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Manufacturing of Building Blocks by Utilising of Iron Ore Tailings

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Abstract:
The exploitation of mineral resources would promote the development of economy and society, but it will also generate massive overburden, mill tailings, silt etc. that may pollute the environment heavily. Therefore, comprehensive utilization of waste/tailings is important. Masonry is widely used to construct both small and large structures because of its structural versatility and attractive appearance. In order to cater to the different needs of construction, various masonry units have been developed and used.

Keyword: Compressive strength; Split tensile strength; Slump test; Compaction factor test.

I. INTRODUCTION

Masonry is widely used to construct both small and large structures because of its structural versatility and attractive appearance. Best designer is one who comes out with a design which gives the stable and economic structure. India has large reserves of metal bearing ore and it occupies sixth position in the world with regard to iron ore reserves. The waste/tailings that are ultra-fines or slimes, having diameter less than 150µm, are not useful and hence are discarded. In India approximately 1500 to 2000 million tons of such mined ore is lost as tailings. The safe disposal or utilization of such vast mineral wealth in the form ultra-fines or slimes has remained a major unsolved and challenging task for the Indian iron ore industry. India's magnetite ore processing plants situated at Kudremukh. Kudremukh Iron Ore Company Limited (KIOCL) has been conducting its mining operations on an area of 4,604.55 ha in the Western Ghats. KIOCL has stored iron ore tailings to the tune of 150million tons in Bhadra dam. This waste has sand particles to the extent of 79% and silt particles to extent of 19%. This can be an ideal sand substitute for construction activities such as building blocks, paver blocks, stabilized mud blocks, paving tiles etc.

II. OBJECTIVES OF THE STUDY

The following are the main objective of the study:

1. To evaluate the fresh properties of control concrete of M10, M15 and M20 and concrete made with iron ore tailings replacement of sand.
2. To evaluate the compressive strength of iron ore tailing concrete of grade M10, M15 and M20 with respect of their mix designs.

III. MATERIALS AND METHODOLOGY

a. cement

In this present work cement of 43 grade ordinary Portland cement (OPC) was used for casting cubes for all concrete mixes. The cement was of uniform colour i.e Grey with a light greenish shade and was free from any hard lumps. The various tests conducted on cement are specific gravity, initial and final settling time and compressive strength. Testing on cement was done as per IS codes. The specific and composting limits of Portland cement are reported in below tables.

Table.1. Physical properties of cement

Particulars	Experimental Results	As per standard IS 8112:2013
Specific gravity	3.15	---
Setting time (minutes)		
Initial setting time	45 minutes	30 minutes (Minimum)
Final setting time	560 minutes	600 minutes (Maximum
Compressive strength		
3 days	22.79MPa	16MPa (minimum)
7 days	34.52MPa	22MPa (minimum)
28 days	46.28MPa	43MPa (minimum)

a. Iron ore tailing

The world reserve base of crude iron is estimated to be 370 billion tones. India is one of the major producers of iron ore in the world, even now, about 25.24 billion tons of iron ore. Iron ores are rocks and minerals from which metallic iron can be economically extracted. The ores are usually rich in iron oxides and vary in color from dark grey, bright yellow, deep purple, to rusty red. The iron itself is usually found in the form of magnetite (Fe_3O_4), hematite (Fe_2O_3), goethite ($FeO(OH)$), limonite ($FeO(OH).n(H_2O)$) or siderite ($FeCO_3$). Ores carrying very high quantities of hematite or magnetite (greater than ~60% iron) are known as "natural ore" or "direct shipping ore", meaning they can be fed directly into iron-making blast furnaces. Iron ore is the raw material used to make pig iron, which is one of the main raw materials to make steel. 98% of the mined iron ore is used to make steel.

b. Coarse aggregate

Locally available coarse aggregate having the maximum size of 20mm for used in the present work. The physical properties of coarse aggregate are prevented in the table 3

