iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** VI **Month of publication:** June 2026

DOI: https://doi.org/10.22214/ijraset.2026.83389

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

Comparison between Waste Fine Material Concrete and Conventional Concrete

Jayant Satish Mehare[1], Prof. Riyaz Sameer Shah[2]
[1]PG Student Masters of Technology in Structural Engineering, Department of Civil Engineering, Prof. Ram Meghe Institute of Technology & Research, Badnera, Maharashtra, India
[2]Assistant Professor, Department of Civil Engineering, Prof. Ram Meghe Institute of Technology & Research, Badnera, Maharashtra, India

Abstract: The growing demand for concrete and the environmental concerns associated with excessive cement consumption have encouraged the utilization of industrial by-products in concrete production. This study presents a comparison between conventional M25 grade concrete and waste fine material concrete incorporating silica fume and fly ash as partial replacements of cement. All concrete mixes were prepared using 100% crushed sand as fine aggregate and crushed stone as coarse aggregate. Silica fume was incorporated at replacement levels of 10%, 15%, and 20%, while fly ash was used at 10%, 20%, and 30%. In addition, combined mixes containing both silica fume and fly ash were investigated at total replacement levels of 10%, 20%, and 30% to evaluate their combined influence on concrete properties. The fresh concrete characteristics were determined through slump cone tests, whereas the hardened concrete properties were assessed using compressive strength, split tensile strength, and flexural strength tests at specified curing periods. The experimental findings showed that the incorporation of silica fume and fly ash affected both workability and strength development of concrete. Concrete containing combined proportions of silica fume and fly ash exhibited improved mechanical performance compared to conventional concrete due to enhanced particle packing and pozzolanic activity. The use of these waste fine materials also contributed to a reduction in cement consumption while maintaining the required strength characteristics. The study concludes that concrete produced with 100% crushed sand and suitable proportions of silica fume and fly ash can serve as an effective and sustainable alternative to conventional concrete, supporting resource conservation and environmentally responsible construction practices.
Keywords: Waste Fine Material Concrete, Conventional Concrete, Silica Fume, Fly Ash, Combined Replacement, 100% Crushed Sand, M25 Concrete, Harden Concrete Tests.

I. INTRODUCTION

Concrete is one of the most widely used construction materials due to its versatility, durability, strength, and suitability for various structural applications. Conventional concrete is primarily composed of cement, fine aggregate, coarse aggregate, and water. Among these constituents, cement production and the excessive consumption of natural resources contribute significantly to environmental concerns, including carbon dioxide emissions, depletion of natural materials, and increased energy consumption. As the demand for infrastructure continues to grow, the development of sustainable and environmentally responsible concrete has become an important area of research. Fine materials play a vital role in determining the fresh and hardened properties of concrete. The quality and characteristics of these materials directly influence workability, strength development, durability, and overall performance. Traditionally, Ordinary Portland Cement (OPC) is used as the primary binding material in concrete. However, the manufacturing of cement is associated with substantial environmental impacts. Therefore, the utilization of industrial by-products and waste materials as supplementary cementitious materials has gained significant attention in recent years.

Silica fume and fly ash are two widely available industrial waste materials possessing excellent pozzolanic properties. Silica fume is an ultrafine by-product generated during the production of silicon and ferrosilicon alloys, while fly ash is obtained from coal-fired thermal power plants. Large quantities of these materials are produced annually, and their disposal presents environmental challenges. The incorporation of silica fume and fly ash in concrete not only helps in effective waste management but also reduces dependence on conventional cement, thereby supporting sustainable construction practices.

Previous studies have reported that silica fume improves particle packing, enhances the interfacial transition zone, and contributes to higher compressive, tensile, and flexural strength. Similarly, fly ash improves workability, reduces heat of hydration, and enhances long-term strength through pozzolanic reactions. The combined use of silica fume and fly ash can provide synergistic benefits by improving both fresh and hardened concrete properties while reducing environmental impact.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

In the present study, M25 grade concrete prepared with OPC 53 grade cement and 100% crushed sand is investigated. Silica fume and fly ash are used individually and in combination as partial replacements of cement at different replacement levels. The performance of waste fine material concrete is compared with conventional concrete through evaluation of workability, compressive strength, split tensile strength, and flexural strength at different curing ages. The study aims to assess the effectiveness of waste fine materials in improving concrete performance while promoting sustainable and economical construction practices.

Accordingly, this research focuses on assessing the suitability of silica fume and fly ash as waste fine materials for producing sustainable M25 grade concrete. Different replacement percentages of cement are adopted to examine their influence on the behaviour of concrete in both fresh and hardened states. Experimental investigations include workability assessment through slump testing, compressive strength evaluation at various curing periods, and determination of split tensile and flexural strengths. The main objective of the study is to identify an effective replacement level that can enhance concrete performance while reducing cement consumption, encouraging the beneficial utilization of industrial by-products, and supporting environmentally sustainable construction practices.

