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

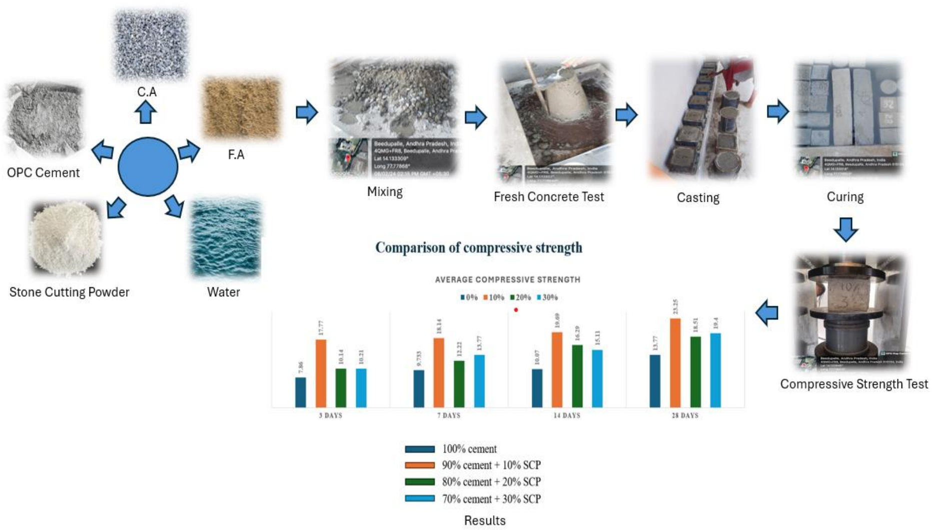
An Experimental Study on M20 Grade Concrete with Replacement of Stone Cutting Powder in Cement

Kummara Siva Prasad[1], C. Mansoor[2], D. R. Rashmitha[3], N. Anusha[4], P. Mounika[5], K. Ekantha[6]

[1]Assistant professor, Sanskrithi School of Engineering, Puttaparthi, Andhra Pradesh, India
[2,3,4,5,6]Studying Final Year student in Sanskrithi School of engineering, Puttaparthi.

Abstract
This experiment investigates the feasibility of replacing cement with stone cutting dust in M20 grade concrete. This study aims to understand the details of varying proportions of stone cutting powder on the workability, compressive strength, and flexural strength of the concrete mix. On the other hand, disposal of stone cutting powder is generated from stone cuttings and it is becoming a problem to environment even there is no chance of growth of plants. So, the cutting powder will be used as replacement material in cement by 10%, 20% and 30%. The aim of this study is to find the maximum content of stone cutting powder by partial replacement of cement. The study of workability and durability properties of M20 grade concrete with replacement of stone cutting powder is achieved at 10% of replacement with good results. Additionally, it also assess the economic viability and environmental impact of this substitution and. Through a systematic experimentation, the study aims to identify the optimal percentage of stone cutting powder replacement that balances performance and sustainability in M20 concrete.

Keywords: Concrete, Stone cutting powder, Compressive strength, Split tensile strength, Flexural strength.



Graphical Abstract:

1. Introduction

1.1 Need for the study

Stone cutting operations generate vast quantities of waste in the form of stone cutting powder, a fine grained residue comprising various minerals and abrasive particles. Traditionally considered a nuisance and disposed of indiscriminately, stone cutting powder presents a compelling opportunity for sustainable utilization in concrete production. By incorporating stone cutting powder as a partial replacement for cement, incorporating stone cutting powder as a partial replacement for cement, not only can the environmental burden of waste disposal be alleviated, but the performance of concrete can also be enhanced through improved workability and durability.

1.2 Background of study

Early civilizations like Mesopotamia and Egypt utilized rudimentary concrete-like materials composed of lime, ash, and aggregates for construction. The Romans pioneered hydraulic cement, creating durable structures like the Pantheon using a mixture of pozzolan and lime. Renaissance advancements drove a resurgence in concrete technology. Joseph Aspdin's invention of Portland cement in 1824 revolutionized production, leading to widespread adoption. The 19th century saw the emergence of reinforced concrete for enhanced strength. Prestressed and high-performance concrete offered solutions for longer spans and durability. Despite its versatility, concrete production contributes to environmental issues. Integrating waste materials like stone cutting powder reduces waste and carbon footprint. Stone cutting powder enhances concrete properties and can be used across various construction sectors. Continued innovation is crucial for addressing 21st-century environmental challenges.

