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Smart Dynamic Concrete –A New Dimension in Self Compacting Concrete

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Abstract

The production of Smart, dynamic concrete (SDC) is made possible by combining an innovative Viscosity Modifying Agent (VMA) with a Superplasticizer. In this study mix design method for obtaining SCC and SDC is based upon simple volume concept starting with the volume of paste was adopted. The method involves very few trails for obtaining SCC and SDC. Nine SCC and SDC mixes were developed using cement contents of 375 kg/m3 and 450 kg/m3 with the fixed water content of 190liters/m3 for all the trails for different paste contents of 0.39, 0.41 and 0.43 and 230 kg/m3 and 280 kg/m3 with the fixed water content of 165 litres/m3 for all the trials for different paste contents of 0.30, 0.32 and 0.34 respectively. The powder content varied from 545kg/m3 to 662kg/m3 for SCC and 361 kg/m3 to 460 kg/m3 for SDC. Water to powder ratio by mass ranged from 0.28 to 0.34 for SCC and 0.36 to 0.45 for SDC. Cubes of 150 mm were cast and tested at 1day, 7days, and 28days. Based on the study it is apparent that the compressive strength and split tensile strength of SCC and SDC increases with the volume of paste for the same water and cement ratio. The compressive strength versus the water-cement ratio follows Abrams hypothesis and use of filler materials not only makes the mix cohesive but also increases the long-term strength. The modified method of

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mixing with the polycarboxylic ether based super plasticiser can be advantageously for enhancing the flowability of the mix.

Keywords: *Recycled Coarse Aggregate (RCA), ACI Mix-design, Steel Fiber, Workability, Compression*

I. INTRODUCTION

Experimental work was conducted to compare the shear strength of full-scale beams constructed with chemically-based, self-consolidating concrete (SCC) with conventional concrete (CC). The workability and compacting strength were observed based on casting time and number of surface cavities, respectively. This comparison indicates that chemically-based SCC possessed comparable shear strength as CC beams Arezoumandi and Volz (2013). A highly flowable concrete is not necessarily self-compacting because SCC should not only move under its weight but should additionally fill the entire form and achieve uniform consolidation without separation. This characteristic of SCC is called filling capacity. In their research Ferraris (1999) et al. measured the rheological properties of the concrete mixtures using two rheometers, the IBB, and the BATHROOM instruments. Thus SCC eliminates the needs of vibration either external or internal for the compaction of the concrete without compromising its engineering properties. This type of concrete industry did not progress as much as everyone hoped it would be. Still, in Japan where the invention took place, the use of SCC is pathetically low. The primary reason was the minimum requirement of 450kg of cementitious material per meter cube of SCC.

Since the evolution of Self Compacting Concrete (SCC) in the 1980s in Japan, the tremendous advantages accruing from of this technology should have replaced conventional vibrated concrete to a greater extent. The excess of cement contents and the extra amount of fines required for SCC requirement, compliance and the logistics, add costs to production. In this concept of low penalties Self Compacting Concrete (Smart Dynamic Concrete-SDC), the primary objective is to obtain all fresh and

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hardened features of SCC by reduction of total cementitious or fines content which would guide to an economical SCC.

In today's fast-moving and competitive environment, the primary concern for the construction industry is to save time and money. More fluid concrete allows for such savings. The common challenges faced by the construction industries include higher durability specifications which require a perfect covering of support to extend the service life of structures.

The fulfillment of these challenges perfectly and simultaneously would require concrete to fulfill the contradicting requirements; cost effectiveness, self-compaction, and robustness. This dilemma can be solved with the revolutionary 'SMART DYNAMIC CONCRETE'.

To obtain specific experimental data, and to understand fresh and hardened properties of the SCC and SDC with fly ash and Reoplast. To study the behavior of SCC and SDC with fly ash, the compatibility of powders in SCC and SDC along with chemical admixtures (SP and VMA), to attain the strength efficiency factors of fly ash in SCC and SDC, the Durability aspect of SCC and SDC made with flyash

2. MATERIAL AND METHODOLOGY

Materials used:

The materials that is used in this study are Flyash, Cement, Fine aggregate, Coarse aggregate and Admixture- Superplasticizer (Glenium B233 for SCC and Glenium sky and test methods adopted to measure the fresh properties of SCC: Slump flow test, L-box test, V-funnel test, U-box test, Marsh Cone test.

Powders

Powders are essential in SCC in order to achieve rich mortar matrix to transport the coarse aggregates and to make them stay in suspension. The need for alternative materials, which not only perform the function of improving the grading of the mix, but also enhance or improve other properties like durability and quality The powders used in SCC are relatively in large amounts, with a size of less than 0.1mm. The powders are found in two groups namely. reactive (which has cementitious value) and inert (those that have no cementitious properties).The addition of powder reduces the risk of segregation and blocking if added in sufficient proportion –

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usually at 30-40 % of binder content. Fines derived from high fines content (>10%) CRF, fly ash, GGBS, PFA, Silica fume, metakaolin and other fillers are suitable. The powder content (cement + fillers + fines from the aggregates) is usually in the range of 450- 650 kg/m3 .

In normal structural concrete, cement content varies from 300-450 kg/m3 , depending upon the strength and the durability requirements. These cement contents of concrete mix may be reduced effectively by the use of supplementary cementitious materials such as silica fumes, granulated blast furnace slag, metakaolin, rice husk ash and fly ash.

Silica fume and Metakaolin are expensive and are not available easily. The vast availability of CRF at low cost made it an ideal powder for use in SCC and large amounts from 200-350kg/m3 could be used for producing SCC.

Cement

Most of the cement complying with Indian standards is suitable for making self-compacting concrete. The choice of the type of cement and content depends on the strength requirements, the exposure class for durability and the minimum amount of fines required for the mix. However the cement used needs to have a compatibility with the superplasticizer employed.

Fly ash

Fly ash available in India is generally classified in to two types as per specifications of IS: 3812-2000. Grade-1 wth Blains fineness greater than 320 m2 /kg and the residue retained on 45µ sieve after wet sieving is done should not be more than 34%, whereas for Grade-2 the Blains fineness should not be greater than 250 m2 /kg and the residue retained on 45µ sieve after wet sieving is done should not be more than 40%. Flyash contributes to the formation of an excellent mortar, which maintains the coarse aggregates in suspension, during and after transportation. Fly ash produces concrete with a characteristic dark grey colour.

