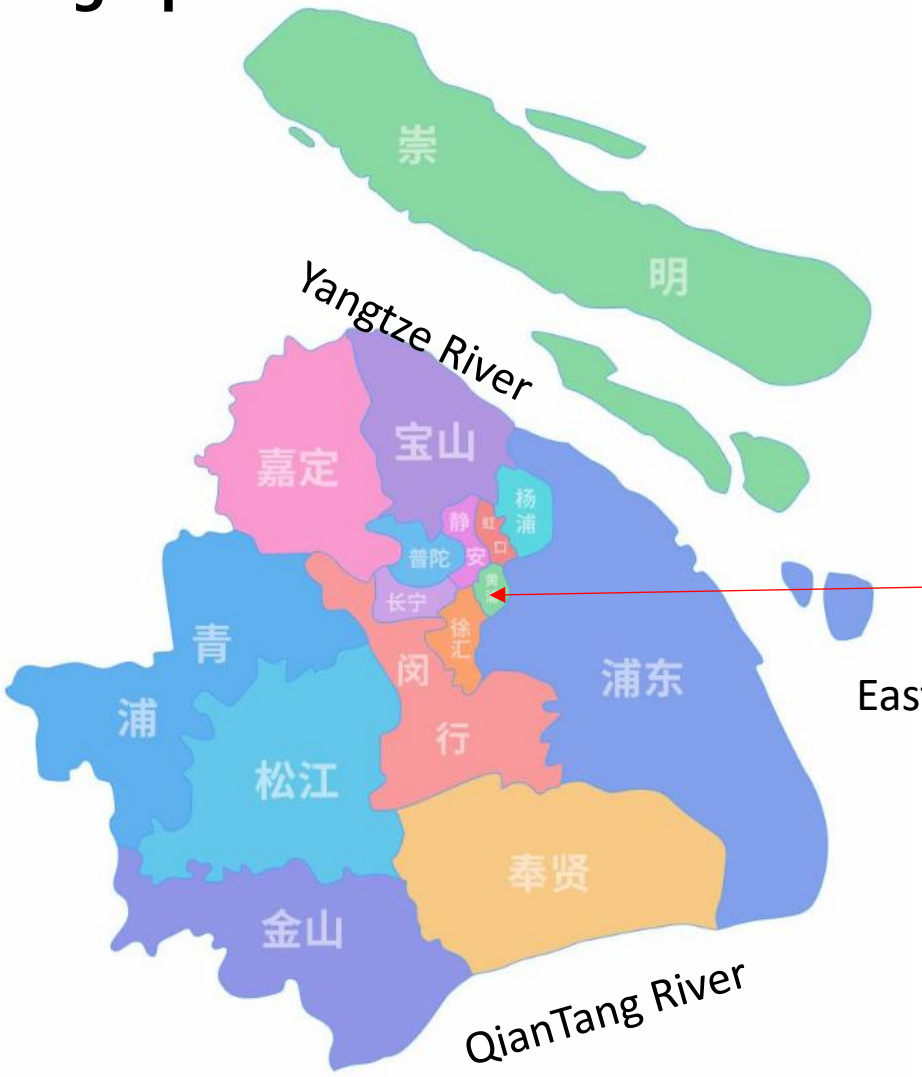


Can we remove the settlement joints between the tower and podium if the 2‰ differential settlement criterion is satisfied?

And will basement beams provide adequate flexural strength due to this differential settlement?

