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Effect of Compaction on Strength of Soil-Pozzlana Mixture

Assistant Lecture
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Abstract

Soil stabilization is the alteration of state of soil to acceptable engineering condition to improve its engineering performance. This is done by mechanical, chemical, thermal, and electrical methods[(1)]. The main engineering properties of soil are strength, permeability, and consolidation. Several previous works were made to investigate the effect of compaction on strength of soil-cement mixture, soil-lime mixture, soil fly ash mixture,….etc. In this paper, the effect of two methods of compaction (impact and static) on unconfined compressive strength of soil-pozzlana mixture was investigated.

Key words: Soil Stabilization, Soil-Pozzlana mixtures, Soil compaction.

تأثير قوة الانضغاط على مقاومة مزيج التربه ـ بوزولانا

الخلاصه :-

من الصعوبات التي تواجه المهندس المدني اثناء التنفيذ هي عدم صلاحية التربه لتحمل المنشأ المقام عليها , وذلك بسبب قصور في الخواص الهندسيه للتربه. ان تثبيت التربه هو احد الحلول التي ان تستخدم لحل تلك المشكله. ويمكننا تعريف تثبيت التربه بأنه تغيير في حالة التربه لغرض تحسين خواصها الهندسيه (المقاومه , النفاذيه , والهطول). هناك عدة طرق لتثبيت التربه منها الطرق الميكانيكيه او الكيمياويه او الحراريه او الكهربائيه. هناك عدة دراسات سابقه عملت لبيان تأثير قوة الانضغاط على مقاومة مزيج التربه ـ سمنت , التربه ـ نوره .....الخ.

في هذا البحث تمت دراسة تأثير طريقتين من طرق قوة الانضغاط (الساكنه والمتحركه) على مزيج التربه ـ بوزولانا والتي لم تتم دراستها سابقا. لقد تم استخدام بوزولانا طبيعيه من مقلع حمرين لهذا الغرض. كما اخذت ثلاث عينات من الترب العراقيه من مختلف المواقع لتشمل جميع انواع الترب العراقيه.

لقد بينت الدراسه بأن المقاومة للتربه تزداد دائما مع زيادة نسبة محتوى البوزولانا في التربه عندما تضغط في محتوى مثالي. كما بينت الدراسه بأن تأثير طريقة الانضغاط يكون اكثر وضوحا في حالة التربه الرطبه عما هي عليه في التربه الجافه. وبينت الدراسه ايضا بأن اكتساب المقاومه للتربه الرمليه الطينيه (الموصل) اكثر من التربه الرمليه الطينيه (ديالى) والتربه الرمليه (البصره).

مفاتيح الكلمات: تثبيت التربه , مزيج تربه- بوزولانا, انضغاط التربه.

1. Introduction

Compaction is a mechanical process by which air voids are reduced to make soil denser [1]. It is one of the earliest methods used to stabilize soils to improve their engineering properties. Impact, kneading, static, and vibratory are common compaction methods used to prepare soil specimens in laboratory.

The effect of method of compaction on strength of compacted clay has been investigated by Seed and Chan[2]. They showed that the method of compaction has little effect on the strength of samples compacted dry of optimum with kneading compaction yielding higher strengths than impact compaction. For samples compacted wet of optimum, the influence of method of compaction is considerable at about 5% strain[2]. When wet of optimum, the strength of similar density and moisture content samples increases in the following order of compaction methods: kneading, impact, vibratory, and static.

It is well known that the more parallel or dispersed the clay structure, the lower its strength[3,4]. In other means, the degree of clay particle orientation and/or the pore-water pressure decrease in the same order so that the more flocculated structure gives the highest strength[2,3,4].