The fly ash produced by Raichur Thermal Power Station (RTPS), Karnataka contains less carbon content and are extremely finer than any other source satisfying the specifications as per IS:3812-2000. So, it can be advantageously used for producing SCC.

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Fine Aggregate

Sand plays a very important role in Self-Compacting Concrete. It manages to fill the voids between the powders and the coarse aggregates. so the sand must be well graded from a particle size point of view, in order to guarantee the filling between various aggregates as much as possible. Sand can be finer than normal, as the material less than 150µ may help increase cohesion, thereby resisting segregation. Locally available manufactured sand from "TRIVENI" confirming to Zone II was used in this study.

Coarse Aggregate

In case of SCC, rounded aggregates would provide a better flowability and less blocking potential for a given water-to-powder ratio, compared to angular and semi-rounded aggregates. The maximum size depends upon the reinforcement layout and formwork dimensions in the same way as the traditional vibrated concrete. Natural aggregates require less water than crushed aggregates in Self-Compacting Concrete.

Chemical Admixtures

Chemical Admixtures are essential for flow characteristics and workability retention. SCC incorporates two types of admixtures namely a super plasticizer and sometimes a viscosity modifying agent.

Superplasticizer

Super plasticizers are available in three types generally, in local market namely, Super plasticizer Melamine based super plasticizers, Naphthalene based Super plasticizers, Poly-Carboxylated Ether (PCE) based super plasticizers. As the locally available PCE based super plasticizers proved to be very effective in SCC, this study is carried out using such type of super plasticizers. Also Viscosity-modifying admixtures can also be mixed along with super plasticizers to make the concrete mix viscous.

The key function of superplasticizer in concrete is to achieve and control the workability of fresh concrete without adversely affecting other features of the cementitious systems, such as setting time, air entrainment, and strength or air void stability.

The early interpretation of the water reduction and fluidizing effect of concrete superplasticizers were largely based upon dispersion phenomena. By adsorbing on the cement particles, the polymeric dispersants

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were capable of rapidly deflocculating agglomerated cement particles which trapped part of the water.

The water released became available for fluidification and hence the water content of the mixture could be reduced, maintaining constant workability. Polycarboxylic ether based superplasticizer has long lateral chains. This greatly improves cement dispersion.

At the start of the mixing process the same electrostatic dispersion occurs, but presence of laterals chains, linked to the polymer backbone, generate a steric hindrance, which stabilizes the cement particles capacity to separate, and disperse.

TEST METHODS

Concrete is normally classified as self-compacting concrete if the requirement for all the three characteristics such as filling ability, passing ability and resistance to segregation is fulfilled.

Filling ability:

The ability of SCC to flow into and fill completely all spaces, within the formwork under its own weight

Passing ability:

The ability of SCC to flow through tight openings such as spaces between steel reinforcing bars without segregation and blocking

Segregation resistance:

The ability of SCC to remain homogeneous in composition during transportation and placing.

Many different test methods have been developed to characterise the properties of SCC. The T500 time is also a measure of the speed of flow and hence the viscosity of the Self-Compacting Concrete.

The flowability of the fresh concrete can be tested using a V-funnel, A funnel test flow time < 6 sec is recommended for a concrete to use as SCC.

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Table 1: List of Test methods for Fresh properties of SCC

Sl. No.	Method	Property
1.	Slump-flow by Abrams cone	Filling Ability
2.	T_{50cm}slumpflow	Filling Ability
3.	J-ring	Passing Ability
4.	V-funnel	Filling Ability
5.	V-funnel at T5minutes	Segregation Resistance
6.	L-Box	Passing Ability
7.	U-Box	Passing Ability
8.	Fill-Box	Passing Ability
9.	GTM Screen Stability Test	Segregation Resistance
10.	Orimet Test	Filling Ability

J – Ring test method provides a procedure to determine the passing ability of self-compacting concrete mixtures. L- Box test assesses the flow of the concrete and also the extent to which it is subject to blocking by reinforcement. Both passing ability and segregation resistance can be detected visually. 'U'- shaped Box test is used to measure the filling ability of self-compacting concrete. In Marsh cone test the optimum dosage of superplasticizer is determined: this dosage is the percentage of superplasticizer beyond which there is no significant increase in fluidity of mix.

METHODOLOGY USED:

The flowability required for the SCC can be obtained by one of three means:

- High cement content
- High content of Fly Ash, GGBS etc
- Use of Viscosity Modifying Admixture (VMA)

With conventional SCC technology the concrete producer has to supply a concrete with high fines content.

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3. EXPERIMENTAL DETAILS

The mixture proportioning was done according the Indian Standard Recommended Method IS 10262-2009, The purpose of this investigation was to make the concrete with targets of 28-day Compressive strength of at least 25 MPa. Proportion of mixtures was selected basing on these targets.

The RHA was trialed to replace for cement with various ratios, namely 0, 10, 20 and 30 % by mass of cement. Ratio of water per total cement binder (cement plus flyash) was fixed at 0.46

3.1 Physical characteristics of materials

In this it deals with the properties of the materials used, the methodology adopted for mix proportioning of various mixes and the parametric evaluation of the mixes.

a. Cement

Table 2: Physical characteristics of cement (OPC, 53 grade)

Sl No	Details	Results	As per IS 12269-1987
1.	Normal Consistency (in %)	35	-------
2.	Specific Gravity	3.15	-------
3.	Setting Time (in Minutes)		
	a Initial Setting Time	70	≥ 30
	b Final Setting Time	406	≤ 600
4.	Compression Strength (Mpa) (70.6 X 70.6 X 70.6 mm Cubes)		
	3 days strength	27.3	≥23
	7 days strength	40.1	≥33
	28 days strength	54.0	≥43
5.	Fineness by Air Blaine Apparatus (m^2/kg)		> 225

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b) Fly ash

Fly ash was obtained from Raichur Thermal Power Station (RTPS), Karnataka. The physical characteristics of fly ash are presented in Table 3.

