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SELF-CONSOLIDATING CONCRETE BASED MATERIALS FOR CERTAIN PRECAST AND REPAIR APPLICATIONS

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Abstract- Self-consolidating concrete (SCC) uses a new technological breakthrough; the system can navigate complex geometries without movement, thus eliminating separation issues such as separation and sound when doing so. More expanded usage of SCC will lead to an improvement in building efficiency, enhanced job security, and improved concrete quality in predicted structural applications. Any improvements that are required to achieve SCC. Workability in mixture proportions can impact hardened properties. This paper presents the progress of the research on different hardening properties of self-consolidating Concrete using ordinary Portland Cement and fly ash as binder materials in making the concrete mixes, along with other ingredients. Measured workability of concrete by using slump flow test and hardened properties like split tensile strength, compressive strength and durability are found in experimental work and are compared with M25 grade of concrete. In the present day, self-consolidating Concrete very helpful for construction companies.

Index Terms – Self consolidating concrete, slump flow, Compressive strength, split tensile strength and Durability.

1.INTRODUCTION

Self-consolidating concrete (SCC) is an advanced cement form that subsists on its own natural kinetic energy without the aid of supplemental external motion to undergo complicated geometric shapes and withstand segregation. It was successfully used for a variety of precast and prepared applications of mixed concrete. The use of SCC can boost the efficiency of the building, protection at work, and quality of the concrete. However, these advantages must be weighed against the potentially increased production prices and the requirement for more engineering skills and quality management actions. Moreover, certain modifications to the mixture amounts necessary to achieve SCC functionality might have detrimental effects on buildable rough skin or thickness. When it comes to these proportions, things rely on local conditions and materials, so you need to change them. Having access to a variety of materials for local study is critical to ensuring SCC is manufactured to fulfill applicable specifications as well as to comparing the engineering qualities of both early and long-term SCC and standard concrete mixtures. This paper provides preliminary findings of the SCC research project for pre-stressed concrete bridges in Texas. The research project Pre-Prestressed Expansion (Project 5134: Self-Pre-Prestressed) The project was specific to predicting structural applications and was done in association with our sister company under the leadership of our sister company's administration center, the University of Texas, and TTI, Texas A&M University.

2.ADVANTAGE AND DRAWBACK OF SCC

For any manufacturer and use, the advantages and drawbacks of SCC must be assessed.
The benefits of SCC can generally consist of: -

- Enhanced concrete's capacity to flow through complex areas and between congested reinforcements
- Enhanced finishing and reduced weaknesses need to be repaired, such as bug holes and wax.
- Decreased building costs as a result of lower labor costs and lower purchasing and servicing rates for vehicles.
- Increased building pace due to reduced building activities.
- Fast unloading of ready-mixed concrete vehicles.
- Job practices improved with fewer vibration removal injuries.
- In some situations, the toughness and hardness of the reinforced concrete improved.
- Vibrators' reduced noise.

The SCC can include drawbacks:

- Admixtures in particular.
- shaping expenses due to economic, environmental, and government-mandated costs
- increased shaping pressure.
- Enhanced expertise in creating and managing mixtures
- Increased variability in properties, in particular functionality
- the need for stricter quality management standards
- In some cases, decreased efficiency of hardened properties is caused by factors such as large volumes of paste or fine mixing grades like elasticity module and dimensional stability.

3. RESEARCH PROGRAM

In this program, I have studied various properties of self-consolidating concrete when cement is replaced by fly ash, which can act as a pozzolana. The flow characteristics of self-consolidating concrete are measured on slump flow test apparatus, J-ring test apparatus, L-box test apparatus, and V-funnel test apparatus, and the strength characteristics of self-consolidating concrete like compressive strength, flexural Strength, tensile strength, and impact strength are found. The research programs carried out in the civil engineering laboratory at Raajdhani Engineering College, Bhubaneswar.

The following steps are required:-

3.1. Design of Concrete mix
3.2. Mixing of concrete
3.3. Workability of Concrete
3.4. Hardness Properties of self-consolidating concrete
3.5. Durability Test
3.6. Results and Discussion

3.1. DESIGN OF CONCRETE MIX

There is no specific code or standard available in India for SCC. So checked by the trial and error method, after 8 to 10 trials, I have decided on the final proportion. Portland cement and fly ash were used as binding materials, and coarse aggregate having a size of not more than 12.5mm and retained at 10 mm was used in an equal weight proportion as coarse aggregate. This retention at 10 mm is fixed for every mix. Fine aggregates passing through a 4.75mm sieve were used. The total powder content in the mix has been taken to 530 kg/m3.The high-performance superplasticizer (Glenium 51) and dosage level were 1.0% to 1.5% of the binder (Cement and Fly ash) content. In the concrete mix, the fly ash content varied by 15%, 20%, 30%, 40%, and 55%.