Table. 2. Physical properties of CA

Particulars	Experimental Results
specific gravity	2.7
water absorption	0.3%
free moisture content	0%

b. Water

Potable tap water was is used for the preparation and curing of the specimens. Mix design The proportioning of the ingredients of concrete is an important phase of concrete technology as it ensures quality and economy. In pursuit of the goal of obtaining concrete with desired performance characteristics the selection of component materials is the first step, the next step is a process called mix design by which one arrives at the right combination of the ingredients. The mix design procedure adopted in the present work to obtain M10, M15, M20 grade concrete is in accordance with IS: 10262-2009. The specific gravities, mix proportion, mix designation of the materials used are as tabulated in the below table 4,5 and 6 respectively

Table.3. Specific gravities of materials used

Materials	Specific gravity
Cement	3.15
Iron ore tailing	2.66
Coarse aggregate	2.70

Table. 4. Mix proportion

W/C ratio	Water (kg/m^3)	Cement (kg/m^3)	Iron 0re tailing (kg/m^3)	CA (kg/m^3)
0.55	211.08	383.78	785.38	1006.4

III. CASTING OF SPECIMEN AND TESTING PROCEDURE

Mixing of materials

Thorough mixing of the materials is essential for the production of uniform mix of materials. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. Normally, a batch mix made with ingredients corresponding to 50 kg cement. This depends on the proportion of mix. For example, for 1:2:4 mix, the ideal mixer of 200 liters capacity. Whereas if the ratio is 1:3:6 the requirement will be 280 liters capacity to facilitate one bag mix. About half the quantity of coarse aggregate is placed in the skip over which about half the quantity of fine aggregate is poured. On that, the full quantity of cement i.e., one bag is poured over the which the remaining portion of coarse aggregate and fine aggregate is deposited in sequence. About 25% of the total quantity of water required for mixing, is introduced into the mixer drum to wet the drum and to prevent any cement sticking to the blades or at the bottom of the drum. Immediately on discharging the dry materials into the drum, the remaining 75% of water is added to the drum. The time is counted from the moment all the materials, the complete quantity of water is fed into the drum

Casting of blocks

Casting Platform

The blocks are produced on a smooth, level and hard surface of 30 mm. thick 1:3:6 cement concrete platform simultaneously finished smooth with 1:3 mortar. A base of brick soling of 12ncm thick lean concrete 1:8:16 may be used as a sub grade. The platform shall be cast in bays of $2m^2$ to avoid random surface cracks. A casting platform of about $80m^2$ (10x8m preferably is required for production of 500 blocks per day

Block making machine

Concrete blocks can be made either by manual method or with a block making machine. In the manual method single block moulds kept in a row are often employed and concrete is compacted in the moulds with a plate vibrator. On the other hand, the block making machine invariably has a replaceable gang mould system to produce two to eight blocks (or even more) in one operation of casting. The vibrating system in the machine is an integral part of the mould. The machine made blocks are superior in strength and finish due to better control possible during compaction of concrete. The production of blocks becomes much faster with the machine as compared to the manual method.

Salient features of the machine are given in the following:

- A portable egg laying type machine.
- Five blocks of size 40x20x15 cm case in one operation.
- Output of 120 to 150 blocks of above size in one hour.
- Better compaction ensured through pressure vibration.
- Two vibrators each of 0.5 KW capacity and frequency 3000 VPM used for consolidation of concrete.
- Suitable for casting stone block, large aggregate concrete blocks traditional concrete block and hollow blocks.
- Operator's access right upto the moulds help in easy placement of stone spalls in casting stone blocks and screeding of concrete in the moulds while casting large aggregate blocks.
- Power required: 3KW

Working and trials

The machine is placed on the casting platform which should be a levelled and well finished concrete floor. Waste newspapers or polythene sheets are laid on the platform for easy removal of the block next day.

IV. EXPERIMENTAL RESULTS

Compression Test

Compression test of masonry blocks plays an important role in controlling and confirming the quality of building blocks. Compression test is most common test conducted on hardened concrete and also building blocks, partly because it is an easy test to perform, and partly because most of the desire characteristic properties of block are quantitatively relative to its compression strength.

