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Experimental Study on The Development & Characteristics of Self-Consolidating Concrete

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Abstract

Self compacting concrete is a balance between fluidity and resistance to segregation. It represents one of the most significant advances in concrete technology for decades. It is high workable concrete and do not require any external vibration for consolidation. Its basic difference with normal concrete is its high passing and filling ability with high resistance to segregation. SCC ensures adequate compaction and facilitate placement of concrete in structures with congested reinforcement and in restricted areas. Since its first development in Japan in 1988, SCC has gained wider acceptance in Japan, Europe and USA due to its inherent distinct advantages. Although there are visible signs of its gradual acceptance in the Indian Sub-continent through its limited use in construction, India has yet to explore the feasibility and applicability of SCC in new construction. The contributing factors to this reluctance appear to be lack of any supportive evidence of its suitability with local marginal aggregates and the harsh environmental conditions. An absolute study is required in the field of self-consolidating concrete for its easy application in India. The study includes evaluating the unique method for its mix design and understanding the variation in its various properties. Local aggregates, cement, admixtures, stabilizers and additives produced by the local suppliers were used in this work. The compressive strength was checked on 7 day, 14 day, 28 day and results indicated that proposed design mix can produce SCC of higher quality with excellent hardened state properties.

Keywords

Segregation, Compaction, Hardened Properties, Workability.

I. Introduction

Lack of proper compaction of the normal conventional concrete may lower the performance of hardened concrete. Self consolidating concrete is high workable concrete and do not require any external vibration for compaction and thus helps in the achievement of durability of concrete, even at places of congested reinforcement and in restricted areas. Self consolidating concrete is one of the type of special concrete which flows and consolidates under its own weight thereby eliminates the problems of placing concrete in difficult conditions and also reduces the time in placing large sections and at the same time giving high strength and better durability characteristics as compared to normal concrete. Self consolidating concrete represents one of the most significant advances in concrete technology for decades. It is characterized by fresh concrete that can flow around reinforcement and consolidate within the formwork under its own weight without any defects due to segregation and bleeding. Its basic difference with normal concrete is its high passing and filling ability with high resistance to segregation.

Almost all countries in the world are facing an acute decline in the availability of skilled labor and hence the use of high workable concrete becomes very essential, which compacts in every corner of formwork without any need of external vibration. SCC is a fluid mixture suitable for placing in structures with congested reinforcement without vibration. Its development must ensure good balance between deformability and stability. The hardened concrete is dense, homogenous and has the same engineering property and durability as traditionally vibrated concrete. It is generally used to place in areas where congested reinforcement is placed and 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.

Inadequate compaction of conventional concrete results in lack of attainment of required strength and durability properties of hardened concrete. In modern construction world the use of closely spaced reinforcing bars, due to special architectural designs have made it very important to produce concrete that can ensure proper filling ability and good durability. This led to the development of self consolidating concrete in late 1980's which, apart from having excellent workability to deform under its own weight, offers new prospects in relation to durability and strength requirements of concrete.

Okamura proposed the use of SCC in 1986. Studies to develop SCC, including a fundamental study on the workability of concrete, were carried out by Ozawa and Maekawa at the University of Tokyo, and by 1988 the first practical prototypes of SCC were produced. By the early 1990's Japan started to develop and use SCC and, as of 2000, the volume of SCC used for prefabricated products and ready-mixed concrete in Japan was over 520,000 yard3 (i.e. 400,000 m3).Till 2003, rational mix design method and an appropriate testing method at job site have both largely been established by Okamura et al, the main obstacle for the wide use of Self-compacting concrete can be considered to have been widely been solved. This chapter deals with literature history of SCC.

K.H. Khayat showed that the workability requirement for successful placement of SCC necessitate that the concrete exhibits excellent deformability and proper stability to flow under its own weight through closely spaced reinforcement without segregation and blockage. Insuring high stability is important to limit bleeding, segregation and surface settlement of concrete after placement and secure uniform properties of hardened concrete. In general, SCC exhibits low yield and moderate viscosity. In addition to the slump flow test used to evaluate deformability, the filling test or V-funnel flow test should be used to evaluate the ability to achieve the smooth flow through restricted spacing without blockage.

