American Journal of Science and Learning for Development
ISSN: 2835-2157
Volume 03 Number 01 (January) 2024
Impact Factor: 9.58
SJIF (2023): 5.349
www.inter-publishing.com

Development of Self Compacting Concrete with Ternary Cementitious Blend Containing OPC, Silica Fume, and High-Volume Fly Ash

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ABSTRACT
Self-compacting concrete (SCC), alternatively known as "self-consolidating concrete" in North America, refers to a variety of customized concretes engineered to possess specific properties while in their fresh state. The standout attribute of SCC is its capability to seamlessly flow into formwork without segregation, relying primarily on its own weight. The key engineering traits of fresh SCC include resistance to segregation, excellent filling capacity, and exceptional flow split tensile strength and compressive strength ability. The suspension of particles within a matrix forms the fresh SCC, with the composite material's properties being influenced by a comprehension of how the mix composition and constituent materials interact. The composition of SCC varies significantly from country to country due to the availability of resources and amalgamation of local practices. Variations in SCC composition directly impact engineering properties such as strength, creep, durability, and shrinkage. Key challenges and opportunities associated with SCC involve aspects like flow modeling, virtual mix design, robustness, sustainability, and the compatibility of constituent materials.

KEYWORDS: SCC, Sustainability, Flow Modeling etc.

INTRODUCTION

SCC is a type of concrete mixture that can be cast without compaction or vibration and has a high resistance to segregation. Dinakar et al. (2008) suggest that fly ash replacement in SCC can reach up to 70–85% for lower strength grades (20–30 MPa), whereas for higher strength grades (60–90 MPa), the replacement percentage ranges from 30–50%.The characteristics of SCC with FA and silica flume (SF) partially replacing cement. Prasad et al. (2009), employed high volume fly ash in SCC results in a significant increase in compressive strength during later periods such as 56 days and 90 days.Pozzolanic materials will contribute to the strength development and their effect should be considered in the mix design. SCC widely used in problematics situations such as dense reinforcement, hazardous environment, etc.Reliability, quality and durability of concrete get enhanced because of increased homogeneity and compaction of concrete. Hossain and Lachemi (2009) found that binder/water ratio of 0.4, the rapid chloride permeability (RCP) decreased as the volcanic ash percentage increased. Al-Attar and Taha (2018)Leung et al. 2016 found that increasing the cement replacement by fly ash from 50-60% had increased the strength. NTPC Kahalgaon, Bihar, FA has been taken in the study of SCC, chemical property of low calcium fly ash has been taken. SF has never undergone chemical analysis. Data from ELKEM South Asia Pvt. Ltd. in Navi Mumbai has been

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used to determine the chemical properties of SF().Superplasticizers (supinated melamine formaldehyde, naphthalene formaldehyde condensate and polycarboxylic ether base superplasticizers) has been used to water reduction (>25%).Viscosity Modifying Admixtures (VMA) were used in SCC to enhance the paste's rheological characteristics. Its better workability gives uniform concrete strength, and its flow property is easily used in large section, so SCC can be used over normal concrete.However, unavailability of design mix procedure and test standard SCC is globally accepted.

AIM AND SCOPE OF WORK

The study of self-compacting concrete using pozzolanic material such as FA and . FA and are mineral admixture. In this study effect on flowability, strength and durability characteristic of SCC will achieve. The percentage of use in this study was 0%, 4%, 6%, 8% as partial replacement to cement. The percentage of FA was 0%, 10%, 20%, 30%, 40%, 50%, 60%, 80% as partial replacement of cement.The study of flowability characteristics of SCC have been assessed as per EFNARC guidelines with the help of flow ability test.

METHODLOGY

The experimental work consists of mix proportion of self-compacting concrete using the IS 10262-2009. The use of FA and in this study was as per recommended by EFNARC. Using a chemical and mineral admixture, the SCC mix proportioning will be carried out to produce high flow ability concrete free from segregation and bleeding. Various assessments will be employed to evaluate the flow ability of fresh concrete, assessing the concrete's ability to flow and pass through specific configurations. Tensile strength properties will be determined through a split tensile strength test, while the compressive strength characteristics of hardened concrete will be evaluated via a compressive strength test for SCC. To ascertain the durability attributes of SCC, both the sorptivity test and the RCPT have been conducted. In this study, 132 tiny cylinders were used to investigate the absorptivity, RCPT durability characteristics of SCC. For mix proportioning guideline of IS 10262:2009 has been applied.

MATERIALPROPERTIES

Cement, river sand, coarse aggregate, FA, super plasticizer, and water that were readily available locally were the materials utilized for the experimental program. The materials used are covered in detail in the ensuing subsections. Cement physical properties given in Table-1

CEMENT

Table1: Physical Property of Cement

Sl.No.	Testconducted	Observed value
1	Specific Gravity(G)	3.15
2	setting time(Initial)	0.5hrs
3	setting time(Finial)	10hrs
4	Fineness(cm^2/g)	2250
5	Normal consistency	30%

FLYASH

FA samples properties of NTPC Kahalgaon is given below.

