A Review on Various Mixes of Concrete with Material as Partial Replacement of Sand

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Abstract - *The present work deals with the results of experimental investigations of Rice husk ash concrete with replacement of natural sand with Quarry Dust. The effect of the Quarry Dust on various strengths of husk ash concrete is studied. Rice Husk ash is a byproduct of rice polishing factories found after burning rice husk which itself is found after the extraction of all economical rice from rice grains. Rice husk ash is found to have pozzolanic properties. First, quarry dust content is varied from 0 to 20% by replacing natural sand at an interval of 5% by weight of sand. The optimum percentage of the quarry dust in the concrete is obtained by the tests carried out on the concrete. After obtaining the optimum percentage of quarry dust in concrete, the natural sand in husk ash concrete is replaced by Quarry dust. Cement concrete is a universal material used for civil engineering construction. Modern civil engineering, constructions have their own structural and durability requirement related with concrete to better suit the intended function of the structure.*

***Key Words*: *pozzolanic properties1, quarry dust content*, etc**.

1. INTRODUCTION

India being one of the largest producers of rice in the world produces nearly 240 million tons per year and therefore large a quantity of rice husk is available. Rice Husk ash has recently been tested in some parts of the world for its use as partial cement replacement material. The husk ash was found to improve some properties of the paste, mortar and concrete including compressive strength and water tightness in certain replacement percentages and fineness. The higher silica content in the husk ash was suggested to be the main cause for these improvements. Although the silica content may vary from ash to ash, depending on burning conditions and other properties of raw materials including the soil on which rice is grown, it has been reported that the silicate undergoes a pozzolanic reaction.[1]

The natural river sand is the cheapest resource of sand. However the excessive mining of river bed to meet the increasing demand for sand in construction industry has led to the ecological imbalance in the state. Now the sand available in the riverbed is very coarse and contains very high percentage of silt and clay. The silt and the clay present in the sand reduces the strength of the concrete and holds dampness. The natural river sand is the product of sedimentation. Mica, coal, fossils and other organic impurities present in the river sand above certain percentage makes the sand useless for concrete work.[2]

Acute shortage and high price for river sand has led to the adulteration of sand with salty sea sand which has raised serious concern in the construction industry. Hence, substitutes have started been used for construction purposes, produced from hard granite stone by crushing, for natural sand, among which one of them is M-sand or manufactured sand.

The crushed sand is of cubical shape with grounded edges, washed and graded to be used as a construction material. The size of quarry dust is less than 4.75mm.

During the crushing process, the quarry dust has irregular shapes. Due to irregular shape of the aggregates there is a better packing among the particles thereby reducing the voids in concrete. Results of the experimental studies show that resistance to penetration of water as proved by rapid chloride penetration test and water permeability test is increased with increasing proportion of manufactured sand in concrete. Results show that river sand can be partially replaced by quarry dust. The use of quarry dust in the construction industry helps to prevent unnecessary damages to the environment and provide optimum exploitation of the resources.

II LITERATURE SURVEY

Concrete is one of the most common material used in the construction industry. In the past few years, many research and modification has been done to produce concrete which has the desired characteristics. There is always a search for green or eco-friendly concrete. Due to the ecological hazards posed by the mining of river bed to meet the need for natural sand, and limestone for the production of cement, several replacements are being used in concrete. A cementitious material such as sugarcane bagasse ash, fly ash etc. are used as cement replacements, and manufactured sand is used as a replacement for natural sand. In the present study, blended cement concrete with the incorporation of rice husk ash and M-sand, replacing certain percentage of cement and natural sand has been introduced to suit the current requirements.[1]

