Available online at
www.ijacskros.com

Indian Journal of Advances in Chemical Science

Indian Journal of Advances in Chemical Science S1 (2016) 230-235

Characterization of Blended Manufactured Sand (M-sand) Based on New Zealand Flow Cone Method

M. C. Nataraja*, H. R. Priyanka

Department of Civil Engineering, Sri Jayachamarajendra College of Engineering, Mysore, Karnataka, India.

Received 10th February 2016; Revised 20th March 2016; Accepted 25th March 2016

ABSTRACT

Natural sand is not readily available nowadays, and the resources are also exhausting very rapidly. Hence, it is the time to find some substitute to natural sand. By-products of some industries and artificial sand produced by crushing machines can be used as an alternative to natural sand. To check the quality of sand, New Zealand sand flow cone method has been adopted here. This test has been extensively used to measure the performance of sand and to estimate properties of blend of two or more sands. From this, we can determine flow time, and void content of oven dried fine aggregate in its loose uncompacted state.

Key words: *Uncompacted density, Percentage voids, Flow time, Manufactured sand and blending of M-sands.*

1. INTRODUCTION

The flow time of sand is a function of grading, particle shape, and texture. Void content is function of water demand of sand. It gives the variation of workability in concrete mixes. Three different samples have been taken, i.e., river sand, slag sand, M-sand. Combinations have been tried with varying percentage replacement of coarse sand with fine sand. They have been tested to determine the loose density, flow time and its uncompacted void content. The aggregate which takes less time to empty out the cone can be referred as a fine graded aggregate because the particles have better shape and surface is smooth.

In this experimental investigation, different grades of M-sands are considered for their characterization. As per IS:383 draft code which has been accepted and will be released to the public shortly, blending of M-sand is recommended. Keeping this in mind, this work is taken up. In the case of M-sand fails in flow requirements, then a certain percentage of blending with good sand is recommended, to get a better performance of blended sands. In this study, the blending of two types of sand at different percentage is tried, and the performance is evaluated.

From this study, the following observations are made. Fine sand will have good flow properties and high void content. However, concrete produced from this demand more water. If the aggregate fail to pass through the cone, it should be mentioned as "did not flow" because of irregular shape of particles, and this is referred as coarse sand. Coarse, poorly shaped, sands have high flow time and high void content. Concrete produced from this sand gives poor performance. It was concluded that sand that lies within the prescribed envelope consistently produces good results. In blending two or more sands, each type of sand is first tested individually. Blends of two sands at various % are mixed and tested. A blend of sand which lies within flow limits is fit for use in the concrete. The actual performance of the mortar or concrete which contains these blended sands can be tested later using different tests.

Use of m-sand is increasing continuously in the production of cement mortar and concrete. Lots of research work at the national and interaction level has taken place with regard to m- sand characterization. The application, characteristics and their influence on performances have been evaluated by many researchers [1-6]. Flow time plays an important role in the characterization of m-sand [7]. IS codes are salient on this parameter and many other characteristics are given prominence [8-10]. This paper discusses mainly on the flow characteristics of m-sand as found from New Zeeland sand flow cone method [7].

2. NEW ZEALAND (NZ) SAND FLOW CONE METHOD

2.1. Significance of NZ Sand Flow Cone Method T 279

The standard test method for testing the fine aggregates as per NZ T279 gives an experimental

*Corresponding Author:
E-mail: nataraja96@yahoo.com

procedure to determine the flow time and voids content of the oven dried fine aggregate in its loose uncompacted state, and this procedure is adopted from NZS 3111:1986. This method is famous for analysis and quality control of fine aggregates. This method gives the variation of workability in the concrete mixes. This is very much suited for plant conditions. This experiment is done at least twice in regression Monte Carlo (RMC's) as per week in New Zealand. This test gives an idea about the grading, particle shape, and texture characteristics of the fine aggregate. Thus, it gives an indication of the workability of the fine aggregate when done.

In this experiment, two things are measured:

a. The time taken by the 1 kg fine aggregate sample to empty out the cone
b. The uncompacted voids content of the fine aggregate sample that gets collected in the receiving can after flow.

The code mentions that this method is applicable only to fine aggregate whose dry density is between 2500 and 2800 kg m^{-3}.

