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New Chemical Stabilizer Effect on Plasticity of Lateritic Soil Properties

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ABSTRACT

The lateritic soil that has high content of iron oxides and aluminum hydroxides and low proportion of silica is widespread in the tropical and semi-tropical countries. Lateritic soil as available materials in these areas utilized in different civil engineering applications as roads, canals, earth dams, railways, building, … etc. These applications are depending in a majority on soil classification in design the construction on this soil type. One of the important parameters in classification of soil is an Atterbage's limits are used in definition of soil type and its strength. Due to increase in population caused an increase in construction to demand the facilities of this growth, therefore the desired soil decrease depend on used and the undesired soil available. Soil stabilization utilized to improve the undesired soil properties by a different technique to achieve the design requirement. Chemical stabilization becomes one of the best solution to soil problems depend on economic and time save. New chemical soil stabilization used is named (NBT II) in this study to exam the effect on plasticity soil properties. Different percentages and different curing time test conducted on lateritic soil to evaluate the range of effect and also examined the effect of plasticity on dry density. The results show decrease in liquid limit with increase in NBT II and then beginning to increase with stabilizer percentage increase the reduction about 11% at 28 days curing, plastic limit increase about 6% at the same time and plasticity index decrease 80%. The results also show the inverse relationship between maximum dry density and plasticity index.

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Keywords: Soil Improvement, Liquid Chemical Stabilizer, Consistency Limits, Curing Time**.**

تأثير المثبت الكيميائي الجديد على خصائص لدونة تربة اللترايت

الخلاصة

تربة اللترايت التي تحتوي على نسبة عالية من اكاسيد الحديد والالمنيوم ونسبة قليلة من السلكا تتواجد بصورة واسعة في المناطق ذات المناخ المداري وشبة المداري. تربة اللترايت المتواجدة في هذة البلدان تستخدم بصورة واسعة في اعمال الهندسة المدنية مثل الطرق, قنوات الري, السدود الترابية , خطوط القطارات, البنايات ..... الخ. هذة التطبيقات تعتمد بصورة رئيسية على تصنيف التربة المستخدمة في تصميم المنشا المعتمد على هذا النوع من التربة. واحد من العوامل المهمة في تصنيف التربة هي حدود اتربك التي تستخدم في تعريف نوع التربة ومقدار مقاومتها للاحمال المسلطة عليها. نتيجة لزيادة النمو السكاني الذي ادى الى زيادة الطلب على البنايات المختلفة لتلبي حاجة الزيادات الناتجة للسكان , هذ ا النمو في المشاريع ادى الى تقليل نسبة الاراضي الصالحة للبناء وذات المواصفات الجيدة وبالنتيجة اضطر اصحاب المشاريع الى استخدام الاراضي ذات المواصفات الهندسية الضعيفة مع استخدام المعالجة. تثبيت التربة احد اهم الحلول المستخدمة لتحسين المواصفات غير المرغوبة في التربة للوصول الى المتطلبات التصميمية. التثبيت الكيميائي اصبح واحد من اهم الحلول المستخدمة في هذا المجال لما لة من فائدة تقليل الكلفة والزمن المستخدم للمعالجة. في هذة الدراسة تم استخدام محلول كيميائي يعرف تجاريا NBT II بنسب مختلفة وتم اختبار تاثير هذة المادة على خواص لدونة التربة. تم استخدام نسب مختلفة من هذة المادة لخلطها مع تربة اللترايت عند فترات نضوج مختلفة تصل الى 28 يوم لتقييم مدى تاثيرها على خواص اللدونة, كذلك تم اختبار تاثير لدونة التربة على الكثافة الجافة العظمى. النتائج المستحصلة من هذة الدراسة اظهرت انخفاض حدود السيولة مع زيادة نسبة المثبت ومن ثم بدات بالزيادة عند النسب العالية, هذا الانخفاض كان تقريبا 11% بعد مرور 28 يوم من الانضاج. حدود اللدونة زادت بنسبة 6% عند نفس زمن الانضاج وبالنتيجة قل مؤشر اللدونة بمقدار 80%. النتائج كذلك اظهرت وجود علاقة عكسية بين الكثافة الجافة العضمى ومعامل اللدونة.

