Suitability of M-Sand Dust in Civil Engineering Application

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Abstract:- Now-a-days good sand is not readily available, there is a need to find some substitute to natural river sand. The practice of replacing natural river sand with M-Sand is taking a tremendous growth M-Sand is produced from hard granite stone by crushing. M-sand can contain larger amounts of fine particles than natural sand, this can affect the strength and workability of the concrete and this fine particles are dumped as a waste by-product called M- Sand dust which cannot be used in any civil engineering applications. Thus, the main objective of this study is to find the suitability of M-sand silt in civil engineering application by conducting tests such as grain size distribution, specific gravity, standard proctor test, permeability test, direct shear and CBR test. Based on the results, the suitability of M-Sand dust for plastering, concrete, pavement, filter media, landfilling and reinforced earth wall backfill are discussed.

Keywords: *Suitability, M-Sand Dust, Civil Engineering Application.*

I. INTRODUCTION

Natural river sand are weathered and worn out particles of rocks of various grades or sizes depending upon the amount of wear. In concrete, approximately 37.5% of its volume is comprised of sand. To produce concrete of high quality and economic, a carful mix of cement, fine and coarse aggregate, water, and admixtures is required to obtain optimum quality and economy. Now-a-days, high-quality sand is not readily available as the required resources are depleting rapidly. Therefore, it is necessary to find a substitute to natural river sand; hence, there is a growing practice in which river sand is replaced with M-Sand. M-Sand is produced from hard granite stone by means of crushing. Using this method, the cost of construction can be controlled through the use of manufactured sand as an alternative material for construction; however, there are a number of disadvantages regarding the production of M-sand. M-sand dust is a by-product produced during the manufacturing of M-sand that cannot be used efficiently in construction projects. Manufactured sand can contain larger amounts of micro fine particles than natural sand. This can affect the strength and workability of the concrete and these fine particles are dumped as a waste by-product called M-Sand dust, which is abundant in quantity but of no use, in this study, it is attempted to find a suitable way to reuse M-Sand dust in the construction industry.

II. LITERATURE REVIEW

Many authors have studied the physical and mechanical properties of manufacturing sand. In the following section, it is briefly explained the quantity of fine M-sand fines, its physical properties and its shape.

Evertsson (2000) in his research, reported that knowledge gained from research should be used by quarry operators to optimize the performance of their equipment and to achieve lower quantities of fines M-sand fines.

Jeffrey et al. (2003) found that the generation of quarry fines is due to the extraction and processing operations in quarries. There are several parameters that influence the production of fine M-sand which are relevant to the rock characteristics and the involved processes. However, the careful design and optimization of extraction and processing could minimize the production of fine sand.

The British Geological Survey (2003) reported that the fine M-sand produced depends on the type of crusher used and the parent rock. In that study, the primary crusher produced 1-10% of fine M-sand, the secondary crusher produced 5-25%, and the tertiary crusher produced 5- 30%. Similarly, limestone contains 20- 25% of fines sand, sandstone contains 35- 40%, and igneous and metamorphic rocks contain 10-30%. The production status of fine M-sand in a quarry is presented in Table 1 after British geological survey (2003).

The properties of crushed stones are collected and listed in table 2.

Production Stage	Type of rock	Percentage of quarry fines produced in quarries (Crusher type)
Primary crusher	Igneous	3 – 6% (Jaw) to 10-15% (Gyratory)
	Limestone	6 – 7% (Jaw) to 20% (Impact)
	Sandstone	1 – 2% (Jaw) to 15 –20% (Gyratory)
Secondary crusher	Igneous	10 – 23% (Cone)
	Limestone	< 10% (Cone) to < 20% (Impact)
	Sandstone	4 – 5% (Jaw and Cone)
Tertiary crusher &	Igneous	5 – 30% (Cone) to 40% (Impact)
	Limestone	< 20% (Impact) to 40% (Hammer mill)
	Sandstone	~15% (Cone) to 40% (Impact)

Table 1:- The production status of fines in a quarry.

