# REUSE OF NATURAL WASTE MATERIAL FOR MAKING LIGHT WEIGHT BRICKS

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**ABSTRACT:** Bricks are a widely used construction and building material around the world. Bricks are prepared from natural waste material which comprises of orange peels and coconut waste. Clay is used as a binding material for natural waste material and paper mill waste. The main objective of the present study is to reduce the quantity of clay with natural waste material. The orange peels and coconut waste which otherwise is land filled has been utilized to make construction bricks that serves a purpose of solid waste management. These wastes are used to reduce the quantity of clay as there is a greater shortage of clay in many parts of world. Initially, characterization of paper mill waste has been carried out by XRF, XRD and SEM. The SEM monographs shows that the waste has porous and fibrous structure. The bricks of prepared by orange peels and coconut waste with varying compositions of clay reduced the quantity of clay by (10% - 40% wt) and (10% - 60%) respectively and tested as per Bureau of Indian (BIS) 1077:1992 (fifth revision) and ASTM C 67-03a standards. From experimentation it is observed that waste create bricks (WCB) prepared is light weight, shock absorbing and meets compressive strength requirements of ASTM C 67-03a and BIS. The brick making procedure being simple can be undertaken as rural entrepreneurship by unskilled labours of developing countries.

**KEYWORDS:** Bricks, natural waste material, orange peels, coconut waste, paper mill waste, light weight, compressive strength.

## 1 INTRODUCTION

BRICKS have been a major construction and building material for a long time. The dried-clay bricks were used for the first time in 8000 BC and the fired clay bricks were used as early as 4500 BC [1, 2]. The worldwide annual production of bricks is currently about 1391 billion units and the demand for bricks is expected to be continuously rising [3, 4]. Conventional bricks are produced from clay with high temperature kiln firing or from ordinary Portland cement (OPC) concrete. Quarrying operations for obtaining the clay are energy intensive, adversely affect the landscape, and generate high level of wastes. The high temperature kiln firing not only consumes significant amount of energy, but releases large quantity of greenhouse gases. Clay bricks, on average, have an embodied energy of approximately 2.0 kWh and release about 0.41 kg of carbon dioxide ($CO_2$) per brick [5, 6]. It is also noted that there is a shortage of clay in many parts of the world. To protect the clay resource and the environment, some countries such as China have started to limit the use of bricks made from clay [7]. The OPC concrete bricks are produced from OPC and aggregates. It is well known that the production of OPC is highly energy intensive and releases significant amount of greenhouse gases.


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Production of 1 kg of OPC consumes approximately 1.5 kWh of energy and releases about 1 kg of $CO_2$ to the atmosphere. Worldwide, production of OPC is responsible for about 7% of all $CO_2$ generated [3]. So the production of OPC concrete bricks also consumes large amount of energy and releases substantial quantity of $CO_2$. In addition, the aggregates are produced from quarrying and thus have the same problems as described above for clay. Raut et al. [4] made fired bricks using clay–sand mixes with different percentages of rice husk ash. The firing durations at 10000C were respectively 2, 4 and 6 h. The effects of rice husk ash content on workable mixing water content, Atterberg limits, linear shrinkage, density, compressive strength and water absorption of the bricks were investigated. The results indicated that (1) the inclusion of rice husk ash increased the compressive strength of bricks, (2) the optimum firing duration was 4 h at 10000C, and (3) the bricks made of clay–sand–rice husk ash mixes could be used in load bearing walls. Faria et al. [7] investigated the recycling of sugarcane bagasse ash waste as a method to provide raw material for clay brick production. Brick samples were produced by using up 20% of sugarcane bagasse ash waste to replace natural clay, and then tested to determine their physical and mechanical properties. It was found that the sugarcane bagasse ash waste was mainly composed of crystalline silica particles and could be used as filler in clay bricks. Coconut is a versatile product and has multiple uses. Almost all the parts of a freshly grown coconut, eatable or otherwise, are used in some or the other manner. India is one of the leading coconut producers in the world, producing 13 billion nuts per annum. Coconut is mostly cultivated in the coastal regions of the country. The states that have abundant coconut growth are Andhra Pradesh, Assam, Goa, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu, Tripura, West Bengal, Andaman and Nicobar Islands, Lashadweep and Puducherry. Coconut has an important place in the Indian culture and has been produced here since time immemorial. Currently, India holds the third place in the list of major coconut producing countries of the world. Coconut production in India is 30475 kg/ha as per the statistics given by the Coconut Development Board of India in the census conducts of 2011-12. The area under the plantation

