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# Study the Effect of Date Seed Powder on the Strength of Kaolinite Clay Soil

**Yahya k. Atemimi[a*], Khitam Abdulhussein Saeed[b]**
a Civil Engineering Departmnt, College of engineering University of Babylon.
b Environmental Engineering Department,College of Engineering Al- Mustansiriyah University

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**ABSTRACT**

The Kaolinite soil is considered as a problematic soil due to its low strength with high water content, low density and low permeability. So, there are attempts to improve the engineering properties of this type of soil by mixing it with different additives. In this study the Date seeds powder was used in two forms, first: as a powder (DSP) and mixed with the Kaolin soil at different percentages by weight (3%, 5%, 7% and 10%), and second, the powder was burned at 450$^{O}$C for 4 hours in furnace (DSPB) then mixed with Kaolin soil at different percentages by weight (3%, 5%, 7%, and 10%). The results show an increase of 755% in the strength of the Kaolinite soils at 5% DSPB as compared to the origin strength when testing in unconfined compressive strength test UCS. Also, the results show a decrease in plasticity index for all mixture percentages in DSPB by 26.2% using 10%DSPB. Curing time results show high percent of increase in strength from 170 to 310 kN/m$^2$ for 0 to 28 days respectively, this increase equal to 1386% from strength of reference soil.



# دراسة تأثير مسحوق نوى التمر على مقاومة ترب اطيان الكاؤلينايت

**الخلاصة**

اطيان الكاؤولين تعتبر من الترب ذات المشاكل من الناحية الهندسية نتيجة لانخفاض مقاومة القص وقابليتها العالية على الاحتفاظ بالماء مما يؤدي الى محتوى مائي عالي مع انخفاض في الكثافة الجافة العظمى ومعامل النفاذية. هنالك محاولات كثيرة لتحسين الخواص الهندسية لمثل هذا النوع من التربة من خلال خلطها مع مختلف المضافات. في هذه الدراسة تم استخدام مسحوق نوى التمر من خلال التعامل مع نوى التمر بطريقتين ، اولا سحق نوى التمر وتحويلة الى مسحوق ناعم وتم الرمز لهذا النوع ب (DSP) اما النوع الثاني فهو حرق مسحوق نوى التمر بدرجة حرارة ٤٥٠°م لمدة اربع ساعات للحصول على البوزولانا وتم الرمز لهذا النوع ب(DSPB) . .تم خلط اربع نسب مختلفة من كلا النوعين (DSP وDSPB ) هي ٣،%٥،%٧،%١٠% . النتائج اظهرت تحسن واضح بمقاومة القص المفحوصة بفحص مقاومة القص غير المحصورة حيث كانت الزيادة بمقدار ٧٥٥% عند نسبة الخلط ٥% مقارنة مع التربة قبل الخلط. كذلك اظهرت النتائج تأثير واضح على معامل اللدونة حيث انخفض لجميع نسب الخلط للتربة المخلوطة مع DSPB .كذلك تم دراسة تأثير وقت الإنضاج على خواص التربة قبل وبعد عملية الخلط ولكلا النوعين (DSP وDSPB ). تم استخدام اربعة اوقات مختلفة هي (٠يوم ،٧يوم ،١٤يوم،و ٢٨يوم) وتم دراسة تأثير وقت الإنضاج على نتائج الكثافة الجافة ومقاومة القص حيث اظهرت النتائج تأثير واضح ومهم خلال فترات الإنضاج المختلفة من خلال الزيادة بالقص من ١٧٠ الى ٣١٠ كنت/م$^2$

