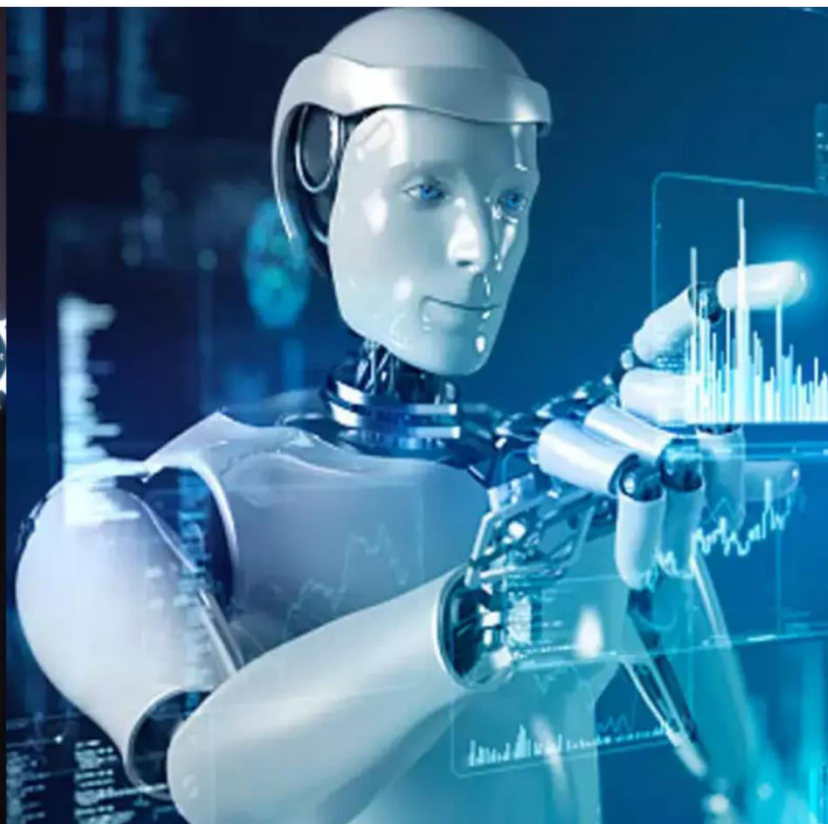




International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 3, March 2025

High Strength Concrete by using Chemical Admixture (Silica Fume)

Shubham Nalawade¹, Yash Kochewad², Yash Labade³, Aditya Garud⁴, Mrs. Preeti Singh Parihar^{*}

Department of Civil Engineering, Rajarshi Shahu Collage of Engineering Polytechnic, Tathawade, Maharashtra, India

ABSTRACT: High Strength Concrete (HSC) is a specialized type of concrete that exhibits superior compressive strength, durability, and workability. The incorporation of chemical admixtures, particularly silica fume, significantly enhances these properties. Silica fume, a byproduct of silicon and ferrosilicon alloy production, is a highly reactive pozzolanic material that refines the microstructure of concrete by reducing porosity and enhancing the interfacial bond between cement paste and aggregates. When added to concrete, it improves compressive strength, durability, and resistance to chemical attacks, making it ideal for high-performance applications such as bridges, high-rise buildings, and marine structures. Additionally, silica fume contributes to sustainability by reducing cement consumption and minimizing environmental impact. This study explores the effectiveness of silica fume as a chemical admixture in achieving high-strength concrete and its potential benefits in modern construction practices.

I. INTRODUCTION

Concrete is the most widely used construction material due to its versatility, strength, and durability. However, with the increasing demand for high-performance structures, traditional concrete often falls short in meeting the required strength and durability parameters. High Strength Concrete (HSC) is an advanced form of concrete that provides superior mechanical properties and enhanced durability, making it suitable for modern infrastructure projects such as high-rise buildings, bridges, and marine structures. Achieving HSC requires modifications to conventional concrete mix designs, including the incorporation of chemical admixtures.