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Table 2: Physical Property of FA

Sl.no.	Test Conducted	Values Observed
I.	Specific gravity	2.2
II.	Settingtime(Initial)	45 min
III.	Settingtime(Final)	280 min
IV.	Consistency	35 %
V.	Soundness(autoclave expansion%)	0.06
VI.	Fineness(cm^2/g)	3680

Figure1 shows the FA Sample.

Figure 1: FlyAsh Sample

Table 3 lists the fly ash's chemical characteristics as provided by the NTPC Kahalgaon Power Station.

Table 3: FlyAsh's Chemical Properties

Sl.No.	Conduct Tests	Observed Values (%)	Requirement
a. I	Loss of ignition,	2.65	05.00(max)
II.	Silica expressed as SiO2,	48.2	35.00 (min)
III.	Summation of SiO2 + Al2O3 + Fe2O3,	82.52	70.00(min)
IV.	Presence of available alkalis as Na2O,	0.41	01.50(max)
V.	Reactive silica content,	25.6	20.00(min)
VI.	Magnesium represented as MgO,	2.36	05.00(max)
VII.	Sulphate content denoted as SO3,	2.25	03.00(max)
VIII.	Total chloride concentration,	0.021	.05(max)
IX.	Lime reactivity.	4.6 N/mm^2	04.5(min)

SILICA FUME AS CEMENTITIOUS MATERIAL

Micro silica, sometimes referred to as silica fumes, is a pozzolanic admixture. Elkem South Asia Pvt. Ltd. provided the silica fume (figure). The physical and chemical characteristics of micro silica grade 920D were analyzed to meet the specified parameters outlined in ASTM C 1240. The obtained results are presented in Tables

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Figure 2: Sample of Silica fume

Silica fume's chemical and physical properties have been considered during analysis. As a fine aggregate regular sand from the Sone riverbed has been taken which have Specific gravity (G), FM WA are 2.64,, 2.60 and 1.5 respectively. Local fine and coarse aggregate (Pakur) has been used.A High Range Water Reducing (HRWR) admixture formulated with polycarboxylic ether was utilized. The properties obtained from the manufacturer are outlined. Properties of Chemical admixture is given in table 4. Mix Proportion of SCC is given in table 5

Table 4. Properties of Chemical Admixture

Colour	Light brown liquid
Relative density	1.08 ± 0.01 at 25 °C
pH	≥ 6 at 25 °C
Chloride ion content	< 0.2 %

Target mean strength *ft=68.25 N/mm^2 has been considered for analysis.*

Table 5. Mix Proportion of SCC

Mix No.	Cement (Kg)	% Fly Ash	% Silica Fume	Water/ Binder ratio	Coarse Agg.(Kg)	Fine Agg. (Kg)	Water (liter)	% Chem. Admixture	Extra Water (Kg)
1	515.14	0	0	0.36	814.59	880.2	206.4	2.2	21.09
2	479.08	10	4	0.36	788.19	851.7	206.2	2.2	20.84
3	468.77	10	6	0.36	786.66	850.0	206.2	2.2	20.80
4	458.47	10	8	0.36	785.12	848.3	206.2	2.2	20.76
5	463.62	20	4	0.36	764.87	826.5	206.2	2.2	20.75
6	453.32	20	6	0.36	763.34	824.8	206.1	2.2	20.71
7	443.02	20	8	0.36	761.80	823.1	206.1	2.2	20.67
8	409.53	30	4	0.36	758.31	819.4	206.5	2.2	21.10
9	399.23	30	6	0.36	756.77	817.7	206.5	2.2	21.06
10	388.93	30	8	0.36	755.23	816.0	206.4	2.2	21.02
11	381.20	40	4	0.36	740.57	800.2	206.6	2.2	21.16
12	370.90	40	6	0.36	739.03	798.5	206.5	2.2	21.12
13	360.59	40	8	0.36	737.50	796.9	206.5	2.2	21.08
14	352.87	50	4	0.36	722.83	781.0	206.6	2.2	21.21
15	342.56	50	6	0.36	721.30	779.4	206.6	2.2	21.17
16	332.26	50	8	0.36	719.76	777.7	206.5	2.2	21.13
17	296.20	70	4	0.36	687.36	742.7	206.7	2.2	21.33
18	285.90	70	6	0.36	685.82	741.0	206.7	2.2	21.29

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19	275.59	70	8	0.36	684.29	739.9	206.7	2.2	21.25
20	267.87	80	4	0.36	669.62	723.5	206.8	2.2	21.39
21	257.57	80	6	0.36	668.09	721.9	206.8	2.2	21.35
22	247.26	80	8	0.36	666.55	720.2	206.7	2.2	21.31

FLOWABILITYTEST

Different tests such as Slump flow test, V-Funnel test, L-Box test and J-Ring test were used for checking SCC properties. Slump flow test (EFNARC 2002) has been used for SCC and its recommended values for T500values are 2-5 sec. This ratio of heights is termed as blocking ratio, which indicates the passing ability of SCC. Recommended value of V-funnel test is 6-12sec.