INTRODUCTION

Lateritic soils widespread in tropical and semi-tropical area, most of the lateritic soils are un-adequate used in different construction application. With population growth the desired land decreases and the alternative choice to use undesired soil with treatment application. Soil improvement by compaction energy or/and chemical additives one of the treatment solutions to the undesired soils. Cement and lime were old chemical additives utilized as a traditional additives in soil improvement [1], then utilized different types of mixture as lime-cement, lime-fly ash, cement- fly ash, emulsified asphalt- cement,….etc.

In recent years are the soil improvement applications forward to utilized nontraditional additives due to the traditional additives have been intensified researched, and their fundamental stabilization mechanisms have been identified. While the nontraditional additives have a wide range of chemicals and variety in

composition with various reactions with soil particles. Unfortunately, few data are available about their interaction with different soil types or their performance stabilization mechanisms.Nontraditional additives include a lot of chemical groups as emulsifier, petroleum resins, salts stabilizers, lignosulfonate stabilizers, Ionic stabilizers, enzyme stabilizers, tree resin stabilizers, and polymer stabilizers [2].

Polymer stabilizer coat soil particles and waterproof with physical bond in soil matrix. The polymer can increase the soil strength in different percentages due to the ability to coat the soil particles and on the properties of the polymer. The polymers normally utilized in granular materials but less effective in fine grained soils due to a high specific surface area that lead to reduce the mixing efficiency [2]. Due to this fact, the compositional factors namely grain size distribution and plasticity characteristics work as an important effect on improvement of the Geotechnical soil properties [3].

Styrene Butadiene Rubber (SBR) is an example of the liquid additives, which is a random copolymer, derived from styrene and butadiene monomers. There are two classes of SBR, emulsion SBR (E-SBR) and solution SBR (S-SBR) [4]. Solution (SBR) is one of the polymer groups that have colossal potential applications in different industries [5]. SBR can be considered as one of the inexpensive chemicals, widely available, non-toxic, and readily soluble in water. Furthermore, it can be applied as a local soil stabilizer in construction site work with no specific instrumentations is required.

According to the published facts, there are no reported data for the use of SBR in the soil improves field; being this report as the first and the only study dealing with the relationship between plasticity characteristic and density of the lateritic soil with curing time. The selection of SBR as a soil stabilizer was due to economic, technical and environmental aspects. Therefore, the current research work emphasizes on improving the weak soil properties for construction purposes. The evaluation of the as-modified soil was performed via different mechanical and engineering properties.

MATERIALS AND SOIL SPECIMEN PREPARATION

Lateritic silty sand soil (SM) was used in this study. The soil was collected from Matang Sampol, Bandar Baharu, Kedah Malaysia with co-ordinate $5^{o}\,21'\,6''$ N and $100^{o}\,32'\,59''$ E. Distributed soil samples collected from depth 0.3 - 1.0 m from ground surface then air dried. Based on the soil properties was classified as SM according to the Unified Soil Classification System (USCS) as in Table (1). The grain size distribution curve for soil as in Figure (1).

The Stabilizer Additive

Next Base Technology (NBT II) is the commercial name for the chemical additives that was used in this experiment, which has a scientific name as SBR "Styrene Butadiene Rubber" this product provided by Next Base Technology Company in Malaysia. Table (2) refers to the chemical composition of the polymer.

MIX INVESTIGATION AND THE TYPE OF TEST CARRIED OUT

Mix design program illustrated in Table (3). All samples were oven dried (105 - 110^{o}C) over 24hour after passing from BS. Sieve No.4 (opening size 4.76 mm). Basic Soil properties conducted on virgin soil as consistency limits, specific gravity and classification test (sieve analysis with a hydrometer) also pH test for soil and chemical composition of the polymer were done. The polymer diluted as a percentage by weight with distilled water at optimum moisture content (OMC) which obtained from compaction test then add to the soil with hand mixing until reach to the uniform color then the sample was stored in a plastic bag and plastic container to maintain on its moisture. Furthermore the liquid limit, plastic limit with curing time and compaction tests were conducted for all soil mixture percentages.

