Viability of Sand Alternatives

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***Abstract*— An average 800 kg of sand is required for 1 cubic meter of concrete, and further assuming that capacity of one truck is 5 tons, we can conclude that India needs approximately 14 crore truckloads of sand each year. The dredging of natural sands has already affected the environment and ecology of many regions of the country. This consequently necessitates a paradigm shift in concrete making practices, calling for the development of manufactured sand as an alternative to natural sand. This paper depicts the results for an experimental study to replace the natural sand with brick powder and quarry dust. Compressive strength and workability of 8 mixes each of M30 and M40 were found out for replacements of fine aggregate by 10-70% of brick powder and quarry dust respectively.**

Keywords*— *Sand, brick powder, quarry dust, compressive srength, workability

I. INTRODUCTION

Cement, sand and aggregate are essential needs for any construction industry. Sand is a major material used for preparation of mortar and concrete and plays an important role in mix design. India produces roughly 260 million tons of cement per year. This quantity of cement is being used for the production of concrete and mortar. Assuming that on average 300 kg of cement is needed to produce 1 cum of concrete/ mortar, then calculating appropriately, we can conclude that India produces 90 crore cubic meters of concrete and mortar. Assuming that on an average 800 kg of sand is required for 1 cubic meter of concrete, and further assuming that capacity of one truck is 5 tons, we can conclude that India needs approximately 14 crore truck loads of sand each year. Clearly, we demand for sand will increase progressively with each year.

The collection of 14 crore truckloads of sand every year from river beds, stratum beds, and pits creates tremendous environmental problems, such as meandering of watercourse, denudation of river banks, and interference with the natural flow pattern of rivers and streams. The dredging of natural sands has already affected the environment and ecology of many regions of the country. This consequently necessitates a paradigm shift in concrete making practices, calling for the development of manufactured sand as an alternative to natural sand.

In general consumption of natural sand is high, due to the large use of concrete and mortar. Hence the demand of natural sand is very high in developing countries to satisfy the rapid infrastructure growth. A developing country like India faces shortage of good quality natural sand and in particular, natural sand deposits are being used up and causing serious threat to environment as well as the society. Rapid extraction of sand from river bed causes so many problems like loss of water retaining soil strata, deepening of the river beds, bank slides, loss of vegetation on the bank of rivers, disturbance of the aquatic life as well as disturbance to agriculture due to lowering of the water table in the well etc. are some of the examples. The heavy-exploitation of river sand for construction purposes in India has led to various harmful problems.

II. LITERATURE REVIEW

Tikalsky, Smith and Ray (1998) to evaluate the potential of using spent foundry or casting sand as a constituent controlled low-strength material (CLSM). The physical characteristics of spent casting sand or foundry sand are similar to those characteristics of fine aggregate used in high quality CL SM. This study developed different mixture proportions for CLSM containing spent casting sand that had strengths between 300 to 800 kPa at 7-days and sufficient flowing characteristics to be self-compacting and self-leveling. Each mixture was tested for strength, water demand, rate of strength development and fluidity. The results show that the spent casting sands provide high quality material for CLSM. The spent chemically-bonded casting sands are excellent replacements for portions of the fine aggregate, while clay-bonded casting sands must be more carefully proportioned and tested to prevent fluidity problems.

Tiwari and Patel (2012), studied that concrete is the most indisputable and indispensable material being used in infrastructure development throughout the world. Umpteen varieties of concretes were researched in several laboratories and brought to the field to suit the specific needs. Although, natural fine aggregates (i.e. river sand) are so far and/or will be superior to any other material in making concrete but their availability is continuously being depleted due to the intentional overexploitation throughout the globe due to rapid urbanization and construction of other amenities. Hence, partial replacement of fine aggregate by the other compatible

material like sintered fly ash, crushed rock dust, quarry dust, glass powder, recycled concrete dust and others are being researched from the past two decades, in view of conserving the ecological balance. In this direction, an experiment investigation of strength and durability was undertaken to use "Spent Fire Bricks" (SFB) (i.e. waste material from foundry bed and walls; and lining of chimney which is adopted in many industries) and

Appukutty, Murugesan (2009) substitution of crusher dust for sand in cement mortar for brick masonry is experimented with brick masonry prisms cast in different ratios of 1:8, 1:6, 1:5 and 1:4. Bricks with basic compressive strength above 3.5 N/MM2and 7.5 N/MM2 were used to cast brick masonry prisms. Three types of fine aggregates, i.e. Cauvery river sand, Crusher dust as is available form stone. Crushers and crusher dust in which fines below 150 microns removed were used for mortar. Three samples of brick masonry prisms in each mortar ratio were built, cured for 28 days and tested for the basic compressive strength. The results of 12 prisms tested in each fine aggregate with different mortar ratios are compared with allowable compressive strength requirements of brick masonry specified by IS 1905-1989. The investigation indicates that the crusher dust can replace natural sand completely in masonry construction with higher strength and cheaper cost.