El-Rawi, Haliburton, and Ganes[5] showed that method of compaction influence strength of soil-cement mixture. They concluded that, for silt-cement mixture, the specimens prepared by kneading compaction gave higher strength than those prepared by impact compaction optimum and dry of optimum water content. The opposite relation showed for wet of optimum. They[5] reported also that, for clay-cement mixtures, the specimens prepared by kneading compaction showed higher strengths at 7 days than those by impact compaction. The opposite relation was found at 28 days. For fine grained soil-cement mixtures, the gain in strength between 7 and 28 days was higher for the specimens prepared by impact compaction. The effect of method of compaction appears to be two-fold, namely, influencing both particle orientation and rate of cement hydration[5].

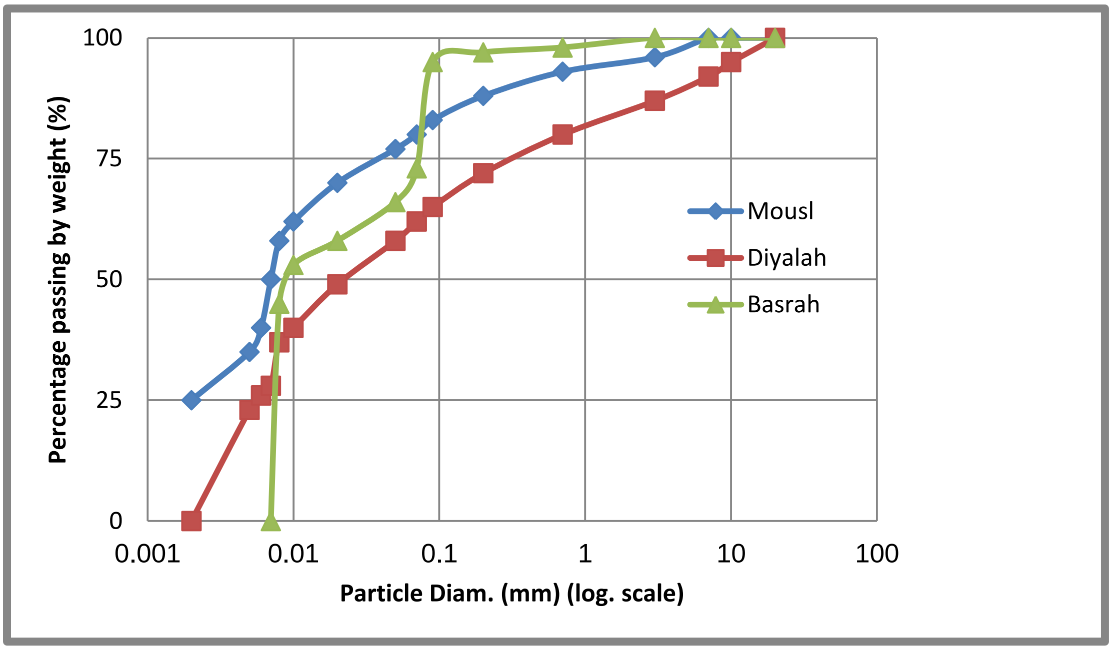
2. Materials used

2.1 soils

Three soils from different locations in Iraq were used. They are silt clay from Mosul, silt clayey sand from Diyalah, a silt soil from Basrah. Figure (1) shows the grain size distribution of the soils used. The properties of the above three soils used are given in table (1).

Table (1) soil properties

Sample no.	1	2	3
Sample location	Mousl	Diyalah	Basrah
Specific gravity	2.68	2.70	2.71
Liquid limit %	37	44	49
Plastic limit %	20	22	26
Dry density(kg/m^3)	1710	1630	1540
Opt. water content %	17	19	22
Soil description	Silt clay	Silt clayey sand	silt



Clay	Silt	Sand			Gravel
		Fine	Med.	Coa.	

Figure (1) grain size distribution

2.2 pozzlana

One source of natural pozzlana that passes sieve No. 200 was used throughout this investigation. The natural pozzlana used was obtained from Hammrin location. The chemical analysis of the natural pozzlana used is given in table (2).

