International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Experimental Study on Self-Compacting Concrete with Partial Replacement of Cement Using Silica fume and Fly Ash

M. Himangeswari[1], S. Maheswari[2], G. Aishwarya[3], K. Sravan Kumar[4], K Vinay Kumar[5], P Surya Chakra Prabhakar[6]

[1]Assistant Professor, Dr. Lankapalli Bullayya college of Engineering, Resapuvanipalem, Visakhapatnam-530013, Andhra Pradesh, India
[2,3,4,5,6] UG Students, Civil Department, Dr. Lankapalli Bullayya college of Engineering, Resapuvanipalem, Visakhapatnam-530013, Andhra Pradesh, India

Abstract

Self-compacting concrete (SSC) is concrete that can flow under its own weight to fill form work and produce a dense, homogenous material without vibration. It's made with super plasticizers and stabilizers to increase its flowability. Self-compacting concrete (SCC) is a revolutionary technology that has transformed the construction industry. SCC eliminates the need for vibration during placement, ensuring improved durability, reduced labor costs, and enhanced surface finish. It is also known as flowable, self-consolidation and Non vibration concrete. It is enormously consistent and highly flowable, without the loss of stability, and more over it can flow due to its weight, fill the formwork and achieve complete compaction even in the presence of crowded reinforcement. In this project, the M40 grade is selected and tests conducted for self-compacting concrete are the slump flow test, V- funnel test, and L-box test. After conducting these test the mechanical properties like compressive strength, and split tensile strength are studied. In this study, cement is replaced with 5-15% silica fume, powder content sufficient amounts of fines (<0.125mm) preferably in the range of 400kg/m^3 to 600 kg/m^3 inclusive of sustainable quantities fine aggregate, and mineral add-mixture like fly ash to improve the desired strength. Durability tests in self-compacting concrete: water penetration test, chloride penetration, carbonation, electrical resistivity, ultrasonic pulse velocity.

Keywords: Self compacting concrete, Silica fume, Fly ash, Superplasticizers, Viscosity-modifying agents.

Introduction

Self – Compacting concrete was first developed in 1985 to achieve durable concrete structures since then been used in practical structures since then ,various investigations have been carried out and this type of companies ,investigations for establishing a rational mix-design method and Self- compatibility testing methods have been carried out from the view point of marking Self -computing concrete a standard concrete .Self -Compacting concrete (SCC) also known as Self consolidating concrete, is a highly fluid type of concrete that can flow and fill frame work under its own weight ,without the need for mechanical vibration . The construction industry has witnessed significant advancements in recent years ,with a growing emphasis on innovative materials and techniques that enhance sustainability , efficiency ,and structural performance . Self -Compacting concrete (SCC) has emerged as a revolutionary technology that addresses these concerns ,offering improved workability, reduced labor cost ,and enhanced durability .

However, the high cost of SCC and Its limited availability have hindered its widespread adoption .To overcome these challenges , researchers have explored the use of supplementary cementitious materials, such as fly ash and fly ash, which are by product of industrial process to improve the properties of SCC ,with a focus on optimizing its composition for improved performance and sustainability.

Methodology:

This study follows a structured methodology to develop and evaluate the mechanical and durability properties of self- compacting concrete (SCC) by using 43-grade OPC cement, 16&20mm coarse aggregate, silica fume, and fly ash. The methodology involves mix design, material selection, mixing, testing, placement, and curing, as detailed below.

I Objective:

The primary objectives of this study are:

1. To Develop a mix design for Self- compacting concrete (SCC) with partial replacement of cement using silica fume and fly ash.
2. To Evaluate the fresh and hardened properties of SCC, including workability, rheology compressive strength, splitting tensile strength, durability aspects.
3. To Compare the performance of SCC with and partial replacement of cement using silica fume and fly ash

II Materials:

1. Cement (53-Grade OPC): Weighed and stored in a moisture-free environment to avoid contamination. Tested for fine ness, consistency, setting time, and compressive strength before mixing.
2. Fine Aggregate (River Sand): Dried and sieved to remove impurities and oversized particles. Tested for specific gravity, fineness modulus, and water absorption before use.
3. Coarse Aggregate (16-20mm Crushed Granite): Washed and dried to remove dust and unwanted fine particles. Tested for specific gravity, water absorption, and impact value to ensure quality.
4. Mineral Admixtures-Silica fume & Fly ash: Various fly ash replacement levels (30%, 40% ,50%) were explored. To improve durability and reduce heat of hydration.
5. Silica fume: Different % of silica fume replacement levels (5%,10%,15%) were considered. To enhance compressive strength and reduce permeability.
6. Superplasticizer: (Auramix400): Measured accurately and added in controlled dose to ensure proper dispersion and improved flowability.

