Laboratory Study of an Injected Soil with Chemical Clayey Grout

By

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Abstract

It is generally accepted that only chemical grouts or solutions are available to penetrate and fill narrow joints or soils with very small pore size. Over the last 30 years a few hundred different compounds have been used for this purpose. Such materials show a wide spectrum of properties. Clayey grouts are among the compounds that are commonly used in chemical grouting because of their high strength and durability against mechanical or physical erosion. In this research work, a new filler of clayey grout is introduced consist of clay additive by two dispersing agent (sodium phosphate) and a passive material necessary for colouring the grout so it can be distinguish from the surrounding soil).

In many samples, the filler has been injected with soil which required to improve, and many factors take into consideration.

Results of lab tests which are employed here indicated that grout efficiency is raised with increasing number of holes, penetration depth, and it is affected clearly by variety in pattern of injection holes.

1-Introuduction

Grouting is a special technique developed in recent years with many applications. It is a procedure which involves grout injection into voids, fissures and cavities in soil or rock formation in order to improve their properties, specifically to reduce permeability, to increase strength and durability or to lessen deformability of the formations. Grouting has a wide application in modern civil engineering world (Nonveiller, 1989 ;and Anagnostopoulos, 2005). There has been extensive use of this technique over the years, and case
histories are reported to date back as far as the end of the19th century (Littlejohn, 2003).More specifically,it is applied to:
- increases the shear strength of soil media; at the same time,it decreases the permeability and compressibility of soils(Shroff and Shah, 1993).
-_ reduce permeability of a ground mass formation inorder to control seepage and loss of stored water in a dam reservoir;_ mitigate the soil liquefaction in structures for the protection of environment;_ control up lift on a structure, or to prevent the danger of erosion of soil from the foundation;_ increase the strength and reduce the deformability of
soil material under the foundation;_ stabilize the ground around cutting face and to control the settlement of ground surface during the opening of a tunnel (Fransson, 2001);
_ fix reinforcing elements (e.g., cables) in pre-cast and
pre-stressed concrete structures;_ fix rock pre-stressing anchors;
_ lift and erect leaning structures and buildings;_ fill voids between rock

and tunnel linings (Yesilnacar,2003);

_ rehabilitate and reinforce old defective masonry on
historical buildings (Yeon and Han, 1997).

-be effective against the possible damage induced under earthquake

loading due to liquefaction and cyclic mobility potential of the

subsoil(Durgunoglu et al,2004).

Many successful applications are described in the literature with different kinds of grout,especially in sands and gravels (Karol, 1990), which, because of their high or very high permeability, pose little or no problem for the permeation of suspensions or solutions (Fig.1). As a result of continuous technological progress, applicationsto lower-permeability soils have been attempted in thelast two decades by using chemical solutions with lower andlower viscosities (Table 1). However, usually organic or toxicsolutions have had to be adopted to achieve this result, withobvious and unacceptable environmental concerns. Various

materials are used for grouting depending onthe purpose of grouting and the properties of the grouted rock or soil (Cambefort, 1977). They may range from plastic mortars, thick or liquid suspensions of cement and other compounds and additives in water (Ohama,1984), chemical solutions (Karol, 1982), resins (Anagnostopoulos and Hadjispyrou, 2004), artificial foams, to hot bitumens and bitumen emulsions. Chemical admixtures such as superplasticizers, accelerators, antifreezers, air entraining agents and many others are used to modify the grout properties and protect it from the environmental conditions. In the last decades, powdered emulsions and water-soluble polymers (latex) are widely used as additives in cement grouts due to their potential influence on rheological properties (Allan,1997), strength (Bureau et al., 2001), durability, impermeability (Gao et al., 2002) and resistance to chemical erosion (Hatzitrifon and Anagnostopoulos, 2000).
To ensure more successful grouting, it is often necessary to improve the physical properties and fluidity of grouts (Akblut and Saglamer,2003)

The work in this study included prepare a new chemical grout contains from clay and dispersing agent of sodium phosphate and it used as a filler in clayey sandy silty soil.

A laboratory model is employed in this study to focus on some significant properties of grouts; which may be definitive guidelines for engineering design.

2-Materials

2-1Native soil which is required to be injected

Table(1) represents a complete summary of all laboratory test results concerning with the soil which is prepared for injection.

2-2 Clay which is used as filler

Table (2) represents a physical and mechanical properties of clay that is used as a filler in this study.

2-3 Sodium phosphate

Sodium phosphate used in these experiments as a dispersing agent with a concentration of 4%.

