Comparison of the Strength Properties of Concrete Using Fly Ash & Rice Husk Ash as a Partial Replacement of OPC

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Abstract - *In the construction industry, we can't think without concrete. Concrete is a crucial component of every construction project and Cement is the primary ingredient in this concrete. However, we must reduce cement production in this case for two reasons. The first reason is that cement is quite expensive and the second reason is that cement production has a significant negative impact on the environment. Cement production produces carbon dioxide (CO_2), which contributes to greenhouse gas emissions. To reduce the production of cement, we have partially replaced the waste materials (Fly Ash & Rice Husk Ash) with Ordinary Portland Cement (OPC) and in this study, we investigated the strength properties of concrete by partially replacing waste Fly Ash (FA) & Rice Husk Ash (RHA) with Ordinary Portland Cement. The aim of the present study is to compare the compressive and Split Tensile strength of concrete prepared with partial replacement of ordinary Portland cement with fly ash at different percentages (5, 10, 15, 20, 25, and 30) and RHA at different percentages (5, 10, 15, 20, 25, and 30).*

Key Words: **Fly Ash, Rice Husk Ash, Ordinary Portland Cement, Compressive Strength, Split Tensile Strength, Compare, Replacement, Concrete, Universal Testing Machine etc.**

1. INTRODUCTION

In the construction industry, concrete is the most essential and important engineering material. The demand for concrete is steadily increasing. Cement is one of the major components of concrete. Making cement is having a very bad impact on our environment. Approximately 5% of global anthropogenic carbon dioxide emissions are attributed to the cement industry. This is a major problem for our environment. As a result, many researchers have been working on this problem over the past few years. Many studies have demonstrated that replacing OPC with Fly Ash and Rice Husk Ash produces excellent results.

1.1 Fly Ash (FA)

Fly Ash is a fine powder produced by the combustion of pulverized coal in an electric power plant. A tremendous amount of ashes is produced by a power plant, which is being disposed of as waste. It has the potential to harm both our environment and our health. So, it is necessary to reduce the amount of fly ash waste disposal by using it as a partial replacement with cement It's a pozzolanic material, which means it's made up of alumina and siliceous element. Concrete strength is improved by using fly ash.

1.2 Rice Husk Ash (RHA)

Rice Husk Ash is an agricultural waste. It is made by burning Rice Husk (RH). The burning method and temperature have an impact on RHA's chemical characteristics. The amount of silica in the ash increases as the burning temperature rises. RHA is a highly reactive pozzolanic material because of its high silica content. RHA is being disposed of as waste like fly ash. It has the ability to pollute the environment. So, it also needs to reduce the amount of Rice Husk Ash waste disposal by using it as a partial replacement with OPC. Using it has various advantages, including increased strength, durability, reduced cost of concrete, and reduced carbon dioxide emissions.

Fly Ash and Rice Husk Ash are example of waste products with pozzolanic characteristics. This study can able to using cementitious materials (Fly Ash & Rice Husk Ash) as a Partial Replacement with OPC.

The compressive strength of each concrete mix was tested on 150×150×150 mm cubes after 7, 14, and 28 days of curing. The Split tensile test was performed on a cylinder with a diameter of 150mm and a length of 300mm. After 7, 14, and 28 days of curing, the test was conducted.

2. MATERIAL USED

2.1 Cement

For this experiment, the most common cement used is Ordinary Portland Cement (OPC). The cement used is Ordinary Portland Cement of Grade 53, as specified by

IS:8112-1989. The physical properties of cement are given in Table 1.0. and Table 2.0 shows the chemical composition of OPC as determined by X-ray analysis.

Table 1.0: Physical Properties of Ordinary Portland Cement

Properties	Test Results	Confirmation Code
Specific gravity	3.10	IS 4031-1998 permissible range 3.1-3.15
Standard Consistency (%)	32%	IS 8112-1989 permissible range 30-35%
Fineness	357 m^2/kg	IS 8114-1989 shall not be less than 225 m^2/kg
Soundness	4 mm	IS 8114-1989 shall not be more than 10 mm
Initial setting time	56 min	IS 8112-1989 not less than 30 not more than 600
Initial setting time	565 min	

Table 2.0: Chemical Properties of Ordinary Portland Cement

Properties	Test results
Silica (SiO_2)	18.20%
Alumina (Al_2O_3)	6.70%
Iron Oxide (Fe_2O_3)	2.00%
Lime (CaO)	65.50%
Magnesia (MgO)	1.60%
Sulphur Trioxide (SO_3)	1.85%
Sodium Oxide (Na_2O)	0.12%
Potassium Oxide (K_2O)	0.85%
Loss on Ignition	2.65%

2.2 Fine Aggregate

As a fine aggregate, river sand that passed through an IS 4.75 mm sieve and confirmed to zone II according to IS: 383-1970 was used. Physical tests have been performed as per IS 2386. The results are given in Table 3.0.

