



# 1 INTRODUCTION

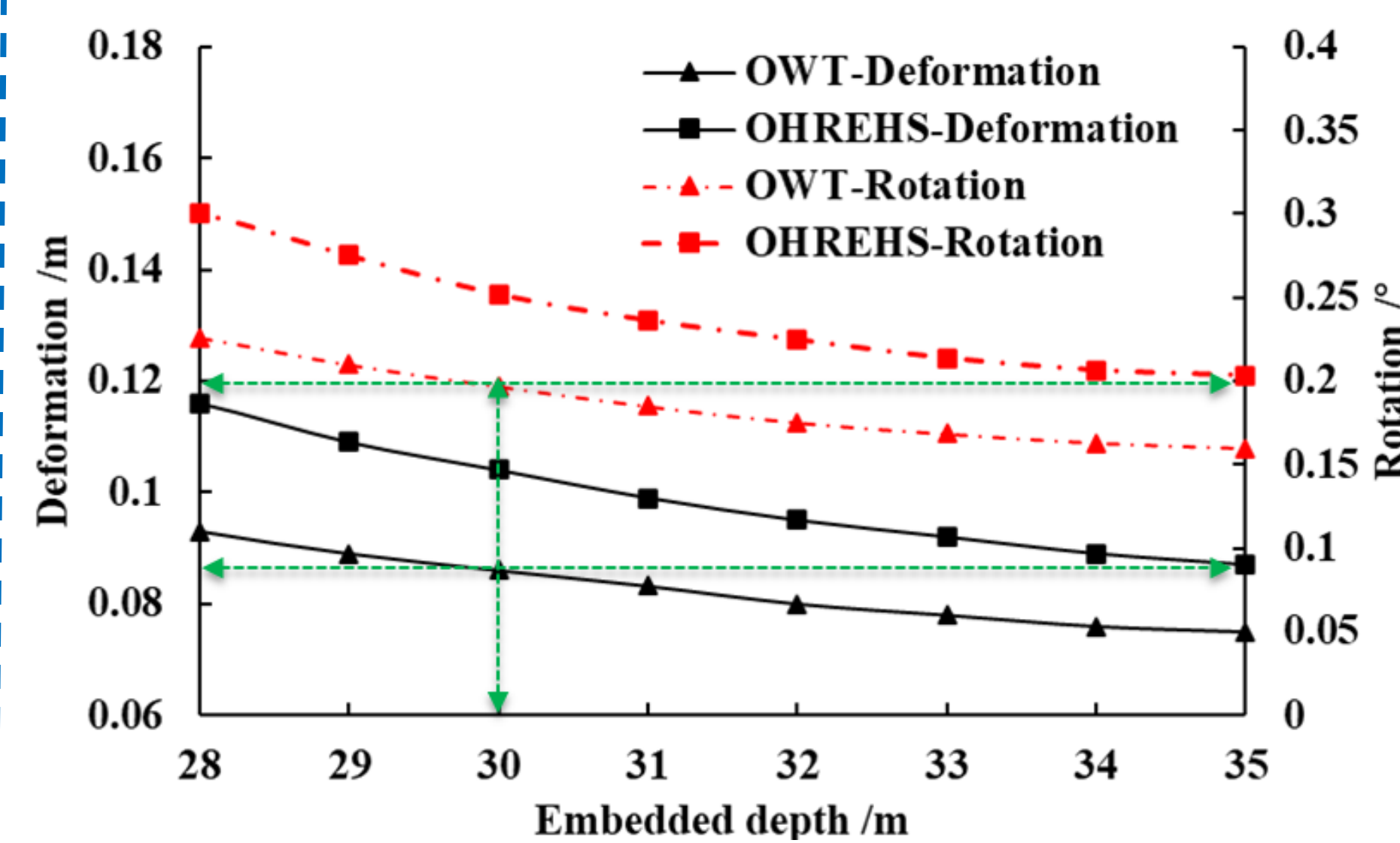
- With the depletion of fossil fuels and the worsening issues of air pollution and global warming, renewable energy, especially offshore renewable energy, has attracted increasing attention.
- Integrating offshore wind turbines (OWT), wave energy converters (WEC), and current turbine (CT) onto a shared platform supported by a shared foundation can significantly reduce construction costs and enhance energy output.
- The integration of multiple energy harvest devices inevitably leads to increased foundation loads, making the design of high-performance foundations crucial for maintaining long-term system stability.

# 2 METHODOLOGY

The Sheringham Shoal Wind Farm is selected to test and design. Based on metocean data and the method proposed by Arany, et al. (2017), loads are calculated, and the design of the superstructure and monopile is conducted. Subsequently, the HOREHS system models supported by monopile and hybrid foundation are established using the FE package, Plaxis 3D. The dimension of hybrid foundation is determined based on structural responses, after which the mechanical interaction between the foundation, soil, and structure is further investigated.

