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STUDY ON ENHANCEMENT OF THAMARACHAL CLAY AND ITS UTILIZATION IN BRICK MAKING

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Abstract

Thamarachal lake located at Puliyoor, Chengannur, Kerala is a waterbody of high strategic importance in the Chengannur municipality. As part of rejuvenation of the lake, an estimated quantity of 43200 m^3 of silt is proposed to be dredged in order to enhance the water storage capacity of the lake. This study focuses on utilizing the dredged material to be used as a potential construction material instead of merely storing in waste dumps. The geotechnical properties of the Thamarachal clay were tested and compared with clay from a factory which is generally used in brick making. It was found that the basic properties were comparable with the clay used in brick factory. Further, different sets of bricks were cast in moulds and subjected to unfired and fired conditions of drying. Unfired Thamarachal clay bricks were of less strength than standard unfired factory bricks but since it is in the range of 1.74 N/mm^2 and 6.24 N/mm^2 it is considerably okay. Fired Thamarachal clay bricks showed less strength and were broken. Thus, inclusion of other available substitutes for further enhancement of these bricks made of Thamarachal clay were considered. By mixing 60% of Thamarachal clay with 40% of an admixture clay, it was observed that there is improvement in properties in terms of compressive strength and water absorption. From the results obtained by conducting various tests on 2 sets of 15 bricks made of Thamarachal clay and mixed clay (Thamarachal and admixture clay) respectively, the strength is observed to be higher for the latter set of bricks which can thus be manufactured for commercial purposes.

Keywords: Thamarachal clay, Admixture clay, Brick making, Properties.

1. INTRODUCTION

Thamarachal lake located at Puliyoor, Chengannur is a waterbody of high strategic importance in the Chengannur municipality. The water body was the major source of drinking water and irrigation for the villagers in the near past. In due course of time, the proliferation of floating aquatic vegetation, siltation, deterioration of water quality due to nutrient loading affected the lake ecosystem considerably leading to reduction in biodiversity in the lake. The water spread area was approximately 15200m^2 and the water is available only for a depth of 0.5 to 0.6m. There is an urgent need for rejuvenation of this lake with primary focus being on the enhancement of water storage. The bed sediments of Thamarachal lake consist of peat soil (organic matter around 78%) for the top 40 cm, silty clay with organic matter around 30% for the next 1 m and silty clay for the next 8m. According to the project proposal for rejuvenation of the lake by expert committee of TKM College of Engineering, the total quantum of soil to be dredged is estimated as 43200m^3. The desilted matter may be dumped at the sites specified as dumping yard after partial removal of water content. After dumping, there may be significant

Fig. 1 Thamarachal site view

reduction in the volume of soil due to the degradation of organic matter. The clayey soil dredged out from the lake can be potentially used as construction material (say, large scale production of bricks or building blocks).

Charai et al. (2020) compared clay bricks before and after firing. The results proved the high thermal stability of fired clay bricks compared to the unfired bricks. Kizinievič et al. (2018) researched on how ecofriendly materials can be put into use for building materials are gaining popularity and this industry is growing rapidly. Green building materials have attracted attention recently due to sustainability issues. Jayasinghe (2007) proposed Compressed Stabilized Earth Bricks as an alternative for clay bricks. He compared the properties of CSEB with that of burnt clay bricks. Sutcu et al. (2015) studied the replacement of specific percentage of clay with marble waste powder. Replacement by a maximum of 30% marble waste improved the strength of brick. According to Hanifi et al. (2005), compressive strength of burned clay bricks can improve by fibre reinforcement. From the study conducted by Ravindaran et al. (2020), 30% replacement of clay to M sand gives better results in strength, water absorption and compression strength.

The aim of the project is to convert the huge quantity of clay left unutilized in the chira into useful masonry units. For making a building unit out of clay soil, its properties including strength, durability, size and ability to absorb water should be studied. The clay from Thamarachal Chira was collected from a depth of approximately 90 cm to 100 cm. Thamarachal site view is shown in Fig. 1 Testing of this clay was carried out in the geotechnical laboratory of TKMCE and the results have been studied in detail. Comparative study of soil properties between the obtained clay as well as clay collected from a factory used to make bricks are also done. Admixture clay was added inorder to improve the properties of the brick.

