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STUDY ON EFFECT OF SIZE OF AGGREGATE ON SELF COMPACTING CONCRETE OF M70 GRADE

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ABSTRACT:-Concrete is a versatile widely used construction material. Ever since concrete has been accepted as a material for construction, researchers have been trying to improve its quality and enhance its performance. Recent changes in construction industry demand improved durability of structures. There is a methodological shift in the concrete design from a strength based concept to a performance based design. At present there is a large emphasis on performance aspect of concrete. One such thought has lead to the development of Self Compacting Concrete (SCC). It is considered as "the most revolutionary development in concrete construction". SCC is a new kind of High Performance Concrete (HPC) with excellent deformability and segregation resistance. It can flow through and fill the gaps of reinforcement and corners of moulds without any need for vibration and compaction during the placing process.The other features of mix proportion of SCC include low water to cementitious material ratio, high volume of powder, high paste to aggregate ratio and less amount of coarse aggregate. One of the popularly employed techniques to produce Self Compacting Concrete is to use fine materials like Fly Ash, GGBFS etc; in concrete, besides cement, the idea being to increase powder content or fines in concrete.The original contribution in the field of SCC is attributed to the pioneering work of Nan Su et al; who have developed a simple mix design methodology for Self Compacting Concrete. In this method, the amount of aggregate required is determined first, based on Packing Factor (PF). This will ensure that the concrete obtained has good flowability, self compacting ability and other desired SCC properties. The European Federation of Producers and Applicators of Specialist Products for Structures (EFNARC) [2005] have also laid down certain guidelines for fresh properties of of study include grade of concrete and effect of size of aggregate. The existing Nan Su [2001] method of mix design was based on packing factor for a particular grade of concrete, obtained on the basis of experimental investigation. SCC characteristics such as flowability, passing ability and segregation resistance have been verified using slump flow, L box and V funnel tests. SCC. The present investigation is aimed at developing high strength Self Compacting Concrete of M70 Grade.

I INTRODUCTION

The versatility and the application of concrete in the construction industry need not be emphasized. Research on normal and high strength concrete has been on the agenda for more than two decades. As per IS: 456–2000[Code of Practice for Plain and

Reinforced Concrete], concretes ranging 25 – 55 MPa are called standard concretes while those above 55 MPa can be termed as high strength concrete. Concretes above 120/150 MPa are called ultra high strength concrete. High strength concrete has numerous applications worldwide in tall buildings, bridges with long span and buildings in aggressive environments. Building elements made of high strength concrete are usually densely reinforced. This congestion of reinforcement leads to serious problems while concreting. Densely reinforced concrete problems can be solved by using concrete that can be easily placed and spread in between the congested reinforced concrete elements. A highly homogeneous, well spread and dense concrete can be ensured using such a type of concrete.Self-compacting concrete (SCC) is a concrete, which flows and compacts only under gravity. It fills the mould completely without any defects. Usually self-compacting concretes have compressive strengths in the range of 60-100 N/mm2. However, lower grades can also be obtained and used depending on the requirement. SCC was originally developed at the University of Tokyo in Japan with the help of leading concrete contractors during 1980"s to be mainly used for highly congested reinforced structures in seismic regions. As durability of concrete structures was an important issue in Japan, an adequate compaction by skilled labors was required to obtain durable concrete structures. This requirement led to the development of SCC. The development of SCC was first reported in 1989. SCC is a new kind of High Performance Concrete (HPC) which has an excellent deformability and segregation resistance. By name it can be defined as a concrete, which can flow through and fill the gaps of reinforcement and corners of the moulds without any need for external vibration. SCC compacts itself due to its self weight and de-aerates almost completely while flowing in the formwork. SCC can also be used in situations where it is difficult or impossible to use mechanical compaction for fresh concrete, such as underwater concreting, cast in-situ pile foundations,Machine bases and columns or walls with congested reinforcement. The high flowability of SCC makes it possible to fill the formwork without vibration. Since its inception, it has been widely used in large construction works or projects in Japan. Recently, this concrete has gained wide use for different applications and structural configurations across the world.High strength concrete can be produced with normal concrete. But these concretes cannot flow freely by themselves, to pack every corner of moulds and all gaps of reinforcement. High strength concrete based elements require thorough compaction and vibration in the construction process. SCC has more favourable characteristics such as high fluidity, good segregation resistance and distinctive self-compacting ability without any need for external or internal vibration during the placing process. It can be compacted into every corner of formwork purely by means of its own weight without any segregation. Hence, it reduces the risk of honey combing of concrete.

II EXPERIMENTAL PROCEDURE

2.1 MATERIALS USED

1. **Coarse aggregate**:The coarse aggregate chosen for Self Compacting Concrete should be well graded and smaller in terms of the maximum size than that used for

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conventionally vibrated concrete (NC). For typical conventional concrete (NC) the coarse aggregate size may be 20 mm and even more in general. The rounded aggregates and smaller size of aggregate particles improves the Flowability, deformability and segregate resistance of SCC. Like in case of conventional concrete (NC), size of aggregate has a key note to play in SCC designs also. Hence, studies are needed to assess the maximum size of aggregate for a particular grade of concrete. Usually, the maximum size of the coarse aggregate used in production of SCC, ranges approximately between10mm and 20mm.

