ARTICLE

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Settlement Improvement of Weak Soil of Natural Moisture Content by Using Geogrid Reinforcement Under Different Dynamic Load

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تحسين تجلس للترب الضعيفة ذات الرطوبة الطبيعية باستخدام البوليمرات تحت انواع مختلفة من الحمل الديناميكي

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ABSTRACT

One of new method to improve the bearing capacity of weak soil is by using geosynthetic reinforcement materials that has become more common in past 40 years for a number of applications to reduce the cost of maintences by increasing design life. This study concerned with the behavior of weak soil and the amount of settlement that happened when the soil exposed to different weight load with different number of blows . Field and laboratory tests done to calculate soil settlement. For experimental tests a model with dimension (150×75×75cm) has been manufactured, clayey silty sand soil in model exposed to different dynamic weight by using load with (4.5kg), load with (7.5kg) and load with (10kg). Each load strick the soil with 9 5 and 10) blows during an experiment for each dynamic load. 12 Laboretory experiments were conductedon 38 test points, 6 experiments done on soil without geogrid and 6 experiments done on soil with geogrid that included 19 test point for each case.

The experiments tests show that by increasing the weight load and increasing in number of blows settlement increase in both cases (without and with geogrid). The experiments show that by using geogrid the settlement decrease comparison with the amount of soil settlement without geogrid. By using geogrid and exposed to weight loads (4.5, 7.5 and 10kg.) with No. of blows = 5 the average percent in settlement decrease 1.2, 2.1,1.7%) and with No. of blows =10 for the same loads the average percent of settlement decrease (1.8, 2.7, 2.7%).

Keywords: Settlement; Bearing capacity; Dynamic load; Blows; soil; geogrid

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الخلاصة

مقدمة:

تهدف الدراسة الى تحديد تأثير ال (Geogrid reinforcement sheet) على تحسين الخواص الهندسية للتربة الضعيفة والتي تحتوي على محتوى مائي قدره 16% اثناء تعرضها الى احمال ديناميكية بأوزان مختلفة (4,5 و 7,5 و 10) كيلوغرام وبعدد ضربات (5 و 10) لكل حمل ديناميكي وبأماكن مختلفة على سطح التربة الموجودة في الموديل لايجاد قدرة تحمل التربة (bearing capacity) ومقدار التأثير على تقليل تجلس بالتربة عند تعرضها الى الاحمال المتحركة والاهتزازات الطبيعية او الحياتية.

بينت نتائج الدراسة بالنسبة للفقرة (أ) ان النسبة المئوية للفرق بين النسبة المئوية للتجلس بدون استخدام (Geogrid sheet) والنسبة المئوية عند استخدام (Geogrid sheet) بالنسبة للتربة ذات الرطوبة الطبيعية (16%) للاوزان 4,5 و 7,5 و 10 كيلوغرام بتسليط عدد ضربات 5 و 10 .

عند تحميل وزن ديناميكي (4,5) كان فرق النسبة المئوية (1,2 و 1,8) وفي وزن (7,5) كيلوغرام هي (2,1% و 2.7%) وفي وزن (10) كيلوغرام يكون (1,7% و 2,7%).

وتكون النتائج عن الفرق بين معدل النسبة المئوية لتجلس التربة بدون استخدام (Geogrid sheet) والنسبة المئوية عند استخدام (Geogrid sheet) للتربة النصف مشبعة هي (5,6% و 14,4% و (5,9% و 5,4%) و (4,1% و 6,7%) لنفس الاوزان وعدد الضربات على التوالي. اما بالنسبة للترب المشبعة تكون النتائج كالآتي: (12,8% و 22,9%) و (9,9% و 15,7%) و (16,6% و 5,7%) لنفس الاوزان وعدد الضربات على التوالي.

الكلمات المفتاحية: التجلس، قوة التحمل، الاحمال الديناميكية، ضربات، تربة.