Table 3: Physical characteristics of fly ash (RTPS)

Sl No	Details	Results
1.	Specific Gravity	2.16
2.	Fineness by Air Blaine Apparatus (m^2/kg)	510
3.	Wet Sieve Analysis % passing through 90µ % passing through 45µ	 78 65

c Admixtures

Commercially available poly-carboxylic ether based superplasticizer (Glenium B233) supplied by BASF chemicals, Bangalore was used in this study. GLENIUM B233 is an admixture of a new generation based on modified polycarboxylic ether

GLENIUM B233 has a different chemical structure from the traditional superplasticisers.

d) Aggregates

Crushed granite stone with a size of 20 mm and 12.5mm was adopted as the coarse aggregate and locally available manufactured river sand was used as the fine aggregate. The tests on fine and coarse aggregate were conducted in accordance with IS 2386 to determine specific gravity and fineness modulus. The sieve analysis results indicate that the sand confirms to Zone-II. The physical characteristics and sieve analysis results are presented in Table 4, 5, and 6

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Table 4: Physical Characteristics of Aggregates

Physical properties	Fine aggregate (sand)	Coarse aggregate(12.5 mm down)
Specific gravity	2.67	2.65
Water absorption (%)	1.5	0.3
Fineness modulus	2.78	-
Loose bulk density (kg/m^3)	1536	1290

Table 5: Sieve Analysis Results of Fine Aggregate

The fine aggregate tested conforms to Zone-II.

Sieve Size	Weight Retained (gm)	Cumulative % Retained	Cumulative % Passing	Zone - Specifications as per IS:383-1970 for % Passing			
				I	II	III	IV
4.75 mm	15	15	98.5	90-100	90-100	90-100	95-100
2.36 mm	13	28	97.2	60-95	75-100	85-100	95-100
1.18 mm	126	154	84.6	30-70	55-90	75-100	90-100
600µ	**362**	**516**	**48.4**	**15-34**	**35-59**	**60-79**	**80-100**
300µ	402	918	8.2	5-20	8-30	12-40	15-50
150µ	70	988	1.2	0-10	0-10	0-10	0-10
Pan	12	1000	-	---	---	---	---

Table 6: Sieve Analysis Results of Coarse Aggregate

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IS sieve sizes mm	Analysis of coarse aggregate fraction,% passing		Percentage passing of different fractions			Percentage passing for graded aggregate as per IS 383
	I 20 to 10 mm	II 10 mm down	I 50 percent	II 50 percent	Combined 100 percent	
40	100	100	50	50	100	100
20	90.78	100	45.39	50	95.39	95-100
10	0.18	85.81	0.09	42.90	42.99	25-55
4.75	0	0	0	0	0	0-10

It is possible to proportion SCC mixes for a given strength and flowability by keeping the paste content constant and by increasing or decreasing the filler content vis-à-vis the cement. Keeping all other parameters constant and only by changing the amount and filler quantities with in a constant paste volume, different grades of concrete can be arrived at and a mix design method in the lines of the absolute volume method can be evolved.

Mix design method adopted was by starting with a fixed volume of paste ($V^p = V_{cement} + V_{flyash} + V_{water} + V_{sp}$). Further the water was fixed at 190 liters/m3 for all the trials of SCC and 160 liters/m3 and different volumes of powder were considered ($V_{pow} = V_{cement} + V_{flyash}$). For each paste content the volume of cement and flyash was changed by keeping the water constant, to get different strengths of concrete. The cement content is taken in the range of 375 kg/m3 to 450 kg/m3 for SCC and 230 kg/m3 to 280 kg/m3 for SDC. Correspondingly, the volume of flyash was calculated based on the absolute volume for the fixed paste content and the chosen cement content.

Taking the total volume of concrete as one unit, the final volume of aggregates can be calculated by deducting the volume of paste from the unit volume. Based on the literature survey and the experience with the materials used in the laboratory, the ratios of CA and FA can be fixed. The optimum dosage of superplasticizer was decided by conducting the ‘Marsh Cone Test” with the powder and water Figures 1, 2 and 3 shows the results of the Marsh cone test.

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Test conducted for different paste content and for different powder ratios. It is interesting to note that the optimum dosage of superplasticizer was nearly the same for particular paste content even when relative volumes of cement and flyash were changed.

