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摘要集

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目　录

Investigation of shear mechanical behaviors of geogrid-coral sand interfaces

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Abstract: Geogrid-reinforced coral sand (GRCS) effectively enhances the strength and stability of marine geo-structures in island and coastal areas. The complex interaction and underlying mechanism of the geogrid-coral sand interface potentially determine the mechanical properties of the GRCS. In this study, large-scale interfacial shear tests were carried out to investigate the mechanical behaviors of geogrid-coral sand interfaces under the coupled influence of grain size, geogrid properties, and stress level. Comparisons with siliceous sand indicate that the mechanical properties of the geogrid-coral sand interface are excellent but suffer from more complex influences originating from particle properties. The interfacial friction angle is more sensitive to grain size, whereas the pseudo cohesion is more sensitive to aperture properties. The shear interface shows a general evolution trend of “contraction-dilation-contraction”, with the maximum and final dilation becoming more prominent as the aperture size and stress level decrease. The increase in grain size, vertical stress and geogrid apertures induces a thicker interface with more particle crushing. Given the microscopic geogrid-coral sand interaction, the force characteristics of the aperture are further analyzed, and an equivalent additional stress calculation method is developed to quantitatively characterize the effects of grain size, geogrid properties, and stress level.

Keywords: Geosynthetics, Marine Coral Sand, Geogrid Reinforcement, Coupling Effect, Interfacial Shear, Particle-Geogrid Interaction, Stress Calculation

Geosynthetic-stabilized aggregate: quantitative modulus evaluation via bender element

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Abstract: Geosynthetics, mainly geogrids and geotextiles, are commonly used to mechanically stabilize unbound aggregate layers in paved road applications. They provide lateral restraint to aggregates to initially increase the layer modulus during construction and minimize its time-dependent decrease under vehicular traffic loading. Different types of geosynthetics may provide different improvement mechanisms and stiffness enhancement levels. Quantitative evaluation of various stabilization geosynthetics is presented herein to compare modulus improvement trends and help incorporate geosynthetic benefits into state-of-the-art mechanistic-empirical (M-E) pavement design procedures. Five geogrids (three extruded, one woven, and one welded) and two geotextiles (one woven and one nonwoven) were studied with a dense graded aggregate in laboratory triaxial testing. Geosynthetics were placed at specimen mid-height and three pairs of Bender Element (BE) sensors were placed at various heights above the geosynthetic to collect shear waves and quantify the degree of mechanical stabilization during resilient modulus testing. While resilient moduli did not distinguish effectiveness of different geosynthetics, shear wave measurements could clearly show local stiffness increases achieved with geosynthetic inclusions. Meanwhile, trends observed in shear modulus profiles at various distances from the geosynthetic, when compared to that of control specimen, properly established the modulus enhancement level achieved in mechanical stabilization with geosynthetics.

Keywords: Geosynthetics, Geogrids, Geotextiles, Unbound aggregates, Bender element, Shear wave transducer, Small-Strain shear modulus

Response of perforated pipes buried in sand under lateral soil–pipe movements

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Abstract: The use of perforated pipes is increasing in many applications to facilitate drainage/infiltration of liquid through opening channels in the pipe wall. However, the design of perforated pipes lacks consideration for lateral soil–pipe interaction induced by differential ground movement, which can generate large pipe stresses and strains. In this study, in-air three-point bending tests were conducted on perforated pipes, which were subsequently evaluated through lateral dragging tests. The mechanical responses of perforated pipes with different hole diameters, spacings between holes, and layer number of opening holes were interpreted. It was found that the load–displacement curves for all tests generally did not show significant differences. The pipe wall thickness had a significant impact on midspan deflection, reflecting by the smallest midspan deflection due to a higher flexural rigidity. All the tested perforated pipes were safe, since the maximum pipe strains were well below the linear elastic limit of 3% for polyvinyl chloride material. The efficacy of two prediction methods from the literature was also assessed: one was found to provide relatively close estimations, while the other solution was found to be suitable for use at relatively small pipe end displacements before the mobilization of peak soil resistance.