1.3.Scope of the work

The scope of integrating stone cutting powder into concrete production involves extensive research, material sourcing, production optimization, quality control, regulatory compliance, and market adoption. It requires investigating its feasibility, sourcing reliable suppliers, optimizing production processes, ensuring quality control, adhering to regulations, conducting environmental impact assessments, and promoting industry acceptance. By addressing these aspects, this initiative can significantly contribute to sustainable construction practices, resource efficiency, and environmental conservation in the built environment.

1.4 Objectives of the study

Validate ingredients: Test cement, aggregates, stone dust, and fillers for strength, durability, workability, and adherence to standards.

Mix design: Determine optimal water-cement ratio, adjust stone dust and fillers for cohesion and density, considering strength and workability needs.

Quality improvement: Enhance strength and durability with advanced additives, maintain consistency through rigorous quality control during production and construction.

1.5. Previous researches study

The literature survey delves into diverse studies on employing waste materials in concrete production for sustainable construction practices.Researchers explore options such as ceramic waste, electronic waste, fly ash, quarry dust, and other substitutes for conventional aggregates and cement. These alternatives demonstrate potential in enhancing concrete properties while lowering environmental impact and construction expenses.Studies also emphasize the importance of optimizing ratios of waste materials to achieve desired strength and durability.Notably, findings highlight the significance of incorporating waste materials to bolster concrete's mechanical properties and sustainability, thereby aiding in waste reduction and resource conservation within the construction industry.

2. Materials and Methodology

Using a blend of materials like Ordinary Portland Cement (OPC), fine aggregate, coarse aggregate, and stone cutting powder, we create a versatile mix for construction purposes. OPC cement serves as the binding agent, while fine and coarse aggregates provide structural support and stability. Stone cutting powder, a byproduct, enhances the mix's workability and sustainability by reducing waste. When combined in precise proportions, these components form a durable and environmentally conscious construction material, suitable for various applications. With careful consideration and proper mixing techniques, this composite blend ensures quality and longevity in construction projects.

Preparation of concrete raw materials; cement, fine aggregate, coarseaggregate, and water, also the concrete moulds. Next process is mix design, in which raw materials were mixed together. In this research, 3 samples were made; water,coarse aggregate,fine aggregate,cement, replacement of 10%,20%,30% by Stone cutting powder. Research underwent examinations; cement setting time and slump test, water absorption test. compressive strength test, split tensile strength test and flexural strength.

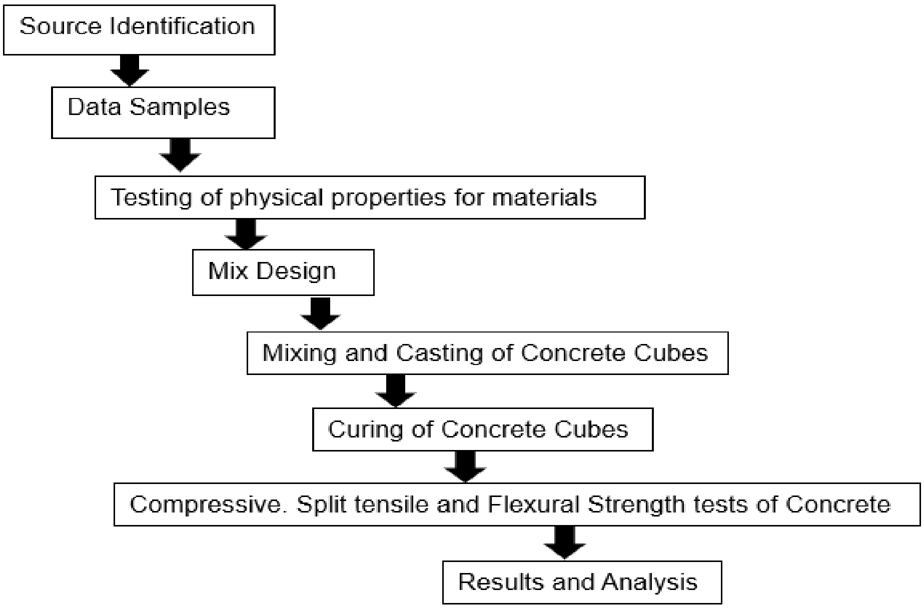


Fig. 1: Methodology used in research

2.1 Materials

2.1.1 Cement- Cement is a fine powder composed of limestone, clay, sand, and iron ore, serving as the binding agent in concrete production. It undergoes hydration upon mixing with water, forming a paste that binds aggregates together to create concrete. Various types of cement exist, including Portland cement and blended cement, tailored for specific applications. Cement production contributes to environmental concerns due to high energy consumption and CO_2 emissions. "Cement is OPC grade 53," could be the significance of cement grade in construction projects. OPC (Ordinary Portland Cement) grade 53 is renowned for its high compressive strength, making it suitable for various applications such as building foundations, bridges, and high rise structures.

