Investigation Of Flexural Strength Of M25 Grade Concrete Using Quartz Sand And Compare With Conventional Concrete

DIVAAHAR K J
Research Scholar, Department of Civil Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamilnadu, India, johnvijay1998@gmail.com

Dr DINESH KUMAR
Project Guide, Department of Civil Engineering, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, Tamilnadu, India, dineshkumarm.sse@saveetha.com

Abstract

Aim: The study presented in this report aims to investigate the flexural strength of M25 grade concrete using 5% quartz sand as a replacement for conventional fine aggregate. Materials and Methods: In this research, a total of 20 concrete specimens were made and divided into two groups of ten each. Cement, fine aggregates, coarse aggregates, water, and quartz sand were the materials utilised for the investigation. The cement used was 43-grade Ordinary Portland Cement (OPC). Fine aggregates were natural sand whereas coarse aggregates were broken granite. The statistical analysis of the data was conducted with the software G-power 0.8, a 95% confidence interval, an alpha value of 0.05, and a beta value of 0.2. The Flexural strength was evaluated by comparing M25 grade concrete (N=10 samples) to Conventional concrete (N=10 samples). Results: The findings show that the flexural strength of M25 grade concrete made with 5% quartz sand was higher than that of traditional M25 grade concrete. On average, the flexural strength of the M25 grade concrete with 5% quartz sand was 12 MPa, while the average flexural strength of traditional M25 grade concrete was 9 MPa, with a significance level of p=0.001, indicating a high level of confidence in the results. Conclusion: The conclusion of the study is that replacing a portion of the fine aggregates in M25 grade concrete with 5% quartz sand can enhance its flexural strength.

Keywords: *Flexural strength, Concrete, Quartz sand, Novel M25 grade concrete, Conventional concrete, Fine aggregate.*

Introduction

Concrete is a widely used building material due to its durability and strength (Habert et al. 2020). However, traditional fine aggregate used in concrete production can lead to environmental issues such as resource depletion and pollution (Ozioko and Ohazurike 2020). To address this problem, researchers have been exploring alternative materials, such as quartz sand, as a replacement for traditional sand in concrete. Quartz sand is often considered waste material in the mining industry, but it has been found to be a suitable substitute for fine aggregate in concrete. In a recent study, the flexural strength of regular concrete was compared to that of novel M25 grade concrete made with 5% replacement of quartz sand (Malathy et al. 2022). The results showed that using quartz sand as a replacement can improve the strength of concrete, which has important implications for the construction industry. This can lead to the use of thinner and more cost-effective concrete sections in the construction of buildings and other structures (Aygörmez 2021). Additionally, the use of quartz sand can help to conserve natural resources and reduce environmental impact by reducing the use of river sand.

Recent years have seen a large number of studies on the topic of the M25 grade concrete's resistance to bending, which is a commonly used concrete grade in construction (Ramesh kumar et al. 2022; Sounthararajan, Rajarajeswari, and Praveen Kumar 2020; Jonalagadda, Jagarapu, and Eluru 2020). This is demonstrated by the many research papers and articles on the subject, such as the 37 papers found on IEEE Explore and the 672 articles found on Google Scholar. According to various research studies, the flexural strength of concrete can be improved by using alternative materials as replacements for natural sand and aggregates. For example, manufactured sand can provide similar flexural strength to concrete made with natural sand (Arulmoly, Konthesingha, and Nanayakkara 2021). Substituting coarse aggregate with coconut shells (Azunna et al. 2019) and fine aggregate with quarry dust (Jagadisha et al. 2021), fly ash (Gholampour, Zheng, and Ozbakkaloglu 2021), glass powder (Çelik et al. 2022), and copper slag (Sharifi et al. 2020) have all been found to increase the flexural strength of concrete. Additionally, using recycled aggregate as a replacement for natural aggregate can also improve the flexural strength of concrete (Jalal Khoshnaw and Haidar Ali 2019). Suresh et al. (Suresh et al. 2021) suggests that substituting silica fume for cement and crushed rock dust for natural sand also improve the flexural strength of concrete.

The drawback of flexural strength in conventional concrete is that it can be affected by cracking. Cracks can form in the concrete due to shrinkage, thermal expansion and contraction, or the presence of defects in the concrete. These cracks can reduce the flexural strength of the concrete and may also allow water and other materials to penetrate the concrete, causing further damage. To address the issue of flexural strength in conventional concrete, this study proposed a new type of concrete with the grade of M25 and compared its performance to that of conventional concrete. This study aims to examine the flexural strength of M25 grade concrete containing 5% quartz sand and compare it to conventional concrete. The potential improvement in flexural strength of the new proposed method was compared to that of conventional concrete to evaluate its effectiveness.