Mix proportions, followed by:-

Mix 1: 85.0% Cement and 15.0% Fly ash.
Mix 2: 80.0% Cement and 20.0% Fly ash.
Mix-3: 70.0% Cement and 30.0% Fly ash
Mix-4: 60.0% Cement and 40.0% Fly ash
Mix-5: 45.0% Cement and 55.0% Fly ash

Table no.1. Mix proportion

Mix Design	Cement (kg/m3)	Fly ash(kg/m3)	fine aggregate (kg/m3)	Coarse aggregate (kg/m3)	super plasticizer	water
mix-1	450.5	78.75	845	850	1.25%	212 (0.40)
mix-2	424	106	845	850	1.30%	222.6 (0.42)
mix-3	371	159	845	850	1.35%	233.2 (0.44)
mix-4	318	212	845	850	1.45%	241.5 (0.46)
mix-5	238.5	291	845	850	1.50%	252 (0.48)

3.2. MIXING OF CONCRETE

The coarse and fine aggregates were mixed with sufficient water to wet the aggregate and mixed for 30 seconds in a pan-type mixer. The cement and fly ash were added together with 70% of the mixing water and mixed for another 2 minutes. The remaining water mixed with super plasticizer was added, and the mixing was continued for one minute. Then the mixing was halted for 2 minutes, and the mixing was continued for another 2 minutes.

3.3. WORKABILITY OF CONCRETE

3.3.1. SLUMP FLOW TEST.

In the absence of barriers, the slump flow is used to estimate the horizontal free flow of SCC. It was created in Japan for the purpose of evaluating underwater concrete. The test method is based on the slump determination test method. The diameter of the concrete circle is a measure of the concrete filling capacity.

Assessment of the test: -

Although two people are required to measure the slump flow test, this is a simple and quick test technique. It can be used on-site. The size of the base plate makes it a little awkward to operate, and level ground is required. It is the most often used test and provides a good indication of filling ability. It provides no indication of the concrete's capacity to move through reinforcement without being blocked, although it may indicate resistance to segregation. Although it could be claimed that a completely free flow without any limitations is not reflective of what happens in practice in concrete buildings, the test can be useful in determining the consistency of ready-mixed concrete on a site.

Mold in the shape of a truncated cone with internal dimensions of 200 mm at the base, 100mm at the top, and a height of 300mm that conforms to EN12350-2. A base plate made of a firm, non-absorbing material that is at least 700mm square and marked with a circle indicating the slump cone's central location and a concentric circle of 500mm diameter.

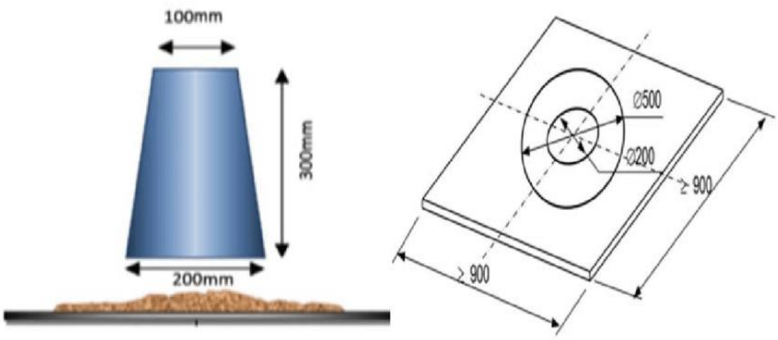

Figure-01 Slump flow test

This test usually requires the following equipment: trowel, Scoop, and stopwatch.

Procedure: -

- About 6 liters of concrete are needed for this test.
- Place the base plate on plane ground.
- Keep the slump cone at the center of base plate.
- Fill the cone help of scoop.
- Do not apply tamp.
- Simply use the trowel to level the concrete.
- Remove the extra concrete lying on the base.
- Lift the cone vertically to allow free flow of the concrete.
- Calculate the average of the two diameters after measuring the concrete's final diameter in two perpendicular directions.
- This is the slump flow test in mm.

