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Effect of Size of Coarse Aggregate on Self Compacting Concrete of M50 Grade

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Abstract - *Concrete is one of those crucial inventions which have transformed man's need of building long-lasting and reliable structures near and around him for numerous purposes. Today, its importance can be justified with the fact that concrete is the second most-consumed material in the world after water. Over time researchers have brought up new design methods, replacements in compositions, and numerous other innovative ideas to achieve better results in concrete. To achieve the required strength and durability of concrete, it requires proper and sufficient compaction while placing it. A requirement of skilled labor for compaction and improper compaction in congested reinforcement is another issue. Therefore to overcome these problems, this concept of SCC emerged in Japan in the 1980s and later spread across many other countries. SCC can be defined as fresh concrete that flows under its own weight and does not require external vibration to undergo compaction.*

The present investigation is aimed at studying the effects of the size of coarse aggregate on M50 grade of SCC. Using Nan Su's Mix design method different mix designs were prepared for 20mm, 16mm & 12.5mm aggregates separately. For checking fresh properties slump test & t_{50} tests were conducted. For hardened properties Compressive strength test, Flexural strength test and Split tensile test were conducted. It was found that with a decrease in the size of coarse aggregate in SCC, it yielded better fresh and hardened properties.

1. MATERIALS

1.1 Cement

Ordinary Portland cement of 53 grade has been used in the study. It was procured from a single source and stored as per IS: 4032-1977. To ensure that the cement of the same company and the same grade are used throughout the investigation, proper care is to be taken.

1.2 Fine Aggregates

River sand with no organic impurities is used as fine aggregates. The physical requirements such as gradation, fineness modulus, specific gravity, and bulk density are tested for the fine aggregate. The sand is surface dried before use.

1.3 Coarse Aggregate

The coarse aggregate used for SCC is round in shape, well-graded and smaller in maximum size than used for conventional concrete. For SCC, the size used is between 10mm-16mm. For better flowability, deformability of concrete and to prevent segregation, round and smaller aggregate particles are used.

1.4 Water

Potable water is used for mixing and curing purposes. This water is free from oils, acids, alkalis, sugar, salts, and organic materials or other substances which is harmful to the concrete or steel. The pH value is to be maintained which should not be less than 6.

1.5 Fly Ash

Fly Ash is the supplementary cementitious material used in the construction field. It is collected from the exhaust gases of any industrial furnace. Fly Ash is inorganic, non-combustible in nature. These are solid spheres in shape and some particles, namely cenospheres, are hollow and some are spheres containing smaller spheres inside which are called planispheres. The particle size ranges from less than 1µm to more that 100 µm. The surface area ranges from 300 to 500 m^2/kg. The relative density ranges from 1.9-2.8.

1.6 Super Plasticizer

Super Plasticizer is used for improving the flow of workability for lower water-cement ratios without having any change in compressive strength. It forms a thin film around the cement particles which decreases the viscosity of the paste.

1.7 Viscosity Modifying Agent

To eliminate the bleeding and segregation in the fresh concrete, these admixtures are used which also enhances the viscosity of water. These are neutral, biodegradable in nature which helps in reducing the bleeding, segregation, shrinkage and cracking that occurs in high water/cement ratio

2. MIX DESIGN

There are many mix proportioning approaches adopted worldwide. In this Experimental study Mix proportioning was done based on the approach adopted by Nan Su which considers the process of filling paste into the loose spaces between the coarse aggregate. Three different mix proportions were achieved for 20mm, 16mm and 12,5mm sized aggregates.

S.No.	Materials	Quantity Before Adjustments (Kg/m³)	Quantity after Adjustments (Kg/m³)	Proportions
1.	Cement	416.07	430.00	1
2.	Fine Aggregates	963.96	945.12	2.2
3.	Coarse Aggregates	770.27	778.16	1.8
4.	Fly Ash	29.11	62.11	0.14
5.	GGBS	29.11	65	0.15
6.	VMA	2	2	0.046
7.	Water	181.94	183.62	0.427

Table 1: Final Quantities and Proportion for 20mm aggregate

S No	Materials	Quantity Before Adjustments (Kg/m³)	Quantity after Adjustments (Kg/m³)	Proportions
1.	Cement	416.07	432.10	1
2.	Fine Aggregates	963.96	950.21	2.19
3.	Coarse Aggregates	792.90	796.92	1.84
4.	Fly Ash	21	57.12	0.13
5.	GGBS	21	52.17	0.12
6.	VMA	1.5	1.5	0.0035
7.	Water	177.62	181.12	0.42

Table 2: Final Quantities and Proportion for 16mm aggregate

S No	Materials	Quantity Before Adjustments (Kg/m³)	Quantity after Adjustments (Kg/m³)	Proportions
1.	Cement	416.07	434.6	1
2.	Fine Aggregates	963.96	954.21	2.19
3.	Coarse Aggregates	795.54	799.10	1.84
4.	Fly Ash	20	57.64	0.132
5.	GGBS	20	55.31	0.127
6.	VMA	1.4	1.4	0.003
7.	Water	177.09	182.70	0.42

Table 3: Final Quantities and Proportion for 12.5mm aggregate

3. TEST PERFORMED

3.1 Tests for Fresh Properties

3.1.1 Slump flow test and T50 cm test

To assess the horizontal free flow of SCC in the absence of obstruction, the slump flow is used. It was developed in Japan for use in the assessment of underwater concrete. The diameter of the concrete circle is a measure of the filling ability of concrete.