2.2. Apparatus

A flow cone apparatus, which consists of a sand flow cone with a 12.7 mm orifice, a stand, 500 ml receiving can and an overflow container.

2.3. Preparation of Sample

1. According to AS 1141.3.1, the sample is divided by riffling to obtain a dry sample mass of at least 4 kg
2. The sample is dried to a constant mass, and it is allowed to cool to room temperature
3. This mass of sample (M_4) is measured to the nearest 1 g
4. Sieve the sample using a 4.75 mm standard sieve. The sieving is done till the mass of material passing the sieve is <1% of the mass of material that has been retained on the sieve
5. The mass of the material retained on the 4.75 mm sieve (M_0) is determined to the nearest 1 g
6. Four subsamples are prepared which weigh 1000 ± 0.5 g from the sample that has passed the 4.75 mm sieve
7. The four subsamples are stored in a clean container. They are sealed and labeled
8. Three subsamples are used in the experiment while one sub-sample is a spare.

2.4. Procedure

1. Place the flow cone in the stand such that the orifice of the cone is placed centrally to the receiving can. In addition, ensure that the top of the flow cone rim is level
2. Take the container having the subsample and shake it to see that the sample appears uniform
3. Cover the orifice to allow the sand to flow and this instance starts recording the time
4. Open the orifice to allow the sand to flow and at this instance start recording the time
5. The time taken for the fine aggregate to empty out of the cone and clears the orifice is recorded to the nearest 0.1 s. If there is any blockage to the flow of the fine aggregate during the test, it should not be disturbed and made to flow again
6. If the subsample does not flow at all, then it is to be recorded as "did not flow"
7. The top of the receiving can is stroked off with a single pass of the spatula to remove the excess heap of the fine aggregate. During this action, make sure that the cylindrical measure in not disturbed which could cause compaction of the fine aggregate in the cylindrical measure. If any grains are adhering outside of the container, it should be brushed off. Gently tap the receiving can so the aggregate settles and avoids spillage when taken out to measure. The brushed off fine aggregate will be collected in the overflow container
8. The mass of the fine aggregate (M_R) in the receiving can is then weighed to the nearest 0.1 g
9. After completion of the test, collect all the aggregate and keep it again in the container
10. Repeat this test for the remaining two subsamples until three sets of results have been obtained
11. Before the next text is done, the whole of the flow cone is thoroughly cleaned with a small brush and scratching on the surface of the cone is to be avoided during this process.

2.5. Calculation

1. The percentage oversize material (P_0) of the fine aggregate is calculated as follows:
   $P_0 = (M_0/M_4)*100\%$
   Where,
   P_0 = Percentage oversize materials (%)
   M_0 = Mass of material retained on 4.75 mm sieve to the nearest 1 g
   M_4 = Mass of sample passing 4.75 mm sieve to the nearest 1 g.
2. The uncompacted voids (AV) content is calculated as follows:
   $AV = (1-[M_R*1000]/[V_R*DD])*100\%$
   Where,
   AV = Uncompacted air voids content (%),
   V_R = Volume of the receiving can (ml),
   M_R = Mass of fine aggregate collected in the receiving can (g),
   DD = Dry density of the fine aggregate (kg m^{-3}).

2.6. Reporting of the Results

The report should include the following data and result:

1. Material description
2. The dry density of the fine aggregate (kg m^{-3})

Table 1: Test results of river sand and different M-sands.

Sample	Loose density (kg/m^3)	Flow time (s)	Uncompacted voids (%)
River sand	1546.4	25.83	41.64
M-sand 1	1557.72	24.33	39.50
M-sand 2	-	-	Did not flow

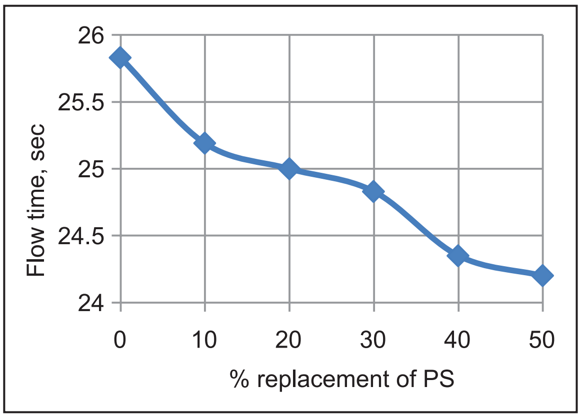

Figure 1: Variation of flow time with % replacement of M-sand 1.