2-4 colored material

A passive material is used here just for reorganization the filler from surrounding soil.

Table(1) A Complete Summary of Laboratory Test Results.

Samples		Depth in (m)		Index Properties %			% Pass. By wt. From Sieve No.				S.p. T.
No.	Type	from	to	M.C.	L.L	P.I	4 Clay	10 Silt	40 sand	200 Gravel	"N" Value
1	D	0	1		53	31	37	48	4	11	
2	SS	1	1.5				40	53	6	1	16
3	D	1.5	3		49	30					
4	U	3	3.5	27	38	16	17	73	10	0	
5	SS	3.5	4				12	66	22	0	12
6	SS	5.5	6		32	12	2	62	36	0	14
7	SS	7.5	8								16
8	SS	9.5	10				-	- 18	82	0	31
9	D	10.5	11.5								
10	SS	11.5	12				-7	–	92	1	33
11	D	13	14		61	32	60	34	6	0	
12	SS	14	14.5		53	31	65	28	7	0	60
13	D	15.5	16.5		50	25	12	32	56	0	
14	SS	16.5	17								32
15	D	18	19.5				-12	-	86	2	
16	SS	19.5	20				-27	-	73	0	
17	Water Sample										

Table (2) Physical & Mechanical Properties of Clay which Used in the Filler

Physical	Liquid Limit	Plastic Limit	Plasticity	Specific

Properties	(L.L)	(P.L)	Index P.I	Gravity G.s
	55	45	10	2.78
Mechanical Properties	C(cohesion) kPa	ϕ(angle of internal friction)		
	125	37^o		

3- Equipment and Tools

-All conventional equipment and tools of soil laboratory to distinguish physical and mechanical properties of clayey filler and sampling the soil which is decided to be injected.

-Plastic mixer of 900 rpm.

-Device of viscosity measurement (it is available in one of project location of old Al-muthana airport.

-[Container+Spatula + Syringe+ Case] all plastic materials to ensure non reactivity .

4-Testing Program

To study injection technique in more focus by clayey filler, Eleven Samples of different cases are taken and subjected to unconfined compression machine. The detailed testing program is demonstrated in Table (3)

Table (3):Testing Program

Test No.	No. of holes (hole dia=5mm)	Penetration depth in mm	Spacing in mm c/c	Location &Pattern
١	1	30		**at centre**
٢	١	٥٠		**at centre**
٣	٢	٣٠	١٠	**one row in middle**
٤	٢	50	١٠	**one row in middle**

٥	٣	٣٠	10	**one row in middle**
٦	٣	٥٠	10	**one row in middle**
٧	٣	٣٠	10	**Triangular shape**
٨	٤	٣٠	10	**one row in middle**
٩	٤	٣٠	10	**two rows(square shape)**
١٠	٦	٣٠	10	**two rows**
١١	٦	**٣٠**	**10**	**three rows**

5-Injection Technique and Testing

After preparing the sample of soil which have length to diameter ratio of 2 and decided to be inject, it covered with rubber membrane and left coated for protection from drying and other variety in degree of temperature , then the filler prepared by following procedure :

-mixing an amount of clay with distilled water by mixer until the viscosity of suspension of 20 centipoises is reached [see (1)in plate (1)].

-adding a color material to the amount of clay and distilled water in mixer such that it enough to paint [see (2)&(3) in plate (1)].

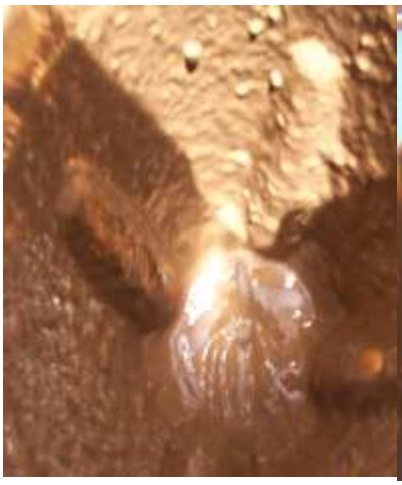
-putting paint suspension in plastic container, then add a dispersing agent of sodium phosphate with mixing by plastic spatula [see (4)&(5) in plate (1)],the suspension left for 16 hours before using as a filler to ensure the chemical reaction .