2.1.2. Fine aggregate- Fine aggregates, typically referred to as sand in construction, are integral components of concrete and mortar mixes. They play a pivotal role in influencing both the mechanical properties and workability of the final product. These granular materials are characterized by their small particle size, typically ranging from 0.075 mm (No. 200 sieve) to 4.75 mm (3/16 inch) in diameter. Composed primarily of naturally occurring substances like sand, crushed stone, or gravel, fine aggregates are sourced from various deposits such as riverbeds, beaches, and quarriesZone-II<4.75mm

2.1.3. Coarse aggregate- Coarse aggregate constitutes a vital component of concrete mixes, typically encompassing gravel, crushed stone, or a combination thereof. It occupies a size range exceeding 4.75 mm (No. 4 sieve) up to 50 mm (2 inches). Generally classified into two categories—fine coarse aggregate (4.75 mm to 19 mm) and coarse coarse aggregate (19 mm to 50 mm)—these materials contribute extensively to concrete's structural integrity. Coarse aggregates confer strength, stability, and durability to concrete, forming a significant portion of its volume alongside cement, water, and fine aggregates Angular 20mm

2.1.4. Stone cutting powder- Stone cutting powder, a byproduct of the stone fabrication industry, is a composite material comprising layers of mineral particles accumulated during the cutting, shaping, and polishing of natural stones such as marble, granite, limestone, and sandstone. Its composition includes silica (SiO_2), calcium carbonate ($CaCO_3$), and aluminum oxide (Al_2O_3), alongside trace minerals and organic matter. Disposal of stone cutting powder poses environmental challenges due to its accumulation in large quantities. However, opportunities exist for recycling and repurposing in various applications, including construction and agriculture.

2.2 Concrete mix design

2.2.1 Mix design

As per Indian Standard Code, the mix design for M20 grade concrete suggests a ratio of 1:1.5:3 for cement, fine aggregate, and coarse aggregate, respectively, by weight. This ensures an optimal balance of strength and durability. The water-cement ratio, typically between 0.4 to 0.6, also influences the final properties of the concrete. Adhering to these guidelines results in consistent and reliable concrete mixes. Engineers and builders can achieve high-quality M20 grade concrete suitable for diverse construction needs by following these specifications diligently.

Table .1: Replacement of stone cutting powder with various Quantity.

% of replacement	0%	10%	20%	30%
Cement(kg)	4.725	4.252	3.780	3.308
Fine Aggregate (kg)	8.073	8.075	8.075	8.075
Coarse aggregate (kg)	9.200	9.200	9.200	9.200
Stone cutting powder (kg)	0	0.472	0.945	1.417

2.2.2 Batching and mixing of materials

2.2.2.1. Batching in concrete production entails precisely measuring and proportioning cement, aggregates, water, and sometimes admixtures according to a specific mix design. It ensures consistency and uniformity in material proportions, critical for achieving desired concrete properties. Proper batching is essential for producing high-quality concrete that meets project specifications and performs reliably. Even minor variations in material proportions can significantly impact the strength, workability, and durability of the finished concrete. Batching forms the foundation for reliable and durable concrete construction.

2.2.2.2. Mixing is the process of thoroughly combining the batched materials, including cement, aggregates, water, and any admixtures, in a mixer. Its goal is to create a homogeneous mixture with a uniform distribution of components throughout. Proper mixing ensures the desired properties of the concrete, such as strength, workability, and durability, are achieved consistently. Uniform distribution of materials is crucial for preventing weak spots or inconsistencies in the final concrete product. Effective mixing is essential for producing high-quality concrete and ensuring the structural integrity of construction projects.

2.2.2.3. Uniformity in concrete production is achieved through batching and mixing processes. Batching ensures consistent material proportions, crucial for maintaining uniformity from batch to batch. Mixing ensures the thorough distribution of materials throughout the concrete mixture, essential for achieving desired properties like strength, workability, and durability. A uniform distribution of components prevents weak spots or inconsistencies in the final product, ensuring structural integrity. Both batching and mixing are essential steps in producing high-quality concrete for construction projects.

