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A simplified analytical model for geosynthetic-reinforced pile-supported embankments with cohesive fills

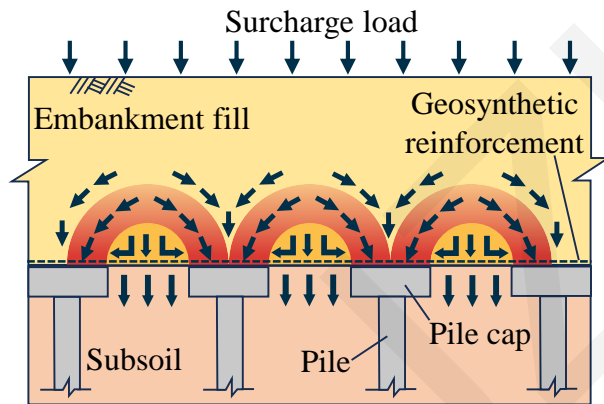
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Keywords:

Geosynthetics; Cohesive fill; Pile-supported embankment; Soil arching effect; Load transfer; Simplified analytical model

Introduction

- Geosynthetic-reinforced pile-supported (GRPS) embankments are widely used to control settlements over soft ground.
- Most existing analytical design methods assume cohesionless fills.
- However, cohesive fills (e.g. clayey soils, stabilized soils) are frequently adopted in engineering practice.
- Neglecting cohesion may lead to overly conservative or inaccurate designs.



A design-oriented analytical framework considering fill cohesion is still lacking

Fig. 1. Illustration of load transfer in GRPS embankment systems

What is proposed

- A simplified analytical model for load transfer in GRPS embankments with cohesive fills.
- The model extends the classical hemispherical soil arching theory.
- Soil arching effect, tensioned membrane effect, and subsoil support are fully coupled.
- Only nine key input parameters, suitable for engineering design.

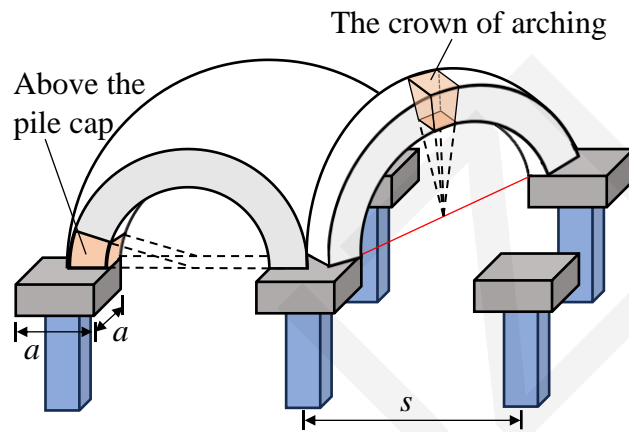


Fig. 2. The hemispherical arching model

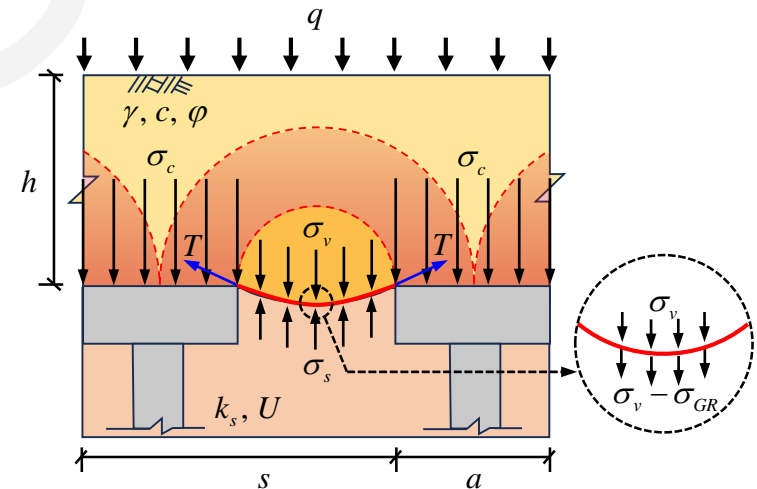


Fig. 3. Stress analysis for the element below the geosynthetic between the pile caps

Model validation

- The proposed model is validated using full-scale field tests and full-scale model tests.
- Predictions are compared with:
 - CUR226 (2016)
 - BS8006 (2010)
 - EBGEO (2011)
 - NGG (2004)
- The proposed model shows closer agreement with measured data.

