



Analyze the latest advancements in eco-friendly construction materials and their environmental benefits

Kokate Pravin Pandurang^{1*}, Dr. Ruchi Chandrakar²

¹ Research Scholar, Kalinga University, Raipur, Chhattisgarh, India

² Supervisor, Department of Civil Engineering, Kalinga University, Raipur, Chhattisgarh, India

Abstract

Research indicates that the compressive strength, split tensile strength, and flexural strength may be enhanced by 2.73 percent, 15.7 percent, and 10.5 percent, respectively, when iron filing and silica fume are combined in a composite form. The results of the durability test reveal that conventional high strength concrete is more permeable than composite high-performance concrete; thus, conventional high strength concrete is less long-lasting than composite high-performance concrete. However, the value of the charge passing through composite high-performance concrete is 7.3% higher than that of conventional high strength concrete. Compared to traditional high strength concrete, composite high performance concrete saves 8.7 percent in costs.

Keywords: Building design, construction, and operation, CTM, UTM machines

Introduction

An approach to building design, construction, and operation that aims to minimise environmental effect, save resources, and produce healthy, energy-efficient buildings and infrastructure is known as sustainable construction, green building, or eco-friendly construction. The building industry's profound effects on society and the environment, such as the loss of natural resources, the release of greenhouse gases, and the accumulation of trash, are the impetus behind this movement. To combat these issues, sustainable construction incorporates eco-friendly methods at every stage of a building's lifespan, from planning and design to operation and destruction.

Using cutting-edge materials is a cornerstone of eco-friendly building practices. Reducing energy consumption, enhancing durability, and decreasing lifespan costs are common goals of innovative materials, which aim to provide sustainable alternatives to typical construction materials. To reduce environmental impact and improve building performance, these materials are crucial for sustainable construction methods to advance.

Life cycle assessments (LCAs) of environmentally friendly building supplies make up the third part of our investigation. The LCA examines the whole material life cycle, beginning with extraction of raw materials and ending with disposal, including transportation, consumption, and ultimate disposal. We can measure environmental effects like carbon footprint, energy use, and waste production to perform informed comparisons between eco-friendly materials and conventional alternatives. This will promote evidence-based decision-making in sustainable building practices.

Literature Review

Zamathula Queen Sikhakhane Nwokediegwu (2024) ^[10], Materials that lessen the toll that building has on the environment have recently been the attention of academics and businesspeople. Among the many cutting-edge materials included in this analysis are recycled polymers, green composites, and high-performance concrete. Superior

strength and durability with minimal resource consumption are the outcomes of high-performance concrete formulations that use sophisticated admixtures and extra cementitious ingredients. Natural fibers and bio-based resins make up green composites, which are a new sustainable option to the old building materials. These composites are in line with the principles of environmentally responsible building techniques since they have a reduced carbon footprint and excellent mechanical qualities. Also, a big step towards the concepts of the circular economy, which deal with plastic pollution, is the use of recycled polymers made from post-consumer waste in building materials. There are a number of ways in which these sophisticated materials help the environment. Their manufacture helps make the building sector more sustainable by reducing the extraction of raw materials, energy consumption, and greenhouse gas emissions. In addition to reducing environmental effect throughout the life cycle, the increased resilience of these materials allows buildings to last longer with less maintenance needed. Sustainable building practices that include modern materials improve building performance while also harmonizing with worldwide initiatives to reduce the built environment's environmental impact.

Abera, Yonatan. (2024) ^[9]. The study's evaluation of the flexural strength of different materials also sheds light on their potential use in actual construction projects. In addition, the research considers properties like energy efficiency, recyclability, and renewability when analyzing the environmental impact of these materials. Various materials' basic characteristics were ascertained via laboratory testing as part of the study. By comparing and analyzing these sustainable options across their entire life cycles, the research highlights their environmental benefits. In order to create a greener and more resilient built environment, architects, engineers, and legislators may use the research output as a comprehensive reference that covers all aspects of sustainable building materials.

