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Durability Studies of High Strength Self Compacting Concrete

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Abstract: Self-consolidating concrete or self-compacting concrete(SCC) is characterized by a low yield stress, high deformability, and moderate viscosity necessary to ensure uniform suspension of solid particles during transportation, placement (without external compaction), and thereafter until the concrete sets. Self Compacting Concrete is characterized by a low yield stress, high deformability, and moderate v Self-consolidating concrete or self-compacting concrete(SCC) is characterized by a low yield stress, high deformability, and moderate viscosity necessary to ensure uniform suspension of solid particles during transportation, placement (without external compaction), and thereafter until the concrete set Self Compacting Concrete is characterized by a low yield stress, high deformability, and moderate viscosity necessary to ensure uniform suspension of solid particles during transportation, placement (without external compaction), and thereafter until the concrete set .The relatively high cost of material used in such concrete continues to hinder its widespread use in various segments of the construction industry, including commercial construction, however the productivity economics take over in achieving favorable performance benefits and works out to be economical in pre-cast industry. The incorporation of powder, including supplementary cementations materials and filler, can increase the volume of the paste, hence enhancing deformability, and can also increase the cohesiveness of the paste and stability of the concrete necessary to ensure uniform suspension of solid particles during transportation, placement (without external compaction), and thereafter until the concrete sets. The relatively high cost of material used in such concrete continues to hinder its widespread use in various segments of the construction industry, including commercial construction, however the productivity economics take over in achieving favorable performance benefits and works out to be economical in pre-cast industry. The incorporation of powder, including supplementary cementations materials and filler, can increase the volume of the paste, hence enhancing deformability, and can also increase the cohesiveness of the paste and stability of the concrete.

Keywords: Self Compacting Concrete, Yield Stress, Filler Materials.

I. INTRODUCTION

The main reason for deterioration of concrete in the past is that too much emphasis is placed on concrete compressive strength. As a matter of fact, advancement in concrete technology has been generally on the strength of concrete. It is now recognized that strength of concrete alone is not sufficient, the degree of harshness of the environmental condition to which concrete is exposed over its entire life is equally important. Therefore, both strength and durability have to be considered explicitly at the design stage. High-strength and High-performance concrete are being widely used throughout the world and to produce them it is necessary to reduce the water/binder ratio and increase the binder content. High-strength concrete means good abrasion, impact and cavitations resistance. Using High-strength concrete in structures today would result in economical advantages. Most applications of high strength concrete to date have been in high-rise buildings, long span bridges and some special structures. Major application of high strength concrete in tall structures have been in columns and shear walls, which resulted in decreased dead weight of the structures and increase in the amount of the rental floor space in the lower stories. Self Compacting Concrete is defined as a category of high performance concrete that has excellent deformability in the fresh state and high resistance to segregation, and can be placed and compacted under its self weight without applying vibration. The elimination of vibration for the compaction of fresh concrete makes the use of the self –compacting concrete beneficial in terms of cost reduction and improvement of the work environment. Due to intrinsic low porosity, SCC usually has high performance properties in terms of mechanical behavior and durability.

Self-compacting concrete (SCC) is a pioneering concrete that does not involve shuddering for insertion and compaction. It is able to gush under its own load, completely filling form work and achieve the full compaction, even in the occurrence of congested support. The hardened concrete is dense, uniform and has the same property and durability as standard vibrated concrete. Making concrete structure without compaction has been done in the past. Like placement of concrete underwater by the use of termite without compaction. Inaccessible areas were concreted using such techniques. The production of such mixes often used expensive admixtures and very large quantity of cement. But such concrete was generally of lower strength and difficult to obtain. This lead to the development of Self Compacting Concrete (SCC) whose concept was first initiated by Japan in the mid of 1980s. SCC is a high performance concrete that consolidates under its self-weight, and adequately fills all the voids without segregation, excessive bleeding or any other separation of materials, without the need of mechanical consolidation. The key properties of SCC are filling ability, passing ability and resistance to segregation. Filling ability helps SCC to flow through the formwork and completely fill all the spaces within it. Passing ability is the property by which it flows without any blocking. The benefit of resistance to segregation imparts the advantage to the concrete in maintaining a uniform composition hence the paste and the aggregate bind together. The application of SCC aims at obtaining a concrete of high performance, better and more reliable, improved durability, high strength and faster construction. For SCC it is generally important to use superplasticizers in order to obtain high mobility.