Table (2) chemical analysis of the pozzlana

Oxide	% by weight
Silica (Sio_2)	51.84
Alumina (Al_2o_3)	13.56
Ferric oxide (Fe_2o_3)	2.52
Lime (Cao)	12.46
Magnesia (Mgo)	3.80
Sulphiric anhydride (So_3)	0.10
Loss on ignition	13.0
Alkalis and other losses	2.62
Total	99.90

3- Specimen preparation

The required pozzlana content as expressed by percentage of dry soil weight was hand mixed with the measured amount of air dried soil. The soil was pulverized to pass U.S. sieve No. 10. The water required to give the desired dry density and water content was added and the mixture was hand mixed again. Two methods of compaction were used in this investigation:-

1- Impact compaction: - a drop hammer of (0.536 kg) with a face diameter of (2 cm) and a drop height of (15 cm) was manufactured for use as a scale model of the standard Procter hammer to produce the required samples. The specimens produced were (4 cm) diameter by (8 cm) high. The soil-pozzlana mixture was compacted in three layers. 25 blows per layer were required by the model hammer to produce equivalent compaction to standard Procter.

2- Static compaction: - specimens were prepared using the same mold as that of impact compaction. The soil-pozzlana mixture was compacted in three layers. Each layer was compressed by the compression machine using a plunger to the pressure required to give a density equal to that obtained by impact compaction. The identical samples were produced to have the same overall density and molding water content(6).

4- Tests

4-1 Properties of soils

4-1-1 Specific gravity

- The specific gravity of soils was tested according to (ASTM-D854-58).

4-1-2 Atterberg limits

- These tests were carried out according to (ASTM-D423-66) AND (ASTM-D424-59).

4-1-3 Dry density

- The water content-density relationship was achieved by the standard Procter test which is specified by (ASTM-D689-70). The model specimens were carried out also for the three soils investigated. The compaction properties are illustrated in figure (2).

4-2 Unconfined compression tests:-

At the specified curing age, the wax and cellophane paper were removed, and the unconfined compression test was carried out according to (ASTM-D2166-66). The unconfined compression tests were carried out at an arbitrary rate of (0.05 in/min.) in a strain controlled machine.

For all tests investigated in this work, the averages of three samples were used for each value reported.

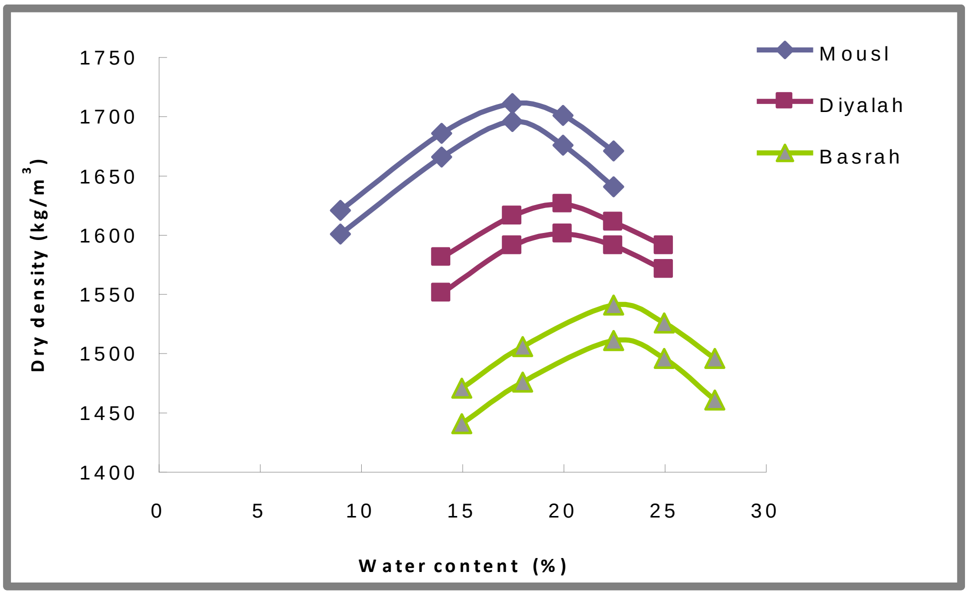


Figure (2) compaction properties

5- Results

5-1 Effect of pozzlana content on unconfined compressive strength

a- For the soils investigated, the unconfined compressive strength increased with the increasing in pozzlana content for the specimens compacted at optimum water content cured for 28 days at 32^{o}c. Figure (3) indicated these relations. This results agrees with the previous findings on soil-cement mixtures(2,7).

