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Mesurement of Soil Parameters By New Apparatus

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---Abstract---
This study provides a method of estimating the parameters of sandy soil by using handle penetrometer needles apparatus and new penetrometer apparatus is also developed by research student and used to assess soil parameters. Classical soil mechanics experiments such as relative density, grain size analysis, specific gravity, maximum dry density and direct shear test. The penetration experiment is then carried out on samples of different densities. A field study was then performed using the developed motorized penetrometer. In situ density and water content were first determined using the sand cone method. The motorized penetration test was the carried out on the same spot, and the results were used to assess different soil parameters. Finally, the commercial finite element program Midas GTS is used for the finite element simulation and finite sliding is modeled using a frictional contact interface**.**

Keywords - *New Apparatus, Sand, Soil parameters, penetrometer, Midas program. , normal stress,*

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I. INTRODUCTION

The main objective of this research is to develop a practical method to estimate soil parameter using penetration method. To assess this objective laboratory tests, field tests, and analytical simulation were applied. In the laboratory testing stage, laboratory tests on sandy soil and imposing densities different comparative and get them on the dry densities the sand user and conduct laboratory tests of various such as, Density in situ, Grain Size Analysis, Specific Gravity Test, Direct Shear Test (DST) and Stress – Strain modulus, two types of sandy soil (fine and coarse sand) were used in this laboratory work in which relationships between normal stress and penetrating distance at different dry densities using the following procedure. Samples of each kind from sand were prepared for the purpose of performing the handled penetrometr needle tests. These samples were prepared in relative density molds. In the field testing stage, the new motorized Apparatus was used to perform penetration tests on sandy soil in the field. Nine densities were used for sandy soil; in situ density was first determined using the sand cone method. The motorized penetration test was the carried out on the same spot, and the results were used to assess different soil parameters. In analytical simulation stage, the commercial Finite element program Midas GTS(Geotechnical and Tunnel Engineering) is used for the finite element display is 2D model type using (50cm height and 50 cm diameter)and kgf/cm for unite system, a frictional contact interface by ground soil property and steel structure for disk used , Mohr coulomb used for type of model and elastic model type for steel disk, ground supports used for boundary condition .interface attribute for element type interface used and create pile ,finally solve analysis by running program.

II. EXPERIMENTAL WORK

2.1. Materials and Preparation of samples

In the first order two types of air dry granular soils (fine and coarse sand) were used in this laboratory work in which relationships between normal stress and penetrating distance at different dry densities using the following procedure. Samples of each kind from sand were prepared for the purpose of performing the handled penetrometr needle tests. These samples were prepared in relative density molds. The sample delivered directly to the laboratory to determine their dry density, water content, specific gravity, direct shear test and penetrating test in finally by using handled penetrometr needle. Five density values were maintained for coarse sand and seven density values for fine sand. Penetration test in the field (campus location) by using new motorized penetrometer needle apparatus developer by the first author **Abuzeid**.

2.2. Handel Penetrometr Apparatus

The apparatus basically consists of a needle attached to a spring **-** loaded plunger through a shank. An array of interchangeable needle tips is available, to facilitate the measurement of a wide range of penetration resistance values. A calibration of penetration against dry unit weight and water content is obtained by pushing the needle in to specially prepared samples for which these values are known and the penetration, shown in Fig (1).

Fig (1): Shape of Handel penetrometer apparatus

2.3. New motorized penetrometr apparatus

The idea of developing the device was when we found that the accuracy of the results and the device dependent all rely on the strength of spring and the power used. So I thought if I have a soil strong resistance how to overcome this tool to get the results and also if the person was found a weak force that uses this device to measure the distance of penetration. From here I have been thinking in the development of finishing off to make it mechanically and hence make it mechanically was thinking about installing a power supply to motor function as And indeed been manufacturing the device position in the form which is a few parts of the first part, a rule was formed so as to be balanced during the tests. Part II is a holder of my head by the stream to move the device inside so that the length of stream equal to the length of the needle penetration that will be infiltrated into the soil and compound mechanical piston-like jack car and pressure up to 1.5 tons. This manually operated piston as possible in the absence of a current source of electricity shown in Fig (2), and also works mechanically by motor in the case of a source of electricity. And the device provides the weight or iron rods in the soil proved not to move the device during the performance of field tests Forms.