2. **Fine Aggregate:**All normal river sands are suitable for SCC. Both crushed and rounded sands can be used. Siliceous and calcareous sands can be used for production of SCC. The amount of fines less than 0.125mm is to be considered as powder which is very important for the rheology of SCC. A minimum amount of fines must be maintained to avoid segregation. The amount of fines has a very significant effect on SCC mix proportions. Fine sand requires more water and Super Plasticizer (SP), but less filler than coarse sand. The SP dosage, water content and cement/filler content could be adjusted by treating the fines (>150 um) in sand as part of the filler.
3. **Cement:**All types of cements conforming to Bureau of Indian standards are suitable as per Indian conditions. Selection of the type of the cement is made depending on the overall requirements of SCC such as strength, durability etc. The cement content can be 350 – 450 kg/m3. The usage of cement more than 500 kg/m3 may increase the shrinkage in the hardened state of concrete, whereas, the quantity less than 350 kg/m3 may decrease the durability of SCC. Hence, cement content shall be judged properly. Less than 350 kg/m3 may also be used with the inclusion of other fine fillers such as fly ash, Ground Granulated Blast furnace Slag (GGBS) and rice husk ash.
4. **Water:**Potable water shall be used for the production of SCC. In case of conventional concretes (NC), the water is proportionate only with the cement content. It is called as the water-cement ratio. This influences the mix and thereby workability. But, in the case of SCC, instead of water-cement ratio the term water binder-ratio will be used. This means the content of water mixed in the SCC is proportionate to the total binders such as cement, fly ash etc.
5. **Mineral admixtures**:Mineral admixtures are added to concrete as a part of the cementations material. They may be used as an addition to or as a part replacement of Portland cement in concrete. This depends on the properties of materials and the desired effect of concrete. Optimum amount of mineral admixtures are used to improve specific concrete properties such as workability and strength.

Self Compacting Concrete is now considered as a high performance concrete, due to its quality, homogeneity in fresh state, improved durability, faster construction and achieving higher strength. To get better strength properties and good performance of SCC, it requires high quality of cementations material, mineral admixtures like fly ash,

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silica fume, GGBFS, limestone powder. To keep the cement quantity at reasonable level, pozzolanic additives are often used. Pozzolonas are also used to produce high performance concrete in terms of strength, workability and durability. This can also be cost effective.

The general advantages of mineral admixture additives are:

1. It increases the hydration process and reduces the porosity of concrete.
2. It fills and closes the pores or adjusts the type of pore structure.
3. It increases hydration products in addition to the filling effect of micro aggregate
4. It adjusts the grading of the components to achieve an optimum compact.
5. It can adjust the cohesiveness and reduce the heat of hydration and reaction rate
6. It can improve the workability.
7. It can improve the durability and resistance to chemical attack and thus reduce micro cracks in the transition zones.

In this study, only fly ash is used as the mineral admixture and an attempt is made to maximize the fly ash content in Self Compacting Concrete.

Fly Ash: Fly ash or pulverized fuel-ash is a residue from the combustion of pulverized coal collected by mechanical separators, from the fuel gases of thermal plants. The composition of fly ash varies with type of fuel burnt, load on the boiler and type of separation. Fly ash materialSolidifies while suspended in the exhaust gasses and is collected by electrostatic precipitators or filter bags. Fly Ash consists mostly of silicon dioxide (SiO_2), aluminum oxide (Al_2O_3) and iron oxide (Fe_2O_3), and is hence a suitable source of aluminum and silicon for geopolymer. They are also pozzolanic in nature and react with calcium hydroxide and alkali to form Calcium Silicate Hydrates (C – S – H).

The average particle size of fly ash is about 20 microns, which is similar to the average particle size of Portland cement. Particles below 10 microns provide the early strength in concrete, while particles between 10 and 45 microns react more slowly. Fig.1.1 shows the SEM micrograph of fly ash particles. The specific gravity of fly ash particles ranges between 2.0 to2.4 Depending on the source of coal. The fineness of fly ash is in the rangeof 250 - 600 m2/kg.

Super Plasticizer:-High range water reducing admixture called as super plasticizers are used for improving the flow or workability for lower water-cement ratios without sacrifice in the compressive strength. These admixtures when they disperse in cement agglomerates significantly decrease the viscosity of the paste by forming a thin film around the cement particles. In the present work, water-reducing admixture Glenium conforming to IS 9103: 1999 [Specification for admixtures for concrete], ASTM C – 494 [Standard Specification for Chemical Admixtures for Concrete] types F, G and BS 5075 part.3 [British Standards Institution] was used.

