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Radiation Shielding Properties of Concrete with dolomite powder as sand replacement

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Abstract

The development of nuclear energy , heavy weight concrete is use as a shielding material to provide protection against radiation hazards. It is also known as radiation shielding concrete. In this concrete is replaced by fine aggregate with dolomite as 10%,20%,30% and 40% by weight of sand is used for gamma radiation interaction test, Cs137 source at a 661.7 keV gamma radiation energy using narrow transmission geometry. Water-cement ratio is to be kept same as that of normal concrete.
Keywords: *dolomite as a radiation shielding, compressive strength of dolomite concrete, radiation test.*

1. INTRODUCTION

Concrete is the basic civil engineering material used in most of the civil engineering structures. Many materials are used to manufacture good quality concrete. Cement, fine aggregate, coarse aggregate, mineral admixtures, chemical admixtures and water are the constituents of concrete. Cement is the most important constituent material, since it binds the aggregates and resists the atmospheric action [3]. Dolomite is a carbonate material composed of calcium magnesium carbonate CaMg $(CO_3)_2$. Dolomite has good weathering resistance and is noted for its remarkable dispersibility and wettability [2]. The normal concrete weight around 68 kg per cubic foot, high-density concretes normally weight from 70 to 90 kg per cubic foot. Among the natural aggregates most commonly used are barite, magnetite, dolomite, limonite, and hematite. The density will depend on the type of material used. The high density concrete protects from harmful radiations X-rays, gamma rays, neutrons [5].

Now a days for more energy consumption nuclear power plants are require to produce electricity, but in this radiation are produce , which is harmful to human body, Also for in the cancer hospital the radiation can be produced. The radiation can be shield by high strength, high density concrete and with the use of high atomic number materials, For the radiation shielding lead and mercury use as a cotting on the wall ,but which is costly. Heavy weight high performance concrete (HPC) can be used when particular properties, such as high strength and good radiation shielding are required. The development of nuclear energy, heavy density concrete is use as a shielding material to provide protection against radiation hazards, It is also known as radiation shielding concrete [11].

1.1 Why Dolomite as Radiation Shielding

Dolomite is a carbonate material composed of calcium magnesium carbonate CaMg $(CO_3)_2$.The dolomite is a high strength and high density material, and the atomic number of dolomite is more than sand so it can be reduce the radiation effect up to certain limit in replacement with sand. Dolomite is a rock forming mineral which is noted for its dispersibility and good weathering resistance. Dolomite is a preferred for construction material due to its higher surface hardness and density. The density will depend on the type of material used; the high density concrete protects from harmful radiations X-rays, gamma rays, and neutrons [11].

1.2 Why Replace With Sand

Replacement with cement is reducing the strength of concrete [1]. And cement also works as radiation shielding material. The density of dolomite is more but the crushing values is less in compare with aggregate the atomic number of dolomite is more than sand so it can be reduce the radiation effect up to certain limit in replacement with sand [11].

2. MATERIALS

2.1 Cement

Cement is one of the constituents of concrete and is the glue that holds the other materials together. Cement is not a new material and as far back as the third century BC, the Romans mixed volcanic ash with lime mortar to make a cement-like material. This was much improved in the 19thcentury and a patent of Portland cement was granted in 1825 to Joseph Aspidin. Today, cement is made by heating limestone with small quantities of other materials (such as clay) in kiln. The resulting clinker, is then ground with gypsum to make Ordinary Portland Cement [12].

2.2 Coarse Aggregate

Aggregates contain 80% of the weight of plain mass concrete. The properties of aggregates which are important include, crushing strength, size, grading, shape and colour. Natural occurring aggregates can be found in gravel beds on land or in the sea. Alternatively, larger rocks can be quarried and crushed to a suitable size for use in concrete. Aggregates which cannot pass through a 4.75mm sieve those are coarse aggregates [12].

2.3 Fine Aggregate

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 4.75 mm sieve [12].

2.4 Dolomite powder

Fig.2.1: Dolomite Powder

Dolomite is an anhydrous carbonate mineral composed of calcium magnesium carbonate, ideally $CaMg(CO_3)_2$. The term is also used for a sedimentary carbonate rock composed mostly of the mineral dolomite. An alternative name sometimes used for the dolomitic rock type is dolostone. The mineral dolomite crystallizes in the trigonal-rhombohedral system. It forms white, tan, gray, or pink crystals. Dolomite is a double carbonate, having an alternating structural arrangement of calcium and magnesium ions. It does not rapidly dissolve or effervesce (fizz) in dilute hydrochloric acid [3].