Fig (2): Mechanical and Motorized new penetrometer apparatus.

2.4. Description of component parts for new penetrometr apparatus.

The device consists of ten parts shown in Fig (3), and described as follows:

[1] Beam C-Channeled To Carry The Device.
[2] Jack Manual To Download And Raise The Needle Penetration.
[3] 12 Volt Motor Rolled Right And Left.
[4] Handle Penetrometer Needle Apparatus.

[5] The Balance Of The Settlement To Adjust The Horizontal Apparatus.
[6] Ruler Listed To See A Penetration Distance In The Ground.
[7] Base To Put The Power Supply On It.
[8] Power Supply.
[9] Triple Base For Stability Apparatus.
[10] Stream To Move The Handle Penetrometer Needle Apparatus Inside To The Bottom And Top.
[11] Circular Base To Install The Device On The Soil.
[12] Coupling Between The Motor And Jack.
[13] Switch To Turn On And Off The Motor.

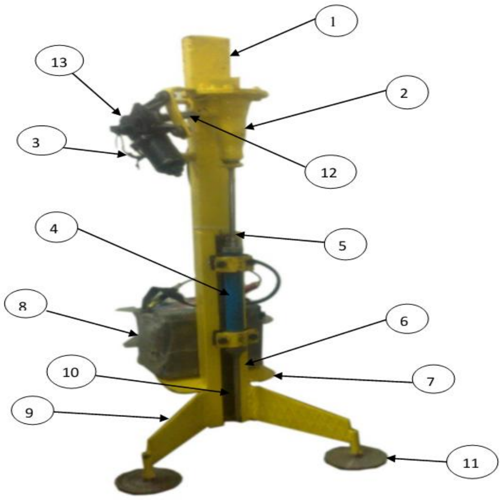

Fig (3): Shape of new penetrometer apparatus

2.5. Calibration new penetrometer apparatus.

To calibrate the new penetrometer apparatus penetration testing was conducted on fiberglass tank filled with sandy soil once using handle penetrometer and again using a new penetrometer apparatus, Shows the convergence test results from each other, shown in Fig (4).

Fig (4): Calibration new penetrometer apparatus

III. RESULTS AND ANALYSIS

Common handle penetrometer was used to perform penetration tests on coarse and fine sand. Five densities were used for coarse sand samples, whereas seven densities were used for fine sand samples as explained above.

3.1. Tests performed on coarse sand

Table (1) shows penetration distance and normal stress regarding a density of 1.72 g/cm^3 for different disk diameters.By plotting the results of normal stress values against that of different penetration distance from 4 cm to 9 cm, a reliable correlation were obtained as shown in Fig (5). The values of coefficient of determination associated with the following best – fitted equation for 2.5 cm diameter disk are

$$\mathbf{y} = 1.737(x) - 4.911$$

$$R^2 = 0.91$$

Figure (5) indicates that normal stress increases with increases of penetration distance. The results showed linear correlation with acceptable coefficient of determination. Similar correlations were determined for disk diameters of 2.0, 1.5, 1.2, and cone. The linear correlations for theses disk diameters are:

2.0 cm diameter disk

$$\mathbf{y} = 2.150(x) - 5.953$$
$$R^2 = 0.934$$

1.5 cm diameter disk

$$\mathbf{y} = 2.850(x) - 7.730$$
$$R^2 = 0.890$$

1.3 cm diameter disk

$$\mathbf{y} = 3.209(x) - 8.579$$
$$R2 = 0.818$$

Cone

$$\mathbf{y} = 2.079(x) - 5.853$$
$$R^2 = 0.908$$

Table (1): Results of Penetrating Distance and Normal Stress at Dry Density 1.72 g\cm^3

