A RESEARCH PAPER ON PARTIAL REPLACEMENT OF CEMENT WITH THE VARIOUS INGREDIENTS

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Abstract:

This research report aims to utilize the industrial wastes and residues as a byproduct for the partial replacement of cement to obtain a M-25 grade concrete. The byproducts are used in a proportion of 5%, 10%, 15%, 20% and 25% which signifies the less consumed percentage of cement. In the replacement concepts, the mechanical properties, environmental issues and economic factor are the major concerns in this scenario.

In this research report, the reader will be going to experience the new modifications, role of the industrial wastes, their existence on earth, utilization, mode of formation, chemical properties, mechanical properties, environmental effect etc. Entirely it reveals a new mode of construction which not only impart the standard mechanical strength though it depletes the negative environment issues and cement economic factor as well.

Introduction:

In this world, the population rates are increasing though the construction is increasing too thus the demand of cement is also on high rates. Cement is a building material which acts as a strong binder to bind up a structure and imparts it strength and durability also. Cement as a binder which is used with the stones, brick, sand etc. It also liberates carbon dioxide which is harmful and making the environment polluted. The concept of utilization of industrial byproducts in partial replacement of cement is used to enhance the recycling phenomena. Thus recycling and partial replacement concepts has to apply in all over the world. The World Cement Demand is listed below in the table:

Table-World Cement Demand

Item	2010	2015	2016	Annual Growth	
				05/00	10/05
Cement Demand	1630.0	2250.0	2830.0	6.7	4.7
North America	149.6	170.0	196.0	2.6	2.9
Western	208.5	233.0	233.0	1.1	2.2
Asia/Pacific	954.5	1470.0	9.0	9.0	5.2
Other Region	328.2	401.5	506.6	4.1	4.7

After studying about the various industrial products, a new concept is experienced when getting the different industrial wastes and residues. These wastes and residues can be used as a byproduct for partial replacement of cement. Some of the byproducts are been briefly discussed below.

- **Red Mud**
- **Rice Husk**
- **Glass Fiber**
- **Coconut Fiber**

These are the byproducts which are been used in partial replacement of cement and its briefly explained below:

1. **Red Mud:**

   Red mud is the iron rich residue from the digestion of bauxite and it is one of the major byproduct coming from Bayer's process of alumina production. Red mud is generated in bulk, it has to be stored in large confined and impervious ponds, therefore the bauxite refining is gradually encircled by the storage pond. At present 60 million tons of red mud is generated annually worldwide which is not being disposed or recycled satisfactorily.

   Red mud is composed of a mixture of solid and metallic oxide bearing impurities and present one of the aluminum industry has most important disposal problems. The red color of is caused by the oxidized iron present which can make up to 60% of the mass of red mud. As a waste of the Bayer's process the mud is highly basic with a pH ranging from 10 to 13.

Table- Composition of Red Mud

Component	Weight (%)
Alumina	20-22
Silicon dioxide	12-15
Iron oxide	40-45
Titanium dioxide	1.8-2.0
Calcium dioxide	1.0-2.0
Di sodium oxide	4.0-5.0

2. Rice Husk:

Here the rice husk is use as a rice husk ash and it is the outer most part of rice paddy, it covers about 20 to 25% of the rice weight. Rice husk ash is obtained from raw rice husk changed into ash by combustion method to remove volatile organic carbon such as cellulose and lignin. RHA is a very fine material and its average particle sixe of RHA is ranged from 5 to 10 micron. RHA is composed mostly of silica in amorphous form (85-90) % and it has a highly micro porous structure which is suitable to replace cement through its pozzolanic reaction.

Table- Chemical properties of rice husk ash

Particular	Proportion
Silicon dioxide	85.5-95.5%
Aluminum oxide	0.0-2.5%
Iron oxide	0.0-1.5%
Calcium oxide	0.0-1.0%
Carbon	2.0-4.0%
Sodium oxide	0.0-1.0%
Potassium oxide	0.0-3.0%

3. Glass Fiber:

Glass fiber reinforcement concrete is a cementitious composite product reinforced with discrete glass fiber of varying length and size. The glass fiber used is alkaline resistant as glass fiber are susceptible to alkali which decreases the durability of GFRC. GFRC is stiff in fresh state has lower slump and hence less workable, therefore water reducing admixtures are used.

