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Devchand College, Arjunnagar,
Kagal, Kolhapur, MS. India.



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Day & Date: Tuesday, 30th October, 2018

Venue: Devchand College, Arjunnagar, Kagal, Kolhapur, MS, India.

CERTIFICATE

This is to certify that

Prof./Dr./Mr./Ms./Mrs. **Kanad Kumbhar** *of*
Appasaheb Birnale College of Architecture, Sangli-416416, Maharashtra, India.

has participated and presented a research paper entitled

Some Investigations in Physico-Chemical Properties of White Clay: A Futuristic Vernacular Building Material

at International Multidisciplinary Conference Organised by Devchand College, Arjunnagar, Kagal, Kolhapur, MS. India on Tuesday, 30th October, 2018.

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(Journal No. 40776)**



**AN INTERNATIONAL MULTIDISCIPLINARY
QUARTERLY RESEARCH JOURNAL
ISSN 2277-5730**



AJANTA

**Volume - VII, Issue - IV
English Part - VIII
October - December - 2018**

**IMPACT FACTOR / INDEXING
2018 - 5.5
www.sjifactor.com**

AJANTA PRAKASHAN

ISSN 2277 - 5730
AN INTERNATIONAL MULTIDISCIPLINARY
QUARTERLY RESEARCH JOURNAL

AJANTA

Volume - VII

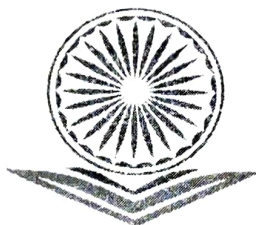
Issue - IV

October - December - 2018

English Part - VIII

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and UGC Listed Journal

Journal No. 40776



ज्ञान-विज्ञान विमुक्तये

IMPACT FACTOR / INDEXING
2018 - 5.5

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Ajanta Prakashan
Aurangabad. (M.S.)

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5. Some Investigations in Physico-Chemical Properties of White Clay: A Futuristic Vernacular Building Material

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Abstract

The history of modern building materials and architecture cannot be stretched beyond 100 years. Still it has great impact on environment and natural resources. It has been estimated that 45 percent of worldwide energy use, 80 percent of potable water and 40 percent of timber harvest is accounted by building activities. The abundant buildings account for 40 percent of municipal solid waste and 30 percent of green house gas emission contributing to global warming. This indicates that the modern building philosophy and technology is not sustainable. Therefore there is an urgent need of revolution in philosophy, technology and materials. The best way is to look at ancient vernacular buildings which have history of more than Ten thousand years. The present work deals with a man made building material, popularly called as 'white clay' or GadhikiMitti. So far no work is found in this regard. Therefore the physico-chemical properties and chemical analysis of white clay is presented and discussed the miraculous behaviour like water seepage, non capillary porosity and absence of cement or lime shown by the material.

Keywords: White Clay Brick; Vernacular Architecture; Physico-Chemical Properties; Building Material

1. Introduction

The construction activities world-wide are main cause of environment depletion and increasing the green house gases. A study in united states reveals that the construction accounts

for 45% of worldwide energy use 80% of potable water used and 50% of timber in north America in addition to that the 40% of municipal solid waste is building debris and 30% of U.S. greenhouse gas emission is caused by the construction activities [1-2].

If one considers the development of architecture and civil building history, the natural resources used for the construction activities in last 100 years are more than those used during 10000 years before last century. The vernacular architecture worldwide represents the collective wisdom of the society leading to less energy, less material, local material, and reusable material. Modern construction industry uses most of the perishable resources like cement, coal, steel etc. And it leads to no sustainable development pattern. Oliver et al. Researchers from oxford institute for sustainable development are estimated that over 90% of structures in existence were designed by the owners and their friend but not architects [3].

The vernacular architecture, traditional buildings are extensively documented in encyclopaedia of vernacular architecture published in 1997 [4]. However this extensive work has missed a miraculous Indian building material called as white play or Gadhi Ki Mitti. This is an artificial preparation from local clay in 11 to 13th Century. It is supposed that with the discovery of gun powder in China the Huns and Mongoles invaded India with big canons and the stone was cannot withstand against the canons. Therefore the people discovered a method of processing local soil microbially so as to achieve miraculous properties like anticracking, antihistaminic, water repellent and insulating. This prove to be a building material, cementing material and plasting material no burning or transportation is involved in the process hence it has zero carbon foot print. So far no information is available on either internet or literature related to this material. In present paper we have tried to investigate some of the physic-chemical properties of this ancient futuristic material. The physic-chemical analysis of white clay along with density, thermogravimetry and water seepage exercise is under taken.