**الكلمات المفتاحية**

تحسين التربة،أطيان الكاؤولين، فحص القص غير المحصور، مسحوق نوى التمر، زمن الانضاج

*Corresponding author.
E-mail addresses: : eng.yahya.kadum@uobabylon.edu.iq

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**Introduction**

The growing in the populations pushes the owners to use all the desirable area, therefore; the undesirable area which is neglected at present time will be used. One of the undesired soils is the soft clays such as kaolinite. The civil engineering applications on the soft soils often requires utilization of ground improvement [1]. Care should be taken when improving kaolinite clay soils. This is due to the nature of these types of soils which having high specific surface and the ability of disturbing the negative charges on surface such as $Ca^{++}$, $Mg^{++,}$ $K^{+}$, and $Na^{+}$ . the charges can be exchanges with other cations when mixing with chemical therefore, be carefully used the additives when improved this soils type [2]. The cement and lime are commonly used in ground improvement but failed with Kaolinite clays when a 5%lime caused a reduction in the dry density by 5% and an increase in the water content by 13% as reported by National Lime Association 2006[3]. Fly ash is success fully used in soft soil as mentioned by US department of transportation but the optimum percentage is still not fixed due to the nature of clay [4]. Significance of the study there is increasing interest to use waste materials as a green technology. In Iraq, many million ton of dry date per year which leaves many thousands of ton of date seed. The date seeds are crashed to use as an animals feed and some of these pieces found as a powder and not used as feeds. This powder can be used as soil improvement materials. In this study used the date seed powder as an additive material with soft clay to improve its strength and study what percent can be add. On the other hand, reduce the waste materials to environment maintain

1- **Materials**

The soil used in this study from Al-Najaf governorate in Al-Salam valley near the see of Al-Najaf at latitude 31.9984639 and longitude 44.3013523 at 20cm from ground level. This soil was brought to the laboratory as rocks and pulverized by Los Angeles devise till al quantity became powder. The date seed powder obtained from Al-Hilla factory for animal feeds as a waste product. The date seed powder was divided in to two groups: in the first group, the dry date seed powder (DSP) was used and in the second group it was burned by muffle furnace at 450ºC during 4 hours' period then mixed with soil as a percent by weight.

2- **Methodology**

In addition to the reference soil, the mixtures of soil and DSP and soil and DSPB were investigated in the present work. To classify soil, liquid limit and plastic limit with sieve analysis and hydrometer were conducted. Compaction test was applied on the samples in order to obtain the maximum dry density (MDD) and optimum moisture content (OMC). Furthermore; the unconfined compressive strength test UCS (38mm dia. x76 mm height at MDD and OMC) was applied on the reference soil and soils mixture to evaluate its strength. On the other hand, the soil was mixed with DSP and DSPB in four percentages (3%, 5%, 7% and 10% by weight) to evaluate the effect of DSP and DSPB on the soil strength. To study the effect of curing time on strength properties the samples were cured and tested as 0, 7,14, and 28 days. The samples used in UCS test were mixed with the DSP and DSPB in different percentages using MDD and OMC for each percent, then covered by nylon sheet and storage in plastic container after celled by adhesive tape until time of test. Specific gravity, organic content and pH value were also conducted on the reference soil only. All specifications according to British Standards and ASTM specifications were listed in table 1

**Table1: Properties of control soil**

| Properties | Results | Specifications |
|---|---|---|
| Gs | 2.59 | BS:1377: part2: 1990, clause 8.3 [10] |
| Color | white to gray | ------------ |
| LL (%) | 72 | BS:1377:part2: 1990,clauses 4 and 5 [10] |
| PL (%) | 30 | BS:1377:part2: 1990,clauses 4 and 5[10] |
| PI (%) | 42 | BS:1377:part2: 1990,clauses 4 and 5[10] |
| % finer<75 µm | 100 | BS:1377:part2: 1990,clause 9.2 |
| % of clay ( < 2 µm | 81 | BS:1377:part2: 1990 [10] |
| Activity | 0.519 | ASTM D2487-2005 [11] |
| pH | 9.0 | BS:1377:part3: 1990,clause 9[10] |
| Organic content (OC)% | 0 | BS:1377:part3: 1990,clause 4[10] |
| MMD g/cm$^3$ | 1.36 | BS:1377: part4: 1990, clause 3.4[10] |
| OMC % | 32 | BS:1377: part4: 1990, clause 3.4[10] |
| USCS | CH | ASTM D2487-2005 [11] |
| Unconfined compressive strength (kN/m$^2$) | 22.4 | ASTM D-2005 [11] |

## 3- Results and discussions

4-1 Atterbreg's limits

Figure 1 shows the plasticity index (P.I) increased as the percentage of additives when DSP was used. The results can be attributed to the ability of DSP to absorbed water and the increased liquid limit and plastic limit of the mixture in different quantities. On the other hand, the DSPB caused a reduction in P.I with increasing additive content by 26.2% at 10% DSPB. The pozolanic action on soil mixture caused particle size to increase due to agglomeration, this enhancement in the particle size led to the soil texture which caused increase in internal friction among the agglomerates. The results obtained from plasticity index in DSPB referred to improve of soil properties as workability and shear strength [6,7].