One of the most effective chemical admixtures for enhancing the properties of concrete is silica fume. Silica fume is an ultrafine, highly reactive pozzolanic material obtained as a byproduct of silicon and ferrosilicon alloy production. When added to concrete, it significantly improves compressive strength, reduces permeability, and enhances resistance to environmental factors such as chloride penetration and chemical attacks. This is due to its ability to refine the microstructure of the concrete matrix, filling voids and reducing porosity, thus increasing the overall density and durability of the concrete.

The use of silica fume in HSC not only improves performance but also contributes to sustainable construction practices. By partially replacing cement, silica fume helps reduce carbon emissions associated with cement production while improving the long-term service life of structures. This paper explores the role of silica fume in achieving high-strength concrete, highlighting its benefits, mechanisms, and applications in modern construction.

The main ingredient of concretes is easily available in most of the places which makes concrete even more popular according to IS 456:2000 - Plain and Reinforced concrete- code of practice ordinary concrete, standard concrete and high strength concrete (HSC).

II. LITERATURE REVIEW

[1] In 2002, Skripkiunas et al. found that: The optimum content of naphthalene formaldehyde super-plasticizer in HSC mixture is 1, 1.5%. Silica fumes increase the degree of cement hydration and decreases Ca (OH)₂ quantity in a hardened concrete. [2] In 2005, Safiuddin and Zain concluded that silica fumes provide better stability and good flow properties than fine aggregate because it's segmented the bleed water channels and acted as ball bearings. [3] In 2011, Laskar concluded that it is always difficult to develop a mix design method that can be used universally because same properties of fresh and hardened concrete can be achieved in different ways from same materials. Composition of material and characteristics vary from place to place. [4] In 2012, Sreenivasulu and Shrinivasha Rao concluded that the strength of the concrete may be still increased by reducing water/cement ratio and increase the percentage of silica fumes. [5] In 2012, Turk et al. concluded that the water sorptivity values of SCC specimen decrease with increase in the

replacement of silica fumes from 5 to 20% whilst the water sorptivity value of Self compacting concrete specimens with fly ash systematically increased with increase in the replacement level of Fine Aggregate from 25 to 40%. [6] In 2013, Muhit et al. concluded that Water permeability and strength characteristics of HPC can be improved considerably by replacing OPC with either silica fumes or fly ash. Lowest water permeability 15 mm for fly ash was obtained at 20% by weight. Lowest penetration of water is 11mm. [7] In 2014, Kumar et al. found that Durability characteristics such as water absorption, permeability, sulphate attack resistance and abrasion resistance are low for the fly ash and silica fume based concrete materials as compared with conventional high-performance concrete

III. OBJECTIVES

3.1 Enhance Strength:

1. Improve the compressive strength of concrete to achieve high-performance structural applications.
2. Improve the bond between cement paste and aggregate, leading to better structural integrity.

3.2 Increase Durability:

1. Increase resistance to environmental attacks such as chloride ingress and sulfate exposure.

3.3 Reduce Permeability:

1. Lower porosity to reduce water and chemical ingress, enhancing service life.
2. Improve the densification of concrete microstructure, leading to better impermeability.

3.4 Optimize Mix Design:

1. Determine the ideal dosage of silica fume (typically 7-12%) for maximum performance.
2. Balance workability, strength, and durability through optimized water-cement ratios.
3. Develop cost-effective mix proportions for efficient use in large-scale projects.

3.5 Improve Workability:

1. Improve flowability for easy placement and compaction in high-strength applications.
2. Ensure uniform dispersion of silica fume to achieve consistent results.

3.6 Mitigate Shrinkage & Cracking:

1. Address early-age shrinkage issues by optimizing curing techniques.
2. Reduce microcracking tendencies that could compromise structural integrity.
3. Develop effective reinforcement strategies to control shrinkage-induced cracks.

3.8 Practical Applications:

1. Utilize silica fume-enhanced HSC in high-rise buildings for superior load-bearing capacity.
2. Implement in bridges and marine structures for improved durability and longevity.
3. Apply in infrastructure projects requiring high resistance to wear and tear, such as pavements and tunnels.