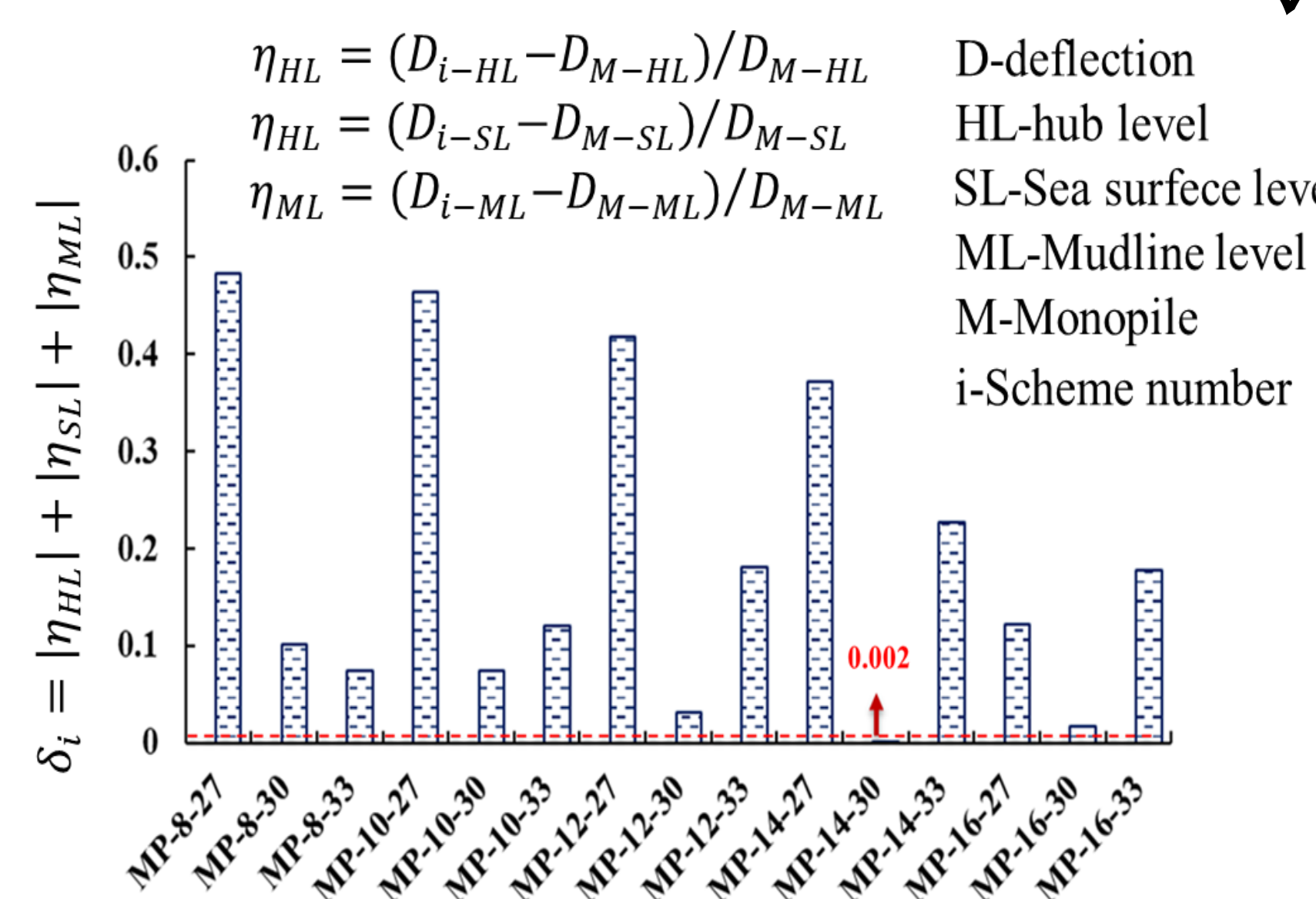
# 3 Results

## Effect of additional devices in HOREHS on monopile response



✓ Under the same magnitude of deformation and rotation, the embedded depth of the monopile for HOREHS is about 16.7% longer than that for the OWT.

