IJERST

International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 3, No. 4
November 2014

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

Int. J. Engg. Res. & Sci. & Tech. 2014

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 3, No. 4, November 2014

Research Paper

HOLLOW CONCRETE BLOCKS AS A REPLACEMENT OF BURNT CLAY BRICKS

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The strength characteristics of any masonry depend on the strength and elasticity parameters of masonry units, mortar and their interactive behavior. Hollow concrete block masonry has several advantages compared to burnt brick masonry. Because of its uniform size and shape, concrete block masonry saves mortar consumption in the bed joint and plastering. In view of high energy consumption and unorganized method of production of burnt brick, the cost of fuel for brick kiln is controlled by its supply and demand in the local market. Whereas in the process of concrete blocks production the major cost component is cement whose price is usually insensitive to supply and demand in the local market. Hence unlike burnt bricks, the unit cost of concrete blocks is somewhat stable. In most of the cases the production of concrete blocks is mechanized thus it is possible to meet the requirement of the ever increasing demand in the urban construction activity with consistent quality blocks. Large quantities of granite fines are generated from the granite industry. As a result, solid waste management including the granite fines has become one of the major environmental concerns in the world. With the increasing awareness about the environment, scarcity of land-fill space and due to its ever increasing cost, waste materials and by product utilization like granite fines has become an alternative to disposal. In this work we have highlighted some aspects concerning the use of granite fines in various proportions in the manufacture of hollow concrete blocks. In this study high performance Hollow blocks are manufactured of size 400 mm x 200 mm x 200 mm utilizing granite fines as an additive. These blocks were tested for routine tests as per IS-2185 (part-I and part II) of Bureau of Indian standards, such as compressive strength, Bulk density and water absorption. Based on the results presented in this paper, it can be concluded that High Strength and High performance Hollow Concrete Blocks can be manufactured by the use of Granite fines as an additive.

Keywords: Granite fines, High performance Hollow Concrete Blocks, Compressive strength, Bulk density and water absorption, Sustainable development

INTRODUCTION

Indian construction industry is one of the largest in terms of economic expenditure, volume of raw materials / natural resources consumed volume of materials and products manufactured, employment generated, environmental impacts,

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etc. With the usage of hollow concrete blocks the energy consumption is low as compared to burnt brick construction. In view of the above facts, hollow concrete blocks are becoming very popular in the buildings construction industry, particularly in the urban area. Though the blocks are available in different grade (load bearing and non-load bearing) for various purposes, these block are being widely used in construction of multi-storey residential buildings, industrial and other building mainly for infill wall masonry. The use of these blocks in the construction of independent residential buildings is low. These blocks are manufactured by several production units in and around every urban setup. Among the production units very few are producing consistent quality blocks in an organized way, while majority of them are unorganized small-scale units. Thus, as in case of burnt clay bricks, the variation of quality among the concrete blocks manufactured by these establishment is very large.

Brick manufacture comes to grinding halt during the monsoon while solid and hollow block making can be carried out throughout the year. However, the quality of the hollow concrete blocks needs to be improved. Use of granite fines, which are often as fine as silt can improve the concrete block quality by filling pores and making them more compact.

The Granite fine is a byproduct dust produced in granite factories while cutting huge granite rocks to the desired shapes. While cutting the granite rocks using the gang saws as shown in Figures 1 and 2, fine powder is produced which is carried along with the water and this water is stored in storage tanks. The granite fines which is carried along with the slurry is channelized to the settlement chamber. This mixture is stirred

Figure 1: Gang Saw

Figure 2: Top View of Gang Saw

after adding chemicals for settling (Figure 3) and is then pumped to huge silos where the granite fines along with the slurry is collected. From the silo's the mixture is pumped into the slurry compacting machine (Figure 4) where the excess water is removed and recirculated. The compacted slurry cakes of granite fines are made to fall in the trucks parked below from the slurry compacting machine. The trucks carry the moist granite fines and dump it in the dumping yard.