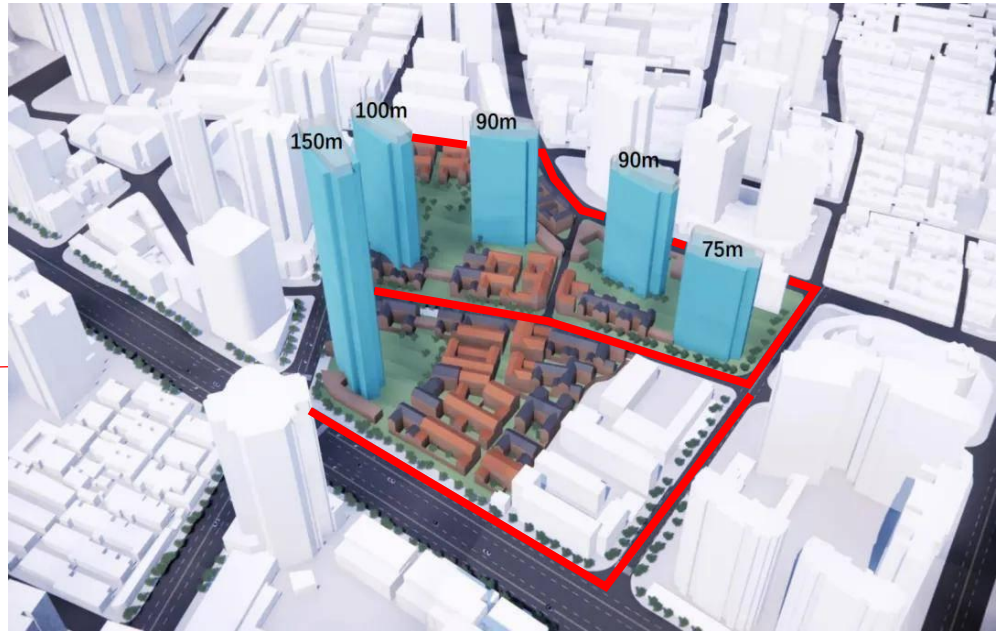
Introduction

■ Geographical location



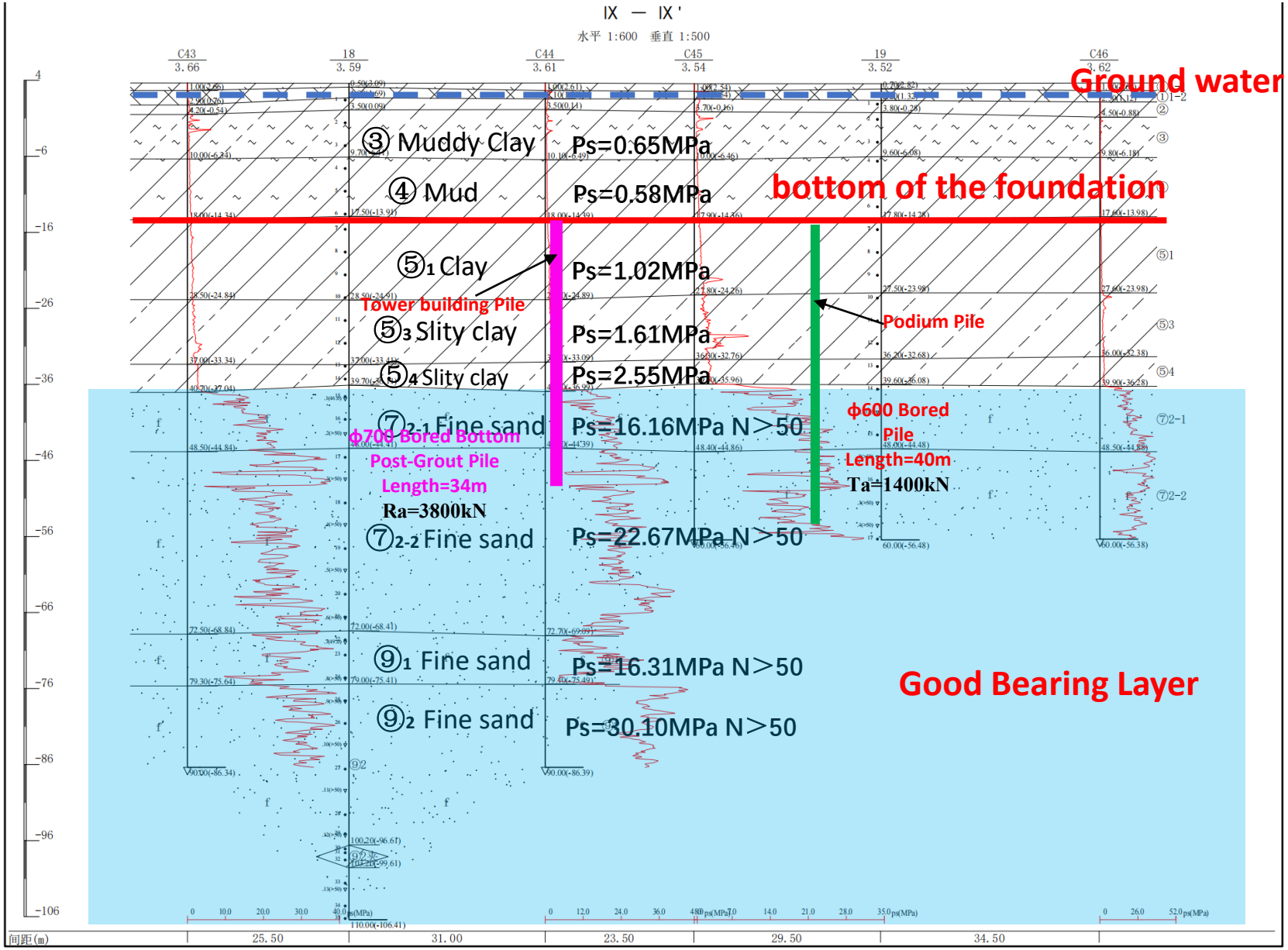
The map of Shanghai

East China Sea

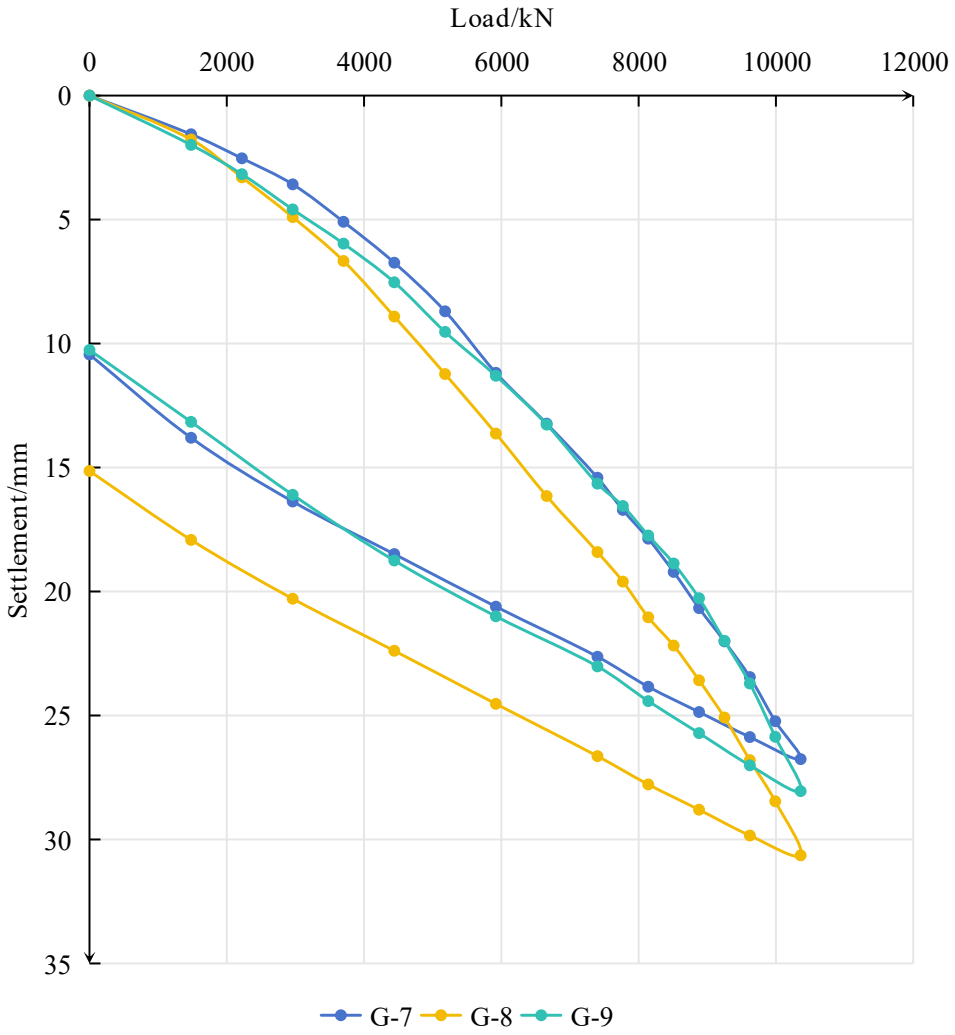


A 24-storey high-rise tower (100 m high) with a 3-storey basement (embedment depth 16 m).

