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FEASIBILITY STUDY ON USING GROG WASTE IN PRODUCTION OF ECOFRIENDLY BUILDING MATERIAL

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ABSTRACT

The study covered in the present paper is an attempt to ascertain the technical feasibility of utilizing an industrial waste material (Grog i.e. crushed fired brick waste) for manufacturing of the construction building material i.e. Burnt clay bricks. Bricks are prepared by replacing the conventional base material i.e. clay by grog in varying percentages of 0%, 10%, 15%, 20% and 25% by wt. The ingredients are mixed and moulded into the size of actual brick unit. The demoulded bricks are sun dried for the period of 7 days followed by baking of bricks in kiln at a temperature of approx 900ºC. The bricks thus prepared were tested for the functional efficiency in terms of surface finish, hardness, soundness, efflorescence, water absorption, bulk density and compressive strength. The test results shows that strength upto 7.34 N/mm^2 is obtained which is not only higher than that of conventional control mix but also higher than strength required for minimum class of bricks as per Indian standard code. Also water absorption is less than 20% which satisfies codal requirement and much less than the conventional control mix.

Keywords: *Base material, Feasibility, Grog, Industrial Waste, Sustainable Construction.*

I. INTRODUCTION

In the last few years, a lot of research has been focused on look out for innovative and alternative building material in construction industry. It is the outcome of this research that various types of wastes such as agricultural waste, industrial waste, mine waste, construction and demolition waste etc. have been channelized form land fills to labs and back to land with better efficiency and effectively in form of new building material. These alternative building materials are not only eco friendly and cost effective but they also add to the strength and durability of the structure. Here grog is used as an alternative material for the production of bricks by replacing virgin material clay. Grog is a granular material that has been crushed down from fired brick, or other pre-fired ceramic product. firebrick, or refractory brick is a block of refractory ceramic material used in foundry bed and walls, and lining of chimney, cooking chamber in wood fired ovens etc. Fire bricks are mostly used in inside lining of Crucible furnace ,Cupola furnace ,Induction furnace etc. that are used for melting the metal to be used to make a metal casting. Out of which most of the waste generates from cupola furnace. The shell of the

cupola, being usually made of steel, has inside fire brick lining to resist temperature. The size of a cupola is generally 12-15 feet long arranged vertically. Raw materials for metal casting are dropped from the top of furnace and day by day as production increases , lining of fire bricks gets damaged. When the degree of damage to the lining of furnace becomes such that the stable operation of the furnace can no longer be ensured, lining is broken down and discarded. These leads to generation of waste. After 25 to 30 tonne production of metal , inside fire brick lining of furnace needs to reconstruct. This reconstruction of lining generates about waste of 300 bricks around every month and as no proper solution for disposal of these waste we can think for sustainable development by reusing it. Therefore here attempt is made to reuse of waste in production of burnt clay bricks. In case of brick-making activity, at present top soil equivalent of 300 mm from 100,000 hectares (1000 sq km) of fertile land are consumed annually. continuous use of such virgin materials in manufacturing the building materials is causing continuous depletion and environmental problem. Therefore it becomes inevitable to steadily switch over to the use of energy efficient building materials and technologies and mechanisms to recycle and reuse of building wastes for the manufacture of building materials and products for the sustainable construction practices. The brick sector consumes about 24 million tonnes of coal per year which is about 8 % of the total coal consumption of the country. The large coal consumption of the brick industry is the cause of significant air pollution in terms of carbon dioxide (CO2), carbon monoxide (CO), sulphur dioxide (SO2), nitrogen oxides (NOx) and suspended particulate matter (SPM) which cause considerable health problems. Hence there is a necessity of using construction materials that have minimum environmental burdens is useful in the sustainable development of a nation.

II. LITERATURE REVIEW

C.M.F. Vieira, S.N. Monteiro(2006) [1]: Have examined the effect of grog addition up to 20 wt% on properties and microstructure of bricks fired at 700°C. Grog was added in 5, 10, 15 and 20 wt% to the clayey body and cylindrical test specimens were casted with a diameter of 31 mm and 11 mm thick, were prepared by uniaxial pressing at 20 MPa, with 8 wt% water. Then these specimens were then fired in an electric laboratory furnace at 700°C. Tests of linear shrinkage, water absorption and mechanical strength were carried out as per Brazilian standard. Result showed that the grog addition slightly increases the water absorption of the industrial ceramic body. The mechanical strength first increases with up to 5% of grog addition and then decreases for higher amounts of addition. So after all evaluated properties it is clear that the additions of grog may be performed up to 5 wt% without impairing either the processing or the quality of the final ceramic.

