COMPARISON OF MECHANICAL PROPERTIES OF SAND BY USING A TRIAXIAL COMPRESSION DEVICE

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ABSTRACT

The first author Balzhan Kaldanova visited Hachinohe Institute of Technology (HIT) to study geotechnical engineering, especially triaxial compression tests, from Oct. 26 2014 to Nov. 28 2014 as a guest researcher of HIT. She is a researcher of geotechnical institute, L.N. Gumilyov Eurasian National University (ENU), Kazakhstan. She conducted experiments by using a triaxial test device under supporting of graduate student Naoki Oyama and researcher Yutaka Hashizume. This report described the introduction of a triaxial compression test which is one of the most versatile shear tests for the soil, and the detailed introduction on the subject of triaxial testing, including comparison of mechanical properties of sand specimens having different relative densities.

Key Words: *triaxial compression test, mechanical properties, maxmum principal stress difference, vertical strein, vertical stress*

キーワード : 三軸圧縮試験、力学特性、最大主応力差、軸ひずみ、軸応力

1. INTRODUCTION

By conducting this experiments in the laboratory, we can estimate how this type of soil will behave under natural conditions (in the field) and get exact results in determining its mechanical properties like the relationship between strength and deformation. For the magnitude of load, we can estimate how this type of soil can sustain the load. By the help of this test, we will get the imoportant factors in the design of buildings and the laying of the foundation: the pore pressure, drainage conditions, the change in the volume of soil with loading.

Triaxial test can evenly distribute the cell pressure on the specimen, then the resulting strain must be uniform and constant. After considering the results of the test, designers can accurately judge the character of the territory ground, the presence of potentially.

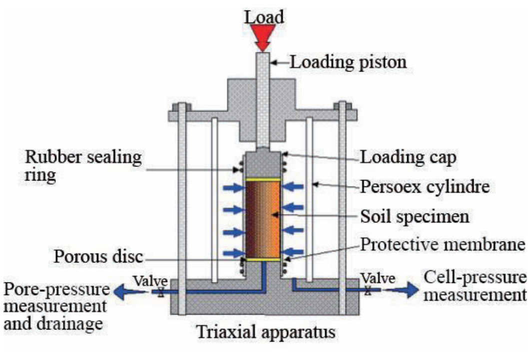

Fig. 1. A general view of the triaxial device

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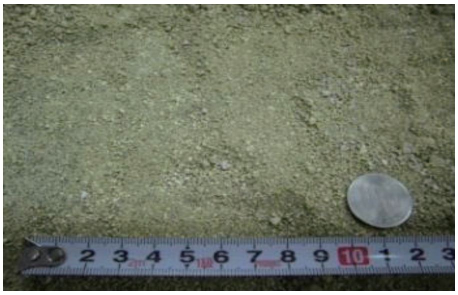

Fig.2. Pit sand

Table 1. Physical properties of test sand

Test sand	Pit sand
Soil particle density (g/cm^3)	2.670
Uniformity coefficient	3.19
Coefficient of curvature	1.1
Main grain size	0.41
Optimum moisture content(%)	23.385
Maximum dry density (g/cm^3)	1.516
CBR(%)	20.7
Design CBR(%)	20

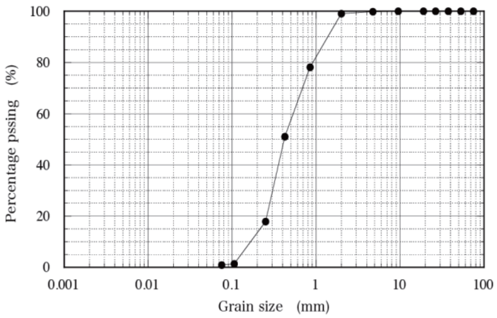

Fig. 3. Grain size distribution curve of test sand

Therefore, the designers will not pass any dangerous processes, and take the final decision on the project.

2. TRIAXIAL COMPRESSION IN PRATICE

Soil sample is taken in a cylindrical thin rubber membrane and placed in a special chamber of the device (triaxial). Lower part of the sample is set on

Fig.4. Dependence of the relative vertical deformation of the vertical stress at constant lateral stress of 100, 200 and 300 kPa.