VARIOUS STRENGTH TESTS

Compressive Strength has been carried by two types of specimens, which dimensions and load is given in table 6

Table 6. Load and specimen details

S.No	Specimen Dimensions (mm) IS: 10086-1982	Load Applied
1	150 Cube	140 kg/cm^2/min
2	150 and300 (Dia. & Height)	140 kg/cm^2/min

Brazilian test has been carried with specimen size 15 cm in diameter and 30 cm in height on CTM, and loading rate as per IS: 5816-1999. For RCPT the sample is placed in spacer ring and from both sides of spacer ring rubber gasket is provided after this stainless-steel wire mess is provided both sides of sample than whole assembly is placed between cell block ends. The left containers (with red color jack) fill with 0.3 Normal NaOH solutions. The right containers (with black color jack) fill with 3.0 % NaCl solution.

Figure 3: Setup for RCPT Test

To find the sorptivity of concrete the cubesampleswerecastedinlabofsize100mm ×50mm,it is curing for28 days in water after this sample is taken out. Further, this concrete samples were tested for sorptivity, the sample is placed in water such that the water level is ≤5 mm from the immersing surface of the specimen.

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RESULTS AND DISCUSSIONS

The results derived from the slump flow test are outlined, while Figure 4 a comparative analysis of these findings.

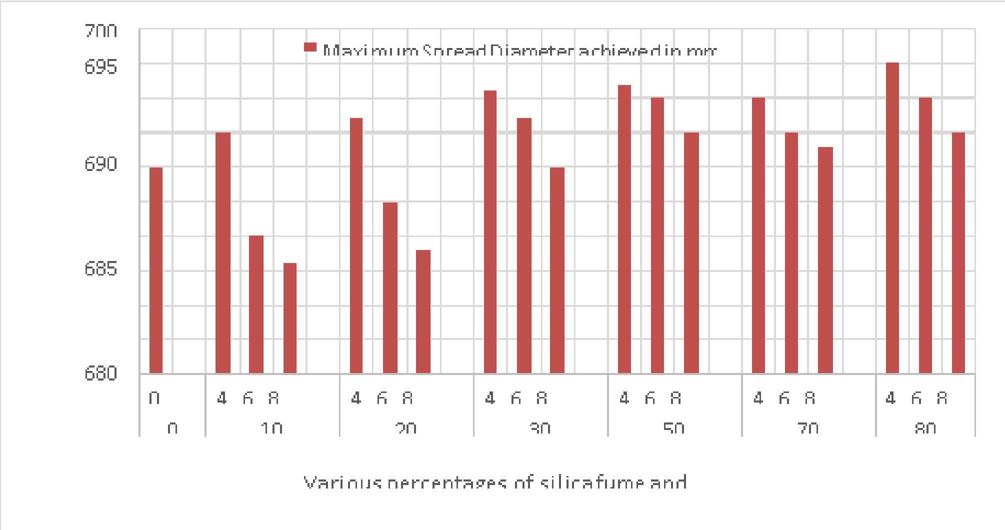

Figure 4: Flow ability Test Results

The outcomes of compressive strength tests are summarized table in table 7 and comparative study are depicted in figure 4

Table 7: Test Results For Compressive Strength

Mixno.	% of Flyash by Weight of Cement	% of Silica Fume by Weight of Cement	Compressive Strength Test Results of Cubein MPa		
			14Day	28Day	56Day
1	0	0	36.45	53.52	64.75
2		4	35.78	53	65.42
3	10	6	36.12	53.78	66.57
4		8	36.98	54.75	66.97
5		4	36.19	54.87	66.57
6	20	6	36.78	55.19	67.54
7		8	37.45	55.79	67.98
8		4	37.75	55.78	67.54
9	30	6	37.92	56.12	68.42
10		8	38.11	56.86	70.65
11		4	38.95	56.97	69.48
12	50	6	39.12	57.65	70.35
13		8	39.97	57.95	72.45
14		4	37.54	55.47	66.75
15	70	6	37.93	55.78	67.28
16		8	38.12	56.12	67.46
17		4	36.98	53.98	63.98
18	80	6	37.12	54.12	64.85
19		8	37.45	54.58	65.25

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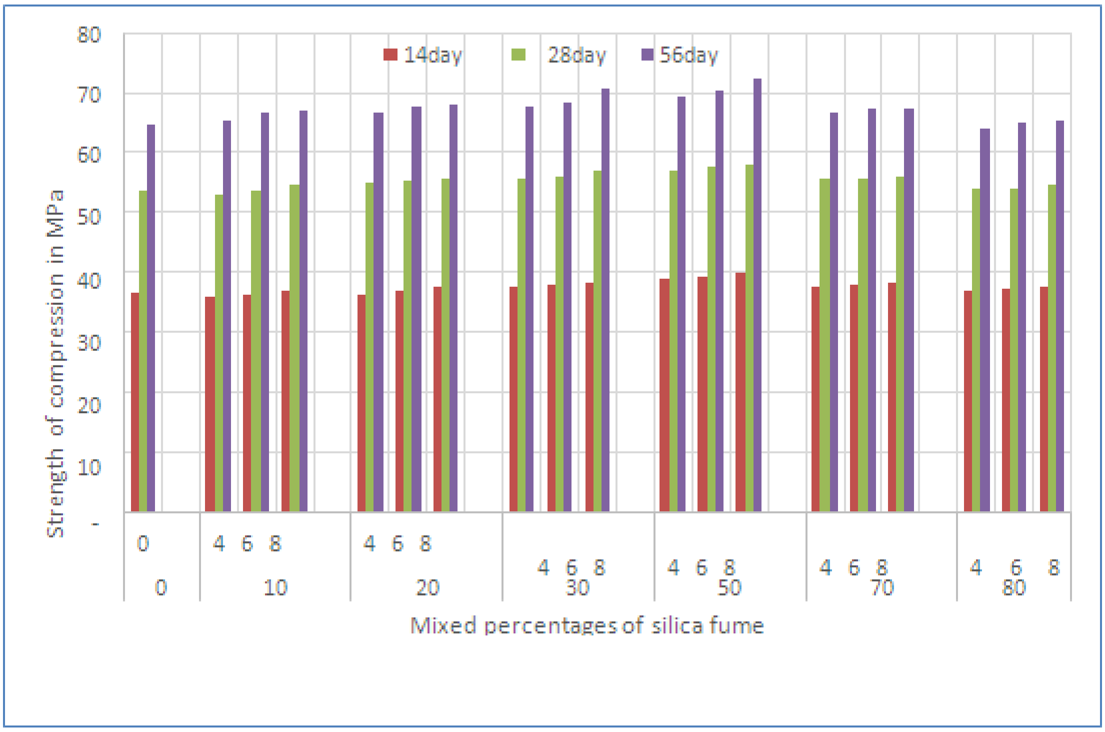

