Journal of Zhejiang University-SCIENCE A

Experience-guided optimization of jacket foundations for offshore wind turbines in varying water depths based on finite element analysis and the genetic algorithm

Jiajia HUANG, Tao JIN, Jianwu HUANG, Shasha SONG, Wei DAI, Chaoqun ZUO, Lizhong WANG, Lilin WANG, Zhen GUO

Cite this as: Jiajia HUANG, Tao JIN, Jianwu HUANG, Shasha SONG, Wei DAI, Chaoqun ZUO, Lizhong WANG, Lilin WANG, Zhen GUO, 2026. Experience-guided optimization of jacket foundations for offshore wind turbines in varying water depths based on finite element analysis and the genetic algorithm. *Journal of Zhejiang University-SCIENCE A*, 27(3):183-199.
https://doi.org/10.1631/jzus.A2500232

Evolution of offshore wind turbine foundations from shallow to deep waters

Water depth<10 m



Gravity-based foundation

Water depth<30 m



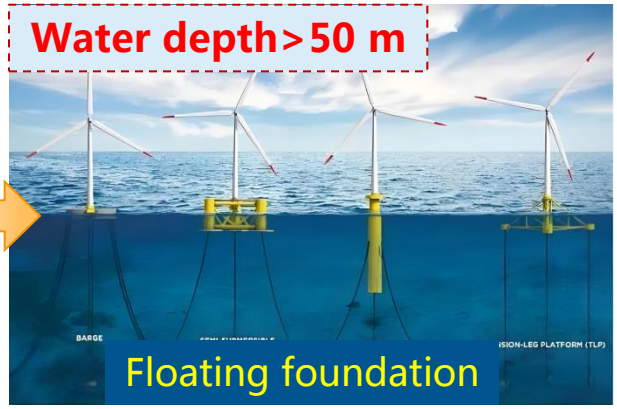
Monopile foundation

20 m<Water depth<80 m



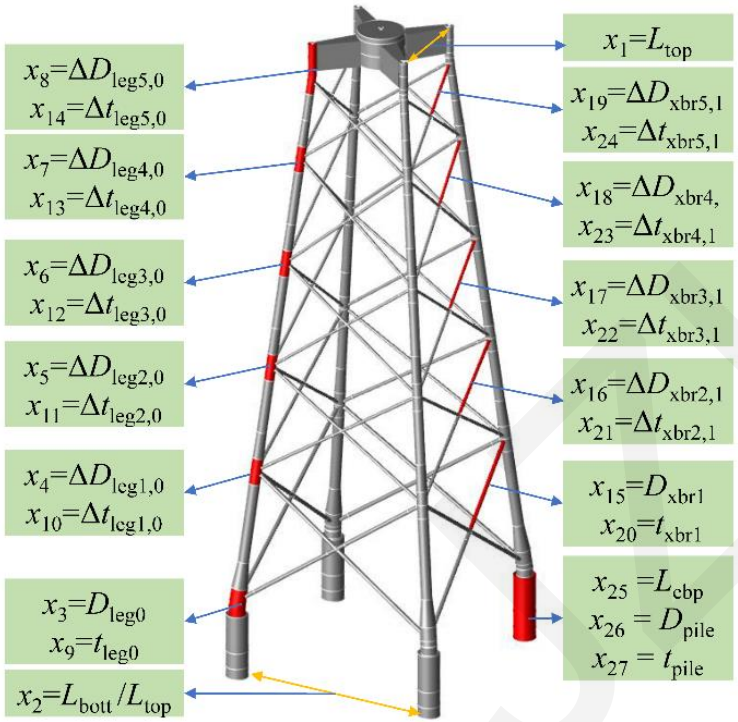
Jacket foundation

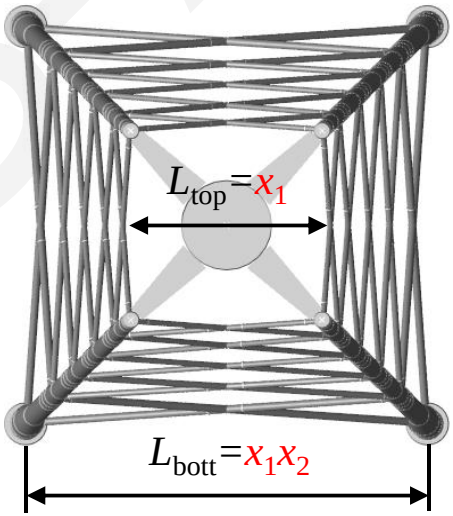
Water depth>50 m

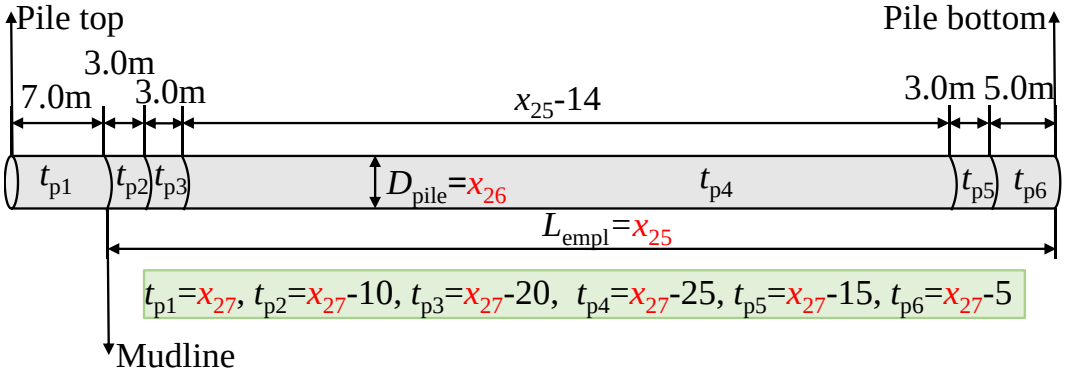


Floating foundation

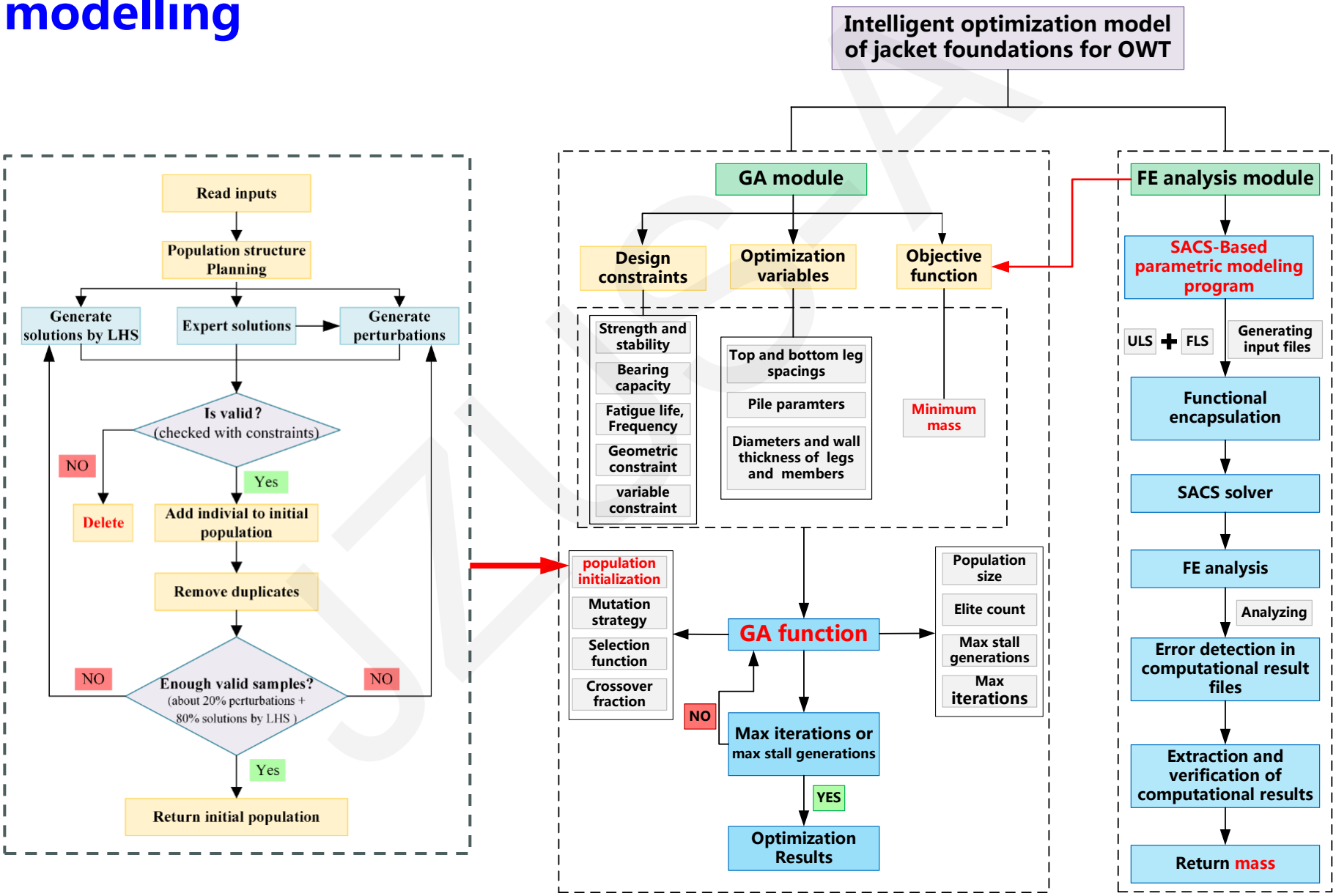
Design variables of the optimization model