Elavenil and Vijaya (2013) scarcity of good quality Natural River sand due to depletion of resources and restriction due to environmental consideration has made concrete manufactures to look for suitable alternative fine aggregate. One such alternative is “Manufactured sand”. Though manufactured sand has been in use in concrete manufacturing in India, the percentage of its contribution is still very negligible in many parts of the country. Except in Kerala and in some pockets in Southern and Western India, real processed manufacture sand is not available and this makes manufacturing of good quality of concrete very difficult. The application of concrete meeting the specification is of paramount importance, to ensure construction of durable R.C.C. structure. Hence durable concrete covers and bears the responsibility of sustaining the entire R.C.C. structure throughout it service life.

Sankh, Biradar, Naghathan, Manjunath and Ishwargol (2014) state that cement, sand and aggregate are basic needs for any construction industry. Sand is a prime material used for preparation of mortar and concrete and which plays a major role in mix design. Now a day’s erosion of rivers and considering environmental issues, there is a scarcity of river sand. The non-availability or shortage of river sand will affect the construction industry; hence there is a need to find the new alternative material to replace the river sand, such that excess river erosion and harm to environment is prevented. Many researchers are finding different materials to replace sand and one of the major materials is quarry stone dust. Using different proportion of these quarry dust along with sand the required concrete mix can be obtained. This paper presents a review of the different alternatives to natural sand in preparation of mortar and concrete. The paper emphasize on the physical and mechanical properties and strength aspect on mortar and concrete.

III. METHODOLOGY

A. *Material*

Brick powder and quarry dust are obtained from industrial sources in raw form in order perform the experimental study. It is washed in potable water and kept immersed for a period of 24hrs before use. During removal of water, they are screened for removing any unwanted particle. Grinding is done to ensure the uniformity of size of the fine aggregate i.e. 2mm.

B. *Experimental procedure*

Concrete mixes containing river sand, brick powder and quarry dust were prepared. Eight different mix designs were investigated for the concrete for M30 and M40. The first of these was a control mix and did not contain any brick dust or quarry sand. The forthcoming mixes were of 10-70% replacements of river sand by brick powder and quarry dust respectively. Mixing and casting procedure

The concrete was mixed in a laboratory mixer. The contents were mixed in dry state first and then water was added to the mix along continuous vigorous mixing. After pouring of the concrete, table vibrator was used to ensure consolidation. All the mixes were taken out of mould after 24hrs and kept for curing. Some sample was used for testing slump of the mix.

C. *Properties of concrete*

Compressive strength and workability of the concrete are calculated properties of concrete. The development of compressive strength in the concrete mixes was found out at 7 and 28 day. Cube specimen of (15cm×15cm×15cm) was cast for compressive strength of concrete. The slump of concrete mix was tested at the time of preparation of mix using slump cone method

Table I Properties of quarry dust

PROPERTY	VALUES
Specific Gravity	2.54-2.60
Bulk Density (Kg/m3)	1720-1810
Absorption (%)	1.20-1.50
Moisture Content	Nil
Fine Particles Less Than 0.075mm (%)	12-15
Sieve Analysis	Zone II

Table II Properties of Brick dust

PROPERTY	VALUES
Bulk Density (Kg/m3)	2000
Porosity (%)	25 To 30
Size Tolerance (%)	+2
WorkingTemperature (Celsius)	1300 To 1400
Crushing (Cold)(N/mm2)	25.5 To 12

