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Swelling behaviour of expansive soils with recycled geofoam granules column inclusion

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Abstract: Structures founded on expansive soils experience large uplift pressure due to the high swelling nature of these soils. In this investigation, an effort is taken to reuse the waste expanded polystyrene (EPS) beads to form geofoam granules column (GGC) and quantify the swelling behaviour of expansive soil with and without GGC inclusion. Several swell tests were carried out in statically compacted soil specimen with uniform thickness of 100 mm placed in a large scale one dimensional consolidation apparatus which can accommodate the California bearing ratio (CBR) mould. Attempts were made to ascertain the performance of GGC inclusion in expansive soil by varying diameters of GGC (25 mm, 40 mm, 50 mm and 75 mm), density of formed GGC (15 kg/m^3 and 20 kg/ m^3) and two placement conditions of soil samples (by varying moisture content). Tests results were analysed which showed that the percentage of swell, swelling pressure and the time rate of swell decreases upon inclusion of GGC and significant reduction is noticed for lesser GGC density. Further, the mechanism of GGCs influence in control swelling of expansive soil is explained with the help of soil-GGC interaction.

Keywords: Geosynthetics; Expanded polystyrene; Geofoam granules column; Expansive soil; Percentage of swell; Swelling pressure; Large scale consolidation apparatus

Effect of vacuum removal on consolidation settlement under a combined vacuum and surcharge preloading

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Abstract: The combined vacuum and surcharge preloading technique is extensively used to accelerate the consolidation process of subsoils. The effect of vacuum pressure is often considered as a loading/unloading cycle of mean effective stress, such that elastic rebound occurs after vacuum removal, which cannot explain the observed postconstruction settlement in the field. In this study, the stress state of subsoils subject to vacuum and surcharge preloading is analyzed and decomposed into two components: (a) geostatic consolidation at a different depth, and (b) loading/unloading in the minor principal stress direction. A series of consolidated drained triaxial tests is conducted to simulate the soil behaviour after vacuum removal. Results show that the contribution of unloading in the minor principal stress direction outweighs the magnitude of elastic rebound after vacuum removal, and hence continued settlement dominates. A field case for highways is provided to further demonstrate the proposed mechanism.

Keywords: Geosynthetics; Vacuum and surcharge preloading; Vacuum removal; Unloading; Minor principal stress direction; Settlement

Behavior evaluation of geogrid-reinforced ballast-subballast interface under shear condition

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Abstract: The effective functioning of a railway track under operating conditions depends largely on the performance of various rail track interfaces (e.g. ballast-subballast interface, subballast-subgrade interface). In this context, a series of large-scale direct shear tests were conducted to investigate the shear behavior of unreinforced and geogrid-reinforced ballast-subballast interfaces at different normal stresses (σ_n) and rates of shearing (S_r). Fresh granite ballast and subballast having average particle size (D_{50}) of 42 mm and 3.5 mm respectively, and five geogrids with different aperture shapes and sizes were used in this study. Tests were performed at different normal stresses (σ_n) ranging from 20 to 100 kPa and shearing rates (S_r) ranging from 2.5 to 10.0 mm/min. The laboratory test results confirmed that the shear strength of ballast-subballast interface was highly influenced by the applied normal stress (σ_n) and rate of shearing (S_r). The friction angle (φ) of unreinforced ballast-subballast interface was found to decrease from 63.24 ° to 47.82 ° and dilation angle (ψ) from 14.56 ° to 5.23 ° as the values of σ_n and S_r increased from 20 to 100 kPa and 2.5–10.0 mm/min, respectively. Further, the breakage of ballast (B_g) was found to increase from 2.84 to 6.69%. However, geogrid inclusions enhanced the shear strength of the ballast-subballast interface and also reduced the extent of B_g. The results indicate that it is possible to establish a relationship between the friction angle (φ) and breakage of ballast (B_g), wherein the friction angle (φ) of both unreinforced and geogrid-reinforced interfaces reduces with the increase in breakage (B_g)). The interface efficiency factor, defined as the ratio of the shear strength of the geogrid-reinforced ballast-subballast interface to the original shear strength of ballast-subballast interface varies from 1.04 to 1.22. Moreover, the current study revealed that the shear behavior of ballast-subballast interface was influenced by geogrid aperture size (A).

