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# 摘要集

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# Load transfer mechanism in geosynthetic reinforced column-supported embankments

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**Abstract:** The load transfer mechanism of geosynthetic reinforced column-supported embankments is governed predominantly by the soil arching mechanism. A large number of studies found in the literature examine the arching over a rectangular arrangement of columns. However, the load transfer mechanism over a triangular arrangement is not widely investigated. This paper investigates the mechanism of soil arching in an embankment supported by columns in a triangular grid, using 3D numerical models. The column efficacy and settlements were compared between triangular and square grids. A visual boundary of the soil arch above the triangular grid of columns was developed based on the 3D modelling. A parametric study was carried out to investigate the influence of geosynthetic reinforcement, mechanical properties and height of embankment, and strength and configuration of columns (spacing and diameter) on the column efficacy and arch shape. Results show that columns experienced lower settlements and the geosynthetic reinforcement was less effective when the column arrangement was triangular, compared to a square arrangement. The most influential parameter on the column efficacy is column spacing and the second is diameter. Both height and width of the soil arches were changed with column spacing. Only the width of the arch was changed with column diameter.
**Keywords:** Geosynthetics, Triangular column arrangement, 3D finite element modelling, Soil arching mechanism, 2D simplification of triangular column grid, Parameters affecting efficacy, Parameters affecting soil arching

# Analytical solution for geogrid-reinforced piled embankments under traffic loads

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**Abstract:** This paper describes a simplified numerical model for geogrid-reinforced piled embankments considering dynamic loads. Based on this model, the vertical stress acting on the geogrid is investigated comprehensively and is found to exhibit an inverse trapezoidal distribution. An analytical solution for the geogrid-reinforced piled embankment under a static load is then derived for vertical equilibrium and an assumed inverse trapezoidal load distribution on the geogrid. This is extended by considering an additional vertical stress induced by the dynamic loads, based on the Boussinesq equation. However, the characteristics of the traffic loads (i.e. frequency and load numbers) are ignored. The analytical solution is then validated against three case studies and parametric numerical studies under various geometries (pile spacing and embankment height), geogrid stiffnesses and embankment friction angles. These parametric studies show that the geogrid tension increases with the pile spacing, embankment height and geogrid stiffness but decreases with the friction angle of the embankment. The pile spacing is found to be the most influential of all the factors examined in this paper, increasing from 2.0 m to 3.0 m when the geogrid tension is increased by approximately 248%.

**Keywords:** Geosynthetics, Analytical solution, Geogrid-reinforced piled embankments, Numerical simulation, Traffic loads

# A case study on geogrid-reinforced and pile-supported widened highway embankment

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**Abstract:** The objective of this case study is to evaluate the development of soil arching in an embankment being widened. In two test sections, earth pressures at different locations were monitored to reveal the load redistribution mechanism due to soil arching. Tensile forces in uniaxial plastic geogrids were measured to evaluate the performance of geosynthetic reinforcement in the widened embankment. The soil arching effect was quantified in terms of stress concentration ratio, soil arching ratio and geomembrane effect. Several existing methods were selected to compare with the measured results. The results of the field tests indicate that a two-dimensional plane soil arch with some eccentricity affects the fill load distribution on pile caps and subsoil between piles, and a realistic critical arch height of less than 2.0 m with a ratio of 1.4 times the pile clear spacing was identified. Although few existing methods could generate close results comparable to the measured values, most of the methods overestimated the load carried by the geosynthetic layer. The results also suggest that the foundation soil reaction underneath the geosynthetic layer should be taken into account in the load transfer mechanism of geosynthetic-reinforced and pile-supported widened highway embankments.