C. M. F. Vieira, J. Alexandre, S. N. Monteiro(2006)[2]: In this paper grog screened at two different particle size, 840 μm (20 mesh) and 420 μm (80 mesh), was used in mixtures with clayey body in 0, 5,10, 20 wt% to make typical red ceramics for bricks. Cylindrical test specimens, with a diameter of 31 mm and 11 mm thick, were prepared by uniaxial pressing at 20 MPa, with 8 wt.% water and then electically fired at 700°C and linear shrinkage, water absorption and mechanical strength were carried out. Result showed that according to the evaluated properties, additions of grog screened at 20 mesh performed up to 5 wt.%. With a finer particle size, screened at 80 mesh, additions may be done up to 10 wt.% without compromising the quality of the ceramic. This result shows the particle size of grog affects the property and microstructure of bricks.

Taner Kavas, Bekir Karasu, Ozlem Arslan(2006)[3]: In this paper the refractory bricks waste of a rotary cement furnace containing of alumina and magnesium chromite were studied in order to determine whether they could be used in the concrete production as aggregates. Three mortars were prepared by mixing 1 part cement, 3 part aggregate(Alumina ,magnesium chromite waste refractory bricks and standard silica as an aggregate materials), 0.5 part water by weight. The compressive and bending strength of samples were determined after 2 and 28 days curing. Resistance to chemicals were established by calculating the weight gain of mortars stored in 2 % HCl solution for 1 h and 24 h. Physical integrity against high temperatures were also determine. Result showed that mortar containing magnesium chromite waste as an aggregate has slightly lower compressive strength than standard mortar but much higher than mortar containing alumina waste. Bending strength of mortar containing magnesium chromite waste was much higher than remaining mortar also HCl absorption percentages were lower compared to other mortars. Also it has retained its physical integrity up to 1200°C whereas mortar containing alumina waste was chipped off at 1050°C. So, it is clear that the properties of magnesium chromite based refractory waste aggregate are comparable to those of the conventional concrete.

III. EXPERIMENTAL PROCEDURE

3.1 Materials and its properties

The raw materials used in this study were the base material and waste material grog. Base material was the agricultural soil, used in kiln had 72% of fines and remaining content of sand which was confirmed by performing wet sieve analysis as per I.S. standard [4]. Grog (refractory waste) was obtained from Foundry located at Naroda G.I.D.C.(Gujarat). In this study the fire brick waste was crushed and screened by passing 425µm I.S. sieve generating a powder material, which is denoted here as grog. Physical and chemical analysis of both the base material and grog was carried out. Result of chemical analysis shows that grog has good silica content which confirm its feasibility for production of bricks with base material. All the tests were carried out in accordance with the relevant Indian standards. The results of the tests are listed below.

Table 1. Physical properties of base material

Properties	value
Wet sieve analysis	Average fines =72%
Free swelling ratio	1.2
Standard proctor test	OMC=13.61% MDD=1.85 gm/cm^3

Table 2. Physical properties of grog

Properties	value
Bulk Density	1809 kg/m^3
Specific Gravity	2.23
Water absorption	4%
Free Swelling ratio	0.9

Table 3. Chemical analysis of grog and base material

Chemical components	Grog	Base material
SIO_2	53.20%	62.40%
Al_2O_3	21.28%	18.30%
FE_2O3	10.44%	10.78%
CAO	1.03%	2.05%
MGO	2.81%	2.94%
NA_2O	1.40%	1.04%
K_2O	1.21%	2.48%
SO_3	0.40%	--
LOI	8.10%	--

3.2 Sample Preparation

Grog was added in 10, 15, 20, 25 wt% with base material and first dry mixing was done. Then water was added to the prepared mix of sufficient moisture, as per requirement [5]. Also one control mix was prepared without addition of grog with experimental bricks for the purpose of clear comparison of various physical and mechanical properties between convention brick and bricks with addition of grog. After mixing of ingredients a dough was prepared and it was thrown with force into the moulds prepared as per Indian standard. The extra remaining soil was then scraped out with a leveler and then the mould was inverted and brick was removed easily without force. Here three bricks specimen were casted for each mix of size 220 mm X 100 mm X 75 mm. Bricks thus prepared were sun dried for 7 days and then fired in the kiln for 7 days at temperature of approx 900℃. Name of mix is given in terms of BM and G. i.e. $BM_{90}G_{10}$ indicates mix with 90% base material and 10% grog.