Now boring tools included syringe of 3ml, drill tool (which is have a small hole in head similar to that used in circulation boring as a bore bit), and plastic case as seen in plate (2) are getted. Further more the sample of soil is gained , [see (1) in plate (3)], then the drill tool installed by bushing down in a certain location of sample surface [see (2) in plate (3)] , after boring process is completed to required depth ,the plastic case is establish to maintain the bore open [see (3)&(4) in plate (3)]. After that a

proper amount of filler is pull by mean of syringe ,and pump slowly into the bore [see (5)&(6) in plate (3)] ,thus the injection is completed as seen in (7) of plate (3) ,and the sample now is ready to subject under unconfined compression machine for testing after time interval of 12 hours at least (gel time) in sake of ensuring two conditions:

First: seepage of filler inside soil sample.

Second: sedimentation of suspension particle and complete the transformation to solid case. The injection technique in this section is repeated for eleven (11) samples according to testing program in previous section [see plate (4) which shows number of holes and pattern of sample injection].



(1)

(2)

(3)

(4)

(5)

Plate(1) preparing the Filler for injection

(1)

(2)

(3)

(4)

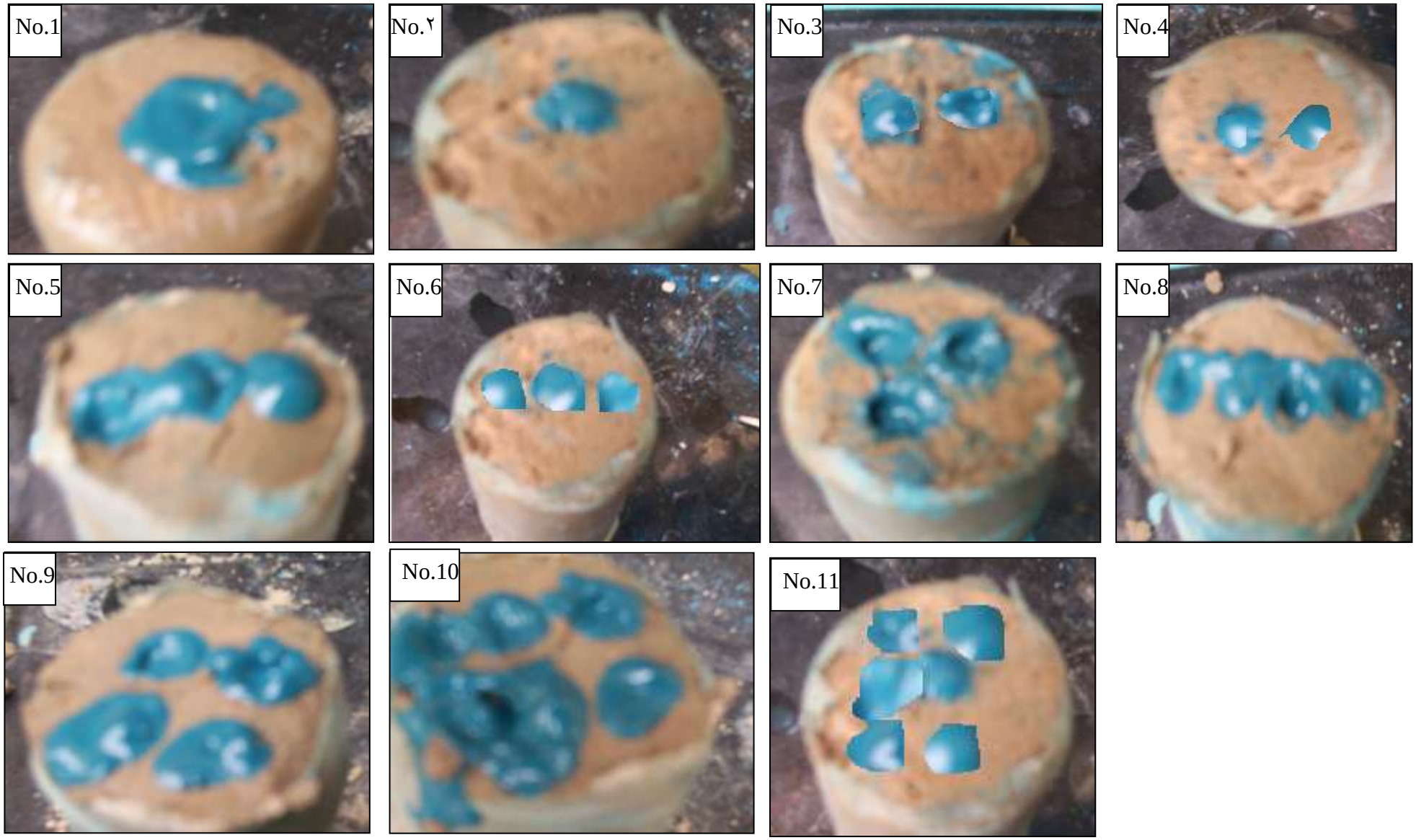


Plate (4) Samples According Test Program

6-Presentation Results and Discussion

In fact, the process of grouting by clayey suspension is good if we used in clayey sandy silty soil and give a good result of soil treatment. The technique ensure grout propagation through soil sample, it can be seen that propagation at failure surface of some samples which failed by axial load of compression machine. Further more it can be traced dissipation of filler before tending in test for example, see decreasing in filler level of sample No.3 as shown in plate (5).

