iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** VI **Month of publication:** June 2023

DOI: https://doi.org/10.22214/ijraset.2023.53697

Flexural Behaviour of SCC Beams Incorporating Industrial Wastes

Sharankumar N[1], Makeshkumar S[2], Chithra S[3]
[1]Student, Dept of Structural Engg, Government College of Technology Coimbatore-641013, India
[2]Assistant Professor, Dept of Structural Engg, Government College of Technology Coimbatore-641013, India
[3]Associate Professor, Dept of Structural Engg, Thanthai Periyar Government Institute of Technology Vellore- 632002, India

Abstract: Self-Compacting Concrete (SCC) is a concrete form developed in Japan. Because of its novelty, this form of concrete differs from traditional concrete. Compaction is required for conventional concrete, but not for SCC which is utilized in substantially reinforced constructions where it is challenging to compact concrete. Industrial wastes such as Fly Ash (FA) and Cement Kiln Dust (CKD) [which contaminate the environment] are used as partial replacements for cement, and, Granite Powder (GP) and Eco Sand (EC) are used as partial replacements for M-sand. The optimum mix proportions of casted beams obtained by Taguchi method are SCC1 (FA30%), SCC2 (FA25%+CKD5%), SCC3 (FA30%+GP20%), SCC4 (FA25%+CKD5%+GP20%), SCC5 (FA30%+EC10%), and SCC6 (FA25%+CKD5%+EC10%). For each composition, the flexural behavior of SCC beams is experimentally investigated. Experimental work is verified by FEM analysis using the ABAQUS software. When the outcomes from the experimental and numerical analysis are compared, it is evident that SCC6 outperformed other mixes in terms of flexure.
Keywords: SCC, Fly Ash, Cement Kiln Dust, Granite Powder, Eco Sand, Flexural behavior, Finite Element Software.

I. INTRODUCTION

Self-Compacting Concrete (SCC) as the name signifies should be able to compact itself without any additional vibration or compaction. Self-compacting concrete should compact by its self-weight and under gravity. The SCC is that which gets compacted due to its self-weight and is deaerated (no entrapped air) almost completely while flowing in the formwork. In densely reinforced structural members, it fills all the voids and gaps completely and maintains a nearly horizontal concrete level after it is placed[5]. With regard to its composition, SCC consists of the same components as conventionally vibrated normal concrete, i.e., cement, aggregates, water, additives, or admixtures. However, the high dosage of super-plasticizer is used for reduction of the liquid limit and for better workability, the high powder content as a 'lubricant'[2]. The use of viscosity agents to increase the viscosity of the concrete has to be taken into account. Superplasticizer enhances deformability and with the reduction of water/powder segregation resistance is increased.

A well-designed SCC mix does not segregate and has high deformability and excellent stability characteristics. Self-compacting concrete is required to flow and fill special forms under its own weight, it shall be flowable enough to pass through highly reinforced areas and must be able to avoid aggregate segregation. Self-compacting concrete with a similar water-cement or cement binder ratio will usually have a slightly higher strength than traditional vibrated concrete, due to the lack of vibration gives an improved interface between the aggregate and hardened paste. Using self-compacting concrete produces several benefits and advantages over regular concrete.

II. MATERIALS USED

Cement, M-sand, coarse aggregate measuring 12.5 mm in size, fines, and viscous moderating agent (superplasticizer) are the ingredients used to create self-compacting concrete. In this SCC, Fly Ash and Cement Kiln Dust partially replace the cement, and Eco Sand and Granite Powder partially replace the fine aggregate Cement.[1],[3],[4]

Fine-grained material known as cement kiln dust is produced during the production of cement, which contains raw materials high in lime. It can be used to replace up to 10% of the cement content to some extent, according to the journals. [6]

Eco sand, a by-product of the cement manufacturing process (semi-wet method) and a product of ACC cement is a very effective pore-filling material. Because of its improved moisture resistance and durability, its micro-filling effect reduces concrete's pore size. It may grow as a result of this.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Granite powder, a waste product from the granite polishing industry, is a material that shows promise for use in concrete. The void content of concrete can be decreased by using these products as a filler material (instead of sand).

