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Experimental Study on Properties of Rheological, Mechanical and Durability of SCC Containing Metakaolin and Copper Slag

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Abstract— The bond between materials of concrete is fundamentally used for development in present time on account of its need however at the same time its disadvantages to condition because of outflow of CO2, so that to beat this issue, I utilize mechanical waste materials to supplant with solid materials, for example, squander Metakaolin and copper slag by methods for concrete and fine total, separately. The Self-compacting concrete is throwing for M30 and M40 review with the bond is supplanted by MK as 0%, 5%, 10%, 15% and fine total is supplanted by CS as 0%, 20%, 40%, 60% by weight. The usefulness of new SCC was evaluated by Slump table stream, L-box, and V-pipe Tests. Compressive test, flexural test, and a split test were done for the set properties. Acid(corrosive) assault, sulphate assault, and sorptivity were done for solidness trial of SCC. The outcome demonstrates that 10MK-40CS mix of SCC gives most extreme quality of all blends. For the two evaluations of SCC, it saw that solid containing metakaolin and copper slag give better execution against sulphate, corrosive resistivity, sorptivity perspective relating to control concrete at 28 Days.

Keywords— Supplementary cementing material (SCM), Copper Slag, Metakaolin, Self-Compacting Concrete (SCC), Superplasticizer, Viscosity Modifying Agent (VMA), etc.

I. INTRODUCTION

Self-compacting concrete (SCC) is a profoundly gooey solid that can spread into place under its own weight and without vibration without uncovering deserts because of segregation(isolation) and bleeding(dying). SCC is a formation of innovative enhancements in submerged solid innovation where the blend is proportioned to ensure high smoothness and in addition high protection from water decrease and isolation. SCC was set up in Japan in the late 1980s, and of late, this solid has extended wide use in numerous countries for basic arrangements and diverse applications.

A few changed methodologies have been utilized to create SCC. One method to accomplish self-compacting property is to increment suggestively the measure of fine materials (e.g., Metakaolin and Copper Slag) without changing the water content identified with basic cement. One elective strategy comprises of consolidating a consistency altering admixture (VMA) to enhance security and stability. The utilization of VMA alongside a reasonable convergence of superplasticizer (SP) can guarantee appropriate deformability and appropriate usefulness, principal to a decent protection from isolation.

In this exploration, cellulose ether as VMA was tried in the making of SCCs alongside superplasticizer. The crisp solid properties (V-channel, L-box test and Slump table stream) and solidified solid properties (compressive, flexural and split elasticity) of blends were anticipated and contrasted and standard solid blends of concrete.

II. MATERIALS

A. Cement

OPC of 53 Grade manufactured by siddhi association was used in SCC identifying with IS:8112. The specific gravity of bond is 3.15.

B. Sand

Natural(river) sand is utilized as fine total. According to May be IS: 2386 (Part III)- 1963, the mass particular gravity in stove dry condition and water assimilation of the sand are 2.65 and 1.1% individually.

C. Aggregate

Smashed stones of greatest size 20 mm are utilized as coarse total. According to IS:2386 (Part III)- 1963, the mass particular gravity in stove dry condition and water retention of the coarse total are 2.68 and 0.3%, separately.

D. Metakaolin

In that undertaking the gathering of metakaolin from Gujarat Earth Minerals Pvt. Ltd. The particular gravity of Metakaolin is 2.61. Compound and Physical properties of metakaolin are given in the Table I and II, individually.

TABLE I
CHEMICAL PROPERTIES OF METAKAOLIN AND COPPER SLAG

Chemical properties		
Properties	**Metakaolin**	**Copper Slag**
SIO_2(%)	54	30.46
Al_2O_3(%)	41.35	2.81
SO_3(%)	-	1.59
MgO (%)	0.065	1.48
Cao (%)	0.016	1.60
Fe_2O_3(%)	0.39	56.28
K_2O (%)	1-2	0.71

TABLE III
PHYSICAL PROPERTIES OF METAKAOLIN (MK)

Physical Properties of Metakaolin	**Results of various Properties**	**As per IS: 3812-1981 Codal Specifications**
Moisture content (%)	0.18	0-0.5
Residual on 325 um sieves (%)	0.24	0-0.5
Specific Gravity	2.62	2.5-2.7
Bulk Density(gm/liter)	328	270-370
Specific surface area(m^2/gm)	16.57	12-18
Physical Form	Amorphous powder	
Appearance(color)	Off-White	

E. Copper Slag

Copper slag is a modern side-effect got amid the purifying and refining procedure of copper in enterprises. Copper Slag got from "Krishna Raj partnership organisation", GIDC Gozaria, Mehsana. Compound and Physical properties of Copper Slag are given in the Table I and III, individually.