A. Objectives of the Study

The key objectives of this investigation are outlined below:

1) To evaluate the feasibility of utilizing waste fine materials such as silica fume and fly ash as partial replacements of cement in M25 grade concrete.
2) To investigate the influence of silica fume, fly ash, and their combined incorporation on the fresh and hardened properties of concrete, including workability, compressive strength, split tensile strength, and flexural strength.
3) To compare the mechanical performance of waste fine material concrete with conventional concrete prepared using Ordinary Portland Cement and crushed sand.
4) To analyze the effect of different replacement levels of silica fume and fly ash on the strength development of concrete at early-age and later-age curing periods.
5) To assess the contribution of waste fine materials towards sustainable concrete production through reduced consumption of conventional cementitious materials.
6) To examine the potential improvement in concrete microstructure and overall performance resulting from the use of finely divided industrial by-products.
7) To evaluate the economic viability of waste fine material concrete by considering material utilization efficiency and resource conservation.
8) To provide a comprehensive comparison between conventional concrete and waste fine material concrete for potential application in sustainable construction practices.

II. LITERATURE REVIEW

Extensive research has been conducted on the utilization of waste fine materials and supplementary cementitious materials in concrete to improve mechanical properties while promoting sustainable construction practices. The increasing depletion of natural resources and environmental concerns associated with cement production have encouraged researchers to investigate alternative materials such as silica fume, fly ash, rice husk ash, ground granulated blast furnace slag (GGBS), biochar, and various industrial by-products as partial replacements for cement.

Previous studies have reported that silica fume significantly enhances the compressive, split tensile, and flexural strength of concrete due to its high pozzolanic activity and micro-filling effect. Researchers observed that optimum silica fume replacement levels generally range between 10% and 15%, beyond which workability decreases and strength gains become less significant. The incorporation of silica fume also improves the density and impermeability of concrete by refining the pore structure.

Several investigations on fly ash concrete have demonstrated that fly ash improves workability and contributes to long-term strength development through secondary hydration reactions. Although fly ash concrete often exhibits lower early-age strength compared to conventional concrete, significant strength enhancement is observed at later curing ages. Optimum performance has commonly been reported at replacement levels ranging from 15% to 30%, depending on the grade of concrete and curing conditions.

Researchers have also examined the combined use of silica fume and fly ash in concrete. The findings indicate that the synergistic action of these materials improves particle packing, reduces porosity, and enhances both strength and durability characteristics. Combined replacement mixtures generally perform better than individual replacements when appropriate proportions are maintained. Excessive replacement levels, however, may adversely affect mechanical properties due to reduced cementitious content.

Various waste materials such as glass powder, coconut shell ash, rice husk ash, red mud, plastic waste, poultry waste, and biochar have also been investigated as sustainable alternatives in concrete production. Most studies reported that moderate replacement levels improve concrete performance and reduce environmental impact, whereas higher replacement percentages may result in reduced strength and workability.

A. Research Gap

Most previous studies have investigated silica fume and fly ash separately as cement replacement materials. Limited research is available on the combined utilization of silica fume and fly ash in M25 grade concrete prepared with 100% crushed sand. Furthermore, comprehensive comparisons of workability, compressive strength, split tensile strength, and flexural strength at both 3-day and 28-day curing periods remain limited. Therefore, the present study focuses on evaluating the combined effect of these waste fine materials and identifying the optimum replacement level for sustainable concrete production.

III. MATERIAL AND METHODOLOGY

An experimental investigation was carried out to compare the performance of Waste Fine Material Concrete and Conventional Concrete.

The study evaluated the influence of silica fume and fly ash as partial cement replacement materials in M25 grade concrete. The methodology included material selection, mix proportioning, specimen casting, curing, and testing of fresh and hardened concrete properties.

A. Materials Used

1) *Cement:* Ordinary Portland Cement (OPC) 53 Grade conforming to IS 12269 was used throughout the investigation. The cement was tested for fineness, standard consistency, setting time, and specific gravity before use.
2) *Fine Aggregate:* Crushed sand (100% M-sand) conforming to IS 383 was used as fine aggregate. The material was clean, well graded, and free from organic impurities.
3) *Coarse Aggregate:* Crushed angular aggregates of nominal maximum size 20 mm conforming to IS 383 were used. The aggregates were washed and air-dried before mixing.
4) *Silica Fume:* Silica fume conforming to IS 15388 was used as a waste fine material for partial replacement of cement. Its high fineness contributed to improved particle packing and strength development.
5) *Fly Ash:* Class F fly ash conforming to IS 3812 (Part 1) was used as a supplementary cementitious material. Fly ash was incorporated to enhance workability and long-term strength.
6) *Chemical Admixture:* A water-reducing plasticizer conforming to IS 9103 was used to maintain the required workability without increasing the water–cement ratio.
7) *Water:* Clean potable water free from harmful impurities was used for concrete mixing and curing.

