A STUDY ON PROPERTIES OF SELF COMPACTING CONCRETE USING BY-PRODUCT OF CHINA CLAY (KAOLIN) PARTIAL REPLACEMENT OF FINE MATERIAL

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ABSTRACT— Need for economic construction material is essential nowadays in order to obtain higher strength for high rise buildings and for structures carrying heavy loads at a lower cost. Development in technology demands rapid construction techniques for which supplementary cementations materials can be used to obtain the desired mechanical strength and durability properties for the structure which includes the use of Fly Ash, by product of Kaolin as Fine material in definite proportions in concrete mix. The aim of present work is to understand the behaviour of High Performance Self Compacting concrete containing Supplementary cementations materials towards strength and durability in order to get the desired strength along with reduction in material cost of concrete.The percentage replacement of byproduct of kaolin will be 0%, 5%, 10%, 15%, 20%,25 %, 30%, 35%, 40%, 45% and 50% with natural fine aggregates. Cubes, beams and cylinders will be casted and tested compressive strength, Split tensile strength, and flexural strength as well as for durability properties. Optimum replacement of byproduct of kaolin can be used in structural concrete.

Key words: by product of kaolin (china clay); Self-compacting concrete; Workability; 25Compressive strength; flexural strength; split tensile strength; durability; etc…

A. INTRODUCTION

Self-compacting concrete (SCC) is a concrete that flows under its own weight and does not require any external vibration for compaction. The importance of Self-Compacting Concrete is that maintains all concrete's durability and characteristics, meeting expected performance requirements. SCC is an innovative concrete that does not require compaction and vibration for placing. It is eco-friendly or environmental friendly. Use of SCC can also help to minimize hearing related damages on the worksite that are induced by vibration of concrete. Addition of by-product of kaolin offers many advantages such as reduction of the amount of by products materials performance improvement SCC was first developed in 1988 so that durability of concrete structures could be Enhanced. In the 1980s,the problem of the durability of concrete structures and acceptable compaction were the main subject that was considered in Japan. The conception of this type of concrete was proposed by professor Hajime Okamura in 1986.It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. Fluidity and segregation resistance of SCC guarantee a high level of homogeneity, negligible concrete voids and uniform concrete strength, providing the prospective for a superior requirement of vibration equipment. This inherent property improves the environment on and near construction sites where concrete is being sited, reducing the exposure of Workers to noise and vibration.

B. MATERIALS

B.1 CEMENT

Ordinary Portland Cement (OPC) of Ultratech Cement conforming of IS 12269-1987 grade cement was used.

B.2 FINE AGGREGATE AND COARSE AGGREGATE

Fine Aggregate used for study as conforming to zone I of IS: 383, 1987.Fine aggregate size less than 4.75mm.Coarse aggregate size is maximum 20mm used for study as conforming to IS: 383, 1970.

	Fine aggregate	Coarse aggregate
Specific gravity	2.64	2.64
Water absorption	0.8	0.75
Moisture Contents	Nil	Nil

B.3 WATER

Potable water available in the v concrte pvt lmt. was used in Casting and curing.

B.4 FLY ASH

Fly Ash was purchased from a merchant at Mundra.

B.5 SUPER PLASTICIZER

The important admixtures are the SP, used with a water reduction greater than 20%. MasterGlenium SKY 8784 is the superplasticiser based on second generation polycarboxylic etherpolymers, developed using nano-technology. The product has been primarily developed for producing economical, high performance, high grade ready-mix concrete Total Performance Control

PERFORMANCE TEST DATA	
Aspect	Light brown liquid
Relative Density	1.1
pH	>6
Cloride ion content	<0.2%

B.6 VMA

MasterMatrix VMA 358 organic, viscosity-modifying admixture (VMA) is a ready-to-use, liquid admixture developed for producing concrete with enhanced viscosity and controlled rheological properties. Concrete with MasterMatrix VMA 358 admixture exhibits superior stability, thus increasing resistance to segregation and facilitating placement.

