Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2014/04/jls.htm
2014 Vol. 4 (S4), pp. 1890-1897/Yarmahmoudi

Research Article

DESIGN AND CONSTRUCTION OF DIRECT SHEAR APPARATUS IN LARGE SCALE

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ABSTRACT
Because of limits of small scale of direct shear test apparatus and reforms which led to changes in grading and natural condition of soil eventually soil strength parameter would be obtained with an area of error. To solve this problem in this paper an analysis has been performed on construction study of large scale direct shear test device. Dimension of soil specimen in this apparatus is 40*40 cm. the process of design, construction and specification of apparatus has been under investigation. The built apparatus has 4 main parts including mechanical system, electronics system, hydraulic system and software and control system which each part has its own deferent parts. At the end, results of experiments of large scale apparatus on almond gravel in buildings have been presented.

Keywords: *Direct Shear, Device, Large Scale*

INTRODUCTION

Direct shear test, one of the most common tests in determination of shear strength of coarse grained soil, is usually experimented on samples which their grading has been corrected by elimination coarse-grained although this change in grading might cause increase in percentage of fine-grained.

Shear strength of mixture of sand and gravel is one of the most important facts in geotechnical engineering. But because of the effects of experimental specimens, most researches have been performed by elimination of mixed coarse grains. For instance Fergatzi and etc discussed effects of coarse grains on density, shear strength and soil shape deformation traits by presenting the concept of density (Fragaszy *et al.*, 1990; 1992).

One of the most issues that we are confronted in determination of shear strength of coarse grains is that most of iran's geo labs are not equipped with direct shear apparatus with big box (30*30) so grading is corrected by elimination of important parts of coarse grains and shear test with a smaller boxes (6*6, 10*10*3) has been performed. Although the biggest dimension of grains should not be more than 1/6 of smallest dimension of box, grading by elimination of coarse grains is performed by one of two simple methods called corrected elimination or elimination by transporting grading curves parallel to main curves "called as parallel curves". Research shows grading and dimension have great effects on shear strength of coarse grain soils (Mirghasemi *et al.*, 2002).

Literature

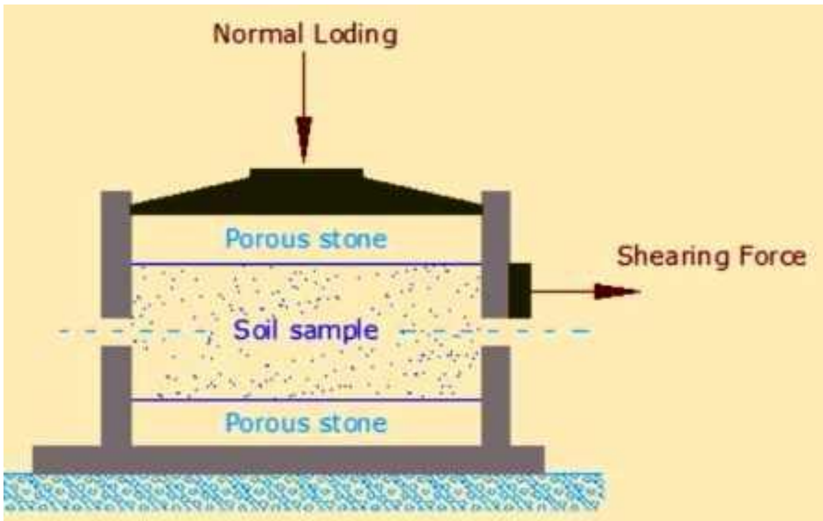
Direct shear test was used first time by coulomb in 1976 and it is one of the oldest shear strength determination tests for cohesive consolidated soil. Shear strength of mixture of sand and gravel is one of the most important issues in geotechnical engineering. But because of effects of dimension of experimental specimens, most studies are performed by elimination of coarse grains. For example Fergatzi and etc discussed effects of coarse grains on density, shear strength and soil shape deformation traits by presenting the concept of density (Fragaszy *et al.*, 1990; 1992).