III Mix Design and Preparation:

1. Control Mix: A control mix with 100% cement was created as a reference and drying mix of cement, fine aggregate, coarse aggregate and water
2. Variable Mixes: Multiple SCC mixes with different combinations for cement, fly ash and silica fume replacing cement (eg:5%, 10%, 15% silica fume, and 30%, 40%, 50% fly ash).
3. water cement ratio: A consistent water-to- binder ratio was maintained across all mixes for the proportion of cement, fine aggregate, coarse aggregate, mineral admixtures (silica fume, fly ash) and superplasticizer (Auramix400) was finalized through trial mixes to achieve optimum workability and strength.

4. Sample Preparation:
1. Mix the concrete materials according to the mix design using a concrete mixer.
2. Cast the concrete samples (cubes, cylinders) in moulds.
3. Curing the samples under standard (room temperature & relative humidity).

IV Testing and Evaluation:

1. Fresh concrete properties: Slump flow test, Flow table test- were conducted.
2. Hardened concrete properties: Compressive strength tests on cube or cylinder specimens of different ages (7,28days), split tensile strength of cylinder specimens (7,28days), and durability tests were conducted.

V Data Analysis:

1. Analyze the test results statistically to determine the effect of fly ash and silica fume on the properties of self -compacting concrete
2. Compare the properties of the replacing materials with conventional mix.
3. Identify the optimal mix proportions for achieving the desired properties of self -compacting concrete.

VI Result Analysis:

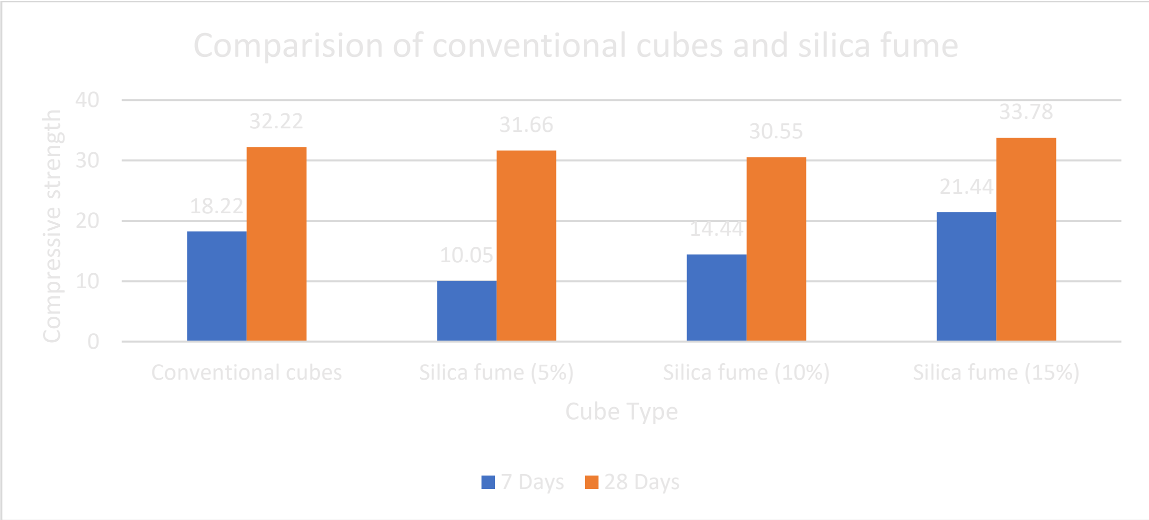
1. Present the results in tables, graphs, and figures. Interpret the results and draw conclusions about the suitability of fly ash and silica fume for SCC.
2. Provide recommendations for future research and practical applications.