TABLE IIIII
PHYSICAL PROPERTIES OF COPPER SLAG (CS)

Physical Properties	**Copper Slag (CS)**
Particle Shape	Angular flaky
Specific Gravity	3.31
Appearance	Black and glassy
Fineness Modulus	3.28
Bulk Density	1900 Kg/m^3
Water absorption	0.35%

F. Admixtures and Superplasticizers

In this examination the accumulation of super plasticizers and VMA from Contech Chemicals Pvt. Ltd. A polycarboxylate ether (Conflow pc2) based super plasticizer and Cellulose ether as VMA were utilized in cement. The properties of admixtures are exhibited in tables IV.

TABLE IVV
TYPICAL PROPERTIES OF CELLULOSE ETHER (VMA)

Typical Properties of VMA	**Cellulose Ether (CE)**
Ash Content	<5.0%
pH Value	5.5-7.0
Appearance	Off-white
Viscosity	865
Humidity	<6.0%

III. MIX DESIGN

A standard mixes or blends M-30 and M-40 review of Self-compacting concrete was computed according to Indian Standard (IS 10262-2009). The cements were set up at cementitious materials (Cement +MK+CS) doses of 405.58 kg/m^3 for M-30 and 470 kg/m^3 for M-40. For every fastener content, the w/c proportion and super plasticize kept steady with various level of beneficial cementitious materials extents were resolved. The blend configuration is given in Table V.

TABLE V
MIX DESIGN FOR M30 AND M40 GRADE OF SCC

Grade of SCC	M30	M40
Mix Ratio	1:2.04:2.14	1:1.76:2.15
W/C ratio	0.45	0.45
Sand (Kg)	825.80	829.93
Cement (Kg)	405.58	471.10
Water (Kg)	182.657	211.50
10 mm Aggregate (Kg)	508.38	559.56
20 mm Aggregate (Kg)	356.61	452.87

IV. TESTING PROCEDURE

For setting up Self-compacting concrete (SCC), a group blender was utilized. First coarse and fine totals, bond(cement), meta kaolin, copper slag was blended with half of the blending water for 2 min. After expansion of VMA and SP, blending proceeded up to add up to 10 min. Slump flow or Droop table stream, V-Funnel and L-box tests were performed on the Self-compacting concrete in crisp state to decide stream capable properties.

- For Compressive quality, tests were led on 150x150x150 mm block moulds, following 28 days of appropriate restoring. 3 Cubes were throwing and tried for every blend.
- For split rigidity, tests were directed on round and hollow moulds with a breadth of 150 mm and a tallness of 300 mm, following 28 days of appropriate relieving. 3 examples were throwing and tried for every mix.
- For Flexural quality, tests were led on 700x150x150 mm bar moulds, following 28 days of legitimate relieving. 3 examples were throwing and tried for every mix.

TABLE VI
PROPORTIONS OF SCC MIXES

Grade of SCC	W/C (%)	Proportions (%)	Superplasticizer (SP) (%)	VMA (%)
M30	0.45	0CS-0MK	1.00	0.6
		20CS-10MK	1.00	0.6
		40CS-10MK	1.00	0.6
		60CS-10MK	1.00	0.6
M40	0.45	0CS-0MK	1.25	0.8
		20CS-10MK	1.25	0.8
		40CS-10MK	1.25	0.8
		60CS-10MK	1.25	0.8

V. EXPERIMENTAL RESULTS AND DISCUSSION

A. Rheological (Fresh) Concrete Properties

A point by point ponder coordinated on different extents included solid/concrete (Mixing extents are given in Table VI) for the cover substance of 405.58 and 471.10 kg/m^3 and the new solid testing results are shown in table VII and VIII concerning w/c proportion of 0.45.

