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EDITORIAL

Guest Editorial for the Special Issue on "Soil–Geosynthetic Interaction"

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The shear resistance at soil–geosynthetic and geosynthetic–geosynthetic interfaces is critically important for the proper design of geosynthetic-reinforced structures, such as retaining walls and embankments, and of geosynthetic-lined landfills, reservoirs, and canals. The design and construction of such applications are enhanced through proper understanding of the related interface behavior. Free draining granular materials, including industrial by-products (e.g., fly ash and furnace slag) and construction and demolition wastes, are often specified as reinforced backfill materials for reinforced soil structures, and cohesive soils of low permeability are specified for geosynthetic-lined landfills and reservoirs. Although the interaction behavior at the soil–geosynthetic and geosynthetic–geosynthetic interfaces is studied mainly by performing modified direct shear tests, inclined plane tests and pullout tests, and some other tests (e.g., ring shear and triaxial compression tests) have also been used for this purpose. The main objective of this special issue is to present the latest, original research findings and developments on soil–geosynthetic and geosynthetic–geosynthetic interactions using conventional or specialized materials and methods. We hope that the readers of this special issue as the collections of 13 articles (Article numbers 67, 73, 77, 78, 80, 81, 82, 83, 84, 85, 86, 87, 88) will find them useful.

Article 67 investigates how the subgrade strength and the location of a geogrid within a ballast layer affect the ability of geosynthetic to stabilize railroad ballast. For this purpose, thirteen large-scale cyclic load tests were performed on unreinforced tie–ballast assemblies and on tie–ballast assemblies reinforced with a geogrid placed at various depths. The results suggest that the compressibility of the subgrade supporting a geogrid-reinforced tie–ballast assembly plays a crucial role in determining the reinforcing efficiency of geogrid. The inclusion of geogrids in railroad ballast leads to reductions in the permanent and resilient settlement of tie which vary depending on the geogrid's location and subgrade compressibility.

In Article 73, the interface shear strength characteristics of marginal lateritic soil in contact with a composite geosynthetic, which can perform the functions of drainage and reinforcement, were examined using large direct shear tests (300 mm × 300 mm × 200 mm) with an emphasis on the influence of suction on soil–reinforcement interaction. The influence of rainfall infiltration on soil–soil and soil–reinforcement interface characteristics was also evaluated. Loss of matric suction within the soil was observed due to rainwater infiltration which reduced the shear strength. This paper demonstrates the reduction in shear strength and interface shear strength to be accounted for rainfall-induced wetting, while considering the marginal lateritic soil as the backfill for reinforced soil slopes/MSE walls.

The aim of the Article 77 is to assess the interaction of biaxial geogrid with two different solid waste materials, namely steel slag and construction and demolition waste (CDW) and compare its performance with a conventional backfill material (sand) by performing direct shear and pullout tests at various normal stress levels. The direct shear test results revealed that both steel slag and CDW exhibit higher shear strength compared to sand. Similarly, the pullout test results indicated that the pullout resistance of the geogrid is higher in steel slag and CDW than in sand. More specifically, the interaction of the geogrid with steel slag and CDW at 25 kPa normal stress was 38% and 33% higher, respectively, than that with sand. Furthermore, an artificial neural network model was developed using data from the current study as well as data gathered from previous studies to predict the pullout resistance of geogrids in a wide range of geomaterials exhibiting a coefficient of determination (R^2) value higher than 0.9.

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Article 78 investigates the effect of geosynthetic materials on the swell reduction of expansive (reactive) soils based on a series of large-scale long-term soil column experiments conducted on a very high plasticity reactive soil under simulated rainfall conditions. Non-woven geosynthetics combined with geogrid and woven geosynthetics were used as primary geosynthetic materials to provide reinforcement and drainage for the soil mass. The obtained results revealed that these geosynthetics did not improve the California Bearing Ratio values of the soil but they greatly reduced the total swell of the soil. Visual observations and the experimental data on water content, suction, and vertical displacements indicated that the geosynthetics provided better drainage of the soil mass limiting the time of water–soil interaction and, thus, reducing the total swell of the soil.

Article 80 studies the causes of post-construction settlement and proposes effective management strategies. Physical model studies revealed that high groundwater levels led to the washing away of particles under the concrete slab, creating soil voids that contribute to settlements. Increasing the use of geotextiles and installing underground pipes to divert water away from vulnerable areas would help reduce settlement. Additionally, finite element analysis demonstrated that the presence of a concrete-paved ditch led to water accumulation at the base of slopes, resulting in soil liquefaction. Pore-water pressure ratios increase with rising underground water levels, leading to a decrease in the factor of safety and an increased risk of structural failure. To address these challenges, effective management and remediation recommendations were proposed, integrating sub-drainage systems with geotextile filtration. Geotextiles play a crucial role in filtering soil particles, preventing their accumulation, and potential damage to the drainage system. The proposed recommendations offer practical solutions for managing and mitigating settlement-related risks in civil engineering projects.

Article 81 investigates the influence of particle shape on the multi-scale shear behavior of sand–geomembrane interfaces through advanced imaging techniques. Two sand specimens with varying particle shapes were scanned using X-ray micro-computed tomography and the data were processed and analyzed to extract shape parameters like sphericity, roundness and fractal dimension. Interface shear tests were conducted using a modified direct shear apparatus, which allows image analysis of sand–geomembrane interactions by capturing the kinematics of particles at the contact plane. Additionally, micro-topographical analysis was carried out using a digital profilometer to measure the surface changes of the geomembranes after shearing. The findings indicated that the increased shear strength observed in irregular particles has a direct correlation with the deeper indentations caused by these particles and the larger localized shear zones associated with these particles.