Table 4. The proportions of the mixtures for brick making

Mix	Grog	Base Material
$BM_{90}G_{10}$	10%	90%
$BM_{85}G_{15}$	15%	85%
$BM_{80}G_{20}$	20%	80%
$BM_{75}G_{25}$	25%	75%

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Fig. 1 procedure of making bricks

3.3 Tests and Results

3.3.1 Hardness, Soundness, and efflorescence test

Hardness test of the bricks was performed by scratching the surface of bricks with metal nail and there was not seen any deep indentation. Soundness test was performed in which the bricks were struck with each other and the sound recorded was ringing. Lastly the efflorescence test was performed as per IS 3495 – 3 (1992) in which bricks were immersed in water of depth 25mm. Bricks were kept as it is until all the water was absorbed and again same water was added and allowed it to evaporate as done before. Efflorescence was recorded after second evaporation and it was absolute nill as there was no deposition of salt on the surface of bricks. So bricks were passed through all the physical tests.

3.3.2 Water absorption

Water absorption test was carried out as per IS 3495 – 2 (1992). Weight of bricks removed from the kiln were recorded. Then bricks were immersed completely in clean water for 24 hours. increase in weight of the bricks was noted and water absorption was calculated. Value has to be less than 20% as per Indian standard code. Result of water absorption is shown in Fig. 2. which shows that all mixes satisfy codal provision. Water absorption of control mix is higher than that of bricks made by addition of grog with base material, which indicates the better packing of grog particles with base material and less porosity leads to less water absorption.

