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Experimental Study on Durability Properties of Concrete with Replacement of Local River Sand by Robo, Marble and Ennore Sand

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Abstract - Cement concrete is widely used in construction especially in developing world due to readily available, ease in construction and cost effective. Concrete is prepared by mixing cement; fine aggregate, coarse aggregate with sufficient amount of water. One of the major constituents in concrete is sand which essentially fills the voids and imparts reasonable strength. The fundamental quality of sand is, it should not react with products of hydration. When sand reacts with products of hydration the composition of concrete changes and it may become vulnerable for attacks from atmospheric agencies and thus affects the durability of concrete. Gradual depletion of sand leads social and environ mental issues also. In the current work durability of M 25 and M 35 grades of concrete made out of Robo sand, Ennore sand and marble sand were studied by comparing with concrete made by locally available river sand. The sulphate resistance Test and water absorption test were conducted. It was found that concrete made with Robo sand as fine aggregate possess better durability followed by Ennore sand and marble sand.

Keywords - Durability of concrete, Ennore sand, Marble sand, River sand, Robo sand, Sulphate resistance.

I. INTRODUCTION

The Robo Sand as used in the building and construction industry is synonymous with fine aggregate which is the material with a particle size less than 5mm. Coarse sand is defined as the material comprising particles of size less than 5mm and with less than 10% being finer than 0.15mm. Fine sand is generally regarded as the material finer than 1.0mm. The particle size distribution of the sand determines its particular use such as roofing tile sand, plaster sand, concrete fine sand, concrete coarse sand, masonry sand, fill sand, grout sand, bedding sand, filter sand and so on.

The river beds are the main sources for the natural sand. These natural resources are being depleted very fast, due to over exploitation and contamination by chemicals and waste from nearby industries. This causes scarcity of natural sand. The natural sand is transported from available places to the construction sites. Transporting river sand to the construction sites increases its sale price significantly. Specifications which are generally guided by Australian and International Standards require sand to have particular physical and chemical characteristics such as particle size distribution limits, hardness, inertness, water absorption limits, density, mineral type, durability and to be free of deleterious matter.

II. LITERATURE REVIEW

Zhou Mingkai et al (2008) stated the influence of natural sand, MS and Stone-Dust (SD) on workability and strength properties of High Strength Concrete (HSC). They found that the workability and the compressive strength of the concrete are improved when the stone dust content is less than7% and found that the elastic modulus is almost equal to the natural sand HSC when the dust content is less than 7%. Beyond that, it is reduced. The results showed that the shrinkage rate of MS-HSC in 7 days age is higher than that of the natural sand HSC, but the difference of the shrinkage rate in the later ages not marked. Meanwhile, the shrinkage rate reduces as the fly ash is added; the specific creep and creep coefficient of MS-HSC with 7% stone dust are close to those of the natural sand HSC.

Mark James Krinke (2004) studied the effect of admixtures in concrete containing Robo Sand. He found that the addition of super plasticizer into a concrete mix improves the workability and strength of the concrete mix. When large amounts of plasticizer are added, the strength improved by around 30 percent on the mix without plasticizer. However, the rate of strength gain of the concrete mix is lowered considerably when the plasticizer is added. In order to maintain the Robo Sand mix as cheaper than the natural sand concrete mix, the amount of super plasticizer added should not exceed 1.5 percent.

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Marble waste is a solid waste material generated by processing the marble. It is than can be used as a filler material in cement concrete. Adding the waste marble dust up to 10% replace by weight of fine sand can increase the tensile strength and compressive strength of concrete and also save the environment and economy. Ecological and environmental problems can be solved to some extent by producing the cheaper and durable concrete using waste marble dust

III. MATERIALS AND PROPERTIES

3.1 Cement

Cement plays vital role in concrete. One of the important criteria tricalcium aluminate (C_3A) content, tricalcium silicate (C_3S) content, dicalcium silicate (C_2S) content etc. It is also necessary to ensure the compatibility of chemical and mineral admixtures with cement.

In this study, Ultratech53 grade Ordinary Portland Cement conforming to IS: 12269–1987 was used for the entire work. The cement was purchased from single source and was used for casting of all specimens. The physical properties of cement are furnished in Table1.