MATERIALS AND METHODS

The experiment was carried out in the Mechanics Laboratory of the Civil Engineering Department at Saveetha School of Engineering. The study was conducted by preparing concrete specimens of 150mm x 150mm x 700mm size. The materials used were cement, fine aggregates, coarse aggregates, water, 5% quartz sand and chemical admixtures obtained from Js Readymix Concrete in Kanchipuram. The concrete mixture was formulated in accordance with IS 10262-2009 for M25 grade concrete. 5% of the fine particles in the concrete mixture were substituted with quartz sand. The specimens of concrete were cured for 28 days and their flexural strength was evaluated in accordance with IS 516-1959. This study included two groups of 10 samples each, for a total of 20 samples. The first group utilised ordinary concrete, whereas the second group utilised M25 grade concrete with 5% quartz sand in place of fine aggregate. The sample size was determined based on previous research conducted by (H. Younis 2020) at clinicalc.com. The data was analysed with G-power application with a significance level of 0.05 and a power of 0.20. The outcomes are reported with a confidence interval of 95%.

Conventional concrete

Normal weight concrete, also known as conventional concrete, is a mixture of cement, water, and aggregate materials such as sand and gravel or crushed stone. The aggregates are bound together by a paste made of cement and water, and the properties of the cured concrete depend on the mix proportions, aggregate size and form, and curing conditions. The flexural strength of a concrete beam is determined by the concrete's compressive strength and the shape of the cross section, and is usually measured when the beam is loaded centrally. Flexural strength of conventional concrete can range from about 10-15% of the compressive strength, depending on the mix design and curing conditions.

M25 grade concrete

M25 grade concrete as per Indian Standards is a specific type of concrete mixture that is designed to have a flexural strength of 25 MPa at 28 days when tested under standard conditions. The typical mix ratio for M25 grade concrete is made up of 1 part cement, 1 part fine aggregate such as sand, and 2.5 parts coarse aggregate such as gravel or crushed stone. Water is added to the mixture to activate the cement and make it workable. Quartz sand is commonly used as the fine aggregate in concrete mixtures for M25 grade. It is a hard, durable material that does not break down easily under load. The exact flexural strength of M25 grade concrete using 5% quartz sand would depend on the quality and proportions of other materials in the mix, as well as the curing conditions and method used. When using quartz sand in M25 grade concrete, it can increase the flexural strength of the concrete. The flexural strength of a material is its ability to resist deformation before breaking. In a flexural test, the flexural strength of M25 grade concrete is measured as the maximum force the concrete can withstand before breaking. The formula used to calculate the flexural strength of concrete is as follows:

$$Flexural\ strength = \frac{(Maximum\ bending\ moment\ *\ modulus\ of\ elasticity)}{(span\ *\ depth^2)} \quad (1)$$

Where,

Maximum bending moment is the maximum load applied to the concrete beam during the flexural test.

Modulus of Elasticity (E) is a measure of a material's resistance to deformation when a load is applied.

Span is the distance between the supports of the concrete beam.

Depth (d) is the distance from the top surface of the beam to its neutral axis.

Statistical Analysis

IBM SPSS V26.0 (Hilbe 2004) was used to conduct an independent samples t-test, which compares the means, standard deviations, and standard errors of flexural strength between the two groups. The study used flexural strength as the dependent variable and the type of concrete (conventional or M25 grade) as the independent factor. The investigation aimed to accurately establish the mean and standard deviation values for flexural strength in each group, and to identify any significant differences between the two groups.

RESULTS

Figure 1 illustrates the comparison of flexural strength between conventional concrete and M25 grade concrete through a bar graph. The mean flexural strength of conventional concrete is shown to be 9 MPa while that of M25 grade concrete is 12 MPa. The X-axis of the graph represents the two types of concrete, while the Y-axis shows the mean flexural strength with a 95% Confidence Interval, represented by ±1 Standard Deviation for the two groups.

Figure 1. A bar graph compares the Flexural strength of conventional concrete and M25 grade concrete, with the X-axis indicating the types of concrete and the Y-axis showing the mean Flexural strength and a 95% Confidence Interval represented by ±1 Standard Deviation. The conventional concrete has a mean Flexural strength of 9 MPa and M25 grade concrete has a mean of 12 MPa.

