

Behavior of Cochin Marine Clay Modified With Cement and Glass Powder, Cement and Glass Fiber

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ABSTRACT: Kochi, 'The Queen of Arabian Sea' also known as Cochin, is a major port city on the south-west coast of India bounded by the Arabian Sea and the Laccadive Sea and is part of the district of Ernakulam in the state of Kerala. The soil found here is clay which is highly compressible and constructions require deep foundations. From the local investigation, it was found that, the waste marine clay is dumped in land filling areas without any treatment and their by a big cheating is done to those land owners. The present study aims to convert this waste marine clay to a useful one by mixing it with cement and glass materials. Soil mixing is a type of ground improvement technique which could be applied for shallow foundations. Thus deep foundation can be avoided for light buildings in Kochi area. The cement content will increase the strength characteristics of marine clay. Reusing of dredged clay from the site could be effectively used in geotechnical applications after mixing with cement and glass powder. Samples are prepared by mixing Cochin marine clay and cement. Shear test is checked in triaxial machine and compressive strength is checked using UCC test apparatus. By considering strength and cost 16% cement by weight of soil is added and this 16% is replaced by glass powder and glass fiber. Beyond 6% glass powder both the shear strength and UCC strength was found to be decreased. Both UCC and MDD values of glass fiber are found to be greater than glass powder. Deep mixing pile is an application of dredged soil in which the dredged soil is modified and is used for the piling.

KEYWORDS: Cochin marine clay, Cement, Glass powder, Glass fiber, deep mixing pile.

I. INTRODUCTION

Construction activities causes large amount of dredging sediments generated, which cannot be used as the construction material because of its poor geophysical properties such as high water content, presence of organic matter and salt. The offshore dumping of the drudged marine soil causes many negative impacts on the marine ecosystem and the environment. Such open dumping also causes the long term damaging pollution. Almost all areas of Kochi are covered with clay soil. The construction in clayey soil is difficult because of its low shear strength and high compressibility. Marine clay stays as a waste product after the deep foundation works. A systematic method for the disposal of this bored clay is not yet developed. From the local investigation, it was found that, they are dumped in land filling areas without any treatment and their by a big cheating is done to the land owners.

Chemical stabilisation is a type of stabilization which deals with the improvement of engineering properties of soil by adding chemicals or other such materials and it is generally cost effective. These additives react with the soil usually clay minerals, with subsequent precipitation of new and insoluble minerals, which bind the soil together. Introduction

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of cement into soft ground, or cement-soil stabilisation, either in the form of dry cement powder or cement slurry is a popular method of ground improvement technique.

Glass stabilization involves the addition of broken glass powder to soil so as to improve its engineering performance. Glass has been experimented on as a substitute aggregate in asphalt concrete. Crushed glass has also been used as an aggregate for sub-base.

The present study aims to study the properties of marine clay treated with cement and glass powder, cement and glass fiber and to analyze the behavior of deep mixing piles both manually and using software (PLAXIS 2D). And also to find the optimum ratio of the admixtures to be used for getting better result and their by, to compare the behavior of stabilized soil with that of unstabilized soil. To reduce the offshore dumping of dredged soil which causes disruption to the aquatic environment.

II. MATERIALS USED

Cochin marine clays were collected from a building site near Kaloor, Ernakulam which is the major port city on the south-west coast of India. Clay was found upto a depth of 2m to 6m. The clay was greenish black in colour and it was rich with organic matters like sea shells. It poses an undesired smell. Clay collected from different bores had been mixed thoroughly into a uniform mass and preserved in polythene bags.

Various laboratory tests were done in Cochin marine clay for getting the basic soil properties. The results obtained for Cochin marine clay after the various tests are shown in Table 1.

Table 1: Properties of Clay

Test		Value
Natural water content		88.2%
Specific gravity		2.08
permeability		$10^{-4} - 10^{-5}$ cm/sec (poor drainage)
Atterberg limits	Liquid limit	94.11%
	Plastic limit	50%
	Plasticity index	44.11%
Particle size distribution	Coarse grained	31.25%
	Fine grained	68.75%
Soil classification :- CH, clay with high compressibility		
Standard proctor test	Maximum dry density	1.5 gm/cm ³
	Optimum moisture content	16%

Cement

Cement can be described as a material with adhesive and cohesive properties, which make it capable of holding material fragment into a compacted aggregate. Ordinary Portland cement of Ramco Company having grade 53 is taken for improving the strength of Cochin marine clay. The properties of cement were tested in the laboratory and the results obtained were shown in table 2.