Table 2.1: Chemical composition of dolomite (%)

S/NO	Compound	Dolomite
1	Cao	23.16
2	SiO_2	21.7
3	Al_2O_3	2.40
4	Fe_2O_3	0.65
5	MgO	15.6
6	TiO_2	0.14
7	SO_3	0.09
8	Ignition Loss	35.7

Table 2.2: Physical Properties of dolomite

S/NO	property	Dolomite
1	Density	1.52gm/cm^3
2	color	White, grey
3	Tenacity	Brittle
4	Moisture content	Nil
5	Crystal system	Trigonal

Table 2.3: sieve analysis of dolomite

Sieve	Retained WT(gm)	Retained WT (%)	Cumulative Retained (%)	Cumulative Passing (%)
4.75 mm	0.0	0	0	100
2.36 mm	0.0	0	0	100
1.18 mm	113	11.3	11.3	88.7
600 mic	724	72.4	83.7	16.3
300 mic	109	10.9	94.6	5.4
150 mic	31	3.1	97.7	2.3
<150 mic	23	2.3	100	0.00

2.5 Admixtures

An admixture is a material other than water, aggregates and cement and is added to the batch immediately before or during its mixing. Admixtures are used to improve or give special properties to concrete. The use of admixture should offer an improvement not economically attainable by adjusting the proportions of cement and aggregates and should not adversely affect any properties of the concrete.
The admixture consist chiefly of those which accelerate and those which retard hydration or setting of the cement, finely divided materials which improves workability, water proofers, pigments, wetting, dispersing and air-entraining agents and pozzolanic. Admixtures ranging from additions of chemicals to waste materials have been used to improve certain properties of concrete. The admixture is generally added in a relatively minimum quantity [13].

3. EXPERIMENTAL PROCEDURE

3.1 Preparation of concrete mixtures

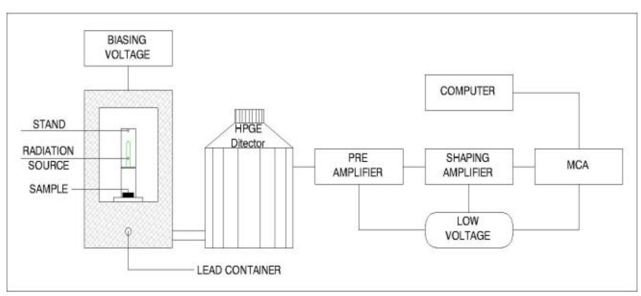
Ordinary Portland cement (53Grade) is use as the main Binder in casting samples. The dolomite used in the Study was obtained from Krishna chemicals and minerals, Ahmadabad. Fine Sand used in this study was of 4.75mm nominal size, coarse aggregate used in this study was of 12.5 mm size. The mixtures were made with 0%, 10%, 20%, 30% and 40% of dolomite as a replacement for sand by weight. The Concrete samples were prepared with same water to cement ratio, this ratio was taken as constant so as to Investigation the effect of dolomite addition to the concrete on the radiation properties and the compressive strength of concrete at age of 28 days of curing.

First, the ingredients were weighed accurately and then mixed properly by concrete mixer .After the Sample has been remixed with water, cube moulds were immediately filled and concrete was compacted by hand. Any air Trapped in the concrete reduces the strength of the cube. It has been found from the experimental studies that1% air in the concrete approximately reduces the strength by 6% .Hence, the cubes were fully compacted. However, care was taken not to over compact the concrete as this may cause segregation of the aggregate sand cement paste in the mix, which may ultimately also reduce the final compressive strength. Slump was measured by Slump cone test having top diameter 10cm, bottom diameter 20 cm and height30 cm. 50 mm cube moulds were filled in three approximately equal layers. During the compaction of each layer, the strokes were distributed in a uniform manner over the surface of the concrete to eliminate air content. This proper tamping of the concrete mix eliminates the air content. After the top layer had been compacted, a trowel was used to finish off the surface level with the top of the mould. The moulds filled with mixture were kept in casting room for 24 hours. They were demolded after put in to water bath until the time of testing [8].

