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STUDY AND ANALYSIS OF MANUFACTURING SAND

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Abstract:

Concrete is prepared by combining cement, fine aggregate (sand), coarse aggregate, and a controlled quantity of water. Traditionally, river sand has been the most widely used fine aggregate due to its easy availability and suitability in mix design. However, excessive extraction of river sand has led to serious environmental concerns such as riverbed erosion and ecological imbalance. In addition, the declining availability of natural sand is creating challenges for construction activities and infrastructure development.

To address this issue, alternative materials like crushed stone sand—commonly known as Manufactured Sand (M-Sand) or Robo Sand—are increasingly being used as a substitute for river sand. The use of such materials not only reduces the dependency on natural resources but also helps in minimizing environmental degradation caused by over-mining of riverbeds.

Before adopting these alternatives in concrete, it is essential to study and compare their properties with those of natural sand. Important parameters such as specific gravity, fineness modulus, and compressive strength need to be evaluated to ensure their suitability.

The main objective of this project is to examine the key characteristics of crushed stone sand and compare them with river sand. Concrete specimens are prepared by replacing natural sand with crushed stone sand in proportions of 0%, 50%, and 100%. The compressive strength of these mixes is then determined for M20 grade concrete with a water-cement ratio of 0.45, to assess the performance and feasibility of using crushed stone sand as a sustainable alternative.

KEYWORDS: - Concrete; M-Sand vs River Sand; Fine Aggregate Replacement; M20 Mix (w/c 0.45); Strength & Properties; Sustainability

I. INTRODUCTION

Sand acts as the fine aggregate in concrete, with river sand traditionally being the most preferred option due to its natural formation and suitable properties. It is produced by the weathering of rocks over millions of years and is commonly extracted from riverbeds. However, excessive sand mining has led to serious environmental issues such as riverbed depletion, habitat destruction, and ecological imbalance. At the same time, the availability of river sand is rapidly decreasing, creating challenges for the construction industry.

To overcome this problem, Manufactured Sand (M-sand), produced by crushing rocks to the required size and grading, is being used as an alternative. It is processed in crushers and sometimes washed to remove excess fines, ensuring better quality control. Unlike natural sand, M-sand offers consistent gradation and fewer impurities, making it suitable for construction purposes.

Concrete, which is the most widely used construction material, mainly consists of cement, coarse aggregate, fine aggregate, and water. Among these, sand contributes a significant portion (around 35% by volume), but its quality from natural sources cannot always be controlled. This makes the use of M-sand more reliable and sustainable.

Due to increasing demand, environmental restrictions, and bans on river sand mining in many regions, the use of M-sand is gaining global acceptance. Studies indicate that M-sand can effectively replace natural sand, even up to 100%, although higher proportions may slightly affect workability. Therefore, it becomes essential to evaluate its properties—such as particle size distribution and fines content—and understand its impact on concrete characteristics like strength and durability.

Statement of Problem

The excessive use of natural river sand has led to its rapid depletion, creating serious environmental and social concerns. Continuous extraction from riverbeds causes issues such as erosion, lowering of the groundwater table, damage to aquatic life, and instability of riverbanks. At the same time, the growing demand for construction materials has made natural sand scarce and expensive.

Since aggregates form a major portion of concrete (about 75%), their quality directly affects strength and durability. Fine aggregate, usually river sand, plays a crucial role in concrete and mortar. However, due to its limited availability, there is a need to explore suitable alternatives.

Manufactured sand (M-Sand) has emerged as a potential substitute for natural sand. This study focuses on evaluating the use of M-Sand as a replacement for river sand by analyzing its properties and its effect on compressive and flexural strength, aiming to develop a reliable and sustainable solution for construction.

II. MANUFACTURED SAND

Manufactured sand (M-sand) is a sustainable substitute for natural river sand, produced by crushing hard rocks such as granite into fine particles using modern machinery. This controlled process ensures uniform size, shape, and quality, making M-sand comparable to river sand in performance. Typically, it has a cubical texture, fewer impurities, and better consistency, which improves bonding and strength in concrete.

The growing demand for construction materials has led to the over-extraction of river sand, causing environmental issues like riverbed erosion and groundwater depletion. As a result, M-sand has gained popularity due to its reliable availability and eco-friendly nature. Since it is produced near construction sites, it also reduces transportation costs, making it economical.

