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Influence of Mineral Admixture on strength Aspects of Self Compacting Concrete

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Abstract : This paper presents an experimental investigation on the strength characteristics of Self-compacting concrete (SCC) with mineral admixture namely flyash. Self-compacting concrete gets compacted under its own weight and de-aerated almost completely while flowing in the formwork. It is cohesive enough to fill the spaces of almost any size and shape without segregation or bleeding. The several series of tests involving various binder combinations, water-binder ratio and high range water reducing admixtures and set retarding admixtures were used to optimize the mixture proportions of SCC. Various tests to study the characteristics of fresh concrete were Slump flow, U-tube, V-funnel and L-box. For hardened concrete, tests namely compressive and split tensile at 3,7,14 and 28 days strength were also investigated. Test results shows that the workability characteristics of SCC are within the limiting constraints of SCC. Replacement of flyash is about 30% by weight of cement. SCC of grades ranging from M30 to M80 were investigated. The maximum compressive strength of SCC for M80 at 28 days age of curing was 81MPa.

History of SCC

SCC was first introduced in the late 1980's by Japanese researchers and it is highly workable concrete that can flow under its own weight through restricted sections without segregation and bleeding. Such concrete should have a relatively low yield value to ensure high flow ability, a moderate viscosity to resist segregation and bleeding and must maintain its homogeneity during transportation, placing and curing to ensure adequate structural performance and long term durability. The successful development of SCC must ensure a good balance between deformability and stability. Researchers have set some guidelines for mixture proportioning of SCC which include (i) reducing the volume ratio of aggregate to cementitious material (ii) increasing the paste volume and water-cement ratio (iii) carefully controlling the maximum coarse aggregate particle size and total volume and (iv) using various viscosity enhancing admixtures.

For SCC, it is generally necessary to use super plasticizers in order to obtain workability and Viscosity Modifying Agent for stability. Adding a large volume of powdered material or viscosity modifying admixture can eliminate segregation. The mineral admixture that can be added are fly ash, silica fume, lime stone powder, glass filler and quartzite filler to obtain high performance.

Since self-compatibility is largely affected by the characteristics of materials and the mix proportions, it becomes necessary to evolve a procedure for mix design of SCC. In this system, the coarse aggregate and fine aggregate contents are fixed and self-compatibility is to be achieved by adjusting the water /powder ratio and super plasticizer dosage. The coarse aggregate content in concrete is generally fixed at 40 % of the total solid volume, the fine aggregate content is fixed at 60% of the mortar volume and the water powder ratio is assumed to be 0.9-1.0 by volume depending on the properties of the powder and the super plasticizer dosage. The required water /powder ratio is determined by conducting a number of trials. One of the limitations of SCC is that there is no established mix design procedure yet.

Materials used in SCC

The following materials are required for the preparation of self compacting concrete

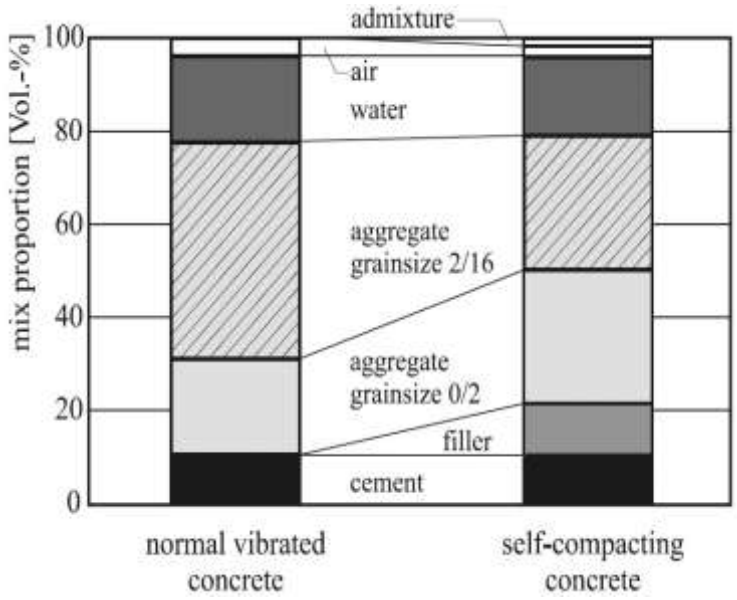
- Cement- Portland Pozzolona Cement - 53 Grade
- Fine Aggregates
- Coarse Aggregates- 20mm and 12mm size
- Mineral Admixtures - Fly Ash
- Chemical Admixtures - carboxylic ether polymer based super plasticizer Super Plasticizer -Glenium B 233

