

Shear Strength Behaviour of Canlite-Treated Laterite Soil

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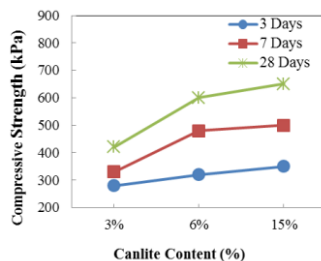
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Graphical abstract



Abstract

This research is to determine the geotechnical properties of laterite soil which are modified with liquid soil stabilizers namely Canlite (SS299). The soft soil samples which are from hilly area at Faculty of Electrical and Electronic, Universiti Teknologi Malaysia, Skudai was used in this research. Physical properties tests that were conducted are Atterberg Limit test, Standard Proctor Compaction test (SPC) while mechanical properties test are Unconfined Compressive Strength (UCS) test. All these tests were conducted in accordance to BS1377:1990. The results showed that SS299 soil stabilizer is able to improve the geotechnical properties of the laterite soil. The unconfined compression strength increased with the curing period, the variation mainly occurring in the first 28 days. Canlite soil stabilizer was therefore finding as an effective stabilizer for lateritic soil.

Keywords: Canlite, stabilization, strength, laterite

Abstrak

Kajian dijalankan untuk menentukan sifat-sifat geoteknik tanah laterit yang diubah suai dengan cecair penstabil tanah iaitu 'Canlite' (SS299). Sampel tanah lembut yang berasal dari kawasan berbukit di Fakulti Kejuruteraan Elektrik dan Elektronik, Universiti Teknologi Malaysia, Skudai telah digunakan dalam kajian ini. Sifat ujian fizikal yang dilakukan adalah ujian Had 'Atterberg', ujian 'Standard Proctor' Pemadatan (SPC) manakala sifat mekanik ujian adalah ujian kekuatan terkurung (UCS). Semua ujian ini dilakukan mengikut BS1377: 1990. Hasil kajian menunjukkan bahawa penstabil SS299 tanah mampu meningkatkan sifat geoteknik tanah laterit. Kekuatan terkurung meningkat dengan tempoh pengawetan, dan perubahan dikenalpasti terutama pada 28 hari pertama. Oleh itu Canlite penstabil tanah terbukti efektif sebagai penstabil efektif untuk tanah laterit.

Kata kunci: Canlite, penstabilan, kekuatan, tanah laterit

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1.0 INTRODUCTION

Soil stabilization has been introduced by researcher for a long time ago in geotechnical engineering field. Soil stabilization is the process of improving the physical and engineering properties of a soil to obtain some predetermined targets.¹ Basically, mechanical stabilization refers more to compaction in site while chemical stabilization is using additives as an agent of stabilization. Both of these stabilization methods are to increase soil strength parameters and loading capacity and decreasing the settlement seem to be a more popular choice. This is due to its low cost and

convenience, particularly in the geotechnical projects that require a high volume of soil improvement.²

Laterite soils are found abundantly in the Tropicana country such as Malaysia. Laterite soil is well known in Asian countries as a building material for more than 1000 years and the temples at Angkor are famous examples for this early use. Generally, Laterite soils are regarded as good foundation materials as they are virtually non-swelling.³ However, Laterite soil contains amount of clay minerals that its strength and stability could not be guaranteed under loads especially under presence of water.⁴ When

Laterite soil consists of high plastic clay, the plasticity of soil may cause cracks and damage on building foundations, pavement, highway or any other construction projects. It is therefore important, to understand the behaviour of Laterite soil and thus figure out the method of soil stabilization.

In this study, a new polymer soil stabilizers namely Canlite (SS299) was introduced. This chemical stabilizer was suitable used for all type of soil based construction. Therefore, the aim of this research is to study the behaviour of Canlite- treated laterite soil in comparison with untreated laterite soil.

2.0 MATERIAL AND TESTING PROGRAMME

The poor Laterite soils were obtained from the hilly area around the Faculty of Electrical and Electronic, Universiti Teknologi Malaysia Skudai Johor. The amounts of Canlite soil stabilizer added to the Laterite soil were 3%, 9% and 15% and. Figure 1.0 shows the testing programme for this particular research. Soil specimens were kept safe and dry in the geotechnical laboratory of Department of Civil Engineering. The liquid polymer soil stabilizer which was used in this research is Canlite (SS299). This soil stabilizer was supplied by GKS soil Stabilizer S/B which is a Johor-based company. Figure 2.0 and 3.0 show the wet laterite soil and liquid polymer SS299 respectively. The physical properties of the natural soils are presented in Table 1.0. Soil is categorized as silt with very high plasticity.