Consistency limits

Laboratory tests were conducted on all samples used in Table (3) to determine the index properties (liquid limits and plastic limits) with curing time used to observe the time effect on index properties of soils. The tests don accordance to the B.S 1377: part 2: 1990, clause 4.3 and 5.3 [6].

Compaction

British standard light compact effort was used. Oven dried soil specimens passing through B.S sieve with 4.76 mm aperture, mixed as in Table 3 without curing time. This test carried out accordance to B.S 1377: part 4: 1990, clause 3.4 [6].

RESULTS AND DISCUSSION

Compaction characteristics

The compaction tests were conducted on different SBR percentages, after mixed with lateritic soil exhibited slightly decreases in maximum dry density (MDD). The optimum moisture content (OMC) was increasing at small SBR% and beginning to decrease with SBR% increase. The density results attributed to the polymer density lower than the untreated soil density. Increase the moisture content at low SBR percentage attributed to agglomeration effects of the fine particles and increase the porosity of the soil skeleton which caused an increase in ability to adsorbed water. The variations of maximum dry unit weight and optimum water content with SBR content are shown in Figure (2).

Consistency limits

The liquid limits and the plastic limits were conducted on all SBR% as in test program Table (3). Investigate the curing time effect on consistency limits for all soils treated. As the results show in Figure (3) decreases with liquid limits at small SBR% and increase with the SBR% increase, on the other hand the liquid limit decrease with curing time increase at a small percentage of SBR but at high SBR% liquid limit increase after 7 days curing. This conduct attributed to the polymer reaction with soil particles, when a small percentage of the SBR play as connected materials between particles, and waterproof effect after coated the particles then increases the percentage over the quantity to fill void ratio work as a lubricant

Material therefore, the particles slipping one on another and the porosity of the soil increase. Then the water adsorbed increase leads to liquid limit increase. While the reduction in plastic limit due to fill the void ratio of soil with small SBR% and the polymer work as a flexible material caused an increase in flexibility of the soil skeleton. With the increase in SBR% the quantity of polymer become over the void ratio capacity then work as dispersion materials to push soil particles and increase the porosity. With curing time the plastic limit increase for all SBR%, this is results refer to time effect by chemical reaction and the bond between particles become more stiff. Figure (4) shows plastic limit results with curing time at different SBR%.

The relation between dry density and Atterberge's limits

The relation between maximum dry density and plasticity index after 28 days curing for lateritic soil exhibited the 1% SBR was the optimum percentage to improve the lateritic soil which has plasticity index 9.5 and maximum dry density 1.84 g/cm^3 as results obtained from Figure (5).

CONCLUSIONS

Based on the results obtained from this study the following conclusion can be drawn:

1. Maximum dry density slightly decreases and optimum water content increase due to lower liquid stabilizer density.
2. Maximum reduction in plasticity index at 5% SBR.
3. Liquid limit decrease in curing time increase at small SBR% (2.5 – 7.5 %).
4. Plastic limit increase with the curing time increase, this increase already affected on the plasticity index by decreasing it.
5. The dry density was affected by plasticity index.

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Table (1) Lateritic soil properties.

Gs	**2.67**
Color	**Reddish yellow**
L.L%	**42**
P.L%	**30.5**
P.I%	**11.5**
% finer < 75 µm	**40**
Cu	**55.6 >3**
Cz	**0.072<1**
pH	**4.6**
Organic content (OC)%	**7**
MDD g/cm^3	**1.89**
OMC %	**13.7**
USCS	**SM**
Void ratio (e %)	**66**

Table (2) Chemical composition of the SBR.

Test	**Property**	**specification**
pH	**5.72**	**BS.1377: Part3:1990**
Refractive Index	**1.402**	**ASTM D1747-09**
Density	**1.050 g/cm^3**	
Shear Strength	**increase with time***	**ASTM D196-99**
Viscosity Conductivity	**increase with time***	**ASTM D196-99**

Carbonate(totalhardness)	**130.3µs/cm8 mg/L**	

***at room temperature and without cover**

Table (3) Mix design program.