cultivation is around 1.78 million hectares in the country [12]. In India, citrus is grown in 0.62 million ha. area with the total production of 4.79 million tonnes. The area under orange cultivation in India increased by 67% from 1.19 lakh ha. in 1991-92 to 1.99 lakh ha. in 2001-02 and the production increased by 57% (i.e. from 10.58 to 16.60 lakh tonnes). Oranges are mostly grown in the states of Maharashtra, Madhya Pradesh, Tamil Nadu, Assam, Orissa, West Bengal, Rajasthan, Nagaland, Mizoram, Arunachal Pradesh. Maharashtra is the second largest producer of citrus after Andhra Pradesh in the country and contributes to about 18.9% of the total production of citrus in the country. The state produces 1.41 m. MT of citrus from an area of 0.28 m.ha having productivity of 5.1 MT/ha. The production of citrus is concentrated in the belts of Amravati, Nagpur, Akola and Aurangabad. The state is producing about 15% of the total production of Mandarin orange in the country. The state produces 0.50 m MT of mandarin orange from an area of 0.13 m. ha with productivity of 3.9 MT/ha. The major orange producing belt is in the Vidarbha region of the state covering the Districts of Nagpur, Akola, Amravati and Wardha and hence the second capital of the Maharashtra state is named as “Orange City” i.e. Nagpur. The main variety grown is Nagpur Mandarin. The National Research Centre for Citrus, located at Nagpur has been providing technological backup. [8]

## 2 METHODS AND MATERIAL

### 2.1 Existing Work Place

Nagpur City more popular known as Orange city is a major centre of administrative & political, commercial, culture & economic activities. City situated at an elevation of 314.79 m above MSL & at 21º8’N latitude & 79º8’E longitude. The climate of the city is characterized by a hot summer (47ºC) well distributed rainfall, general dryness except during the rainy season.

### 2.2 Experimental Detail

In our experimental process, we are using clay as binding material for both paper mill waste and orange peels and coconut waste bricks. Starting with the collection of the material required as brick making clay (B. C. Soil) is collected from suburban of Nagpur, paper mill waste is collected from Hardoli Paper Mill, Kondhali, Nagpur and orange peels are collected from the various juice centres and local vendors of Nagpur. Similarly, coconut wastes are collected from local vendors and various temples of Nagpur. We are preparing the bricks of size 20cm x 10cm x 10cm which is nominal size of brick as prescribed by BIS 1077:1992 (fifth revision) and for that the moulds of the same size are fabricated. Initially the paper mill waste is characterized by XRF, XRD and SEM. By doing this the waste is sun dried for a month. Simultaneously, the orange peels are also cut into the pieces of size 2cm to 3cm and later it is also sun dried for 15 days. Then the bricks are prepared with the mixture of clay – paper mill waste – orange peels of varying compositions of and left for sun dried for 10 to 12 days and later it was burnt at muffle furnace at 9000C at different durations. Coconut waste is also utilized for preparing bricks in the manner where it was previously go through the process of removing the husk and manual crushing of its shell. The treated coconut waste is mixed with clay and the bricks are prepared with varying compositions and left sun drying for 10 to 12 days and further it was burnt at muffle furnace at 9000C at different durations.