Other researchers like Joan Valkho, Kokoshoo and etc, worked on increasing in strength by increasing goarsegrains (Kokusho *et al.*, 2004; Vallejo, 2001). Yakiz researched grains shape effects on shear strength of soil. Base of this research shows sharp corner grains of gravel causes increase in shear strength of sandy soil against round corner grains (Yagiz, 2001). Based on the researches of Gholam hossein Babaiee which errors of correcting grading on 7 different specimens gathered from coarse grains in Tehran under optimum proctor humid condition and equal dry weight were studied and their correlations have been presented (Babaei, 1999).

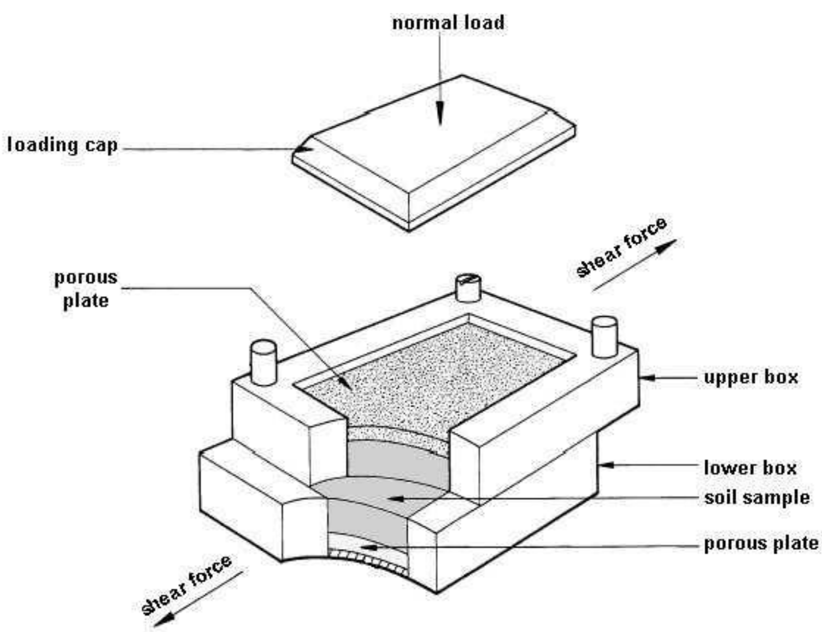
By consideration done by Wang and etc. in smaller specimen, time dependent shear deformation which specimen yields is less than bigger specimen shear deformation and shear tension to displacement curve has sharper steep (Wang, 2004).

Description and Discussion

This experiment is one of most common methods for determination of drained shear strength (Shear strength based on effective tension) in non-cohesive soil. In Figure below a picture of direct shear apparatus has been presented. Purpose of this experiment is cutting the specimen from middle and along yielding surface. This apparatus is made of two steel shear boxes which specimen is inside that box. Lower part of box is linked to apparatus and that is fixing and upper part moves in horizontal direction. For evaluation of horizontal and vertical deformation, Analog gauges should be used.



a) Shear box cross-section



b) 3D section of shear box with square plan

Figure 1: Direct shear apparatus figure

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Designing Parts and Components of Device

To design different parts of this device, have been used some software such as 3DMAX, AutoCAD and etc. At first in AutoCAD details of different parts of apparatus have been determined; pictured and discussed. These different parts in 3DMAX have been gathered 3D. And also for deigning hydraulic system, electronics and software of apparatus other software and program have been used.

In generally parts of Apparatus are check valve, relief valve, support for floor and upper parts of box, big box, main shear box, Jack, deviant control of big box, needed table, pressure transformer and its gauge, pumps, potentiometer, rails, surface cover of floors and on boxes, columns and supports of device, electronics panel and etc.