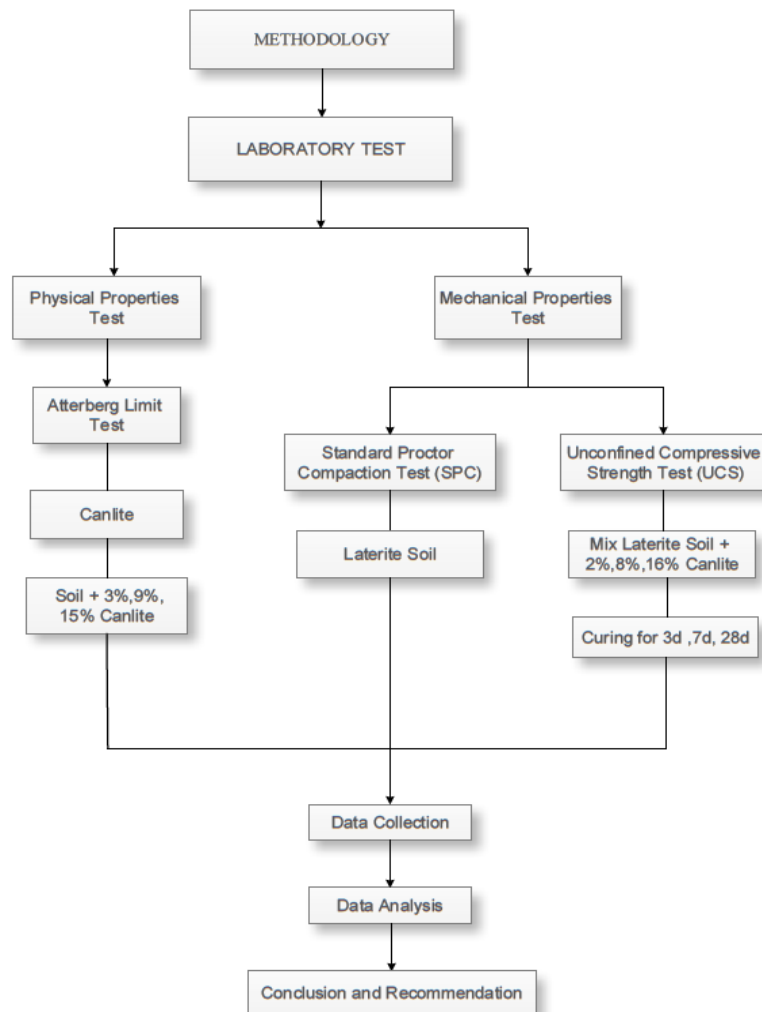


Figure 1 Testing programme



Figure 2 Wet laterite soil



Figure 3 Canlite (SS299) liquid soil stabilize

Table 1 Physical properties of laterite soil

Properties	Untreated soil (0% canlite)
Liquid Limit, LL (%)	75
Plastic Limit, PL (%)	41
Plasticity Index, PI (%)	34
Specific Gravity, G _s	2.69
Maximum dry density (Mg/m ³)	1.31
Optimum moisture content (%)	34
BS classification	MV

3.0 SPECIMEN PREPARATION

The poor Laterite soils were obtained from the hilly area around the Faculty of Electrical and Electronic, Universiti Teknologi Malaysia Skudai Johor. The amounts of Canlite and Probase soil stabilizer added to the Laterite soil were 2%, 8% and 16%.

All the treated soil samples were cured for 3, 7 and 28 days. Results obtained from the compaction tests play an important role in the preparation of treated specimen. All the treated specimens were prepared referring to the respective maximum dry densities (MDD) and optimum moisture contents (OMC) of untreated soil. The principle behind maintaining OMC for the mixtures is to maintain the consistency of comparison with control samples (i.e.

untreated samples). The required dry mass of soil samples can be calculated with the reference of the mould volume and the MDD. Predetermined quantities of Canlite was then measured based on the dry mass of soil sample and mixed until homogenous. The soil specimen was then mixed with water content corresponding to the OMC.