3.2 Transmitted γ-ray

The narrow beam γ-ray transmission geometry was used for the attenuation measurements of prepared concrete specimens using mono energetic gamma radiation source 137Cs has an energy of 661.7keV. We have conduct experiment by with fix geometry by in siding the fabricated concrete block between detector and gamma source is counted for 100 sec. the hyper pure germanium semi conduct detector which has rative efficiency 25.6% inside a lead chamber. The radioactive source was procured from physical research laboratory at Ahmadabad, India. Under the guidance of Anil shukla sir and Dipak panda sir, they are working as a scientist in a PRL. The experimental setup is shown in Fig. 3.1.

Fig.3.1: experiment setup



4. RESULTS

Table 4.1: M-30 grade concrete Compressive strength (N/mm2)

Dolomite Replacement	7 days	28 days
0%	11.2	35.1
10%	11.7	36.4
20%	12.4	37.5
30%	13.6	39.8
40%	12.7	38.3

Table 4.2: M-40 grade concrete Compressive strength (N/mm2)

Dolomite Replacement	7 days	28 days
0%	17.6	49.6
10%	17.9	51.4
20%	19.2	52.6
30%	20.4	53.3
40%	19.6	52.9

Table 4.3: M-50 grade concrete Compressive strength (N/mm2)

Dolomite Replacement	7 days	28 days
0%	22.3	60.5
10%	24.1	62.3
20%	25.8	64.1
30%	24.7	63.1
40%	23.2	61.8

Table 4.4: M-60 grade concrete Compressive strength (N/mm2)

Dolomite Replacement	7 days	28 days
0%	26.2	69.9
10%	27.8	71.7
20%	31.8	74.2
30%	29.6	73.1
40%	28.1	72.5

Fig.4.1: 7 Days Compressive Strength

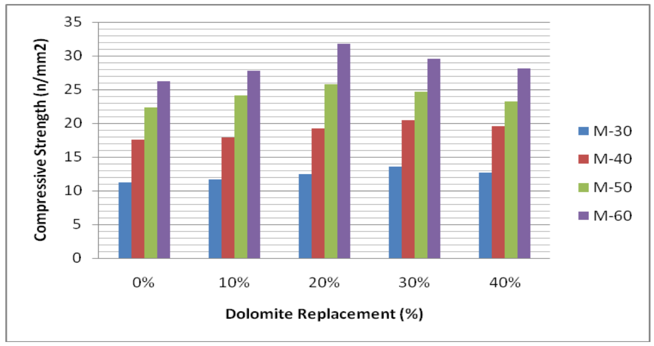


Fig.4.2: 28 Days Compressive Strength

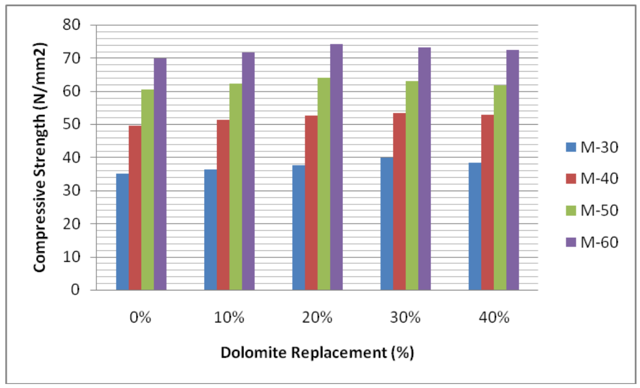


Table 4.5: Radiation Net Count

Concrete	Net Count	Dolomite Replacement
M-30	19613	0%
M-30	19225	30%
M-40	19353	0%
M-40	19255	30%
M-50	19152	0%
M-50	19127	20%
M-60	18447	0%
M-60	13972	20%

Fig.4.3: Radiation Test

5. CONCLUSIONS

The compressive strength and density of concrete is increase with increase in dolomite content. In the M-30 and M-40 Grade concrete the strength of concrete is increase up to 30% replacement of dolomite with sand and in the high strength concrete M-50 and M-60 Grade the strength can be increase up to 20% replacement of dolomite with sand at a 28 days. from the radiation test the 22 % radiation will be shielding by M-60 grade concrete with 20% replacement of dolomite with sand.

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