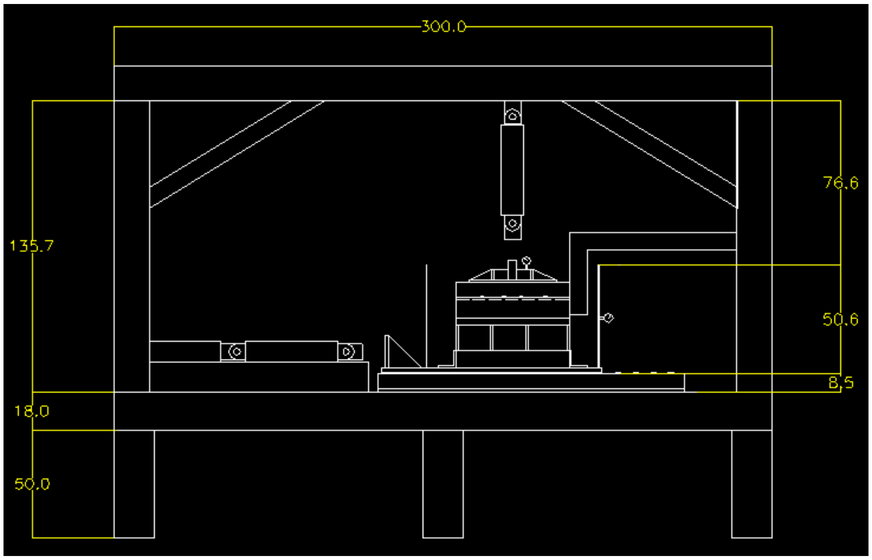

Figure 2: Design details of large scale direct shear device

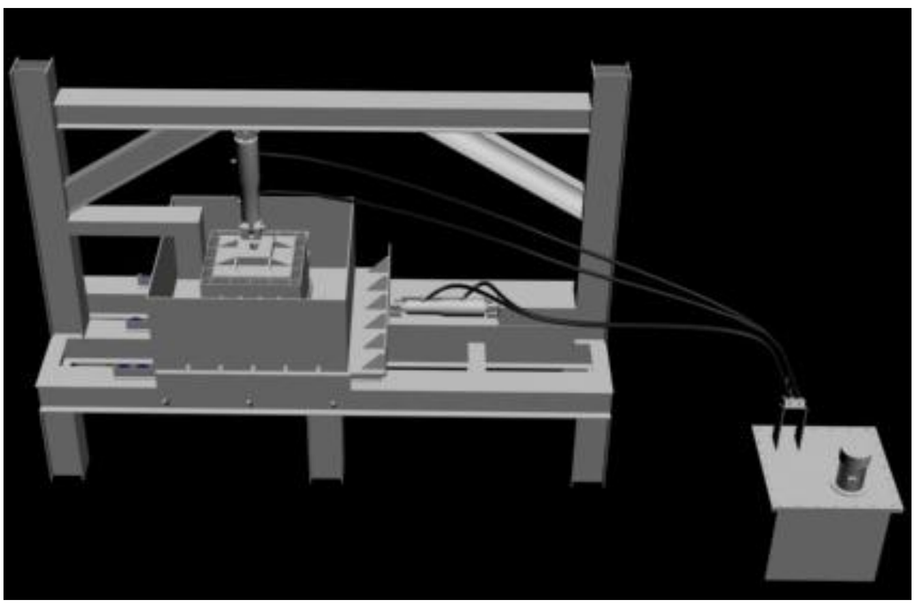

Figure 3.3D: Figure of large scale direct shear apparatus in 3DMAX

Hydraulic System Design

In this map oil moves path and pressure transportation and also their relationships have been presented.