An admixture of a new generation based on modified polycarboxylic ether is MASTER GLENIUM SKY 8233. The products have been created primarily for high-performance concrete applications where the highest durability and performance are required. MASTER GLENIUM SKY 8233 has a low alkali content and is chloride-free. It works with all varieties of cement.

TABLE I
Properties of cement

TEST	RESULTS	REMARKS
Specific gravity	3.15	IS:4031-Part 11-1988
Fineness test	6%	IS:4031-Part 1-1996
Standard consistency	30%	IS:4031-Part 4-1988
Grade of cement	OPC 53	-
Initial setting time	49 min	IS:4031-Part 5-1988
Final setting time	350 min	IS:4031-Part 5-1988

TABLE II
Properties of Other Materials

MATERIALS	SPECIFIC GRAVITY	BULK DENSITY (kg/m^3)
Coarse Aggregate	2.83	1670
M-Sand	2.54	1870
ECO sand	2.66	1680
Granite Powder	2.67	2650
Cement kiln dust	2.78	1400

III. MIX PROPORTIONS

A mix of proportions is done by using the Okamura method. There are 6 mix ID’s named SCC1, SCC2, SCC3, SCC4, SCC5, SCC6 with mix proportions (70% C + 30% FA) + M + CA + SP, (70% C + 25% FA + 5% CKD) + M + CA + SP, (70% C + 30% FA) + (80% M + 20% GP) + CA + SP, (70% C + 25% FA + 5% CKD) + (80% M + 20% GP) + CA + SP, (70% C + 30% FA) + (90% M + 10% ES) + CA + SP, (70% C + 25% FA + 5% CKD) + (90% M + 10% ES) + CA + SP respectively.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

IV. EXPERIMENTAL STUDY

A. Casting

A trowel was used to finish the top surface after the freshly mixed SCC was poured into the mould. After being in the mould for 24 hours, the specimen was removed. On the specimen's exposed face, identification marks were made, and it was covered using wet gunny bags for curing. After 28 days of curing, the specimen was tested and its flexural strength was evaluated.

Fig. 1 Casting and Curing of Beams

B. Experimental Setup

A steel spreader beam with two points of bearing and a length of 0.433 m from center to center was placed in the middle of each beam specimen, which had a total length of 1.5 m and a clear span length of 1.2 m. The single-point load has now been split into two points. i.e., the two loads were transmitted through the steel spreader beam at 216 mm from the midspan. The data log system was able to measure strain from 6mm strain gauges and deflection from LVDTs. Three strain gauges were installed in total, one on each of the top, bottom, and middle heights of the side faces of the beam, and they were all wired to the data logger. Hydraulic jacks were used to place the load on the beams. Up until the beam failed, the test was conducted. With the aid of a data logger, the applied load, the measured midspan deflection, and all strain from strain gauges installed at the concrete and rebar were measured. The data was recorded in an Excel file and stored on a PC. The properties of beams with dimensions of 100 x 200 x 1500 mm and effective span of 1350 mm with longitudinal reinforcement of top & bottom dia of 10 mm and stirrup of 8 mm @ 100 mm c/c with steel grade of Fe 500.

Fig. 2 Experimental Setup for Beam Specimen

V. NUMERICAL INVESTIGATION

Instead of a 2D plane stress simulation, a 3D FE Model is used to increase the accuracy of numerical results in the study. The element type used in the FE model for concrete is 8-node linear brick (C3D8R). Moreover, reinforcement steel is a 2-node linear 3-D truss (T3D2).

The values of the variables measuring hardening and softening were used to calculate the trends in crushing and cracking, respectively. The development of the yield surface and the loss of elastic stiffness are caused by them. In general, experimental measurements or existing constitutive models, like those put forth by Hognestad and Kent et al., could be used to characterize uniaxial compressive behavior for free-standing concrete. Concrete damaged plasticity (CDP) model, Concrete Damage Plasticity Parameters of Dilation angle of 36, Eccentricity of 0.1, fb0/fc0 of 1.05, K of 0.67, Viscosity Parameter of 0. The modulus of elasticity of steel was taken as 210 GPa and Poisson’s ratio as 0.3.