2.2.2.4. Quality control in concrete production relies on proper batching and mixing techniques to uphold standards and meet project specifications. These processes are fundamental for ensuring the quality, consistency, and uniformity of the concrete mixture. By adhering to rigorous quality control measures, construction teams can ensure the structural integrity and performance of the finished concrete structures. Effective quality control practices are essential for producing durable and reliable concrete that meets the needs of the project.

3.1 Material Properties

Indian Standard (IS) codes define methods for evaluating construction materials' key properties. For instance, IS 2386-3:2016 assesses fine aggregate fineness via sieve analysis. IS 2386 (Part 3) - 2016 covers specific gravity for both fine and coarse aggregates. IS 4031 (Part 11) - 1988 determines cement density using the Le Chatelier Flask method. IS 2386 (Part 3) - 2016 also outlines water absorption testing for aggregates. These standards ensure consistent quality and aid in reliable concrete mix design for construction projects.

Table. 2: Tests on Materials Properties

Material Characteristics	Coarse Aggregate	Fine Aggregate	Cement	Stone cutting powder
Fineness(mm)	20	2.75	6.6%	6.73%
Specific Gravity	0.999	0.999	3.06	2.463
Density(kg/m³)	2786	2392	1250	1139
Water absorption(%)	1.52	1.214	-----------	5.5

3.2 Tests on Fresh Concrete

The slump cone test, as per IS 1199:1959, is widely used due to its simplicity and effectiveness in evaluating the consistency and workability of fresh concrete. It provides valuable insights into the concrete's ability to flow and fill the formwork properly, crucial for achieving desired structural integrity. Moreover, the test results aid in adjusting the mix proportions or admixtures to optimize workability without compromising strength or durability. On the other hand, the compaction factor test, also specified by IS 1199:1959, offers a quantitative measure of the degree of compaction achieved during concrete placement. By compacting the concrete in a standardized manner and measuring the volume reduction, this test helps assess the ease of compaction and identify any potential issues such as segregation or bleeding. These tests play a pivotal role in quality control during concrete production and placement, ensuring that the material meets the stringent requirements of construction standards and specifications. Engineers and contractors rely on the results of these tests to make informed decisions regarding mix design adjustments or construction practices, ultimately contributing to the successful completion of durable and resilient structures.

Table. 3: Tests on Fresh Concrete

% of replacement	0%	10%	20%	30%
Slump cone test (mm)	25	26	24	26
Compaction factor test	0.824	0.907	0.823	0.854

3.3 Compressive Strength

The graph illustrates the impact of stone cutting powder (SCP) inclusion on the average compressive strength of concrete at different curing periods. Across all curing durations, from 3 to 28 days, there is a consistent trend of decreasing compressive strength as the percentage of SCP in the concrete mix increases. At 3 days of curing, concrete with 30% SCP exhibits

