

Shear Behaviour of Misurata Wet Sand

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Abstract. The foundation design of buildings depends on the bearing capacity of soil and foundation shaft resistance, upon this reason, for buildings safety, the study of shear behaviour of soil is very important to analyse and evaluate the foundation settlement and friction between soil and foundation surface. especially in the case of deep foundation. The paper is to study and evaluate the shear behaviour of Misurata wet sand around foundation surface under the effect of different axial loads by using direct shear box test. This study contains nine laboratory tests were done to measure the Sand-Aluminum interface of smooth surfaces, and other nine tests for Sand-Aluminum interface of rough surfaces, to simulate foundation surface in the site. Also, another nine tests were done to measure Sand-Sand interface shear behaviour resulting from friction between wet sand grains under different normal loads, soil type and initial sand density in three cases of soil, loose, medium and dense wet sand. The test results showed that the value of soil displacement and interface friction angle (δ) are very important for foundation design, especially for deep foundations. Also, from the evaluation of experimental test results we found that the interface friction angle (δ) depends on roughness of the foundation, initial compactness, water content and porosity of sand.

1 Introduction

The foundation design of buildings depends on the bearing capacity of soil and foundation shaft resistance, upon this reason, for buildings safety, the study of static behaviour of sand shear resistance is very important to analyse and evaluate the foundation design, especially in deep foundation [1] Figure (1) shows the direct shear box, which used to measure soil bearing capacity factors (ϕ , c).

Nine laboratory tests were done to measure the sand-aluminum interface shear friction of smooth surfaces, and other nine tests for rough surfaces to simulate foundation surfaces in the site. Also, another nine tests were done to measure sand-sand interface shear behaviour resulting from friction between wet sand grains under different normal loads, soil type and initial sand density.

To analyse the interface friction between soil and foundation, and to evaluate the foundation settlement, it is necessary to know the shear behaviour of sand around and underneath the foundations. The roughness of foundation surface has high effect on foundation shaft friction development especially for deep foundation [2].

The study contains interface friction tests between soil and two types of construction materials with smooth and rough surfaces by using the direct shear box under different axial loads.

The aim of the tests is to study the effect of normal stress, initial soil density, foundation type and roughness of foundation surface on the friction resistance. From the test results, we can know the interface friction angle values (δ), and we can make comparison between these values and internal friction angle values (ϕ) of wet sand.

2 Soil properties

Table (1) shows the physical properties of sand, which used in the study of this paper. From this paper, we found that, the shaft resistance between sand and foundation surfaces increasing directly with increasing their surfaces roughness, but some papers confirmed that, the interface friction angle (δ), approximately equal sand-sand friction angle (ϕ), where the failure may happened in sand neighboring the foundation surface.

Table 1. Physical properties of sand

Condition of soil	Specific density	Dry density gm/cm ³	Void ratio e	Relative density Dr %
Loose wet sand	2.70	1.48	0.81	28
Medium wet sand	2.70	1.58	0.66	63
Dense wet sand	2.70	1.69	0.55	72

3 Experimental works

All the experimental tests were done on the models of construction materials in three different soil conditions, loose, medium dense and dense wet sand in direct shear test apparatus. The direct shear test apparatus which shown in figure (1) is used to measure the values of internal friction angles.



Fig. 1. Direct Shear Box

For preparing the model tests, the sand was poured in the shear box to simulate loose sand as in the site with initial density 1.45 gm/cm^3 , where in the case of medium dense sand the soil was poured in the box and tamped by tamper until initial density 1.56 gm/cm^3 is received, but in the case of dense dry sand the soil was poured in the box by layers and every layer is compacted by a tamper until we get the initial density 1.67 gm/cm^3 . sand-construction materials shaft shear tests, two aluminum model plates were prepared by dimensions (60 mm, 60 mm, 10 mm) one of them has smooth surface, where the other with rough surface, which equal the volume of bottom half of shear box, the sand was poured in the upper half of the box as mentioned before in three cases of sand, then the shear box instrument was started to work horizontally with 1 cm / min under applied normal load, Surface roughness of the aluminum model structural has an important effect on the shear stresses.

