APPLICATION OF GEOSYNTHETICS FOR GROUND IMPROVEMENT:
AN OVERVIEW

Gohil D.P.
Research Scholar, Department of Applied Mechanics, S.V. National Institute of Technology, Surat–395007, India.
E-mail : dpgohilcapri_2005@yahoo.com

C.H. Solanki
Assistant Professor, Department of Applied Mechanics, S.V. National Institute of Technology, Surat–395007, India.
E-mail : chs@amd.svnit.ac.in

A.K. Desai
Assistant Professor, Department of Applied Mechanics, S.V. National Institute of Technology, Surat–395007, India.
E-mail: akd@amd.svnit.ac.in

ABSTRACT: Geosynthetics is manmade material used for soil reinforcement. Soil transfers the built up forces in earth to reinforcement by friction which develops tension in reinforcement. Geosynthetics is used in locations where shear stresses are generated because shearing stress between soil and reinforcement restrains the lateral deformation of the soil. Geosynthetics used for increasing bearing capacity and permeability of soil, reducing settlement of soil. Under dynamic shear excitations, slip deformations occur along smooth geosynthetic interfaces. Thus, in a landfill application seismically induced slip deformations along a bottom geosynthetic liner can result in reduced accelerations transmitted to landfill waste. Preliminary shaking table test on smooth high density polyethylene and geotextile showed that this concept of using geosynthetics to isolate a structure from incoming seismic waves had great promise. Shaking table tests of a building model placed on a selected geosynthetic liner results the benefits of utilizing a special geosynthetic liner as an energy absorbing system that can reduce building response during an earthquake. Displacement transducers are use to measure the slip along the geotextile interface and to measure the distortion of the columns of the building model. This paper presents a review of the existing experimental and analytical work done in this field and identifies different areas needing further attention.

Key Words: Geosynthetics, High Density Polyethylene, Seismic Waves, Displacement Transducers.

1. INTRODUCTION

Geotextiles are the largest and most diverse group of geosynthetic materials and include all fabrics produced from polymer fibers. There are five main functions of geosynthetic materials: to separate dissimilar geomaterials; to reinforce soil masses; to act as a filter in controlling the transport of solid particles within the soil; to provide drainage pathways within the soil mass; or to impede fluid flow by acting as a containment/flow barrier. Geosynthetic functions of separation, filtration, and reinforcement involve interactions with the surrounding soil.

2. APPLICATION OF GEOSYNTHETICS

Geotextiles and geogrids are widely used to reinforce soil masses in the design of retaining walls and slopes. In these Mechanically Stabilized Earth (MSE) applications, horizontal layers of the geosynthetics are sandwiched between compacted layers of fill during construction. Lateral spreading of the soil mass is resisted by shearing along the soil–geosynthetic interface and the development of tensile stresses within the reinforcing layers. Internal stability also requires that the geosynthetic layers provide tensile anchorage against potential slope failures by extending into the stable soil mass.

The principal parameters in design are the tensile strength and stiffness of the geosynthetic, and the soil–geosynthetic interface shear and bond resistance. Horizontal layers of geosynthetics are also used as basal reinforcements for embankments constructed over soft foundation soils. Basal reinforcement provides additional short-term stability and greatly aids constructability in these situations. Tensile stresses develop due to membrane action in the centre of the basal reinforcement due to undrained deformations of the soil. These stresses transfer through interface shear tractions into both the overlying embankment fill and underlying soft soil improving coherence in the side slopes and redistributing the forces transferred to the underlying clay.

The use of geotextiles to separate the soil sub grade from the overlying aggregate (unpaved) road base or railway ballast.
rely on tensile stiffness and strength properties of the geosynthetics. The geotextile allows drainage but prevents intrusion of aggregate into a softer underlying material while preventing the pumping of fine particles from the sub grade into the ballast. Geotextiles are frequently used as filter fabrics in subsurface drainage and erosion control applications. Geosynthetic materials are routinely used for subsurface drainage; these include edge/fin drains behind earth retaining walls and prefabricated vertical drains used to accelerate the consolidation of low permeability clays.

3. IMPROVEMENT OF SOIL DUE TO GEOSYNTHETICS

Ling & Liu (2001) showed that geosynthetic reinforcement increased the stiffness and bearing capacity of the asphalt concrete pavement. Under dynamic loading, the life of the asphalt concrete layer was prolonged in the presence of geosynthetic reinforcement.

Sireesh (Article in press) showed that geocell mattress can substantially increase the bearing capacity and reduce settlement of the clay sub grade with void. The geocell mattress must spread beyond the void at least a distance equal to the diameter of the void. With increase in the height of the geocell layer, its moment of inertia and hence bending and shear rigidity of the geocell mattress increases that it effectively bridges the void and transmits the footing pressure to the adjacent soil mass. The overall bearing capacity of the foundation bed increases with increase in density of the fill soil. It is therefore profitable to have a dense fill in the geocells.

Ghazavi & Lavasan (2008) did a parametric study that revealed the role of the distance between reinforcing layers and footings and the width and depth of reinforcing layers on the bearing capacity. The results showed that the bearing capacity of interfering footing increases with the use of geogrid layers, depending on the distance between two footings. Reinforcement caused the bearing capacity of interfering footings to increase by about 1.5 and 2 for one and two reinforcement layers.

