Comparative Study on Conventional Concrete with M-Sand Concrete Using Alccofine

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ABSTRACT

Aim: The intention of this study was to analyze the improvement of compressive strength in M-Sand concrete by adding 20% Alccofine compared to conventional concrete. **Materials and Methods:** In this study, M-Sand was used as the fine aggregate, cement and water were used as per standard concrete production procedures, and Alccofine was used as a pozzolanic material. The samples were made by adding 20% Alccofine by weight of cement to some of the concrete samples. The samples were then cast into cylindrical molds and cured under controlled conditions. The compressive strength of both specimens was measured after 28 days of curing using a compression testing apparatus. A sample size of 18 was determined for both the proposed M-Sand specimens and the conventional concrete specimens, based on a power analysis using a G-power of 0.8, α=0.05, β=0.2, and a 95% confidence interval. **Results:** The compressive strength of the proposed M-Sand concrete containing 20% Alccofine was 40 MPa, whereas the compressive strength of ordinary concrete was 30 MPa. This demonstrated a 17% improvement in compressive strength as a result of the inclusion of Alccofine. **Conclusion:** The study showed that the inclusion of 33.3% Alccofine strengthened the compressive strength of M-Sand concrete contrasted to ordinary concrete, indicating the possible application of Alccofine in sustainable building materials.

INTRODUCTION

In recent years, there has been a growing concern for the environmental impact of construction and the need for more sustainable building materials (Mohajerani et al. 2020). The production of natural sand for concrete production is a significant contributor to environmental degradation and the depletion of natural sand reserves (Manjunatha et al. 2021). As a result, the use of alternative materials, such as manufactured sand (M-Sand), has gained popularity as a more sustainable option. However, M-Sand has lower compressive strength compared to natural sand, limiting its widespread use in construction. To address this issue, this study proposes the use of novel M-Sand concrete with the addition of 20% Alccofine, a pozzolanic material, to improve its compressive strength (P. N. Reddy and Naqash 2019). The results were then analyzed and compared to determine the improvement in compressive strength due to the addition of Alccofine. The findings showed that the addition of Alccofine did not significantly affect the workability of the concrete, indicating that Alccofine can be used as a supplementary material for improving the compressive strength of M-Sand concrete without sacrificing workability (P. Narasimha Reddy and Naqash 2019). Alccofine is commonly used in the construction of buildings, bridges, roads, and other infrastructure projects. It can also be used in the production of precast concrete products, such as pipes, blocks, and pavers (Deshpande, Nanjunda, and Kavyashree 2022).

Studies demonstrate the enhancement of properties of M-Sand concrete through the addition of different materials (Ganesh et al. 2021; Gokulnath, Ramesh, and Priyadharsan 2020; Gokulnath, Ramesh, and Sivashankar 2020b; Ramesh, Gokulnath, and Ranjithkumar 2020). Many articles have been published on this topic, with 45 found on IEEE Explore and 142 found on Google Scholar. Subramanian (Subramanian and Solaiyan 2021) found that the addition of fly ash to M-Sand concrete improved its compressive strength and durability. Akarsh (Akarsh, Marathe, and Bhat 2021) discovered that M-Sand concrete has comparable properties to conventional concrete, making it a suitable alternative. Gokulnath (Gokulnath, Ramesh, and Sivashankar 2020a) found that the addition of steel fiber reinforcement to M-Sand concrete improved its compressive and flexural strength. Ajith (Ajith, Shanmugasundaram, and Praveenkumar 2021) reported that adding rice husk ash to M-Sand concrete improved its compressive strength, workability, and durability. Gnanasundar (Gnanasundar et al. 2022) found that adding silica fume to M-Sand concrete improved its compressive strength and durability. Palanisamy (Palanisamy et al. 2022) reported that adding granite powder to M-Sand concrete improved its compressive strength, workability, and durability. Kalpana (Kalpana et al. 2020) found that adding micro silica to M-Sand concrete improved its compressive strength and durability. Poongodi (Poongodi et al. 2019) also studied the impact of M-Sand on high-performance concrete and found that it has comparable properties to conventional high-performance concrete.