Geotechnical Condition

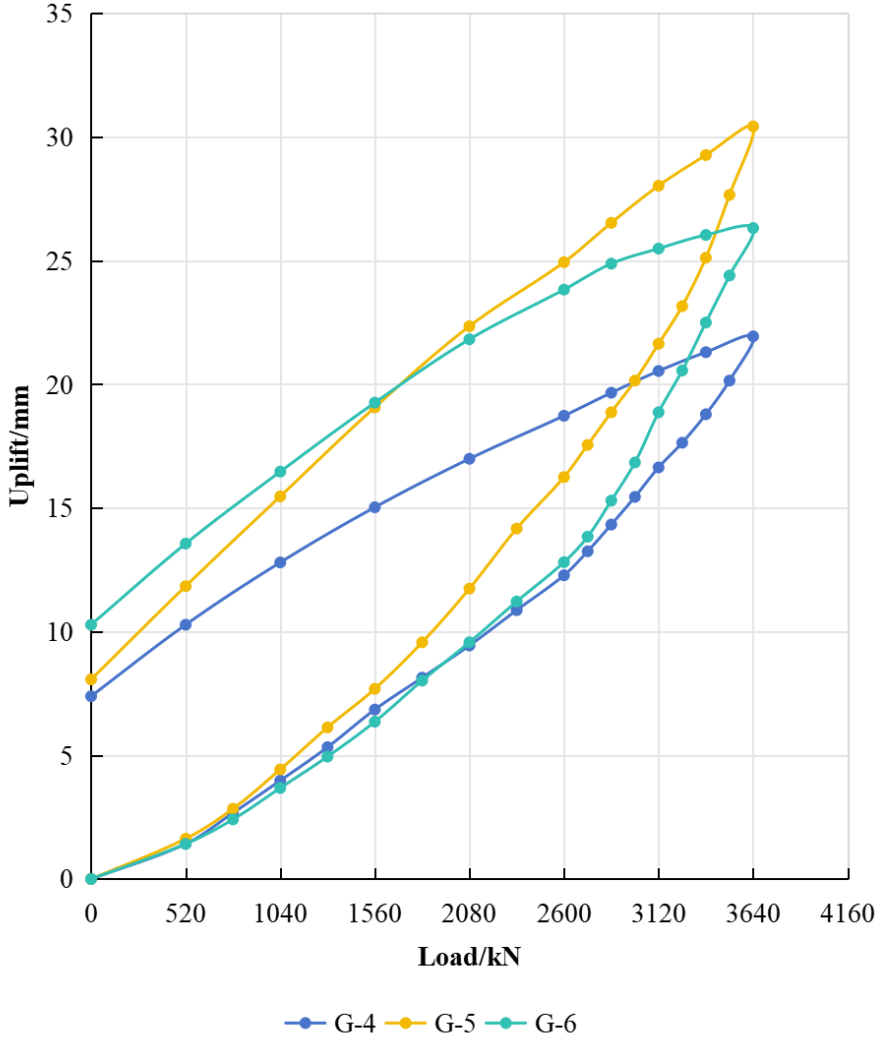


Trial Pile Load Test Results



Trial pile test results - Tower building

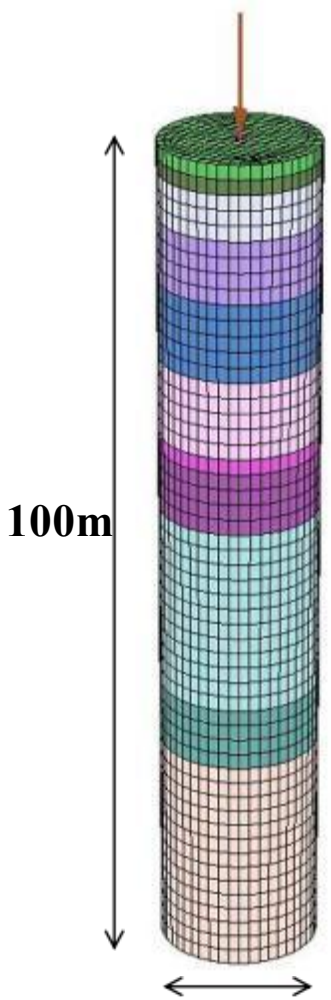
ϕ700 Bored Bottom Post-Grout Pile Length=34m