The type of analysis employed affects the accuracy of the results obtained. From the model, the beam is simply loaded with a static force and we require the displacements, strains, rotations, etc. as outputs. This makes the model mechanism a static one since these outputs do not vary with time. The small displacement static option was used since we do not expect our model to undergo very large deflections. A time increment of 1 was used to run the analysis. In order to help with the convergence of the non-linear solution, a very small minimum step value was specified. The nlgeom option was switched on to consider the non-linear effects of the loading of the section.

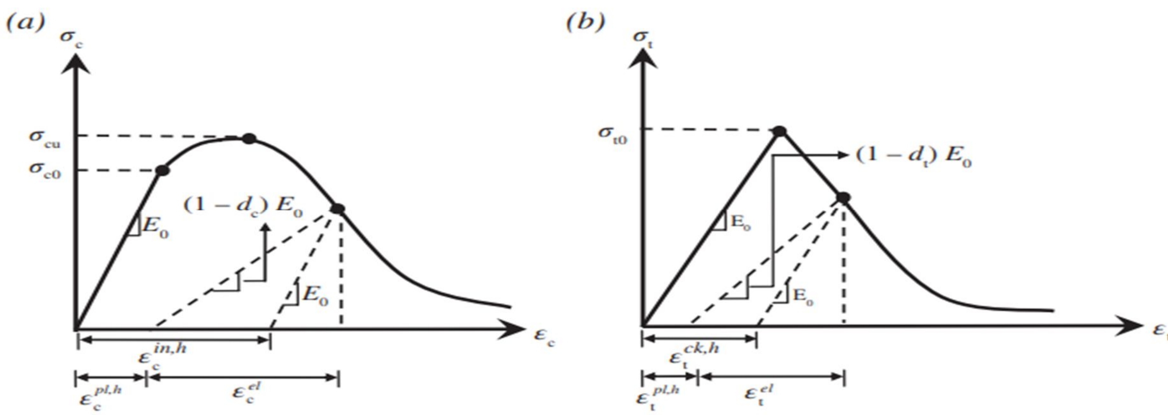


Fig. 3 Response of concrete to (a) Compression and (b) Tension

VI. RESULTS AND DISCUSSIONS

A. Fresh properties of SCC

There is currently no accepted standard for the test procedures used to evaluate the properties of freshly mixed self-compacting concrete. The SCC testing specification and guidelines, as well as the limiting values to obtain SCC, have been developed by EFNARC using the board practical experiences of all members of the European Federation with SCC [10].

TABLE III

Fresh Properties of Concrete

Mix Id	Slump Flow	J-Ring	L-Box	V-Funnel
	RANGE 650-800(mm)	RANGE 0-30(sec)	RANGE 0-10(mm)	RANGE 8-12(sec)
SCC1	725	21	7	9
SCC2	700	23	8	11
SCC3	690	23	8	10
SCC4	700	20	8	10
SCC5	750	18	6	8
SCC6	730	21	7	8

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

B. Load vs Deflection

The load-deflection graphs below were created using the load-deflection data that was obtained using a data logger. The list of graphs below includes load deflection data for a total of six different types of beams, namely SCC1, SCC2, SCC3, SCC4, SCC5, and SCC6. Based on concrete grade and functional grade specifications, these beam types were developed.

Ultimate Failure load is the load in which the beam has reached its maximum load-carrying capacity and can no longer support any additional load. In the FE model, this is indicated by an insurmountable convergence failure of the model while in the experimental model, it is indicated by the total collapse of the beam specimen.

