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Geotextile filters: from idealization to real behaviour （Giroud Lecture 2023)

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Abstract: Geotextiles have been used as filters in geotechnical and geoenvironmental works for decades. Despite their broad utilization, these filters still find obstacles to the expansion of their application in larger projects and under complex soil and flow conditions. However, environmental issues are increasingly pressing for a greater use of geotextile filters in substitution to natural granular materials. Even though many important studies in the literature have improved the understanding of soil-fluid-geotextile filter interaction, some issues still require thorough investigation aiming at a better understanding of the behaviour of geotextile filters and the development of better design methodologies. This paper discusses how geotextiles filters are expected to behave in the field and some contradictions between idealized and real behaviour. Concerns regarding the use of geotextile filters under severe and critical conditions and how filter malfunction can be avoided or minimised are also addressed as well as approaches available to predict filter behaviour. A broad investigation on geotextile filter behaviour under severe and critical conditions was carried out and shows that these filters have been very successful, particularly bearing in mind the small number of failures in comparison with the huge number of applications of geotextile filters.
Keywords: Geosynthetics, Filters, Geotextiles, Filter behaviour, Clogging, Piping

Selection of long-term shear strength parameters for strain-softening geosynthetic interfaces (2023 IGS Rowe Lecture)

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Abstract: The behavior of strain-softening geosynthetic interfaces that can lead to progressive failures in lined containment facilities has been a source of confusion in slope stability evaluations for over 30 years. This paper presents 15 mechanisms that can potentially induce displacements along strain-softening interfaces, along with measures that can be considered to reduce strain-softening displacement. New quantifications of shear strength variability that can be caused by manufacturing, installation, and construction practices are introduced. Guidance and recommendations are given that are applicable to numerical continuum as well as limit-equilibrium approaches to assist in selecting appropriate geosynthetic shear strength parameters for containment facilities that have strain-softening interfaces. While most of the paper focuses on deep-seated critical interfaces for high-normal-stress bottom liners, low-normal-stress veneer covers are also addressed.
Keywords: Geosynthetics, Strain-softening, Progressive failure, Liner systems, Slope stability

Geosynthetic MSE walls research and practice: past, present, and future
(2023 IGS Bathurst Lecture)

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Abstract: The technology of geosynthetic mechanically stabilized earth (MSE) walls can help solve classical geotechnical earth retaining wall problems. It can also contribute to achieving the new required performance for infrastructures, such as reliance and sustainability. To further develop this technology, it is essential to analyze the history of its progress. This study summarizes the state-of-the-art research on the mechanical and soil interaction properties of geosynthetics, physical modeling and in situ measurements, analytical and numerical modeling, and reliability analyses by reviewing approximately 728 papers published in well-known international journals in this field and some notable conference paper contributions during the period of approximately 50 years from 1972 to 2023. The latest analytical methods, such as risk-based life cycle cost and CO_2 emission assessments and damage/failure predictions, are introduced to evaluate the resilience and sustainability performance of geosynthetic MSE walls. Finally, the prospects of a seismic isolation technique with new types of geosynthetics and life cycle management using a long-term sensor for geosynthetic MSE walls are discussed.

Keywords: Geosynthetics, Reinforced soil walls, The state of the art, Resilience, Sustainability

Impact of differential settlement on leakage through geomembranes in waste covers

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Abstract: To quantify the effects of differential settlement on leakage through a geomembrane (GMB) hole in waste (landfill/mine tailings) covers, field experiments were conducted at Queen's University Experimental Liner Test Site on two sections, each with a 4H:1V slope. Over 13 months, measurements showed that a 3 m×2 m×0.12–0.17 m depression in Section B led to a 51-fold increase in leakage when compared to Section A, which had no such depression (493 l vs 11.1 l). Notably, in Section B, 284 mm of precipitation between November and February resulted in 281 l of leakage, whereas 537 mm of precipitation between June and September led to a mere 142 l of leakage. A 3D numerical investigation provides encouraging agreement with the experimental measurements and confirms a counterintuitive 43% increase in leakage with a decrease in the temperature of cover sand from 21.9°C to 1°C, due to the influence of temperature-dependent viscosity on the hydraulic conductivity of the cover soil. This paper offers insights for optimizing waste cover design and inspection procedures to mitigate the challenges of contaminant control.
Keywords: Geosynthetics, Leakage, Geomembranes, Waste, Settlement, UN SDG 6: Good health and well-being, UN SDG 13: Climate action

