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Strength Analysis of Concrete by Partial Replacement of Cement by RHA & FA

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Abstract:

As the Cement is most expensive constituents in construction of Concrete. So it is necessary to find the waste product that minimize the use of Cement to reduce the total cost of construction. Fly ash (FA) and Rice husk ash (RHA) has pozzolanic properties and they can be used as the partial replacement material for cement. In Research this Paper detailed study was done to study the combined and separate effect of partial replacement of cement by Fly ash (FA) and Rice husk ash (RHA) on M40 grade concrete. The mix proportion of Fly Ash and Rice Husk Ashes taken first at 0% (FA) & 30% (RHA) then at 5% (FA) &25% (RHA) and again at 10% (FA) & 20% (RHA) and continued till we reached 30%(FA) and 0%(RHA) and then raw sewage water from factories is used in place of ordinary fresh water for every sample and also comparison is made with strength of specimen which are made by ordinary water. After mixing FA & RHA in cement, the compressive, tensile& flexural strength of the concrete was found for all the mix proportion of FA & RHA. The work done in this study shows the change in strengthening behavior of concrete when partially replaced with some definite proportions of FA and RHA.

Keywords:

Cement; Concrete; Pozzolanic material; Fly ash; Rice husk; supplementary cementing materials; Sewage water mix;

1. Introduction

The increasing global population brings high demand for construction and higher quality at low cost is need of this era, so it is need of the hour to producing sustainable alternate construction materials to reduces the environment pollution due to the waste products like FA & RHA, they were tested by replacing the cement in concrete construction. During milling of paddy about 73% of weight is received as rice, broken rice and bran, rest 27% of weight of paddy is received as husk. The rice husk to obtain is used as fuel to generate steam for parboiling process in many industries. The husk contains about 75% organic volatile matters and balance 25% of husk is converted into ash during the firing process known as Rice Husk Ash (RHA). Thermal power plants produce fly ash as the process of combustion of coal takes place in coal industries. Fly ash is much similar to volcanic ashes which are used in production of pozzolanic cement. Fly ash is the one of the most commonly used pozzolanic material in the world. Fly ash being the most hazardous waste product cause harmful effects on the agricultural land, surface & subsurface waste pollution, soil & air pollution. So researchers have proposed that fly ash can be replaced by cement due to similar properties. Concrete is the heterogeneous mixture of Cement, Sand, Aggregates and Water. The mechanical properties of concrete can be enhanced by using various admixtures. Properties of concrete canalso modified by using various waste products as shown by many researchers by partial replacing of cement by fly ash and other fine waste products. Likewise, combined replacement of fly ash and rice husk ash showed satisfactory compressive strengths when mixed in desired proportion as predicted in this piece of work and also effects of factory sewage water is analyzed on the strength of concrete.

2. Literature review

Combined and seprate effect of fly ash and rice husk ash on concrete by replacing 30% of cement is seen by Sathawane et. al. and they found that they get maximum compressive strength when they replaced 22.5% cement by FA and 7.5% cement by RHA after control specimens and same improvement is found in the split tensile strength and flexural strength of concrete. Likewise, Kene et. al. also conducted the test on M25 grade concrete by 30% replacement of cement at every single percentage increment in one component and deduction in other component like first they took only 30% FA and next they used 29% FA and 1% of RHA. They continued this process till they reached 0% FA and 30% RHA. After all this extensive work Kene et. al. concluded that they got maximum compressive strength and flexural strength at 25% FA and 5% RHA at 90 days testing. Due to more work is needed on this topic tests are repeated as given in the present experimental work and also strength reduction is noted after use of factory sewage water.

3. Material Used

3.1. Cement:

Ordinary Portland cement is used of grade OPC43 which is locally available in market and have characteristics as mention in IS 8112:1989.

3.2. Aggregates:

Aggregates which are produced from crushing stones from Aravali Hills were used. Specific gravity of fine and coarse aggregate is 2.65 and 2.7 respectively.

3.3. Water:

Ordinary tap water is used in which all constituents are in permissible limits in accord to IS 3025.