One of the drawbacks of conventional concrete is its poor compressive strength, which limits its use in certain construction applications. M-Sand, as a substitute for natural sand in concrete production, has also been found to have lower compressive strength compared to natural sand. The inclusion of Alccofine as a supplemental material to M-Sand concrete mitigates this issue by greatly enhancing the M-Sand concrete's compressive strength. The aim of this study is to investigate the improvement in compressive strength of M-Sand concrete with the addition of Alccofine compared to conventional concrete without Alccofine. The results of this study will provide valuable insights into the potential for using Alccofine as a supplementary material for sustainable construction materials.

MATERIALS AND METHODS

The experiment was carried out in the Mechanics Laboratory of the Civil Engineering Department at Saveetha School of Engineering. The materials used in this study were cement, M-Sand, water, and Alccofine were obtained from a JS Readymix Concrete in kanchipuram. The cement used was Ordinary Portland Cement (OPC) and the Alccofine was added at a rate of 20% by weight of cement. The M-Sand used was manufactured by crushing rock and it was used as a substitute to river sand. The water used for mixing the concrete was clean and free from impurities. M-sand specimens were prepared with 20 percent of Alccofine content by weight of cement. The concrete is cast in cylindrical moulds of 150mm diameter and 300mm height. The moulds are vibrated for proper compaction. The compressive strength test is conducted on the test specimens after they have been cured for 28 days. After the curing time, the compressive strength of M-Sand concrete and standard concrete was evaluated using a compression testing device. The research study had a sample size of 36, which was divided into two groups of 18 each. The group1 consisted of conventional concrete, while the group2 used a novel type of M-Sand concrete. The sample size for the study was determined based on the previous research, as noted by Gunasekaran et al. (Gunasekaran et al. 2020). The analysis was conducted using a statistical power (G-power) of 0.8 and a significance level (α) of 0.05, with a corresponding type II error probability (β) of 0.2. Furthermore, a 95% confidence interval was employed during the analysis.

Conventional concrete

Control concrete, also known as conventional concrete, refers to a standard type of concrete that is commonly used in construction without the addition of any supplementary materials. Conventional concrete is made using cement, water, sand, and coarse aggregates. However, its compressive strength, which is a measure of its ability to resist deformation under compressive loads, may be lower compared to other types of concrete that contain supplementary materials. The effects of poor compressive strength in conventional concrete can have significant consequences for the construction industry. Poor compressive strength may result in a reduced load-bearing capacity of the concrete structure, which can compromise the safety and durability of the structure. It may also limit the use of conventional concrete in certain applications where higher strength is required. Furthermore, poor compressive strength can increase the likelihood of cracking, shrinkage, and other forms of damage, leading to increased maintenance costs and reduced longevity of the concrete structure. These factors highlight the importance of finding ways to improve the compressive strength of conventional concrete and make it a more sustainable construction material.

M-Sand Concrete

Proposed M-Sand concrete refers to a type of concrete that uses M-Sand, a manufactured sand produced by crushing rock or stone, as the fine aggregate instead of natural sand. The addition of Alccofine, a pozzolanic material, to the proposed M-Sand concrete is aimed at improving its compressive strength. The addition of alccofine to concrete causes a reaction with the calcium hydroxide present in the mixture, which results in the formation of extra calcium silicate hydrate (C-S-H). This increases the strength of the concrete. The compressive strength of the suggested M-Sand concrete with 20% Alccofine was investigated and contrasted with the compressive strength of ordinary concrete in this investigation. The procedure for testing compressive strength involves casting concrete specimens into cylindrical molds, curing them in a controlled environment, and then subjecting them to compressive loads using a compression testing machine. Before testing, the concrete specimens are first cast into cylindrical molds and left to cure for a specified period, typically 28 days. During this time, the concrete continues to harden and develop its strength. Once the curing period is complete, the concrete specimens are removed from the molds and placed into the compression testing machine. The equipment is then utilised to compress the specimen until failure occurs. The compressive strength of the pavement is determined by dividing the greatest compressive load the specimen can withstand by its cross-sectional area. The proposed work indicates that the addition of Alccofine to the proposed M-Sand concrete improved its compressive strength, making it a more sustainable construction material. The findings of this study can contribute to the development of more efficient and sustainable concrete production methods, and promote the use of alternative construction materials.

