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Effect of Confinement Pressure on Soil Behavioral Parameters (Numerical Study)

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ABSTRACT

The analysis of soil behavior depends on several factors dealing with physical characteristics such as humidity rate , shape and size of grains, density , degree of saturation , time , temperature and the situation of present and previous stresses .From one hand , soil behavior , as a composed substance , changes based on types of loading , therefore , the study of stress ways which depends upon the rate of confinement pressure on soil will have a great role in identification of the soil behavior which is created by loading. In this research, at first, the purpose is calculating the impact of confinement pressure on the cohesion and on internal friction angle and also the study of its effect on mean principle stress-strain curves in samples. Numerical analyses in studying environments are done by using finite element software Plaxis. Accomplished studies indicate that the amount of internal friction angle and cohesion in samples changes by pressure change and also the soil behavior is dependent on the rate of confinement pressure.

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INTRODUCTION

Geotechnical activities are difficult, expensive and time consuming, in addition, they require the proficient and skillful persons as well as the ability of information analysis besides, it is not possible to do it in the distances close to each other and the errors resulting from human factors not calibrating the instruments and information analysis may cause lack of curtaining in soil behavior. Study of soil geotechnical features not only requires the identification of region and precision in widening, but also it needs the correct recognition and entire cognition of the performance of structure composition and initial studies for determining the critical parameters of soil behavior. So, the numerical analysis as an effective way can be useful to decrease the errors and expenses. Mohr presented a theory for substances failure in 1900. Based on his model, substances are failure in a critical mixture of direct stress and shearing stress Meyerhof [6] and De beer proposed that the angle of internal friction to be applied to the bearing capacity formula must be selected in accordance with the stress level beneath the footing. Hettler and Gudehus [5] supported Meyerhof's suggestion and Perkins [6] applied it to a highly frictional material. By Katsutushi Ueno *et al* [1] the Prediction of ultimate bearing capacity of surface footings within regard to size effects has been studied. Their study showed that the effective mean principle stress tends to range from 2γB to 10γB for strip footings and from γB to 15γB for circular footings. Katsutushi Ueno *et al* [1] studied the reappraisal of size effect of bearing capacity from plastic solution. They presented a simple method for calculating the ultimate bearing capacity of footings placed on the sand in which the dependence of internal friction angle of materials to confinement pressure has been considered. Soil behavior prediction under footings regard to the elasto-plastic models studied by Khazaie *et al* [4].they showed that in the large footing due to the increasing the confined zone that located under the foundation and decreasing deviatoric stress in this zone bearing on the footing can increase. Also this agent cause the increase of reaction earth in the middle of footing compared to the edges.

In this research the effect of confinement pressure on cohesion and internal friction angle, stress-strain curves and soil behavior has been studied. These studies indicated that the behaviors of soil samples are a function of stress rate.

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2-Modelling:

In this research, the Plaxis software has been used for numerical modeling. The used parameters are given in table 1. The hardening soil model has been used to simulate the soil behavior in triaxial drained test. Boundary conditions are described as in one side of model gridded in X direction and transitively in Y direction and in the other side the load applied. The normal loading applied to the top of the model and under the sample grid in Y direction and transitively in X direction. There for not only the balance of the whole model is kept in horizontal direction , but also move freely in vertical direction which is the direction of loading and weight. The pattern of model has been represented in figure 1.

Table 1: difinite parameters of soil samples used in numerical analysis.

sample	C	ϕ	γ
S1	0	41	17/5
S2	0	34	18
SW	0	33	17/3
SC	25	5	16

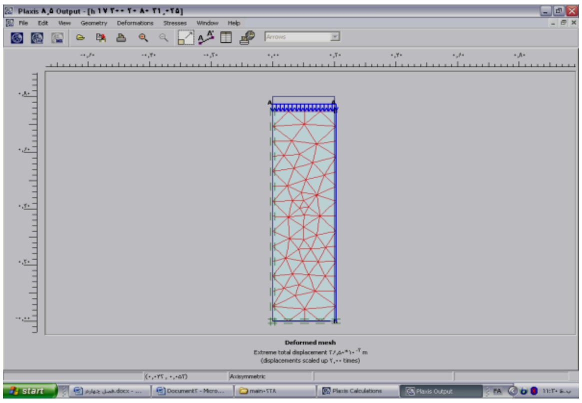

Fig.1: Model in Plaxis software.

