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Study on The Development of High-Density Concrete with Variouscoarse Aggregate and Silica Fume

P. Dhanabal[1], S.Sameer[2], P. Narendra Reddy[3], P. Hema Kumar[4]

[1,2,3,4]Assistant Professor, Department of Civil Engineering, Annamacharya Institute of Technology and science, Tirupati, Andhra Pradesh, India

ABSTRACT

This study deals with finding an optimal locally available coarse aggregate for the production high density concrete. Magnetite, shonkinite and dolerite were identified through consultation with geologists in salem. All the mentioned aggregates had its specific gravity more than that of conventional aggregate. The aggregates were then manually crushed to the required size. A mix design (volume mix) was arrived at for the different aggregates and the cubes were casted. The slump was around 50mm for all the three mixes, but the compressive strength and density were not the same. Magnetite mix had the highest compressive strength and density, followed by dolerite mix and finally shonkinite mix. Taking into consideration the availability and quality of the aggregates, the dolerite mix was selected. And further testing to find its bond strength, split tensile strength and flexural strength has been planned for the dolerite mix. To increase the density further a study on the utilization of silica fume has also been included.

Keywords: silica fume, high density concrete, concrete properties.

INTRODUCTION

Concrete, composed of portland cement, sand, aggregate (stones, gravel, etc.), and water, is one of the most common materials used in the construction of commercial buildings. Its properties make concrete an excellent choice for structures, cladding systems and floor slabs. On the other hand, concrete is also widely used for radiation shielding in radiotherapy facilities and nuclear reactors, and for the prevention of radiation leakage from radioactive sources, as well. Although, aggregate has been basically considered as an inert, inexpensive material, it is not truly inert and influences the performance of the concrete due to its physical and sometimes chemical properties. Concrete is a very strong material when compressed. However, it is extremely weak in tension. The strength and other properties of concrete are dependent on how the above-mentioned four ingredients are proportioned and mixed. The maximum resistance that a concrete structure will sustain, when loaded axially in compression in a testing machine at a specified rate, is measured as the compressive strength. High density concrete or heavy weight concrete is the concrete, which should have density greater than 2600kg/m3. High density concrete can be made from natural heavy weight aggregates such as barites, magnetite, hematite etc. Apart from the replacement of aggregates, the other way to produce HDC is by the addition of Iron balls, this increases the density of concrete significantly proportionately the cost of manufacturing HDC would also increase. Heavy weight or high density concrete can be designed in same way as normal weight concretes, but its higher weight must be considered with respect to the load-rated capacities of transport vehicles, roadways and installation cranes. Transporting high-density concrete for extended periods of time can result in excessive consolidation. or packing. So, additional density means that smaller volumes can only be transported and placed. The formwork for conventionally placed high-density concrete must be carefully selected and inspected, as it will be subjected to considerably higher stresses than comparable forms for ordinary concrete.

APPLICATIONS OF HIGH DENSITY CONCRETE

- Nuclear power plants, Nuclear weapon development and Radiotherapy treatment rooms to shield radiation.
- Precast concrete used in storage facilities of radioactive wastes.
- Ballasts for offshore pipelines.
- Breakwater structures
- Counterweights
- Sound or vibration attenuation walls

OBJECTIVE OF THE STUDY

The main objective of this investigation is

- To study the properties of locally available aggregates of high density. To study the behaviour as well as properties of HDC in fresh and hardened state. To compare the compressive strength of HDC produced by replacement of coarse aggregates and choosing the best aggregate after factoring in all the data. To study the effect of silica fume in the production of HDC. To study the other mechanical properties such as split tensile strength, flexural strength and bond strength of high density concrete. To conduct the water permeability test on HDC to find its porosity before and after addition of silica fume. To determine the optimum percentage of silica fume to be used as a replacement materials for cement in concrete.

2. LITERATURE REVIEW

2.1 LITERATURE BASED ON HIGH DENSITY CONCRETE

ElżbietaHorszczaruka et al (2015) presentedan experimental study on theperformance of shielding concrete with magnetite aggregate subjected to high temperature. Two concretes with magnetite aggregate and one ordinary concrete with natural aggregate were tested. Mechanical properties were studied at ambient temperature and after thermal exposure. Compressive strength and splitting tensile strength have been tested. For each test, the specimens were heated at a rate of 1°C/min up to different temperatures (300, 450, 600 and 800°C). In order to ensure a uniform temperature throughout the specimen, the temperature was held constant at the target temperature for 1 h before cooling. In addition, the specimen mass was measured before and after heating in order to determine the weight loss of tested samples. Studies have shown that use of magnetite aggregate can diminish the negative impact of elevated temperatures on mechanical properties of concretes.

