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Investigation on Replacement of River Sand by Manufactured Sand for use in Mortar and Concrete

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Abstract - *Sand is an important minor mineral for our society. It is a non-renewable natural resource with potentially rapid degradation rates and extremely slow formation and regeneration processes. Sand is the one of main constituents of concrete. Sand in concrete is around 30% of total dry material is facing great demand. There are different sources of sand the most important among them is the river. Extraction of sand from rivers becoming an environmental issue as the demand for sand increases in industry and construction due to infrastructure development. So it is time to find viable solution to the declining availability of natural sand to make eco-balance. Use of manufactured sand (M-sand) has been accepted as one of the building material. Also the properties M-sand properties are very much similar to river sand. Along with Specific Gravity, Water absorption and silt and clay content, particle size distribution of M-sand are compatible for use in construction as river sand. Henceforth M-sand is a suitable substitute for river sand at reasonable cost.*

***Key Words*: River sand, M-sand, mortar, concrete, fresh and mechanical properties.**

1. INTRODUCTION

Sand is used in many industries like building construction, electronics, plastics, and water filtration. Due to the rapid growth in global population and rapid urbanization demand of sand increased worldwide. Also increased living standard increases the consumption of sand. It is non-renewable resource produced due to disintegration of rock. Sand is a valuable commodity and is essential to the economies of countries around the world [1]. Almost every house, dam, road, wine glass, and cellphone contains some type of sand-related material. Hence United Nations Environment Programme (UNEP) considers that sand has become one of the most consumed natural resources at present [2]. Around half of all non-renewable resources mankind consumes are used in construction, making it one of the least sustainable industries in the world. Mankind has spent the majority of its existence trying to manipulate the natural environment to better suit its needs so today our daily lives are carried out in and on constructions of one sort or another [3]. The cement concrete is essential component for the construction industry. Concrete is largest manmade item by human society [4]. It is the backbone of an infrastructural development of any country. Concrete is mixture of cement, aggregate (coarse and fine) and water. The coarse aggregates are particles more than 4.75 mm size and lesser size particles are fine aggregates. Fine aggregate is an important component of concrete, because properties of aggregate influence the durability and presentation of concrete [5].

From the ancient times sand is used as an aggregate material for different civil constructions. In India, the main sources of sand are river bed, coastline sand and sand from agricultural fields. Sand used as fine aggregates in concrete is mostly mined from river. Rivers are the most important life supporting system of nature. Humans have been enjoying the natural benefits provided by rivers from the ancient time to the present. Man has changed the nature of many of the world's rivers by controlling their floods, constructing large structure like dam. Without understanding much on how the river ecosystem functions exploitation of river continued [6]. Natural river sand was the least expensive resource of sand and it is easily available hence used in concrete and mortar production. Due to the extensive use of concrete or mortar the overall consumption of river sand used as a fine aggregate very high [7]. Growing need of sand in large utilization of mortar and concrete results in scarcity of good quality sand and especially in India, deposits of natural sand are being exhausted which create a serious threat to the river [8].

2. OBJECTIVES

1. To study the environmental impacts of excessive sand exploitation.

2. To study the alternative to river sand.

3. To study the properties of the M-Sand and its behavior in mortar and concrete.

3.LITERATURE REVIEW

3.1 Environmental Impacts of Sand Mining

Rivers, Forests, Minerals and such other resources constitute Nation's natural wealth. Sand is a "minor mineral" and widely used commodity whose demand is continuously increasing. It is widely used across the country by common citizens, stated in draft Ministry of Mines, Government of

India (2018), prepared on sand mining recommendation stated, in India the demand of sand is around 700 million tons per annum and it is increasing at the rate of 6-7%. However, production and supply of sand is not uniform and its availability depends upon rain and renewal rate of sand in rivers. Due to uncertainties in supply, the selling rate of the material varies significantly with shortages in supply leading to black marketing and illegal mining of the mineral [9]. M. Naveen Saviour in his study on Environmental Impact of Soil and Sand Mining stated Sand is an important mineral for our society in protecting the environment. It acts as a buffer against strong tidal waves and storm, habitat for crustacean species and marine organisms. Also used for making concrete, filling roads, building sites, brickmaking, making glass, sandpapers, reclamations, and in our tourism industry in beach attractions. He also said demand for sand increases in industry and construction leads increase in sand mining which adversely affects environment [10].