TABLE VII
RHEOLOGICAL (FRESH) PROPERTIES OF M30 GRADE OF SCC

Grade of Concrete	Proportion (%)	Flow Test(mm)	V-Funnel Test(sec)	L-Box Test
M30	0CS-0MK	745	11.0	1.00
	20CS-10MK	710	9.5	0.95
	40CS-10MK	685	8.2	0.89
	60CS-10MK	670	8.0	0.84

TABLE VIII
RHEOLOGICAL (FRESH) PROPERTIES OF M40 GRADE OF SCC

Grade of Concrete	Proportion (%)	Flow Test(mm)	V-Funnel Test(sec)	L-Box Test
M40	0CS-0MK	710	11.4	0.97
	20CS-10MK	682	9.9	0.93
	40CS-10MK	674	8.5	0.86
	60CS-10MK	658	8.3	0.82

B. Hardened (Solidified) Concrete Properties

The 7 days and 28 days compressive qualities for both M30 and M40 review SCC, in Table IX and Chart 1 and 2. The 28 days flexural qualities for both M30 and M40 review SCC, in Table X and Chart 3 and 4. The 28 days split rigid qualities of SCCs are given in Table XI and Chart 5 and 6 are appeared.

TABLE IX
COMPRESSIVE STRENGTH RESULTS OF M30 AND M40 GRADE OF SCC

Grade of Concrete	Proportions (%)	Compressive strength (quality) at 7 days (N/mm^2)	Compressive strength (quality) at 28 days (N/mm^2)
Normal (M30)	-	26.07	38.59
SCC M30	0CS-0MK	25.20	38.13
	20CS-10MK	27.85	40.33
	40CS-10MK	29.54	42.67
	60CS-10MK	27.69	40.78
Normal (M40)	-	34.28	48.42
SCC M40	0CS-0MK	33.00	49.42
	20CS-10MK	35.37	51.74
	40CS-10MK	36.95	53.61
	60CS-10MK	34.82	51.86

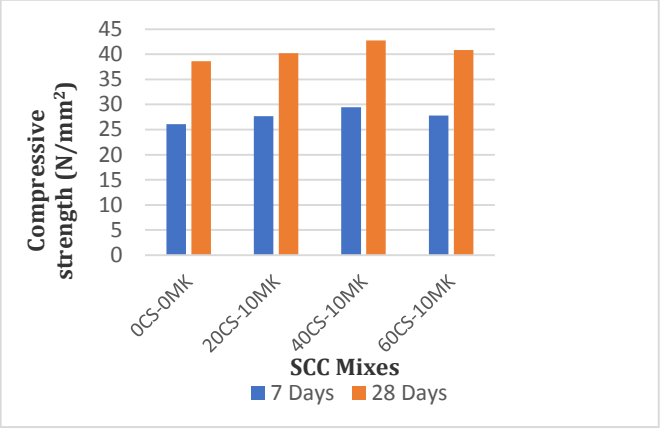

Fig. 1 Compressive strengths of M30 grade of SCC

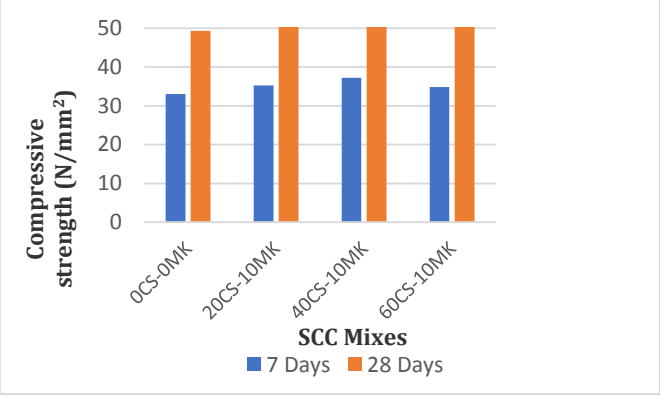

Fig. 2 Compressive strengths of M40 grade of SCC

TABLE X
FLEXURAL STRENGTH RESULTS OF M30 AND M40 GRADE SCC

Grade of Concrete	Proportions (%)	Flexure strength at 28 days (N/mm^2)
Normal (M30)	-	3.81
M30	0CS-0MK	3.89
	20CS-10MK	4.62
	40CS-10MK	5.25
	60CS-10MK	4.00
Normal (M40)	-	4.45
M40	0CS-0MK	4.56
	20CS-10MK	5.34
	40CS-10MK	5.90
	60CS-10MK	4.72

