

DURABILITY STUDY ON PROPERTIES OF CONCRETE BY REPLACING NATURAL SAND WITH M-SAND & QUARRY DUST AT DIFFERENT SIZES OF COARSE AGGREGATE

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Abstract : In concrete, fine and coarse aggregates are major ingredients and are generally occupy 60 to 80% of the total volume of concrete. Huge demand, depletion and environmental issues of natural sand has resulted to identify substitute material to natural sand as fine aggregate. Concrete made with properly graded aggregates exhibits high workability, density, strength, durability and lower shrinkage. In the present experimental study, the durability strength tests were conducted on the concrete mixtures prepared with Manufactured sand (M-sand) and Quarry dust at varying proportions used as full replacement for natural sand and 20 mm coarse aggregates are partially replaced with 12 mm and 6 mm aggregates at different proportions to obtain better gradation. The experiments were conducted on M20 design mix concrete proportions of 1:2.288:4.039 with a total of 99 specimens. To study the effect of sulphuric acid attack, the test specimens were casted. For the first 28 days, the specimens were cured in potable water. After 28 days curing, cube surfaces were cleaned and weighed. The identified specimens were then immersed in 5% H₂SO₄ (sulphuric acid) solution for 90 days. The experimental results showed that, the loss of compression strength is achieved at the proportions of fine aggregate (90% of M-sand and 10% of quarry dust) and coarse aggregate (65% of 20mm, 15% of 12mm and 20% of 6mm aggregate).

Index Terms - Manufactured sand, Quarry dust, Aggregates, Design mix, Acid attack, Strength.

I. INTRODUCTION

Fine aggregate has important effects on the technical and economic performance of concrete, its dosage in concrete is only second to coarse aggregate. In recent years, under the pressure of environmental protection and the needs of the flood control, digging natural sand is restricted or even forbidden and the availability of sand at a low cost as a fine aggregate in concrete is not suitable and that is the reason to search for an alternative material. Manufactured sand and Quarry dust satisfy the reason behind the alternative material as a substitute for sand at very low cost. Manufactured sand is widely used in concrete engineering, and the performance of the manufactured sand and its concrete has become an important research subject. Grain shape and surface characteristics of aggregate is the important factor to determine water dosage of the concrete mix, the bigger the surface area, the bigger the effect is. Foreign scholars believe that 4.75-2.36mm particles have the biggest effect of the performance of concrete. Angularity of the particles can increase the compressive and flexural strength of concrete. cementation of rough particles and cement paste is better, it's benefit of enhancing the strength, especially the flexural strength. Compared with natural sand concrete, manufactured sand concrete has larger unit water consumption, higher compressive strength, better permeability and frost resistance. Researchers generally consider that is mainly due to the grain shape and surface state of the manufactured sand. And also quarry dust is by product from crushed stone.

Concrete made of Ordinary Portland cement are highly alkaline with PH values normally above 12.5 and not easily attacked by acidic solutions. As the PH of the solution decreases the equilibrium in the cement compounds are essentially altered by hydrolytic decomposition which leads to the severe degradation of the technical properties of the material. At PH values lower than 12.5 portlandite is the first constituent starting dissolution. If the PH decreases to values lower than stability limits of cement hydrates, then the corresponding hydrate loses calcium and decomposes amorphous hydrogel. The final reaction products of acid attack are the corresponding calcium salts of the acid as well as hydrogels of silicium, aluminum and ferric oxides. Therefore, leads to loss weight, loss of compression strength. Natural Sand is a very important building material which can be used for construction of buildings, repair works & road construction etc. But the quantity of extraction of natural sand is not meeting the demands of customers. Mining of natural sand on river beds are also prohibited at most of the sites. Mining is also posing environment problems.

II. LITERATURE REVIEW

Vinay Chandwani et al. (2016); in each case, the cube compressive strength test, and beam flexure tests were conducted. The results of the study show that, the strength properties of concrete using crushed rock sand are nearly similar to the conventional

concrete. The study has shown that crushed stone sand can be used as economic and readily available alternative to river sand and can therefore help to arrest the detrimental effects on the environment caused due to excessive mining of river sand.

