Proceedings of "National Conference on Emerging Trends in Science and Advances in Engineering"
Organized by Phaltan Education Society's College of Engineering Phaltan, www.coephaltan.edu.in
International Journal of Innovations in Engineering Research and Technology [IJIERT]
ISSN: 2394-3696, Website: www.ijiert.org, July, 2023

# A COMPARATIVE STUDY on EXPLORING POSSIBLE ALTERNATIVES to RIVER SAND in CEMENT MORTAR for BRICK MASONRY

Soelim Khan[1], Sachin Rokade[1], Saurabh Pise[1]

[1]UG Students, SVERIs College of Engineering, Pandharpur, Civil Engineering Department ,Pandharpur Maharashtra India

[1]rokadesachin52@gmail.com

**Contact number:**7887783347/9511786548

---------------------------------------------------**SECTION**------------------------------------------------------------

**Abstract:- This study presents a comprehensive comparative analysis aimed at exploring potential alternatives to river sand in cement mortar for brick masonry. With the growing concern over the depletion of river sand and its adverse environmental impacts, identifying suitable substitutes has become crucial for sustainable construction practices. The research methodology involved examining various alternative materials, including slag sand, manufactured sand, and demolished sand, as potential replacements for river sand. The properties of these alternatives were evaluated in terms of their physical, chemical, and mechanical characteristics. Additionally, their compatibility with cement mortar with proportions 1:3 and their influence on the performance of brick masonry were thoroughly investigated. The experimental results revealed that each alternative material exhibited distinct properties, highlighting their unique potential as substitutes for river sand. Factors such as particle size distribution, grading, and angularity were found to significantly influence the workability, strength, and durability of the cement mortar. Moreover, the behaviour of the brick masonry in terms of bond strength, water absorption was examined to assess the overall performance of the substitutes. Based on the comprehensive analysis of the experimental data, certain alternatives demonstrated promising suitability for brick masonry applications with 1:3 proportions. The findings provide valuable insights into the selection and usage of alternative materials, aiding engineers, architects, and construction professionals in making informed decisions regarding sustainable and environmentally friendly construction practices. This comparative study contributes to the on-going efforts in the construction industry to reduce reliance on river sand and promote the use of viable alternatives. It serves as a valuable reference for future research and development in the field of construction materials and contributes to the sustainable development of the built environment.**

**Keywords:- Comparative study, slag sand, demolished sand, manufactured sand, bond strength, water absorption, grading, durability, workability, sustainable development.**

## 1. INTRODUCTION

Rapid urban population expansion necessitates the construction of adequate public and residential infrastructure. Infrastructure needs are mostly met by the construction industry. Consequently, there is a need for construction materials in a variety of construction applications. One of the crucial building materials, river sand is utilized as fine aggregate in plastering, concrete, mortar, and other types of construction. River sand is getting scarce because of how much demand there is for it. Rivers that are being drained or being eroded are the primary sources of natural sand. The eroding rivers also have an impact on aquatic life. In the current situation, alternatives are required that can either completely or partially replace natural sand.

There is a demand for substitutes that can address the issues with landfills, can be recycled, and are acceptable in society. Numerous studies on these alternatives are currently being conducted globally by various research programs. As a result, there are a variety of alternatives to river sand, as proposed by experimental research. Three options are recognized in the current analysis, namely manufactured sand plus slag sand, manufactured sand plus construction and demolition waste, and manufactured sand plus red clay. The three options come from several sources.

The current study on alternatives to river sand is focused on sustainability. All the suggested substitutes use trash from various sectors, which reduces the need for landfill space and supplants

natural aggregates. These substitutes are byproducts that can be used inexpensively in construction projects. These alternative materials lessen negative environmental effects, making them socially acceptable.

## 2. LITERATURE REVIEW

**Leonardo F. R. Miranda et. al (2013) [4]** studied the properties of recycled sand produced at construction site in bedding mortar. The main objective of the study was to present a proposal for the use of recycled aggregates produced from demolition sites in bedding mortar. Different physical properties of recycled aggregates were examined and mortar mix was produced for proportions of 50, 75 and 100% replacement to natural sand. Ceramic blocks were used to construct bending prisms and and shear strength of prisms were analysed. Tensile strength of (> 0.5 MPa) and compressive strength of (4-7 MPa) were proposed for bedding mortar produced with recycled sand.