The following assumptions have been considerable for more simple analysis.

1. The issue has been analyzed as an axisymmetry model.
2. Regarding to considering long term behavior of soil, the sample has been studied in drained condition.
3. The study has been carried out parametrical.

3. The results of analysis:

In this part the mesh effect, model dimensions and also the effect of confinement pressure on the shear strength parameters and the stress strain curves have been studied.

3-1-mesh effect:

in order to survey mesh effect in obtained results three samples, in similar conditions, have been analyzed with very fine middle and very large meshes and similar loading .the q' versus axial strain has been presented for each three samples in figure2.the acquired result indicate that dimensions has no effect on the obtained results.

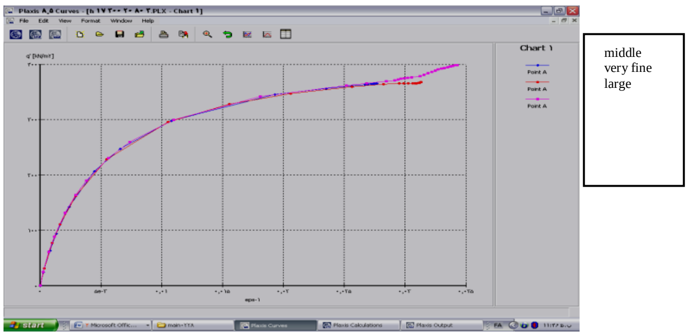

Fig. 2: mesh effect.

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3-2-Dimensions effect:

In order to study the dimensions effect, three samples have been examined with dimension of 1.9×7.62, 80×80 and 100×100 cm and with similar conditions of loading, mesh and time which the acquired results of samples analysis presented in figure3.by comparing the obtained results, we can conclude that the dimension changes has no effect on the final results.

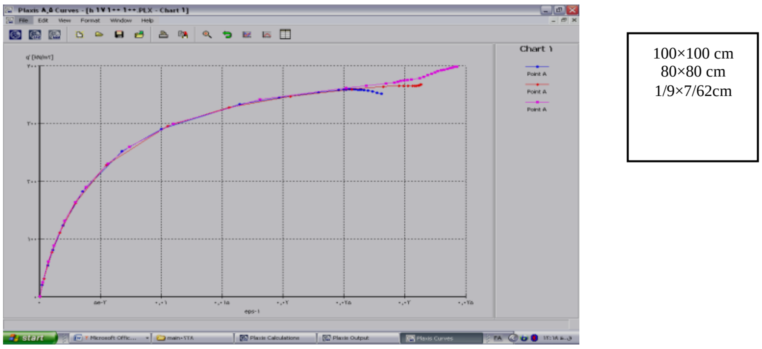

Fig. 3: The impact of dimension on obtained results of numerical model.

3-3-Efficancy on the mean principle stress -strain curves:

In order to study the effect of confinement pressure on mean principle stress-strain curve diagram, related diagrams have been presented in figures 4 to 7.

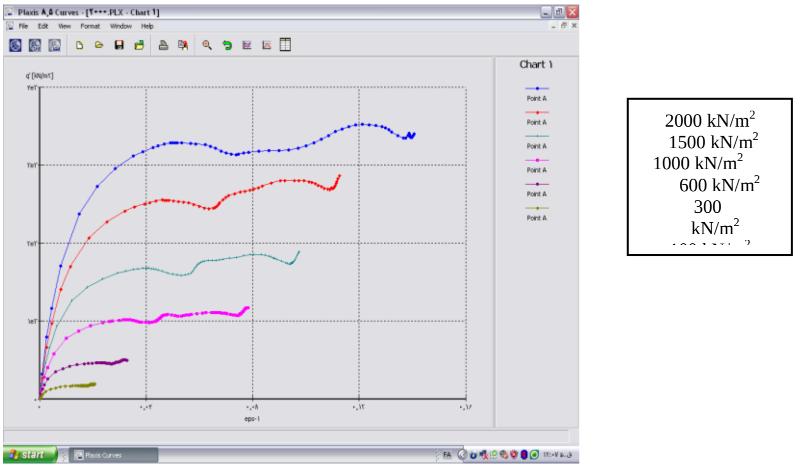

Fig. 4: Q’ vs. strain curve in sample s1 in confinement pressure from 100 to 2000 kN/m^{2}.

