Replacement of River sand by M-sand

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Abstract — The huge quantity of concrete is consumed by construction industry all over the world. In India, the conventional concrete is produced using natural sand from river beds as fine aggregate. Decreasing natural resources poses the environmental problem and hence government restriction on sand quarrying resulted in scarcity and significant increase in its cost. This project presents the optimization of replacement of manufactured sand by natural sand with super plasticizer admixture. Concrete mixes for M20, M25 and M30 were evaluated for compressive strength. The super plasticizer was added by 0.5%, 1%, 1.5% of weight of the cement respectively to the different concrete mixes (M20, M25, M30). The results indicated that there is an increase in the compressive with the use of manufactured sand. The results also revealed that addition of super plasticizer in percentage of cement, increased the compressive strength of Concrete.

Keywords*—M-Sand, Quarry Dust, super plasticizers, compressive strength*

1. Introduction

Quality of construction is the most important aspect under consideration in the construction sector. Factory manufactured items always play a vital role in the quality of products. There comes the importance of Ready mixed concrete (RMC) and Manufactured sand (M Sand). RMC consist of cement, fine and coarse aggregate, water and admixture. Of this cement and admixture is factory made, water is naturally available, coarse aggregate is naturally available and factory crushed. Hence these components normally maintain a standard quality. Fine aggregate is quite often obtained from river beds. This became very scarce since the ban on the mining of the same has been imposed due to the environmental hazards. The quality of the river sand normally depends on its source and most of the time it varies quite a lot. As the use of fine aggregate in concrete is more than 30% of the composite, its mechanical properties affect the quality of RMC. Hence manufactured sand and quarry dust has been identified as a substitute for river sand thereby solving the issue of mining of sand from river beds and improving the quality of fine aggregate.

In the experimental study different concrete mixes with different percentage of admixture were prepared and the respective fresh and hardened properties of the resulting concrete mixes were determined and analyzed. This paper presents the result of experimental investigations carried out on M Sand and the details of RMC designed using M Sand on comparison with quarry dust. Finally, from the obtained results conclusions were made and recommendations were forwarded.

The following factors contribute to the production of good quality concrete:

• Knowledge of the properties and fundamental characteristics of concrete making materials and principles of design, Reliable estimates of site conditions and costs,
• Quality of component materials,
• A careful measurement of weigh-batching of cement, water and aggregate,
• Proper transport, placement and compaction of the concrete,
• Early and thorough curing, and
• Competent direction and supervision

2. Materials used

2.1. Manufactured Sand (M SAND)

The term-manufactured sand is used for aggregate materials having dimensions less than 5.0mm that are processed from crushed rock or gravel and intended for construction use. The term sand refers to relatively small particles and there are some variations of sand with regard to particle size.

In modern technology, natural aggregates have proved to be significantly economical in use, for which reason extensive use of manufactured aggregates has been concentrated to regions or projects where the availability of natural aggregates has been limited.

Crushed /manufactured sand has rough surface texture and the particle size distribution curve can be adjusted in the manufacturing of the material. Another advantage in manufactured sand is quarries can be kept in the near vicinity to its place of end use, therefore shortening transport distances, and increased employment opportunities for the locals. In the future it is expected that manufacturing of sand from rock will increase and production from natural.

need of m sand

- The Civil engineers, Architects, Builders, and Contractors agree that the river sand, which is available today, is deficient in many respect. It does content very high silt fine particles (as in case of Filter sand).
- Presence of other impurities such as coal, bones, shells, mica and silt etc makes it inferior for the use in cement concrete. The decay of these materials, due to weathering effect, shortens the life of the concrete.
- Now-a-days, the Government have put ban on lifting sand from River bed.
- Transportation of sand damages the roads.
- Removing sand from river bed impact the environment, as water table goes deeper & ultimately dry.

General Requirements of M Sand

- All the sand particles should have higher crushing strength.
- The surface texture of the particles should be smooth.
- The edges of the particles should be grounded.
- The ratio of fines below 600 microns in sand should not be less than 30%.
- There should not be any organic impurities
- Silt in sand should not be more than 2%, for crushed sand.
- In manufactured sand the permissible limit of fines below 75 microns shall not exceed 15%.