Walter Leal Filho et al (2021) reported in their article on the Unsustainable Use of Sand, that sand is used as a major component for producing concrete. Many industries depend on sand as an essential resource in the production of various products. Rivers sand is commonly used in construction. The very high volume of sand being currently extracted is having a serious negative impact on rivers. Habitat destruction for different species, depletion of fish populations, interruption of fish migration, replacement of lotic species by lentic species, extinction of certain local species, invasive species, reduced fish reproduction, impacts in food web structure, oxygen depletion these are impacts of Sand mining on fauna. Sand mining also adversely affects flora, land/soil, water and air. Henceforth urgent measures are required to limit these effects [1].

Tariro Madyise (2013) in his studied the environmental impacts of sand mining and gravel extraction for urban development mentioned that excessive mining of river sand and gravel leads to excavation as well as threatening bridges, bridge piers and buried pipelines [11]. Sreebha S (2008) in his study mentioned that "despite its importance in supporting the life and greenery of tropics and subtropics, rivers have been widely exploited by humans". Author found that turbidity in water level increases due to sand mining. For maintaining and improving the health of the river environment, aquatic vegetation plays an vital role, which is of greatest significance for fisheries will damage [12].

Podila Sankara Pitchaiah el at. (2017) revealed removal of vegetation and destruction of the soil profile destroys habitat above and below the ground and faunal population decrease. It also increases the velocity of flow in river which destroy flow-regime eventually erodes the river banks. In his investigation in the Marathwada region of Maharashtra State he found that Godavari River has been mined so badly for its sands. As it is almost dried up and villagers depending on tanker water. Wells have dried up and farmers have to have water piped in over long distances [13].

National Green Tribunal [14], of India in 2020 in their report pointed out destruction of ecosystem of rivers. Also reveal danger to safety of bridges, weakening of riverbeds, and increase in salinity of water river. National Green Tribunal has taken cognizance of this and has enforced severe restrictions on sand mining from river beds and relevant laws for obtaining license have been made very stringent. Hence there is a need to look for alternatives to river sand without sacrificing performance of concrete/mortar.

3.2 Alternative to river sand

G. Naga Venkat et.al (2020) admitted in their research that pozzolanic materials such as silica fume, Metakaolin, GGBS contains cementetious properties which improve the strength of concrete. and also silica content in concrete and manufactured sand which gives higher strength compared to river sand and is less economic which is used as fine aggregate. A pozzolanic material gives strength and also plays a prominent role in economic and environmental considerations. Silica fume is a by-product from silica alloys gives higher strength and also high durability and acts as filler material the particle size is less than particle size of cement. Metakaolin obtained by heating a mineral kaolin it gives higher strength concrete and mortar its particle size is more than silica fume and less than cement it resist sulphate attack and improve workability. GGBS is by product from iron and it gives good strength and particle size is less than cement [15].

Manoj Kumar Dash et al. (2016) investigation affirmed that industrial wastes like waste foundry sand, steel slag, copper slag, imperial smelting furnace slag (ISF slag), blast furnace slag, coal bottom ash, ferrochrome slag, palm oil clinker etc. can be the alternative to river sand. The extraction of sand from the waterway enhances the cost of sand and has severely affected the financial viability of the construction industry. Industrial by products can be utilized as a part of concrete innovations at greatest amount for a sustainable standard strength, durability and eco-friendly concrete. Physical properties such as bulk density, specific gravity and grain size distribution of all industrial wastes were almost equal to the properties of natural sand except the particle size distribution of foundry sand. Assuming industrial waste in the form of fine aggregate for concrete production can be considered one of the environmental benefits and also shows better performance in concrete [8].