4 Test results

The maximum shear stresses developed by rough surfaces of structural models is higher than that developed by smooth surfaces, hence, from figures (2) and (3) we found that the values of horizontal displacements at maximum shear stresses in the case of sand-sand interfaces approximately equal that values for maximum shear stresses in the case of sand-rough aluminum interfaces, which ranges between (2.0-5.0) mm. This is attributed to that, the surface roughness of aluminum models approximately equal to the roughness of sand grains.

Figure (3) and (4) shows that in the case of rough model surface the maximum interface shear stresses are developed at smaller horizontal displacement than that in the case of smooth surfaces.

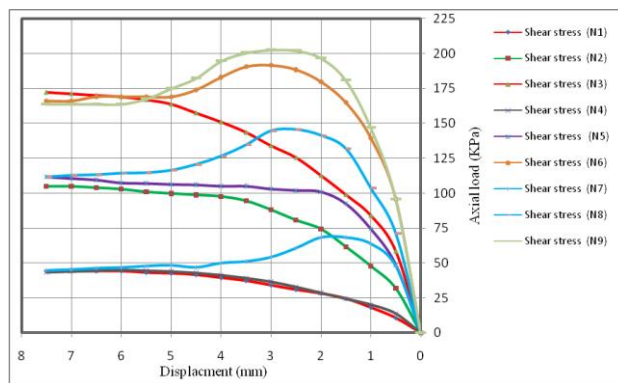


Fig. 2. The Relationship between Shear Displacement and Shear Stress for Sand-Sand Interface

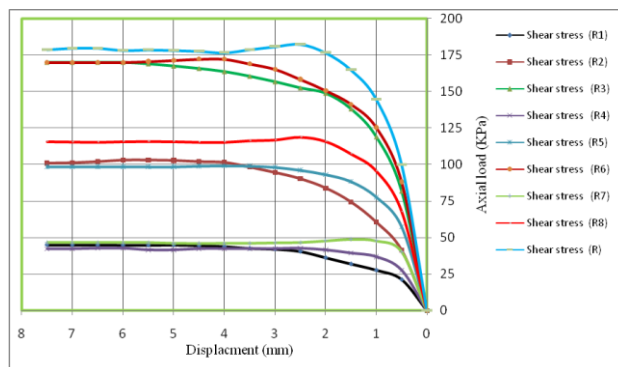


Fig. 3. The Relationship between Shear Displacement and Shear Stress for Sand-Rough Alum. Interface

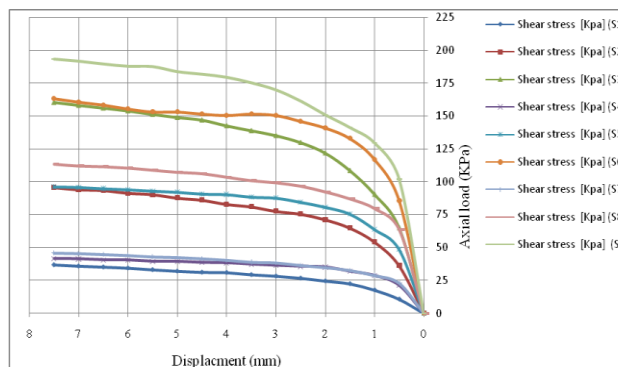


Fig. 4. The Relationship between Shear Displacement and Shear Stress for Sand-Smooth Alum. Interface

Table (2) shows the results of direct shear tests sand-sand interface, which done on wet sand under different normal loads (100 KPa , 200 KPa , 300 KPa) where, table (3) shows the results of direct shear tests which done on the wet sand and models of aluminum in smooth surfaces under different normal loads, and table (4) shows the results of direct shear tests, which done on the wet sand and models of aluminum rough surfaces under different normal loads.

The results of testing shows that, the sand-sand shear stresses, increases directly with increasing normal stress (σ) and with increasing the initial density of sand for smooth and rough aluminum model surfaces.

In the case of rough surfaces, we got the maximum values of shear stresses (τ_p), at the horizontal

displacement between (2.0-5.0) mm, and equal (7.0-7.5) mm in the case of model aluminum smooth surfaces.

Table 2. Results of Direct Shear Test for Wet Sand.