2. MATERIALS AND METHODS

Apart from the Thamarachal Clay, few other clays were tested such as the standard clay with which standard bricks are prepared and another set of admixture clay which comprises of two types of clay. The admixture clay consists of yellow coloured clay which constitutes the major proportion and is the locally available one. The second one is a dark bluish black clay which has very high adhesive property, its

Fig. 2 Thamarachal clay

proportion varies in accordance to the local clay's quality. Disturbed sample of clay that was obtained from Thamarachal chira is shown in Fig. 2. And the properties of clay are compared with each other.

Testing of the clay was done in order to determine its properties and to know whether they have the sufficient qualities to be converted into a potential building unit. Thamarachal clay was compared to the properties of standard brick clay after the further testing of latter clay. Bricks prepared from Thamarachal clay was compared to the factory bricks and to improve the strength admixture clay was added. It comprises of yellow clay, and dark blueish black clay in the proportion 5:2. New set of brick were prepared using 40% admixture clay and 60% Thamarachal clay, and its properties were tested.

2.1. Laboratory Testing and Analysis for Clay

In order to compare the properties of clay, tests like Specific gravity test, Atterberg limits, Hydrometer analysis, Wet sieve analysis, Unconfined Compressive Strength test and Swell test were carried out for Thamarachal clay, Factory Brick clay and Admixture clay.

The determination of specific gravity was done according to IS 2720 – 3 (1980). Atterberg limits were found according to IS 2720 – 5 (1985). As per ASTM D 7928-17, hydrometer analyses were

conducted for the determination of grain size distribution of particles of soil finer than 75 microns.

The percentage silt and clay were obtained from wet sieve analysis according to IS 1607(1977). Unconfined Compressive Strength (UCS) stands for the maximum axial compressive stress that a soil specimen can bear under zero confining stress. Unconfined Compressive Strength test and Swell test were carried out according to IS 2720 (Part-10)-1973 and IS 2720 – 40 (1977) respectively.

2.2. Procedure for hand moulding of brick

The steps adopted were as follows:

1. Removal of stones and other unwanted materials from clay
2. Thorough mixing of dry clays by adding 30% water
3. Mould of size 24.1cm x 11.4cm x 7.6cm were made using wood, shown in Fig. 3(b)
4. Properly mixed clay filled into the mould without air voids
5. Filled clay is pushed through the mould from top and left for air drying for 10 days
6. The unfired handmade bricks made (Fig. 3(a)) can be further taken for firing in kiln

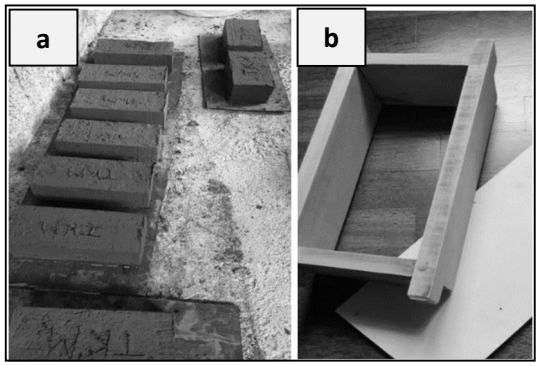

Fig. 3 Moulding (a) Hand mould brick using Thamarachal clay; (b) Mould

2.3. Laboratory Testing and Analysis for Bricks

In order to know the properties of clay bricks, tests like Soundness Test, Shape and Size, Colour, Hardness Test, Compressive strength test, Water absorption and Efflorescence were carried out using fired factory bricks and fired mixed clay bricks, according to IS 1077(1922). Compressive Strength test was done for Unfired Factory bricks and Unfired Thamarachal bricks.

3. RESULTS AND DISCUSSION

3.1. Clay

Three trials were conducted for each test on Thamarachal clay, Factory Brick clay and Admixture clay. The specific gravity obtained for brick clay is 2.62 and that of Thamarachal clay is 2.48. Compared to Thamarachal clay and brick clay, Admixture clay shows lower specific gravity of 2.28. The lower values of specific gravity indicates the presence of organic matter. The result from wet sieve analysis shows that the percentage of silt and clay comprises the majority proportion, hence can be classified as silty clay. For Thamarachal clay the percentage of silt and clay obtained was 84.5%, likewise for brick clay it was obtained as 80%. For admixture clay the percentage of silt and clay was 83.4%. Table 2 shows Wet Sieve Analyses Results of Thamarachal clay, Brick Clay and Admixture Clay.