Huajian Li et al. (2016); the results showed an improvement in the workability of the M-sand concrete by introducing granite dust. The early strengths of manufactured sand concrete decreased with the fly ash replacement, but the compressive strengths, bending strengths and elastic modulus increased in the later stage when the replacement ratio was 20%. Compared with pure cement concrete, the 56 days chloride penetration resistance of the modified concretes was enhanced remarkably. Although the electric flux increased with the increasing granite dust dosage, it was always located at the low permeability level. The dynamic elastic modulus only had a slightly decrease after 350 freezing and thawing cycles when the granite dust dosage was within 20%, but it obviously dropped down when that dosage reached 30%. The drying shrinkage of the modified concrete was also inhibited within 14 days, compared with the pure cement concrete.

Bhavana(2015); This thesis reported the durability of concrete made with the partial replacement of cement by quarry dust with 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% by weight of cement. The cubes are immersed in the sulphuric acid and hydrochloric acid is conducted at 5% by volume of water.

Vijayalakshmi .M et al. (2013); the experimental study indicated that the replacement of natural sand by GP waste up to 15% of any formulation is favorable for the concrete making without adversely affecting the strength and durability criteria however it is recommended that the GP waste should be subjected to a chemical bleaching process prior to blend in the concrete to increase the sulphate resistance.

Telmaramos et al. (2013); the results showed that granitic quarry sludge waste, if ground to sufficient fineness, produces a denser matrix promoting up to 38% reduction in expansion due to ASR and almost 70% improvement in resistance to chlorides, without compromising workability and strength. This surprising improvement in terms of chloride resistance seems to derive from captivation of chlorides by aluminates present in the waste with formation of chloroaluminates. Finally, a properly engineered use of granitic waste in cement-based composites, leading to enhanced durability can turn granitic quarry sludge, an abundant waste, into a valuable resource and therefore contribute to sustainable construction.

Fattuhi .N.I et al. (1986); two separate test series were carried out and a total of fifty six cubes (including two cubes of 'Densit' Concrete) were immersed in a continuously flowing solution of approximately 2% sulphuric acid. The changes in weight with time for each cube were determined. The results indicated that styrene butadiene coatings can provide good protection to concrete, but only for a limited period of time before maintenance would be necessary. 'Densit' concrete showed relatively good acid resistance and should open up new areas of application.

III. MATERIAL AND METHODS

In this experimental investigation we used cement, M-sand and quarry dust as fine aggregate, coarse aggregate of size 20mm, 12mm, 6mm and water.

Ordinary Portland Cement (53 grade):

Cement assumes crucial part in concrete, ordinary Portland cement (OPC) are classified into three types i.e., 33, 43 and 53 grades depending upon the strength of the cement at 28 days. In this project the grade that we used 53grade OPC (Sagar brand). The properties of cement are tabulated in Table 1

Table 1 Properties of Cement of 53 grade OPC (Sagar brand)

S.No.	Property	Value
1	Specific gravity	3.133
2	Fineness of cement by sieving	7%
3	Normal consistency	31%
4	Initial setting time & final setting time	55min. & 270min.

Fine Aggregate:

M-Sand

The M-sand that is used in this project is taken from the nearby quarry and it is free from organic impurities. Manufactured sand is characterized as a reason made smashed fine total created from an appropriate source material. Generation for the most part includes crushing, screening and potentially washing, partition into discrete portions, recombining and mixing. The different properties of M-Sand are tabulated in Table 2.

Table 2 Properties of Fine Aggregates (M-sand)

S.No.	Property	Value
1	Grading of Sand	Zone II as per IS 383
2	Specific Gravity	2.57
3	Water absorption	2.26%
4	Fineness Modulus	2.75

Quarry dust

Quarry dust used in this study was procured from Puttur, Chittoor district of Andhra Pradesh, in India. The quarry dust crusher dust is obtained as solid wastes, during crushing of stones to obtain aggregates. The annual production of quarry dust is roughly around 200 million tons. the quarry dust will occupy some area for dumping and creates environmental problems. The properties of quarry dust are shown in Table 3.

