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REVIEW ARTICLE

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A REVIEW ON GGBS, PAPER SLUDGE AND LATERITE SOIL IN BRICK MANUFACTURING

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ABSTRACT

Bricks are one of the common building material around the world. In many areas there is already a shortage of natural material for production of the conventional bricks. As the demand of clay increases the cost also increases. An alternate method to decrease the usage of clay is by incorporating the waste material into the clay bricks. The utilisation of these wastes will help to reduce the negative effects of their disposal. This paper presents a review on utilization of waste materials to produce bricks. A wide variety of waste materials have been studied to produce bricks with different methods and also a review is done on bricks with GGBS, Paper sludge and late rite soil. The physical and mechanical properties of bricks were analysed and discussed.

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INTRODUCTION

BRICK is one among the normal material that used as a construction material. The term brick said a unit composed of clay. A brick will be composed of clay-bearing soil, sand, and lime, or concrete materials. Bricks square measure made in varied categories, types, materials, and sizes that vary with region and fundamental measure, and square measure made in bulk quantities. 2 basic classes of bricks square measure laid-off and non-fired bricks. Around 90 percentage of the clay bricks employed in India is hand moulded solid bricks. A number of studies had taken serious steps in manufacturing bricks from several waste materials. To avoid excess consumption of useful fertile soil, incorporate organic particles into soil mixture. Recent reviews on bricks have shown that variety of organic and inorganic solid waste materials can be used as an additional material in brick making. Consequently, the use of waste has emerged as a viable technology in brick making offering two major advantages recycling of the waste to minimise the disposal problem and preserve the precious fertile soil, which is essential for the cultivation of agricultural crops.

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Ground granulated blast furnace slag is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). Use of GGBS significantly reduces the risk of damages caused by alkali–silica reaction (ASR), provides higher resistance to chloride ingress, reducing the risk of reinforcement corrosion, and provides higher resistance to attacks by sulphate and other chemicals. With the use of modern technology such as the printing press and the highly mechanised harvesting of wood, disposable paper has become a cheap commodity. This has led to a high level of consumption and waste. The production and use of paper has a number of adverse effects on the environment which are known collectively as paper pollution. Pulp mills contribute to air, water and land pollution. Paper waste faces the additional hazard of toxic inks, dyes and polymers that could be potentially carcinogenic when incinerated, or commingled with groundwater via traditional burial methods such as modern landfills. Laterite soil is a rusty colour, iron and aluminium rich rock like appearing soil that gets formed due to prolonged weathering of the parent rocks mainly in hot and humid tropical areas. Laterite soil contains minerals and compounds contents including contents like –

Aluminium Oxides, micas, Potash mica, Black mica, Hematite, Iron Oxides, Manganese Oxides, Pyroxene, Plagioclase, etc. Laterite soil is used for growing rich crops that need aluminium and iron. It is also used for beautifying construction needs. They also contain clay minerals like kaolinite and illite, the materials used for construction of bricks.

Review on Manufacturing of Bricks with Ggbs, Paper Sludge and Laterite Soil

Bricks with GGBS

Clay bricks available in certain region are poor in quality, which have forced engineers to look for better materials capable of reducing the cost of construction. In this contest recommended the use of waste materials as an alternative building material to clay bricks. GGBS is such a waste material from the iron and steel industry. The additional of GGBS to the stabiliser systems has enhanced many engineering properties. The unfired clay technology incorporating GGBS helps reduce the energy costs of the firing process and environment damage. Mohamad Nidzam *et.al.* (2016) conducted a study on stabilised clay- pulverised Fly ash eco-friendly bricks. In this research Lower Oxford Clay (LOC) was combined with Pulverised Fly Ash (PFA) as target materials were stabilised with Lime, Portland Cement (PC) and blended binders comprising of Lime and PC blended with Ground Granulated Blast-furnace Slag (GGBS). The bricks were prepared with Lime: GGBS (30:70) and Portland cement: GGBS (40:70) blending ratio shows greater compressive strength and low thermal conductivity. Bricks made with Portland cement: GGBS (40:70) shows minimum rate of water absorption. Another study was conducted by Shankarananth *et.al.* (2016) on fly ash bricks made with Glass powder, GGBS and Perlite. Bricks made with 20% of GGBS, 10% of perlite, and 2% of glass powder give a greater compressive strength of 16.186 N/mm^2. As the percentage of GGBS increases the compressive strength decreases. The percentage of the GGBS decreases, the water absorption of the bricks increases and the percentage of the GGBS increases, density of the bricks increases. When the bricks are immersed in water and dried, white patches were not formed, so the results of efflorescence for bricks are nil. Malhotra and Tehri (1995) done a study on bricks made slag-lime mix with sand also give good quality bricks. Slag–lime mix and sand both 50% by weight gives greater compressive strength of $15MN/m^2$ and lower water absorption rate. Bulk density of these brick was $1820kg/m^3$.

