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Mitigation of ground vibrations induced by high speed railways using double geofoam barriers: Centrifuge modeling

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Abstract: This paper presents a study of the propagation and mitigation of ground vibrations induced by high speed railways using 8 centrifuge tests. In the reported tests here, geofoam is used as a barrier in various locations and arrangements (single and double) to mitigate ground vibrations. The results show that the surface waves guide the propagation pattern of ground vibrations induced by high speed railways and also reveal that geofoam is a proper material for the mitigation of such ground vibrations. While the use of single geofoam barriers can reduce ground vibrations by up to 54.5%, their performance at low input frequencies are undesirable. Double geofoam barriers are used and tested in various locations to eliminate such inconvenient effects and improve the mitigation of ground vibrations. The results show that double geofoam barriers can mitigate the vibrations by about 14%- -35% more than a single geofoam barrier and undesirable performances for the mentioned low input frequencies are also eliminated.

Keywords: Geosynthetics; Ground vibrations; High speed railways; Centrifuge modeling; Geofoam barrier

Required strength of geosynthetics for reinforced 3D slopes in cohesive backfills with tensile strength cut-off

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Abstract: In extant studies, most of the stability analyses of geosynthetic-reinforced slopes focused on two-dimensional conditions using the Mohr-Coulomb (M-C) failure criterion to describe the strength of backfills. However, in reality, all failures of slopes indicate a somewhat three-dimensional (3D) feature, and the M-C criterion is observed to overestimate the tensile strength of cohesive soils. To partially remedy this shortcoming, the concept of tensile strength cut-off is adopted to include the actual tensile strength of backfills in the yield envelope, and a kinematic approach is presented to evaluate the required strength of geosynthetics for 3D reinforced slopes in cohesive backfills. A 3D rotational mechanism of collapse that is associated with the strength envelope with tension cut-off is developed. The amount of required reinforcement is evaluated and listed as a dimensionless coefficient. The results indicate that the inclusion of the 3D effect and soil cohesion can lead to substantial savings in terms of the reinforcement to be made. In addition, a higher amount of reinforcement is required when the effect of tension cut-off is considered; this effect is more distinct for backfill with a higher amount of cohesion.

Keywords: Geosynthetics; 3D reinforced slope; Cohesive backfill; Tensile strength cut-off; Kinematic approach

Chemical interaction and hydraulic performance of geosynthetic clay liners isothermally hydrated from silty sand subgrade

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Abstract: The effects of the silt aggregation, compaction density, and water content of the subgrade on the hydration of five different geosynthetic clay liner (GCL) products is reported based on a series of laboratory column experiments conducted over a six-year period. GCLs meeting typical specifications in terms of minimum hydraulic conductivity and swell index are hydrated to equilibrium from the same subgrade soil with sufficient cations to cause cation exchange during hydration. It is then shown that the GCL bentonite granularity and GCL structure can have a significant (~four orders of magnitude) effect on hydraulic conductivity under the same test conditions (from 8 X 10~ -12m/s for one GCL to 6 X 10 -8 m/s for another GCL product). The effect of subgrade water content on the hydraulic performance of GCLs are not self-evident and quite dependent on the bentonite granularity, GCL structure, and permeant. Varying the subgrade water content from 5 to 16% and allowing the GCL to hydrate to equilibrium before permeation led to up to 5-fold difference in hydraulic conductivity when permeated with tap water and up to 60-fold difference when the same product is permeated with synthetic municipal solid waste leachate. When permeated with synthetic leachate, increasing stress from 70 kPa to 150 kPa led to a slight (average 37%; maximum 2.7-fold) decrease in hydraulic conductivity due to a decrease in bulk void ratio. It is shown that hydraulic conductivity is lower for GCLs with a scrim-reinforced geotextile, and/ or with finer bentonite. It is shown that selecting a GCL based on the initial hydraulic conductivity and swell index in a manufacturers product sheet provides no assurance of good performance in field applications and it is recommended that designers pay more attention to selection of a GCL and preparation of the subgrade for important projects.
Keywords: Geosynthetics; Geosynthetic clay liner; GCL; Isothermal hydration; Hydraulic conductivity; Silty sand; Water content; Landfill; Barrier

Investigation on geogrid reinforcement and pile efficacy in geosynthetic-reinforced pile-supported track-bed