**S. Elavenil and B. Vijaya (2013) [5]** have studied the properties of concrete produced with M-sand as an alternative for river sand. Different grades of concrete were produced at varying water cement ratios with100% replacement value for natural sand. The experiments were conducted on both fresh and hardened properties. Concrete produced with M-sand has shown a workability of 170mm which is higher than the concrete made with natural sand. The compressive strength exhibited for natural sand is 49 MPa whereas for the concrete made with M-sand is 53 MPa i.e., 7.5% higher than that of natural sand.

**A. K. Sachan and Anil Kumar Sahu [10]** Examined whether crushed stone dust waste would work as a fine aggregate in concrete. Test outcomes showed crushed stone dust waste can be used in place of natural sand in concrete with success. Concrete produced using this substitution can reach equivalent compressive strength, tensile strength, rupture modulus, and shrinkage levels as control concrete.

**V. S. Kshirsagar and Manik Deshmukh et.al (2021) [12]** Based on experimental research done on the three alternatives, m-sand (produced in aggregate manufacturing plant), slag sand (industrial by-product from steel mill), and C&D waste (recycled fine aggregate). According to IS codal rules, zone-2 sand can be classified using sieve analysis on all three possibilities. All three alternatives have a lower specific gravity than natural sand. M-sand and slag sand both have water absorption properties of about 2%. However, C&D waste showed 6%, which is consistent with earlier research results. This is because the mortar particles are surrounded by mortar that is attached. substituting the river sand in the 1:6 mortar mix at 25%, 50%, 75%, and 100% to examine the options.

## 3. METHODOLOGY

The following section provides a brief explanation of the methodology with regard to each objective:

**1.** To assess the physical characteristics of potential substitutes for river sand.

To do this, a similar procedure to determining physical attributes will be used, and test results will be compared to samples of natural sand. For that listed above tests will be used.

• Sieve analysis

• Specific gravity

• Water absorption

• Bulk density

• Bulking of fine aggregate

**2.** To ascertain the characteristics of masonry mortar using different substitutes for river sand.

The procedure used to accomplish this goal is similar to that used to assess the qualities of masonry mortar when it is new and when it is hardened. The studies will be conducted for that aim using a mortar mix design, and the outcomes will be compared to river sand.

**3.** To ascertain the characteristics of brick masonry built using the alternatives chosen for the current investigation.

The behaviour of brick masonry constructed with three different types of masonry mortar is the major focus of the current study in order to accomplish this goal. Tests on brick masonry such as compressive strength, water absorption, flexural strength, and shear strength will be conducted for that reason.

**4.** To compare other materials economically to river sand.

To achieve this purpose, it will be necessary to compare the costs of all the alternatives and river sand in order to determine which option is more cost-effective. River sand is in short supply, which s causing issues for the construction industry. There is a need for alternatives to river sand, according to several studies. Approximately eleven options have so far been found. Three different materials are the subject of the current inquiry. The three options are made up of three different types of trash: M-sand, Slag-sand, and C&D waste. This research deals with the experiments on alternatives and mode of procurement.

The present chapter is mainly divided in two parts as follows:

1 Physical property-based classification of alternatives to river sand.

2 Investigating substitutes by substituting river sand in 1:3 mortar mix at 50%, and

100%(50%m-sand+50%s-sand,50%m sand+50% D&C waste).

## 3. ALTERNATIVES TO RIVER SAND

The three options that were taken into consideration in this study were brought in and processed to produce fine aggregates. These consist of

M-SAND:- In an aggregate producing factory, rocks are crushed to the necessary size to create manufactured sand, often known as artificial sand. To get the correct aggregate size, specialised crushers are used. To obtain fine aggregates of high quality, the dust particles created during the crushing process are cleaned. The sample is sieved, meaning that elements that are retained at 4.75 mm and pass through 150 sieves are disregarded. The sample is further investigated to learn more about its varied features.