From Hydrometer analyses on Thamarachal clay, the average clay content obtained from three trials was found as 50.3%. Average silt content in the tested sample was found to be 39% and the sand content was 10.7%. Table 1 shows the distribution of particles of the three clays. Particle size distribution Chart of Thamarachal Clay, Brick Clay and Admixture Clay are shown in Fig 5. The swell index for Thamarachal clay is obtained as 9.1% and that for brick clay is 4.5%. For admixture clay the values of swell index is 11.4%. Since the value of swell index of Thamarachal clay, brick clay and admixture clay are less than 20%, the degree of expansiveness is under low category.

Atterberg Limits

Four stages of consistency namely liquid, plastic, semi–solid or solid state are used to describe the consistency of soil. The water contents at which the soil passes from one state to the next are known as consistency limits or Atterberg's limits. Liquid limit, plastic limit, shrinkage limit and plasticity index of Thamarachal clay, Factory Brick clay and Admixture clay were studied. The liquid limit obtained for Thamarachal clay is 48.8%. For factory clay the value

of liquid limit is obtained as 40%. For admixture clay a slightly higher value of 49.3% was obtained. The average plastic limit for trials of Thamarachal clay is obtained as 27.4% and that for brick clay is 20.6%. For admixture clay the values of plastic limit is 34.2%. The higher value for plastic limit in admixture clay suggests a slightly higher water content to attain its plastic limit as compared to that of brick clay. Even though the plastic limit of Thamarachal clay is slightly more than that of brick clay they are comparable. The shrinkage limit of Thamarachal clay is 23.2% and that of brick clay is 30.1%. Value of shrinkage limit for admixture clay is 15.5%.

The plasticity index of Thamarachal clay is 21.5% and that of brick clay is 19.4%. Also, for Admixture clay it is 17.2%. From the Plasticity index chart shown in Fig. 4, it is found that the Thamarachal clay comes under the region for 'silt or organic matter of intermediate compressibility', brick clay comes under 'clays of intermediate compressibility' and the admixture clay comes under the region of 'silt or organic clays of high compressibility'.