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INTRODUCTION

One of the modern methods for improving weak soil and increasing its bearing capacity are using geosynthetic reinforcement. It has been used for the last 40 years, these methods allow to design a heavy complex constructions in any kind of soil that need high strong foundations, such as, railways, embankments, dams and underground structures.[1], Considering the population increase and technological development in project designs, the slope stability of dams effect by the increasing the load weight[2]. which necessitates the need to build on soft lands or developed new lands as industrial lands. It has become necessary to improve the engineering properties of soil to increase its bearing capacity [3].Soft soil is a weak soil that has unconfined compressive strength less than 50kN/m2, high compressibility and low permeability [4]. The settlement that occur due to compressive deformation of soil is the main reason of settlement [5]. It is the global problem, specially for weak soil because sometime it is difficult to change the location of facilities. Also, some countries create artificial island to increase their areas or to promote tourism which requires building facilities on these recycled soil. Settlement effected by many factors such as, soil dimensions and depth of soil foundation, soil density, applied dynamic load and soil grain size distribution [6]. There is less dangerous if the settlement happen immediately during foundation building [7]. But must be careful if the settlement happen in long time such as, weak soil or clayey soil. [8]. To calculate settlement value and stresses distribution, it is assumed that the soil must be homogeneous, isotropic and linearly elastic soil, [9]. There are many types of geosynthetic reinforcement such as, geotextial, geocell, geonet and geogrid, each one of them gesigned for a specific purpose, [10]. The two kinds of geogrid (uniaxial and biaxial) are the new material used to increasing the geotechnical properties and strong the bearing capacity of soil. The geogrids have high durability, strength and decrease the cost of improvement due to its easy and speed of use [11]. Previous studies close to the research are: Mhammad saham, (2015), focuses on the influence the abaility of geogrid to transmit the dynamic load to the constructions below the ground service. It was found that settlement decreased about 13-45% when using geogrid reinforcement in loose sand. Nader Ghafoori, (2016), study the effectiveness of biaxial and triaxial geogrid- reinforced flexible pavements to reduce roadway section was carried out. The results revealed that the both kinds of geogrid reduce the surface rutting and vertical stresses in sub- grade interface. Zahraa et. al, (2021), found that the geogrid reinforcement supported the shllow foundation of Nasseriyh soil, which is weak soil, by reducing the settlement and increasing the bearing capacity of such weak soil. The goals of the research are to calculate the settlement in soft soil when exposed to many kinds of dymamic loads with number of blows (5 and 10) during without using (geogrid) or with using (geogrid) in the soil and observed the settlement in the boundary points of soil.

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1.1 Study Area position

The experimental weak soil taken from Babylon governorate (Kifel District), with 32°13' 04"*N* and 44°30' 01*E* coordinates. Near imam Zaid Ibn Ali as shown in figure 1.