Figure 5: Compressive Strength Test Results

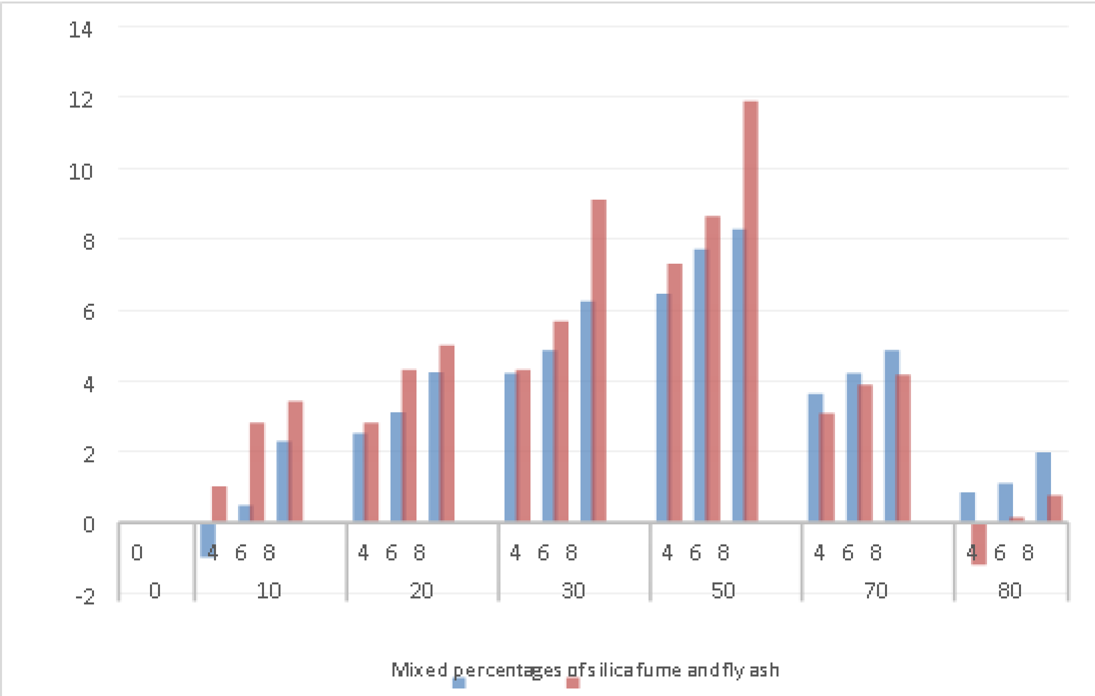

Figure 6: Percentage Change in Compressive Strength

The test results of split tensile strength and compressive strength these cylinder specimens are depicted graphically in figures 6 and 7, and a detailed summary is provided.