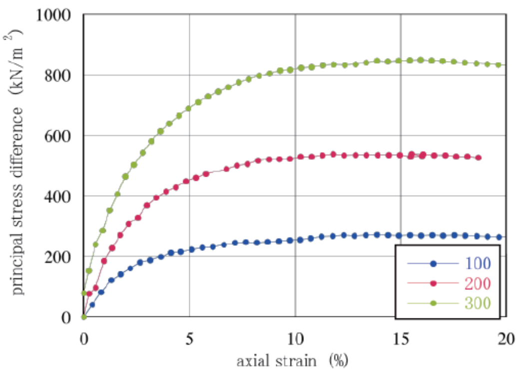

Fig. 5. Back pressure and principal stress difference

Table 2. Physical properties of test sand

Back pressure	Principal stress difference(max)
100	264.86
200	526.98
300	830.91
Slope of the straight line f_0	25.135
Slope m_0	2.8303
Angle of shear resistance Φ	35.87
Cohesion c	12.84

a porous stand. After loading, when the soil sample is ready for test pressure, the axial load is transmitted progressively from the top downwards. Triaxial compression means the loading in the three axis from all sides. For this purpose, the free space between the sample chamber and the device is liquid. Thus, we can get an extra uniform lateral pressure (**Fig. 1**).

Thanks to the uniform compression of the sample, geotechnical engineers can get the necessary

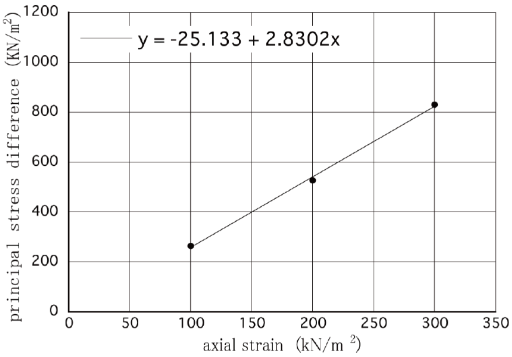

Fig. 6. Results of test

Fig.7. Dependence of the relative vertical deformation of the vertical stress at constant lateral stress of 100, 200 and 300 kPa.

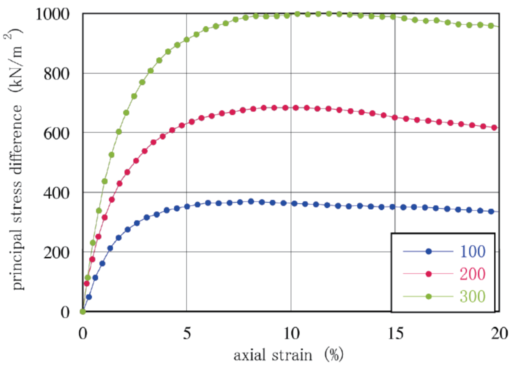

Fig. 8. Back pressure and principal stress difference

evidence, and the relationship between deformation and strength of the soil can be calculated as the final figures.

This test is greatly important in the construction of houses and buildings. Only on the basis of the obtained parameters the disigners can correctly calculate the foundation and the technical details of future construction.

Table 3. Physical of test sand

Back pressure	Principal stress difference(max)
100	369.46
200	684.02
300	999.85
Slope of the straight line f_0	54.294
Slope m_0	3.151
Angle of shear resistance Φ	37.71
Cohesion c	26.65

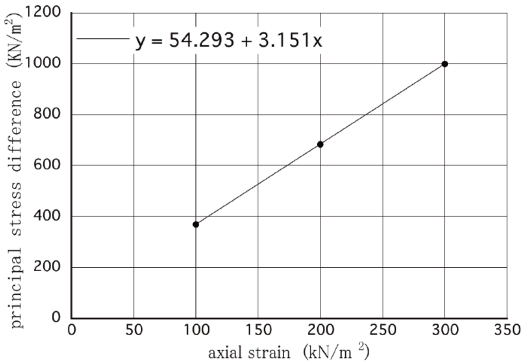

Fig. 9. Results of test

3. EXPERIMENTAL PAET

In the experiment we used the Pit sand (**Fig. 2**). Physical properties of the sand is shown in **Table 1**. This test was conducted with sample of sand, a relative density of 75%, in different triaxial lateral pressures of 100, 200 and 300 kPa (**Fig. 4**).