Disk diameters	Penetrating distance (cm)	Normal stress (kg/cm2)		
		Trial 1	Trial 2	average
2.5 cm	9	12.04	12.25	12.145
	8	7.66	7.15	7.405
	7	6.64	6.64	6.64
	6	6.23	6.23	6.23
	5	3.78	3.57	3.675
	4	2.14	2.25	2.195
2.0 cm	9	14.97	14.33	14.65
	8	9.56	9.56	9.56
	7	8.28	7.96	8.12
	6	7.81	7.17	7.49
	5	4.78	4.78	4.78
	4	2.71	3.03	2.87
1.5 cm	9	20.06	20.06	20.06
	8	12.71	12.71	12.71
	7	11.02	11.87	11.445
	6	10.45	11.02	10.735
	5	6.22	6.78	6.5
	4	3.67	4.24	3.955
1.3 cm	9	23.70	24.44	24.07
	8	15.05	16.54	15.795
	7	13.16	13.16	13.16
	6	12.05	12.41	12.23
	5	7.52	8.65	8.085
	4	4.14	4.51	4.325
cone	9	14.30	14.50	14.4
	8	9.09	8.58	8.835
	7	7.88	7.89	7.885
	6	7.39	7.39	7.39
	5	4.48	4.28	4.38
	4	2.54	2.65	2.595

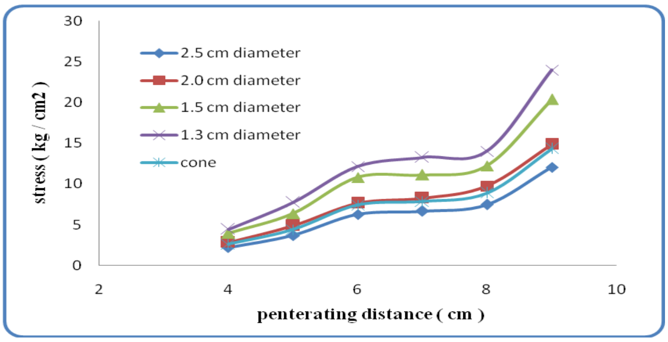

Fig (5): Correlation between normal stress and penetration distance at dry density 1.72 g/cm^3

Similar correlations were obtained for samples of other used densities. All Correlations above indicates that normal stress increases with increases of penetration distance.

The previously explained penetration/stress correlations were used to obtain a correlation between soil density and normal stress. Fig (6) Shows correlations between dry density and normal stress for different disk diameters for each penetration distance. These correlations may be used to estimate soil density directly by knowing penetration distance corresponding to used disk diameter and resulting normal stress.

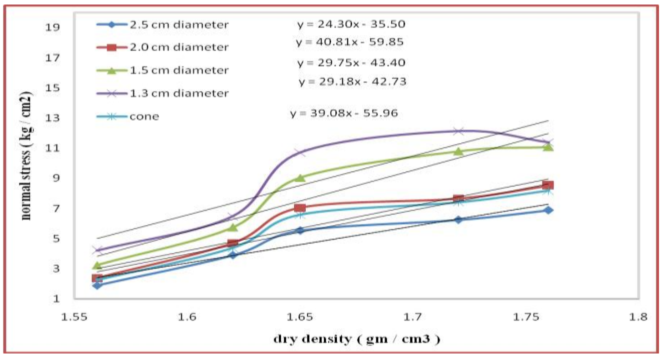

Fig (6) Correlation between normal stress and dry density at 6 cm penetration distance with different diameters of disk

3.2 Tests performed on fine sand

Table (2) shows penetration distance and normal stress regarding a density of 1.65 g/cm^3 for different disk diameters.By plotting the results of normal stress values with that of different penetration distance from 4 cm to 9 cm, a reliable correlation were obtained as shown in Fig (7). The values of coefficient of determination associated with the following best – fitted equation are:

$$\mathbf{y} = 0.720(x) - 1.465$$
$$R^2 = 0.956$$

Fig (7) indicates that normal stress increases with increases of penetration distance. The result is linear correlation with acceptable coefficient of determination.
Similar correlations were determined for disk diameters of 2.0, 1.5, 1.2, and cone, as shown in Fig (5).the linear correlations for theses disk diameters are:

2.0 cm diameter disk

$$\mathbf{y} = 0.867(x) - 1.509$$
$$R^2 = 0.969$$

1.5 cm diameter disk

$$\mathbf{y} = 1.089(x) - 1.709$$
$$R^2 = 0.965$$

1.3 cm diameter disk

$$\mathbf{y} = 1.383(x) - 2.708$$
$$R2 = 0.973$$

Cone

$$\mathbf{y} = 0.862(x) - 1.796$$
$$R^2 = 0.965$$

Table (2) Results of Penetrating Distance and Normal Stress at Dry Density 1.65 g\cm^3

