Enhancement of Concrete Strength by Partial Replacement of Cement with Fly Ash, Bagasse Ash and Rice Husk Ash

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Abstract— **In this study, the main concern is to find an alternative for cement. Substitution of cement by fly ash , Bagasse ash and rice husk ash will serve both solid waste minimization and waste recovery. The study focuses to determine the relative performance of concrete by using fly ash, Bagasse ash and rice husk ash. Concrete of rice husk ash, Bagasse ash and fly ash gained more strength than concrete with normal cement concrete.**

The utility of fly ash, Bagasse ash and rice husk ash as partial replacement in concrete mixes is on rise these days. Fly ash is a waste product which is generated in thermal power stations. The quantity of fly ash produced from thermal power plants in India is approximately 105 million tons each year, and its percentage utilization is less than 13%. Majority of fly ash produced is of Class F type. The use of these materials would reduce the disposal problems now faced by the thermal power stations and industrial plants. During the last few years, some cement companies have started using fly ash in manufacturing cement, known as " Pozzolona Portland Cement ", but the overall percentage utilization remains very low, and most of the fly ash is dumped at landfills.

The study focuses to determine the relative performance of concrete by using rice husk ash, Bagasse ash and fly ash, waste minimization of industrial wastes and concrete making in economically and ecofriendly

Keywords: fly ash , Bagasse ash, rice husk ash, Pozzolona Portland Cement.

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INTRODUCTION

Concrete is the most widely used man-made construction material in the world, and is second only to water as the most utilized substance on the planet. It is obtained by mixing cementing materials, water and aggregates, and sometimes admixtures in required proportions. The mixtures when placed in forms and allowed to cure, hardens into a rock-like mass known as concrete. The hardening is caused by chemical reaction between water and cement and it continues for a longtime, and consequently the concrete grows stronger with age. The hardened concrete may also be considered as an artificial stone in which the voids of coarse aggregates are filled by fine aggregates and the voids of fine aggregates are filled with cement.

1.1 COMPONENTS OF CONCRETE:

1. Cement
2. Fine aggregates
3. Coarse aggregates
4. Water
5. Fly ash
6. Rice husk ash
7. Bagasse ash
8. Super Plasticizers

1.1.1 Cement: Cement commonly used is Ordinary Portland Cement of 53 grade. Grade 53 is known for its rich quality and is highly durable. Hence it is used for constructing bigger structures like building foundations, bridges, tall buildings, and structures designed to withstand heavy pressure. The chemical components of Ordinary Portland cement are magnesium (MgO), alumina (Al_2O_3), silica (SiO_2), iron (Fe_2O_3), and Sulphur trioxide (SO_3). Ordinary Portland cement is in great demand in India and will continue to be used in Indian infrastructural up gradation and other constructions.

1.1.2 Fine Aggregates: Fine aggregates as natural sand (river sand) is a naturally occurring granular material composed of fine divided rock and mineral particles. Sand shall be durable and free from adherent coating and organic matter and not contain any appreciable amount of clay balls and pellets.

1.1.3 Coarse Aggregates: Coarse aggregates are the aggregates which are retained on 4.75mm sieve. It consists of hard, sharp, angular pieces, broken to specified size.

Aggregates shall be free from dust and dirt and washed to ensure that all faces are perfectly clean.

1.1.4 Water: Water is a liquid at standard temperature of 273.15k (0°C, 32°F). The intrinsic color of water and ice is a very slight blue hue. Water is a good polar solvent and is often referred to as the universal solvent. Water is used in concrete should be free from acids and alkalis and PH value is in between 6.5 – 8.5.

1.1.5 Fly Ash: Flyash is the ash component of coal liberated during combustion in thermal power stations. It can be used as a admixture or as replacement of Portland cement. In addition to Ordinary Portland Cement results in increased workability. Development of compressive strength is slow at longer periods of curing and develops higher strengths than the normal concrete.

1.1.6 Rice Husk Ash: Rice husk ash contains silica in amorphous and highly cellular form, with 50-1000m2/gm surface area. It minimizes the alkali-aggregate reaction , reduces expansion and blocking the large voids in hydrated cement paste through pozzolonic reaction.

1.1.7 Bagasse Ash: Bagasse ash is the ash component of coal liberated during combustion in thermal power stations. It can be used as a admixture or as replacement of Portland cement. In addition to Ordinary Portland Cement results in increased workability. Development of compressive strength is slow at longer periods of curing and develops higher strengths than the normal concrete.

