Experimental Research on Characterization of Self-Compacting concrete

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Abstract:- *One of the latest advancement in concrete technology is Self-Compacting Concrete (SCC). SCC is defined as concrete with enhanced properties not found in normal concrete. Some of these properties include better workability and higher compressive strength. This research focuses the characterization of self-compacting concrete by using local materials and SikaPlast-151V (High Performance Concrete Super plasticizer).Concrete Mixtures A, B, C, D and E are made to find the properties of SCC in fresh state and compressive strength. In this research, design strength is 7975 psi (or) 55 MPa. The physical properties of local materials are carried out according to ASTM standard. The trial mix design is calculated step by step according to ACI method. Slump flow, L-box and V-funnel tests are performed for properties of SCC in fresh state and the results are compared with the recommendation limits of EFNARC (European Federation of national trade associations representing producers and applicators of specialist building products). Finally the test results of the SCC concrete mixtures are compared.*

Key Words: **Self-Compacting Concrete (SCC), fresh state, workability, compressive strength, Super plasticizer**

1. INTRODUCTION

One of the latest advancement in concrete technology is Self-Compacting Concrete (SCC). Self-Compacting Concrete (SCC) is a very fluid concrete and a homogeneous mixture that solves most of the problems related to ordinary concrete. Besides, SCC gets compactness under its own weight and there is no need any vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The property of SCC in hardened state is dense, homogeneous and has the same engineering properties and durability as traditional vibrated concrete. It offers a rapid rate of concrete placement, with faster construction times and ease of flow around congested reinforcement. The fluidity and segregation resistance of SCC ensures a high level of homogeneity, minimal concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure. The improved construction practice and performance, combined with the health and safety benefits, make SCC a very attractive solution for both precast concrete and civil engineering construction. This research aims to achieve Self-Compacting Concrete (SCC) using local materials that are available in our country. The main objectives of this research are to evaluate the mix design procedure for SCC according to ACI method, to study the available strength of SCC in Myanmar and to get comprehensive knowledge about developing SCC for the modern concrete technology.

2. ADVANTAGES AND DISADVANTAGES OF SCC

Self-Compacting Concrete (SCC) is modified concrete with the use of chemical and mineral admixtures in the concrete. SCC exceeds the properties and constructability of normal concrete. SCC is mainly produced for steel congestion. Normal special materials are used to make these specially concretes that meets a combination of performance requirements. The advantages of Self-Compacting Concrete (SCC) are the following important factors.

(a)Self-Compacting Concrete (SCC) shows a good filling ability especially around reinforcement.

(b)Because of high fluidity, this concrete does not need any vibrations so that it allows to save energy and to ensure suitable cost in place.

(c)Reduce noise at sites, the precast factory and neighborhood; hence, it is a silent concrete.

(d)SCC yields homogenous concrete in situations where the castings are difficult due to congested reinforcement. Minimizes voids on highly reinforcement areas.

(e)Construction with SCC is not affected by the skill of the workers, and shape and arrangement of reinforcing bars of the structure.

(f)It can be able the concrete supplier to provide better consistency in delivering concrete, which reduces the interventions at the plants or job sites.

(g)Ease of filling restricted sections and hard to reach areas results in achieving desired structural and architectural shapes.

(h)Shorter construction periods and resulting cost saving and less labour works.

(i)Reduction in wear and tear of forms, therefore, it extends the surface life of forms.

(j)Greater freedom design and improved pump ability.

(k)SCC is high strength concrete and gives thinner sections.

(l)Most suitable for concrete filled tubes (CFT) technology construction for high-rise building.

The disadvantages of Self- Compacting Concrete (SCC) are the following important factors.

(a)It is sensitive due to high water reduction.

(b)It is higher formwork pressure because of high density.

3. TESTING OF MATERIALS USED IN THIS RESEARCH

In this research, Self-Compacting Concrete (SCC) is made up of materials from construction material markets in Myanmar. They are Alpha cement (Grade-42.5), fine aggregate from Ayeyarwaddy River, coarse aggregate from Ohm Gyaw and SikaPlast-151V (High Performance Concrete Super plasticizer). The Chipping (20 mm or ¾″) and B (10 mm or 3/8″) aggregates proposed to be used for making concrete specimens is crushing stone from Ohm Gyaw. The physical properties of cement, sand and aggregate are tested according to ASTM procedures. The test result are summarized in Table 1 to 4 and compared with ASTM Specifications and the technical data for SikaPlast-151Vis described in Table 5.