Table 1 Physical properties of cement

S.No	Characteristics	Test Results	Requirements as per IS 12269 - 1987
1	Fineness (retained on 90-µm sieve)	6%	<10%
2	Normal Consistency	33%	--
3	Initial setting time of cement	50 min's	30 minutes (minimum)
4	Final setting time of cement	480 min's	600 minutes (maximum)
5	Expansion in Le - Chatelier's method	4 mm	10 mm (maximum)
6	Specific gravity	3.15	3.10 – 3.25

3.2 FINE AGGREGATE

The natural sand taken for this investigation is the locally available natural river sand. It was collected and cleaned for impurities, so that it is free from clayey matter, salt and organic impurities. Particles passing through IS sieve of 4.75 mm conforming to grading zone-II of IS: 383-1970 was used in this work. Properties such as gradation, specific gravity, fineness modulus, bulk density had been assessed. The physical properties of sand are furnished in Table 2.

Table 2 Physical properties of Fine Aggregate

S.No.	Tests Conducted	Results Obtained	Permissible Limits as per IS 383-1970
1	Specific gravity	2.62	2.5 to 3.0
2	Fineness modulus	3.05	--
3	Bulk density	**Loose State** 1450 kg/m^3 **Compacted State** 1520 kg/m^3	1400 to 1750 kg/m^3
4	Water absorption (%)	1.09	Max 3%
5	Sieve Analysis	Zone – I	--

3.3 COURSE AGGREGATE

Locally available machine Crushed angular granite, retained on 4.75mm I.S. sieve of maximum size of 20mm confirming to I.S: 383-1970 was used in the present experimental investigation. It is free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is tested for its various properties such as specific gravity, fineness modulus, elongation test, flakiness test, sieve analysis, bulk density in accordance with in IS 2386 – 1963. The physical properties of Coarse Aggregate are furnished in Table 3.

Table 3 Physical properties of Coarse Aggregate

S.No.	Tests Conducted	Results Obtained	Permissible Limits as per IS 383-1970
1	Specific gravity	2.67	2.5 to 3.0
2	Fineness modulus	7.52	--
3	Bulk density	**Loose State** 1480 kg/m^3 **Compacted State** 1560 kg/m^3	1400 to 1750 kg/m^3
4	Water absorption (%)	1.09	Max 3%
5	Elongation Index	20%	Max 25%

3.4 WATER

Water used for mixing and curing shall be clean and free from injurious quantities of alkalies, acids, oils, salts, sugar, organic materials, vegetable growth (or) other substance that may be deleterious to bricks, stone, concrete, or steel. Potable water is generally considered satisfactory for mixing.

Water acts as a lubricant for the fine and coarse aggregates and acts chemically with cement to form the binding paste for the aggregate and reinforcement. Less water in the cement paste will yield a stronger, more durable concrete; adding too much water will reduce the strength of concrete and can cause bleeding. Impure water in concrete, effects

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the setting time and causing premature failure of the structure.

To avoid these problems quality (potable) water must be proffered in construction works and PH value of water should be not less than 6. And also Quantity of water to be taken is important

3.5 ENNORE SAND

Ennore sand was collected from Ennore, Tamil Nadu.
The Physical and Chemical Properties are listed below in table 4.

Table 4 Physical and Chemical Properties of Ennore Sand

S.No.	Property	Value
1	Colour	Grayish White
2	Specific Gravity	2.64
3	Absorption (in 24 Hours)	0.80%
4	Shape of grains	Sub Angular
5	SiO_2	99.30%
6	Fe_2O_3	0.10%

3.6 Marble sand:

Marble Sludge Powder (MSP) / Marble Dust is obtained in wet form directly taken from deposits of Marble factories. Wet marble sand was dried before the sample preparation. The properties are given in Table 5.

Table 5 Physical Properties of Marble sand

S.No.	Property	Value
1	Specific Gravity	2.14
2	Bulk Density (Kg/m^3)	1680
3	Fineness Modulus	1.90

3.7 ROBO SAND

Robo Sand is procured from Machine Crushed nearby Quarry and its properties are listed below in Table 6.

