

Evaluation of Strength of Concrete on Optimum Use of Fly Ash, Rice Husk Ash and Super Plasticizer in Nominal Mix

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ABSTRACT: Concrete is an important material of construction in which cement play an major role as binding material. The production and consumption of cement is increasing day by day due to heavy demand of infrastructure development. Heavy production of cement is a matter of concern for environment as well. Civil engineering researches are continuously striving to explore the alternative material which may replace partially the cement without compromising the quality aspects. The replacement of materials offers cost reduction, energy savings and protection of environment. Fly ash and rice husk ash was used as a replacement of cement in some literature works but this investigation discovers the feasibility of the substitution of fly ash and rice husk ash for cement to achieve economy and environment friendly concrete. In the present investigation optimum percentage of replacement of cement with combination of fly ash and rice husk ash in conjunction with super plasticizers for nominal mix (M20) grade of concrete has been evaluated. Parameters selected for investigation are workability and compressive strength. The research work as M-tech dissertation was carried out as per the standards in the controlled situation at the civil engineering laboratory of NITTTR, Bhopal (India). The results of investigation and evaluation of study has proved that the selected materials as mentioned above may be useful for partial replacement of cement as presented in the results and ultimately helping the environment.

KEYWORDS: Concrete, environment, typical waste, Fly ash, Rice Husk Ash, Super plasticizer, Optimum use.

I. INTRODUCTION

Concrete can be defined as the mixture of cement, sand, aggregate, and water. It is most extensively used man made building material all over the world. The popularity of the concrete is due to fact that the common ingredients, the properties of concrete can meet the demand of any type of engineering project. Concrete can be casted in almost every shape, that's why it is very popular and is used in various typical architectural forms.

Several researchers have studied and reported the impact of using Fly Ash and Rice Husk Ash in Concrete, whereas few researches have been carried out using FA, RHA and Super plasticizers. Fly Ash and Rice Husk Ash are industrial waste and agricultural waste and they can be used as studied in literature in some quantity after replacing small amount of cement because these waste materials have binding property. Presently these materials are not being used commonly in construction industry of India. This research gives us the conclusion that how Fly Ash and Rice Husk Ash can be successfully and optimally used specially in nominal mixes say M20. Due to the environment concerns, the needs to save energy, various research efforts have been directed toward the utilization of waste materials. Fly ash is one of the residues produced in the combustion of coal in power generation facilities. The components of the fly ash produced vary considerably, depending upon the source and structure of the coal being burned, but all fly ash includes significant amount of silica (silicon dioxide, SiO₂) (both crystalline and amorphous) and lime (calcium oxide, CaO). Fly ash is usually used to add-on Portland cement in concrete production, where it can make both technical and economic benefits, and is more and more finding use in forming of geopolymers and zeolites. RHA is an agricultural waste product. In

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India, rice husk is one of the major agricultural wastes. When rice husk is burned in controlled conditions, the ash is produced in the form of non-crystalline or amorphous silica with cellular structure. The rice husk ash is a pozzolanic material containing a large amount of silica. Rice Husk Ash can be used to replace part of Portland cement with proper burning and grinding. Super plasticizers are the High Range Water Reducing Agents (HRWA). These are used to produce highly workable concrete with enhanced durability and strength without using more water in concrete. The use of super plasticizer can result in reduction of 25 to 35 percent of water in a concrete mix, thus it reduces w/c ratio and enhance the strength of the concrete. By adding super plasticizer in the concrete the water molecules gets dispersed from the cement molecules and thus water absorption gets slower down thus water requirement in the concrete gets reduced.

