

## DIRECT SHEAR TESTS: EXPERIMENTAL SETUP BASED ON A LABVIEW APPROACH - EXPERIMENTAL RESULTS IN A SILTY SAND SOIL

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### ABSTRACT

This work describes an experimental setup that was developed in order to automate the direct shear Tests, to characterize the strength of soils. This experimental setup assures repeatability in the data acquisition, avoiding human errors, mainly when the tests data vary with a high dynamic. The described setup is based on LabVIEW, LVDT sensors and a 16 Bit Data Acquisition Board. For the direct shear Test it was used an apparatus, covered in ASTM standard D-3080 / D3080M - 11, "Standard Method for direct shear test on soils under consolidated drained conditions". This paper exposes the applicability study of the direct shear test to an existing silty sand soil, from the city of Braganza, Portugal, with the purpose to verify the applicability of this test with this instrumented apparatus. The results obtained and de main conclusions are presented.

**Keywords:** Direct Shear Test, Mechanical characterization of soils, LabVIEW.

### INTRODUCTION

In this work, it is described an experimental setup, existent in the Geotechnical Laboratory of the Polytechnic Institute of Bragança, that was developed in order to automate the direct shear tests. This experimental setup assures repeatability in the data acquisition test, avoiding human errors. Human errors occur mainly when the tests data vary with a high dynamic, being impossible to humans, that use an analog sensor with a display, to register the correct values.

The system, developed for acquisition and data register for the tests, is based on LVDT (Linear Variable Differential Transformer) sensors, a data acquisition board, a PC software LabVIEW application and specific dedicated hardware.

For the direct shear test it was used an apparatus, covered in ASTM D-3080 / D3080M - 11 standard [1], "Standard Method for direct shear test on soils under consolidated drained conditions". The direct shear device is used to determine failure envelopes for soils. This device is not suitable for the determination of stress-strain properties of soils. In many engineering problems such as design of foundation, retaining walls, slab bridges, pipes, sheet piling, the value of the angle of internal friction and cohesion of the soil involved are required for the design. Direct shear test is used to predict these parameters quickly. Based on the analysis of the acquired data, a laboratory report is produced, covering the laboratory procedures for determining these values, for cohesionless soils.

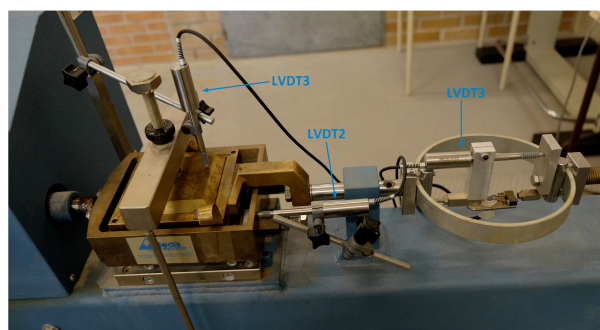
The direct shear test as we now know it [1] was perfected by several individuals during the first half of the twentieth century [2].

### DATA ACQUISITION SYSTEM AND RESULTS OF A REAL TEST FOR A SILTY SAND SOIL

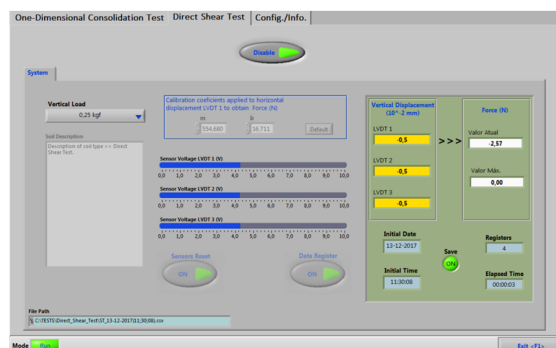
The system, developed for acquisition and data register for soil consolidation tests, is based on LVDT (Linear Variable Differential Transformer) sensors, a data acquisition board and a PC software LabVIEW application. The test apparatus, typically accepts a 60-75 mm (2. 5-3. 0 in) rectangular sample and subjects it to a vertical load, P. For more details it is recommended to read [3].