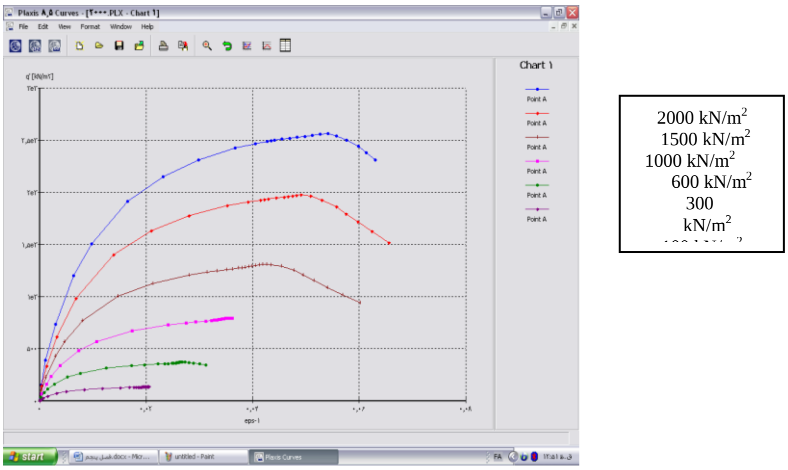

Fig. 5: Q’ vs. strain curve in sample s2 in confinement pressure from 100 to 2000 kN/m^{2}.

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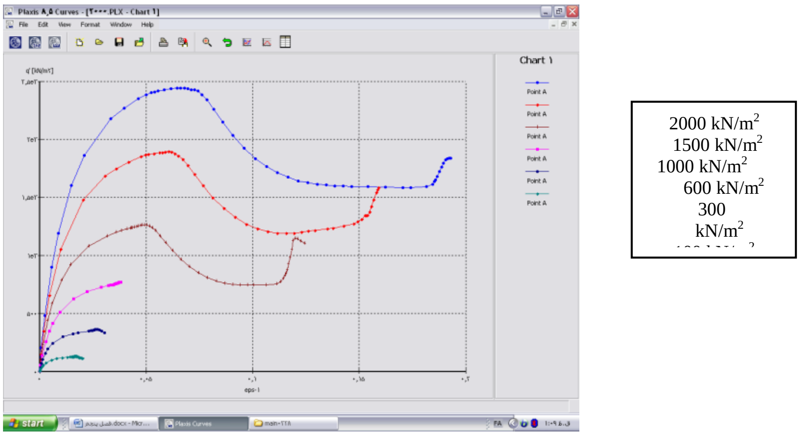

Fig. 6: q' vs. strain curve in sample SW in confinement pressure from 100 to 2000 kN/m^2.

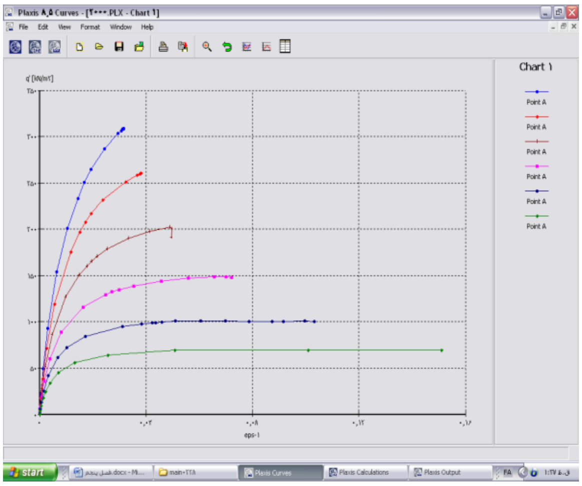

Fig. 7: Q' vs. strain curve in sample SC in confinement pressure from 100 to 2000 kN/m^2.