Table 1: Physical properties of fine aggregates

Sr No.	Properties	Result Value	ASTM Standard range
1	Specific gravity	2.62	2.5 to 2.9
2	Finess Modulus	2.05	2 to 3.1
3	Water Absorption	0.84%	<3%

Table 2: Physical properties of Alpha cement

No	Properties		Alpha Cement (Grade-42.5)	ASTM Specifications
1	Normal Consistency		32%	26 – 33%
2	Specific gravity		3.15	3.1 – 3.25
3	Fineness		4050 cm^2/gm	2800 cm^2/gm
4	Soundness		0.8mm	1 mm (Max)
5	Setting time	Initial	125 mins	45 mins (Min)
		Final	190 mins	375 mins (Max)
6	Compressive strength	3days	3457 psi	1740 psi (Min)
		7days	4734 psi	2799 psi (Min)
		28days	5110 psi	3915 psi (Min)

Table 3: Physical properties of coarse aggregates Chipping (20 mm or ¾″)

Sr No.	Properties	Result Value	ASTM Standard range
1	Specific gravity	2.73	2.5 to 2.9
2	Finess Modulus	7.00	6 to 8
3	Water Absorption	0.38%	<3%

Table 4: Physical properties of coarse aggregates Chipping (10 mm or 3/8″)

Sr No.	Properties	Result Value	ASTM Standard range
1	Specific gravity	2.73	2.5 to 2.9
2	Finess Modulus	6.42	2 to 3.1
3	Water Absorption	0.5%	<3%

Table 5: Technical Data of SikaPlast-151V (High Performance Super plasticizer)

Colour	Light Brown Colour
Chemical Base	Blend of modified Polycarboxylate in water
Specific Density	1.075 - 1.095 kg/liter (at + 20°C)
pH value	4.00 - 6.00
Dosage	0.8 - 2.0 liter per 100kg of cement (Typical 1.0 - 1.8 liter/100 kg of cement)
Storage Condition	Store in dry conditions protected from direct sunlight and at temperatures between +5 and +30 degree Celsius.
Shelf – Life	One year if stored properly in original unopened packaging
Packaging	25 200 / 1000 liters / drum

4. CALCULATION OF TRIAL MIXES DESIGN

Mix design procedures are calculated step by step according to ACI method. In this research, mixtures of A, B, C, D and E are prepared by mixing of Alpha cement ,coarse aggregate from Ohm Gyaw, fine aggregate from Ayeyarwaddy River. In addition to, SikaPlast-151V (High performance concrete superplasticizer) is used in all concrete mixtures. Research concrete mixtures with different dosages of SikaPlast-151V are shown in Table 6.In calculation of mix design, the slump

value of 7 in (For Flowing Concrete) and air content 2% is considered. The design strength of mix 55 Mpa (7975 psi) is considered. The summary of the mix proportion for one cubic-yard and one cubic-meter of fresh concrete are shown in Table 7, where coarse aggregate content is the combination of Chipping and B aggregates with 1:1. The average unit weight of fresh SCC for all mix designs is in average 152 lb/ft^3.

5. COMPARISON OF RESEARCH MIXTURES AND RECOMMENDATIONS OF EFNARC

In designing the mix it is most useful to consider the relative proportions of the key components by volume rather than by mass. According to recommendation of EFNARC, indicative typical ranges of proportions and quantities in order to obtain self-compactability are shown in Table 8, where coarse aggregate content is content percent by volume of the mix and fine aggregate content is content percent by volume of the mortar. Coarse aggregate content, fine aggregate content, powder content, water content, Sand- Aggregate ratio (S/A ratio) and water/powder ratio of research mixtures are shown in Table 8 by comparison with the recommendations of EFNARC for SCC mix design.

Table 6: Research Concrete Mixtures wit DifferentDosages of SikaPlast-151V

Sr no.	Mixtures	Water/Cement Ratio	SikaPlast-151V
1	A	0.4	1.4 litre per 100kg of cement
2	B	0.35	1.4 litre per 100kg of cement
3	C	0.3	1.4 litre per 100kg of cement
4	D	0.35	1.6 litre per 100kg of cement
5	E	0.3	1.6 litre per 100kg of cement

Table 7: Summary of Batch Weight per Cubic-yard and Cubic-meter for Research Mixtures

Items		SikaPlast-151V (1.4%)			SikaPlast-151V (1.6%)	
Mixtures		A	B	C	D	E
W/C ratio		0.4	0.35	0.3	0.35	0.3
Reduced water (%)		16%	17%	18%	17%	18%
Reduced C.A (%)		23%	24%	25%	24%	25%
Cement	lb/yd^3	755	854	983	854	983
Water	lb/yd^3	302	299	295	299	295
Coarse Aggregates(C.A)	lb/yd^3	1408	1390	1372	1390	1372
Fine Aggregates (F .A)	lb/yd^3	1525	1464	1379	1459	1374
SikaPlast-151V (litres)	Litre/ yd^3	4.79	5.42	6.24	6.2	7.13

6. PROPERTIES OF SCC IN FRESH STATE

The three main properties of SCC in fresh state are filling ability (excellent deformability), passing ability (ability to pass reinforcement without blocking) and high resistance to segregation. The properties of SCC in fresh state such as slump flow , T_{50cm} slump flow, L-Box, V-funnel and V-funnel at $T_{5\ min}$ are tested for mixtures A, B, C, D and E. The summary test results of research mixtures are shown in Table 9 comparing with the recommendation limits of EFNARC.