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Abstract: This paper presents a full-scale model study of geosynthetic-reinforced pile-supported (GRPS) track-bed to investigate the effect of geogrid reinforcement and the evolution of pile efficacy (ratio of load borne by the pile cap to the total applied load). Three testing procedures were followed: model construction, static loading and subsoil settlement (simulated by discharging of water bags surrounding the pile caps). The results indicated that partially mobilized soil arching was developed during the first two procedures. When sufficient subsoil settlement was reached, fully mobilized soil arching was established. The geogrid was proven to effectively transfer load from the water bag to the pile cap. The stress difference induced by the geogrid showed lower absolute values for the corresponding sensors above the water bag during loading and settlement procedures, due to the inverse triangular distribution of the vertical-directional geogrid tensile force above the water-bag area. The experimental results of pile efficacy were compared to the estimations of four analytical models. For the present test at partially mobilized arching state, the pile efficacy increased with the construction height increasing and decreased as the static loading increased. The partially mobilized arching also resulted in overestimations of the pile efficacy from all four analytical models. At fully mobilized arching state, the pile efficacy stayed relatively stable, being well predicted by all four analytical models.

Keywords: Geosynthetic reinforcement; Pile-supported track-bed; Full-scale model test; Soil arching effect; Pile efficacy

Experimental studies on inclined pullout behaviour of geosynthetic sheet Vis-À-Vis geogrid - Effect of type of anchor and sand

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Abstract: This paper presents the details of an experimental investigation using large-scale inclined pullout apparatus on sheet geosynthetic and geogrid embedded in run-out, I-type, and L-type anchors. The influence of the type of sand on the behaviour of the sheet and the geogrid is also investigated. The results show that in both the sheet and the geogrid, I-type anchor provides approximately 50% and L-type anchor provides 90% higher pullout force than the run-out anchor. The maximum pullout force increases by more than 20% as the inclination of pullout force increases from 0° to 30° for both the sheet and the geogrid.
Keywords: Geosynthetics; Geogrid; Inclined pullout; Anchor trench; Landfill cover; Low normal stress

Direct shear tests of shear strength of soils reinforced by geomats and plant Roots

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Abstract: To investigate the shear strength of root- geomat reinforced soil (RMS), direct shear tests were conducted in laboratory on soil samples cultivated with three- dimensional geomats and Bermuda grass. The test results showed that the shear strength of RMS could be significantly improved by the combined reinforcement with grass roots and geomats, particularly at a low vertical stress level. The shear strength increment was increased exponentially with the total reinforcement content of roots and geomats. Concurrently, the soil cohesion was significantly increased, but the influence on the friction angle was generally negligible. With the increase in root or geomat content and decrease in water content, both the soil shear strength and cohesion were remarkably increased. Owing to the higher tensile strength of geomat than that of roots, the effect of geomat content on shear strength was larger than that of root content. Furthermore, the shear strength increment caused by root- geomat reinforcement was larger than the sum of the respective increments caused by root and geomat. Moreover, the soil shear strength and cohesion increments induced by the combined root- geomat mutual interlocking effect were increased exponentially with the total reinforcement content.

Keywords: Geosynthetics; Root-geomat reinforced soil; Soil shear strength; 3D geomat; Direct shear test

A short-term model for extrapolating unconfined creep deformation data for woven geotextiles

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Abstract: This study reports results for creep deformation with data acquired in 72h of testing. A system capable of performing 8 simultaneous tests was used to test four woven geotextiles of different weights, following all of the recommendations outlined in the standards related to equipment setup. A mathematical model was used to generate time-dependent creep curves for four different load levels up to 40% for each sample and using a database which presented stage II creep conditions (i.e. without rupture) through the end of the tests, up to 10,000 h. The coefficients of variation for the conventional creep tests were below 10%. The compatibility between the experimental data and the model indicates that short-term (72 h) loading tests may be used to extrapolate long-term creep deformation in woven geotextiles.
Keywords: Geosynthetics; Geotextiles; Creep; Durability

Deformation characteristics of soil between prefabricated vertical drains under vacuum preloading

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Abstract: The deformation characteristics of soil among prefabricated vertical drains (PVDs) subjected to vacuum pressure are investigated using a model test conducted on dredged slurry. Red iron particles are used to indirectly indicate the lateral displacement of soil under vacuum preloading. Test results showed that, in addition to the settlement of soil between two PVDs, there was also lateral displacement that varied with consolidation time and lateral distance from the PVD because of lateral vacuum suction. The lateral displacement arose successively with the increasing lateral distance. And it increased from zero on the PVD surface and dropped back to zero again at the midpoint between the two PVDs. There should have been a maximum value of the lateral displacement at a point near the PVD. The combined vertical and lateral displacement formed a soil pile around the PVD and showed a "V' shaped soil surface.

