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EVALUATION OF RECYCLED CONCRETE AGGREGATE AND RICE HUSK ASH WITH POLYVINYL ALCOHOL FIBRE FOR MECHANICAL PROPERTIES OF CONCRETE

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ABSTRACT

The present research work has been done to find the best suitable mix on addition and replacement with some other materials possessing similar physical properties as conventional concrete materials. The materials used in this study were Recycled Concrete Aggregates (RCA), Rice Husk Ash (RHA) and Polyvinyl Alcohol Fibre (PVA). Coarse aggregates were replaced with RCA in varied percentages like 0%, 25%, 50%, 75% and 100%, whereas cement was replaced fractionally as 5%, 10%, 15% and 20% with RHA by weight. PVA fibre has been added to a fixed percentage of 0.25% by weight of concrete. PVA fibre with geometric length of 6mm and aspect ratio of 428 was used. Different destructive and non-destructive testing had been done for 7 days and 28 days. Experiment had shown best results at 50% of RCA and 10% RHA with PVA fibre fulfilling the design requirements for the appliance in construction industry. Further it was seen for higher percentages of RCA and RHA, strength of the concrete start decreasing due to effect in pozzolanic properties of concrete.

Key words: Recycled concrete aggregate (RCA), Rice husk ash (RHA), Polyvinyl alcohol (PVA), Compressive strength, Flexural strength, Split tensile strength, Scanning Electron Microscopy (SEM) etc.

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1. INTRODUCTION

Construction industry is growing day by day all around the world at very high rate. The materials required for the construction purpose are mainly from natural resources, so at some point there will be scarcity of these materials. So there is a need to discover out optional materials to replace the concrete materials as partial or complete replacement. Due to excessive need of these materials we are affecting the environment which will have adverse effects on earth. To prevent such effects there is need to find such materials which will not affect nature. This can be done by utilizing waste materials as replacement of concrete constituents. The wastes can be from agricultural, constructional and industrial waste which can be used as an alternative of construction materials. The wastes from all these sources needs to be dumped which requires large space of land, which in turn affecting the habitat. So to prevent nature, these wastes are being utilised in concrete as a partial replacement/additive material to reduce landfill problem. For experimental study, waste concrete was used as a replacement by weight with coarse aggregates called RCA. It was obtained from waste concrete which was broken into smaller pieces which could be used as replacement of CA. RCA was used in different %ages varying from 0-100% for different mixes.

RHA is a farming bi-product of smoldering rice husk under controlled temperature of below 800°C. It contains higher amount of silica content which makes it highly pozzolanic. RHA was used as fractional replacement of binder in various percentages of 0-20% for different concrete mixes.

PVA is a supreme eco-friendly cement reinforcing material. It has unique molecular structure which helps concrete from crack formation and improves bending strength.

2. MATERIALS

2.1. Cement

The cement used to perform experimentation was OPC 43 grade confirming to IS-8112:2013. Several tests were performed on OPC 43 grade cement, following observation were drawn as shown in table 1.

Table 1: Substantial properties of OPC 43 grade cement

S.NO.	Particular	Values Opted	IS:8112-2013
1	Specific gravity	3.12	3.10-3.15
2	Primary setting time	33 min	30 min
3	End setting time	182 min	600 min
4	Consistency	32%	30-35%

2.2. Rice Husk Ash

RHA is a farming bi-product of smoldering rice husk under controlled temperature of below 800°C. It contains higher amount of silica content which makes it highly pozzolanic. The specific gravity of RHA is 2.14.

Table 2 Properties of RHA

S.NO.	Properties	Values
1	SiO_2	85-90%
2	Fe_2O_3	0.07%
3	CaO	0.21%
4	MgO	0.11%
5	K_2O	0.22%
6	Na_2O	0.24%
7	Loss on ignition	2.98%

2.3. Aggregates

A. Coarse Aggregates

Coarse aggregates are one of main material in concrete which plays momentous role in strength advancement. The aggregates were taken from an area crusher, irregular and angular shape. The aggregates whose size varies between 12.5mm to 20mm were used in study. The specific gravity of CA was 2.74 which confirm to IS 383-1970.

B. Fine Aggregates

Fine aggregates were taken from river sand which is free from impurities. The aggregates were passed through 4.75mm sieve size of zone II confirming IS 383-1970. Specific gravity of FA was 2.62 and water absorption of 0.92.