b- The gain in strength with the increasing in pozzlana content is higher for Mousl soil than for Diyalah soil. And for Diyalah soil is higher than for Basrah soil. This is because that the soils from Mousl and Diyalah are silt clay and silt clayey sand respectively, and these are more flocculent(8) than Basrah soil which is silt soil.

c- At all pozzlana contents investigated, specimens prepared by static compaction showed higher strengths than identical specimens prepared by impact compaction. This could be explained in terms of soil structure as static compaction produces less disturbance and hence lower degree of particle orientation (more flocculent structure) than impact compaction resulting in higher strength.

d- Figure (3) indicates that as pozzlana content increases, the difference in unconfined compressive strength between specimens prepared by static and impact compaction slightly increases. This was particularly true for the silt clay from Mousl. It is known that the addition of pozzlana to a plastic soil tends to make it more flocculent(8). Therefore, the method of compaction influences soil structure particularly when the pozzlana content is higher than optimum.

5-2 Effect of molding water content

The effects of method of compaction on soil-pozzlana mixtures when molded at different water contents are shown in figures (4, 5, and 6). From these figures the following results are obtained:-

a- The strength-water content relations followed patterns similar to the density-water content curves. The strength increased to a maximum and then decreased.

b- Maximum strength occurs at the optimum water content for the mixture.

c- Static compaction produced higher strength than identical specimens prepared by impact compaction at different molding water contents and for all soils investigated. However as illustrated in figure (4), for the silt clay from Mousl, the effect of the compaction method is more pronounced for wet of optimum compared with dry of optimum water content. This is because with dry of optimum the degree of particle orientation is small and the effect of method of compaction is not as marked as it is wet of optimum. The higher strength of specimens prepared wet of optimum by static compaction compared with those prepared by impact is therefore due to two reasons. First, static compaction produced less particle orientation, and second the addition of pozzlana produces further flocculation of the soil, the degree of which could have been influenced by method of compaction.