Disk diameters	Penetrating distance (cm)	Normal stress (kg/cm2)		
		Trial 1	Trial 2	average
2.5 cm	9	5.305	5.41	5.3575
	8	4.08	3.88	3.98
	7	3.57	3.57	3.57
	6	3.265	3.165	3.215
	5	2.145	2.245	2.195
	4	1.325	1.53	1.4275
2.0 cm	9	6.69	6.69	6.69
	8	4.935	5.255	5.095
	7	4.46	4.775	4.6175
	6	4.14	4.14	4.14
	5	2.705	2.865	2.785
	4	1.75	2.23	1.99
1.5 cm	9	8.755	8.475	8.615
	8	6.495	7.06	6.7775
	7	5.93	5.645	5.7875
	6	5.645	5.365	5.505
	5	3.67	5.265	4.4675
	4	2.26	2.54	2.4
1.3 cm	9	10.525	10.525	10.525
	8	7.52	7.895	7.7075
	7	7.145	7.145	7.145
	6	6.39	6.39	6.39
	5	4.51	4.885	4.6975
	4	2.63	2.63	2.63
cone	9	6.295	6.41	6.3525
	8	4.845	4.63	4.7375
	7	4.24	4.22	4.23
	6	3.875	3.765	3.82
	5	2.545	2.645	2.595
	4	1.57	1.78	1.675

All Correlations above indicates that normal stress increases with increases of penetration distance.The previously explained penetration/stress correlations were also used to obtain a correlation between soil density and normal stress. Fig (4) Shows correlations between dry density and normal stress for different disk diameters for each penetration distance. These correlations may be used to estimate soil density directly by knowing penetration distance corresponding to used disk diameter and resulting normal stress.

3.3. Correlation between soil density and normal stresses

The previously explained penetration/stress correlations were used to obtain a correlation between soil density and normal stress. Fig (6) show correlations between dry density and normal stress for different disk diameters for each penetration distance. These correlations may be used to estimate soil density directly by knowing penetration distance corresponding to used disk diameter and resulting normal stress, but we'll show one penetration distance.

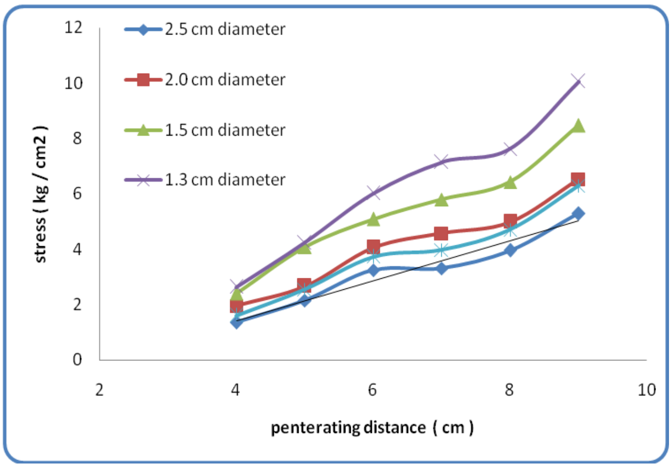

Fig (6): Correlation between normal stress and penetration distance with cone at dry density 1.65 g /cm^3

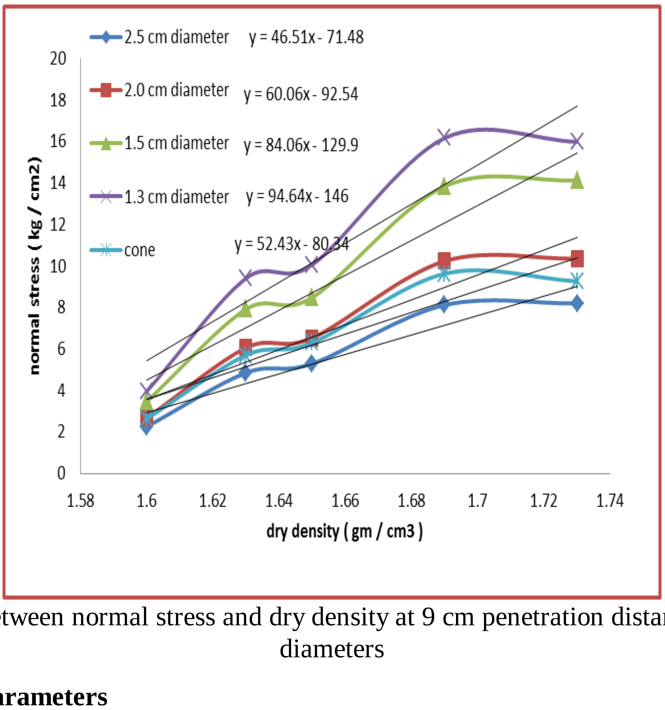

Fig (7): Correlation between normal stress and dry density at 9 cm penetration distance with different disk diameters