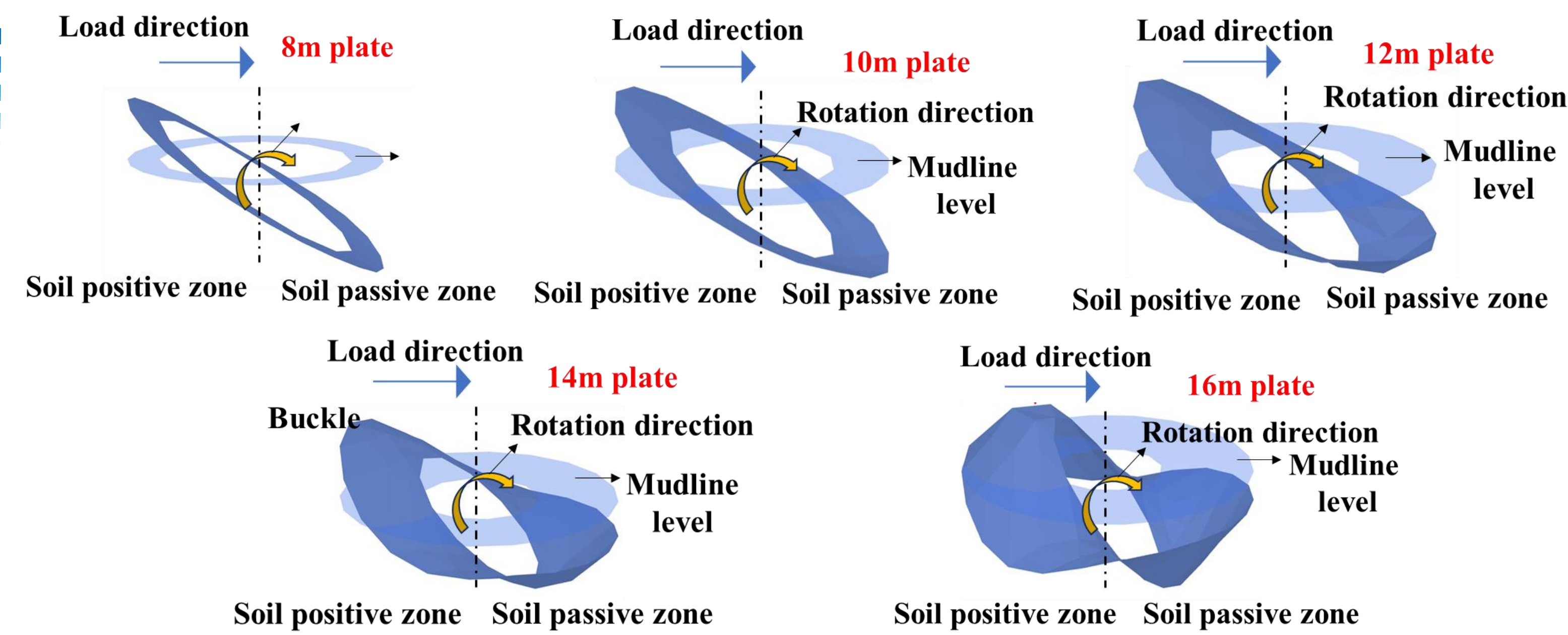
## Hybrid foundation determination



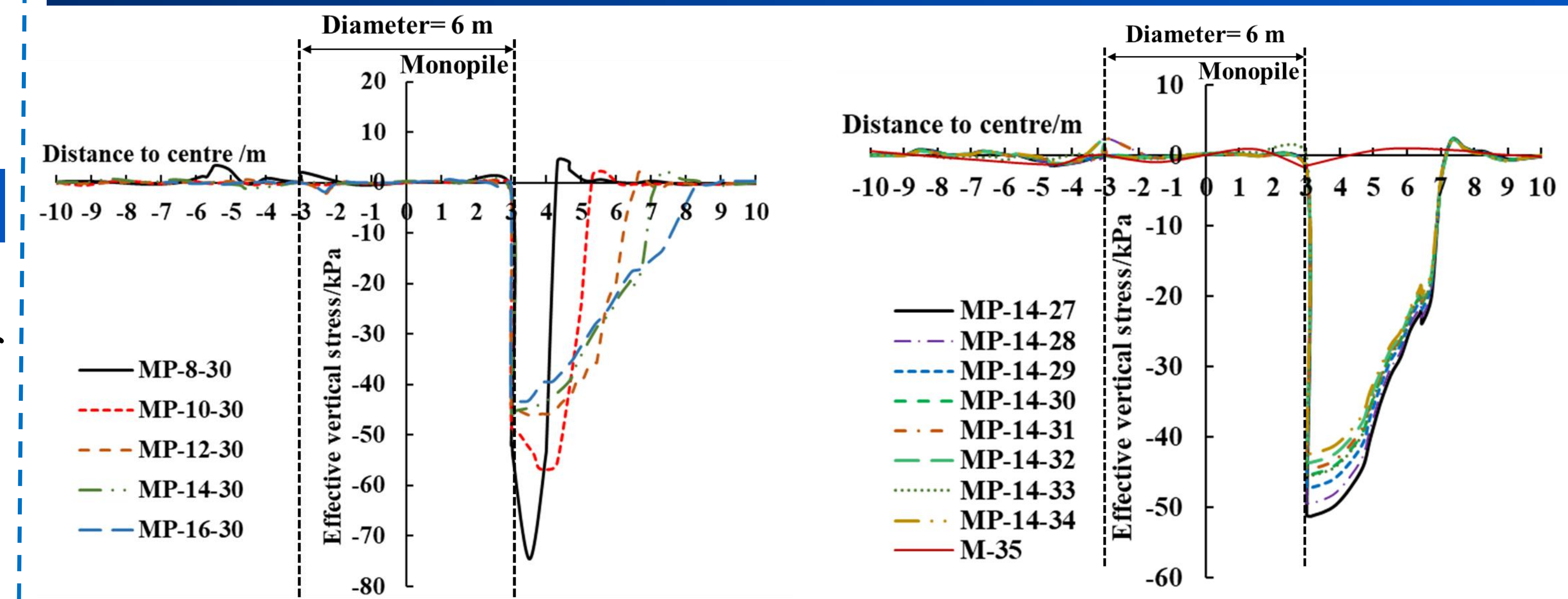
✓ Utilising a steel plate with a diameter of 14 m enables a reduction of the embedded length of monopile for HOREHS from 35m to 30m for this site. This will significantly decrease the construction costs and construction difficulty while ensuring system stability.

