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Research Article

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Application of Novel Hypo Sludge and Addition of Sikacrete to M25 Grade of Concrete and Comparison of Improved Flexural Strength with Conventional Concrete

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Abstract

Aim: This research examined the impacts of hypo sludge on concrete in an effort to increase its mechanical strength properties. To assess the economic and environmental benefits of using novel hypo sludge and Sikacrete in concrete mixes, such as reduced waste disposal costs and lower carbon footprint.

Method: Effect of Sikacrete addition and hypo sludge (Paper pulp) replacement in cement on flexural strength of concrete in comparison to conventional concrete grade M25.

Results: This experimental study used concrete of the M25 grade and a flexural strength test to examine the impacts of hypo sludge optimum level of 30% on the strength characteristics. The test findings reveal that hypo sludge infused concrete outperforms cement-only concrete in terms of performance. The mean flexural strength of the novel hypo sludge-added concrete was 14.96 N/mm^2, whereas the conventional concrete's value was 12.91 N/mm^2. When comparing the accuracy rate of both novel hypo sludge and conventional concrete, the statistically significant value is computed as p-value = 0.000, ($p < 0.05$), two-tailed and is regarded as such. Standard deviation (0.66145, 0.76014), standard error of the mean (12.9111, 14.6611), and mean (0.15591, 0.17917).

Conclusion: The addition of hypo sludge (Paper pulp) to cement and Sikacrete can consequently significantly improve the performance of high strength concrete.

Keywords

Novel hypo sludge, Sikacrete, M25 grade, Conventional concrete, Cement, Solid waste, Flexural strength

Introduction

Concrete is the most abundantly produced of all construction materials and the most widely utilized man-made construction material. Nano concrete is a type of concrete that incorporates nano materials, with particle sizes less than 500 nm, or includes nanomaterials as additives [1-3]. It is believed that the addition of nanoparticles enhances the strength of conventional concrete by improving its bulk properties, often referred to as the packing model structure. Nanoparticles act as efficient fillers, refining the interstitial zone in cement and resulting in denser concrete [4, 5]. This filler effect helps eliminate common issues in concrete microstructure such as micro voids, porosity, and deterioration caused by alkali silica reaction [6]. Furthermore, nanomaterials can serve as binding agents smaller than cement particles, improving the structure of hydration gel and creating a more compact and solid hydration structure [7]. Through the combination of fillers and additional chemical reactions in the hydration system, nano concrete with improved durability and performance characteristics has been developed [8].

The integration of nanotechnology in concrete began in the early millennium, driven by the growing demand for ultra high-performance concrete (UHPC) [9]. While conventional UHPC mixtures incorporating silica fumes offer enhanced durability and strength, the limited availability and high cost of silica fumes have led to a decline in the demand for UHPC technology compared to high strength concrete [10]. However, advancements in nano production technology have led to the development of alternative materials to silica fume [11]. Nano silica, which mimics the action of silica fumes, has emerged as one of the latest advancements in nanomaterials processing and is being used as a substitute for silica fumes [12].

Since the introduction of nano silica, numerous nano-based particles, such as nano alumina, titanium oxide, carbon nanotubes, and polycarboxylates, have been developed for use in nano concrete. These materials offer various properties and applications, contributing to the ongoing development and advancement of nano concrete technology.

Materials and Method

The Civil Engineering Department at Saveetha School of Engineering (Chennai, Tamil Nadu, India), the project was done. This experiment and study employed cement of Ramco 53 grade. River sand and aggregates that have been through an IS screen measuring 75 mm are used as fly ash in traditional concrete. It complies with IS 383-1970. Crushed stone provides coarse aggregates. Concrete uses aggregates with an angular shape and a size of 20 mm or less. The cement is shown in figure 1a. Coarse aggregates are defined as those that can pass through a 75 mm sieve while still holding on to 4.75 mm. Figure 1b shows hypo sludge, while figure 1c shows Sikacrete. The evaluation of coarse aggregates must be communicated, per IS 383-1970 regulations. The cement industry accounts for 9% of global greenhouse gas emissions. whereas India generates 420 million tons of industrial waste per year through chemical processes.

The mix design was made using the codebook IS 10262:2009. M25 grade concrete was selected as the mix proportion for this experiment. In order to reduce issues with paper waste disposal and cement production, alternative binders must be created in the construction sector. Figure 2 shows the flexural beam mold.

Two sets of specimens are ready for an experimental test. For group 1 specimens, the flexural strength test for regular concrete was developed, whereas group 2 specimens underwent the flexural strength test for modified concrete. The flexural beam mold, measuring 500 mm by 100 mm by 100 mm, was employed. In light of economic, environmental, and technological considerations, using industrial waste materials. In this study, paper waste (also known as "hypo sludge") is used as a partial replacement for cement. It is crucial to create lucrative construction materials from hypo sludge. The slump cone testing is seen in figure 3. Concrete was mixed with hypo sludge, a 30% partial cement replacement.