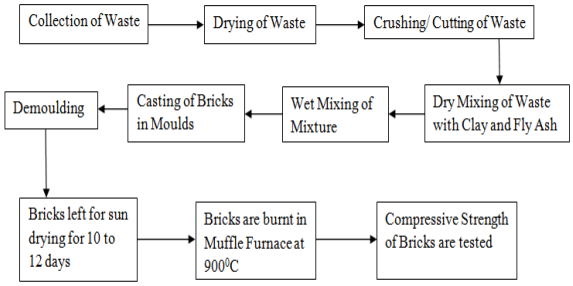


**Fig. No. 1:** Block Diagram of Methodology

### 2.3 Preparation of Bricks by Orange Peels & Paper Mill Waste

Firstly, bricks of orange peels are trying to prepare but orange peels are not getting bonded properly with clay and when the sample get dries, it crumbles. Thus orange peels are bonded with paper mill waste with clay and fly ash (10%) and various compositions are prepared with each other. Four samples of each composition are made and then they are left for sun drying for 10-12 days and further they are burnt in the furnace at 9000C for 2 hours and later they are tested in compressive testing machine to find the compressive strength of the bricks. However, the results are obtained as expected thus, applying the same method the bricks are now burnt for the duration of 4 hours at 9000C. It has been noticed that there is an increment in compressive strength of nearly 14.00%.

### 2.4 Preparation of Bricks by Coconut Waste

Now, it is the turn for the coconut waste to show its potential and for using it for making lighter bricks by substituting the clay content. The coconut waste is firstly collected from the various temples of Nagpur city as the Hindu devotees of India use the coconut to offer prayer. Later by using its fruit the coconut is thrown by the management of temples to the dumping yard or sent the waste to the solid waste management authority of the Nagpur city. By collecting coconut waste, firstly its husk (coir) is removed from the shell and shell was manually crushed to size of pieces of 2cm to 3cm and coir was cut down by the cutter of an average fibre length of 6 cm to 7cm, then it has been soaked in water for 24 hours in the water such that it should not soaked water of the wet of clay and fly ash. It has been studied by the various literatures that the diameter of coconut fibre is 0.60 mm. Then the aspect ratio becomes 116.67 i.e. (70mm/0.60mm). The fibre is laid in the layers of 3.0 cm thick wet mix. After preparing the bricks it has been laid for sun drying for 10 to 12 days later it the bricks are sent for oven drying for 24 hours and further it is burnt at 9000C for 4hours because it has been seen earlier in the case of orange bricks that duration of 4 hours gives good results as compared to 2 hours burning. Similarly, the shorter fibres are also used because while cutting many of the fibres are come out as waste and hence, the bricks of

shorter fibres are also used and the size of fibre 3.0cm to 4.0cm are used and some of them are also cut by cutter and thus the aspect ratio of those fibre becomes 83.33 i.e. (50mm/0.60mm) and later the same treatment has been given to these bricks as it was previously given to other types of bricks especially which is mentioned in the coconut waste bricks.

## 3 RESULTS AND DISCUSSION

### 3.1 Characterization of Paper Mill Waste

Elemental analysis by X- Ray Fluorescence (XRF) below in Table 1 shows that silica content in PMW is 22.36% and silica participates in reaction to form cementitious material. Heavy metals copper (Cu), strontium (Sr), zirconium (Zr) and manganese (Mn) were present in traces (less than 0.1%). Therefore, the possibility of leaching heavy metals is insignificant. The diffraction patterns of virgin and PMW are given in Fig. 2. The samples present amorphous patterns based on small reflection angles and 2Θ peak between 20 and 30. SEM monograph (Fig.2) for PMW clearly indicate the presence of irregular pores and fibrous nature of PMW. The PMW holds the moisture in the pores and the fibrous structure of PMW provides the obstacles for moisture there by creating a barrier for moisture to move towards the surface. Fibrous nature gives very high absorbing ability and good compressive strength.