Three specimens (blocks) from each type of mix proportions, cured for 7 days and 28 days, the compression test is carried out on specimen cubical, cylindrical in shape and prism shape. The block specimen is of the size 200X150X400mm

Table .5. The Compressive Strength of Respective Specimens

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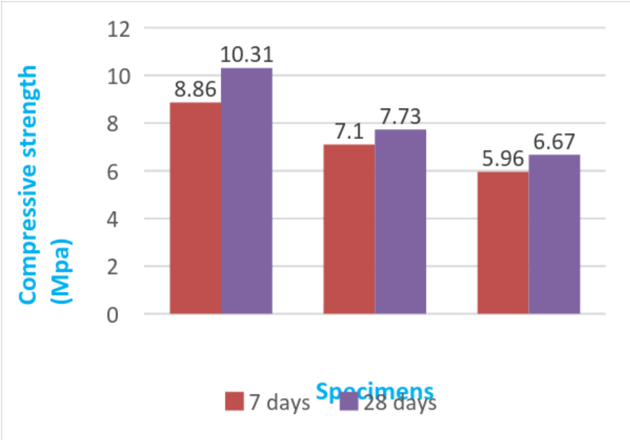
Reference Mix			Modified Mix		
Mix Code	**Compressive Strength In(Mpa)**		**Mix Code**	**Compressive Strength In(Mpa)**	
	7 Days Strength	**28 Days Strength**		**7 Days Strength**	**28 Days Strength**
1RM	4.97	5.60	1TM	9.58	10.90
	4.61	5.46		8.17	10.30
	4.74	5.23		8.83	9.68
2RM	4.08	4.58	2TM	7.03	7.93
	3.84	4.94		6.95	7.68
	4.25	4.82		7.19	7.60
3RM	3.44	3.93	3TM	6.21	6.70
	3.35	3.67		5.96	6.87
	3.76	4.08		5.72	6.46

Average compressive strength of specimen cured for 7 and 28 days



V. DISCUSSIONS AND OBSERVATIONS

The following observations are made from the experimental results and graphs :

1. Curing is an important factor governing the strength of block. The main objective of curing is to avoid shrinkage cracks and enable full hydration to take place.
2. The test specimen is stored in place free from vibration. Blocks are stored at temperature within the range of 22^{o} C to 32^{o}C .They should be marked for later identification for testing for 7 and 28 days. The clear water of temperature 24^{o}C to 30^{o}C should be used.
3. Three specimens (blocks) from each type of mix proportions, cured for 7 days and 28 days, the compression test is carried out on specimen cubical, cylindrical in shape and prism shape. The block specimen is of the size 200X150X400mm.
4. The compressive strength obtained from 7days of curing for M10-6.21Mpa, M15-7.03 Mpa, M20-9.58.
5. The compressive strength obtained from 28days of curing for M10-6.70Mpa, M15-7.93 Mpa, M20-10.90.

VI. CONCLUSION

The total production of iron ore in India is expected to 400 million tons within the next decade. The exploitation of mineral resources would promote the development of economy and society, but it will also generate massive waste/tailings that may pollute the environment heavily and bring other issues such as land degradation, deforestation, acid mine drainage etc. Therefore comprehensive utilization of waste/tailings is important in saving resources, improving surrounding and for sustainable development. In the present study substitution of iron ore tailings and quarry dust shows better compressive strength without much change in water absorption. It is also revealed that the mix with tailings has the highest compressive strength for 28 days curing. By using these wastes instead of conventional materials, we would not only be preserving the natural precious resources, but also solving the problems of disposal of waste, which has become a national problem. Building blocks from mine waste are eco-friendly as it utilizes waste and reduces air, land and water pollution. It is energy efficient and also cost effective Therefore, the use of alternative materials for brick construction should be encouraged. There is large scope for utilizing mine wastes for the manufacture of building materials and products. Mine wastes and tailings can be converted into bricks/paving blocks, which can meet the demand of bricks in metropolitan cities for the next few decades. Also building blocks from mine waste are eco-friendly as it utilizes waste and reduces air, land and water pollution. It is energy efficient and also cost effective as reported by various investigators in the past.

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