**Fig I. Heap of M-sand in aggregate manufacturing plant**


**Fig II. Collecting M-Sand**

Slag sand:- Slag sand, also known as blast furnace slag, is a byproduct of the steel making process that is created in the smelting process. It is non-metallic in nature and contains silicates and alumino silicates of lime in the glass particles. This steel byproduct is frequently piled up and kept outside the production facility in accordance with its 4.75mm in size hence the sand is sieved with 1.18mm, 600, 300 sieve and used in experimental programme for(1:30).

Demolition sand:- Using demolition sand as a substitute for river sand is a widespread practice in various construction and building projects. While river sand has traditionally been a popular choice for construction purposes, its availability and environmental impact have raised concerns in recent years. Demolition sand offers an alternative that can address some of these challenges.

## 4. PHYSICAL PROPERTIES OF FINE AGGREGATES

**1. Sieve analysis:-** Grain size distribution is carried out for the air-dried sample at room temperature. The weighed sample is kept on sieve shaker for 10-12 minutes and care must be taken to ensure that sieves are free from dust particles before the analysis. Sieves of varying sizes from 4.75mm to 150μ are selected. After sieving, material retained on each sieve is weighed to find the cumulative percentage of fines which is shown in Tables 1.

$$\text{Fineness modulus} = \frac{\text{Sum of percentage cumulative wt. retained}}{100}$$

**Table I : Grain size distribution of aggregates**

| SIEVE SIZE (MM) | WT. RETAINED of RIVER SAND (GM) | WT. RETAINED of M SAND (GM) | WT. RETAINED of SLAG SAND (GM) | WT. RETAINED of DEMOLITION SAND(GM) | WT.RETAINED of RED SAND(GM) |
|---|---|---|---|---|---|
| 4.75 | 53 | 0 | 0 | 52 | 34 |
| 2.36 | 49 | 171 | 50 | 224 | 193 |
| 1.18 | 121 | 445 | 89 | 370 | 247 |
| 600μ | 141 | 182 | 313 | 188 | 237 |
| 300μ | 243 | 111 | 464 | 105 | 163 |
| 150μ | 308 | 44 | 106 | 28 | 70 |
| FINENESS | 2.2 | 3.44 | 2.35 | 3.71 | 3.26 |

***2.* Specific Gravity*:-*** The specific gravity we got from testing river sand and different alternatives are noted in Table . The specific gravity found by the formula given below **.**

$$Sg = \frac{w2-w1}{(w2-w1)-(w3-w4)}$$

**Table II : Specific gravity of River sand and alternatives**

| MATERIAL | W1 (gm) | W2 (gm) | W3 (gm) | W4 (gm) | SPECIFIC GRAVITY |
|---|---|---|---|---|---|
| RIVER SAND | 598 | 1071 | 1800 | 1473 | 3.19 |
| M-SAND | 650 | 1121 | 1820 | 1517 | 2.80 |
| SLAG SAND | 650 | 1037 | 1742 | 1517 | 2.38 |
| C & D WASTE | 650 | 1068 | 1793 | 1517 | 2.94 |
| RED CLAY | 650 | 1022 | 1717 | 1517 | 2.16 |

Where,

W1 = pycnometer weight in gm,

W2 = pycnometer weight, containing sample by one third of its volume in gm,

W3 = pycnometer weight filled with water and sample in gm,

W4 = pycnometer weight filled only with water in gm.

**3. Water Absorption**:- Determine the water absorption of materials, known quantity of sample is immersed in water for about 24 hours. Sample is weighed as (W1) in surface saturated dry (SSD) condition after removing water. Then the sample is kept in oven for 24 hours at a temperature of $105^0$C to $115^0$C. The sample is then cooled to room temperature and the weight is noted down as (W2). Water absorption is calculated as shown below. The observations and % of water absorption is given in Table 4.6.

$$\text{Water absorption} = 100\,(W1-W2)/W2$$

Where,

W1 = weight of sample in SSD condition in g

W2 = Weight of oven dried sample in gm

**Table III: Water absorption of River sand and alternatives**

| MATERIAL | W1(GM) | W2(GM) | WATER ABSORPTION (%) |
|---|---|---|---|
| NATURAL SAND | 110 | 106 | 3.77 |
| M-SAND | 150 | 146 | 2.74 |
| SLAG SAND | 100 | 98 | 2.04 |
| C & D waste | 102 | 96 | 6.25 |
| Red Clay | 99 | 92 | 7.60 |