One of the most commonly used SCC tests at present is Slump Flow. As described in ASTM C 143 [Standard Test Method for Slump of Hydraulic-Cement Concrete], this test involves the use of slump cone with conventional

3.2 Tests for Mechanical Properties.

3.2.1 Compressive Strength

The compressive strength of a material is the value of uniaxial compressive stress reached when the material fails completely. The cube specimens of size 150 mm x 150 mm x 150 mm are tested in accordance with IS: 516 – 1969 [Method of test for the strength of concrete] in this experiment. A compressive testing machine of 300 tons capacity is used for this test. The rate of loading is controlled with the help of a control valve in this machine. The machine has been calibrated to the required standards. The plate is cleaned, oil level was checked and kept ready in all respects for testing.

In this experiment, the compressive strength is performed on concretes with different sizes of coarse aggregate. SCC of grade M50 at 3,7 and 28 days was tested.

3.2.2 Flexural Strength

For Flexural Strength, the Standard beam test (Modulus of rupture) was carried out on the beams of size 100 mm x 100 mm x 500 mm as per IS: 516 [Method of test for the strength of concrete], by considering that material is similar. The testing on a beam of span 400mm for a 100mm specimen is performed by applying two equal loads placed at third points. A central point load is applied on a beam supported on steel rollers placed at the third point to get these loads as shown in the figure. The rate of loading is 1.8 kN/min for 100mm specimens and the load was increased until the beam failed. The flexural tensile strength of the sample is estimated based on the type of failure, the appearance of fracture, and fracture load.

As explained, in this experiment, the flexural strength test has been conducted on concretes with different sizes of coarse aggregate M50 grade of SCC at 3, 7, and 28 days.

If 'a' be the distance between the line of fracture and the nearer support, then for finding the modulus of rupture, these cases should be considered.

- When a > 133 mm for 100 mm specimen
- f_{cr}= PL/bd^2, where P = total load applied on the beam
- When 110 mm < a < 133 mm, f_{cr}= 3Pa/bd^2
- When a < 110 mm, the result should be discarded.

3.2.3 Split Tensile Strength

This test is also known as the "Brazilian Test" as this test was developed in Brazil in 1943. This test comes under indirect tension test methods. In this test, a cylindrical specimen is placed horizontally between the loading places of a compression testing machine, and the load was applied until the cylinder fails along the vertical diameter as shown in the figure. A concrete cylinder of size 10mm diameter and 300mm height was subjected to the action of a compressive force along two opposite edges. The cylinder was subjected to compression near the loaded region and the length of the cylinder is subjected to uniform tensile stress.

Horizontal tensile stress=2P/Π DL

Where P= Compressive load on the cylinder.
L= Length of the cylinder.
D= Diameter of the cylinder.

In this experiment, the split tensile strength test has been conducted on concrete with different sizes of coarse aggregate for M 50 grade of SCC at 3, 7, and 28 days.

4. RESULT AND DISCUSSION

4.1 Fresh Properties

S No	Size of aggregates	Slump Flow diameter r (mm)	T50 cm slump flow (sec)
1	20mm	732	3
2	16mm	738	3
3	12.5mm	745	4

Table 4: Fresh Properties

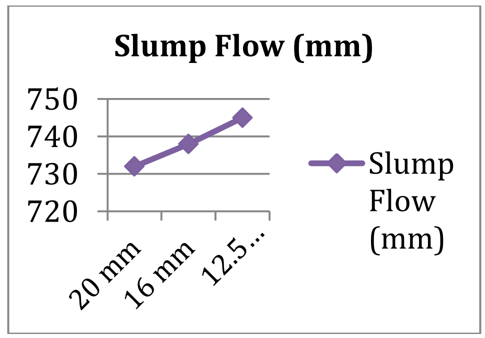

Chart 1: Slump Flow

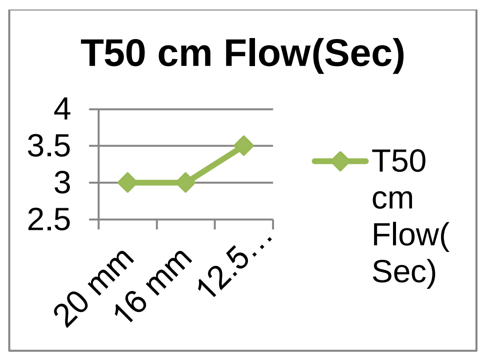

Chart 2: T50 cm

4.2 Compressive Strength

Size of aggregates	3 days	7 days	21 days
20mm	32..11	38.61	53.74
16mm	34.97	41.93	56.33
12.5mm	37.02	42.17	59.39