Priyanka A. Jadhav and Dilip K. Kulkarni (2013) stated in their studied that fly-ash, slag limestone and siliceous stone powder are some materials that can used in concrete mixtures as a partial replacement of natural sand [16]. Non-availability of natural sand at reasonable cost, forces to search for alternative material. But sustainable infrastructural growth needs the alternative material that

should satisfy technical requisites of fine aggregate as well as it should be available abundantly.

3.3 Properties of the M-Sand and its behavior in mortar and concrete.

As per the Guidelines Sustainable Sand Mining Management (2016) of Ministry of Environment, Forest and Climate Change - greater use of substitute material Manufactured Sand, artificial sand and sustainable use of the resource could drastically reduce adverse impact of mining on the environment [17]. Shen et al., (2016) stated M-Sand is produced by mechanically crushing the rocks boulders. The features of M-Sand differentiate from natural sand with their uneven surface, irregular particle shape, angular edges, higher roundness and length-width ratio and mineralogy [18].

Meghashree M et al (2016) compare properties of Manufactured Sand with natural sand. They found these properties are within the range specifies by the Indian standard code of practice. By conducting various tests on physical properties they found that specific gravity, bulking, Bulk density of manufactured sand is higher than natural sand. From fineness modulus obtained by sieve analysis they confirmed that M-sand is slightly coarser. Finally they concluded that manufactured sand has almost same properties as that of natural sand [19]. K. Suseela and Dr. T. Baskaran (2017) in their in investigation reported that M-Sand contrasts from natural sands in its evaluating, texture, and particle shape; and commonly has among 10% and 20% fines. In M-sand, these fines generally are more expected smaller size fractions of compacted aggregate; the fines can be mud or different injurious particles in natural sands. Their experimentation result shows the workability of concrete decreases while utilizing manufactured sand in Concrete as replacement of river sand. Compressive and split tensile Strength of M-sand concrete increases compare to river sand concrete. Durability of Concrete is improved by utilizing manufacture sand as replacement of river sand. They also conclude that M-sand is cost and performance effective in replace of river sand [20].

M. Adams Joe et al (2013) found in their experimentation, the silt and clay show in the sand decrease the strength of the concrete and holds dampness. M-sand was observed to be the more appropriate individual to replace river sand. M-Sand not include impurities so utilization of can radically lessen the cost since, as river sand, it does. Wastages was zero as it is create with present day innovation and machinery [21]. Kalyana Chakravarthy P. R and Kalaiselva (2019) in there experimental investigations of Replacement of River sand by M-sand observed that M-Sand has balanced physical and chemical properties that can withstand any aggressive environmental and climatic conditions. It enhanced durability, greater strength and overall economy. Usage of M-Sand can overcome the defects occurring in concrete such as honey combing, segregation, voids, capillary etc. The superior shape, proper gradation of fines, smooth surface texture and consistency in production parameter of chemically stable sands provides greater durability and higher strength to concrete. M-Sand has optimum initial and final setting time as well as excellent fineness [22].

S.S.Saravanan and Dr. P. Jagadeesh (2017) in their Studied performance of manufactured sand as fine aggregates in high strength concrete constructions found that the bulk density of M-sand is higher than R-sand also fineness modulus higher for M-sand but specific gravity lower for the same zone. Water absorption and moisture content is also less for M-sand comparing to R-sand. Also they recommended use of M-sand high strength concrete. They carried out their investigation on M-60 grade of concrete with 100 % river sand and 70% replacement of river sand with and without use of admixture. Their investigation revealed that compressive strength decreases at 28 days for concrete without admixture and beyond 70% replacement of natural sand by M-sand. On the other hand, compressive strength decreases at 28 days for concrete with admixture for beyond 70% replacement of natural sand by M-sand. Hence for achieving maximum strength of M60 concrete, the optimum replacement of natural sand up to 70% permissible with admixture and beyond 70% replacements of natural sand also yields the better strength than the natural sand [23].