Ahmed S. Ouda (2014) made a study on the development of high-performance heavy density concrete using different aggregates for gamma-ray shielding. His research was oriented towards the application of HDC in primary and secondary containment structures are the major components of the nuclear power plant (NPP). The performance requirements of the concrete of containment structures are mainly radiological protection, structural integrity and durability, etc. For this purpose, high-performance heavy density concrete with special attributes can be used. The aggregate of concrete plays an essential role in modifying concrete properties and the physico-mechanical properties of the concrete affect significantly on its shielding properties. After extensive trials and errors, 15 concrete mixes were prepared by using coarse aggregates of barite, magnetite, goethite and serpentine along with addition of 10% silica fume (SF), 20% fly ash (FAs) and 30% ground granulated blast-furnace slag (GGBFS) to the total content of OPC for each mix. To achieve the high-performance concrete (HPC- grade M60), All concrete mixes had a constant water/cement ratio of 0.35, cement content of 450 kg/m3 and sand-to-total aggregate ratio of 40%. Concrete density has been measured in the case of fresh and hardened. The hardened concrete mixes were tested for compressive strength at 7, 28 and 90 days. In some concrete mixes, compressive strength was also tested up to 90 days upon replacing sand with the fine portions of magnetite, barite and goethite. The attenuation measurements were performed by using gamma spectrometer of NaI (Tl) scintillation detector. The utilized radiation sources comprised 137Cs and 60Co radioactive elements with photon energies of 0.662 MeV for 137Cs and two energy levels of 1.173 and 1.333 MeV for 60Co. Some shielding factors were measured such as half-value layer (HVL), tenth-value layer (TVL) and linear attenuation coefficients (m). Experimental results revealed that, the concrete mixes containing magnetite coarse aggregate along with 10% SF reaches the highest compressive strength values exceeding over the M60 requirement by 14% after 28 days of curing. Whereas, the compressive strength of concrete containing barite aggregate was very close to M60 and exceeds upon continuing for 90 days. The results indicated also that, the compressive strength of the high-performance heavy density concrete incorporating magnetite as fine aggregate was significantly higher than that containing sand by 23%. Also, concrete made with magnetite fine aggregate improved the physico-mechanical properties than the corresponding concrete containing barite and goethite. Therefore, high-performance concrete incorporating magnetite as fine aggregate enhances the shielding efficiency against γ-rays.

Mudasir Hussain Pandit et al (2014) conducted an experiment on highdensity concrete using fly ash, micro silica and recycled aggregate. Concrete is the most important engineering material and the addition or replacement of some of the materials may change the properties of the concrete. In recent years a lot of research work has been carried out in order to obtain more durable and long term performance of concrete structures in the dynamic environment. In this experimental study, concrete mixes of different proportions with Fly ash, micro silica and recycled concrete aggregate are prepared and tested after different days of moisture curing and what is the effect of these materials on the strength of concrete is studied We are replacing the cement by Fly ash and Micro silica with 0%, 5%, 10% and 15% and the coarse aggregate with Recycled Concrete Aggregate with 0%, 5%, 10% and 15%. Here the grade of concrete is M 25. The experimental investigation was carried out and was found out that, Fly ash and micro silica increases the strength of concrete more than 17% due to their pozzolanic properties.

3. METHODOLOGY

Fig. 1: Flow chart of methodology

4. MIX PROPORTIONS

cement	Fine aggregate	Coarse aggregate	Water
390 kg/m3	647.31 kg/m3	1204.82 kg/m3	167.7 kg/m3
1	1.66	3.09	0.43

Table 1: Mix proportion

5. EXPERIMENTAL WORK AND RESULTS

Totally 6 cubes were cast for each trial mix and their slump values during fresh stage and compressive strength after hardening and curing were found out and have been tabulated below:

Trial	Workability	Compressive strength	
	Slump (mm)	7-day (N/mm2)	28-day (N/mm2)
1	65	29.8	37.25
2	58	31.2	39.6
3	49	32.6	40.5

Table 2: Slump & compressive strength

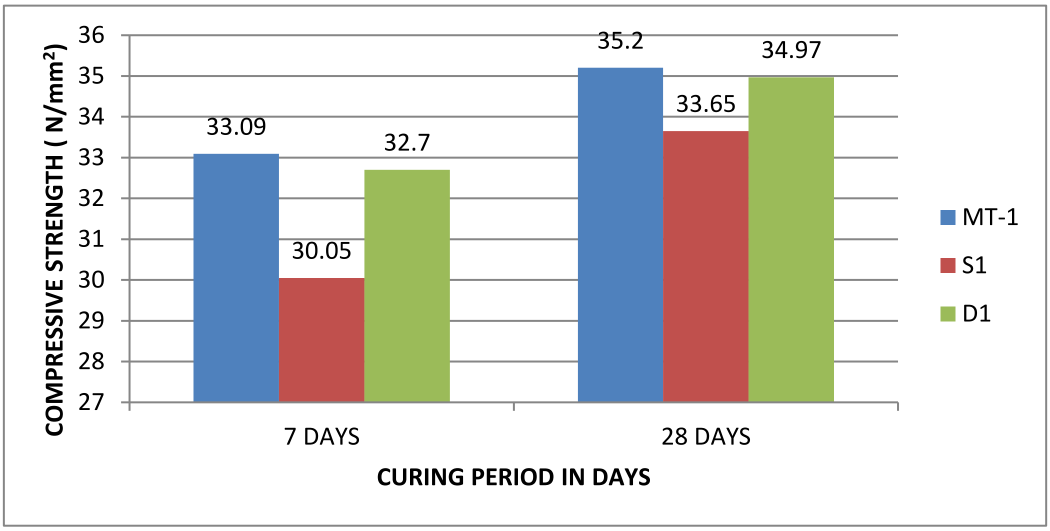

Figure 2; Compressive strength

Trial	split Tensile strength	
	7-day (N/mm2)	28-day (N/mm2)
1	2.91	3.86
2	3.12	3.93
3	3.23	4.2

