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Centrifuge parametric study of the geosynthetic overlap for reinforced piled embankment

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Abstract: Geosynthetic-reinforced piled-supported embankments may require the use of several strips of geosynthetics. The overlap of two strips of equivalent geogrids, located at the bottom of the granular (Hostun sand mixture) load transfer platform of constant height, is studied. The methodology follows the physical modelling technique in Centrifuge. The instrumented small-scale models (scale 1/12th) are based on the use of the Mobile Tray Device in the Geotechnical Centrifuge of the Gustave Eiffel University. The width of the overlap (in the range between zero and the pile spacing) is studied, for three area ratios, in terms of efficiency (load transfer) and surface differential settlements. The objectives are: 1) to observe the behavior; 2) to understand the mechanisms; 3) to quantify the effects of the parameters studied on key design quantity for practice. Depending on the overlap, up to three successive mechanisms of deformation and load transfer are observed during the tests. For practical applications, the results provide a first set of bi-linear relationships for both the efficiency and the differential settlement versus the overlap width.

Keywords: Geosynthetics, Reinforced Soils, Load Transfer, Centrifuge Modelling, Embankment, Geotextiles, Geomembranes & Geogrids

Road subgrade stabilization with cement-coated geotextile under static and cyclic loading

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Abstract: In the current study, the use of cement-coated geotextile (CCG) in subgrade stabilization was evaluated through static and repeated load tests. Static load tests showed that the use of CCG resulted in a maximum improvement factor (I_F) of 6.86 and a settlement reduction (PRS) of 92.69%, compared to 3.80 and 75.05%, respectively, for uncoated geotextile. Repeated load tests revealed that CCG reinforcement yielded the highest Traffic Benefit Ratio (TBR) of 110 at 33 mm deformation and a maximum Rut Depth Reduction (RDR) of 53.31% after 5000 load cycles, whereas uncoated geotextile reinforcement resulted in a TBR of 36.89 at 46 mm deformation and an RDR of 35.42%. This study also introduces a novel parameter, the reinforcement efficiency factor (u_z), which reflects the combined influence of factors such as reinforcement depth, number, and vertical spacing between reinforcements. The bearing pressure values obtained from static loading tests for three different cases were analyzed in relation to the u_z values. The analysis revealed a strong correlation between bearing pressures and u_z , with R^2 values of 0.9896, 0.9919, and 0.9953 for the CCG-reinforced case and 0.84, 0.9626, and 0.9902 for the G-reinforced case at deformation levels of $d = 0.05 D$, $d = 0.10 D$, and $d = 0.15 D$, respectively.

Keywords: Geosynthetics, Geotextile, Geomembranes & Geogrids, Cement coated geotextile (CCG), Subgrade stabilization, Repeated load test, Static load test, Reinforcement efficiency factor (u_z)

Reinforcement mechanism and effect of S-PVD vacuum preloading method for dredged sludge

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Abstract: The conventional vacuum preloading method using prefabricated vertical drains (PVDs) suffers from vacuum pressure attenuation with depth. To address this limitation, this paper proposes a novel stacked PVD (S-PVD) vacuum preloading method that enhances vacuum pressure transmission and consolidation efficiency. Comparative laboratory tests were conducted on conventional PVD, reverse prefabricated vertical drain (R-PVD), and S-PVD to evaluate the reinforcement effectiveness, with particle migration patterns during the reinforcement process being systematically analyzed through particle image velocimetry (PIV) techniques. The test results indicate that the S-PVD vacuum preloading method represents a rapid and effective enhancement. Compared to the conventional PVD method, S-PVD achieved significant improvements in various indicators, such as water discharge and surface settlement, within 75% of the reinforcement period. Furthermore, the soil reinforced with S-PVD exhibits superior uniformity, with a 32.37% improvement in vane shear strength uniformity between the top and bottom of the drainage board. For the soil at the bottom of the drainage board, pore water pressure dissipation increases by 97.17%, and the radius of the influence area expands by 84.59%. This demonstrates that S-PVD effectively facilitates the transmission of vacuum pressure into bottom soil layers, thereby enhancing reinforcement efficacy and enabling synchronous and efficient consolidation at various depths.