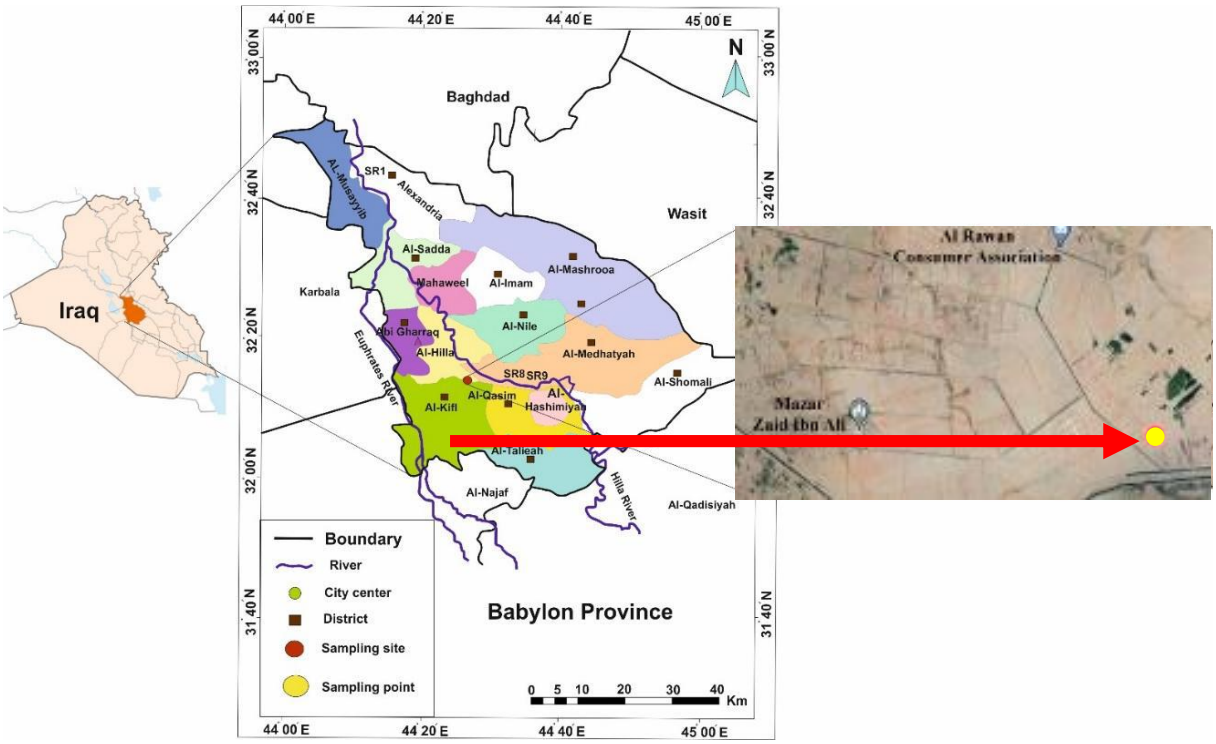

Figure (1) Experimental soil position near Imam Zaid Ibn Ali

1.2 Geology of the Study Area :

The area of the study consist of clastic materials, it contain of sand, sult, and clay[12]. Which is quaternary deposit. The area related to Palestocene and Holosene period, [13] it called (Mesopotamian zone) within the geosyncline basin between zagros mountains in the north, east and the stable Arabian plate in the south,[14].

1.3 Climate:

The climate is one of the most important components of the natural environment and has significant impact on the stiffness of the soil layers. The study area represent within arid or semi ared zone of Iraq which is desert climate, that is very hot in summer and cold in winter and with little rain, [15]. Study of climate of the study area to know the moisture content of the soil during the seasons. As Shown in Figure (2) , Figure (3).

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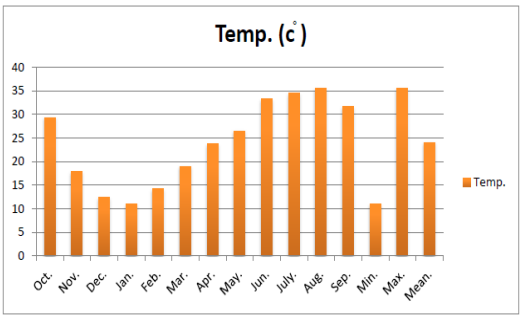

Figure (2) Change in The Average Temperature During the studied period (1980/2020)

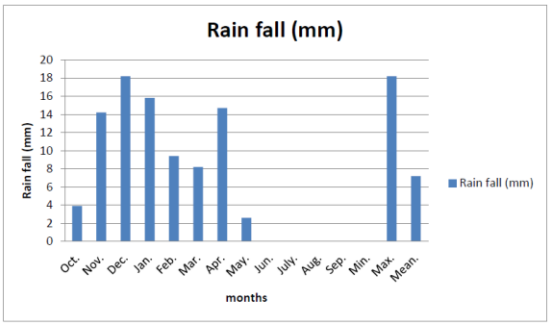

Figure (3), Change Average rainfall during the period (1980-2020).