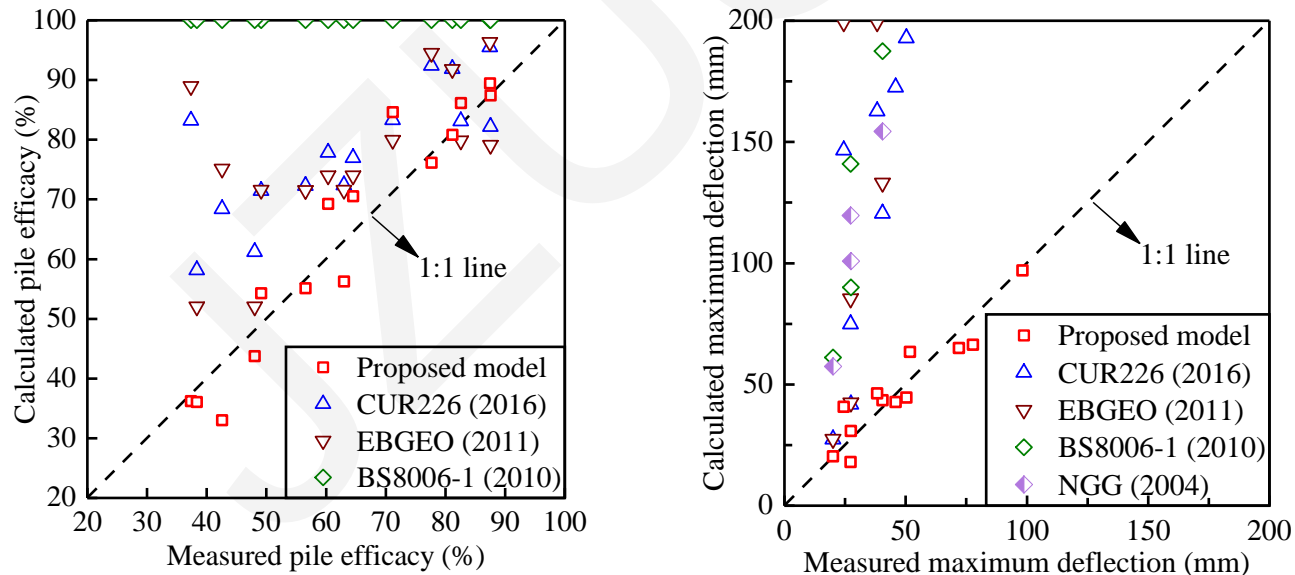


Fig. 4. Comparison of different model predictions against measured results

Parametric analyses

- A critical normalized fill height $H/(s-a) \approx 2.5$ is identified.
- Cohesion effects become significant when the improvement area ratio exceeds 10%.
- Increasing geosynthetic stiffness alone is less efficient than optimizing fill properties.

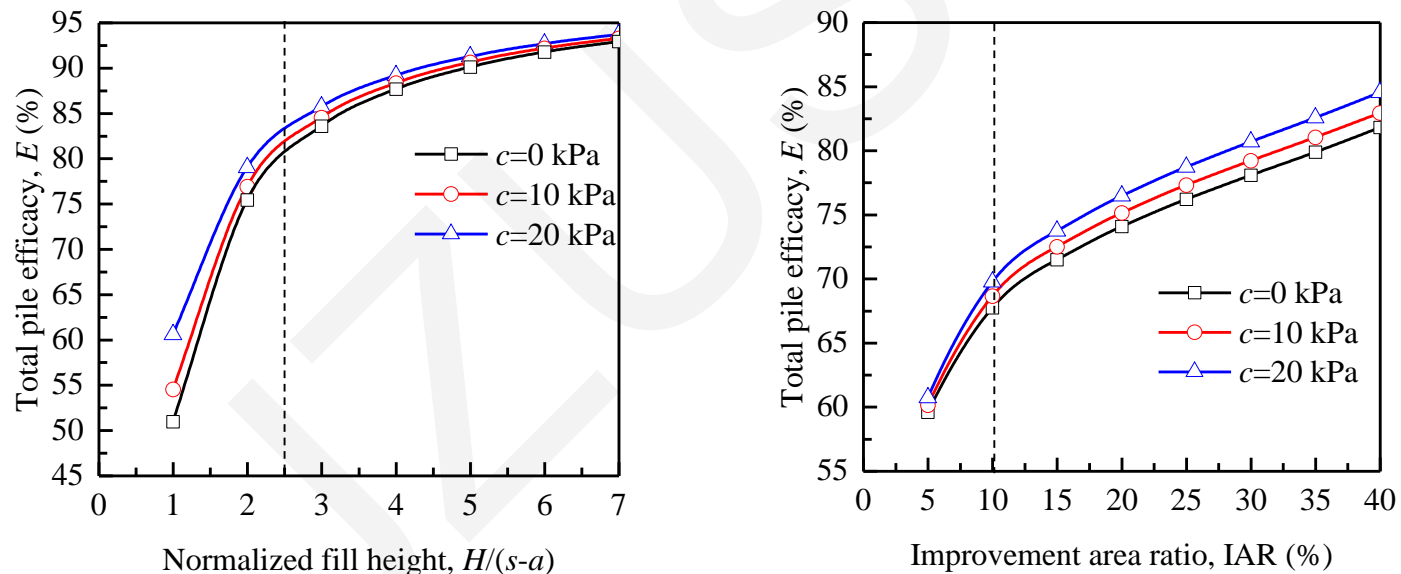


Fig. 5. The influence of normalized fill height and improvement area ratio on the total pile efficacy

Conclusions

- A simplified analytical model is proposed to evaluate load transfer in geosynthetic-reinforced pile-supported embankments with cohesive fills by extending the classical hemispherical soil arching theory, explicitly incorporating fill cohesion while retaining simplicity and compatibility with existing design frameworks.
- Validation against field and experimental data demonstrates that fill cohesion significantly enhances soil arching and pile efficacy while reducing geosynthetic deflection, indicating that the proposed model provides a practical and efficient tool for the preliminary design and assessment of GRPS embankments using cohesive fills.