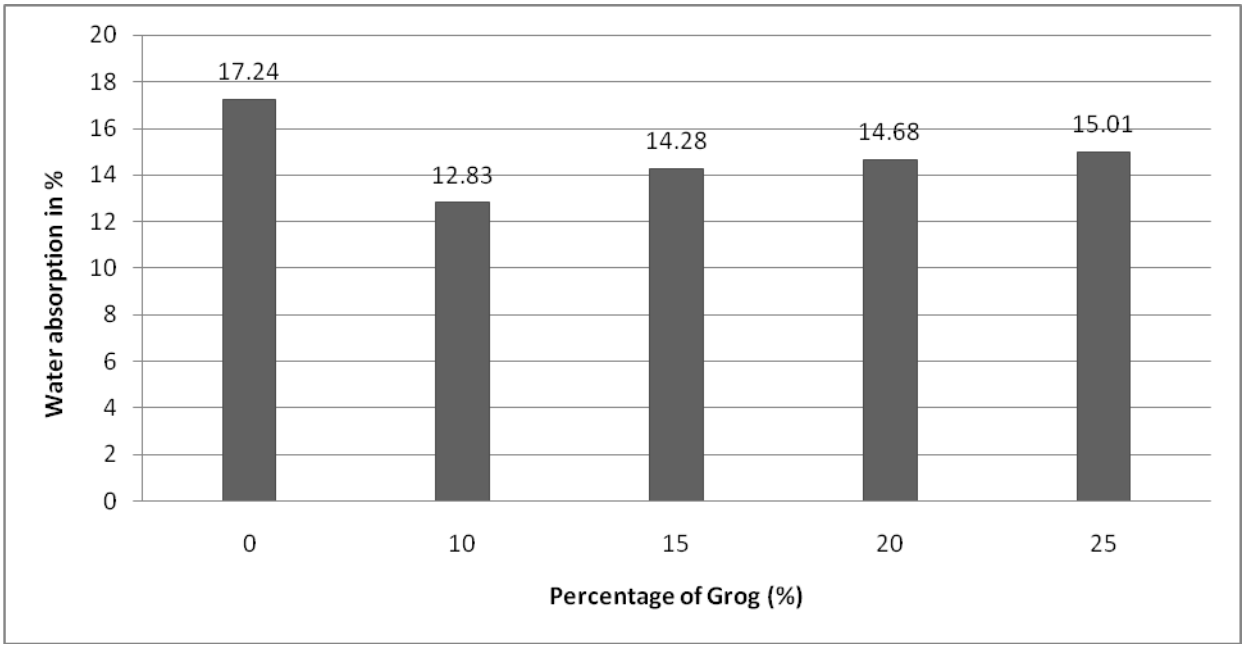

Fig. 2 Water absorption of the bricks versus percentage of grog

3.3.3 Compressive strength test

Compressive strength tests of the bricks was carried out as per IS 3495-1 (1992). The aim was to achieve the brick with compressive strength grater of 3.50 Mpa to satisfy the strength criteria for at list lower class of bricks as per classification of brick[6]. Result shows that the maximum strength was achieved of 7.34 N/mm^2 for mix of 10% grog and 90% base material. other mixes also gave higher class of bricks above 5.

Table 5 Summary of results

Mix	Bulk Density (g/cm^3)	Water Absorption (%)	Compressive Strength (N/mm^2)
Control mix	1.67	17.24	4.68
$BM_{90}G_{10}$	1.75	12.83	7.34
$BM_{85}G_{15}$	1.71	14.28	6.97
$BM_{80}G_{20}$	1.71	14.68	6.77
$BM_{75}G_{25}$	1.71	15.01	6.38

