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目 录

Strength characteristics of soilbags under inclined loads

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Abstract: The application of soilbags in permanent or semi-permanent projects is becoming increasingly wider. When used in some projects like retaining walls, soilbags are usually undertaken loads that are not perpendicular to their long axis direction, i.e. under inclined loads. In this study, a 2D strength formula of soilbags under inclined loads is derived, expressed as the apparent cohesion c_T resulting from the tensile force of the bags. A way of modeling flexible bags in DEM simulation is proposed. The soilbags stacked at different inclination under biaxial compression is numerically simulated by DEM to verify the derived strength formula of soilbags. The results indicate that under inclined loads, the developed tensile forces of the bags and thus the corresponding apparent cohesion cT of soilbags decrease with the increasing inclination of soilbags.
Keywords: Geosynthetics; Soilbag; Inclined load; Strength formula; DEM; Biaxial compression

Centrifuge modeling of the geotextile reinforced slope subject to drawdown

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Abstract: Geotextile is an effective reinforcement approach of slopes that experiences various loads such as drawdown. The geotextile reinforcement mechanism is essential to effectively evaluate the safety of geotextile-reinforced slopes under drawdown conditions. A series of drawdown centrifuge model tests were performed to investigate the deformation and failure behaviors of slopes reinforced with different geotextile layouts. The deformation and failure of unreinforced and reinforced slopes were compared and the geotextile reinforcement was indicated to significantly increase the safety limit and the ductility, reduce the displacement, and change the failure feature of slopes under drawdown conditions. The slopes exhibited remarkable progressive failure, downward from the slope top, under drawdown conditions. The progressive failure was induced by coupling of deformation localization and local failure based on full-field measurements of displacement of slopes subjected to drawdown. The geotextile reinforced the slope by decreasing and uniformizing the slope deformation by the soil-geotextile interaction. Through geotextile displacement analysis, the geotextile-reinforced slope was divided into the anchoring zone and the restricting zone by a boundary that was independent of the decrease of water level. The geotextile restrained the soil in the anchoring zone and the soil restrained the geotextile in the restricting zone. The reinforcement effect was distinct only when the geotextile was long enough to cross the slip surface of the unreinforced slope under drawdown conditions.

Keywords: Geosynthetics; Slope; Geotextile; Reinforcement; Drawdown; Centrifuge model test

A comparison of the performances of polypropylene and rubber fibers in completely decomposed granite

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Abstract: This fundamental study investigates how two very different types of fibers, very elongated polypropylene fibers with high tensile resistance, and larger rubber fibers with a smaller aspect ratio and low shear and Young's moduli affect the compression and shearing of a soil. The same host soil was used for both types of fibers, a well-graded decomposed granite. As well as providing a realistic base for the study with its well graded nature, the decomposed granite's tendency to contract upon shearing is used to highlight the underlying mechanisms causing any difference in behavior. The soil mixtures were prepared at an optimal fiber content for each kind. The general patterns of behavior of the reinforced soils, such as the stress-dilatancy behavior, and the normal compression and critical state lines, are compared. It is found that the specimens with rubber fibers are initially much less stiff than those with polypropylene fibers, so that they require larger deformations to reach failure. At failure, they can provide as much extra strength as polypropylene fibers if the rubber fiber-soil mixture has been consolidated to a low confining stress, although very much larger quantities are needed, even to the point of being unrealistic for engineering applications. At high confining pressures, the rubber fibers, which have become slack during compression, tend to lose in efficiency. The soil reinforced with polypropylene fibers develops consistently higher strength, but the compressive nature of the base soil has the effect of hindering their full mobilization as would be seen in a dilative soil.
Keywords: Geosynthetics; Residual soils; Reinforced soils; Laboratory tests

Laboratory and numerical modeling of strip footing on geotextile reinforced sand with cement-treated interface

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Abstract: This paper presents the results of a laboratory and numerical study on the effects of cement treatment of the interface between geotextile and sand on the bearing capacity of a foundation built on geotextile reinforced sand. The bearing capacity of a 25 cm*7.5 cm strip footing on a 90 cm*25 cm *30 cm sand box reinforced using a single-layer reinforcement of different lengths including, 20, 30, 45, 60, 75 and 90 cm, was studied in a laboratory. A cement-treated zone was created on the geotextile to improve the friction and adhesion of the interface zone. Tests were also conducted on reinforced soil without a cement-treated zone and the results were compared. A finite element model was calibrated and used for further studies. The results of the laboratory tests indicated that cement treatment of the interface between the geotextile and sand increases the bearing capacity of the foundation by 6%e17%, depending on the length of the reinforcement. The effectiveness of the cement-treated interface on improving of the bearing capacity is more evident with shorter-length reinforcements. For a certain bearing capacity, the required length of the reinforcement was reduced by approximately 40% when the interface zone of the sand and reinforcement was cement-treated. The effect of the cement-treated zone on the bearing capacity was more evident in low settlement levels, and decreased as the length of the reinforcement increased.