Slump flow between conventional concrete & SCC:

Test	Conventional concrete	Self compacting concrete
Slump flow test	392.5mm	575mm

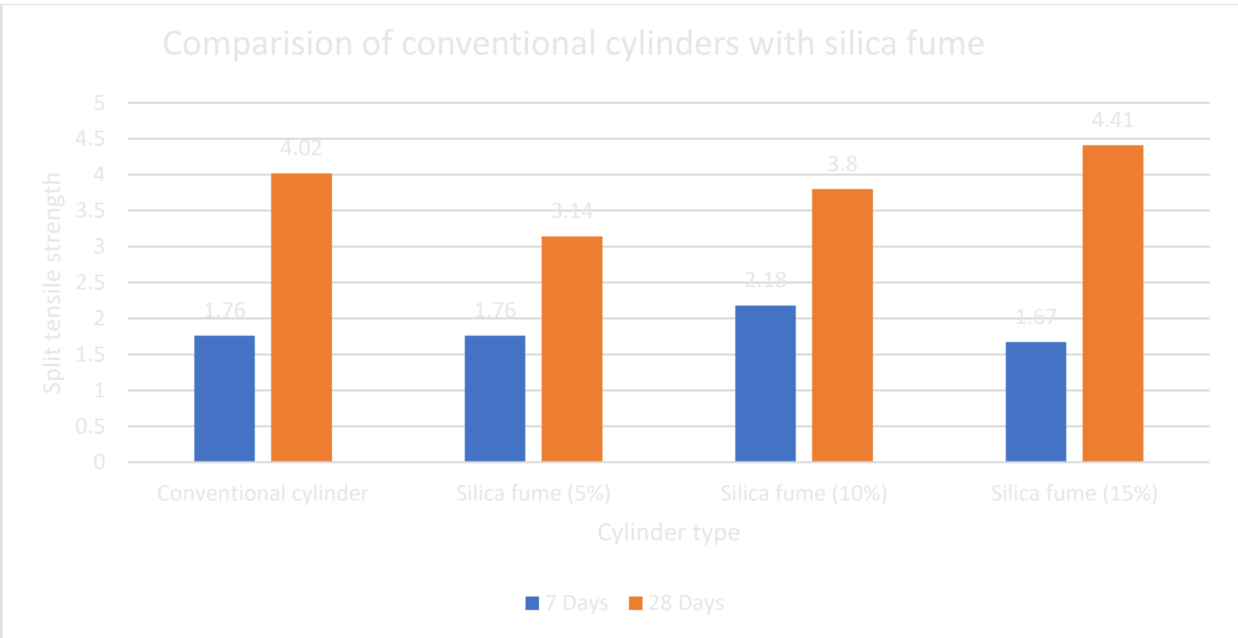
COMPARISION OF COMPRESSIVE STRENGTH BETWEEN CONVENTIONAL CUBES AND SELF COMPACTING CONCRETE BY USING SILICA FUME

s.no	Mix proportions	Compression strength	
		7days	28days
1	Conventional cubes	18.22	32.22
2	SCC 5%Silica fume	10.05	31.66
3	SCC10%Silica fume	14.44	30.55
4	SCC15%Silica fume	21.44	33.78



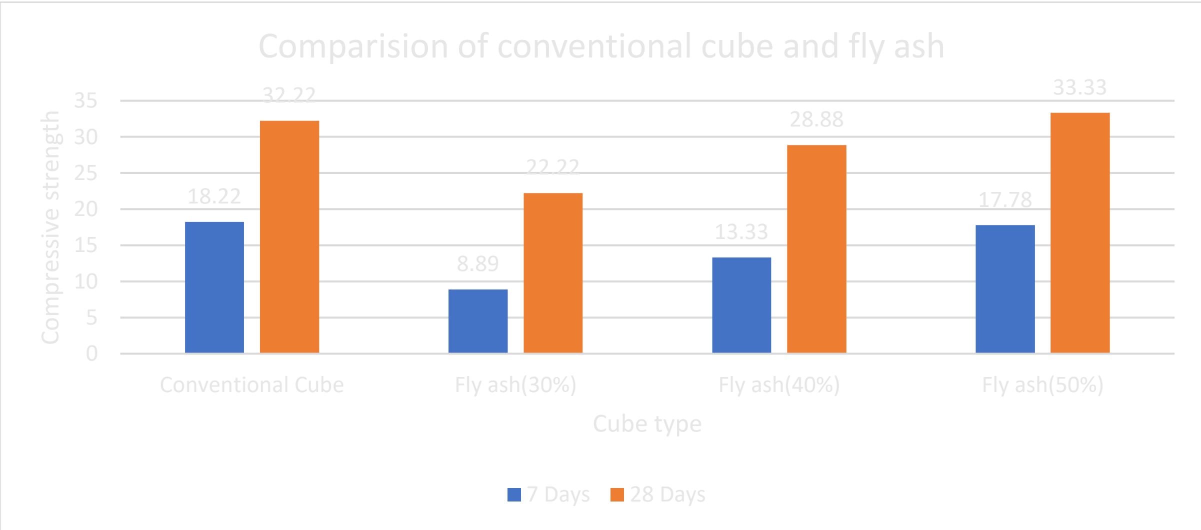
COMPARISION OF SPLIT TENSILE STRENGTH BETWEEN CONVENTIONAL CYLINDERS AND SELF COMPACTING CONCRETE BY USING SILICA FUME.