**4. Bulk Density:-** Bulk density of materials is determined in two states i.e., loose, and dense state and they can be calculated by using the following two formulas

**Table IV: Bulk density of River sand and alternatives**

| Material | Loose bulk density (Kg/m3) | Rodded bulk density (Kg/m3) |
|---|---|---|
| River sand | 1549 | 1749 |
| M-sand | 1792 | 1977 |
| Slag sand | 1486 | 1502 |
| C & D waste | 1545 | 1639 |
| Red Clay | 1517 | 1570 |

## 5. RESULTS AND DISCUSSION

### 1. Compressive Strength (7days)

1. A higher compressive strength of 8.9 MPa was demonstrated by the typical blend of 50% manufactured sand and 50% slag sand.
2. The compressive strength of the conventional mix, which contains 100% river sand, is 8.1 MPa, which is less than that of m-sand plus s-sand.
3. The compressive strength of the standard mix, which contains 50% manufactured and 50% demolition sand, was 9.86 MPa, higher than that of river sand and the two types of sand together.
4. The compressive strength of the standard mix, which contains 50% river sand ,25% Msand,25% Demolition sand is 8.98 MPa, which is greater than that of river sand.

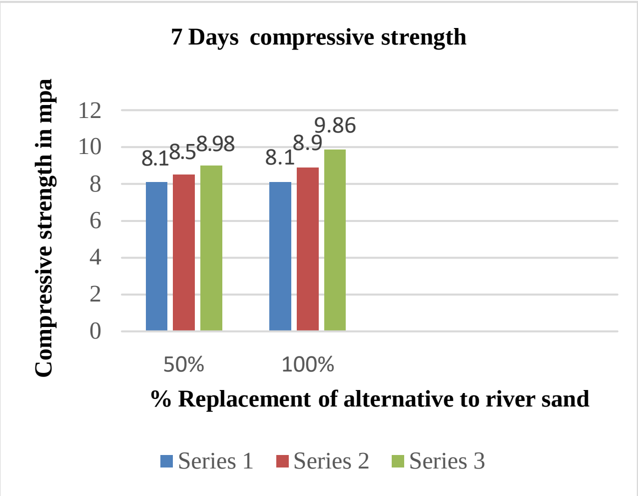


Fig III: Compressive Strength at 7 Days

### 2. Compressive Strength (28days)

1. The typical mix, which consists of 50% manufactured sand and 50% slag sand, has a greater compressive strength of 49.35 MPa.
2. The compressive strength of the conventional mix, which contains 100% river sand, is 46.25 MPa, which is less than that of M-sand plus Slag sand.
3. The compressive strength of the standard mix, which contains 50% manufactured sand, and 50% demolition sand is 51.35, greater than that of river sand and the mix of m sand and slag sand.
4. The compressive strength of the standard mix, which contains 50% river sand ,25% Msand,25% Demolition sand is 48.8 MPa, which is greater than that of river sand.
5. There may have been less surface area and better particle packing because of the improved characteristics of MS and demolition and slag sand throughout the manufacturing process. This enhanced the compressive strength and improved the binding with the existing cement paste.