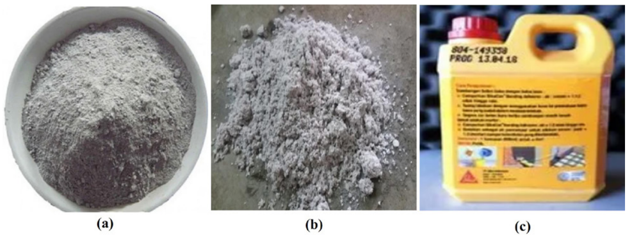

Figure 1: **(a)** Cement, **(b)** Hypo sludge, and **(c)** Sikacrete.

Figure 2: Preparing flexural beam mold.

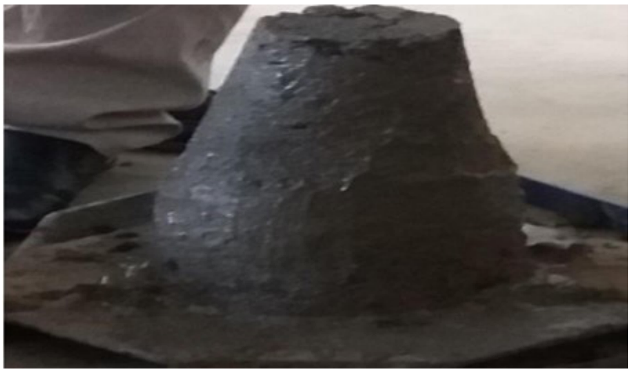

Figure 3: Slump cone test.

Additionally, a chemical additive called silcrete increases the strength of the features. According to the analysis of the mix percentage for M25 grade, 50 ml should be added for each cube while mixing concrete. It aims to create lightweight, inexpensive concrete using the by-products of the paper industry. As a substitute for concrete formulations as supplementary cementitious materials has been tested. Following the construction of the cube specimen, a compressive strength test was performed to measure the strength of the concrete. In figure 4, a flexural beam is evaluated using a flexural testing equipment.

The goal of these experiments was to assess the mechanical qualities such as flexural strength after 28 days. The strength of hypo sludge-made concrete is compared to that of normal concrete. Flexural strength was tested using standard testing equipment.

Statistical analysis

With the use of the SPSS version 26 program, the experiment's outcomes were examined. An independent sample

Figure 4: Beam specimen testing by using flexural testing machine.

t-test was used to assess the statistically significant results between the control and study groups. There are no dependent factors in this study; instead, the variables that determine. The following factors are independent: flexural strength, concrete quality, water-to-cement ratio, cement quality, and curing days. With this tool, the flexural strength mean, calculations were made for constant mean inaccuracy and constant deviation. P = 0.000 ($p < 0.05$) hence, this study shows the statistically significant difference. Statistical data for the sample group of M25 grade concrete with 30% hypo sludge. Mean (12.9111, 14.6611), standard error of the mean (0.66145, 0.76014), and (0.15591, 0.17917). Figure 5 shows a bar chart used to compare the mean flexural strength of modified and traditional concrete. The 30% novel hypo sludge-added concrete is stronger as compared to regular concrete. The typical detection accuracy is within ±1 standard deviation.

Results

The findings show that the flexural strengths of conventional M25 grade concrete were increased by the addition of novel hypo sludge. Concrete made with 30% hypo sludge and the mean flexural strength of 50 ml of Sikacrete was 14.21 N/mm^2, as opposed to 12.91 N/mm^2 for regular concrete. Flexural strength between hypo sludge and ordinary M25 grade concrete rises by 15.87%. While silcrete can increase the yield strength of concrete by up to 30% and replace some of the hypo sludge in the cement: this percentage will begin to decrease as soon as more than 20% more polypropylene concrete is added. When p = 0.000 ($p < 0.05$), the incident was considered significant. The statistically significant difference is also demonstrated by this investigation. Table 1 shows the flexural strength of concrete for normal M25 grade. Table 2 also displays the flexural strength of grade M25 concrete with novel hypo sludge added.