M-sand conforming to Zone II as per IS: 383–1970 is commonly used in construction and is tested according to Indian Standards. Its grading can be controlled during production, ensuring suitability for different construction needs. Overall, the use of M-sand not only supports sustainable construction but also helps maintain environmental balance by reducing dependence on natural sand resources.

III. LITERATURE REVIEW

A review of previous studies was carried out using research papers, journals, and conference publications to understand the use of manufactured sand (M-sand) as a replacement for natural river sand in concrete.

Several researchers have reported that replacing river sand with M-sand improves concrete performance. Studies by Nimitha **Vijaya Raghavan and A.S. Wayal (2013)** showed that compressive strength increases with higher proportions of M-sand, with maximum improvement observed at 100% replacement. They also highlighted environmental concerns due to excessive river sand mining and emphasized M-sand as a sustainable alternative.

Research findings indicate that crushed sand has physical properties similar to natural sand, such as specific gravity and particle size distribution, making it suitable for concrete. However, due to its angular shape, M-sand may slightly reduce workability, requiring proper mix adjustments.

Work by Kiran M. Mane (2017) and others demonstrated that partial and full replacement of natural sand with crushed stone improves strength characteristics. Similarly, studies by Saravanan et al. (2017) reported nearly 20% improvement in strength properties when eco-friendly sand was used.

Durability and long-term strength were also found to improve with the use of crushed sand. Umamaheswaran et al. (2015) observed better strength at later curing stages (56 days). Research involving GGBS and M-sand (Murali Krishnan et al., 2018) further confirmed enhanced concrete performance.

Some studies also focused on workability and mix behavior. Manufactured sand requires a slightly higher water-cement ratio due to its angular texture, as reported by Martins Pilegis et al. Additionally, the presence of fines in crushed sand can influence concrete properties, but up to a certain limit (around 15%), it does not adversely affect strength.

Other researchers, including Balapgol et al., found that replacing natural sand with crushed basalt sand significantly increases compressive and flexural strength while reducing permeability. Sanjay Mundra and P.R. Sindhi (2016) concluded that crushed stone sand provides comparable strength to conventional concrete and serves as an economical and environmentally friendly alternative.

Overall, the literature supports that manufactured sand can effectively replace natural sand, improving strength and durability while reducing environmental impact caused by excessive river sand mining.

IV. AIMS AND OBJECTIVE

The project titled *"Study and Analysis of Manufactured Sand (M-Sand)"* focuses on finding a sustainable alternative to natural river sand, whose excessive extraction has led to environmental damage and resource depletion. Due to these challenges, M-sand is being considered as a practical substitute in construction.

The main aim of this study is to evaluate the properties and performance of M-sand in comparison to natural sand. Laboratory tests are conducted to analyze parameters such as particle size distribution, density, strength, and durability. Based on these results, the suitability of M-sand for applications like concrete, plastering, and other construction works is assessed.

The project also examines the economic aspect of using M-sand. Although there may be an initial cost involved in production, it can reduce transportation expenses and dependency on natural resources, making it cost-effective in the long run.

From an environmental perspective, M-sand offers significant advantages as it reduces riverbed mining and helps in conserving natural ecosystems. However, certain challenges such as quality variation, raw material availability, and acceptance in the construction industry are also considered in this study.

Overall, the project aims to provide a clear understanding of the feasibility of replacing natural sand with M-sand and offers practical recommendations for promoting its use in sustainable construction practices.

V. METHODOLOGY

This study focuses on evaluating the suitability of manufactured sand (M-sand) as a replacement for river sand in concrete. Due to the environmental issues caused by excessive river sand mining, M-sand is considered a sustainable alternative. Concrete mixes of grades M20 and M25 were prepared with different replacement levels of fine aggregate (0%, 50%, and 100%) at a water-cement ratio of 0.45, following relevant Indian Standards such as IS 383 and IS 516.

Materials Used

Ordinary Portland Cement (53 grade), crushed coarse aggregate (12.5 mm), river sand, M-sand, and potable water were used. M-sand, produced by crushing rocks, has angular particles, while river sand is smoother and more rounded.

Material Testing

Basic tests like sieve analysis, specific gravity, and density were conducted to understand the properties of both sands.