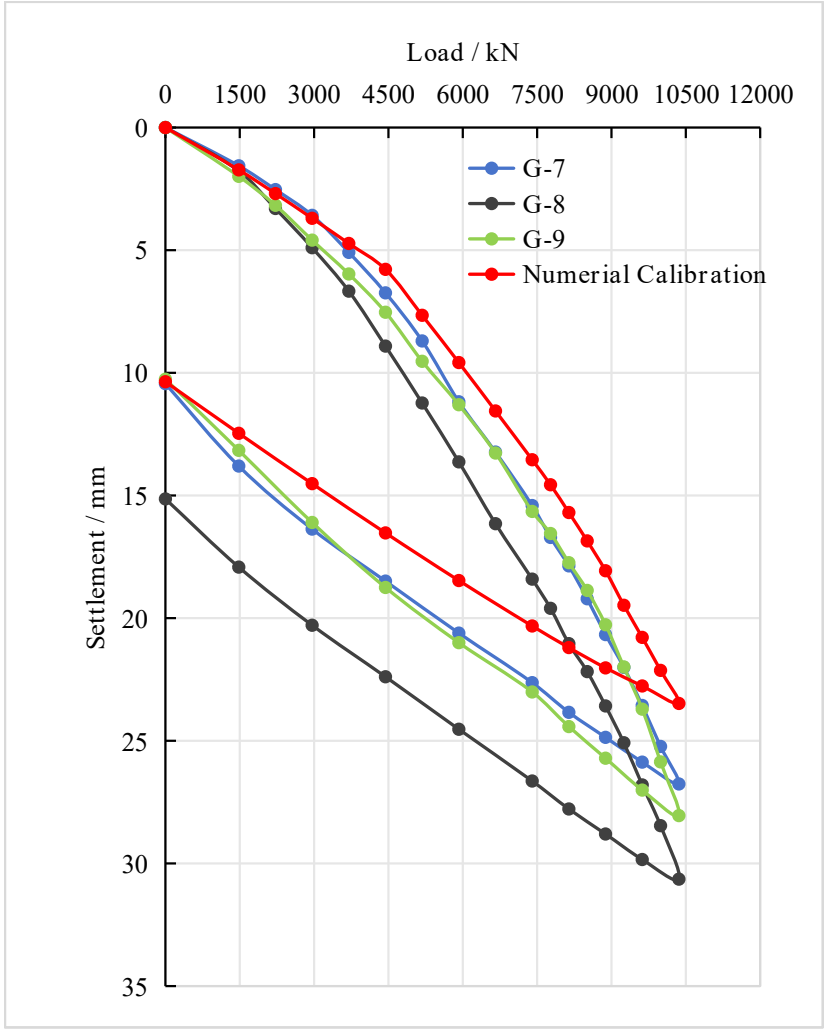


Trial pile test results - Podium

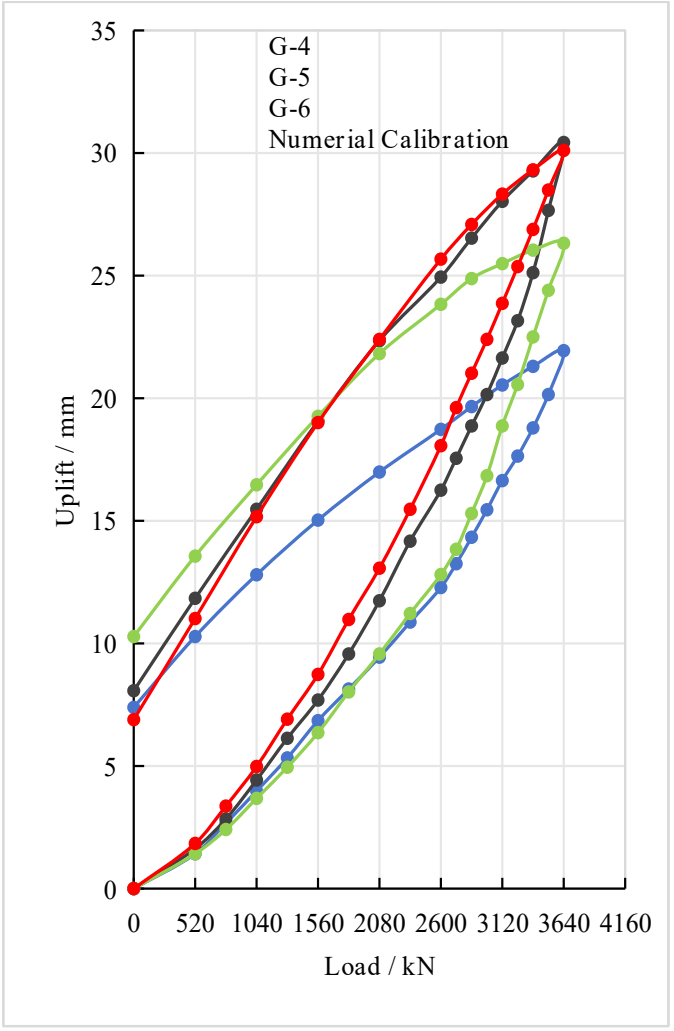
ϕ600 Bored Pile Length=40m

Single Pile Calibration





Tower building trial pile test results v.s. ZSoil numerical calibration result

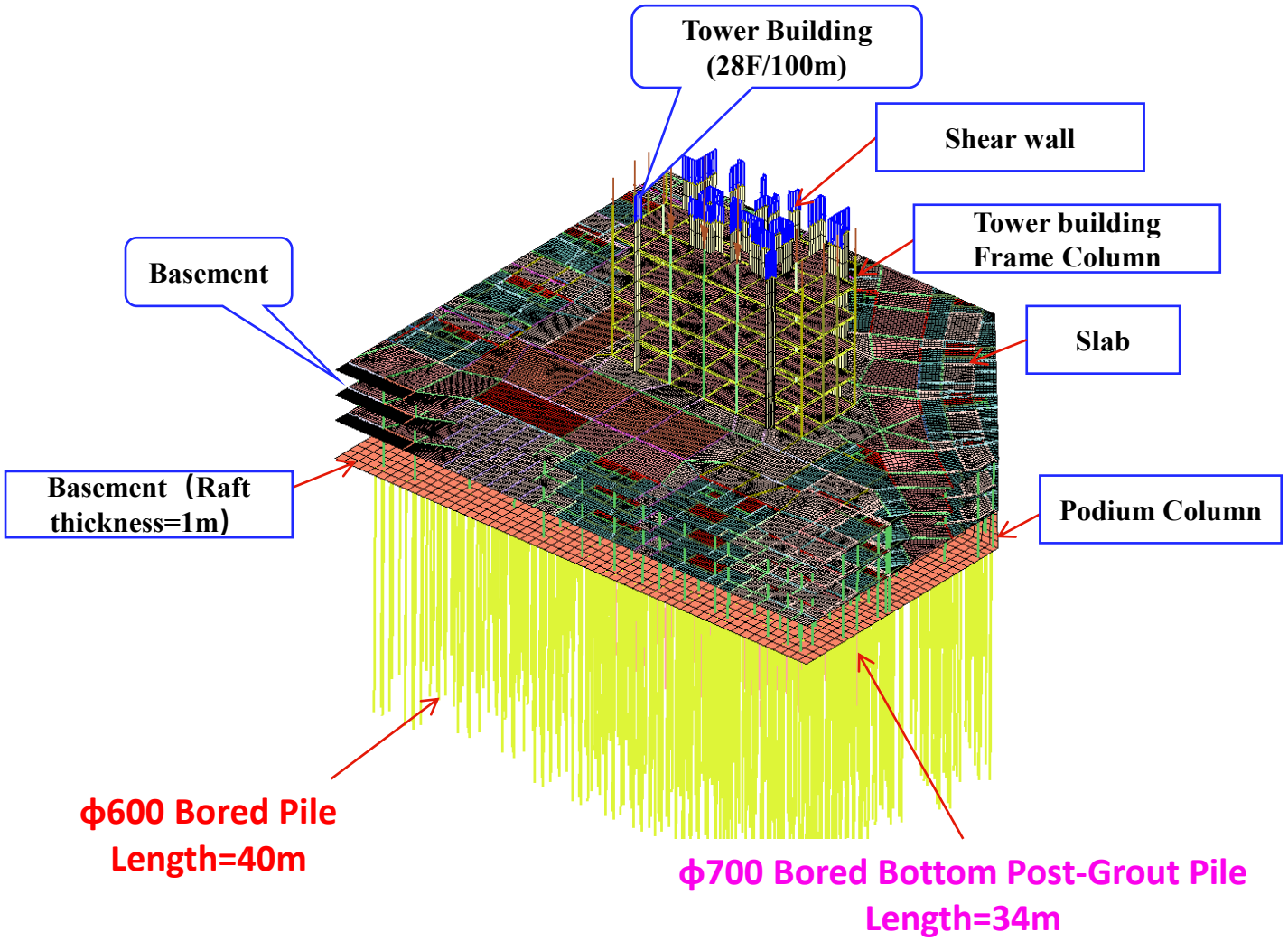


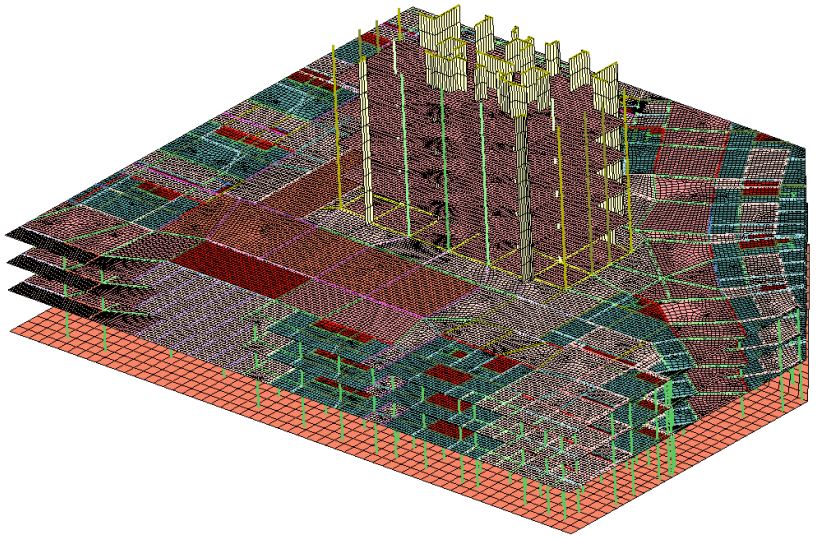
Podium trial pile test results v.s. ZSoil numerical calibration result

Soil Parameters