Table 3: Split Tensile Strength

Trial	Flexural strength	
	7-day (N/mm2)	28-day (N/mm2)
1	4.85	4.86
2	4.12	5.99
3	4.36	6.25

Table 4: Flexural Strength

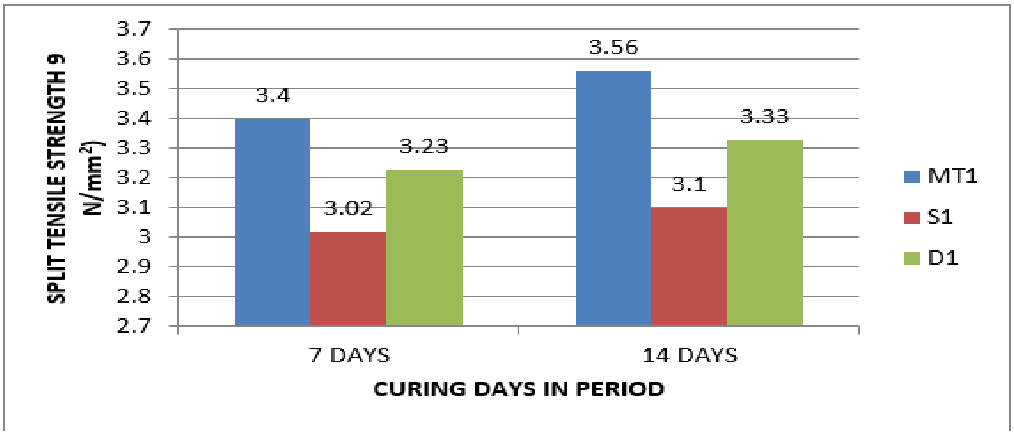

Figure 3: Split Tensile Strength

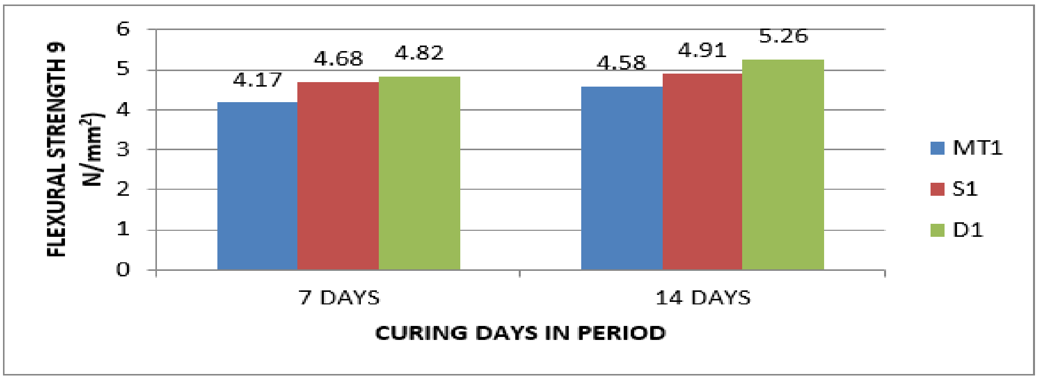

Figure 4: Flexural Strength

6. CONCLUSION –

- Through literature review it was concluded that with the replacement of conventional aggregates with heavy aggregates (sp. gravity higher than 2.7) HDC can be produced and with the addition of silica fumes to the HDC mix the concrete can be made even denser.
- The heavy aggregates that can be used for HDC which are found in Salem district are magnetite, shonkinite and dolerite.
- Magnetite though available in abundant quantity in Salem, it exists in a combined state with quartzite makes it vulnerable and also the restrictions in procuring the aggregate for commercial purposes from the source almost eliminates its option.
- Shonkinite is the other dense aggregate available in Salem, but not in an abundant nature, it is a small deposit. The nature of aggregate found is weathered; hence the rock is not as hard as it was supposed to be.
- Dolerite is the third heavy aggregate found in high volume at Salem. And also the quality of the material is high, since is taken from the waste of granite slabs manufacturing factory.
- After conducting preliminary tests on the aggregates, the mix was designed and cubes were casted. The results of the compressive strength and the density of the HDC tested were along expected line, the density and compressive strength of MT1 mix was highest followed by D1 mix and finally S1 mix.

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