Keywords: Geosynthetics, Geotechnical Engineering, Ground Improvement, Vacuum Preloading, Soft Ground, Reinforcement Effect, Stacked Prefabricated Vertical Drain, UN SDG 13: Climate Action

Blended polyolefin geomembrane degradation in water and extreme pH mining environments

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Abstract: Three blended polyolefin (BPO) geomembranes (GMBs) with nominal thicknesses of 1.0 mm (BzSw10), 1.5 mm (BzSw15), and 2.0 mm (BzS20) were immersed for 9.3 years in highly acidic (L1-pH 0.5) and highly alkaline (L8-pH 13.5) heap leaching solutions, and water (pH 6.5–7.6), at 85, 75, and 65°C. The solutions simulated pregnant liquors from metal recovery processes. BzSw10 and BzSw15 shared the same resin and antioxidant package, while BzS20 had a different formulation. All three comprised around 90% linear low-density polyethylene (LLDPE) and 10% high-density polyethylene (HDPE) resin. Times to antioxidant depletion and nominal tensile failure generally increased from BzSw10 to BzSw15 to BzS20 across all media. Among the solutions, pH 13.5 was the most aggressive, causing faster antioxidant depletion and onset of degradation, followed by water (pH 6.5–7.6) and pH 0.5. In pH 13.5, melt index and break strength initially decreased but later stabilized at low values, reflecting the strong influence of solution chemistry. Compared to a HDPE GMB previously immersed in the same pH 13.5 and pH 0.5 solutions, the BPOs exhibited faster antioxidant depletion but generally outperformed the HDPE in terms of mechanical property degradation, including break strength and stress-crack resistance.

Keywords: Geosynthetics, Geomembranes, Mining, Copper, Heap leaching, Blended Polyolefins, Degradation, Arrhenius, Geoenvironment, Mining & Quarrying, Geopolymers, Degradation of geomaterials

Impact of dichloromethane on groundwater below landfills with geomembrane composite liners

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Abstract: This paper examines dichloromethane (DCM) transport through geomembrane (GMB) composite liners with holed wrinkles. Consideration is given to the specified GMB composite liner designs from different jurisdictions on an attenuation layer (AL) with a GMB overlying a geosynthetic clay liner (GCL) and/or a compacted clay liner (CCL): (1) the GMB+CCL+AL liner, (2) the GMB+GCL+AL liner, and (3) the GMB+GCL+CCL+AL liner. The peak DCM impact on groundwater quality and the leakage rate from different GMB composite liner designs are compared using a two-dimensional numerical model. Sensitivity analysis indicates that the key factors affecting the GMB composite liner performance are the utilization of a GCL and/or a CCL, the CCL hydraulic conductivity when used, the AL thickness, and the aquifer potentiometric head. Most results show poor performance of examined GMB+CCL+AL liners to limit the peak DCM impact at the landfill cell downgradient edge within the jurisdictional allowable limits for DCM in drinking water. GMB+GCL+CCL+AL liners outperform GMB+GCL+AL liners because the additional layer of protection provided by the CCL (with the hydraulic conductivity of 1×10^{-9} m/s or lower) in the case of GCLs experienced typical cation exchange or permeated with aggressive inorganic solutions under holed wrinkles.