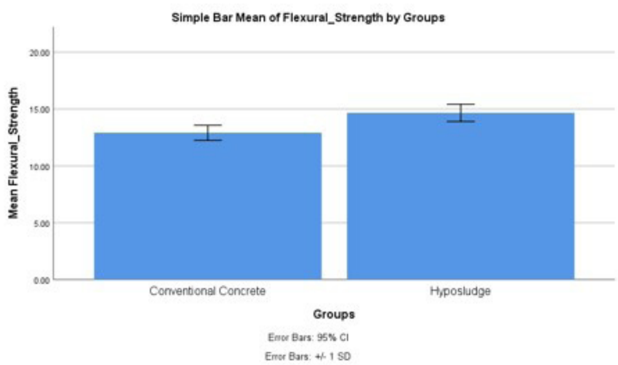

Figure 5: The average flexural strength of modified and ordinary concrete is analyzed using a bar chart. Compared to standard concrete, the concrete with 30% novel hypo sludge added is stronger. Mean detection accuracy is +/- 1 standard deviation. The group of conventional concrete and hypo sludge concrete group is displayed on the X-axis. The mean flexural strength is displayed on the Y-axis in N/mm^2.

Table 3 uses Levene's test for equality of variances to compare the results for the two groups, conventional concrete and conventional concrete. that has been partially replaced with hypo sludge and silcrete, with a p-value of 0.05 and a 95% error rate. The findings of the examination of group statistics are shown in table 4.

Discussion

A waste product gathered from the paper industry is called hypo sludge. Hypo sludge behaves like cement because of the properties of silica and magnesium. It works well as the concrete's binding chain ingredient. The bundle chains are given even greater stability and strength by the regular packing of the chains, which forms hard, stable crystalline areas in some locations. Hypo sludge is utilized in concrete in place of 10%, 15%, 20%, 25%, and 30% of the cement. Additionally, both split tensile strength and compressive strength were assessed after 7 and 28 days, respectively. The control specimens for the dissertation work are M20 and M30 grade concrete with 0.45 and 0.55 w/c ratios, respectively. 10%, 20%, and 30% by weight of cement are among the percentages of hypo sludge that are substituted. This project's objective is to evaluate and examine whether producing affordable, incredibly durable, and useful concrete with waste from the paper industry may replace cement.

Table 1: Flexural strength outcome of conventional concrete in M30 grade.

Mix type - conventional concrete	Flexural strength for 28 Days (N/mm^2)
S1	13.4
S2	13.7
S3	13.6
S4	13.5
S5	13.1
S6	11.4
S7	12.8
S8	12.1
S9	13.7
S10	12.5
S11	12.7
S12	13.6
S13	12.5
S14	12.2
S15	12.2
S16	13.4
S17	12.9
S18	13.1

Table 2: Flexural strength result of M30 grade modified concrete.

Mix type - modified concrete	Flexural strength for 28 Days (N/mm²)
S1	14.70
S2	15.90
S3	14.90
S4	15.70
S5	14.40
S6	13.60
S7	14.10
S8	14.30
S9	15.00
S10	14.70
S11	14.00
S12	15.80
S13	13.80
S14	14.40
S15	13.50
S16	15.60
S17	14.20
S18	15.30

This is just another effort to lower cement production, which increases greenhouse gas emissions. The researchers will gather all the necessary information, examine the influences on concrete's strength, conduct several experiments to gauge concrete's strength, and contrast the costs and strengths of typical concrete that has been replaced in part. The literature of this study is hypo sludge may require additional processing or treatment to remove impurities and ensure its suitability for use in concrete. This can increase the cost and complexity of using hypo sludge as a sustainable alternative to traditional concrete ingredients.

The future scope of this study is to consider the sustainability implications of using different ratios of Sikacrete and varying the grade of concrete. While these adjustments may improve the environmental performance of concrete, they can also have trade-offs in terms of cost, availability of materials, and overall carbon footprint.

Conclusion

To strengthen the mechanical strength of the concrete, the innovative hypo sludge concrete was largely replaced by cement. The average flexural strength of 30% hypo sludge concrete with 50 ml of Sikacrete was 14.96 N/mm², while the flexural strength of M25 grade conventional concrete was 12.91 N/mm². Flexural power increased in hypo sludge concrete by 15.87%.

Table 4: Group statistics for a sample group of 30% of hypo sludge concrete. Mean (12.9111, 14.9611), standard deviation (0.66145, 0.76014), and standard error mean (0.15591, 0.17917).

	Group	N	Mean	Std. deviation	Std. error mean
Flexural strength (N/Mm²)	Conventional concrete	18	12.9111	0.66145	0.15591
	Modified concrete	18	14.6611	0.76014	0.17917

Acknowledgements

None.

Conflict of Interest

None.

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Table 3: Results of the independent samples t-test for 30% of the hypo sludge concrete. This study shows the flexural strength showed a statistically significant difference in an independent sample t-test p = 0.000 since it was smaller than p = 0.05.

Flexural strength	Levene's test for equality of variances		T-test for equality of means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% CI of the difference: Lower	95% CI of the difference: Upper
Equal variance assumed	0.440	0.512	-7.368	34	0.000	-1.75000	0.23750	-2.23266	-1.267
Equal variance not assumed	-	-	-7.368	33.363	0.000	-1.75000	0.23750	-2.23300	-1.267

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