Fig.(1) shows relationship between number of injection holes and degree of soil improvement (which it can be defined as failure load of treated soil /failure load of untreated soil),it is clearly that the degree of soil improvement is increased proportionally with number of injection holes and maximum efficiency is getted by six holes are inserted.

Also it can be demonstrated that degree of soil improvement is affected by penetration depth as it referring in Fig. (2).

In addition to number of injected holes and penetration depth a ,further parameter is control represented by pattern of holes[see Fig.(3)], the pattern six injection holes of three rows satisfy a typical pattern of grouting, in fact that simulated with almost last studies

Plate (٥) Decreasing Filler Level as a Result of Penetration the Filler through Soil Sample

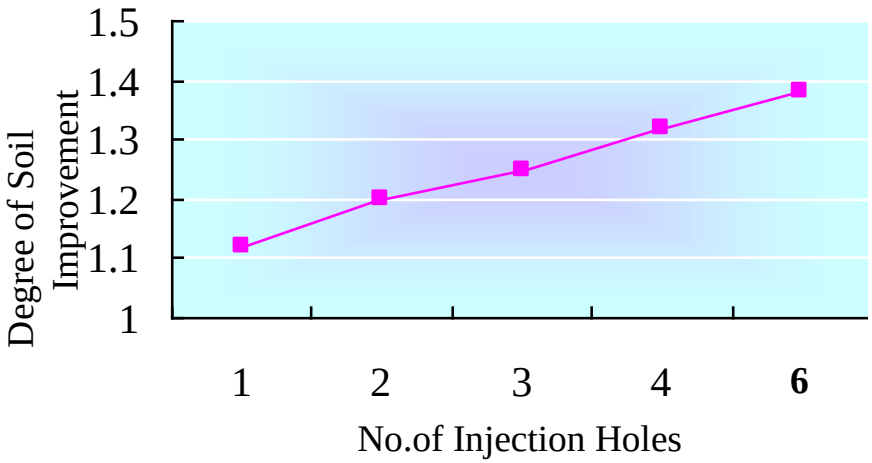


Fig. (1) Relationship between Number of Injection Holes and Degree of Soil Improvement

