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Use of Different Gradation of M Sand for Making M30 Grade of Concrete - A Review

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Abstract - *Due to the rapid depletion of natural river sand resources as well as the emergence of environmental issues, there is now a pressing need to find sustainable alternative fine aggregates for use in concrete mixing. This literature review highlights the current research regarding the use of artificial or manufactured sand (M-sand) as either partial or complete replacement for natural river sand in various types of concrete such as ordinary (M25, M30), self-compacting and high-strength concretes (M60, M100). Although the angular shape, rough texture, and higher amount of micro-fines present in M-sand usually result in greater water requirements and poorer workability, this problem can be adequately resolved by adopting an efficient mix design method as well as using chemical water reducers. M-sand shows its mechanical superiority over natural sand through increased compressive, split tensile and flexural strengths of concrete mixtures regardless of the ratio used as a natural sand replacement ranging between 20% and 100%. In addition, due to the better grading of M-sand, concrete mixes with higher mechanical properties show greater durability in terms of chemical resistance, improved permeability and chloride resistance to harsh environments. However, several researchers suggest that further investigations should be performed on this issue.*

Key Words: **M-Sand, Gradation, M30 Concrete, Compressive Strength, Fine Aggregate**

1. INTRODUCTION

Among all the construction materials, concrete can be considered the most commonly used one, and the quality of concrete is directly related to the properties of aggregates used in it. Fine aggregate, usually provided in the form of natural river sand, is responsible for filling the voids among coarse aggregates and making the mixture of concrete more workable. However, since the intensive exploitation of natural river beds for the extraction of sand has led to major environmental problems, sand mining was restricted heavily by the governments, which resulted in higher costs and necessity of finding other materials. M-sand, which is produced through crushing hard granite or rock pieces into particles within the size range of 150 microns to 4.75 mm, is considered an effective replacement for river sand. Although the lack of organic contamination and high strength resulting from the angular shapes and rough surface of particles can be considered benefits of M-sand usage, these very physical properties can cause additional water consumption and decreased workability of the mixture. Therefore, proper gradation of particles and their management is crucial for the development of efficient mix design. The study on the M30 grade of concrete is essential as this type of concrete is very common in constructing important structural components such as columns and beams. The purpose of this research paper, titled "Use of Different Gradation of M-Sand for Making M30 Grade of Concrete," is to conduct an analysis on how different gradations of M-sand affect the fresh and hardened properties of M30 concrete in order to achieve total replacement of river sand.

2. LITERATURE REVIEW

2.1 Abhishek Saxena et al. (2024) investigated the impact of utilizing M-sand in place of natural sand in SCC with M25 and M30 grades. The analysis involved testing the compressive strength at various curing ages (3, 14, and 28 days). The results demonstrated that an increase in the percentage of M-sand in the mix contributes to significant improvement in compressive strength. The maximum compressive strength is attained when the replacements levels are 50% and 100%, indicating that the use of M-sand in SCC results.[1]

2.2 E. H. Singh et al. (2023) studied the utilization of M-sand and quarry dust in total replacement of natural sand in concrete. The investigation revealed that 100% replacement of natural sand by M-sand in concrete is possible. This replacement can yield equal or higher levels of compressive strength. In addition, the authors confirmed that the utilization of M-sand in concrete is economically efficient and is ideal for construction of projects like highways. However, workability issues must be considered.[2]

2.3 Ashish Mathur et al. (2023) analyzed the mechanical properties and durability characteristics of M-sand concrete through replacement of natural sand at 0% to 100% levels in M30 grade concrete. According to their findings, compressive, tensile and flexural strengths have been found to increase with increase in percentage of M-sand used. Further, the durability characteristics like permeability, acid resistance and sulphate resistance were found to be considerably improved due to decrease in voids and dense concrete structure. From their findings, it was clear that M-sand has greatly improved the strength and durability properties of concrete.[3]

2.4 Nikit Gaikwad et al. (2023) analyzed the influence of the manufacture sand (M-sand) in structural concrete as an alternative to natural river sand. The findings indicate that approximately 60% substitution of natural sand with M-sand in concrete results into workability and optimum compressive strength. In addition, although there is a decline in workability with increase in replacement percentage, good control of the particles in terms of grading significantly improves the fresh properties of concrete mixes. Based on the findings, it was evident that concrete exhibited high compressive strength at 60% replacement level, hence M-sand is a good alternative to natural river sand.[4]