B.7 By product of kaolin(china clay)

By product of china clay is obtained from the raw material. After washing the raw material the By product of china clay is separated by sieve size 4.75 of raw material. Raw material is washed for taking out the china clay material which is useful for making the tiles. In the raw material about 10% is china clay which is supplied to the ceramic factories and 90% by product of kaolin waste material.

Test No.	Test Name	Test Method	Test Result of BK	Specific Requirment
1.	Fineness modulus	IS 383:1970	2.64(II)	2.2-3.2
2.	Silt Content	IS 2386:P-2	1.02%	Max. 3%
3.	Water Absorption	IS 2386:P-3	1.28%	Max. 2%
4.	Specific Gravity	IS 2386:P-3	2.66	-

Chemical properties of by-product of kaolin

Sr. No	Test description	Obtain Value in %
1	Loss on ignition as LOI	0.06
2	Silicon dioxide as Sio2	97.57
3	Aluminum oxide as Al2O3	1.10
4	Iron oxide as Fe2O3	0.08
5	Calcium oxide as Cao	1.07
6	Magnesium oxide as Mgo	0.02

C. MIX DESIGN OF M-30 GRADE CONCRETE

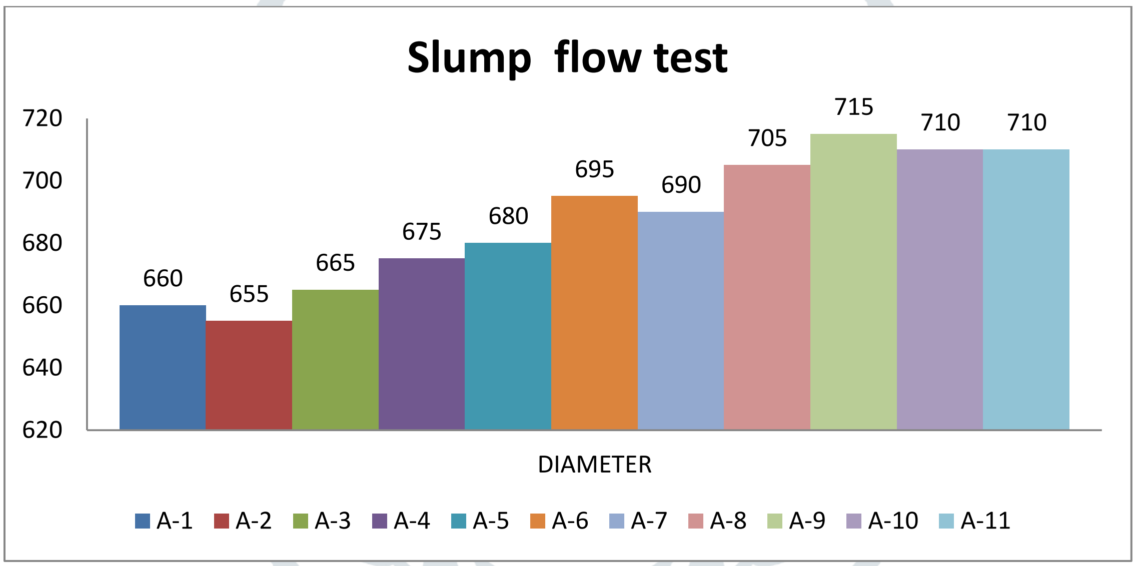
Mix	w/c ratio	Cement (kg)	Fly Ash (kg)	F.A. (kg)	B.K. (kg)	C.A. (kg)	Water (kg)	S.P. (kg)	V.M.A. (kg)
A-1	0.35	350	150	936.65	0	789.75	175	5	1
A-2	0.35	350	150	889.82	46.83	789.75	175	5	1
A-3	0.35	350	150	842.99	93.66	789.75	175	5	1
A-4	0.35	350	150	796.15	140.5	789.75	175	5	1
A-5	0.35	350	150	749.32	187.33	789.75	175	5	1
A-6	0.35	350	150	702.49	234.16	789.75	175	5	1
A-7	0.35	350	150	655.66	280.99	789.75	175	5	1
A-8	0.35	350	150	608.82	327.83	789.75	175	5	1
A-9	0.35	350	150	561.99	374.66	789.75	175	5	1
A-10	0.35	350	150	515.16	421.49	789.75	175	5	1
A-11	0.35	350	150	468.33	468.32	789.75	175	5	1