Sharma (2021) ^[8] Essential elements that aid in reducing environmental consequences are the eco-friendly materials

(EFMs). Materials that are no longer needed in construction are considered and used as an EFM as part of efforts to address issues with waste management and resource conservation. These have positive effects on human health and are simple to manufacture from recycled materials. The functioning of roads has seen tremendous changes due to several factors, including research on conventional and paperback materials, the needs of rising traffic, and other factors. One of the most common and successful approaches is to use eco-friendly building materials. The first step is to choose materials with low environmental impact. (2) With the goal of selecting eco-friendly products. Consequently, Portland pozzolanic cement (PPC), AAC blocks, low volatile organic compound (VOC) paints, low-emissivity (E) glass windows, glass cloth, fly ash from coal industries, bamboo, and glass powder are the most first-rate eco-friendly materials that can be developed and utilised to improve construction technology.

Shukla (2024) [7] In a world where people are more worried about environmental protection, the building industry is a pivotal stage for bringing about groundbreaking transformation. Sustainable construction materials are the focus of this research study. This area is where innovation and environmental concern come together to change civil engineering. By delving into state-of-the-art construction methods, materials, and the massive environmental impacts they produce, this essay aims to provide light on the path to a more sustainable future.

Firoozi (2024) [6] We place an emphasis on the use of automated fabrication and 3D printing, two cutting-edge production processes that greatly improve construction sector efficiency and reduce waste. These materials have been rigorously tested to ensure they are practical and long-lasting according to standards like ASTM for mechanical qualities and ISO for environmental concerns. However, there are a number of hurdles to overcome before these materials can be widely used, including prohibitive starting prices, difficulties with technology integration, and strict regulatory regimes. We illustrate our points with concrete instances, such as the monetary effect of using bio-based composites and the technological changes needed to use recycled plastics in structural applications. The article explores future possibilities and areas for further study, drawing attention to the fact that these sustainable materials can only be fully used if they are scalable and integrated into standard building procedures.

Research Methodology

Data Collection

The main objective of this research project is to examine and compare the characteristics of traditional high strength concrete with composite high-performance concrete. In order to achieve this goal, information is gathered on the M-75 grade concrete mix design, specimen preparation, and material specifications. All the data that has been gathered will be used to conduct experiments.

Specifications of material used

Chemical admixtures, such as high range water reduction admixtures, fly ash, slag, sand, gravel, and cement are some of the ingredients that must be carefully chosen and measured out in order to produce high-performance concrete (HPC). Superior in strength and durability to standard concrete is high-performance concrete. Therefore, the ingredients in high-performance concrete and those in conventional cement concrete are quite similar. But there are a lot of ways it's different from conventional concrete. It's quite strong, has a smooth fracture surface, isn't very porous, has discontinuous pores, etc. This is caused by a combination of factors, including a low water to cementitious material ratio, chemical admixtures, and cementitious materials. Between the time of installation or completion and two or three days after processing, the essential curing phase for HPC lasts.

Data Analysis

Abrasion resistance of concrete

Abrasion resistance has been calculated using the depth of surface wear. Figure 1 is a graph showing the wear depth fluctuation with respect to the various percentages of waste granite slurry utilised as a partial cement substitute:0%, 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, and 20%.

A progressive increase in concrete abrasion loss was seen as the quantity of granite used to replace cement increased. Table 1 displays the abrasion loss value for series-I granite eco-friendly fibrous concrete.

Figure 2 shows the wear depth variance at a water/cement ratio of 0.3 as a function of various percentages of series-II demolition building debris utilised to replace part of the fine aggregates. Percentages vary from zero and forty percent.

A progressive increase in concrete abrasion loss was seen as the quantity of granite used to replace cement increased. Table 2 displays the abrasion loss value for series-II of eco-friendly fibrous concrete.

With respect to the various percentages of demolition construction waste as fine aggregates (0% to 40%) and granite slurry waste (GSW) as partial cement replacement (0% to 20%), the graph in Fig. 3 shows the fluctuation in wear depth with respect to these variables with a 2.5% interval.

Concrete abrasion loss was found to be steadily rising when the amount of combination mixes made from demolition construction waste and granite slurry was used to partially substitute cement and fine aggregates. Abrasion loss value for series III eco-friendly fibrous concrete is shown in Table 3. From the numbers above, it is clear that the control sample has the least amount of thickness loss (abrasion). However, the most significant loss happens when 20% granite slurry waste and 40% demolition construction waste are replaced. In addition, the previous Tables and Figures demonstrate that there is less than 1 mm of concrete thickness loss when using replacement levels of 2.5 to 20% GSW and 5 to 40% demolition building debris. It is OK to utilise these samples to create concrete blocks.

