STRENGTH AND DURABILITY STUDIES ON CONCRETE USING QUARRY DUST AS FINE AGGREGATE

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ABSTRACT

Conventional Cement Concrete (CCC) consists of Portland Cement (PC) as binder, which binds the inert aggregate system. Concrete has found its wide application in buildings throughout the world because of positive attributes such as durability, high resistance to loads, and the possibility of using local raw materials in the preparation of concrete (Sand, Crushed Stone). The use of river sand in making the concrete is the best Fine Aggregate (FA). Seasonal non – availability and scarcity leads to the higher cost. There is a need to tackle this problem. So the replacement of conventional river sand is necessary. For this the abundantly available material at all season at a cheaper rate is in need. The use of Quarry Dust – the fines which is found as the remains of the crusher industry, as a replacement of sand is being tried at different places, but no authentic results are available for the characteristics strength and the optimum proportion by which it can be included as FA. Properties such as: compressive, split tensile and flexural strengths besides durability of concrete made with Quarry Dust have been investigated. Cement Concrete mix using Quarry Dust as Fine Aggregate is designed using M20. Combinations used for this study,

i. *Concrete using 100% natural sand as fine aggregate.*
ii. *Concrete using 75% natural sand and 25% Quarry Dust.*
iii. *Concrete using 50% natural sand and 50% Quarry Dust.*
iv. *Concrete using 25% natural sand and 75% Quarry Dust.*

Key words: Durability, Quarry dust, Material test.

1. INTRODUCTION

In the context of increased awareness regarding the ill effects of the over exploitation of natural resources, eco –friendly technologies are to be developed for effective management of resources. The cost effectiveness in construction will be achieved only if we are thinking from every corner of construction materials. Concrete is a composite material formed by the combination of Cement, Aggregate and Water, in particular proportion in such a way that the concrete meets the need as regards its workability, strength, durability and economy.

River Sand is widely used for concrete as Fine Aggregate. No one can give assurance how far it can be available due to scarcity and cost of river sand. Engineering Research and Development department are amazing in the search of new material for replacement of fine aggregate. Unlimited quarrying of sand are now available which are used as fine aggregate in the preparation of cement mortar resulted in lowering of water table, soil erosion etc., in this study, an attempt has been made to find the suitability of quarry dust as fine aggregate. Cost of construction can be effectively reduced if quarry dust is available near the site. Even there is scope for using quarry dust in the preparing of mortar for plastering purpose after conducting proper investigation.

2. MATERIALS FOR PRODUCTION OF CONCRETE WITH QUARRY DUST

2.1 CEMENT

Cement in the general word described as a material with adhesive and cohesive properties which is capable of bonding mineral fragments into a compact whole. The important component of cement that is responsible for strength is C_3S and C_2S.

2.2 COARSE AGGREGATE

Coarse Aggregate is the strongest and least porous component in concrete. It reduces drying shrinkage and other dimensional changes due to moisture. For optimum compressive strength with high cement and lower water cement ratio, size of coarse aggregate must be used.

2.3 FINE AGGREGATE

Naturally occurring river sand was used as fine aggregate. Advantage of natural sand is that particles are cubical rounded with smooth surface texture and gives good workability.

2.4 QUARRY DUST

Quarry dust is a waste material obtained from stone quarries while crushing stones, stone crusher dust, which is available abundantly from crusher units at a low cost in many areas, provides a viable alternative for river sand in concrete. Earlier investigation indicates that stone crusher dust has a good potential as fine aggregate in concrete construction. Crusher dust not only reduces the cost of construction but also helps to reduce the impact on environment by consuming the material generally considered as a waste product with few applications. Crusher dust has potential as fine aggregate in concrete structure with a reduction in cost of concrete by about 20 percent compared to conventional concrete.

3. DETAILS OF EXPERIMENTAL WORK

3.1 Preparation of Test Specimens

The test specimens were cast in cast-iron steel moulds. The inside of the moulds was applied with oil for easy demoulding. The solid ingredients were weighed on a digital balance and placed in pan mixer machine for mixing in dry condition. It was ensured that a uniform color of the mix was obtained before adding water. Water is added for correct quantity using measuring jar. Proportioning of a concrete mix means determining the relative amounts of materials (cement, aggregate, water) required for batches of concrete of required strength. The investigation was carried out with standard mix M_{20} (1:1.5:3) with water cement ratio 0.55. This is done to know the possibilities of inclusion of quarry dust in optimum proportion in the ordinary construction activities using cement concrete.