Soil:SBR Ratio	**Curing time (Days)**
1: 0.025	**1,3,7,14,28**
1: 0.05	**1,3,7,14,28**
1: 0.075	**1,3,7,14,28**
1: 0.1	**1,3,7,14,28**
1:0.125	**1,3,7,14,28**

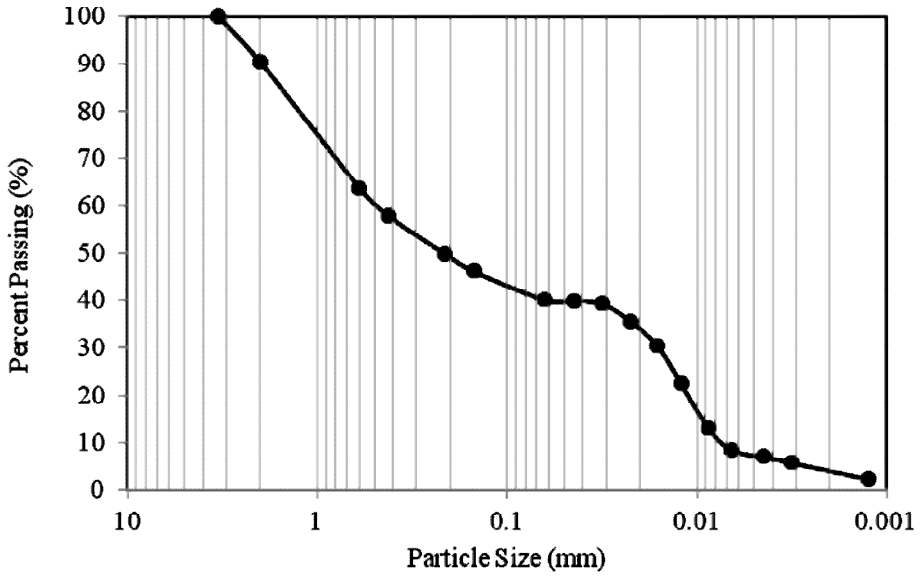

Figure (1) Particle size distribution curve for lateritic soil.

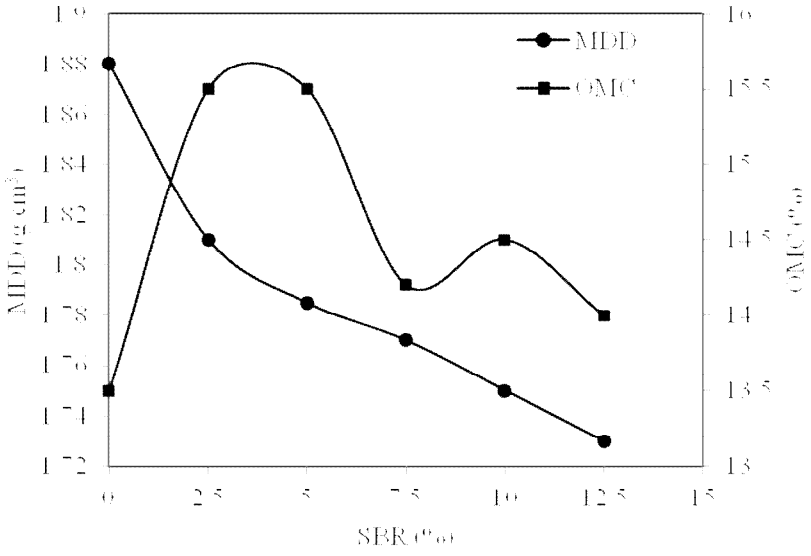

Figure (2) Effect of SBR% on compaction test results.