Table 3.0: Chemical Properties of Fine Aggregate

Properties	Test results
Particle Shape	Round
Size	4.75 mm down
Specific gravity	2.62
Water absorption	1.60%

2.3 Coarse Aggregate

As a coarse aggregate, sizes ranging from 20 mm to 4.75 mm are used. The sieve analysis of aggregates confirms the specification of IS: 383-1970. Physical tests have been performed as per IS 2386. The results are given in Table 4.0.

Table 4.0: Chemical Properties of Coarse Aggregate

Properties	Test results
Particle Shape	Angular
Size	20 mm
Specific gravity	2.67
Water absorption	1.10 %

2.4 Water

The water used in the research was potable water, as specified by IS 456-2000. The water was clear and free of obvious contaminants.

2.5 Fly Ash

Fly Ash used in the current investigation is an industrial by-product of coal-fired power plants. Class F Fly Ash was used for this investigation. The Specific gravity of Fly Ash (Class F) 2.3. Table 5.0 presents the physical properties and the chemical composition of FA as discovered by X-ray analysis is shown in Table 6.0.

Table 5.0: Physical Properties of Fly Ash

Properties	Test results
Colour	Whitish grey
Specific gravity	2.3
Particle Shape	Spherical

Table 6.0: Chemical Properties of Fly Ash

Properties	Test results
Silica (SiO_2)	63.04%
Alumina (Al_2O_3)	26.57%
Iron Oxide (Fe_2O_3)	3.10%
Lime (CaO)	1.46%
Magnesia (MgO)	1.35%
Sulphur Trioxide (SO_3)	1.03%
Sodium Oxide (Na_2O)	0.73%
Potassium Oxide (K_2O)	1.13%
Loss on Ignition	1.30%

2.6 Rice Husk Ash

Rice Husk Ash was made by burning Rice Husk (RH). It is an agricultural waste product. The Specific gravity of Rice Husk Ash 2.1. Table 7.0 presents the physical properties and the chemical composition of RHA as discovered by X-ray analysis is shown in Table 8.0.

Table 7.0: Physical Properties of Rice Husk Ash

Properties	Test results
Colour	Grey
Specific gravity	2.1
Particle Shape	Irregular

Table 8.0: Chemical Properties of Rice Husk Ash

Properties	Test results
Silica (SiO_2)	95.20%
Alumina (Al_2O_3)	0.24%
Iron Oxide (Fe_2O_3)	0.59%
Lime (CaO)	0.44%
Magnesia (MgO)	0.38%
Sulphur Trioxide (SO_3)	0.17%
Sodium Oxide (Na_2O)	0.10%
Potassium Oxide (K_2O)	1.67%
Loss on Ignition	1.12%

3. EXPERIMENTAL PROGRAMME

This mix design approach was used in this research to obtain the M30 grade conforms with IS 10262:2009 and 456:2000. Following obtaining the proportions of Control concrete, the trial mix was determined to be 1:1.42:2.46 for a water-cement ratio of 0.45. (Shown in Table 9.0)

Table 9.0: Mix Specification of 1 m³ Control Concrete

Cement (kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (kg/m³)	Water (kg/m³)
438.13	622.35	1079.91	197.16
1	1.42	2.46	0.45

Replacement approaches are explored for Fly Ash and Rice husk ash (RHA) concrete. Waste Materials (Fly Ash & Rice Husk Ash) have been used to partially replace OPC on a weight basis. (Shown in Table 10.0)

Table 10.0: Mix Specification of 1 m³ Fly Ash & Rice Husk Ash Concrete

MIX	Cement (kg/m³)	Fly Ash (kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (kg/m³)	Water (kg/m³)
5% FA	416.22	21.91	622.35	1079.91	197.16
10% FA	394.32	43.81	622.35	1079.91	197.16
15% FA	372.41	65.72	622.35	1079.91	197.16
20% FA	350.5	87.63	622.35	1079.91	197.16
25% FA	328.6	109.53	622.35	1079.91	197.16
30% FA	306.69	131.44	622.35	1079.91	197.16
5% RHA	416.22	21.91	622.35	1079.91	197.16
10% RHA	394.32	43.81	622.35	1079.91	197.16
15% RHA	372.41	65.72	622.35	1079.91	197.16
20% RHA	350.5	87.63	622.35	1079.91	197.16
25% RHA	328.6	109.53	622.35	1079.91	197.16
30% RHA	306.69	131.44	622.35	1079.91	197.16

All of the tests on hardened concrete were carried out using a Universal Testing Machine (As shown in figure 1.0). The tests were conducted for compressive and split tensile strength.