D. FRESH PROPERTIES OF SCC

Mix No.	Slump flow	L-Box	V-funnel	V-funnel at T5 minutes
A-1	660	0.8	11	13.5
A-2	655	0.81	11	13
A-3	665	0.83	10.5	12.5
A-4	675	0.83	10.5	12.3
A-5	680	0.85	10.2	12
A-6	695	0.86	10	11.8
A-7	690	0.89	9.5	11.5
A-8	705	0.88	9	11
A-9	715	0.9	9	10.5
A-10	710	0.93	8.6	10.5
A-11	710	0.9	8.4	10

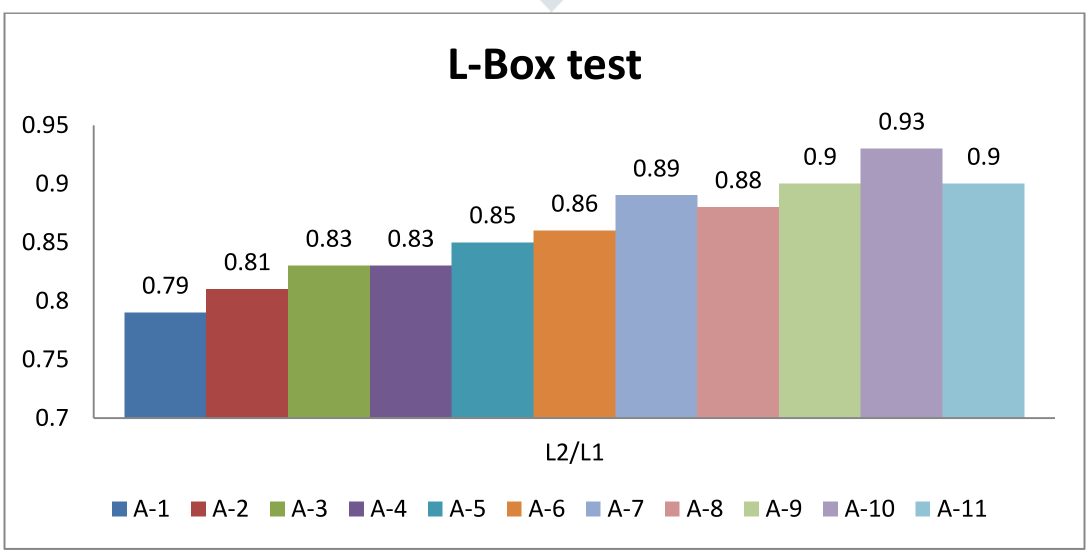
1. Slump flow test

Filling ability and fluidity of the Self-consolidation mixtures are to test using the slump flow test. The slump flow is the mean diameter of the horizontal spread of the concrete which flow on surface, after lifting the slump cone if the flow value is higher than it has greater fluidity to fill formwork under its self-weight. A value of at least 650 mm min and 800mm max is required for SCC.