Keywords: Geosynthetics, Perforated Pipe, Drainage Hole, Flexural Rigidity, Soil-Pipe Interaction, Laboratory Tests

Milling of geosynthetic-reinforced asphalt layers: field operations and milling byproducts

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Abstract: With the increased use of geosynthetic interlayers, including geogrids, paving geocomposites and paving mats in asphalt rehabilitation works, an increase is also expected in projects involving the milling of asphalt layers that incorporate these geosynthetics. Although significant experience exists in milling conventional asphalt layers, such experience is limited when the milled material contains polymeric or fiberglass interlayers. Consequently, better understanding is needed on the differences in the milling process in asphalt layers with and without geosynthetics. In this study, an experimental field track was constructed at Salvador International Airport (Brazil), featuring five different geosynthetic-reinforced asphalt test sections that were milled after their construction. Evaluation of the field campaign results indicates that all geosynthetic interlayers proved to be "millable". However, the milling operations exhibited varying milling efficiencies and resulted in milling byproducts (or Reclaimed Asphalt Pavement with Geosynthetics, G-RAP) with different physical characteristics. An average reduction of 18% in milling efficiency of reinforced asphalt layers was observed compared to that of unreinforced pavements. The G-RAP byproducts were found to include geosynthetic fragments of different sizes but maintained a particle size distribution similar to that of the control RAP. Furthermore, the collected G-RAP showed beneficial impact on mechanical characteristics of asphalt mixtures with 20% G-RAP, particularly in Marshall stability, flow, and indirect tensile strength, confirming their suitability for reuse in transportation applications.

Keywords: Geosynthetics, Asphalt rehabilitation, Reinforced asphalt layers, Milling, Reclaimed asphalt pavement

Laboratory experimental study on GESC combined with electroosmosis for ground improvement

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Abstract: To verify the effect of electrokinetic geosynthetics-encased stone columns (GESC) combined with electroosmosis on soft soil foundation reinforcement, laboratory experiments were conducted using non-encased stone columns (SC), GESC, and GESC combined with electroosmosis (E-GESC). The energy consumption coefficient and drainage rate of electroosmosis, the shear strength and water content distribution of the soil, and the deformation law of the pile section after static load tests at different depths were studied. The experimental results showed that the strength of the soil around the pile increased after electroosmosis, enabling better support for the pile body, while the pile–soil stress ratio of the gravel pile was reduced and side friction resistance was effectively exerted. Moreover, the expansion deformation distribution of the gravel pile in both the E-GESC and GESC configurations was basically the same, and the maximum radial deformation was less than that observed in the SC. Most of the deformation occurred within a range of two times the pile diameter below the boundary line of the wrapped section. The ultimate bearing capacity of the composite foundation formed by the E-GESC method was 6.6 times that of the SC and 3.8 times that of the GESC, demonstrating a significantly enhanced reinforcement effect.

Keywords: Geosynthetics, Electroosmosis, Pile–Soil Stress Ratio, Combined Method, Ground Improvement, Deformation, Bearing Capacity

Study on the mechanical properties and particle breakage of geogrid-reinforced tunnel spoil

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Abstract: The use of tunnel spoil as subgrade filler can save resources and promote the sustainable and low-carbon development of transportation infrastructure. To investigate the mechanical properties evolution law of tunnel spoil as subgrade filler, SEM and large-scale triaxial tests were conducted to analyze its macroscopic and microscopic characteristics, and particle breakage behavior. The study focuses on the impact of geogrid on the shear strength, deformation, and particle breakage of tunnel spoil and its working mechanism. The results indicate that an increase in soft rock content reduces the shear strength and weakens its shear induced dilatancy. The average peak shear strength of tested geogrid reinforced dense specimens can be increased by 10%, and the residual shear strength can be increased by about 30%. The relative breakage index increases in an S-shaped pattern with increase in soft rock content. Higher confining pressure and soft rock content lead to more particle breakage, however, particle breakage in the reinforced specimens can be significantly reduced. The research findings contribute to the enhanced design and implementation of waste material repurposing, thereby advancing the sustainable development of traffic infrastructure.
Keywords: Geosynthetics, Tunnel Spoil, Soft Rock Content, Geogrid Reinforcement, Strength Parameters, Particle Breakage