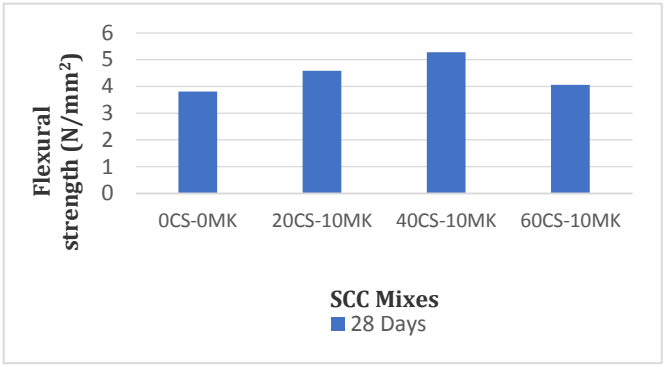

Fig. 3 Flexural strengths of M30 grade of SCC

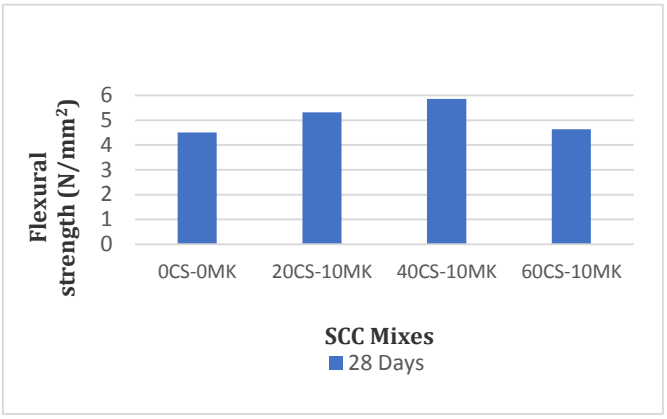

Fig. 4 Flexural strengths of M40 grade of SCC

TABLE XI
SPLIT TENSILE STRENGTH RESULTS OF M30 AND M40 GRADE OF SCC

Grade of Concrete	Proportions (%)	Split tensile strength results at 28 days (N/mm^2)
Normal (M30)	-	3.28
SCC M30	0CS-0MK	3.17
	20CS-10MK	3.36
	40CS-10MK	3.72
	60CS-10MK	3.26
Normal (M40)	-	3.44
SCC M40	0CS-0MK	3.36
	20CS-10MK	3.68
	40CS-10MK	4.12
	60CS-10MK	3.43