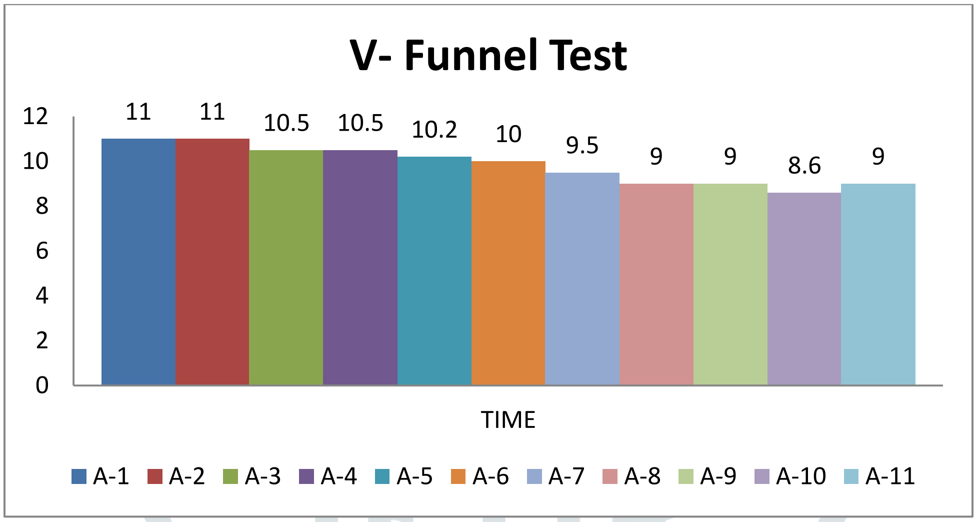
2. L-box test

The L-box test is used to evaluate the passing ability of SCC mix. L-box was fabricated in the laboratory as per the dimensions given in European guideline EFNARC, 2005. The vertical part of the box was filled with about 12 liters of concrete. Then the open the gate and the concrete flows out of the vertical part into the horizontal part through the reinforcement bars under its self-weight. H1 and H2, after the concrete has stopped flowing. The height ratio of H2/H1, called the blocking ratio (BR), was evaluate to determine the ability of passing.

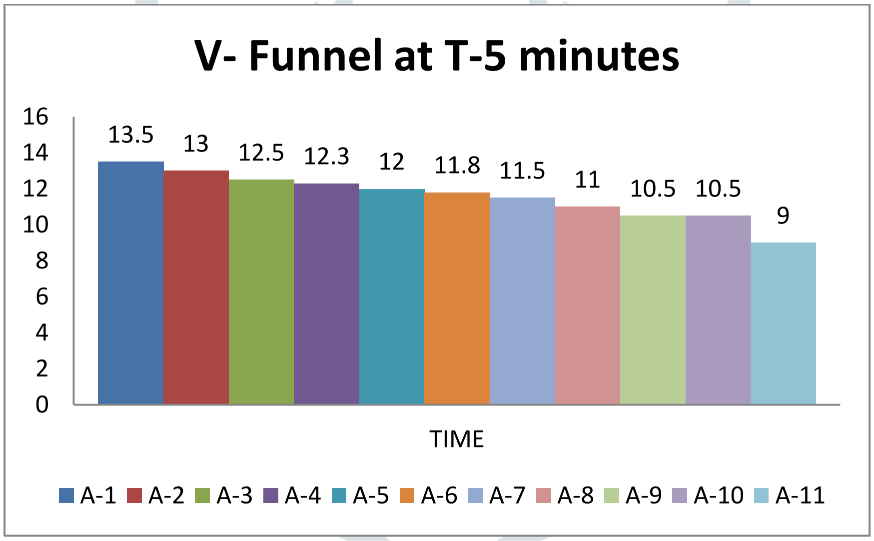


3. V- Funnel Test

The V-funnel test is an alternative method to use flow ability, which indicates the period of a defined volume of SCC needs to empty the funnel by narrow opening. Filling ability of self-consolidation concrete is also evaluated using the V-funnel test by measuring the time (T in seconds) taken for the mixture to completely empty the V-funnel, which had a rectangular opening of 75 mm x 65 mm. The target V-funnel time of self-consolidation concrete mixes is ranging between 6 to 12 seconds.