2. Methodology

This research included a series of steps:

2.1 Model Manufacturing :

The model design which is a container with (150×75×75 cm) dimensions, also has two slides frames. The model manufactured from high quality iron material with thickness of (4mm), It is suitable for the exact purposes of the research.Figure 4 .

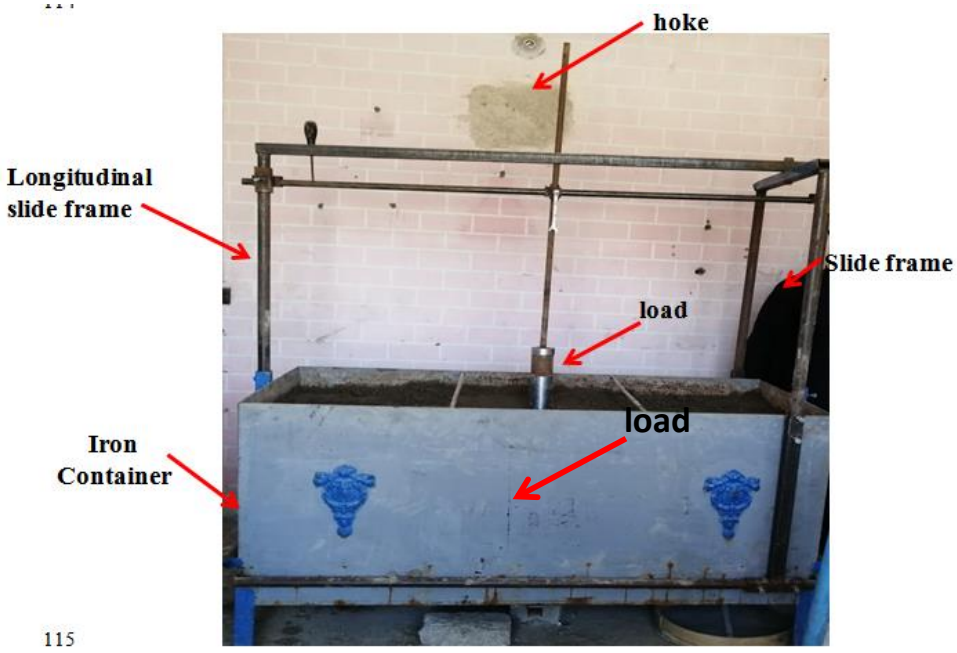

Figure (4) Model design

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2.2 Office information stage

Involves collection reports, researchs, scientific papers about the use of geogrid reinforcement to improve the strength and stabililty of weak soil, esspacially under dynamic loads.

2.3 Field work stage

Many undesterbed samples are taken by Shulby tube from different places from Babylon governoret to find weak soil site depends on the soil investigation reports which is located in National center of research and construction labortories .

Figure (5) shulby sample for undisturbed soil

2.4 Soil geotechnical tests :

1- soil physical properties include :

Grain size distribution (ASTM D422, 2007) [16], Atterberg limil (ASTM D4318, 2010) [17]. in two branches, liquid limit and plasticity index. Specific gravity (ASTM D 854, 2005) [18]. and dry and wet density (ASTM D 4253, 2000) [19].

2- Engineering properties of soil :

Shear strength (ASTM D 3080- 2011) [20]. California bearing ratio (ASTM D 1883, 2004) [21]. Uniaxial compressive strength (ASTM 2266, 2006) [22]. Permeability test (ASTM D 2166, 2006) [23] and consolidation test (ASTM D2435, 2004) [24].

3- chemical analysis :

Carbonate, chlorid, gypsum, organic material, total soluble salts and sulphat. All the tests carried by "British standard institution" [25].

2.5 Location of the tests in the model

The soil in the container is spread in three layers, the bottom and middle layers have 20cm. thickness and the above layer has 30cm. thick, each layer compacted slightly, the above surface of the soil divided into (9) points of equal distances. There is a symbol for each with dynamic load (4.5kg) and with number of blows (5 and 10) strick the position points of soil. As shown in Fig (6).