India is one of the best granite deposits in the world, having excellent varieties comprising over

Figure 3: Settlement Tank

Figure 4: Slurry Compacting Machine

200 shades. India accounts for over 20% of the world resources in granite. Granite reserves in India have now been estimated by the Indian Bureau of Mines at over 42,916 million cubic meters. In India there are 350 major granite factories are running, so the total production of granite fines waste may go up to 1 lakh m^3 which can be effectively utilized in the production of concrete and related products for sustainable development. The objective of this paper is to produce high strength hollow concrete blocks with the addition of granite fines as an additive because of the properties of granite fines it is possible to fill the pores in the hollow concrete block which otherwise is very porous. By varying the proportions of fines, the optimum proportion of fines addition can be determined. The data thus obtained can be compared with the hollow concrete blocks manufactured by conventional lean mix concrete available in the market. Different mix proportion is taken to study the strength of the hollow blocks by using granite fines.

EXPERIMENTAL PROGRAM

The Experimental program included first the preliminary investigation of materials used in the study like cement, fine aggregates, coarse aggregates and granite fines. The results as indicated below:

Cement

Cement is used for this project is BIRLA PLUS 53 grade. As per IS: 12269. The various properties of the cement were determined and is tabulated as shown in Table 1.

Table 1: Properties of Cement

S. No.	Properties	Values obtained	Requirements as per IS: 12269-1987	
1	Fineness		2.5% by Wt	Should not exceed 10% by weight
2	Soundness		1mm	Not more than 10mm
3	Setting Time	Initial	34 min	Not less than 30min
		Final	380 min	Not more than 600 min
4	Compressive Strength	7 days	39 N/mm^2	Not less than 37 N/mm^2
		28 days	55 N/mm^2	Not less than 53 N/mm^2
5	Standard Consistency		33 %	–
6	Specific gravity		2.6	–

Quarry Dust

Quarry dust was used in the present study as partial replacement of sand. Locally available quarry dust was selected. Quarry dust contained 86% of sand size particles and 14% of silt size particles.

Fine Aggregate (Sand)

Fine aggregates are the second ingredient of the aggregate phase in concrete. Sand is the most commonly used fine aggregate in concrete. Fine aggregates pass the 4.75 mm (No. 4) sieve but are retained on 75 g (No. 200) sieve.

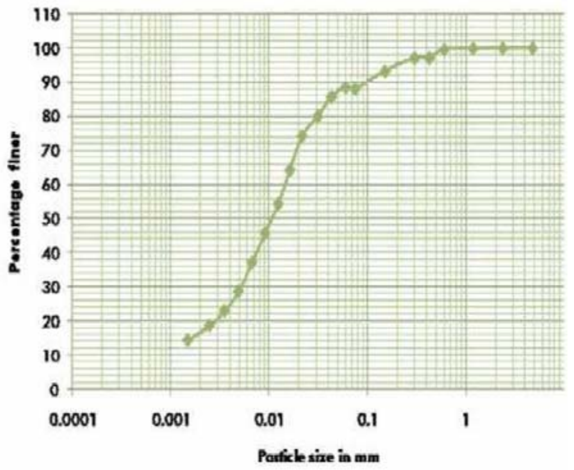
Coarse Aggregate (12.5 Down Size)

The aggregates used in the manufacture of blocks at the mixer or the mixing platform shall be clean and free from deleterious matter and shall conform to the requirements of IS: 383-1970 Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel. They shall be hard, strong, dense, durable, clear and free from veins and adherent coating. And free from injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances as far as possible. Flaky, scoriaceous and elongated pieces should be avoided.

Granite Fine

The granite is procured from Bidadi. The granite fine contained 12% of sand size particles, 71% of silt size particles, 16.6% of clay size particles with specific gravity of granite fines as 2.6 .The grain size distribution for granite fines is shown in Figure 5 below.