2.2 Properties of M sand

a. Greater Durability

M-Sand has balanced physical and chemical properties that can withstand any aggressive environmental and climatic conditions as it has enhanced durability, greater strength and overall economy. Usage of M-Sand can overcome the defects occurring in concrete such as honey combing, segregation, voids, capillary etc.

b. High Strength

The superior shape, proper gradation of fines, smooth surface texture and consistency in production parameter of chemically stable sands provides greater durability and higher strength to concrete by overcoming deficiencies like segregation, bleeding, honey combing, voids and capillary.

c. Offsets Construction Defect

M-Sand has optimum initial and final setting time as well as excellent fineness which will help to overcome the deficiencies of concrete such as segregation, bleeding, honeycombing, voids and capillary.

d. Greater Workability

The crusher dust is flaky and angular in shape which is troublesome in working. There is no plasticity in the mortar which makes it even difficult for the mason to work, whereas the cubical shape with grounded edge and superior gradation gives good plasticity to mortar providing excellent workability.

e. Eco-Friendly

M-Sand is the only alternative to river sand. Dredging of river beds to get river sand will lead to environmental disaster like ground water depletion, water scarcity, threat to the safety of bridges, damsetc.Beside with the Government contemplating ban on dredging of River beds to quarry river sand, as part of the growing concern for environment protection, M-Sand will be the only available option.

f. Economy

Usage of M-Sand can drastically reduce the cost since like river sand, it does not contain impurities and wastage is NIL. In International Construction Scenario, no river sand is used at all, only sand is manufactured and

used, which gives superior strength and its cubical shape ensures significant reduction in the cement used in the concrete.

2.2. Quarry dust

Quarry dust is the by product formed when the stones are crushed by quarrying. They are the waste materials which are used as fine aggregate in this study for preparing the concrete.

Uses of Quarry Dust

- Quarry dust being a waste material, useful utilization of it will reduce the environmental strain caused in its disposal.
- Reduces the strain on natural sand resources as the demand decreases.
- Makes Cement Concrete more economical.
- Reduces the inflated costs on fine aggregate's by decreasing transportation distances.
- Research has shown that quarry dust concrete gives better workability compared to regular concrete.
- The Scope of complete replacement of sand by quarry dust is targeted to locations where naturally occurring river sand or pit sand is scarce, expensive.

Comparison of M Sand

Table 1 - Comparison of properties of M Sand and Quarry Dust

S.NO	FEATURES	M SAND	QUARRY DUST
1	Colour	Grey	Grey
2	Particle Shape	Cubically shaped	Flaky
3	Manufacturing Process	International technology controlled manufacturing process through imported machines	No controlled manufacturing process as it is the by product of stone crusher.
4	Gradation	As per IS 383-1970 zone II	Does not adhere to any standards.
5	Suitability Of Concreting	Recommended for usage in concrete and masonry works worldwide by concrete technologists.	Not recommended for use in concrete and masonry works

Table 2 - Comparison of sieve analysis of River & Manufactured Sand

IS Sieve	% of passing(River Sand)	% of passing (Manufactured Sand)	Zone II (As per IS:383)
4.75mm	100	100	90-100
2.36mm	99.7	90.7	75-100
1.18mm	89	66.2	55-90
600micron	60.9	39.8	35-59
300micron	17.7	25.5	8-30
150micron	3.1	9.9	0-20
75micron	Max 3	Max 15	Max 15
	Zone II	Zone II	
Zone II Note: The gradation of manufactured sand can be controlled at crushing plant.			

2.3. Admixtures

Admixtures are materials other than cement, aggregate and water that are added to concrete either before or during it's mixing to alter its properties such as workability, curing temperature range, setting time or colour. These days a mix without admixture is an exception.

Admixture is a chemical product which is added to the concrete mix in quantities not larger than 5% by mass of cement during mixing or during an additional mixing operation prior to the placing of concrete, for the purpose of achieving a specific modification to the normal properties of concrete.