Table 5: **Compressive Strength**

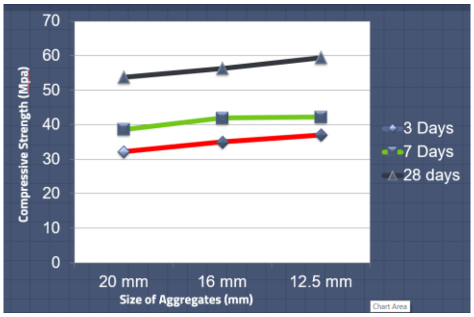

Chart 3: Compressive Strength

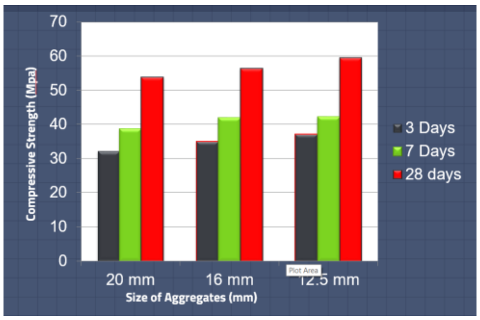

Chart 4: Bar graph of Compressive Strength

4.3 Flexural Strength

Size of aggregates	3 days	7 days	21 days
20mm	3.17	3.56	3.91
16mm	3.34	3.72	4.41
12.5mm	3.54	3.92	4.67

Table 6: Flexural Strength

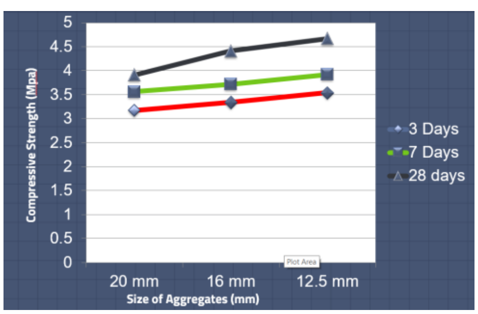

Chart 5: Flexural Strength

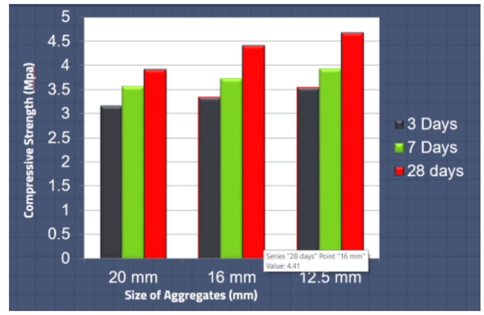

Chart 6: Bar graph of Flexural Strength

4.4 Split Tensile Strength

Size of aggregates	3 days	7 days	21 days
20mm	2.31	3.46	4.01
16mm	2.88	3.33	5.01
12.5mm	3.01	3.56	5.52

Table 7: Split Tensile Strength

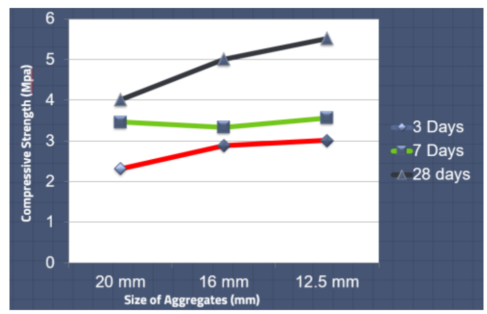

Chart 7: Split Tensile Strength

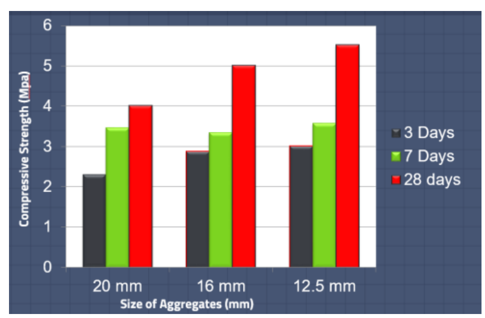

Chart 8: Bar Graph of Split Tensile Strength

5. CONCLUSIONS

The following conclusions can be made from the results of this experimental study:

1. In Fresh Properties- Smaller size aggregates have yielded better Fresh properties than larger sized aggregates.

2. In Hardened properties- Smaller sized aggregates have yielded better Strength than larger sized aggregates.

3. The addition of cementitious materials like Fly Ash & GGBS helped in achieving desired Fresh properties and reduced overall cost.

Future Scope:

1. Variations can be made in the use of other Mineral Admixtures

6. ACKNOWLEDGMENT

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8. BIOGRAPHIES

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