2.1 Green concrete

Green concrete can be defined as the concrete with material as a partial or complete replacement for cement or fine or coarse aggregates. The substitution material can be of waste or residual product in the manufacturing process. The substituted materials could be a waste material that remain unused, that may be harmful (material that contains radioactive elements). Green concrete should follow reduce, reuse and recycle technique or any two process in the concrete technology. The three major objective behind green concept in concrete is to reduce greenhouse gas emission (carbon dioxide emission from cement industry, as one ton of cement manufacturing process emits one ton of carbon dioxide), secondly to reduce the use of natural resources such as limestone, shale, clay, natural river sand, natural rocks that are being consumed for the development of human mankind, thirdly use of waste materials in concrete that also prevents the large area of land that is used for the storage of waste materials that results in the air, land and water pollution. This objective behind green concrete will result in the sustainable development without destruction of natural resources. The philosophy of green concreteis based on the principle of optimizing its embodied energy *i.e.* on minimizing the energy spent to put it into its final functional form. It therefore depends on the practices related to every stage of its production.[5]

2.2 Rice husk ash (RHA)

Rice husk ash (RHA) is a by-product from the burning of rice husk. Rice husk is extremely prevalent in East and South-East Asia because of the rice production in this area. The rich land and tropical climate make for perfect conditions to cultivate rice and is taken advantage by these Asian countries. The husk of the rice is removed in the farming process before it is sold and consumed. It has been found beneficial to burn this rice husk in kilns to make various things. The rice husk ash is then used as a substitute or admixture in cement. Therefore the entire rice product is used in an efficient and environmentally friendly approach.

Fig 2.1 Rice Husk ash

The rice husk ash is a highly siliceous material that can be used as an admixture in concrete if the rice husk is burnt in a specific manner. The characteristics of the ash are dependent on the components, temperature and time of burning. During the burning process, the carbon content is burnt off and all that remains is the silica content. The silica must be kept at a non-crystalline state in order to produce an ash with high pozzalonic activity. The high pozzalonic behavior is a necessity if you intend to use it as a substitute or admixture in concrete. It has been tested and found that the ideal temperature for producing such results is between 600 °C and 700 °C. [4]

2.3 Quarry Dust

Sand is used as fine aggregate in mortars and concrete. Natural river sand is the most preferred choice as a fine aggregate. River sand is a product of natural weathering of rocks over a period of millions of years. It is mined from the river beds and sand mining has disastrous environmental consequences. River sand is becoming a scarce commodity and hence exploring alternatives to it has become imminent. Rock crushed to the required grain size distribution, is termed as Quarry Dust. In order to arrive at the required grain size distribution the coarser stone aggregates are crushed in a special rock crusher and some of the crushed material is washed to remove fines.

When rock is crushed and sized in a quarry the main aim has generally been to produce coarse aggregates and road construction materials meeting certain specifications. Generally, this process has left over a proportion of excess fines of variable properties, generally finer than 5-mm size. The premixed concrete industry has for some time tried to find ways to utilise this material as a controlled replacement of natural sand. In order to do this it has been recognised that provided the material is appropriately processed and selected from suitable materials then a sand replacement can be produced to meet the highest quality concrete specification. Quarry Dust is defined as a purpose-made crushed fine aggregate produced from a suitable source material. Production generally involves crushing, screening and possibly washing.[1,2]

Fig 2.2 Quarry Dust

Following are the uses of Superplasticising admixture

- To produce pumpable concrete
- To produce high strength, high grade concrete by substantial reduction in water resulting in low permeability and high early strength.
- To produce high workability concrete requiring little or no vibration during placing.

Advantages are enlisted as follows

- Improved workability - easier, quicker placing and compaction.
- Increased strength - provides high early strength for precast concrete with the advantage of higher water reduction ability.
- Improved quality - denser, close textured concrete with reduced porosity and hence more durable.[3]
- Higher cohesion - risk of segregation and bleeding minimized; thus aids pumping of concrete.
- Chloride free - safe in prestressed concrete and with sulphate resisting cements and marine aggregates.
- Workability- can be used to produce flowing concrete that requires no compaction.
- Durability reduction in W/C ratio enables increase in density and impermeability thus enhancing durability of concrete.

III COMPARATIVE STUDY OF VARIOUS MIXES

The present research work is experimental and requires preliminary investigations in a methodological manner.