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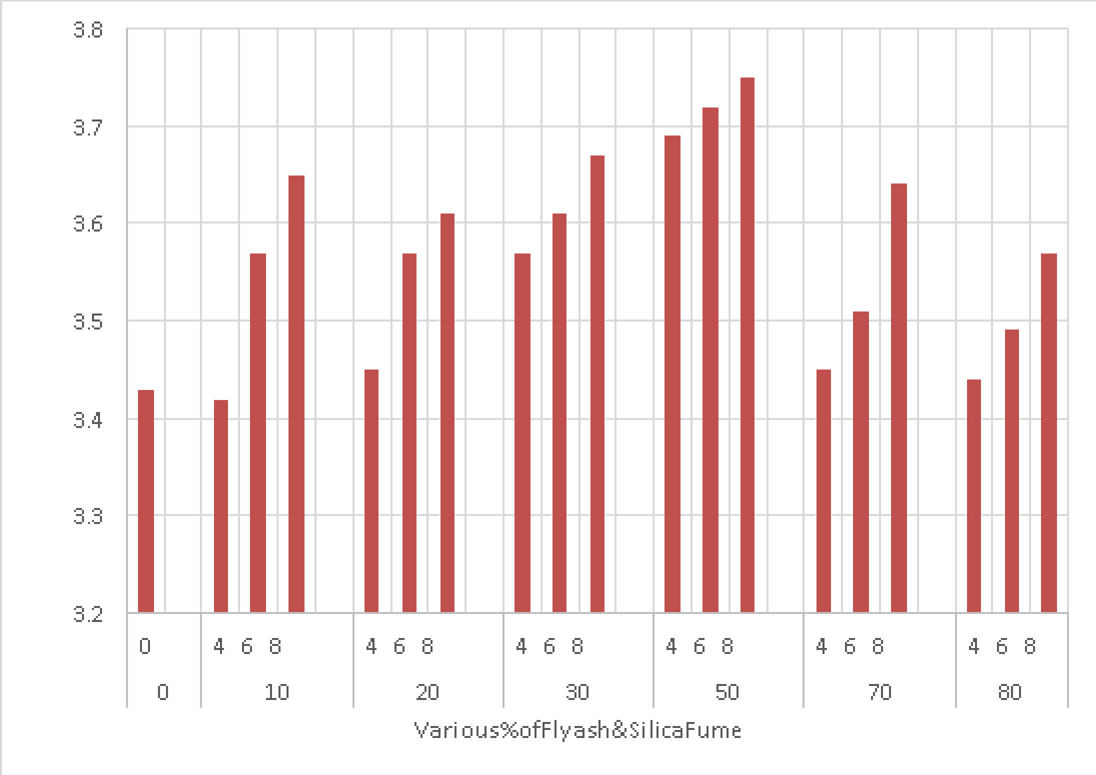

Figure 7: Split Tensile Strength Test Results

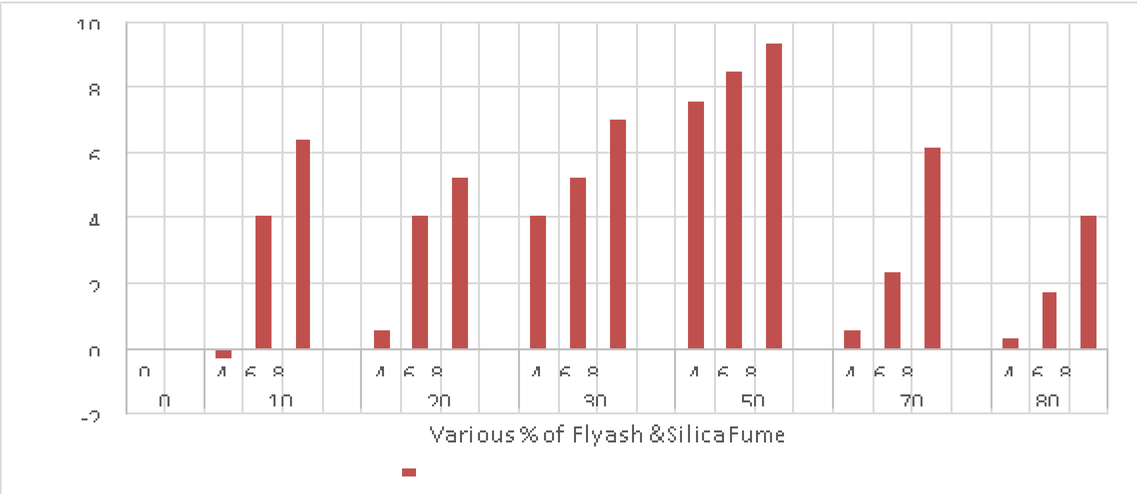

Figure 8: Percentage Change in Split Tensile Strength

RCPT measures concrete durability indirectly. Chloride ion penetration through the concrete sample depends upon the various factors such as homogeneity of concrete, amount of damage, pressure height and concentration of chloride ionThe most trustworthy and widely used test to assess the durability of concrete is the RCPT test. To ascertain the durability of concrete in a fire-exposed condition, the RCPT test was conducted at various temperatures. The basic concept of RCPT test is that the more charge passes through the highly permeable concrete and vice versa.

The ability of concrete samples to withstand the passage of chloride ions through them was used to gauge their durability.

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The basic assumption of this test is that more charge pass through highly porous concrete. The quantity of charge that passed through the concrete sample were measured after 6 hours. One side of concrete sample was immersed in NaOH solution which is strong base and other side was immersed in NaCl solution which is salt. The direct current of 60 V passes through the concrete sample and kept continuous until the test was finished. The charge that was passed through the specimen is noted in terms of coulombs. The charge that noted was indirect measurement of durability and chloride ion permeability of concrete.

