Strength assessment of concrete using rice husk ash, recycled concrete aggregate and polyvinyl alcohol fiber

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Abstract: This research work presents the finest proper mix by adding and replacing with some admixture materials having same properties as standard concrete materials. The substances that are used in this Rice husk ash (RHA) Recycled concrete aggregates (RCA) and polyvinyl alcohol fiber (PVA). Coarse aggregates was replaced with RCA at 50% and 0-20% RHA in scheming concrete mixes. For this, 5 to 20% (such as 5%, 10%, 15% and 20%) of RHA has been used as a fractional replacement of cement. PVA fiber has been added to this mix at fixed percentage of 0.50% by weight of concrete. 6 mm geometric length of PVA fiber which were aspect with ratio of 428 were used in this research work. In the present research work I did non-destructive and destructive tests after 7 days and 28 days. The values of tests were 10% for RHA and 50% of RCA with fiber fulfills which was PVA which were designed as for the requirement of construction industry. The results show that by adding more amount of RHA and RCA the concrete strength starts decreasing. Tests performed over concrete: Rebound Hammer Test, Flexural Strength Test, Water Absorption Test, Compressive Strength Test, Split Tensile Strength Test, and Ultrasonic Pulse Velocity Test.

Keywords: Recycled concrete aggregate, polyvinyl alcohol, Rice husk ash, Compressive strength etc.

1. INTRODUCTION
1.1 General
The waste from construction which is increasingly accumulated due to demolition of old structure is also an environmental concern. In India, the Pollution Board has made research that 48 million tones solid waste is generated about every year and out of which 25% solid waste is from the construction field. In this research work the calculated amount of waste concrete with amount of calculated recycled aggregates which is called RCA were used as for experimental work. Some waste concrete was broken to small pieces first and then were used as in place of coarse aggregates [1–4]. The concrete which I prepared was having more amount of Silica which the concrete was a highly Pozzolanic Concrete. From 0 to 20 percent of RHA was used in place of binder in different
concrete mixes. PVA fiber is a cement reinforcing, highly eco-friendly material. PVA fiber which having Special molecular structure which has great ability to prevent crack formation in concrete and improve the flexural strength properties of the concrete.

1.2 Recycled Concrete Aggregate
Recycled concrete aggregates are obtained from old constructional waste. Due to higher porosity in recycled concrete aggregates it was found that there is need of 5% extra water for concrete mixing to gain the similar workability. Due to texture and shape index of these aggregates workability may also get affected. The shape index, absorption and density of raw and recycled aggregates depend upon the age of the concrete waste that we have recycled to prepare RCA. Concrete prepared from 50% of recycled aggregate needs high quantity of binder to gain high compressive strength. RCA is very much helpful in reducing the cost of construction [5], See Table 1 and figure 1.

![Figure 1 Recycled Concrete Aggregate](https://www.indiamart.com/proddetail/recycled-concrete-aggregate-18310988530.html)

| S.no. | Property                   | Value        |
|-------|----------------------------|--------------|
| 1     | Absorption                 | 2.03         |
| 2     | Specific gravity           | 2.53         |
| 3     | Moisture content           | 1.57%        |
| 4     | Bulk density               | 1250 kg/m³   |
| 5     | Angularity number          | 9.50         |
| 6     | Fineness modulus           | 6.79         |
| 7     | Aggregate impact value     | 12.7%        |
| 8     | Nominal Maximum Size       | 20mm         |
| 9     | Open porosity              | 5.03         |
| 10    | Oven dry specific gravity  | 2.48         |

1.3 RICE HUSK ASH
RHA is a produce of farming product of rice husk which after burning husk under restricted
temperature conditions of below 800°C converted into ash. There are mainly two modes to flame rice husk: restricted and unrestricted methods. Firstly the rice husk burned in open area under normal temp varying from 300°C to 450°C and converted into ash [6–8]. This method of burning rice husk was uncontrolled in which burning temperature was below 500°C, so the ignition was not complete and after testing some quantity of un-burnt carbon substance was found in the form of ash. Due to the presence of un-burnt carbon content in ash the uncontrolled method is less preferred than controlled method of burning husk because the burning is done at higher temperature ranging 550°C and 700°C by incinerating temp for 1 h which converts the silica of the ash into amorphous form, see figure 2 and table 2.