3.4. Fly Ash: Fly ash taken from PRISM JOHNSON LIMITED (RMC Plant), having specific gravity 2.3.

3.5. Rice Husk ash: Rice husk ash taken from PRISM JOHNSON LIMITED (RMC Plant), having specific gravity 2.14.

3.6. Sewage Water: Sewage water is collected from the local Sewage treatment plant situated near Kumbha Marg.

Figure-1 Fly Ash (FA)

Figure-2 Rice Husk Ash

4. Experimental Program

We have tested 42 cubes (of size 150mm×150mm×150mm), 42 cylinders (of size 150mm×300mm) and 42 beams (of size 100mm×100mm×500mm) in accordance for the testing mentioned in the IS 516:1959. Triplicate samples are made and names were assigned to the specimens which are prepared in ordinary water and sewage water as shown in below Table-1.

Table-1 Configuration and naming of cubes

Name assigned	Type of water used	% cement replaced by FA	% cement replace by RHA
CUO-30	ordinary	30	0
CUO-25	ordinary	25	5
CUO-20	ordinary	20	10
CUO-15	ordinary	15	15
CUO-10	ordinary	10	20
CUO-5	ordinary	5	25
CUO-0	ordinary	0	30
CUS-30	sewage	30	0
CUS-25	sewage	25	5
CUS-20	sewage	20	10
CUS-15	sewage	15	15
CUS-10	sewage	10	20
CUS-5	sewage	5	25
CUS-0	sewage	0	30

Here CU stands for cube and O stands for ordinary water and S stands for sewage water and last number depicts the percentage of cement replacement with fly ash. Likewise, cylinder and beams are named like CYO-30 and BEO-30. All the specimens are made and cured for 28 days in fresh water tank before testing.

4.1. Mix Proportioning:

The mix proportion of M40 grade concrete is made

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to study the strength of concrete. It is designed as per IS 10262:2009.

5. Test Performed:

5.1. Compressive Strength Test:

This compressive loading test on concrete was conducted on compressive testing machine of capacity 2000KN as loading rate of 5KN/sec. Compressive strength of the cube specimen of 150mmX150mmX150mm is obtained by the following formula.

$$\text{Compressive Strength} = \frac{\text{Ultimate Compressive Load}}{\text{Loaded Surface Area}}$$

Figure-3 Compression test machine

Table-2 Compressive strength in N/mm^2

Name assigned to Cubes	Type of water used	Compressive strength (N/mm^2)
CUO-30	ordinary	41.05
CUO-25	ordinary	43.57
CUO-20	ordinary	44.67
CUO-15	**ordinary**	**46.23**
CUO-10	ordinary	42.36
CUO-5	ordinary	41.54
CUO-0	ordinary	39.63
CUS-30	sewage	36.67
CUS-25	sewage	37.79
CUS-20	sewage	39.64
CUS-15	**sewage**	**41.08**
CUS-10	sewage	38.98
CUS-5	sewage	36.82
CUS-0	sewage	34.69