Figure 5: Grain Size Distribution for Granite Fines



FABRICATION OF THE STEEL MOULD

For the fabrication of steel mould to prepare hollow Concrete blocks steel sheets of thickness 5 mm and the dimensions of steel sheets were 2 no's of 400 x 200 mm and 2 no's of 200 x 200 mm sheets. They were connected through welding to make rectangular box shape, at one corner end its welded with hinge and other diagonally opposite end its fixed with the clamp for the purpose of de-moulding which can done easily. To make hollows in the blocks wooden inserts were used. For the bottom side wooden plank with groves of depth 7 mm for the fixing

Figure 6: 2 Hole Hollow Block Fabricated Mould

Figure 7: 4 Hole Hollow Block Fabricated Mould

rectangular steel mould and inserts onto the wooden plank. Two patterns of hollowness were introduced one with two rectangular holes and another pattern with four holes as shown in Figure 6 and 7. The size of inserts for a 2 holed block were 100 mm x 125 mm x 200 mm and that of 4 holed were 145 mm x 45 mm x 200 mm with both inserts uniformly tapering at the bottom by 1 cm.

MANUFACTURING OF CONCRETE BLOCKS

Manufacturing process of concrete blocks were 10, either using sprinklers or pressurized/non-conducted manually using the moulds as shown in pressurized steam curing until they are sufficiently Figure 6 and 7 which operate on a level concrete hardened to handle without damage platform. Firstly the proportion of raw materials such as cement, fine aggregate, granite fines, quarry dust, coarse aggregate are calculated. The proportions used are given in the Table 2. The base proportion was taken as 1:4:5 and granite fines were added in different proportions substituting the fine aggregates. Water is mixed in concrete mixing machine. Mixing these cleaned raw materials in appropriate proportion with proper water cement ratio in this project we kept the water cement ratio 0.65. Precise mix design may be done with the available ingredients to monitor the quality of units produced. And the concrete from the mixer is poured into the steel mould in three layers with constantly tamping with the rod, when mould is filled fully then it kept on the vibrating machine for further compaction then the top most layer levelled with rod. Then after 24 h de-moulding is done and the freshly prepared block is ready for curing. Curing is the most important aspect of the production of the blocks. All efforts to produce quality blocks will be useless if curing is not done properly. Also in the study, in order to reduce the water cement ratio blocks were cast using water reducing plasticizer SP-430 at a dosage of 1.25 L/100 kg of cement at a water cement ratio of 0.45 to study the effect of water reducing agent. The concrete blocks are usually cured for at least 14 days [IS 2185 – Part 1 (1979)] page no 10, either using sprinklers or pressurized/non-pressurized steam curing until they are sufficiently hardened to handle without damage.

Figure 8: Demoulding of Blocks

Figure 9: Curing of Blocks

RESULTS AND DISCUSSION

In this present study high strength hollow concrete blocks were manufactured manually with uniform hand compaction utilizing granite fines as an additive and partial replacement of granite fines. The block sizes cast were 400 mm x 200 mm x 200 mm. The test were carried out for the various specimens and its values were compared with requirements as per IS: 2185 (part I)-1979 which classifies the hollow blocks into three grades as Grade A, Grade B and Grade C based on its compressive strength, Density of block and Water absorption. The hollow blocks were cast in four proportions, one proportion with lean mix concrete and the other three with granite fines as an additive. In the earlier mentioned proportions, two categories of blocks one with 2 holes and the other with 4 holes were cast. The following points summarize this report .

Table 2 : List of Hollow Concrete Block Specimen casted with and without granite fines

S.No.	Speciment Notation	% Replacement of Fine Aggregate	Cement	Granite Fines	Fine Agg.		Coarse Agg.	Remarks	No. of Specimens in Each Variant
					Quarry Dust	Sand			
1	2HHCB1	0	1	0	2	2	5	Uniform Hand Compaction	3
2	2HHCB2	12.5	1	0.5	1.75	1.75	5		3
3	2HHCB3	25	1	1	1.5	1.5	5		3
4	2HHCB4	37.5	1	1.5	1.25	1.25	5		3
5	4HHCB5	0	1	0	2	2	5		3
6	4HHCB6	12.5	1	0.5	1.75	1.75	5		3
7	4HHCB7	25	1	1	1.5	1.5	5		3
8	4HHCB8	37.5	1	1.5	1.25	1.25	5		3
9	2HHCBP9	25	1	1	1.5	1.5	5	Uniform Hand Compaction With Plasticiser	3
10	4HHCBP10	25	1	1	1.5	1.5	5		3