Cumulative deformation behavior of GRS bridge abutments under cyclic traffic loading

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Abstract: This paper presents an experimental study on reduced scale geosynthetic reinforced soil (GRS) abutment models subjected to cyclic traffic loading, aimed at investigating the influences of cyclic load amplitude, self-weight of bridge superstructure, and reinforcement vertical spacing on the cumulative deformations. The GRS abutment models were constructed using sand backfill and geogrid reinforcement. A static load was first applied to account for the self-weight of bridge superstructure, and then the cyclic loads were applied in several phases with increasing amplitude. The results indicate that significant cumulative footing settlement under cyclic loading mainly occurs within the first few hundred loading cycles, and the settlement increases with increasing cyclic load amplitude. The cyclic load amplitude and reinforcement vertical spacing have significant impacts on the cumulative deformations of GRS abutments under cyclic loading. The maximum facing displacement under cyclic loading occurs near the top of the wall. The cyclic load has a greater impact on the reinforcement strains near the upper middle reinforcement layers, while it has a smaller impact on the lower reinforcement layers.
Keywords: Geosynthetic, Geosynthetic reinforced soil, Bridge abutment, Cyclic loading, Cumulative deformation, UN SDG 11: Sustainable cities and communities

Ternary medium constitutive model of frozen rubber-reinforced expansive soil

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Abstract: The application of waste rubber for soil improvement is feasible, and the static and dynamic properties of rubber-reinforced soils have been extensively studied. However, the mechanical properties of frozen rubber-reinforced expansive soils have not been effectively studied due to the complexity of multiphase media under the action of multiple fields, and no applicable constitutive models describe them. In this paper, the stress-strain relationship model for frozen rubber-reinforced expansive soils is investigated over a range of strain rates from 0.18% to 0.3% and the following conclusions were obtained: (1) The structural model of the frozen rubber-reinforced expansive soil can be considered a ternary medium model that consists of elasto-brittle bonding elements, elasto-plastic friction elements and elastic friction elements. (2) The stress-strain relationship can be divided into three stages: linear elastic stage, elasto-plastic stage and strain softening ($R_C \leq 15\%$) or hardening ($R_C = 20\%$) stage. (3) The rubber content has a greater influence on the stress-strain relationship. When the rubber content reaches 20%, the expression of the stress-strain curve changes from strain softening to strain hardening, at which time the rubber dominates. (4) The maximum shear strength of frozen rubber-reinforced expansive soil is obtained at 10% rubber content.
Keywords: Geosynthetics, Expansive soil, Rubber content, Freezing, Confining pressure, Ternary media model, UN SDG 11: Sustainable cities and communities

Analytical model for geotextile-enhanced horizontal drain vacuum consolidation of slurries

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Abstract: Horizontal drains are gradually introduced to the vacuum preloading method to improve dredged slurries by adding geotextiles to alleviate the blockage in the consolidation process. This study considers the consolidation of slurries enhanced by the vacuum preloading method with geotextile combined horizontal drains based on a double-layered consolidation model. The model approximates geotextile as a special soil layer possessing an equivalent consolidation factor. An analytical solution of the layered consolidation model is obtained using the Laplace transform and the finite Fourier transform method. The effectiveness of the solution is verified by comparing it with the one-dimensional double-layered consolidation solution and the one-dimensional consolidation with a partially permeable boundary. Through comparison with laboratory experiments, the model shows good fitness with the test results in the literature. The influences of related parameters, including the drain arrangement densities, soil parameters, and geotextile parameters, are discussed on average consolidation degree and pore water pressure. The influence mechanism is explained regarding drainage path and vacuum pressure transfer. Findings demonstrate that geotextile facilitates vacuum transfer and promotes soil consolidation, especially when the smaller density of drains' deposition and lower soil permeability are applied.
Keywords: Geosynthetics, Consolidation, Horizontal drain, Geotextiles, Vacuum preloading method, Dredged slurries