Keywords: Geosynthetics; Prefabricated vertical drains; Vacuum preloading; Lateral displacement; Vacuum suction; Soil pile

Centrifuge model studies on the performance of soil walls reinforced with sand-cushioned geogrid layers

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Abstract: This paper is to investigate the effectiveness of encapsulating geogrid layers within thin sand layers, for enhancing the deformation behavior of vertical reinforced soil walls constructed with marginal backfills. Centrifuge model tests were performed on vertical soil walls, reinforced with geogrid layers, using a 4.5 m radius large beam centrifuge available at IIT Bombay at 40 gravities. The backfill conditions, height of soil wall, reinforcement length, and reinforcement spacing, were kept constant in all the tests. A wrap around technique was used to represent flexible facing. Three different geogrid types with varying stiffness were used in the present study. The walls were instrumented with vertical linear variable differential transformers to monitor surface settlements during the tests. Marker- based digital image analysis technique was used to determine face movements and distribution of geogrid strain along the wall height. The deformation behavior of soil walls, reinforced with geogrid layers encapsulated in thin layers of sand, were compared against a base model having no sand-cushioned geogrid layers. Provision of sand -cushioned geogrid layers and increase in geogrid stiffness were found to limit normalized face movements (S_f/H), normalized crest settlements (S_c/H), and change in maximum peak reinforcement strain ($d\varepsilon_{pmax}$). Sand-cushioned geogrid layers were also found to limit the development of tension cracks behind and within the reinforced zone. Significant reduction in rate of maximum face movement (dS_{fmax}/dt) and rate of maximum peak reinforcement strain ($d\varepsilon_{pmax}/dt$) was observed, with an increase in value of normalized reinforcement stiffness $J_g/\gamma H^2$) of geogrid layers. The analysis and interpretation of centrifuge model tests on soil walls, constructed with marginal backfills and reinforced with sand-cushioned geogrid layers, indicate that their performance is superior to the walls without sand- cushioned geogrid layers.

Keywords: Geosynthetics; Reinforced soil walls; Centrifuge modeling; Marginal fills; Sand-cushioned geogrid layers

Long-term performance of a HDPE geomembrane stabilized with HALS in chlorinated water

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Abstract: A high density polyethylene geomembrane (GMB) stabilized with hindered amine (light) stabilizers (HALS or HAS) is immersed in four chlorinated water solutions with a simulated free chlorine concentration range of 0.5 -5 ppm at five different temperatures (25, 40, 65, 75, and 85°C) for 70 months. Standard and high pressure oxidative induction time (OIT) tests are performed to monitor antioxidants depletion while melt flow index, tensile, and stress crack resistance (SCR) tests are conducted to monitor degradation in physical and mechanical properties. Degradation in the GMB properties occurred shortly after immersion in chlorinated water at all temperatures except at 25°C. Increasing the free chlorine concentration resulted in faster degradation of the tensile properties and SCR. The predicted time to nominal failure based on SCR ranges between 25 years at 40°C and 5 years at 85 °C in chlorinated water (with 0.5 ppm free chlorine). A comparison between the degradation in SCR of this GMB and a GMB with a different resin and without HALS shows significant difference in their performance in chlorinated water but not in other incubation media.
Keywords: Geomembrane; Chlorinated water; HDPE; HALS; Stress crack resistance; Nominal failure; Potable water reservoirs

Deformation analysis of geosynthetic-encased stone column using cavity expansion models with emphasis on boundary condition

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Abstract: This paper presents a modified theoretical model to predict the deformation of geosynthetic-encased stone column (GESC) and surrounding soil, using cylindrical cavity expansion model (CEM). The model was distinguished for single GESC and GESC in groups with emphasis on the different boundary conditions. The displacement boundary of CEM was used for GESC in groups, and the stress boundary of CEM was adopted for single GESC. The plasticity development of the soil obeying the Mohr-Coulomb yielding criterion was considered. The stress and settlement of the GESC were analyzed by radial stress and vertical stress equilibrium. This method has been verified via comparison with test data and numerical simulation results. The influences of applied loading, geosynthetic encasement stiffness, and soil stiffness on the mechanical performance of the GESC and the surrounding soil have also been investigated. The proposed theoretical approaches are suitable for predicting the deformation of the GESC, and the surrounding soil. The proposed method in unit cell analysis was more reasonable for GESC in groups.

Keywords: Geosynthetics; Stone column; Radial displacement; Settlement; Cavity expansion