TABLE IV
Data obtained from flexural test on beams

Beam ID	Load at first crack P_{crk} (kN)	Moment at first crack, M_{crk} (kNm)	Ultimate load, P_u (kN)	Ultimate moment, M_{ut} (kNm)	Deflection at yield Δ_{yld} (mm)	Ultimate deflection Δ_{ut} (mm)	Ductility ratio [Ultimate deflection Δ_{ut} / yield deflection Δ_{yld}]
SCC1	12	2.4	43	8.6	10.4	51.2	4.92
SCC2	12	2.4	40	8	8.8	38.2	4.34
SCC3	10	2	33	6.6	10	45.4	4.54
SCC4	8	1.6	28	5.6	10	51	5.1
SCC5	10	2	31	6.2	9.8	51.2	5.22
SCC6	14	2.8	57	11.4	10	51	6.1

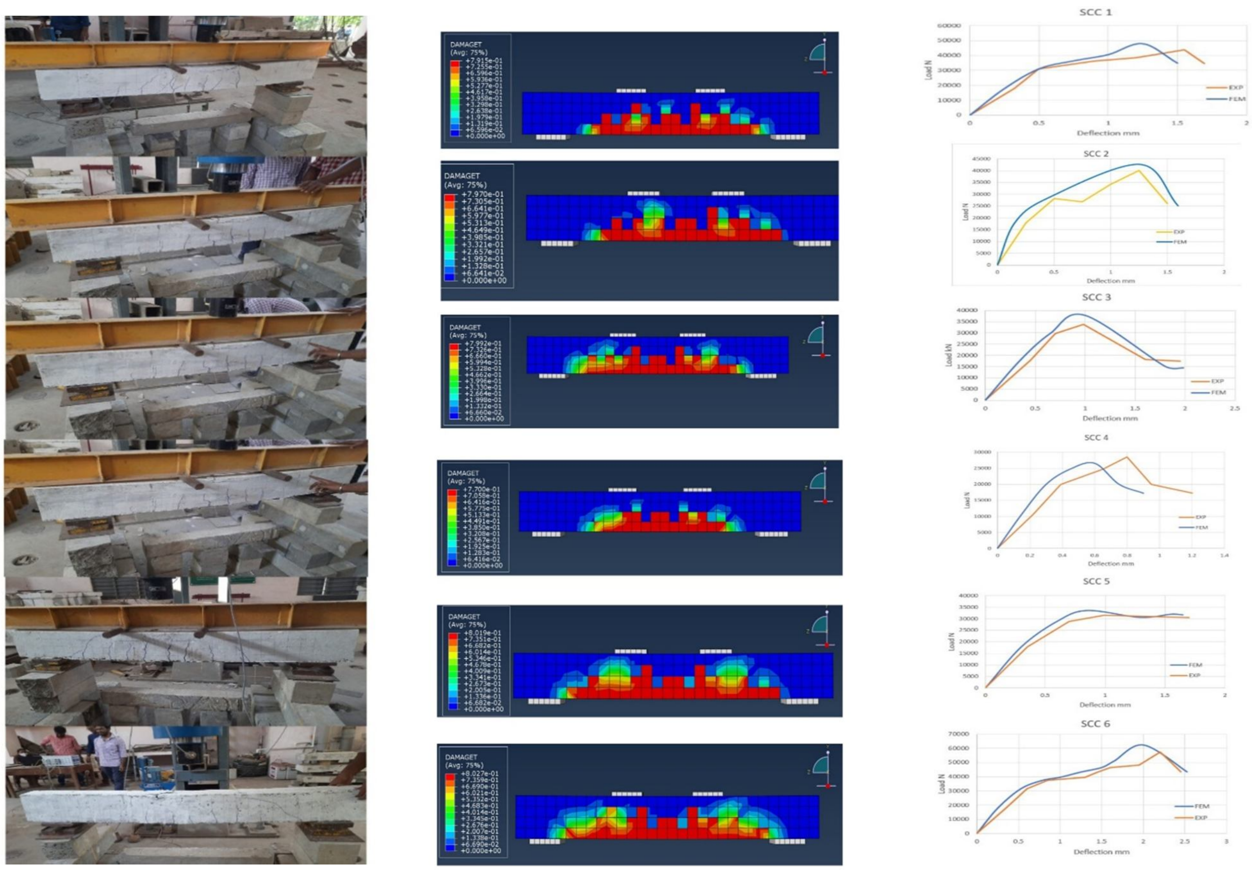


Fig. 4 Experimental setup, FEM model and Load graph for all 6 beams

From comparing the ultimate load of all 6 beams, SCC 6 performs well as compared to other mixes which is expressed as the graph below