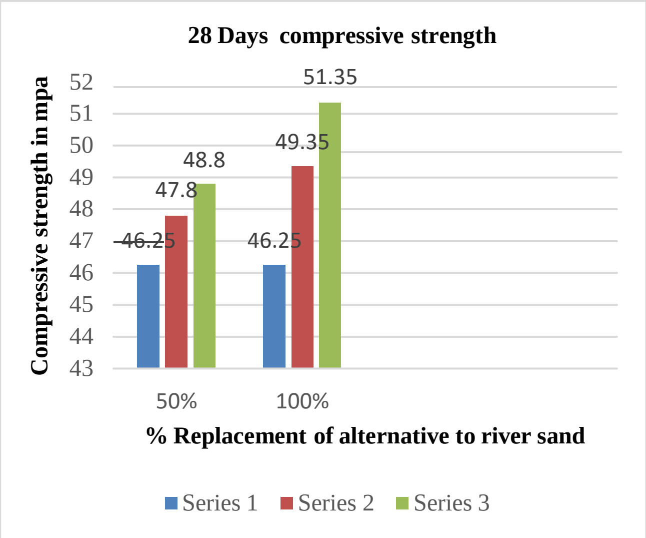


Fig IV : Compressive Strength at 28 days

**3. Flexural Strength:-** Flexural strength of mortar specimens is carried out according to IS: 10078- 1982 standards. To evaluate the strength beam specimen of size 100x100x500 mm is used.

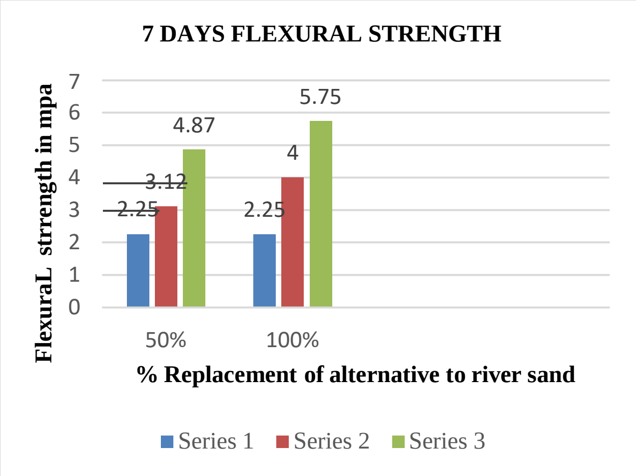


Fig V: Flexural strength at7 days

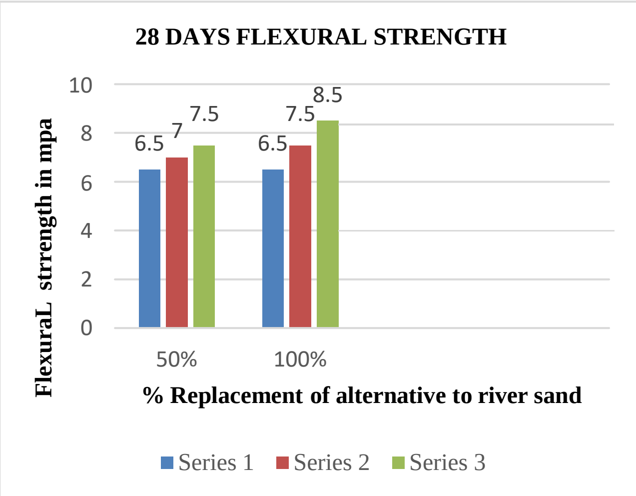


Fig IV: Flexural strength at 28days

## CONCLUSIONS

The following conclusions can be derived from the experimental research done on the three alternatives, namely m-sand (produced in an aggregate production plant), slag sand (an industrial by-product from a steel plant), and C&D trash (recycled fine aggregate). According to IS codal regulations, zone-III sand can be classified for all three possibilities based on sieve analysis.

1. All three alternatives have a lower specific gravity than natural sand. The literature review states the same thing.
2. M-sand and slag sand both have a water absorption rate of about 2%. However, C&D waste showed 6%, which is consistent with earlier research results. This is because the mortar particles are surrounded by mortar that is attached.
3. Slag sand and C&D waste had lower loose and rodded densities while M-sand has displayed high values when compared to natural sand's density values.
4. The capacity of the sand particles to absorb water is measured by their bulking property, which is comparable to that of natural aggregates. But m-sand has higher bulking 48.71% which is greater than river sand.
5. The addition of Manufactured sand and C&D waste to concrete mixtures enhances the compressive strength compared to river sand alone. Mixture containing Msand and slag sand demonstrate higher compressive strengths than river sand, indicating their effectiveness as concrete components.
6. The addition of Manufactured sand and Slag sand to concrete mixtures enhances the compressive strength compared to river sand alone. Mixture containing M sand and slag sand demonstrate higher compressive strengths than river sand, indicating their effectiveness as concrete components.
7. The combination of manufactured sand and slag sand in varying proportions significantly improves the flexural strength of the concrete mix compared to using river sand alone.
8. The combination of manufactured sand and demolition sand shows the highest flexural strength, surpassing both river sand and the combination of manufactured sand and slag sand.
9. In conclusion, the combination of 50% manufactured sand and 50% slag sand showed improved compressive strength compared to the usual mixture of river sand, highlighting the potential for enhanced performance in brick specimens. However, the typical mixture of 50% manufactured sand and 50% demolition sand exhibited the highest compressive strength among all combinations.

