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Sustainable Construction Material Management Using GIS (A case study of partial replacement of M-Sand with River Sand in Trichirappali District)

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ABSTRACT: Sand becomes a crucial natural resource for construction industry. Although industries increasing dependence on sand used as fine aggregate, there are unfortunate challenges that construction industry needs to deal with: depleting source of sand, illicit sand mining and adverse environmental impact of sand mining like depletion of ground water level, ground water movement and land sliding etc., The aim of paper is to focus an overview of overall scenario of river sand and its availability and focus on feasibility of using M-Sand as an alternative material after considering engineering properties and economic viability. To achieve sustainability of river sand, an experiment is performed by replacement of river sand in varying proportion of 0, 5, 10, 15, 20, 25, 30, 35 and 40% with M-Sand. This study concluded that, increase in percentage of manufacturing sand in the range of 35% to 40% will result in increasing trend in engineering aggregate properties of (i) Gradation, (ii) compressive strength, (iii) durability and (iv) workability.

KEYWORDS: Manufactured Sand (M-Sand), River/Natural sand, Sustainability, Mix design, Physical property and Engineering Property.

I. INTRODUCTION

Sustainable Construction Materials, which generates less waste, uses raw materials and more durable. There are many tools and techniques available today for selection of construction material that are less damaging to the environment. The objectives of this paper include i) To understand the concept of Sustainability in Construction Materials ii) To Assess the Demand and Supply of Construction Materials in Cauvery River Basin, iii)To analyze the mining activities of River sand in Cauvery Basin, iv) Compare the Engineering Properties and strength parameters of alternate building Materials v)To develop GIS map for potential suppliers and consumers for Effective Material Management. There are Environmental Concerns through Regulations for Rivers, Water Bodies and Sea Water, Ground Surface- Earth Air, Inter Relation and Eco- System. In construction all activities related to building engineering structures, Natural Resources and Materials, Water Pollution, Air Pollution, Noise Pollution, Effect on Eco-system.

II. Mineral Resources of Trichirappalli District

The Trichirappalli district is located in North Latitude between 10°15' 00" to 11°12' 00" and east Longitude between 78°10' 00" to 79°05' 00".It found variety of rocks and rich deposit of sand material in Cauvery and Kollidam River from west to east. Manapparai region of Trichirappalli district is hard terrain rock like Granite, Charnocknite and gneissic rock. This area is having rich deposits color granites. The black color granites had worked as a small pocket deposit Thalugai village of Thuraiyur. The Charnocknite area had worked rough stone quarries with crushers. In other area like Musiri, Thuraiyur and Padaloor area of Lalgudi taluk. In sedimentary deposits likes lime stone, gypsum, fire clay, steatite, kankar, soap stone and phosphatie nodules are occurring in Dalmiapuram and Pullambadi region. A great Dalmia Cement corporation (Dalmiapuram) and their mines are located in Kallakudi (klk), Kovandakurichi (kvk) and Vengadachalapuram. A heavy mineral of Garnet sand is also occupying in Musiri, Thuraiyur, Thottiam taluk areas of Tank, Eri, Pond and Odai. The upper region contains only

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a moderate quantity of valuable minerals of which the magnetic iron beds and garnet sand in Musiri area are the most important [2].

III. Problem Statement

The construction and infrastructure segment of Tamil Nadu state is facing acute river sand shortage, which has delayed innumerable construction projects across the state. This leads to multi fold increase in price of river sand which results in increase in cost of construction. Apart from cost of construction, unlawful Sand Mining has vulnerably affected the environment. Ultimately it led to prohibit on mining of river sand. As per intervention of Tamil Nadu High Court and detailed investigation, court has proposed an order to government on 29th November 2017, that within a period of six months all the river sand quarries should be closed and no new quarries shall be opened. As on alternate of local river sand, state Government encouraged importing sand from neighboring countries particularly in Malaysia, Dubai etc., but these sand fails to meet the requirements of IS codal specifications particularly it contains excess level of organic impurities. To meet the daily requirements of 35,000 loads of river sand, government opt for M-sand as an alternate material for river sand. But mushroom growth of M-sand manufactures and not familiar in standards of using M-sand, results in confusion of using M-sand among common people. Public Works Department of Tamilnadu verified that out of 300 M-sand manufacturing unit only 10 units meets the requirements of standards. But these 10 units produce only 2000 loads which against actual demand 35,000 loads. To cope up with the crisis of demand on quantity and qualitative river sand, industries are now looking for other alternatives for fine aggregate. M-sand is a nearby alternative solution for demand of river sand which one is moderately available in hilly areas. In future construction industries fully rely on M-sand. Hence it is important to study its physical, chemical and engineering properties and its behavior on concrete [1].

