International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 06 | June 2022 www.irjet.net p-ISSN: 2395-0072

MANUFACTURED SAND CONCRETE: A REVIEW

Batham Geeta[1], Akhtar Saleem[2], Rajesh Bhargava[3]

[1]PhD Scholar, UIT-RGPV, Bhopal, India,
[2] Professor, UIT-RGPV, Bhopal, India,
[3] Professor, RGPV, Bhopal, India.

ABSTRACT: This paper presents a review on performance of cement concrete containing manufacturing sand as an alternative material to natural sand. The primary objective of this study is to understand the effect of manufactured sand on the fresh, hardened and durability properties of concrete. Several papers have been studied to take an overview of recent innovations in concrete containing manufactured sand with and without various mineral admixtures and this paper is aimed to review the application of concrete containing manufactured sand and its performance to set a benchmark for future research work in this field.

Key Words: Manufactured sand, mineral admixture, concrete, fresh, hardened and durability properties.

1. INTRODUCTION

Now a day's, sustainable infrastructural growth demands the alternative material that should satisfy technical requisites of fine aggregate as well as it should be available abundantly. The promotional use of manufactured sand (M Sand), which is purpose made fine aggregate produced by crushing and screening, will conserve the natural resources for the sustainable development of the concrete in construction industry. By using appropriate impact crushing technology, it is possible to produce cubical particle shapes with uniform grading, consistently under controlled conditions [Bhikshma, 2012]1. Manufactured sands contain high fines content [Jawahar and Mounika, 2016]2 and [Anuradha et. al., 2012]3. Generally, the fines are composed of rock dust rather than the silts and clays in the case of natural sands. Due to the presence of high fines content, the M sand has a significant influence on the water demand and the workability of the mortar and [Sujata T., et. al., 2012]4 and [Davidovits, 1999]5.

Fine and coarse aggregate constitute about 75 % of total of volume. The most commonly used fine aggregate is natural river sand. Now a days demand for river sand is increasing due to its lesser availability. Sand quarrying has resulted in scarcity and poses environmental problem such as loosing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, disturbs the aquatic life as well as affects agriculture. So there is an immediate need to control the sand quarrying and provide a sustainable development of river sand. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is essential component of concrete. Manufactured sand in concrete not only act as replacement for concrete but also leads to the development of eco-friendly construction as well as reduction in cost of construction. Manufactured sand offers a viable alternative to natural sand and it is purposely made fine aggregate produced by crushing and screening or further processing [Lokeshwaran and Natrajan, 2015]6. One possible source of construction aggregate is sand that has been manufactured from the surplus material (crusher dust) that results when coarse aggregate is produced in hard rock quarries. Coarse aggregate production typically yields 25 % to 45 % crusher dust depending on parent rock, crushing equipment and crushing conditions [Kaya et. al, 2009]7.

General requirements of manufactured sand are: a. all the particles should have higher crushing strength. b. the surface texture of the particles should be smooth. c. the edges of the particles should be grounded. d. the ratio of fines below 600 microns in sand should not be less than 30 %. e. there should not be any impurities. f. silt in sand should not be more than 2% for crushed sand. G. in manufactured sand the permissible limit of fines below 75 microns shall not exceed 15 %. [Shyam Prakash, 2007]8 concluded that manufactured sand satisfies the requirements of fine aggregate such as strength, gradation and shape angularity. It is possible to produce manufactured sand falling into the desired grade. Mechanical properties of manufactured sand depend upon the source of its parent rock material. Hence the selection of quarry is very important to quality fine aggregate. [Saravanan and Jagdeesh, 2016]9 concluded manufactured sand qualifies and proved the physical properties as per Indian standards and specifications and cost of manufactured sand is cheaper than the natural sand.

[Vijyaraghvan and Wayal, 2013]10 found concrete with manufactured sand shows higher compressive strength when compared to concrete with natural river sand. [Sureshbabu and Thomas, 2013]11 observed bond strength of concrete with M-sand is more and hence development length of re-bar can be reduced, leading to economy in construction.

