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Dynamic response of rubber-sand bags: application for machine foundations

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Abstract: Rubber Soil Bags (RSBs), containing mixtures of sand and rubber, were assessed as low-cost systems to improve the dynamic response of a machine foundation or similar vibrating system. In this paper, both steady-state vibration tests using a semi-large scale vibrating system and post-impulse free vibration tests are reported. Geotextile bags were filled with 5 different proportions of rubber particles (0%–10% by mass) mixed with sand. A geophone measured the velocity response of the system. Accelerometers were placed above and below the bags. To diagnose the influence of the bags on the dynamic response of the system, Resonant Amplitude, Resonant Frequency, Equivalent Dynamic Stiffness, Equivalent Damping Ratio, Equivalent Dynamic Shear Modulus and Equivalent Dynamic Shear Strain were measured and computed above the bags. The results show that increasing the rubber content leads to a decline of both stiffness and frequency. Damping decreased so that the vibration amplitude increased at low rubber contents (from 0% to 7.5%), but the trend reversed at 10% rubber content such that the damping was greater, and the amplitude less, even than the no-rubber case. Additionally, results showed that vertical displacement beneath the bag was increasingly reduced relative to the above-bag value as rubber content increased.

Keywords: Geosynthetics, Rubber-soil bag, Soil-rubber mixture, Dynamic response, Vibrating system model

Particle size effect on the mechanical behavior of coral sand – geogrid interfaces

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Abstract: Particle size distribution (PSD) of coral sand is a critical factor that influences the mechanical properties at the coral sand-geogrid (CS-GG) interface, affected by both particle breakage and various temperatures. However, relevant research is currently scarce. This study conducts a series of large-scale interface shear tests on coral sand with three PSD ranges (0.25~1 mm, 1~2 mm, and 2~4 mm) at varying temperatures (5°C ~ 80°C). Experimental results demonstrate that the I_B value at the CS-GG interface ascends and then descends with the increase of PSD from 20°C to 40°C. The I_B value at the interface descends and then ascends with the increase of PSD from 60°C to 80°C. The PSD curves at the interface indicate that the particle breakage degree of coral sand increases with rising temperature (5°C ~ 40°C). The larger PSD of coral sand, the smaller fractal dimensions (D) of the interface. A mathematical formulation of the relationship between the relative breakage rate (B_r) and the D value at interfaces is presented, which considers temperature effects. The relationship between the total input energy (E) and the B_r value has been expressed by empirical formulations with different PSD ranges, where the fitting curve for 2~4 mm coral sand exhibits a hyperbolic pattern.

Keywords: Geosynthetics, Coral Sand-Geogrid Interface, Particle-Scale Behaviour, Particle Breakage, Temperature Effects, Large-Scale Direct Shear Test, Shear Characteristics

Effect of temperature on geogrid-soil interface performance based on pullout test

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Abstract: The geosynthetic–soil interface interaction mechanism under changes in ambient temperature may influence the serviceability of geosynthetic–reinforced soil (GRS) structures. However, very few studies analysed the effect of temperature on interface behaviour. This study conducted 20 pullout tests to investigate the effects of interface temperature and normal stress on the geogrid–sand interaction. The test results demonstrated that the interface temperature significantly affects the pullout performance. At lower interface temperatures, the peak pullout forces at the interfaces under the same normal stress are higher, whereas the time to reach the peak pullout force is longer at higher interface temperatures. The lag effect in the tensile force transfer along the reinforcement length becomes more prominent as the interface temperature increases, and both the geogrid displacement and average strains farther from the loading end decrease significantly. Additionally, the interface shear strength decreases as the interface temperature increases. In this paper, two reduction factors involving the interfacial cohesion and friction angle are presented, and the relationship between each reduction factor and interface temperature is established. The results provide valuable insights into the design of GRS walls subjected to varying environmental temperatures.