Viscosity Modifying Agen- Glenium Stream 2

Chemical admixtures used

1.4 Initial Mix Proportion for SCC:

- Water Powder ratio by volume is to be 0.8 to 1.0
- Total Powder content to be 400-600 kg per m^3
- The Sand content may be more than 38% of the mortar volume
- Coarse Aggregate content should normally be 28-35% by volume of the mix
- Water Cement ratio is selected as 0.4 based on the strength. In case water content should not exceed 200 lit/m^3



The following steps are included in this phase

- Mix proportion for high strength self-compacting concrete
- Trial and error method
- Determination of optimum dosage of chemical admixture in concrete using marsh cone
- Study of workability of SCC using
    - Slump cone test
    - U-box test
    - L-box test
    - V-funnel test
- Study of strength characteristics on SCC
    - Compressive strength
    - Split tensile strength

Selection of Ingredients

- **Cement**

Ordinary Portland cement 53 grade

- **Fine Aggregate**

Locally available river sand confined IS 383-1970

- **Coarse Aggregate**

Locally available blue granite as per IS 383 – 1970

- **Mineral Admixture**

Dry Fly ash confined as per IS 3812-2000

- **Chemical Admixture**

Super plasticizer – Glenium- B233

Viscosity modifying agent -Glenium stream -2

- **Water**

Portable water as per IS 456-2000

Experimental Investigation

An experimental investigation is undertaken for self-compacting concrete with mix M_1, M_2, M_3, M_4, M_5, M_6, M_7, M_8 which are designated equivalent to grades M30, M35, M40, M45, M50, M55, M60, M65, M70, M75 & M80.The water cement ratio differs for various mixes. The self-compacting mixture had a cement replacement of 20% fly ash. Structure 100(m) carboxylic ether polymer based super plasticizer with dosage of 0.8 % of powder (cement +20% fly ash).

The workability characteristics of self-compacting concrete such as filling ability, passing ability % segregation resistance are thoroughly understood with Slump cone flow test, L-box test, U-Box test and V-funnel test.

A total of 44 cubes of 150 mm side and 44 cylinders of 100mm dia, 200mm height self-compacting concrete and conventional concrete with 20% fly ash are cast.

Mixing of concrete was carried out by machine mixing. The specimens were de moulded at least 24 hours after casting and then wet-cured by full immersion in lime-saturated tap water up to a total curing age of 3, 7, 14 , 28 days to prevent the leaching of calcium hydroxide from concrete prior to testing.

Compressive strength is recorded after 3, 7, 14, 28 days of curing for conventional concrete, conventional concrete with 20% fly ash and self-compacting concrete. Whereas split tensile test and flexural strength test are tested after 3, 7, 14, 28 days of curing.

Testing was carried out in Structural Technology Center of Kumaraguru College of Technology using Compression Testing Machine and Universal Testing machine.

Table shows the mix proportion for Various Mixes

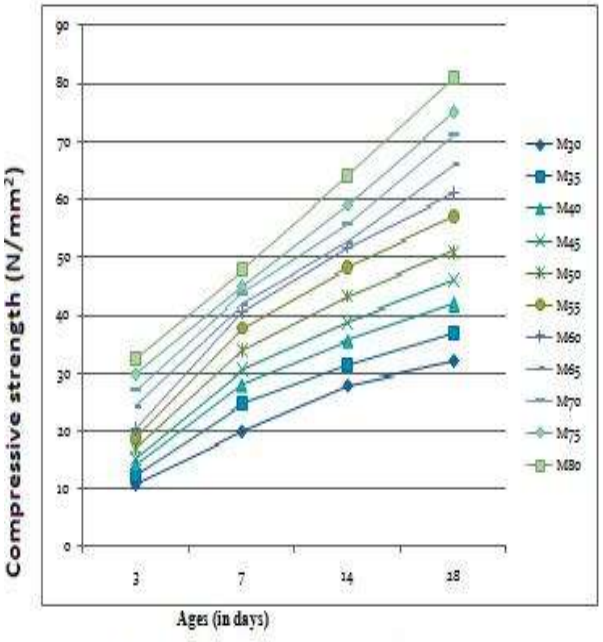
Component	M30	M40	M50	M60	M70	M80
Cement (Kg)	479	504.21	563.5	618	662.1	713.07
Fly ash (Kg)	95.8	100.85	112.7	123.6	132.4	142.7
Sand (Kg)	522.75	509.51	481	303.1	288.05	274.05
Gravel (Kg)	449.565	438.178	417	259	248	236
Water (litres)	191.6	191.6	191.6	185.4	185.4	185.4
Super plasticizer (litres)	10.83	11.54	12.67	13.905	14.89	15.93
W/c ratio	0.40	0.38	0.34	0.3	0.28	0.26