Sharma et. al. (2009) showed that the bearing capacity of soil improved when reinforced by geosynthetics and that better improvements were obtained when the reinforcement is placed within a certain depth (or influence depth) beyond which no significant improvement will occur.

Hajiani, et al. (2003) proved that the bearing capacity increase with increasing number of reinforcement layers, if the reinforcements were placed within a range of effective depths.

4. DEVELOPMENT OF GEOSYNTHETIC FOR USE AS FOUNDATION ISOLATION

During the past 30 years, the use of reinforced soils to support shallow foundations has received considerable attention. Many experimental, numerical, and analytical studies have been performed to investigate the behaviour of Reinforced Soil Foundation (RSF) for different soil types.

The selection or development of a proper geosynthetic material for use as foundation isolation was the first important task of the research. Several candidate interface materials were explored for their suitability as foundation isolator. Ideally, foundation isolation material should satisfy requirements including:

- The friction coefficient during sliding should be small to minimize the acceleration transmitted through the interface. In general, friction coefficients between 0.05 and 0.15 would be desirable for the isolation concept to be used worldwide not only in regions of high seismicity, but also where earthquakes pose a moderate threat, and seismic mitigation measures can be cost prohibitive.
- The static friction coefficient should be slightly larger than the dynamic coefficient to prevent sliding under non seismic loads including wind.
- To simplify introduction of foundation isolation in engineering design, the friction coefficient should be insensitive to several factors including sliding velocity, normal stress, sliding distance, moisture, and temperature.
- The interface material should be resistant to chemical and biological attacks, and to long-term creep effects.
- The maximum and permanent slip displacements induced by an earthquake should be small enough to allow functionality of the structure and its utilities.

4.1 Behaviour of Geosynthetics under Cyclic Loading

Unnikrishnan et. al. (2002) indicate that a thin layer of high-strength sand provided on both sides of the reinforcement is effective in improving the strength and deformation behaviour of reinforced clay soils under both static and cyclic type loadings.

Yegian & Kadakal (2004) explained the use of geosynthetics liners for dynamic response of landfill. Slip deformations occurring along geosynthetic interface can limit the earthquake energy transmitted to overlying waste or soil. Results from dynamic analysis demonstrated that smooth HDPE geomembrane/ geotextile liners significantly reduce the landfill acceleration, beyond an input base acceleration of 0.2 g. A dynamic analysis assumed the complete shear transfer through geosynthetic liners can significantly over estimate landfill acceleration.

4.2. Geosynthetic Liners for Foundation Isolation

The suitability of various synthetic materials for the purpose of foundation isolation. The dynamic interface properties of
these materials are being investigated using a shaking table to identify the most promising material for this application.

Now-a-days geotechnical engineers have interested in research program that was focused on exploring the technical feasibility of using synthetic materials as an alternative low-cost seismic isolation technique. A base isolator provides a discontinuity between a footing and the overlying column. A base isolator performs two functions: (1) It shifts the natural period of the building away from that of the earthquake. (2) It provides additional damping to absorb the energy. Hushmand & Martin (1991); Kavazanjian et al. (1991); and Yegian & Lahlaf (1992) proposed the concept of using a smooth geosynthetic liner underneath building foundations to dissipate earthquake energy through sliding along the geosynthetic interface, thus transmitting reduced accelerations to the overlying structure. The research program identified a synthetic liner that is well suited for seismic isolation. Two alternate schemes were explored for the use of the liner. The first was the placement of the liner immediately underneath the foundation of a structure. This approach is foundation isolation and is shown schematically in Figure 1.

In the second approach, the synthetic liner is placed within the soil profile at some depth below the foundation of a structure. This approach is referred to as soil isolation.

Yegian & Catan (2004), paper presents typical experimental test results, which support the selection of a synthetic liner most suitable for seismic isolation. The details and results of shaking table experimental tests that were conducted using a rigid block as well as a model structure to investigate the performance of a foundation-isolated structure are presented. Analysis and discussions of the research results are presented demonstrating the technical feasibility of using a synthetic liner to dissipate earthquake energy, thus reducing structural response and minimizing the potential for damage from an earthquake.

Various tests including cyclic loading and rigid block shaking table experiments are performed to evaluate the dynamic response of various interfaces. Displacement transducers are used to measure the slip along the geotextile interface and to measure the distortion of the columns of the building model. Tests were carried out by varying the normal contact stress, amplitude of displacement (slip) and the rate of slip. Under these different test conditions, the friction coefficients of the interfaces were measured and evaluated.

Using UHMWPE/geotextile liner, the column shear force in the building model placed on the geosynthetic liner to the column shear force in the model that was fixed to the table were compared. The horizontal axis defines the peak accelerations to which the three earthquake records were scaled. The results show that at a base acceleration greater than 0.07g the geosynthetic liner absorbs energy, and thus dramatically reduces the column shear forces in the building model. For example, at a base acceleration of 0.4g, the column shear force in the building model on foundation isolation is only 35% of that corresponding to the fixed case. This demonstrates the excellent energy absorption capacity of UHMWPE/geotextile interface.

5. SUMMARY

Due to various functions and advantages geosynthetics are best option in geotechnical projects. New immerging field for geosynthetics as foundation isolator to reduce seismic energy transmitted to buildings can be a very cost effective. It is also a simpler alternative to earthquake hazard mitigation measures conventionally used in current engineering practice.

REFERENCES