Note: - (i) There is no water, cement paste, or mortar without coarse aggregate at the edge of the spread concrete.
(ii) The required slump flow for self-consolidating concrete is between 650 mm and 800 mm.

3.4. HARDNESS PROPERTIES OF SCC

3.4.1. **PREPARATION OF MOULDS**

Three types of moulds were used in this investigation, namely the cube, and cylinder, The sizes of cubes are 150*150*150mm and cylinders are 150*300mm. Different molds have been cleaned and oiled for easy demolding after conducting the test. The concrete mix was poured into the molds required for strength assessment. After pouring the concrete into the moulds, no compaction was given, either through vibration or hand compaction. The concrete did not require any finishing operations. After 24 hours of casting, the specimens were demolished and put into the curing tank. After the curing periods of 7, and 28 days, specimens are removed from the curing tank, cleaned of all surfaces, and taken for testing.

Figure-02 Curing of concrete Moulds

Table no.2 Harden Properties of SCC

Description	Mould Size (mm)	No.of mould	Days of Testing	Total no.of mould	Volume for one mould(m3)	Volume for all mould(m^3)
Comp. strength test	Cube (150*150*150)	3	7, 28	6	0.0034	0.0204
Split tensile test	Cylinder (150Dia.&300 Hight)	3	7, 28	6	0.0056	0.0336
Durability test	Cube (150*150*150)	3	7, 28	6	0.0035	0.021
					Total Volume of Mould	0.075

3.4.2. COMPRESSIVE STRENGTH TEST

A test result is obtained by comparing three standard-cured specimens made from the same concrete sample and tested at the same age. Concrete strength is checked 7 and 28 days of curing. The concrete cubes were tested after 7 and 28 days for their compressive strength in the following manner: During the first cleaning of the bearing surface of the compression testing machine, the axis of the concrete mould was carefully aligned with the centre of thrust of the plate. No packing was used between the faces of the test concrete mould and the plate of the testing machine. Then, until the mould could continue to resist the growing weight, the load was progressively applied and raised constantly at a rate of around 140 Kg/cm2/min.The compressive stress is calculated in Kg/cm2 from the maximum load sustained by the cube before failure.

Figure-03 Compressive Strength test

Formula

Compressive Strength (σ_c) = P/A

Where, P = Load in kg and A= Surface area of cube in cm^2.

3.4.3. SPLIT TENSILE STRENGTH TEST

This test is conducted by applying a diametric compressive force along the length of a cylindrical concrete mould. This loading induces tensile stress on the plane containing the applied load. Tensile failure occurs differently from compressive failure. To determine the splitting tensile strength, the maximum load is divided by the required geometrical components. A diametric compressive load is then applied along the length of the cylinder concrete mould until it fails because without RCC concrete, which is much weaker in tension in comparison with compression, the cylinder concrete mould will typically fail due to horizontal tension and not vertical compression. Normally, concrete cylinders, testing 7 and 28 days of curing in water, are tested for their tensile strength in the following manner:

Figure-04 Split tensile Strength test

Formula

Split tensile Strength(T) = 2P/πDL

Where, P = Load in kN , D= diameter in mm and L= Length in mm

3.5.DURABILITY TEST:

To determine the durability of Self consolidating Concrete against salt and sulphate the concrete cubes were soaked in Nacl solution of concentration 4% (dissolved 40gm of Nacl in 1 liter of water) for 90 days and loss in weight and strength of Self consolidating Concrete were compared with unsoaked concrete cubes. The required quantity of Nacl was dissolved in water to make the solution of desired concentration. The weight of concrete moulds is measured before kept in Nacl solution Kept for 90 days, observed the visual change in concrete moulds and measure the change in weight with original weight. Also measured the change in the Compressive strength of concrete cube with respect to unsoaked specimen after 90 days.

3.6 RESULTS AND DISCUSSION

Table no-03 Slump Flow Test

Mix design	Slump flow(mm)	Slump flow Range (mm)
mix-1	645	650-800
mix-2	657	650-800
mix-3	672	650-800
mix-4	695	650-800
mix-5	720	650-800

There are different methods of measuring workability for SCC, like slump flow tests, L-box tests, U-box tests, V-funnel tests, etc., but I have used slump flow tests to measure the workability of concrete. Different mix proportions: the first mix proportion does not satisfy the range, but mix proportions 2nd, 3rd, 4th,4th and 5th satisfy this condition.