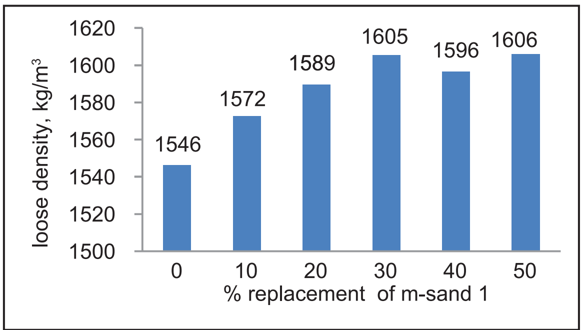

Figure 2: Variation of loose density with % replacement of M-sand 1.

3. The percentage oversize materials (P_0) to the nearest 1%
4. The flow time of each run and the calculated average of the three tests to the nearest 0.1 s
   For the subsamples that did not flow, it should be reported as "did not flow"
5. The uncompacted voids content (AV) to the nearest 0.5%
6. References required for understanding and carrying out this experiment.

This method is not applicable to slag sand as its dry density is below 2500 kg m^{-3}. M-sand 2 did not flow because of its elongated and flaky shape of aggregate, hence blending of M-sand is recommended. The three types of sand used in the present investigation and their properties are presented in Table 1.

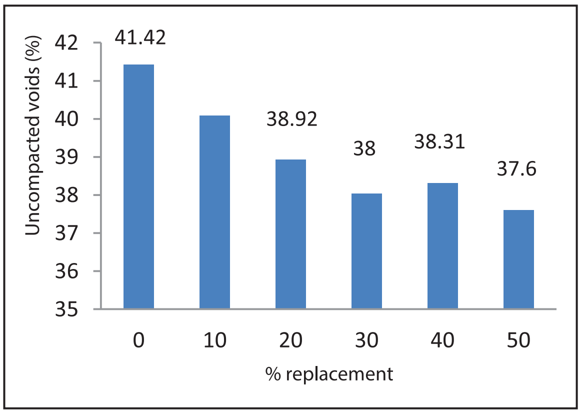

Figure 3: Variation of uncompacted voids with % replacement of M-sand 1.

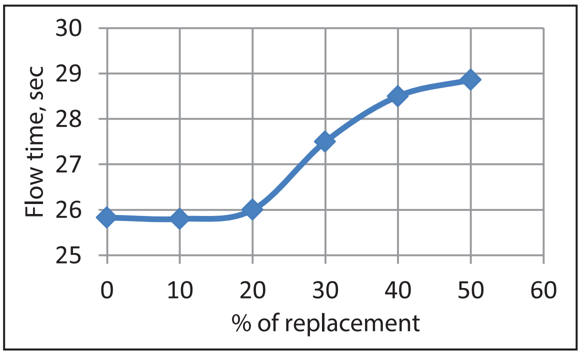

Figure 4: Variation of flow time with % replacement of M-sand 2.

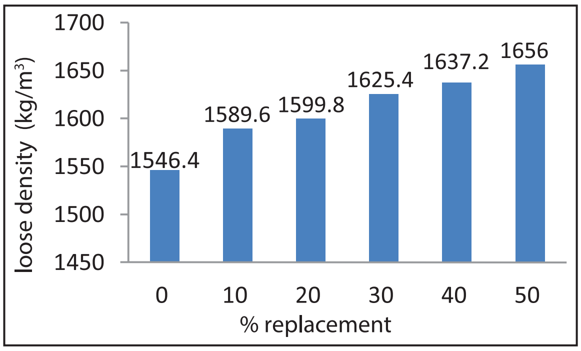

Figure 5: Variation of loose density with % replacement of M-sand 2.

3. EXPERIMENTAL RESULTS OF THE NZ FLOW CONE METHOD

3.1. Blending of M-sand 1 with River Sand

From Figure 1, the flow time for river sand is high when compared with blended sand with % variation of M-sand 1. As the % of M-sand 1 with river sand increases, the flow time decreases because of the finer particles of M-sand 1.