IV. MATERIAL USED IN HIGH STRENGTH CONCRETE

1. **Cement:** Cement is the primary constituent for manufacturing concrete. Here Pozzolana Portland Cement (53grade) conforming to IS12269-1987 was used. Specific gravity of cement is 3.15.
2. **Fine aggregate:** Locally available river sand free of silt conforming to IS 383-1970 with specific gravity 2.65 is used.

3. **Coarse aggregate:** Crushed stone aggregate of 10-12 mm size is added from nearby quarry with specific gravity 2.74 confirming to IS 383 1970
4. **Endura Admixture (superplasticizer):** The hyper plasticiser shall be ADDMIX 389, high range water reducing, Superplasticizer based on polycarboxylic ether formulation. The product shall have specific gravity of 1.1 & solid contents not less than 40% by weight.
5. **Silica Fume:** Silica fume is very fine non crystalline silica. It is produced in electric arc furnace having specific gravity 2.64.
6. **Fly Ash:** This is produced from thermal power plant in the form of dry powder confirming to IS 3812-1981
7. **Water:** Water used for mixing and curing should be potable and free from any harmful material

V. METHODOLOGY

In this investigation we replace the cement with mineral admixture such as Metakaolin, Silica fume and Fly ash in various percentages. We take W/c ratio in constant percentage. Here super plasticizer is used for better workability. By using cube of 150 x 150 x 150 mm size, different concrete mixes are cast and test is conducted to find compressive strength at 7 days, 14 days and 28 days curing period.

5.1 Compression test:

The compression test on Concrete is done on the standard size of cube 150 x 150 x 150 mm. The test is performed after 7, 14 and 28 days curing.

The Compression strength is calculated as follows.

$$f_{ck} = P/A$$

Where,

1. P = Load at Failure (N)
2. A = Cross sectional area (mm²)
3. f_{ck} = Compressive Strength (N/mm²)

5.2 Concrete Mix Design:

1. Concrete mix design for M-30 Grade concrete with 10% Silica Fume: -

1. Cement:- 330 Kg/m³
2. Fly-ash :- 70 kg
3. Silica fume :- 40 kg/m³
4. Crushed Sand:- 734 kg/m³
5. Aggregate of 10 mm :- 443 kg/m³
6. Aggregate of 20 mm :- 670 kg/m³
7. Water: - 165 kg/m³
8. Admixture (Endura) :- 5.2 kg/m³
9. W/C ratio:- 0.4125
10. Concrete Grade ratio of M30 grade concrete :- 1 : 1 : 2

3. Concrete mix design for M-30 Grade concrete with 15% Silica Fume: -

1. Cement:- 330 Kg/m³
2. Fly-ash :- 70 kg
3. Silica fume :- 60 kg/m³
4. Crushed Sand:- 734 kg/m³
5. Aggregate of 10 mm :- 443 kg/m³
6. Aggregate of 20 mm :- 670 kg/m³
7. Water: - 165 kg/m³