B. Mix Design

Concrete mix proportions were designed for M25 grade concrete in accordance with IS 10262:2019 and IS 456:2000. A control mix containing OPC 53 grade cement was prepared and compared with mixes incorporating silica fume, fly ash, and their combined replacement. Cement replacement levels of 10%, 20%, and 30% were adopted. A constant water–cement ratio and plasticizer dosage were maintained to ensure uniformity and adequate workability.

C. Preparation of Specimens

Concrete was mixed in a laboratory mixer to obtain a uniform and homogeneous mix. Fresh concrete was tested for workability using the slump cone test, and the remaining concrete was used for casting specimens.

1) Cubes of size 150 mm × 150 mm × 150 mm were cast for compressive strength testing at 3 and 28 days.
2) Cylinders of size 150 mm diameter × 300 mm height were prepared for split tensile strength testing at 3 and 28 days.
3) Beams of size 100 mm × 100 mm × 500 mm were cast for flexural strength evaluation at 3 and 28 days.

After 24 hours, all specimens were demoulded and cured in clean water under laboratory conditions until the specified testing age. The hardened concrete properties were evaluated through compressive strength, split tensile strength, and flexural strength tests.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

D. Batching and Mixing of Concrete

The concrete ingredients, including OPC 53 grade cement, 100% crushed sand as fine aggregate, coarse aggregate, water, silica fume, fly ash, and plasticizer, were weighed accurately according to the finalized mix proportions. Mixing was carried out to achieve a homogeneous and uniform concrete mix, ensuring proper dispersion of silica fume, fly ash, and the water-reducing admixture.

Figure 1: Concrete Mixing and Batching

E. Fresh Concrete Tests

1) Slump Cone Test (Workability Test)**:** The workability of fresh concrete was evaluated using the slump cone test in accordance with IS 1199:2018. The test was conducted for the control mix and all waste fine material concrete mixes containing silica fume, fly ash, and their combined replacements with the use of a plasticizer.

2) Purpose of the Test: The slump test was conducted to:

- Assess the workability of concrete mixes
- Evaluate the effect of silica fume, fly ash, and plasticizer
- Ensure uniform consistency before casting specimens

Figure 2: Slump Cone Test

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

F. Placement and *Compaction*

The fresh concrete was placed into the moulds in layers. Each layer was compacted adequately using manual tamping to remove entrapped air and to achieve dense concrete. Care was taken to avoid segregation and bleeding during placement. After compaction, the top surface of each specimen was finished smoothly using a trowel. All specimens were properly labelled and marked to indicate the mix type, replacement level, and intended testing age (3 days or 28 days).

G. Curing of Specimens

Curing is a critical stage in concrete production as it directly influences the hydration process, strength development, and durability of concrete. In the present study, standard water curing was adopted for all specimens to ensure uniform and controlled curing conditions.

Purpose of Curing in the Present Study-

Proper curing was essential in this investigation to:

- Facilitate complete hydration of cementitious materials
- Enhance the pozzolanic reaction of silica fume and fly ash
- Achieve consistent strength development
- Ensure meaningful comparison of compressive, split tensile, and flexural strength results at 3 days and 28 days

Figure 3: Water Curing of Concrete Specimens

H. Testing of Specimen

After completion of the specified curing period, the concrete specimens were tested to evaluate the mechanical properties of conventional concrete and waste fine material concrete. The tests were conducted at 3 days and 28 days in accordance with relevant Indian Standard specifications. All tests were carried out using calibrated testing machines under laboratory conditions.

The compressive strength test was conducted on cube specimens of size 150 mm × 150 mm × 150 mm to determine the compressive strength of concrete. The test was performed in accordance with IS 516. After the completion of the curing period, the specimens were removed from the curing tank and allowed to surface dry. Each cube was placed centrally between the platens of the Compression Testing Machine (CTM). Load was applied gradually and uniformly without shock until failure of the specimen occurred. The maximum load at failure was recorded.

The split tensile strength test was conducted on cylindrical specimens of size 150 mm diameter and 300 mm height to evaluate the tensile strength of concrete. The test was carried out in accordance with IS 5816. After curing, the cylindrical specimen was placed horizontally between the loading platens of the Compression Testing Machine. Load was applied uniformly along the length of the specimen until failure occurred due to splitting along the vertical diameter. The maximum load at failure was noted.