MARSH CONE TEST RESULTS FOR DIFFERENT PASTE CONTENT

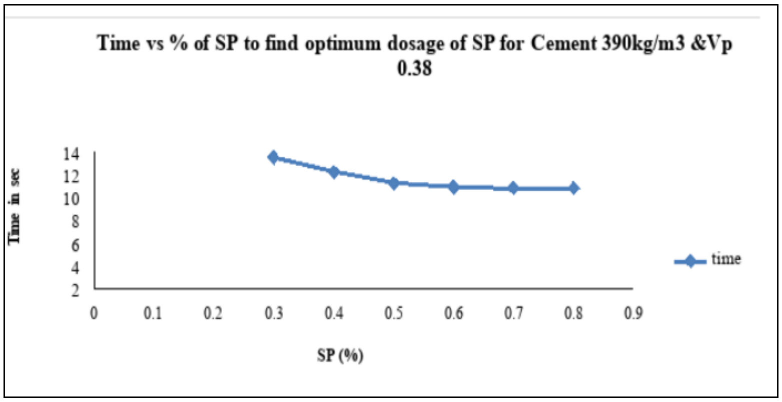

Fig 1: Time v/s % of SP for V_p -0.38

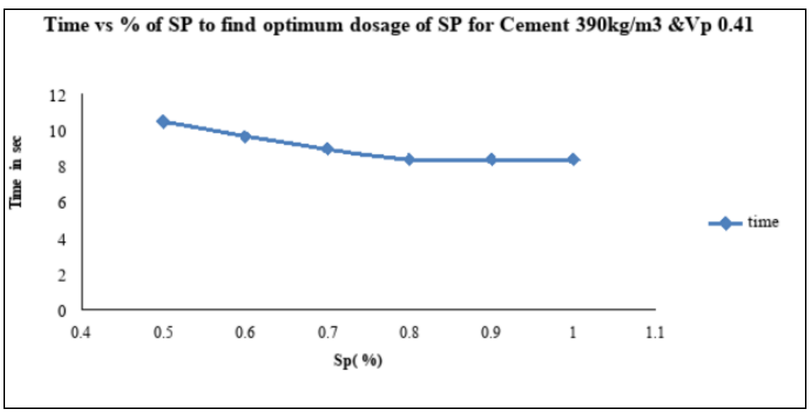

Fig 2: Time v/s % of SP for Vp – 0.41

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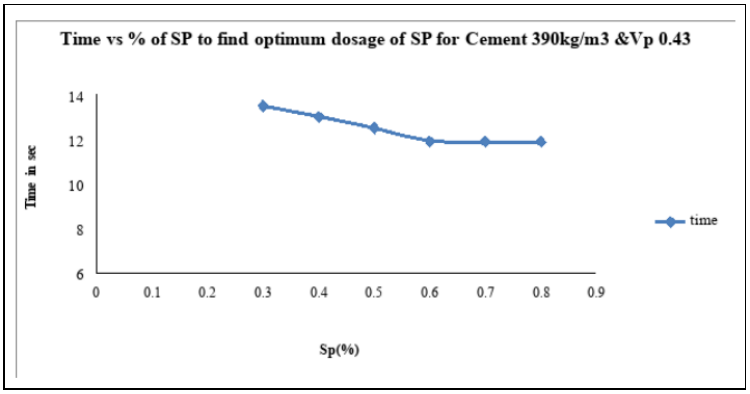

Fig 3: Time v/s % of SP for Vp – 0.43

Table 7 shows the mix proportions of SCC by mass for fixed water content of 190 litres /m3 . It may be noted that since flyash had a lower specific gravity than cement, as cement content increases the mass of powder also increased when powder content is constant by volume.

Table 7: Mix Proportions of SCC in terms of mass and volume (for fixed Water-190lt/m 3)

Mix no	Vp	w/c	Cement (kg/m^3)	Flyash (kg/m^3)	Total powder (kg/m^3)	w/p	C.A (kg/m^3)	F.A (kg/m^3)	V_{CA}	V_{FA}	OP SP%
MIX 1	0.39	0.50	375	174	545	0.34	1015	606	0.38	0.23	0.70
MIX 2	0.39	0.42	450	125	575	0.33	1015	606	0.38	0.23	0.75
MIX 3	0.41	0.50	375	218	593	0.32	982	586	0.37	0.22	0.70
MIX 4	0.41	0.42	450	168	618	0.30	982	586	0.37	0.22	0.80
MIX 5	0.43	0.50	375	261	636	0.29	949	566	0.36	0.21	0.70
MIX 6	0.43	0.42	450	211	662	0.28	949	566	0.36	0.21	0.75

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Table 8 gives the proportions by absolute volume. Further for the SCC mixes so developed Cubes and cylinders were cast and tested for compressive strength at different ages of 1day, 7days, 28 days.

Table 8: Mix Proportions of SDC in terms of mass and volume (for fixed Water- 160 lt/m 3)

Mix no	Vp	w/c	Cement (kg/m^3)	Flyash (kg/m^3)	Total powder (kg/m^3)	w/p	C.A (kg/m^3)	F.A (kg/m^3)	V_{CA}	V_{FA}	OP SP%
MIX 7	0.30	0.72	230	130	360	0.45	1165	695	0.44	0.26	0.70
MIX 8	0.30	0.59	280	95	375	0.44	1165	695	0.44	0.26	0.70
MIX 9	0.32	0.72	230	173	403	0.41	1132	675	0.43	0.25	0.70
MIX10	0.32	0.59	280	136	416	0.39	1132	675	0.43	0.25	0.70
MIX11	0.34	0.72	230	217	447	0.36	1098	656	0.41	0.25	0.70
MIX12	0.34	0.59	280	179	459	0.36	1098	656	0.41	0.25	0.70

3.2 Mixing and Curing

Thorough mixing and adequate curing are most important and essential for achieving good SCC. In view of the fact that the superplasticizer plays a very important role in the flowability of SCC mixes, a modified method of mixing procedure was adopted to take the benefit of action of adsorption of molecules of poly-carboxylic ether based superplasticizer on the cement particles for all the mixes.

In the modified method, about 80% of optimum dosage of superplasticizer was mixed with water. To this cement and flyash was added and mixed thoroughly in a pan

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mixer of 100 liters capacity, for two minutes. Then fine aggregate and coarse aggregate were added and mixed thoroughly for further two minutes. The remaining superplasticizer and fibres was added in second installment and mixed again for two minutes. The total mixing time was kept constant at six minutes. Fresh properties of SCC mixes were determined in the next 20 to 30 minutes. This modified method was arrived as the best out of a number of trials conducted in which the percentage of superplasticizer dosage added in installments to the mix at the beginning was varied from 50 to 100%. .

It was observed that by adopting this modified method of mixing about 30mm to 50mm greater slump flow was obtained than when fine aggregate, coarse aggregate, cement and flyash were first mixed dry and then water was added to this dry mix along with superplasticizer and the whole material was mixed for three minutes. By adding only 80% of the superplasticizer to the water initially and then the rest in a second installment, better adsorption on to the surface of cement particles could be achieved. The increase in flowability is also possibly due to unique carboxylic ether polymer based superplasticizer having longer lateral chains which is responsible for a higher slump flow than that obtained by the conventional method, 'one – go' mixing procedure.

The mixing time was kept constant at 3 to 4 minutes for Comparable Normal Concrete (CNC). For Normal and SCC, the specimens were demoulded on the next day after casting and were immersed in curing water immediately and were taken out only at the time of testing

4. RESULTS AND DISCUSSION

4.1 Results for SCC:

From Table 9, the volume of paste considered in this study is 0.39, 0.41 and 0.43. The total powder content is in the range of 545 kg/m 3 to 662 kg/m 3 . Water to powder ratio (W/P) by volume ranges from 0.79 to 0.95 and water to powder ratio by weight ranges from 0.29 to 0.36. The quantities of cement considered are 375 kg/m 3 and 450 kg/m 3 for each paste content. For all the trials water was fixed as 190 ltr/m 3 . The w/c ratio corresponding to cement content 375 kg/m3 and 450 kg/m 3 is 0.50 and 0.42. The ratio of fine and coarse aggregates was taken based on the minimum void content test and the optimum

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dosage of super plasticizer was fixed based on the marsh cone test.