One approach to enhance viscosity is to lower the w/cm ratio to maintain adequate cohesion friction between the mortar and coarse aggregate and insure uniform flow of SCC through restricted sections. Another way is to incorporate a low to moderate dosage of a VMA without lowering the w/c.

A brief literature review on SCC indicates that the SCC has several

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advantages over the traditional vibrated concrete, mainly the ease and precision in placement and lack of vibration. Savings in labor costs might offset the increased cost related to the use of more powder and super plasticizer, and the mineral admixtures, such as pulverized fuel ash (PFA), ground granulated blast furnace slag (GGBS) or lime stone powder (LSP), Marble dust could increase the fluidity of the concrete, without any increase in the cost. These supplementary cementing materials also enhance the rheological parameters and reduce the risk of cracking due to the decreased heat of hydration, and therefore, improve the durability.

II. Trial Mixes

Eight trial mixes were prepared by varying the limestone powder content, fine to coarse aggregate ratio, and super plasticizer content. Two levels of the marble dust powder 150 and 200 kg/m^3, two levels of fine to coarse aggregate ratio: 1.1 and 1.15 (by mass), and two levels of super plasticizer (sulphonated melamine formaldehyde) : 0.7 and 0.9% (by mass of powder) were used for preparing and testing eight trial mixes. For each trial mix, a constant water/powder ratio of 0.44 (by mass) and a constant amount of stabilizer (3.5kg/cum) were taken as presented in Table 1.

Table 1: Weights of constituents in trial mixes

S. No.	Trail mix	Mix variables			Quantities of min ingredients (kg/cum)						
		FA/CA ratio	Filler content (kg/cum)	SP %	Water	Cement	FA	CA	SP	Stabilizer	Density
1.	Mix A	1.1	125	0.7	190	350	850	773	3.3	3.00	2340
2.	Mix B	1.1	125	0.9	190	350	850	773	4.3	3.00	2340
3.	Mix C	1.1	150	0.7	199	350	830	755	3.5	3.00	2320
4.	Mix D	1.1	150	0.9	198	350	830	755	4.5	3.00	2320
5.	Mix E	1.15	125	0.7	190	350	900	783	3.3	3.00	2340
6.	Mix F	1.15	125	0.9	189	350	900	783	4.3	3.00	2340
7.	Mix G	1.15	150	0.7	198	350	870	757	3.5	3.00	2320

III. Compressive Strength of Trial Mixes

The specimens were capped with sand to obtain a horizontal surface. Prior to capping, the dimensions of the specimens were measured. The capped specimens were then placed in a compression testing machine. The Compressive strength was calculated by dividing the failure load by the average cross sectional area of the specimen. . The results of compressive strength tests are shown with corresponding graphs