Petavratzi (2006) found that large amounts of dust of fractions below 75 microns are generated from various ores. The researcher also found that different types of rock produced different amounts of fine sand with different.

Apparent density/Kg·m-3	Packing density/Kg·m-3	Crush index (%)	Clay content (%)	Acicular and flaky Granule
2685	1750	9	2.8	8.1

Table 2:- Properties of crushed stones after Petavratzi (2006)

From table 2, it is clear that the diameter of the manufactured sand particles are coarser than the natural sand particles. .The coarser particles have a less specific surface area; therefore these particles may require less water. The value of d10, d50, d90 size of natural sand and manufacturing sand are listed in table 3 below.

Fine aggregate	d10 (microns)	d50 (microns)	d90 (microns)
M sand	4.47	15.83	43.49
Natural sand	3.05	12.2	32.42

Table 3:- Particle sizes of the NS and MS (< 75 microns)

The University of Leeds (2007) found that quarry dust is produced from various activities, with the blasting stages considered the most liable in generating such dust. The amount of dust produced during blasting is estimated to be as high as 20%. Mitchell (2007) suggested that the quarrying sector would consider using new technologies, which would reduce the fine production. Hence, further research work is required to identify the capital and operational costs associated with quarry dust.

Hartwiger and O'Brien (2008) found that manufactured sand is extremely angular and has a wide particle distribution curve. Fine and very fine particles are screened out during the manufacturing process of M-sand. Seven factors need to be evaluated in the sand selection process: particle size, shape, crushing potential, chemical reaction, hardness, infiltration rate, colour, and overall playing quality.

Shreyas (2017) conducted a compressive strength test on a concrete cube by replacing natural sand with manufacturing sand in different percentages and observed its compressive strength over 7, 14, and 28 days during the curing period. The results of the test are noted in table 4.

S. No	Percentage of manufacturing sand	Average strength at 7 days (N/mm^2)	Average strength at 14 days (N/mm^2)	Average strength at 28 days (N/mm^2)
1	0	18.44	22	25.3
2	10	28.59	36.87	47.78
3	20	31.22	40.2	49.0
4	30	32.55	41.52	50.53
5	40	32.73	40.2	47.1

Table 4:- Comparison of compressive strength for various specimens with varying % manufacturing sand for 7, 14, and 28 days during the curing period after Shreyas (2017).

Looking at the results in Table 4, it is clear that the compressive strength of M- Sand concrete cube increases with the increases in the percentage of M-Sand. The strength increases when M-Sand in the concrete cube is increased up to 30%, however, after that, it gradually decreases for the curing period of 7, 14 and 28 days.

Also, Persson (1998) and Fletcher et al. (2000) described an image technique to determine the grain size and shape distribution of fine aggregate.This is a potentially useful method of classifying quarry products in order to determine their suitability for various applications.

During the manufacturing of M- sand, which is an alternative to river sand and is used as an aggregate of concrete, particularly as a fine aggregate; a by- product called M-sand dust is produced This waste material cannot be used in any civil engineering applications. The natural stone industry offers an output of 68 million tonnes of the processed product (dust or slurry) annually. There are 320 units present in Tamil Nadu, where 30,000 loads of sand are required across the state daily.

M-sand accounts for nearly 12,000 loads. This statistic shows that there is an increasing need to reduce and reuse such M-Sand dust. Dust owing to the large area of land required to store it, as well as its ability to cause severe air-borne diseases. In the majority of studies, researchers discuss the physical properties, particle size, production of fines, strength and the method used to reduce the production of fines in detail. However, there is no literature available regarding the utilization of M-Sand dust in the construction industry. In this study, it attempted to find out the suitability of M- Sand dust, which is commonly dumped as waste, in construction projects. Thus, the main objective of this study is to find out the suitability of M-sand dust in civil engineering applications.

III. MATERIALS AND METHODS GENERAL

To find the suitability of M-Sand dust in civil engineering applications, it is identified a number of relevant experiments. We provide details of the testing methods and procedure of these experiments later in this chapter.