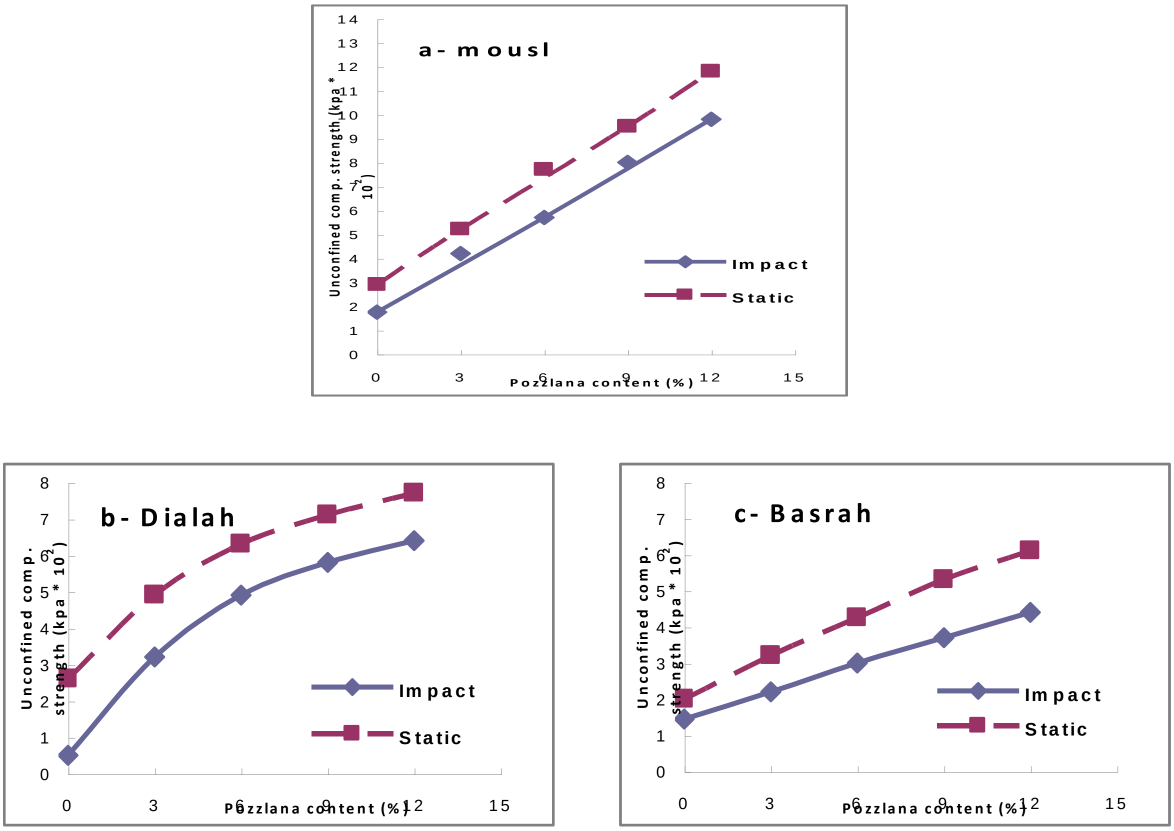


Figure (3) Effect of compaction and pozzlana content on strength of soil-pozzlana mixtures molded at optimum water content cured 28 days at 32°c.