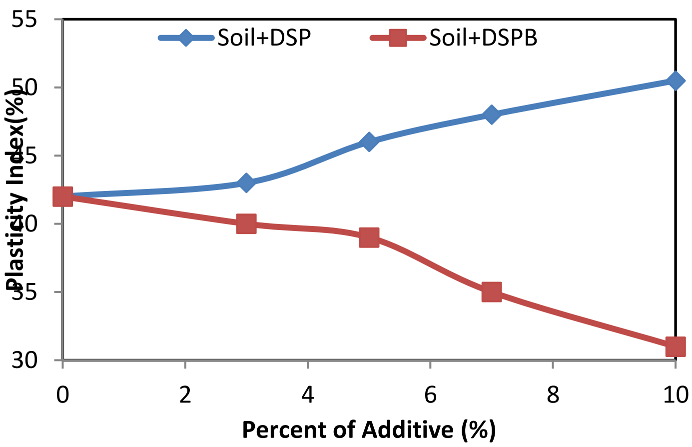


**Figure 1: The relation between the plasticity index and the percentage of Additives for both additive types (DSP and DSPB**

**4-2 Compaction result**

Figures 2 and 3 shows the relation between maximum dry density and curing time for different additive percentages. Figure 2 shows the reduction in MDD with DSP percent and increase in MDD with curing time progressed as can be seen from figure 3, there was a decrease in MDD with DSPB percent while there was increase in MDD with curing time increase till be equal with reference soil density with 5%DSPB at 28 days curing, this result agrees with that presented by many researchers such as [7,8]. The reduction in MDD was attributed to the variation between the DSP, DSPB density and the density of soil. Therefore, the replacement of soil by the additive caused a decrease in the total density of the mixture. On the other hand, the increase in the MDD during curing time can be attributed to the agglomerate action and change in the particle size.

