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DENSIFICATION OF CONCRETE TO ENHANCE ITS SHIELDING ABILITY TO NUCLEAR RADIATION

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Abstract- *High density concrete has been known as radiation shielding concrete provide protection against X-rays and Gamma-rays which are harmful to the health and is commonly used for radiation shielding of nuclear-reactors etc. Dense concrete is designed by replacing natural aggregates by some heavy weight aggregates like barite, magnetite, goethite and serpentine.*

Integral part of this paper is replacing natural fine aggregate by barite aggregate fully. The concrete mixes are designed as per the recommendation of ACI 211.1 for both normal or control and barite concrete. Experimental results revealed that, the concrete mixes containing barite fine aggregate have maximum density and higher radiation shielding ability compared to normal weight concrete.

Keywords: *Heavy concrete, Attenuation coefficient, heavy minerals, Radiation shielding*

I. INTRODUCTION

Concrete is a common material used for construction in Pakistan and all over the world. It has a very wide use in buildings, roads, dams, hydropower stations, airports, bridges and foundations. Concrete is not only economical but also a very versatile material. Being a composite material its properties are variable depending upon the ingredients. Different types of concrete are available, distinguished by the proportions of the main ingredients such as Low Weight Concrete (LWC), Normal Weight Concrete (NWC) and Heavy Weight Concrete (HWC).

High density concrete is a concrete having a density in the range of 6000 to 6400 kg/cu.m. High density concrete is also known as Heavy weight concrete. High density concrete is mainly used for the purpose of radiation shielding, for counterweights and other uses where high density is required [1]. The high density concrete has a better shielding property, so that it can protect harmful radiations like X-rays, gamma rays, and neutrons [2-3]. High density aggregates are used to achieve heavy weight concrete. Some of the high density aggregates are barite, ferrophosphorus, limonite, hematite, ilmenite, magnetite, goethite, steel punching, and steel shots. The point to remember is that in order to achieve this type of concrete, high fixed water content is required. The selection of the mentioned aggregates mainly depends upon the physical properties like bulk density, specific gravity, availability of materials, and its expenses. In order to achieve workability, high density the aggregates should be free from dirt, oil or grease stains and other foreign matter.

II. MATERIALS

A. Cement

The properties of cement is used in this research study are shown in Table 1.

Table-1 Properties of Cement

S.No	Properties	Value obtained	Standard values
1	Normal consistency	32%	----
2	Specific Gravity	3.01	----
3	Fineness	4.5%	<10
4	Density	1440 kg/m^3	----
5	Initial Setting Time	45 min	Not less than 30 min
6	Final Setting Time	270 min	Not greater than 600 min

B. Fine Aggregate

The locally available sand basic properties are shown in Table 2.

Table-2 Properties of Fine Aggregate

S.No	Properties	Values
1	Type	Natural
2	Specific Gravity	2.50
3	Fineness Modulus	2.9

C. Barite Fine Aggregate

In Barite is an iron ore which is used as Fine aggregate in the treated samples in this study. It was brought from ring road Peshawar. The physical properties and gradation curve of Barite aggregate are given in Table 3.

Table-3 Basic Properties of Barite Fine Aggregate

S.No	Properties	Values
1	Specific Gravity	3.5
2	Fineness Modulus	2.9

D. Coarse Aggregate

Locally available well graded coarse aggregates were used in this research shown in Figure 1. The different properties of coarse aggregates are evaluated and shown in Table 5.

Table-4 Basic Properties of Coarse Aggregate

S.No	Properties	Values
1	Type/Size	Crushed / 1" Down
2	Specific Gravity	2.76
3	Bulk density	1631.16 kg/m^3

Figure-1 Normal Coarse Aggregate

III. MIX PROPORTIONING AND SAMPLE PREPARATION

Mixing and proportioning of both concrete samples i.e. normal/control and dense concrete American Concrete Institute's code ACI 211.1 was followed and concrete mixes were prepared on different water to cement ratio shown in Table 5.