![Rice Husk Ash](https://www.indiamart.com/proddetail/rice-husk-ash-4217927062.html)

| S.no. | Property                      | Value         |
|-------|-------------------------------|---------------|
| 1     | Dampness                      | 3.7%          |
| 2     | Color                         | Dark grey     |
| 3     | Specific surface area         | 22,000-23,000 kg/m² |
| 4     | Size of particle              | 75-100 umm    |
| 5     | Silicon dioxide               | 70-90%        |
| 6     | Alumina                       | 1-5%          |
| 7     | Specific gravity              | 2.27          |
| 8     | Liquid limit                  | 45.63         |
| 9     | Plastic limit                 | Non-Plastic   |
| 10    | Maximum dry density           | 1.19          |

1.4 POLYVINYL ALCOHOL
The material Polyvinyl alcohol fiber is a supreme environment-friendly cement reinforced material, which has a unique molecular structure helps against alkali and weather effect [9,10], taking on excellent resemblance to cement, very effective in prevention of crack development, enhances several engineering properties of the conventional concrete. It has high elastic modulus and
strength as compared to other common natural fiber which are mainly used in reinforcing concrete. Fiber prolongation is about 6-10%. PVA fiber has tensile strength of fiber fluctuate between 880-1600MPa below. One of the main uniqueness of PVA fiber is strong bond forming ability with cement matrix. The doses of PVA fiber varies from 0.1% to 2% by weight of total mix, see Table 3.

Table 3 Properties of Fiber

| S.no. | Properties               | Values           |
|-------|--------------------------|------------------|
| 1     | Specific gravity         | 1.31             |
| 2     | Moisture content         | 0.5%             |
| 3     | Young’s modulus          | 2750-3050 MPa    |
| 4     | Tensile strength         | 180-350 MPa      |
| 5     | Length                   | 19-22 mm         |
| 6     | Diameter                 | 0.19-0.22mm      |
| 7     | Fusion temperature       | 249°C            |
| 8     | Colour                   | Whitish          |
| 9     | Ultimate strain          | 20%              |
| 10    | Density                  | 1.41 g/cm³       |
| 11    | Melting point            | 249°C            |
| 12    | Transition temperature   | 69°C             |

2. LITERATURE REVIEW

2.1 GENERAL

Present work has been done after studying literature from previous work. The main aim of the research work was to learn the strength parameters of recycled concrete aggregate specimen using Rice Husk Ash as partial substitution of cement (by weight) at 5%, 10%, 15%, 20% and Recycled aggregate substitution of coarse aggregate at 50%. PVA fiber was used at a preset percentage of 0.25% by total in place of concrete [11,12]. Various Researchers worked on the enrichment of strength and stability properties of the concrete by substitution of RHA as cement alternative. The study focuses on durability tests that are to be performed on the binder concrete in acidic mix of 5 wt.% NaCl and 5 wt.% H₂SO₄ by addition various sizes and natures of rice husk ash. From research it was observe that, lowering RHA size increases the pozzolanic reaction rate and bulk density; durability of RHA incorporated concrete boosts by decreasing thermal diffusivity. An experiential sample foresees the mechanical and stability of RHA added binder concrete adequately. The strength in compression increases with reducing the particle size of RHA in concrete design mixes. The corrosive fighting of the RHA alternative in cement concrete is multiplied for declining thermal diffusivity [13,14].

laboured on thermal balance of PVA fibre stress hardening cement-based totally composites. Present paper reviews the answers of a research at the impact of PVA fibre on pre-heating and on the strength performance of PVA pressure fermenting binder-based totally composites with the use of uni-axial tensile, flexibility and compression exams. Checks have been carried out on the casted samples which had been previously heat up to temp varying from ninety °C to 250°C and unheated samples. The heating variations were chosen primarily based at the effects of thermal exams taken.
out to analyse the thermal poverty of the PVA fibre. The effects shown that samples preheated to 90°C supplied a pressure hardening conduct with a stated a couple of cracking sample. This reaction is sort of the same as located for the unheated specimens. Compressive electricity of the composite has indicated a growth as much as one hundred ninety °C because of a fine-tuning of the matrix pore shape as indicated by way of the micro-structural research [15–17].