II. EXPERMIENTAL METHODS

A. Development of High Strength Self Compacting Self Curing Concrete with Mineral Admixtures

The experimental investigation done by C. Selvamony et.al involved evaluating the effectiveness of various percentages of mineral admixtures in producing SCC. Okamura's method, based on EFNARC specifications, was adopted for mixed design. Different mixes were prepared by varying the amount of coarse aggregate, fine aggregate, water powder ratio, super plasticizers and VMA. After several trials, SCC mix satisfying the test criteria was obtained. In their study, the effect of replacing the cement, coarse aggregate and fine aggregate by limestone powder(LP) with silica fume(SF), quarry dust and clinkers respectively and their combinations of various proportions on the properties of SCC has been compared

B. Development of High Strength Self Compacting Concrete with Reduced Segregation Potential

The experimental work done by Dr.R.Sri Ravindrarajah et.al is an investigation into the development of self-compacting concrete with reduced segregation potential. The self-compacted concrete mix having satisfied the criterion recognized by the differential height method is modified in many ways to increase the fine particle content by replacing partially the fine and coarse aggregates by low-calcium fly ash. A systematic experimental approach is followed for the partial replacement of coarse and fine aggregate to produce self-compacting concrete with low segregation potential as assessed by the V-Funnel test. General purpose Portland cement and low-calcium fly ash were used as binder materials in making the concrete mixes. Crushed river gravel having a maximum size of 20mm and 10mm were used in equal weight proportion combination as coarse aggregate. Napean river coarse sand and Botany fine sand were used as fine aggregate in equal weight proportion. A control concrete having the cement and fly ash contents of 350 kg/m^3 and 134 kg/m^3, respectively were used in this study. A high-performance superplasticizer (Glenium 51) used and the dosage level was fixed at 0.54% of the binder (i.e. cement + fly ash) content. In order to reduce the bleeding capacity of the concrete mix, the fly ash content was increased by 10%, by partially replacing the one of the following: fine aggregate, coarse aggregate or a combination of fine and coarse aggregates. Once the appropriate replacement method is decided based on the test results, the fly ash content was increased to 20% and 25%.

C. Effect of Size of Aggregate and Fines on Standard and High Strength Self Compacting Concrete

The experimental work done by S. Venkateswara Rao et.al aims at developing standard and high strength Self Compacting Concrete (SCC) with different sizes of aggregate based on Nansu's mix design procedure. The role of different sizes of coarse aggregate on the standard and high strength concrete is studied. Further, fly ash optimization is done in the second stage of study with the graded course aggregate. The variables involved in the study are size of aggregate, dosage of fly ash and grade of concrete. The mechanical properties viz., compressive strength, flexural strength and split tensile strengths were studied at the end of 3, 7 and 28 days for standard and high strength SCC with different sizes of aggregate.

D. Self Compacting Concrete

In experimental investigation done by Hajime Okamura et.al established a rational mix design method and self compact ability testing methods of making self compacting concrete a standard concrete. First the author emphasis on the development of self compacting concrete and the mechanism for achieving self compatibility. Okamura and Ozawa achieved self compatibility by (i) Limited aggregate content (ii) Lower water powder ratio and (iii) Usage of superplasticizer. To check whether or not concrete is self-compactable for the structure, to check the mix proportions when the self compatibility is not sufficient and to characterize materials; test methods were described and employed. Later the factors influence of coarse aggregate on the spacing size, its content, shapes and grading, role of mortar as fluid and solid particles was mentioned. Finally the acceptance at site and applications of SCC were mentioned.