8. Admixture (Endura) :- 5.2 kg/m³
9. W/C ratio:- 0.4125
10. Concrete Grade ratio of M30 grade concrete :- 1: 1 : 2

VI. RESULTS

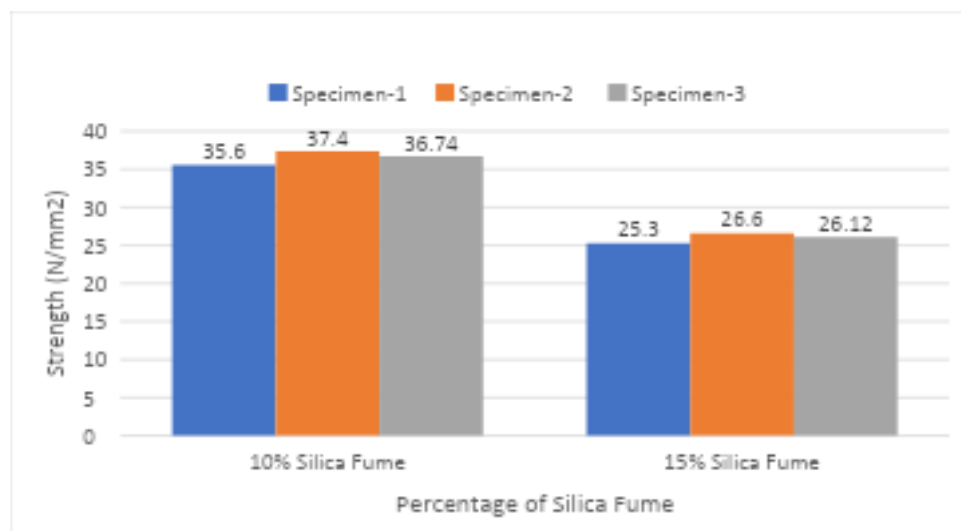
6.1.1 Test report on concrete cube with 10% Silica Fume of 7th day: (23/02/2025)

GRADE OF CONCRETE (M30 GRADE)	TESTING DATE	AGE (DAYS)	WEIGHT (KGS)	MAX LOAD (KN)	STRENGTH (N/mm ²)	AVG
SPECIMEN-1	23/02/2025	07	8.800	802.3	35.60	36.58 N/mm ²
SPECIMEN-2	23/02/2025	07	8850	842.8	37.40	
SPECIMEN-3	23/02/2025	07	8820	826.6	36.74	

6.1.2 Test report on concrete cube with 15% Silica Fume of 7th day:(23/02/2025)

GRADE OF CONCRETE (M30 GRADE)	TESTING DATE	AGE	WEIGHT (Kg)	MAX LOAD (KN)	STRENGTH (N/mm ²)	AVG
SPECIMEN-1	23/02/2025	07	8.634	569.2	25.30	26.01 N/mm ²
SPECIMEN-2	23/02/2025	07	8.624	599.5	26.60	
SPECIMEN-3	23/02/2025	07	8.645	587.9	26.12	

6.1.3 Bar chart representing test reports of 7th day: -



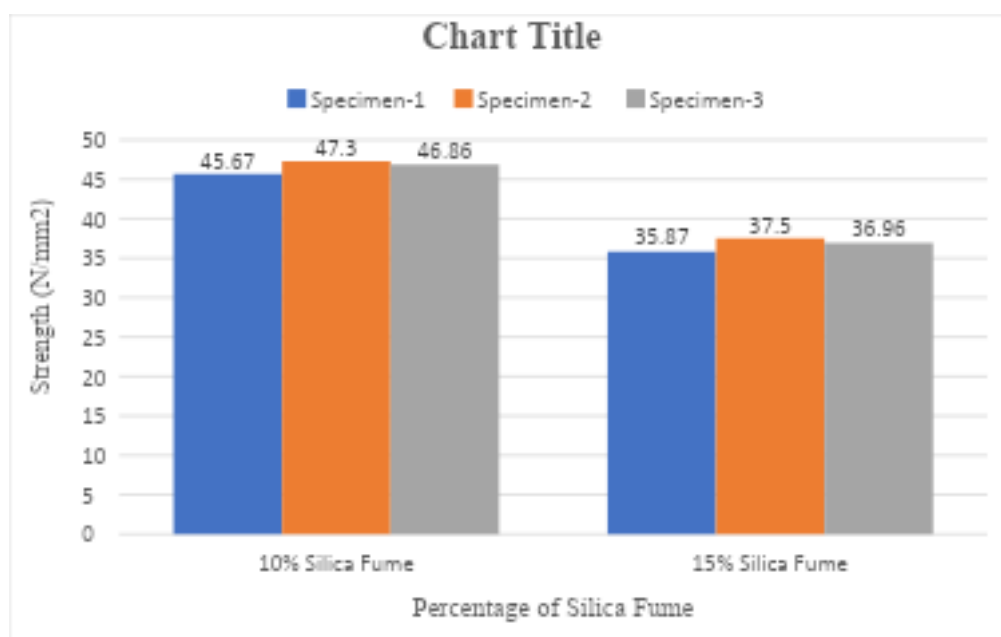
GRADE OF CONCRETE (M30 GRADE)	TESTING DATE	AGE (DAYS)	WEIGHT (KGS)	MAX LOAD (KN)	STRENGTH (N/mm ²)	AVG
SPECIMEN-1	02/03/2025	14	8.935	1050.6	45.67	46.61 N/mm ²
SPECIMEN-2	02/03/2025	14	8.960	1064.9	47.30	
SPECIMEN-3	02/03/2025	14	8.983	1056.7	46.86	