From Figure 2, it is observed that the loose density of river sand is lower than that of blended sand because the fines content is less in river sand compared to

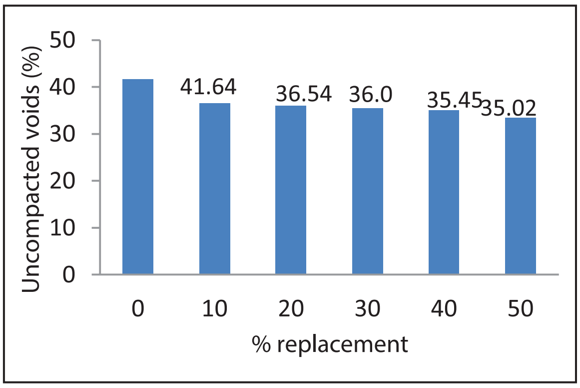

Figure 6: Variation of uncompacted voids with % replacement of M-sand 2.

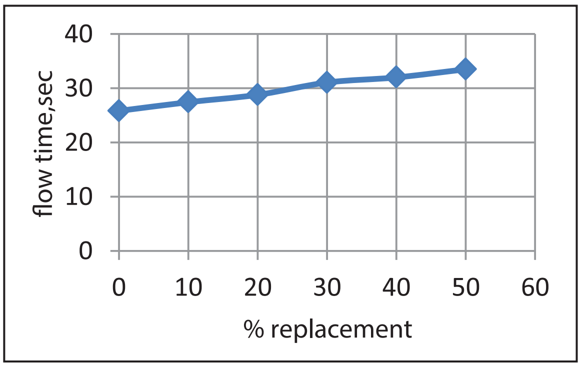

Figure 7: Variation of flow time with % replacement of slag sand.

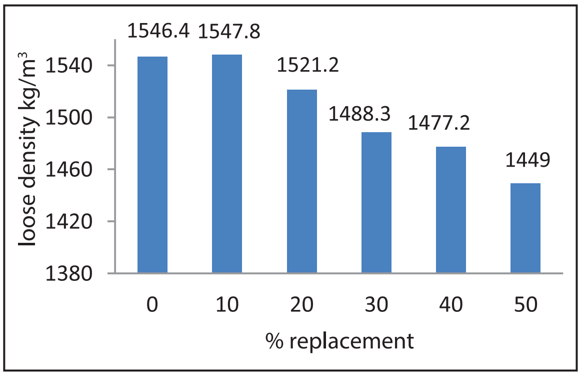

Figure 8: Variation of loose density with % replacement of slag sand.

blended sand. River sand with 50% of M-sand 1 has the highest density.

From Figure 3, it is observed that river sand has highest percentage of voids compared to the blended sand because some of the voids get filled up by the fines present in M-sand thus reducing the voids content. River sand with 50% of M-sand 1 has the least % of voids.

3.2. Blending of M-sand 2 with River Sand

From Figure 4, it is observed that the river sand has the least flow time compared to blended sand

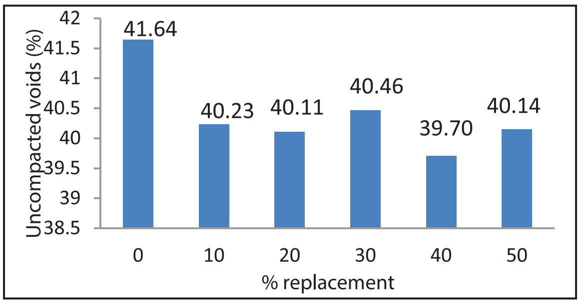

Figure 9: Variation of uncompacted voids with % replacement of slag sand.

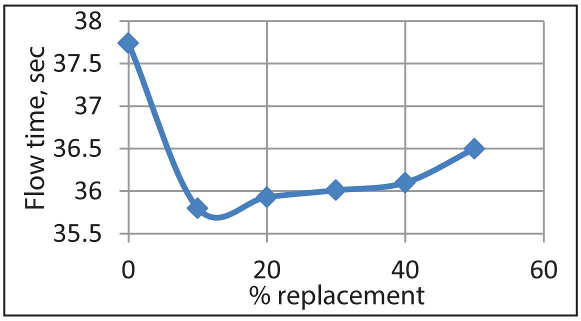

Figure 10: Variation of flow time with % replacement of slag sand with M-sand 2.