s.no	Mix proportions	Compression strength	
		7days	28days
1	Conventional Cylinders	1.76	4.02
2	SCC 5%Silica fume	1.76	3.14
3	SCC 10%Silica fume	2.18	3.80
4	SCC 15%Silica fume	1.67	4.41



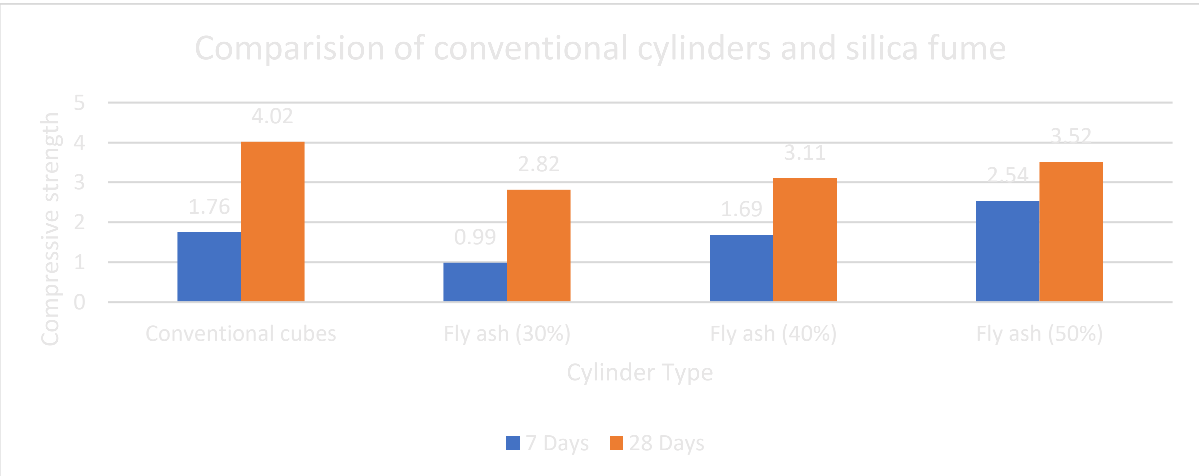
COMPARISION OF COMPRESSION STRENGTH BETWEEN CONVENTIONAL CUBES AND SELF COMPACTING CONCRETE BY USING FLY ASH

s.no	Mix proportions	Compression strength	
		7days	28days
1	Conventional cubes	18.22	32.22
2	SCC 30% Fly ash	8.89	22.22
3	SCC 40% Fly ash	13.33	28.88
4	SCC 50% Fly ash	17.09	33.33