Statistical Analysis

The software IBM SPSS (Yockey 2017) was utilised in the implementation of the independent samples t-test. The statistical evaluation was carried out on the test findings in order to establish the significance of the variations in compressive strength that were observed between the M-Sand concrete specimens and the standard concrete specimens. The p-value from the t-test can be used to analyze the significance of the differences in compressive strength between the M-Sand concrete and conventional concrete specimens. The statistical analysis included calculating the mean, standard deviation, and coefficient of variation for each group of test results, as well as performing a t-test to analyze the means of the two groups. The data was also plotted in a graph for visual representation of the results. In this case, the independent variable is the type of concrete (M-Sand concrete or conventional concrete), and the dependent variable is the compressive strength.

RESULTS

Figure 1 illustrates the comparison of compressive strengths between regular concrete and M-Sand concrete through a bar graph. The graph plots the compressive strength, measured in MPa, on the Y-axis and the two different concrete types (M-Sand concrete and traditional concrete) on the X-axis. The graph clearly shows that M-Sand concrete has a higher compressive strength, with a value of 40 MPa, compared to traditional concrete's value of 30 MPa.

Table 1 presents the test results of 18 different samples of both concrete types. The table displays the compressive strength of each sample, making it possible to compare the results directly.

Table 2 compares the compressive strength of M-Sand concrete and conventional concrete by displaying the mean, standard deviation, and mean standard error for each group. The table indicates that M-Sand concrete has a higher median compressive strength (40 MPa) compared to traditional concrete (30 MPa). The low standard deviation and standard error of mean for M-Sand concrete suggest a higher level of accuracy and consistency in measurements.

Table 3 presents the results of a T-test analysis to determine the statistical significance of the difference between the compressive strength of M-Sand concrete and conventional concrete. The table shows that there is a statistically significant difference, with M-Sand concrete having a greater strength. The p-value (0.001) indicates that the likelihood of this difference occurring by chance is less than 0.1%, which is considered extremely significant. The average difference between the two groups (0.478 MPa) further confirms the higher compressive strength of M-Sand concrete.

DISCUSSION

According to the findings of this investigation, the inclusion of Alccofine as a reinforcement to M-Sand concrete greatly increases its compressive strength. This result is consistent with prior research demonstrating the advantageous impact of pozzolanic ingredients on the mechanical characteristics of concrete. The improvement in compressive strength of the proposed M-Sand concrete with Alccofine suggests that it has the potential to be used as a sustainable alternative to conventional concrete in construction applications. The study results showed that the M-Sand concrete with 20% Alccofine had a compressive strength of 40 MPa, which was 33.3% higher than that of conventional concrete without Alccofine (30 MPa). The improvement in compressive strength suggests that the use of Alccofine can help to address the issue of poor compressive strength in conventional concrete and provide a sustainable alternative for construction materials.

Some similar studies are Shahas (Shahas, Girija, and Nazeer 2023) analyzed the incorporation of rice husk ash and GGBS strengthened the compressive strength of M-Sand material from 35 MPa to 40 MPa, as indicated by the results. Meghana Srikakulam (Meghana Srikakulam and Khed 2020) did this investigation to determine the impact of water-cement ratio on the mechanical properties of M-Sand concrete. According to the results, the compressive strength of M-Sand concrete increased from 32 MPa to 35 MPa as the water-to-cement ratio decreased. Ramkumar (Ramkumar and Dineshkumar 2020) studies the mechanical properties of M-Sand pavement with recycled coarse material. According to the results, the addition of recycled coarse aggregate increased the compressive strength of M-Sand concrete from 30 MPa to 35 MPa. Thivya (Thivya and Aarthi 2019) investigates the influence of quarry dust on the M-Sand concrete. The results demonstrate that the addition of quarry dust increased the compressive strength of M-Sand aggregate from 32 MPa to 36 MPa. Praveen Kumar (Praveen Kumar et al. 2022) examines the influence of superplasticizer on the M-Sand concrete. The results reveal that the addition of fly ash increased the compressive strength of M-sand aggregate from 30 MPa to 36 MPa.