Table-5 Normal and Barite Concrete Mix Proportioning and Sample Details

Water-cement Ratio	Slump Value (cm)	Admixture (%)	Mix Proportion	No of Samples	Curing (Days)
0.30	2.2	3	1 : 0.8 : 1.8	06	28
0.35	3.5	2	1 : 1.2 : 2.1	06	28
0.40	3.8	1.5	1 : 1.5 : 2.4	06	28
0.45	4.5	1	1 : 1.8: 2.7	06	28

IV. RESULTS AND DISCUSSION

A. Linear attenuation coefficient calculation

Linear attenuation coefficient was calculated to compare shielding ability of normal and barite loaded concrete. Geiger Muller tube and detector was used to conduct the test. Gamma ray intensity was determine first in the absence of any sample between radiation source and detector and was noted as N_o then samples of normal and barite loaded concrete was placed between source and detector and intensity of gamma ray was determined and noted as N. Then linear attenuation coefficient was calculated.

It is observed in both normal and barite loaded concrete that attenuation coefficient is dependent upon density besides samples thickness. Density is increasing with increase in water-cement ratio up to 0.40 and so linear attenuation coefficient and beyond 0.40 a decrease is observed both in the density as well as in the attenuation coefficient as presented in Figure 2.

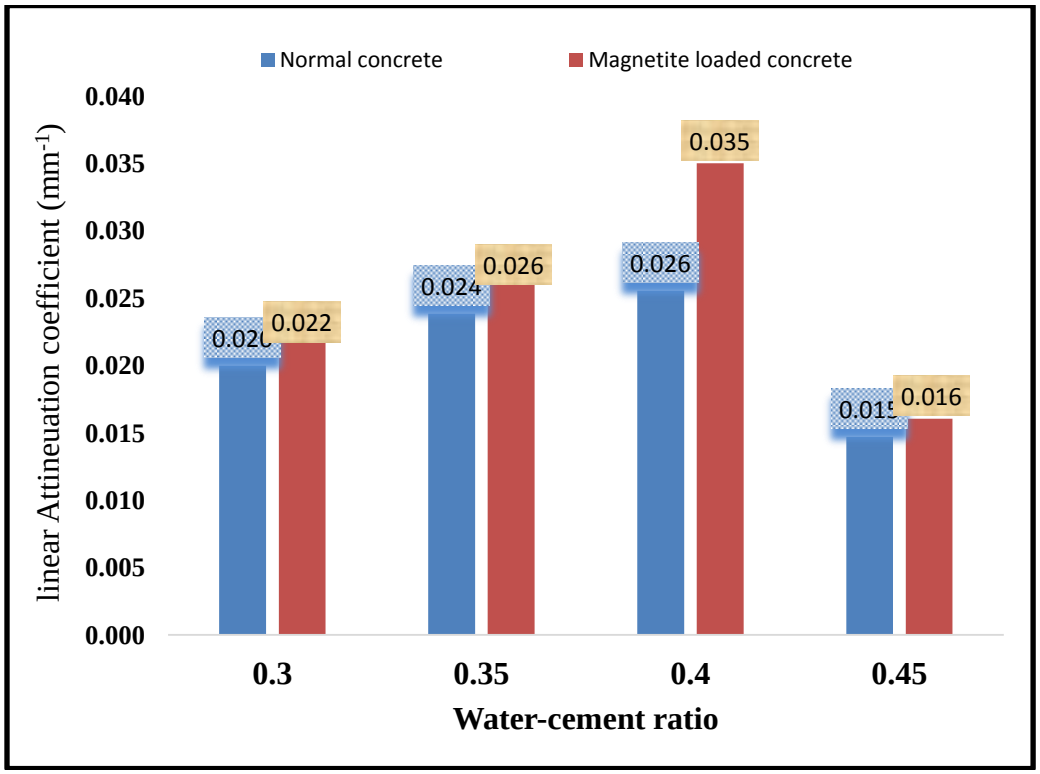

Figure-2 Linear attenuation coefficient comparison at different water-cement ratios

V. CONCLUSIONS

Radiation shielding ability of concrete depends on its density. A linear relation exists between density of concrete and linear attenuation coefficient. Using magnetite as aggregate in concrete increases its density and so enhances its radiation shielding ability. 0.40 is suitable water-cement ratio to attained maximum shielding of normal as well as denser concrete.

VI. REFERENCES

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