Admixtures are capable of imparting considerable physical and economic benefits with respect to concrete production. It is an established fact that the use of admixtures result in concomitant savings, for example, in the cost of labour required to effect compaction and in improving durability without the use of additional measures.

Types of admixtures

Based on the function, the classification of admixtures as per ASTM C494-92 is as follows:

- Type A Water reducing
- Type B Retarding
- Type C Accelerating
- Type D Water reducing and retarding
- Type E Water reducing and accelerating
- Type F High range water reducing or superplasticizing
- Type G High range water reducing and retarding, or superplasticizing and retarding.

Superplasticizers (Ceraplast 300)

ASTM C 494-92 refers to superplasticizers as "water-reducing, high range admixtures". Compared to what is commonly referred as "water reducer" or "mid-range water reducer" superplasticizersare "high range water reducers". Superplasticizers are water-soluble organic polymers, which have to be synthesized, using a complex polymerization process, to produce long molecules of high molecular mass, and they are therefore relatively expensive.

High range water reducers are admixtures that allow large water reduction or greater flow ability without substantially slowing setting time or increasing air entrainment.

Effects of superplasticizers

The main action of the long molecules is to wrap themselves around the cement particles and give them a highly negative charge so that they repel each other. These results in deflocculating and dispersion of cement particles. At a given water/cement ratio and water content in the mix, the dispersing action of super plasticizers increases the workability of concrete.

The second use of super plasticizers is in the production of concrete of normal workability but with an extremely high strength owing to a very substantial reduction in the water/cement ratio. Mechanism of the action of superplasticizershas not been fully explained, it is known that they interact with C3A whose hydration is retarded.

Dosage of super plasticizers

For increasing the workability of the mix, the normal dosage of super plasticizers is between 1 and 3 liters per cubic meter of concrete, the liquid super plasticizer containing about 40% of the active material. When super plasticizers are used to reduce the water content of the mix, their dosage is much higher, 5 to 20 liters per cubic meter of concrete. The effectiveness of a given dosage of super plasticizer depends on the water/cement ratio of the mix. Specifically, at a given dosage of the super plasticizer, the percentage water reduction, which maintains a constant workability, is much higher at low water/cement ratios than at high water/cement ratios.

Uses of super plasticizers

- They are used as dispersants to avoid particle aggregation.
- The reduction of the water to cement ratio, not affecting the workability of the mixture.
- Enables the production of self-consolidating concrete and high performance concrete.
- The initial setting time may be accelerated up to an hour earlier or retarded to be an hour later according to its chemical reaction.

3. Concrete mix design

Mix design is a process that consists of two interrelated steps:

- Selection of the suitable ingredients (cement, aggregate, water and admixtures) of Concrete.
- Determining their relative quantities ('proportioning') using IS: 10262 design procedure to produce, as economically as possible, concrete of the appropriate workability, strength and durability. Although many concrete properties are important, most design procedures are based primarily on achieving a specified compressive strength at some given workability and age.

4. Procedure on cube testing

a. Casting

Casting is a manufacturing process by which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. In this study the casting is done by the following methodology:

- With the arrived mix proportion, M20, M25 and M30 grade concrete mixes were prepared using M sand as fine aggregate and the super plasticizer as admixture added by 0.5%, 1% and 1.5% of weight of the cement respectively to each of the concrete mixes (M20, M25, M30).
- Similarly, same procedure is followed with Quarry Dust as fine aggregate.
- Then the concrete mixes were tested for compressive strength after 28 days of curing.
- Two trials for each combination was done to arrive the average value

b. Testing

Once the concrete cubes are dried, the concrete cubes are tested to determine its compressive strength using Universal Testing Machine. Using this machine the amount load that the cubes can withstand is found. By dividing the load with that of area of the cube gives the compressive strength of the concrete.

5. Test results and discussion

It was stated above that the main objectives of the laboratory test specimens were to:

- Determine if a suitable workability and strength can be achieved in concrete containing manufactured sand as a partial or complete replacement for natural sand.
- Determine what percentage of super plasticizer is required to achieve a suitable workability for concrete with or without manufactured sand.
- Determine the rate of strength gain for the concrete with and without manufactured sand.
- In the following sections, the test results are presented and evaluated in light of the requirements of concrete strength and workability.