2. Experimental

2.1 Materials

The white clay brick sample has been collected from Nandani Village, Kolhapur District, Maharashtra, India from around 150 year old house. For comparison kiln burnt brick and stabilised mud brick has been collected from local sites near the Nandani Village. The entire chemicals used to determine the physic-chemical parameters were of analytical grade and were

used without any further purification. The distilled deionised water has been used throughout the experiment.

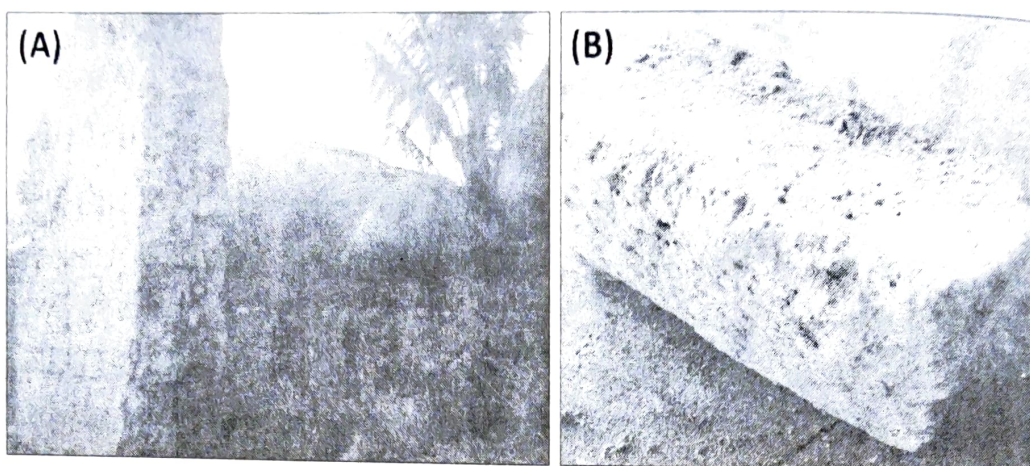


Figure 1. (A) 150 Years Old Vernacular House Built by (B) White Clay Bricks.

2.2 Methods

The water seepage measurements were carried out by dipping the brick samples in water up to 210 seconds with 30 second increment. The weight loss due to heating has been determined by gravimetric analysis. The effect of heating with respect to weight loss has been determined by thermo gravimetric analysis technique using DSC-TGA; Universal V4.5A Instrument (model: SDT Q600 V20.9). The density (d) of the samples was determined using the general equations, $d=m/V$; where m is the mass and V is the volume of sample brick. The chemical soil assay such as pH, E.C., organic carbon, potassium, and phosphorus was carried out using known reported methods. The micronutrients such as Manganese (Mn), Iron (Fe), Zinc (Zn) and Copper (Cu) have been determined using atomic absorption spectrometer (AAS, Model- Systronics, India). The compressive strength measurements were carried out using UTM machine.

3. Results and Discussion

3.1 Water Seepage Study

The water seepage study has been carried out at different time intervals with an increment of 30 seconds at ambient temperature and the results are as shown in table 1. It is observed that the water permeability due to porosity in the brick is compared with two types of burnt bricks. It has been observed that though the white clay brick is more light and porous than remaining two. The water seepage is far less than burnt bricks indicating the material is water repellent and withstand for more time in rainy area. The density of the unburnt white clay brick is 1199.81

kg/M³ and that of modern county kiln brick is 1246.02 kg/M³ while roasted ancient brick has intermediate density of the order of 1218.97 kg/M³.

Table 1. Water seepage study at different time intervals of different brick samples

| Sample | Sample Weight (kg) | Amount of water seepage in (kg) | | | | | | | Density study (kg/M ³) |
|-----------------------|--------------------|---------------------------------|-------|-------|-------|-------|-------|-------|------------------------------------|
| | | 30 s | 60 s | 90 s | 120 s | 150 s | 180 s | 210 s | |
| White clay brick | 2.576 | 0.119 | 0.170 | 0.213 | 0.241 | 0.262 | 0.278 | 0.296 | 1199.81 |
| Roasted ancient brick | 1.452 | 0.336 | 0.395 | 0.403 | 0.404 | 0.405 | 0.407 | 0.407 | 1218.97 |
| Kiln burnt brick | 2.166 | 0.418 | 0.459 | 0.464 | 0.469 | 0.469 | 0.469 | 0.469 | 1246.02 |

3.2 Thermo-Gravimetric Analysis:

The results of thermo gravimetric analysis (Figure 1) reveal that the material contains the moisture, bonded water, carbon from biomass and carbonates. The superficial moisture seems to be removed at about 55 °C. Further weight loss at 125 °C can be attributed to loosely bonded water by non bonding interactions. Above 350 °C carbonates and or sulphates of alkaline earth metals might be decomposing showing major 6.392 % weight loss.