Sand-Sand Interface						
Soil condition	σ KPa	Test No.	τ_P	τ_U	ϕ_P	ϕ_u
Loose wet sand	100	N ₁	44.1	44.1	32.6	32.6
	200	N ₂	105	105		
	300	N ₃	172	172		
Medium dense wet sand	100	N ₄	44.6	43.6	36	31.5
	200	N ₅	112	112		
	300	N ₆	191	166		
Dense wet Sand	100	N ₇	68.3	44.6	34	30.8
	200	N ₈	146	112		
	300	N ₉	203	164		

Table 3. Results of Direct Shear Test for Sand-Rough Aluminum Surfaces.

Sand-Rough Aluminum surfaces						
Soil Condition	σ KPa	Test No.	τ_P	τ_U	δ_P	δ_u
Loose Wet Sand	100	R ₁	43	41.5	32.4	32
	200	R ₂	99	98.3		
	300	R ₃	170	167		
Medium Dense Wet Sand	100	R ₄	44.9	44.2	32.4	32.2
	200	R ₅	103	101		
	300	R ₆	172	170		
Dense Wet Sand	100	R ₇	48	46.8	33.8	33.4
	200	R ₈	119	116		
	300	R ₉	182	179		

Table 4. Results of Direct Shear Test for Sand-Smooth Aluminum Surfaces.

Sand-Smooth Aluminum surfaces						
Soil Condition	σ KPa	Test No.	τ_P	τ_U	δ_P	δ_u
Loose Wet Sand	100	S ₁	35.7	35.7	32	32
	200	S ₂	95.7	95.7		
	300	S ₃	160	160		
Medium Dense Wet Sand	100	S ₄	42.5	42.5	31.8	31.8
	200	S ₅	96.2	96.2		
	300	S ₆	167	167		
Dense Wet Sand	100	S ₇	45.7	45.7	36	36
	200	S ₈	114	114		
	300	S ₉	193	193		

Figures (5), (6) and (7) shows the sand-aluminum interface shear resistance in two cases of aluminum model surfaces smooth and rough in three cases of wet sand, loose, medium dense and dense wet sand.

Figures (5), (6) and (7) shows the maximum sand-sand interface friction angles (ϕ_P) and the maximum sand-aluminum interface friction angles (δ_P) in the case of smooth and rough surfaces in three conditions of sand, loose, medium dense and dense wet sand, Also, the figures show the ultimate sand-sand interface angles (ϕ_u) and the ultimate sand aluminum interface angles (δ_u) in

smooth and rough surfaces in three cases of loose, medium dense and dense wet sand

Figures, (5), (6) and (7) shows that the sand-sand interface friction angles (ϕ_P, ϕ_u) approximately equal the sand aluminum interface friction angles (δ_P, δ_u) in the case of rough surfaces, this attributed to the roughness equality of sand grains and the aluminum model structural surfaces, where, in the case of smooth surfaces, we found that the sand-aluminum interface friction angles (δ_P, δ_u) is smaller than the sand-sand interface angles (ϕ_P, ϕ_u), similar results were shown in papers [1],[2],[4] and [5].

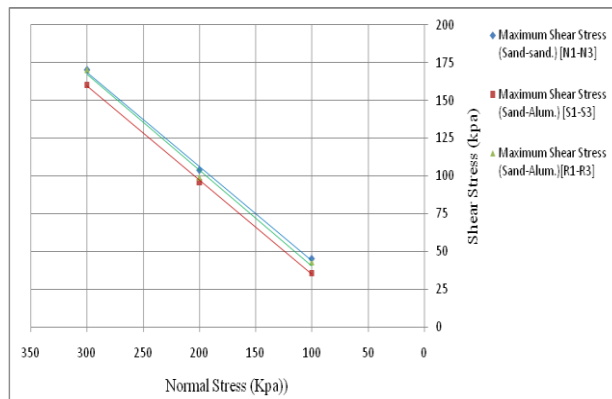


Fig. 5. The Maximum Sand-Aluminum interface angles and the Maximum Sand-Sand friction angles for loose wet sand