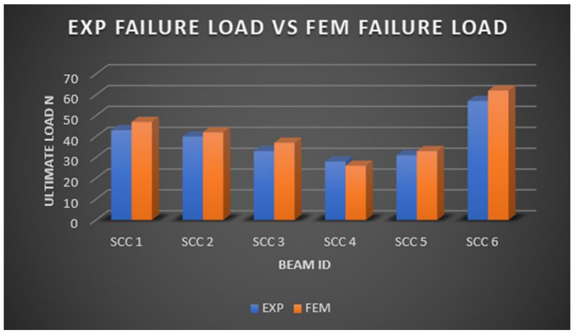


Fig. 5 Comparison of EXP failure load with FEM failure load for all 6 beams

VII. CONCLUSION

The failure pattern and ultimate failure load of the simulated model of SCC beams are similar to the experimental findings. It is clear from the analysis of the flexural strength results that the SCC6, which replaces up to 25% fly ash, 5% cement kiln dust, and 10% eco sand, provides greater flexural strength than the traditional SCC. On examining load deflection graphs, beam-SCC6 which is 21% more ductile but 5.5% higher load-carrying capacity than conventional SCC1. This demonstrates that the application of SCC6 to concrete beams will increase both ductility and load-carrying capacity.

VIII. ACKNOWLEDGMENT

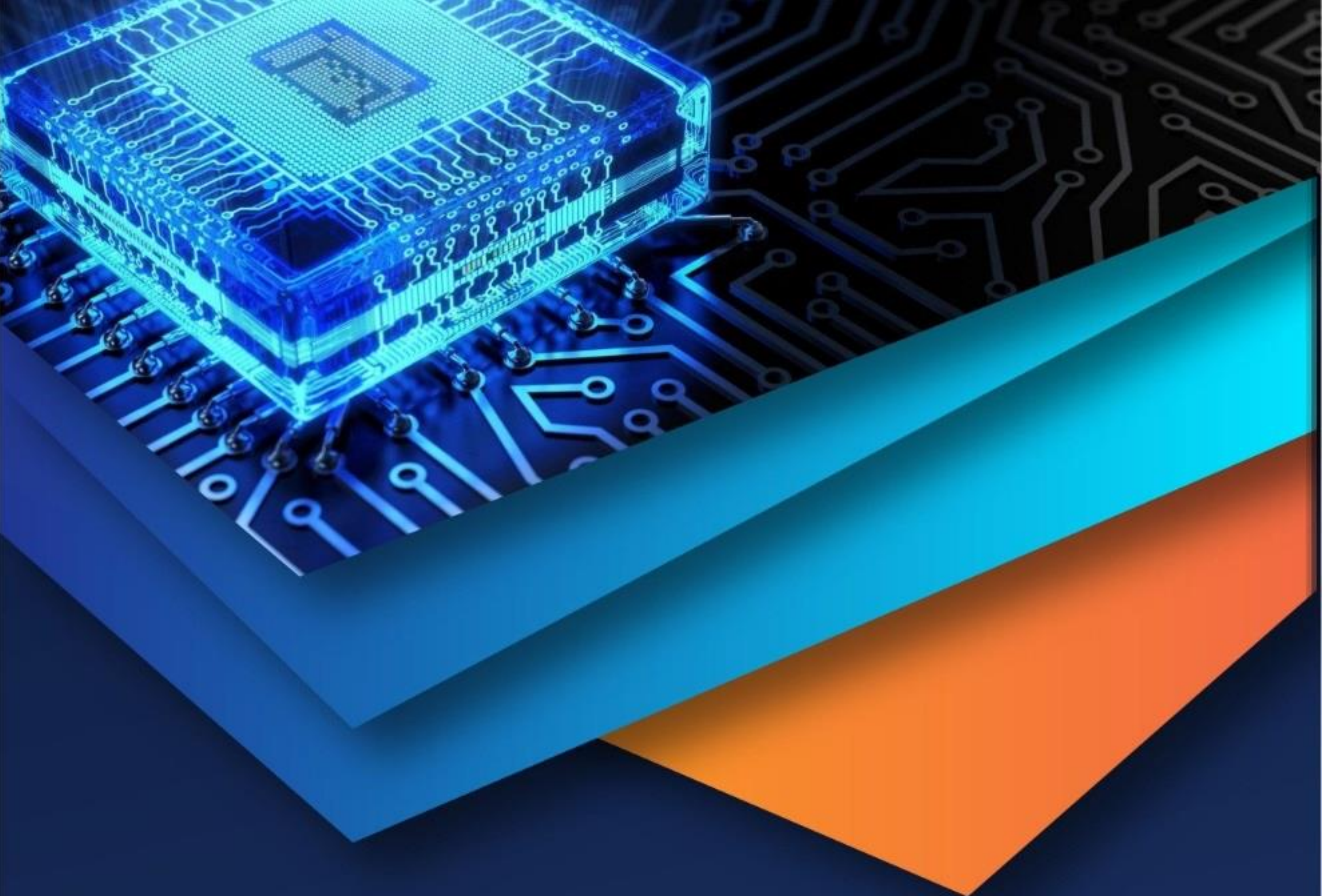
First of all, I thank the Almighty for giving his grace, knowledge, and blessing which enabled me to complete this project in the most successful manner.