Radhakrishna and Praveen Kumar (2018) in an experimental investigation on the properties of cement mortar observed, when the percentage of M-sand increases, the flow increases at constant water cement ratio. M-sand mortar requires comparatively lesser water content when compared to river sand to attain a particular flow. This may be attributed to action of fines in production of higher amount of paste volume. M-sand mortar gives consistently higher compressive strength at all replacement levels. Modulus of elasticity of mortar is not much affected by replacement of M-sand. They recommended partial or full replacement of M-sand in plastering mortar [24].

Dr.S.Elaveni and B. Vijaya (2013) conclude that compared to concrete made from natural sand, high fines concrete generally had higher flexural strength, improved abrasion resistance, and higher unit weight and lower permeability due to filling the pores with micro fines. He also said that major projects around the world insist on the compulsory use of manufactured sand because of its consistent gradation and zero impurity [25]. AMZ Zimar et al (2017) in their study on Effect of Manufactured Sand as A Replacement for Fine Aggregates in Concrete found that the main reason for the strength increment with M-Sand is the excellent bonding between coarse and fine aggregates, as it is attributed by the formation of water cement gel in matrix [26].

From the reviews of literature it is understand that Demand for fine aggregates for making concrete is increasing day by day and river sand cannot meet the rising demand of

construction sector. Excavation of river sand has negative environmental impacts on both the local and global levels. M-sand have similar properties to river sand. It can replace without affecting properties of mortar and concrete.

4. CONCLUSIONS

River sand is used extensively in construction industry. Unfortunately sand mining from river beds increases which negatively effects on the environment. It alters the river bed. Also destroys the habitat of aquatic animals and micro-organisms besides affecting groundwater recharge. Sand mining damages to Fauna, flora, land/soil, and quality of water reduces. There is need to find Sustainable alternatives for river sand. Other alternative materials are not in huge amount to replace river sand. Manufactured sand is as suitable substitute for river sand at reasonable cost. Sustainable use of the resource like M-sand could drastically reduce adverse impact of mining on the eco-system. Conclusion content comes here

REFERENCES

[1] Walter Leal Filho et al, The Unsustainable Use of Sand: Reporting on a Global Problem, Sustainability (2021) 13, 3356. https://doi.org/10.3390/su13063356

[2] UN Environment (UNEP). Rising Demand for Sand Calls for Resource Governance, (2019) [Online]. Available: https://www. unenvironment.org/news-and-stories/press-release/rising-demand-sand-calls-resource-governance.

[3] WD Re-Thinking Ltd., The Impacts of Construction and the Built Environment on behalf of Willmott Dixon Briefing note 2010.

[4] Weiguo Shen, Yi Liu et al, Mixing design and microstructure of ultra high strength concrete with manufactured sand, Construction and Building Materials, Volume 143, (2017).

[5] Bureau of Indian Standards, IS 383:1970, Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, UDC 691.322, New Delhi 110002 (1997).

[6] Shaji J and Dr R Anilkuar Socio-Environmental Impact of River Sand Mining: An Example from Neyyar River, Thiruvananthapuram District of Kerala, India. IOSR Journal Of Humanities And Social Science (IOSR-JHSS) Volume 19, Issue 1, Ver. VI (Jan. 2014), PP 01-07.

[7] C. Sudha, P. T. Ravichandran, K. Divya Krishnan, P. R. Kannan Rajkumar and A. Anand, Study on Mechanical Properties of High Performance Concrete using M-Sand, Indian Journal of Science and Technology, Vol 9(5) (2016) DOI: 10.17485/ijst/2016/v9i5/87262.

[8] Manoj Kumar Dash et. al, Sustainable use of industrial-waste as partial replacement of fine aggregate for preparation of concrete - A review, International Journal of Sustainable Built Environment, Elsevier, (2016) 484–516.

[9] MINISTRY OF MINES, GOVERNMENT OF INDIA (2018), "Draft Sand Mining Recommendation", Ministry of Mines New Delhi, Shastri Bhavan 2018. Available on www.mines.gov.in.