### 3.2 Bricks Analysis

Initially, the various engineering tests are conducted on the material i.e. clay such as moisture content, liquid limit, plastic limit, plasticity index, shrinkage limit, shrinkage ratio and volumetric shrinkage ratio. Similarly, the moisture content of paper mill waste is also carried out and it is found to be approximately 60%. The details of test results are shown in the Table 2. The samples of brick each from orange peels and coconut waste of varying compositions were used for conducting the compressive strength tests. The test results shown in Table 3 indicate that the bricks confirm to the minimum compressive strength requirements stipulated in IS 1077:1992 but the bricks prepared from the coconut waste are more efficient than orange peels.

**Table No. 1:** XRF Result of Paper Mill Waste

| Na2O | MgO | Al2O3 | SiO2 | P2O5 | SO3 | CaO | TiO2 | Fe2O3 | SrO | ZrO2 |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.65% | 1.75% | 5.39% | 22.36% | 0.15% | 5.18% | 9.54% | 1.30% | 7.38% | 0.02% | 0.03% |
| Cl | K2O | Cr2O3 | MnO | Rb2O | CuO | NiO | ZnO | Br | BaO | PbO |
| 1.53% | 0.57% | 0.04% | 0.12% | 0.003% | 0.06% | 0.01% | 0.08% | 0.005% | 0.04% | 0.01% |