C. Recycled Concrete Aggregates

Recycled concrete aggregates were prepared from throw away concrete taken from NH-5 site near Chandigarh University. The aggregates used having size between 20 mm to 10mm and had specific gravity of 2.40 and have water absorption of 4.8.

2.4. Polyvinyl Alcohol Fibre

PVA fibre was used in concrete mix have 6mm length and aspect ratio of 428. The fibre percentage used was 0.25% by weight of concrete. Formula for PVA is $(CH_2CHOH)_n$.

Table 3 Properties of PVA fibre

S.NO.	Characteristics	Values
1	Configuration	Bunchy Monofilament
2	Color	Off white
3	Specific Gravity	1.30
4	Length	6mm
5	Tensile Strength	1100-1400 MPa

2.5. Admixture

Admixture used for the present research work was SIKAPLAST 4202 NS which is basically a water reducing super plasticizer. The admixture was taken from SIKA INDIA Pvt.Ltd.

Table 4 Properties of admixture

S.NO.	Characteristics	Value
1	Type	Poly carboxyl Ether(PCE)
2	Form	Liquid
3	Color	Dark Brown
4	Specific Gravity	1.10
5	PH	>6

6	Dosage	0.5%to2% by weight of cement

2.6. Water

Water used for the mixing purpose was free from all kind of impurity.

3. MIX PROPORTIONS

Mix design was prepared confirming code IS: 10262-2009. RHA was added as a surrogate of cement by weight in dissimilar percentages such as 5%, 10%, 15% and 20%. RCA was used as surrogate of natural coarse aggregate in dissimilar percentages 25%, 50%, 75% and 100%. PVA fibres were added as an addition to the mix with a fixed percentage of 0.25% by weight of concrete.

Table 5 Concrete mix proportions

Mix	PVA fibre (%age)	RHA (%age)	RCA (%age)	Water cement ratio
C	0	0	0	0.40
M1	0.25	0	100	0.40
M2	0.25	5	75	0.40
M3	0.25	10	50	0.40
M4	0.25	15	25	0.40
M5	0.25	20	0	0.40

4. EXPERIMANTAL WORK

4.1. Compressive Strength

The ability of a material to endure loads tending to failure can be tested by performing compressive strength test on that specimen. Concrete Specimens of size 150x150x150 mm were prepared for the testing of compressive strength. Cube strength was determined later than 7 days & 28 days of remedial with water. The strength was premeditated by applying load at a rate of 5kN/sec. The test was performed as per IS 516-1959.

$$\text{Compressive strength} = \frac{Load\ at\ failure}{Cross\text{-}sectional\ Area}$$

4.2. Splitting Tensile Strength

Concrete is a brittle material and frail in tension so to check how much direct tension it can abide we perform split tensile strength test. Concrete cylinder of size 150 mm dia. & 300 mm in stature were casted. Split strength of cylinder was determined later than 7 days & 28 days of remedial with water. The test was performed as per IS 5816-1959.

$$\text{Splitting Tensile Strength} = \frac{2P}{\pi LD}$$

4.3. Flexural Strength

Flexural strength of an unreinforced concrete beam was tested to check its failure in bending. For this, the beams of size 500x100x100 mm were casted and strength was determined after 7 days & 28 days remedial with water. Loading system used for testing of beams was two-point loading system. The test was performed as per IS 516-1959.

$$\text{Flexural strength of the beam} = \frac{PL}{BDD}$$

4.4. Ultrasonic Pulse Velocity

Internal flaws or homogeneity of concrete cubes were checked with Ultrasonic pulse velocity testing apparatus. Specimen values for UPV were checked after 28 days curing with water. The transmitting end and receivers end were positioned in direct transmission mode on the cube sample. The size of the specimen was 150x150x150 mm.

