

# *Influence of geotextile reinforcement on shear modulus of saturated sand*

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**Abstract**—The increasing use of geotextile-reinforced soil systems for important earth structures requires proper understanding of their behaviour and validation of the assumptions in their design. This paper investigates the shear modulus of saturated reinforced sand throughout the undrained cyclic triaxial tests. The cyclic triaxial tests are conducted on remolded specimens which reinforced by different arrangement of non-woven geotextile. The tests results indicate that the geotextile reinforcement increase  $G_{max}$  of saturated silty sand and  $G_{max}$  increased as the geotextile layer increased. It is also concluded that as the geotextile close to the top of the specimen (load applying part) the maximum shear modulus increased and by increasing space between geotextile and cap of the sample, the reinforcement effect on  $G_{max}$  decreases.

**Keywords**— *Dynamic Behavior; Reinforced Sand; Triaxial Test; Geotextile; Shear Modulus*

## I. INTRODUCTION

Soil reinforcement is one of the improvement methods in which tensile elements are set into the soil body to compensate the soil weakness in tension. Although examples of reinforced soils can be seen in ancient structures, it was only in the 1960's that the modern concepts of composite soil-inclusion material were developed. Steel strips or meshes were primarily being used as inclusions before geosynthetics appeared within the last two decades. Since 1970s, the use of geotextile as reinforcement has become more popular due to a more satisfactory performance compared with metal reinforcement, which has been reported in several instances [1]. The reason is that geotextiles or synthetic fabrics have relatively low stiffness compared to that of metals. Thus, they are more compatible with soil in view of deformability. Currently, three main geosynthetic families of products are used as soil reinforcement: geogrids, geotextiles, and synthetic fibers. Geotextile reinforced structures are increasingly being used in a wide range of applications, such as transportation infrastructures, coastal protection, slope stabilization, embankment dams, retaining walls and also in preventing liquefaction of sand deposits [2]-[7]. These structures are subjected to various loading conditions including dynamic or cyclic loads. The most important parameters in evaluation of dynamic behavior of aforementioned soil structures are and

axial modulus. The locus of points corresponding to the tips of hysteresis is loops of various cyclic strain amplitudes is called a backbone (or skeleton) curve (Fig. 1); its slope at the origin (zero cyclic strain amplitude) and certain cyclic strain amplitude represent the largest value of the shear modulus,  $G_{max}$  and secant shear modulus  $G_{sec}$ , respectively [8]. Similarly, according to Fig. 2, maximum elastic modulus ( $E_{max}$ ) and  $E_{sec}$  estimated by slope of deviatoric stress  $\sigma_d$  versus axial strain  $\epsilon$ , [9].

The present study is aimed at obtaining a better understanding of shear modulus during cyclic undrained loading of geotextile reinforced saturated sand. This study included a number of undrained cyclic triaxial tests on Firouzkuh #161 sand samples reinforced with different arrangement of geotextile, to characterize the role played by this inclusion on the shear and axial modulus.

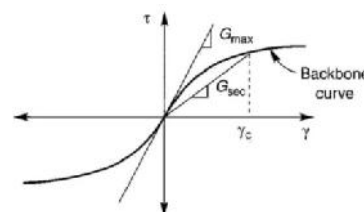


Fig. 1. Backbone curve showing the typical value of  $G_{max}$  and  $G_{sec}$  [8].

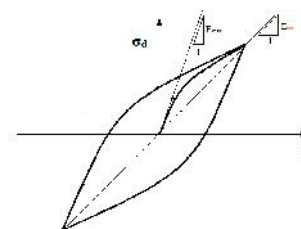


Fig. 2. The  $E_{max}$  and  $E_{sec}$  definition in hysteresis loop of deviatoric stress  $\sigma_d$  versus axial strain  $\epsilon$  [9].

## II. EXPERIMENTAL APPARTUS AND MATERIAL USED

### A. Cyclic Triaxial Setup

Specimens were tested in a cyclic triaxial device. The device is instrumented with LVDT, a load cell, pore pressure and a cell pressure transducer and a computer controlled data acquisition system (Fig. 3).

### B. Material Used

#### Sand

The sand used in this study is Firouzkoh #161 crushed silica sand. This type of sand has a golden yellow color and has a uniform aggregation, which henceforth briefly named Firouzkoh Sand (Fig. 4). Toyoura and Sengenyama standard sands that their characteristics are described in this paper were compared to Firouzkoh sand (Table1). Grain size distribution curves of the last two mentioned sands are presented in Fig. 5.



Fig. 3. Cyclic triaxial device set



Fig. 4. Magnified picture of Firouzkoh sand grains.

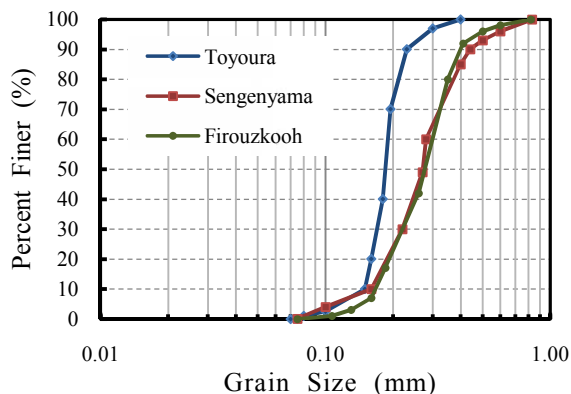


Fig. 5. Grain size distribution curve of Firouzkoh sand compared with the curves.

TABLE I. FIROUZKUH SAND PHYSICAL CHARACTERISTICS AND COMPARING WITH TOYOURA AND SENGENYAMA

Sand type	Firouzkoh #161	Toyoura	Sengenyama
Gs	2.685	2.65	2.72
$e_{max}$	0.94	0.97	0.91
$e_{min}$	0.60	0.597	0.55
$D_{50}$ (mm)	0.27	0.17	0.27
$C_u$	1.87	-	-
$C_c$	0.88	-	-

### Geotextile

Table 2 presents the properties of this non-woven PET geotextile. The picture of geotextile is shown in Fig. 6.

TABLE II. GEOTEXTILE PROPERTIES

Properties	ASTM method	Quantity
Unit weight	D-5261	500 gr/m <sup>2</sup>
Thickness	D-5199	3.5 mm
Puncture strength	D-4833	1100 N
Wide width tensile strength	D-4595	23.1 kN/m