3-3-1-Sample S1:

in this sample after the elastic behavior and reaching to the maximum resistant, softening occurs in the sample and that by addition of confinement pressure will increase the range of softening behavior and after hardening, again the softening behavior happens in the sample .by increasing the confinement pressure the range of plastic strain in the sample in the pressure of 2000 kN/m^2 increase 7 times of strain in the 100 kN/m^2 pressure

3-3-2-Sample S2:

in this sample in the confinement pressure of 100,300 and 600 kN/m^2 the behavior in the elastic region is linear and the plastic strains increase smoothly until the sample failures. By increasing the confinement pressure from 1000 kN/m^2 to 2000 kN/m2 diagrams indicated development of elastic and plastic behavior. By comparing of diagrams these results are inferred:
-confinement pressure increasing, will growth the rate of plastic strains
-Pressure from 1000 kN/m^2 to 2000 kN/m^2, after reaching the maximum shear resistance, softening behavior is seen in samples.
-the range of softening behavior gradually increased and after reaching the confinement pressure1500 kN/m^2 is reduced.
-softening behavior in the pressure of 2000 kN/m^2 is lower than the pressure of 1500 kN/m^2.

3-3-3-Sample SW:

The sample treated at 100 kN/m^2 and 300 kN/m^2 $^{\text{confinement}}$ in the elastic and plastic strain as linear gentle slope increases with. Then the behavior of the sample is softening until failure .hardening behavior is seen in 600 kN/m^2 confinement pressure. with increasing pressure from 1000 kN/m^2 to 2000 kN/m^{2}after reaching the maximum shear resistance, increased the range of softening behavior and then hardening behavior occurred and the hardening behavior decreased by increasing the pressure. Maximum tolerable strain increases up to 9-fold by increasing confinement pressure.

3-3-4 Sample SC:

Unlike the samples above, all were grain soils, this sample is sandy clay one.

In confinement pressure from 100 kN/m^2 to 600 kN/m^2 strains in the elastic region increases with increasing pressure and after reaching to the maximum shear resistance, the plastic strain amplitude is reduced with increasing pressure. From pressure of 1000 kN/m^2 to 2000 kN/m^2 plastic strains are almost eliminated and the soil behavior is linear and elastic until failure happened. Interestingly in this diagram, the strain is reducing in tolerable strain by increasing pressure.

In short:

In S1: The pattern of deformation is almost constant.

In S2: By increasing the pressure first softening increases and then it decreases.

In SW: First the softening behavior is observed then hardening and ultimately softening and hardening are observed again.

In SC: By pressure increasing, reduction of softening and hardening is reconsidered.

3.4. The effect of confinement pressure on shear resistance parameters:

To know the effect of confinement pressure on shear resistance parameters, the maximum shear resistance values measured on the confinement pressure corresponding stress – strain curves obtained for each sample. Based on the results, cohesion and the internal friction angle of, is calculated and presented in table 2.

Table 2: changes of C and ϕ with confinement pressure.

sample	S1 ϕ_{in}=41		S2 ϕ_{in}=34		SW ϕ_{in}=33		SC ϕ_{in}=5	
σ3	ϕ	C	ϕ	C	ϕ	C	ϕ	C
100	36.33	16.02	35.19	0	32.3	10.3	7.86	46.56
300	40.2	0	35.13	0	35	0	7.86	46.56
600	39	0	34.83	0	33.9	0	6.7	60.3
1000	38.6	10.2	34.6	0	33.6	0	5.4	82.65
1500	36	188.1	32.52	121.14	30.9	133.7	5	103.1
2000								

As can be seen the cohesion and internal friction angle with changes in pressure will change.

Conclusion:

Upon to the observed results amount of stress, especially stress way had the most critical impact on the deformation properties. This effect, in grain soils, by increasing the internal friction angle is reduced as can be seen. The SC sample behaved softening at lower pressure and finally acted as a fragile sample.

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