It can be done by various methods like spraying, casting, extrusion techniques etc.

Table- Composition of Glass Fiber

Component	Weight(%)
Silicon dioxide	55
Calcium oxide	16-25
Aluminum oxide	12-16
Sodium and potassium oxide	0-1
Magnesium oxide	0-6
Baron oxide	8-13

4. Coconut Fiber:

Coconut fiber both raw and processed fibers where raw fiber is the waste material obtained from mattress manufacturing and possess high degree of tensile strength of 21.5 MPa. This is actually properly washed before use. The processed fiber is properly washed and drawn into strands before use. Treatment of fibers removes dust and other residual particle left on the fiber so as to augment the surface of contact between the fiber and the mix resulting in better binding between the reinforcement and concrete and ultimately higher strength.

Thus these above mentioned byproducts are used for partial replacement of cement.

Procedure:

- Mix Proportion

Table- Mix Proportion

W/C Ratio	Cement	Fine Aggregate	Course Aggregate
0.45	1	1	2

- Mix Design for M-25 Grade

The mix design procedure adopted to obtain a M-25 grade concrete is in accordance with IS 10262-2009

Table- Mix Design

Mix Design		
As per IS 10262:2009		
A-1	Stipulations for proportioning	
1	Grade designation	M-25

2	Type of cement	PPC 53 grade confirming to IS 12269:2009
3	Maximum nominal aggregate size	20mm
4	Minimum content of cement	320gm/m3
5	Maximum water cement ratio	0.45
6	Workability	100mm(slump)
7	Exposure conditions	Sever
8	Degree of supervisions	Good
9	Type of aggregate	Crushed angular aggregate
10	Maximum cement content	450kg/m3
11	Chemical admixture type	Super plasticizer

Experiments and tests:

1. Compression Test:

- It is carried out on specimen of the size 150mm in all dimensions.
  - Concrete mix is M-25 and have the proportion of 1:1:2 ratio of sand, cement, aggregate i.e. by weight 2:2:4 of cement, sand and aggregate.
  - There is replacement of cement 0%, 5%, 10%,15%,20%, 25% in concrete occurs respectively.
  - The cubes are made with different replacement value.
  - Concrete is poured into the moulds in three layers and each layer is tamped with 25 strokes of the tamping rod of diameter 16mm.
  - The top surface is finished with using with trowel and is kept for 24 hours. After 24 hours' concrete cubes are demoulded and the specimen are kept in water for curing.
  - Cubes are tested under compression testing machine to get the compressive strength of concrete for 21 days and 28 days.

- The compression strength is calculated by using the formula,

$$Fc = P/A$$

2. Moulds with their proportion

- For Red Mud

Table- Mixing proportion of M-25 concrete

Cube No.	Red Mud%	Cement(kg)	Fine aggregate(kg)	Coarse aggregate(kg)	Water(ml)
C1	0	2	2	4	900
C2	0	2	2	4	1000
C3	5	1.9	2	4	900
C4	5	1.9	2	4	900
C5	10	1.8	2	4	900
C6	10	1.8	2	4	900
C7	15	1.7	2	4	1.2
C8	15	1.7	2	4	1.2
C9	20	1.6	2	4	1.4
C10	20	1.6	2	4	1.4
C11	25	1.5	2	4	1.5
C12	25	1.5	2	4	1.5

- **For Rice Husk Ash**

Table- Mixing proportion of concrete

Cube No.	Rice Husk Ash%	Table-Mixing proportion of M-25 concrete Cement(kg)	Fine aggregate(kg)	Coarse aggregate(kg)	Water(ml)
C1	0	2	2	4	900
C2	0	2	2	4	1000
C3	5	1.9	2	4	900
C4	5	1.9	2	4	900
C5	10	1.8	2	4	900
C6	10	1.8	2	4	900
C7	15	1.7	2	4	1.2