- **Sieve Analysis** was performed to determine particle size distribution and confirm grading (Zone II). M-sand showed slightly coarser grading compared to river sand.
- **Specific Gravity Test** was carried out using a pycnometer to evaluate density-related properties, which are important for mix design.

  These tests ensured that the materials were suitable for concrete production.

Mix Preparation and Casting

Concrete mixes were prepared by replacing river sand with M-sand in varying proportions (0%, 50%, and 100%). The materials were first mixed in dry condition, followed by the addition of water to achieve a uniform mix. Specimens were cast in standard moulds, compacted properly, and cured in water.

Workability Test (Slump Test)

The slump test was conducted to measure the workability of fresh concrete. It was observed that as the percentage of M-sand increased, the slump value decreased. This is because M-sand has angular and rough particles, which increase internal friction compared to smooth river sand.

Compressive Strength Test

Compressive strength tests were carried out on concrete cubes after 7 and 28 days of curing using a compression testing machine. Results indicated that although early strength of M-sand concrete may be slightly lower, the strength improves with time and becomes comparable or even higher than conventional concrete. This is mainly due to better bonding and interlocking between angular M-sand particles and cement paste.

VI. RESULT AND DISCUSSION

This chapter presents the analysis of experimental results obtained from tests conducted on natural river sand and manufactured sand (M-sand). The study compares their physical and mechanical properties to evaluate the suitability of M-sand as a replacement for river sand in M20 and M25 grade concrete.

The investigation includes sieve analysis, specific gravity, slump test, and compressive strength test. The effect of replacing natural sand with M-sand at 0%, 50%, and 100% levels is examined, particularly focusing on strength development at 7, 14, and 28 days.

Key Observations

- **Gradation:** Both natural sand and M-sand fall within Zone II limits, indicating similar particle size distribution and suitability for concrete.
- **Strength:** Compressive strength increases with higher M-sand content. For example, in M20 concrete, 28-day strength improved

from **17.77 MPa (0%) to 19.55 MPa (100%)**.

- **Sustainability:** M-sand proves to be a better alternative as it reduces river sand mining, lowers environmental impact, and supports cost efficiency.

6.2 Sieve Analysis

Sieve analysis was carried out to determine particle size distribution using standard IS sieves. The results show that both sands have nearly identical gradation and satisfy Zone II requirements, confirming that M-sand can effectively replace natural sand without affecting mix quality.

6.3 Specific Gravity Test

The specific gravity of M-sand was determined using a pycnometer. The values ranged between **2.5 to 2.9**, indicating good density and suitability for concrete mix design. This parameter is important as it influences strength and durability.

6.4 Slump Test

The slump test was performed to evaluate workability. It was observed that slump decreases as the percentage of M-sand increases. This is due to the angular and rough texture of M-sand, which increases internal friction compared to smooth natural sand.

6.5 Compressive Strength Test

Concrete cubes were tested using a compression testing machine after curing for 7, 14, and 28 days.

Results Summary

- **M20 Grade:**
  0% M-sand: 17.77 MPa (28 days)
  50% M-sand: 18.22 MPa
  100% M-sand: 19.55 MPa
- **M25 Grade:**
  0% M-sand: 21.77 MPa (28 days)
  50% M-sand: 22.66 MPa

VII. SURVEY WORK

The survey on replacing natural sand with manufactured sand (M-sand) was carried out to understand its feasibility, performance, and acceptance in the construction industry. The study began with clearly defining objectives such as analyzing the availability of natural sand, evaluating the properties of M-sand, and identifying challenges in its adoption.

A detailed literature review was conducted using research papers, case studies, and industry reports to understand existing knowledge and trends. Data collection was done through questionnaires and interviews with stakeholders like engineers, contractors, suppliers, and government officials to gather both quantitative and qualitative insights.

Site visits were also conducted to observe the actual use and performance of M-sand in construction projects. In addition, laboratory tests were performed to compare the physical and mechanical properties of M-sand with natural sand.

The collected data was analyzed to identify trends, benefits, and limitations. Based on the findings, suitable recommendations were made to promote the effective and sustainable use of M-sand. The results were then shared through reports and presentations to spread awareness and support better decision-making in the construction sector.

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