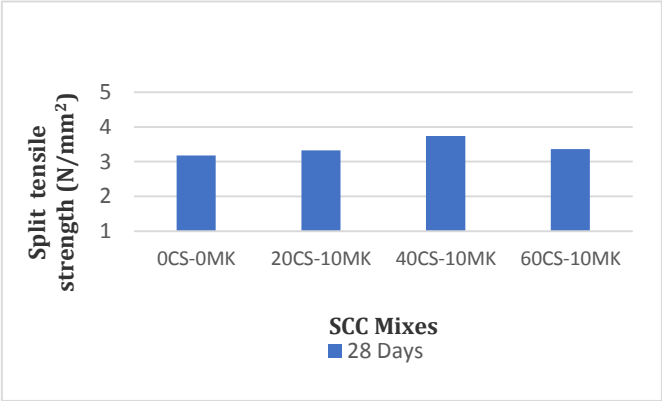

Fig. 5 Split tensile strength results of M30 grade of SCC

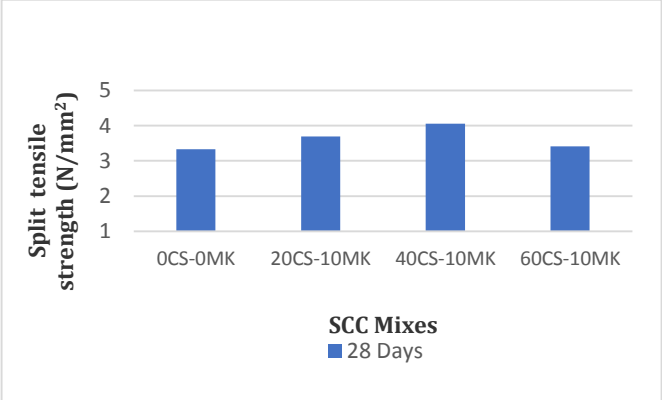

Fig. 6 Split tensile strength results of M40 grade of SCC

C. Durability Properties of Concrete

The 28 days strength test results were given in graphs and tables as demonstrated as follows.

- In acid attack/corrosive opposition test, solid shapes concrete cubes of various mixes were contrasted and ordinary shape concrete cube by mass dissemination, compressive quality and outwardly review.
- In sulphate obstruction test, 3D square scc cubes are drenched in 5% concentrated sodium sulphate arrangement and mass dissemination ought to be checked.
- In sorptivity test, it is a basic and fast test to decide the inclination of cement to intrigue or assimilate water by slim activity. Tests were situated on the help gadget kept in the dish so that around 1 to 3 mm profundity of water was over the help gadget and the perusing was noted around seizing the example from the skillet after the interim of 1, 5, 10, 20, 30, 60 min and every hour up to 6 hours from the beginning of the test time.

TABLE XII
BULK DIFFUSION AND COMPRESSIVE STRENGTH AFTER RESISTIVITY IN ACID AT 28 DAYS

Grade of Concrete	Proportions (%)	Wt. of cubes after 28 days of water curing (Kg)	Wt. of cubes after 28 days of acid curing (Kg)	Bulk Diffusion (kg)	Compressive strength after 28 days in acid
Normal (M30)	-	8.89	7.62	1.27	25.88
SCC M30	0CS-0MK	8.72	7.56	1.16	26.14
	20CS-10MK	8.19	7.41	0.78	28.49
	40CS-10MK	7.93	7.37	0.56	33.56
	60CS-10MK	7.80	7.12	0.68	27.63
Normal (M40)	-	9.21	7.99	1.22	36.25
SCC M40	0CS-0MK	8.98	7.88	1.10	38.36
	20CS-10MK	8.40	7.66	0.74	41.48
	40CS-10MK	8.16	7.57	0.59	40.74
	60CS-10MK	8.05	7.34	0.71	38.23