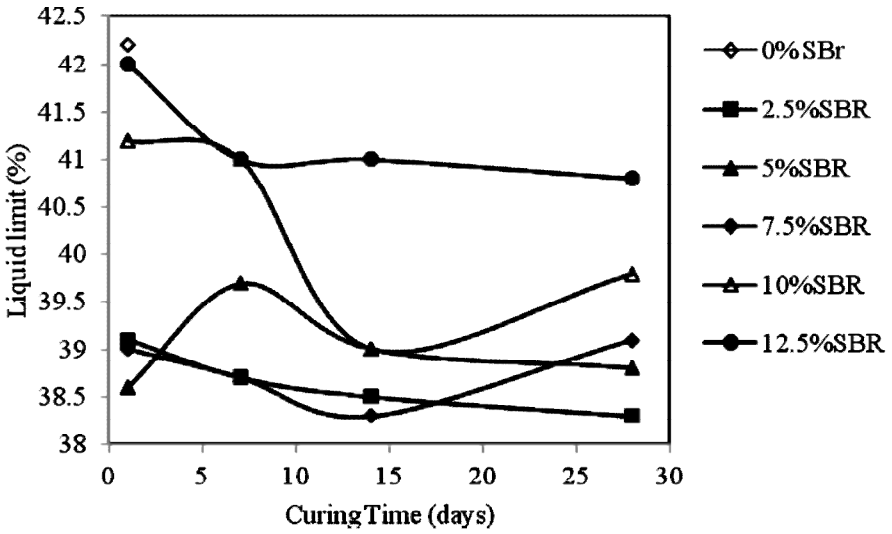

Figure (3) Liquid limit with curing time at different SBR%.

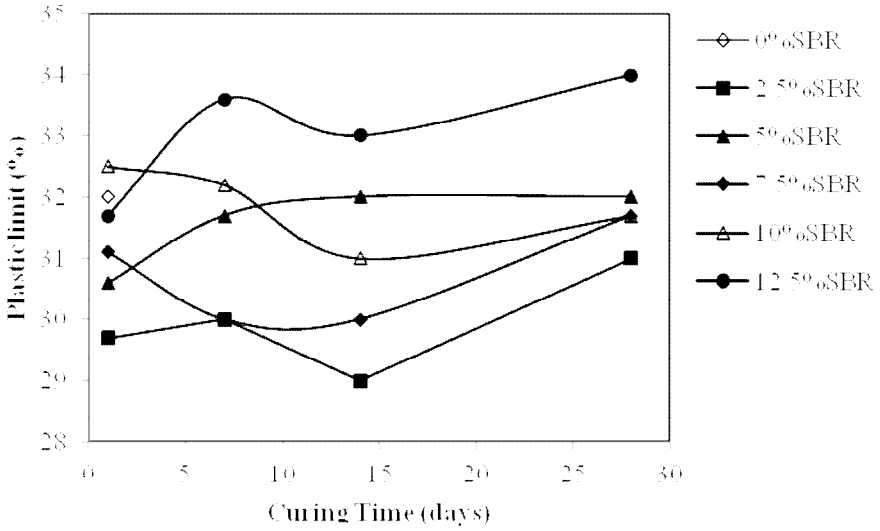

Figure (4) Effect of SBR% on plastic limit at different curing time.

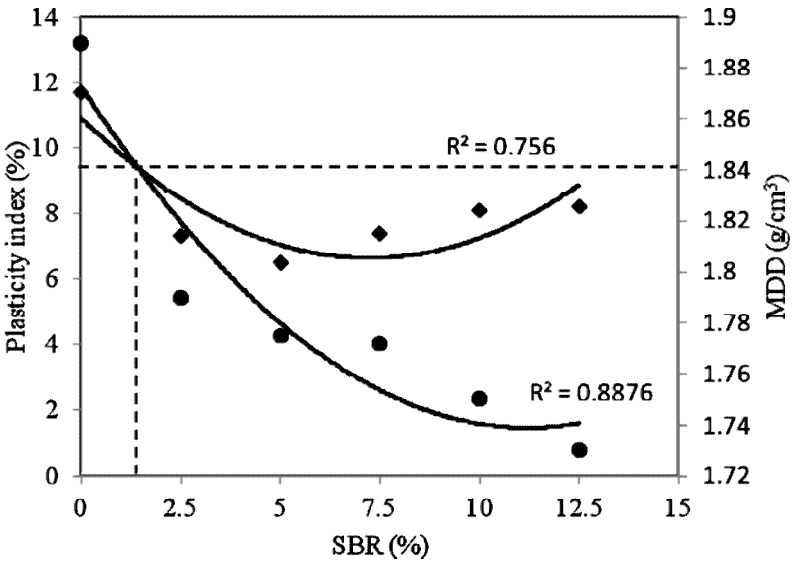

Figure (5) Relation between plasticity index and maximum dry density.