III RESULTS & DISCUSSION

Mix proportions for SCC

The mix proportion of M70 grade of concrete designed on the basis of Nan Su method for different maximum sizes of aggregates 10, 12.5 and 20 mm. For the mix proportions obtained, Tables 4.1, highlights the details of various parameters including total aggregate – cement ratio (A/C), water – cement ratio (w/c), coarse aggregate - fine aggregate ratio (CA/FA) and fine aggregate – total aggregate ratio (S/a) for various aggregate sizes.

size of aggregat	A/C	w/c	w/p	CA/FA	S/a

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10	2.42	0.38	0.26	0.935	0.52
12.5	2.43	0.36	0.25	0.914	0.51
20	2.45	0.36	0.23	0.820	0.55

Compressive strength

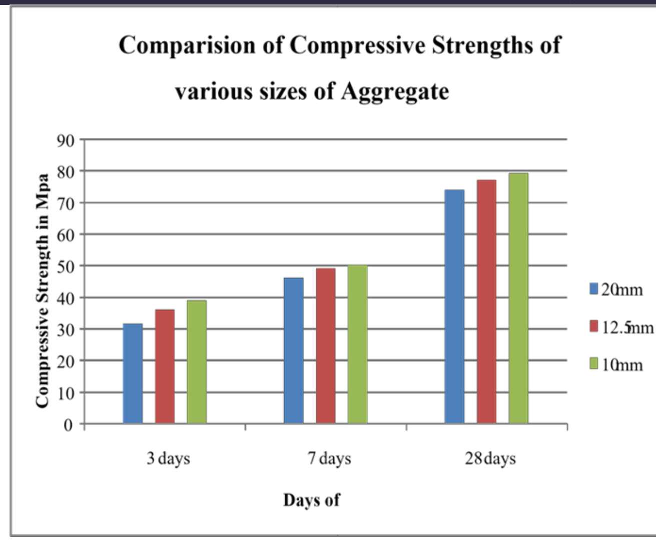
Size of Aggregate	3 Days	7 Days	28 Days
20 mm	31.80	46.30	74.00
12.5 mm	36.20	49.00	77.10
10 mm	38.33	49.66	79.30

Split tensile strength

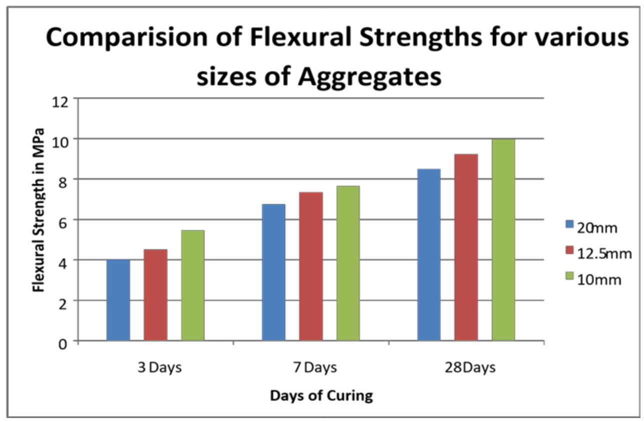
Size of Aggregate	3 Days	7 Days	28 Days
20 mm	2.40	6.04	9.15
12.5 mm	2.80	5.90	9.62

Flexural strength

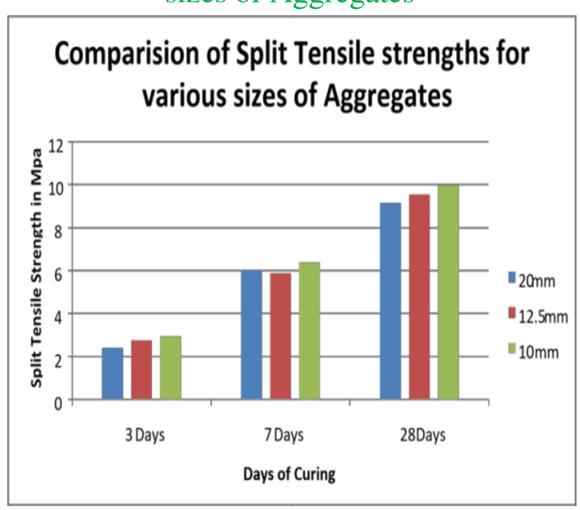
Size of Aggregate	3 Days	7 Days	28 Days
20 mm	4.03	6.75	8.50
12.5 mm	4.60	7.47	9.13
10mm	5.35	7.65	9.35



Bar Diagram of Compressive Strength with various sizes of Aggregates



Bar Diagram of Flexural Strength with various sizes of Aggregates



Bar Diagram of Split Tensile Strength with various sizes of Aggregates

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IV CONCLUSION

Based on the systematic and detailed experimental study conducted on SCC mixes with an aim to develop performance mixes, the following are the conclusions arrived.

1. The mixes designed using the lower size of aggregate yielded better fresh properties than higher size of aggregates.
2. As the strength of concrete increases, the effective size of aggregate has decreased.

Large amounts of powder materials are required to achieve the self compatibility. However, if an excess amount of cement is added, the cost of materials and dry shrinkage will increase. To avoid the above two, a pozzolanic material like flyash (class - F) was taken into consideration in the present mix design procedure... % fly ash in total powder (y) = 68.43 – 0.535 x grade of concrete (x) (7.6) From the above equation, it is easy to find the percentage of fly ash content in total powder for any grade of concrete.

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