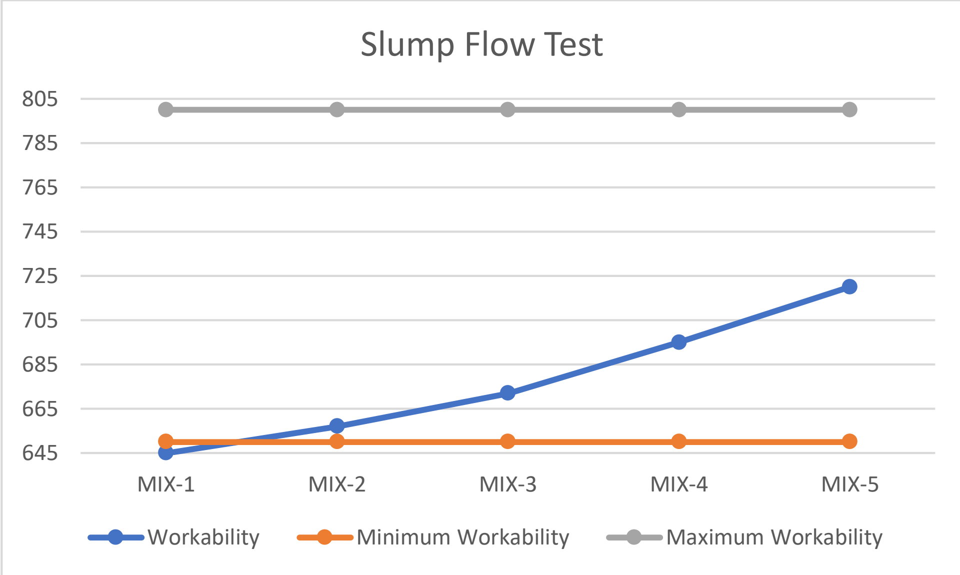

Table no-04 Compressive Strength Test

Srial.No.	Type of mix	Mould size	Applied load (KN)	Compressive strength after (7 days) in Mpa	Compressive strength after (28 days) in Mpa
1	M25	150*150*150 mm	643.53	18.59	28.31
2	MIX-1	150*150*150 mm	833.53	24.07	36.67
3	MIX-2	150*150*150 mm	726.52	20.98	31.96
4	MIX-3	150*150*150 mm	637.68	18.42	28.05
5	MIX-4	150*150*150 mm	536.34	15.49	23.59
6	MIX-5	150*150*150 mm	456.32	13.18	20.07

Compressive strength Test results obtained by variation of load for different mix conditions and comparison with M25-grade concrete