Scheme test in consolidated-drained using trajectory compression was conducted. Test results are shown in **Fig. 5**, and the stress differences are shown in **Table 4**. We get the curve between principal stress difference and axial strain (**Fig. 6**).

The next test was conducted using samples of high density sand that density of 90%, and in different cell pressure of 100, 200 and 300 kPa (**Fig. 7**).

Scheme test consolidated-drained using trajectory compression was conducted. Test results are shown in **Fig. 8**, and the stress differences are shown in **Table 5**. We get the curve between principal stress difference and axial strain (**Fig. 9**).

4. CONCLUSIONS

The use of methods of triaxial compression to a large extent eliminates the shortcomings of current practice laboratory research when the same mechanical properties determined on several samples using various force loading conditions.

The tests in a triaxial compression will be possible more completely to understand behavior of the soil in the future based on the buildings or strucures in the laboratory. By comparing different sand density, it is shown that high density sand has a lager principal stress difference.

5. ACKNOWLEDGEMENT

I'm grateful to Professors, Hachinohe Institute of Technology, A. Hasegawa and K. Kaneko, also for his geotechnical laboratory, where I was able to conduct experiments. And special thanks to researchers Geotechnical Institute, who helped me to carry out experiments. I have very fond memories about Japan, especially Hachinohe Institute of Technology in Hachinohe.

要　旨

筆頭著者バルジャン・カルダノバ氏（Balzhan Kaldanova）は、2014 年 10 月 26 日から 11 月 28 日まで、地盤工学、特に三軸圧縮試験に関する研究のために、八戸工業大学客員研究員として来日した。 現職は、カザフスタンの首都アスタナ市にある国立ユーラシア大学の研究員である。大学院生小山直輝君と研究員橋詰豊氏の支援のもとで、砂の三軸圧縮試験を実施した。この報告は、試験の概要と異なる相対密度の供試体について行った試験結果を示し、比較考察したものである。

キーワード : 三軸圧縮試験、力学特性、最大主応力差、軸ひずみ、軸応力

Table 4 – Stress differences

	100 kPa		200 kPa		300 kPa	
time	Axial strain	Principal stress difference	Axial strain	Principal stress difference	Axial strain	Principal stress difference
1	0.41	41.00	0.25	77.35	0.00	79.10
2	0.82	81.70	0.57	97.15	0.24	153.22
3	1.31	121.98	0.95	185.06	0.55	239.50
4	1.75	141.69	1.34	227.74	0.88	285.74
5	2.20	161.22	1.72	270.00	1.23	352.85
6	2.65	180.55	2.12	307.76	1.60	406.48
7	3.14	187.65	2.56	329.14	1.97	463.67
8	3.65	198.60	2.99	369.86	2.38	503.07
9	4.13	213.45	3.43	394.63	2.79	542.14
10	4.60	216.36	3.89	415.20	3.21	580.63
11	5.11	223.07	4.36	427.94	3.63	614.61
12	5.61	229.70	4.83	448.01	4.06	639.80
13	6.12	232.33	5.31	460.40	4.50	664.65
14	6.64	238.76	5.79	472.56	4.96	689.09
15	7.15	245.14	6.75	489.28	5.42	709.37
16	7.66	247.62	7.25	501.15	5.88	729.18
17	8.19	246.19	7.76	505.52	6.37	744.69
18	8.71	248.57	8.25	517.12	6.85	760.01
19	9.23	250.89	8.77	521.06	7.33	775.17
20	9.76	253.15	9.26	521.78	7.81	786.34
21	10.25	255.46	9.77	522.16	8.30	797.16
22	10.76	259.59	10.28	529.69	8.79	804.03
23	11.26	265.44	10.79	530.12	9.29	814.41
24	11.79	267.48	11.30	533.93	9.78	817.21
25	12.31	269.49	11.81	537.71	10.30	823.45
26	12.82	267.94	12.33	534.50	10.80	825.99
27	13.36	269.83	12.87	534.61	11.33	831.93
28	13.87	271.76	13.38	534.82	11.84	834.45
29	14.40	270.09	13.92	534.81	12.36	832.75
30	14.92	268.45	14.43	534.94	12.87	834.93
31	15.45	270.27	14.96	534.93	13.37	840.88
32	15.97	268.61	15.47	529.05	13.87	846.61
33	16.51	270.29	16.01	531.56	14.39	844.81
34	17.02	268.63	15.51	537.99	14.91	846.56
35	17.56	270.26	16.07	537.68	15.43	848.31
36	18.07	268.59	16.58	534.36	15.95	849.89
37	18.62	266.78	17.12	534.12	16.48	847.65
38	19.12	265.14	17.64	530.77	17.00	845.51
39	19.66	263.36	18.17	530.48	17.52	843.19
40	20.20	264.86	18.70	526.98	18.05	840.83
41					18.59	838.18
42					19.11	835.88