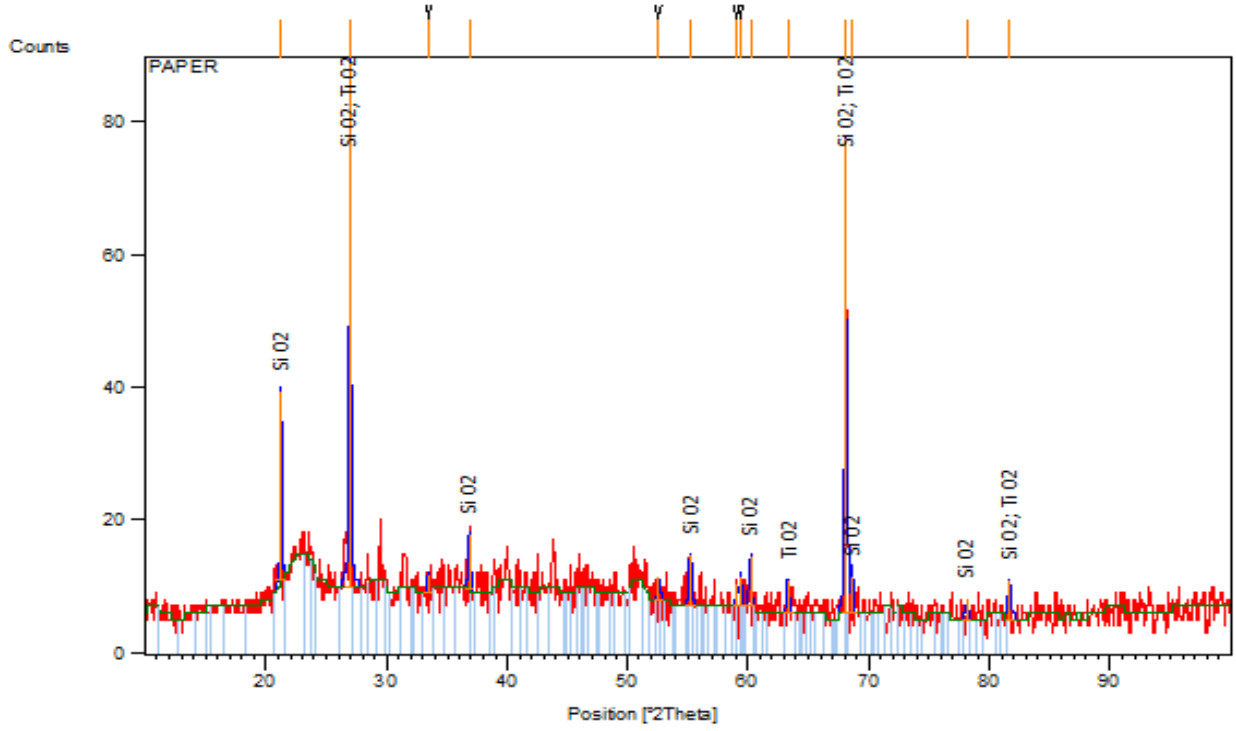


Fig. 2 XRD Pattern of virgin PMW

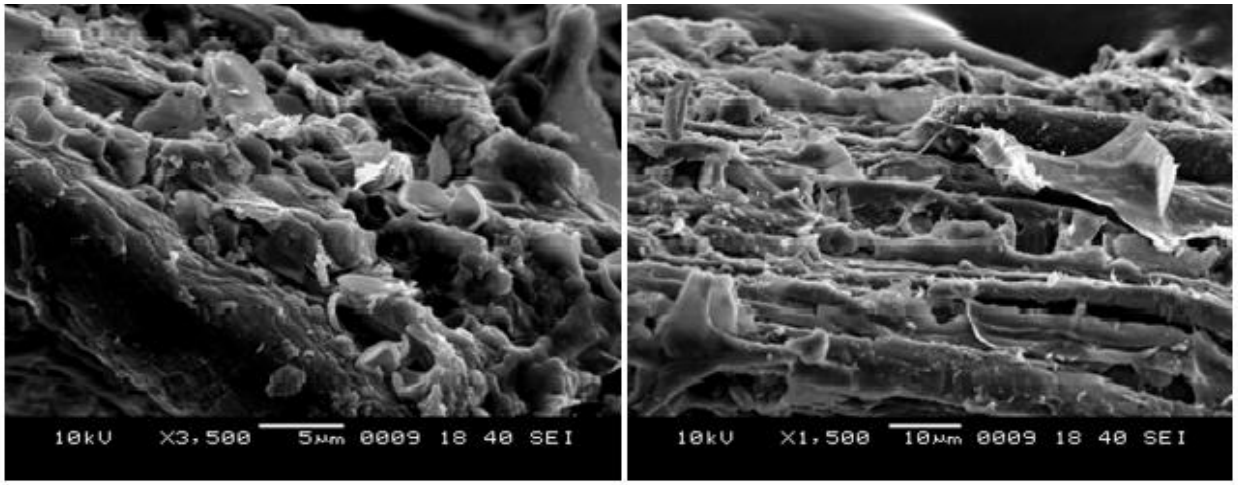


**Fig. No. 3:** SEM Monographs of PMW

**Table No. 2:** Properties of Clay

| Name of Test | Results |
|---|---|
| Moisture Content | 88.14% |
| Liquid Limit | 64.00% |
| Plastic Limit | 26.20% |
| Plasticity Index | 37.80% |
| Shrinkage Limit | 15.72% |
| Shrinkage Ratio | 1.65 |
| Volumetric Shrinkage | 30.96% |

**Table No. 3:** Details of Prepared Bricks by Natural Waste Material

| Sr. No. | Clay + Fly Ash (%) | Waste (%) | Avg. Value of Compressive Strength of Bricks Prepared By (N/mm2) | | Avg. Value of Weight of Bricks (Kg) | |
|---|---|---|---|---|---|---|
| | | | Orange Peels | Coconut Waste (AR=83.33) | Orange Peels | Coconut Waste (AR=83.33) |
| 1. | 80% | 20% | 4.25 | 4.65 | 2.80 | 3.52 |
| 2. | 70% | 30% | 3.70 | 4.31 | 2.62 | 3.38 |
| 3. | 60% | 40% | 2.45 | 4.00 | 2.42 | 3.13 |
| 4. | 50% | 50% | 2.20 | 3.65 | 2.30 | 2.80 |
| 5. | 40% | 60% | - | 3.50 | - | 2.39 |