4. V-Funnel at T-5 Minutes

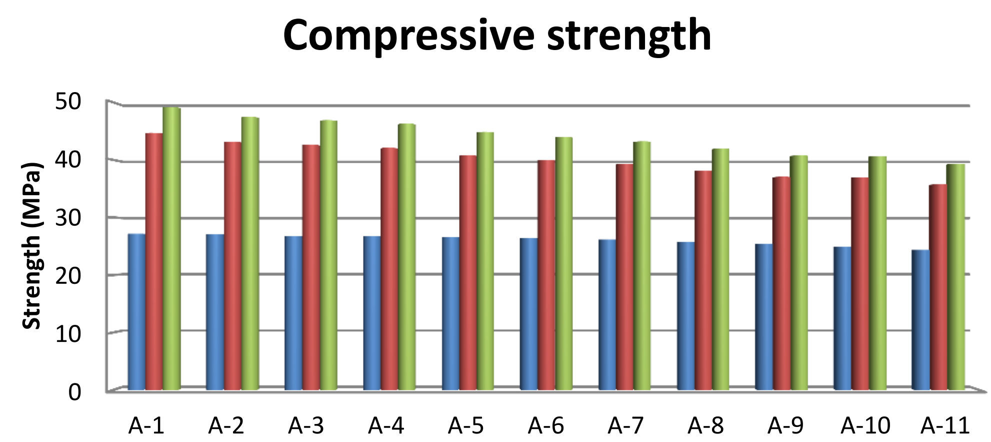


E. HARDENED PROPERTIES OF SCC

1. Compressive strength

The compressive strength of self-compacting concrete decreases with increase the percentage of Silica Sand. Compressive strength of SCC is lower at early age but comparable at later age due to fly ash content. The result of compressive strength of SCC is shown as below

MIX NO.	7 day (N/mm^2)				27 day (N/mm^2)				56 day (N/mm^2)			
	1	2	3	AVG.	1	2	3	AVG.	1	2	3	AVG.
A-1	26.92	27.16	27.40	27.16	44.57	44.31	45.11	44.66	49.03	48.74	49.62	49.13
A-2	27.36	26.71	27.04	27.04	43.11	43.37	42.88	43.12	47.42	47.71	47.17	47.43
A-3	26.82	26.72	26.85	26.8	42.51	42.83	42.47	42.60	46.76	47.11	46.71	46.86
A-4	26.67	26.85	26.58	26.70	42.56	41.81	41.81	42.06	46.81	45.99	45.99	46.26
A-5	26.62	26.58	26.56	26.59	40.88	40.68	40.70	40.76	44.97	44.75	44.77	44.83
A-6	26.36	26.46	26.30	26.37	39.55	40.22	40.14	39.97	43.51	44.24	44.15	43.97
A-7	26.18	26.20	26.10	26.16	39.46	39.04	39.30	39.27	43.41	42.94	43.23	43.19
A-8	25.79	25.65	25.86	25.77	38.44	37.79	38.12	38.12	42.28	41.57	41.93	41.93
A-9	25.53	25.36	25.31	25.40	36.91	37.34	36.87	37.04	40.60	41.07	40.55	40.74
A-10	24.91	25.01	24.88	24.93	36.69	37.65	36.48	36.94	40.36	41.41	40.12	40.63
A-11	24.44	24.38	24.18	24.33	35.62	35.52	36.02	35.72	39.18	39.08	39.62	39.29