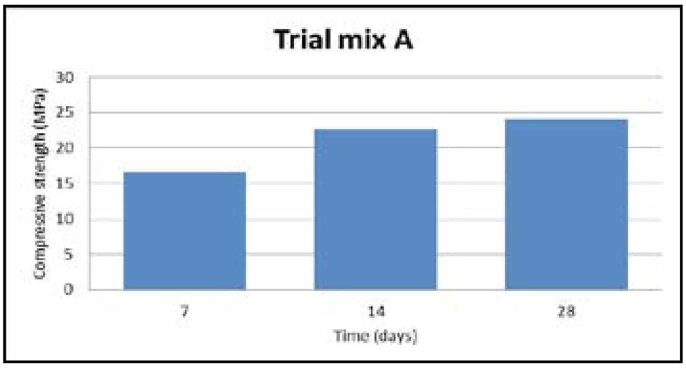

Fig.1 : Variation of compressive strength of trial mix A with curing age

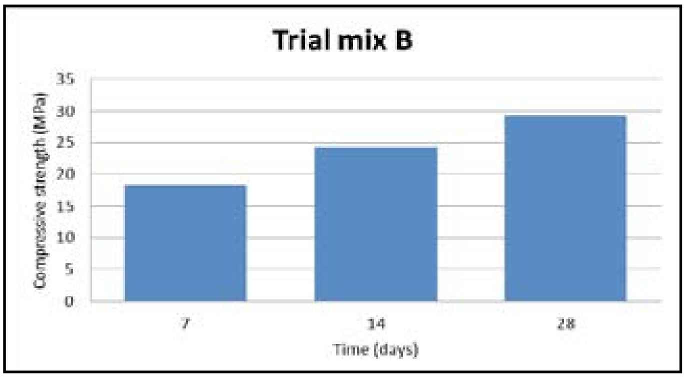

Fig.2 : Variation of compressive strength of trial mix B with curing age

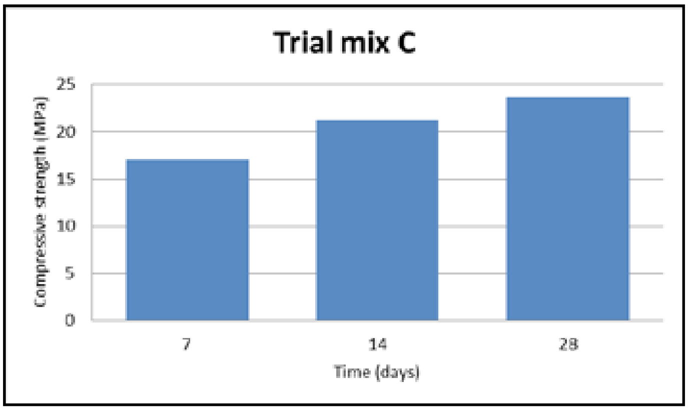

Fig.3 : Variation of compressive strength of trial mix C with curing age

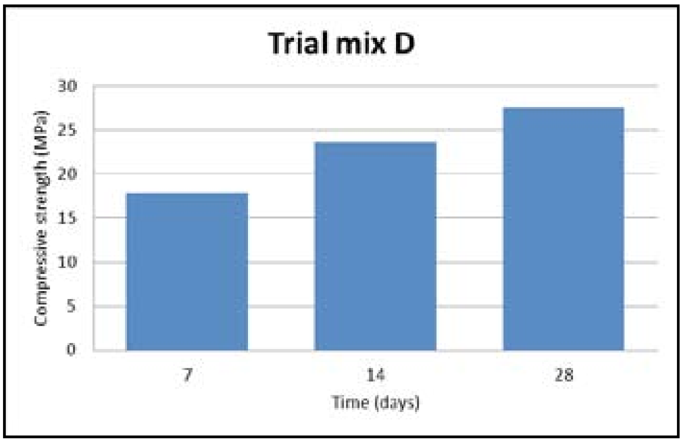

Fig. 4: Variation of compressive strength of trial mix D with curing age

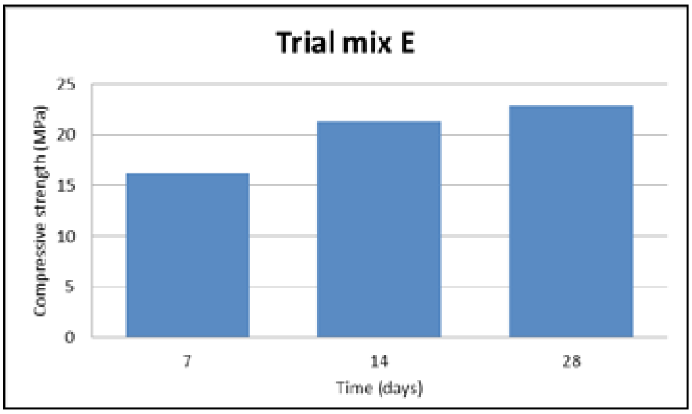

Fig. 5: Variation of compressive strength of trial mix E with curing age

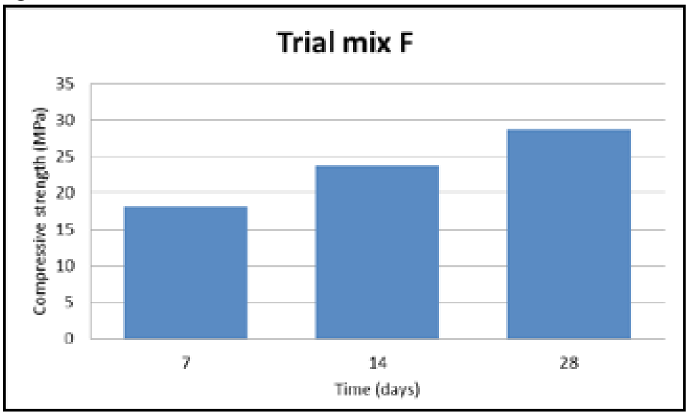