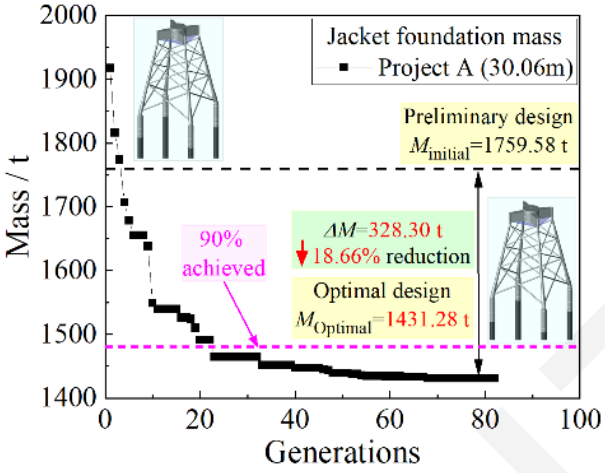


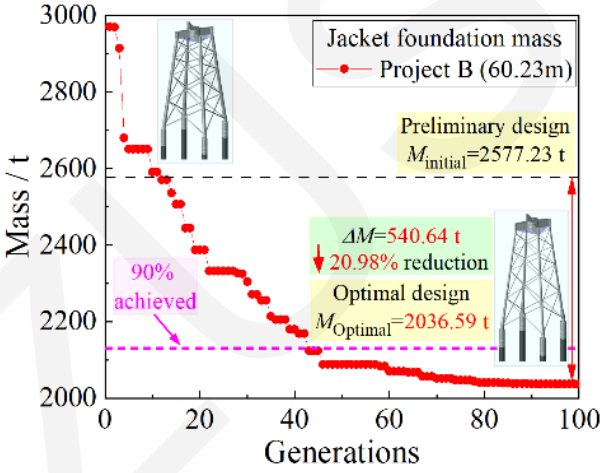


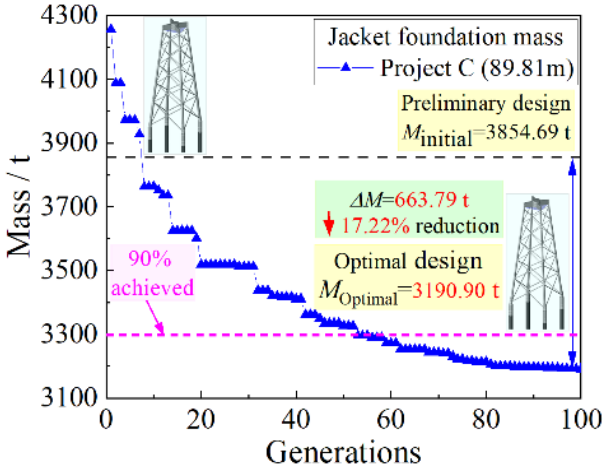
Experience-guided optimization model integrating the genetic algorithm and parametric finite element modelling



Experience-guided optimization model integrating the genetic algorithm and parametric finite element modelling