3.2 Preparation of Marine Environment

The marine environment has been prepared by the major salts Sodium Chloride, Magnesium Sulphate and Calcium Sulphate in ratio of 20:1:1. It is stirred well and then the cast prisms with reinforced bars of standard size are kept for curing and allowed for alternative wetting and drying for about 15 cycles.

Compressive Test on Cubes

The cubes (Size 150 mm) were tested in saturated surface dried condition as per IS 516, using a compression – testing machine of 100 tonne capacity.

Fig 1 - Compressive Test on Cubes

3.3 Split Tensile Test on Cylinders

This is an indirect tension test method (IS 516) where a cylindrical specimen is placed horizontally between the loading surfaces of a compression testing machine and the load is applied along the vertical diameter.

3.4 Flexural Test on Beams

The prism specimens (size 100 mm X 100 mm X 500 mm) were tested at the age of 28 days of curing as per ASTM C 78-1994. The third –point loading was employed, using a UTM of 100 tonne capacity. The specimens were tested immediately after removal from moist storage. Prisms with reinforced bars were cast for testing of durability parameters.

Fig 2 - Flexural Test on Beams

4. TEST RESULTS AND DISCUSSION

4.1 Compressive Strength

Figures 4 shows the relationship between the compressive strength of concrete for 7 days, 14 days and 28 days and type of mix made with quarry dust. From the table, it is inferred that the control mix and the mix M1 will give approximately equal strength in 7 days. For M2, the strength was reduced, but it is acceptable. For M3, the strength was reduced to about 18.12 %.

For 14 days, the control mix and the mix M1 gives good strength. For the mix M2 and M3, the strength gets reduced by 19.03 % and 25.51 % and it is not advisable to use in concrete works.

For 28 days, it is inferred that the control mix and the mix M1 gives equal strength of 37.99 MPa. For M2, the strength was reduced but it is acceptable. For the mix M3, the strength was reduced by about 11.34 %.

4.2 Split Tensile Strength

From the table 2, it is inferred that the control mix and mix M1 will give approximately equal strength in 7 days. For mix M2, the strength was reduced, but it is acceptable. For M3, the strength was reduced by about 3.77 %.

For 14 days, the control mix and mix M1 gives approximately equal strength. For the mix M2, strength was reduced, but it is acceptable. For mix M3, the strength gets reduced by 25.9 %.

For 28 days, it is inferred that the control mix and the mix M1 gives equal strength of 37.99 MPa. For M2, the strength was reduced but it is acceptable. For the mix M3, the strength was reduced by about 21.23 %.

4.3 Flexural Strength

From the table 2, for 28 days, it is inferred that the control mix and the M1 will give approximately equal strength of 3.5 MPa. For M2, the strength was reduced, but it is acceptable. For the Mix M3, the strength was reduced by about 12.10 %.

4.4 Durability

Weight of steel reinforcement in prism at the time of casting is 1.2 kg for all concrete mixes. After 15 cycles of alternate wetting and drying, the weight of steel reinforcement in prism is 1.2 kg for all concrete mixes. Therefore it is observed that after 15 cycles there was no change in the weight of steel reinforcement.

Fig 3 – Casting of Reinforcement Prism

5. DISCUSSIONS

- From the charts, it is observed that when the replacement percentage is more, the strength of concrete is found to decrease.
- 25 % replacement of quarry dust with fine aggregate gives same strength values as control mix. Hence it is advisable to use the quarry dust in cement concrete by partial replacement to about 50 %.

6. CONCLUSION

It is said, “Necessity is the mother of inventions”. Since from the origin, man is searching of better techniques in all fields to fulfill his requirements. This search or need leads to the development of modern technology. Continuous research works are carried out for improving the workability and durability of concrete in all parts of the world.

- Quarry dust has the required properties of the river sand to be used as fine aggregate and has an equivalent usage in the concrete.
- The properties exhibited by the concrete made with Quarry dust as fine aggregate matches with the conventional concrete.
- 50 % of Quarry dust can be replaced in sand so as to produce the optimum strength of concrete.
- From the durability test, it is found that the pH value is between 12.5 to 13.5 which give a good passive cover to the steel.
- Also, it is observed that there is no appreciable change in the weight of the steel reinforcement which is placed under severe condition for about 15 days.