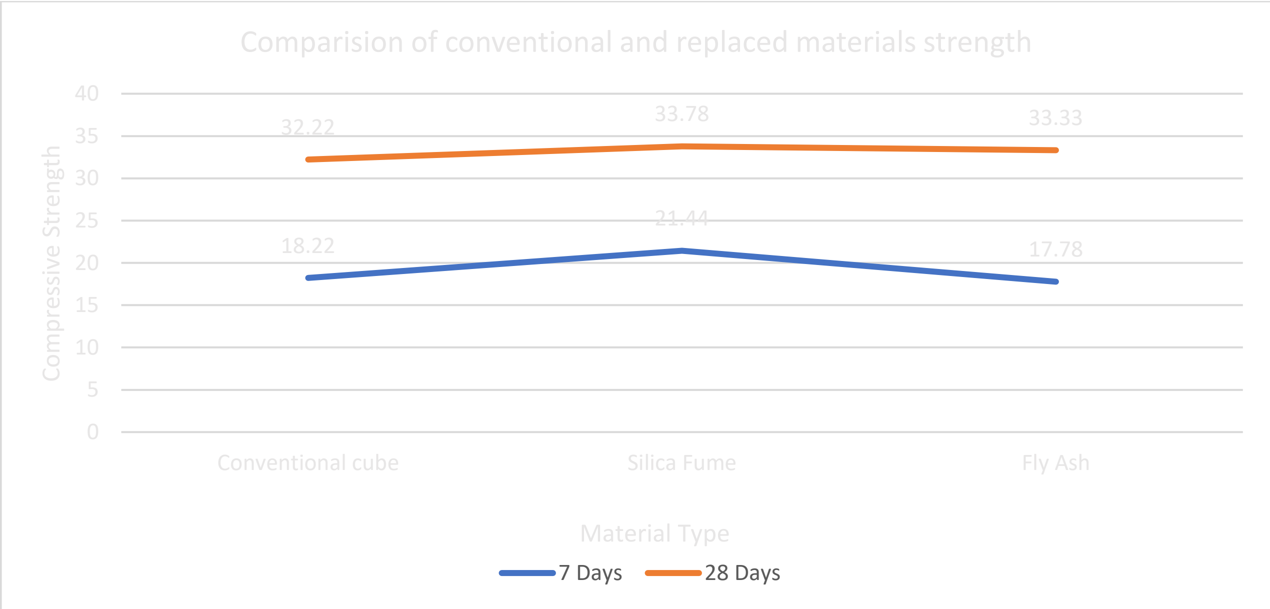


COMPARISION OF COMPARISON OF SPLIT TENSILE BETWEEN CONVENTIONAL CYLINDERRS AND SELF COMPACTING CONCRETE BY USING FLY ASH

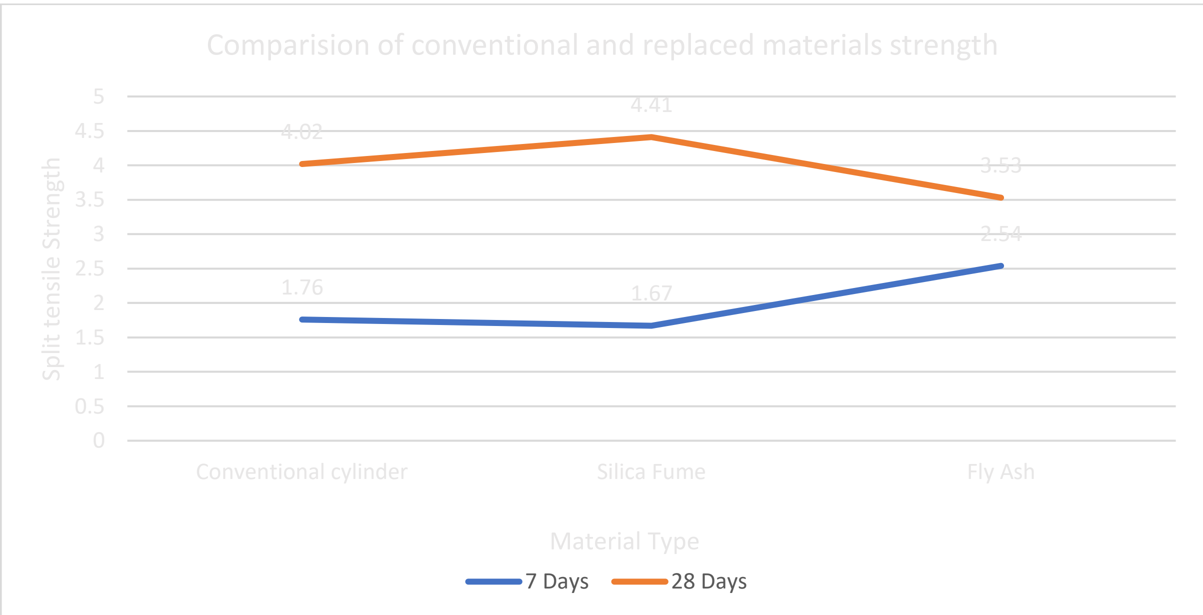
s.no	Mix proportions	Compression strength	
		7days	28days
1	Conventional cylinders	1.76	4.02
2	SSC 30% Fly ash	0.99	2.82
3	SSC 40% Fly ash	1.69	3.11
4	SSC 50% Fly ash	2.54	3.53



s.no	Mix proportions	Compression strength	
		7days	28days
1	Conventional cubes	18.22	32.22
2	SSC silica fume	21.44	33.78
3	SSC Fly ash	17.78	33.33



s.no	Mix proportions	Compression strength	
		7days	28days
1	Conventional cylinders	1.76	4.02
2	SSC silica fume	1.67	4.41
3	SSC Fly ash	2.54	3.53