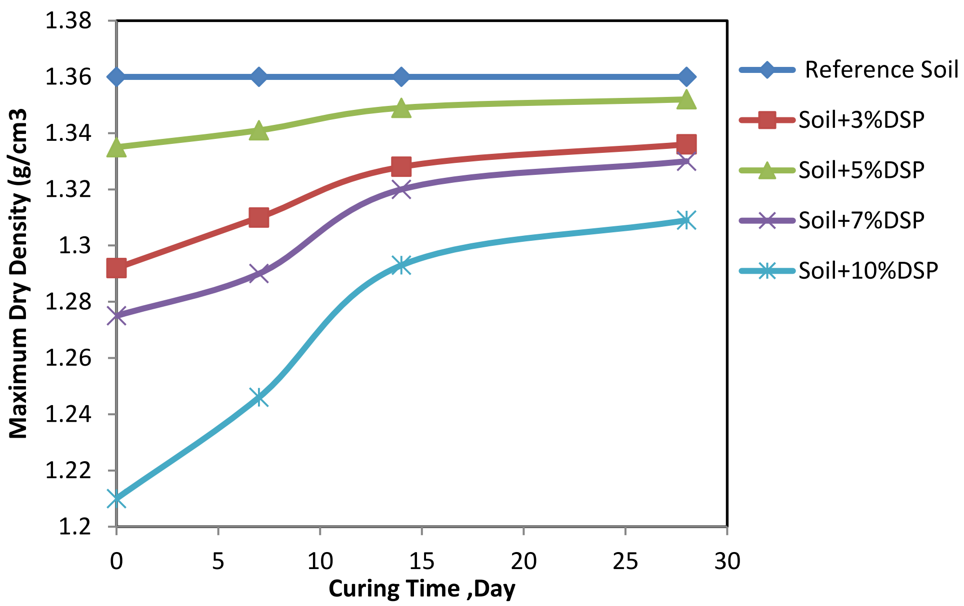


**Figure 2: Curing time effect on maximum dry density for different DSP percentages**

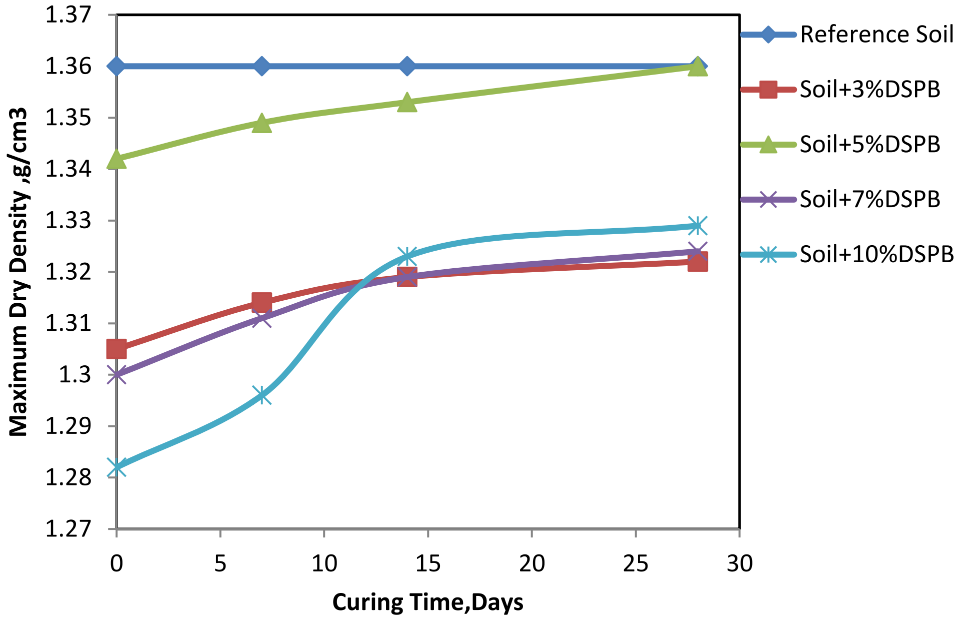


**Figure 3: Curing time effect on maximum dry density for different DSPB percentages**

### 4-3 Unconfined compressive strength

As shown in Figures 4 and 5 the results showed an increase in the unconfined compressive strength for both types of soil-additives (soil-DSP and soil-DSPB) as compared to that of reference soil. Figure 4 show the strength enhanced by 311% in 5%DSP after 28 days curing. On the other hand, all percentages of additives from DSP showed an increase in the strength compared with the reference soil. Figure 5 showed significant increase in the strength compared with the reference soil; the increase reached to 1386% at 5% DSPB after 28 days. The subsequent increase in the strength is attributed to the formation of cementation bond between DSPB as well as pozolanic present in DSPB. The reduced strength in the DSPB-soil mixture in the percentage more than 5% (7% and 10%) is attributed to the higher percent of pozolana compared with the CaOH in the mixture which caused abundance of pozolana. The soil before improving classified due to $q_u$ value as listed in table 2, as a soft soil ( $q_u$= 22.5 kN/$m^2$) and is classified as a very stiff ($q_u$= 311kN/$m^2$ ) after improving . The curing effect was significant on the UCS such that prolonging curing time from zero to 28 days increased strength from 170-311.87 kN/$m^2$. The results of the present study also indicated that, both DSP and DSPB enhanced the strength at any time through the 5% was more efficient.