5. RESULTS AND ANALYSIS

5.1. Compressive Strength

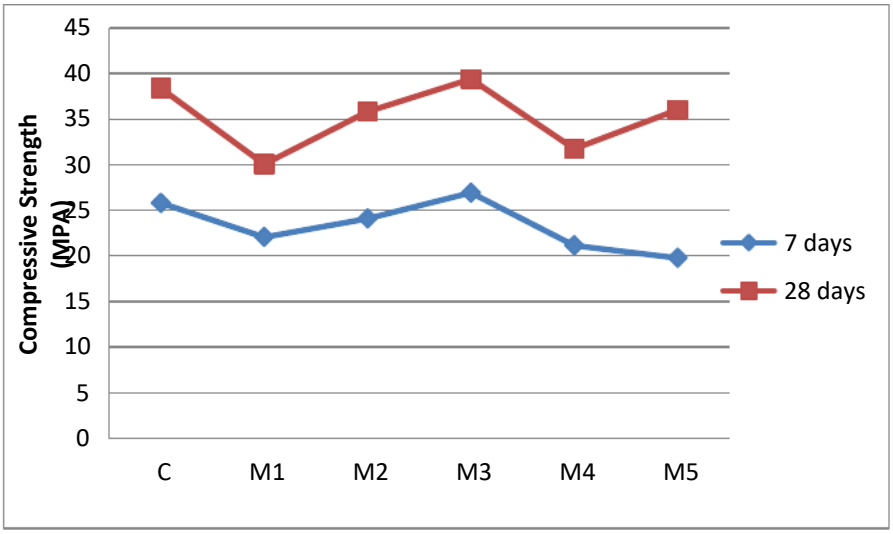

Figure 1 Compressive Strength test Results

5.2. Flexural Strength

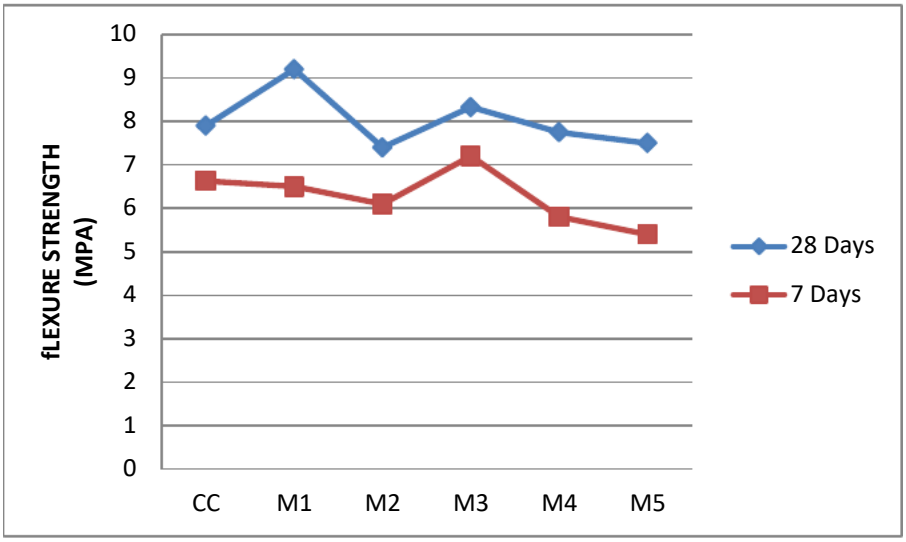

Figure 2 Flexural strength test results

5.3. Splitting Tensile Strength

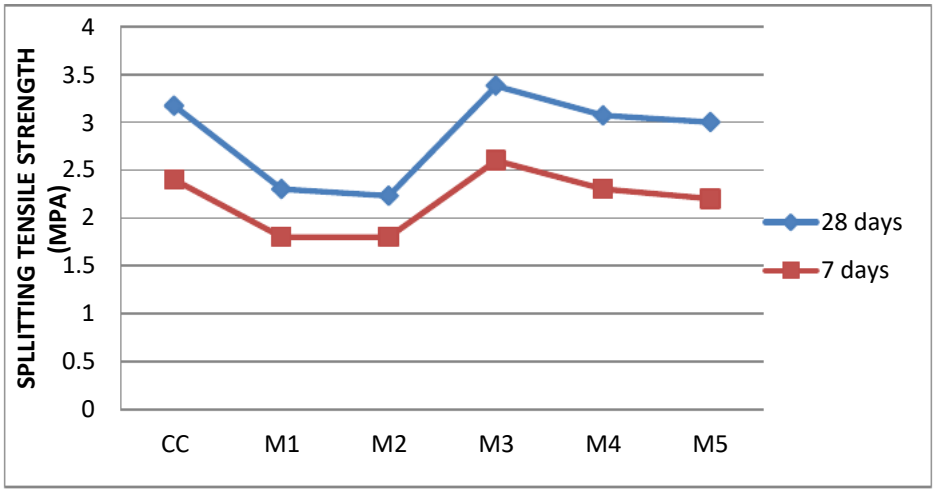

Figure 3 Split tensile strength test

5.4. Ultrasonic Pulse Velocity Test

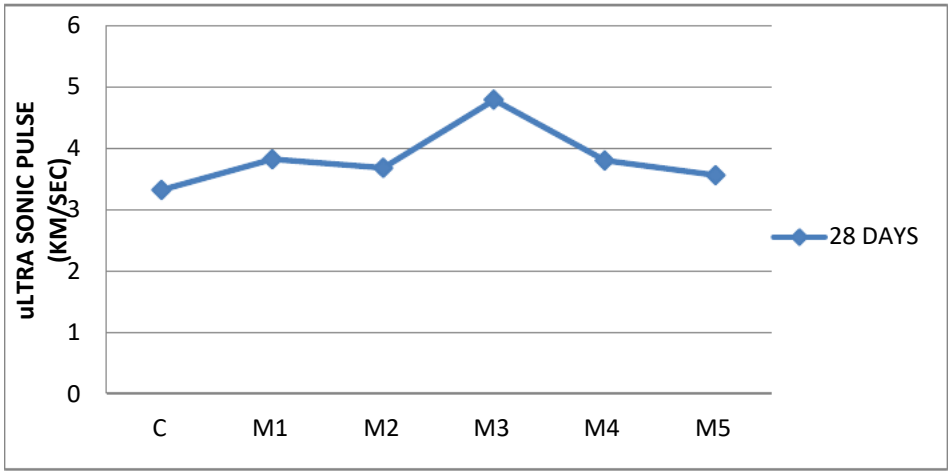

Figure 4 UPV test results

5.5. Scanning Electron Microscopy

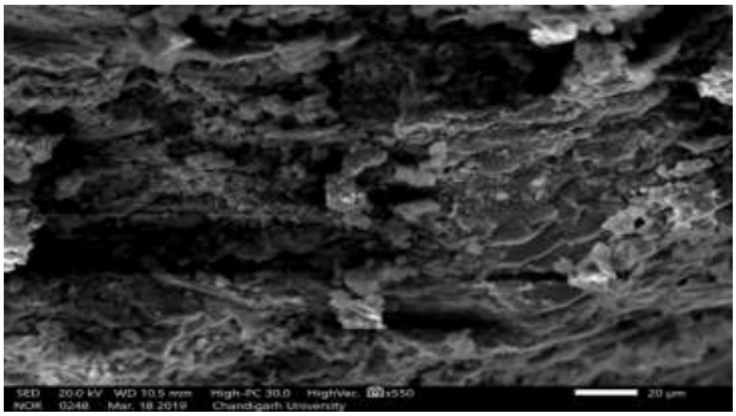

Figure 5 SEM image of M3 mix.

6. CONCLUSIONS

Outcome from experimental work leads to the subsequent conclusions:

- The experimental work reveals that mechanical properties of concrete added with RCA have close semblance in results to conventional concrete.
- For 50% substitution (M3 mix) of RCA with CA have shown better results than conventional concrete for compressive strength after 28 days.
- On 10% replacement of cement with RHA and 50% RCA with CA in addition to 0.25% PVA fibre the compressive strength achieved is more than target mean strength of control mix.
- Split tensile strength for 28 days of M2 & M3 mixes is higher than conventional concrete.
- Flexural strength of the design mixes M1 and M3 have higher strength than conventional concrete.
- The maximum value was obtained for M2 mix in which 50% RCA and 10% RHA was added as replacement of CA and cement respectively and 0.25% of PVA fibre were added to the mix.
- Ultrasonic pulse velocity for M3 design mix had shown excellent results.
- The results for M3 mix has shown good bonding strength due to the addition of cementitious material RHA and PVA Fibre which improves microstructure of concrete as shown in SEM.

Hence RCA, RHA and PVA fibre can be effectively used in concrete as ingredient replacement for almost all mixes. These materials have extra advantage of cost effectiveness and are environmental friendly.

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