Sodium sulphate attacks $Ca(OH)_2$:

$$Ca(OH)_2 + Na_2SO_4\ 10\ H_2O \ .....CaSO_4\ 2H_2O + 2NaOH + 8H_2O$$

The reaction with calcium aluminates hydrate:

$$2(3CaO\ Al_2O_3\ 12H_2O) + 3(Na_2SO_4\ 10\ H_2O)........3CaO\ Al_2O_3\ 3CaSO_4\ 3\ H_2O + 2Al\ (OH)_3 + 6\ NaOH + 17\ H_2O$$

III. RESULTS & DISSCUTIONS

Table1. Physical Properties of Ordinary Portland cement

S.No.	PROPERTY		Test Results
1	Normal Consistency		29%
2	Specific Gravity		3.12
3	Setting time		
	A)	Initial Setting time	110Min
	B)	Final Setting time	180Min
4	Fineness of Cement(IS Sieve no. 9)		2.76%
5	Compressive Strength		
	At 7 days		37Mpa
	At 28 days		54Mpa

Coarse Aggregate:

Table2. Physical properties of coarse aggregate

S.No	Property	Result
1	Fineness Modulus	7.176
2	Specific Gravity	2.645
3	Bulk Density	
	Loose State	1.181gm/cc
	Compacted State	1.498 gm/cc

Table3. Typical Oxide composition of micro silica (Oriental Trexim Pvt. Ltd)

S.No	Constituents	Percentages
1.	Silica, SiO_2	92.00
2.	Alumina,Al_2O_3	0.46
3.	Iron Oxide, F_2O_3	1.60
4.	Lime, CaO	0.36
5.	Magnesia, MgO	0.74
6.	Sulphur Trioxide, SO_3	0.35
7.	Loss on Ignition	2.50
8.	Na_2O	0.70
9.	K_2O	0.90
10.	p^H	7.60
11.	Accelerated Pozzolanic Acidity in 7 days	104.00
12.	Accelerated Pozzolanic Acidity in 28 days	117.00
12.	Surface Area in m^2/kg	1890
13.	Moisture Content	1.00
14.	Bulk Density	450-650

Table4. Quantities of Materials required for $1m^3$ of High Strength Self Compacting Concrete mixes

MIX	w/c_m	Cm	Cement	Fly ash	Microsilica	Water	CA	FA	SP Type	SP	VMA
M100	0.22	700	500	125	75	154	774.985	766.195	SP3	11.2	0.35

Table5. percentage decease of weight specimen (100mm x 100mm x 100mm) at 28 days without & with different chemical immersion of High Strength Self |Compacting Concrete of M100 grade

Grade	Average weight without chemical immersion	Name Chemical used (10%)	Decrease weight after 28 day chemical immersion	percentage decrease weight after 28 days
M100	2.415 Kg	HCL	2.270 Kg	5.86
M100	2.398 Kg	H_2SO_4	2.210 Kg	7.85
M100	2.393 Kg	Na_2so_4	2.240 Kg	6.25

IV. CONCLUSION

Natural materials used for road construction are exhaustible in nature its quantity is decline gradually. Also cost of extracting good quality of natural material is increasing. At the same time the rapid growth in population and industrialization cause generation of large quantities of wastes. The bulk wastes generated due to industrial activities are discharged either treated or untreated into the environment. The disposal of industrial wastes creates a potential negative impact on the environment. Expansive clays undergo a large swell when they are subjected to water. Thus, expansive clay is one of the most abundant problems faced in geotechnical engineering applications. It causes heavy damages in structures, especially in water conveyance canals, lined reservoirs, highways, airport runways etc, Hence stabilization of expansive soils becomes challenging task for Geotechnical Engineers. In order to overcome these three problems industrial wastes are utilized in the stabilization of expansive soils. The benefits of this solution are many- Helps in safe disposal of Wastes by a eco-friendly way; improved solid Waste management; better environmental hygiene; value added to Industrial wastes; cost is less; saves select material for higher value projects; Depending on the project locations, transportation distances may be reduced, which saves fuel and reduces emissions; reduces the amount of wastes going to landfills, saving that space for true wastes. Hence researchers are made an attempt and found use of industrial wastes such as stone dust and Cement Kiln dust can be effectively used to stabilize the expansive soils. Addition of fly ash and quarry dust in the proportions made an effect in the soil properties such that

- Decrease in the liquid limit
- Non plastic
- Decrease in the OMC value and increase in the maximum dry density
- Increase in the unconfined compressive strength
- Increase in the CBR value

From the above results and discussions it can be noted that the proportion having 50% soil, 20% fly ash and 30% quarry dust gives the best results.

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