IV. Material Management for Alternative Resources

Materials management is a process of utilizing limited resources in effective manner without affecting flow of operation. It requires effective planning, efficient execution and tight control over site and inventory activities in construction. The key success factors for construction activities requires finding suppliers with credit worth and searching suitable alternative materials which includes quality of raw materials, best negotiable price of materials, and its availability, procurement and delivery process, technical expertness, financial viability, location, goodwill, management practice and its organizational procedure. Effective supplier selection include realizing the demand for a specific product, Identify key procurement processes and critical factors, determine method sourcing and its supply source, finding limited suppliers in selection pool, adjudicate the method for final selection, select suppliers and reach terms and condition.

V. Geographical Information System Model

Geographic Information System (GIS) is a system of software hardware, and set of procedures which is designed to support the entrap, handling, and analysis of modeling and display of spatially referred data for solving complex planning and management problems"[(11).] GIS map is used to show geographical locations of specific location with attributes of features found at these locations which one is helps to prepare thematic map of material management for construction activities which one is used to control the inventory level of materials. Attributes in thematic mapping can be geographically referenced by a hierarchical reference system/ discrete system. This feature used to identify locations in the delivery of material services. In geographic data model, geographic data are abstracted into series of independently defined layers. Each set of these layers represents a selected set of closely associated spatial objects like roads; rail networks etc., In GIS modeling, and these spatial objects in a particular geographic space are classified and stored separately. The attribute data for the spatial objects in each of the layers are stored in relational/attribute tables. The descriptive and spatial data are logically linked by means of unique identifiers. These tables can be logically joined with one another when required during geographic data processing and analysis of inventory management.

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VI. Materials and Methods

Materials used in analysis are (i) Ordinary Portland cement of 53 Grade (ii) Manufacturing Sand of three locations (iii) Blue granite crushed stone aggregate.

6.1 Tests on Physical properties of concrete Materials:

Tests on cement is carried out for its (i) Fineness of binding material (cement) , (ii) Consistency (iii) Soundness test (iv) Sp. gravity and (v) Setting Time (Initial and Final).

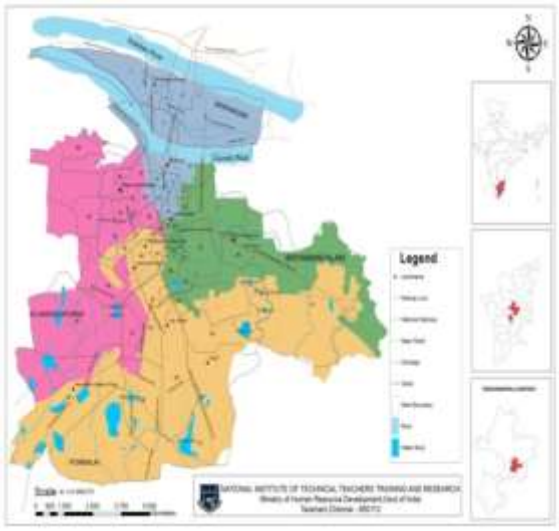

Figure 1. Study Area

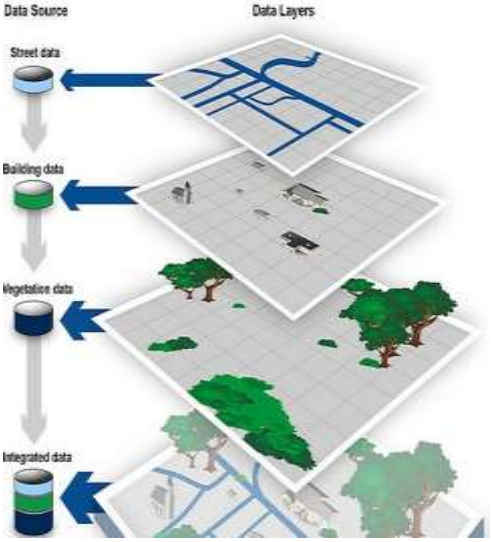

Figure 2 : GIS Model for Material Management (Source : GAO)