## ACKNOWLEDGEMENT

This is a sincere expression of my insightful thankfulness to all those who made it possible for me to complete this project work. I would like to express my deep-felt thankfulness to my guide Prof.C.R.Limkar and Head of the Department of Civil Engineering for accepting my studentship and continuously assessing my work providing great guidance through timely suggestions and discussions at every stage of this work.

I sincerely thank Prof. Dr. B. P. Ronge, Principal, SVERI's College of Engineering, Pandharpur. I am thankful to my father, mother, who always guided me not only in my studies but also in daily life. I want to thank all the people whose assistance was directly or indirectly a milestone in the completion of this project.

---

## REFERENCES

***[1]*** **B. V. Venkataram Reddy,** "*Suitability of manufactured sand (M-sand) as fine aggregate in mortar and concrete", CSIC Project sponsored by department of mine and geology (Govt. of Karnataka), July (2011).*

***[2]*** H. M. A. Mahzuz, A. A. M. Ahmed and M. A. Yusuf, *"Use of stone powder in concrete and mortar as an alternative of sand", African Journal of Environmental Science and Technology, Vol. 5(5), May 2011, pp. 381- 388*

***[3]*** Priyanka A. Jadhav, Dilip K. Kulkarni, *"Effect of replacement of natural sand by manufactured sand on the properties of cement mortar", International Journal of Civil and Structural Engineering, Volume 3, no 3, (2013).*

***[4]***Leonardo F. R. Miranda, Camila S. Constantino, Carla R. Monich and Antonio A. de M Neto, *"Use of Recycled Sand Produced at Construction Sites in Bedding Mortars" American Society of Civil Engineers Library, (2013).*

***[5]***S. E. Enavenil and B. Vijaya, *"Manufactured Sand, A Solution and an Alternative to River Sand and In Concrete Manufacturing" Journal of Engineering, Computers & Applied Sciences (JEC&AS), Volume 2, No.2, February (2013).*

***[6]*** M. C. Nataraja, P.G. Dileep Kumar, A. S. Manu and M. C. Sanjay, *"Use of granulated blast furnace slag as fine aggregate in cement mortar", International Journal of Structural and Civil Engineering Research, Volume.2, No.2, May (2013).*

***[7]***Mohammed Nadeem and Arun D. Pofale, *"Utilization of Industrial Waste Slag as Aggregate in Concrete Applications by Adopting Taguchi's Approach for Optimization", Open Journal of Civil Engineering, 2012, 2, pp.96-105.*

***[8]*** J. Silva, J. de Brito and R. Veiga, *"Recycled Red-Clay Ceramic Construction and Demolition Waste for Mortars Production", American Society of Civil Engineers Library, (2010).*

***[9]***Sanjay Mundra and P.R. Sindhi, *"Crushed rock sand an economic and ecological alternative to natural sand to optimize concrete mix" © 2016 Published by Elsevier GmbH*

***[10]*** A. K. Sachan and Anil Kumar Sahu, *"Crushed Stone Waste as Fine Aggregate for Concrete," The Indian Concrete Journal, 77(1), 2003, 845-847*

***[11]*** S A Kulkarni and K Bajoria, M *"Strength and Durability of concrete with crushed Sand," proceedings of 27th conference on Our world in concrete & structures, 2002, 1-7*

***[12]*** V. S. Kshirsagar and Manik Deshmukh, *"Use of M-Sand, Slag Sand and C&D Waste as an Alternative Material for River Sand to Apply in Mortar for Brick Masonry" Journal of Advances and Scholarly Researches in Allied Education Vol. 18, Issue No. 4, July-2021, ISSN 2230-7540*