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Table 2: Basic Cement Properties

Tests	Test results	Is code limits
Fineness	8%	<10 (IS 1489 part I)
Specific gravity	3.15	3.0 – 3.15 (IS 4031-1988)
Standard consistency	34%	33 – 35%
Initial setting time	35 min	Not less than 30 min (IS 1489 part I)
Final setting time	360 min	Less than 600 min (IS 1489 part I)

Glass powder

Glass is totally inert and therefore non-biodegradable. It degrades in a manner similar to natural rock. As an inert construction material, it can increase the strength. . The familiar type of waste glass materials found around are drinking vessel and windows, most of the readily available waste glass materials are soda-lime glass, composed of about 75% silica (SiO₂) plus Na₂O, CaO, and several additives. For this study waste glass bottles were collected from the local stores and it was powdered by using Los Angeles Abrasion apparatus. That portion which passes through 150 mm IS sieve is taken for the work.

Glass Fiber

Randomly distributed fibers offer strength isotropy and limited potential plane of weakness that can develop parallel to oriented reinforcement fibers are used to evaluate a methodology for preventing crack developments in clays due to desiccation. Glass fiber is formed when thin strands of silica-based or other formulation glass are extruded into many fibers with small diameters suitable for textile processing. For the study fiber is collected from Ernakulam. The properties of glass powder and glass fiber are shown in Table 3.

Table 3 Properties of Glass Powder and Fiber

Property		Value
Glass powder	Specific gravity	2.53
	Length	13 mm
Glass fiber	Diameter	0.034 mm
	Aspect ratio	928.5
	Fraction volume	1%
	Density	2600 Kg/cm ³

III. EXPERIMENTAL RESULTS AND DISCUSSION

Samples having 38 mm diameter and 76 mm height are casted by adding different percentages of cement. Casted samples are place in polythene bags and kept air and water tight. As the next stage the amount of cement is replaced by adding various percentage of glass powder and glass fiber and samples are prepared for testing. From the strength

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values the percentage to be replaced by the glass powder and fiber is fixed. Different proportion adopted for the sample preparation is shown in table 4.

Table 4: Sample Details

Sample	Proportion
Cement only	4, 8, 12, 16, 20 % by weight of clay
Cement + glass powder	Cement replaced by 2, 4, 6, 8 % by weight of cement
Cement + glass fiber	Cement replaced by 2, 4, 6, 8 % by weight of cement

Strength Improvement by Adding Admixtures

(i) Optimization of cement percentage

Triaxial test is used to determine the shear strength of the mix. Varying percentage of cement is added to the clay and the casted samples are placed for curing. The results obtained after doing unconsolidated undrained (UU test) shear strength test are illustrated in the fig. 4 below.