The sensors that instrument the direct shear apparatus can be seen in Figure 1-(a), where it can be observed that for the force measurement a dynamometer ring was used [4] [5]. Figure 1-(b) shows the main window of the developed LabVIEW software interface for the shear test. This environment provides a friendly user interface for the final user.

The results of a real test are presented for a silty sand soil from city of Braganza, Portugal. The results obtained in the software are presented in Figure 1-(c), where the layout file is presented (in CSV file). Briefly, this file presents the time vs displacements reading. LVDT1 is the deformation of the dynamometer ring (shear force), LVDT2 is the displacement of the lower box and LVDT3 is the displacement of the upper rigid plate (where the normal load P is applied). With these results, it is possible to obtain the graph presented in Figure 1-(d) (representation of the shear displacement (LVDT2) of a sample with the shear stress, which is a function of the deformation of the dynamometer ring (LVDT1). This type of graph is used to determine the maximum value of the shear force and thus determine the mechanical parameters of the soil.



(a)

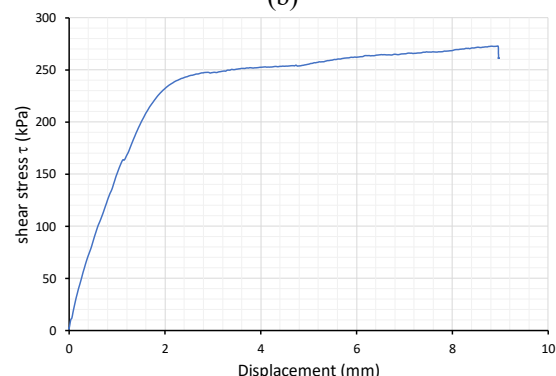


(b)

Description of soil type >> Direct Shear Test  
 Test Date: 30-11-2017

Seconds	Minutes	SORT(minutes)	LVDT1 (10 <sup>-2</sup> mm)	LVDT2 (10 <sup>-2</sup> mm)	LVDT3 (10 <sup>-2</sup> mm)	Shear Force T (N)	$\tau$ kPa	Displ.(mm)
0	0	0	0	0	0	16.711	1.6711	0
1	0.02	0.13	0	0	0	17.26568	1.726568	0
2	0.03	0.18	-0.1	0	0	16.15632	1.615632	0
3	0.05	0.22	-0.2	0	0.1	15.60164	1.560164	0
4	0.07	0.26	-0.1	0	0.1	16.15632	1.615632	0
5	0.08	0.29	-0.2	0	0.1	15.60164	1.560164	0
6	0.1	0.32	0	0	0.1	16.711	1.6711	0
7	0.12	0.34	0	0	0.1	16.711	1.6711	0
8	0.13	0.37	-0.1	0	0.1	16.15632	1.615632	0
9	0.15	0.39	-0.1	0	0.1	16.15632	1.615632	0
10	0.17	0.41	-0.1	0	0.1	16.15632	1.615632	0
11	0.18	0.43	0	0	0.1	16.711	1.6711	0
12	0.2	0.45	0	0	0.1	16.711	1.6711	0
13	0.22	0.47	5.8	1.3	-0.2	48.88244	4.888244	0.013
14	0.23	0.48	15.2	3.4	-0.2	101.02236	10.102236	0.034
15	0.25	0.5	18.1	5.7	-0.1	117.10808	11.710808	0.057
16	0.27	0.52	22.4	7.9	0	168.69332	16.869332	0.079
17	0.28	0.53	36.1	10.1	0.2	216.95048	21.695048	0.101
18	0.3	0.55	44.8	12.4	0.4	265.20764	26.520764	0.124
19	0.32	0.56	53.2	14.7	0.5	311.80076	31.180076	0.147

(c)



(d)

Fig. 1 – Direct Shear Tests: a) Direct shear apparatus instrumentation; b) Shear test user interface; c) Example of csv file layout of the data acquisition program, time vs displacements reading; d) Example of shear stress vs. shear displacement curve for a silty sand soil.

As future work the authors intend to develop studies based on the analysis of data acquired with the described acquisition system.

## **REFERENCES**

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