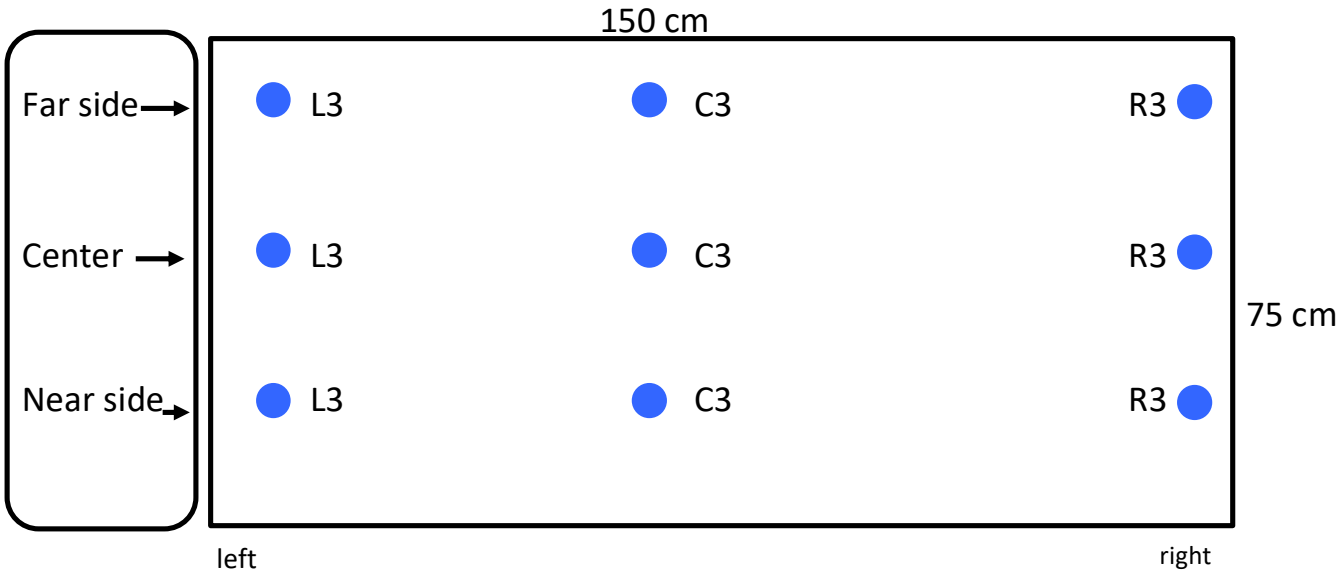

Figure (6) Locations of dropping points

3. Results

3.1 laboratory work stage

1. Soil Geotechnical tests index and basic properties: (raid, 2000)

Table (1) Soil Properties results

Grain size distribution: sieve analysis	coarse material	Fine material
	59%	41
Atterberg limit tests	L.L%	29
	P.L %	23
	P.I %	6
	M.C%	16%
S.G %	2.71	
ρ_d %	1.85 g/cm3	
ρ_{wet} %	1.937 g/cm3	
USCS	SM	

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2. Engineering Tests:

Table (2) Soil strength results

shear strength	C		Ø
	12 KN/m^2		25 degree
C.B.R	C.B.R	mc	P_{dmax}
	4.3%	9%	1.850 g/cm^3
UCS	47.8 KN/m^2		
Permeability	1×10(-6) K(cm/sec)		
Consolidation	Pc	Cc	Cr
	115KN/m^2	0.187	0.044

3. Test Chemical analysis:-

Table (3) Chemical Tests

SO_3 %	0.229
$CaCO_3$%	48
CL %	0.7
Soluble salt %	0.32
Organic material	0.23

3.2 Experiments results of soil with (16%) moisture content :

the experiments passed through three stages

1- with dynamic load (4.5kg) and with number of blows (5 and 10) strick the position points of soil.

2- with dynamic load (7.5kg) and with number of blows (5 and 10) strick the position points of soil.