Table 8: Chloride Ion Penetrability Based on Charge Passed (ASTMC1202)

Chloride Penetration	56 – Day Rapid Chloride Permeability Charge Passed (Coulombs)
High	>4,000
Moderate	2,000 to 4,000
Low	1,000 to 2,000
Very Low	100 to 1,000
Negligible	< 100

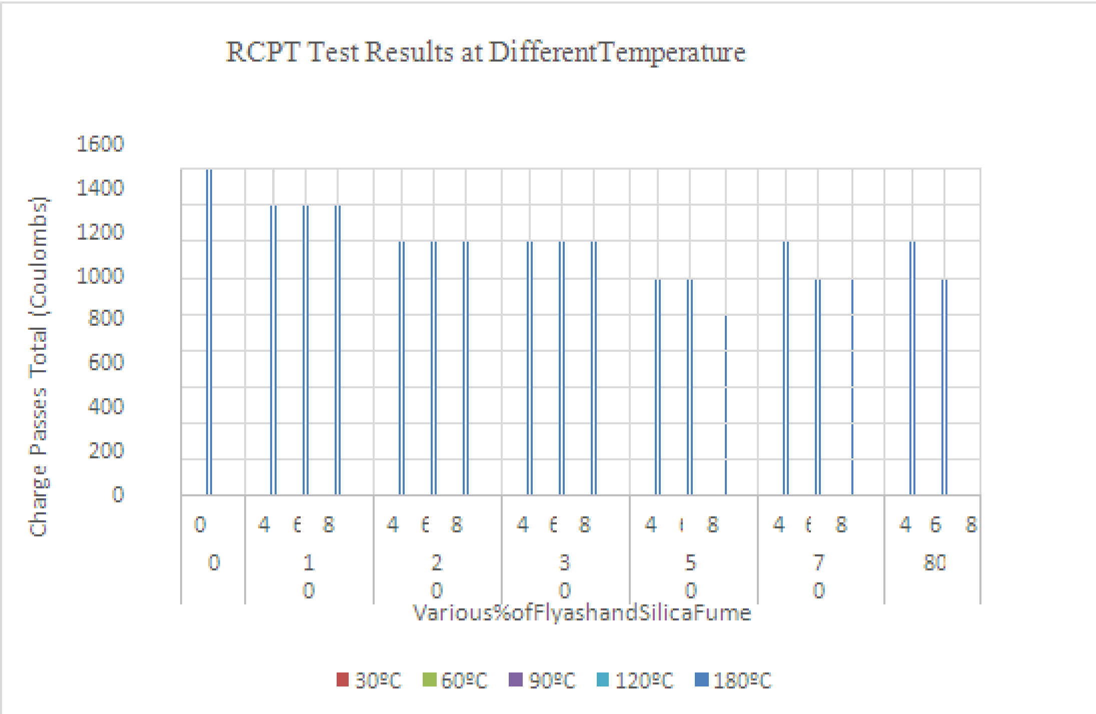

Figure 9: RCPT Test Results at Different Temperature

The rate at which water permeates a concrete sample's pores is known as its sorbtivity. the water that seeps through because of capillarity. In the lab sorptivity test, it was discovered that the amount of water absorbed per unit area decreased as the percentage of fly ash in SCC mixes increased. This was due to the fine nature of fly ash, which fills the micro air void in the concrete specimens.

Because silica fume is finer than fly ash, it decreased water absorption more than fly ash when it was present in SCC mixes. This suggests that silica fume filler has a higher filler efficiency than fly ash.

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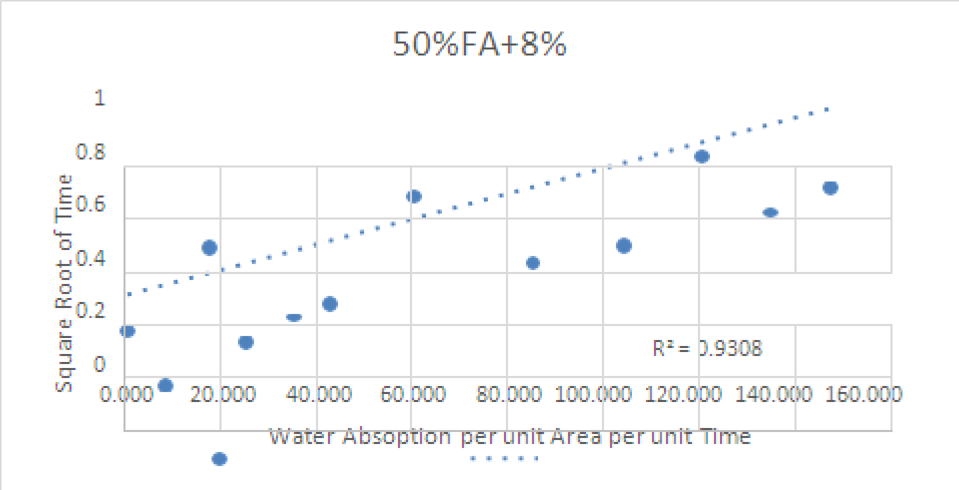