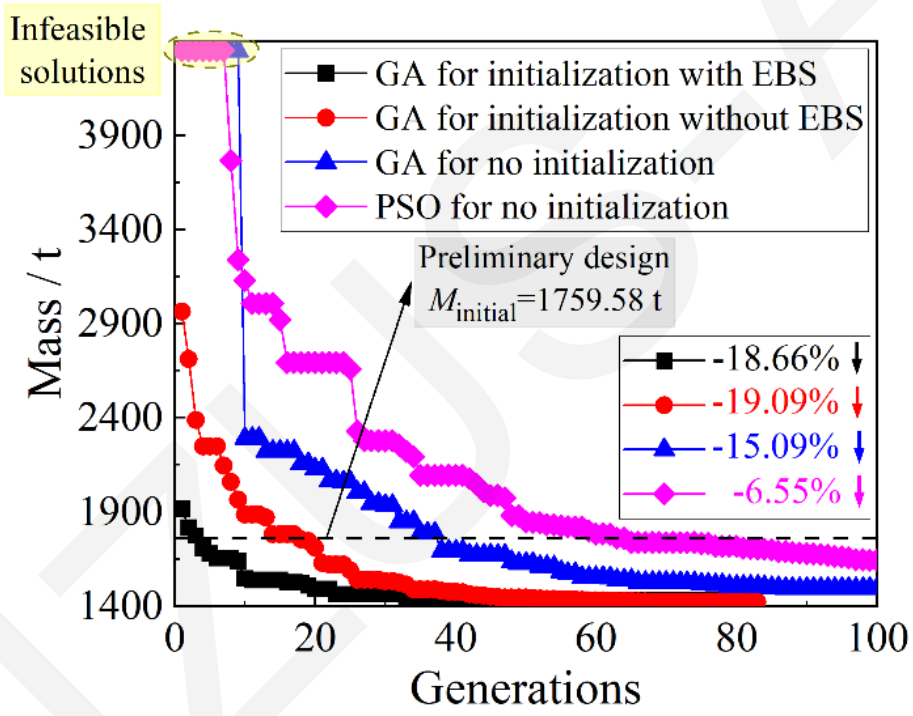






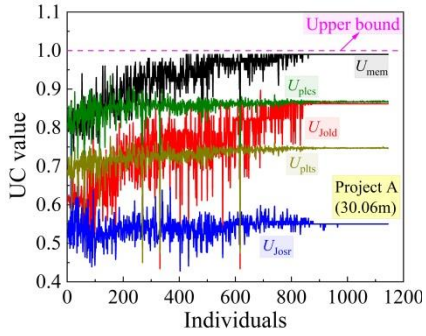
Mass optimization process of jacket foundations with different water depths via genetic algorithm iterations

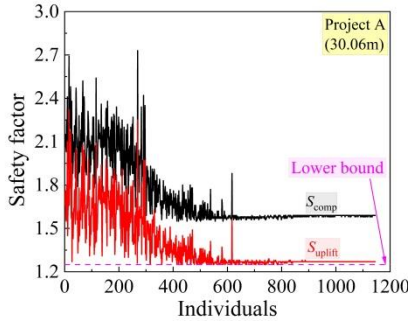
The influence of initialization strategy on mass optimization

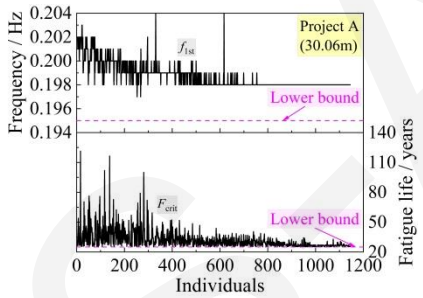


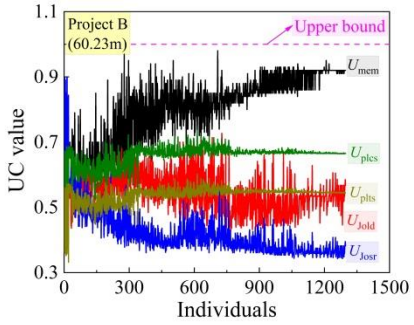
Comparison of optimization performance among GA with different initialization strategies and PSO without initialization

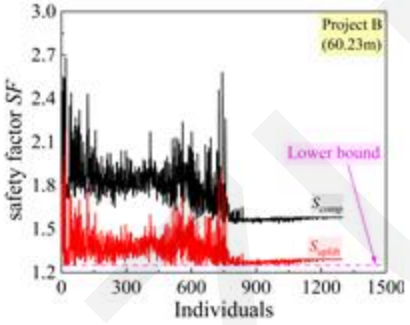
The influence of initialization strategy on mass optimization

