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EXPERIMENT ON HIGH DENSITY CONCRETE INCORPORATING HEMATITE

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ABSTRACT

Concrete has an extensive role to play both in construction and improvement of our civil engineering and infrastructure. It's great strength, durability and versatility are properties that are utilised in the construction of roads, bridges, airport, railways, tunnels, ports and harbours and many other major infrastructure projects. To call the concrete, as high density concrete, it must have unit weight ranging from 3360 kg/m3 to 3840 kg/m3. They can, however be produced with the densities upto about 5280 kg/m3. Amongst a number of dense materials and metals that may be used for shielding of harmful high energy electromagnetic rays, HDC is compatible with normal concrete and it provides visible and economical solution for gamma ray shielding. Consequently, the role of HDC in contributing equivalent shielding at the reactor vault (RV) region, wherein the thickness of concrete has to be reduced for space constraints, is vital. High density concrete offers reliable, cost-efficient radiation shielding and can be used alongside other shielding materials to maximize protection in the available space. They can be used to shield linear accelerators, vault walls, high dose radiation rooms and more. The presence heavy metal increases its density correspondingly. High density aggregates are the key ingredient in High density concrete. The more common aggregates used to achieve the required densities are Hematite, Ilmenite, Magnetite and Steel aggregate. The concrete was studied using Hematite (iron ore) having a density varies from 3400-3600 Kg/^{m3}. Several properties of concretes with design mix of M30 grade were also studied that include the compression, split tensile and densities at fresh and harden stages and Gamma shielding evaluation values. The high density concrete was also compared with normal weight concrete of the same strength grade with respect to the above parameters.

KEYWORDS: HDC, RV, Sand, Aggregate, Cement, Hematite

General

- In this topic the materials used for the manufacture of specimen are listed.
- This topic covers the testing of the materials and the corresponding values from the results are tabulated.

Materials Used

- Cement
- Fine Aggregate (River sand)
- Coarse Aggregate
- Hematite as Coarse aggregate and as Fine aggregate

DESCRIPTION OF MATERIALS

Cement

Cement is made by heating limestone (calcium carbonate) with small quantities of other materials (such as clay) to 1450 °C in a kiln, in a process known as calcinations, whereby a molecule of carbon dioxide is liberated from the calcium carbonate to form calcium oxide, or quicklime, which is then blended with the other materials that have been included in the mix. The resulting hard substance, called 'clinker', is then ground with a small amount of gypsum into a powder to make 'Ordinary Portland Cement', the most commonly used type of cement (often referred to as OPC). Portland cement is a basic ingredient of concrete, mortar and most non-specialty grout. The most common use for Portland cement is in the production of concrete.

The grades of OPC are – 33, 43 and 53. Grade-33 cement would meet the structural requirements of ordinary and small scale consumers. 43 grade cement may be utilised for precast concrete production besides the sleeper manufacturers and other building components producers, 53 grade., cement may be utilised by builders of heavy infrastructure such as bridges, fly over's, large span structures and high rise structures. The common man's perception that 53 grade cement is the best cement is not only due to the aggressive marketing strategies of the cement manufacturers but also on the presumption that the heat generated during hardening of concrete is an index of its quality. When 53 Grade, cement is used the heat generated is very high. Hence, consumers believe that it is a better cement when actually it is not so. Each type of cement has to be chosen for a particular use. Cement used in construction is characterized as hydraulic or non-hydraulic. Hydraulic cements (e.g., Portland cement) harden because of hydration, chemical reactions that occur independently of the mixture's water content; they can harden even underwater or when constantly exposed to wet weather.

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Fine Aggregate (River Sand)

The size of aggregates which are lesser than 4.75mm are considered as fine aggregate. The most commonly used fine aggregate is the river sand. It passes through 4.75mm sieve.

The three types of sand are,

- River Sand
- Pit sand
- Sea Sand

Sand covers the major part of the construction forum. Until the introduction of fly ash and quarry dust river sand was the only fine aggregate to be used. In Tamil Nadu the most common places where river sands are collected are Trichy and karur. In the recent decade River sand is being fast replaced by Quarry Dust, Fly Ash and Pond Ash.

Coarse Aggregate

Aggregates are the most mined materials in the World. The coarse aggregate is the important material to be added in concrete. The aggregates of size greater than 4.75mm are generally termed as coarse aggregates. The types of coarse aggregates are,

- Crushed Aggregates
- Uncrushed Aggregates

Mostly uncrushed aggregates are not used in concrete due to their smooth surface. The strength value decreases with the usage of this aggregate. The crushed aggregates have high strength compared to uncrushed aggregates. Workability of Crushed aggregate is very much lesser compared to uncrushed aggregate. The size of the aggregate used in this project ranges from 4.75mm – 6mm.

Hematite

Hematite is the mineral form of iron (III) oxide (Fe_2O_3), one of several iron oxides. Hematite crystallizes in the rhombohedra system, and it has the same crystal structure as ilmenite and corundum. Hematite and ilmenite form a complete solid solution at temperatures above 950 °C. Hematite is a mineral, colored black to steel or silver-gray, brown to reddish brown, or red. It is mined as the main ore of iron.