Table 3 Properties of Fine Aggregates (Quarry dust)

S.No.	Property	Value
1	Grading of sand	Zone II as per IS 383
2	Specific gravity	2.6
3	Water absorption	1.3%
4	Fineness modulus	3.8

The entire tests are carried out as per IS 2386-part3

Coarse aggregate:

From IS 383-1970 consisting 20 mm, 12 mm & 6 mm sizes maximum size of aggregates has been taken from the local quarry industry. After that we tested the aggregate physically and mechanically mainly such as specific gravity and sieve analysis results are written as below. The properties of coarse aggregate are tabulated in Table 4.

Table 4 Properties of coarse aggregate (20 mm, 12 mm & 6 mm)

S.No	Property	20 mm	12 mm	6 mm
1	Specific Gravity	2.79	2.75	2.74
2	Water Absorption	1%	1%	0.8%
3	Impact Value	-	24.3	32.2
4	Bulk Density	1560 Kg/m ³	1610 Kg/m ³	1800 Kg/m ³

Water:

Water is the least expensive but the most important component of concrete. Locally available fresh bore well water confirming to the requirements of IS: 456 - 2000 was used for mixing concrete and curing the specimens as well and this water is free from impurities.

CONCRETE DESIGN MIX CALCULATION FOR M 20

Benefits of concrete mix design is that it provides the right proportions of materials, thus making the concrete construction economical in achieving required strength of structural members. As, the quantity of concrete required for large constructions are huge, economy in quantity of materials such as cement makes the project construction economical.

The mix design was done according to IS: 10262-2009. The proportions adopted per m³ of concrete for M 20 design mix are given in Table 5.

Table 5 Concrete Mix Design,

Cement	Fine Aggregates	Coarse Aggregates	Water
312	714.14	1260.24	172
1	2.288	4.039	0.55

IV. RESULTS AND DISCUSSIONS

The present investigation was conducted to explore the possibility of 100% replacement of river sand by M-sand (95% & 90%) and quarry dust (5% & 10%) and 20 mm coarse aggregates partially replaced by 12 mm (5%, 10%, 15% & 20%) and 6 mm (5%, 10%, 15% & 20%). Totally 198 specimens (99 cubes) are cast and cured in mould for 24 hours, after 24 hours, all the specimen are demoulded and kept in curing tank for 28 days. After 28 days all specimens are kept in atmosphere for 2-days for constant weight, subsequently, the specimens are weighed and immersed in 5% sulphuric acid (H₂SO₄) solution for 90-days. 2-trials were conducted with each trail having 16 different proportions (48 cubes) were taken into consideration for conducting Durability strength tests and it is compared to the conventional concrete casted with natural sand at 0% of 12 mm & 6 mm aggregate (A0). Each proportion an average of 3 specimens was considered for calculating strength. 1st trail (95% of M-sand and 5% of quarry dust and varying proportions of coarse aggregate) results are presented in Table 6 & 7 and their respective graphs are shown in Fig. 1 and 2.

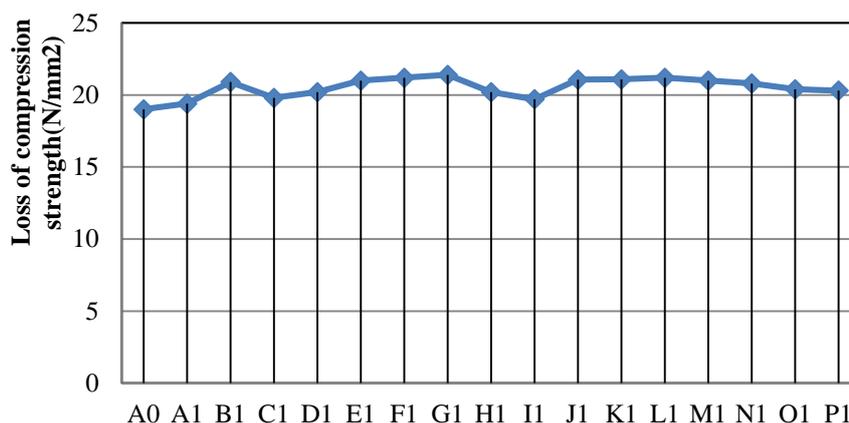
Table 6 Loss of compression strength of concrete (1st trail)

