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Concrete made using cold bonded artificial aggregate

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Abstract: - Property of concrete made from cold bonded aggregate from fly ash and quarry dust are studied in this paper. The aggregate are manufactured through polarisation method in different proportion of fly ash and quarry dust with ordinary Portland cement as binder. Three types of artificial aggregate are manufactured for this study and test results of aggregates shows that each have different strength characteristics. The tests carried out in concrete are porosity, compaction factor and compressive strength of 28 days for different water cement ratio 0.35, 0.45, 0.55 and 0.65. The results indicate that the usage of above aggregate in concrete is an alternative for natural aggregate in concrete industry and future practice in concrete also reduces the environmental impact.

Keywords: - *Artificial aggregate; Concrete; cold bonding; compressive strength; water absorption; workability.*

I. INTRODUCTION

In the present scenario, construction industry is growing very fast manner. The availability of raw materials for the construction is facing many problems in most of the world. The continuous usage of natural resources for the production of the concrete in some locations create many threatens to the environmental conditions .Researchers have carried out extensive work on this area are trying for new alternative materials for this deficiency in the construction industry. In this condition, the present study on artificial coarse aggregate has much importance. The coarse aggregates from waste materials like fly ash and quarry dust with cement as binder can be used in concrete. The quarry dust is a by-product of granite quarry and fly ash from thermal plants, both are creating environmental problems. One of the essential requirements of the green building is to use environmental friendly building materials such as the industrial waste products like fly ash [1]. The concurrent use of the fly ash and quarry dust by products will lead to a range of economic and environmental benefits [2].

According to ASTM-C 618[3] categorizes natural pozzolanas and fly ashes into the following three categories (i) Class N Fly ash: Raw or calcined natural pozzolans such as some diatomaceous earths, opaline chert and shale, stuffs, volcanic ashes and pumice come in this category. Calcined kaolin clay and lateritic shale also fall in this category of pozzolana. (ii) Class F Fly ash: Fly ash normally produced from burning anthracite or bituminous coal falls in this category. This class of fly ash exhibits pozzolanic property but rarely if any, self-hardening property. (iii) Class C Fly ash: Fly ash normally produced from lignite or sub- bituminous coal is the only material included in this category. This class of fly ash has both pozzolanic and varying degree of self cementations properties. Most class C fly ashes contain more than 15 % CaO. But some class C fly ashes may contain as little as 10 % CaO. In this study the fly ash is collected from thermal plant belongs to class F type of above category. The chemical analysis is shown in Table.1 and witch indicates that the presence of CaO content is very low and has less binding property.

Quarry dust is another raw material is a by- product obtain through the crushing processes of different grade aggregates in the granite quarry and having particle size less than 90micron thus it is very fine in nature is used here for the production of artificial aggregates. The chemical classification quarry dust is shown in Table 1.

Table1 Chemical Constituents in Cement, Fly Ash and Quarry Dust

Chemical constituents	Weight by percent in materials		
	Cement	Fly ash	Quarry dust
SiO2	21.4	57.1	62.5
Al2O3	5.1	24.7	18.7
Fe2O3	2.9	10.5	6.5
CaO	64.0	2.5	4.8
MgO	1.6	1.4	2.5
SO3	2.0	0.9	1.0

The artificial course aggregate is produced in a pelletiser by cold bonding processes of minimum energy utilization method. The shape of aggregate produced is round in nature but having different surface texture character for fly ash and quarry dust. The binder ordinary Portland cement of 20 percent by weight of raw material is added in the mix for the production of aggregate. Three types of aggregate produced with different percentages of raw materials as shown in Table 2 is then kept for curing in water for 28days and also kept for curing 30minutes before aggregate taken for concrete production.