Keywords: Geosynthetics, Landfills, Geomembrane Composite Liners, Dichloromethane, Groundwater Contamination, Numerical Model, UN SDG 6: Clean water and sanitation

In-situ modulus assessment of geosynthetic-reinforced flexible pavements

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Abstract: In Surat, India, a total of 15 full-scale test sections were constructed to examine the performance of geosynthetic-reinforced flexible pavement. The impact of different factors, including the types of geosynthetics, their characteristics, and their placement locations, on the in-situ modulus of the pavement layer was assessed through Falling Weight Deflectometer (FWD) testing. The Modulus Improvement Factors (MIF) established from the three-year field study were found between 1.30 and 1.60 for the geocell-reinforcement, and Layer Coefficient Ratios (LCR) were found between 1.27 and 1.40 for the geogrid-reinforcement. FWD testing revealed an increasing trend in average base layer modulus values in February 2021 compared to initial readings from November 2019, indicating improved stiffness due to traffic compaction and reinforcement effects. However, a slight reduction in modulus was observed in July 2022, attributed to seasonal moisture infiltration from pre-monsoon rainfall. Additionally, deflection basin parameters were analyzed to assess the structural benefits of geosynthetic reinforcement.

Keywords: Geosynthetics, Full-scale Tests, In situ testing, Falling weight deflectometer, Modulus improvement factor, Deflection basin parameter

Experimental study of granular platforms reinforced by geosynthetics over soft subgrade

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Abstract: A series of large-scale laboratory tests was conducted to evaluate the impact of geotextile reinforcement on the performance of unpaved roads. An experimental protocol was established, detailing the preparation of the road base soil, installation of geotextiles, and soil compaction procedure, and then implemented. Seven unpaved road sections were successively tested under vertical cyclic loading (plate load tests) and two under traffic loading (using a Simulator Accelerator of Traffic or SAT) in a large experimental box (1.8 m in width, 5 m in length, and 1.1 m in height). Two road base thicknesses and two geotextiles with two different stiffness values were tested. The results demonstrated the effectiveness of geotextile reinforcement, with findings highlighting the influence of road base thickness on reinforcement efficiency and the impact of loading type on performance outcomes. A comparative analysis was also conducted between the experimental results and design predictions from Giroud and Han's (2004b) method.

Keywords: Geosynthetics, Geotextiles, Unpaved Roads, Soft Subgrade, Cyclic Load, Traffic Load

Modified AASHTO empirical pavement design method for geosynthetic-reinforced asphalt

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Abstract: Geosynthetics are commonly adopted to retard problems associated with reflective cracking in asphalt, although their inclusion as asphalt reinforcements also provides structural benefits. However, methodologies are yet to develop to incorporate these structural benefits into design. This study proposes a design method to account for structural capacity increase by geosynthetics in asphalt. The proposed method relies on quantifying a tensile strain reduction ratio (α) defined as the ratio between elastic tensile strain in HMA in a geosynthetic-reinforced asphalt road and that in an equivalent unreinforced road. Implementation of the design method involves incorporating a modified structural number or modified ESAL into AASHTO1993 design by using an equivalent modulus or an equivalent axle load factor for asphalt-geosynthetic composite. The geosynthetic benefits were ultimately accounted for in design either by reducing the asphalt thickness or by increasing the traffic volume. This paper presents the results of parametric evaluations of geosynthetic benefits for α ranging from 0.8 to 0.4. Design charts were developed to facilitate adoption of the proposed design method, and a design example is provided to illustrate the predicted benefits. It was found that 20% to 33% reduction in asphalt thickness, or 1.8- to 4.0-fold increase in traffic volume, is feasible.

Keywords: Geosynthetics, Reinforcements, Reinforced Pavement Design, Asphalt Thickness Reduction, Traffic Benefit Ratio, Interlayer, Fatigue Crack, Increased Traffic Volume

Improved cyclic load resistance of sand beds with geogrid-reinforced dense gravelly layers