Test results

The results of compressive strength of concrete for M Sand and Quarry Dust with 0.5%, 1.0% & 1.5% of super plasticizer with M20, M25 and M30 Grade are shown.

a. Compressive strength of Quarry dust

The results of compressive strength of concrete made of Quarry Dust for M20, M25 and M30 grade with 0.5%, 1.0% and 1.5% of superplasticizer after 28 days curing are shown.

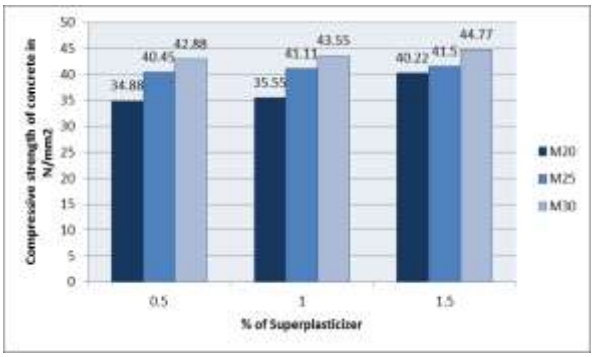

Fig 1

b. Compressive strength of M Sand

The results of compressive strength of concrete made of M Sand for M20, M25 and M30 grade concrete mixes with 0.5%, 1.0% and 1.5% of superplasticizer after 28 days curing are shown

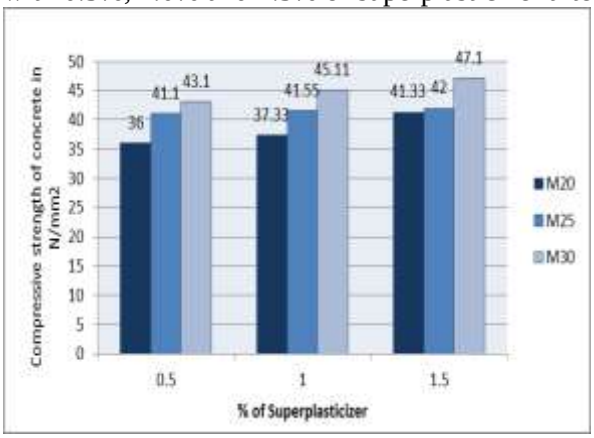

Fig 2

6. Comparison of test results

a. Comparison for M20 grade concrete

Following chart represents the comparison of compressive strength of M20 grade of concrete of Quarry dust with that of the M sand for 0.5%, 1.0% and 1.5% of superplasticizer.

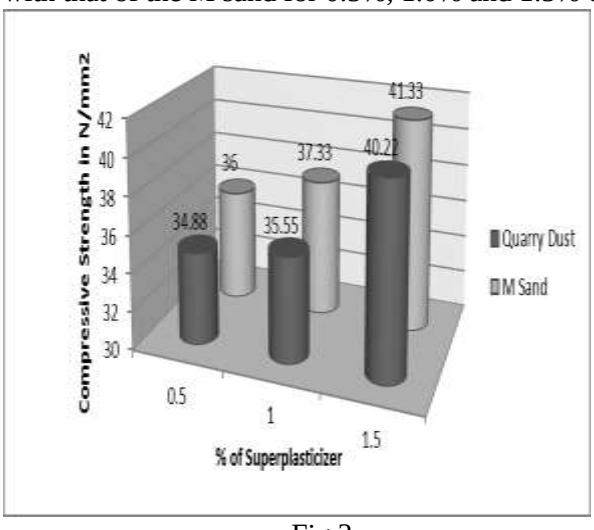

Fig 3

b. Comparison for M25 grade of concrete

Following chart represents the comparison of compressive strength of M25 grade of concrete of Quarry dust with that of the M sand for 0.5%, 1.0% and 1.5% of superplasticizer.