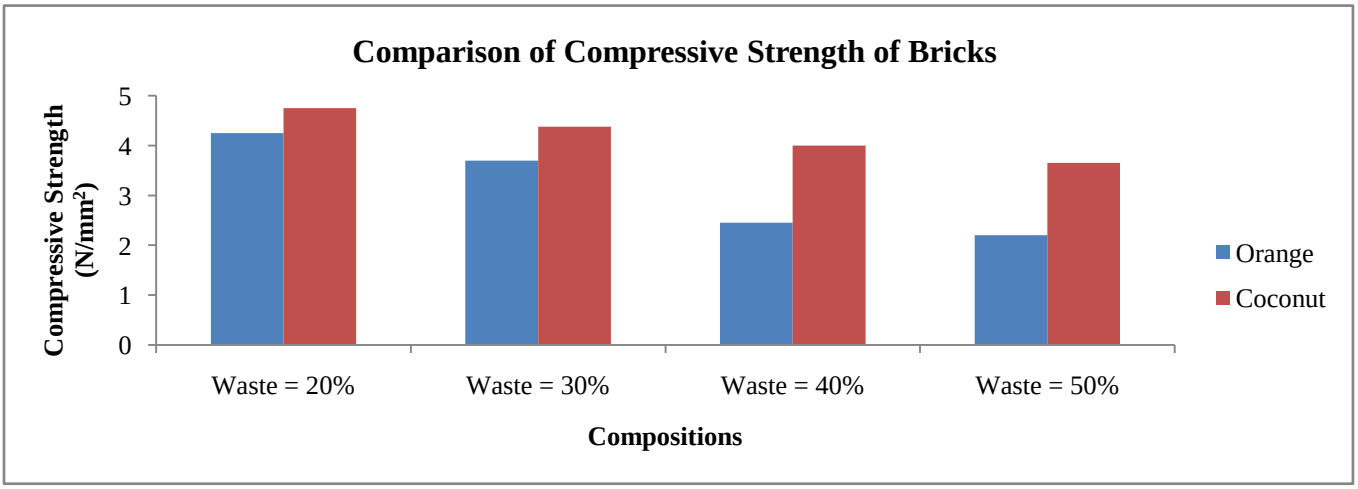


**Fig. No. 4:-** Comparison of compressive strength of bricks when it is prepared by Orange peels and coconut waste.

## 4. CONCLUSION:

Based on the present study which is conducted on production of bricks from natural waste materials, the following conclusions can be drawn: By the characterization of paper mill waste by Scanning Electron Microscope (SEM) it has been very clear that it is porous and fibrous and it holds the moisture by providing a barrier for moisture to move towards the surface. Fibrous nature gives very high absorbing ability and good compressive strength. Elemental analysis of paper mill waste by X- Ray Fluorescence (XRF) shows that silica content is highest in PMW is 22.36% and silica participates in reaction to form cementitious material. Heavy metals copper (Cu), strontium (Sr), zirconium (Zr) and manganese (Mn) were present in traces (less than 0.1%). Therefore, the possibility of leaching heavy metals is insignificant. It is observed that as the temperature increases the compressive strength of bricks is also increases and as the percentage of the soil reduces the strength of the brick decreases. It is noted that as the clay content is reduces the bricks become lighter in weight. At the composition where the soil content is only 30%, then the waste material comprises of paper mill waste and orange peel does not make a good bond with each other and it crumbles only when it is totally dried. Orange peel does not make bond with paper mill waste and soil and thus, it is not a good binding agent and it cannot be used as an ingredient for construction purpose.

Coconut waste is more efficient than orange peels and paper mill waste.

Coconut waste can be easily handled and utilized for making light weight bricks.

In case of coconut waste, the shorter fibre gives good results as compared to longer fibre.

The preparation of making bricks with coconut waste is so easy that even the unskilled labours can be engaged. It is find by this current study that upto 60% of the clay can be reducing by natural waste material for making bricks.

## 5. ACKNOWLEDGEMENT

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