Fig 1:- A Satellite image of SRC crusher, Thiruvannamalai district.

❖ *Collection of Materials*

The M-Sand dust was collected from the SRC crusher located in Chithathur village, Cheyyar taluk, from Thiruvannamalai district in Tamil Nadu. The altitude of the SRC crusher is 12^{0}43’33.5”N, 79^{0}36’26.4”E. Figure 1shows a satellite image of the crusher. In this section, the experiment that are conducted describes the index properties, density characteristics, and engineering properties.

❖ *Methods*

The methodology is represented as a flow chart in Figure 2.

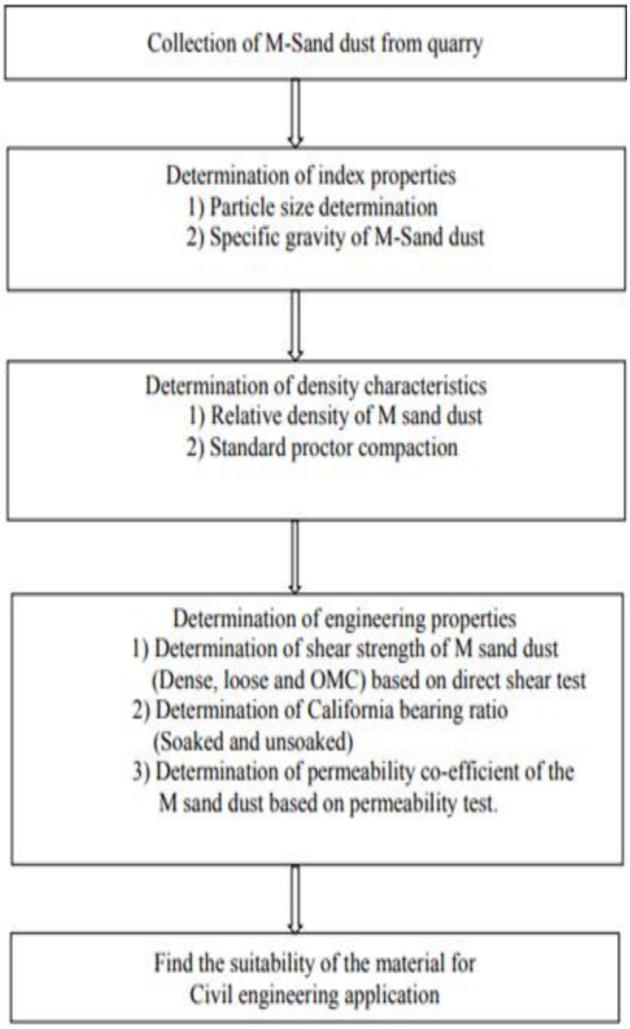

Fig 2:- Flow Chart of Methpdology

A. Index Properties, Compaction and Permeability Characteristics

The index properties such as grain size distribution, specific gravity and relative density tests were conducted as per the Indian standard code IS 2720 Parts[(IV- 1970), (IV-1975), (III-1980), (XIV-1983)] respectively and the grain size distribution curve and the standard proctor compaction curve is shown in the figure 3 and 4 respectively.

Grade	Percentage %
Gravel	0
Coarse sand	0
Medium sand	2
Fine sand	59
Silt	38
clay	1