7. REFERENCES

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Table 1 Properties of Ingredients of concrete with Quarry Dust

(a) Properties of Cement

Type	Cement
Compressive strength (MPa)	43
Specific gravity	3.12
Initial setting time (minutes)	37
Final setting time (minutes)	570
Standard consistency (%)	31

(b) Properties of Aggregates

Type	Fine Aggregate	Coarse Aggregate
Shape	Equidimensional	Cubical to irregular
Fineness Modulus	3.24	4.0
Specific gravity	2.816	2.83
Size	Passing through 4.75 mm sieve	Passing through 20 mm and retaining in 10 mm sieve
Water absorption (%)	1	0.5

(c) Properties of Quarry Dust

Type	Quarry Dust
Fineness Modulus	2.56
Specific gravity	1.77

Table 2 Strength Properties (7 days, 14 days and 28 days) of concrete made with Quarry dust

Type of Concrete	Mix ID	7 days Compressive Strength (MPa)	14 days Compressive Strength (MPa)	28 days Compressive Strength (MPa)	7 days Split Tensile Strength (MPa)	14 days Split Tensile Strength (MPa)	28 days Split Tensile Strength (MPa)	28 days Flexural Strength (MPa)
Control Mix	CM	25.6	35.2	37.99	1.9	2.864	3.25	3.568
Control Mix with 25 % replacement of Quarry dust	M1 - 25 %	24.2	28.5	37.99	1.86	2.342	3.04	3.456
Control Mix with 50 % replacement of Quarry dust	M2 - 50 %	21.58	27.56	34.55	1.56	2.228	2.83	3.216
Control Mix with 75 % replacement of Quarry dust	M3 - 75 %	20.96	26.22	33.68	1.183	2.12	2.56	3.136

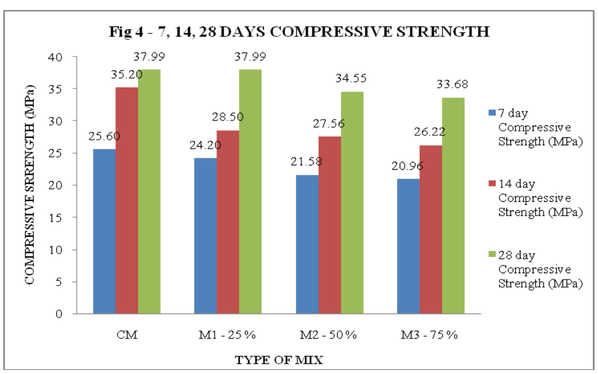

Fig 4 - 7, 14, 28 DAYS COMPRESSIVE STRENGTH

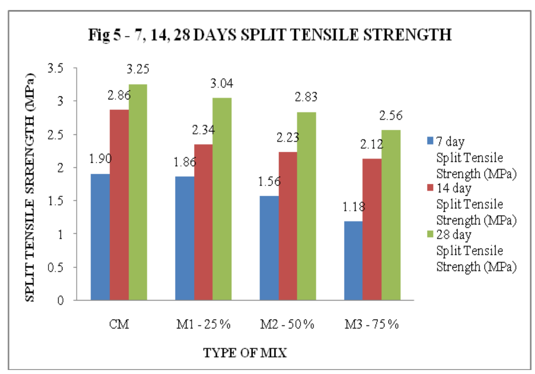

Fig 5 - 7, 14, 28 DAYS SPLIT TENSILE STRENGTH

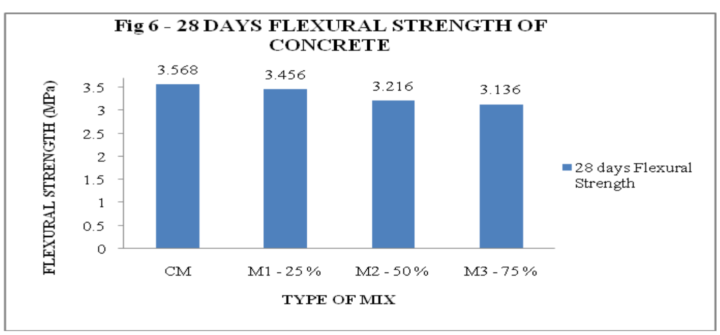

Fig 6 - 28 DAYS FLEXURAL STRENGTH OF CONCRETE