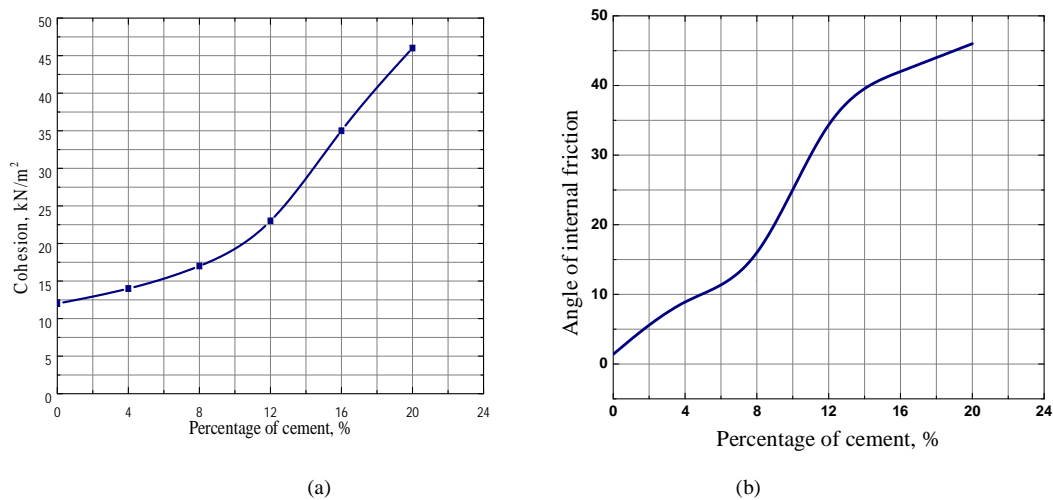


Fig. 1 Triaxial test results (a) Variation of Cohesion with cement (b) variation of Angle of Internal Friction with cement

From the tri axial test results, it is clear that, as the percentage of cement added in clay increases, the shear strength parameters such as cohesion and angle of internal friction also increases. As per Mohr - Coulomb theory;

$$S = C + \sigma \tan (\phi)$$

From this relation it is clear that, when $c - \phi$ value increases the shear strength automatically increases. Therefore we can say that as the cement content increases the shear strength also increases. By considering these basic concepts behind the cement stabilization 16% of cement by weight of soil is taken as the optimum for further studies.

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(ii) Addition of glass powder and glass fiber

Since cement is a costly material, replacement of cement will reduce the total cost of work. For doing that the cement is replaced by glass powder and glass fibers. Shear strength and unconfined compressive strength is done for its analysis.

Fig. 2 shows the variation in the (a) cohesion, when the cement was replaced by different percentages of glass materials and (b) angle of internal friction when cement was replaced by different percentages of glass materials. From the fig. 2, it is clear that 6% inclusion of glass materials can be taken as the optimum percentage for better shear strength. That is when Cochin marine clay is mixed with 10% cement and 6% glass materials (glass powder and glass fiber) we will get a good result.

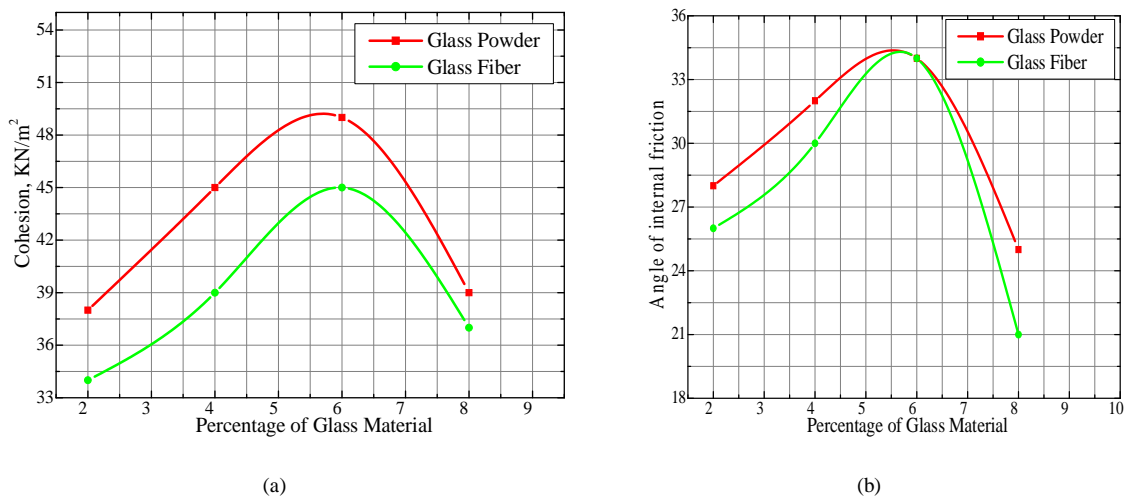


Fig. 2 (a) Variation of cohesive with percentages of cement content and glass material content (b) Variation of angle of internal friction with percentages of cement content and glass material content

Fig. 3 shows the variation of UCC strength with cement and Glass Material. From fig. 3, it was found that, as the percentage of glass materials replaced by the cement increases, UCC strength of the clayey soil increases but the after 6% of replacement of cement by glass materials the shear parameters decreases. Also it was clear that the strength increases with the time. Now we got the optimum mix containing clay + 10% cement + 6% glass powder and clay + 10% cement + 6% glass fiber.