Table 5:- The grain size distribution of the given M-Sand dust

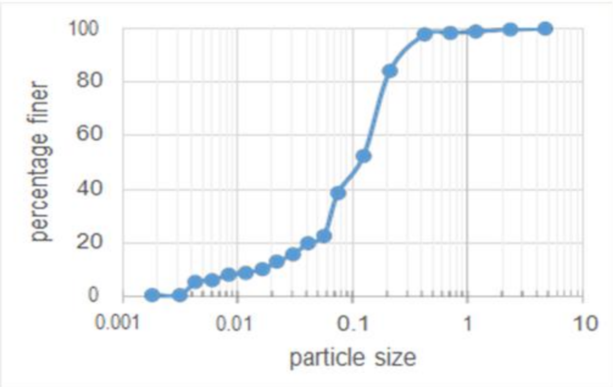

Fig 3:- Grain size distribution curve

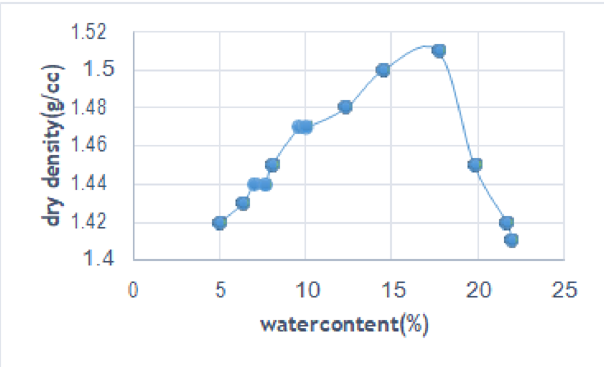

Fig 4:- Standard proctor compaction curve

From the figure 4, The optimum moisture content and dry density of the given M-Sand dust is 17.7% and 1.51g/c. The results of the grain size distribution, Specific gravity Standard proctor compaction and the Permeability is listed in the table 5 and 6**.**

S. NO	TEST	RESULT
1	Specific gravity	2.33
2	Relative density	γ_{dmin} = 1.3g/cc γ_{dmax} =1.47g/cc
3	Standard proctor test	omc 17.7% & Dry density 1.51g/cc
4	Permeability (k)	4.03x10^{-4}cm/sec

Table 6:- Results of Specific gravity, Relative density, Standard proctor and permeability test

B. Direct Shear Test

The Direct shear test was conducted as per Indian Standard code IS code 2720 (Part XIII) – 1972. The test was conducted for three conditions dense, loose and maximum dry density.

➤ *Dense Condition*

Maximum density of the M-sand dust is 1.47 g/cc. Shear stress Vs normal stress curve for dense condition is shown in figure 5.

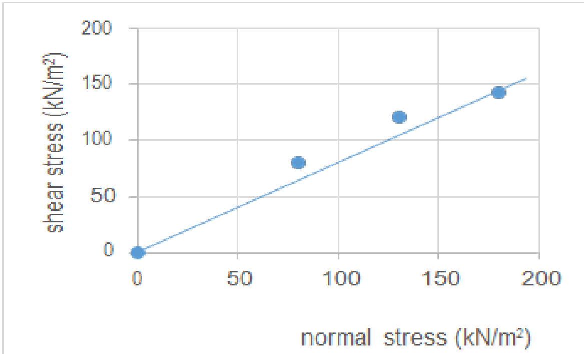

Fig 5:- shear stress Vs normal stress curve for dense condition

From the figure 5, the angle of internal friction of the provided M-Sad dust for dense condition is 45^{0}.

➤ *Loose Condition*

Minimum density of the M-sand dust is 1.3 g/cc. Shear stress Vs normal stress curve for loose condition is shown in figure 6.

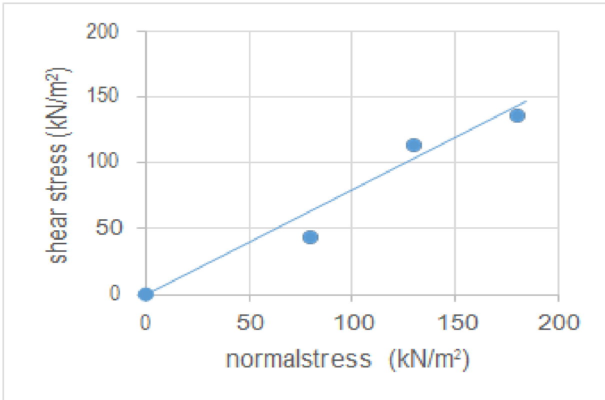

Fig 6:- shear stress Vs normal stress curve for loose condition

From the figure 6, the angle of internal friction for the given M-Sand dust is 33$^{0.}$

➤ *OMC Condition*

Density of the M-sand dust is 1.51 g/cc Shear stress Vs normal stress curve for OMC condition is shown in figure 7.