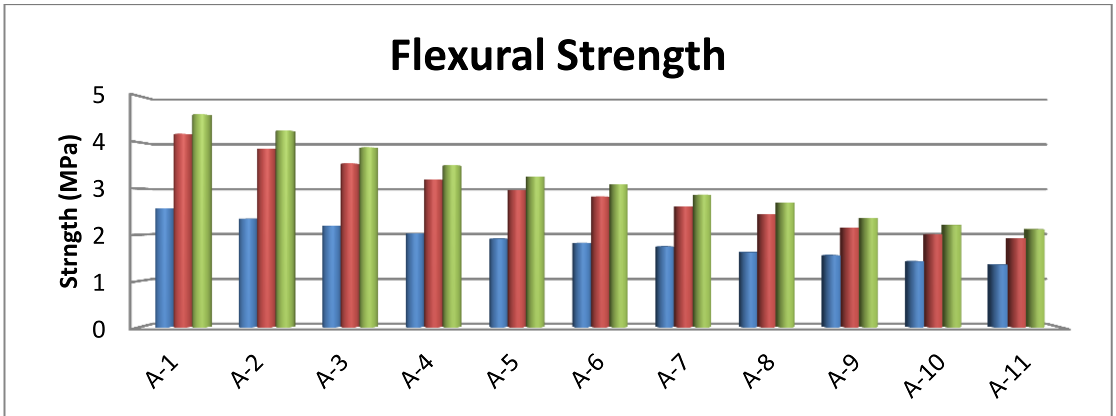


	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11
7 DAYS	27.16	27.04	26.8	26.7	26.59	26.37	26.16	25.77	25.4	24.93	24.33
28 DAYS	44.66	43.12	42.6	42.06	40.76	39.97	39.27	38.12	37.04	36.94	35.72
56 DAYS	49.13	47.43	46.86	46.26	44.83	43.97	43.19	41.93	40.74	40.63	39.29

2. Flexural Strength

The flexural strength of SCC with Silica Sand and fly ash decreases with increase the percentage of Silica Sand. Flexural strength of SCC is lower at early age but comparable at later age due to fly ash content. The result of flexural strength is shown as below.

MIX NO.	7 day (N/mm^2)				27 day (N/mm^2)				56 day (N/mm^2)			
	1	2	3	AVG.	1	2	3	AVG.	1	2	3	AVG.
A-1	2.56	2.6	2.56	2.57	4.15	4.18	4.23	4.18	4.56	4.6	4.65	4.60
A-2	2.38	2.33	2.34	2.35	3.86	3.89	3.83	3.86	4.25	4.3	4.21	4.25
A-3	2.19	2.17	2.23	2.19	3.53	3.56	3.53	3.54	3.88	3.92	3.88	3.89
A-4	2.07	2.02	2.02	2.03	3.17	3.16	3.25	3.19	3.48	3.45	3.57	3.5
A-5	1.97	1.85	1.93	1.91	2.92	2.97	3.02	2.97	3.21	3.27	3.32	3.26
A-6	1.8	1.85	1.83	1.82	2.84	2.79	2.86	2.83	3.12	3.01	3.14	3.09
A-7	1.76	1.73	1.74	1.74	2.66	2.6	2.59	2.61	2.92	2.86	2.85	2.87
A-8	1.65	1.57	1.66	1.62	2.46	2.41	2.5	2.45	2.7	2.65	2.75	2.7
A-9	1.56	1.54	1.57	1.55	2.1	2.15	2.21	2.15	2.3	2.36	2.43	2.36
A-10	1.44	1.39	1.43	1.42	1.98	2.02	2.03	2.01	2.18	2.22	2.25	2.21
A-11	1.39	1.35	1.33	1.35	1.96	1.92	1.9	1.92	2.13	2.11	2.12	2.12