Figure – 1.0: Universal Testing Machine (UTM)

4. TEST RESULTS

After 7 days, 14 days, and 28 days of normal curing, the compressive and split tensile strength was determined.

The results of the overall compressive strength of control & Fly Ash concrete are shown in table 11.0 below.

Table 11.0: Compression Strength (N/mm²) of Fly Ash

Types of Concrete	7 Days	14 Days	28 Days
100 OPC	22.11	27.80	34.70
95% OPC + 5% FA	21.50	27.13	35.11
90% OPC + 10% FA	20.11	25.49	35.91
85% OPC + 15% FA	18.61	24.26	32.30
80% OPC + 20% FA	16.93	21.37	31.90
75% OPC + 25% FA	15.38	20.33	31.10
70% OPC + 30% FA	11.29	18.74	25.37

Figure – 2.0 shown the result of the compression strength of Control and Fly Ash Concrete in graphical representation.

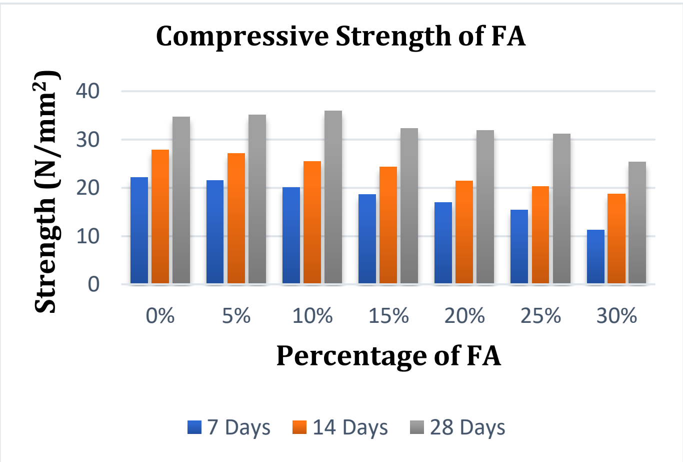

Figure – 2.0: Compressive Tensile Strength Test Result of Fly Ash

The results of the overall compressive strength of control & Rice Husk Ash concrete are shown in the table 12.0 below.

Table 12.0: Compression Strength (N/mm²) of Rice Husk Ash

Types of Concrete	7 Days	14 Days	28 Days
100 OPC	22.11	27.80	34.70
95% OPC + 5% RHA	20.62	26.34	37.26
90% OPC + 10% RHA	20.91	26.94	36.69
85% OPC + 15% RHA	19.50	25.10	33.93
80% OPC + 20% RHA	18.10	22.82	31.84
75% OPC + 25% RHA	17.31	20.19	27.33
70% OPC + 30% RHA	12.23	18.75	24.11

Figure – 3.0 shown the result of the compression strength of Control and Rice Husk Ash Concrete in graphical representation.

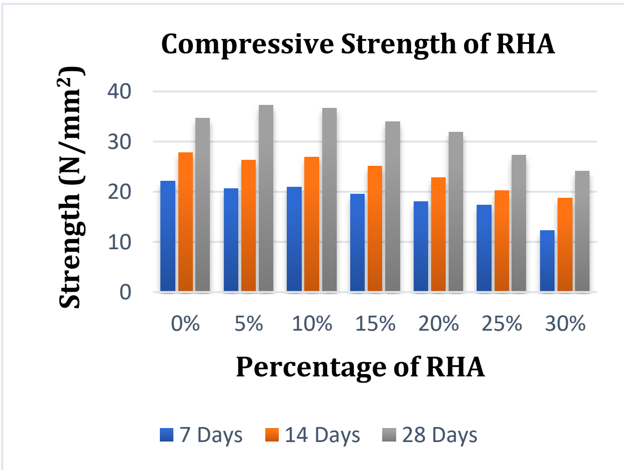

Figure – 3.0: Compressive Strength Test Result of Rice Husk Ash

The results of the overall Split Tensile strength of control & Fly Ash concrete are shown in the table 13.0 below.

Table 13.0: Split Tensile Strength (N/mm^2) for Fly Ash

Types of Concrete	7 Days	14 Days	28 Days
100 OPC	2.16	2.40	3.06
95% OPC + 5% FA	2.53	2.84	3.21
90% OPC + 10% FA	2.40	2.90	3.10
85% OPC + 15% FA	1.90	2.20	2.35
80% OPC + 20% FA	1.43	1.70	1.90
75% OPC + 25% FA	1.16	1.56	1.71
70% OPC + 30% FA	1.02	1.15	1.20

Figure – 4.0 shown the result of the split tensile strength of Control and Fly Ash Concrete in graphical representation.