Then, the mixtures were compacted in 38mm X 76mm cylindrical mould with designed optimum water content and maximum dry density as specified in clause 4.1.5 of BS 1924: Part 2: 1990b.⁵ The percentages of the Canlite added to the Laterite soil was 2%, 8% and 16%.

The specimen was removed from the mould and put in the thin wall PVC tube, wrapped with thin plastic and sealed to the atmosphere with rubber tight lids. These samples were stored for curing periods, 3, 7, and 28 days in a controlled temperature room ($27 \pm 2^\circ \text{C}$). In order to ensure the accuracy of the result, three samples for each mix design for each curing time were prepared. These specimens made were used in unconfined compressive strength test (UCS) in geotechnical laboratory. In the experiment, single test was performed for each mixture for different curing time. Nevertheless, triplicate samples were first tested to make sure the repeatability and accuracy of testing data as shown in Figure 4. There were three soil specimens prepared for the control samples and being tested on the UCS test. The results obtained from the three samples were 210kPa, 250kPa and 230kPa respectively and the average of the three samples were 230kPa.

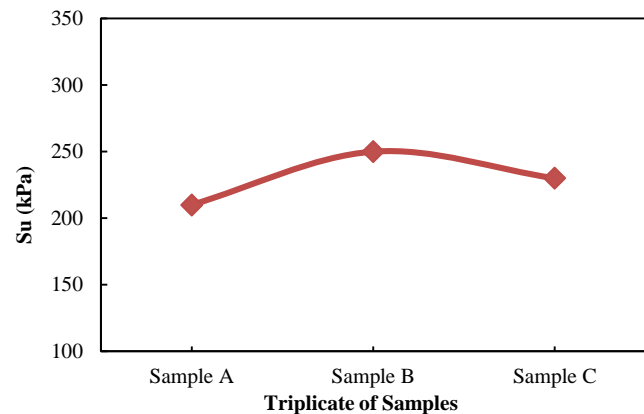


Figure 4 Repeatability data for UCS test of untreated sample

4.0 RESULTS AND DISCUSSIONS

All the result that had done in the laboratory was analysed and discuss in this chapter. The discussion will included the analysis of the before and after the soil sample treated with chemical liquid stabilization namely Canlite. Results of laboratory tests such as Atterberg Limits, compaction characteristics and unconfined compressive strength (UCS) were obtained and discussed. A standard proctor compaction test was carried out for the untreated Laterite soil. However, for the Atterberg Limits test, it was carried out for both treated and untreated for comparison purposes. The UCS test was conducted to all the soil samples with different stabilizer content at different curing period such as 3, 7 and 28 days. Samples with vary chemical percentage and difference curing period which was 3,7 and 28 days were made in order to determine the relationship between the unconfined compressive strength and curing time.

4.1 Atterberg Limit Test

The results from the soil physical properties testing which is Atterberg Limits test were analysed. In this research, Unified Soil

Classification System (USCS) will be used to classify the soil. The Liquid Limit (LL), Plastic Limit (PL) and Plasticity Index (PI) of the natural soil samples are 74.0%, 41.0% and 33% respectively. According to Whitlow (1995), liquid limit less than 35% indicates low plasticity, between 35% and 50% indicates intermediate plasticity, between 50% and 70% high plasticity and between 70% and 90% very high plasticity and greater than 90% extremely high plasticity. This shows that natural soil and mixture soil with Canlite were very high plasticity. The addition of Canlite in 3%, 9% and 15% to the samples caused the changes in the liquid limits and plastic limits which were shown in Table 2. Figure 4 shows the effect of Canlite content on laterite soil at 3%, 9% and 15%. Generally, the plasticity index of treated soil is decreased when increasing the percentage of chemical stabilizer

as shown in Figure 5. These reductions in plasticity index are indicators of soil improvement. Canlite comprises two working agents denoted as AC 101 (Alkaline Composite Ionize Polymers Volume 101) and SS 299 (Soil Stiffener 299). When the Canlite added to the Laterite soil, these two agents actually diminish the water membrane surrounding the soil particles and thus substituting the water membrane with its high plasticity, adhesive characteristic.^{6,7} As a result, the soil samples become harder as the percentage of Canlite goes higher. From the plasticity chart of Figure 6, the Canlite-treated soil was classified as “Silt with Very High Plasticity (MV)” based on USCS.