The flexural strength test was conducted on beam specimens of size 100 mm × 100 mm × 500 mm to determine the flexural strength of concrete. The test was performed using a Universal Testing Machine (UTM) in accordance with IS 516. After curing, the beam specimens were placed on two supporting rollers with a specified span. Load was applied gradually at the specified loading points until failure occurred. The maximum load at failure was recorded.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

Figure 4: Compressive Strength Test (ACTM)

Figure 5: Split Tensile Test (ACTM)

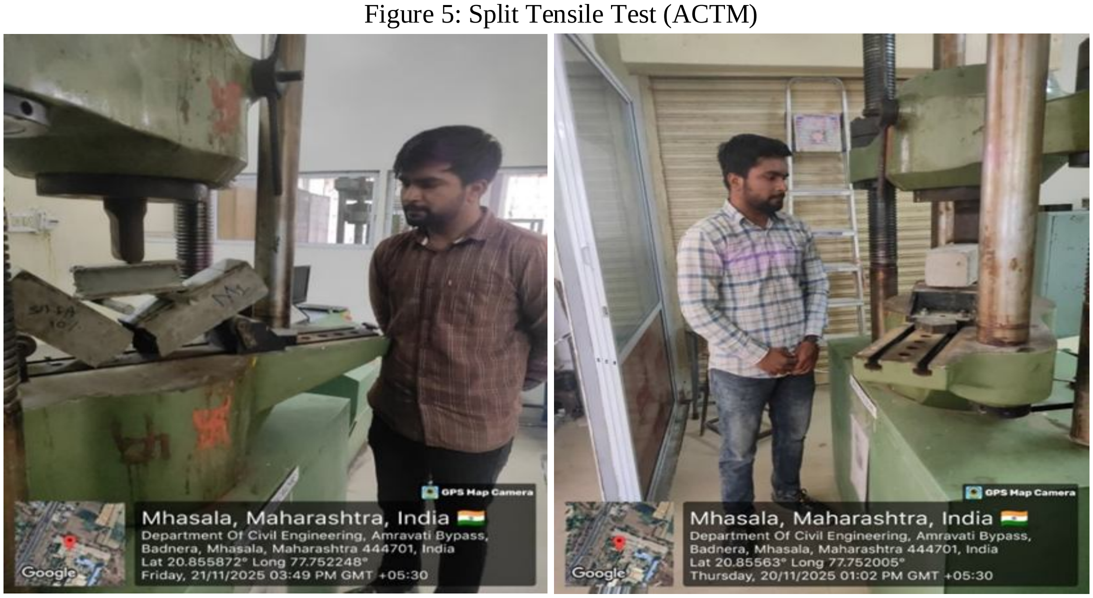

Figure 6: Flexural Strength Test (UTM)

IV. RESULT AND DISCUSSION

A. *Slump Cone Test (Workability)*

The workability of fresh concrete was determined using the slump cone test. Workability refers to the ease with which concrete can be mixed, transported, placed, compacted, and finished. In this study, slump tests were conducted on M25 grade concrete mixes prepared with different percentages of silica fume, fly ash, and their combined replacement of cement. The fine particle characteristics of silica fume and fly ash influenced the consistency of the concrete mixes, resulting in variations in slump values. A plasticizer was added to all mixes to obtain the required workability. The measured slump values were used to evaluate the effect of silica fume and fly ash on the fresh concrete properties.

Table 1 Slump Cone Test Result (Workability)

Mix ID	Type of Mix	Replacement Level (%)	Slump Value (mm)
M0	Conventional Concrete	0	122
SF10	Silica Fume Concrete	10	111
SF15	Silica Fume Concrete	15	98
SF20	Silica Fume Concrete	20	89
FA10	Fly Ash Concrete	10	116
FA20	Fly Ash Concrete	20	100
FA30	Fly Ash Concrete	30	95
SF+FA10	Combined SF &FA	10	115
SF+FA20	Combined SF & FA	20	100
SF+FA30	Combined SF & FA	30	85

The slump test results indicated noticeable changes in workability with the incorporation of silica fume and fly ash. Mixes containing fly ash generally exhibited improved consistency due to the spherical shape of its particles, while higher silica fume contents tended to reduce slump because of its very fine particle size and increased surface area. The combined mixes showed satisfactory workability when used within the selected replacement levels. The observed workability was adequate for mixing, placing, and compaction without signs of excessive segregation or bleeding, indicating that the selected replacement percentages were suitable for producing workable M25 grade concrete.