Table 1: Abrasion Resistance Test Results for Concrete specimen using granite slurry waste (100 mm Size)

Series	Specimen No.	% Replacement of coarse aggregate slurry	W ₁ (gm) Initial Wt.	W ₂ (gm) final wt. after abrasion test	W ₁ – W ₂ Abrasion Loss (“W ₁ – W ₂ ”)	Abrasion Loss (“T mm”)
Series I	CC	0	2667	2652	15	0.57
	S1	2.5	2648	2631	17	0.64
	S2	5	2629	2610	19	0.72
	S3	7.5	2600	2579	21	0.80
	S4	10	2582	2560	22	0.87

S5	12.5	2603	2579	22	0.89
S6	15	2665	2641	24	0.94
S7	17.5	2570	2545	25	0.98
S8	20	2602	2576	26	0.99

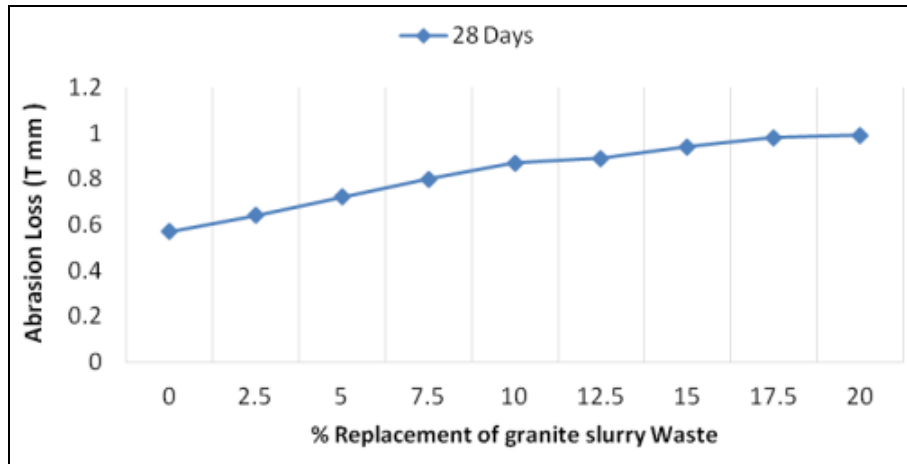


Fig 1: Abrasion Loss of Concrete with Granite Slurry Waste: A Graphical Analysis

Table 2: Abrasion Resistance Test Results for Concrete specimen using demolition construction waste (100 mm Size)

Series	Specimen No.	% Replacement of demolition construction waste	W ₁ (gm) Initial Wt.	W ₂ (gm) Final wt. after abrasion test	W ₁ - W ₂ Abrasion Loss ("W ₁ - W ₂ ")	Abrasion Loss ("T mm")
Series II	CC	0	2667	2652	15	0.57
	P1	5	2602	2585	17	0.65
	P2	10	2662	2644	18	0.68
	P3	15	2611	2592	19	0.73
	P4	20	2602	2484	21	0.84
	P5	25	2578	2556	22	0.86
	P6	30	2599	2575	24	0.93
	P7	35	2628	2603	25	0.96
	P8	40	2615	2590	25	0.97