Table8: Comparison between Research Mixtures and Recommendations of EFNARC for SCC Mix Design

Items	EFNARC Recomm-endations	Mixtures				
		A	B	C	D	E
C.A content of the mix	28 - 35 (%)	30.6	30.2	29.8	30.2	29.8
Total powder content	400 - 600 kg/m^3	448	507	583	507	583
S/A ratio	> 0.50	0.52	0.513	0.501	0.512	0.5
F.A content of the mortar volume	> 40%	51.3	48.9	45.8	48.8	45.7
Water content	< 200 liter/m^3	179	177	175	177	175
Water/ powder ratio by volume	0.80 - 1.10	1.26	1.1	0.95	1.1	0.95

7. COMPRESSIVE STRENGTH TEST RESULTS OF SCC

Compressive strength is a measure of the maximum resistance, a concrete specimen can maintain against axial loading. It is one of the primary parameters for concrete quality control testing. Compressive strength of concrete is mainly affected by water-cement ratio.

In this research, the cube test for SCC is used. The average compressive strength of each mix design is tested at 7, 14 and 28 days respectively. The summary of test results of compressive strength are shown in Table 10 and these are plotted in Figure 1.

Table 9: Summary Test Results of Research Mixtures in Fresh State

No	Test	EFNARC Recommendations		Mixtures				
		Min	Max	A	B	C	D	E
1	Slump flow	650 mm	800 mm	550	680	735	695	770
2	T_{50cm} Slump flow	2sec	5sec	8	5	3	3	2
3	L-box (H_2/H_1)	0.8	1	-	0.88	0.93	0.92	0.99
4	V-funnel	6sec	12sec	-	12	11	11	9
5	V-funnel at $T_{5\ min}$	11sec	15sec	-	15	13	14	11

Table10: Summary of Compressive Strength Test Result

Mix-ture	Water-cement ratio	Curing period (days)	Average Compressive strength(psi)	Percentage of 28-days Compressive Strength
A	0.4	7	6025	89.5%
		14	6377	94.8%
		28	6729	100%
B	0.35	7	6898	89.1%
		14	7318	94.5%
		28	7738	100%
C	0.3	7	8037	89.8%
		14	8491	95%
		28	8945	100%
D	0.35	7	7053	86.3%
		14	7605	93%
		28	8176	100%
E	0.3	7	8237	85.9%
		14	8911	93%
		28	9584	100%
Mix-ture	Water-cement ratio	Curing period (days	Average Compressive strength(psi)	Percentage of 28-days Compressive Strength

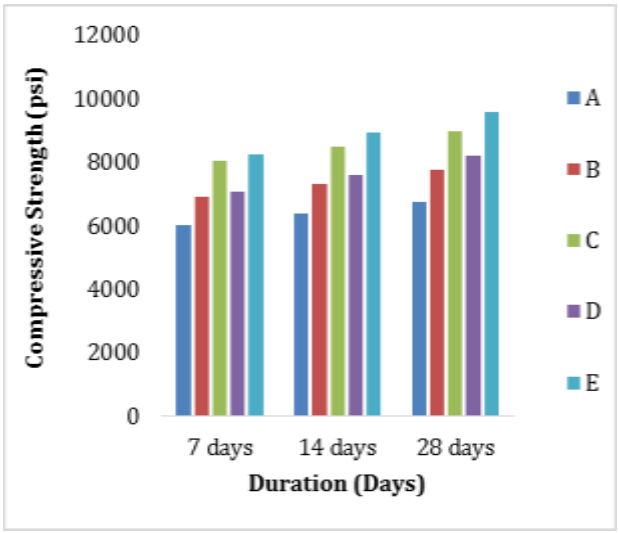

Chart -1: Compressive Strength Test Results of Five Different Mixtures

8. DISCUSSION

SikaPlast-151V (High Performance Super plasticizer) is used as constituent materials of SCC. Mix design of SCC is calculated according to ACI method and recommendation limits of EFNARC. In SCC mix, coarse aggregate content is the combination of Chipping and B aggregates with 1:1.The properties of SCC in fresh state according to recommendation limits of EFNARC are performed.

In Table 8, the water/powder ratio of mixture A is more than the recommendation of EFNARC for SCC mix design. According to the test result, the properties of mixture A in fresh state are not satisfactory with the recommendation limits of EFNARC for SCC. In table 9, the test results of mixture A are not satisfactory with the recommendation limits of EFNARC for SCC. Therefore, mixture A cannot be identified as SCC. The test results of other research mixtures B, C, D and E are satisfactory with the recommendation limits of EFNARC, so mixtures B, C, D and E can be identified as self-compacting concrete (SCC).

To know the compressive strength test and workability test results of concrete mixtures, the dosages of SikaPlast-151V are increased from 1.4 to 1.6 liter per 100 kg of cement .From strength point of view, all mixtures attained over 85% of 28-days Compressive Strength at 7 days. Strength of mixture C, D and E reached at design strength (7975 psi).It is found that mixture E gives the maximum strength.

9. CONCLUSIONS

The following conclusions may be drawn from the research.

1. According to the test results, SCC mixes are achieved for water/cement ratio of 0.35 and 0.3.

2. It is found that 7 days compressive strength of SCC is over 85% of that at 28 days and so SCC concrete may be used if early strength concrete is required.

3. It is obvious that about 25% of the amount of course aggregate may be reduced for SCC concrete.

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