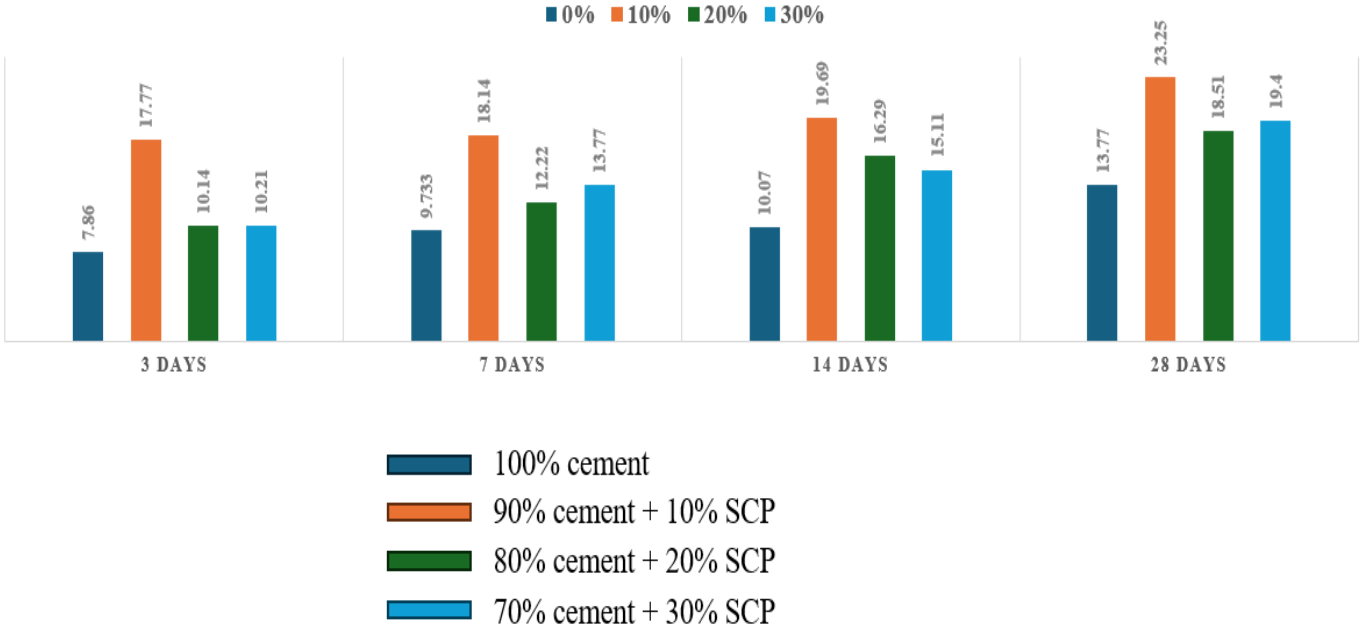


Fig. 2: Comparison of compressive strength for 0%,10% ,20% &30%

the lowest compressive strength compared to mixes with lower SCP content. And 10% of SCP give the high strength compare to 20%,30%. This trend continues at 7, 14, and 28 days of curing, with the compressive strength diminishing as the SCP content rises. Notably, the concrete with 100% cement consistently demonstrates the highest compressive strength throughout all curing periods.

The bar graph illustrates the compressive strength of concrete samples at different curing ages (3 days, 7 days, 14 days, and 28 days) with varying percentages of stone cutting powder (SCP) replacement. It's evident that replacing 10% of cement with SCP enhances the concrete's strength compared to the control mix (100% cement) at all curing ages. However, increasing SCP replacement to 20% results in a slight decrease in strength, and further increasing it to 30% leads to a more significant reduction in strength, particularly noticeable at later curing ages. This suggests that 10% replacement of cement with SCP optimally enhances concrete strength, while higher replacement percentages may have diminishing returns or even adverse effects on strength over time.

3.4 Split tensile strength

The split tensile strength test evaluates concrete's tensile properties, crucial for crack resistance in structures under flexural loading. It detects material variations, aiding quality control by identifying mix inconsistencies or workmanship issues. Additionally, it validates structural models and design assumptions, ensuring safety and durability. In essence, this test is pivotal for quality assurance and structural reliability in construction projects.

Split tensile strength (σ)=2p/πLD

σ = split tensile strength of concrete

P=Ultimate load at failure

D=Diameter of cylinder

L=Length of the cylinder

The value ranges between 8% of M20 =12% of M20

The pie chart provides a comparison of standard test scores (STS) for concrete samples with varying percentages of stone cutting powder (SCP) inclusion. Samples with 0% SCP exhibit an STS of 2.16, which increases progressively with higher SCP content. At 10% SCP, the STS rises to 2.59, indicating a slight improvement. Further increases in SCP content to 20% result in a higher STS of 2.96. Notably, samples with the highest SCP content of 30% demonstrate the highest STS at 3.01. This suggests a positive correlation between SCP inclusion and standard test scores, with higher SCP percentages potentially contributing to improved performance characteristics in the concrete samples.