Keywords: Geosynthetics, pullout test, interface temperature, geogrid-soil interaction, UN SDG 13: Climate action

Natural weathering effects on white, green, and black HDPE textured GMs

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Abstract: This study investigates the degradation of textured High-Density Polyethylene (HDPE) geomembranes (GMs) subjected to natural weathering for 8.5 to 10.5 years. The GMs, denoted as GM-W/B (white and black), GM-G (green) and GM-B (black), had a nominal thickness of 1.00 mm and were manufactured using a flat die process with texture on both surfaces. Standard Oxidation Induction Time (Std-OIT) tests and Thermogravimetric Analysis (TG/DTG) were performed to assess the antioxidant depletion and thermal decomposition. Additionally, degradation due to Ultraviolet (UV) radiation and environmental agents was assessed through retained physical and mechanical properties, including the Melt Flow Index (MFI) measured under various loading conditions. Antioxidant depletion and TG/DTG analyses indicated that environmental exposure compromised the thermal stability of these GMs. Among the tested GMs, GM-W/B exhibited the greatest reduction in both Std-OIT and MFI, followed by GM-G and GM-B, suggesting a direct correlation between these properties. While GM-B appeared to be still in the antioxidant depletion stage (Stage I), GM-W/B and GM-G showed signs of degradation beyond Stage I. This study provides insights into the degradation of textured HDPE GMs in the face of weathering exposure effects and the durability of colored HDPE GMs.

Keywords: Geosynthetics, Geomembranes, Durability, Textured HDPE Geomembranes, Colored HDPE Geomembranes

Geotechnical characterization of soil-rubber mixtures with well-graded gravel

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Abstract: Shredded rubber from waste tyres has progressively been adopted in civil engineering due to its mechanical properties, transforming it from a troublesome waste into a valuable and low-cost resource within an eco-sustainable and circular economy. Granular soils mixed with shredded rubber can be used for lightweight backfills, liquefaction mitigation, and geotechnical dynamic isolation. Most studies have focused on sand-rubber mixtures. In contrast, few studies have been conducted on gravel-rubber mixtures (GRMs), primarily involving poorly-graded gravel. Poorly-graded gravel necessitates selecting grains of specific sizes; therefore, from a practical standpoint, it is of significant interest to examine the behaviour of well-graded gravel and shredded rubber mixtures (*wgGRMs*). This paper deals with *wgGRMs*. The results of drained triaxial compression tests on *wgGRMs* are analysed and compared with those on GRMs. Stress-strain paths toward the critical state and energy absorption properties are evaluated. The tested *wgGRMs* exhibit good shear strength and remarkable energy absorption properties; thus, they can be effectively utilised in several geotechnical applications.

Keywords: Geosynthetics, Laboratory tests, Recycling & reuse of materials, UN SDG 9: industry, innovation and infrastructure, UN SDG 12: responsible consumption and production, Gravel-rubber mixtures, Energy absorption properties

Comparing CO₂ emissions: ordinary stone vs. geosynthetic encased columns

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Abstract: The design engineers' responsibility is not limited to finding a safe solution but includes considering the environmental impact of the suggested design. In many cases a soil improvement becomes necessary when constructing an embankment on soft subsoil conditions. One of the alternative soil improvement methods is installing stone columns. A more recent alternative is installing Geosynthetic Encased Columns (GEC). In this study a comparison was made on the environmental impact both methods will create. As the measure of the environmental impact, the equivalent carbon dioxide (CO_{2eq.}) emissions was taken. For this purpose, a soft subsoil condition was considered with three different levels of weakness and three different embankment heights. In the comparison, transportation distances of geosynthetic products and granular column materials have been estimated. Since GECs can use any granular material as fill, only one hauling distance was estimated. Stone columns necessitate a more specific granular fill; hence four different hauling distances were taken into consideration. It was determined that the GEC alternative produces a much smaller CO₂ footprint than the stone column alternative. Furthermore, it was seen that the advantage of GEC solution becomes more efficient in terms of reducing the CO₂ emission with increasing embankment height.