Experimental Results

Compressive Strength

Table - Compressive strength of concrete cubes for various mix with different ages:

MIX	3rd day (N/mm²)	7th day (N/mm²)	14th day (N/mm²)	28th day (N/mm²)
M 30	10.7	20.0	28.0	32.0
M 35	12.3	24.7	31.5	37.0
M 40	14.0	28.0	35.7	42.0
M 45	15.3	30.7	39.1	46.0
M 50	17.0	34.0	43.4	51.0
M 55	19.0	38.0	48.5	57.0
M 60	20.3	40.7	51.9	61.0
M 65	24.3	42.0	52.6	66.0
M 70	27.0	43.7	55.7	71.0
M 75	29.7	45.0	59.1	75.0
M 80	32.3	47.7	63.9	81.0

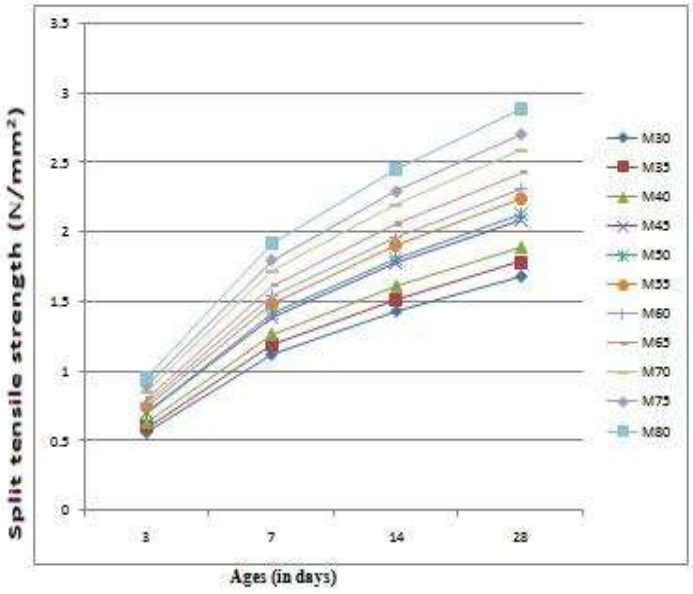


Graph 13.1: Variation of Compressive Strength with age of concrete

Split tensile Strength

Table - Split tensile strength of concrete cubes for various mix with different ages:

MIX	3rd day (N/mm2)	7th day (N/mm2)	14th day (N/mm2)	28th day (N/mm2)
M 30	0.56	1.12	1.43	1.68
M 35	0.60	1.19	1.52	1.79
M 40	0.63	1.27	1.62	1.90
M 45	0.70	1.39	1.78	2.09
M 50	0.71	1.42	1.81	2.13
M 55	0.75	1.49	1.90	2.24
M 60	0.77	1.55	1.97	2.32
M 65	0.81	1.62	2.06	2.43
M 70	0.86	1.73	2.20	2.59
M 75	0.90	1.80	2.29	2.70
M 80	0.96	1.93	2.46	2.89



Graph 13.2: Variation of Split tensile strength with age of concrete

Conclusion

Based on the experimental investigation, the following conclusions are drawn within the limitations of the test results.

- The test results of fresh concrete are within the limits of SCC i.e., flow ability, passing ability and resistance against segregation.
- Compressive strength of Self-compacting concrete of M80 grade at 7 days is 47.7MPa and at 28 days is 81.0 MPa has been obtained with a water-cement ratio of 0.26

- It is found that the ratio of gain in strength is almost same or even better than that of conventionally vibrated concrete.
- The volume of coarse aggregate content was reduced to 46% instead of 50% to avoid segregation.
- The dosage of plasticizers required maintaining the self-compatibility of concrete, increased linearly by weight of cementations materials.
- Fresh concrete made with mortar of low viscosity may cause aggregates segregation, where as mortar of high viscosity it may reduce flow ability.
- The strength characteristics remained same as that of normal vibrated concrete at 28 days.
- Suitability of self-compacting concrete mixture proportion was verified through displacement trials in a complicated mould and field trials.
- Adequately proportioned SCC is used to cast highly reinforced structure, which can be successfully made without internal or external vibration there by simplifying and accelerating the construction process.

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