Article 84 explores the application of geosynthetic reinforcement for performance improvement of Landfill mined soil like fraction (LMSF) as a fill material. Large direct shear tests were carried out to quantify the shear strength parameters at LMSF–geogrid and LMSF–geotextile interfaces resulting in interaction coefficient values of about 0.6 and 0.58, respectively. Moreover, plate load tests have been conducted on LMSF–geogrid and LMSF–geotextile-reinforced fill at various depths of embedment and varying areal extents of reinforcement. An enhanced bearing capacity ratio of 2.1 and 1.8 has been obtained for geotextile- and geogrid-reinforced LMSF, respectively; that is comparable with reinforced soils adopted for fill applications. The findings of this study reflect the potential of geosynthetic-reinforced LMSF as a sustainable fill material, a small step towards achieving United Nations sustainable goals.

Article 87 assesses the shear strength of five interfaces identified in cover systems used in the closure of mining waste deposits. The shear strength of each interface was determined through a large-scale direct shear testing program at low normal stresses (< 50 kPa) using samples of geomembranes (GM), geosynthetic clay liners (GCL), granular soils (GS) and low-permeability soils (LPS). The test results were compared with other studies aiding in identifying and understanding the mechanisms and factors influencing the interface shear strength. These factors include the gravel content and characteristics of coarse particles in GM–GS and GCL–GS interfaces, the fines content in GM–LPS interfaces, and the type of geotextile composing the GCL in GCL–GM interfaces.

Article 82 presents insights from small-scale model tests on a statically loaded strip footing placed on dense base sand with a single geotextile layer over a loose subgrade. The evaluation of the geotextile's benefits involved comparing the load–settlement curves obtained for the reinforced soil model against those observed in the unreinforced beds. The influence of inclusion on relative soil–geotextile displacements is assessed using LVDTs attached to the geotextile, digital image correlation technique, and digital microscopes. The soil–geotextile interaction mechanism was experimentally analyzed by closely observing the displacements of both the geotextile and surrounding sand. Additionally, the microscopic particle motion around the geotextile was tracked to verify the macro behavior of the sand–geotextile interface during footing pressure increment. The results of this study improve the understanding of sand–geotextile interaction during strip surcharge on soft subgrade reinforced foundation beds.

In the Article 83, triaxial compression testing data obtained for a soil reinforced with a geosynthetic, and specimens with different dimensions (diameters 70 and 150 mm) were used to assess changes in shear strength and to carry out a statistical analysis. The increases in shear strength of the reinforced soil and of the soil–geosynthetic interface were analyzed using equations from the literature. The difference between the triaxial compression test results obtained from specimens of different sizes was assessed using an Analysis of Covariance (ANCOVA). When the joint term of the regression model was not statistically significant, the characterization from different specimen sizes was used to generate soil failure envelopes. Thus, a new methodology to obtain a failure envelope with different specimen sizes is presented.

In the Article 86, the results of an extensive series of soil–geosynthetic interface tests are reported to evaluate the degradation of stress–displacement–strength properties following contamination of soil specimens with crude oil. For this purpose, constant normal load tests on the interfaces between sand and clay soil specimens in contact with a woven geotextile (GTX) and a PVC geomembrane (GMB) were conducted. The results confirm that contamination with crude oil leads to degradation of the peak and critical state friction and dilation angles in the purely frictional sand alone and sand–geosynthetic interfaces. Increase in contamination content causes progressive degradation of the friction angle and adhesion intercept in the crude oil contaminated clay alone and clay–GTX interface. Compared to the clay–GTX interface, the adhesion intercepts in the crude oil contaminated clay–GMB interface are less sensitive to contamination content and from a practical view, the decrease in friction angle owing to increase in contamination content appears negligible in the clay–GMB interface.

Article 85 compares the interface performance between separating subgrade and base materials of roadways with an assembly of a nonwoven geotextile overlaid with a geogrid versus a geogrid–geotextile composite. Large-scale pullout tests were performed to measure the geosynthetic–geosynthetic interaction between a geogrid and nonwoven geotextile. Large-scale direct shear tests were also performed to measure the soil–geosynthetic interaction of the geogrid–geotextile composite and representative subgrade and base course soil. The results indicate that the geosynthetic–geosynthetic interface has lower shear strength than the soil–geosynthetic interface. This suggests that the use of a geogrid–geotextile composite can potentially improve soil reinforcement compared to layering a geogrid on a separate nonwoven geotextile by eliminating the critical geosynthetic–geosynthetic shear plane.

Article 88, which is part of a broader investigation into the feasibility of replacing soils used in landfill final cover systems by recycled construction and demolition (RC&D) materials, analyzes the inclined plane shear behavior of the interface between a fine-grained RC&D material and a drainage geocomposite. Inclined plane shear tests were performed with different vertical stresses and different compaction conditions (degree of compaction and water content) of the RC&D material. The friction angle at the RC&D material–geocomposite interface was estimated by two approaches: the standard and the one based on the Mohr–Coulomb failure envelope. The main findings of this work include the friction angle (standard approach) at the RC&D material–geocomposite interface decreases by increasing the applied vertical stress and the RC&D material water content and tends to increase by increasing the degree of compaction of the RC&D material; the behavior of the RC&D material under inclined plane shear movement does not differ significantly from that of the RC&D material–geocomposite interface; the failure envelope approach is more conservative (smaller friction angles) than the standard approach.

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