Table 9: Tests results for fresh properties of SCC

Mix no	V_p	Slump flow(mm)	$T_{500\ mm(in\ seconds)}$	L box
Mix1	0.39	585	2.4	0.80
Mix2	0.39	600	2	0.87
Mean	-	**592.5**	**2.2**	**0.835**
Mix 3	0.41	640	1.8	0.90
Mix 4	0.41	730	1.2	0.90
Mean	-	**685**	**1.5**	**0.90**
Mix 5	0.43	598	2.2	0.89
Mix 6	0.43	675	1.7	0.83
Mean	-	**636.5**	**1.95**	**0.86**

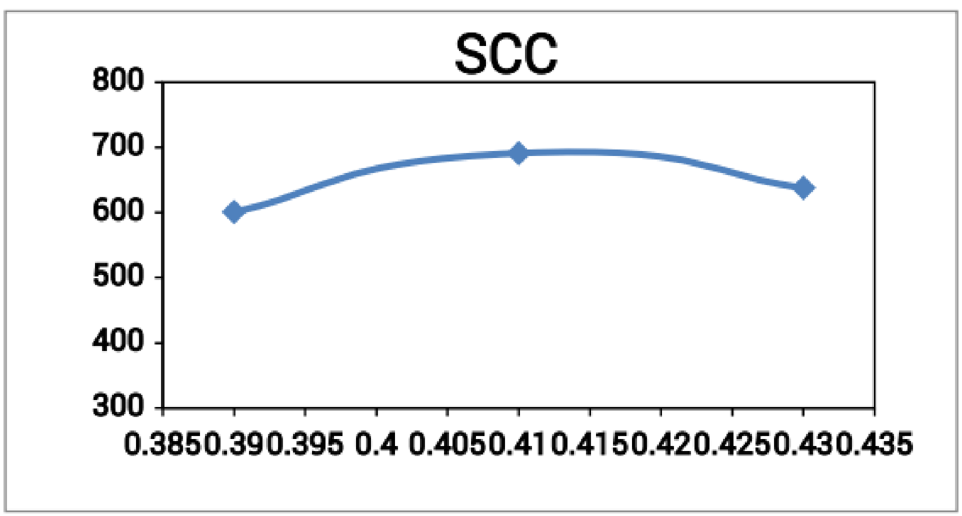

Fig 4: Relationships between Slump Flow and Vp of SCC

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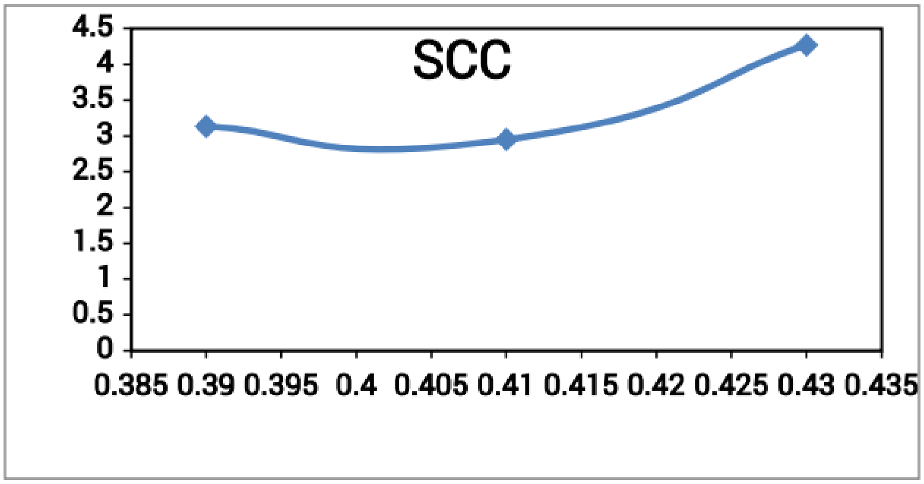

Fig 5: Relationship between T500 cm and Vp of SCC

Slump flow is related to yield strength of the concrete and T500 is related to plastic viscosity. It can be seen from the Table 9 that as the paste content increases, the yield stress decreases and higher slump flow can be achieved with a lower yield stress. Since, water is same for all the mixes less yield strength is observed for higher paste content. It is also evident that the greater is the total aggregate content higher is the yield stress i.e., lesser the slump flow as seen with lesser paste content of 0.39.

As the volume of paste increases, the plastic viscosity decreases, indicating a faster flow. More fly ash reduces the viscosity or makes the mix more viscous as can be seen from the Table 8 and there is a correlation between slump flow and T 500 values. Higher the cement content greater is the time taken to reach 500 mm, as the powder is less, the plastic viscosity is more for constant water content.

The results also show that the Slump flow can be achieved with the angular coarse aggregate or with similar type of materials as used in this study with water to powder ratio by volume in the range of 0.79 to 0.95

4.2 Compressive strength

Tables 10, shows comparison of average compressive strength for different paste content for cubes and cylinders tested at 1days, 7days and 28 days

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Table 10: Showing Compressive strength results for SCC

Mix no.	V_p	w/p	Cement (kg/m³)	Flyash	Total powder	Compressive Strength (Mpa) of cubes		
						1 day	7 days	28 days
Mix 1	0.39	0.34	375	174	545	8.5	24.7	46.5
Mix 2	0.39	0.33	450	125	575	9.8	34.6	53.5
Mix 3	0.41	0.32	375	218	593	9.1	32.1	56.9
Mix 4	0.41	0.30	450	168	618	9.9	43.6	60.8
Mix 5	0.43	0.29	375	261	636	8.0	31.9	52.5
Mix 6	0.43	0.28	450	211	662	9.0	40.3	54

From the Table 10, the average compressive strength at the end of 7 days for 150 mm cubes for a paste content of 0.39 with a cement content of 450 kg/m 3 was found to be 34.6N/mm 2 for SCC, for a paste content of 0.41, the value was 43.6N/mm 2 and for a paste content of 0.43 the value was 40.3N/mm 2 for SCC. It can be observed that the average compressive strength at 7 days for a paste content of 0.43 is lesser, when compared with the paste content of 0.41. For higher paste content the volumes of fly ash increases and in the present study, for paste' content from 0.39 to 0.43 the volume of flyash increases from 0.046 to 0.097. The volume of aggregates also reduces and in the present study for a paste content of 0.39 to 0.43 the volume of aggregate reduces from 0.61 to 0.57. The lower strength at 7 days observed for higher paste content is probably due to high fly ash content and lesser coarse aggregate content.