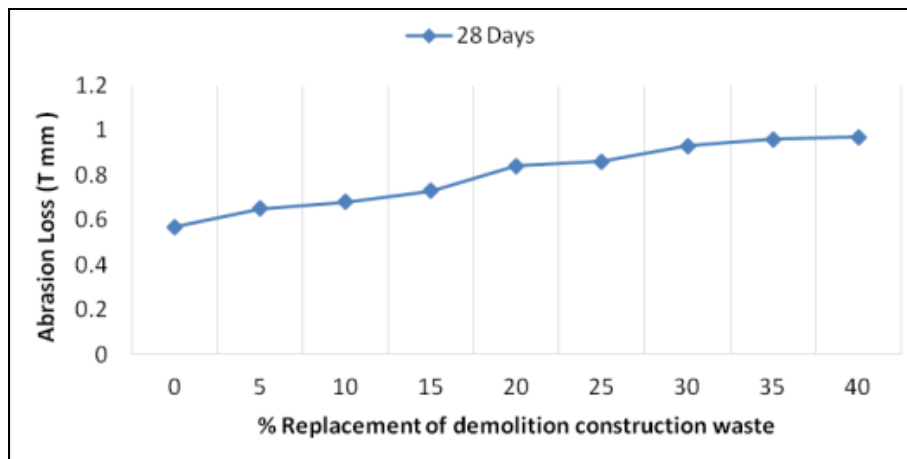


Fig 2: Visual Changes in Abrasion Loss from Concrete with Demolition Construction Waste

Concrete containing a combination of granite slurry and demolition construction waste shows graphical fluctuations

in abrasion loss, as shown in Table 3, which represents the results of an abrasion resistance test.

Table 3: Graphical Fluctuation in Abrasion Loss of Concrete Containing combo mix of Granite Slurry and Demolition Construction Waste

Series	Specimen No.	% Replacement of demolition construction waste	% Replacement of quarry dust	W ₁ (gm) Initial Wt.	W ₂ (gm) Final wt. after abrasion test	W ₁ - W ₂ Abrasion Loss ("W ₁ - W ₂ ")	Abrasion Loss ("T mm")
Series III	CC	0	0	2667	2652	15	0.57
	A1	2.5	5	2654	2636	18	0.68
	A2	5	10	2596	2577	19	0.73
	A3	7.5	15	2639	2619	21	0.80
	A4	10	20	2605	2583	22	0.85

A5	12.5	25	2578	2556	22	0.85
A6	15	30	2675	2618	19	0.86
A7	17.5	35	2648	2630	18	0.68
A8	20	40	2668	2652	16	0.60

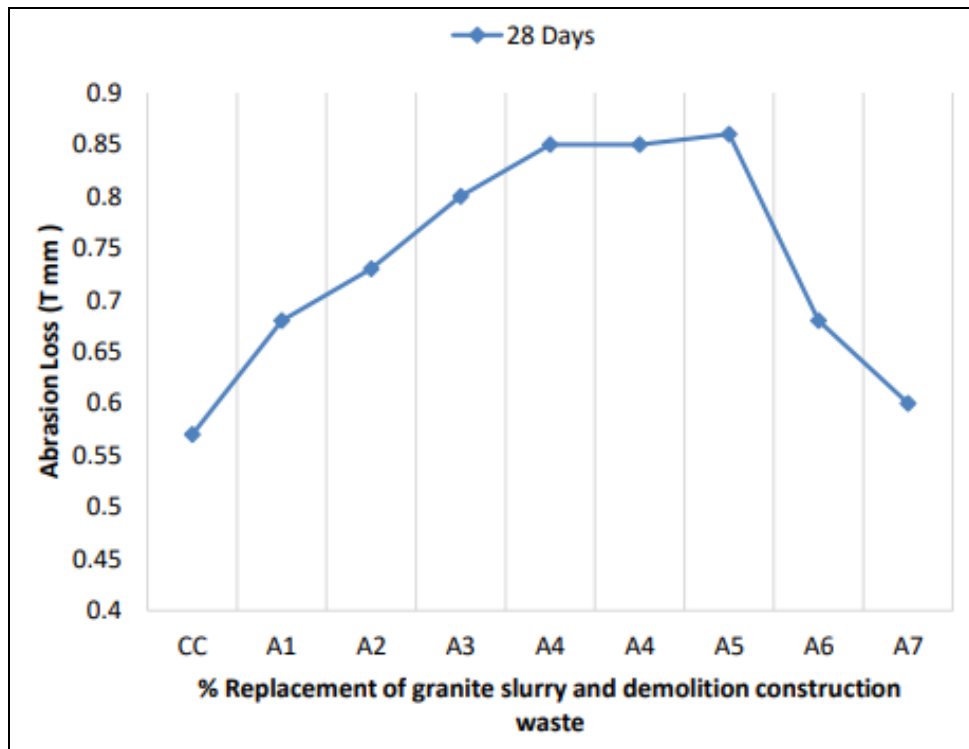


Fig 3: Graphical Fluctuation in Abrasion Loss of Concrete Containing combo mix of Granite Slurry and Demolition Construction Waste