Bricks with paper sludge

Paper sludge is waste product from the paper industry which produces many environmental problems. Thus incorporating it into the bricks can reduce the use of clay and also reduce the disposal problems of paper sludge. Recycle Paper Mill Waste (RPMW) - cement combination low carbon foot print bricks with varying composition of cement (0–20% wt) have been prepared and tested. This study was conducted by S P Raut et.al (2012) from experimentation it was observed that bricks prepared using RPMW-cement combination was light weight, shock absorbing and meets compressive strength requirements of ASTM C 67-03a. 5–20% addition of cement to RPMW exhibits a compressive strength which is three times greater than the conventional clay bricks. But in the case of water absorption rate they show high rate of absorption. This can only be reduced by applying water proof coating over bricks. From the tests results it had been observed that even with increase in cement percent above 10% there is no appreciable improvement in the properties of bricks however bricks with 5% cement appears fragile and do not have enough binding strength. From this it is concluded that RPMW-10% cement is the optimum composition. Fly ash bricks were casted with hypo sludge which has a very good content of CaO this study was done by Apurva Kularni *et.al.* (2014). Brick contains fly ash, Lime, water, and Quarry dust. The replacement of hypo sludge by weight with lime with permutation of 5%, 10%, 15% and 20% is done. After 21 days 10% partial replacement of hypo sludge shows greater compressive strength. Hypo sludge bricks reduce the seismic weight of building. It reduces the density of brick masonry from 20 to 12. It reduces the cost of material per unit. Use of Hypo sludge in brick can solve the disposal problem; reduce cost and produce a ‘greener’ Eco-friendly bricks for construction. Rajput D *et al.* (2012) conducted a study on cotton waste, paper mill waste and Portland cement were added in 1-5%, 85-89% and 10% by weight percentage. 85% PW, 5% CW and 10% of cement by weight gives higher compressive strength of 23.6MPa and lesser thermal conductivity.

Bricks made with cotton waste and paper mill waste shows higher water absorption rate so these can reduced by applying water proof coating over brick surface. From this it was concluded that 85% PW–5% CW–10% cement is the optimum composition. Another study was conducted by J.A. Cusidó et.al (2015) on incorporation of paper sludge in 5-25 weight % of clay bricks. 5 wt% sludge shows greater compressive strength whereas the percentage of sludge increases the thermal conductivity of bricks decreases. Water absorption rate was increases with increase in percentage of sludge. There was no remarkable hazardous inorganic and VOC emission during firing. Mucahit and Sedat (2009) investigated production of porous and lightweight bricks with reduced thermal conductivity and acceptable compressive strength by using paper processing residues as an additive to earthenware bricks. Apparent porosity and water absorption values were increased with increase in residue addition. Depending on the increase in the residue addition and porosity content, compressive strength of the samples decreased. Compressive strengths of the brick samples produced in this study were higher than that required by the standards. The thermal conductivity values decreased up to 50% while adequate mechanical strength could be maintained. The results indicated that the paper processing waste could be utilized together with brick raw materials to produce porous and lightweight bricks with reduced thermal conductivity and acceptable compressive strength.