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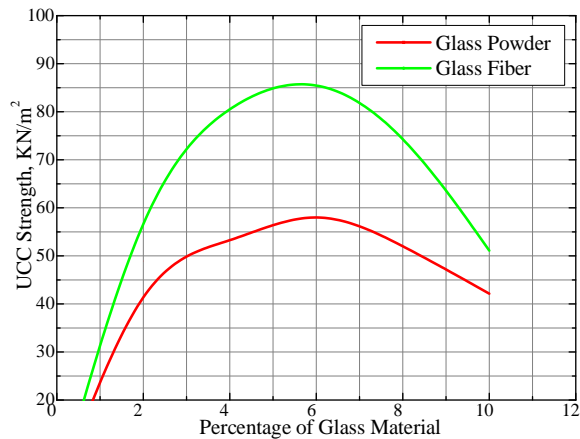


Fig.3 Variation of UCC strength with cement and Glass Material

IV. DEEP MIXING PILE

Mixing creates mass or column soil-cement (soilcrete), used for soil stabilization, as earth support, or as foundation support. Cost is very low comparing with the precast pile and in-situ cast pile. Cost is very low comparing with the precast pile and in-situ cast pile. This excavated clay can be incorporated in the forming the deep mixing columns.

Laboratory analysis

Models had made with both glass powder pile and glass fiber pile. Loading is continued upto 2.5mm settlement and the corresponding load settlement variations of soil + cement + glass powder (S+C+GP) and soil + cement + glass fiber (S+C+GF) are represented in fig. 5 (a) and (b) respectively.

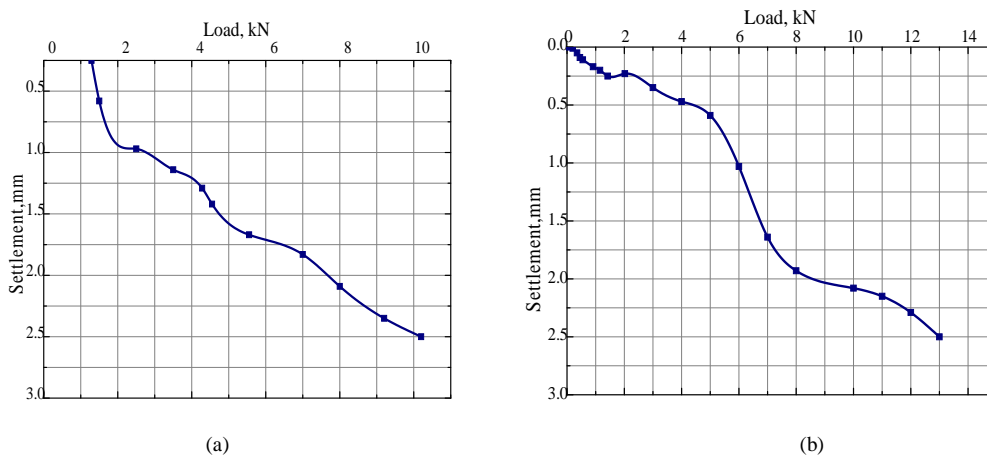


Fig. 5 Load settlement analysis (a) Glass powder pile (b) Glass fiber pile

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The S+C+GF pile can take about 13kN load for 2.5mm settlement. The S+C+GP pile can takes 10.2kN load for 2.5mm settlement.

Analysis on PLAXIS

Let's consider a deep mixing pile through an 11m thick clay layer into sand of 7m thick. Since the pile driving is a dynamic process vibrations are caused in the surrounding soil. So while analysis these vibrations have to be considered. Fig. 6 shows the geometry model of soil strata after assigning the material properties in PLAXIS 2D.