Table 1. Results on Physical and chemical properties of 53G OPC

S.No	Physical Properties	Field Test (N/mm^2)	Requirements as per IS: 8112-1989	Reference
1	3-Days Compressive strength	28.00	-	Compression Machine (IS: 4031-Part 6)
2	7-Days Compressive strength	37.50	43	
3	28-Days Compressive strength	52.80	53	
4	Specific surface area (m^2/kg)			
5	Initial Setting Time (hours, min)	40	30 minimum	Vicat Apparatus (IS:4031 Part -5)
6	Final Setting Time (hours, min)	200	600 maximum	
7	Normal Consistency			IS 4031- Part 4
8	Soundness in mm	6	< 10 mm	Lechatelier Test: IS : 4031 Part -3
9	Standard Consistency in %	28	30-35 %	Vicat Apparatus (IS:4031 Part -4)

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Table 2.Properties of M-Sand

S.No	Properties	M-Sand Sample Location			Recommended Values as per IS 383-1970
		Keeranur	Pudukottai	Trichy	
1	Fineness Modulus	2.74	2.83	2.90	2.20-3.20
2	Specific Gravity	2.73	2.81	2.75	2.40-2.90
3	Water Absorption	1%	1%	1%	IS: 2386 (Part -3) & 2%
3	Grading Zone	II	II	II	-
4	Maximum Size	4.75 mm	4.75 mm	4.75 mm	-

Table 3. Test on Coarse Aggregate

Tests on coarse aggregates are carried out for its

(i) Sieve analysis

(ii) Specific gravity

(iii) Water absorption

(iv) Aggregate tests on shape, crushing and Impact

(v) Los Angeles abrasion test.

S.No	Properties	Laboratory Results	Permissible Value	Reference
1	Fineness Modulus	2.98	2.30 – 3.10	IS: 2720 (Part-4)
2	Sp. Gravity- Bulk	2.57	2.5 – 3.2	IS: 2386 (Part-3)
3	Sp. Gravity - Apparent	2.48		
4	Water Absorption Ratio	1.2%	< 2.0 %	IS: 2386 (Part-3)
5	Flakiness Index	21%	< 30 %	IS : 2386- I(1963)
6	Elongation Index	22%		
7	Aggregate Crushing Limit	19.20	< 30 %	IS:2386-(Part-4)
8	Impact Test	18%	< 24%	IS:2386-(Part-4)

Table 4. Test on River Sand

S.No	Properties	Test Result	Reference
1	Sieve Analysis (% by weight)		
(a)	Passed on (4.75 – 2.00 mm)	6.10	IS: 383 -1970
(b)	Passed on (2.00 – 0.425 mm)	71.90	
(c)	Passed on (0.425 – 0.075 mm)	22.00	
2	Sp. Gravity	2.65	

3	Water Absorption	Nil	IS: 2386 (Part-3) - 1963
4	Moisture Content (%)	1.48	
3	Bulk Density (kg/m^3)	1460	
4	pH	8.90	

6.2 Mix Design of M 25 Concrete

With the aim of preparing the concrete mix of the required, compressive strength, durability, and workability as economically as possible. A volumetric batching is carried out for the material mix to design the quantity required for casting each cube specimen considering the design mix as M25 grade with the proportion of 1: 1: 2 as per IS 383-1970 & IS 456-2000 guidelines, standards and specifications [(6)(9)(10).]

The percentage of M-sand is varied from 0 , 5,10, 15, 20, 25, 30, 35 and 40 % is used in the concrete mix and is tested for concrete compressive strength in the stages of 7, 14 & 28 days. The tested results are shown in Table 6 as a comparison of characteristic strength between PCC mix and M-sand as an admixture for the concrete mix of M25 grade for an mean value of five specimens [(1)(3)(8).].