II. BACKGROUND INFORMATION

Chi et al. (2003) [4] used three types of cold bonded cement based fly ash aggregates for the production of concrete. The study indicates that type of light weight aggregate and water to binder ratio are the significant factors influencing strength of concrete. Gesoglu et al. [5] prepared concrete using cold bonded fly ash aggregate containing Portland Type 1 cement as binder. The variables of this study are water cement ratio cement content and coarse aggregate ratio. The artificial aggregates are used after soaking for a period of 30 minutes in water. The compressive strength of concrete is found to be between 20 and 47 MPa. Test results indicate that compressive strength decreases with coarse aggregate to total aggregate ratio. Jo et al. [6] produced geo-polymer concrete of strength grade of 33 MPa using cement based fly ash artificial aggregates. Joseph and Ramamurthy [7] determined the fresh and hardened properties of concrete made using cold bonded fly ash aggregate. The cement content of 250 and 450 kg/m3 is used for the preparation of concrete. The variables considered are cement content, water cement ratio and aggregate ratio. It is found that the compacted density of concrete reduces with increase of in volume fraction of cold bonded fly ash aggregate. The workability of concrete is found to be controlled by content of cold bonded aggregate. The test results indicate that the strength of the concrete increases with increase cement content. The failure of concrete is found to be controlled by aggregate fracture. Joseph and Ramamurthy [8] studied the influence of high volume of fly ash in concrete containing cold bonded fly ash aggregate. The replacement ratio of cement with fly ash is 10, 30 and 50 percent is used. The coarse aggregate ratio of 50 and 65 percent is used. The fresh density of concrete reduces with increase in replacement of cement with fly ash and cold bonded aggregate ratio. The workability of concrete increases with increase in fly ash content. Joseph and Ramamurthy [8] studied the workability and strength properties of concrete made using cold bonded fly ash aggregate. It is reported that workability of concrete is influenced by volume fraction of cold bonded fly ash aggregate. The failure of concrete is explained by the failure of mortar phase or aggregate phase. The test results indicated that cement content in concrete influences the failure of mortar phase. The strength of concrete decreases with increase in volume fraction of cold bonded aggregate. Joseph and Ramamurthy (2011) [9] studied the influence three different types of curing methods, namely, mist, sealed, air curing on strength of artificial aggregate concrete. The moisture movement from aggrgate to the paste in the matrix is evaluated at different ages. The test results indicate that the strength and hydration of matrix are insensitive to the type of curing. This indicates that the cold bonded fly ash aggregates act as internal curing agents in concrete. Guneyisi et al. [10] prepared self-compacting concrete using cold bonded lime cement based fly ash aggregates. The test results indicated that the ball shaped aggregates particles enhanced the workability of the cold bonded aggregate concrete. Bui et al. [11] studied the strength of concrete produced using artificial aggregates made from ground granulated blast furnace slag (GGBS), rice husk ash and class F fly ash. The binder used in preparation of artificial aggregate is alkaline activator solution containing sodium silicate and sodium hydroxide. The concrete of compressive strength between 14.8 and 38.1 MPa is prepared using the geo-polymer artificial aggregates. Gesoglu et al. [10] prepared concrete of strength grade 51 MPa using artificial aggregate. The cold bonded aggregates containing ground granulated blast furnace slag and fly ash are used. Two types of Fly ash, namely, class F and class C are used. The ordinary Portland cement is used as the binder. The test results indicated that aggregates prepared using class F fly ash without Portland cement is not suitable for concrete production. The crushing strength of aggregate as per BS 812-110 [12] is shown in Table.2. The compressive strength of concrete is find out as per IS:516 [13] is indicate that the compressive strength influence by the crushing strength of aggregates.

III. MATERIALS AND METHODS

Cement

Ordinary Portland cement of grade 43 and a specific gravity of 3.12 is used. The initial setting time and final setting time is found to be 90 and 150 minutes respectively. The chemical composition of ordinary Portland cement is shown in Table.1

Fly ash

Fly ash is a finely divided residue resulting from the combustion of pulverized coal and transported by the flue gases of boilers fired by pulverized coal. The fly ash belongs to class F type is used and specific gravity 2.1.The presence of chemicals in the fly ash is shown in Table.1

Table 2 Proportion of constituent materials in artificial aggregate

Type of artificial aggregates	Percent by weight of constituent materials			Properties of cured artificial aggregates			
	Cement	Quarry dust	Fly ash	Specific gravity	Water absorption (%)	Loose bulk density (kg/m^3)	12 mm diameter ball crushing strength (N)
A	20	80	-	2.43	20.1	1238	1510
B	20	-	80	1.85	17.3	998	2820
C	20	40	40	2.18	18.7	1112	2210

Quarry dust

The dust collected from granite quarry is used for preparation of artificial aggregates. The specific gravity of quarry dust is found to be 2.65 and contains 15 percent of fines of size smaller than 90 micron. The chemical composition of quarry dust is shown in Table.1

Artificial aggregates

Artificial aggregates are manufactured by cold bonding process. The quarry dust, fly ash and cement are dry mixed in a pelletizer. The angle of rotation of the drum of the pelletizer is set as 25 degrees and speed of revolution is 26 rpm. The water is sprayed to the rotating drum containing dry mix.