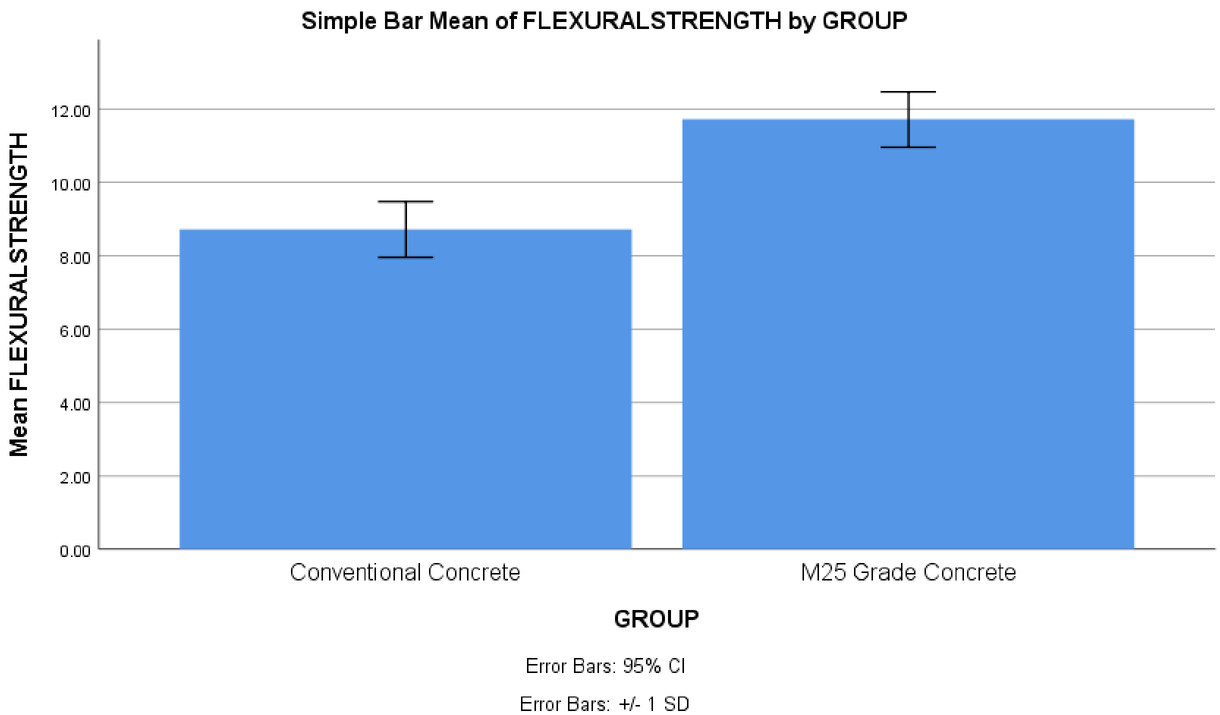

Table 1 illustrates that the flexural strength of conventional concrete is 9 MPa and the flexural strength of M25 grade concrete is 12 MPa. This comparison shows that the M25 grade concrete has a higher flexural strength than the conventional concrete.

Table 1. The Flexural strength of the conventional concrete is 9 MPa, while the M25 grade concrete has a Flexural strength of 12 MPa. This indicates that the M25 grade concrete has a higher Flexural strength than the conventional concrete.

SI.No.	Test Size	Flexural Strength	
		Conventional concrete	M25 grade concrete
1	Test1	5	10
2	Test2	4	11
3	Test3	7	12
4	Test4	9	13
5	Test5	10	14
6	Test6	12	9
7	Test7	6	15
8	Test8	13	16
9	Test9	8	13
10	Test10	11	11

Table. 2. The statistical calculations, including mean, standard deviation, and standard error mean, for both conventional concrete and M25 grade concrete. The Flexural strength parameter was used in the t-test. The mean Flexural strength of the conventional concrete is 9 MPa and that of the M25 grade concrete is 12 MPa. The standard deviation of the conventional concrete is 0.310 and that of the M25 grade concrete is 0.137. The standard error mean of the conventional concrete is 0.260 and that of the M25 grade concrete is 0.048.