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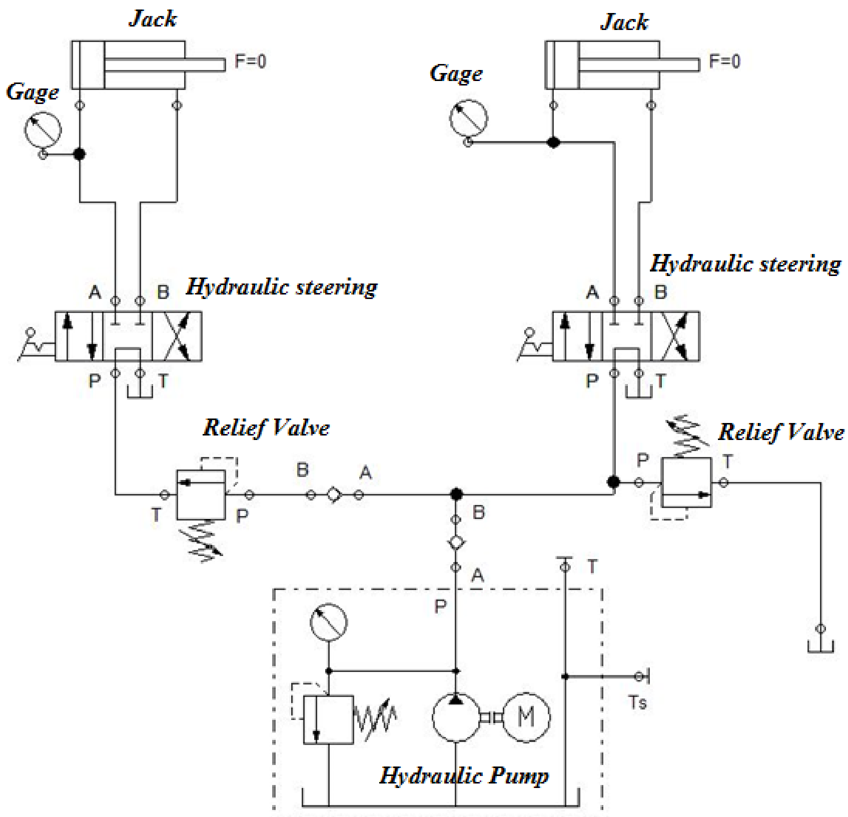