Static Modulus of Elasticity (SME) of Concrete

The SME of the concrete sample was determined after 28 days of curing age. Tables 4 and 5 show the results of the static modulus of elasticity (SME) of concrete amended with different concentrations of demolition construction debris and granite slurry. Table 6 also shows results of the static modulus of elasticity (SME) of concrete at w/c 0.4 with two different levels of replacement using a combination mixture of demolition construction waste (5%, 10%, 15%, 20%, 25%, 30%, and 40%) and granite slurry waste (2.5%, 5%, 7.5%, 10%, 12.5%, 15%, and 20%). Visual changes of the static modulus of elasticity (SME) at a water-to-solids ratio of 0.4 are also shown in Figures 4, 5, and 6.

Series I has a high modulus of elasticity of 42300 MPa when 7.5% of the cement is replaced with granite slurry waste (GSW) after 28 days of curing. Series II has a high modulus of elasticity of 41900 MPa when 15% of the fine aggregates are replaced with demolition construction waste (DCW) after 28 days of curing. Series III has a high

modulus of elasticity of 44615 MPa when 10% of the cement is replaced with granite slurry waste (GSW) and 20% of the fine aggregates are replaced with demolition construction waste (DCW) after 28 days of curing.

It is clear that series-I concrete has an expandable modulus of elasticity up to 7.5% replacement level, whereas series-II concrete has an expandable modulus of elasticity of 15% or below. The modulus of elasticity of concrete decreases when a combination of demolition construction waste (DCW) and granite slurry waste (GSW) is used to partially substitute cement and fine aggregates at a weight-to-cement ratio of 0.4. The static modulus of elasticity (SME) of the concrete is decreasing after a fifteen percent partial replacement of tiny particles, as seen in Fig. 4 of series-II. The behaviour of eco-friendly fibrous concrete is shown in Figure 5. Research has shown that a water-to-cement ratio of 0.4 improves the reduction of concrete's elasticity modulus when 10% of the cement is replaced by fine aggregates (River Sand) and 20% by water.

Table 3: Static Modulus of Elasticity Test Result of Various Mixes of Concrete using Granite Slurry Waste

Series	Specimen No.	% Replacement of granite slurry	Modulus of Elasticity MPa
Series I	CC	0	34100
	S1	2.5	36420
	S2	5	40800
	S3	7.5	42300
	S4	10	39350
	S5	12.5	37200
	S6	15	35850
	S7	17.5	34200
S8	20	32110	

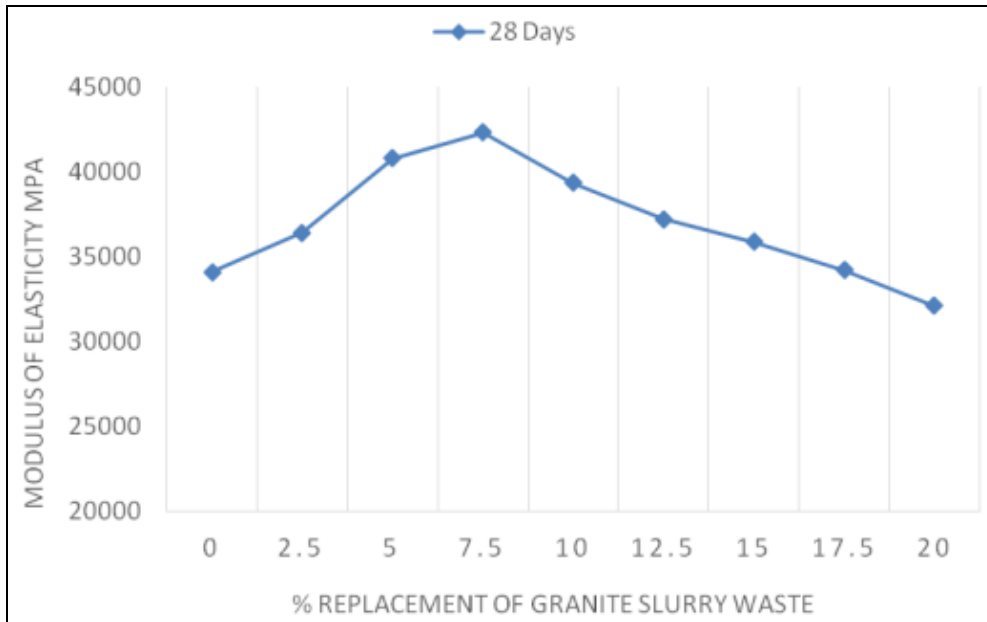


Fig 4: Graphical Fluctuation in Static Modulus of Elasticity using Granite Slurry Waste