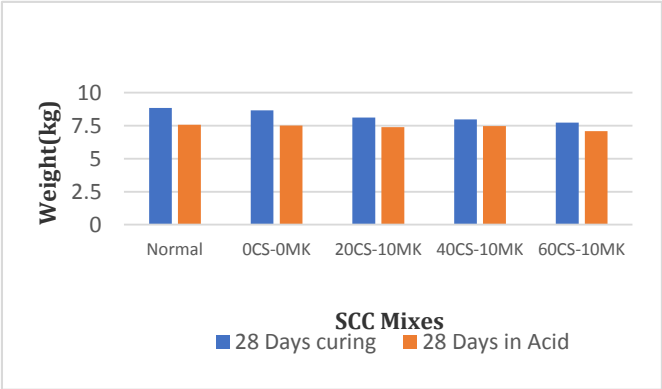

Fig. 7 Avg. bulk diffusion in acid assault of M30 grade of SCC

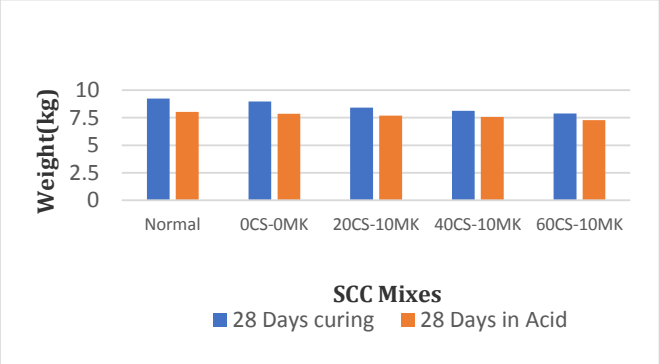

Fig. 8 Avg. bulk diffusion in acid assault of M40 grade of SCC

TABLE XIII
BULK DIFFUSION AND COMPRESSIVE STRENGTH AFTER RESISTIVITY IN SULPHATE SOLUTION AT 28 DAYS

Grade of Concrete	Proportions (%)	Wt. of cubes after 28 days of water curing (Kg)	Wt. of cubes after 28 days of sulphate curing (Kg)	Bulk Diffusion (kg)	Compressive strength after 28 days in sulphate solution
Normal (M30)	-	8.38	8.49	0.16	34.12
SCC M30	0CS-0MK	8.15	8.28	0.17	33.48
	20CS-10MK	7.97	8.14	0.21	35.25
	40CS-10MK	7.76	7.94	0.23	36.98
	60CS-10MK	7.54	7.86	0.31	33.36
Normal (M40)	-	9.26	9.40	0.14	45.28
SCC M40	0CS-0MK	9.14	9.31	0.16	44.42
	20CS-10MK	8.84	9.03	0.19	45.86
	40CS-10MK	8.56	8.77	0.21	47.58
	60CS-10MK	8.18	8.45	0.27	44.46