IV. EXPERIMENTAL STUDY

The concrete is prepared using three types of cold bonded artificial aggregates. The proportion of concrete mix is arrived at based on absolute volume method given by IS 10262 [14]. The designation of concrete mix and the weight of constituent materials are given in Table 4. The variables considered are type of aggregate and water cement ratio. The water content is recommended by IS 10262 [14] by 20 mm coarse aggregates is considered and is equal to 186 kg per cubic meter of concrete. The cement content corresponding to water cement ratio and water content is determined. The ratio of coarse aggregate to total aggregate is taken as 0.65. The weight of fine and coarse aggregates is determined based on absolute volume method. The cold bonded artificial coarse aggregates are pre-soaked for 24 hours to compensate the water absorption. Table 3 shows the mix proportion.

The cement and fine aggregate are mixed dry in a rotating drum mixture. The water content is compensated for the surface moisture present in the pre-soaked coarse aggregate. The seventy five percent of the adjusted water content is added drum and mixed. The pre-soaked coarse aggregates are discharged into the drum and mixing operation is continued. The balance 25 percent of the adjusted water content is added at the end of mixing process.

Table 3 Mix Proportion of Concrete Containing Artificial Aggregates.

Mix designation	Water to cement ratio	Designation of artificial aggregate	Weight of constituent materials in kg per cubic meter of concrete			
			Water	Cement	Fine aggregate	Coarse aggregate (cold bonded)
A35	0.35	A	186	531	560	780
A45	0.45	A	186	413	600	830
A55	0.55	A	186	338	620	970
A65	0.65	A	186	286	630	990
B35	0.35	B	186	531	560	880
B45	0.45	B	186	413	600	830
B55	0.55	B	186	338	620	860
B65	0.65	B	186	286	630	880
C35	0.35	C	186	531	560	800
C45	0.45	C	186	413	600	850
C55	0.55	C	186	338	620	880
C65	0.65	C	186	286	630	900

V. RESULTS AND DISCUSSION

The property of cold bonded artificial aggregate concrete experimentally determined. The workability of fresh concrete is tested by compaction factor test, water absorption by porosity strength of concrete by compressive strength test.

Compacting factor

The workability of concrete mix is also determined by compacting factor. The variation of compacting factor is given in Fig 1. The compacting factor is found to be increasing with increase in water cement ratio. This may be attributed to the fact that the workability increases with the increase in the paste volume. The surface of the fly ash aggregate is smooth and causes less friction between the aggregate balls and the paste. The round shape aggregate mobilizes ball bearing effect in the fresh matrix. The magnitude of the compacting factor was found to be greater than 0.8. The test results indicate that artificial aggregate can be used for the preparation of workable concrete.

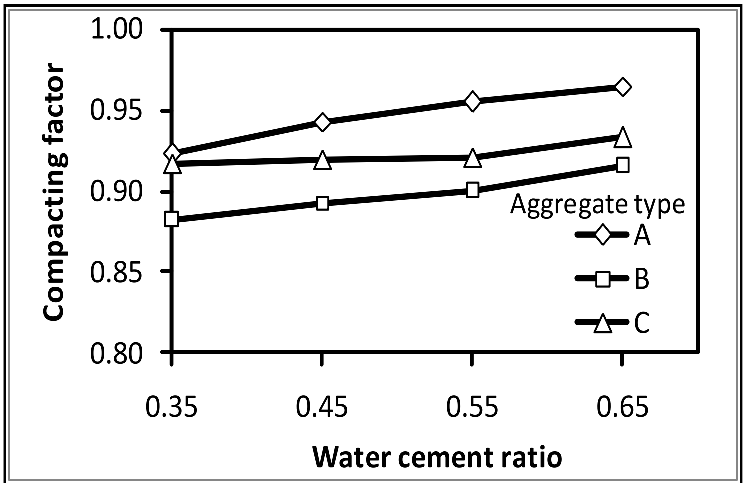

Fig 1. Compacting factor of fresh concrete containing artificial aggregate

Porosity

Porosity of concrete containing artificial aggregates is determined and is given in Fig 2, The porosity is the volume fraction of pores to the bulk volume of concrete. The amount of pores is determined based on the volume of the water absorbed by the bulk concrete specimen. The water penetrates to the pores in the aggregate and matrix phase. The A-type aggregate contains greater volume of pore when compared to the B or C type aggregate. Hence the porosity of concrete containing A-type aggregate is found to be greater than the corresponding test data of concrete containing B or C-type aggregate. The pores in the matrix phase are proportional to the amount of water added to the concrete. Hence, the porosity of the concrete is found to be increasing with the increase in water cement ratio of concrete.