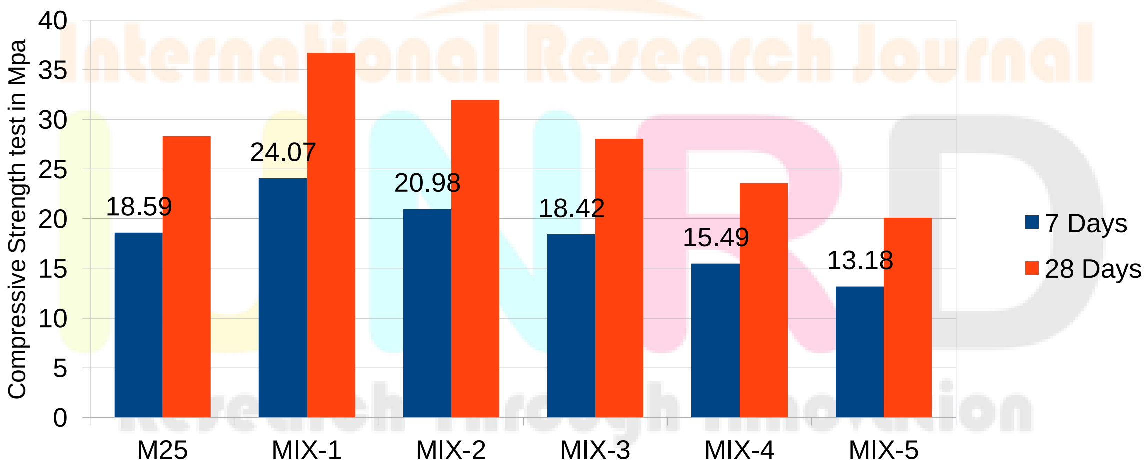

Table no-05 Split Tensile Strength test

Srial No	Type of mix	Mould size	Applied load (KN)	Split Tensile Strength after (7 days) in Mpa	Applied load (KN)	Compressive strength after (28days) in Mpa
1	M25	150ϕ&300L	102.321	1.45	201.672	2.85
2	MIX-1	150ϕ&300L	95.621	1.35	230.563	3.26
3	MIX-2	150ϕ&300L	123.652	1.75	245.635	3.47
4	MIX-3	150ϕ&300L	87.561	1.24	195.343	2.76
5	MIX-4	150ϕ&300L	101.221	1.43	167.24	2.36
6	MIX-5	150ϕ&300L	92.891	1.31	146.532	2.07

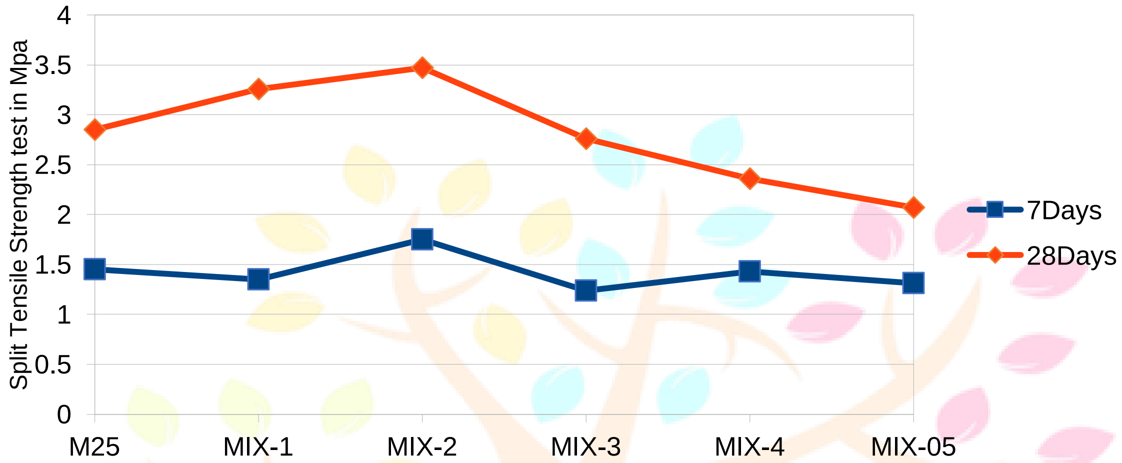

Table no-06 change in weight when mould soacking in Nacl solution

Srial no	Type of Mix	Mould Size	Initial Weight(Kg) before soaking in Nacl Solutions	Final Weight(Kg) after 90 days soaking in Nacl Solutions	Percentage Change in Weight after 90 days
1	M25	150*150 mm	8.431	8.279	-1.80
2	MIX-1	150*150 mm	8.362	8.267	-1.13
3	MIX-2	150*150 mm	8.521	8.408	-1.32
4	MIX-3	150*150 mm	8.452	8.323	-1.53
5	MIX-4	150*150 mm	8.311	8.213	-1.18
6	MIX-5	150*150 mm	8.281	8.092	-2.28

For durability, test the concrete cube's weight and put it in the Nacl solution for 90 days. After that, weighing the cube, some percentage loss of the weight is shown in the table

CONCLUSIONS

- Self-consolidating concrete gives good finishing as compared to ordinary concrete without any mechanical vibrator being used for compaction.
- The measure workability test by using the slump flow test of self-consolidating concrete at 15 percentage of fly ash and 1.25 percentage of superplasticizer did not satisfy workability criteria and other mixed conditions satisfied the criteria.
- Compressive strength of self-consolidating concrete is better than ordinary concrete for adding 20% and 30 percentage of fly ash.
- The strength of self-consolidating concrete is better than ordinary concrete for adding 20 % and 30% of fly ash.
- Durability of self-consolidating concrete is better than ordinary concrete by checking after 90 days as compared to M25 grade Concrete.
- Self consolidating concrete is better workability as compared to ordinary concrete easily placed in congusted area of reinforcement.
- The strength of concrete increases by using self-consolidating concrete because no voids are presented.

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