Table 2 Summary of Atterberg Limits Test

Samples	Percentage of Stabilizer (%)	Curing Period (days)	LL (%)	PL (%)	PI (%)	Plasticity Chart Classification
Untreated Sample (US)	0	0	74	41	33	Silt with very high plasticity
US + Canlite	3	0	89	65	24	Silt with very high plasticity
	6	0	90	74	16	
	15	0	90	82	8	

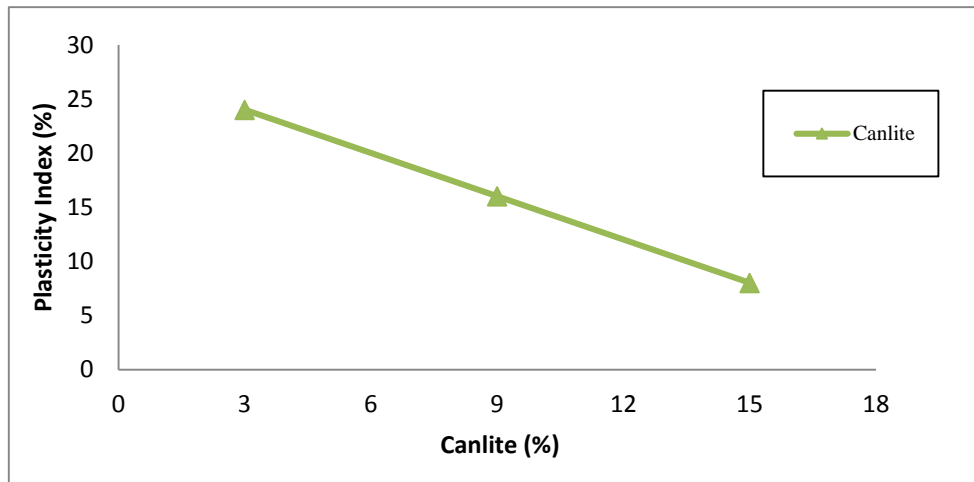


Figure 5 Effect of canlite content on plasticity index

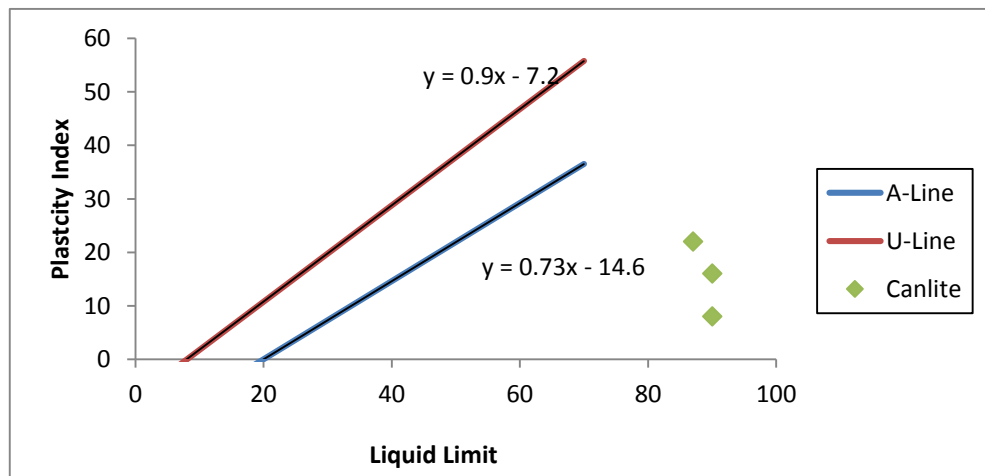


Figure 6 Plasticity chart for Canlite-treated samples

4.2 Standard Proctor Compaction (SPC) Test

Standard Proctor Compaction (SPC) standard is originally developed to simulate field compaction in the lab. The purpose of this test was to determine the optimum moisture content (OMC) at which the maximum dry density (MDD) was attained. The optimum moisture content of the sample made was used in unconfined compressive strength test (UCS). The density of the liquid base soil stabilizer which known as Canlite is same with the density of the water. Therefore, the SPC test was only conducted on the natural soil. Compaction graph was tabulated in Figure 7. From the graph analysis results for standard Proctor compaction test (natural soil), the OMC and MDD was 34.15% and 13.16 kN/m³ respectively. Insufficient amount of water will cause the specimens to be brittle while extracting it from the specimen mould. The usage of 34% of water that was used to prepare the specimens does not mean that the specimens would obtain the exact amount 34% moisture content. This was because the moisture content of the specimens would decrease due to evaporation of the water during the mixing process and during the compaction of the specimens in the mould.

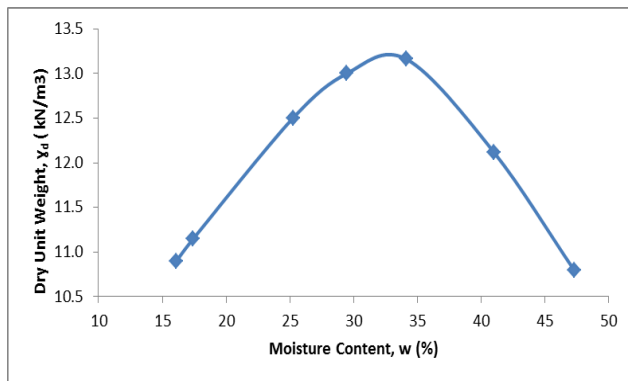


Figure 7 Compaction curved for laterite soil

4.3 Unconfined Compressive Strength (UCS) Test

The main objective of the UCS test is to determine the compressive strength of the soil samples before and after the polymer stabilization. The summary result of unconfined compressive strength of specimens with different SS299 concentration and curing time was presented in Table 3. Three samples for a particular specimen were made to ensure a more consistent and accurate results. In this section, the development in shear strength was analysed by taking into consideration on additive contents and the influence of the curing period.