Notations	Cement	Fine Aggregates		Coarse Aggregates			Loss of compression strength (N/mm ²)
		M-sand	Quarry dust	20mm	12mm	6mm	
A0	100%	0%	0%	100%	0%	0%	19.1
A1	100%	95%	5%	90%	5%	5%	19.4
B1				85%	5%	10%	20.9

C1				80%	5%	15%	19.8
D1				75%	5%	20%	20.2
E1				85%	10%	5%	21
F1				80%	10%	10%	21.2
G1				75%	10%	15%	21.4
H1				70%	10%	20%	20.2
I1				80%	15%	5%	19.7
J1				75%	15%	10%	21.07
K1				70%	15%	15%	21.09
L1				65%	15%	20%	21.2
M1				75%	20%	5%	21
N1				70%	20%	10%	20.8
O1				65%	20%	15%	20.4
P1				60%	20%	20%	20.3

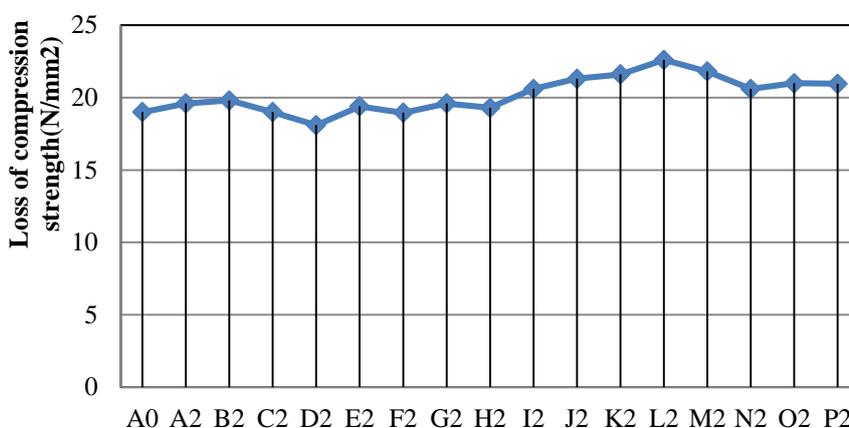
Table 7 Loss of compression strength of concrete (2nd trail)

Notations	Cement	Fine Aggregates		Coarse Aggregates			Loss of compression strength (N/mm ²)
		M-sand	Quarry dust	20mm	12mm	6mm	
A0	100%	0%	0%	100%	0%	0%	19.1
A2	100%	90%	10%	90%	5%	5%	19.6
B2				85%	5%	10%	19.8
C2				80%	5%	15%	19
D2				75%	5%	20%	18.1
E2				85%	10%	5%	19.4
F2				80%	10%	10%	18.95
G2				75%	10%	15%	19.6
H2				70%	10%	20%	19.3
I2				80%	15%	5%	20.6
J2				75%	15%	10%	21.3
K2				70%	15%	15%	21.6
L2				65%	15%	20%	22.6
M2				75%	20%	5%	21.8
N2				70%	20%	10%	20.6
O2				65%	20%	15%	20.99
P2	60%	20%	20%	20.95			



Notations

Fig.1 Loss of compression strength of concrete (1st trail)



Notations

Fig.2 Loss of compression strength of concrete (2nd trail)

V. CONCLUSIONS

- The durability strength test was conducted on the hardened concrete specimens by fully replacement of fine aggregate with M-sand and Quarry dust and partial replacement of 20 mm coarse aggregate with 12 mm and 6 mm aggregates at an age of 90 days immersed in 5% sulfuric acid per 1litre of water.
- 2-trails were conducted with each trail (48 cubes) having 16 different proportions were taken into consideration.
- 2nd trail (90% of M-sand and 10% of quarry dust) given better durability strengths than 1st trail.
- The durability strength increased from **19.10** N/mm² to 22.6 N/mm² (**18.32%**) at partial replacement of 20 mm coarse aggregate by 15% of 12 mm and 20% of 6 mm aggregates.
- Less damage to environment as compared to river sand.

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