3.1 Material and Grade of Control Mix

- Selection of type and grade of control mix, mix design by an appropriate method, trial mixes, final mix proportions.
- Estimating total quantity of concrete required for the whole experimental work.
- Estimating quantity of cement, fine aggregate, coarse aggregate, Quarry Dust, rice husk ash, super plasticizers required for the work.
- Testing of properties of cement, fine aggregate, coarse aggregate.
- Obtaining the properties of Quarry Dust and rice husk ash.[8]

3.2 Production of Concrete Mixes

- Production of control mix (concrete of grade M-50) in laboratory is carried out by ACI method.
- Modified Concrete is produced by adding Quarry Dust to the plain concrete as fine aggregate replacement. Rice husk ash was added to the modified concrete as a cement replacement varied from 5% to 20% at constant interval of 5% by weight of cement.

3.3 Test Conducted on Material used in Experimental work

The ingredient of concrete *i.e.* cement, fine aggregate are tested before producing the concrete. The relevant Indian standard codes were followed for conducting various tests on concrete.

3.3.1 Tests on cement

The cement used in this experimental work is "53 grade ordinary portland cement". All properties of cement are tested by referring IS 12269 – 1987[18] specification for 53 grade ordinary Portland cement. Test results are presented in Table 3.1.

Table 3.1 Physical Properties of Cement. (Confirming to IS 12269 – 1987) [18]

Sr. No.	Description of test	Results
1	Fineness of cement (residue IS sieve No .9)	3%
2	Specific gravity	3.15
3	Standard consistency of cement	29%
4	Setting time of cement	
	a) Initial setting time	135 minute
	b) Final setting time	288 minute
5	Sound test of cement (with le- Chatelier's mould)	1.5 mm
6	Compressive strength of cement	
	a) 7 days	57.8 N/mm^2
	b) 28 days	79.5 N/mm^2

3.3.2 Water

Potable water available in laboratory is used for mixing and curing of specimen.

3.3.3. Tests on aggregates

Natural sand from Godavari River (Paithan) confirming to IS 383-1970 [21] is used. Various tests such as specific gravity, water absorption, impact strength, crushing strength, sieve analysis etc. have been conducted on CA and FA to know their quality and grading. The above said test results are given in Tables 3.2 to 3.5. Crushed black trap basalt rock of aggregate size 20 mm down and 10 mm down was used confirming to IS 383-1970.[7]

Table 3.2 Physical Properties of Fine Aggregate (sand)

Sr. No.	Property	Results
1	Particle shape, size	Round,4.75 mm down
2	Fineness modulus	3.17
3	Silt content	2%
4	Specific Gravity	2.75
5	Bulking of sand	4.16%
6	Bulk density	1793kg/m^3
7	Surface moisture	2%

3.3.4 Properties of superplasticizer

The properties of SP supplied by the Fosroc manufacturer Chemicals Pvt. Ltd., Mumbai in the literature is given in Table 3.6 which complies IS: 9103.

Table 3.3 Properties of superplasticizer.

Sr. No.	Properties	Description
1	Chemical Admixture	Conplast SP430
2	Specific gravity	1.220 to 1.225 at 30^{0}C
3	Chloride content	Nil to IS:456
4	Air Entrainment	Approx. 1% additional air is entrained

3.3.5 Properties of rice husk ash

Rice husk ash (RHA) is available in dry powder form. It is available in 50 kg bags, color of which is gray. The chemical and physical properties of RHA are shown in Table 3.6 and 3.7. These chemical properties are taken from different research papers.[11,12]

Table 3.4: Chemical Properties of RHA

Chemical Composition	Percentage Weight (wt. %)
SiO_2	57.63
CaO	6.14
Al_2O_3	1.33
Fe_2O_3	1.50
MgO	1.56
K_2O	7.33
Na_2O	0.22
SO_3	3.52
Loss on ignition (%)	2.1

Table 3.5 Physical Properties of RHA

Particulars	**Value**
Density(gm/cm^3)	2.52
Blaine surface area (cm^2/gm)	5140
Particle size (µm)	28.9
Colour	Gray

3.3.6 Test on Quarry Dust or Quarry Dust

Tests are conducted on the Quarry Dust to find out its fineness modulus and physical properties and are shown in Table 3.6.