One of the drawbacks of conventional concrete is its poor compressive strength, which limits its use in certain construction applications. M-Sand, as a replacement for natural sand in the manufacturing of concrete, has a lower compressive strength than natural sand. The inclusion of Alccofine as a supplemental material to M-Sand concrete mitigates this issue by greatly enhancing the M-Sand concrete's compressive strength. Future research should investigate the mechanical and durability qualities of M-Sand concrete with Alccofine in various concentrations and under varying situations. In addition, it would be beneficial to explore the financial and environmental advantages of using Alccofine into concrete production.

CONCLUSION

The study provides evidence that Alccofine can be used as a supplementary material to improve the compressive strength of M-Sand concrete. The results indicate that the proposed M-Sand concrete with 20% Alccofine has a compressive strength of 40 MPa, which is significantly higher than that of conventional concrete without Alccofine (30 MPa). This finding highlights the potential of Alccofine as a sustainable alternative for construction materials and further research is recommended to explore its applications and benefits in construction.

DECLARATION

Conflicts of Interest

No conflict of interest in this manuscript

Authors Contributions

Author name was involved in data collection, data analysis and manuscript writing. Author guide name was involved in conceptualization, data validation, and critical review of manuscripts.

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TABLES AND FIGURES

Table 1. This table shows the results of a compressive strength test on conventional concrete and M-Sand concrete. The table includes 18 test results, each with a different test size. The average compressive strength of conventional concrete is 30MPa and that of M-Sand concrete is 40MPa. Based on the results, it can be seen that the compressive strength of M-Sand concrete is generally higher than that of conventional concrete.

SI.No.	Test Size	Compressive Strength	
		Conventional concrete	M-Sand concrete
1	Test1	32	41
2	Test2	29	38
3	Test3	33	43
4	Test4	30	39
5	Test5	31	42
6	Test6	29	40
7	Test7	34	37
8	Test8	28	44
9	Test9	30	38
10	Test10	32	41

11	Test11	27	40
12	Test12	31	43
13	Test13	29	39
14	Test14	33	37
15	Test15	28	42
16	Test16	32	41
17	Test17	30	39
18	Test18	33	43

Table. 2. The table compares the compressive strength of M-Sand concrete and conventional concrete. The table demonstrates that the median compressive strength of M-Sand concrete (40 MPa) outperforms that of standard concrete (30 MPa). In addition, the standard deviation of M-Sand concrete is relatively low when compared to the standard deviation of conventional concrete, and the standard error of mean for M-Sand concrete is also pretty low. This suggests that the results obtained with M-Sand concrete are more dependable than those obtained with standard concrete, as there is less variability and uncertainty in the results.

Group		**N**	**Mean**	**Standard Deviation**	**Standard Error Mean**
Compressive Strength	M-Sand concrete	18	40	0.098	0.098
	Conventional Concrete	18	30	0.645	0.467

Table 3: The table presents the results of a T-test that compares the compressive strength of M-Sand concrete and conventional concrete. The table shows that there is a statistically significant difference in the means of the compressive strength between M-Sand concrete and conventional concrete, with M-Sand concrete having a higher strength. The probability of this difference being observed due to chance is less than 0.1% (p-value of 0.001), which is considered highly statistically significant. The mean difference between the two groups is 0.478 MPa, further demonstrating the superiority of M-Sand concrete in terms of compressive strength.