Note: 2HHCB1 - 2 Holed Hollow Concrete Blocks with No granite fines and Hand Compacted. 2HHCB2 - 2 Holed Hollow Concrete Blocks with 12.5% granite fines and Hand Compacted. 2HHCB3 - 2 Holed Hollow Concrete Blocks with 25% granite fines and Hand Compacted. 2HHCB4 - 2 Holed Hollow Concrete Blocks with 37.5% granite fines and Hand Compacted. 4HHCB5 - 4 Holed Hollow Concrete Blocks with No granite fines and Hand Compacted. 4HHCB6 - 4 Holed Hollow Concrete Blocks with 12.5% granite fines and Hand Compacted. 4HHCB7 - 4 Holed Hollow Concrete Blocks with 25% granite fines and Hand Compacted. 4HHCB8 - 4 Holed Hollow Concrete Blocks with 37.5% granite fines and Hand Compacted. 2HHCBP9 - 2 Holed Hollow Concrete Blocks with 25% granite fines and Hand Compacted & with Plasticizer. 4HHCBP10 - 4 Holed Hollow Concrete Blocks with 25% granite fines and Hand Compacted & with Plasticizer.

Table 3: Summary of the Test Results for Various Specimens

No of holes	Proportions		Dry weight, Kg	Water absorption %	Mean %	Dry density Kg/m³	Load (kN)	Compressive strength at 28 days N/mm²	Mean Comp strength at 28 days N/mm²
2 HOLES HCB	2HHCB1 1:04:05	1	25.13	3.26	3.02	1570.3	480	6	5.55
		2	25.34	2.55		1583.4	440	5.5	
		3	25.03	3.24		1564.4	412	5.15	
	2HHCB2 1:0.5:3.5	1	26.11	2.28	1.96	1631.9	630	7.88	8.79
		2	26.51	1.66		1656.6	680	8.5	
		3	26.2	1.93		1637.2	800	10	
	2HHCB3 1:1:3:5	1	26.65	1.65	2.06	1665.3	800	10	9.79
		2	25.73	2.51		1608.1	720	9	
		3	25.83	2.03		1614.4	830	10.38	
	2HHCB4 1:1.5:2.5:5	1	25.81	2.44	2.35	1612.8	320	4	4.67
		2	25.88	2.28		1618	400	5	
		3	25.86	2.34		1615.9	400	5	
4 HOLES HCB	4HHCB5 1:04:05	1	24.5	2.61	2.44	1531.3	610	7.63	7.46
		2	25.35	2.29		1584.1	620	7.75	
		3	25.62	2.42		1601.3	560	7	
	4HHCB6 1:0.5:3.5	1	25.59	1.95	1.51	1599.1	600	7.5	8.25
		2	25.35	1.5		1584.4	730	9.13	
		3	26.32	1.08		1645	650	8.13	
	4HHCB7 1:1:3:5	1	26.56	1.49	1.7	1659.7	590	7.38	6.46
		2	25.17	2.46		1572.8	460	5.75	
		3	26.36	1.16		1647.5	500	6.25	
	4HHCB8 1:1.5:2.5:5	1	24.22	3.3	3.07	1513.4	210	2.63	3.54
		2	24.96	2.74		1560	300	3.75	
		3	25.49	3.16		1592.8	340	4.25	
2 HOLES	2HHCBP9 1:1:3:5	1	26.51	1.15	1.17	1658.8	630	7.87	5.16
		2	26.86	1.04		1678.7	310	3.87	
		3	26.17	1.3		1635.6	300	3.75	
4 HOLES	4HHCBP10 1:1:3:5	1	25.31	1.46	1.51	1581.8	360	4.5	5.29
		2	25.95	1.66		1621.8	600	7.5	
		3	25.2	1.42		1575	310	3.87	

Water absorption, bulk dry density and compressive strength of lean mix proportion without granite fines is 3.02%, 1573 kg/m^3 and 5.55 MPa, respectively for 2 Holed Hollow Concrete Blocks (2HHCB1) and 2.44 %, 1572 kg/m^3 and 7.46 MPa, respectively for 4 Holed Hollow Concrete Blocks (4HHCB5).

