Cost Analysis of Dry Lean Concrete as Partial Replacement of Cement with Fly Ash and Rice Husk Ash

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***Abstract*: The cement is the main ingredient used for concrete. The production of cement involves emission of large amount of carbon dioxide into the atmosphere. Therefore, the search of any other such material which can be used as an alternative to cement should lead to lowest possible environment impact. The Fly Ash and Rice Husk Ash are these type of materials which can be used as partial replacement of cement in concrete construction. Dry lean concrete used in sub base course for rigid pavement, so the desired strength is low as compare to normal concrete. Fly ash and RHA is a waste material and also pozzolanic in behavior so we can be used these materials as a partial replacement of cement, by this we can manage the quantity of such materials and lower the bad impact in environment as compare to cement. The huge amount of Fly Ash over the years is likely to pose a serious threat for its disposal and cause environmental problems. In this research paper we basically discussed the cost analysis of dry lean concrete because we know that Fly Ash and RHA is a waste materials and if we use it in concrete its reduces the overall cost of the production.**

***Keywords*: Cost analysis, Fly Ash, RHA, Waste materials.**

1. INTRODUCTION

Ordinary Portland cement is the most extensively used construction material in the world. Cement is the third most energy intensive material after steel and aluminum produced in tones. Over 5% of global CO2 emission can be credited to Portland cement production. Cement industry consumes raw materials rich in silica, alumina, iron and calcium. Therefore this industry has been actively involved in finding ways to use waste products in the manufacturing of cement both as secondary fuel and raw material. To reduce the limitation of cement (OPC), it can be partially replaced with green materials which have pozzolanic characteristics. Number of green materials has been studied for the replacement of cement partially like Fly ash, Rice Husk ash etc. Increasing concern for environmental protection, energy conservation with minimal impact on economy have been motivating researchers to look for other alternatives for cement in the concrete industry. If some of raw materials having similar composition can replaced by weight of cement in concrete then the cost could be reduced without affecting its quality. For this reason Fly Ash and Rice Husk Ash (RHA) are the main byproducts can be used as binders, partially replacing cement.

Presently about 105million Fly ash is generated every year in India as a by-product of coal consumed in the thermal power plants. The thermal power plant is the only source to produce 65% of the total electricity produced in our country.

The type of fly ash collected at the bottom of the boiler furnace having lesser fineness and high carbon content is called bottom fly ash.

The finest fly ash is called dry fly ash, collected from different electrostatic precipitators in dry form. While the ash mixed with water forming slurry and drained out in ponds is referred as pond fly ash.

At present fly ash is disposed in slurry from in large ponds managed by thermal power corporation plant units. A small percentage that is 3% to 5%of fly ash is being used in India while in other countries the percentage of utilization is 30% to 80%, whatever be the type of fly ash. Due to presence of toxic metal in fly ash, it causes water pollution through percolation. Fly Ash is being consumed by several organizations in production of cement, bricks, cellular blocks, asbestos sheets.

India is one of the leading producers of rice. Globally rice paddy of about 600millions tons is being produced. In most of the cases, the husk is produced during the processing of the rice is either burnt or dumped as waste material. RHA contains 90%-95% of reactive silica, it is estimated that the world rice harvest is about 588million tons per year and India is the second largest producer in the world with a production of 132million tons per year annually. Most of these studies have been performed in order to find out the effectiveness of RHA as a pozzolanic by concentrating on the amount of ash present in the mix and on the enhanced characteristics resulting from it use.

In this research paper we discussed that with use of these waste materials, cost of the overall production of concrete is very less, because these waste materials are easily available from the industry waste and cost of Fly ash and RHA are very low as compared to cement, So with use of these materials, cost of the project is very less, and also reduce the environmental pollution. Fly ash and RHA used in concrete also enhance the strength of concrete and it's a best way to use these waste materials.

2. MATERIALS

The materials used in the preparation of concrete are cement, sand, coarse aggregate, Rice Husk Ash, Fly ash, and water etc.

CEMENT: Ordinary Portland Cement (OPC53), IS: 12269-1987 which is available in the market has been used. The physical properties of the cement used are as listed in table below.

TABLE-2.1 Physical properties of Ordinary portland cement

PROPERTIES	TEST VALUES
Specific Gravity	3.15
Consistency	30%
Initial setting time	30 min
Final setting time	600 min
Density	1440 kg/m^3

SAND: The narmada river sand available in the market and having specific gravity of 2.66 (Conforming to Zone II) has been used. The physical properties of the fine aggregate are as listed in table below:

TABLE-2.2 Physical properties of Fine Aggregates

PROPERTIES	TEST VALUES
Specific gravity	2.66
Water absorption	1%
Fineness modulus	2.61

COARSE AGGREGATES: crushed granite conforming to IS: 383:1987 and having specific gravity 2.70 has been used. the coarse aggregate with nominal size of aggregates as 20mm (50%) and 10mm (50%) as per Indian standard were used . the physical properties of the coarse aggregate are listed in table below:

TABLE-2.3 Physical properties of coarse aggregates

PROPERTIES	CA-20	CA-10
Type	Crushed	Crushed
Specific gravity	2.65	2.70
Water absorption	0.50%	0.50%
Fineness modulus	6.8	6.5

WATER: water is an important ingredient of concrete as it actively participated in the chemical reaction with cement .clean portable water which is available in college campus has been used.
FLY ASH: The fly ash used was of class F with specific gravity of 2.10

Chemical characteristics
Fly ash is a fine particular material with the main chemical constituents being SiO_2, Al_2O_3, Fe_2O_3 and Cao these chemicals are responsible for its pozzolanic activity. The general variation in three principal constituents will be as follows Sio_2 (25-60%), Al_2O_3 (10-30%) and Fe_2O_3 (5-25%)
TABLE-2.4 Chemical requirements of fly ash (As per BIS)