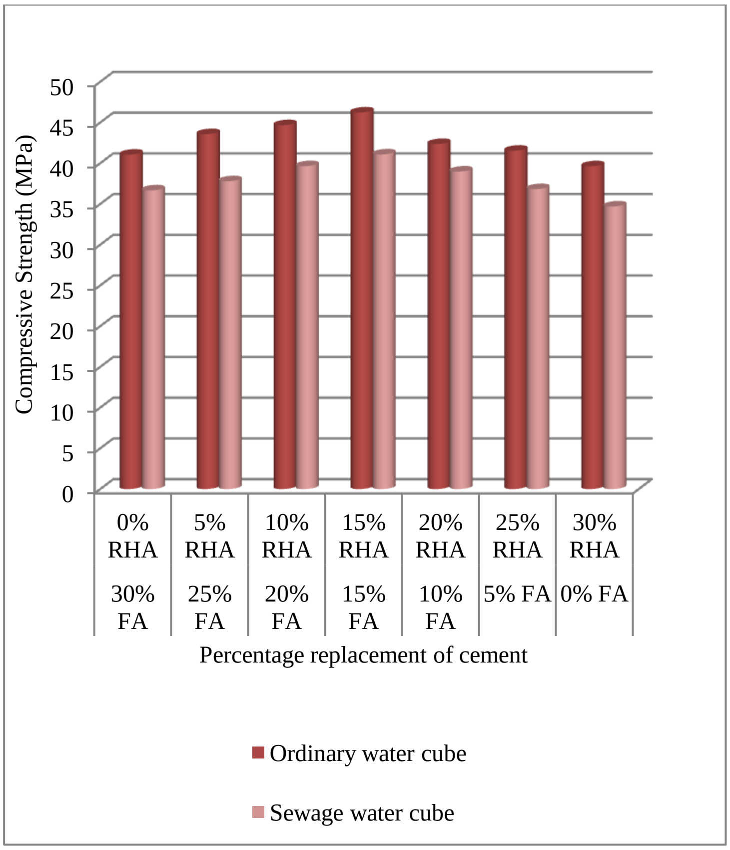

Figure-4 Comparison graph of Compressive Strength between ordinary water and sewage water

5.2. Split Tensile Strength Test:

Split tensile strength test is conducted as with IS516:1969. Cylinder of size 150mmX300mm is used for this test. The split tensile strength test was conduct on compressive testing machine.

$$\text{Split Tensile Strength} = \frac{\text{Total Load Applied}}{\text{Bearing Area Of Cyilender}}$$

$$= \frac{2P}{\pi DL}$$

Figure-5 Split tensile strength

Table-3 Split tensile strength in N/mm^2

Name assigned to Cylinders	Type of water used	Split Tensile strength (N/mm^2)
CYO-30	ordinary	4.06
CYO-25	ordinary	4.37
CYO-20	ordinary	4.50
CYO-15	**ordinary**	**4.75**
CYO-10	ordinary	3.56
CYO-5	ordinary	3.40
CYO-0	ordinary	3.16
CYS-30	sewage	3.64
CYS-25	sewage	4.03
CYS-20	sewage	4.24
CYS-15	**sewage**	**4.42**
CYS-10	sewage	3.12
CYS-5	sewage	3.00
CYS-0	sewage	2.74