considered the progressed flexural fatigue fighting of PVA fibre-reinforced concrete studied below the accomplishment of freezing and thawing reputations. undeniable and PVA fibre-strengthened concrete samples had been processed under the action of freezing and thawing cycles, then a flexural weakness check with a wheel load turned into executed with a pressure intensity in the variety. The impact of PVA fibre reinforcing on the flexural fatigue fighting changed into appraised by the pressure ratio–fatigue lifestyles courting. The flexural fatigue take a look at effects showed that recurring freezing and thawing moves no longer simplest decreased the static power but also dramatically reduces the confrontation to fatigue failure. PVA fibre reinforcement helps in the flexural fatigue power improvement of concrete under thawing and freezing cycles because of increase within the resistance for thawing and freezing movement and the barrier for flexural fatigue failure [18–20].

3. OBJECTIVES
The major purpose of the current study is to increase and relate the strength parameters of concrete consuming recycled concrete aggregates as complete replacement of Coarse aggregates and rice husk ash as fragmentary in place of cement. To achieve this goal certain sub-objectives needs to be considered which are as follows:

- To study the effect of recycled aggregate, rice husk ash and polyvinyl alcohol fiber over strength of the conventional concrete using compressive strength test.
- To study the effect of recycled aggregate, rice husk ash and polyvinyl alcohol fiber over flexural strength of the conventional concrete using flexural strength test.
- To study the effect of recycled aggregate, rice husk ash and polyvinyl alcohol fiber over split tensile strength of the conventional concrete using split tensile strength test.
- To define the numerous other strength aspects of the recycled aggregate, rice husk ash and polyvinyl alcohol fiber based concrete using rebound hammer test, ultrasonic pulse velocity test and the water absorption test.
- To compare several strength aspects of recycled aggregate, rice husk ash and polyvinyl alcohol fiber based concrete and the conventional concrete.

4. RESULT AND DISCUSSIONS
The key objective of the research work is to learn the strength parameters of recycled concrete aggregate specimen using RHA as fractional substitution of binder at 0%, 5%, 10%, 15%, 20% and Recycled aggregate as fractional replacement of natural coarse aggregate at 50%. PVA fiber was used at a fixed percentage of 0.50% total in place of concrete. After casting, the samples are kept in water for 7 days and 28 days for proper curing. Then all the samples are tested and the test results are shown further. Concrete mix design and all the process of mixing concrete with the admixtures and preparing of concrete cubies and concrete tests were done as per Indian standards. In this concrete mix design the water cement ratio was 0.4 which all the mix design are show in Table 4.

Table 4: Mix Proportions
Mix | Substitution of cement with rice husk ash (%) | Substitution of coarse aggregate with rca (%) | Pva fiber as additive (%) | Water-binder ratio
---|---|---|---|---
M0 | 0 | 0 | 0 | 0.38
M1 | 0 | 50 | 0.50 | 0.38
M2 | 5 | 50 | 0.50 | 0.38
M3 | 10 | 50 | 0.50 | 0.38
M4 | 15 | 50 | 0.50 | 0.38
M5 | 20 | 50 | 0.50 | 0.38

4.1 Compressive Strength Test Outcomes
The mechanical strength was calculated for RHA and RCA as partial replacement with binder and CA respectively, PVA fiber as addition. RHA as fractional substitution of binder at 5%, 10%, 15%, 20% and Recycled aggregate as fractional replacement of natural coarse aggregate at 50%. PVA fiber was used at a fixed percentage of 0.50 % total weight of concrete. After casting, the specimens are kept in pool water for 7 and 28 days for proper curing, see Table 5.

Table 5: Compressive Strength Outcomes

| Mix | Compressive strength past 7 days(n/mm²) | Compressive strength past 28 days(n/mm²) |
|-----|----------------------------------------|----------------------------------------|
| M0  | 24.26                                  | 37.14                                  |
| M1  | 24.97                                  | 37.75                                  |
| M2  | 25.41                                  | 38.49                                  |
| M3  | 26.91                                  | 39.38                                  |
| M4  | 23.46                                  | 36.98                                  |
| M5  | 22.17                                  | 34.19                                  |

4.2 Flexural Strength Test Results
The flexure strength was calculated for RHA and RCA as partial replacement with binder and CA respectively, PVA fiber as addition. RHA as fractional substitution of cement at 5%, 10%, 15%, 20% and Recycled aggregate as fractional replacement of natural coarse aggregate at 50%. PVA fiber was used at a fixed percentage of 0.50 % total in place of concrete. After casting, the samples are kept in pool of water for 7 days and 28 days for proper curing. Results for flexural strength are shown in Table 6.