Soil Type	Unit Weight(kN/m^3)	Water Content(%)	Φ' (°)	c' (kPa)	E_{50} (kPa)	E_{ur} (kPa)	E_0 (kPa)	m	*v*
①$_3$ fill	18.0	20.0	25	5	4000	20000	100000	0.8	0.2
②$_3$ silt clay	18.4	33.4	26	6	2500	12500	62500	0.8	0.2
③ muddy silty clay	17.5	41.8	26	2	2200	11000	55000	0.7	0.2
④ muddy clay	16.8	49.4	26	2	2000	10000	50000	0.95	0.2
⑤$_1$ clay	17.9	36.3	27	4	3600	18000	90000	0.95	0.2
⑤$_3$ slity clay	18.1	33.5	28	4	5600	28000	140000	0.95	0.2
⑤$_4$ slity clay	19.8	22.8	26	16	8900	44500	222500	0.9	0.2
⑦$_{2\text{-}1}$ fine sand	20	21.1	30	3	56000	168000	504000	0.7	0.2
⑦$_{2\text{-}2}$ fine sand	20.1	20.4	32	3	75000	225000	675000	0.5	0.2
⑨$_1$ fine sand	20.4	17.3	30	3	85000	255000	765000	0.9	0.2
⑨$_2$ fine sand	20.8	14.2	32	2	100000	300000	900000	0.5	0.2

FE Model

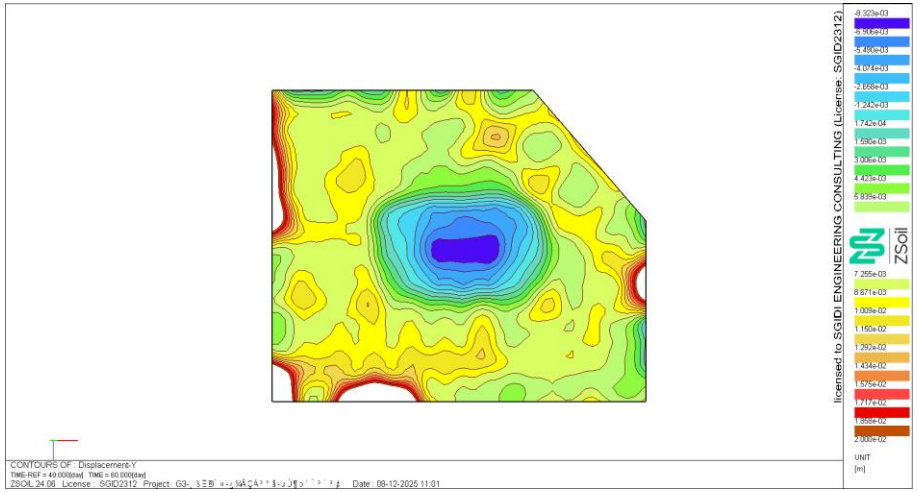




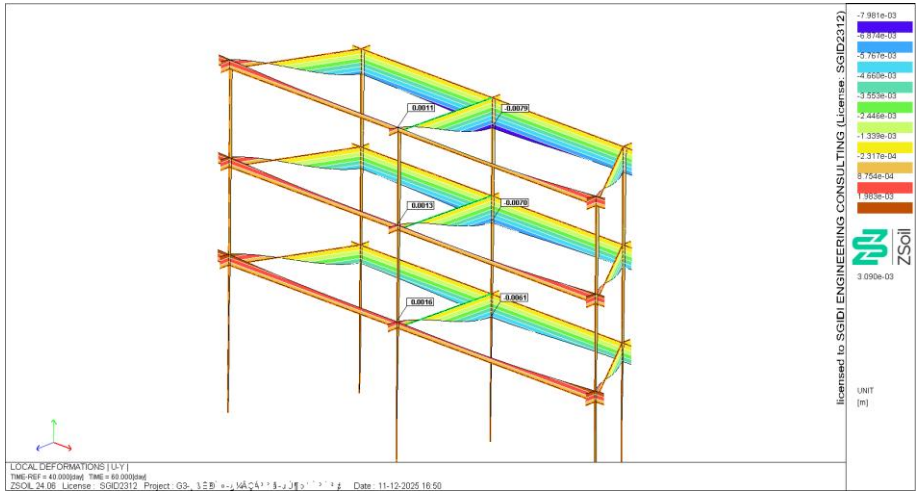
Soil-Piled-Raft Interaction Foundation Model **V.S.** **Rigid Foundation Model**