Manufactured sand is utilized in many nations such as Norway, South Africa, India and Australia. In USA limestone and granite record for 86% of the rock used to produce manufactured sand, while the rest are from basalt, dolomite, sandstone and quartzite [Ahn and Fowler, 2001]12. The scarcity of river sand is forcing the builders to look for an alternative material and many have started using manufactured sand as a substitute for construction activity. With the river sand supply dropping by over 80%, the necessity for the use of manufactured sand is increasing. This M-sand has been well defined in IS 383-1970 clause 2 [IS: 383 1970, Reaffirmed: 2002]13.

2. MANUFACTURED SAND CONCRETE WITHOUT MINERAL ADMIXTURES

Fresh properties

[Reddy et. al., 2015]14 carried out study to investigate workability of concrete using manufactured sand for partial replacement of natural sand for grade M20 and M30. Replacement percentage were 0%, 20%, 40%, 60% and 100%. It was found that concrete containing 60 % manufactured sand reduces workability. [Mane et. al., 2017]15 conducted experimental study to investigate the effect of percentage replacement of manufactured sand by natural sand as 0%, 20%, 40%, 60%, 80% and 100% respectively on workability of concrete. M30 grade of concrete with W/C ratio 0.45 were used for investigation. It was observed that incorporation of manufactured sand to any replacement percentage reduces workability due to angular shape and rough surface textures of manufactured sand particles. [Saravanan and Jagdeesh, 2016]9 investigated properties of concrete using manufactured sand by replacement of natural sand for grade M40 and M50. Replacement percentage for manufactured sand were 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%. High range water reducing admixtures CERAPLAST 300 RS (G) were used to improve workability of concrete. It was found that incorporation of manufactured sand in concrete for replacement of natural sand reduces water absorption, water binder ratio. [U. Dilek, 2015]16 carried out study to investigate the effects of particle angularity, particle size, and fine-particle content of manufactured sand with a wide range of particle angularities and fines contents on water demand of mortar and concrete. Result indicated that particle angularity and fineness of the sand gradation as quantified by fineness modulus influenced the water demand of mortars. Testing performed on a paired comparison basis on individual sizes with substantially different angularities indicated that, as the particle size decreased, the exponential increase in surface area overshadowed any difference caused by particle angularity between particles of comparable size. Author developed a statistically based water demand model for conventional strength concrete. The regression-based model enabled the evaluation of the contribution of each attribute and the relative importance and statistical significance of each contribution. Particle angularity was found to be the dominant contributor to water demand with the secondary contribution from fineness of the overall sand gradation, as quantified by the fineness modulus and quantity of very fine particles. The influence of these factors was statistically significant. Effects caused by well-graded particle distributions were not found to be significant, contrary to initial expectations.

Hardened Properties

[Reddy et. al., 2015]14 carried out study to investigate strength properties of concrete using manufactured sand for partial replacement of natural sand for grade M20 and M30. Replacement percentage were 0%, 20%, 40%, 60% and 100%. Study reveals that there is an increase in compressive, split tensile and flexural strength of about 20% at 60% replacement of natural sand by manufactured sand for both grades. [Mane et. al., 2017]15 conducted experimental study to investigate the effect of percentage replacement of manufactured sand by natural sand as 0%, 20%, 40%, 60%, 80% and 100% respectively on compressive strength and shear strength properties of concrete. M30 grade of concrete with W/C ratio 0.45 were used for investigation. It was observed that compressive strength and shear strength continues to increase up to 60 % replacement after that compressive strength and shear strength starts decreasing. [Radhakrishna and Kumar, 2018]17 investigated flow and strength characteristics of 1:3 and 1:4 cement mortar using manufactured sand. Replacement percentage for manufactured sand were 20%, 40%, 60%, 80% and 100%. Flow test of mortar, compressive strength of mortar cube and modulus of elasticity of mortar prisms were tested in the laboratory. Compressive strength were tested at the age of 7, 14, 28, 56 days of curing. Result indicated that compressive strength and modulus of elasticity of manufactured sand mortar increases