Table 6 Flexural Strength Outcomes

| Mix | Flexural strength past 7 days(n/mm²) | Flexural strength past 28 days(n/mm²) |
|-----|-------------------------------------|-------------------------------------|
| CC  | 4.37                                | 6.14                                |
| M1  | 4.75                                | 6.59                                |
| M2  | 4.97                                | 7.09                                |
| M3  | 5.21                                | 7.33                                |
| M4  | 4.46                                | 6.19                                |
| M5  | 3.84                                | 5.94                                |
4.3 Split Tensile Strength Test Results

The split tensile strength was calculated for RHA and RCA as partial replacement with binder and CA respectively, PVA fiber as addition. Rice Husk Ash as fractional substitution of cement at 5%, 10%, 15%, 20% and Recycled Concrete aggregate as fractional replacement of natural coarse aggregate at 50%. PVA fiber was used at a fixed percentage of 0.50% by total in place of concrete. After casting, the specimens were kept in water for 7 and 28 days for proper curing. Results and observations are shown in Table 7.

| Mix | Split tensile strength past 7 days (N/mm²) | Split tensile strength past 28 days (N/mm²) |
|-----|------------------------------------------|------------------------------------------|
| CC  | 2.24                                     | 2.97                                     |
| M1  | 2.49                                     | 3.16                                     |
| M2  | 2.54                                     | 3.22                                     |
| M3  | 2.61                                     | 3.38                                     |
| M4  | 2.26                                     | 3.06                                     |
| M5  | 2.21                                     | 2.84                                     |

5. Conclusion, Limitations and Future Scope

The outcome of the various experiments performed i.e. for compressive strength, split tensile strength, flexural strength, is as under:

- The compressive strength of concrete starts decreasing suggestively after addition of 10% Rice Husk Ash as substitution of OPC-43. The rate of declining in compressive strength rises with the raise in RHA amount which affect the bonding in the concrete mixture.
- Compressive strength of concrete specimens had shown better result at 50% replacement of RCA with NCA. For higher percentage of RCA replacement the strength starts decreasing which is due adhered mortar in RCA which affect bonding and due higher water content needed for mix strength gets affected.
- The specimen with 50% substitution of RCA and 10% of rice husk ash had maximum split tensile strength than that of achieved concrete. This is due to good homogeneous mixture formation and appropriate quantity of Silica content to form higher C-S-H gel leads to higher strength also the microstructure gets improved.
- Results of flexural strength showed rise in strength of specimen with 50% RCA and 10% RHA for higher percentages strength gets decreased. But for 100% RCA with 0.25% PVA fiber the results for flexure strength had shown better results than other mix which is due PVA fiber which have formed good bond with RCA due to their shape index.
- The addition of PVA fiber to the mix which had shown great characteristics in improving the microstructure of the concrete. Due to this mechanical properties have shown higher strength.
- Super-plasticizer had been added to all the design mix and the percentage used was 1%. Water content used was reduced by 10% by adding super-plasticizer which has direct impact on the strength of the specimen. Mechanical properties of the specimen had shown better results as related to the control mix.

5.1 Limitations

- Addition of Rice Husk Ash increases the water absorption and by this concrete become the
less workable. For ease of placement addition of the admixture should be necessary.

- Use the unburned Rise Husk Ash concrete production is not acceptable.
- Adding of Recycle Aggregate beyond the certain % demote the quality of the concrete
- Adding of Recycle Aggregate effect the durability of concrete. To overcome the problem has to add special substance such as Fly ash.

5.2 Future Scope

- Cost saving and Increasing Strength:- Rise Husk Ash (RHA) is better material than any other additional substance which involve higher transportation cost.
- Recycling Material :- Using of Recycled Concrete Aggregates is very much helpful in decreasing the manufacturing cost of concrete.
- By adding of Poly Vinyl Alcohol the concrete will be more durable against alkali and weather effect and Increases its impact and abrasion resistance

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