3.4 Estimation of soil parameters

Table (3) shows the result of laboratory tests which ware alleged to all densities used in research so as to estimate the internal friction angle and young's modulus. Been drawing a relationship between density and internal friction angle and it is to know the angle of friction of any density within existing densities in Figures (9) and (10) respectively.

Table (3): Results of Young's Modulus and Friction Angle for Sandy Soil

Dry density (gm/cm^3)	m_v	$E_{oed} = (1/m_v)$	E(kg/cm^2)	Φ(degrees)
1.79	0.001	612	510	40
1.75	0.001	598.8	499	39
1.73	0.001	574.8	479	38
1.71	0.001	525.6	438	37
1.69	0.002	489.6	408	36
1.68	0.002	465.6	388	36
1.67	0.002	452.4	377	35
1.65	0.002	404.4	337	34
1.63	0.003	355.2	296	33
1.62	0.003	342	285	32
1.6	0.003	294	245	32
1.56	0.004	256.8	214	31

$$E_{oed} = (1/m_v)$$

$$E_{oed} = E\,(1-\nu) / (1+\nu)\,(1-2\nu)$$

Where:

m_v = coefficient of volumetric compressibility.

E = young's modulus

ν = poisons ratio in this research assumed 0.25

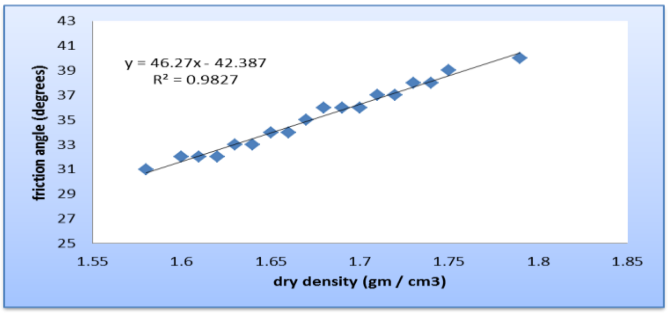

Fig (9): Correlation between friction angle and dry density for sandy soil

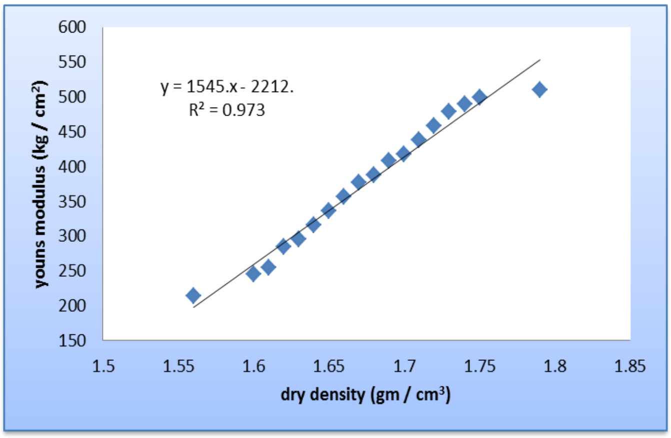

Fig (10): Correlation between dry density and Young's modulus for sandy soil

3.5. Analytical model

In analytical simulation stage, the commercial Finite element program Midas GTS(Geotechnical and Tunnel Engineering) is used for the finite element display is 2D model type using (50cm height and 50 cm diameter)and kgf/cm for unite system, a frictional contact interface by ground soil property and steel structure for disk used , Mohr coulomb used for type of model and elastic model type for steel disk, ground supports used for boundary condition .interface attribute for element type interface used and create pile ,finally solve analysis by running program, shown in Figures (11 to 16).