From the Table 3, the compressive strength of the control sample was 230 kPa. In general, the strength of treated samples was increased significantly as SS299 concentration was added from 3% to 15%. On the other hand, the strength of treated sample also improved by increasing the curing time as compare to untreated sample in different SS299 concentration.

Figure 8 shows the important role of the polymer emulsions in the development of UCS of polymer treated soil. It is observed that the value of UCS increased, when the amount of Canlite increased. For example, 3 days UCS increased from 230kPa to 320kPa when 2% Canlite increased to 9% and further increased to 350kPa with addition of 16% Canlite; improvement of 190kPa was found at 28 days UCS when 3% Canlite added to the soil and continuous increase to 650kPa when Canlite increase to 15%. The soil used in this research was Laterite soil which contains amount of clay minerals. So, the bonding of the fine particle size in Laterite becomes stronger due to the presence of the adsorption mechanism of the polymer emulsion and an increase in value of UCS.⁸ The Canlite is categorized as cationic polymer; the molecules of the polymer can easily form an electrostatic bond with clay particles in the Laterite and cause more cohesion between the soil particles. This is another reason the UCS was improved.

Although the optimum stabilizer content was not observed in the Canlite-treated samples, but the percentage of strength improvement was found started to be constant after addition of 9% canlite content. It is therefore could be concluded that, the addition of 9% of canlite is considered as sufficiently effective to stabilize laterite soil.

Table 3 Summary result of UCS test

Samples	Water Content (%)	Compressive Strength (kPa)			
		0 day	3 days	7 days	28 days
Untreated Sample (US)	34	230	-	-	-
US + 3% Canlite	32	-	280	330	420
US + 9% Canlite	26	-	320	480	600
US + 15% Canlite	18	-	350	500	650