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Abstract: Foundations bearing on uncompacted coarse-grained soil deposits (e.g. aeolian fine sands) can experience excessive settlements under monotonic and cyclic loading conditions. Straightforward strategies for improving their geomechanical behaviour include mass replacement of the uniform fine sand with high-quality soil (typically coarser sand-with-gravel (S-G) material), along with including geosynthetic reinforcement layers, although this approach may prove uneconomical in practice. The present study advocates an alternative approach employing geogrid-reinforced thin dense S-G layers incorporated at discrete depths within the backfilled fine-sand deposit. A comprehensive programme of $1g$ testing was performed to investigate the relative performances of fine sand beds incorporating geogrid layers, unreinforced thin dense S-G layers and geogrid-reinforced thin dense S-G layers compared to the plain (fully unreinforced) fine sand bed. A 150-mm dia. footing bearing on the surface of the sand beds was subjected to a combination of static loading followed by 2000 load cycles of different intensities. The experimental results confirmed that compared to the unreinforced/geogrid-reinforced sand beds, the sand beds with geogrid-reinforced dense S-G layers demonstrated superior performance in terms of limiting the cumulative footing settlement. The demonstrated concept could be of practical use in the economic construction of reinforced soil walls, reinforced foundation beds, and so on.

Keywords: Geosynthetics, Thin sand layer, Uniform fine sand, Geogrid, Cyclic load, Settlement, Repeated loading, Sands

Geocell performance in stabilising railway ballast over soft clay subgrade

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Abstract: A three-dimensional finite element model is developed to investigate the effects of geocell inclusion within a railway ballast overlying typical soft clays found in the coastal regions. A cyclic train wheel load with an appropriate dynamic amplification factor was considered to realistically model operational train speeds on a narrow-gauge network. The effect of the geocell placement depth within the ballast/subballast zone, geocell stiffness, geocell shape and ballast shear strength was studied. Track and subgrade settlement, stresses, as well as lateral ballast stability were monitored and reported. Contrary to some previous studies, the track response is more realistically captured, providing a proper indication of maintenance issues. Geocells are found to increase track performance by reducing track settlement by as much as 73%, with a substantial reduction of subgrade settlement (maximum 35% reduction) and transmitted stresses (maximum 71% reduction). Track resilience, measured as long-term settlement and stress amplitudes, was found to improve with geocells. Triangular geocells showed a superior performance in reducing track settlement and stresses, while the rhomboidal shape reduced lateral spreading the most. Geocell deformation was examined to explain the different observations. The geocell placement depth influences the lateral ballast spreading, subgrade stresses and geocell strains.

Keywords: Geosynthetics, Geotextiles, Geomembranes & Geogrids, Rail Track Design, Numerical Modelling, Clays, Finite-Element Modelling, Soil-Geosynthetic Interaction

Shear reinforcement effect of geosynthetic encased stone column in liquefiable sands

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Abstract: This paper presents a numerical investigation of the shear reinforcement effect of geosynthetic encased stone column (GESC) in liquefiable sands under seismic loading. The sands and stone column were characterized using a pressure-dependent multi-yield surface constitutive model for dynamic analysis. The geosynthetic encasement was represented using linear elastic geogrid element in the finite difference model, which was subsequently validated against shaking table test results for GESC in a saturated loose sand layer, including excess pore water pressure and acceleration time histories. The dynamic response of stone column and GESC unit cell were analyzed and compared. A parametric analysis was subsequently performed to examine the influences of critical design variables such as reinforcement stiffness and surcharge load on the dynamic response of the GESC unit cell. Results demonstrate that the geosynthetic encasement effectively enhances the shear reinforcement effect under seismic loading. Furthermore, the inclusion of geosynthetic encasement effectively improves the stress-strain response of the column and surrounding liquefiable soils. GESC exhibits enhanced shear reinforcement effect under higher vertical stress, increased encasement stiffness, and greater seismic intensity, providing new insights into the shear reinforcement mechanism of GESC, especially the development of longitudinal strain in the encasement under seismic loading.

Keywords: Geosynthetics, Geosynthetic Encased Stone Column, Seismic Loading, Shear Reinforcement Effect, Liquefiable Sands, Geosynthetic Applications