Varieties include kidney ore, martite (pseudomorphs after magnetite), iron rose and specularite (specular hematite). While the forms of hematite vary, they all have a rust-red streak. Hematite is harder than pure iron, but much more brittle. Maghemite is a hematite- and magnetite-related oxide mineral.

Huge deposits of hematite are found in banded iron formations. Grey hematite is typically found in places where there has been standing water or mineral hot springs, such as those in Yellowstone National Park in the United States. The mineral can precipitate out of water and collect in layers at the bottom of a lake, spring, or other standing water. Hematite can also occur without water, however, usually as the result of volcanic activity.Fig1and 2 shows Hematite sample

Figure 1: Hematite as Fine Aggregate

Figure 2: Hematite as Course Aggregate

TESTING OF MATERIALS

Cement

In this project, Ordinary Portland Cement of 53 Grade conforming to Indian standards available in local market of standard brand is used for casting cubes,

cylinders for M30 concrete mixes. The cement used was fresh, uniform color and without any hard lumps. Testing of cement was done as per IS: 12269-1987. The various test results conducted on the cement.

Table 1: Properties of Cement

Sl. No.	Description	Test Results
1	Standard Consistency	33 %
2	Initial setting time	45 minutes
3	Final setting time	145 minutes
4	Fineness (by sieve analysis)	1 %
5	Compressive strength (at 28 days)	55.06 N/mm^2
6	Specific gravity	3.15

Fine Aggregates

The locally available river sand was used as fine aggregate in the present investigation. The sand should be devoid of impurities like clay matter, salt and organic matter and is tested for different properties as per IS 383-1970 such as specific gravity, fineness modulus, water absorption etc., Sieve analysis is carried out and it is passing through 4.75 mm sieve. Properties of the fine aggregate used in this project work are tabulated in Table 2.

Table 2: Properties of Fine Aggregates (River sand)

Sl. No.	Description	Test Results
1	Type	Uncrushed (natural)
2	Grading	Zone-II
3	Specific gravity	2.78
4	Total water absorption	0.86 %

Coarse Aggregates

Machine crushed angular granite metal of 20mm size from a local source was used as coarse aggregate. It is from impurities such as dust, clay particles and organic matter etc., The coarse aggregate is also tested for its various properties. The aggregates of size greater than 4.75mm are generally termed as coarse aggregate. Testing of coarse aggregate is done as per IS: 383-1970. The results of various tests conducted on course aggregate are given in Table 3.

Table 3: Properties of Coarse Aggregates

Sl. No.	Description	Test Results
1	Type	Crushed
2	Maximum size	20mm
3	Specific gravity	2.79
4	Total water absorption	Nil
5	Impact value	12.62 %
6	Crushing value	24.97 %

Hematite As Fine Aggregate & Coarse Aggregate

Hematite is a mineral, colored black to steel or silver-gray, brown to reddish brown, or red. It is mined as the main ore of iron. While the forms of hematite vary, they all have a rust-red streak. Hematite is harder than pure iron, but much more brittle. Hematite can also occur without water, however, usually as the result of volcanic activity. They are found as huge rocks in mining areas. The test results are tabulated below.

Table 4: Properties of Hematite -Fine Aggregates

Sl. No.	Description	Test Results
1	Type	Crushed
2	Grading	Zone-II
3	Specific gravity	4.19
4	Total water absorption	2.13 %

Table 5: Properties of Hematite –Coarse Aggregates

Sl. No.	Description	Test Results
1	Type	Crushed
2	Maximum size	20mm
3	Specific gravity	3.33
4	Total water absorption	0.93 %
5	Impact value	18.02 %
6	Crushing value	27.13 %

Table 6: Characteristics of Hematite

Sl. No.	Chemical Composition	Per Cement Content (%)
1	Silica (SiO_2)	0.92
2	Calcium Oxide (CaO)	0.02
3	Ferric Oxide (Fe_2O_3)	98.26
4	Alumina (Al_2O_3)	0.23
5	Manganese Oxide (MnO)	0.014
6	Phosphorus (P)	0.013
7	Sulphur (S)	0.005

Water

Water is the least expensive but most important ingredient of the concrete. The water used for making concrete should be clean and free from deleterious impurities like oil, alkalinities, acids etc., In general, the water fit for drinking is ideal for concrete making. In this project, potable tap water in the laboratory was used for the concrete preparation and for the curing of specimens.

Table 7: Mix Design For M30 Grade –High Density Concrete

Water	Cement	Fine aggregate	Coarse aggregate	Chemical admixture
213.65	394	1072.81	1451.75	7
0.45	1	2.72	3.68	0.018

CONCLUSION

Based on the experimental investigations carried on the conventional concrete, the following points are concluded,

- Conventional Concrete has more Compressive strength and Split tensile strength values are found out.
- In phase II the high density concrete strengths are compared to normal concrete
- In future study give a idea about high density concrete strength and behavior
- Load and deflection are compared with conventional concrete and the graph has been plotted
- Stress strain curve are compared with the concrete and the strength characters of high density concrete will be studied

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