Engineering properties of biodegradable vertical drains for soft ground improvement

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Abstract: The vertical drainage consolidation method is widely employed for soft ground improvement, traditionally using prefabricated plastic vertical drains (PPVDs) to facilitate effective pore water discharge. However, the non-biodegradable nature of PPVDs poses environmental challenges and complicates subsequent construction activities. To address these issues, natural prefabricated vertical drains (NPVDs) and prefabricated straw vertical drains (PSVDs) have emerged as sustainable alternatives. This study reviews the chemical composition, discharge capacity, tensile strength, and biodegradability of PPVDs, NPVDs, and PSVDs. The results demonstrate that PSVDs exhibit superior drainage performance due to their robust rectangular channels, while NPVDs degrade more rapidly under microbial and chemical influences. Although biodegradation benefits the environment, there is an associated decline in drainage efficiency. However, the field test shows that the degradation of NPVD and PSVD has no significant effect on soil consolidation. Future research should prioritize material optimization to balance biodegradability and durability, conduct long-term performance evaluations under varying environmental conditions, and integrate numerical simulations with field monitoring to predict the lifespan and effectiveness of NPVDs and PSVDs in practical applications. These findings underscore the potential of biodegradable drains as a sustainable solution for soft ground improvement while addressing critical challenges in material performance and environmental impact.
Keywords: Geosynthetics, Filters & drains, Degradation of geomaterials, Ground improvement, UN SDG 11: sustainable cities and communities

Compaction-induced prestressing effect of geocell reinforcement

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Abstract: The loading and unloading actions of rollers during the construction of geocell-reinforced soil subgrade lead to the compaction of infill materials, which further causes the geocell pockets to expand. Due to the pre-tensioning of the geocells, such responses result in increased lateral confinement of the infill soil prior to the service of the geocell-reinforced soil subgrade. The phenomenon was defined as the Compaction-induced Prestressing Effect (CIPE) in this paper, which was verified through the finite difference method-discrete element method (FDM-DEM) coupling numerical simulations on reinforced subgrade with the aid of FLAC^{3D} and PFC^{3D} software. An equation was proposed to quantitatively describe the influence of CIPE on the initial stiffness of the reinforced subgrade. Furthermore, experiments and numerical simulations were employed to investigate the evolution of Modulus Improvement Factor (MIF) values over time, where the rheological properties of geocells were considered. The findings indicated that geocell sheets experienced a normal deformation of approximately 0.5 mm and tensile strains ranging from 0.17% to 0.21% following vibration compaction. The MIF values ranged from 2 to 6 due to CIPE. When the prestressing strain of the geocell sheet reached 0.1%, the geocell strain stabilized within 300 s, with the MIF decreasing by 27.6%.
Keywords: Geosynthetics, Numerical modelling, Compaction-induced prestressing effect (CIPE), Modulus improvement factor

Effect of drains layout density on consolidation of layered slurry induced by PHDs-VP

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Abstract: Prefabricated horizontal drains (PHDs) combined with vacuum preloading (VP) presents distinct advantages over prefabricated vertical drains (PVDs) and has become a popular method for the treatment of dredged slurry. However, the effect of drains layout density on the consolidation characteristics of slurry has not been extensively investigated. This study addresses this gap by conducting three groups of experiments using the layered filling approach, one of which focused on the PHDs-PVDs-VP method. Throughout the consolidation process, water discharge and surface settlement were monitored. Post-consolidation, soil properties were assessed and shapes of prefabricated drains were examined. The results indicate that increased drains layout density accelerates consolidation rate. Additionally, using the layered filling approach can increase the treatment capacity of disposal sites by 25%, enhance the reinforcement effectiveness of deep soil layer, and achieve more uniform settlement. Moreover, the PHDs-PVDs-VP method can enhance the treatment effectiveness of slurry without the requirement for a substantial increase in drains layout density. These insights into the dewatering and reinforcement mechanisms offer valuable guidance for practical engineering applications.
Keywords: Geosynthetics, Consolidation, Prefabricated Horizontal Drains, Vacuum Preloading, Dredged Slurry Treatment, Layered Filling