Results

■ Settlement and differential settlement (Soil-Piled-Raft Interaction model)



Raft settlement and uplift



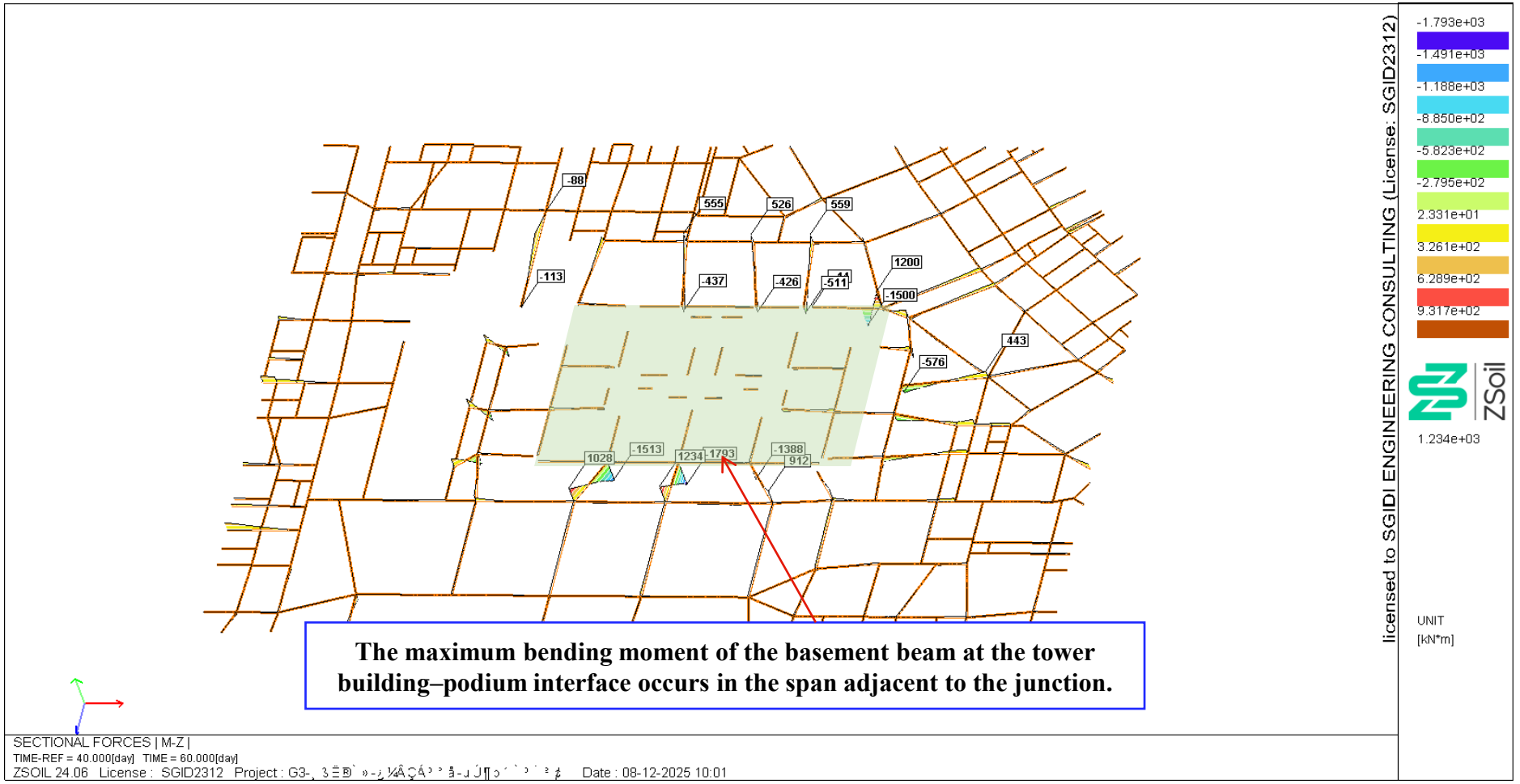
Differential settlement of basement beam between the tower and podium

The tower raft settles 8.3 mm, the podium raft uplifts 11.5 mm, and the corresponding raft tilt is 1.5‰.