Keywords: Geosynthetics; Strip footing; Laboratory test; Bearing capacity; Cement

Seismic behavior of geosynthetic encased columns and ordinary stone columns

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Abstract: This study is concerned with evaluating and comparing the behavior of geosynthetic encased stone columns (GECs) and ordinary (conventional) stone columns (OSCs) during and after seismic excitations. For this purpose, well instrumented GECs and OSCs are installed in kaolinite clay beds consolidated in a large steel tank. In order to simulate the seismic behavior of columns supporting an embankment, surcharge loads are applied and the experimental setup is subjected to large-scale shaking table tests. The strains in the encasement are measured by making use of water-proof strain gauges during the course of the experiments. The vertical load capacities of GECs and OSCs after the seismic excitation were measured by a series of stress controlled column load tests. The experimental data at hand suggests that under the action of seismic loads there is a significant strain demand on the encasement confining the GECs. An almost linear relationship between the seismic energy input expressed in terms of IA (Arias Intensity) and reinforcement strain amplitude is observed. GECs in general have exhibited a superior performance both under static and seismic loads when compared to OSCs.
Keywords: Geosynthetics; GEC; Earthquake loading; Shaking table; Model tests

Failure analysis of a geomembrane lined reservoir embankment

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Abstract: This paper presents case study and failure analysis of an embankment enclosing a raw water reservoir at a coal based thermal power plant. The embankments and the base of the reservoir were all lined with geo membrane. Major breaches occurred in the embankment separating two compartments of the reservoir (i.e., the partition embankment) approximately one year after the filling of one of the reservoirs. Seepage and slope stability analyses were carried out to detect the causes of failure. The post–failure field observations and results of stability analyses indicated that the use of a single layer geomembrane as the sole component of barrier layer was inadequate. Pipe drains provided at the base of the reservoir to intercept rising groundwater level acted as a flow pathway for water seeping from tears and punctures in geomembrane liner at the base of the reservoir. The design of internal drainage system for both the partition embankment and peripheral embankment (i.e., the embankments other than the partition embankment surrounding the reservoir) was insufficient. The remedial measures which could be adopted for geosynthetic lined reservoir and embankment were evaluated and presented in the paper. The study highlights the need to provide a secondary liner in form of clay or geosynthetic clay liner whenever a geomembrane is used as a barrier layer. In cases where use of single layer of geomembrane is unavoidable, seepage and safety analysis should be carried out with the assumption that it may leak. This is important when an adequate quality control in laying the geomembrane is lacking or the embankment facilities would continue to be operated at full head even after the design life of the geomembrane is exceeded.

Keywords: Geosynthetics; Embankment; Failure; Geomembrane; Liners; Slope stability; Piping analysis

Laboratory tests on the engineering properties of sensor-enabled geobelts (SEGB)

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Abstract: To measure geosynthetic reinforcement strains, sensor-enabled geobelts (SEGB) that perform the reinforcement and self-measurement functions were developed in this paper. The SEGB of high-density polyethylene (HDPE) filled with carbon black (CB) were fabricated by both the industry and the laboratory. To study the mechanical properties and tensoresistivity performance of the SEGB, in-isolation tests and in-soil tests were performed. Hot pyrocondensation pipes (HPP) were used to protect the SEGB against the influence of water. For the SEGB specimens developed in the laboratory, the optimal CB filler content was 47.5%. For the SEGB fabricated by the industry, the optimal CB content was slightly decreased compared to the SEGB fabricated in the laboratory. For the modified SEGB sealed with HPP, the strain at the fracture was improved, while its tensile stress and the frictional property of the geobelt-soil interfaces both decreased slightly. In the pull-out tests, the self-measurement function of the SEGB was proved to be effective for evaluating the deformation behavior of geosynthetic reinforcement. The results are helpful for further application of SEGB technology in engineering.
Keywords: Geosynthetics; Sensor-enabled geobelts; Strain; Tensoresistivity; Pull-out tests

Study of the behavior of mechanically stabilized earth (MSE) walls subjected to differential settlements

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Abstract: The limit equilibrium (LE) analysis has been used to design MSE walls. Presumably, the deflection of MSE walls can be limited to an acceptable range by ensuring sufficient factors of safety (FOSs) for both external and internal stabilities. However, unexpected ground movements, such as movements induced by excavations, volume changes of expansive soils, collapse of sinkholes, and consolidations of underlying soils, can induce excessive differential settlements that may influence both the stability and the serviceability of MSE walls. In this study, a numerical model, which was calibrated by triaxial tests and further by a specially-designed MSE wall tests, investigated the behavior of an MSE wall as well as the influence of various factors on the performance of the MSE wall when the wall facing settled relatively to the reinforced zone. The numerical results showed that the differential settlement would cause substantial vertical and horizontal movements for the MSE wall, as well as an increase in lateral earth pressure and geosynthetic reinforcement strain. The maximum horizontal movement and increase of the lateral earth pressure occurred at about 1.0 m above the toe. The differential settlement resulted in a critical plane that coincided with the plane of $45°+\phi/2$. The maximum increase of the strain for each geogrid layer occurred in that plane, and the bottom layer had the greatest strain increase among all layers of reinforcement. The study further indicated that the surcharge, backfill friction angle, tensile stiffness of geogrid, reinforcement length and MSE wall height had noticeable influences on horizontal and vertical movements, and strain in geosynthetics. According to the results, the MSE wall that had a higher factor of safety would have less movements and geosynthetic strain increase. In contrast, only the friction angle, tensile stiffness and MSE wall height showed some degree of influence on the lateral earth pressure due to differential settlements.
Keywords: Geosynthetics; MSE wall; Differential settlement; Lateral earth pressure; Strain