Keywords: Geosynthetics; Ballast-subballast interface; Large-scale direct shear test; Rate of shearing (S_r); Friction angle (φ); Interface efficiency factor (α)

Application of the two-layer system theory to calculate the settlements and vertical stress propagation in soil reinforcement with geocell

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Abstract: This paper presents a methodology for determining the surface settlements of the geocell-reinforced soil layer and the vertical stresses propagated to the foundation subgrade at the layers interface, on the subgrade. Based on the theory of equivalent thicknesses, which is an approximation of the theory of elasticity for layered systems, a generalized equation for determining settlements was proposed in a two-layer system composed of geocell-reinforced soil layer over the subgrade. The equation obtained is dependent only on the relations between the elastic parameters of these two layers, such as the deformation moduli and Poisson's ratio, and geometric parameters, such as geocell layer thickness and loading width. The proposed equation generated very close results with rigorous solutions of the two-layer system from the theory of elasticity. It was applied, together with rigorous methods, in an instrumented field Plate load test allowing the determination of the geocell-reinforced soil layer modulus of deformation by retro analysis and the vertical stresses propagated to the subgrade. The results showed that the two-layer system theory from theories of elasticity and equivalent thicknesses can be used in a simple and efficient way for determining settlements and the propagation of vertical stresses. The proposed methodology also satisfactorily calculated these results when compared with the rigorous methods and with the values obtained in the field test.
Keywords: Geosynthetics; oil reinforcement; Layered system; Theory of elasticity; Theory of equivalent thickness

Hydro-mechanical behavior of a lateritic fiber-soil composite as a waste containment liner

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Abstract: In waste disposal landfill projects, the hydraulic conductivity of the barriers is a major consideration. The use of fibers mixed with backfill may improve the overall performance of the barriers. Fiber-soil composites show a more resistant and ductile behavior than the soil alone. The presence of fibers may reduce cracking problems related to shrinkage or traction in liners or covers. In this study, laboratory tests were performed to evaluate the use of fiber-soil composites as a containing barrier. Hydraulic conductivity and diametral-compression tests were carried out on PET fiber reinforced and unreinforced compacted soil specimens. The tests were conducted under confinement conditions similar to those found in the field. Diametral-compression tests were used to induce cracks in the specimens. Hydraulic conductivity was measured at different stages during the diametral loading. In the tests performed under low confinement pressure (10 kPa), the crack openings led to a significant increase in hydraulic conductivity. The results showed that the addition of fibers increases the tensile strength of the soil-fiber mass and delays the opening of cracks. Moreover, in the tests under high confinement pressure (100 kPa), a decrease in hydraulic conductivity occurred at all stages of the diametral load application.
Keywords: Geosynthetics; Fiber; Lateritic soil; Soil liners; Diametral-compression testing; Hydraulic conductivity testing; Hydro-mechanical behavior

Biodegradable geotextiles – An overview of existing and potential materials

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Abstract: Geotextiles are a group of mostly thermoplastic polymers, which are processed to flexible material sheets, and are installed on various landscapes for reinforcing or protective purposes. Most applied materials in the field are non-degradable polymers, such as polyolefins or polyesters, which can implicate environmental problems concerning soil pollution and accumulation of micro plastics. Because of these drawbacks, for some applications time-consuming re-collection of the material becomes necessary. Hence, the development of more environmentally friendly and biodegradable geotextiles is of interest for several application purposes. In this review biodegradable alternatives to the conventional polymeric geotextile fibers are discussed. In general, there are two material classes available, which are natural fibers and biodegradable polymers. While there is already quite a number of natural-fiber-based geotextiles available on the market, the idea of applying industrial biopolymers for this purpose is relatively unexplored. Geotextile fabrics, made of plant fibers, represent a promising approach and were already successfully installed in several applications. However, the use of natural fibers also entails some limitations regarding water uptake and stability. Therefore, the potential use of a different material class, which comprises degradable, thermoplastic biopolymers, is discussed in this overview as well. There is only little information available on the use of these biopolymers in connection with geotextiles, thus their suitability regarding biodegradation, price and mechanical properties were evaluated.
Keywords: Geosynthetics; Degradable geotextiles; Biopolymers; Natural fibers; Poly (lactic) acid

Interface transmissivity of conventional and multicomponent GCLs for three permeants