But, however from the results at 28 days as seen from the Table 10, for the same mix i.e., with cement content of 450 kg/m 3 , the

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average compressive strength was 53.5 N/mm 2 for paste content 0.39, 60.8N/mm 2 for 0.41 and 54.0N/mm 2 for 0.43. The average compressive strength increases with higher paste content at 28 days but decreases at a particular value of 0.43. This can be attributed to the use of higher flyash content of 221 kg/m 3 for 0.43 paste content when compared with 125 kg/m 3 for 0.39 paste content. The effect of initiation of pozzolonic activity with higher quantity of flyash can be seen in this study as obtained from the results at 28 days.

Similar trends were seen for 150 mm cubes for a cement content of 375 kg/m 3 and 450 kg/m 3 , wherein when compared at 7 days the average compressive strength for higher paste content of 0.43 reduces or shows marginal variation in relation to 0.41 and 0.39, but increases at 28 days.

The results, however shows that when comparison is made at 7 days for a particular paste content and with different cement content there is an increase in strength at 7 days. As can be seen from the Table 10, for a paste content of 0.39, the average compressive strength of SCC was 24.7 N/mm 2 for 375 kg/m 3 and 34.6 N/mm 2 for 450 kg/m 3 . This trend is similar to the well-established Abram's law, for Normal concrete, that the strength increases as the w/c reduces. This observation is true for all the paste content and cement content. That is the average compressive strength increase with decrease in w/c for the same paste content at 1 day, 7 days and 28 days.

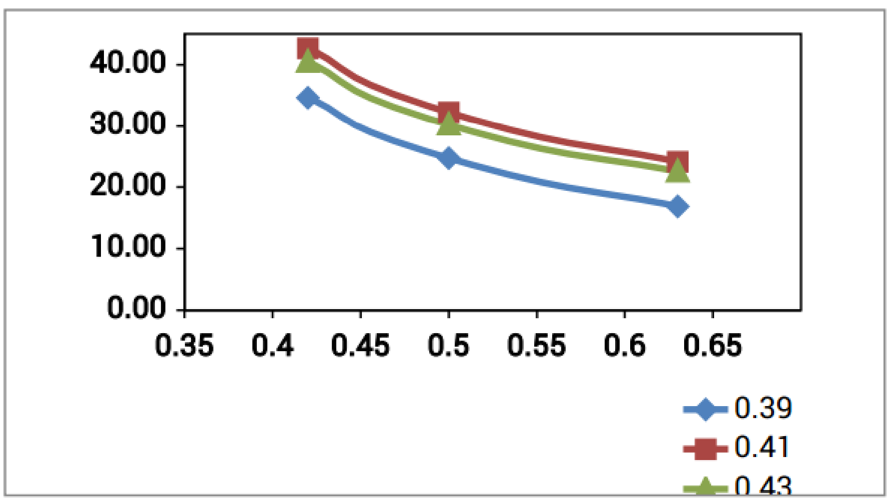

Fig 6: 7 days compressive strength (of 150 mm cubes) vs w/c for diff. Paste content of SCC

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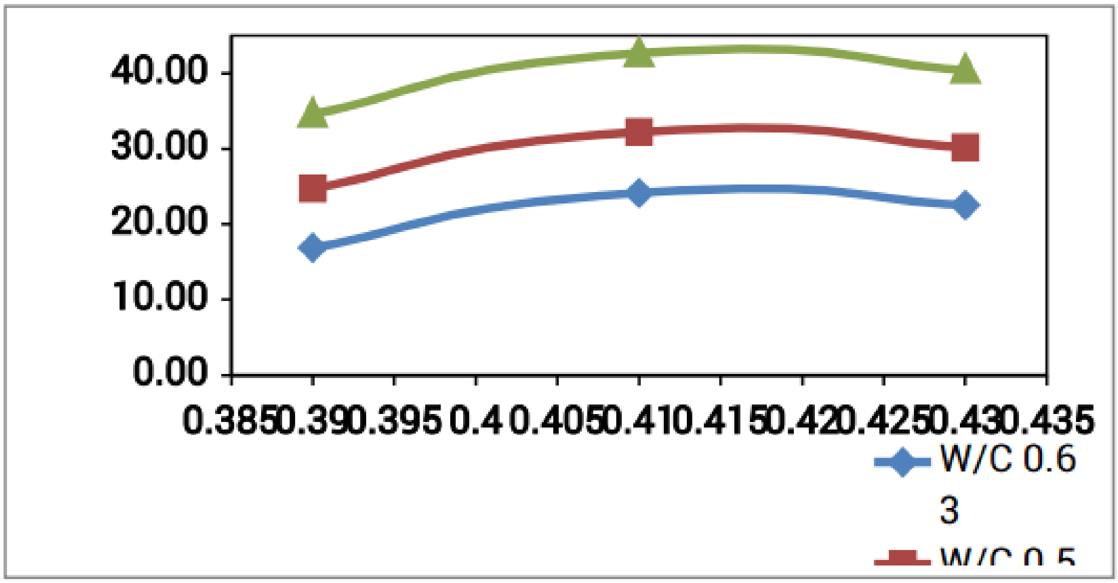

