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**RESEARCH ARTICLE**

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**“STUDY ON HEAVY WEIGHT CONCRETE FOR ENHANCING THEIR PROPERTIES BY PARTIAL  
 REPACEMENT OF COARSE AGGREGATE WITH HEMATITE”**

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**Manuscript Info**

**Key words:-**

High Density Concrete, Hematite,  
 Radiation Shielding, Density

**Abstract**

Heavy weight concrete or high density concrete is commonly used for radiation shielding either in nuclear power plant or in radiation therapy units. It can also be used as ballast in offshore location such as pipelines. Heavy weight concrete is designed by using heavy weight aggregate such as hematite, magnetite, barite, etc. The rise in construction activity has resulted in an increase in demand for variety of materials. This research into alternative material for used as concrete ingredient that are not inferior to conventional material. This project focuses on the partial replacement of coarse aggregate with hematite aggregate in a varying percentage of M30 concrete mix. In this work, conventional coarse aggregate is partially replace with hematite aggregate that passes through 20mm IS sieve size. Hematite replace in a percentage of 25%, 50%, and 75%, and compressive strength are determined.

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**Introduction:-**

Heavy weight concrete (M30) or heavy density concrete (HDC) is a concrete type specially introduced for arresting ionization radiation in accordance with the limited space availability in a nuclear power plants, in hospitals and other radiation zones. The concrete is ideal for radiation shielding in varieties of environments using less space than traditional concrete construction. Since, concrete contains more than 70% aggregate, the only way to make it highly dense is to choose suitable high density aggregates. The high density aggregates employed here were obtained from the TANMAC region of Tamil Nadu. Thus, according to the Turkish code, conventional concrete should be durable against harmful water, fluids and gases (18). There are no such requirements for heavy weight concrete – unless it is used for protection against radiation (15-17). Structures like hospitals and nuclear power plant buildings etc. using these concretes must have some engineering properties like compressive strength, importantly durability and workability. According to Akkurt and coworkers

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(19), in building construction two features are most important: resistance against earthquake represented by strength of the building and resistance against radiation expressed as radiation attenuation. Since environmental protection is now a significant issue, more efforts must be made to understand heavy weight concrete and their structural behavior. This limited to discussion and identification of suitable raw materials for high density shielding concrete (HDSC), its mix design and optimization, testing of mechanical properties. The advantages of using concrete as a shielding material are related to its good compromise thickness requirements for neutron and photon shielding; it can also be cast into almost any complex shape. Its use as a radiation shielding material is well – established as indicated by the availability of existing knowledge and literature. Other benefits of using concrete include the local availability of the required high density aggregates, its versatility, composite nature, economic savings, low maintenance, ease of manufacture and structural integrity. Concretes are highly durable and provide permanent shielding installations, unlike materials such as lead which may lack structural integrity, or use of water that might cause complications such as rusting and leakage of containers. Materials have different shielding properties for different types of radiation and therefore the selection of shielding material is a function of the radiation type and the energies of the specific radiation.

### Characteristics and Properties:

Hematite is an iron oxide with a chemical composition of  $\text{Fe}_2\text{O}_3$ . Pure hematite has a composition of about 70% iron and 30% oxygen by weight.

Physical Properties Of Hematite	
Chemical Classification	Oxide

**Table 1:-** Physical properties of hematite.

Color	Black to steel gray to silver; red to reddish brown to black
Streak	Red to reddish brown
Luster	Metallic, submetallic, earthy
Diaphaneity	Opaque
Cleavage	None
Mohs hardness	5 to 6.5
Specific gravity	5. to 5.3
Chemical composition	$\text{Fe}_2\text{O}_3$
Crystal system	Trigonal
Uses	The most important ore of iron. Pigment, heavy media separation, radiation shielding, ballast

### Literature Review:-

#### Beatrice Pomaro:

He has done study on “Radiation Damage In Concrete For Nuclear Facilities: From Experiments To Modeling” by this study he concluded that cement paste shrinks under drying condition, the decrease in volume being only partially covered by the thermal expansion due to high temperature arisen by associated radiation heat. Shrinkage of the cement paste is mostly explained by water hydrolysis and water evaporation occurring under gamma- ray irradiation. On the other hand, aggregates expand due to accumulation of defects in their crystal structures generated mainly by neutron collisions. This uneven volume expansion in between cement matrix and aggregates is pointed out as a primary cause of damage in irradiated cementitious materials, based on the available experimental study. [1]

#### M. S. Sethumadhav

In this study on “Iron Ore Deposits of India” he studied that hematite and magnetite are the most important ore minerals in Indian iron ore deposits. About 59% hematite ore deposits are found in Eastern Sector. Hematite is considered to be superior because of its higher grades and occurs in massive, laminated, friable and powdery form. In India, major amount of hematite is found in Orissa, Jharkhand, Chhattisgarh, Karnataka and Goa. Minor amount of hematite is found in Andhra Pradesh, Assam, Bihar, Maharashtra, Madhya Pradesh, Meghalaya, Rajasthan and Uttar Pradesh. [2]

**Wu, Sofi, M. Mendis:**

In this study on “High Strength Concrete for Sustainable Construction” they concluded that the constituents of high density concrete have been discussed. It is noted that the necessary ingredients making the concrete such as fly ash, slag and silica fume are mostly industrial byproducts which are otherwise wasted in landfills. This should be considered toward recognition of HSC as an environmentally friendly material. [3]

**Amr M. Ibrahim**

In a study conducted by Amr M. Ibrahim where no significant variation between shielding properties of mixes with hematite and iron slag. Thermal was improved by using hematite aggregate. Using Highslag cement improves the mechanical concrete. Specific heat is increased by using iron slag as coarse aggregate replacement.