3- with dynamic load (7.5kg) and with number of blows (5 and 10) strick the position points of soil.

The experiments done on the natural moisture content soil (16%) without using geogrid as reinforcement.

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3.3 Experiments results without using deogrid:

Table (4) Average percentage settlement of experiments results for test without using geogrid

Location of points in model	Settlement %					
	Load = 4.5 kg		Load = 7.5 kg		Load = 10 kg	
	Blows = 5	Blows = 10	Blows = 5	Blows = 10	Blows = 5	Blows = 10
Right side :						
R1	4.1	6.9	5.7	9.3	8.6	12.1
R2	3	6	5.7	9.4	8.7	11.9
R3	3.7	6.1	5.7	9.3	8.4	11.7
Center side :						
C1	3.9	6.1	5.7	9.1	9.7	12
C2	3.4	6.1	6.3	9.6	9.1	12.7
C3	4.3	6.6	6.4	9.9	9.4	12.3
Left side :						
L1	5.1	6.6	5.7	8.9	7.9	12
L2	4.7	6	6.4	9	9	12.4
L3	5.4	7	6.4	9	9.1	12.7

From the test results table (4), By using load (4.5kg) and no. of blows 5, the max. settlement happened at L3= 5.4%. By using load (7.5kg) and 5 blows, the max. settlement happened at C3, L2 and L3= 6.4% and by using load (10kg), no. of blows 5, the max. settlement happened at C1= 9.7%.

In another hand, By using load (4.5kg) and no. of blows 10, the max. settlement happened at L3= 7%. By using load (7.5kg) and 10 blows, the max. settlement happened at C3, L2 and L3= 9.6% and by using load (10kg), no. of blows 10, the max. settlement happened at L3 and C2= 12.7%.

3.4 Experiments by using geogrid:

3.4.1 Position of geogrid

The position of geogrid change tension stress absorption of the reinforcement, someone thought that geodrid should be placed near the load. Other have found that should be near the bottom or at mid height. (ASTM D4439, 2004) [26].

Giroud et al., (1995) consider that geogrids could improve the subgrig weak soil by 3 mechanisms [27] :-

The geodrid ribs increase the strength and bearing capacity of weak soil, redaction in stress due to the influence of tensional membrane and for weak soil the geogrid must put in suitable place

within the soil depending on its specifications and the soil properties. The biaxial geogrid used in this research and put at 10cm. below soil surface in the model. Soil height model is 70cm.as shown in Figure (6). Postion of geogrid =10cm under the soil surface in the model.

Figure (7) Geogrid used in the study.

3.4.2 Tests result by using geogrid:

Table (5) Average percentage settlement of experiments results for test with using geogrid

Location of points in model	Settlement %					
	Load = 4.5 kg		Load = 7.5 kg		Load = 10 kg	
	Blows = 5	Blows = 10	Blows = 5	Blows = 10	Blows = 5	Blows = 10
Right side :						
R1	3	5.3	3.7	6.4	5.9	9.4
R2	2.9	4.3	3	6.6	5.6	9.7
R3	3.1	4.7	3.3	6.4	6	9.1
Center side :						
C1	2.9	4.4	3.7	6.9	8.6	10.1
C2	2.9	4.3	3.4	6.7	7.6	8.6-9.6
C3	3.3	5	3.9	7	9	10.4
Left side :						
L1	2.7	4.9	4.9	6.7	7.3	10.6
L2	3	4.1	4	6	6.7	9.7
L3	3.1	4.4	5	6.4	8.4	10.1

From the test results table (5), By using load (4.5kg) and no. of blows 5, the max. settlement happened at C3= 3.3%. By using load (7.5kg) and 5 blows, the max. settlement happened at L1 and C3 = 5% and by using load (10kg), no. of blows 5, the max. settlement happened at L1= 9%.

In another hand, By using load (4.5kg) and no. of blows 10, the max. settlement happened at R1= 5.3%. By using load (7.5kg) and 10 blows, the max. settlement happened at C1 and C3= 7% and by using load (10kg), no. of blows 10, the max. settlement happened at L1= 10.6%.