6.2.1 Test report on concrete cube with 10% Silica Fume of 14th day: (02/03/2025)

6.2.2 Test report on concrete cube with 15% Silica Fume of 14th day: (02/03/2025)

GRADE OF CONCRETE (M30 GRADE)	TESTING DATE	AGE (DAYS)	WEIGHT (KGS)	MAX LOAD (KN)	STRENGTH (N/mm ²)	AVG
SPECIMEN-1	02/03/2025	14	8.559	828.9	35.87	36.78 N/mm ²
SPECIMEN-2	02/03/2025	14	8.570	844.3	37.50	
SPECIMEN-3	02/03/2025	14	8.581	836.4	36.96	

6.2.3 Bar chart representing test reports of 14th day: -



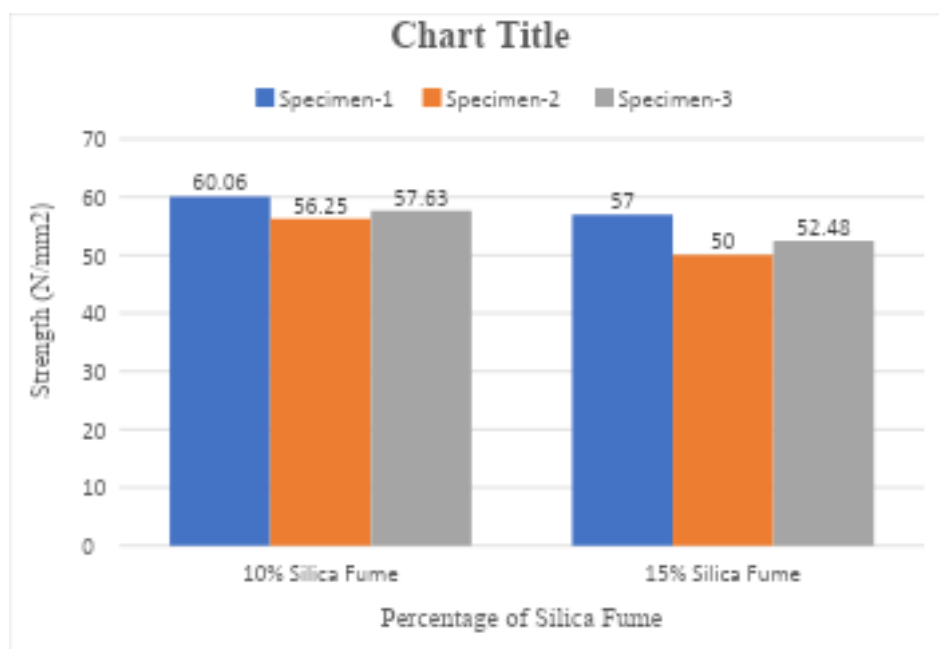
GRADE OF CONCRETE (M30 GRADE)	TESTING DATE	AGE (DAYS)	WEIGHT (KGS)	MAX LOAD (KN)	STRENGTH (N/mm ²)	AVG
SPECIMEN-1	16/03/2025	28	8.810	1351.9	60.06	57.96 N/mm ²
SPECIMEN-2	16/03/2025	28	8.740	1265.6	56.25	
SPECIMEN-3	16/03/2025	28	8.865	1296.7	57.63	