Table 3.6: Sieve Analysis of Quarry Dust

Sr. No.	**Sieve size**	**Weight retained (gm)**	**Cumulative wt. retained**	**% Cumulative wt.**	**% Passing**
1	4.75mm	0.015	0.015	2.50	97.50
2	2.36mm	0.090	0.105	17.50	82.50
3	1.18 mm	0.190	0.295	49.20	50.80
4	600µ	0.150	0.445	74.20	25.80
5	300µ	0.080	0.525	87.50	12.50
6	150µ	0.065	0.590	98.30	1.70
7	Pan	0.010	0.600	-	
Total					329.20

Fineness Modulus = 3.29

According to IS 383-1970 [24], the fineness modulus should not be more than 3.29 for fine aggregate. The fineness modulus of the Quarry Dust in the experiment is found to be 3.29, which is in close compliance with the IS recommendation. The Quarry Dust used is a little coarser than natural sand.

3.4 Mix design of concrete

ACI method of mix design is used for mix design of M-50 grade of concrete. The optimum percentage of rice husk ash to give maximum compressive strength was achieved by making trial mixes with rice husk ash as cement replacement at a constant interval of 2.5% by weight of cement. The trial mixes were made for rice husk ash from 5% to 20 %. The quantity of ingredient materials and mix proportions as per design is as under.

Table 3.7 Quantity of Materials Per Cubic Meter of Concrete

Material	Proportion by weight	Weight in Kg/m3
Cement	1	339
F.A	2.36	802
C.A (20 mm)	3.6	1223
w/c	0.4	131

3.5 Preparations of specimen

3.5.1 Measurement of ingredients

All cement, sand, coarse aggregate (20 mm), RHA, and Quarry Dust are measured with digital balance. The water is measured with measuring cylinder of capacity 1 liter and measuring jar of capacity 100 ml and 200 ml.[14]

3.5.2 Mixing of concrete

The ingredients were thoroughly mixed over a G.I. sheet. The sand, cement and aggregate were measured accurately and were mixed in dry state for normal concrete. Whereas, for rice husk ash concrete, first measured quantity of cement and required percentage of RHA (*i.e.* from 5% to 20%) by weight of cement, were mixed thoroughly and then added to dry mix of aggregates. Similarly, for modified rice husk ash concrete, the required quantities of Quarry Dust (*i.e*. from 5% to 20%) were measured by the weight of fine aggregates.

3.5.3 Workability of concrete

At every batch of mixing the concrete slump is measured and recorded with slump cone apparatus as per relevant IS. Workability is measured in terms of slump. Results from Table 4.1, indicate that for same mix proportion and same SP dose.

3.5.4 Placing of concrete

The fresh concrete was placed in the moulds by trowel. It was ensured that the representative volume was filled evenly in all the specimens to avoid segregation, accumulation of aggregates etc. While placing concrete, the compaction in vertical position was given to avoid gaps in moulds.

3.5.5 Compaction of concrete

Moulds are cleaned and oiled from inside for smooth demoulding. Concrete is mixed thoroughly and placed in the mould in three layers and compacted by using tamping rods. Concrete is tamped till concrete woes out of mould. The tamping is continued till the concrete oozes out cement slurry, on the surface of moulds. Care has been taken of cement slurry not to spill overdue to vibration and segregation.

3.5.6 Finishing of concrete

After tamping, the moulds were kept on ground for finishing and covering up for any leftover voids. The concrete is worked with trowel to give uniform surface. Care has been taken not to add any extra cement, water or cement mortar for achieving good surface finish. The additional concrete is chopped off from top surface of the mould for avoiding over sizes etc. The density of fresh concrete is taken with the help of weigh balance. Identification marks are given on the specimens by embossing over the surface after initial setting.