IV. RESULT AND DISCUSSION

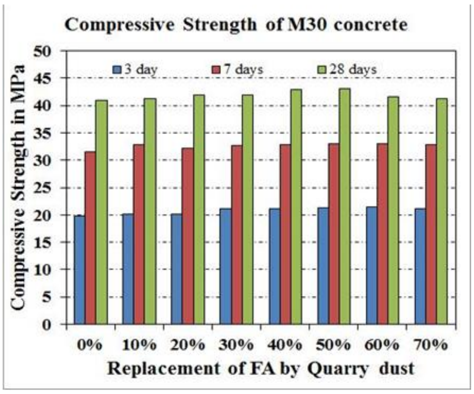

Fig. 1: Graph showing compressive strength of M30 with Quarry dust

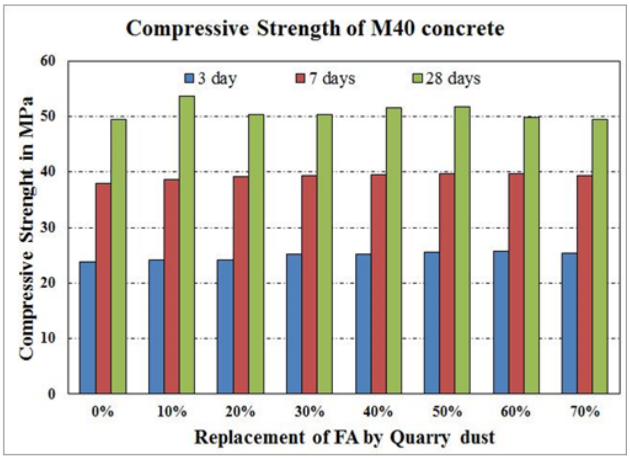

Fig. 2: Graph showing compressive strength of M40 with Quarry dust

Table III Compressive strength of M30 Quarry Dust

% REPLACEMENT	AVG COMPRESSIVE STRENGTH		
	3 days	7 days	28 days
0%	20.76	31.92	41.42
10%	20.16	33.72	41.73
20%	20.16	33.2	43.4
30%	22.28	33.4	43.4
40%	22.12	33.56	44.52
50%	23.76	33.68	44.68
60%	23.6	33.68	42.76
70%	22.44	33.36	41.44

Table IV Compressive strength of M40 Quarry Dust

% REPLACEMENT	AVG COMPRESSIVE STRENGTH		
	3 days	7 days	28 days
0%	23.76	37.92	49.42
10%	24.16	38.72	53.73
20%	24.16	39.2	50.4
30%	25.28	39.4	50.4
40%	25.12	39.56	51.52
50%	25.76	39.68	51.68
60%	25.6	39.68	49.76
70%	25.44	39.36	49.44

From table 3 it is observed that the 28 days compressive strength is highest for the 50% replacement of fine aggregate by Quarry dust and strength increased by 5.2% as compared to 0% replacement. Considerable level variation in compressive strength is represented in figure 1. From table 4 it is observed that the 28 days compressive strength is highest for the 10% replacement of fine aggregate by Quarry dust and strength is increased by 8.72% as compared to 0% replacement. Considerable level variation in compressive strength is represented in figure 2.

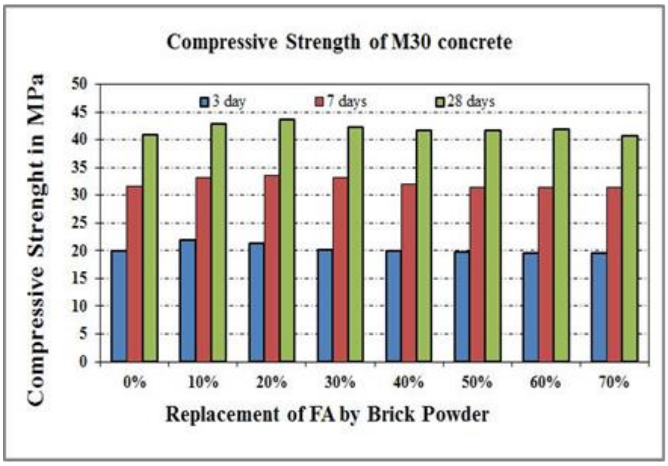

Fig. 3: Graph showing compressive strength of M30 with Brick Powder

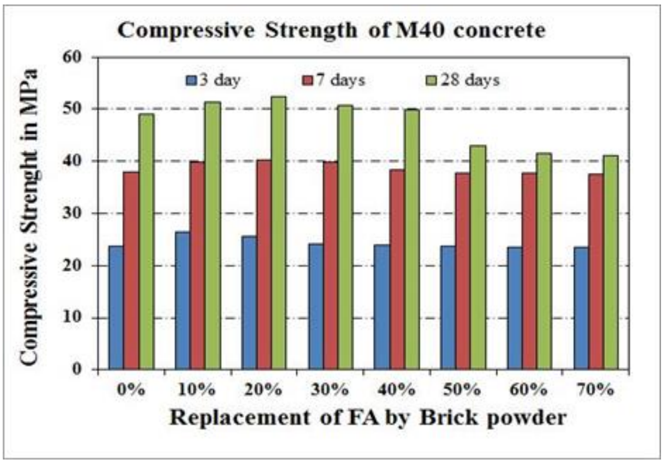

Fig. 4: Graph showing compressive strength of M40 with Brick Powder

Table V Compressive strength of M30 Brick Powder

% REPLACEMENT	AVG COMPRESSIVE STRENGTH		
	3 days	7 days	28 days
0%	19.87	31.6	40.93
10%	22	33.2	42.8
20%	21.33	33.47	43.6
30%	20.13	33.13	42.26
40%	19.87	32	41.6
50%	19.73	31.47	41.63
%	19.6	31.47	41.9
70%	19.6	31.33	40.66