[10] M. Naveen Saviour, Environmental Impact of Soil and Sand Mining: A Review, International Journal of Science, Environment and Technology, Vol. 1, No 3, 2012, 125 – 134.

[11] Tariro Madyise, Case Studies of Environmental Impacts of Sand Mining and Gravel Extraction for Urban Development in Gaborone, (2013).

[12] Sreebha S, Environmental Impact of Sand Mining: A Case study in the River Catchments of Vembanad Lake, Southwest India. (Reg. No. 290 I) Thesis submitted to the Cochin University of Science and Technology in partial fulfillment of the requirements for the award of the degree of Doctor of Philosophy in Environmental Management, (2008).

[13] Podila Sankara Pitchaiah, Impacts of Sand Mining on Environment – A Review, SSRG International Journal of Geo informatics and Geological Science (SSRG-IJGGS) – Volume 4 Issue 1 Jan to April 2017.

[14] National Green Tribunal, Report of Oversight Committee in Compliance of Order of NGT, Original Application No. 360/2015 in Re: National Green Tribunal Bar Association Vs. Virendra Singh [State Of Gujarat] with Regards to the Illegal Sand Mining (2020).

[15] G. Naga Venkat et. al, Comparative study on mechanical properties and quality of concrete by part replacement of cement with silica fume, metakaolin and GGBS by using M-Sand as fine aggregate, Materials Today: Proceedings, Elsevier (2020).

[16] Priyanka A. Jadhav and 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).

[17] Ministry of Environment, Forest and Climate Change (2016). Sustainable Sand Mining Management Guidelines, GOVERNMENT of INDIA, New Delhi 110003, (2016).

[18] SHEN, W., YANG, Z., CAO, L., CAO, L., LIU, Y., YANG, H., LU, Z. & BAI, J. Characterization of manufactured sand:

Particle shape, surface texture and behavior in concrete. Construction and Building Materials (2016), 114, 595-601.

[19] Meghashree. M, Arpitha. K. Gowda and K. Roopa, Comparison of Physical Properties between Natural Sand and Manufactured Sand. IJIRST –International Journal for Innovative Research in Science & Technology Volume 3 Issue 07 December 2016.

[20] K. Suseela and Dr. T.Baskaran, Strength Analysis on Concrete with M-Sand as A Partial Replacement of Fine Aggregate, International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 12, December 2017, pp. 583-592.

[21] M.Adams Joe, A.Maria Rajesh, P.Brightson and M.Prem Anand, Experimental Investigation on the Effect of M-Sand in High Performance Concrete, American Journal of Engineering Research, Volume 2, Issue 12, 2013, pages 46-51.

[22] Kalyana Chakravarthy P. R and Kalaiselvam. A, Replacement of River sand by M-sand, Journal of Architecture & Technology, Volume XI, Issue II, 2019.

[23] S.S.Saravanan and Dr.P.Jagadeesh, Study on Performance of Manufactured Sand as Fine Aggregates in High Strength Concrete Constructions, International Journal of Engineering and Technology (IJET). DOI: 10.21817/ijet/2016/v8i6/160806097 Vol 8 No 6 Dec 2016-Jan 2017.

[24] Radhakrishna and Praveen Kumar K b, Characteristics of Cement Mortar with M-sand as Replacement of Fine Aggregates, Materials Today: Proceedings 5 Elsevier (2018) 25412–25419.

[25] Dr.S.Elavenil and B. Vijaya, Manufactured Sand, A Solution and An Alternative to River Sand in Concrete Manufacturing, International Journal of Civil Engineering Research and Development, Volume 3, Number1 (2013).

[26] AMZ Zimar, GKPN Samarawickrama, WSD Karunarathna, S Jayakody, Effect of Manufactured Sand as A Replacement for Fine Aggregates in Concrete, 8 th International Conference on Structural Engineering and Construction Management, 2017.