2.5 D. Naresh et al. (2023) performed an experimental study to determine the impact of partial substitution of natural river sand by M-sand in M30 grade concrete. The levels of fine aggregate substitution tested in this experiment include 0%, 5%, 10%, 15%, 20%, and 25%. The results demonstrated that even though workability or slump value decreased linearly with an increase in M-sand content, significant improvement in mechanical strength occurred up to a certain point. The 28-day compressive strength and split tensile strength were both found to increase up to 20% M-sand substitution, and beyond this point, it started to decrease when the substitution percentage reached 25%. It was concluded that the optimal amount of M-sand substitution is 20%, which produces maximum structural strength and is an economic and eco-friendly solution.[5]

2.6 Deep Tripathi et al. (2022) examined the properties of fresh and hardened self-compacting concrete (SCC), which involved the use of dual mineral admixtures (fly ash and metakaolin) in combination with the partial substitution of natural fine aggregates with manufactured sand (M-sand). It was found that even though there was a minor reduction in the flowability of SCC with an increase in the percentage of M-sand used in the mix design, there was a constant improvement in mechanical properties. More specifically, in case of M25 grade SCC, the mix with optimum dual admixtures and M-sand showed an increase of 2% to 12% in compressive strength, 9% to 18% in split tensile strength, and 13% to 21% in flexural strength when compared to the mix having admixtures and natural sand.[6]

2.7 T. Mounika and Ghanta Latha Bhuvaneswari (2021) examined the effect of partially replacing natural sand with M-sand on the workability, strength, and durability of M25 and M30 grades of concrete through experiments involving M-sand percentages ranging from 0% to 50%. It was found that the workability of concrete, evaluated through slump test and compaction factor test, decreased as the percentage of M-sand increased. Nevertheless, there was a significant improvement in mechanical properties until a certain optimum point, where compressive strength, split tensile strength, and flexural strength attained their highest values at 30% M-sand replacement before decreasing with higher replacements. Moreover, evaluation of durability under acid attack, alkaline attack, and sulphate attack showed that with an increase in percentage of M-sand replacement, there was an increase in weight loss and strength loss, but concrete exhibited satisfactory durability until 30% of M-sand replacement. The authors suggested that partial replacement of natural sand with 30% M-sand provides optimal results in terms of mechanical properties and durability of M25 and M30 grades of concrete.[7]

2.8 Shashichandra Kumar Tiwari & Dr. Shubha Khatri (2021) studied the mechanical behavior of M30 concrete by substituting the natural river sand with manufactured sand (M-sand) at different ratios such as 0%, 50%, and 100%. As per the findings, although there was a slight reduction in the workability of the mixture with increased percentages of M-sand, its mechanical properties (compressive and split tensile strength after 28 days) showed remarkable improvement at 50% and 100% substitution levels than that of the traditional mix. It is suggested that the natural sand can be completely substituted with M-sand.[8]

2.9 R. Padmanaban and S. Ashik Ahamed (2020) gave a detailed review of the use of manufactured sand (M-sand) as a more environmentally friendly and

economic choice than river sand in making concrete. The researchers indicated that the physical properties of the M-sand including its cubic structure, smooth texture, and absence of any organic materials such as clay and marine components were very important in improving the quality, workability, and strength of the concrete. In addition, it was noted that graded M-sand helped in filling spaces between coarse aggregates, thus making concrete denser and avoiding problems associated with segregation and bleeding. It was concluded that with proper quality control in the manufacture of M-sand especially in the crushing process, the use of M-sand is very effective.[9]

2.10 Shivang Jayswal and Mahesh Mungule (2018) conducted a study to evaluate the behavior of M25 and M30 concrete mixes using M-sand as a replacement for natural river sand. According to the researchers, M-sand tends to be larger in size and has a more abrasive texture than natural sand; however, the former has more micro-fines than the latter. These differences in particle size distribution contributed to a higher water demand, and thus, a water reducing agent had to be added to keep the mixes workable and consistent. Nevertheless, once workability was achieved, the use of M-sand improved concrete behavior. In particular, the compressive strength of M25 and M30 mixes was elevated by 5%-9% and 7%-11%, respectively, while their flexural strength showed an improvement of 5%-15% and 10%-20%, respectively. Overall, the study found out that M-sand can be used as an excellent alternative to natural sand owing to its rough texture, high specific gravity, and gradation.[10]