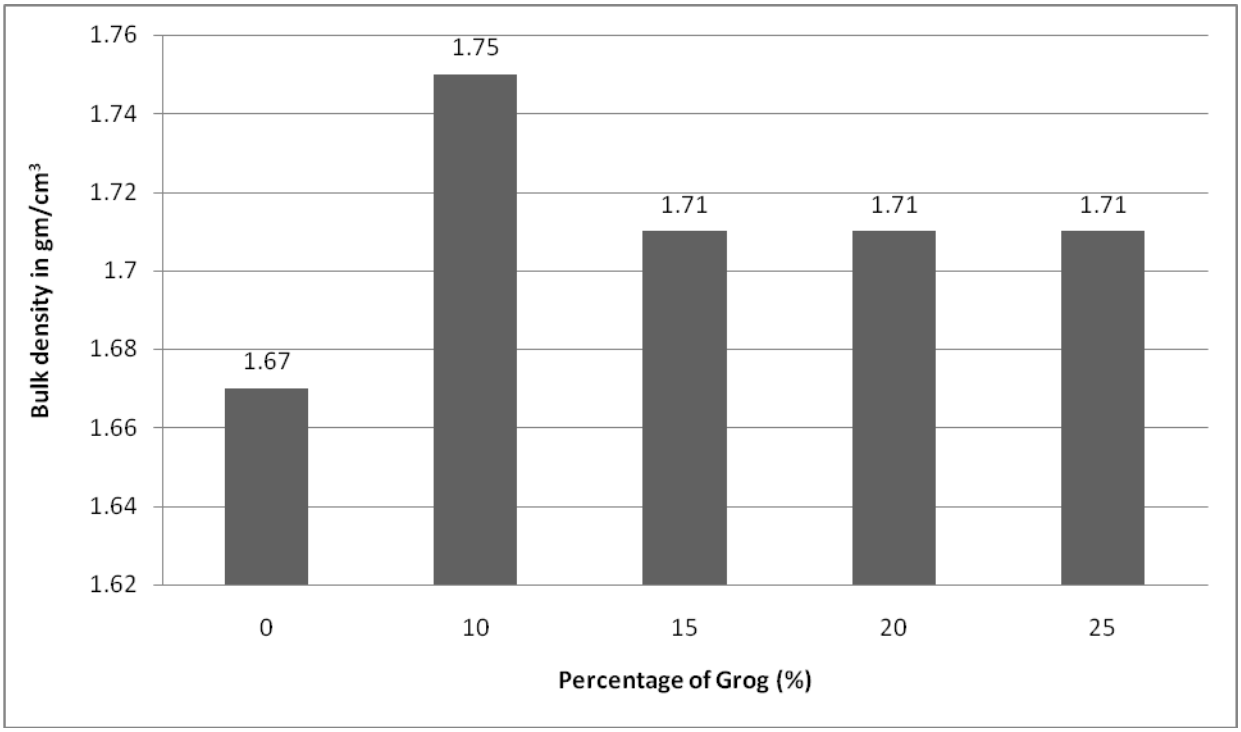

Fig. 3 Bulk density of the bricks versus percentage of grog

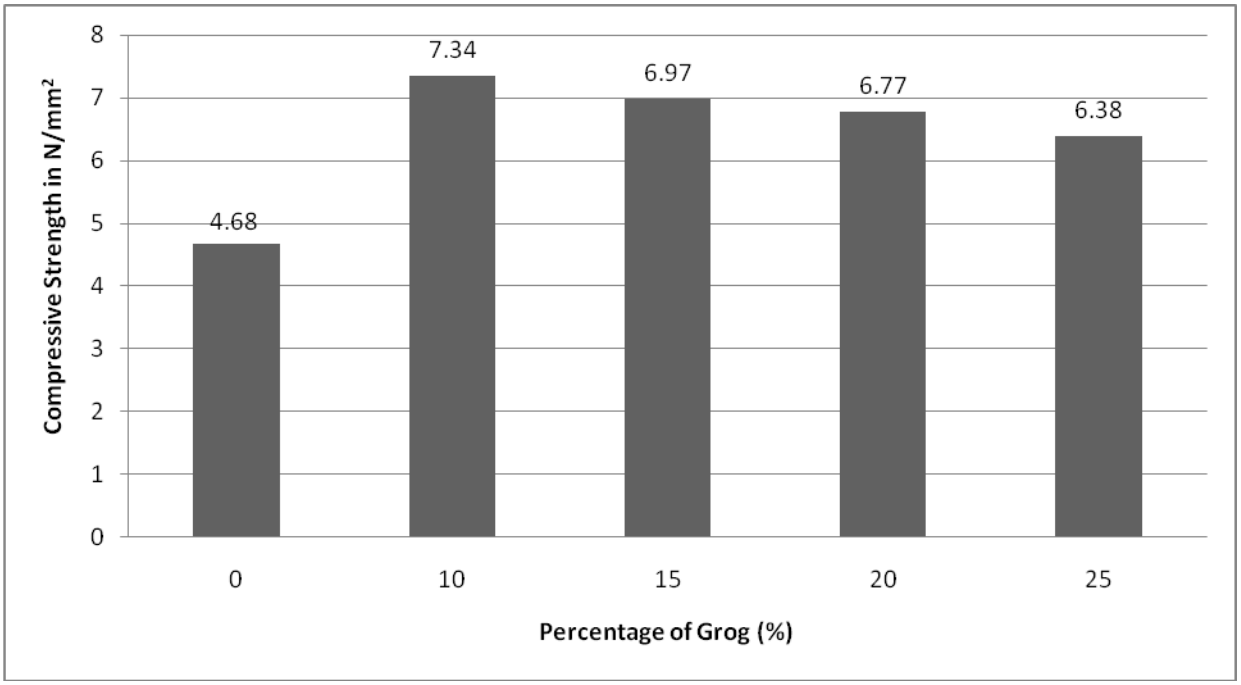

Fig. 4 Compressive strength of the bricks versus percentage of grog

IV. CONCLUSION

Table below indicates the parameters of conventional bricks Vs. innovative bricks using grog.

Table 6 Comparative range of various parameters

Parameter	Conventional bricks	Innovative brick
Compressive strength	4.6 to 5.4 N/mm^2	6.34 to 7.35 N/mm^2
Water absorption	>16%	14 to 15 %
Weight	2.9 kg	2.8 to 2.85 kg
Bulk density	1.67 g/cm^3	1.7 to 1.75 g/cm^3

- This study demonstrated that it is possible to utilize grog as partial replacement for clay in burnt clay bricks.
- Here study is expanded beyond the research work done in literatures by using actual brick size as specimens in order to draw conclusion for manufacturing commercial bricks for Indian context.
- Result shows that bricks produced for all mixes satisfy the minimum codal requirements as per Indian Standard Codes.
- Compressive strengths of the grog added bricks are higher than the grog free reference brick.
- Better value of bulk density and water absorption gives clear indication of dense packing of materials and less porosity of bricks made with addition of grog with clay.
- The study shows that as the replacement of grog percentage increases the compressive strength reduces, however the strength was still higher than that of control mix which proves the efficiency of grog material in enhancing the characteristic properties of burnt clay bricks.
- The reuse of grog waste in brick production shows highly positive results in terms of environmental protection, waste management , and saving of raw materials for the production of eco-friendly building material.

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