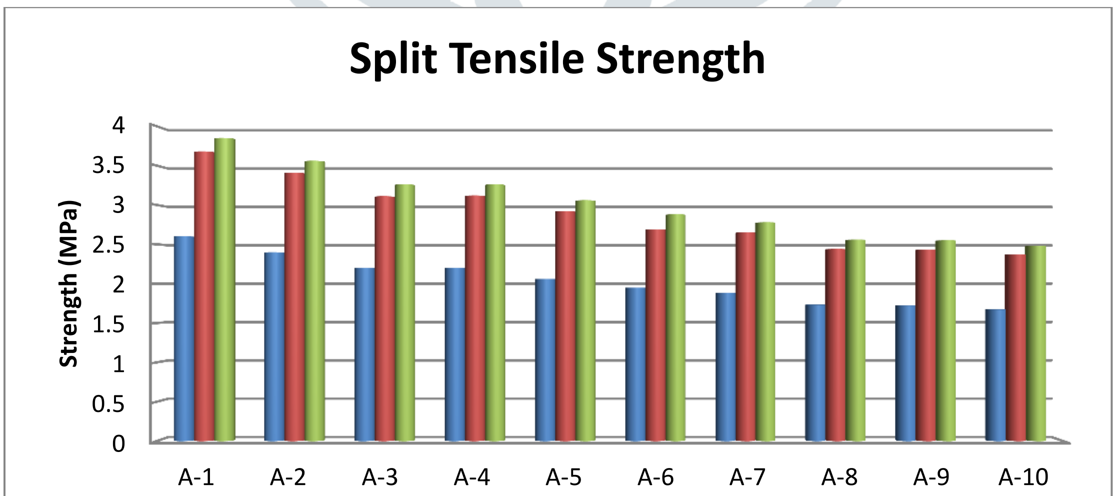


	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11
7 Day	2.57	2.35	2.19	2.03	1.91	1.82	1.74	1.62	1.55	1.42	1.35
28 Day	4.18	3.86	3.54	3.19	2.97	2.83	2.61	2.45	2.15	2.01	1.92
Series 3	4.6	4.25	3.89	3.5	3.26	3.09	2.87	2.7	2.36	2.21	2.12

3. Split tensile strength

The Split tensile strength of SCC with Silica Sand and fly ash decreases with increase the percentage of Silica Sand. Split tensile strength of SCC is lower at early age but comparable at later age due to fly ash content. The results of split tensile strength of SCC is shown as below.

MIX NO.	7 day (N/mm^2)				27 day (N/mm^2)				56 day (N/mm^2)			
	1	2	3	AVG.	1	2	3	AVG.	1	2	3	Avg.
A-1	2.54	2.69	2.58	2.60	3.59	3.80	3.66	3.68	3.76	3.96	3.84	3.85
A-2	2.48	2.35	2.37	2.40	3.50	3.36	3.37	3.41	3.67	3.46	3.54	3.56
A-3	2.12	2.21	2.27	2.20	2.99	3.12	3.22	3.11	3.14	3.25	3.38	3.26
A-4	2.26	2.19	2.16	2.20	3.19	3.09	3.06	3.12	3.35	3.22	3.22	3.26
A-5	2.06	2.11	2.03	2.06	2.90	2.97	2.88	2.92	3.05	3.10	3.02	3.06
A-6	1.95	1.92	1.98	1.95	2.75	2.70	2.62	2.69	2.88	2.82	2.95	2.88
A-7	1.84	1.98	1.81	1.88	2.59	2.80	2.57	2.65	2.72	2.92	2.70	2.78
A-8	1.77	1.62	1.78	1.73	2.50	2.29	2.52	2.44	2.63	2.39	2.65	2.56
A-9	1.67	1.81	1.68	1.72	2.35	2.56	2.38	2.43	2.47	2.67	2.50	2.55
A-10	1.63	1.77	1.61	1.67	2.30	2.50	2.29	2.37	2.42	2.61	2.40	2.48
A-11	1.55	1.47	1.67	1.57	2.19	2.08	2.38	2.22	2.30	2.17	2.50	2.32



	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10
7 Day	2.6	2.4	2.2	2.2	2.06	1.95	1.88	1.73	1.72	1.67
28 Day	3.68	3.41	3.11	3.12	2.92	2.69	2.65	2.44	2.43	2.37
Series 3	3.85	3.56	3.26	3.26	3.06	2.88	2.78	2.56	2.55	2.48

F. DURABILITY

1. Acid Attack

The result shows compressive strength of SCC in HCL solution curing are partially greater than the normal water curing. The percentage of weight loss of specimen in this solution is negligible. The graph gives the value of Acid test of concrete specimen of various proportion of mix design.