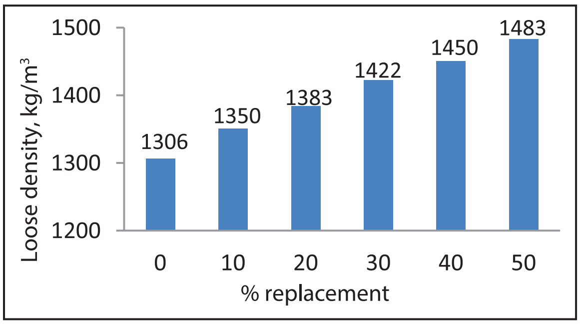

Figure 11: Variation of loose density with % replacement of M-sand 2 with slag sand.

because the river sand particles have better shape and surface is smooth compared to blended sand due to its natural weathering action. If the fine aggregate is having high flow time, then it indicates that the grading is coarser, or the particle shape is more flaky and elongated.

From Figure 5, it is observed that the loose density of river sand is lower than that of blended Sand because the fines content is less in river sand compared to blended sand. River sand with 50% of M-sand 1 has the highest density.

From Figure 6, it is observed that river sand has the highest percentage of voids compared to the blended sand because some of the voids get filled up by the fines present in m-sand thus reducing the voids content. River sand with 50% of M-sand 1 has the least % of voids.

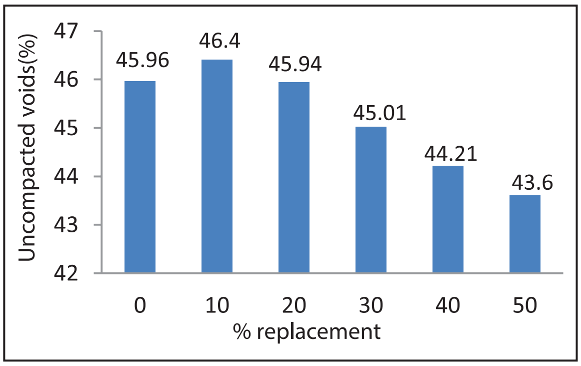

Figure 12: Variation of uncompacted voids with % replacement of M-sand 2 with slag sand.

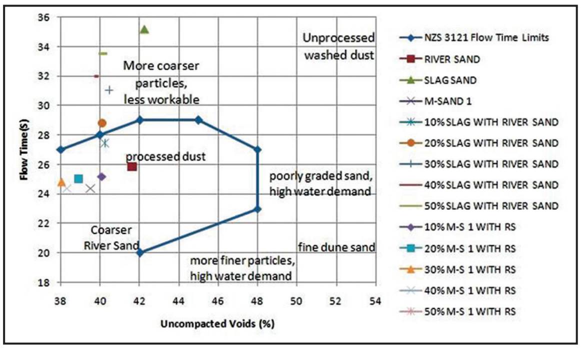

Figure 13: Results plotted in the flow time limits graph.

3.3. Blending of Slag Sand with River Sand

From Figure 7, it is observed that the river sand has the least flow time compared to blended sand because the river sand particles have better shape and surface is smooth compared to blended sand.

From Figure 8, it is observed that the loose density of river sand is higher than that of slag sand because specific weight of slag sand is less than that of river sand. River sand with 50% of slag sand has the lowest loose density.

From Figure 9, it is observed that river sand has highest percentage of voids compared to the blended sand because some of the voids get filled up by the fines present in M-sand thus reducing the voids content.

3.4. Blending of M-sand 2 with Slag Sand

M-sand 2 alone did not flow because of its irregular shape of particles; hence, it was blended with slag sand. From Figure 10, it is observed that slag sand has highest flow time because of flaky and elongated particles, but when blended with % of M-sand 2 flow time decreased. Slag sand with 10% of M-sand 2 has the lowest flow time.

From Figure 11, it is observed that the loose density of slag sand is lower than that blended sand because specific weight of slag sand is less than that of M-sand 2. Slag sand with 50% of M-sand 2 has the highest loose density.

From Figure 12, it is observed that slag sand has highest percentage of voids. As percentage of M-sand 2 increases, the percentage of voids decreases.