Table 5. Test Results on Plain Cement Concrete and Partial Replacement of Manufacturing Sand

S.No	Experiment	Average Test Results	Permissible Value	Partial Replacement of M.Sand	Reference
1	Slump Test	Slump for 0.55 W/C ratio	-	Slump for 0.55 W/C ratio	IS:7320-1974
2	Compaction Factor	0.85	-	0.85	IS:1199-1959
3	Vee Bee consistometer	24 seconds	-	22 seconds	IS-10510-1983
4	Compressive strength in N/mm^2				
(i)	7 - days	17.60	17.00	29.00	IS:1489-1991
(ii)	14 - days	21.80	22.00	32.00	
(iii)	28 - days	25.15	25.00	47.50	

Table 6. Comparison of compressive strength in PCC specimens for

7, 14 days & 28 days in N/mm2

S.No	Partial Replacement of % of M-Sand	Average Strength at		
		7 Days	14 Days	28 Days
1	0	17.98	21.50	24.67
2	5	22.93	28.70	35.63
3	10	27.88	35.90	46.59
4	15	29.16	37.55	47.18
5	20	30.44	39.20	47.78
6	25	31.09	39.87	48.52
7	30	31.74	40.50	49.27

8	35	39.42	39.85	47.59
9	40	47.10	39.20	45.92

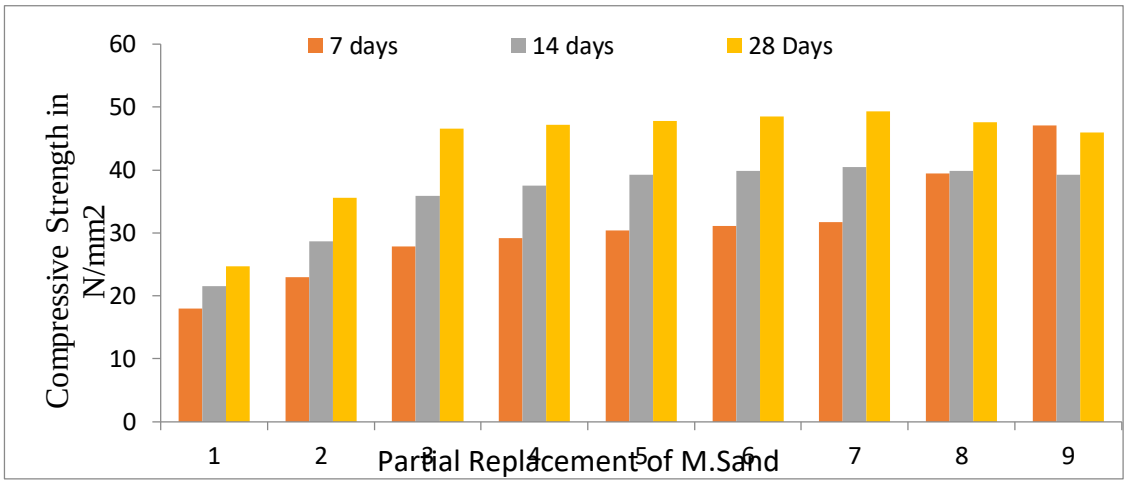

Fig 3. Compressive strength of PCC Vs M- Sand as admixture for 7, 14 and 28 days.

VII. Conclusion

The following conclusions are arrived from the test results:

1. M – Sand provides an appreciable performance in concrete in terms of strength, quality and in economical aspects with forty percent replacement of river sand.
2. Increasing in trend is obtained in durability and workability of test specimen in replacement of forty percent river sand.
3. Replacing M-Sand test specimen shows 6-9 percent higher compressive strength and 12-15 percent higher flexural strength against normal PCC specimens.
4. M-Sand specimen mix consume lower water-cement ratio against nominal mix which produce better characteristics in the hardened state.
5. Standard and Qualitative M-sand is not available in throughout the state which affects the quality of concrete.
6. The cost of manufactured sand totally depends on the location and availability.

Pumping concrete consumes more cement when M-Sand is used which one is not cost effective.

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