6.3.1 Test report on concrete cube with 10% Silica Fume of 28th day: (16/03/2025)

GRADE OF CONCRETE (M30 GRADE)	TESTING DATE	AGE (DAYS)	WEIGHT (KGS)	MAX LOAD (KN)	STRENGTH (N/mm ²)	AVG
SPECIMEN-1	16/03/2025	28	8.348	1283.8	57.00	53.16 N/mm ²
SPECIMEN-2	16/03/2025	28	8.452	1125.5	50.00	
SPECIMEN-3	16/03/2025	28	8.510	1180.9	52.48	

6.3.2 Test report on concrete cube with 15% Silica Fume of 28th day: (16/03/2025)

6.3.3 Bar chart representing test reports of 28th day: -



VII. DISCUSSION AND CONCLUSION

The findings of this study provide valuable insights into optimizing the use of silica-based additives, such as micro-silica and nano-silica, in HSC mixtures with varying partial replacement of cement. This knowledge can contribute to the design and production of more sustainable and durable high-strength concrete structures. The following conclusions were derived from the experimental investigation:

1. As w/c ratio is low superplasticizer is required for better workability.
2. For High strength concrete 10 – 12 mm size coarse aggregate gives better results than 20 mm size aggregate.
3. For higher the strength of concrete lower the w/c ratio required.
4. The max strength achieved at 28 days is 60.06 Mpa with replacement of mineral admixture 10% Silica fume to cement.
5. The max strength achieved at 28 days is 57.00 Mpa with replacement of mineral admixture 15% Silica fume to cement.
6. The percentage of mineral admixtures such as Fly ash, Metakaolin, Silica fume are gives better results in combination of two admixtures than single.
7. It observed that workability of concrete decreases when adding mineral admixtures.
8. The optimum dosage of replacement mineral admixtures to cement is 10-15%. But 10% gives out maximum outcome.

VIII. FUTURE SCOPE

The future scope of High-Strength Concrete (HSC) using silica fume is vast, driven by advancements in infrastructure, sustainability, and smart construction technologies. In infrastructure development, HSC with silica fume will be widely used in high-rise buildings, long-span bridges, tunnels, and marine structures due to its superior strength, durability, and resistance to environmental factors like chloride and sulphate attacks. Its low permeability and high strength make it ideal for critical applications such as dams, flyovers, and underground structures, ensuring long service life with minimal maintenance.

From a sustainability perspective, silica fume in HSC reduces cement consumption, lowering CO₂ emissions and promoting the use of industrial byproducts like fly ash and GGBS. The enhanced durability and reduced maintenance requirements make HSC a preferred choice for eco-friendly construction, contributing to a circular economy. Additionally, advanced concrete technologies such as Ultra-High-Performance Concrete (UHPC), self-healing concrete, and 3D-printed structures will benefit from silica fume's superior bonding properties and strength-enhancing characteristics.

ACKNOWLEDGMENT

We extend our heartfelt gratitude to our Principal, **Dr. S. S. Gaikwad**, and our Head of Department, **Mrs. L. K. More**, for their invaluable guidance and unwavering support throughout the completion of our project, **“High Strength Concrete By Using Chemical Admixture (Silica Fume)”**. Specially, we express our sincere appreciation to our project guide, **Mrs. P.S. Parihar** and project coordinator, **Mrs. P.S. Parihar**, whose expertise and mentorship have been instrumental in the success of this endeavour. We also acknowledge and appreciate all staff of the civil department who were indirectly involved in providing guidance and support.

REFERENCES

1. “Effect of Metakaolin Content on the Properties of High strength concrete” (P. Dinakar, Pradosh K. Sahoo, and G. Sriram) International Journal of Concrete Structures and Materials Vol.7, No.3, pp.215–223, September 2013 DOI:10.1007/s40069-013-00450-1 ISSN 1976-0485 / eISSN 2234-1315.
2. “Strength Development Characteristics Of High Strength Concrete Incorporating An Indian Fly Ash” (Arka Saha, Dr. Samresh Pan, Soumen Pan) international journal of technology enhancements and emerging engineering research, vol 2, issue 6 101 issn 2347 4289/2014.
3. “High Strength Concrete using Supplementary Cementing Materials and Chemical Admixtures” (Dr. M. Vijaya Sekhar Reddy, Dr.M. C. Nataraja Dr. I. V. Ramana Reddy, J. Rajendra Prasad M. Sesha Lalitha) The Masterbuilder March 2015/Investigation: High strength Concrete.