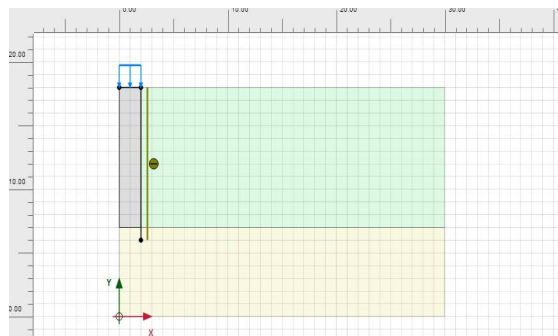


Fig. 6 The geometry model

The calculation of the generated mesh diagram consists of 3 phases. In the initial phase, the initial stress conditions were generated and the pile is constructed. In the second phase the pile is subjected to a single stroke, which is simulated by activating half a harmonic cycle of load. In the third phase the load is kept as zero and the dynamic response of the soil is analysed in time. Fig. 7 shows the shear stress diagram of soil layers after providing piles.

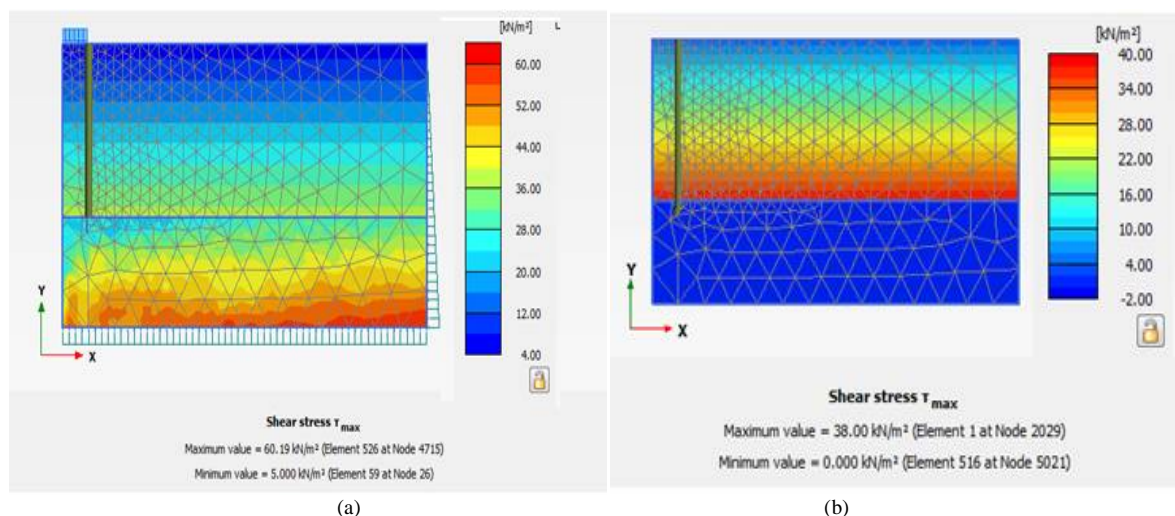


Fig. 7 Shear stress diagram (a) soil layer on glass powder piles (b) soil layer on glass fiber piles

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After the calculations a pictorial representation of the results were obtained for both glass powder pile and glass fiber pile. Fig. 8 shows the Effective normal stress diagram of soil layers after providing piles.