Figure 10: Sorptivity Test Result

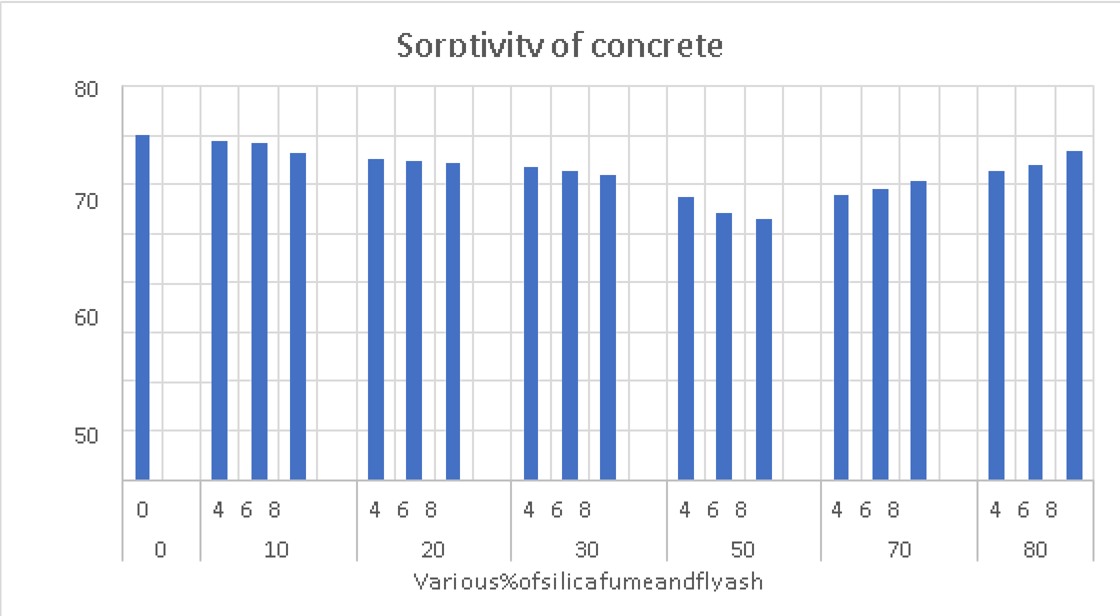

Figure 11: Sorptivity Test Results

Conclusion

An increase in fly ash percentage leads to a rise in the spread diameter of the mix, potentially causing segregation, which is mitigated by the inclusion of silica fume. Silica fume augments the mix's viscosity, thereby reducing the spread diameter and enhancing the segregation resistance. At a given fly ash percentage, increasing the percentage of silica fume leads to an increase in compressive strength. It was found that replacing 8.0% of the cement with silica fume and 50.00% of the fly ash produced superior compressive strength. In comparison to the reference mix, this blend exhibits an 8.30% increase in compressive strength at 28 days and an 11.90% increase in strength at 56 days. The maximum split tensile strength is noted when 50.00% fly ash and 8% silica fume are used in place of cement. When compared to the reference mix, this combination produces a split tensile strength that is higher than 9.3%.

REFERENCES

1. Al-Attar, T. S., and Taha, A. A. (2018). "Performance of High-volume Fly Ash Self-compacting

Concrete Exposed to External Sulfate Attack." Sixth InternationalConferenceon the Durabilityof Concrete Structures,502(July).

2. Benli, A., Karataş, M., and Bakir, Y. (2017). "An experimental study of differentcuring regimes on the mechanical properties and sorptivity of self-compactingmortarswithflyashandsilicafume." Construction andBuildingMaterials.
3. Dean, S., Bassuoni, M., Nehdi, M., and Greenough, T. (2006). "Enhancing theReliability of Evaluating Chloride Ingress in Concrete Using the ASTM C 1202RapidChloridePenetrabilityTest."Journal of ASTMInternational.
4. Dinakar,P.,Babu,K.G.,andSanthanam,M.(2008)."Durabilitypropertiesofhighvolumeflyashself compactingconcretes."Cementand Concrete Composites.
5. Kumar, N., Kumar, P., Kumar, A. and Kumar, R., 2023. An Investigation of Asphalt Mixtures Using a Naturally Occurring Fibre. AMERICAN JOURNAL OF SCIENCE AND LEARNING FOR DEVELOPMENT, 2(6), pp.80-87.
6. Kumar, A., 2023. WEB OF SYNERGY: International Interdisciplinary Research Journal
7. Ajay Kumar and Sujeet Kumar (2023) "Review Paper on Assessment of Deterioration in Concrete Filled with Steel Tubular Section via Guided Waves", World of Science: Journal on Modern Research Methodologies, 2(8), pp. 12–19. Available at: https://univerpubl.com/index.php/woscience/article/view/2444 (Accessed: 8 August 2023).
8. Ajay Kumar,Onkar Yadav,Sagar Kumar, "AN OVERVIEW ARTICLE ON INCORPORATING HUMAN HAIR AS FIBRE REINFORCEMENT IN CONCRETE", International Journal of Creative Research Thoughts (IJCRT), ISSN:2320-2882, Volume.11, Issue 6, pp.e967-e975, June 2023, Available at :http://www.ijcrt.org/papers/IJCRT2306566.pdf
9. Kumar, A. and Bohara, J., A REVIEW REPORT ON INFLUENCE OF FIBER ADDITION ON THE MECHANICAL AND DURABILITY CHARACTERISTICS OF NO-FINES CONCRETE.
10. Kumar, A. and Nirala, B., 2023. Studies on Strength and Durability of Concrete Made with Manufactured Sand. Studies, 7(2).
11. Kumar, P. and Alam, M.F., Seismic Analysis of RC Building with Steel Bracing.
12. Jha, S.K., Prakash, C. and Kumar, A., 2022. Design and Synthesis of Polymer Nano Composite Enamel for Improvement in Weathering and Corrosion Resistance.
13. Kumar, A. and Kadian, A., 2022. Research on Strength and Durability of Concrete Manufactured with Artificial Sand.
14. Dinakar, P., Kartik Reddy, M., and Sharma, M. (2013). "Behaviour of selfcompacting concrete using Portland pozzolana cement with different levels offlyash."Materials andDesign.
15. Ghafoori, N., and Diawara, H. (1999). "Abrasion resistance of fine aggregatereplacedsilicafume concrete." ACIMaterialsJournal.
16. Hossain, K. M. A., and Lachemi, M. (2009). "Fresh, Mechanical, and DurabilityCharacteristics of Self-Consolidating Concrete Incorporating Volcanic Ash."Journalof Materials in Civil Engineering.
17. Khan, M. I., and Siddique, R. (2011). "Utilization of silica fume in concrete: Reviewofdurabilityproperties."Resources, ConservationandRecycling.
18. Kristiawan, S. A., and Aditya, M. T. M. (2015). "Effect of high volume fly ash onshrinkageof self-