1.1.7 Super Plasticizer: Super plasticizer also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. It improves the workability and reduces the tendency for segregation and bleeding. It increases the consistency and achieves higher compressive strength and also reduces the water content in concrete.

1.2 OBJECTIVES OF THE PROJECT:

In this study, the main concern is to find an alternative for cement. Substitution of cement by fly ash , Bagasse ash and rice husk ash will serve both solid waste minimization and waste recovery. The study focuses to determine the relative performance of concrete by using fly ash, Bagasse ash and rice husk ash. Concrete of rice husk ash, Bagasse as hand fly ash gained more strength than concrete with normal cement concrete.

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The study focuses to determine the relative performance of concrete by using rice husk ash, Bagasse as hand fly ash, waste minimization of industrial wastes and concrete making in economically and eco-friendly.

1.3 DETAILS OF THE PROJECT:

Conservation of natural resources and preservation of environment is the essence of any development. The problem arising from continuous technological and industrial development is the disposal of waste material. If some of the waste materials are found suitable in concrete making, not only cost of construction can be cut down, but also safe disposal of waste materials can be achieved. So in my project, an attempt has been made to assess the suitability of rice husk ash, Bagasse as hand fly ash in concrete making. In the laboratory flyash, Bagasse ash and rice husk ash has been tried as partial replacement in place of cement in concrete making. Cubes, cylinders and prisms were cast and tested for compressive strength, split tensile strength and flexural strength after a curing period of 28 days. The results indicated effectiveness of partial replacement of cement by fly ash (30%), Bagasse ash(20%)and rice husk ash (10%) without affecting the design strength.

The mix design was carried out based on the recommended guidelines in Indian Standards(IS 10262-1982). The basic assumption made in the Indian standard method for mix design is that the compressive strength of workable concrete is by and large governed by the water/cement ratio. In this method the water content and proportion of fine aggregate corresponding to a maximum size of aggregate are first determined from the reference values of workability, water-cement ratio, and the grading of fine aggregate. The water content and proportion of fine aggregate are then adjusted for any difference in workability, water/cement ratio and grading of fine aggregate in any particular case.

LITERATURE REVIEW

N. Venkat Rao, M. Rajasekhar, Dr. T. Muralidhara Rao[1] in their Research Paper "High Volume Flyash - A boon for preventing reinforcement corrosion" describes about the presence of fly ash reduces - permeability, lowers water / cement ratio and how HVFA is responsible for decrease in drying shrinkage and increases durability of the concrete. The paper also makes an effort to present some statistical data how the nations all around the world are spending much of their financial resources and what will be the cost of their resources in terms of their GNP's to draw their attention towards this global problem in the construction industry. In this it is experimentally proved that the fly ash enhances durability of reinforcement and resists sulfate attack and alkali silica.

Jagath Kumari. Dungi, and K.Srinivasa Rao[2] in their Research Paper " Optimising the Cement Content in HVFA Concrete for Durability and Sustainability " describes about the a new approach of optimising the cement content in a nominal grade concrete M20 mix of conventional concrete and 50% replacement of fly ash with cement (HVFA), in which the compressive strengths are investigated at appropriate water-to-cement ratio (w/c) to meet the target strength, workability, and durability requirements, in order to prevent negative impact on durability, and environment. The present research has investigated the strengths of HVFA concrete mixture with 50%, 0% replacement of cement (OPC), by optimizing the cement content constraint in the design mix of I.S code method and also a Chemical Admixture (Super Plasticizer 250 ml per 50kg of cement) is added to the HVFA concrete mixture is conforming to IS: 9103-1999 to improve desired workability.

Keith Bargaheiser, Tarunjit S. Butalia[3] in their Research Paper "Prevention of Corrosion in Concrete Using Fly Ash Concrete Mixes" describes about a landmark study conducted by Battelle Memorial Institute for the National Bureau of Standards, it is estimated that corrosion damage in the United States is 4.2 percent of the Gross National Product (GNP). Corrosion of concrete takes place when carbon dioxide (CO_2) and chlorides penetrate concrete. As the chlorides and CO_2 penetrate concrete, the pH level of the concrete begins to drop from 12- 13 to about a value of 9. In concrete construction, the 1.5 to 2 inches of concrete cover over the rebar acts as protective layer from the chlorides/CO_2 reaching the rebar. Once the threshold is reached, the concrete cover is compromised and the pH of the concrete surrounding the rebar allows for corrosion. This weakens the concrete and reduces its service life. This subsequently increases costly maintenance on repair and restoration projects for the damaged concrete structure. There are several practical methods used to counteract problems caused by corrosion, including adequate concrete cover, better quality concrete (low permeability, no cracks), epoxy coated rebar, stainless steel reinforcement, cathodic protection, protective coatings, a corrosion inhibitors. Recent research has indicated the benefit of using fly ash in preventing corrosion damage in concrete. Reduced permeability, lower water/cement ratio, decreased drying shrinkage/cracking, and increased durability are all benefits of fly ash concrete.