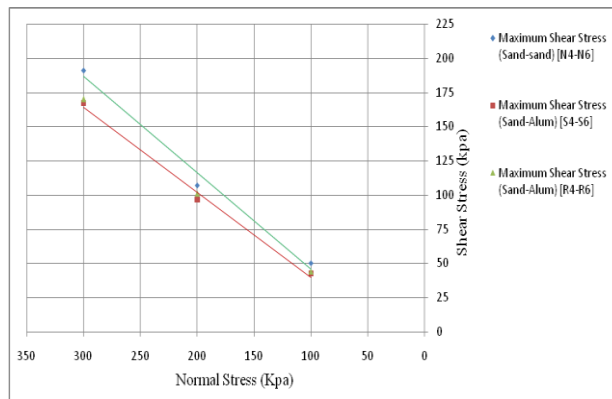


Fig. 6. The Maximum Sand-Aluminum interface angles and the Maximum Sand-Sand friction angles for medium wet sand

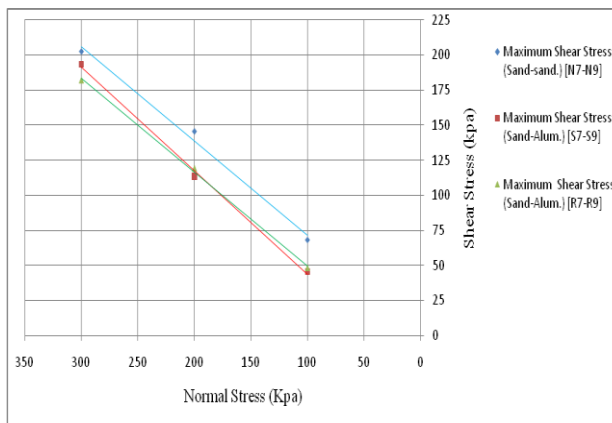


Fig. 7. The Maximum Sand-Aluminum interface angles and the Maximum Sand-Sand friction angles for dense wet sand

5 Summary

The test apparatus, direct shear box is more important methods to study shear behaviour between soil and construction material surfaces, it offers certain features that can be advantageous in analysing the foundation–soil interaction.

For this reason, tests were done on sand-aluminum interface shear behaviour in two cases smooth and rough surfaces, Also, sand-sand interface tests were done to know sand shear behaviour under different conditions.

6 Conclusion

On the basis of the tests, which were done (9 sand-smooth aluminum interface, 9 sand-rough aluminum interface and 9 sand-sand interface) the following conclusion can be drawn:

- 1-The maximum sand-sand interface shear resistance (τ_p) and the ultimate sand-sand interface shear resistance (τ_u) depends on the effects of shear stresses.
- 2-The shear displacement to mobilise the maximum shear stresses (τ_p) for sand in the case of aluminum rough surface is smaller than that in the case of smooth surface.
- 3-In dense wet sand, the shear displacement to mobilise maximum sand-sand shear stresses (τ_p) smaller than that in the case of loose wet sand to reach the maximum values of shear stresses.
- 4-The value of maximum and ultimate shear stresses increases directly with increasing surface roughness of structural materials.
- 5-The sand-aluminum interface friction angles (δ) decreases with density decrease and porosity increase.

References

1. M. M. Shahin, (Shaft resistance of model pile in wet sand) 3rd National Structural Engineering Conference, ALkhoms - Libya (2004)
2. M. M. Shahin, (Shaft resistance of model pile in dry silt) 6th Asian Pacific Structural Engineering and Construction Conference, Kuala Lumpur-Malaysia (2006)
3. M. .F. Randolph, (The Axial Capacity of Deep Foundation in sand), proceedings international conference of calcareous sediments, perth, Australia, vol. 2, Balkema (1988)
4. T. B. Edil, M. A. Abdel Rahman, (Shaft resistance of model pile in granular soil) {Deep Foundation on bored and auger piles} BAP 11, Ed. VANE IMPE, W.F.A. A.Balkema / ROTTERDAM/BROOKFIELD/ (1995)
5. I. B. Mochtar, T. B. Edil, (shaft resistance of model pile in clay), J.Geotech. Engrg, ASCE, Vol.114, No.. 11 November (1988)