3.5.7 Demoulding of specimens

The plain cement concrete specimens are demoulded after 24 hours of casting wet concrete and kept in water tank for curing upto 7 days and 28 days.

3.5.8 Curing of test specimens

The specimens were demoulded after 24 hours of casting and immediately stored in the curing tank for continuous curing. M-50 grade plain cement concrete is cured in curing tank for 7 days and 28 days. Quarry Dust concrete (MSC) specimens of different MS content and modified rice husk ash specimens of different RHA content are water cured for 7 days and 28 days for same grade of concrete.

3.6 Details of Test Specimens for Tests on Hardened Concrete

The specimen used was cubes, beams, cylinders and cube specimens specially prepared to measure pull out strength, confirming to IS: 10086-1982 [28]. Dimensions of each test specimen are as under:

Cube: 150 mm x 150 mm x 150 mm

Beam: 500 mm x 100 mm x 100 mm

Cylinders: 100 mm diameter and 200 mm in height

- Beam specimens were used to determine flexural strength, and equivalent compressive strength.
- Cubes of 150 mm size were used to find the compressive strength.
- Cubes of 150 mm size with 12 mm inserted steel rods were used to find the pull out strength.
- Cylinders were used to determine the split tensile strength.[8,9]

Workability of wet concrete is determined by slump cone test and bulk density is calculated by taking weight of concrete cylinder in wet state. Table shows the results of workability and wet density of various concrete mixes. Compressive strength of cubes are determined at 7 days and 28 days using compression testing machine (CTM) of capacity 2000 KN. Universal testing machine (UTM) of capacity 400 KN was used to determine the equivalent cube strength on beam prisms. Split tensile test, flexure test and bond strength is carried out on universal testing machine of 400 KN capacity.

3.7 Test Conducted on Hardened Concrete: Confirming to IS 516-1959 [22]

In present study cube compression test, flexural test on beams, split test, pullout test on plain and modified rice husk ash concrete with varying fraction were carried out with constant Quarry Dust content on number of samples.

3.7.1 Flexural test on plain concrete and MRHAC

Standard beams of size 100 mm x 100 mm x 500 mm were supported symmetrically over a span of 400 mm and subjected to three points loading till failure of the specimen. The two broken pieces (prisms) of flexural test were further used for equivalent cube compressive strength.[12]

3.7.2 Flexural shear strength

Maximum flexural shear strength of the beam specimen was computed by the equation from theory of strength of materials

3.7.3 Split tensile test

The split tensile test is well known indirect test used to determine the tensile strength of concrete. Due to difficulties involved in conducting the direct tension test, a number of indirect methods have been developed to determine the tensile strength of concrete. In these tests, in general a compressive force is applied to a concrete specimen in such a way that the specimen fails due to tensile stresses induced in the specimen.

3.7.4 Bond strength of concrete (Pull out test)

The specimen were cast according to ASTM standard C 234-91 [26] with 12 mm diameter tor steel rod embedded in 150 mm x 150 mm x 150 mm concrete cube cast and compacted on vibrating Table. The verticality of 12 mm embedded tor steel rod is ensured by supporting till concrete hardens.[15]

IV CONCLUSION

Cement one of the ingredient in concrete is the most energy intensive materials to produce, and during the production of cement the carbon dioxide is released in the atmosphere which is the great cause for environmental pollution. Therefore it is the best opportunity to reduce cement content in the concrete mix, by replacing it with admixtures and pozzolans, such as fly ash, silica fume, rice husk, metakaolin etc .These pozzolans are available in abundance, there for pozzolans in concrete not only solves the problem of its disposal also improve the properties like workability, durability, impermeability, strength etc. Rice Husk is a by-product from rice milling industries which is burnt to generate power required for different activities in the factory. The burning of rice husk leave ash as a waste, which has a pozzolanic property that could potentially be used as a cement replacement material.

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