II. RELATED WORK

Archana Khare, Archana Tiwari (2015) reported the investigation on concrete strength using locally available industrial and agricultural waste products such as rice husk ash, fly ash and stone dust. The purpose of this study was to replace 20% cement with rice husk ash and fly ash with different proportions and also to replace the sand by stone dust by different percentage simultaneously. The mix proportions were taken as cement replacement with rice husk ash and fly ash (10%RHA+20%FA, 10%RHA+20%FA, 5%RHA+25%FA) along with sand replacement by stone dust (40%, 30%, 40%) respectively. Concrete cubes were tested on compression testing machine after 3, 7, 14 and 28 days of curing. On the basis of observations and results it was found that the 10% rice husk ash 20% fly ash and 30% stone dust gives maximum compressive strength to the concrete. Hence it was concluded that the industrial and agricultural waste products like fly ash, stone dust and rice husk can be used as supplementary materials in concrete production.

Jitender Kumar, Varinder Singh and Ravi Kant Pareek (2015) reported that how the strength parameters of pavement quality concrete is affected by using Fly Ash and Rice Husk Ash as cement replacement. The purpose of their study was to determine the compressive strength and flexural strength of concrete after replacing cement by fly ash and rice husk ash. Three water cement ratios (0.40, 0.35, 0.30) were taken to make concrete with different water quantity. The curing period was 7 and 28 days. The proportion of fly ash was taken up to 10%, 20% and 30% also same as for rice husk ash. Also the combined proportions of fly ash and rice husk ash were (10% FA & 10% RHA), (10% FA & 20% RHA) and (20% FA & 10% RHA). Based on their research it was concluded that the concrete made with 30% fly ash attains maximum strength for all water/cement ratios. Also there is decrease in strength with increase in percentage of rice husk ash. The flexural strength was found to be higher at 20% replacement with fly ash than the minimum required flexural strengths as per PQC standards therefore it can be used in pavement quality concrete.

Reshma.S, Dr. S.Siddiraju (2015) reported the comparison of compressive strength of M20 grade Fly Ash with Rice Husk Ash concrete. The main purpose of this study was to compare the compressive strength of OPC concrete and Fly Ash concrete with concrete produced with or without Rice Husk Ash. The samples were tested after 3, 7, 14 and 28 days of curing. The compressive strength of M20 grade fly ash concrete, compressive strength of M20 grade fly ash with rice husk ash concrete and compressive strength of M20 grade OPC concrete were compared simultaneously. Based on the observations it was found that the compressive strength of fly ash concrete is increased by 7.45% when compared with OPC concrete, also the compressive strength of fly ash with rice husk ash concrete increased by 13.677% when compared with Fly Ash concrete, and the compressive strength of fly ash with rice husk ash concrete increased by 20.01% when compared with OPC concrete. It was also found that the fly ash can be used to replace up to 30% cement. Rice husk ash improves compressive strength, bond strength and abrasion resistance.

III. OBJECTIVE OF THE EXPERIMENTAL RESEARCH STUDY

The objectives of present study are:

- To prepare concrete cubes of nominal mix (M20) using Fly Ash, Rice Husk Ash and Super Plasticizer.
- To evaluate the optimum mix design with regards to the amount of water, RHA (Rice Husk Ash), FA (Fly Ash), cement ratio under the effect of admixture.
- To perform test for strength and workability as per IS 516:1959.
- To study the relative strength development with different percentage of (RHA + FA) concrete.

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- To assess the economy aspects of concrete.
- To justify the safeguard to the environment by utilizing typical wastes.

IV. EXPERIMENTAL METHODOLOGY

4.1 MATERIALS USED:

Cement: This is the most common binding material used in construction industry. The cement used in this study is Ultra-tech OPC of 53 grade conforming to IS: 12269-1987 is used in this study.

Fine aggregate: Locally available fresh Narmada river sand, free from organic matter, was used. The result of sieve analysis confirms to zone-II (according to IS: 383-1970).

Coarse aggregate: For this study the locally available coarse aggregate is used. The size of coarse aggregate varies from 10 mm to 20 mm, means the material passed from 20mm IS sieve but retained in 10mm IS sieve.