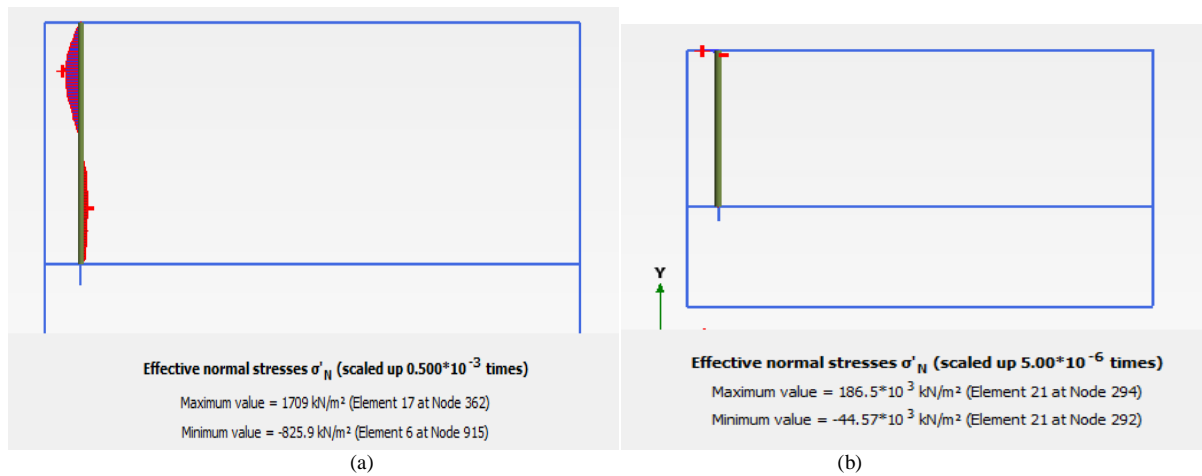


Fig. 8 Effective normal stress diagram (a) soil layer on glass powder piles (b) soil layer on glass fiber piles

Fig. 9 shows the deformation versus time graph. The maximum vertical settlement for glass powder pile is less than 10mm and final settlement observed is less than 7mm. in the case of glass fiber pile maximum settlement and final settlement observed is nearly 7mm.

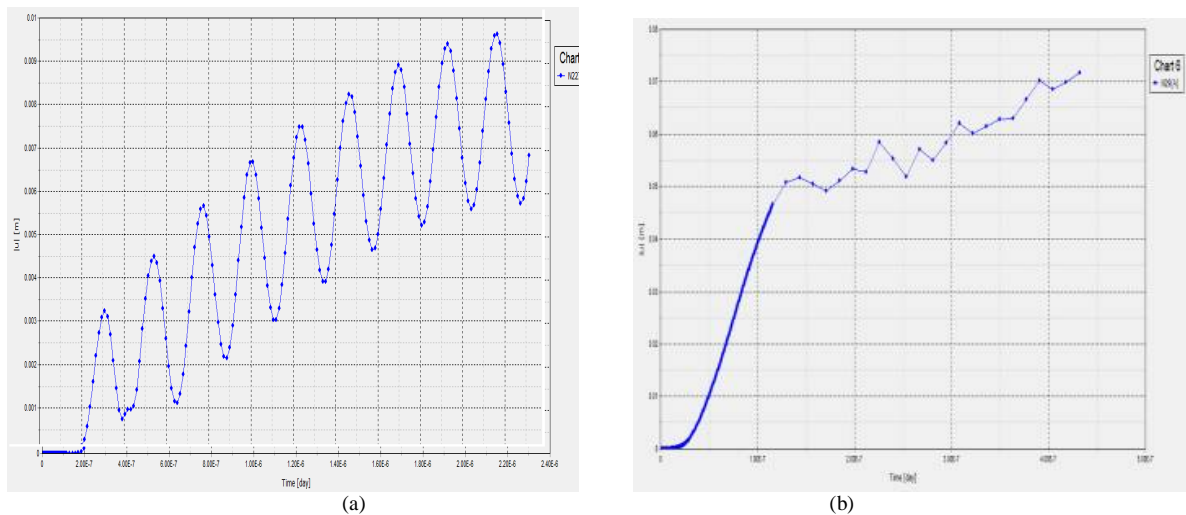


Fig. 9 Deformation versus time graph (a) soil layer on glass powder piles (b) soil layer on glass fiber piles

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V. CONCLUSION

- The shear strength and UCC strength is improved by adding cement and glass materials to the clay.
- As the percentage of cement increases the shear strength also increases. 16% inclusion of cement was considered as the optimum mix.
- Upto 6% replacement of cement by glass materials the strength increases, beyond that strength decreases.
- Cohesion, angle of internal friction, OMC yields for glass powder but the UCC strength and MDD yields for glass fiber.
- For 2.5mm settlement glass fiber pile take more load than glass powder pile.
- From PLAXIS, it was found that, with time S+C+GF pile undergo less deformation than S+C+GP pile.
- Shear strength of pile S+C+GP pile is found twice the shear strength of S+C+GF pile.
- The effective stress and maximum deformation is obtained for S+C+GF pile is more than S+C+GP piles.

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