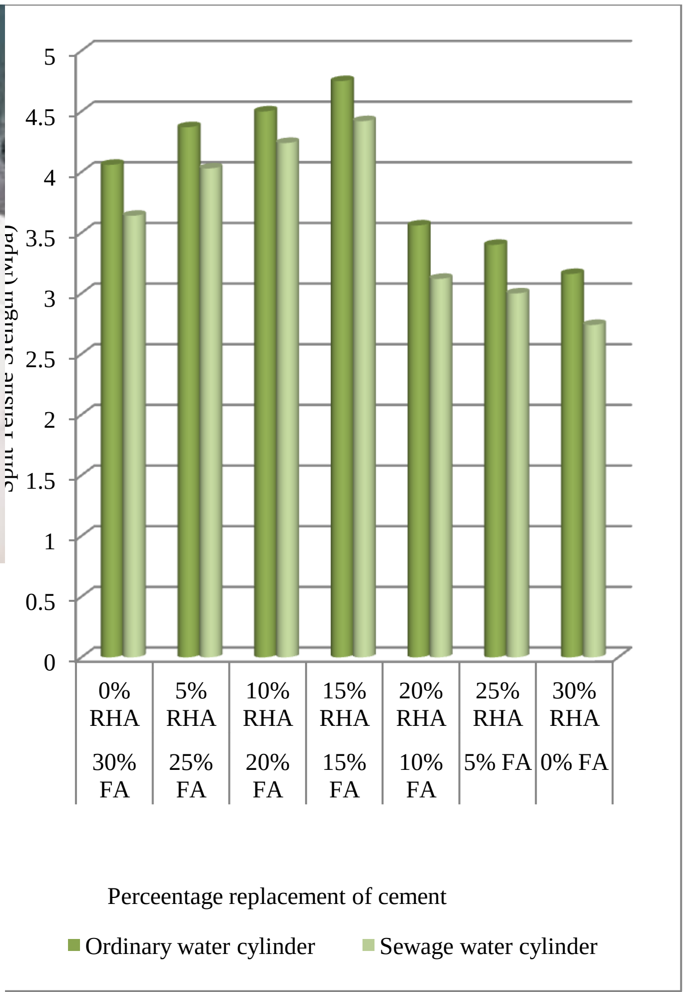

Figure-6 Comparison graph of Split tensile Strength between ordinary water and sewage water

5.3. Flexural Strength Test:

The flexural strength test is conducted in accordance with IS516:1959. Beam of 150mmX150mmX750mm size were used for this test as aggregate used is lesser than 20mm. Load is gradually applied at a rate of $0.7mm^2$/min.

$$\text{Flexural Strength} = \frac{\text{Total Applied Load}}{\text{Bearing Area Of Beam}}$$

$$= \frac{P \times L}{B \times D^2}$$

Figure-7 Flexure strength test

Table-4 Flexural strength in N/mm^2

Name assigned to Beams	Type of water used	Flexural strength (N/mm^2)
BEO-30	ordinary	5.83
BEO-25	ordinary	6.34
BEO-20	ordinary	6.44
BEO-15	**ordinary**	**6.65**
BEO-10	ordinary	5.09
BEO-5	ordinary	4.86
BEO-0	ordinary	4.52
BES-30	sewage	5.21
BES-25	sewage	5.77
BES-20	sewage	6.21
BES-15	**sewage**	**6.36**
BES-10	sewage	4.47
BES-5	sewage	4.29
BES-0	sewage	3.92

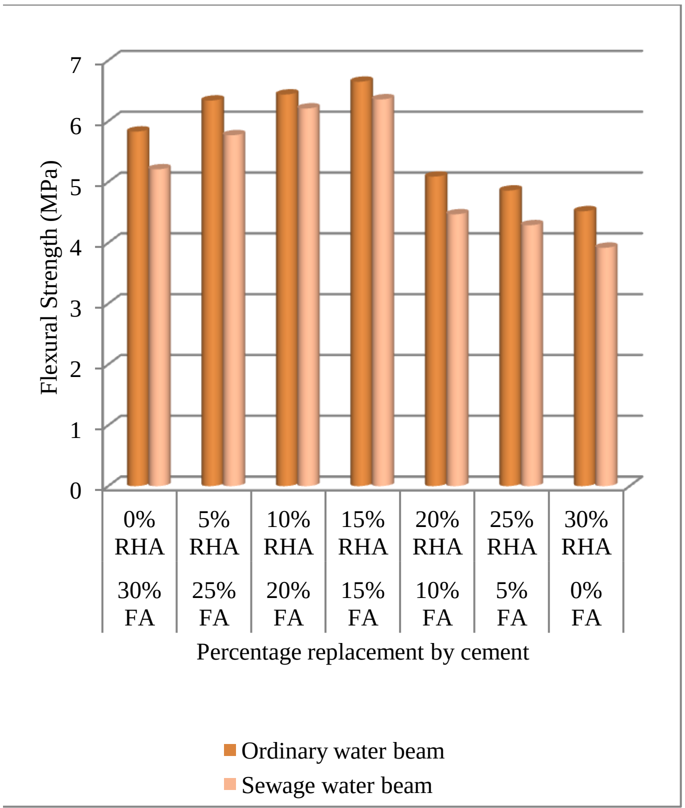

Figure-8 Comparison graph of Flexure Strength between ordinary water and sewage water

6. Conclusion

- The Split Tensile and Flexural Strength are found maximum at 15% RHA & 15% FA proportion.
- The strengths of concrete decreased by 5% to 8 % when performed by sewage water instead of ordinary water.
- As rice husk ash has low specific gravity it reduces the mass per unit volume of concrete.
- Use of Fly ash and Rice Husk ash in concrete reduces the environment pollution.

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