compactingconcrete." ProcediaEngineering.

19. Leung, H. Y., Kim, J., Nadeem, A., Jaganathan, J., and Anwar, M. P. (2016)."Sorptivityof self-compactingconcretecontainingflyashand silicafume."Constructionand BuildingMaterials.
20. Ponikiewski, T., and Gołaszewski, J. (2014). "The influence of high-calcium fly ashon the properties of fresh and hardened self-compacting concrete and highperformanceself-compactingconcrete." Journal ofCleaner Production.
21. Prasad, B. K. R., Eskandari, H., and Reddy, B. V. V. (2009). "Prediction ofcompressive strength of SCC and HPC with high volume fly ash using ANN."Constructionand Building Materials.
22. Salem, T. M. (2002). "Electrical conductivity and rheological properties of ordinaryPortland cement-silica fume and calcium hydroxide-silica fume pastes." CementandConcrete Research.
23. Siddique, R. (2011). "Properties of self-compacting concrete containing class F flyash."Materials and Design.
24. Kumar, A. and Kadian, A., Concrete Strength Characteristics as a Result of Artificial Sand.
25. Kumar, A., Yadav, O. and Kumar, A.N., A REVIEW PAPER ON PRODUCTION OF ENVIRONMENT FRIENDLY CONCRETE BY USING SEWAGE WATER. International Journal of Creative Research Thoughts (IJCRT), ISSN, pp.2320-2882.
26. Kumar, A., & Yadav, O. (2023). Concrete Durability Characteristics as a Result of Manufactured Sand. Central Asian Journal of Theoretical and Applied Science, 4(3), 120-127. https://doi.org/10.17605/OSF.IO/8P5HE.
27. Kumar, N. ., Kumar , P. ., Kumar, A. ., & Kumar, R. . (2023). An Investigation of Asphalt Mixtures Using a Naturally Occurring Fibre. AMERICAN JOURNAL OF SCIENCE AND LEARNING FOR DEVELOPMENT, 2(6), 80–87. Retrieved from http://inter-publishing.com/index.php/AJSLD/article/view/1977.
28. Kumar, P. and Singh, A., 2019. Groundwater contaminant transport modelling for unsaturated media using numerical methods (FEM, FDM). Int. J. Recent Technol. Eng.(IJRTE), 8(7), pp.2277-3878.
29. Kumar, P., 2023. Detection of air pollution, air quality monitoring, and control using a wireless sensor network. In Recent Advancement of IoT Devices in Pollution Control and Health Applications (pp. 23-28). Woodhead Publishing.
30. Kumar, P., 2023. IoT-based solid waste management and collection system using infrared sensors. In Recent Advancement of IoT Devices in Pollution Control and Health Applications (pp. 29-36). Woodhead Publishing.
31. Kumar, S., Parhi, P.K., Kumar, P. et al. Zone-Wise Optimal Operation Policy and Evaluation of System Performance Measures. J. Inst. Eng. India Ser. A 102, 1129–1138 (2021). https://doi.org/10.1007/s40030-021-00553-w
32. Roy, S. and Kumar, P., 2021. Comparative Review of Defluoridation Efficiency in Wastewater. International Journal of Prevention and Control of Industrial Pollution, 7(1), pp.15-21.
33. Kumar, A. and Yadav, O., 2023. Effect of Fiber Reinforcement on the Tensile Strength and Ductility of Fly Ash Based Composites. Web of Synergy: International Interdisciplinary Research Journal, 2(6), pp.137-143.
34. Kumar, A. and Yadav, O., 2023. Concrete Durability Characteristics as a Result of Manufactured Sand. Central Asian Journal of Theoretical and Applied Science, 4(3), pp.120-127.

35. Kumar, A., Yadav, O. and Shukla, R., 2023. A COMPREHENSIVE REVIEW PAPER ON PARTIAL CEMENT SUBSTITUTION IN CEMENT MORTAR WITH WOOD ASH. Research in Multidisciplinary Subjects, 1, p.26.

36. Turk, K., Karatas, M., and Gonen, T. (2013). "Effect of Fly Ash and Silica Fume oncompressive strength, sorptivity and carbonation of SCC." KSCE Journal of CivilEngineering.

37. Vaidevi, C., and Kala, T. F. (2016). "Comparative Study on Durability of Self-CompactingConcretewithMarbleWastebyUsingRCPTMethod."7(12),389–393.