as compared to conventional mortar. [Cortes et. al., 2008]18 conducted research program to identify shape-related differences of round natural sand and angular manufactured sand on the mechanical performance of mortars. Author used two natural and two manufactured sands with different water-cement ratios and fine aggregate- to-cement ratios to test flow ability, stiffness and strength for the same standard gradation. Study revealed that adequate compressive strength were attained when the volume of paste exceeded the volume of voids in the loosely packed aggregate.

Durability properties

[Reddy et. al., 2015]14 carried out study to investigate durability of concrete using manufactured sand for partial replacement of natural sand for grade M20 and M30. Replacement percentage were 0%, 20%, 40%, 60% and 100%. It was found that concrete containing 60 % manufactured sand offer good durable properties. [Saravanan and Jagdeesh, 2016]9 investigated durability properties of concrete using manufactured sand by replacement of natural sand for grade M40 and M50. Replacement percentage for manufactured sand were 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100%. High range water reducing admixtures CERAPLAST 300 RS (G) were used to improve workability and durability of concrete. It was found that incorporation of manufactured sand in concrete for replacement of natural sand reduces chloride iron permeability, loss of weight due to acid and alkaline attack, increases acid resistance, alkaline resistance, impact resistance, and abrasion resistance than the conventional sand concrete. Optimum percentage for durability was found at 70 % and at 100% replacement manufactured sand concrete shows better durability than conventional concrete. [Cortes et. al., 2008]18 conducted research program to identify shape-related differences of round natural sand and angular manufactured sand on the mechanical performance of mortars. Author used two natural and two manufactured sands with different water-cement ratios and fine aggregate- to-cement ratios to test flow ability, stiffness and strength for the same standard gradation. Study revealed that adequate flow attained when the volume of paste exceeded the volume of voids in the loosely packed aggregate.

3. MANUFACTURED SAND CONCRETE WITH MINERAL ADMIXTURES

The overuse level of cement and natural sand for civil industry has several undesirable social and ecological consequences. As an answer for this, industrial wastes called by-products like fly ash, GGBFS, silica fume and metakaolin can be used to interchange partially cement and natural fine aggregate by manufacturing sand. So this will solve two problems simultaneously, viz. the bulk utilization of pozzolanic materials and saving the natural quarries of sand [Mane et. al., 2021]19.

Fresh properties

[Subramaniana, and Solaiyan, 2020]20 investigated effect of GGBS and M-sand impact on workability properties of G-30 fly ash based geopolymer concrete. Natural sand replaced by manufactured sand in varying percentages like 0%, 25%, 50%, 100% and GGBS by 0%, 10%, 20%, 30% of the total binder of fly ash. Study reveals that workability decreases with higher GGBS & M-sand content. [Dammika et. al., 2021]21 investigated the fresh properties of high-strength concrete using three different types of rocks, namely granophyre, basalt, and granite for replacement of natural fine aggregate. It was observed that 40 % replacement of natural sand decreases slump and bleeding of concrete. Decrease in slump and bleeding was approximately15% and 50% respectively.

Hardened properties

[Muralikrishnan et. al., 2018]22 conducted experimental program to investigate characteristics of high performance concrete M60 grade with partial replacement of cement by GGBS and fine aggregate by manufactured sand. Replacement percentage for GGBS and manufactured sand were 0%, 5%, 10%, 15% and 0%, 25%, 50%, 75% respectively. The dosage of super plasticizer used in the study were 0%, 1% and 1.3% by weight of cement. Study reveals that incorporation of 50 % manufactured sand increases flexural strength as compared to normal concrete. [Sudha et. al., 2016]23 used 100 % manufactured sand for replacement of natural sand and 0%, 10%, 20%, 30%, 40% bagasse ash for replacement of cement in high strength concrete of M60 grade. M-sand has been fully replaced by volume of fine aggregate. Effect of M-sand on mechanical properties of concrete with and without partial replacement of bagasse ash were studied. Study reveals that M-sand with 20% to 30% bagasse ash can be used effectively for high strength concrete of M-60 grade. [Hidayawanti et. al., 2020]24 conducted experimental program to investigate compressive strength and water absorption content of concrete with partial replacement of natural sand by manufactured sand and coarse aggregate by waste marble. Replacement percentage for manufactured sand and waste