Figure 4: Hydraulic map of device

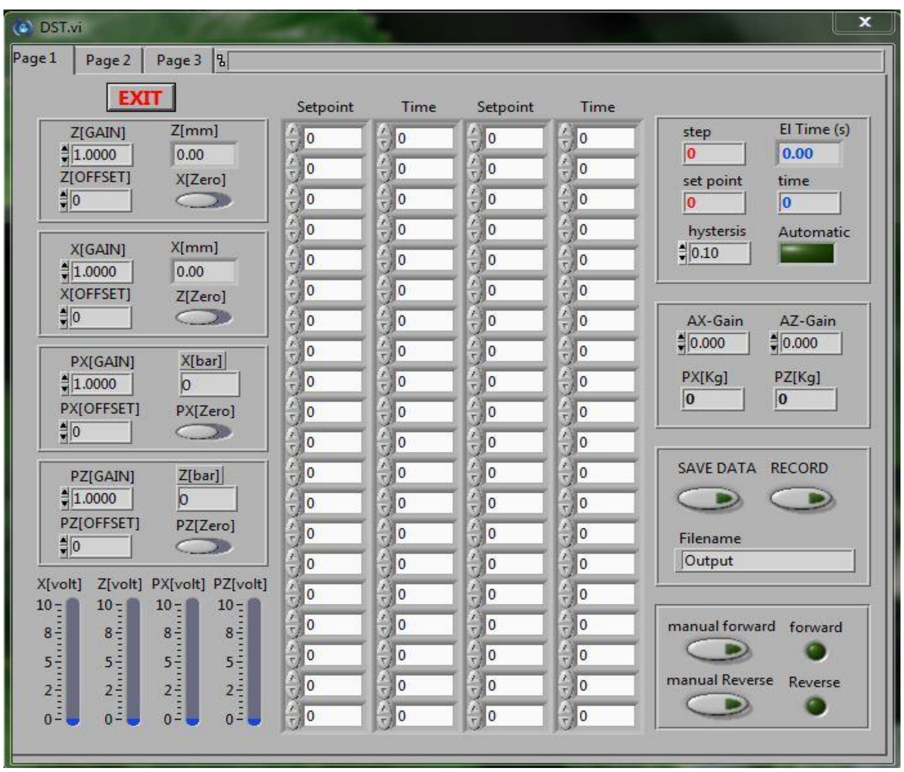

Figure 5: Apparatus computer program figure

Design of Control Software System

Following picture is about apparatus program which in left menu horizontal and vertical displacement and pressure have been presented. In middle columns set point and time section, pressure could be described in different time steps it means point loads 200, 600, 1000 and others have been put in section set respectively. in time section for load 400 time 2 second and for other loads like this or other times we do the same which at first load 200 has been put horizontal for 2 second and then other loads should be put based on their time. Load values and their time steps have been applied automatically by motors on horizontal relief valves.

Right menu is about errors and corrections that are used for transforming power and pressure. Data savings, forward moves or pressure relief retreat which reduces or increases pressure are in this section too that could be changed or modify.

Built Device

Built apparatus is like below picture after putting different parts. General process is that the first pump turns on and oil and hydraulic power values are put. In second step which relates to pressure relief, the vertical one should be adjusted by constant pressure manually (seen on gauge for example 40 bar) and horizontal pressure begins from zero and orders are given by program from lap top to device. Loads increase gradually to the value that shear box moves and soil has been sheared from middle and experiment stops. Shearing could be seen by program and eye.

Figure 6: Completed Direct Shear device

RESULTS AND DISCUSSION

Results

Experiments have been performed on almond gravel that is used in building with biggest almond gravel grain about 4 cm. specific gravity of specimen is 18 KN/m3and experiments have different vertical tension. In direct shear test force or vertical stress is constant and horizontal force or stress would change. In this paper results of one of experiments with vertical load of 500 Kg and variable shear strength have been presented. Although time step is 0.005 second which means force steps are about 2500 steps in 40 second time.

In presented figures in following part, 6 curves for each experiment have been shown which 4 of them are about changes of vertical and horizontal forces and vertical and horizontal displacement against time. The fifth curve is about changes of horizontal stress to vertical stress. To determine horizontal and vertical stress by considering that specimens are 40* 40cm we could obtain shear and vertical stress by dividing applied load to each section. This experiment has been performed by constant vertical load of 500 kg and variable horizontal shear strength. Curves have been presented respectively.

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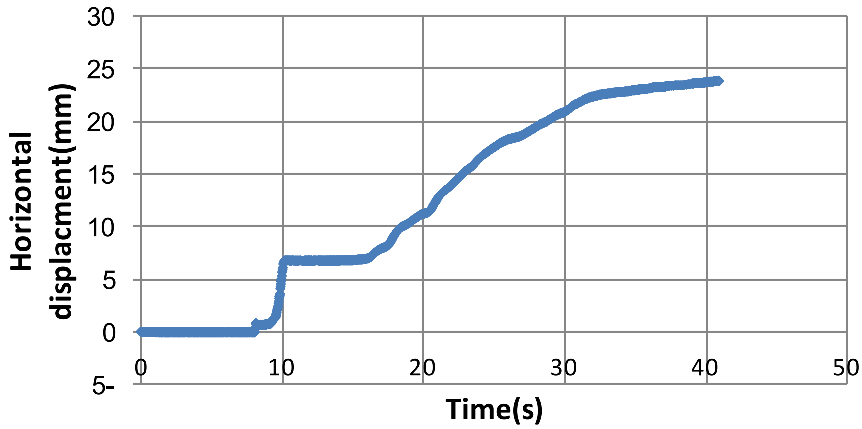