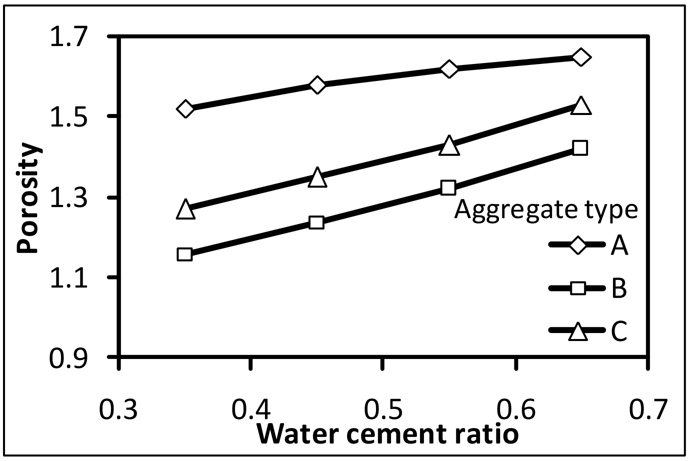

Fig 2. Porosity of concrete containing artificial aggregate

Compressive strength

The compressive strength of the concrete containing artificial aggregates is determined using standard cube specimens and given in Fig 3. The strength of concrete depends on the strength of the matrix and aggregate phase. The strength of the concrete containing B-type artificial aggregate is found greater than A and C-type aggregate concrete. This may be attributed to the fact that the ball crushing strength of fly ash aggregate is greater when compared to the of quarry dust aggregate. The strength of the matrix phase decreases with increase in pore, which is directly proportional to the water cement ratio. This may be the reason for the decrease in the compressive strength with increase in water cement ratio.

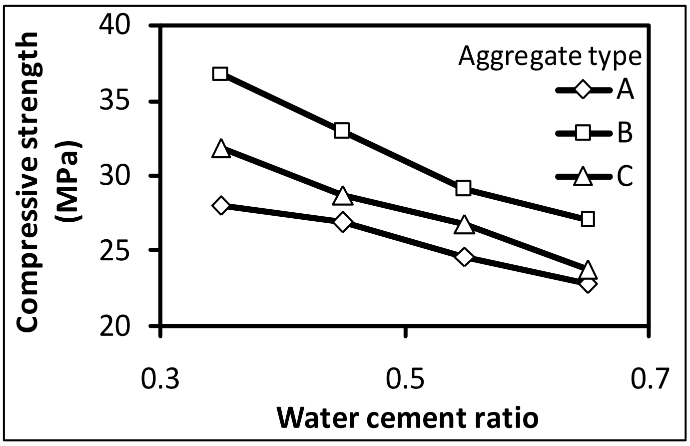

Fig 3. Compressive strength of concrete containing artificial aggregate

VI. CONCLUSIONS

Based on the experimental study following conclusions are arrived at.

- The fly ash aggregate concrete shows less amount of water absorption than other two type aggregates this indicate that the dense packing of fly ash particle in the aggregate.
- The compaction factor of concrete is always depends on water cement ratio, When water cement ratio increases paste volume in the concrete also increases this increases the compaction factor rate.
- The surface texture of aggregate also play an important role in the compaction factor, experiment study indicate that aggregate type A shows more compaction than type B aggregate.
- The compressive strength of the concrete depends on the aggregate strength. The concrete containing fly ash aggregates having higher strength is found to have higher strength when compared to the corresponding test data of concrete containing quarry dust aggregate.

The compressive strength of quarry dust aggregate concrete is found to be about 75 percent of the strength of corresponding mix with fly ash aggregate. Hence, it may be concluded that, cold bond quarry dust aggregates can be used for the production of concrete with appropriate modification in the mix design procedure. The quarry dust aggregate is an alternate potential constituent in concrete industry.

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