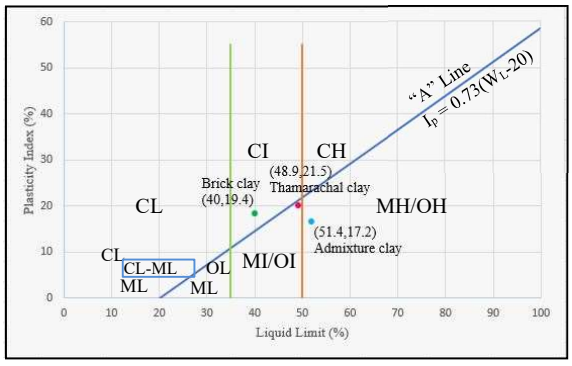

Fig .4 Plasticity Index Chart

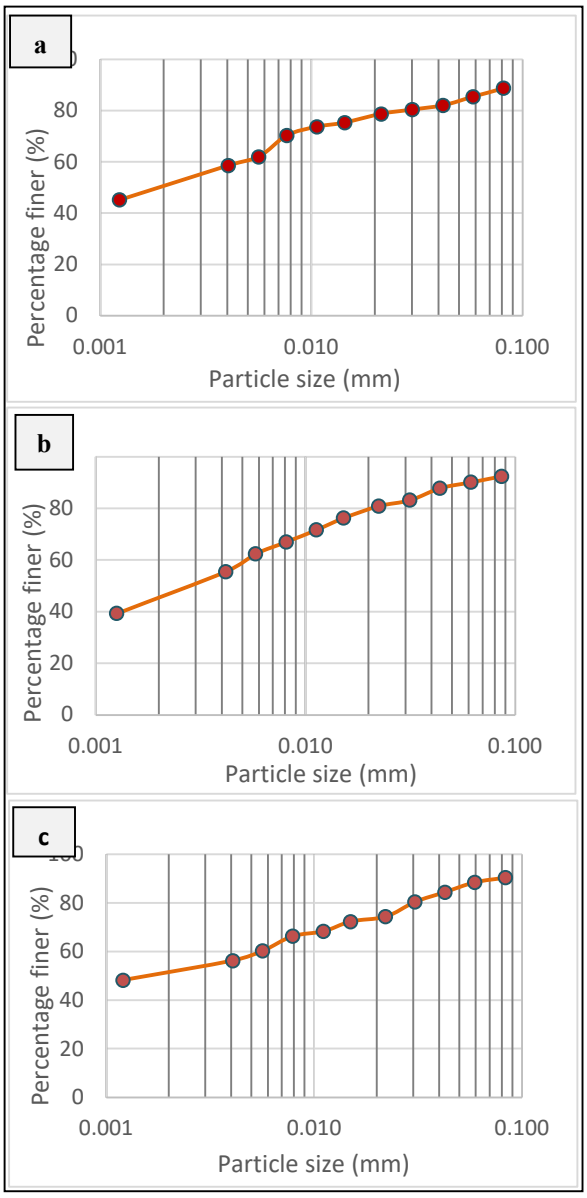

Fig. 5 Particle size distribution Chart: (a) Thamarachal clay; (b) Brick clay; (c) Admixture clay

Table 1 Hydometer Analysis Results

	Thamarachal clay	Brick clay	Admixture clay
Percentage sand	10.7	9.7	11.3
Percentage silt	39	45.7	38.3
Percentage clay	50.3	44.7	50.3

Table 2 Wet sieve Analysis Results

	Thamarachal clay	Brick clay	Admixture clay
Percentage gravel	0	0	2.8
Percentage sand	15.5	20	13.8
Percentage silt & clay	84.5	80	83.4

Unconfined Compression Test

The unconfined compressive test results for Thamarachal clay, brick clay and admixture clay specimens were used to plot the graph of stress vs strain. Fig 7 shows Unconfined Compressive Strength of Thamarachal Clay, Brick Clay and Admixture Clay. The unconfined compressive strength of admixture clay is almost double as that of Thamarachal clay. This shows that addition of admixture clay can improve the strength of the bricks. Table 3 shows unconfined compressive strength and cohesion of the three clays.

3.2 Unfired Brick

Three trials of Compressive Strength test was done for both Unfired Thamarachal bricks and Unfired Factory bricks. The bricks were of dimension 23cm×11.1cm×7.2cm.

Compressive strength

Compressive strength test on bricks is carried out to determine the load carrying capacity of bricks under compression with the help of compression testing machine. Test was carried out on unfired handmade bricks from raw Thamarachal clay and unfired factory clay. Fig. 6 shows Compressive Strength Test of Unfired Thamarachal Brick. The average compressive Strength for unfired Thamarachal Brick obtained as 2.05 N/mm^2 and for Unfired Factory brick it was obtained as 2.96 N/mm^2. Unfired Factory brick takes higher load than Thamarachal bricks and gives slightly higher compressive strength.

Fig. 6 Compressive Strength Test of Unfired Thamarachal Brick

Table 3 Unconfined compressive strength results

	Thamarachal Clay	Brick Clay	Admixture Clay
Unconfined Compressive Strength	13.62 kN/m^2	10.73 kN/m^2	20.57 kN/m^2
Cohesion	6.81 kN/m^2	5.36 kN/m^2	10.28 kN/m^2