The maximum differential settlement of the basement beam at the tower-podium interface is 7.7 mm

Results

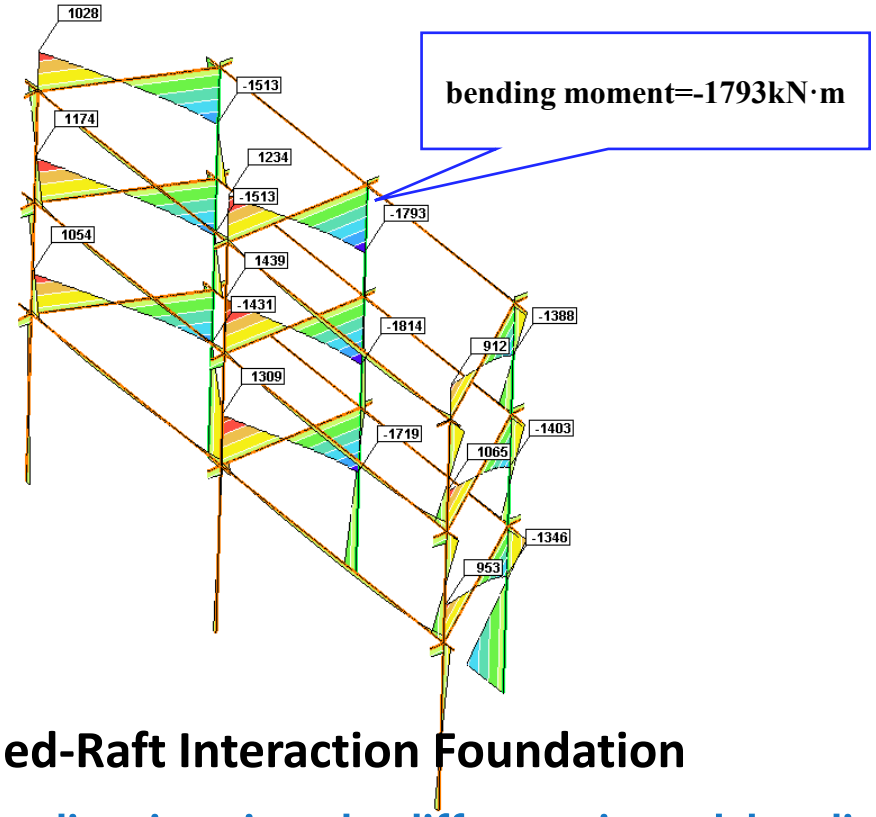
■ Bending moment of the basement beam (Soil-Piled-Raft Interaction Model)

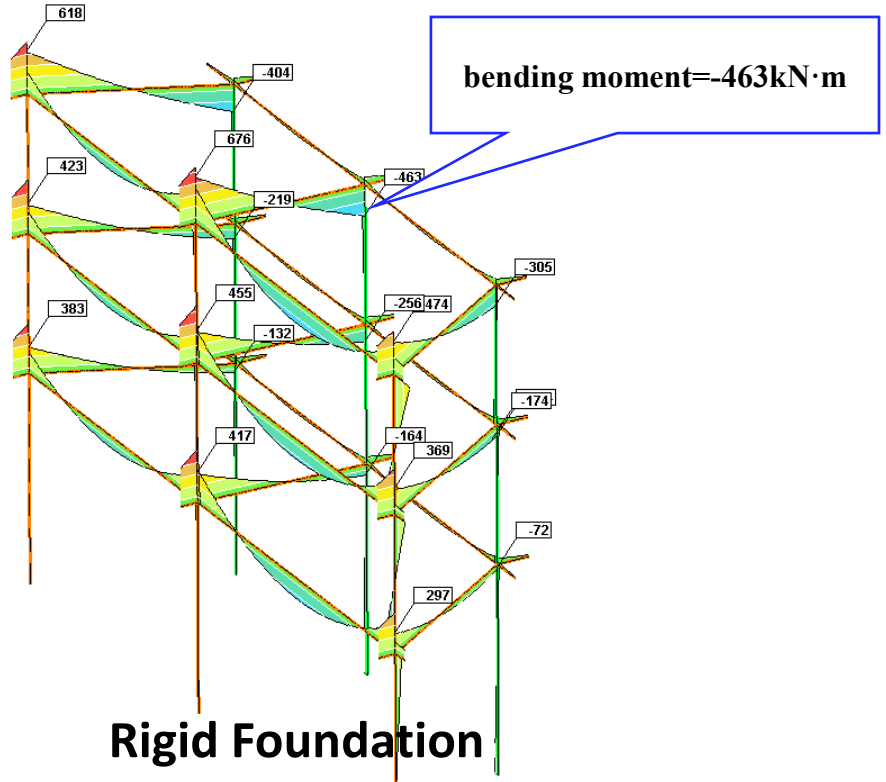


At the tower–podium junction, the peak bending moment in the adjacent basement beam reaches –1793 kN•m

Results

■ Comparison of bending moments: soil–piled-raft model vs. rigid foundation model





Soil-Piled-Raft Interaction Foundation **V.S.** **Rigid Foundation**

At the tower–podium junction, the difference in peak bending moment between the soil–piled-raft interaction model and the rigid foundation model reflects the secondary bending moment induced in the adjacent basement beam by differential settlement. This secondary moment is approximately three times the value from the rigid foundation model.

Consequently, cancellation of the post-poured strips at the tower–podium junction is not recommended, even though the raft tilt remains below 2‰

Conclusion

The main conclusions are as follows:

- The 3D ZSoil finite-element soil-piled-raft interaction model can effectively capture the differential settlement, rotation, and resulting secondary internal forces (especially secondary bending moments) in the superstructure caused by differential foundation settlement between the main tower and the podium.

- The conventional 2‰ differential settlement criterion is too general and may be unsafe in certain cases. It is therefore recommended that project-specific assessments be conducted, with comprehensive consideration of superstructure load distribution, stiffness, and span lengths, through an integrated soil-piled-raft-superstructure interaction analysis, rather than applying a blanket limit.