Table 5 – Stress differences

	100 kPa		200 kPa		300 kPa	
time	Axial strain	Principal stress difference	Axial strain	Principal stress difference	Axial strain	Principal stress difference
1	0.29	49.05	0.20	94.34	0.24	114.06
2	0.6	113.85	0.46	175.78	0.48	231.08
3	0.94	161.93	0.75	252.51	0.77	338.64
4	1.32	213.48	1.06	316.42	1.06	437.32
5	1.72	248.49	1.40	375.64	1.39	526.82
6	2.15	275.15	1.77	430.19	1.73	603.45
7	2.6	297.45	2.14	468.30	2.09	667.36
8	3.07	315.86	2.56	505.83	2.47	722.64
9	3.55	326.13	2.97	539.04	2.86	769.52
10	4.03	340.30	3.40	567.86	3.26	808.12
11	4.52	346.54	3.84	588.49	3.67	842.41
12	5.01	352.76	4.29	608.82	4.10	872.43
13	5.51	358.89	4.76	624.89	4.54	894.44
14	6.01	364.99	5.23	637.02	4.99	912.45
15	6.53	363.30	5.71	648.92	5.46	930.17
16	7.05	365.44	6.20	656.84	5.92	947.75
17	7.56	367.58	6.69	664.63	6.39	957.50
18	8.08	369.64	7.19	668.51	6.86	967.18
19	8.6	367.90	7.69	676.21	7.35	980.35
20	9.12	366.15	8.19	680.01	7.82	986.22
21	9.64	364.41	8.69	683.80	8.31	991.80
22	10.16	362.65	9.20	683.85	8.80	990.04
23	10.68	360.96	9.72	683.88	9.31	991.68
24	11.21	359.30	10.23	684.01	9.80	993.52
25	11.73	357.36	10.75	684.02	10.31	998.68
26	12.26	355.47	11.27	680.38	10.81	996.77
27	12.78	353.45	11.80	680.32	11.31	998.36
28	13.31	354.96	12.32	676.75	11.82	999.85
29	13.83	352.85	12.86	673.03	12.32	997.77
30	14.35	350.78	13.38	669.42	12.82	995.76
31	14.87	352.21	13.91	665.72	13.35	993.31
32	15.39	350.09	14.45	658.44	13.86	991.09
33	15.91	351.44	14.99	651.20	14.38	988.72
34	16.43	349.30	15.53	647.39	14.90	989.76
35	16.96	347.12	16.05	643.79	15.43	983.90
36	17.5	344.93	16.58	640.11	15.95	978.09
37	18.02	342.83	17.11	636.36	16.48	975.45
38	18.55	340.67	17.65	632.61	16.99	976.28
39	19.08	338.50	18.17	628.93	17.52	970.18
40	19.61	336.34	18.70	625.17	18.04	964.16
41	20.13	334.20	19.23	621.41	18.56	961.39
42			19.76	617.61	19.08	961.87