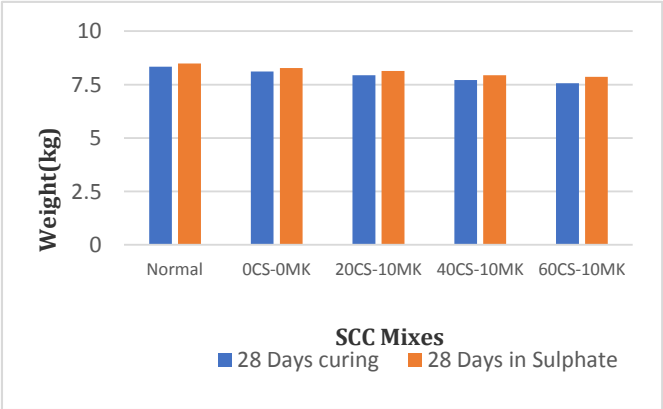

Fig. 9 Avg. bulk diffusion in sulphate assault of M30 grade of SCC

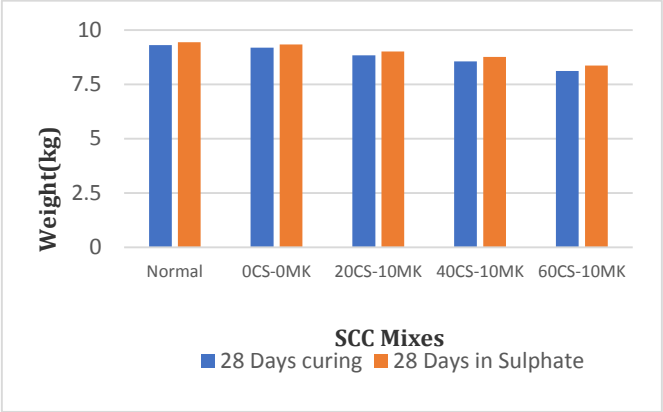

Fig. 20 Avg. bulk diffusion in sulphate assault of M40 grade of SCC

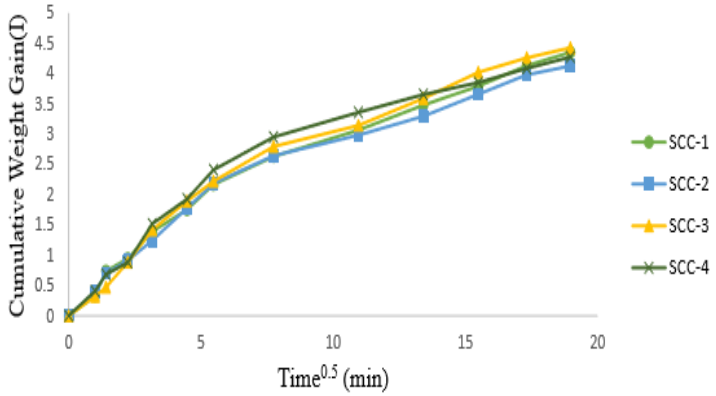

Fig. 31 Sorptivity Results: M30 grade of SCC

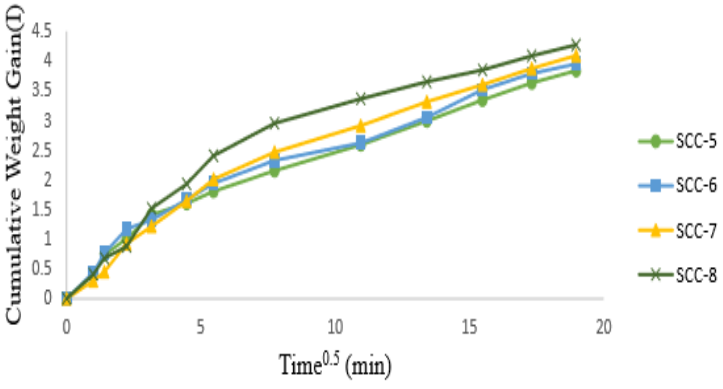

Fig. 42 Sorptivity Results: M40 grade of SCC

VI. CONCLUSIONS

Rheology test results demonstrates that, Slump stream test esteems diminishes, L-box test esteems reductions, and V-Funnel time increments by expanding the level of substitution of sand by copper slag. Substitution of metakaolin over 10% decreasing quality of SCC. The compressive quality was most extreme for 10MK-40CS among all blends at each relieving period. For M30 review of SCC, at 28 days compressive quality, flexure quality and split elasticity was expanded by 10.78% ,38.65% and 17.52% with 10% bond supplanted by metakaolin and 40% sand supplanted by copper slag. For M40 review of SCC, at 28 days compressive quality, flexure quality and split elasticity was expanded by 8.58% ,30.86% and 21.72% with 10% concrete supplanted by metakaolin and 40% sand supplanted by copper slag. By including over 40% of copper slag, it diminishes the compressive quality, flexure quality and split tensile value. For M30 and M40 review of SCC, it seen that solid containing metakaolin and copper slag give better execution against sulfate resistivity, acid or corrosive resistivity and sorptivity angle comparing to control concrete at 28 Days.

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REFERENCES

[1] Rahul Sharma, Rizwan A. Khan, "Durability assessment of self-compacting concrete (SCC) incorporating copper slag as fine aggregates*"*, *Elsevier*, 2017.
[2] Rahul Sharma, Rizwan A. Khan, "Sustainable use of copper slag in self-compacting concrete containing supplementary cementitious materials (SCM)", *Elsevier*, 2017.
[3] Efstratios G. Badogiannis, Ioannis P. Sfikas, Dimitra V. Voukia, Konstantinos G. Trezos, Sotirios G. Tsivilis, "Durability of metakaolin self-compacting concrete (SCC)", *Elsevier*, 2015.
[4] Rahmat Madandoust, S. Yasin Mousavi, "Fresh and hardened properties of self-compacting concrete (SCC) containing metakaolin", *Elsevier*, 2012.
[5] Ionnis P. Sfikas, Efstratios G. Badogiannis, Konstantinos G. Trezos, "Rheological and mechanical characteristics of Self-compacting concrete (SCC) mixtures containing Metakaolin", *Elsevier*, 2014.
[6] IS 519:1959, "Methods of Tests of Strength of Concrete*"*, *Bureau of Indian Standards (BIS).*
[7] EFNARC- "Specifications and guidelines for self-compacting concrete (SCC)". *European Federation of Producers and Applicators of Specialist Products for Structures*, 2002.
[8] IS 456:2002, "Plain and Reinforced Concrete: - Code of Practices*"*, *Bureau of Indian Standards (BIS).*
[9] IS 10262:2009, "Concrete *Mix* Proportioning- Important Guidelines*"*, *Bureau of Indian Standards, (BIS).*
[10] ASTM C 1012-04, "Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulphate Solution*"*, *American Society for Testing and Materials*, United States, 2004.