marble were 40 % and 0%, 25%, 50%, 75% and 100% respectively. Optimum percentage for compressive strength was found at 40% manufactured sand and 50% waste marble whereas the optimum percentage for water absorption obtained at 40% manufactured sand with 0% waste marble. [Dammika et. al., 2021]21 investigated the hardened properties of high-strength concrete using three different types of rocks, namely granophyre, basalt, and granite for replacement of natural fine aggregate. It was observed that 40 % replacement of natural sand decreases marginally tensile strength of concrete. Decrease in the compressive strength and drying shrinkage was 50 MPa at 28 days of curing, 520 micro-strains at 56 days of curing respectively. [Li et. al, 2009]25 investigated the effect of limestone fines content in manufactured sand on abrasion resistance of concretes. Highest abrasion resistance found at 7 % to 10 % limestone content. [Li et. al., 2011]26 investigated influence of manufactured sand characteristics, such as rock micro-fines (particles smaller than 75 μm) content, surface roughness, crushing value and rock types of manufactured sand particles, on the strength and abrasion resistance of pavement cement concrete. Study reveals that increment of limestone micro-fines in manufactured sand from 4.3% to 20% increases the compressive and flexural strengths and improves the abrasion resistance of the manufactured sand-pavement cement concrete. The MS-PCC has higher compressive and flexural strengths when the surface roughness of the sand particles is larger and the crushing value is lower. The abrasion resistance of MS-PCC is improved with the increment of surface roughness, decrement of crushing value and Los Angeles abrasion value of sand particles, while it has not evident relation with the silicon content of sand. [Magudeaswaran and Eswaramoorthi, 2016]27 investigated strength properties of high performance concrete with silica fume by 100 % replacement of natural sand with manufactured sand. Study reveals that compressive strength, split tensile strength, flexural strength and modulus of elasticity increased with increase in silica fume in the concrete mix up to 10% replacement. Optimum percentage for silica fume found to be 10 %. Maximum increase in compressive strength, split tensile strength and flexural strength with 10 % silica fume were found 32%, 30% and 22% as compared to control concrete. The modulus of elasticity of HPC mixes increased with the addition of M-Sand. The highest modulus of elasticity found at 10% silica fume with 100% M-Sand, which is 17% more than the control concrete.

Durability properties

[Mane et. al., 2021]19 conducted experimental program to investigate the durability properties of concrete produced by replacing natural sand by manufactured sand in varying percentages like 0%, 10%, 20%, 30%, 40%, 50%, 60% 70%, 80%, 90% 100% and 20% cement replacing with pozzolanic materials. M30 concrete grade was prepared with w/c ratio 0.45. Study reveals that 60% replacement of natural fine aggregate by manufactured sand and 20% replacement of cement by silica fume yields minimum water absorption, sorptivity, chloride permeability and denser microstructure than conventional concrete. [Subramaniana, and Solaiyan, 2020]20 investigated effect of GGBS and M-sand impact on strength properties of G-30 fly ash based geopolymer concrete. Natural sand replaced by manufactured sand in varying percentages like 0%, 25%, 50%, 100% and GGBS by 0%, 10%, 20%, 30% of the total binder of fly ash. Study reveals that strength increases with higher GGBS & M-sand content. Maximum increase in compressive, split tensile & flexural strengths were found about 44%, 44% & 19% respectively. It was observed that optimum percentage replacement of 20% of GGBS & 50% of M-sand has been yielded G30 grade geopolymer concrete easily. Author achieved better strength by full replacement of natural sand with M-sand. [Dammika et. al., 2021]21 investigated properties of high-strength concrete using three different types of rocks, namely granophyre, basalt, and granite for replacement of natural fine aggregate. The lowest void contents of the combined fine aggregates were found at 40% to 60% replacement. [Li et. al, 2009]25 investigated the effect of limestone fines content in manufactured sand on chloride ion permeability and freeze–thaw resistance of low and high strength concrete. Author also tested sulfate attack of mortars. Results indicated that limestone fines from 0% to 20% improves resistance to chloride ion penetration and decrease resistance to freezing for low strength concrete. Whereas limestone fines from 0% to 15% have no influence on chloride ion penetration and freezing for high strength concrete. Further it was found that sulfate resistance increases with the increase in limestone percentage. Author concluded that the durable concretes can be made from manufactured sand with at least 10% limestone fines.

4. CONCLUSION

On the basis of study reviewed here it can be concluded that incorporation of manufactured sand in concrete for partial replacement of natural sand enhances properties of concrete whether it is fresh, hardened or durability properties. Utilisation of manufactured sand not only reduced environmental pollution but also results in reduced construction cost, possibility of achieving green construction, suitable application of wastes rather than dumping, optimum use of conventional material etc.

REFRENCES

[1]. Bhikshma V., Kotireddy M. and Srinivas Rao T. (2012), "An Experimental Investigation on Properties of Geopolymer Concrete", Asian Journal of Civil Engineering, Vol. 3, pp. 841-853.

[2]. Guru Jawahar J. and Mounika G. (2016), "Strength properties of fly ash and GGBS based geopolymer concrete", Asian Journal of Civil Engineering, Vol.17, pp.127-135.

[3]. Anuradha R., Sreevidya V., Venkatasubramani R. and Rangan BV. (2012), "Modified Guidelines for Geopolymer Concrete Mix Design Using Indian Standard", Asian Journal of Civil Engineering, Vol.13, pp. 353-364.

[4]. Sujatha T., Kannapiran K. and Nagan S. (2012), "Strength assessment of heat cured geopolymer concrete slender column", Asian Journal of Civil Engineering, Vol.13, pp. 635-646.

[5]. Davidovits J. (1999), Chemistry of geopolymeric systems, terminology, Proceeding of Geopolymer International Conference, Saint-Quentin, France.

[6] M. R. Lokeshwarn and C. Natrajan, (2015), "Study on the properties of cement concrete using manufactured sand", Advances in Structural Engineering, Springer, pp 1803-1809.

[7] Kaya T., Hashimoto M., and Pettingell H. (2009), "The development of sand manufacture from crushed rocking Japan using advanced VSI technology", Proceedings of the International Centre for Aggragtes Research Symposium; Austin, TX, USA.

[8] Shyam Prakash (2007), "Ready mixed concrete using manufactured sand as fine aggregate", 32nd conference on our world in concrete structures, Singapore.

[9].S. S. Saravanan and Dr. P. Gagadeesh (2016), "Effect of manufactured sand on the durability characterstics of concrete", Carbon Science and Technology, ASI, Vol. 8 (4), pp 70-81.

[10] NimithaVijyaraghvan and A. S. Wayal (2013), "Effect of manufactured sand on compressive strength and workability of concrete", International Journal of Structural and Civil Engineering Research, Vol. 2(4).

[11] Sureshbabu N. and job Thomas (2013), "Bond characteristics of rebar in concrete with manufactured sand as fine aggregate", American Journal of Engineering Research, vol. 1, pp 54-58.

[12] Ahn, N., and Fowler D. W., (2001), "An experimental study on the guidelines for using higher contents of aggregate microfines in Portland cement concrete," International Center for Aggregates Research, Research Report ICAR 102-1F, p.435.

[13] IS: 383 (1970, Reaffirmed: 2002), Code of Practice: Specification for Coarse and Fine Aggregates from Natural Sources for Concrete, Bureau of Indian Standards, New Delhi.

[14] Marreddy Yajurved Reddy, D. V. Swetha and S. K. Dhani (2015), "Study on properties of concrete with manufactured sand as replacement to natural sand", International Journal of Civil Engineering and Technology, Vol. 6 (68), pp 29-42.

[15] Kiran M. Mane, Dr. Dilip K. Kulkarni and Abhishek A. Joshi (2017), "Strength and workability of concrete with manufactured sand", International Journal of Engineering Research and Technology, Vol. 10 (1).

[16] U. Dilek (2015), Effects of Manufactured Sand Characteristics on Water Demand of Mortar and Concrete Mixtures, Environmental Science, Journal of Testing and Evaluation.

[17] Radhakrishna and K. Praveen Kumar (2018), "Characteristics of cement mortar with M-sand as replacement of fine aggregates", Materials Today: Proceedings Vol. 5 (11), part 3, pp 25412-25419.

[18] D. D. Cortes, Hyun-ki Kim, J. Santamarina, (2008), "Rheological and mechanical properties of mortars prepared with natural and manufactured sands", Materials Science, Cement and Concrete Research.

[19] Kiran M. Mane, D. K. Kulkarni and K. B. Prakash, (2021), "Near-Surface and Chloride Permeability of Concrete Using Pozzolanic Materials and Manufactured Sand as Partial Replacement of Fine Aggregate", Iranian Journal of Science and Technology, Transactions of Civil Engineering.

[20] Nagajothi Subramaniana, and ElavenilSolaiyan, (2020), "GGBFS & M-sand impact on workability and strength properties of fly-ash based geopolymer concrete, Indian Journal of Engineering & Materials Sciences, Vol. 27, pp. 67-76.

[21] Dammika P. K. Wellala, Ashish KumerSaha, Prabir Kumar Sarkerand and Vinod Rajayogan (2021), "Fresh and hardened properties of high-strength concrete incorporating byproduct fine crushed aggregate as partial replacement of natural sand", Frontiers of Structural and Civil Engineering vol. 15, pages 124–135.

[22] S. Murlikrishnan, T. Felix Kala, P. Asha and S. Elavenil (2018), " Properties of concrete using manufactured sand as fine aggregate", International Journal of ChemTech Research, Vol. 11(3), pp 94-100.

[23] C. Sudha, Ajesh K. Kottuppilli, P. T. Ravichandran and K. Divya Krishnan (2016), "Study on mechanical properties of concrete with manufactured sand and bagasse ash", Indian Journal of Science and Technology, Vol. 9 (34), pp 1-5.

[24] R. Hidayawanti, Yuhanah, D. Mayasari and B. Wicaksono(2020), "The effect of M-sand and waste marble for strength of concrete", 4thInternational Conference on Civil Engineering Research, Surabaya, Indonesia, vol. 930, Material Science and Engineering.

[21] Dammika P. K. Wellala, Ashish KumerSaha, Prabir Kumar Sarkerand and Vinod Rajayogan (2021), "Fresh and hardened properties of high-strength concrete incorporating byproduct fine crushed aggregate as partial replacement of natural sand", Frontiers of Structural and Civil Engineering vol. 15, pages 124–135.

[25] Beixing Li, J. Wang, Mingkai Zhou, (2009), "Effect of limestone fines content in manufactured sand on durability of low- and high-strength concretes", Materials Science, Construction and Building Materials.

[26] Beixing Li, Ke Guoju and Mingkai Zhou (2011), Influence of manufactured sand characteristics on strength and abrasion resistance of pavement cement concrete, Materials Science, Construction and Building Materials.

[27] Magudeaswaran. P and Dr. Eswaramoorthi. P, " High Performance Concrete Using M Sand", Asian Journal of Research in Social Sciences and Humanities Vol. 6, Issue 6, Special Issue June 2016 pp. 372-386.