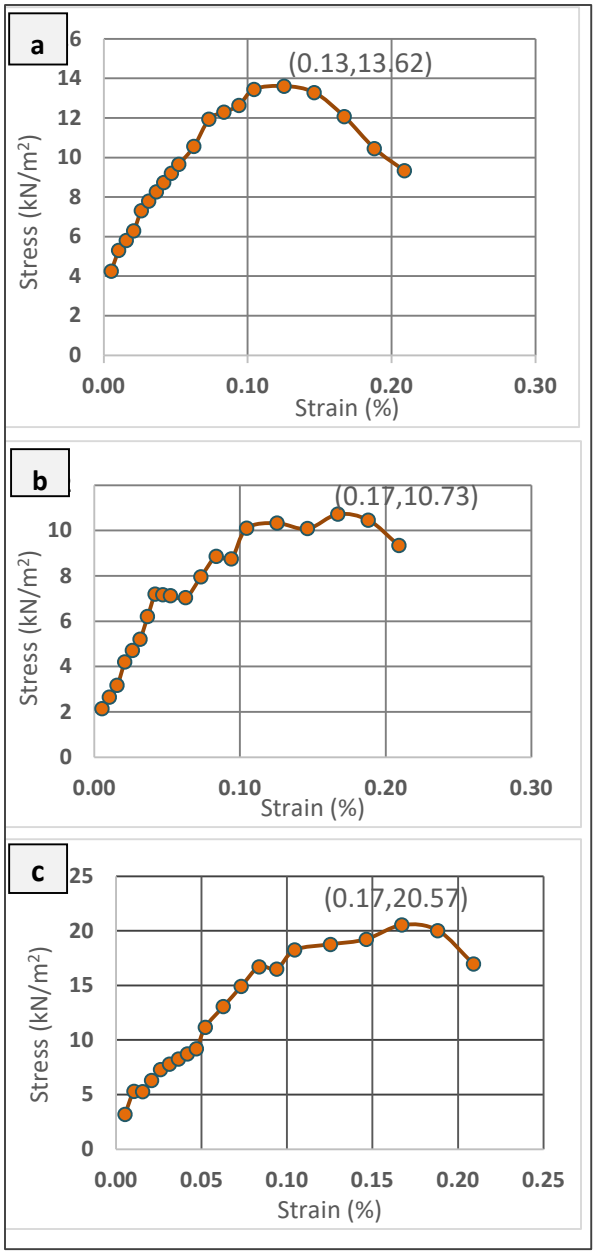

Fig. 7 Unconfined compressive strength: (a) Thamarachal clay; (b) Brick clay; (c) Admixture clay

3.3 Fired Brick

It was found that Thamarachal Clay alone when made into bricks were not strong enough because it was found to broken after firing. The addition of 40% admixture clay improved the strength and properties of the brick. Factory and mixed clay bricks had dimension of 22.8cm×10.6cm×7cm and 22.8cmx10.8cmx7cm respectively. The shape of bricks were rectangular with sharp edges. Color observed for the fired bricks were copper red.

Factory bricks and mixed clay bricks were struck against its own variant and produced a metallic ringing sound without the bricks breaking, this indicates that the bricks are well burnt. Both factory and mixed clay brick were found to resist scratches against sharp objects. Upon dropping from a height of 1m, both factory as well as mixed clay brick did not break. Mixed clay brick and factory brick had a volume shrinkage of 17.4% and 18.9% respectively. This shows that the mixed clay brick has a better volume shrinkage property. Only a slight efflorescence was observed in factory bricks and mixed clay bricks.

Compressive strength test

The average compressive strength of factory brick was obtained as 8.53N/mm^2 and mixed clay brick as 9.24 N/mm^2. Both satisfies the minimum compressive strength of Class II bricks, i.e., 6.87N/mm^2.

Water absorption

The average water absorption of factory brick was obtained as 21.0% and mixed clay brick as 17.5%, which conforms to IS specification. The mixed clay bricks show lesser water absorption than factory bricks.

4. CONCLUSION

From the various tests conducted on the different clays, the properties of mixed clay bricks are found to be desirable as compared with the standard factory bricks. The unconfined compressive strength of Thamarachal clay is found to be greater than standard factory brick clay. The remaining soil properties showed similar values for Thamarachal clay, factory clay as well as admixture clay. The values of compressive tests done on unfired bricks made from raw Thamarachal clay was 2.05 N/mm^2 which is of less strength when compared to that of standard factory bricks. Also, those bricks made of raw Thamarachal clay after firing were found to be broken, hence Thamarachal clay alone cannot be used for making fired bricks. Therefore addition of admixtures is required. Test results of mixed clay bricks which comprises of 40% admixtures and rest 60% Thamarachal clay showed improved properties than

standard factory bricks. The unconfined compressive strength value for admixture clay was double to that of Thamarachal clay which indeed led to an increase in the compressive strength of fired mixed clay bricks. There was an increase in compressive strength from 8.53N/mm^2 for fired factory bricks to 9.24N/mm^2 for fired mixed clay bricks. Thus, both tested factory bricks and mixed clay bricks comes under class II brick category. Thus, from this study it can be concluded that Thamarachal clay can be converted into a good quality masonry unit upon enhancement using 40% of admixture clay (which is made of yellow clay and dark blueish black clay in the ratio 5:2). This work presents an engineering solution for the effective use of the waste clay material from Thamarachal lake in construction activities. The bricks made through this project would be helpful for housing projects for the poor, proposed under the life mission project of Kerala government.

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