Mix no.	Comp. strength(MPa)	Comp. strength after HCL Attack (MPa)				Avg. loss of com strength (%)
		1	2	3	Avg.	
A-1	49.13	45.82	45.32	45.89	45.68	7.02
A-2	47.43	44.92	44.37	43.63	44.31	6.57
A-3	46.86	43.78	43.90	43.30	43.66	6.82
A-4	46.26	44.00	42.32	42.63	42.98	7.09
A-5	44.83	41.83	41.48	41.36	41.56	7.29
A-6	43.97	41.16	41.24	40.84	41.08	6.57
A-7	43.19	40.53	39.94	39.99	40.15	7.03
A-8	41.93	39.75	38.43	38.88	39.02	6.94
A-9	40.74	37.27	37.75	37.42	37.48	7.98
A-10	40.63	38.38	38.60	36.98	37.98	6.49
A-11	39.29	36.83	36.34	36.87	36.68	6.63

2. Sulphate attack

The cubes are casted with the size of 150mm x 150mm x 150mm and kept at ambient temperature for 24 hours. After 28days, the cubes are immersing in a solution of Sulphuric Acid (H2SO4).After 28 of curing, the specimens has taken and are washed in water. During sulphate attack test, it can be observed that there was less effect on the concrete cube surface and the top surface of cube remained same as before. Specimens gained weight in most cases. The Sulphuric Acid solutions readily react with the calcium hydroxide present in Portland cement pastes to form soluble salts of calcium. There is no surface cracking due to action of sulphate acting on the surface of concrete hence good resistance to sulphate.

Mix no.	Comp. strength(MPa)	Comp. strength after HCL Attack (MPa)				Avg. loss of com strength (%)
		1	**2**	**3**	**Avg.**	
A-1	49.13	44.82	45.61	43.29	44.5	9.42
A-2	47.43	44.51	43.57	43.93	44.00	7.23
A-3	46.86	43.37	43.90	42.60	43.29	7.61
A-4	46.26	44.15	42.12	43.63	43.3	6.39
A-5	44.83	42.53	41.18	42.16	41.95	6.42
A-6	43.97	41.06	40.24	40.99	40.76	7.30
A-7	43.19	40.83	38.94	39.58	39.78	7.89
A-8	41.93	39.96	37.43	38.78	38.72	7.65
A-9	40.74	36.57	37.92	37.42	37.30	8.44
A-10	40.63	38.77	38.20	36.58	37.85	6.84
A-11	39.29	36.8	36.78	36.52	36.7	6.59

G. CONCLUSION

1. By product of kaolin has no negative effect in properties of SCC.
2. There is improvement in fresh properties of SCC with the increment of By product of kaolin.
3. In Slump flow test, the result shows that, by replacing the By product of kaolin with 50% in fine aggeregate there is increase in the slump flow up to 7.58%.
4. In V-Funnel Test, The result shows that, by replacing the By product of kaolin 50% by fine aggeregate. So there will be decrease in the time of V-Funnel test 23.63% which means it improve fresh properties of SCC.
5. In L-Box Test, The result shows that, replacing the the By product of kaolin 50% by fine aggeregate there will be increases the ratio (H2/H1) of L-box test 12.5%.
6. In Hardened property such as Compressive strength, Flexural strength and Split tensile strength , by product of kaolin can be used up to 35% achieve target mean strength of concrete for M 30 grade.
7. In Compressive Test, The result shows that, by replacing 50% by product of kaolin in fine aggregate., there is decrement in the compressive strength of concrete by 20.01% at 28 Days of Casting.

8. In Flexure Test and Split tensile test, The result shows that, by replacing 50% by product of kaolin in fine aggregate, there is decrement in the strength of concrete by 54.06% and 39.67% respectively at 28 days of casting.
9. In Durability test using HCL solution and H2So4 Solution in M-30 grade of concrete, Results shows that there is **minimum** % loss in HCL was 3.35% at mix A- 10(45% B.K. & 55% FA) and in H2So4 was 5.31% at mix A- 5(20% B.K.& 80% FA).
10. In Durability test using HCL solution and H2So4 Solution in M-30 grade of concrete, Results shows that there is **maximum** % loss in HCL was 7.93% at mix A- 9 (40% B.K. & 60% FA) and in H2So4 was 6.58% at mix A-1 (0 % S.S. & 100% FA).

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