Long-term performance of HDPE extrusion welds aged at 85°C in synthetic leachate

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Abstract: The effect of ageing at 85°C of extrusion welds of 1.5 mm-thick high-density polyethylene (HDPE) geomembrane, immersed in synthetic municipal solid waste leachate, is investigated with respect to its standard oxidative induction time (Std-OIT) and stress crack resistance (SCR). Results show that the heat-affected zones (HAZ) adjacent to the squeeze-out bead (flashing) may exhibit faster STD-OIT depletion than the sheet. Generally, individual weld SCR failure times were observed to be between that of the notched and unnotched sheet. Welds with high welding-induced geometric irregularities (WIGI), and overheated fusion and extrusion welds are shown to result in SCR failure times close to that of a notched sheet. The average time to nominal failure (taken to be when t_{NF}=250 h) of Cool and Good welding parameter combinations ranges between 3% and 15% shorter than the unnotched sheet. Differences in tNF were attributed to accelerated craze formation in welds with high WIGI from stress concentration. No significant difference was observed between the SCR values of fusion and extrusion welds during 40 months of immersion in MSW-L3. This paper shows that overgrind negatively impacts the SCR of welds and accelerates the degradation of SCR.
Keywords: Geosynthetics, Extrusion welds, Fusion welds, Ageing, Long-term performance, Stress cracking resistance, HDPE, Geomembranes, Quality assurance

Deformation characteristics and creep behaviour of rigid particulates-EPS beads composites

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Abstract: The compression behaviour of the mixture of glass beads (representing rigid particles) and EPS beads (representing deformable particles) during the loading-unloading process is systematically examined through performing two sets of large-size oedometer experiments, including incremental step-by-step and one-step loading scenarios. At each step during the loading-unloading cycle, the void ratio (e) and the at-rest coefficient of lateral earth pressure (K_0) are measured for pure rigid samples and rigid-soft particle mixtures. To consider the creep effect, the overburden pressure at the final loading step is maintained on the sample for 24 h prior to unloading. The results show that at a given overburden pressure, with the addition of soft particles to the pure rigid aggregates, the values of e and K_0 decrease. Additionally, for both pure rigid samples and rigid-soft particle mixtures, with increasing the overburden pressure, e decreases whereas K_0 augments. Moreover, due to the creep behaviour during the constant loading step, K_0 decreases over time for both samples; a phenomenon which is observed to be more pronounced for pure rigid aggregates compared to rigid-soft particle mixtures. Finally, a well-established creep model is used to simulate the creep behaviour of pure rigid samples and rigid-soft particle composites.
Keywords: Geosynthetics, Lightweight material, EPS beads, Glass beads, Creep, Unloading behaviour, Rigid-soft contact

Natural weathering effects of nonwoven geotextile exposed to different climate conditions

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Abstract: Humidity, air temperature, rainfall and solar radiation all contribute to the weathering of geosynthetics. Over time, their useful life can be affected and changes in properties can be observed, which affects the performance of these materials. As geosynthetics durability analyses must encompass each work condition, assessing the climate effects is essential for design purposes. This study exposed a nonwoven needle-punched poly(ethylene) terephthalate geotextile to natural weathering in three Brazilian cities (different exogenous environments) for 18 months. Mechanical tests were conducted to evaluate the geotextile changes due to weathering. This was demonstrated by the results: exposure to weather leads to the deterioration of the geotextile mechanical properties and increased stiffness. After four months, the tensile strength fell by half, while the deformation needed more than 12 months to have this same reduction; ultraviolet radiation intensity was the most effective weathering condition in the field; humidity and rainfall can affect the stiffness of geotextiles; the impact of accumulated climate factors gradually showed a convergence in the response of geotextile to weathering. Thus, this work highlights the need to evaluate the climate conditions in each location to understand the material's behavior on the exposure time.
Keywords: Geosynthetics, Geotextile, Durability