With a deep sense of gratitude, I extend my earnest and sincere thanks to my project guide Prof. S. Makesh Kumar, M.Tech., Assistant Professor, Department of Civil Engineering who is our lighthouse in the vast ocean of learning with his inspiring kind guidance and encouragement to complete the project.

I extend my gratitude to my parents who have been a constant support to me with encouragement. I thank all the faculty members and non-teaching staff of the Department of Civil Engineering and my friends for their help in completing this project work.

REFERENCES

[1] Prakash Nanthagopalan, Manu Santhanam, "Fresh and hardened properties of self-compacting concrete produced with manufactured sand", ELSEVIER Cement and Concrete Composites 2010.
[2] Iliana Rodríguez Viacava , Antonio Aguado de Cea , Gemma Rodríguez de Sensale," Self-compacting concrete of medium characteristic strength", Elsevier – Construction and Building materials 2012.
[3] Mohamed I. Abukhashaba , Mostafa A. Mostafa, Ihab A. Adam," Behavior of self-compacting fiber reinforced concrete containing cement kiln dust", Alexandria Engineering Journal 2013.
[4] Mostafa Abd El-Mohsen, Ahmed M. Anwar, Ihab A. Adam'' Mechanical properties of Self-Consolidating Concrete incorporating Cement Kiln Dust", Elsevier - HBRC Journal 2015.
[5] Eehab Khalil, Mostafa Abd-Elmohsen, Ahmed M. Anwar," Impact Resistance of Rubberized Self-Compacting Concrete", ELSEVIER Water Science 2015.
[6] Khalid B. Najim , Ibrahim Al-Jumaily, Abdukhaliq M. Atea," Characterization of sustainable high performance/self-compacting concrete produced using CKD as a cement replacement material", Elsevier – Construction and Building materials 2015.
[7] IS: 4031-1988,"Methods of testing for hydraulic cement".
[8] IS: 2386-1963,"Methods of testing of aggregates for concrete".
[9] IS: 383-2016,"Coarse and Fine Aggregates for Concrete".
[10] EFNARC guidelines for testing SCC.



10.22214/IJRASET

INDEX COPERNICUS 45.98

ISRA JIF IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY