Research Article
Volume 10:7, 2020

Journal of Civil & Environmental Engineering

ISSN: 2165-784X

Open Access

Suitability of Crushed Manufactured Sand for Replacement of Natural River Sand to Produce C-25 Concrete

Dessalegn Mamaru*

Department of Civil Engineering, Faculty of Civil and Environmental Engineering, Jimma Institute of Technology, Jimma University, Jimma, Ethiopia

Abstract

The global consumption of natural sand is very high, due to the extensive use of concrete or mortar. The fine and coarse aggregates generally occupy 60% to 75% concrete volume (70% to 85% by mass) and strongly influence the concrete's fresh and hardened properties. Now a day's sand is becoming a very scarce material. Natural sand deposits are being depleted and causing serious threats to the environment and society. The culture of using alternative ingredients to produce materials is weak in Ethiopia. Around Jimma town, quality sand is not readily available and it is transported from Worabe, Gambella, and Chewaka that needs high transportation costs. In this situation, research began for an inexpensive and easily available alternative material to natural sand. The main objective of this study was aimed to determine the fresh and hardened properties of C-25 concrete by replacing natural sand with manufactured sand in Jimma town. This experimental study was conducted by preparing three concrete cubes for each percentage replacement. The replacement was done at 0%, 10%, 20%, 40%, 60%, and 100%. According to this study, the slump values for the above percentage replacement were 48.91 mm, 45.23 mm, 38.98 mm, 32.56 mm, and 26.14 mm respectively. The compressive strengths were 27.08 MPa, 29.34 MPa, 31.25 MPa, 27.25 MPa, and 29.22 MPa, and the flexural strengths were 3.28 MPa, 3.35 MPa, 4.37 MPa, 3.26 MPa, and 4.26 MPa respectively. The maximum compressive strength was obtained at 40% replacement with the corresponding compressive and flexural strengths were 31.25 MPa and 4.37 MPa respectively. From this result it is concluded that manufactured sand can be used as natural sand partial and fully replacement

Keywords: Aggregates • Compressive strength • Flexural strength • Percentage of replacement • Manufactured sand • Natural sand

Introduction

The global consumption of natural sand is very high, due to the extensive use of concrete or mortar. In general, the demand for natural sand is quite high in developing countries to satisfy the rapid infrastructure growth, in this situation, developing countries facing a shortage in good quality natural sand [1-4]. The importance of using the right type and quality of aggregates cannot be overemphasized. The fine and coarse aggregates generally occupy 60% to 75% of the concrete volume (70% to 85% by mass) and strongly influence the concrete's freshly mixed and hardened properties, mixture proportions, and economy [5,6]. Fine aggregates generally consist of natural sand or crushed stone with most particles smaller than 5 mm (0.2 in.). Natural sand is mainly excavated from river beds and always contains a high percentage of impurities that adversely affect the properties of concrete by reducing the life of the structure [7].

Now-a-days sand is becoming a very scarce material, in this situation research began for an inexpensive and easily available alternative material to natural sand [8,9]. Some alternative materials have already been used as a part of natural sand e.g. fly-ash, slag limestone, and siliceous stone powder are used in concrete mixtures as a partial replacement of natural sand. However, scarcity in the required quality is the major limitation in some of the above materials. Hence, sustainable infrastructural growth demands the alternative material that should satisfy technical requisites of fine aggregate as well as it should be available abundantly [10-12]. Therefore, the main objective of this study was to evaluate the effect of percentage replacement of natural sand by manufactured sand at 0%, 10%, 20%, 40%, 60%, and 100%.

Statement of the problem

Natural sand deposits are being depleted and causing serious threats to the environment as well as society. Increasing extraction of natural sand from river beds causing many problems, losing water retaining sand strata, deepening of the river courses and causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering the underground water table are few examples [13,14].

In the present situation, the scarcity of natural sand has become a problem for the construction industry, after much research the developed technology gave rise to a new generation of sand named crushed sand or manufactured sand. Due to the booming of construction activities in Ethiopia, natural or river sand resources are increasingly depleted and its cost is becoming increasingly high [15,16]. Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete and cement mortar. The most commonly used fine aggregate is a natural river or pit sand. Fine and coarse aggregate constitute about 75% of the total volume. Therefore, it is important to obtain the right type and good quality aggregate at the site because the aggregate forms the main matrix of concrete or mortar [17,18].

Around Jimma town, quality sand is not readily available and it should be transported from other areas, such as Worabe, Gambella, and Chewaka which are far away from the town, it needs high transportation costs to construct building projects. Since transportation is a major factor in the delivery price of construction. This leads to additional project costs. Excavation of the sand leads to different problems like deforestation, soil disturbance, and erosion, ecological disturbance. For this reason, this research was carried out in substituting natural river sand with manufactured sand. Replacing the natural riverbed sand with manufactured sand shall be studied to pose an unquestionable issue by coming up with an excellent combination of materials for compressive and flexural strengths.

***Address for Correspondence:** Dessalegn Mamaru, Department of Civil Engineering, Faculty of Civil and Environmental Engineering, Jimma Institute of Technology, Jimma University, Jimma, Ethiopia, Tel: +251-913-943-105; E-mail: mam.wree@gmail.com*

Received 30 October, 2020; **Accepted** 11 November, 2020; **Published** 18 November, 2020

Significant of the study

This study has significant for different stakeholders. The construction parties will obtain another alternative construction material other than natural river sand with minimum transportation distance. This can reduce the overall construction project cost. The other benefit of this study is, it helps environmental protection authority by giving awareness to construction parties and then the natural disturbance to natural sand mining will reduce. It can also keep as it is the biodiversity.

Scope of the study

This research is limited to around Jimma town which is southwest of Ethiopia. The research covered determining the effects of natural sand replacement with manufactured sand of C-25 concrete properties. This experimental study only limited to 0%, 10%, 20%, 40%, 60% and 100% of replacement. In this experimental study, only some engineering properties of aggregates, slump value, and the compressive and flexural strength of concrete were done. Therefore, it did not include other properties of concrete like permeability, creep, durability, and others.

Materials and Methods

Study area

The research was conducted in the Jimma Zone, located in the south-western part of Ethiopia. Jimma Zone has a latitude and longitude of 704°'N 36°5°'E / 7.667°N 36.833°E. The climate of the Zone is the tropical rainforest climate. It features a long annual wet season from March to October. The temperature at Jimma is in a comfortable range, with daily mean staying between 20°C and 25°C year-round.

Materials

For this study the researcher was used, worabe natural sand, manufactured sand, ordinary Portland cement, coarse aggregates from the local market, and water from Jimma Technology Institute Water Supply.

Equipment

Since the research was an experimental study, the researcher was used different laboratory testing equipment. To mention some of them, sieves for both fine and coarse aggregates, enamel tree, oven, soaker, slump cone, cube mold, tamper, digital balance weight, compressive testing machine, flexural testing machine, ruler, test tubes, curing tank, and a plastic jar.

Sample size and sampling procedure

In this study, the purposive sampling technique was used for sampling. To determine the sample size of the test samples, it needs to consider the Standards' specifications. According to ASTM 33; it requires a minimum of 3 samples of cube size of (150 × 150 × 150 mm) mold for each test of the characteristic compressive strength of concrete and (100 × 100 × 500 mm) for flexural strength. Total sample sizes of 72 samples were cast and tested at the age of 7th, 14th, & 28th days. These samples were used to conduct compressive and flexural strength.

Study variables

Dependent variable

C-25 concrete properties with partial replacement of river sand by manufactured sand.

Independent variables

- Percentage of manufactured sand.
- Properties of fine and coarse aggregates.
- Curing age of cubes.

Research design

The study was an experimental study of C-25 concrete properties with and without replacement of manufactured sand. The study was conducted in different steps. These include material preparation, determining engineering property of materials, and concrete compressive, and flexural strength tests.

Material preparation

All the laboratory investigations on the aggregates and concretes are carried out at Jimma University, Jimma Institute of Technology, Material Laboratory. Generally, natural sand and manufactured sand, ordinary Portland cement, coarse aggregates, and water were materials used in this study. This replacement material (manufactured sand) was taken from the aggregate crushing plant of the Jimma zone.

Sources of materials

a) Cement- Dangote OPC is available at markets. The product of this factory cement was purchased from the shops available at Jimma town.

b) Coarse aggregate, Natural Sand, and Manufactured sand - local market

c) Water -In this research, water is obtained from the Jimma Institute of technology water supply

Determining engineering property of materials by different methods

The engineering property of all materials necessary for describing the type of materials used and also properties that can affect the production of concrete were determined before production. The test methods used for the aggregates are listed in Table 1.

Sieve analysis and fineness modules

This is a procedure for the determination of the particle size distribution of the aggregate. It is also used to determine the fineness modulus, an index to the fineness, coarseness, and uniformity of aggregates. These properties of the aggregate greatly affect the property of the concrete. The sieve analysis both for fine and coarse aggregates were done by using standard square sieve openings.

Unit weight

Unit weight can be defined as the weight of a given volume of graded aggregate. It is thus a density measurement and is also known as bulk density. But this alternative term is similar to bulk specific gravity, which is quite a different quantity, and perhaps is not a good choice. The unit weight effectively measures the volume that the graded aggregate will occupy in concrete and includes both the solid aggregate particles and the voids between them. The unit weight is simply measured by filling a container of known volume and weighing it. However, the degree of compaction will change the amount of void space, and hence the value of the unit weight. Since the weight of the aggregate is dependent on the moisture content of the aggregate, the constant moisture content is required. An oven-dried aggregate sample is used in this test [19]. The approximate bulk density (unit weight) of aggregate commonly used in normal-weight concrete ranges from about 1200 to 1750 kg/m^3 (75 to 110 lb/ft^3) [20].

Table 1. Property tests and test methods.

Property tests	Test methods
A sieve analysis(natural river sand, manufactured sand, coarse) aggregates	ASTM C136
Unit weight aggregates	ASTM C29
Silt content natural river sand	ASTM C117
Specific gravity and absorption aggregates	ASTM C127, BS 812:part 2:1995
Moisture content aggregates	ASTM C 566

Specific gravity and absorption capacity

Specific gravity is an expression of the density of an aggregate. It is the ratio between the weight of the substance and that of the same volume of water. Aggregates contain pores in their structure, therefore the specific gravity depends on whether the pores are included in the measurement or not. The apparent specific gravity of an aggregate refers to the solid materials excluding the pores and bulk specific gravity refers to total volume i.e. including pores of the aggregate.

Silt content

The material in fine aggregates which is finer than 75µm is generally regarded as silt. This silt in the sand for the concrete has a severe effect on the quality of the concrete. It mainly affects the workability of the concrete, and also results in the reduction of strength.

Moisture content

Aggregates can hold water in two ways: absorbed within the aggregate porosity or held on the particle surface as a moisture film. Only the surface moisture, not the absorbed moisture, becomes part of the mixing water in concrete. Surface moisture percentages are used to calculate the amount of water in the aggregates to reduce the amount of mix water used for batching. Besides the batch weight of aggregates should be increased by the percentage of surface moisture present in each type of aggregate. If adjustments are not made during batching, surface water will replace a portion of the aggregate mass and the mix will not yield properly [21]

The absorption and surface moisture of aggregates should be determined so that the total water content of the concrete can be controlled and correct batch weights determined. The internal structure of an aggregate particle is made up of solid matter and voids that may or may not contain water [22]. The moisture content of fine aggregates was determined by oven drying a sample of fine aggregate (500 g) in an oven at a temperature of 110°C for 24 hrs and dividing the weight difference by the oven-dry weight. Test for cement was not conducted because Dangotie (OPC) standard cement with a strength grade of 42.5 was used. The samples for the property test were taken from the production site by using the quartering method.

Concrete mix design

Mix design is the process of determining the required and specified characteristics of a concrete mixture. The required or specified concrete characteristics can be fresh concrete properties, mechanical properties of the hardened concrete such as strength and durability requirements, and the inclusion or exclusion of specific ingredients [23].

Concrete fresh properties

Concrete remains in its fresh state from the time it is mixed until it sets. During this time the concrete is handled, transported, placed, and compacted. Properties of concrete in its fresh state are very important because it influences the quality of the hardened concrete. Some of the fresh properties of the concrete are consistency, workability, settlement & bleeding, plastic shrinkage, and loss of consistency. Among these properties, the workability of the concrete is dominantly quality checking property in the fieldwork.

Workability

The workability of a concrete mix is the relative ease with which concrete can be placed, compacted, and finished without separation or segregation of the individual materials. Workability is not the same thing as consistency. Mixes with the same consistency can have different workability, if they are made with different sizes of stone the smaller the stone the more workable the concrete. It is not possible to measure workability but the slump test, together with an assessment of properties like stone content, cohesiveness, and plasticity, gives a useful indication [24].

Compressive and flexural strength test

A compressive strength test was carried out on the samples prepared to compare the compressive strength of the concrete with and without manufactured sand. Compressive strength tests of 7th, 14th, and 28th days were conducted according to Ethiopian standard after immersed in water for 7, 14, and 28 days respectively. The flexural strength of the study was conducted after curing for 28 days.

Data collection process

Filed observation: The field observation was comprised of supervising quarry sites and aggregates production companies that are available in the study area. The observation helps to get information about the sources of laboratory input data that the researcher was used in the laboratory tests.

Laboratory test: This is how the researcher used to collect data from the results of experimental procedures at the laboratory and record them in the proper format. The data is served as input for the analysis of the suitability replacement of natural sand with manufactured sand.

Data processing and analysis

To come across the research objectives, this part was conducted in two steps: the first step was evaluating some engineering properties of natural and manufactured sands and coarse aggregates and then determining the compressive and flexural strength of hardened concretes.

Analyzing concrete strength

The compressive and flexural strength of concrete both without and with manufactured sand was conducted by taking the mean of three samples as stated in the procedure of the Ethiopian standard (ES C.D4.001). The mean compressive strengths of concrete without manufactured sand were compared with each concrete cube samples with manufactured sand. Further, the data found were computed with different standards. According to ASTM(C 90-70) and (ASTM C-129-70) average of three (3), concrete cube samples are required. Therefore, the means were computed and compared according to Ethiopian standards (ES. C.D3.301), and individually with ASTM the results were analyzed and presented in tables and graphs.

Results and Discussion

Physical properties of materials

Tests on the physical properties of Natural River sand and coarse aggregate were conducted to verify that the materials are suitable for making concrete. The results of the tests were further used in the mix design process to make C-25 concrete.

Silt content of natural sand (NS)

Fine aggregate was checked for the silt content for the specification of the material for the concrete production. This is because the higher content of silt in concrete negatively affects the performance of concrete when it is under load and in environmental situations. The testing procedure was as per ASTM C 117.

According to Ethiopian Standard, it is recommended to wash or reject if the silt content exceeded 6%. Based on the test result of silt content as it is seen from Table 2 above, the fine aggregate materials used were within the limit of the Ethiopian Standard for silt content. Therefore, the material can be used without washing [25].

Gradation tests on fine aggregate

The purpose of this study was to conduct a systematic comparison of the effects of replacing natural river sand with manufactured sand on compressive strength, and flexural strength of C-25 concrete. The gradation properties of manufactured sand result and the percentage of particles passing through

Table 2. Test result of silt content of fine aggregate.

Fine Aggregate Type	Silt Content (%)
NS	3.29

various sieves were compared with natural sand as it is presented in Table 3 and Figure 1.

According to ASTM (C33- 03) standard, the particle size distribution curve of the natural sand possesses good grading but with large size, particles were falling on the finer limit. Manufactured-sand possesses coarser grading which is above the upper limit of ASTM C33-03. According to ASTM C33-03, the fine aggregate has not more than 45% passing any sieve and retained on the next consecutive sieve, and its fineness modulus not less than 2.2 and not more than 3.2. So that fineness modulus of manufactured sand is 3.62 and natural sand is 2.87 for this reason, manufactured sand is not well-graded and natural sand is well-graded. Very fine sand and very coarse sand is not suitable for construction, fine sand is uneconomical and coarse sand gives difficult workability. Therefore, for such a problem, the solution is the mixing of the two aggregates or looking up another fine aggregate. But for this study, the first option was adopted (Table 4).

Table 3. Sieve analysis comparison of manufactured sand with natural sand.

Sieve size (mm)	Cumulative percentage passing		ASTM (C33- 03) standard for percent pass
	Manufactured sand	Natural sand	
9.5	100	100	100
4.75	96.99	97.23	95-100
2.36	78.32	94.64	80-100
1.18	52.74	82.52	50-85
0.6	25.34	50.92	25-60
0.3	14.64	6.94	10-30
0.15	9.21	0.63	2-10
0.075	3.03	0.25	-
pan	0	0	
F.M	3.62	2.87	

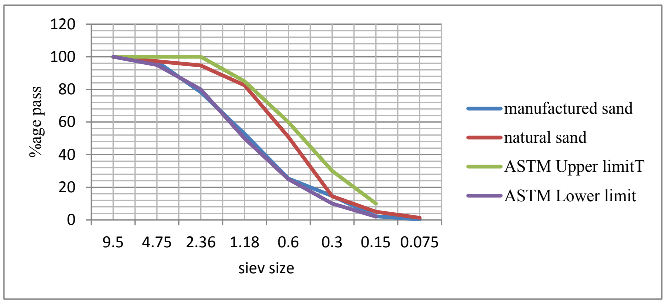

Figure 1. Particle size distribution curve.

Table 4. Sieve analysis comparison of manufactured sand with natural sand.

Sieve size(mm)	Cumulative Percentage pass for different replacement				ASTM (C33- 03) standard for % pass
	90% NS+10% MS	80% NS+20% MS	60% NS+40% MS	40% NS+60% MS	
9.5	100	100	100	100	100
4.75	95.12	96.12	96.57	95.7	95-100
2.36	82.2	81.02	73.82	66.89	80-100
1.18	52.14	56.06	62.57	51.96	50-85
0.6	25.21	27.91	32.56	31.33	25-60
0.3	2.5	8.58	7.45	10.75	10-30
0.15	1.3	3.68	4.13	6.05	2-10
0.075	0.02	1.53	1.7	2.85	-
pan	0	0	0	0	
FM	2.49	2.86	2.95	3.10	

From Figure 2 above, as the percentage of manufactured sand (MS) increases the percentage of the pass of the mixture of natural and manufactured sand decreases. From the above figure, when the percentage of manufactured sand was 60%, the curve of percentage pass was near to the ASTM lower limit curve that is the amount of pass is little. According to ASTM C33-03, the fine aggregate has not more than 45% passing any sieve and retained on the next consecutive sieve, and its fineness modulus not less than 2.2 and not more than 3.2. So that fineness modulus of 10%, 20%, 40%, and 60% replacement varied from 2.49 to 3.10. Therefore, the replaced mixed sample was well-graded (Table 5 and Figure 3).

Coarse aggregates consist of crushed stone with particles predominantly larger than 9.5 mm and generally between 9.5 mm and 37.5 mm are readily used in concrete after minimal processing [26].

Absorption and the specific gravity of fine aggregate composition and coarse aggregate

The absorption capacity of both fine and coarse aggregate determines the quantity of mixing water needed to be added as it affects the amount of water required for the hydration process. The specific gravity of aggregates on the other hand is needed to be known for the determination of the quantity of aggregates in the process of mix proportioning. In this study, absorption

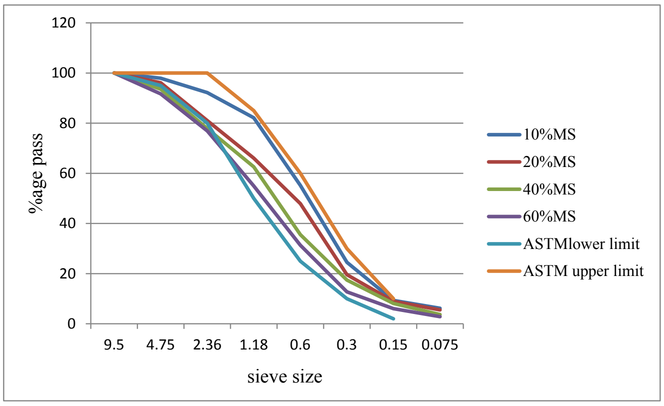

Figure 2. Particle size distribution curve for different percentage composition.

Table 5. Sieve analysis of coarse aggregate.

Sieve size	Weight retained	Percentage retained	Cumulative percentage retained	Percentage pass
37.5	0.00	0.00	0.00	100
25	0.00	0.00	0.00	100
19	55.25	2.76	2.76	97.24
12.5	356.50	17.83	20.59	79.41
9.5	445.26	22.26	42.85	57.15
4.75	1139.99	57.00	99.85	0.15
pan	3.00	0.15	100.00	0.00
total	2000			

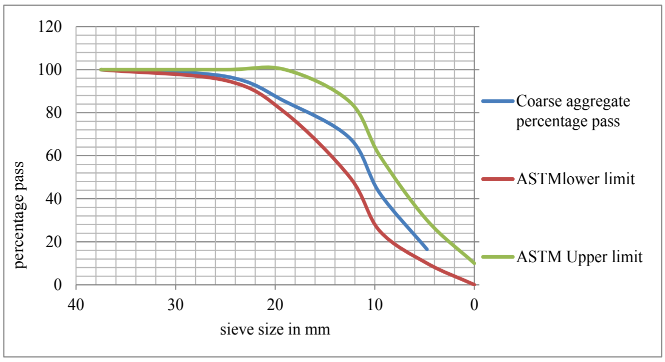

Figure 3. Coarse aggregate particle distribution curve.

and specific gravities of Natural River sand, manufactured sand, and coarse aggregate have been tested according to standards specified (Figure 4) (Table 6 and Table 7) [27].

Influence of manufactured sand (MS) on workability

A proper the concrete mixture should be mixed, handled, placed, and consolidated without difficulty to avoid creating issues in the cost of handling and led to poor durability and strength. The workability of the concrete is indirectly measured through its consistency. The consistency of concrete mostly depends on aggregate characteristics. Manufactured Sand shows poor workability in the concrete compared to the river sand. As it is seen from Table 8 and Figure 4 below when the percentage of manufactured sand increases from 10% to 60% the slump value of the fresh concrete decreases from 48.91 mm to 32.56 mm. This implies that the workability decreases by 33.43% with the above amount manufactured sand increment [28] (Figure 5).

Experimental tests of compressive and flexural strength

In this experimental investigation, the characteristics strength of concrete was calculated using natural river sand for the grade of concrete C-25. The manufactured sand was partially and fully replaced for fine aggregate. For the present investigation, concrete cubes and beams were cast and tested after 7, 14, and 28 days of curing. The chosen mix designs were full and partial replacement of manufactured sand for 0%, 10%, 20%, 40%, 60% and 100% .The tests were carried out conforming to obtain compressive strength of concrete at the age of 7, 14, and 28 days.

Figure 4. Compressive strength test results.

Table 6. Unit weight, absorption, and the specific gravity of the fine aggregate composition.

S. No	Type of fine aggregate composition	Unit weight kg/m³	Absorption (%)	Specific gravity
1	Natural sand 100%	1764.20	1.75	2.62
2	Manufactured sand 100%	1738.30	4.3	2.32
3	Natural sand 90% Manufactured 10%	1753.70	2.1	2.48
4	Natural sand 80% Manufactured 20%	1751.72	2.8	2.44
5	Natural sand 60% Manufactured 40%	1749.30	3.4	2.38
6	Natural sand 40% Manufactured 60%	1743.71	3.98	2.35

Table 7. Unit weight, absorption, and the specific gravity of the coarse aggregate.

S. No	Type of aggregate	Unit weight kg/m³	Specific gravity	Absorption (%)
1	Coarse aggregate	1631	2.91	2.52

Table 8. Workability test result of the different aggregate composition.

S. No	Aggregate Composition	Slump value(mm)	Remark
1	100% MS	26.14	Fully manufactured sand
2	100% NS	50.00	Fully natural river sand
3	10% MS+90% NS	48.91	
4	20% MS+ 80% NS	45.23	
5	40% MS+60% NS	38.98	
6	60% MS+40% NS	32.56	

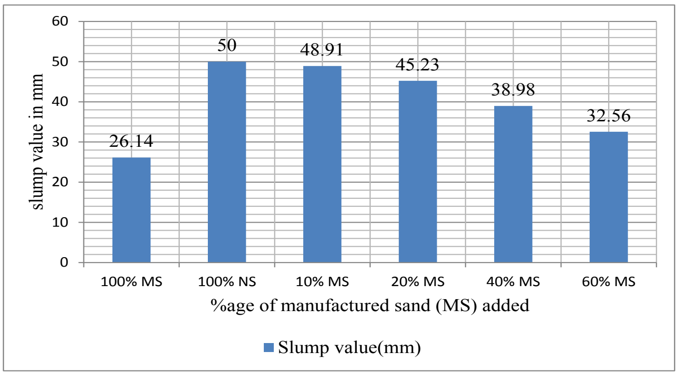

Figure 5. Influence of manufactured sand (MS) on workability.

Table 9. Compressive strength for various replacement percentage of natural sand with manmade sand.

S. No	Aggregate Composition	7th day Compressive Strength	14thday Compressive Strength	28thday Compression Strength
1	100% MS	21.56	24.67	29.22
2	100% NS	19.23	20.52	25.65
3	10% MS+90% NS	17.85	19.98	27.08
4	20% MS+ 80% NS	20.97	22.26	29.34
5	40% MS+60% NS	21.91	22.42	31.25
6	60% MS+40% NS	21.51	22.32	27.25

Test on compressive strength

To obtain the compressive strength, 54 cubes were cast and tested. Nine cubes were cast for 7, 14, and 28 days age. The compressive strength results of fully and partially replacement of manufactured sand were given below in Table 8 and Table 9 (Figure 6).

According to the test results, the mean strength was described above for the 7th, 14th, and 28th day was obtained from the compressive strength tests on each day samples. The incremental in compressive strength from 7th up to 28th day is easily observed in Table 8. From the table, it is easily observed that, as the days increase the compressive strength also increases this is mainly due to the curing of concrete. Manufactured sand increases the value of compressive strength up to 40% replacement of natural sand. All percentage replacement of manufactured sand had greater compressive strength from the control sample. This is due to the manufactured sand have high surface area and roughness for bondage with paste than the natural sand (Figure 7).

Test on flexural strength

The Flexural strength test was carried out conforming to C-25 obtain at the 28 days strength with partial replacement of natural sand with manufactured sand. The maximum flexural strength was obtained at 40% of manufactured

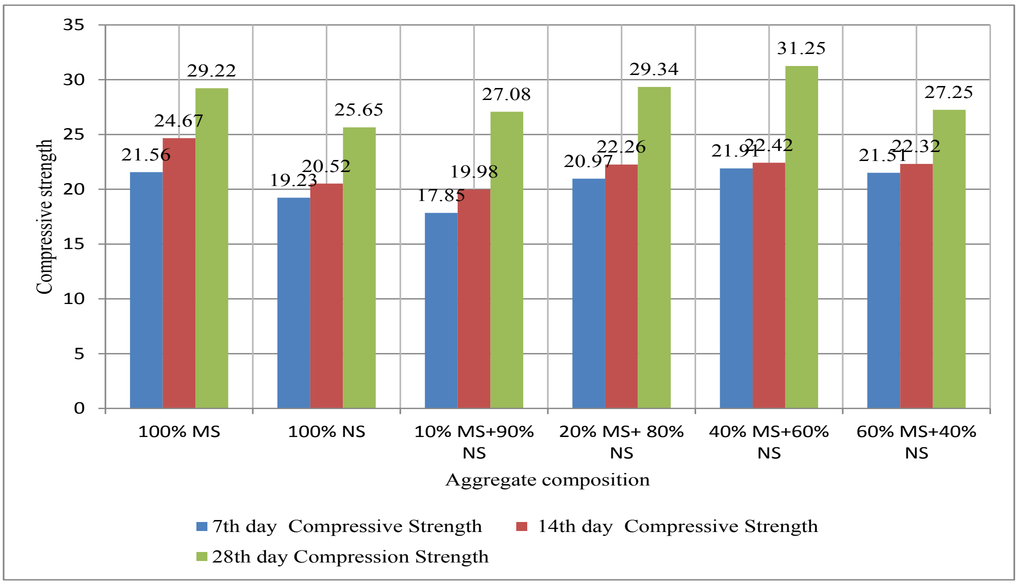

Figure 6. Aggregate composition vs compressive strength at different curing ages.

Figure 7. Specimens for compressive strength.

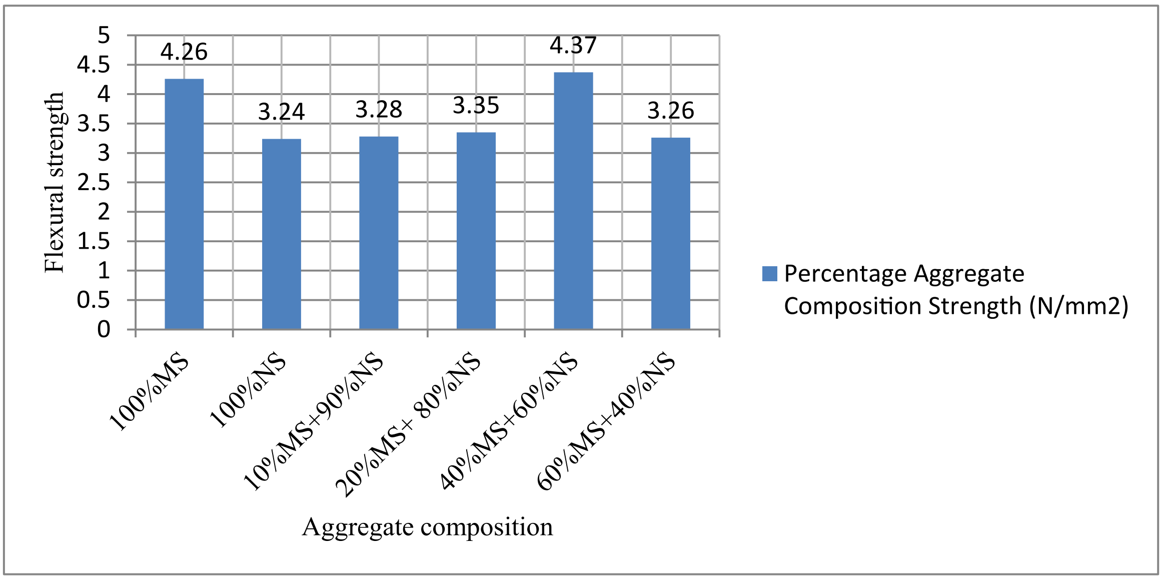

Figure 8. Aggregate composition vs flexural strength.

Figure 9. Specimens during testing for flexure.

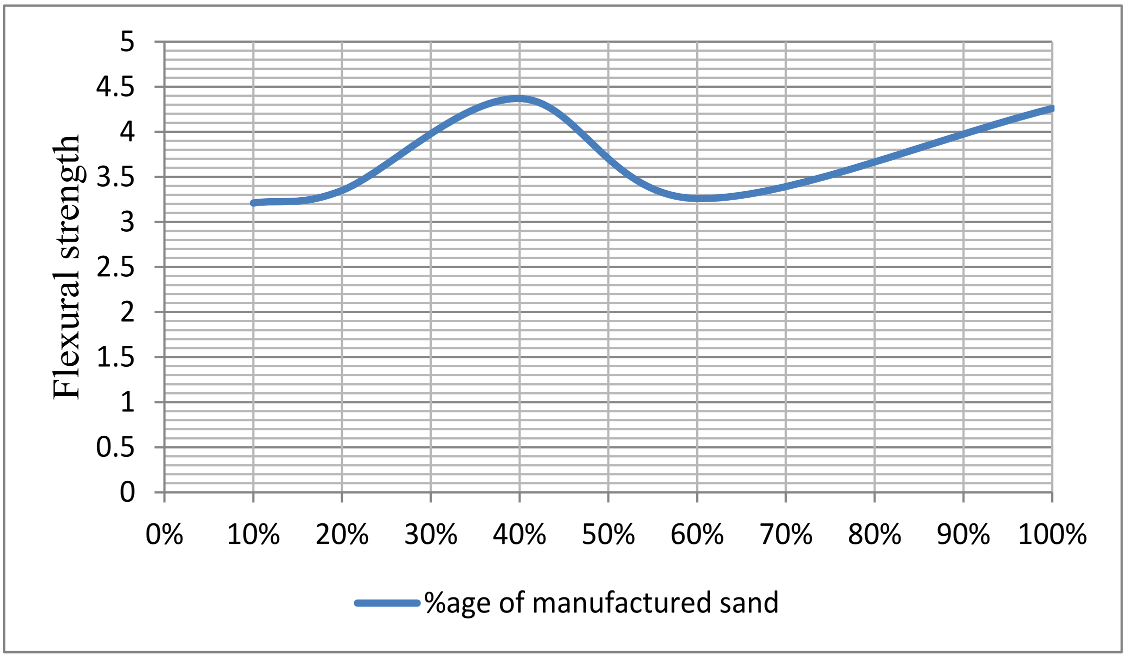

Figure 10. Graph of % age of manufactured sand vs flexural strength.

Table 10. Flexural strength value for various replacement of natural sand by manufactured sand.

S. No	Percentage Aggregate Composition	Average flexural strength at 28th days	
		Load (kN)	Strength (N/mm²)
1	100% MS	9.02	4.26
2	100% NS	8.25	3.24
3	10% MS+90% NS	8.36	3.28
4	20% MS+ 80% NS	8.60	3.35
5	40% MS+60% NS	9.07	4.37
6	60% MS+40% NS	8.40	3.26

sand replacement from the control sample on the 28-day. The flexural strength of concrete is one way of estimating the tensile strength of concrete. During this test, the specimen is subjected to a bending moment. For a bending force applied downward on a member supported simply at its two ends, fibers above the neutral axis are generally subjected to compressive stresses and those below the neutral axis to tensile stresses (Figure 8).

Table 10, Figure 7, and Figure 9 show us the flexural strength values for Natural River sand and manufactured sand replaced concrete. From the graph, it was found that there is an increase in the flexural strength values for concrete 10%, 20%, and 40% replacement of natural sand with manufactured sand. When the replacement percentage increases more than 40% the flexural strength decreases (Figure 10).

Conclusion

The use of manufactured sand as natural sand replacing material in concrete production was studied and after the research work is done, the following conclusions were made: Generally, as the replacing materials increase the absorption of the sample increase, specific unit weight decreases, specific gravity decreases, and the workability of fresh concrete decreases. The maximum compressive strength of natural sand replacement with manufactured sand was obtained at 40% replacement and the corresponding compressive strength is 31.25 MPa. The use of manufactured sand in the construction industry can save the environment and provide optimum exploitation of the resources. Generally, it is concluded, physical properties of fully or partially replaced natural sand by manufactured sand are fulfilled the minimum standards for unit weight, absorption, specific gravity, fineness modulus, and gradation at 40%. The workability of fresh concrete was decreased by 33.43% when manufactured sand increases from 10% to 60%. The maximum compressive and flexural strengths at 40% replacement were 31.25 MPa and 4.37 MPa respectively for the target concrete grade C-25 [29].

Recommendations

According to the study conducted on the suitability of natural sand replacement with manufactured sand for C-25 concrete properties with fully or partially replaced natural sand by manufactured sand the following recommendations are forwarded:

The construction units of the town administration should create awareness for the construction parties about the use of manufactured sand as partial replacements of natural sand to prevent unnecessary damages to the environment and provide optimum exploitation of the resources without compromising the strength of concrete.

The future researchers are recommended to conduct further studies on fine aggregate (manufactured sand) as partially replacing natural sand materials for concrete production, the different percentage that is not considered in this study.

References

1. Katz, Amnon K and Hadassa Baum. "Effect of high levels of fines content on concrete properties." (2006): 474-481.
2. Manasseh, Joel. "Use of Crushed Granite Fine as Replacement to River Sand in Concrete Production." *Leonardo El J Pract Technol* (2010): 85-96.
3. Jadhav, Priyanka A and Dilip K. Kulkarni. "Effect of replacement of natural sand by manufactured sand on the properties of cement mortar." *Int J Civ Struct Eng* (2013) 3.
4. Lakhan Nagpal, Arvind Dewangan, Sandeep Dhiman and Sumit Kumar (2013). "Evaluation of Strength Characteristics of Concrete Using Crushed Stone Dust as Fine Aggregate." *International Journal of Innovative Technology and Exploring Engineering* 2 (2013):102-103.
5. Ahmed, A. "Aggregates for concrete." *Int J Constr Build Mater* (2018):1-19.
6. BP, H. "Manufactured sand for concrete." (1997): 237-240.
7. Maza, M, Naceri A and Zitouni S. "Physico-Mechanical Properties of Mortar Made With Binary Natural Fine Aggregates (Dune Sand and Crushed Sand) With and Without Chemical Admixture." *Asian J Civ Eng* (2015): 663-682.
8. Monika, S. "Partial Replacement of M-Sand on Concrete by Self Curing and Standard Curing Method." 4 (2015).
9. Varsha Doijad, AV "Comparative Study of Replacement of Natural Sand to Waste Tiles." *International Research J Engand Tech* (2020): 1-5.
10. Jaiganesh, D. "An Investigation of Using Aerocon Block and M-Sand in Constructing Low-Cost Housing." *J Mech Civil Eng* (2017): 70-75.
11. Adams Joe, AM, A Maria Rajesh, P Brightson and M Prem Anand. "Experimental investigation on the effect of M. sand in high-performance concrete." *American J Eng Research* (2013): 46.
12. Karan Verma, PP. "Effects of partial replacement of natural sand with crushed sand along with supplementary cementing materials fly Ash and GGBS." (2015).
13. Suman Luitel, ST. "Effect of Natural Rubber Latex on Mechanical Properties of Concrete with Manufactured Sand as a Complete Replacement to River Sand." *Int Res J Eng Technol (2018): 646-651*.
14. Brijendra Pratap, AK (2017). "A study on m-20 concrete with partial replacement of stone dust and sugarcane bagasse ash." *Intl J Engg Sci Adv Research* 30-40.
15. Adise, AG. "Suitability of crushed jema sandstone for concrete production as an alternative to river sand. Addis Ababa: Addis Ababa University." (2017).
16. Dinku Belay, Shewaferaw. "The use of manufactured sand in concrete production, test result, and cost comparison." *Const Technoland Manag* (2006).
17. Wilby. "Concrete materials and structures." (1991).
18. AM, N. "Properties of concrete long man scientific & technical series." (1986).
19. Taylor, G. "Materials in construction." (1995)
20. Sidney Mindess, FY. Concrete (2003).
21. Steven Kosmatka H, BK. "Design and Control of Concrete Mixtures." (2003).
22. https://civilblog.org/2015/04/09/what-are-the-properties-of-fresh-concrete/
23. Dinku, A. "Construction Materials Laboratory Manual." *Addis Ababa University Printing Press* (2002).
24. Troxell, G. "Composition and properties of concrete." (1968).
25. Vaidya, Bhishma K and Shreedhar D Patil. "Comparative Study on Cost Analysis, Strength of Concrete with Natural and Manufactured sand in Residential Building." *International Journal on Recent and Innovation Trends in Computing and Communication* (2015): 3.
26. Committee, A. "Guide for Measuring, Mixing, Transporting, and Placing Concrete. America: America concrete institute (2000).
27. https://agris.fao.org/agris-search/search.do?recordID=XF2015048396
28. Nawy G, Edward. "Concrete construction Engineering handbook." (2008).
29. Mehta, P Kumar and Paulo JM Monteiro. "Concrete microstructure, properties, and materials." (1976).

How to cite this article: Mamaru, Dessalegn. "Suitability of Crushed Manufactured Sand for Replacement of Natural River Sand to Produce C-25 Concrete." Civil Environ Eng 10 (2020): 368 doi: 10.37421/jcde.2020.10.368