Conclusion

- The compressive strength for 7days varies from 10.05 Mpa (5% silica fume) to 21.44 Mpa (15% silica fume)
- Conventional cubes exhibited strengths of 18.22 MPa and 21.44 MPa at 7 days, increasing to 32.22 MPa and 33.78 MPa at 28 days
- Split tensile strength for 7days varies from 1.67 (5%silica fume) to 2.18MPa (10% of silica fume). The comparison of compressive strength between conventional concrete cylinders and silica fume concrete cylinders at 7 and 28 days showed notable differences. Conventional cylinders achieved strengths of 1.76 MPa and 2.18 MPa at 7 days, increasing to 4.02MPa and 4.41 MPa at 28 days
- The additional flyash acceleralted the early age strength gain of self compacting concrete, with 7 days the compressive strength ranging from 8.89 Mpa (30% fly ash) to 17.78Mpa (50% fly ash).
- Conventional cubes exhibited strengths of 18.22 MPa and 17.78 MPa at 7 days, increasing to 21.44 MPa and 33.33 MPa at 28 days
- The addition of fly ash accelerated the early age strength gain of SCC with 7days split tensile strength value range from 0.99 MPa (30% fly ash) to 2.54 MPa (50% fly ash).
- Conventional cylinders achieved strengths of 1.76 MPa and 2.18MPa at 7 days, increasing to 4.02MPa and 3.53 MPa at 28 days.
- Silica fume replacement resulted in the highest split tensile strength at days compared to conventional and fly ash mixes.
- Fly ash replacement showed an increase split tensile strength at days compared to the 7days strength, but the resulted in lower strength than the conventional mix at 28days.
- Silica fume replacement resulted in the highest compressive strength at both 7 &28 days compared to conventional and fly ash mixes.
- Fly ash replacement showed a decrease in compressive strength compared to the conventional mix,especially at 28days.

Reference

1. Abdul Aziz, Syed Saqib Mehboob, Qadir Bux, Imran Latif Qureshi (2024 :12326): Enhancing Sustainability in Self-Compacting Concrete by Optimizing Blended Supplementary Materials
2. Jawad Ahamd, Zhigung Zhou, Ahmed Faroulc Deifalla (2023)-Self Compacting Concrete with Partial Substitution of Waste Marble.
3. Jagadesh Jesus Prodo gill, Neemiasilva, Manterio, Rebaca Martinez Garcia (2023: 1483-1498): Assessing the Compressive Strength of Self-Compacting Concrete with Recycled Aggregate Using a Machine Learning.
4. Arul Sivanantham Panneerselvam (2018)- Self-Compacting Concrete: SCC to be made using various mineral admixtures and fibers to meet the demand in the construction industry for large and complex structures, which makes traditional reinforced concrete (RC) difficult to use.
5. Kanlsh Kapoor, S.P. Singh, Bhupindhar Singh (2016): Durability of Self Compacting Concrete Made with Recycled Concrete Aggregate and Mineral Admixtures.
6. Shao, Y., & Huang, Q. (2016) – "Behavior of Self-Compacting Concrete with Recycled Concrete Aggregate"
7. Castro, J., & dos Santos, J. (2010) – "The Use of Self-Compacting Concrete for Prefabricated Concrete Elements"

8. Ferrara, L., & Montagnaro, F. (2009) – "Development and Durability of Self-Compacting Concrete": The studied the durability of SCC by incorporating various pozzolanic materials, such as fly ash and silica fume.
9. Soutsos, M. N., & Leese, J. (2004) – "The Development of Self-Compacting Concrete for Use in Precast Concrete Products"
10. Okamura, H., & Ouchi, M. (2003) – "Self-Compacting Concrete": In this pioneering study, Okamura and Ouchi introduced self-compacting concrete (SCC) and focused on its mix design, highlighting the importance of fine aggregate content and the use of superplasticizers.