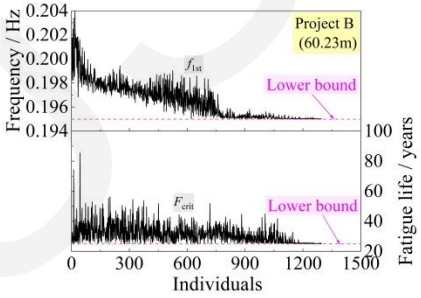


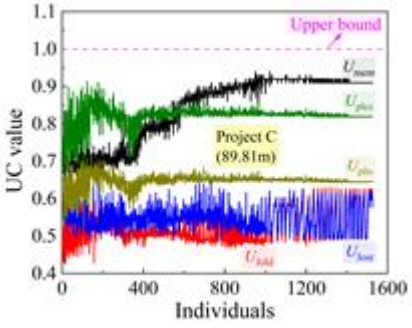


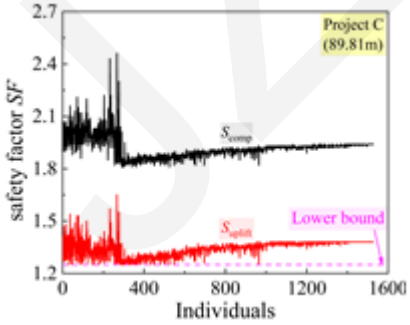


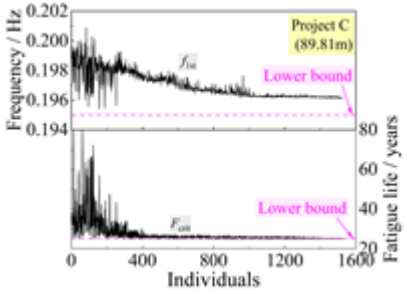








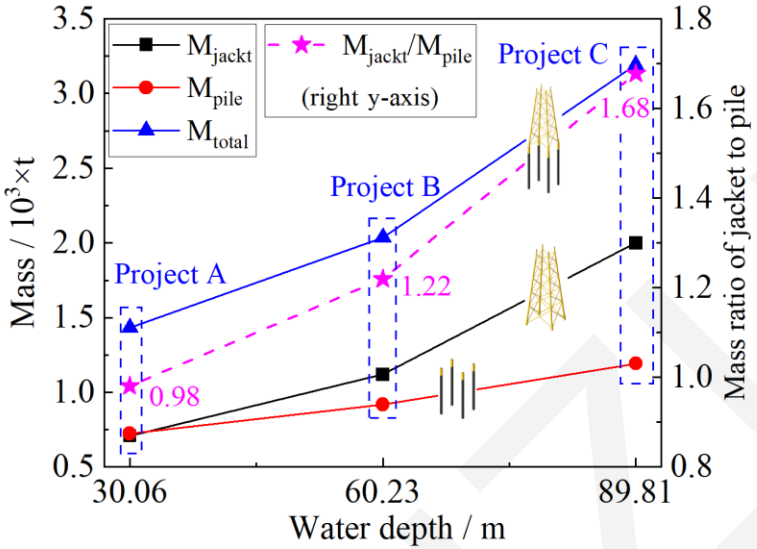


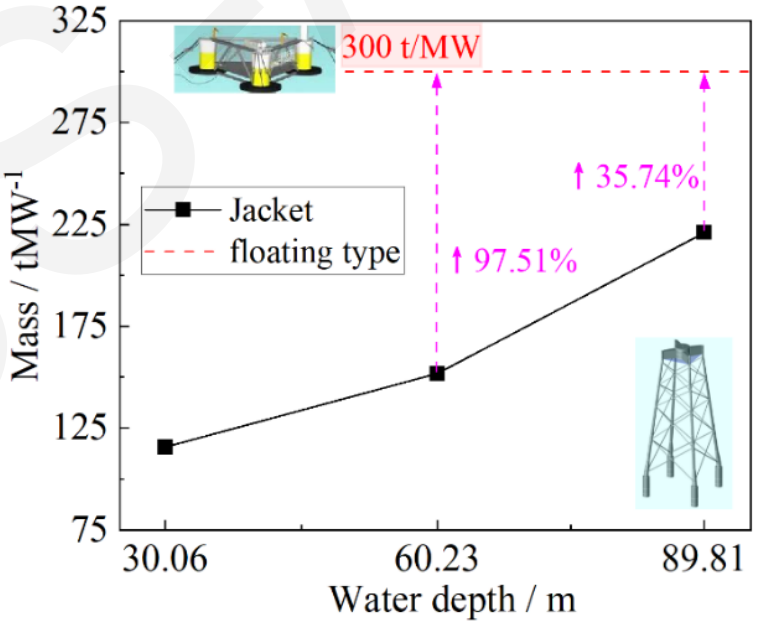


The optimization process is predominantly constrained by the first natural frequency, the bearing capability of the pile and the fatigue durability of the jacket foundation.