B. *Compressive strength*

1) 3-Day Compressive Strength: The control mix attained a compressive strength of 14.06 MPa. Silica fume significantly enhanced early-age strength, with SF15 achieving 18.94 MPa. The combined mix SF+FA20 exhibited the highest 3-day compressive strength of 22.20 MPa, indicating accelerated hydration and improved microstructure.
2) 28-Day Compressive Strength: All mixes exceeded the target mean strength of M25 concrete. The control mix achieved 38.18 MPa at 28 days. The highest compressive strength of 44.33 MPa was recorded by SF+FA20, representing approximately 16% improvement over conventional concrete. SF15 also demonstrated excellent performance with a strength of 43.80 MPa. Fly ash at 20% replacement achieved 39.33 MPa, while higher replacement levels resulted in strength reduction due to dilution of cementitious content.

C. *Split Tensile Strength*

1) 3-Day Split Tensile Strength: The conventional concrete exhibited a split tensile strength of 0.95 MPa. Silica fume mixes showed notable improvement, with SF20 achieving the highest value of 1.66 MPa. Combined mixes also demonstrated enhanced tensile resistance, indicating improved bonding within the concrete matrix.
2) 28-Day Split Tensile Strength: At 28 days, SF20 recorded the highest split tensile strength of 2.70 MPa, representing approximately 38% improvement over the control mix (1.95 MPa). The SF+FA20 mix achieved 2.29 MPa, confirming the beneficial effect of combined mineral admixtures on crack resistance and tensile behavior.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

D. Flexural Strength

1) 3-Day Flexural Strength: The control mix achieved a flexural strength of 2.055 MPa. Among silica fume mixes, SF15 showed the highest early-age flexural strength of 2.89 MPa. Fly ash mixes exhibited lower early-age flexural strength due to slower pozzolanic activity.
2) 28-Day Flexural Strength: The highest flexural strength of 4.02 MPa was obtained by FA20, exceeding the control mix value of 3.75 MPa. SF20 achieved 3.87 MPa, while SF+FA20 recorded 3.67 MPa. The results indicate that fly ash contributes significantly to later-age flexural performance and ductility.

Table 2 Comparative analysis of mechanical properties of M25 concrete mixes (3 days)

Mix ID	Compressive Strength (MPa)	% Increase vs 12.64 MPa	Split Tensile Strength (MPa)	Flexural Strength (MPa)
M0	14.06	11.23%	0.95	2.055
SF10	15.19	20.17%	1.124	2.198
SF15	18.94	49.4%	1.30	2.89
SF20	15.68	24.05%	1.66	1.29
FA10	14.99	18.59%	0.95	1.56
FA20	12.55	-0.71%	1.05	1.45
FA30	12.21	-3.40%	1.10	1.41
SF+FA10	16.41	29.93%	1.40	1.74
SF+FA20	22.20	75.63%	1.21	2.10
SF+FA30	18.66	47.63%	1.32	2.05

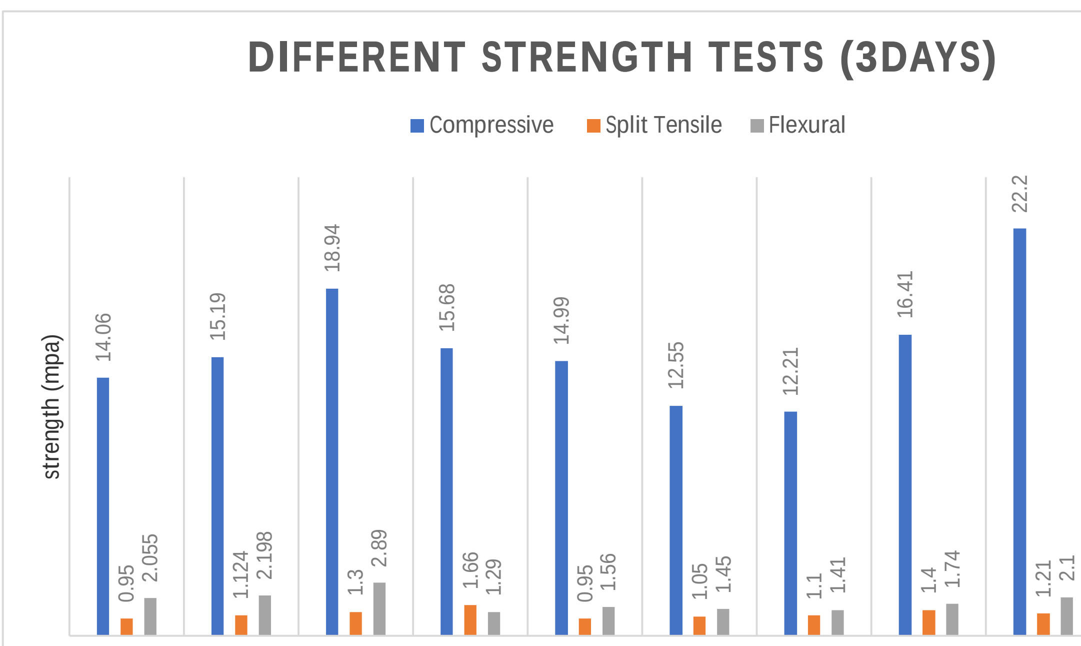

Figure7: Comparison of Compressive vs Split Tensile vs Flexural Strength Test (3 Days)