Bricks with laterite soil

Laterite soil is a good building material and laterite stone is a construction material. Laterite soil is available from the laterite quarries are also used for many engineering purposes. There some properties are similar to that of clay, so it can be used for brick manufacturing. Muraleedharan M A *et al.* (2017) conducted a study on bricks using laterite soil. In this study bricks were casted using laterite soil, 10% of 53 grade OPC, 1.5% of Magnesium Oxide and 1% of coir fibre all were added according to the weight basis. With these mix both modular and non-modular size bricks were prepared. These bricks have a compressive strength of $10.53N/mm^2$ which comes under first class bricks category.

Table 1. Comparison of bricks with ggbs

<table>
<tr><td rowspan="2">AUTHOR AND YEAR</td><td colspan="3">TEST</td></tr>
<tr><td>COMPRESSIVE STRENGTH (N/mm^2)</td><td>WATER ABSORPTION (%)</td><td>THERMAL CONDUCTIVITY (W/mK)</td></tr>
<tr><td>Mohamad Nidzam Rahmat et.al [2016]</td><td>Lime:GGBS 1.972kN/m^2-28days
PC:GGBS 2.7-28days</td><td>Lime:GGBS-16
PC:GGBS- 7</td><td>Lime:GGBS – 0.264 at 7.5^0C
PC:GGBS – 0.271 at 7.5^0C</td></tr>
<tr><td>Shankarananth et.al [2016]</td><td>16.186</td><td>3.01</td><td></td></tr>
<tr><td>Malhotra and Tehri [1995]</td><td>15</td><td>6.2</td><td></td></tr>
</table>

Table 2. Comparison of bricks with paper sludge

<table>
<tr><td rowspan="2">Author and year</td><td colspan="5">TEST</td></tr>
<tr><td colspan="3">Compressive strength (N/mm^2)</td><td>Water absorption (%)</td><td>Thermal conductivity (W/mK)</td></tr>
<tr><td>S P Raut et.al (2012)</td><td colspan="3">9.6Mpa</td><td>83.3%</td><td></td></tr>
<tr><td>Apurva Kularni et.al (2014)</td><td colspan="3">21 days – 7.76N/mm^2</td><td></td><td></td></tr>
<tr><td>Rajput D et al. (2012)</td><td colspan="3">23.6MPa- 85% PW, 5% CW and 10% of cement by weight</td><td>99.3%- 89% PW, 1% CW and 10% of cement by weight</td><td>85% PW, 5% CW and 10% of cement by weight - 0.25</td></tr>
<tr><td>J.A. Cusidó et.al (2015)</td><td colspan="3">5% - 49</td><td>0%-8.8% 5%-11.5%</td><td>25% - 0.43</td></tr>
<tr><td rowspan="3">Mucahit Sutcu and Sedat Akkurt (2009)</td><td></td><td>pressing direction</td><td>transverse direction</td><td rowspan="3"></td><td rowspan="3">30% paper sludge- 0.42</td></tr>
<tr><td>0%</td><td>40</td><td>45</td></tr>
<tr><td>10%</td><td>16</td><td>23.5</td></tr>
</table>

Table 3. Comparison of bricks with laterite soil

<table>
<tr><td rowspan="2">Author and year</td><td colspan="4">TEST</td></tr>
<tr><td colspan="2">Compressive strength (N/mm^2)</td><td colspan="2">Water absorption (%)</td></tr>
<tr><td>Muraleedharan *et. al (*2017)</td><td colspan="2">10.53</td><td colspan="2">9.90</td></tr>
<tr><td rowspan="2">Emmanuel A Okunade (2008)</td><td colspan="2">90% laterite – clay+0% sawdust+10% woodash:
Dry compressive strength – 19.15</td><td colspan="2">90% laterite – clay+0% sawdust+10% woodash:
24h cold water absorption- 5.8</td></tr>
<tr><td colspan="2">Wet compressive strength – 17.34</td><td colspan="2">5h boil absorption – 8.7</td></tr>
<tr><td rowspan="2">Gaurav Goel *et. al* (2017)</td><td colspan="2">10% PMS+Laterite soil:</td><td colspan="2">10% PMS+Laterite soil:</td></tr>
<tr><td>850^0C – 23.93</td><td>900^0C – 33.17</td><td>850^0C – 38</td><td>900^0C – 41</td></tr>
<tr><td rowspan="2">Rahman M A (1987)</td><td colspan="2" rowspan="2">Laterite soil(60): clay(40) 4h – 22.78</td><td colspan="2">Laterite soil(60): clay(40)</td></tr>
<tr><td>24h absorption:
6h-13.51</td><td>5h boiling absorption:
6h – 18.05</td></tr>
<tr><td rowspan="2">Rahman M A (1988)</td><td colspan="2" rowspan="2">Laterite soil (60):clay (40) +20% RHA
4h- 24.9</td><td colspan="2">Laterite soil (60):clay (40) +20% RHA for 4h</td></tr>
<tr><td>24h absorption:4h- 17.1</td><td>5h boiling absorption: 4h –22.1</td></tr>
</table>