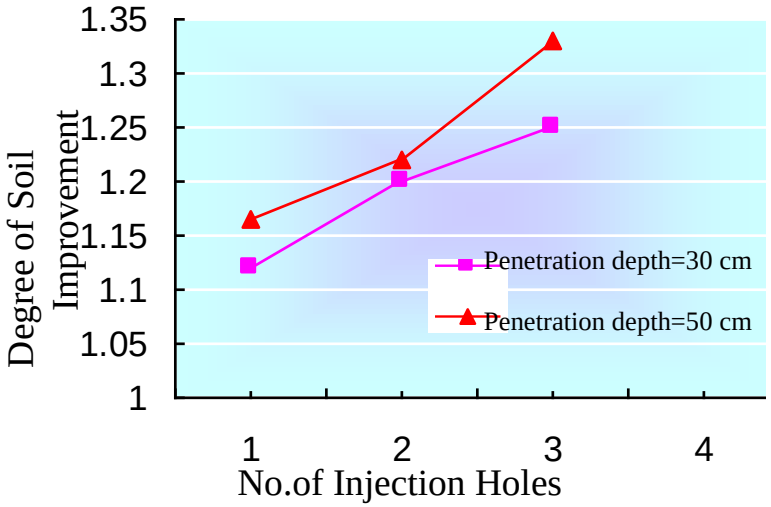


Fig.(2) Degree of Soil Improvement Effected by Penetration Depth of Injection

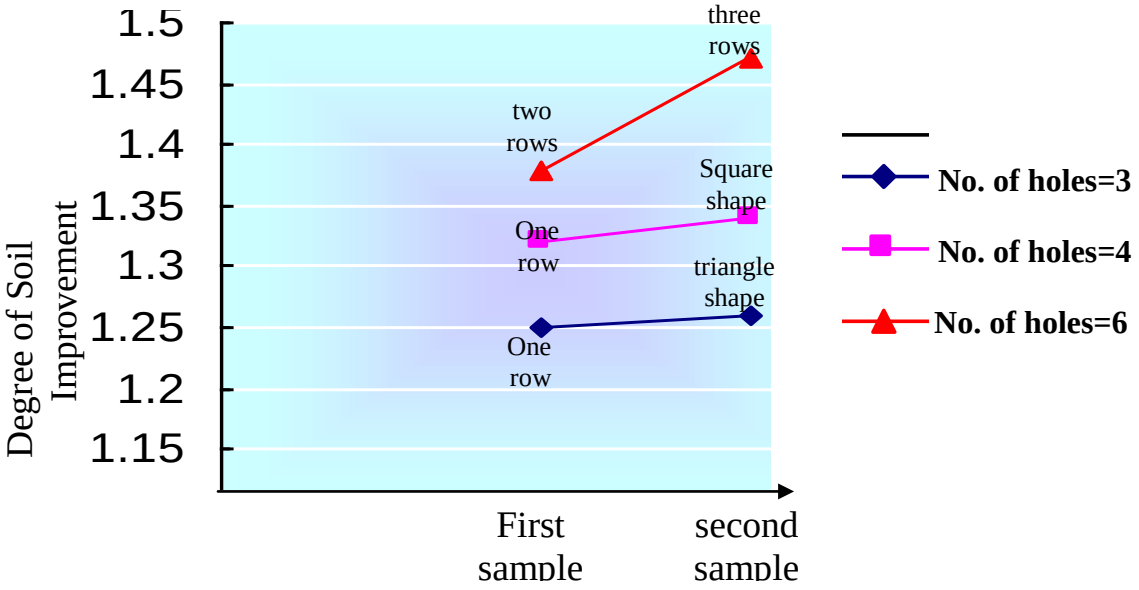


Fig.(3) Difference in Pattern of holes

7-Conclusions

Some fundamentals can be concluded from this paper; are

-the process of grouting by clayey suspension is good if we used in clayey sandy silty soil and give a good result of soil treatment.

-the degree of soil improvement is increased proportionally with number of injection holes and penetration depth.

- degree of soil improvement is clearly effected by pattern of injection .

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التمثيل المختبري للخلية المركبة من مادة الحقن الكيميائية والتربة المحيطة بها من اجل دراسة العوامل التي تتحكم في تحسين التربة المحقونة

أعداد

نسرين كردي ذباح

ماجستير في هندسة التربة والأسس

جامعة ذي قار

الخلاصة:

يمكن تعريف عملية الحقن في التربة على أنها تلك العملية التي تقضي بملء فراغات التربة أو تشققات الصخور بمادة الحقن (الحشوة filler) ،وبهذا تتحدد في الترب الحبيبية الخشنة من اجل ضمان انسياب مادة الحقن السائلة خلال فراغاتها وشقوقها،يتم استعمال مادة الحقن من الاسمنت (cement) أو البنتونايت (Bentonite) في اغلب الحالات العملية في ترب رملية خشنة أو متوسطة الخشونة.

لقد قدمت الباحثة في هذا البحث مادة حقن جديدة تتألف من الطين مضاف إليه مادة كيميائية من فوسفات الصوديوم تعمل كمادة مشتتة في الطين لفترة زمنية لتتمكن مادة الحقن (الحشوة) من اختراق فراغات التربة خلالها. علما" أنه تم إضافة مادة خاملة كيميائيا" تعمل فقط على تلوين مادة الحقن من اجل تميزها عن لون تربة النموذج المحقون.

لقد تم حقن مجموعة من النماذج المختبرية بمادة الحقن هذه وتم إخضاعها للتحميل المحوري (axial load) في ماكنة الضغط اللامحصور (unconfined compression machine) باستخدام عدد حفر حقن مختلفة (number of injection holes) ، وأعماق اختراق مختلفة (penetration depth) مع اختلاف طريقة ترتيب مواقع الحفر (pattern) وقد تم تقييم طريقة الحقن هذه في تحسين التربة الرملية الغرينية الطينية (المستخدمة هنا في إعداد النماذج التي تم حقنها) من خلال مقارنة نتائج الفحوصات.

لقد أثبتت نتائج الفحوصات المختبرية التي تم توظيفها هنا بأنه تزداد كفاءة مادة الحقن مع زيادة عدد الحفر وأعماق الاختراق لها،وتتأثر بشكل واضح باختلاف طريقة ترتيب الحفر.