Table 4: Static Modulus of Elasticity Test Result of Various Mixes of Concrete using Demolition Construction Waste

Series	Specimen No.	% Replacement of Demolition Construction Waste	Modulus of Elasticity (MPa)
Series II	CC	0	34100
	P1	5	37229
	P2	10	39610
	P3	15	41900
	P4	20	32750
	P5	25	30600
	P6	30	28550
	P7	35	25810
	P8	40	24005

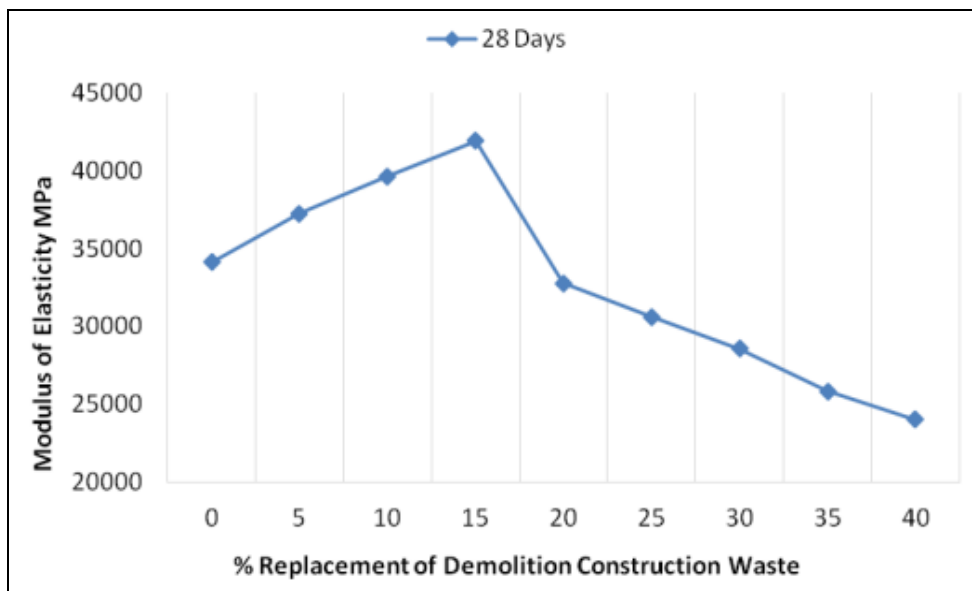


Fig 5: Graphical Fluctuation in Static Modulus of Elasticity (SME) of Concrete using Demolition Construction Waste

Table 5: Static Modulus of Elasticity Test Result of Various Mixes of Concrete using Combo mix of Granite Slurry Waste and Demolition Construction Waste

Series	Specimen No.	% Replacement of granite slurry	% Replacement of granite slurry and demolition construction waste	Modulus of Elasticity MPa
Series III	CC	0	0	34100
	A1	2.5	5	36730
	A2	5	10	39570
	A3	7.5	15	41350