Dr. Shirish V. Deo[4] in their Research Paper " A Review of High Volume Low Lime Fly Ash Concrete" in their Research Paper has given an overview of advantages of HVFA Concrete to increase workability and durability of concrete. In the present study a large number of relevant papers are discussed to understand the problems associated with low lime fly ash HVFAC concrete. The literature surveyed has also listed the slower strength gain at early ages as major problem in making HVFA Concrete very popular in the Indian construction industry which is only focused on short term strength gain. Major studies on HVFA Concrete were based on high lime fly ashes. Low lime fly ash in concrete is totally dependent on lime from cement for the formation of C-S-H gel. This limits the percentage replacement of cement with low lime fly ash.

MATERIAL PROPERTIES

3.1 SELECTION OF MATERIALS:

3.1.1 Cement: Ordinary Portland cement of 53 grade, Anjani Portland cement, confirming to IS: 12269 is used in the experimental work.

3.1.2 Fly ash: Fly ash is collected from Vijayawada Thermal Power Station (VTPS) was used in the experimental work.

3.1.3 Rice Husk Ash: Rice husk ash is collected from local hotels was used in the experimental work.

3.1.4 Bagasse Ash: bagasse ash is collected from thaduvai sugar cane factory was used in the experimental work

3.1.5 Fine Aggregates: Natural river sand was used. The specific gravity was found to be 2.54 and sieve analysis confirmed to zone II.

3.1.6 Coarse Aggregates: Crushed stone aggregate of maximum size 20mm was used Specific gravity was found to be 2.66.

3.1.7 Super Plasticizer: Conplast SP - 430.

Figure 1 cement

Table 1 Properties of Cement:

S.NO	Property	Result
1	Specific gravity	3.02
2	Fineness of cement	0.0816
3	Normal Consistency	0.35
4	Initial setting time	30 min
5	Final setting time	360 min

Figure 2 sand

Table 2 Properties of Fine Aggregate:

S.N0	Property	Value
1	Specific gravity	2.54
2	Bulking of sand	0.0408
3	Sieve analysis	Zone II
4	Fineness modulus	2.5

Figure 3 Coarse Aggregate.

Table 3 Properties of Coarse Aggregate:

S.N0	Property	Value
1	Specific gravity	2.66
2	Sieve analysis	7.58

Figure 4 Fly Ash

Table 4 Properties of Fly Ash, Rice Husk Ash, Bagasse Ash

S.NO	Property	Result		
		Fly Ash	Rice Husk Ash	Bagasse Ash
1	Specific gravity	2.96	2.93	2.83
2	Fineness of fly ash	2.6%	0.83%	2.6%

4 MIX DESIGN FOR M30 GRADE OF CONCRETE

Table 5 Material Quantities For Normal Concrete

Materials	Quantity Kg/M^3	proportion
Cement (Kg)	458.51 kg/m^3	1
Fine Aggregates(Kg)	1111.66 kg/m^3	1.6
Coarse Aggregates (Kg)	762.96 kg/m^3	2.42
Water(Litres)	197.6 kg/m^3	0.43

Mix ratio for conventional concrete is 1:1.6:2.42

Table 6 Material Quantities For Repalced Concrete

Materials	Quantity per1 M^3	proportion
Cement (Kg)+fly ash(Kg)	489.47 kg/m³	1
Fine Aggregates(Kg)	759.46 kg/m3	1.55
Coarse Aggregates (Kg)	1106.56 kg/m³	2.26
Conplast 430@1.5%(Litres)	7.2	-
Water(Litres)	186 kg/m³	0.41

Mix Ratio for Self Compacting Concrete is **1:1.55:2.26**

5 EXPERIMENTAL INVESTIGATION

TESTS ON FRESH CONCRETE:

5.1 WORKABILITY:

Workability is defined as the property of concrete which determines the amount of useful internal work necessary to produce full compaction. Tests conducted for workability are compacting factor test and slump cone test.