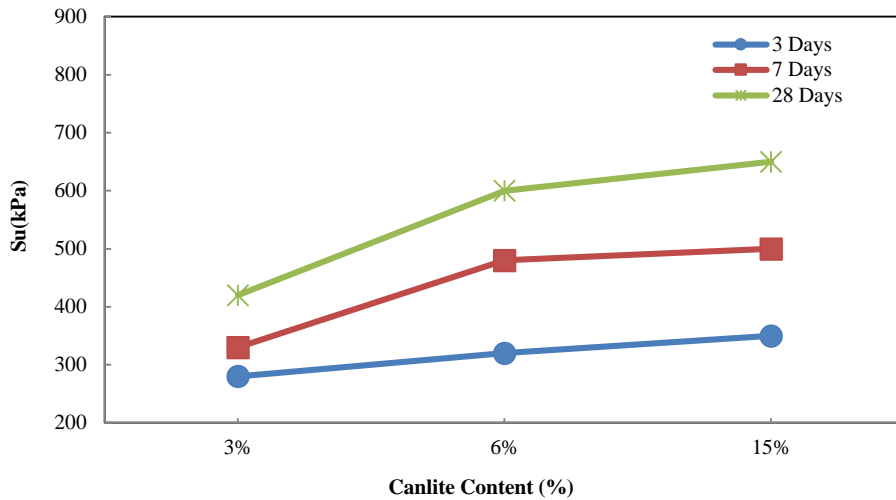


Figure 8 Effect of polymer content on the UCS of the Canlite-treated Laterite

Figure 9 presents the percentage of soil strength increment with different curing period for 3, 6, 15% concentration of SS299. All the soil samples were cured for 3, 7 and 28 days. In each case, the compressive strength increased with the increasing curing time. For instance, the compressive strength of the 6% Canlite-treated achieved 600kPa at 28 days, which was approximately 3 times greater than the strength of the natural Laterite. The Canlite gained over 100 percent of strength in 28 days. The highest strength recorded at 28days was 650kPa for Laterite treated with Canlite respectively. Principally, longer curing periods improved the reaction process between the soil particles and the liquid stabilizers because the loss of moisture content caused the soil

samples drier and harder, thus to sustain the load. Moreover, curing of the polymer emulsion taking place by “breaking” of the emulsion subsequent water loss occurs by evaporation.⁸ Besides, the breaking of the emulsion proceeds when the individual emulsion droplets suspended in the water phase combined and the emulsion particles “wet” the surface of the soil particle before the polymer was deposited on the surface.⁹ Hence, the compressive strength of the soil is affected by the amount of polymer deposited on the surface of the soil particle. The more polymers deposited on the surface, the more percentages of the liquid stabilizers, the more compressive strength it gained.

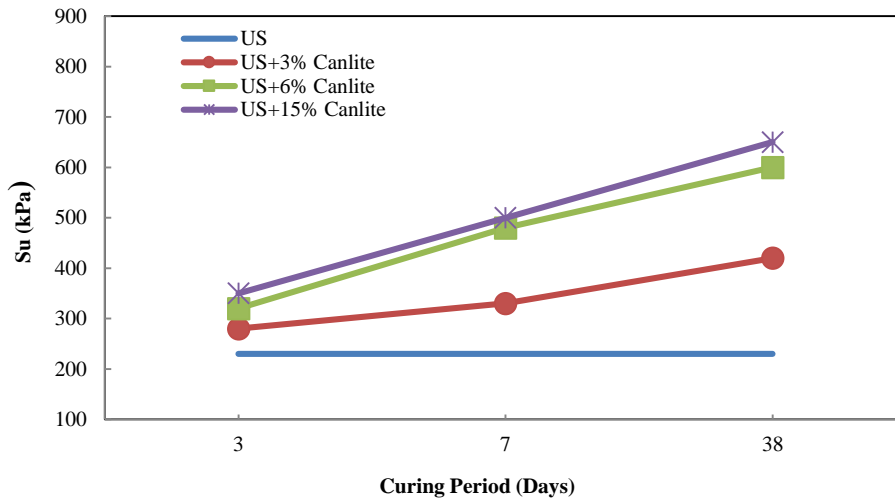


Figure 9 Effect of curing time on Canlite-treated Laterite

5.0 CONCLUSION

Based on the laboratory tests, polymer soil stabilizer (SS299) had shown a good effect on stabilization treatment of Laterite soil. In general, additional amount of SS299 causes the beneficial change in the unconfined compressive strength of Laterite soil used in this research. It was observed from laboratory testing that the properties of stabilized soil vary and depend on the concentration rate of SS299 and also the curing time. Moreover,

the UCS improves with the increased of curing time and it was mainly occurs in first 28 days.

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