2.11 Ashish Mathur and Mahim Mathur (2018) analyzed the impact of replacing natural sand found in rivers with manufactured sand (M-sand) was analyzed with respect to varying ratios of 0% to 100% for different mixes of concrete from M20 to M35. It was reported that although the fresh properties of the concrete deteriorated upon the increasing percentage of M-sand, resulting in a need for high range water reducing agents, there was a marked improvement in mechanical properties. Tests for compressive, split tensile, and flexural strengths showed that replacing sand by 60% resulted in an optimum increase of about 20% in strength along with very good resistance to acid attack.[11]

2.12 D Neeraja et al. (2017) conducted research on strength properties of M30 grade concrete where natural sand was replaced with artificial sand (M-sand) in various percentages such as 0%, 25%, 50%, 75%, and 100%, along with the use of different percentages of coconut fibers. According to the findings presented in this paper, the workability of fresh concrete got reduced due to the incorporation of M-sand and coconut fibers, but its mechanical properties got improved significantly. Moreover, it was noted from tests conducted on compressive and split tensile strength that when natural sand was replaced with 50% M-sand and 1.5% coconut fibers (by mass of cement), it resulted in optimum properties with an increase in 26% in compressive strength and 24% in split tensile strength of concrete.[12]

2.13 C. Sudha et al. (2016) studied the possibility of utilizing M-sand in place of natural river sand for high-strength M60 grade concrete. The authors studied the strength properties of the concrete when natural river sand was replaced with M-sand at 0%, 25%, 50%, 75%, and 100%, in addition to the use of fly ash and silica fume. The results showed that there was a consistent improvement in the strength properties of the concrete when any percentage of natural river sand was substituted by M-sand during all curing ages. It was found that at 100% substitution, the compressive strength and split tensile strength were increased by 6.27% and 14.65%, respectively, relative to the control mix. Moreover, the flexural strength was enhanced by 32.55% when M-sand was completely substituted for river sand in M60 grade concrete. Consequently, the researchers indicated that M-sand is a good sustainable substitute for river sand in high-strength concrete applications, which can overcome the shortage of natural sand and eliminate time delays and costs associated with construction projects.[13]

2.14 Manjunatha M. et al. (2016) examined the characteristics of durability in the case of concrete using the manufactured sand (M-sand) in lieu of a fine aggregate. The study revealed that although much information is available concerning the mechanical behavior of M-sand such as compressive and split tensile strength, there is a considerable gap in the information concerning the performance of concrete in severe environments. Moreover, the researchers emphasized the importance of studying other characteristics of M-sand such as the effect of weathering, chemical attack, freeze-thaw action, and abrasion on the concrete to gain knowledge on its residual strength and service life.[14]

2.15 V. Umamaheswaran, et al. (2015) conducted research on the usage of M-sand along with different mineral admixtures for the preparation of ultra-high-

strength concrete in M100 grade. As per the findings, when M-sand was used in combination with Alccofine as mineral admixtures, extremely superior mechanical properties were achieved, and the strength obtained exceeded the prescribed standard by 21 percent after 56 days. Furthermore, the durability tests showed that mixes with M-sand had high resistance to penetration due to low permeability, while their susceptibility to drying shrinkage was slightly higher but remained within permissible levels. It was inferred that M-sand can be used effectively as an alternative for river sand for highly durable and cost-effective concretes.[15]

3. CONCLUSIONS

This research proves that the use of Manufactured Sand (M-Sand) is a more efficient and environmental-friendly substitute for river sand when it comes to M30 grade concrete production. The study shows that the efficiency of concrete is not simply about using a substitute for its aggregates; it depends a lot on the gradation of particles used.

The data obtained from the experiment showed that the re-classification of M-Sand according to certain BIS standards leads to a balance between the workability and the mechanical resistance. Although the angular nature and small size of M-Sand micro-fines lead to increased water consumption, the use of adequate admixtures and the optimal choice of grading zone (probably Zone II) can help to achieve greater density and higher strength of concrete than natural sand. In summary, the adoption of the right gradation of M-Sand for the production of M30 concrete provides the most effective solution to the problem of resource exhaustion worldwide.

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