5.1.1 Compaction Factor Test:

Compaction factor = 0.78

Fig.5 COMPACTION FACTOR APPARATUS

5.1.2 Slump Cone Test:

Slump Value = ZERO

Fig.6 SLUMP CONE APPARATUS

5.2 TESTS ON HARDENED CONCRETE:

5.2.1 COMPRESSIVE STRENGTH TEST:

(a) Before testing of specimen

(b).After testing of specimen

Fig. 7 TESTING OF CUBE

5.2.2 SPLIT TENSILE STRENGTH TEST :

Split Tensile Strength = $\mathbf{2P/(\pi \times \mathit{l} \times d)}$

Where P = maximum load recorded

l = length of cylinder

d = diameter of the cylinder

Fig. 8 TESTING OF CYLINDER

5.2.3 FLEXURAL STRENGTH TEST:

$$F_b = (PxL)/(bxd^2)$$

When 'A' is greater than 20.0 cm for 15.0 cm specimen or greater than 13.3 cm for a
10.0 cm specimen.

$$F_b = (3PxA)/(bxd^2)$$

When 'A' is less than 20.0 cm but greater than 17.0 cm for 15.0 specimens, or less
Than 13.3 cm but greater than 11.0 cm for a 10.0 cm specimen.

Where, F_b = flexural strength of specimen
b = measured width in cm of the specimen
d = measured depth in cm of the specimen
L= length in cm of the span on the which the specimen was supported

P = maximum load in kg applied to the specimen
A = distance between line of fracture and the nearer support.

Fig.9 Testing of prism

Fig.10 Tested cubes and cylinders

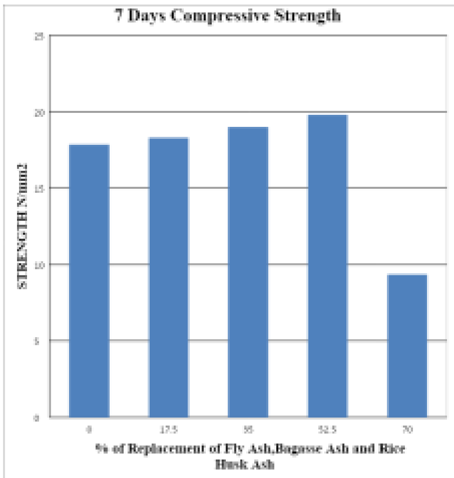
5.3 QUANTITY ESTIMATION:

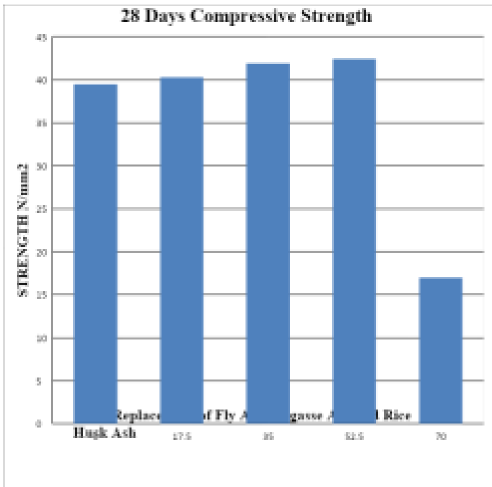
Particulars	Conventional Concrete	17.5% Replacement	35% Replacement	52.5% Replacement	70% Replacement
Cement (kg)	37.2	32.06	25.2	18.51	11.65
Fine Aggregates (kg)	59.5	59.5	59.5	59.5	59.5
Coarse Aggregates (kg)	90.1	90.1	90.1	90.1	90.1
Fly Ash (kg)	-	5.778	11.63	17.37	23.27
Rice Husk Ash (kg)	-	0.964	1.937	2.904	3.88
Bagasse Ash (kg)		3.75	5.57	4.87	2.95
Super Plasticizer (ml)	-	194.03	194.03	194.03	194.03