A laboratory investigation on the impact resistance of a woven geotextile

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Abstract: This paper focuses on the impact resistance of geotextiles when subjected to impact loadings induced by dropping of stones. Such scenarios occur when geotextiles are used as a protective measure for fine granular material where is prone to be washed away. Usually, these geotextiles are restrained by placement of stones on top of them. A laboratory testing program is performed to expose a woven geotextile under dropping of a concrete block with various dropping energies and geometries. The induced damage on the geotextiles is inspected after the drop. Results indicate that as the drop energy increases, not only the possibility of puncturing of geotextiles increases but, in case of puncturing, the punctured area of geotextile expands as well. In addition, it is found that the geometry of the concrete block, where it collides on the geotextile, plays an important role on the survivability of geotextiles. In addition, PIV analysis has been performed to better understand the deformation pattern of the geotextile under impact loading. Based on the PIV results a simple scheme is suggested to estimate the drop energy threshold that the geotextile can survive under certain block geometry.

Keywords: Geosynthetics; Woven geotextile; Impact resistance; Drop test; Puncture; PIV

Calculating local geomembrane strains from a single gravel particle with thin plate theory

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Abstract: A new method is presented to calculate geomembrane strains induced by a single gravel particle (or grain) under vertical load from the deformed shape of the geomembrane for axisymmetric conditions. Past equations consider only vertical displacements of the geomembrane and neglect the contribution of radial displacements on strain and, consequently, underestimate the maximum strain. Axisymmetric large-strain-displacement relationships are used to relate radial strain to vertical and radial displacements. Vertical displacements are obtained from measurements of the deformed geomembrane from a physical experiment. Radial displacements do not need to be measured, but are related to tangential strain in the strain-displacement formulation. A linear elastic constitutive relationship is invoked and radial strains at the mid surface of the geomembrane from membrane elongation are solved for using Airy's stress function. Bending strains are obtained from the curvature of the deformed shape. Extreme fibre strains are the sum of the membrane and bending strains. Results from the new method match the maximum strain and pattern of strain when compared to large-displacement finite-element analysis. The new method is used to show that neglecting radial displacements underestimates the maximum strain by 25%, while neglecting radial displacements and bending strains underestimates the maximum strain by 60% (for a 2.5-mm-deep, Gaussian-shape indentation) and hence could affect selection of an appropriate geomembrane protection layer.
Keywords: Geosynthetics; Geomembrane; Landfill; Strain

Strain distribution along geogrid-reinforced asphalt overlays under traffic loading

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Abstract: While there is significant field evidence of the benefits of geosynthetic-reinforced asphalt overlays, their use has focused on minimizing the development of reflective cracks. Yet, geogrids in asphalt overlays are also expected to develop reinforcement mechanisms that contribute to the pavement structural capacity. Specifically, the use of geosynthetics in asphalt overlays may also improve the mechanical behavior of paved roads by controlling permanent displacements and reducing strains in the pavement layers. While relevant advances have been made towards identifying the mechanisms in geosynthetic stabilization of base courses, such mechanisms may differ from those that develop in geosynthetic-reinforced asphalt overlays. This paper investigates the development and distribution of tensile strains along geogrids used to reinforce asphaltic layers. Experimental data was collected from large-scale paved road models subjected to the repeated loading imparted by wheel traffic. Specifically, the study examines both the elastic and permanent components of displacements induced in geogrids by using mechanical extensometers attached to the geogrids. The testing program includes a number of geosynthetic-reinforced paved road models, as well as a control (unreinforced) section that was also instrumented for comparison purposes. Asphalt strain gauges were used to measure strains within the asphalt concrete layer, providing an additional source of information that proved to be highly consistent with the results obtained from the extensometers. The experimental results showed a progressive mobilization of permanent geogrid strains that reached a final profile beyond which additional traffic loading did not result in additional straining. In comparison, higher strains developed in the unreinforced model, which showed a continuously increasing trend. Elastic tensile strains in the asphalt mixture and rutting under the wheel load were comparatively smaller when using geogrids. Overall, the results generated in this study indicate that the presence of geogrids in asphalt overlays results in a lateral restraining mechanism that influences on the mechanical behavior of flexible pavements.

Keywords: Geosynthetics; Geogrid; Asphalt overlay; Reinforcement mechanism; Strain distribution