Table 6 Physical Properties of Robo Sand

S.No.	Property	Value
1	Specific Gravity	2.84
2	Bulk Density (Kg/m^3)	1768
3	Fineness Modulus	2.84

3.8 MIX PROPORTIONS

Mix design was carried out using local natural river sand and also by replacing local natural river sand with Robo sand, Ennore sand and Marble sand. The deism results of various mix proportions of M 25 and M 35 are presented in table 7 and 8.

Table 7 Quantities of Ingredients per Cum of M 25 Grade Concrete

S.No.	1	2	3	4
Concrete Combination	CC	CC+RS	CC+ES	CC+MS
Robo Sand (Kg)	0	587.6	0	0
Ennore Sand (Kg)	0	0	623.7	0
Marble Sand (Kg)	0	0	0	566.2
Coarse Aggregate (Kg)	1190	1309	1309	1309
Fine Aggregate(Kg)	714.5	0	0	0
Cement(Kg)	327	327	327	327
Water(Lit)	163.5	163.5	163.5	163.5

Table 8 Quantities of Ingredients per Cum of M 35 Grade Concrete

S.No.	1	2	3	4
Concrete Combination	CC	CC+RS	CC+ES	CC+MS
Robo Sand (Kg)	0	557.05	0	0
Ennore Sand (Kg)	0	0	591.2	0
Marble Sand (Kg)	0	0	0	536.7
Coarse Aggregate (Kg)	1181.6	1297.8	1297.8	1297.8
Fine Aggregate(Kg)	680.3	0	0	0
Cement(Kg)	370.6	370.6	370.6	370.6
Water(Lit)	166.7	166.7	166.7	166.7

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IV. RESULTS AND DISCUSSIONS

4.1 TEST RESULTS FOR M 25 GRADE OF CONCRETE

4.1.1. SULPHATE RESISTENCE

It is observed that concrete with 100% Marble Sand exhibits 2.32% loss of weight and 100% replacement with Robo Sand shows 1.51% of Loss of Weight, Full Replacement of Fine Aggregate with Ennore sand (100%) shows 2.12% of Loss of Weight. When we consider the Compressive Strength, The loss for Marble sand is 4.74%, for Robo Sand is 2.63%, as well as for Ennore Sand is 4.36% consider 28days of test results. The Graphical Representations of the above results are shown below with various Combinations are shown in Fig1and Fig 2.

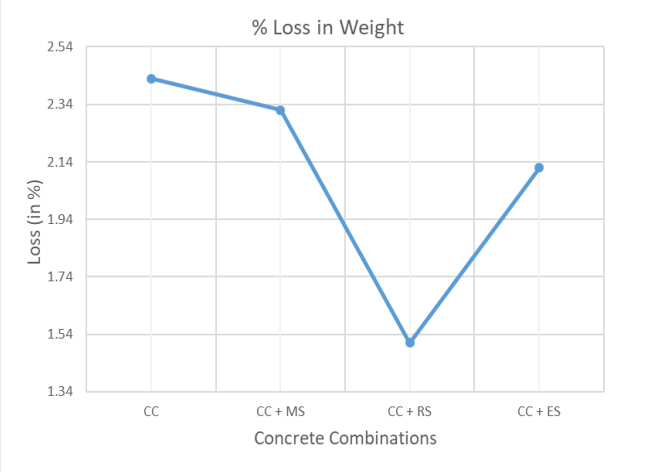

Fig 1 Comparison of Loss of Weight of Control Concrete with various proportions of Ennore Sand (100%), Robo Sand (100%) and Marble Sand (100%)