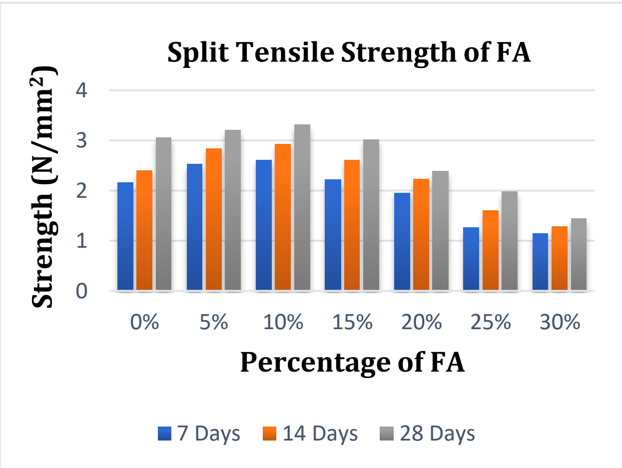

Figure – 4.0: Split Tensile Strength Test Result of Fly Ash

The results of all Split Tensile strength of control Concrete and concrete made with Rice Husk Ash are shown in Table 14.0 below.

Table 14.0: Split Tensile Strength (N/mm^2) of RHA Concrete

Types of Concrete	7 Days	14 Days	28 Days
100 OPC	2.16	2.40	3.06
95% OPC + 5% RHA	2.85	2.96	3.30
90% OPC + 10% RHA	2.20	2.60	3.02
85% OPC + 15% RHA	2.10	2.22	2.56
80% OPC + 20% RHA	1.60	1.76	2.06
75% OPC + 25% RHA	1.18	1.53	1.79
70% OPC + 30% RHA	1.05	1.24	1.39

Figure – 5.0 shown the result of the split tensile strength of Control and Rice Husk Ash Concrete in graphical representation.

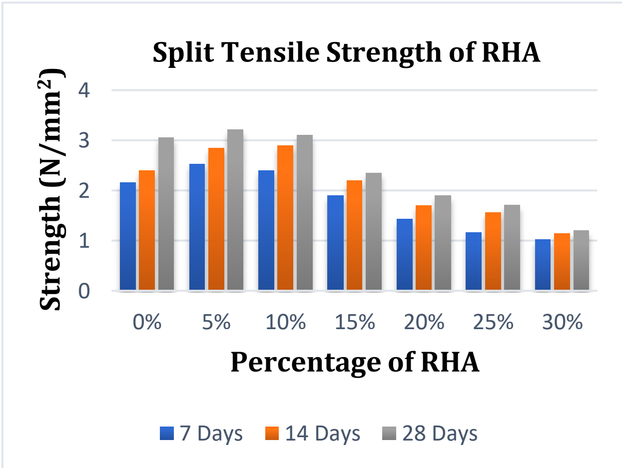

Figure – 5.0: Split Tensile Strength Test Result of Rice Husk Ash

5. CONCLUSIONS

The following is the result of a compressive and Split Tensile strength test performed on concrete with varying percentages of Fly Ash and Rice Husk Ash:

Fly Ash-

- When Fly Ash was utilized to replace the OPC, the concrete improved.
- When Fly Ash was utilized to replace 10% of the OPC, the concrete reached its maximum compressive strength of 35.91 N/mm^2 at 28 days.
- When Fly Ash was utilized to replace 5% of the OPC, the concrete reached its maximum Split Tensile strength of 3.21 N/mm^2 at 28 days.
- It has been demonstrated, Fly Ash can be used as a substitute for cement, lowering construction costs and reducing cement

use and for this, the environmental pollution will be less.

- The concrete with Fly Ash demonstrates significantly higher compressive and split tensile strength than the control concrete mix.

Rice Husk Ash-

- When Rice Husk Ash was utilized to replace the OPC, the concrete improved.
- When Rice Husk Ash was utilized to replace 5% of the OPC, the concrete reached its maximum compressive strength of 37.26 N/mm^2 at 28 days.
- When Rice Husk Ash was utilized to replace 5% of the OPC, the concrete reached its maximum Split Tensile strength of 3.30 N/mm^2 at 28 days.
- It has been demonstrated, Rice Husk Ash can be used as a substitute for cement, lowering construction costs and reducing cement use and for this, the environmental pollution will be less.
- The concrete with Rice Husk Ash demonstrates significantly higher compressive and split tensile strength than the control concrete mix.

Comparison between Fly Ash and Rice Husk Ash-

- It is observed that both Fly Ash and Rice Husk Ash are excellent waste materials for partial replacement of OPC.
- According to the experimental results the Rice Husk Ash concrete mix can produce high compressive and Split tensile strength than the Fly Ash concrete mix.
- Rice Husk Ash concrete mix produces slightly better outcomes than Fly Ash concrete mix.
- The concrete with Fly Ash and Rice Husk Ash mix both are showed significantly higher compressive and split tensile strength than the control concrete mix.

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BIOGRAPHIES

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