Density and water absorption was obtained as more than that of clay bricks and fly ash bricks whereas the efflorescence was found as slight for these bricks. It was a good suggestion for important works and gives considerable saving in energy and waste laterite soil produced in the laterite quarry can be efficiently utilized. Another study was conducted in Nigeria by Emmanuel A Okunade (2008). Different sample mixes were obtained by mixing the 70:30 parts by weight laterite – clay blend with varying proportions of saw dust and wool ash admixtures. The density of bricks made with the addition of sawdust and wood ash decreases whereas the compressive strength of the sample made with 10% wood ash and 0% saw dust show higher compressive strength than the control mix. Water absorption is closely associated with porosity of the material. The influence of saw dust increases the porosity and thus the water absorption, while the wood ash was decrease the water absorption. The increase in saw dust content produce opposite result of finished products, mainly due to the effect of producing a less compact structure in finished products.

Comparison of bricks with Laterite Soil

Gaurav Goel *et al.* (2017) deals with the manufacture of eco-friendly light weight bricks through a mix of paper mill sludge (PMS) and soil both laterite and alluvial soils were used. The mix ratio between PMS and soil was varied from 0 – 20% and fired at 850^0C and 900^0C. An optimum mix of 10% PMS with both soil types was found suitable for brick production at a firing temperature of 900^0C. Firing at higher temperature decrease the open porosity, leading to reduced water absorption. Firing at 900^0C provides improved durability of bricks. Lateritic soil – clay bricks were manufactured using a mix of 20 and 40% clay by weight mixed with lateritic soil, this study was conducted by Rahman M A (1987). The bricks were burned at 1000^0C for 2, 4 and 6 hours. For the results it was observed that addition of 40% of clay in lateritic soil was optimum for the production of bricks from lateritic soil. Another study was conducted by Rahman M A (1988) on lateritic soil – clay bricks with rice husk ash (RHA). The clay was added in 40% by weight of lateritic soil along with that RHA was added in 5 – 20%. The bricks were burned at a temperature of 1000^0C for 2, 4 and 6 hours. The linear shrinkage decreases almost linearly with RHA content. Both dry and firing densities of bricks decrease with increase in RHA. The decrease in density indicates it produce light weight bricks. The compressive strength of both fired and unfired bricks increases with increase in RHA content. Higher compressive strength is more for 4 hour soaked bricks. The water absorption rate increase with increase in RHA content. 4-hour firing duration at 1000^0C was optimum for the firing of lateritic soil-clay- RHA mixed bricks.

Conclusion

From the reviewed literatures the following conclusions were made,

- Compressive strength of bricks made with Lime:GGBS and PC:GGBS shows higher strength and lesser water absorption rate for 28days. Bricks made with sand and GGBS shows better compressive strength, lesser water absorption rate and thermal conductivity as age increases.

- Bricks made with paper sludge shows better compressive strength upto 5-15% and the thermal conductivity decreases with increase in paper sludge.
- Increase in water absorption is the main limitation observed in increase in addition of paper sludge.
- Bricks made with laterite soil shows improved compressive strength and water absorption rate. Laterite soils have similar properties to that of clay whereas laterite-clay bricks show more water absorption than that of clay bricks.

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