Fig.6 : Variation of compressive strength of trial mix F with curing age

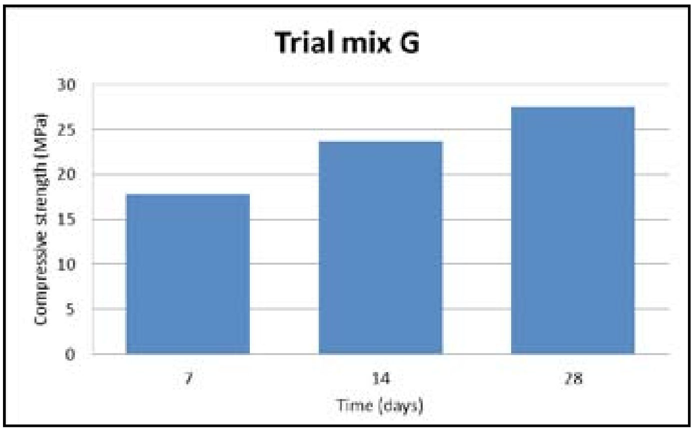

Fig.7 : Variation of compressive strength of trial mix G with curing age

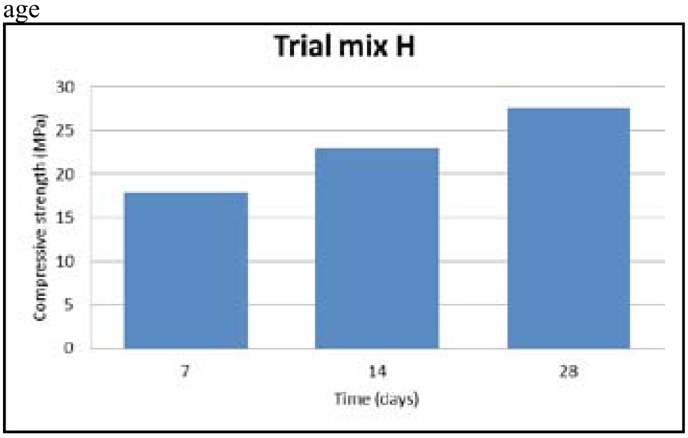

Fig. 8: Variation of compressive strength of trial mix H with curing age

IV. Results & Discussion

The average compressive strength, split tensile strength & flexural strength of SCC specimens for SP-1 and SP-2 super plasticizer for 7 days, 14 days & 28 days are shown in graphs 9 to 11.

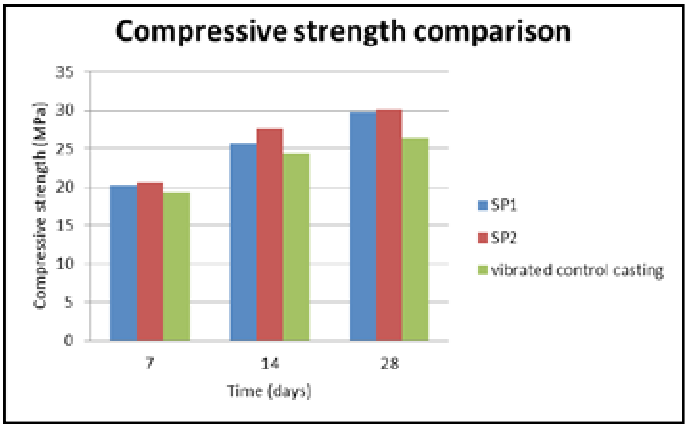

Fig. 9: Comparison of gain of compressive strength with the use of two SP's and control castings