The comparative evaluation of 3-day strength results shows the influence of silica fume and fly ash on early-age concrete performance. The conventional concrete mix (M0) achieved a compressive strength of 14.06 MPa, split tensile strength of 0.95 MPa, and flexural strength of 2.055 MPa, serving as the reference mix. Silica fume mixes demonstrated significant improvement in early-age strength, particularly SF15, which achieved 18.94 MPa compressive strength and 2.89 MPa flexural strength. The combined mix SF+FA20 recorded the highest 3-day compressive strength of 22.20 MPa, indicating rapid strength development. The highest split tensile strength of 1.66 MPa was obtained by SF20, showing enhanced bonding and crack resistance. Fly ash mixes exhibited comparatively lower early-age strength due to slower pozzolanic activity. Overall, the incorporation of silica fume and fly ash improved early-age performance, with SF+FA20 emerging as the best-performing mix at 3 days.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

Table 3 Comparative analysis of mechanical properties of M25 concrete mixes (28 days)

Mix ID	Compressive Strength (MPa)	% Increase vs 31.6 MPa	Split Tensile Strength (MPa)	Flexural Strength (MPa)
M0	38.18	20.82 %	1.95	3.75
SF10	38.96	23.29 %	2.22	3.24
SF15	43.80	38.61 %	2.21	3.32
SF20	40.81	29.15 %	2.70	3.87
FA10	37.55	18.83 %	2.14	3.17
FA20	39.33	24.46 %	2.15	4.02
FA30	34.56	9.37 %	2.06	3.24
SF+FA10	41.12	30.13 %	2.08	2.97
SF+FA20	44.33	40.28 %	2.29	3.67
SF+FA30	37.10	17.41 %	2.16	3.11

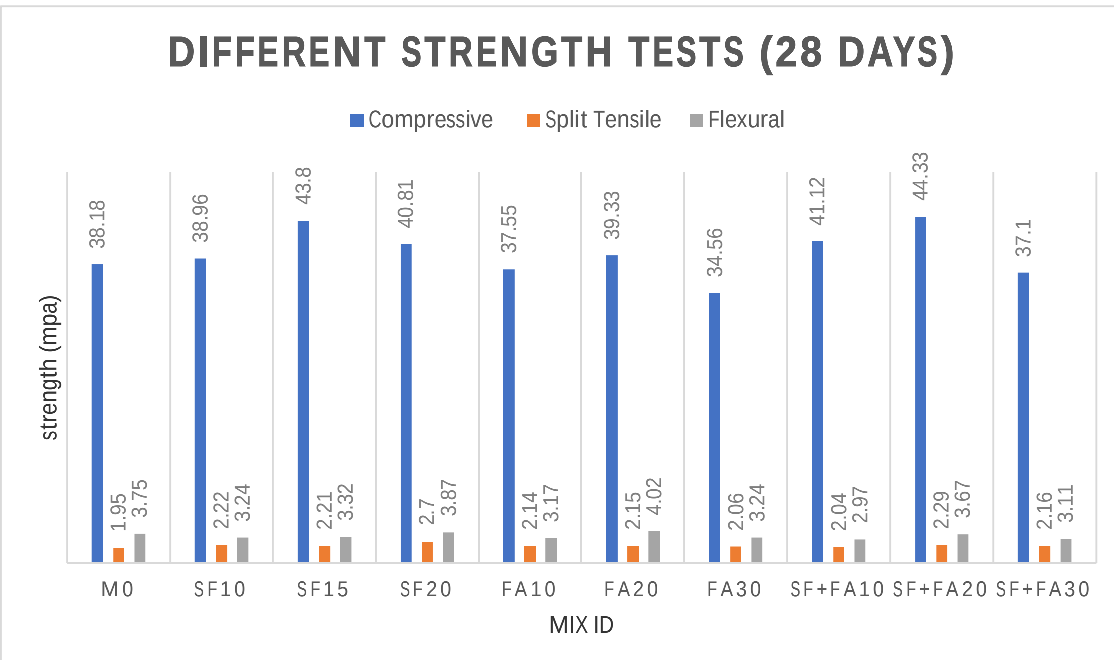

Figure 8 Comparison of Compressive vs Split Tensile vs Flexural Strength Test (28 Days)