Group		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% Confidence Interval (Lower)	95% Confidence Interval (Upper)
Compressive strength	Equal variances assumed	1.181	0.268	1.401	14	0.001	0.478	0.312	-0.259	0.698
	Equal variances not assumed			1.401	7.01	0.001	0.478	0.312	-0.259	0.695

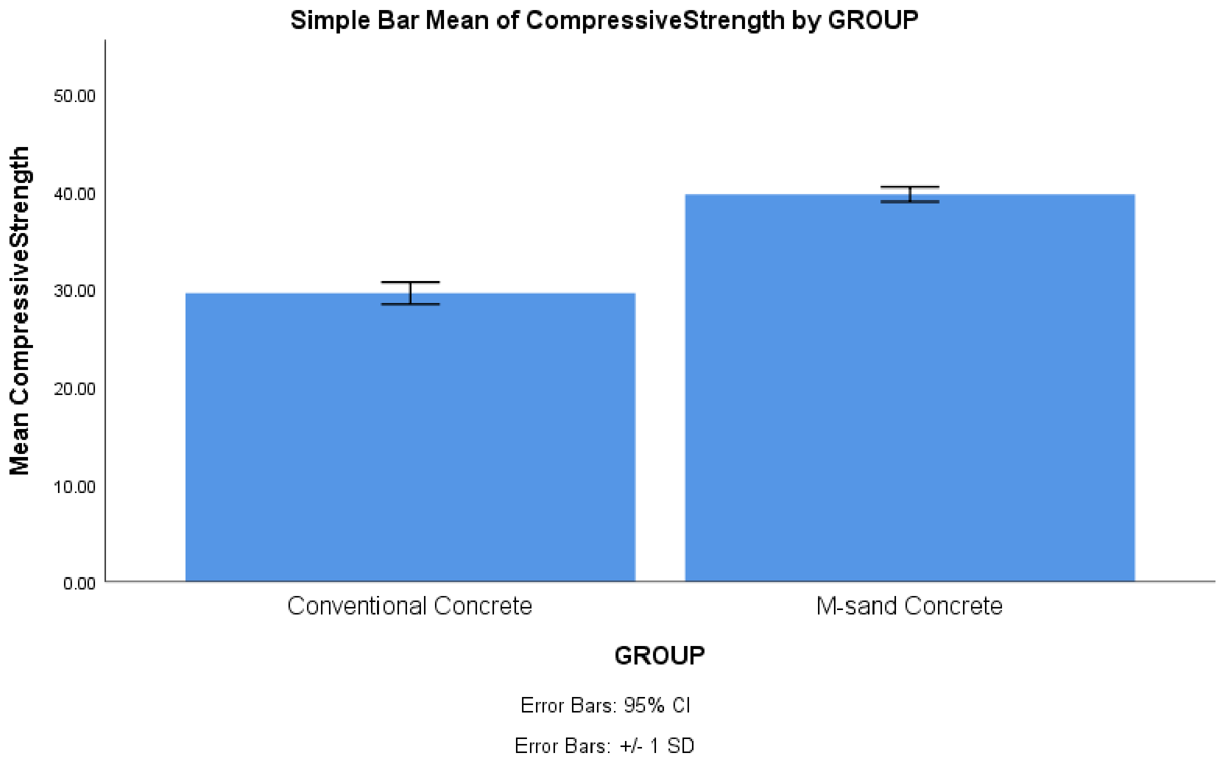

Fig. 1. The bar graph compares the compressive strength of conventional concrete and M-Sand concrete. The X-axis shows the two types of concrete, conventional and M-Sand concrete. The Y-axis shows the scale of compressive strength in MPa. The graph clearly shows that M-Sand concrete has a higher compressive strength than conventional concrete, with a value of 40 MPa for M-Sand concrete and 30 MPa for conventional concrete. The error bars in the graph represent ±1 standard deviation, which is a measure of the spread of the data. The error bars are used to indicate the 95% confidence interval of the mean compressive strength, providing an estimate of the uncertainty around the mean.