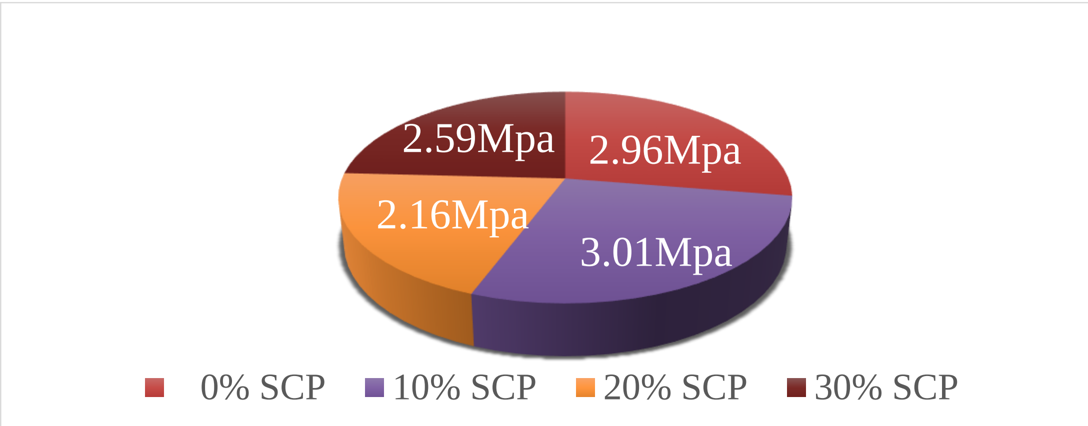


Fig.3: Comparison of Split Tensile Strength

3.5 Flexural strength

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

The flexural strength test, also known as the modulus of rupture test, measures the maximum load a material can withstand before breaking or fracturing when subjected to bending forces. In concrete, this test involves applying a load to a beam specimen supported at its ends until failure occurs. The resulting failure pattern typically involves cracking and eventual fracture. Flexural strength is an important mechanical property for materials used in construction, as it indicates the ability of a material to resist bending and withstand structural loads. This test is commonly used to assess the quality of concrete and other construction materials, providing valuable data for structural design and quality control purposes.

Flexural strength (fb) = $\frac{P*L}{2*B*D}$

fb = Flexural strength

P = load

B = breadth of prism [150mm]

D = depth of prism [150mm]

L = length of prism [750mm]

The graph provides a comparison of the flexural strength (FS) of concrete samples with varying percentages of stone cutting powder (SCP) inclusion. Initially, at 0% SCP, the flexural strength is recorded at 2.16. However, as SCP content increases, there is a noticeable improvement in flexural strength. Concrete with 10% SCP shows a significant increase in flexural strength to 2.94, further rising to 3.15 at 20% SCP. Interestingly, at 30% SCP, there is a slight reduction in flexural strength to 2.74. Overall, the graph demonstrates a positive correlation between SCP inclusion and flexural strength, with optimal enhancement observed at 20% SCP content.

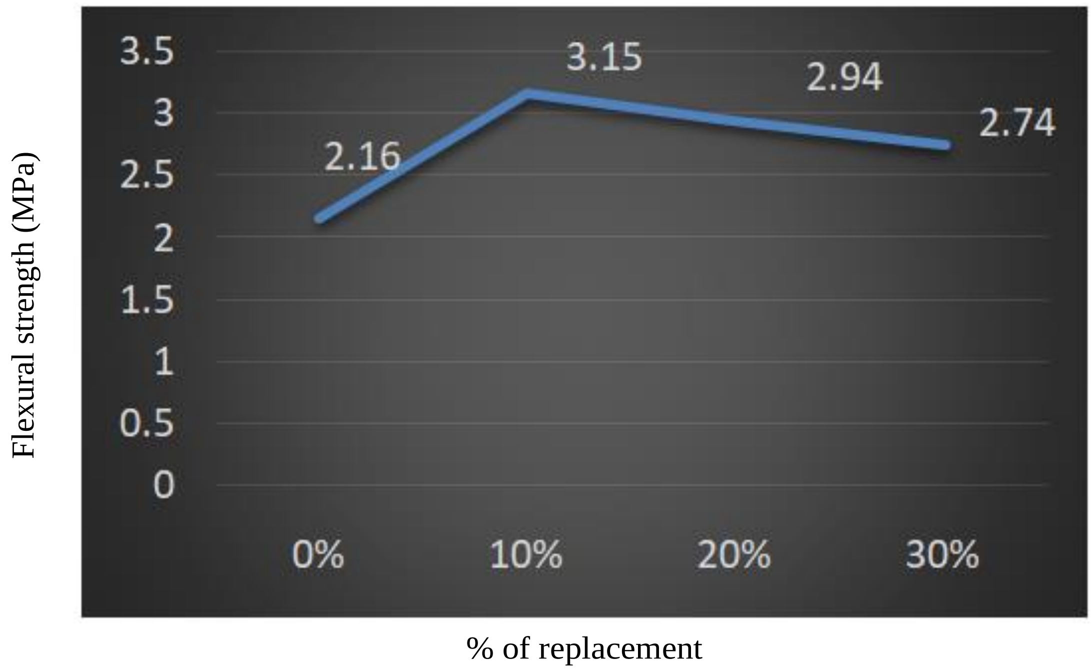


Fig. 4: Comparison of Flexural strength

International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

(a) Mixing

(b) slump cone test

(c) Compaction factor

(d) compressive strength test

(e) Split tensile test

(d) Flexural test

Fig.5: Photo gallery of various experiments

3.6 Crack propagation in compressive test of concrete

According to the Indian Standard (IS) code, specifically IS 456:2000 "Code of Practice for Plain and Reinforced Concrete," the permissible crack width for reinforced concrete structures is limited to 0.2 mm under serviceability conditions. This criterion ensures the structural integrity, durability, and aesthetic appearance of concrete elements. Additionally, the code provides guidelines for controlling crack widths through proper design, detailing, material selection, and construction practices. Compliance with these specifications is essential for ensuring the safety, performance, and longevity of concrete structures in service.