The comparative evaluation of 28-day strength results demonstrates the significant influence of silica fume and fly ash on the mechanical performance of concrete. The conventional concrete mix (M0) achieved a compressive strength of 38.18 MPa, split tensile strength of 1.95 MPa, and flexural strength of 3.75 MPa, serving as the benchmark for comparison. Among the silica fume mixes, SF15 exhibited a high compressive strength of 43.80 MPa, while SF20 recorded the highest split tensile strength of 2.70 MPa, indicating superior crack resistance and bond strength. The fly ash mixes FA20 achieved the maximum flexural strength of 4.02 MPa, reflecting improved bending performance and ductility. The combined mix SF+FA20 showed the best overall performance with the highest compressive strength of 44.33 MPa, along with satisfactory split tensile strength (2.29 MPa) and flexural strength (3.67 MPa). The results confirm that the combined use of silica fume and fly ash enhances concrete strength through improved microstructural densification and pozzolanic activity. Therefore, SF+FA20 can be considered the optimum mix for achieving superior overall performance at 28 days.

E. Optimum Mix Identification

Based on the overall evaluation of workability, density, compressive strength, split tensile strength, and flexural strength, the SF+FA20 mix was identified as the optimum concrete mixture. The combined action of silica fume and fly ash improved hydration, reduced porosity, enhanced particle packing, and produced a denser microstructure. Consequently, waste fine material concrete demonstrated superior mechanical performance compared to conventional concrete while supporting sustainable utilization of industrial by-products.

V. CONCLUSION

1) The workability of concrete decreased with increasing silica fume and fly ash content due to the higher fineness and surface area of these supplementary cementitious materials. However, the use of a plasticizer maintained adequate workability for all mixes.
2) The conventional concrete mix achieved a 28-day compressive strength of 38.18 MPa, while all modified mixes exceeded the target strength requirement of M25 grade concrete.
3) The highest compressive strength of 44.33 MPa was obtained for the SF+FA20 mix, representing an improvement of approximately 16% compared to conventional concrete. This indicates the beneficial combined effect of silica fume and fly ash on strength development.
4) Split tensile strength increased significantly with the incorporation of waste fine materials. The maximum tensile strength of 2.70 MPa was recorded for the SF20 mix, demonstrating improved resistance to cracking and enhanced bond characteristics.
5) The highest flexural strength of 4.02 MPa was achieved by the FA20 mix, indicating that fly ash contributes positively to bending resistance and overall structural performance.
6) The combined mix SF+FA20 exhibited the best overall performance by providing the highest compressive strength along with satisfactory split tensile and flexural strengths, making it the optimum mix among all combinations investigated.
7) Strength development at both 3-day and 28-day curing periods confirmed that silica fume improves early-age strength, while fly ash contributes significantly to later-age strength through pozzolanic reactions.
8) The utilization of silica fume and fly ash as partial cement replacements enhances concrete performance while reducing cement consumption, thereby supporting sustainable and environmentally responsible construction practices.
9) Based on the experimental investigation, the SF+FA20 mix (10% silica fume + 10% fly ash replacement) is recommended as the optimum proportion for M25 grade concrete prepared with 100% crushed sand.
10) The replacement of a portion of cement with silica fume and fly ash can contribute to cost savings by reducing cement consumption while maintaining or improving the mechanical performance of concrete, making the proposed mixes economically attractive for practical applications.
11) The experimental results successfully fulfilled the objectives of the study by evaluating the effects of silica fume and fly ash on the fresh and hardened properties of concrete and identifying an optimum mix with enhanced strength and durability characteristics.
12) The study demonstrates that waste fine material concrete can effectively replace conventional concrete for structural applications while providing improved mechanical properties, resource conservation, reduced environmental impact, and potential economic benefits.

REFERENCES

[1] Dr.Y.S. Patil, Dr.M.S. Kuttimarks (2015) "Study on Concrete by Replacement of Silica Fume" International Research Journal of Engineering and Technology (IRJET). JETIR September 2015, Volume 11, Issue 9 pp. 54-65.
[2] K. Gopala Rao, Dr. B. Krishna Rao. (2018), "Experimental Study on Partial Replacement of Cement by GGBS and Fly Ash in Conventional Concrete" International Research in Journal of Engineering Research & Technology (IRJET), Volume 11 Issue XI Nov 2023, pp.28-40.
[3] Ali Hassan, Muhammad Tariq (2014) "Partial Replacement of Cement with Fly ash to Produce Environmentally Friendly Concrete" International Journal of Engineering Research & technology (IJERT). Volume 7, Issue 19, pp. 24-32.
[4] B G Naresh Kumar, Punith N, A P Puneeth Raj, Yashas P. (2019), "Study on Partial Replacement of Cement by Poultry Waste in Concrete" International Journal for Research in Applied Science & Engineering Technology JETIR June 2019, Volume 6, Issue 6.
[5] Dr. Pranab Jyoti Barman, Manash Pratim Deka, Ankita Gogoi (2025), "Comprehensive Study of Partial Replacement of Cement with Biochar in Concrete" A Multidisciplinary peer-reviewed Journal Int. J. ScienceDirect., 2025 Volume 12 Issue 8.
[6] Wegdan W. El-Nadoury. (2016) "Eco-friendly concrete using by-products as partial replacement of cement" International Journal of Engineering Research & technology (IJERT) e-ISSN, Volume 9, Issue 13.