4. FLOW TIME LIMITS GRAPH

In the 1980's, the New Zealand ministry of works tested many varieties of sands and measured their influence on the properties of fresh concrete. By these results, they developed an envelope from which we could conclude that sand that lie within the prescribed envelope consistently gave good results when used in concrete and mortar. This envelope which is known as the NZS 3121 flow time limits.

Now the results for different combinations of blended sand are plotted in the below graph to determine the nature of the sand. The fine aggregates which fall within the flow time limits can be characterized as a good fine aggregate and will perform better when used in concrete and mortar.

From Figure 13, it is observed that slag sand, slag sand with river sand (20%, 30%, 40%, 50%) lies outside the flow time limits whereas river sand, M-sand 1, 10% slag sand with river sand and blend of M-sand 1 and river sand (10%, 20%, 30%, 40%) lies within the flow time limits. Hence, we can say that river sand with 10% of slag sand is better among other % of variations, since the fine aggregates falling within the limits as has the highest loose density and least voids content.

5. CONCLUSIONS

1. Flow cone is one of the best ways to characterize sand for its properties which helps in understanding the behavior of mortar and hence concrete
2. Of all the fine aggregates tested, the river sands has better particle shape compared to manufactured sands. M-sand 1 is the best manufactured sand as it is having the highest loose density, lesser flow time, and uncompacted voids
3. In the blended sands, 10-40% of m-sand 1 with river sand and 10% slag sand with river sand lies inside the NZS 3121 flow time limits
4. NZ flow time limits have been taken into account to check whether the fine aggregate will perform better when used in mortar or concrete. It is observed that the plots of fine aggregates which are better lies inside the flow time limits as seen in the graph
5. The quality of the m-sand obtained should be assessed at RMC sites where even a slight change in the property of fine aggregate will also result in the changes in concrete. Hence, the NZ flow cone instrument comes as a handy equipment to check and control the quality of the M-sands procured from batch to batch.

6. REFERENCES

1. S. Allena, C. M. Newtson, (2014) Materials specification needs for future development of UHPC ASTM, ***Journal of Advances in Civil Engineering Materials*, 2(4):** 198-207.
2. S. Goldsworthy, (2005) Manufactured sands in Portland cement concrete - The New Zealand experience, Proceedings of the 13th Annual ICAR Symposium.
3. B. Pedersen, (2011) Manufactured sand in concrete - Effect of particle shape on workability. COIN Project Report 34.
4. T. Thomas, (2007) Research Reports on Manufactured Sands - National Test Methods and Specification Values. Cement Concrete & Aggregates, Australia.
5. ACI 211R: 1996 [Reapproved in 2001], Guide for Use of Normal Weight and Heavy Weight Aggregates in Concrete. Reported by ACI Committee 221.
6. K. Obla, (2011) Variation in concrete performance due to aggregates - Part VII of concrete quality series, ***Concrete Infocus*, 10:** 9-14.
7. Test Method T279 for Determining Flow Time and Voids Content of Fine Aggregate by Flow Cone. T279 is a NSW Government Document Based on NZS 3111:1986.
8. BIS, (1970) ***IS: 383:1970 [Reaffirmed in 2011], Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete*,** New Delhi: Bureau of Indian Standards.
9. BIS, (1963) ***IS 2386 (Part I):1986 [Reaffirmed in 2011], Methods of Tests for Aggregates For concrete-Particle size and Shape,*** New Delhi: Bureau Of Indian Standards.
10. BIS, (1963) ***IS 2386 (Part III):1963 [Reaffirmed in 2011], Methods of Tests Aggregate for Concrete-Specific Gravity, Density, Density, Voids, Absorption and Bulking,*** New Delhi: Bureau of Indian Standards.

***Bibliographical Sketch**

Dr. M.C. Nataraja is a Professor in the Department of Civil Engineering, Sri Jayachamarajendra College of Engineering, Mysore. He is the recipient of many awards including the prestigious ICI-Outstanding concrete technologist award for the year 2012-13 and ICI best technical paper award for 2015. He has research experience of 25 years and published over 160 technical papers in national and international journals and conferences in his research field. His areas of interest are SFRC, concrete mix design, HPC, GPC and controlled low strength materials. He has travelled different countries in connection with academic and technical assignments.

H. R. Priyanka is BE in Civil Engineering and presently pursuing M. Tech. in Industrial structures at SJCE Mysuru. She is interested in the area of structural engineering and concrete technology.