Fly ash: Class-F Fly ash is used as a partial replacement of cement in concrete and it is passed from 600 micron IS sieve. The fly ash used in this study is collected from HEG plant, Bhopal (M.P.).

Rice husk ash: Rice husk ash used in this study is collected from a rice factory named SSA International Limited, Mandideep, Bhopal (M.P.).

Super plasticizers: Super plasticizer used in this investigation is Sikament® 3070 NS. It is a retarding Super plasticizer with Integral Water Proofing ability. It is a dark brown liquid solution approved by IS 9103-1999, ASTM C494, IS 2645.

Table-1 Physical properties of Fly ash

Physical property	Value
Color	Grey
Bulk density	1.12 gm/cc
Specific gravity	2.52
Fineness	351 m ² /kg

Table-2 Physical properties of Rice Husk Ash

Physical property	Value
Color	Gray with slight black
Bulk density	105.9 kg/m ³
Specific gravity	1.96
Fineness	2775 cm ² /gm
Particle size	90 μm

4.2 EXPERIMENTAL PROGRAM

This experimental program is based on the proposed mix trials shown in Table-4 in which cement is replaced by combination of fly ash and rice husk ash. Concrete cube samples were prepared and tested for evaluating the compressive strength after 7 and 28 days of curing.

Table-4 Proposed Mix Proportions for M20 Concrete

Trial	Cement (%)	Fly Ash (%)	Rice Husk Ash (%)
TR.1	100% (control mix)	0%	0%
TR.2	90	7.5	2.5
TR.3	90	5	5
TR.4	90	2.5	7.5
TR.5	80	15	5
TR.6	80	12.5	7.5
TR.7	80	10	10
TR.8	80	7.5	12.5
TR.9	80	5	15

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As per standards all ingredients were batched and proportioned properly and concrete cube samples were prepared in moulds of size 150 x 150 x 150 mm. The quantity of super plasticizer in trials TR.2 to TR.9 is kept fixed at 1.5% of the weight of the cement taken in the concrete mix. Hand mixing method was used for producing a concrete batch.

Slump cone test was conducted to check the workability of prepared fresh concrete as per IS guidelines. Then compressive strength tests were conducted as per IS guidelines on all samples of each trial and results were obtained to find the optimum trial.

V. EXPERIMENTAL RESULTS

5.1 SLUMP CONE TEST:- Slump cone test is done on freshly prepared concrete to check its workability. The effect of super plasticizer is determined by this test. The results are shown in Table-5 and Figure-1.

Table-5 Slump Values of each trial

Trials	Slump Values (mm)
TR.1	80
TR.2	105
TR.3	55
TR.4	45
TR.5	25
TR.6	110
TR.7	75
TR.8	55
TR.9	10