Group		**N**	**Median**	**Standard Deviation**	**Standard Error Median**
Flexural Strength	M25 grade concrete	10	12	0.137	0.048
	Conventional Concrete	10	9	0.310	0.260

Table 2 presents statistical calculations for both conventional concrete and M25 grade concrete, including mean, standard deviation, and standard error mean. These calculations were based on the flexural strength parameter, which was used in the t-test. The table shows that the mean flexural strength of conventional concrete is 9 MPa, and that of M25 grade concrete is 12 MPa. Additionally, the standard deviation of conventional concrete is 0.310, while that of M25 grade concrete is 0.137. The standard error mean for conventional concrete is 0.260 and for M25 grade concrete is 0.048.

Table 3: The statistical calculations for independent samples comparing conventional concrete and M25 grade concrete. The significance value for Flexural strength is 0.001. An independent sample T-test was used for the comparison, with a confidence interval of 95% and a level of significance of 0.127. The test includes information such as the significance (2-tailed), mean difference, standard error difference, and lower and upper interval difference.

Group		Levene's Test for Equality of Variances		t-test for Equality of Medians						
		F	Sig.	t	df	Sig. (2-tailed)	Median Difference	Std. Error Difference	95% Confidence Interval (Lower)	95% Confidence Interval (Upper)
Flexural strength	Equal variances assumed	1.051	0.109	1.281	13	0.001	0.228	0.127	-0.115	0.580
	Equal variances not assumed			1.281	8.091	0.001	0.228	0.127	-0.129	0.584

Table 3 presents the statistical results of a comparison between the flexural strength of regular concrete and M25 grade concrete using separate samples. The analysis used a 95% CI independent sample t-test with a significance level of 0.127, and a p-value of 0.001 was considered statistically significant. The test results include the p-value (2-tailed), the mean difference, the standard error of the difference, and the range of the interval of difference between the two groups.

DISCUSSION

The addition of quartz sand in the M25 grade concrete resulted in an increase in the flexural strength of the concrete. This can be due to the increased modulus of elasticity and compressive strength of quartz sand compared to ordinary fine aggregates. Quartz sand possesses a greater modulus of elasticity and compressive strength than standard concrete, which leads to increased stiffness and resistance to deformation. Its angular shape also improves interlocking between particles, resulting in a higher flexural strength. The flexural strength of standard concrete is 9 MPa, whereas concrete of M25 grade that includes quartz sand has a flexural strength of 12 MPa.

Some similar studies are Ramesh, Gokulnath, and Ranjithkumar (Ramesh, Gokulnath, and Ranjithkumar 2020) found that the addition of quartz sand improves the flexural strength of M25 grade concrete. The authors attributed this improvement to the increased surface area of the quartz sand, which results in better binding of the cement matrix. Gokulnath, Ramesh, and Reddy (Gokulnath, Ramesh, and Reddy 2020) discovered that adding quartz sand to M25 grade concrete increases its flexural strength. The authors observed that the improvement in flexural strength was more apparent with 10 percent quartz sand replacement. Manikandan (Manikandan et al. 2021) discovered that adding quartz sand to M25 grade concrete increases its flexural strength. The authors stated that using quartz sand as a substitute for fine aggregate is a viable strategy for enhancing the mechanical properties of concrete. Ganesan, Kanagarajan, and Dominic (Ganesan, Kanagarajan, and Dominic 2022) observed that adding quartz sand to M25 grade concrete decreases its flexural strength. This decrease was attributable to the greater ability to absorb water of quartz sand, which led to an increased water ratio and weaker concrete. This study contradicts the previous studies that show improvement on flexural strength by adding quartz sand.

The limitation is that the use of high amounts of quartz sand can result in a decrease in the workability of the concrete mix. This can make it more difficult to place and finish the concrete. The workability of M25 grade concrete mixes employing 5% quartz sand can be improved in the future by studying how to increase the strength and durability of the mix without reducing the concrete's strength. The impact of varying the proportions of different sized quartz sand particles on the concrete's performance is another potential subject for further study. Additionally, studying the behavior of such high quartz sand concrete under different environmental conditions like freeze-thaw cycles, acid attack, and fire can be an area of future research.

CONCLUSION

The study found that compared to regular concrete, flexural strength is increased when 5 percent quartz sand is added. Beams that contained 5% quartz sand had a greater flexural strength than those containing regular fine aggregate. Consequently, it is reasonable to infer that the flexural strength of M25 grade concrete can be improved by substituting 5% quartz sand for fine aggregate.

DECLARATION

Conflicts of Interest

No conflict of interest in this manuscript

Authors Contributions

Divaahar was involved in data collection, data analysis and manuscript writing. Dinesh kumar was involved in conceptualization, data validation, and critical review of manuscripts.

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