A4	10	20	44615
A5	12.5	25	40990
A6	15	30	39050
A7	17.5	35	34110
A8	20	31400	

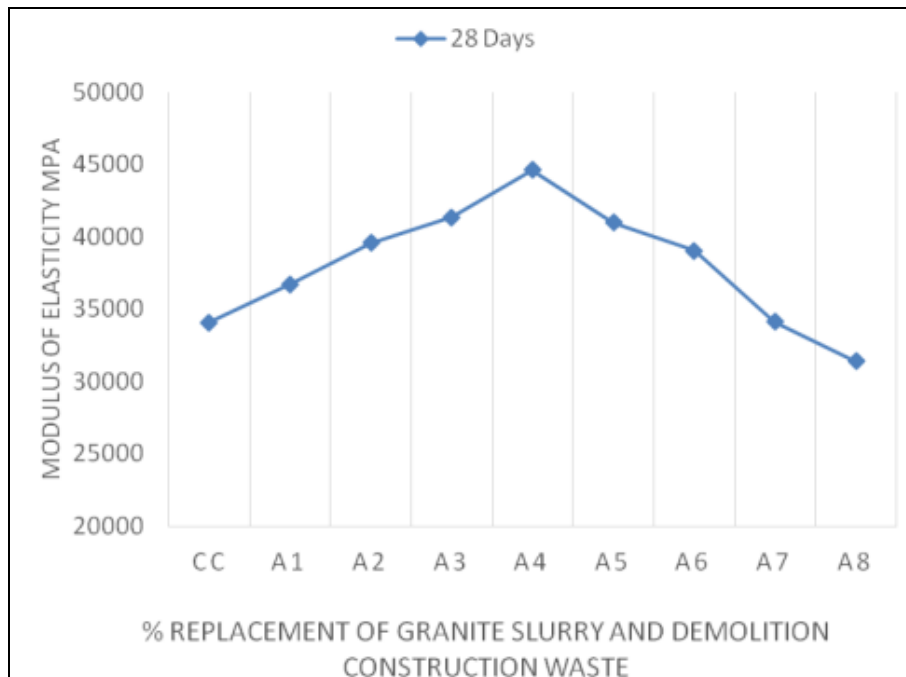


Fig 6: Fluctuation in Static Modulus of Elasticity (SME) of Concrete using Granite Slurry Waste and Demolition Construction Waste

Conclusion

Modified fibrous concrete has also been subjected to the acid attack, carbonation, and abrasion tests, which measure durability. In order to demonstrate that fibrous concrete was produced with quality control in mind, an ultrasonic pulse velocity (UPV) test was also performed. In earlier chapters, we covered the results of these experiments for different levels of replacement (2.5, 7.5, 10%, 12.5%, 15%, 17.5%, and 20%) of granite slurry waste and demolition construction waste (5%, 10%, 15%, 20%, 25%, 30%, 35%, and 40%).

Reference

1. Madiraju SVH, pamula ASP. A brief guide to the 50 eco-friendly materials transforming sustainable construction. *Austin environmental sciences*,2024:9:1-12. 10.26420/austinenvirosnci.2024.1105.
2. Khan S, rayhan S, salam SM, khan H, rahman D. Recent advances in sustainable building materials for the construction industry: mechanical performance and applications, 2023. 10.1016/b978-0-323-96020-5.00191-6.
3. Patel P, patel A. Use of sustainable green materials in construction of green buildings for sustainable development. *Iop conference series: earth and environmental science*,2021:785:012009. 10.1088/1755-1315/785/1/012009.
4. Kumar D, chandrashekar R, kurien S, nijhawan G, pahwa S, habelalmateen M, *et al.* A comprehensive review on using sustainable materials for environmentally friendly construction practices. *E3s web of conferences*, 2024, 529. 10.1051/e3sconf/202452901030.

5. Martinez A, carter S, mario C. The future of sustainable construction materials: innovations and market trends, 2024.
6. Firoozi AA, firoozi AA, oyejobi DO, avudaiappan S, saavedra flores E. Emerging trends in sustainable building materials: technological innovations, enhanced performance, and future directions. *Results in engineering*,2024:24:103521. 10.1016/j.rineng.2024.103521.
7. Shukla R, kumar S. Sustainable construction materials: innovations and environmental impact in civil engineering. *Journal of sustainable solutions*,2024:1:9-12. 10.36676/j.sust.sol.v1.i1.03.
8. Sharma N, jha A. Overview of eco-friendly construction materials, 2021. 10.1007/978-981-15-8820-4_11.
9. Abera Y. Sustainable building materials: a comprehensive study on eco-friendly alternatives for construction. *Composites and advanced materials*, 2024, 33. 10.1177/26349833241255957.
10. nwokediegwu ZQS. advanced materials for sustainable construction: a review of innovations and environmental benefits. *engineering science & technology journal*, 2024, 5(1).