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Abstract: A laboratory investigation of the interface transmissivity is reported for five different geosynthetic clay liners (GCLs) and a range of different geomembranes (GMBs) for a range of stresses from 10 to 150 kPa. The GCLs were prehydrated under normal stress before permeation. The GCLs examined comprised three multicomponent (a smooth coated, a smooth laminated, and textured coated) and two conventional (one with granular and one with powdered sodium bentonite) GCLs. The effect of a 4mm circular defect in the coating of a multicomponent GCL directly below the 10mm diameter hole in the GMB is investigated. The effect of GMB stiffness and texture is examined. Additionally, the effect of hydration and permeation of smooth coated GCL with highly saline solution and synthetic landfill leachate (SL3) is presented. It is shown that the 2-week interface transmissivity ($\theta_{2\text{-}week}$) can be one to two orders of magnitude higher than steady-state interface transmissivity ($\theta_{steady\text{-}state}$) at low stresses (10 kPa–50 kPa), whereas at high stresses (150 kPa) the variation is substantially less. For a smooth coated GCL hydrated and permeated with reverse osmosis (RO) water, GMB stiffness and texture has a limited effect on interface transmissivity when the coating is placed in contact with GMB at normal stresses of 10 kPa–150 kPa, whereas coating indentations result in much high interface transmissivity when placed in contact with GMB. GCL prehydration and permeation with highly saline solutions leads to higher interface transmissivity compared to RO water. With a 4.0mm defect in the coating, the interface transmissivity between the coating and woven geotextile is higher than that between the coating and GMB for the stress levels and GCL examined.

Keywords: Geosynthetics; Interface transmissivity; Coated GCLs; Synthetic landfill leachate; Saline solution; RO water

Investigating the mechanism of downslope bentonite erosion in GCL liners using X-Ray CT

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Abstract: Exposed composite GMB-GCL liners are at risk of downslope bentonite erosion caused by the release of low ionic strength condensed water onto the top surface of the GCL following daily solar heating. This paper investigates the use of X-ray computed tomography (X-ray CT) to quantify the thinning of the bentonite layer and the application of X-ray diffraction techniques (XRD) to investigate the changes in clay chemistry (if any) of the bentonite from the virgin GCL to the eroded bentonite. The effect of specimen size and scanning orientation was investigated resulting in a revised testing procedure in which the CT scanning orientation was changed from horizontal to vertical to permit a longer test specimen which was also sealed at the bottom edge to minimise the edge boundary condition. The X-ray CT results provide highly visual evidence that a) bentonite thinning immediately under the upper cover geotextile is the initial location of erosion, and b) the bentonite core erodes at a significantly higher rate when not covered by a geotextile than when covered by a geotextile. These observations indicate that the upper geotextile of the GCL plays a significant role in controlling the rate of bentonite erosion. Finally, a comparison of the virgin and runoff bentonite properties was conducted to investigate potential changes in swell index, X-ray diffraction results, and concentration of Na and Ca cations. The runoff bentonite was observed to had a significantly higher swell index (40 ml/2 g) than the virgin bentonite (28 ml/2 g) and lower Na and Ca concentrations. This finding is consistent with the observation from XRD analyses of the runoff bentonite which illustrate that the clay fraction of the bentonite is preferentially eroded by the application of DI water.
Keywords: Geosynthetic clay liner; Composite geosynthetic liner; Bentonite erosion

Field study of a retaining wall constructed with clay-filled soilbags

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Abstract: This paper presents a field study of constructing retaining walls using soilbags that are formed by filling the excavated clayey soils into woven bags (geosynthetics). The strength and deformation of the soilbags filled with clayey soils were studied via laboratory tests. A 100m testing retaining wall was constructed with soilbags in a waterway project. The lateral deformation, the lateral pressures and the surface settlements of the testing retaining wall were monitored during construction and after 7 months operation. The results show that the soilbags can increase the strength of clayey soils. After 7 months of the completion, the lateral deformation and the surface settlement of the testing retaining wall tend to be stable with the maximum values of 29.4 cm and 19.2 cm, respectively. The lateral earth pressure on the front retaining structure could be positively reduced owing to the interlayer's friction of soilbags. Compared to the conventional gravity concrete retaining wall, about 38% construction cost was saved in the 100 m testing retaining wall.
Keywords: Geosynthetics; Clayey soil; Field study; Retaining wall; Soilbags; Waterway project