## Steel plate deformation analysis

- ✓ The deformation patterns of steel plates vary significantly with diameter. Smaller plates (e.g., 8 m) show rotation around a vertical axis with minimal bending due to limited seabed resistance, while larger plates experience increased rotational resistance, leading to noticeable edge bending. This bending is more pronounced on the passive side of the soil, with inward buckling, while the active side also bends but to a less extent.

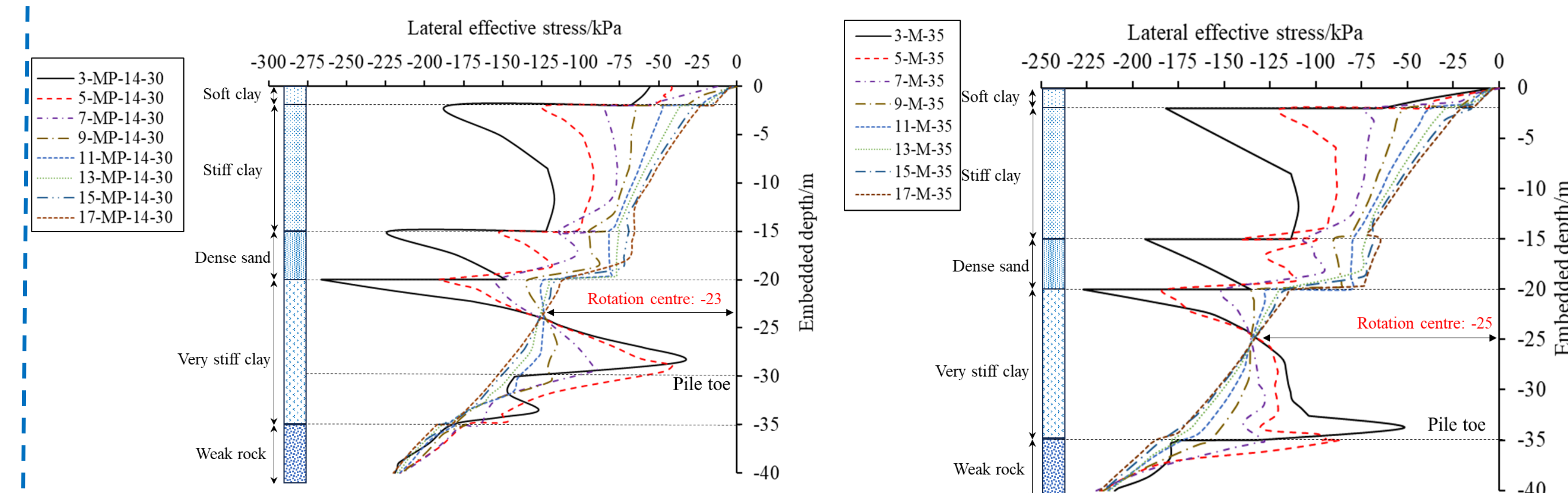


## Vertical effective stress at mudline level



- ✓ As the steel plate diameter increases, the point of maximum vertical effective stress shifts inward due to bending, but stabilises at 3 m from the center once the diameter exceeds 14 m.
- ✓ Due to the growing contact area with soil, the load distribution is enhanced, and the maximum vertical effective stress value decreases

## Lateral effective stress along loading direction



- ✓ Adding steel plates does not change the influence range of lateral effective stress, but the effective lateral stress of hybrid foundation is larger than that of monopile.

# 4 Reference

Ma Y, Cui L, Bhattacharya S. Ocean Engineering, 2025, 323: 120519.  
 Arany L, Bhattacharya S, Macdonald J, et al. Soil Dynamics and Earthquake Engineering, 2017, 92: 126-152.