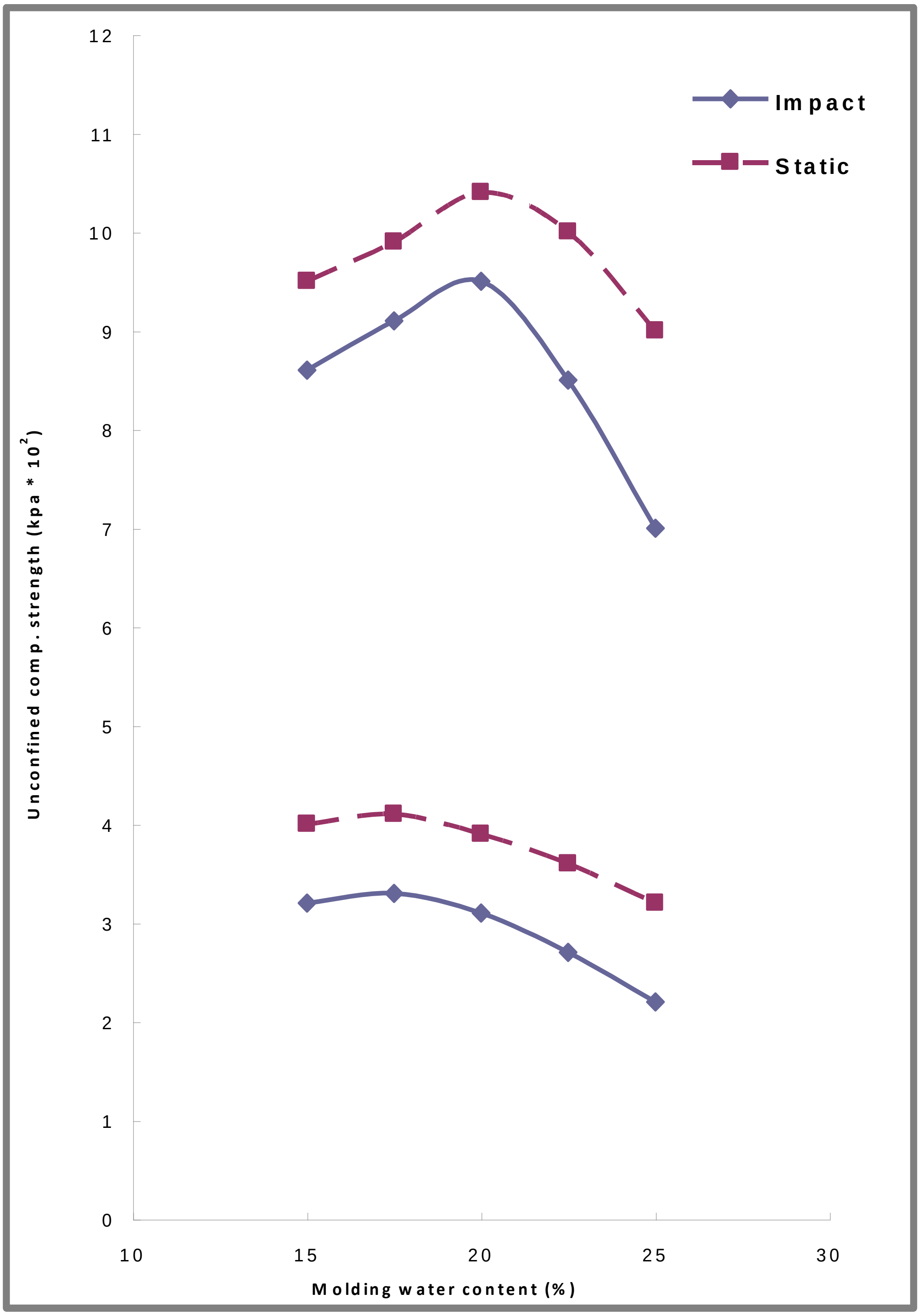


Figure (4) Effect of method of compaction and molding water Content on strength of soil-pozzlana mixtures from Mousl. (28 days at 32ºc).

d- The soils investigated behaved differently at different molding water contents. While with soils from Mousl and Diyalah, a reasonable amount of pozzlana could be used for stabilization, the results indicate that soil from Basrah is difficult to stabilize with pozzlana alone. This might be due to the presence of salts materials in Basrah soil, which render the specimens to be very weak as shown in figure (6).

e- Figure (7) shows the relationship between unconfined compressive strength and curing ages for the three soils investigated compacted at optimum water content. The unconfined compressive strength increased with the increasing in curing ages for all soils used as shown in figure (7). The gain in strength between 7 and 28 days was higher for soil from Mousl than other soils used in this work. Static compaction gave higher strength than impact compaction for all soils investigated. This effect is more pronounced for soil from Mousl than other soils also.