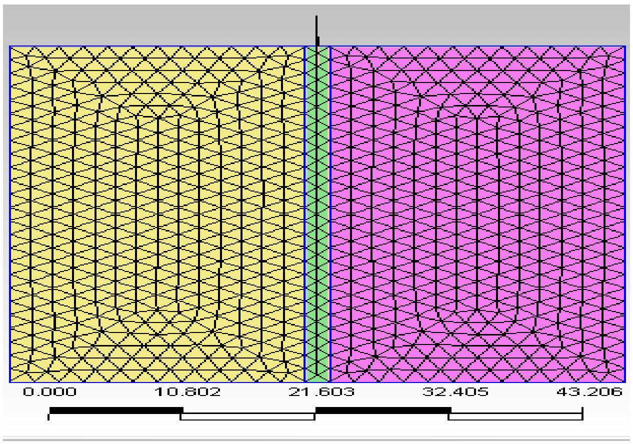

Fig (11): Deformation Mesh on Model Used

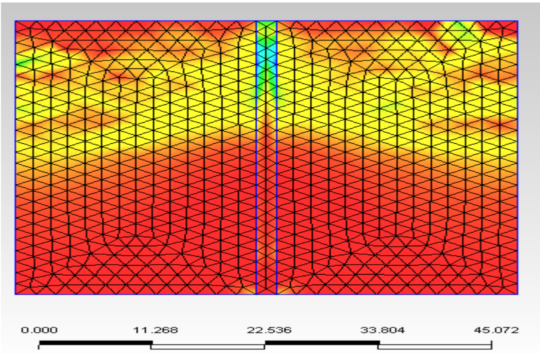

Fig (12): Deformation Field around the Disk Penetration

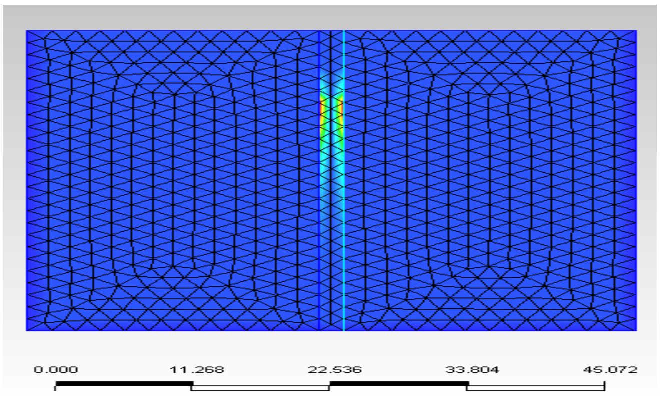

Fig (13): The Plastic Zone at Different Depths of Penetration

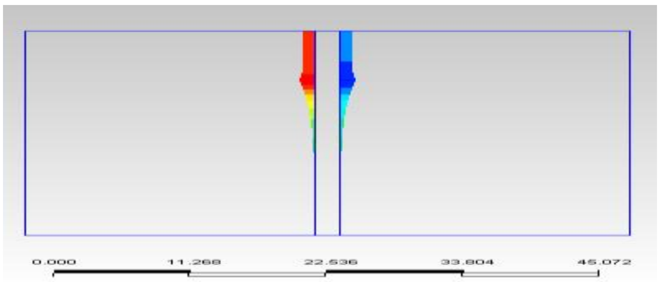

Fig (14): Displacement Soil around Penetration Disk

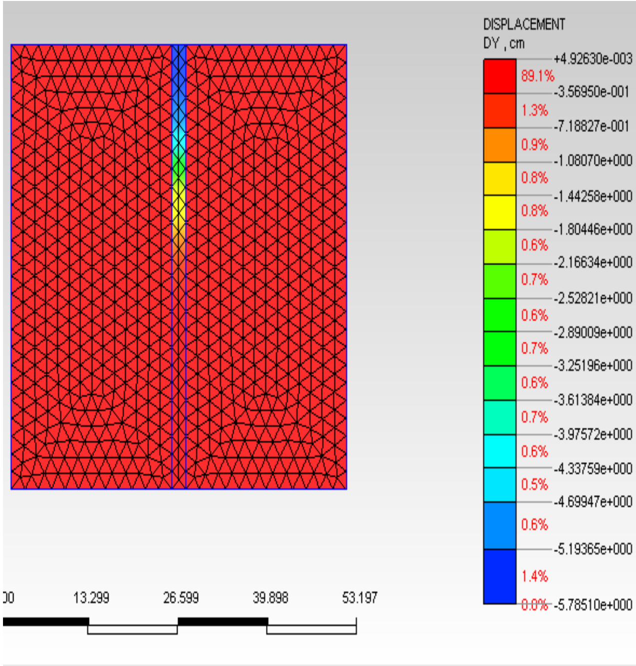

Fig (15): Correlation between Load and Penetration Distance (6cm) by Using 2.5 cm Diameter of Disk