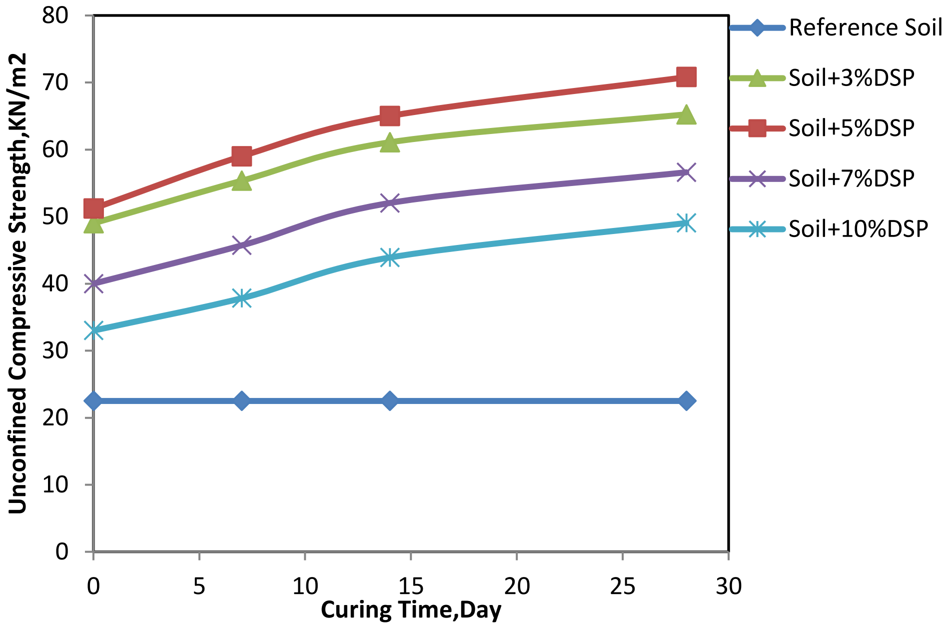


**Figure 4: Effect of curing time on UCS with different DSP percentages**

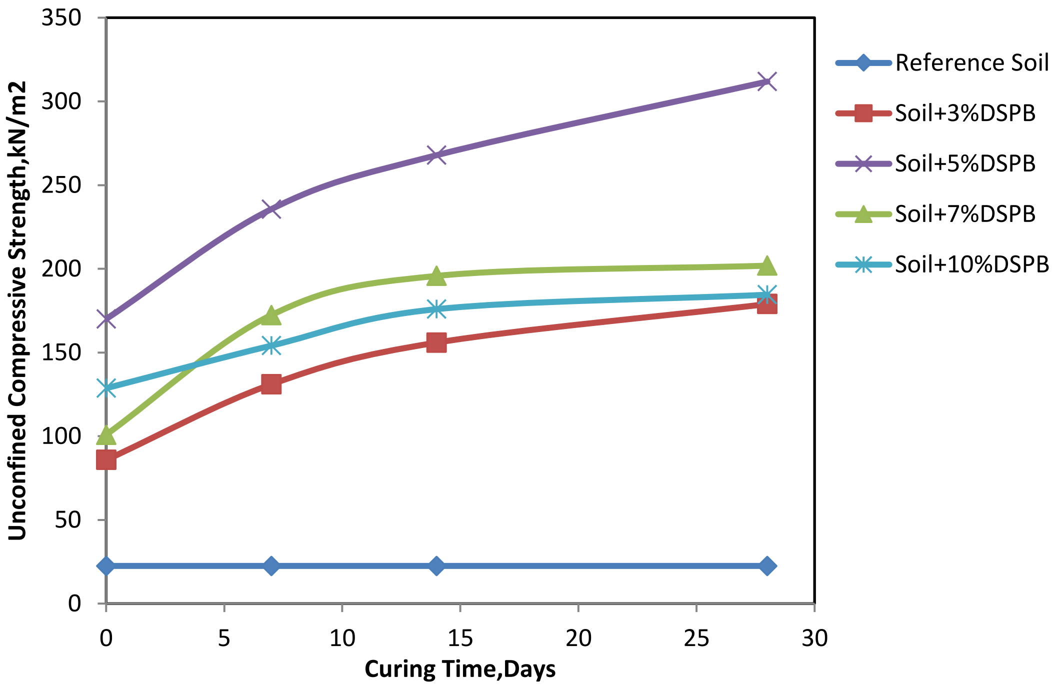


**Figure 5: Effect of curing time on UCS with different DSPB percentages**

**Table 2: The relation between consistency and unconfined compressive strength after (K.R. Arora2004) [9]**

| Consistency | $q_u$(kN/m$^2$) |
|---|---|
| Very soft | < 25 |
| Soft | 25-50 |
| Medium | 50-100 |
| Stiff | 100-200 |
| Very stiff | 200-400 |
| Hard | >400 |

**Conclusion and recommendations**

1- Use of DSPB is better than DSP in Kaolinite clay soil
2- 5% DSP and 5%DSPB recorded the highest strength value
3- The results shown that the curing time is very important parameter in soil improvement
4- The mixing of DSPB with lime in Kaolinite clay is recommended for the next studies.
5- Prolonging curing time from 28to 180 days or more is also recommended.

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