Table VI: Compressive strength of M40 Brick Powder

% REPLACEMENT	AVG COMPRESSIVE STRENGTH		
	3 days	7 days	28 days
0%	23.76	37.9	49.116
10%	26.4	39.84	51.36
20%	25.6	40.16	52.32
30%	24.15	39.756	50.712
40%	23.83	38.4	49.92
50%	23.68	37.764	43.06
60%	23.52	37.764	41.6
70%	23.52	37.59	41.2

From table 5 it is observed that the 28 days compressive strength is highest for the 20% replacement of fine aggregate by Brick powder and strength is increased by 6.52% as compared to 0% replacement. Considerable level variation in compressive strength is represented in figure3. From table 6 it is observed that the 28 days compressive strength is highest for the 20% replacement of fine aggregate by Brick powder and strength is increased by 6.52% as compared to 0% replacement. Considerable level variation in compressive strength is represented in figure 4.

Table VII Workability of Concrete with Quarry Dust

% REPLACEMENT	SLUMP (IN MM)	
	M30	M40
0%	140	135
10%	130	130
20%	120	120
30%	120	120
40%	120	120
50%	110	105
60%	110	105
70%	110	100

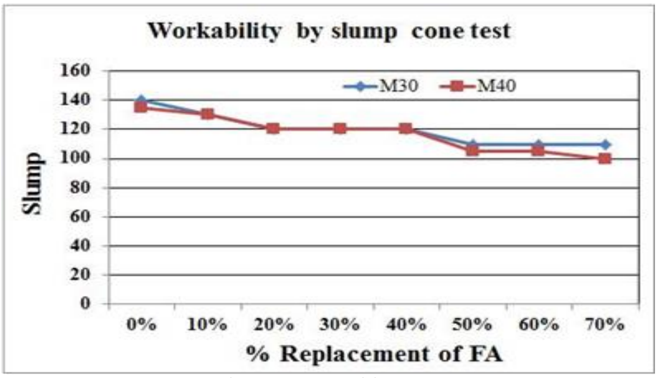

Fig. 5: Variation of slump value of fresh concrete with quarry dust

Table VIII Workability of Concrete with Brick powder

REPLACEMENT	SLUMP (IN MM)	
	M30	M40
0%	130	125
10%	120	110
20%	110	105
30%	85	95
40%	65	80
50%	55	80
60%	50	75
70%	40	65

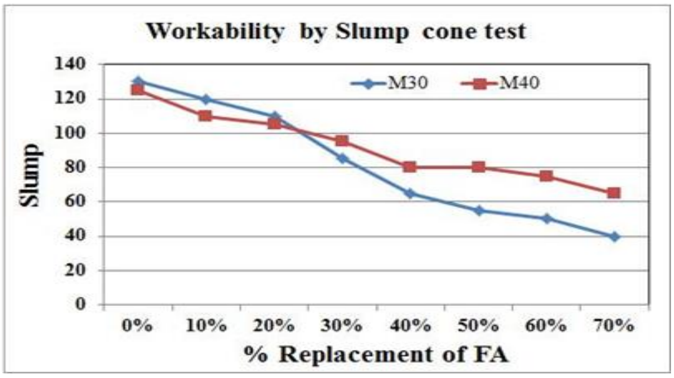

Fig. 6 Variation of slump value of fresh concrete with Brick powder

For brick powder maximum slump is found at 10% replacement and minimum at 70% replacement. Reduction in slump is up to 50%. For quarry dust maximum slump is for 10% replacement and minimum slump is for 70% replacement. Reduction of slump is up to 30%.

V. CONCLUSION

For brick powder maximum slump is found at 10% replacement and minimum at 70% replacement. For quarry dust maximum slump is for 10% replacement and minimum slump is for 70% replacement. The optimum replacement of sand with brick powder is found to be 20%, strength is increased by 6.52% as compared to 0% replacement for M30 and M40. It is observed that the 28 days compressive strength is highest for the 10% replacement of fine aggregate by Quarry dust and strength is increased by 8.72% as compared to 0% replacement for M30. It is observed that the 28 days compressive strength is highest for the 50% replacement of fine aggregate by Quarry dust and strength increased by 5.2% as compared to 0% replacement for M40.

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