Fig 7: 7 days compressive strength (of 150 mm cubes) vs Vp of SCC

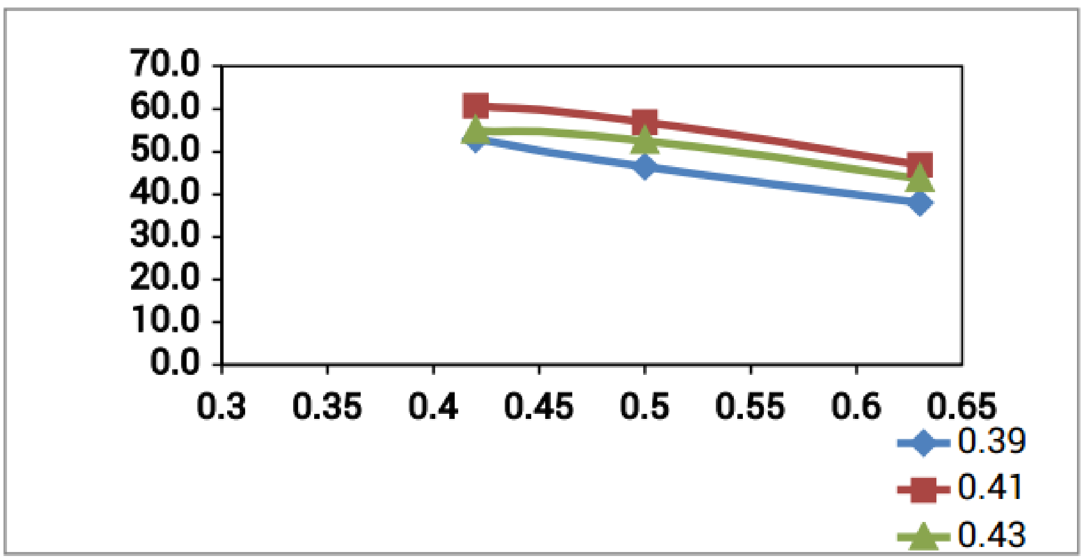

Fig 8: 28 days compressive strength (of 150 mm cubes) vs w/c for diff. Paste content of SCC

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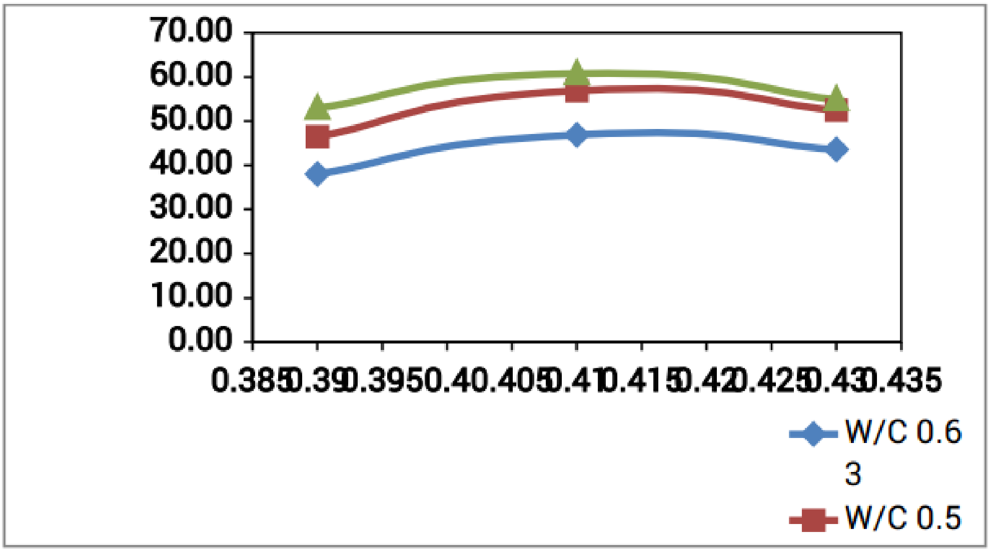

Fig 9: 28 days compressive strength (of 150 mm cubes) vs w/c for Vp of SCC

Table 11: Fresh properties test results for SDC

MIX NO	Vp	Slump flow	T_{500mm} in seconds	L-BOX(H_1/H_2)
Mix 7	0.30	553	2.7	0.78
Mix8	0.30	562	2.6	0.80
Mean	**0.30**	**557.5**	**2.65**	**0.79**
Mix 9	0.32	574	2.4	0.87
Mix10	0.32	589	2.2	0.89
Mean	**0.32**	**581.5**	**2.3**	**0.88**
Mix11	0.34	561	2.6	0.82
Mix12	0.34	554	2.7	0.84
Mean	**0.34**	**557.5**	**2.65**	**0.83**

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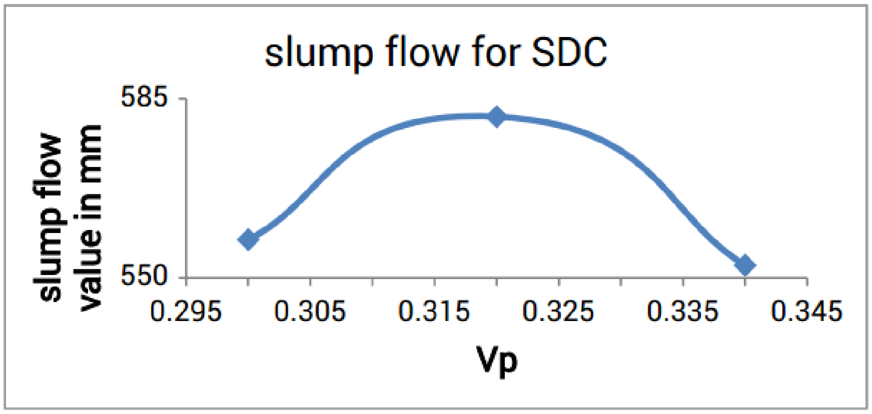