***[13]*** Dr. M. Kannan and Paul Imbrish, *"Replacement of River Sand by M Sand Concrete" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 CONFCALL - 2019 Conference Proceedings*

***[14]***Surabh Singh and Suraj Kumar Singh, *"Finding Alternative to River Sand in Building Construction" EVERGREEN Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 09, Issue 04, pp973-992, December (2022).*

***[15]***Anzar Hamid Mir, *"Replacement of Natural Sand with Efficient Alternatives: Recent Advances in Concrete Technology" Anzar Hamid Mir Int. Journal of Engineering Research and Applications www.ijera.com ISSN: 2248-9622, Vol. 5, Issue 3, (Part -3) March 2015, pp.51-58*

***[16]***Akshay. C. Sankh and Parveen M Birader, *"Recent Trends in Replacement of Natural Sand with Different Alternatives" IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 59-66 www.iosrjournals.org*

***[17]*** Y Sombabu and k. Prabakar, *"Partial Replacement of River Sand with Robosand" © October 2017 | IJIRT | Volume 4 Issue 5 | ISSN: 2349- 6002*

***[18]*** Dessalegn Mamaru, *"Suitability of Crushed Manufactured Sand for Replacement of Natural River Sand to Produce C-25 Concrete" Journal ofCivil & Environmental Engineering Volume 10:7, (2020) .*

***[19]*** A Jyaraman and S. B. Prasath, *"Effect of using Different Types of Sand on Workability, Mechanical and Durability Performance of High Strength Concrete" International Journal of Chemtech Research CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455 – 9555 Vol. 12 No.02, pp 37-50, (2019).*

**[20]** Akanksha. P. Tawade and Lomesh. P. Cnandewar, *"A Review Paper on Artificial Sand by Replacement of Natural Sand with Artificial Sand" IOSR Journal of Engineering (IOSRJEN) www.iosrjen.org ISSN (e): 2250-3021, ISSN (p): 2278-8719 PP 45-46*

**[21]** Manguriu and G. N. Karugu, *"Partial replacement of natural river sand with crushed rock sand in concrete production," global engineers &technologists review july (2013).*

**[22]** Mr. Sumit Mathane, Divyajeet Chauhan, *"Comparative analysis between natural sand and crushed sand (ARTIFICIAL SAND, M-SAND)," 2021 IJCRT | Volume 9, Issue 4 April 2021 | ISSN: 2320-*

**[23]** Ashish Mathur and Mahim Mathur, *"An Experimental Study on the Effect of Replacement of Natural Sand with Manufacture Sand," International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 RTCEC - 2018 Conference Proceedings*

**[24]** Ashwini Manjunath B T and Lakshmi K, *"Use of Sea Sand in Partial Replacement of River Sand in Concrete for Construction," International Journal of Innovative Science and Research Technology ISSN No: - 2456-2165*

**[25]** Jayanthi Vellingiri and Balraj Narayana Murthy, *"Strength Analysis on Concrete with Full Replacement of River Sand" IOP Conf. Series: Materials Science and Engineering 955 (2020)*

**[26]** C. Venkata Siva Rama Prasad and T. V. S. Vara Lakshmi, *"Use of crushed rock sand as an alternative to river sand in bacterial concrete" i-manager's Journal on Civil Engineering, Vol. 9 No. 1 December 2018 - February (2019)*

**[27]** Le Hung Anh and Florin-Constantin Mihai, *"Life Cycle Assessment of River Sand and Aggregates Alternatives in Concrete" Materials 2023, 16, 2064*

**[28]** T. ShanmugaPriya, *"A study on crushed sand as an alternative for natural sand in high performance concrete" International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 2, December (2017).*

**[29]** Vijaya Bhoopathy and Senthil Selvan Subramanian, *"The way forward to sustain environmental quality through sustainable sand mining and the use of manufactured sand as an alternative to natural sand," Environmental Science and Pollution Research (2022).*

**[30]** Branavan Arulmoly and Chaminda Konthesingha, *"Performance evaluation of cement mortar produced with manufactured sand and offshore sand as alternatives for river sand," Construction and Building Materials 297 (2021) 123784.*