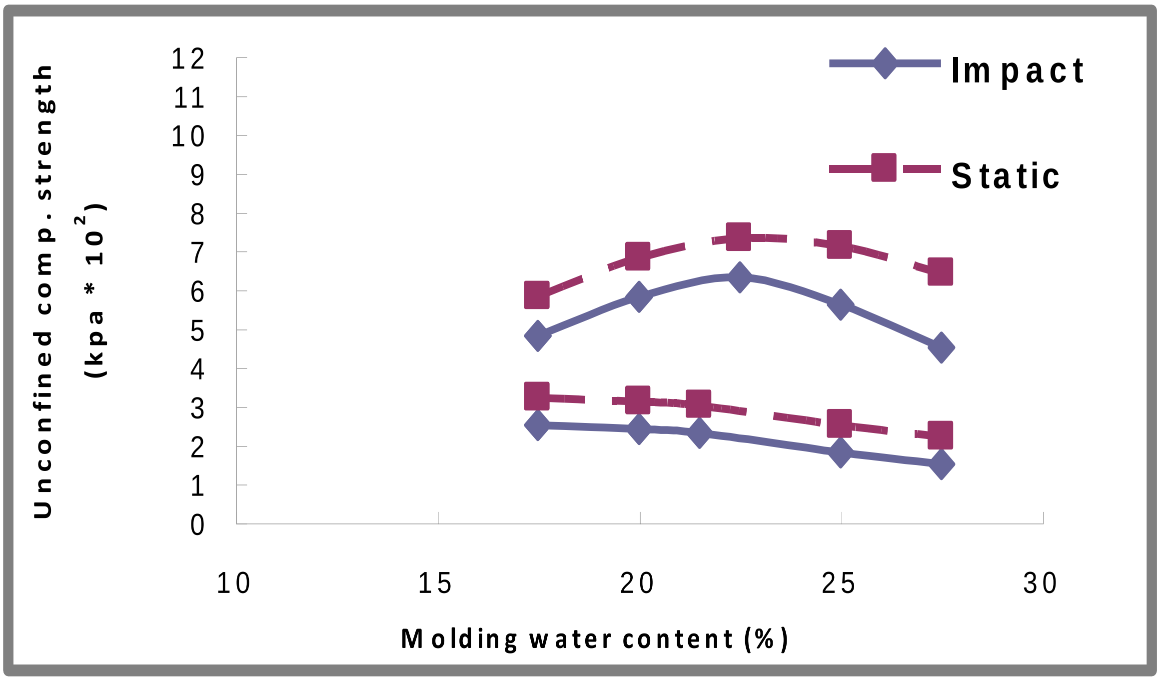


Figure (5) Effect of method of compaction and molding water Content on strength of soil-pozzlana mixtures from Diyalah. (28 days at 32°c).

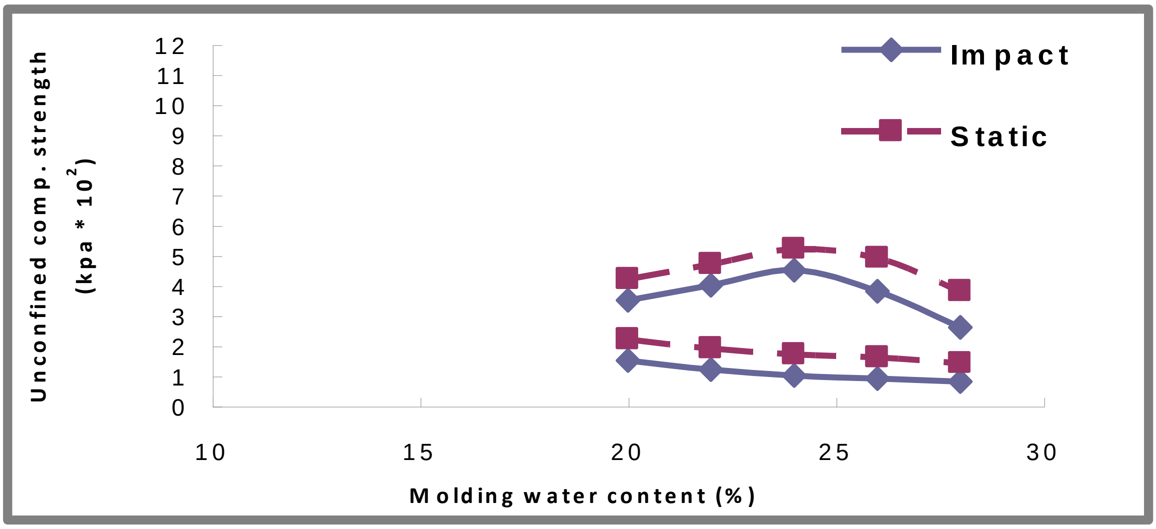


Figure (6) Effect of method of compaction and molding water Content on strength of soil-pozzlana mixtures from Basrah. (28 days at 32°c).