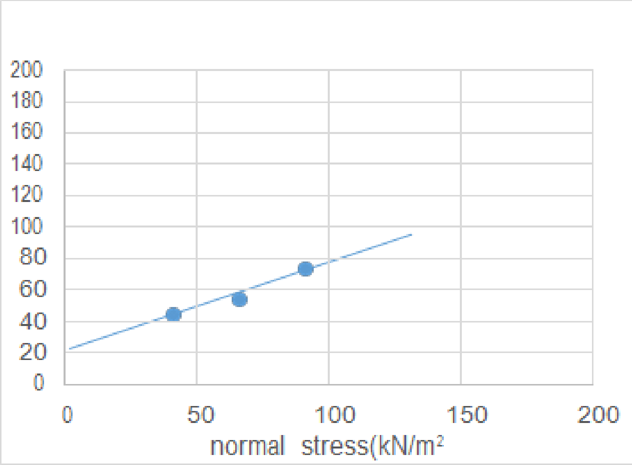

Fig 7:- shear stress Vs normal stress curve for OMC condition

From the figure 7, angle of internal friction and apparent cohesion are 38.3^0 and 20 kN/m^2 respectively.

C. Determination of California Bearing Ratio

The California bearing ratio test is conducted as per the Indian standard code IS code IS 2720 (Part XVI) – 1987.

The California bearing ratio curve is shown in fig 8.

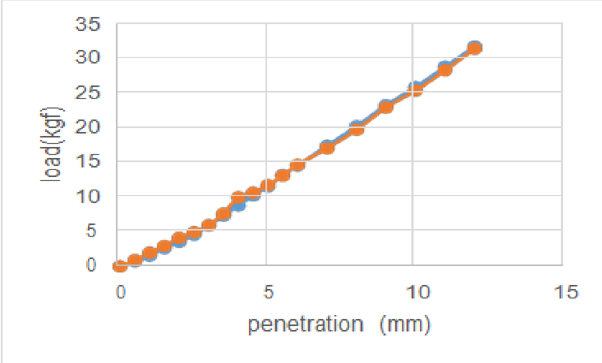

Fig 8:- CBR curve

From the figure 8 For soaked condition, CBR value at 2.5 mm and 5 mm penetration are 3% and 5% respectively. For unsoaked condition, CBR value at 2.5 mm and 5 mm penetration are 3.5% and 5.7% respectively.

IV. RESULTS AND DISCUSSION

Based on the above results, the suitability of M-Sand dust for plastering, concrete, mortar, pavement, filter media, landfilling and reinforced earth wall backfill are discussed below.

A. For Plastering IS 2386 (Part I) - 1973

The guidelines proposed by IS 2386 (Part I) - 1973 for plastering work are compared with the parameters of M-sand dust are presented in the table 7.

Properties	**Code provisions**		**Parameters of M-Sand dust**	
Fineness modulus	>1.5		2.4	
Grading	Sieve size	%passing	Sieve size	% passing
	10mm	100	10mm	100
	4.75mm	95-100	4.75mm	99
	2.36mm	95-100	2.36mm	98
	1.18mm	90-100	1.18mm	97

Table 7:- The codal provisions for plastering and the properties for M-Sand

From the table 7, the fineness modulus and the grading sieve size passing percentage is within the range provided in the IS code. Thus, the M-Sand dust can be effectively used for plastering.

B. For Flexible Pavement (IRC 37-2012)

The particle size grading, the CBR value range and its permeability value for the selection of M-Sand fines for pavement as per the guidelines in (IRC 37- 2012), along with values of M-Sand dust is listed in the table 8.