Table.4: Maximum Crack Width

% of replacement	0%	10%	20%	30%
Maximum crack width	1.5	2.0	1.0	2.5

3.7 Optimum percentage and Cost-effectiveness

Optimizing stone cutting powder (SCP) in concrete involves systematic experimentation. Tests consistently show that replacing 10% of cement with SCP yields higher strength compared to 20% and 30% replacements. Cost analysis considers procurement, processing, and environmental benefits like waste reduction. Quality control ensures mix consistency, while collaboration fosters innovation. Documentation and dissemination of findings contribute to concrete science. Continuous monitoring drives ongoing improvement for enhanced sustainability and cost-effectiveness.

4. Conclusions

3. The comprehensive examination of different replacement ratios of stone cutting powder in M20 grade concrete has highlighted the remarkable effectiveness of the 10% replacement ratio.
4. Through rigorous testing, including assessments of compressive, split tensile, and flexural strength, it was evident that the 10% replacement ratio showcased unparalleled strength.
5. This unequivocal performance demonstrates a significant advancement in concrete formulation techniques, offering promising prospects for enhancing structural integrity and durability in a wide array of construction projects.
6. The findings underscore the importance of judicious material substitution strategies in concrete production, emphasizing the potential for optimizing performance while also contributing to sustainability efforts in the construction industry.
7. The 10% replacement ratio of stone cutting powder in M20 grade concrete demonstrates superior strength compared to other ratios.
8. Rigorous testing, including assessments of compressive, split tensile, and flexural strength, consistently shows the effectiveness of the 10% replacement ratio.
9. The remarkable performance of the 10% replacement ratio indicates a significant advancement in concrete formulation techniques.
10. This advancement holds promising prospects for enhancing structural integrity and durability in various construction projects.
11. The findings underscore the importance of judicious material substitution strategies in concrete production.
12. Optimizing performance while contributing to sustainability efforts in the construction industry is emphasized.
13. Collaborative efforts among researchers, manufacturers, and industry stakeholders are essential for driving innovation in concrete formulation and sustainable construction practices.

4.3 scope of work

In future work, efforts will focus on optimizing stone cutting powder (SCP) levels in concrete for imprved performance and cost-effectiveness while minimizing environmental impact. This will involve advanced testing methods to gain deeper insights into SCP's effects on concrete properties, alongside innovative applications across diverse construction sectors. Research will also target the refinement of SCP characteristics through processing techniques or alternative sources. Comprehensive lifecycle assessments are crucial to evaluate SCP-integrated concrete's overall environmental footprint. Strategies will be developed to promote market adoption, engage with policymakers, and foster international collaboration. Advocacy for supportive policies and standards will be central to facilitating widespread SCP implementation. Through these endeavors, the aim is to advance SCP's role in sustainable construction practices globally.