Evolution of design constraint values across genetic algorithm individuals for the three projects

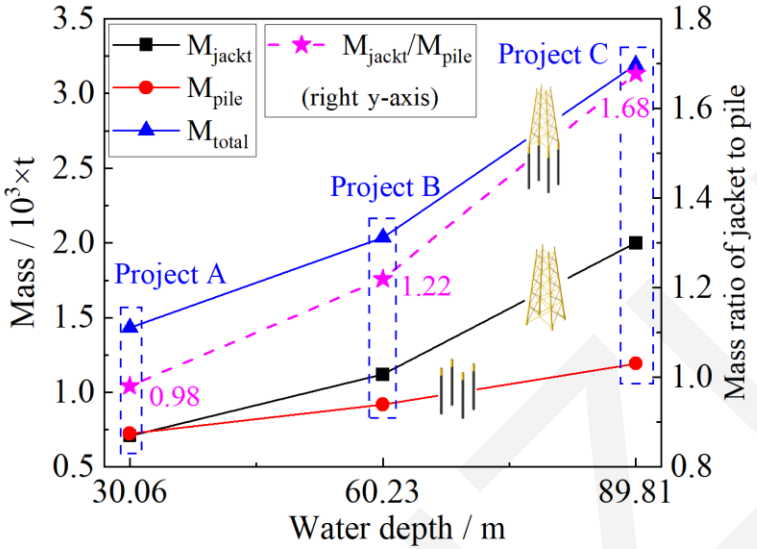
The influence of initialization strategy on mass optimization

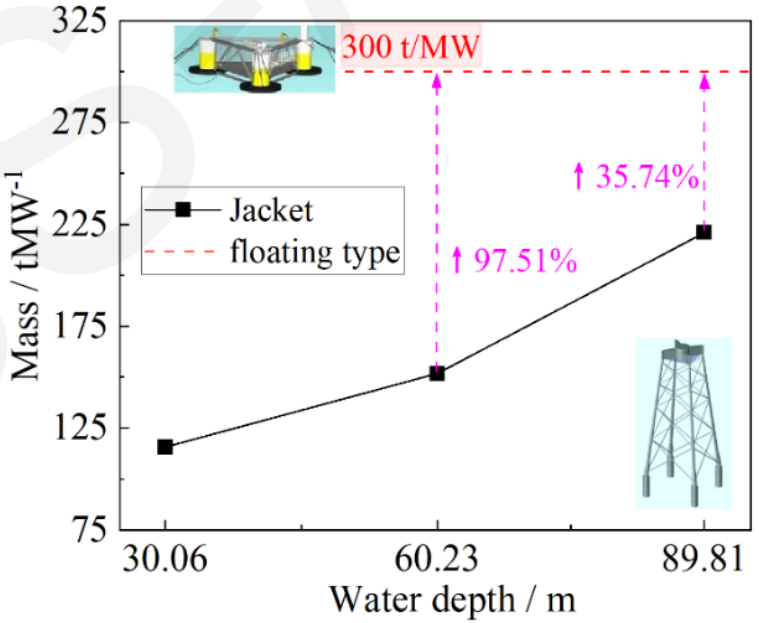




Mass characteristics of jacket foundations under var-ying water depths and comparison of jacket foundation mass with floating foundation mass

The influence of initialization strategy on mass optimization





Mass characteristics of jacket foundations under var-ying water depths and comparison of jacket foundation mass with floating foundation mass

Conclusions

- A hybrid initialization strategy that incorporates engineering experience can markedly improve early-stage feasibility and enhance search efficiency.
- Fatigue durability and the first natural frequency are the primary governing conditions for jacket foundations across all water depths.
- Water depth has a significant effect on jacket weight. Jacket foundations exhibit clear cost advantages in shallow to intermediate waters, and the applicable water-depth threshold separating jacket and floating foundations is approximately 100 m.

JZUSA