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3.5 comparisim between the Soil without and with Geogrid for different locations

Fig from (8) to Figure (15) show the effect of using geogrid on settlement of soil by decreacing soil subsudince. Geosynthetic reinforcement materials have the high ability to improve weak soil in a safe side therefor, the engineers can design foundations and buildings for the most heaver and beautiful structures on such soil.

3.5.1 compression between soil tests without and with Grid with different load and No. of blows=5

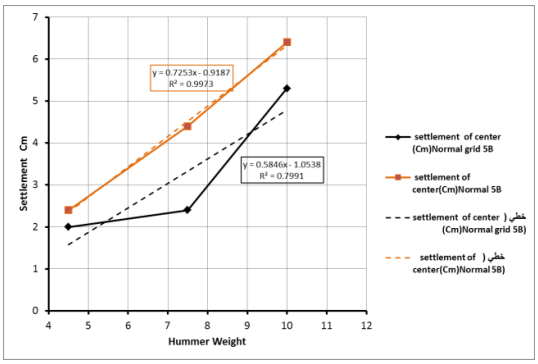

Figure (8) (Center) Center side point

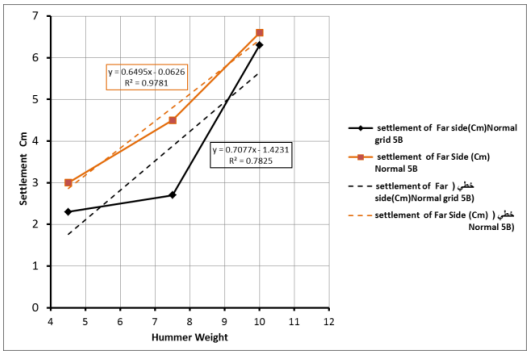

Figure (9) (Far) Center side point

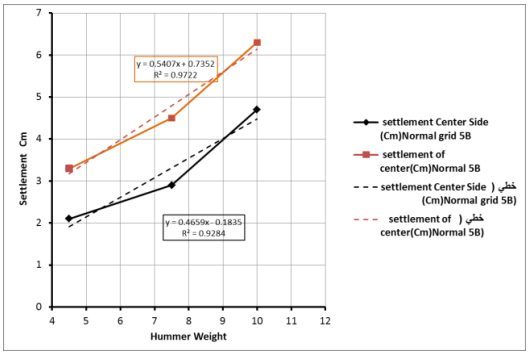

Figure (10) (Center) Left side point

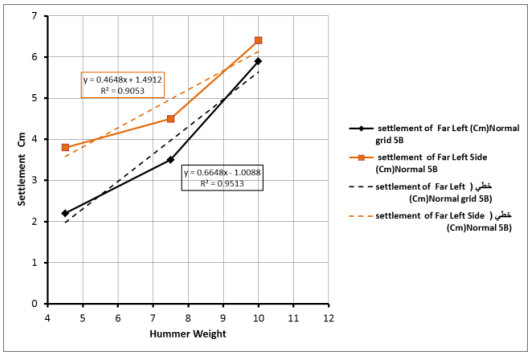

Figure (11) (Far) Left side point

3.5.2 compression between soil tests without and with Grid with different load and No. of blows=10