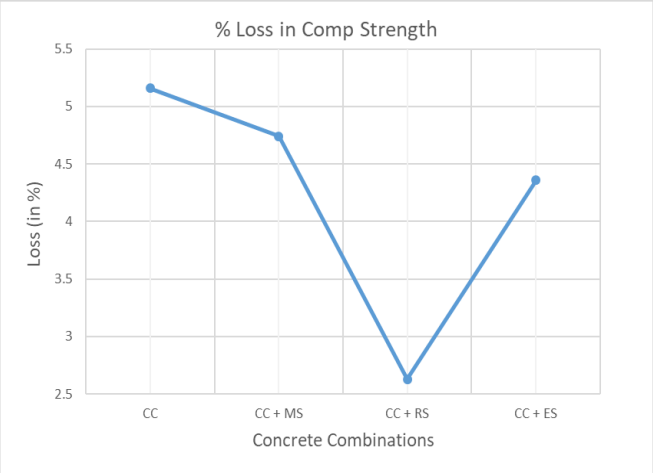

Fig 2 Comparison of Loss in Compressive Strength of Control Concrete with various proportions of Ennore Sand (100%), Robo Sand (100%) and Marble Sand (100%)

4.1.2WATER ABSORPTION

It can be observed that Water Absorption for Control Concrete is 6.32%, when we Replace the marble sand it is observed that the gain of Weight increases 5.98% over the conventional concrete, when we Replace the Robo sand it is observed that the gain of Weight increases 4.97% over the conventional concrete and when we Replace the Ennore sand it is observed that the gain of Weight increases 5.15% over the conventional concrete. The Graphical Representations of the above results are shown below with various Combinations are shown in Fig 3.

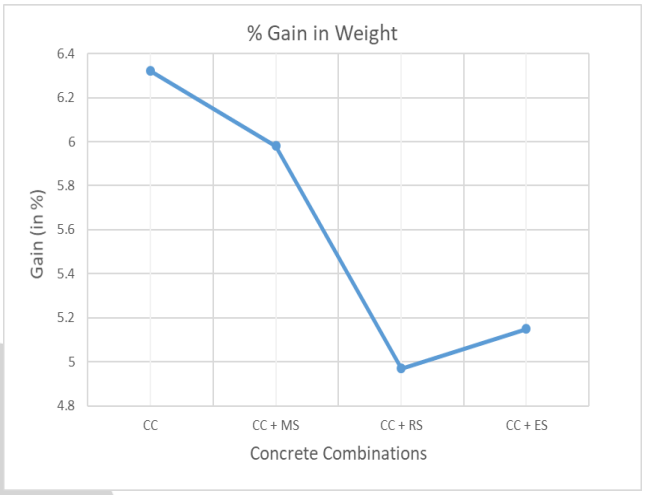

Fig 3 Comparison of Water Absorption (% Gain) of Control Concrete and Concrete with various proportions of Ennore Sand (100%), Robo Sand (100%) and Marble Sand (100%)

4.2 TEST RESULTS FOR M 35 GRADE OF CONCRETE

4.2.1. SULPHATE RESISTENCE

It is observed that, Concrete with 100% Marble Sand exhibits 2.63% loss of weight and 100% replacement with Robo Sand shows 1.56% of Loss of Weight, Full Replacement of Fine Aggregate with Ennore sand (100%) shows 2.02% of Loss of Weight. When we consider the Compressive Strength, the loss for Marble sand is 5.29%, for Robo Sand is 3.89%,as well as for Ennore Sand is 4.69% when considered 28 days of test results. The Graphical Representations of the above results are shown below with various Combinations are shown in Fig 4and Fig 5.

Fig 4 Comparison of Loss of Weight of Control Concrete with various proportions of Ennore Sand (100%), Robo Sand (100%) and Marble Sand (100%)

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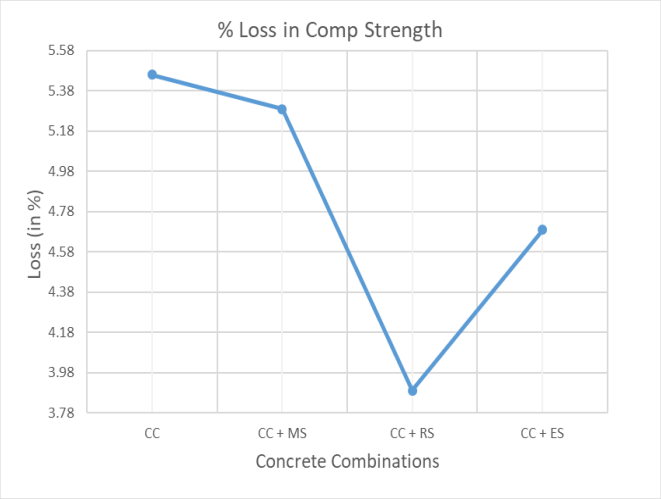