Figure 7: Changes of horizontal displacement against time

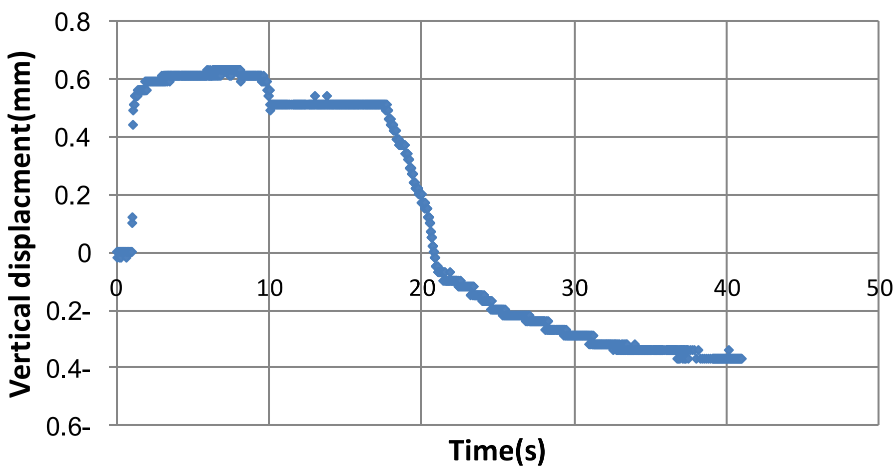

Figure 8: Changes of vertical displacement against time

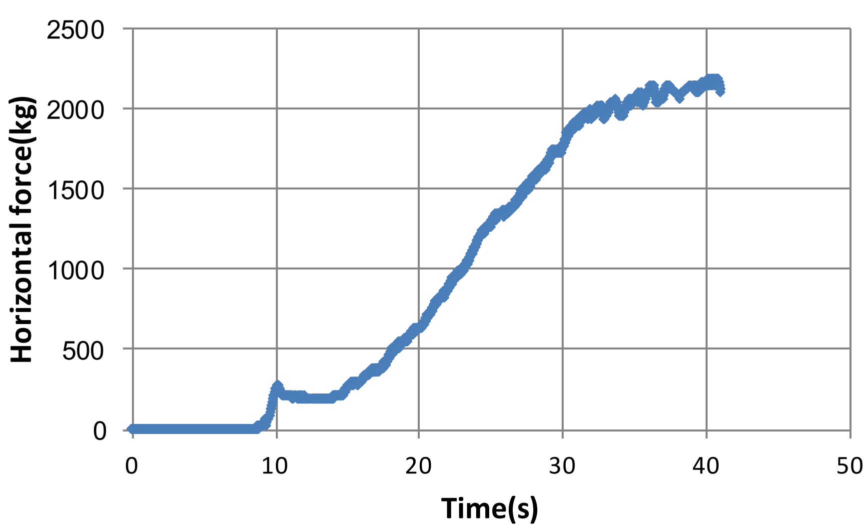

Figure 9: Changes of horizontal force against time

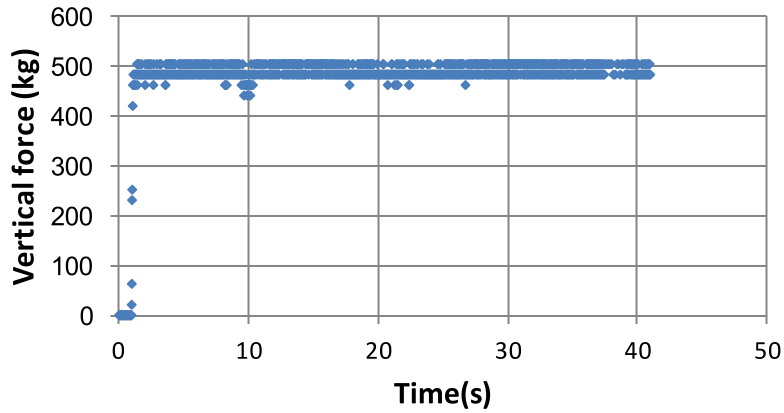

Figure 10: Changes of vertical force against time

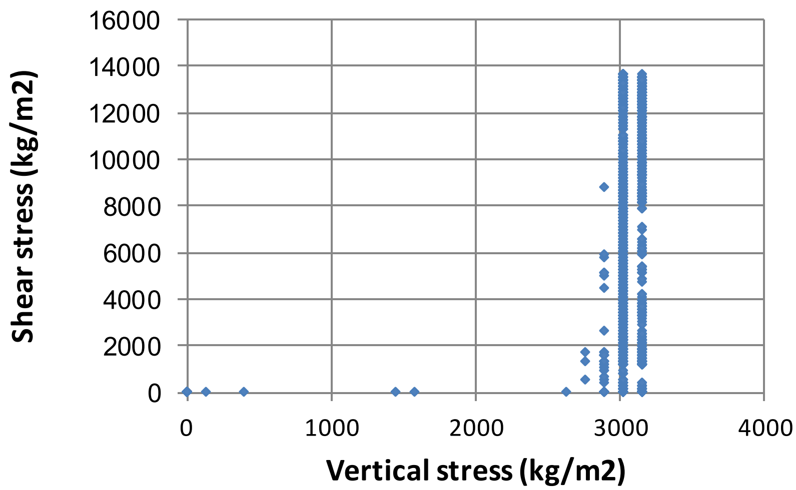

Figure 11: Changes of shear stress due to vertical stress

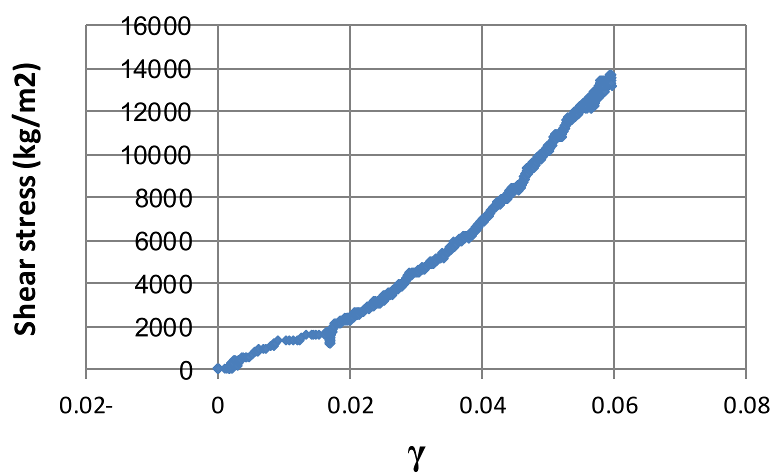

Figure 12: Changes of shear stress against changes of horizontal shear displacement

Conclusion

✓ In most geotechnical laboratory in country, due to lack of large scale direct shear apparatus (30*30*15cm), coarse grain experiments have been performed by 6*6*2 and 10*10*3 boxes which soil grading has been done by elimination of coarse grain.

✓ Designing parts of apparatus are general include hydraulic system, designing of software and designing of different parts of apparatus like shear box and its valve, big box of device, apparatus table and other parts.

✓ In large scale direct shear apparatus four different systems have been used to build the device.

- Mechanical system: parts of this system are supports of upper box of shear device, external box, shear boxes, wheels of deviant control of big boxes, shear boxes, bottom of external shear box, apparatus table, rails, shield of floor and upon of boxes and columns and supports.
- Electronic system; includes pressure relief, potentiometer and electrical panel
- Hydraulic system: includes pressure transformer and its gauge in vertical and horizontal direction, jacks, one direction valve and pump device.
- Software system: is about written program for applying load in different direction and data extracting from experiments which all process is based on computer.

✓ Four experiments on almond gravel “used in construction works” with different vertical and horizontal stress have been performed by large scale direct shear device, all the results are acceptable.

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