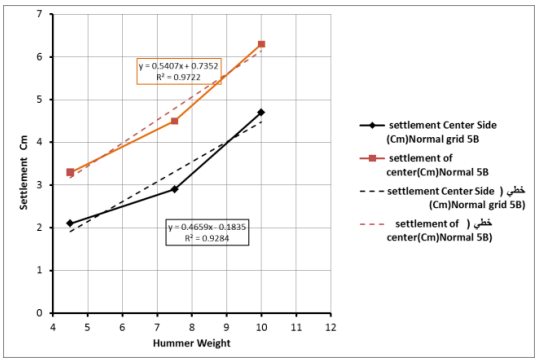

Figure (12) (Center) Center side point

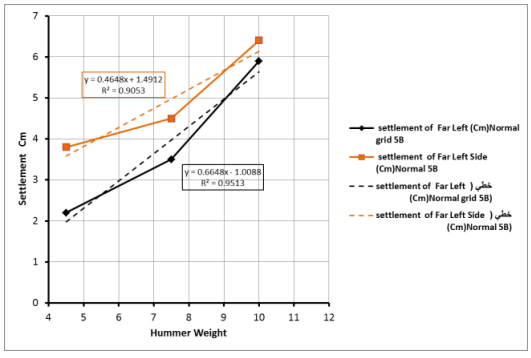

Figure (13) (Far) Center side point

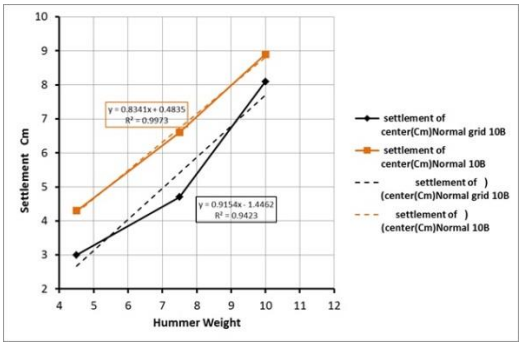

Figure (14) (Center) Left side point

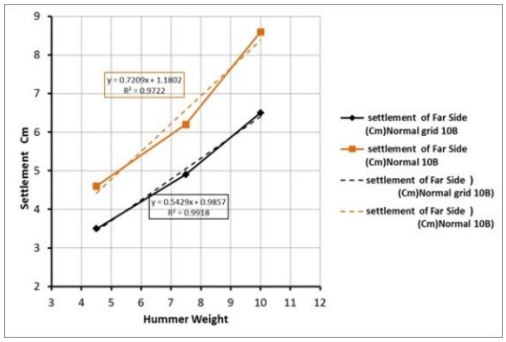

Figure (15) (Far) Left side point

From fig (8) to fig (15) show that the soil settlement increase by increasing the weight load and increasing the number of blows in both cases without and with geogrid. All figers show that there is acleare difference between curves without and with geogrid. The soil has good improvrmrnt by using geogrid as a geosyntthetic reinforcement.

The experiments tests show that by increasing the weight load and increasing in number of blows settlement increase in both cases (without and with geogrid). The experiments show that by using geogrid the settlement decrease comparison with the amount of soil settlement without geogrid. By using geogrid and imposed weight loads (4.5, 7.5 and 10kg.) with No. of blows = 5 the average amount in settlement decrease 0.8cm., 1.5cm.,1.3cm.) and with No. of blows =10 for the same loads the average amount of settlement decrease (1.4cm., 1.8cm., 1.8cm.). The geogrid make axcellent improvement in weak soil and increasing in bearing capacity .

4. Conclusion

The improvement in natural moisture content soil by using geogrid show that:

The settlement decline by 1.2% with No. of blows (5) and decline by 1.8% with No. of blows (10) when load (4.5kg) exposed to the weak soil. The settlement decline by 2.1% with No. of blows (5) and decline by 2.7% with (10) blows when soil exposed to load (7.5kg). The settlement decline by 1.2% with No. of blows (5) and decline by 0.9% with (10) blows when soil exposed to load (10kg)

1. The settlement effected by the weight of dynamic loads, if the loads is light the settlement be shallow, vice versa, the settlement be deep if the load is heavy.
2. The settlement influence by the number of blows, so that with increasing No. of blows the settlement be deeper.
3. The study shows that placing the geogrid at a depth of 10 cm under the soil surface has a good effect in improving the soil when exposed to dynamic loads of different weights and different blows.

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4. It observed that the points on both sides of the soil in the model are generally has higher settlement because of the manual compaction and the edge of the geogrid are below the point.

Conflict of interests.

There are non-conflicts of interest.

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