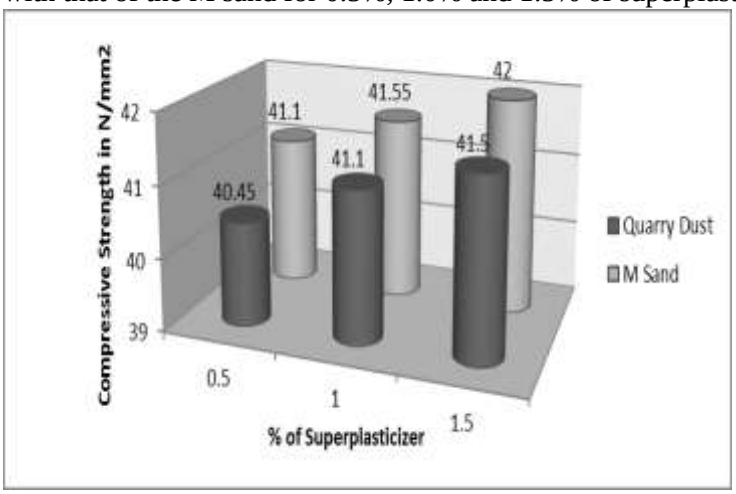

Fig 4

c. Comparison for M30 grade of concrete

Following chart represents the comparison of compressive strength of M30 grade of concrete of Quarry dust with that of the M sand for 0.5%, 1.0% and 1.5% of superplasticizer.

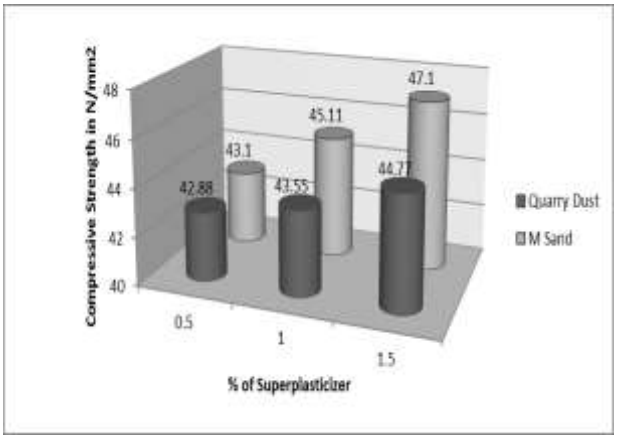

Fig 5

7. Conclusions

The use of manufactured sand in producing concrete for normal strength, intermediate strength and high strength were studied and after the research work is done, the following conclusions are made and recommendations are forwarded.

- The results of the hardened properties of the mix have shown that the concrete mix with proportion of manufactured sand achieved a higher compressive strength almost at all tested age of concrete.
- Analysis made on the influence of manufactured sand in the cost of the concrete revealed that almost 50% of the cost can be saved with full replacement of the manufactured sand with natural one.
- Manufactured sand offers important economic advantages in regions where the availability of natural sand is scarce or in cities where transportation cost is high.
- The use of manufactured sand in the construction industry helps to prevent unnecessary damages to the environment and provide optimum exploitation of the resources.
- Manufactured sand offers a viable alternative to the natural sand if the problems associated with the workability of the concrete mix can be resolved by using superplasticizer. The addition of superplasticizer to a concrete mix with manufactured sand allows the mix to have a better workability.

- Compressive strength of concrete for M20, M25 and M30 grade of concrete with M sand is marginally higher when compared with Quarry dust at all respective combinations.
- It is reliable that M Sand can be used as fine aggregate in the concrete instead of natural sand for producing good quality concrete at cheaper price.

RECOMMENDATIONS

- To minimize cost of manufactured sand transportation more advanced mobile plants might be a solution.
- In order for a manufactured sand mix containing super plasticizer to be more economical, the maximum dosage of the super plasticizer should be made optimum by reducing the volume of admixture and to get the required consistency.
- As the amounts of fines depend on the characteristics and on the strength of individual minerals, control over the selection of the raw material has to be made.
- The manufacturing process of manufactured sand requires active production control of all processes, storage should be dry and transportation has to be minimized to prevent segregation and cost too.
- Concerned authorities have up-to-date information about the locations and details of existing quarries in addition with the potential of available quarries.
- Designers, specifiers, contractors and material suppliers need to understand the effects of manufactured sand angularity as well as fines content on concrete water demand and concrete durability.

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