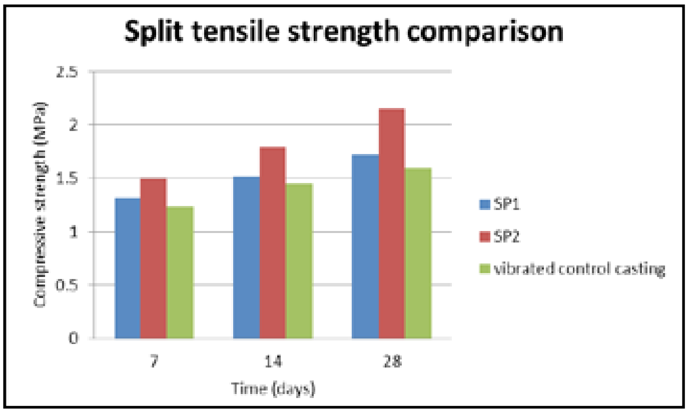

Fig. 10: Comparison of gain of split tensile strength with the use of two SP's and control casting

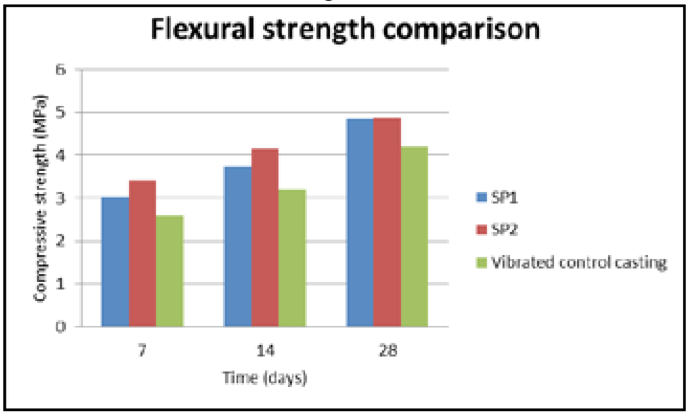

Fig.11: Comparison of gain of flexural strength with the use of two SP's and control casting

Water absorbtion

The average water absorption in the SCC specimens is lower than that of conventional concrete. The average water absorption of conventional concrete produced using river sand as fine aggregate and crushed aggregate as coarse aggregate is 5.0%. The lower water absorption exhibited by SCC specimens is an indication of lower porosity of SCC compared to the conventional concrete hence better durability

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V. Conclusions

The main conclusions drawn from the results are summarized below:

1. From all mixes, a mix with FA/CA ratio of 1.1, filler content of 125 kg/m3 and 0.9% super plasticizer was found to meet the compactibility criteria and possessed maximum compressive strength.
2. Increasing the quantity of Marble dust as filler may result in increase or decrease in compressive strength of concrete depending on FA/CA ratio and percentage of super plasticizer keeping the water content and stabilizer constant.
3. The self consolidating concrete showed excellent properties with regard to water absorption. The water absorption of specimens exposed to normal laboratory conditions was 2.88%.
4. The test results showed that self consolidating concrete specimens yielded more strength than normally vibrated concrete.
5. Modified lignosulphates displayed excellent displayed better strength than sulphonated melamine formaldehyde.
6. Effect of different super plasticizers on strength is approximately 2% N/mm^2.

VI. Future Scope

Following are some suggestions for future research.

1. The durability properties of SCC can be evaluated by varying mix proportions, like aggregate content, cement content, super plasticizer content, maximum aggregate size and the use of different types and quantity of filler.
2. Comparative study related to non-vibrated concrete can be studied using the mix design adopted in this research.
3. Long-term study on durability of SCC considering rebar corrosion monitoring in addition to other durable properties of concrete.
4. Comparison of elastic modulus, creep and shrinkage between SCC and conventional concrete can be made using the mix design of this research.

VII. Recommendations

Following parameters are recommended for producing SCC using local aggregates:

1. FA/CA	: 1.1
2. Filler content	: 125 kg/m^3
3. Super plasticizer	: 0.9%
4. Water/Powder ratio	: 0.4
5. Cement	: 350 kg/m^3
6. Stabilizer	: 3 kg/m^3

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