Table 2. Loss in Weight by Gravimetric Method of White Clay Brick Sample

| Sr. No. | Time of heating(hr) | Heating Temperature (°C) | Loss in weight(%) |
|---------|---------------------|--------------------------|-------------------|
| 1 | 1 | 400 | 0.0781 |
| 2 | 1 | 800 | 0.1239 |

Table 3. DSC-TGA Analysis Showing Weight Loss at Different Temperature of White Clay Brick Sample

| Temperature | 55 °C | 125 °C | 350 °C | 500 °C | 630 °C |
|-------------|----------------------|--------|-----------------|-----------------|---------------|
| % loss | 5.225 | 4.112 | 2.493 | 2.274 | 1.625 |
| Loss due to | Superficial moisture | Water | CO ₂ | CO ₃ | decomposition |

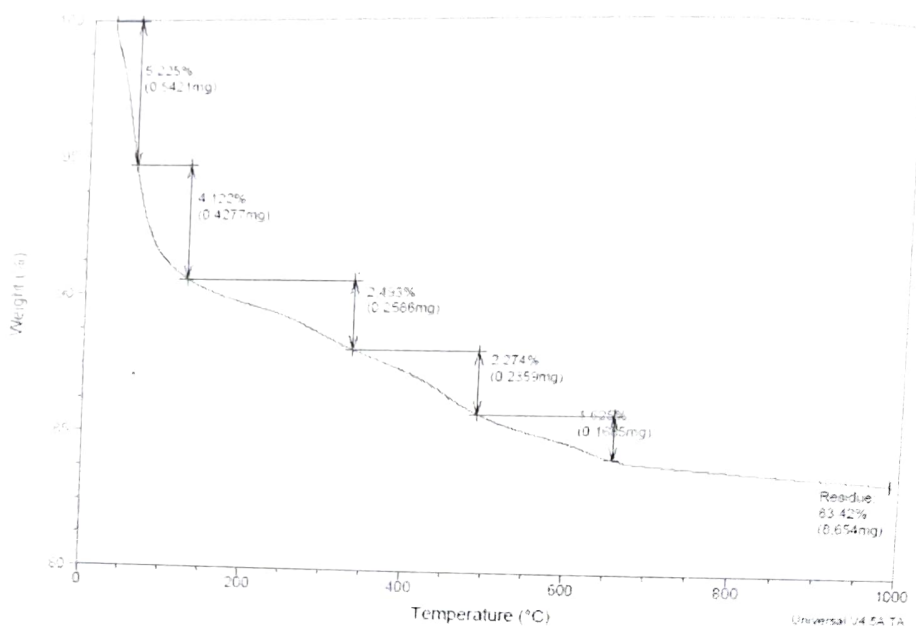


Figure 2: DSC-TGA Micrograph of White Clay Brick Sample

3.3 Physico-Chemical Parameters:

The physico-chemical parameters are shown in table 4. The white clay brick material is nearly neutral, ruling out the presence of cement or lime. The electrical conductivity is moderate, of the order of 0.99 mS/cm. The material shows poor carbon content which is characteristic of local agricultural soil. The high percentage of K and P and low percentage of micronutrients shows that the people used the clay wisely for brick making.

Table 4. Physico-Chemical Parameters of White Clay Brick Sample

| Sr. No. | Parameter | Result |
|---------|----------------|-------------|
| 1 | pH | 7.84 |
| 2 | E.C. | 0.99 mS/cm |
| 3 | Organic carbon | 0.69 % |
| 4 | Potassium (K) | 4594 kg/ha |
| 5 | Phosphorus (P) | 3.520 kg/ha |
| 6 | Mn | 12.51 ppm |
| 7 | Zn | 6.332 ppm |
| 8 | Cu | 5.332 ppm |
| 9 | Fe | 3.912 ppm |
| 10 | Ca | 3.7815% |

Conclusion

The white clay brick is strong, long lasting materials for construction. It is lighter in weight having non capillary porosity leading to water repellence which decreases the erosion by

the rain or wind along the time. The assay of local agricultural soil nearly matches to the assay of clay in the white clay brick showing the brick is prepared form local materials. As no burning is involved, the material is live and sustainable and can be recycled and reused many times. The walls of white clay brick is built with white clay as cementing materials and plastered with fibre reinforced white clay mud so it is complete eco-friendly building material for the future. Further investigations in this field is required and suggested.

Acknowledgement

Author (KK) is grateful to Principal V.B. Sambrekar, Appasaheb Birnale College of Architecture, Sangli-416416, Maharashtra, India for inspiration and support. Authors are thankful to Department of Science and Technology, New Delhi, India, for sanctioning grant under DST-FIST program (No/SR/FST/College-151/2013(C)) to Jaysingpur College, Jaysingpur.

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