Fig 10: showing slump flow results of SDC

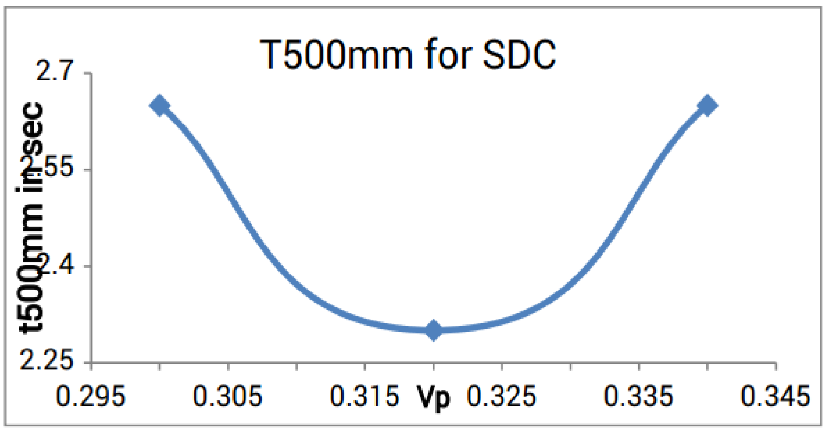

Fig 11: Showing t_{500mm} in sec for SDC

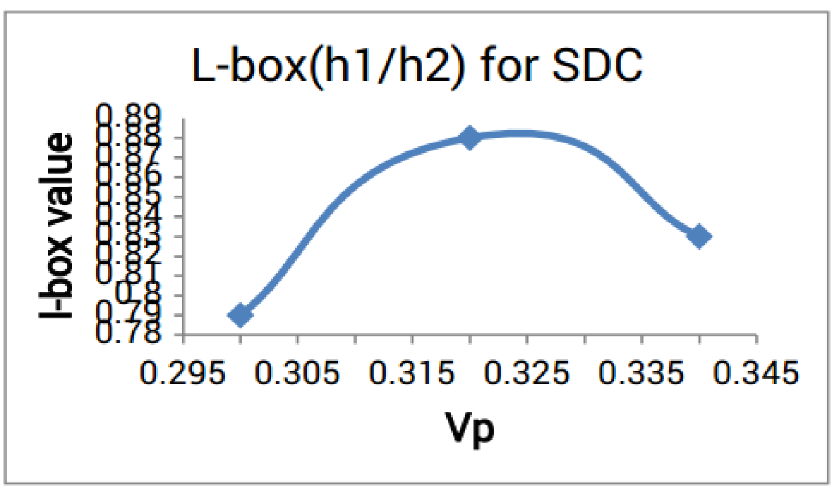

Fig 12: Showing l-box value for SDC

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Table 12: Compressive strength results for SDC

Mixno.	V_p	w/p	Cement (kg/m³)	Flyash (kg/m³)	Total Powder (kg/m³)	Compressive Strength of cubes (Mpa) 1 day	7 days	28 days
Mix 7	0.30	0.45	230	130	360	7.11	25.11	38.33
Mix 8	0.30	0.44	280	95	375	7.52	26.92	39.70
Mix 9	0.32	0.41	230	173	403	11.30	31.85	40.10
Mix 10	0.32	0.39	280	136	416	12.65	33.12	40.92
Mix 11	0.34	0.36	230	217	447	8.92	34.65	44.81
Mix 12	0.34	0.36	280	179	459	8.15	35.92	45.99

CONCULSIONS

1) An innovative concept utilizing a viscosity modifying agent (VMA) combined with appropriate polycarboxyllate ether (PCE) based Superplasticizer facilitates the production of Smart Dynamic Concrete (SDC) with self-compacting properties despite relatively low fines content and cost.

2) The rheology, anti-segregation, cohesive and stable properties imparted by the unique admixture provide SDC with adequate robustness even with minor

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variations in materials and mix design composition.

3) The use of SDC can be extended to "everyday" concrete in the ready-mixed and precast concrete industries.

4) SDC reduces the carbon footprint of concrete and the construction processes because of the lower cementitious content, less energy, lower in-place costs, better finishability and enhanced durability.

5) SDC is an attractive proposition for designers, contractors and owners because it is economically viable without compromising aspects such as the durability of structures.

6) SCC is best achieved within a small window of paste content ranging from 0.39 to 0.43 with the optimum value around 0.41 for a water content of 190lt/m 3 .

7) Higher paste content not only makes the mix cohesive but also increases the compressive strength but decreases at a Vp 0.43 indicating an optimality at 0.41.

8) Based on the fresh concrete properties it can be concluded that higher the powder content in SCC mixes higher will be the slump flow (lesser yield stress).

REFERENCES

[1] Mahdi Arezoumandi, and Jeffery S. Volz, 'An Experimental Study on Shear Strength of Chemically-Based Self-Consolidating Concrete', International Journal of Concrete Structures and Materials, Vol.7, No.4, pp.273–285, December 2013

[2] Subramanian, S. and D. Chattopadhyay, "Experiments for mix proportioning of self-compacting concrete", The Indian Concrete Journal, pp.13-20 (2002).

[3] Okamura, H, "Self-Compacting High-Performance Concrete", Concrete International, pp.50-54(1997).

[4] Ferraris, C. F., "Measurement of the Rheological Properties of High-

Page 1-27 © MANTECH PUBLICATIONS 2017. All Rights Reserved

Performance Concrete”, J.Res. Natl. Inst. Techn., Vol. 104, No. 5, pp.461-477 (1999).

[5] Dr. Mario Corradi, Dr. Jan Kluegge, Nilotpol Kar, Dr. Bruce Christensen and Jianying Yang, ‘A new viscosity modifying agent (VMA) for low fines self-consolidating concrete’. 5th International RILEM Symposium on Self-Compacting Concrete. Vol. 2, 2007. pp. 875-880.

[6] CORRADI M, KHURANA R AND MAGAROTTO R, ‘Low fines content self-compacting concrete’, 5th International RILEM Symposium on Self-Compacting Concrete. Vol. 2, 2007. pp. 839-844.

[7] Wallevik, O.H., ‘Rheology - A Scientific Approach to Develop Self-Compacting Concrete’, 3rd International Symposium on Self-Compacting Concrete, Rilem, Reykjavik, Iceland, August 2003, P. 10.

[8] Y. W. Choi, H. K. Lee, S. B. Chu, S. H. Cheong, and W. Y.Jung, ‘Shear Behavior and Performance of Deep Beams Made with Self-Compacting Concrete’, International Journal of Concrete Structures and Materials, Vol.6, No.2, pp.65–78, June 2012

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