Properties	**Code provisions**		**Parameters of M-Sand dust**	
CBRvalue soaked condition	>5		5	
Grading	Sieve size	%retained	Sieve size	% retained
	4.75mm	0.8	4.75mm	0
	2.36mm	9.3	2.36mm	0.3
	1.18mm	21.9	1.18mm	1.1
	0.71mm	16.2	0.71mm	1.5
permeability	$5x10^{-3}$		$4.032x10^{-4}$	

Table 8:- The codal provisions for flexible pavement and the properties for M-Sand

From the table 8, all the parameters of the M-Sand dust exceed the codal value, thus M-Sand dust is not suitable for flexible pavements.

C. For Filter Media (IS 8419 part 1)

The parameters for filter media sand is based on its uniformity coefficient and dry density according to IS 8419 part 1. The codal provision and the parameter of the M-Sand is listed in table 9.

Properties	**Code provisions**	**Parameters of M-Sand dust**
Uniformity coefficient	< 4	2
Specific gravity	<2.5	1.51

Table 9:- The codal provision for filter media and the parameters for M-Sand

Table 9 shows that the specific gravity and the uniformity coefficient is within the range and the effective size is selected according to the purchaser. Thus it can be used as filter media.

D. For Concrete Work (IS 383- 1970)

For concreting works, the dry density specified in the code IS 383-1970 and the parameter for the M-Sand dust is tabulated in table 10.

Properties	**Code provisions**		**Parameters of M-Sand dust**	
Dry density	>2.5		1.51	
Grading	Sieve size	%passing	Sieve size	% passing
	10mm	100	10mm	100
	4.75mm	90-100	4.75mm	99
	2.36mm	80-100	2.36mm	98
	1.18mm	50-90	1.18mm	97
	0.71mm	20-65	0.71mm	98

Table 10:- The codal provision for concrete works and the parameters for M-Sand

From the table 10, the dry density of the M-Sand dust lags behind the suitable range. Thus, it is not suitable for concreting works.

E. For Landfilling (IGCFAR)

The uniformity coefficient, specific gravity and fineness modulus for the selection of M sand dust for landfilling as analyses as per the guideline (IGCFAR). The parameter of M-Sand dust is listed in the table 11.

Properties	**Code provisions**	**Parameters of M-Sand dust**
Uniformity coefficient	< 6	2
Dry Density	1.5-1.8	1.51
Specific gravity	<2.6	2.33
Fineness modulus	2.2-3.2	2.4

Table 11:- The codal provision for landfilling and the parameters for M-Sand

From the table 10, the dry density, specific gravity, the fineness module and uniformity coefficient of the M-Sand dust are in the acceptable range as per the code. Thus it is suitable for the landfilling.

F. Reinforced Earth Walls for Backfill (DS-SP-S01)

The selection criteria for the reinforced earth wall for backfill is selected as per DS-SP-S01 and the M-Sand dust parameter is listed below in table 11.

Properties	**Code provisions**	**Parameters of M-Sand dust**
Uniformity coefficient	< 6	2
Angle of internal friction	$>36^0$	38.3^0
Sieve size 75µ	%passing < 15	38

Table 12:- The codal provision for reinforced earth wall and the parameters for M sand dust

From table 12**,** the angle of internal friction is near to the acceptable value, the passing percentage through 75 µm and the uniformity coefficient is lies between acceptable ranges. Thus it is suitable for the usage of reinforced earth wall for backfilling.

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V. CONCLUSION

From the above results, it is concluded that the M-Sand dust is suitable for plastering, the fineness modulus and the grading sieve size passing percentage is within the range provided in the IS code.

- It can be used as a Filter media, because the dry density and the uniformity is within the range according to the code.
- It can be used for landfilling as the dry density, specific gravity, the fineness module and uniformity coefficient of the M-Sand dust are in the acceptable range as per the code.
- It can be used as reinforced earth wall backfill because the angle of internal friction is near to the acceptable value, the passing percentage through 75 µm and the uniformity coefficient is lies between acceptable ranges.
- It is not suitable for concreting, because the dry density of the M-Sand dust lags behind the suitable range.
- It is not suitable for flexible pavement application due to the presence of fine content which is more than the permissible limit. For further application it is to be modified by removing the fines then it is used

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