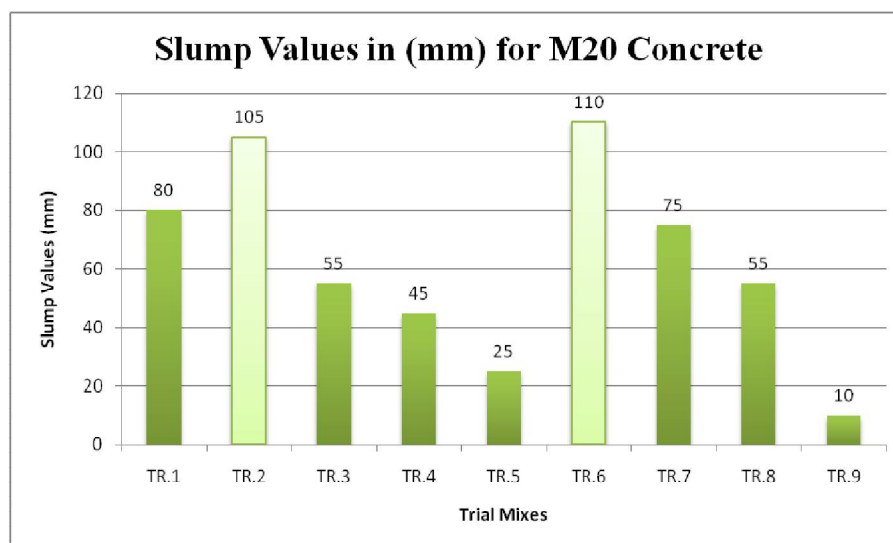


Figure-1 Bar Chart for Slump Values

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The result of slump cone test is showing that the workability is improved by adding super plasticizer even after replacing the cement. However the workability decreases as the rice husk content increases. From the results we found that the workability of the trials TR.2 and TR.6 is improved when compared to TR.1 (control concrete).

5.2 COMPRESSIVE STRENGTH TEST:- Total 54 cubes i.e. 6 samples for each trial mix (3 for 7 days & 3 for 28 days) was tested. Compressive strength results were obtained by testing cubes under compression in UTM. The average 7 days strength results and 28 days strength results are shown in Table-6 for each trial. The graphical representation of compressive strength tests results are shown in Figure-2. Results of trial mixes TR.2 to TR.9 were compared with TR.1 (control concrete).

Table-6 Results showing 7 & 28 Days Compressive Strength of M20 concrete

Trial	Average 7 Days Compressive Strength (N/mm ²)	Average 28 Days Compressive Strength (N/mm ²)
TR.1	23.54	30.87
TR.2	22.69	32.66
TR.3	17.38	37.275
TR.4	26.985	30.115
TR.5	21.68	36.06
TR.6	24.605	33.755
TR.7	22.08	28.43
TR.8	22.725	33.375
TR.9	17.385	29.375

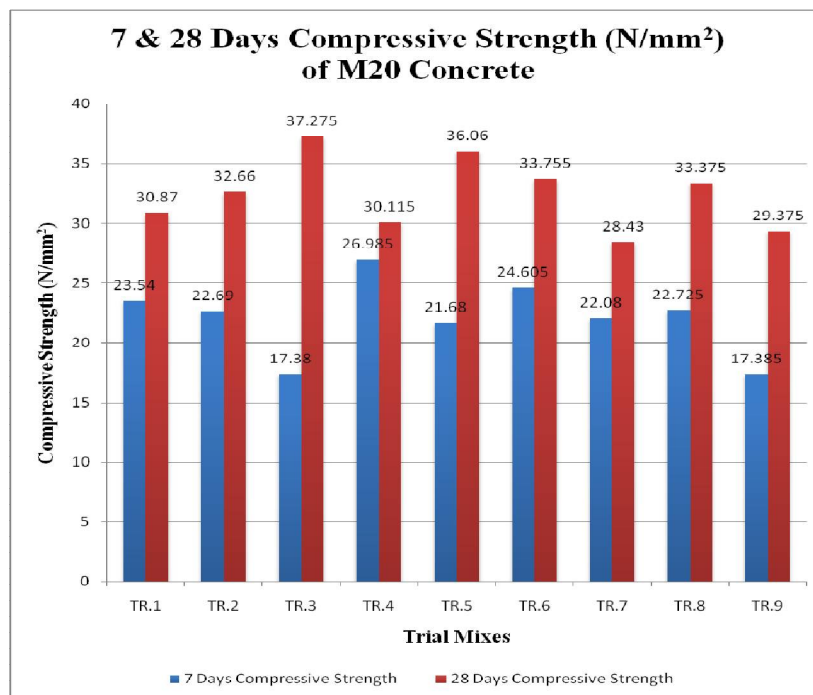


Figure-2 Bar Chart for 7 & 28 Days Compressive Strength

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From the results it is observed that trial TR.4 and TR.6 are showing good 7 days compressive strength values when compared to conventional concrete and also it is observed that trials TR.3, TR.5 and TR.6 are having good 28 days compressive strength. But TR.3 and TR.5 is not having good 7 days compressive strength. It means the only trial TR.6 is common in 7 & 28 days compressive strength test results. But, more consideration is required to find an optimum trial.