- With 12.5% replacement of fine aggregate blocks have shown marginally good results for both 2 holed and 4 holed hollow concrete blocks. For 2 holed blocks there is a decrease in water absorption by 35.14% , increase in bulk density by 4.19% and increase in compressive strength by 58.41%. Also for 4 holed blocks there is a decrease in water absorption by 38.04%, increase in bulk density by 2.32% and increase in compressive strength by 10.61%.
- For 25% replacement of fine aggregate 2 holed blocks showed considerably better results than 4 holed. Compressive strength is increased by 76.43% in 2 holed blocks but in case of 4 holed blocks it decreased by 13.41 %, the reason would be due to difficulty in proper compaction in case of 4 holed blocks. However, Water absorption and density is marginally varied in both 2 holed and 4 holed blocks.
- For 37% replacement of fine aggregates, the compressive strength has considerably decreased for both 2 holed and 4 holed blocks in the range of 16% and 52%, respectively. From the result of this variation it is evident that increase in the amount of granite fines increases the amount of surface area of the fines and decrease the compressive strength of the blocks. With respect to the bulk density there is a marginal variation. However the water absorption has increased by 25.77% in 4 holed blocks and in 2 holed blocks it is decreased.
- With the addition of Plasticizer to the hollow concrete blocks, it is observed that the water absorption has reduced when compared to blocks with granite fines of the same proportion and the density is marginally changed. However the compressive strength of the blocks have reduced considerably in the range of 47% and 18% for 2 holes and 4 holes, respectively. This may be due to retarder in the plasticizer.
- All the blocks mentioned above were manufactured manually by uniform compaction from the research point of view and has shown promising results. However there is a need to set up mechanical machines to manufacture the blocks mechanically in order to cater the high strength blocks for the commercial market purpose.

CONCLUSION

Based on the results of the experimental investigation following conclusions are drawn:

1. The Blocks manufactured in this experimental program with granite fine particles as an additive ensures effective packing and large dispersion of cement particles which resulted in a good degree of surface finish and edges.
2. It is evident from the results obtained that the compressive strength and the performance of the Hollow concrete blocks can be increased with proper compaction techniques. When compared to compaction with machine vibration the blocks manufactured with uniform hand compaction gives higher compressive strength.

3. The 28 days compressive strength of the 2 holed hollow concrete block with mix proportion 1:4:5 with is taken as base without granite fines is 5.55 Mpa and it is observed that with the addition of granite fines in various proportion as replacement to fine aggregates, i.e., with 12.5% and 25% replacement the compressive strength is increased to 8.79 MPa and 9.79 MPa respectively with a percentage increase of 58.41% and 76.43%, respectively when compared to specimen without the granite fines as an additive. However with further increase in percentage of fines, i.e., with 37.5%, it is observed that the mean compressive strength is reduced to 4.67 MPa indicating that higher amount of granite fines increases the surface area of fine particles there by demanding more cement for bonding and thus reducing its compressive strength.
4. It is seen from the experimental data the optimum replacement of fine aggregates by granite fines is 25% and further increase in granite fines reduces the strength of hollow concrete blocks.
5. With the addition of plasticizer to the hollow concrete blocks, it is observed that the water absorption has reduced when compared to blocks with granite fines of the same proportion and the density is marginally changed. However the compressive strength of the blocks have reduced considerably when compared to blocks with granite fines of the same proportion in the range of 47% and 18% for 2 holes and 4 holes, respectively.
6. All the blocks mentioned above were manufactured manually by uniform compaction from the research point of view and has shown promising results. However there is a need to set up mechanical machines to manufacture the blocks mechanically in order to cater the high strength blocks for the commercial market purpose.

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International Journal of Engineering Research and Science & Technology
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ISSN 2319-5991
9 772319 599001 04