REFERENCES

1. Dr Sanjeev Nukala, Strength Appraisal of Fiber Reinforced Concrete by Replacing 40% of Ordinary Portland Cement (OPC) with Mineral Admixtures Fly Ash, GGBS and Metakaoline, International Journal of Civil Engineering and Technology 10(2), 2019, pp. 1347–1354.
2. N Venkat Rao and B Suresh, Evaluation of Engineering Properties of Concrete by the Partial Replacement of Natural River Sand by Robo Sand, International Journal of Civil Engineering and Technology, 9(4), 2018, pp. 737–743.
3. M.R. Ganesamoorthy and Dr. S. Arivalagan. Experimental Behaviour of Composite Infilled Column by using Silicafume & Metakaolin. International Journal of Civil Engineering and Technology, 8(1), 2017, pp. 203–208
4. Comparative Study of M35 Concrete using Marble Dust as Partial Replacement of Cement and Fine Aggregate . Kapil Katuwal, et al.5, Assam, India: International Journal of Innovative Research in Science, Engineering and Technology, 2017, Vol. 6. ISSN : 2319-8753 .
5. Cement Replacement in concrete with Marble Dust Powder . Ruchi Chandrakar, et al.5, Bhopal, INDIA: International Research Journal of Engineering and Technology (IRJET) , 2017, Vol. 4. ISSN: 2395 -0056 .
6. Deepanshu Patel, et al.4, Gujarat, India : International Journal ofCivil Engineering and Technology (IJCIET) , 2016, Vol. 7. ISSN: 0976-6316.
7. Partial Replacement of Cement to Concrete by Marble Dust Powder. Vijaya Kumar YM, et al.5, Karnataka, India : International Journal for Modern Trends in Science and Technology , 2016, Vol. 2. ISSN: 2455-3778.
8. G.Hymavathi (2016) “An experimental study on behaviour of partial replacement of with round Granulated Blast Furnace Slag”, Int. Journal of Engineering Research and Application ISSN: 2248-9622, Vol. 6, Issue 12, (Part -3) December 2016, pp.01-04
9. G.balamurugan (2013) “Use of Quarry Dust toReplace Sand in Concrete –An Experimental Study” International Journal of Scientific and Research Publications, Volume 3, Issue 12, ISSN 2250-3153
10. Balapgol et al (2002) “Strength and durability of concrete with crushed sand” 27th Conference on our world in concrete & structures: 29 -30 August 2002, Singapore
11. Ilangovana et al (2008) “Strengthand durability properties of concretecontaining quarry rock dust as fineaggregate”, VOL. 3, NO. 5, ISSN1819-6608 ARPN Journal ofEngineering and Applied Sciences
12. Venu Malagavelli et al (2010) “highperformance concrete with ggbs androbo sand”, International Journal ofEngineering Science and TechnologyVol. 2(10), 2010, 5107- 5113

13. Sivakumar et al (2011)"Characteristic studies on themechanical properties of quarry dustaddition in conventional concrete",Journal of Civil Engineering andConstruction Technology, Vol. 2(10),pp. 218-235, ISSN 2141-2634 ©2011Academic Journals
14. Kulkarni (2013) "Effect ofreplacement of natural sand bymanufactured sand on the propertiesof cement mortar", internationaljournal of civil and structuralengineering Volume 3, No 3, ISSN0976 – 4399
15. Akshay G.Kadao (2016) "study ofreplacement of natural sand byartificial sand in concrete"International Conference onElectrical, Electronics, andOptimization Techniques (ICEEOT) –2016
16. B Singh Kalchuri et al "Study OnConcrete Using Marble Powder WasteAs Partial Replacement Of Sand", Int.Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 5, Issue 4, (Part -6) April 2015, pp. 87-89
17. Prof. Veena G. Pathan, Prof. Md. Gulfam Pathan Feasibility and Need of use of Waste Marble Powder in Concrete Production, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 23-26
18. Dr. K.M. Tajne et.al. (2014), Effect of Glass Fiber on Ordinary Concrete, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 11, pp 17632-17634.
19. Jashandeep Singh, Er. R. S. Bansal, Partial Replacement of Cement with Waste Marble Powder with M25 Grade, International Journal of Technical Research and Applications, Vol 3, Issue 2, PP 202-205
20. B. V. Bahoria, Dr D. K. Parbat, Dr. P. B. Nagaernaik, Effect of Characterization Properties on Compressive Strength of Concrete Containing Quarry Dust and Waste Plastic as Fine Aggregate, International Journal of Civil Engineering and Technology, Vol 8, Issue 2, PP 699-707
21. J. D .Chaitanya Kumar, G. V. S. Abhilash, P. Khasim Khan, G. Manikantasai, V. Tarakaram, Experimental Studies on Glass Fiber Concrete, American Journal of Engineering Research, Vol 5, Issue 5, PP 100-104
22. N. Kavibala, Experimental Study on Partial Replacement of Cement with Marble Powder and Fine Aggregate with Quarry Dust and with addition of polypropylene fiber, ICCREST-2016
23. IS 10262:2009, 'Concrete Mix Proportioning – Guidelines' First Revision, July 2009
24. IS – 516-1959, Edition 1991-07, Method of tests for strength of concrete – Bureau of Indian standard, New Delhi.
25. Vaidevi C "Study on Marble Dust as partial replacement of cement in concrete " ISSN:2319 - 7757 EISSN 2319-7765,Indian Journal Of Engineering., Volume 4,No. 9,July 2013.