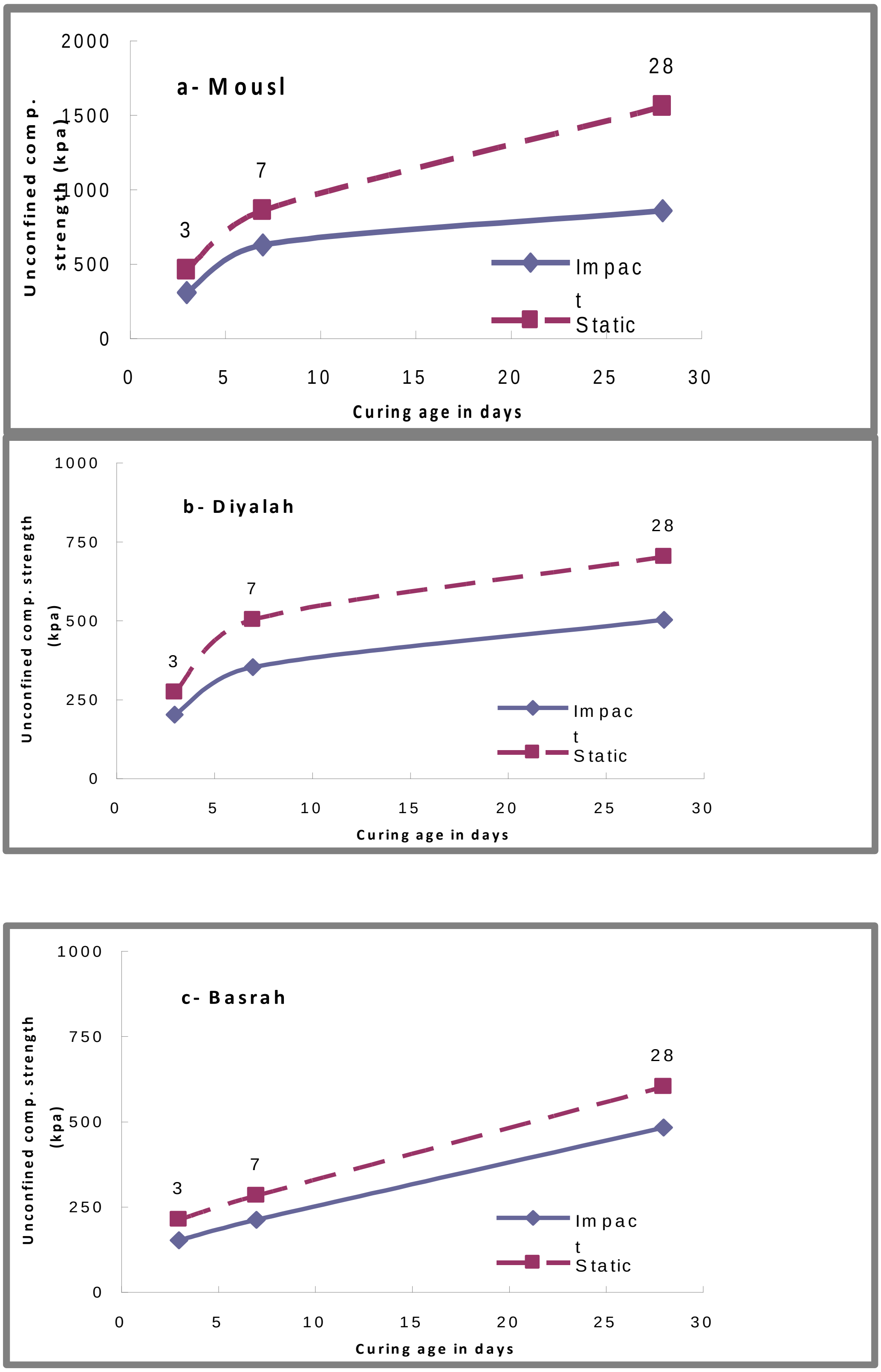


Figure (7) Effect of curing age on unconfined compressive Strength of soil-pozzlana mixtures.

6- Conclusions

From the above results the following conclusions may be drawn, limited to the soils and test conditions investigated

1- The strength of soil was always increased with the increasing in pozzlana content compacted at optimum water content.

2- The method of compaction influences strength of soil-pozzlana mixtures and the compaction method that results in less soil particle disturbance (static compaction) produces higher strength.

3- The effect of method of compaction on strength is more pronounced wet of optimum than dry of optimum water content.

4- The gain in strength for silt clayey soil from Mousl is more pronounced than silt clayey sandy soil from Diyalah and silt soil from Basrah.

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