Fig 5 Comparison of Loss in Compressive Strength of Control Concrete with various proportions of Ennore Sand (100%), Robo Sand (100%) and Marble Sand (100%)

4.2.2WATER ABSORPTION

It can be observed that Water Absorption for Control Concrete is 4.86%, when we Replace the marble sand it is observed that the gain of Weight increases 4.82% over the conventional concrete, when we Replace the Robo sand it is observed that the gain of Weight increases 4.51% over the conventional concrete and when we Replace the Ennore sand it is observed that the gain of Weight increases 4.67% over the conventional concrete .The Graphical Representations of the above results are shown below with various Combinations are shown in Fig 6.

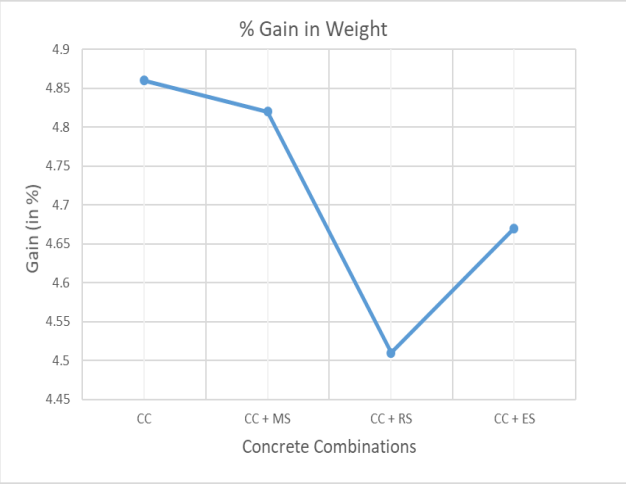

Fig 6 Comparison of Water Absorption (% Gain) of Control Concrete and Concrete with various proportions of Ennore Sand (100%), Robo Sand (100%) and Marble Sand (100%)

V. CONLUSIONS

5.1 Sulphate Resistance:

1. For M 25 Grade of Concrete – It is observed that fine aggregate with 100% Marble Sand exhibits 2.32% loss of 100% replacement with Robo Sand shows 1.51% of Loss of Weight, Full Replacement of Fine Aggregate with Ennore sand (100%) shows 2.12% of Loss of Weight. When we consider the Compressive Strength, the loss for Marble sand is 4.74%, for Robo Sand is 2.63%,as well as for Ennore Sand is 4.36% when considered 28 days of test results.
2. Similarly in M 35 Grade of Concrete – It is observed that concrete with 100% Marble Sand exhibits 2.63% loss of weight and 100% replacement with Robo Sand shows 1.56% of Loss of Weight, Full Replacement of Fine Aggregate with Ennore sand (100%) shows 2.02% of Loss of Weight. When we consider the Compressive Strength, the loss for Marble sand is 5.29%, for Robo Sand is 3.89%,as well as for Ennore Sand is 4.69% when considered 28 days of test results.

5.2 Water Absorption:

1. For M 25 Grade of Concrete -It can be observed that Water Absorption for Control Concrete is 6.32%, when we Replace the marble sand it is observed that the gain of Weight increases 5.98% over the conventional concrete, when we Replace the Robo sand it is observed that the gain of Weight increases 4.97% over the conventional concrete and when we Replace the Ennore sand it is observed that the gain of Weight increases 5.15% over the conventional concrete.
2. Similar For M 35 Grade of Concrete – It can be observed that Water Absorption for Control Concrete is 4.86%, when we Replace the marble sand it is observed that the gain of Weight increases 4.82% over the conventional concrete, when we Replace the Robo sand it is observed that the gain of Weight increases 4.51% over the conventional concrete and when we Replace the Ennore sand it is observed that the gain of Weight increases 4.67% over the conventional concrete.

The above research – It is concluded that Fine Aggregate can be replaced with Robo Sand for improved Durability Properties such as Sulphate Resistance, Water Absorption.

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