4. "Strengthening effect in high strength Silica fume Concrete" (Vijay Agarwal, Rajesh Gupta, Ajaykumar Gautam) International Journal of Advances in Mechanical and Civil Engineering, ISSN: 2394-2827 Volume-3, Issue 4, Aug.-2016.
5. "Study of High Strength Concrete using Metakaolin at elevated Temperatures" (P. Muralinatha, A. Joshu Daniel, S. Sivakamasundari) IJPAM Volume 119 No14 2018,1267-1273.
6. "Experimental Investigations on M80 Grade Concrete Using Supplementary Cementitious Materials" (Malavika Chakravarthy P.G Fayaz. Shaik) IJLTEMAS Volume V Issue XI November 2016/ISSN 2278-2540.
7. "Characteristics of High-Performance Concrete Using Metakaolin" (B. Naresh Goud, K. Nagaraj) International Journal of Innovative Research in Science, Engineering and Technology Vol. 6, Issue 8, August 2017.
8. Karumanchi Meeravali, Avula Gopikrishna, Regulagunta Madhu, Vipparla Veera Brahmachari and Pathakota Brahma Reddy, "Design of high strength concrete-M100 grade using silica fumes, fly ash and super plasticizer," Pramana Research Journal, vol. 8, no. 7, pp. 31-40, 2018.
9. Kazim Turk, Mehmet Karatas and Tahir Gonen, "Effect of fly-ash and silica fumes on compressive strength and carbonation of SCC", KSCE Journal of Civil Engineering, vol.17, no.1 pp. 202-209, 2013.

BIOGRAPHY

<p>Prof. Preeti Singh Parihar (BE) Civil Engineering (ME) Construction Technology & Management "Civil Department" JSPM's College of Engineering Tathawade Pune. Paper published:02</p>	
<p>Mr. Shubham Ramakant Nalawade Pursuing Diploma in civil engineering third year, At JSPM'S, Rajarshi Shahu college of engineering and polytechnic, Tathawade, Pune-33. Skills: - Technical Knowledge in Civil Engineering</p> <ol style="list-style-type: none"> 1. Understanding fundamental engineering concepts related to structures, transportation, geotechnics, water resources, etc. 2. Explaining complex engineering projects in a simplified manner for a general audience. 3. Recognizing the significance of the engineer's contributions to the field. 	
<p>Mr. Yash Parmeshwar Kochewad Pursuing Diploma in civil engineering third year, At JSPM'S, Rajarshi Shahu college of engineering and polytechnic Tathawade, Pune -33. Skills: - Analytical and Critical Thinking Skills</p> <ol style="list-style-type: none"> 1. Evaluating the engineer's impact on society, infrastructure, and technological advancements 2. Comparing their work with other engineers and historical developments in civil engineering 3. Drawing connections between their innovations and modern engineering practices 	
<p>Mr. Aditya Bharat Garud Pursuing diploma in civil engineering third year, At JSPM'S, Rajarshi Shahu college of engineering and polytechnic, Tathawade, Pune-33 Skills: - Organization and Time Management</p> <ol style="list-style-type: none"> 1. Creating a timeline of the engineer's life and career milestones. 2. Prioritizing significant contributions and avoiding unnecessary details. 3. Managing deadlines for research and writing. 	

Mr. Yash Balu Labade

Pursuing Diploma in civil engineering third year

At JSPM'S, Rajarshi shahu college of engineering and polytechnic, Tathawade, Pune-33.

Skills: - Research Skills

1. Gathering information about the engineer's education, career, and achievements
2. Using credible sources such as academic journals, technical reports, and professional organizations (e.g., ASCE, ICE)
3. Avoiding plagiarism by correctly summarizing and paraphrasing information.





INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details