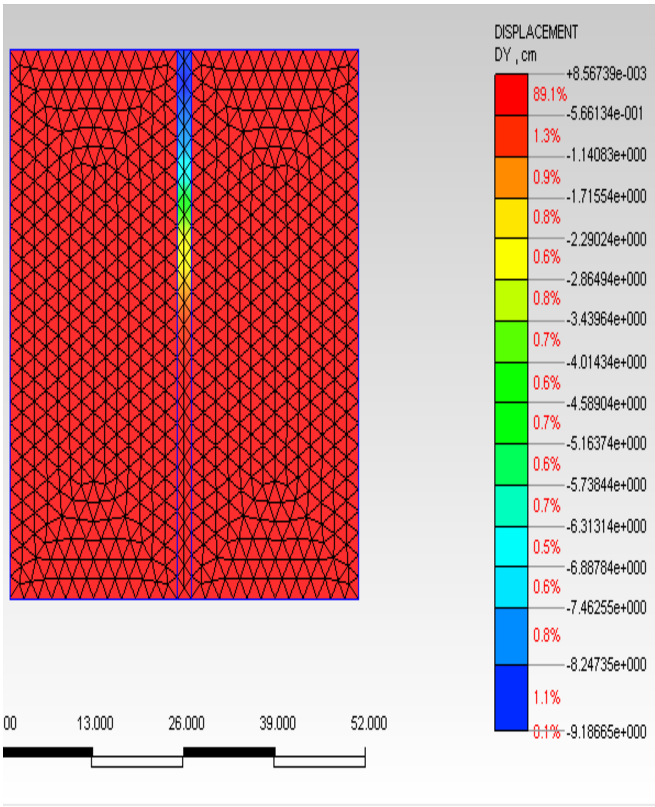

Fig (16): Correlation between Load and PenetrationDistance (9cm) by Using 2.5 cm Diameter of Disk

3.6. Comparison between the results of the MIDAS program and fiberglass tank results.

Shape (17) illustrates the difference between the results of finite element analysis system and the results of field and laboratory tests on the same model.

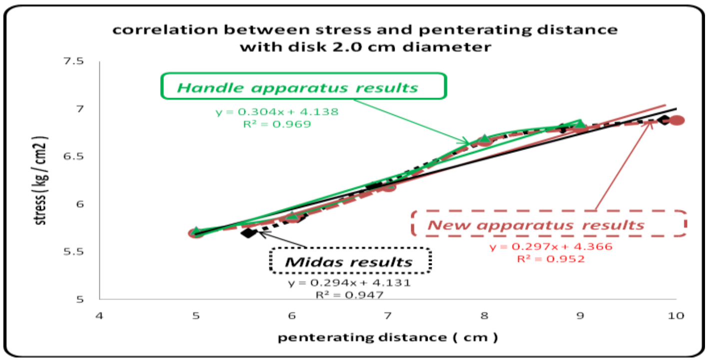

Fig (17): Correlation between normal stress and penetration distance with disk 2.0 cm diameter at dry density 1.71 gm / cm^3 at the circular fiberglass tank by Midas calculation program, fiberglass tank, and handle penetrometer results

IV. Conclusions

Based on laboratory and field tests results, the following conclusions can be drawn, for sandy soil with Correlation between normal stress and penetration distance with different rings (cm) diameter at different dry density (gm / cm^3) for coarse sand , Correlation between Normal Stress and Dry Density at different Penetration Distance with Different Diameters of Rings for coarse sand, Correlation between normal stress and penetration distance with different rings (cm) diameter at different dry density (gm / cm^3) for fine sand and Correlation between Normal Stress and Dry Density at different Penetration Distance with Different Diameters of Rings for fine sand

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