**Experimental Program**

An experimental study is conducted on Hematite partially mixed with cement concrete. The normal grade of concrete M30 mixed with varying percentage of hematite by replacing coarse aggregate. Experimental study is carried out to investigate both fresh and hardened concrete properties.

**Materials Used:-**

Main constituents of the concrete is cement, fine aggregate, coarse aggregate, Hematite. The materials used in the present program are shown below:

**Cement**

Locally available Ordinary Portland Cement of 53 grade of ultra-tech brand conforming to ISI standards has been procured, and following tests have been carried out according to IS: 8112 – 1989

Sr.No.	Physical Property	Results of OPC(53 grade)
1.	Initial Setting time	30 min
2.	Final Setting time	600 min
3.	Fineness	6%
4.	Specific Gravity	2.03
5.	Consistency	33%
6.	Soundness	0.5mm

**Table 2:-** Physical properties of 53 grade OPC.

**Fine aggregate**

The locally available natural river sand conforming to grading zone-II IS 383-19100 has been used as Fine aggregate. Following tests have been carried out as per the procedure given in IS 383(1970)

Sr. No.	Properties of aggregates	result of fine aggregate
1.	Bulk Density	0
2.	Fineness Modulus	2.24
3.	Specific Gravity	2.29

**Table 3:-** Tests on Fine Aggregate (FA).

**Coarse aggregate**

Machine crushed granite conforming to IS 383-19100[23] consisting 20mm maximum size of aggregates has been obtained from the local quarry. It has been tested for physical and mechanical properties such as specific gravity, sieve analysis and the results have been shown in the Table 4

Sr. No.	Properties of aggregates	Test results of Fine aggregates
1.	Loose	1235kg/m <sup>3</sup>

	Density	
2.	Rooded Density	1325kg/m3

**Table 4:-** Tests on Coarse Aggregate (CA).

### Water

Potable water has been used in this experimental program for mixing and curing.

### Mix design

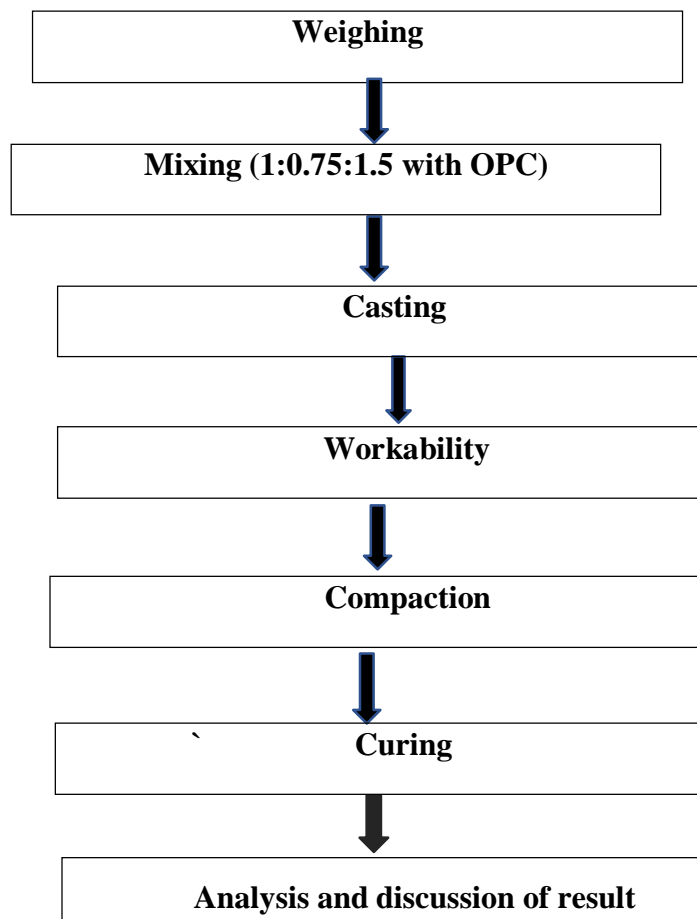
Mix design is defined as process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economic as possible.

### Mix design of M30 grade concrete

In the present investigation M30 grade of concrete has been considered. The mix of concrete is designed as per the guidelines given in IS 456:2000 and IS 10262-2009, subsequently mixes were prepared with a partial replacement of coarse aggregate by Hematite of 0%, 25%, 50% & 75% by weight of aggregate for Cubes and beams.

### Preparation of Test

Concrete cubes specimens of 150 mm x 150 mm x 150 mm size and concrete beam specimens of 150 mm x 150 mm x 700 mm size were casted to evaluate the variation in compressive strength and flexural strength respectively. After casting, the concrete specimens were kept in the moulds for 24 hours. The specimens were then demoulded and moist cured in a curing tank till the age of 7, 14, 28 days.



**Gap finding**

1. Physical properties of heavy weight concrete have been improved with desired workability.
2. It provide a radiation shielding against the radiations as it is very compact in crystalline structure.
3. It gives natural colour to the concrete without using artificial pigments.

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