SNO.	Characteristics	Requirements	
		Siliceous Fly Ash	Calcareous Fly Ash
1	$Sio_2+Al_20_3+Fe_2O_3$ (%by mass, Min.)	70	50
2	SiO_2 (% by mass, Min.)	35	25
3	Reactive silica (% by mass, Min.)	20	20
4	MgO (% by mass, Max.)	5	5
5	SO_3 (%by mass, Max.)	3	3
6	Na_2O (%by mass, Max.)	1.5	1.5
7	Total Chlorides (% by mass, Max.)	0.05	0.05
8	Loss on Ignition (% by mass, Max.)	5	5

TABLE-2.5 Chemical requirements of Fly Ash (As per ASTM)

SN.	Characteristics	Requirements	
		Siliceous Fly Ash	Calcareous Fly Ash
1	$SiO_2 + Al_2O_3 + Fe_2O_3$ (%by mass, Min.)	70	50
2	Moisture Content (%by mass, Max.)	3	3
3	SO_3 (%by mass, Max.)	5	5
4	Loss by Ignition (%by mass, Max.)	6	6

RICE HUSK ASH: RHA is a carbon neutral green product. Lots of ways are being thought of for disposing them by making commercial uses of this RHA. RHA is a good super pozzolan. This super pozzolan can be used in a big way to make special concrete mix.

TABLE-2.6 Physical properties of RHA (Bui and Stroeven, 2009)

Fineness-medium particle size (μm)	8.6
Specific gravity	2.14
Pozzolanic activity index (%)	99
Water absorption test (%)	104

TABLE-2.7 Chemical properties of RHA (Bui and Stroeven, 2009)

Chemical compound	Percentage
SiO_2	97.69
Al_2O_3	0.00
Fe_2O_3	0.22
CaO	0.29
MgO	0.00
Na_2O	0.41
K_2O	1.39

3. Cost analysis

This section mainly focused on the cost analysis of dry lean concrete. Time, cost and quality are the three main factors which assume significance in construction due to their impact on the industry as a whole. Any development which has positive impact on these factors is always in the interest of civil engineering. The cost analysis work is done mainly for 1 m^3 concrete production and as this reference we calculate for whole production cost. So firstly we calculate how much material is used for 1 m^3 concrete and its cost then for different percentage where we partially replaced cement with Fly ash and Rice Husk ash. The optimum strength is gain when we replace cement with 10% of Fly ash, the required amount of dry lean concrete grade mix for 1 m^3 shown in **table-3.1** with the help of this we calculate the cost of the concrete mix when we replace the cement with fly ash. The rates are calculated as per scheduled rate of Jabalpur district. The rates are calculated by without replacement of cement in dry lean concrete mix shows in **table-3.2** and this procedure also done for Rice husk ash to calculate the rate of the production. The cement replacement with 10% Fly ash data and cost analysis is given in **table-3.3** and the cement replacement with 10% RHA data and cost analysis is given in **table-3.4** percentage of reduction in cost for 10% replacement is shown in **table-3.5**

Table-3.1
Required amount of dry lean concrete mix for 1m^3 concrete

MATERIALS	QUANTITY FOR DRY LEAN CONCRETE MIX
Cement	170Kg
Fine aggregates	515Kg
Coarse aggregate	1650Kg
Water	142Litre

Table-3.2
Without replacement of cement for dry lean concrete mix

Material	Quantity (in bag)	Quantity in m^3	Per m^3 or Per bag rate	Rate (R.s)
Cement	4	0.11	450	1530
Fine aggregate	-	0.36	1300	468
Coarse aggregate	-	1.06	800	848
			Total Rs.	**3226**

Scale: 1 bag= 50kg (cement)

Table-3.3

Cement replacement with 10% Fly ash cost analysis

Materials	Quantity (in bag)	Quantity in m^3	Per m^3 or per bag rate	Rate
Cement	3	0.106	450	1377
Fine aggregate	-	0.36	1300	468
Coarse aggregate	-	1.06	800	848
Fly ash	0.42	0.004	40	16.8
			Total Rs.	**2710**

Scale: 1 bag=50kg (cement) 1 bag=40kg (Fly ash)

Table-3.4

Cement replacement with 10% Rice Husk ash cost analysis

Material	Quantity (in bag)	Quantity in m^3	Per m^3 or per bag rate	Rate
Cement	3.06	0.106	450	1377
Fine aggregate	-	0.36	1300	468
Coarse aggregate	-	1.06	800	848
RHA	0.42	0.004	45	18.9
			Total Rs.	**2712**

Scale: 1 bag = 50kg (cement) 1 bag = 40kg (RHA)

Table-3.5 percentage reduction in cost (replacement of cement 10%)

DRY LEAN CONCRETE MIX	QUANTITY OF CONCRETE	PRODUCTION COST	REDUCTION IN COST %
No Replacement	1 m^3	3226	-
10% Fly ash	1 m^3	2710	16
10% RHA	1 m^3	2712	15.2

4. CONCLUSIONS

Based on the cost analysis process, following conclusion can be drawn:

- The cost analysis process shows that when we use waste material as a cement replacement it is very cost effective.
- The production cost of dry lean concrete with Fly ash reduces the cost by 16%.
- When we use RHA as replacement it also reduces the cost by 15.2% but the strength is not good as compared to Fly ash.
- Thus the cheaper sub base concrete can be made with industrial waste products for an equivalent strength.
- The utilization of Fly Ash and RHA in dry lean concrete solves the problem of its disposal thus keeping the environment free from pollution.
- We increase the percentage of reduction of cost with proper handling, transporting and material use.

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