To find optimum trial, consider 7 days and 28 days strength along with slump value on a linear scale of 0 to 120. If these parameters of trials TR.2 to TR.9 are compared with TR.1 then it is observed that the trial TR.2 and TR.6 are more workable so, other trials should not be considered to use them practically on the field; but trial TR.6 has more 7 and 28 days strength along with enhanced workability, hence it is concluded that the trial TR.6 is the optimum one in this study. Figure-3 represents optimum results of compressive strength (7 and 28 days) and slump values of each trial.

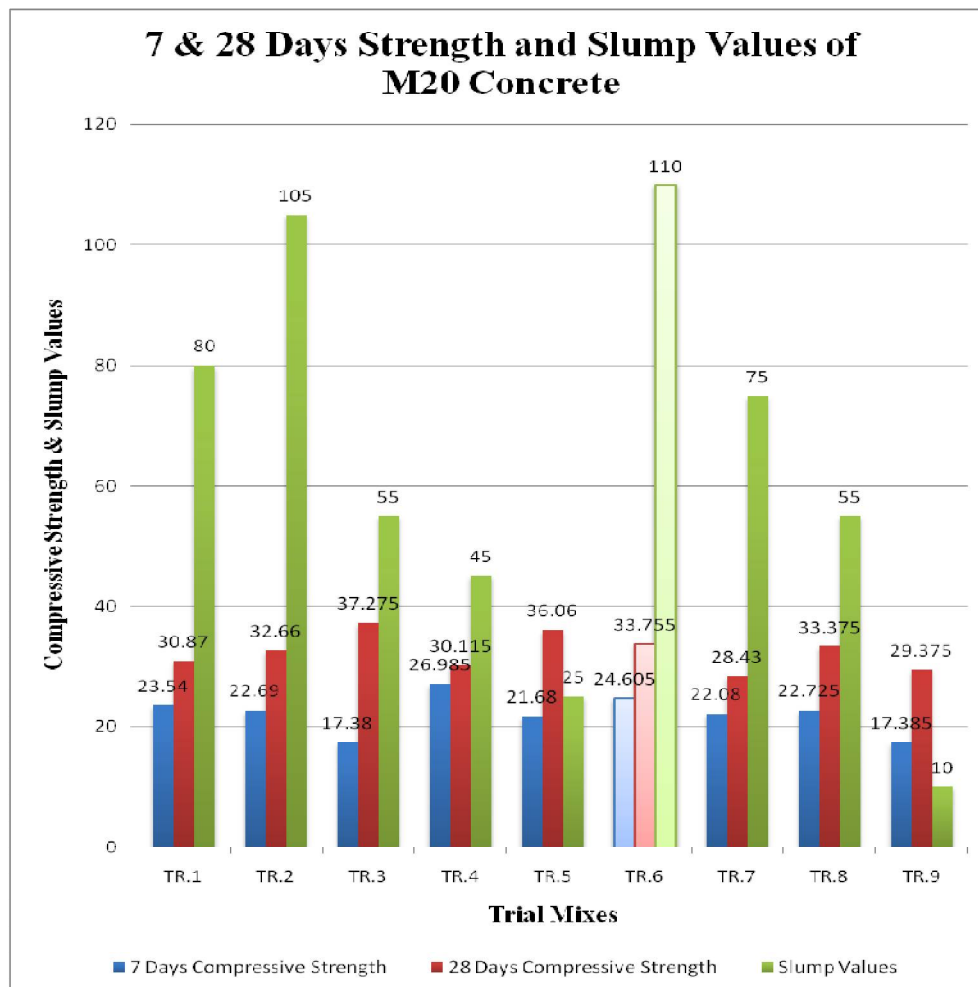


Figure-3 Bar Chart representing 7 & 28 Days Compressive Strength and Slump Cone Values

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5.3 COST ANALYSIS

Cost analysis is done on the basis of following mix proportions per cubic meter used for M20 concrete.