5.4 RATE ANALYSIS:

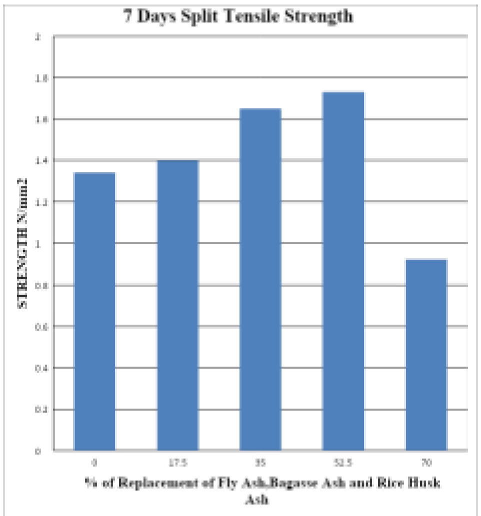
Particulars	Conventional Concrete	17.5% Replacement	35% Replacement	52.5% Replacement	70% Replacement
Cement (Rs)	260.4	224	175	130	81.5
Fine Aggregates (Rs)	115	115	115	115	115
Coarse Aggregates (Rs)	148	148	148	148	148
Fly Ash (Rs)	-	1.44	2.9	4.3	5.8
Rice Husk Ash (Rs)	-	2	2	2	2
Bagasse	-	10	10	10	10
Super Plasticizer (Rs)	-	20	20	20	20
Total Amount (Rs)	523.32	510.44	462.9	419.3	372.3

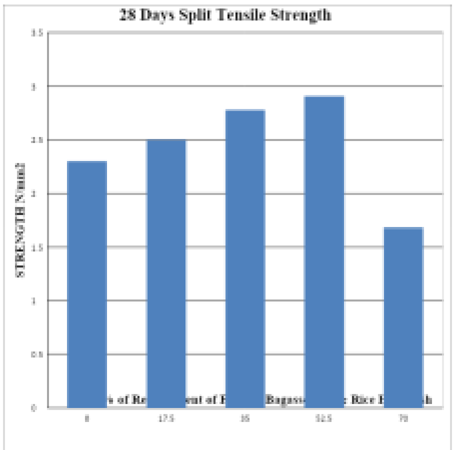
RESULTS AND DISCUSSIONS



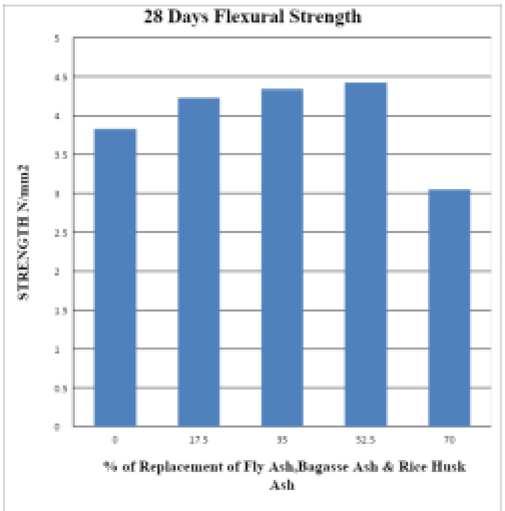


6.1 Percentage of Fly Ash & Rice Husk Ash vs Compressive Strength





6.2 Percentage of Fly Ash , Bagasse Ash & Rice Husk Ash vs Tensile Strength



6.3 Percentage of Fly Ash, Bagasse Ash & Rice Husk Ash vs Compressive Strength:

CONCLUSIONS

In this experimental investigation the compression, tension and flexural behavior of concrete by replacement of fly ash, bagasse ash and rice husk ash in cement for M30 grade concrete.

- By seeing the compression strength results, there is a nominal increase in the strength up to 45% of fly ash, 20% of bagasse ashand 7.5% of rice husk ash replacement and decreasing in the case of above 45% of fly ash,20% of bagasse ash and 7.5% of rice husk ash replacement with reference to conventional concrete at 28 days.
- By seeing the split tensile strength results, there is a nominal increase in the strength up to 45% of fly ash,20% of bagasse ash and 7.5% of rice husk ash replacement and decreasing in the case of above 45% of fly ash,20% of bagasse ash and 7.5% of rice husk ash replacement with reference to conventional concrete at 28 days.
- By seeing the flexural strength results, there is a nominal increase in the strength up to 45% of fly ash,20% of bagasse ash and 7.5% of rice husk ash replacement and decreasing in the case of above 45% of fly ash,20% of bagasse ash and 7.5% of rice husk ash replacement with reference to conventional concrete at 28 days.

FUTURE SCOPE OF STUDY

The results of this project shows that higher strength can be achieved by using alternate materials like fly ash and rice husk ash. The quality of concrete in general is defined by compressive strength of concrete.

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