**Keywords:** Geosynthetics, Field test, Piles, Soil arching effect, Widened embankment

# Load-deformation of piled embankments considering geosynthetic membrane effect and interface friction

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**Abstract:** The use of high-strength geosynthetics to enhance the load transfer mechanism onto columns is an established and increasingly popular technique in geosynthetic-reinforced and column-supported embankments. The main focus of this paper is to extend the existing models that describe the membrane action and soil arching with skin friction along the geosynthetic. This extension was undertaken to identify the parameters that affect the tension in the geosynthetic and assess the effect of geosynthetics on the load transfer. A general expression for the increase in load-bearing capacity due to the membrane action based on strict equilibrium conditions is also shown. The geosynthetic deformation is described assuming both circular and parabolic deformation shapes. These two deformation shapes do not result in a significantly different membrane effect. Therefore, the choice of deformation parameter is more important than the choice of deformation shape. The new method using both deformation models was combined with the Concentric Arches model of Van Eekelen and co-workers, and compared with the measurements and numerical results. A reasonable consistency is found. For the considered cases, the skin friction along the geosynthetic reduces the maximum geosynthetic deflection to 2.5 to 5.3%. This reduction becomes more important when the embankment is higher.
**Keywords:** Geosynthetics, Piled embankment, Analytical model, Interface friction, Membrane effect, Arching theory

# Geosynthetic-reinforced pile-embankments: numerical, analytical and centrifuge modelling

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**Abstract:** This paper presents numerical and analytical models to complement experimental data obtained from 40 centrifuge tests of geosynthetic-reinforced piled embankments, 12 of which had a surcharge applied at the embankment surface. The main parameters of study were pile diameter, pile spacing, embankment height and geosynthetic stiffness. The tests measured the force transferred to the piles, the embankment surface settlements and the maximum geosynthetic reinforcement deflections below the embankment under conditions without any support from the underlying soil. Maximum geosynthetic deflections measured longitudinally between piles were then compared with values predicted by European design guidelines. A 3D numerical model, initially validated by centrifuge tests, was then used to compute those geosynthetic tensile forces not measured in the reduced-scale physical models. Numerical values of geosynthetic tensile forces were also compared with corresponding values predicted by European guidelines.
**Keywords:** Geosynthetics, Analytical methods, Centrifuge modelling, Numerical modelling, Piled embankment, Reinforcement

# Geosynthetic-reinforced pile-supported embankment: settlement in different pile conditions

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**Abstract:** Three centrifuge model tests were conducted on geosynthetic-reinforced pile-supported (GRPS) embankments with side slopes to investigate the influence of pile end-bearing conditions and pile modulus on their performance. This study found that when end-bearing piles were used, differential settlement occurred at the base of the embankment and the majority of the embankment load was transferred to the piles. Floating piles, however, behaved as rigid inclusions and formed a composite foundation with their surrounding soil, which shared the total load under an approximately equal-strain condition. The use of end-bearing piles with low modulus increased the total settlement of the piles and the foundation soil at the base of the embankment and promoted lateral movement of the side slopes. Two theoretical methods were adopted with some modifications to calculate pile head settlement compared with the measured data. When the end-bearing piles were used to support the geosynthetic-reinforced embankment, the modified Vesic method considering negative skin friction along pile shafts was used to calculate the pile head settlement close to the measured one. When floating piles were used to support the geosynthetic-reinforced embankment, the modified equivalent footing method was used to calculate the settlement, matching reasonably well with the measured one.

**Keywords:** Geosynthetics, Centrifuge, Embankment, Negative skin friction, Pile, Settlement

# Load transfer and deformation of geogrid-reinforced piled embankments: field measurement

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**Abstract:** The collected field data for a geosynthetic-reinforced pile-supported structure (GRPS) in Hamburg is studied to identify the effect of environmental changes on the load transfer process over the structure lifetime. The prediction models in three design codes are applied to estimate the loads and strains in different structural components of the embankment. The results show that the models fail to accurately estimate the geogrid reinforcement deflection and overestimate the loads on the pile foundation in this project.

**Keywords:** Geosynthetics, Piled embankment, Load transfer, Soil arching, Field measurements, Prediction of deflections

# Quantitative performance evaluation of GRPE: a full-scale modeling approach

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**Abstract:** The quantitative performance of a geosynthetic-reinforced piled embankment (GRPE) and an unreinforced piled embankment were compared using two full-scale experiments. During the installation of the fill, the measured pile efficacy increased until the soil arching was fully developed. Subsequently, the case with the geosynthetic reinforcement (GR) showed a more stable arching mechanism than the case without GR. In both cases, the measured pile efficacy showed good agreement with the values calculated using three existing soil arching theories. The geotextile reinforcement increased the measured pile efficacy by 18% at the final height of the embankment.
**Keywords:** Geosynthetics, Full-scale experiments, Geosynthetic-reinforced piled embankment, Pile efficacy, Soil arching effect