Table-8 Mix Proportions of Concrete

WATER	CEMENT	FINE AGGREGATE	COARSE AGGREGATE
186.69 lit/m ³	373.38 Kg/m ³	609.6 kg/m ³	1220.8kg/m ³

- Number of cement bags used in 1 cubic meter concrete = $373.38/50 = 7.5$ Bag.
- Therefore Cost of 7.5 bags = $7.5 \text{ bags} \times 300 = \text{Rs.}2250$
- 20% replacement of cement by waste FA & RHA = $20/100 \times 373.38 = 74.676 \text{ Kg/ m}^3$
- Reduction in Cement Bag = 1.493 Bag. (approx 1.5 bag)
- Cost of 1 bag Cement = Rs.300
- Cost of reduced Cement Bag= $1.5 \times 300 = \text{Rs.}450$
- Cost of FA & RHA is negligible. Let's suppose the cost of FA & RHA = Rs.1/kg
- Therefore, cost of 74.676 kg FA & RHA = Rs.75 (approx)
- Super plasticizer is also used, Cost = Rs.25/litre
- Quantity used per cubic meter concrete is = 5.60 litres
- Total cost of super plasticizer = Rs.140
- Expenses on FA, RHA and Super plasticizer = $75+140 = \text{Rs.}215$
- Hence, total saving per cubic meter concrete is = $450-215 = \text{Rs.}235$

Hence it was concluded that by replacing 20% of cement, cost per m³ i.e. 235 Rs (approx) can be reduced.

5.4 DISCUSSIONS

From the above experimental investigation using fly ash, rice husk ash & super plasticizer as construction material were investigated. Various concrete cubes have been casted using these materials to investigate compressive strength and slump values.

The above results shows that replacement of 20% of cement with combination of waste fly ash and rice husk ash (12.5% FA + 7.5% RHA) and doping of super plasticizer at 1.5 % of weight of cement shows maximum slump value along with very good compressive strength in the experiment as compared to other replacement trials of cement.

Hence, 12.5% FA + 7.5% RHA in the combination is the optimum replacement of cement in this investigation with enhanced workability and compressive strength at low water cement ratio.

VI. CONCLUSIONS

- As we found that; the trial **TR.6** (12.5% FA + 7.5%RHA) is the optimum replacement of the cement with addition of super plasticizer in M20 concrete. Fly ash gives more strength to the concrete instead of rice husk ash but both can be used as construction materials to replace cement partially in conjunction with super plasticizer to make a good quality concrete with enhanced workability.
- It is observed that using super plasticizer in the concrete can enhance the workability of the concrete even after using less water cement ratio as 0.42 instead of 0.50. It is found that there is increment of 37.5% in workability in trial TR.6 when compared to control concrete.
- It is also observed from the results that the, as rice husk ash content increases the slump value get decreases.

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- The average 7 days compressive strength of optimum mix (TR.6) concrete is enhanced by 4.52% when compared with conventional concrete compressive strength also the 28 days compressive strength is enhanced by 9.34%.
- From the cost analysis results it is justified that if we replace 20% cement by the waste materials like fly ash and rice husk ash we that save the cost of production of concrete per cubic meter, thus economical concrete can be produced for the construction projects. The cost of these waste materials is almost negligible as compare to the cost of cement.
- Cement industries are the main source of Carbon dioxide (CO₂) emissions. The usage of cement for concrete is reduced by using these supplementary materials thus we can reduce the amount of CO₂ gas emission. It can control the greenhouse effect up to some extent so that we can safeguard our environment. The fly ash and rice husk ash are environment friendly waste products; there is no objection in using these materials to replace the cement partially in the concrete.

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