Keywords: Geosynthetics, CO₂ footprint, Stone columns, Geosynthetic encased column

Seismic performance of thinner rubber-sand mixture cushion reinforced by geosynthetics

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Abstract: Rubber-sand mixture (RSM) has proven to be a cost-effective fill material, serving as a seismic isolation cushion between natural site soil and structure foundations. Although the isolation effect improves with increased cushion thickness, the stability of the superstructure tends to decrease while costs rise with greater thickness. Hence, it is crucial to minimize cushion thickness while attaining the optimal isolation objective. This study experimentally assesses the seismic performance of thinner RSM cushions reinforced by geosynthetics, specifically geocells, geotextiles, and geogrids. The effects of superstructure mass, cushion thickness, and excitation mode on the isolation coefficient of geosynthetic-reinforced rubber-sand mixture cushions (GRRSMC) are thoroughly evaluated. The results indicate that the isolation effect of reinforced cushions exceeds that of the unreinforced ones with the same thickness. Among the different reinforcements, geotextile provides the highest isolation efficiency, followed by geocell and geogrid. The seismic performance of GRRSMC is primarily attributed to the low shear modulus. Additionally, geosynthetic reinforcement enhances the vertical modulus, which helps to attenuate seismic waves. These findings validate GRRSMC as a viable low-cost seismic approach, ensuring superstructure stability, and reducing cushion thickness.

Keywords: Geosynthetics, Seismic Isolation, Rubber-Sand Mixtures, Shaking Table Test, Dynamic Transformation Coefficient

Performance of geogrid- and geotextile- reinforced low to moderately expansive subgrades

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Abstract: This study evaluates the performance of model pavements constructed in a $1.5 \text{ m} \times 1.5 \text{ m} \times 1.1 \text{ m}$ test chamber under differential swell pressure induced by expansive subgrades. Three configurations were tested— one with a 400 mm Wet Mix Macadam (WMM) layer directly over the subgrade, another with a 400 mm WMM layer over a 250 mm prepared subgrade, and a third with a 400 mm WMM layer over a 500 mm prepared subgrade. Differential swell pressure was simulated using a 250 mm dia. plate, resulting in subgrade rise of 12.5 mm, reported as potential vertical rise (PVR) in the unreinforced scenario. The same pressure was applied to reinforced scenarios, where geogrid and geotextile reinforcements with tensile strengths of 100 kN/m and 200 kN/m were placed at the subgrade level to mitigate swell-induced heave. Geotextile reinforcement reduced PVR by 85%, 78%, and 58% under swell pressures of 150 kPa, 225 kPa, and 425 kPa, respectively; while geogrid reinforcement achieved reductions of 77%, 68%, and 36% under the same pressures. Both reinforcements minimized swell pressure transfer to pavement layers, enhancing stability and improving the pavement performance. The findings demonstrated the effectiveness of geogrid and geotextile reinforcements in significantly mitigating heave under expansive subgrade conditions.

Keywords: Geosynthetics, Geogrid, Geotextile, Swell pressure, PVR, Efficiency, Flexible pavement

Mechanical properties of SCA modified EPS lightweight soil and modification mechanism

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Abstract: Expanded Polystyrene (EPS) granular lightweight soil (ELS) is an eco-friendly material made of EPS particles, cement, soil, and water. This study investigates the modification of ELS using a silane coupling agent (SCA) solution to improve its performance. Various tests were performed, including flowability, dry shrinkage, unconfined compressive strength (UCS), triaxial, hollow torsional shear, and scanning electron microscopy (SEM) analysis, to evaluate the physical and mechanical properties at different SCA concentrations. The results show that the optimal SCA concentration was 6%, improving flowability by 13% and increasing dry shrinkage weight by 4%. The UCS increased with SCA concentration, reaching 266 and 361 kPa after 7 and 28 days, respectively, at 6% SCA. Triaxial and shear tests indicated improved shear strength, with the maximum shear strength reaching 500 kPa, internal friction angle rising by 4%, and cohesion reaching 114 kPa at 6% SCA. Hollow torsion shear tests showed that 6% SCA enhanced stiffness and resistance to deformation, while reducing the non-coaxial effect. SEM analysis revealed that SCA strengthened the bond between EPS particles and the cement matrix, improving the interfacial bond. This study highlights the potential of modified ELS for sustainable construction.

Keywords: Geosynthetics, EPS Particles, SCA Modification, Physical Properties, Mechanical Properties, Non-Coaxial Angle, Microscopic Mechanism Analysis, UN SDG 11: Sustainable cities and communities, UN SDG 12: Responsible consumption and production