[7] Arya S, Arun H J. (2017), "An Experimental Investigation on Mechanical Properties of Concrete by Partially Replacing Cement with Silica Fume and Fly Ash" International Journal of Engineering Research & Technology (IJERT) Vol. 6 Issue 05, May – 2017. pp. 28-36.
[8] Lucas Sequeira, Javier Forero, Miguel Bravo, Luís Evangelista (2022) "Durability of Concrete with Partial Replacement of Portland Cement by Incorporating Reactive Magnesium Oxide and Fly Ash" Department of Civil Engineering, Architecture and Georesources, (ResearchGate) Volume7, Issue 18.pp. 88-95.
[9] G.V.V. Raj Kishore (2021) Experimental study on Strength Attainment of concrete containing silica fume and fly ash" IOP Conf. Series: Materials Science and Engineering Volume 5, Issue 17. pp. 21-32.
[10] Mohammed Ramshad P, Salmanul Faris M (2018) "Comparison on Compressive Strength of Conventional Concrete with Red Mud Concrete" International Research Journal of Engineering and Technology (IRJET). Volume10, Issue 13. Pp. 32-41.
[11] S. Divya, P. Atchaya, G. Gayatri (2021) "An Experimental Investigation on Partial Replacement of Cement by Rick Husk Ash" International Journal of Scientific Development and Research (IJSDR). Volume 6, Issue 3. pp. 66-70
[12] M. Arivazhagan, T. Balakrishnaan (2023) "Experimental Study on Partial Replacement of cement by Groundnut Shell Ash in Concrete" International Research Journal of Engineering and Technology (IRJET). Volume 6, Issue 21, pp. 32-41.
[13] Abdullahi M (2005), "Compressive Strength of Sandcrete Blocks in Bosso and Shiroro Areas of Minna Nigeria". International Research Journal of Engineering and Technology (IRJET). 9 No. 2, pp. 126-132.
[14] Bureau of Indian Standards (BIS), IS 383:2016 – Specification for Coarse and Fine Aggregates for Concrete, Bureau of Indian Standards, New Delhi, India.
[15] Bureau of Indian Standards (BIS), IS 2386 (Part 1-8): 1963 – Methods of Test for Aggregates for Concrete, Bureau of Indian Standards, New Delhi, India.
[16] Bureau of Indian Standards (BIS), IS 6240:2008 – Specification for Copper Slag, Bureau of Indian Standards, New Delhi, India.
[17] Bureau of Indian Standards (BIS), IS 10262:2019 – Guidelines for Concrete Mix Design Proportioning, Bureau of Indian Standards, New Delhi, India.
[18] Bureau of Indian Standards (BIS), IS 456:2000 – Code of Practice for Plain and Reinforced Concrete, Bureau of Indian Standards, New Delhi, India.
[19] Bureau of Indian Standards (BIS), IS 516 (Part 1): 2020 – Method of Tests for Strength of Concrete, Bureau of Indian Standards, New Delhi, India.
[20] Bureau of Indian Standards (BIS), IS 1199:1959 – Methods for Sampling and Analysis of Fresh Concrete, Bureau of Indian Standards, New Delhi, India.
[21] Bureau of Indian Standards (BIS), IS 4031 (Part 1-15): 1988 – Methods of Physical Tests for Hydraulic Cement, Bureau of Indian Standards, New Delhi, India.
[22] Bureau of Indian Standards (BIS), IS 5816:1999 – Splitting Tensile Strength of Concrete, Bureau of Indian Standards, New Delhi, India.
[23] Bureau of Indian Standards (BIS), IS 516 (Part 2): 2020 – Durability Testing Methods for Concrete, Bureau of Indian Standards, New Delhi, India.
[24] Bureau of Indian Standards (BIS), IS 15388:2003 – Guidelines for Utilization and Disposal of Industrial Waste Materials in Cement and Concrete, Bureau of Indian Standards, New Delhi, India