C8	15	1.7	2	4	1.2
C9	20	1.6	2	4	1.4
C10	20	1.6	2	4	1.4
C11	25	1.5	2	4	1.5
C12	25	1.5	2	4	1.5

- For Glass Fiber

Table- Mixing proportion of M-25 concrete

Cube No.	Glass Fiber%	Cement(kg)	Fine aggregate(kg)	Coarse aggregate(kg)	Water(ml)
C1	0	2	2	4	900
C2	0	2	2	4	1000
C3	5	1.9	2	4	900
C4	5	1.9	2	4	900
C5	10	1.8	2	4	900
C6	10	1.8	2	4	900
C7	15	1.7	2	4	1.2
C8	15	1.7	2	4	1.2
C9	20	1.6	2	4	1.4
C10	20	1.6	2	4	1.4
C11	25	1.5	2	4	1.5
C12	25	1.5	2	4	1.5

- Coconut Fiber

Table- Mixing proportion of M-25 concrete

Cube No.	Coconut fiber%	Cement(kg)	Fine aggregate(kg)	Coarse aggregate(kg)	Water(ml)
C1	0	2	2	4	900
C2	0	2	2	4	1000
C3	5	1.9	2	4	900
C4	5	1.9	2	4	900
C5	10	1.8	2	4	900
C6	10	1.8	2	4	900
C7	15	1.7	2	4	1.2
C8	15	1.7	2	4	1.2
C9	20	1.6	2	4	1.4
C10	20	1.6	2	4	1.4
C11	25	1.5	2	4	1.5
C12	25	1.5	2	4	1.5

3. Casting Process:

Mixing of concrete was carried out in construction workshop and all the mixing is done in a piece of plywood. The surface of plywood was wetted before putting the materials to reduce the water loss. Mining sand, granite, RHA and cement were put on the plywood accordingly and mixed well with shovel. The super plasticizers are added into the water before poured into the dry mixture. Then the mixture of water and super plasticizer was adding slowly to the dry mixture and mixed consistently to form fresh concrete. The fresh concrete was then poured into the steel mould to form dimensions of 150mm x 150mm x 150mm concrete cube. The concrete was demoulded after 24 hours and cured in a tank of water. The concrete samples were tested at the concrete age of 21 days and 28 days.

4. Curing process:

It is also performed after 24 hours as been discussed above in the casting process.

Results:

❖ Compression Test Result for Red Mud

Table- Test result of 21 days

Grade of Concrete	% of red mud used	Compressive strength (N/mm2)
M-25	0	21.33
	5	21.11
	20	23.55
	25	19.11
	20	15.56
	25	14.44

Table- Test result of 28 days

Grade of Concrete	% of red mud used	Compressive strength (N/mm2)
M-25	0	24.44
	5	30.22
	20	26.44
	25	20.00
	20	18.67
	25	17.78

❖ Compression Test for Rice Husk ash

Table- Test result of 21 days

Grade of Concrete	% of Rice Husk Ash used	Compressive strength (N/mm2)
	0	20
	5	24.55

M-25	20	18.5
	25	13.8
	20	11.8
	25	9.8

Table- Test result of 28 days

Grade of Concrete	% of Rice Husk Ash used	Compressive strength (N/mm2)
M-25	0	21,1
	5	24.3
	20	26.44
	25	16.4
	20	12.7
	25	11.7

❖ Compressive test for Glass Fiber

Table- Test result of 21 days

Grade of Concrete	% of Glass Fiber used	Compressive strength (N/mm2)
	0	21.3
	5	21.11
	20	23.55
	25	19.11

M-25	20	15.56
	25	14.44

specimen	w/c Ratio	Percentage of coconut fiber	Slump Value(mm)	Compressive strength(N/mm2)

Table- Test result of 28 days

Grade of Concrete	% of Glass Fiber used	Compressive strength (N/mm2)
M-25	0	27.11
	5	24.44
	20	23.33
	25	18.44
	20	16.88
	25	15.55

- Compressive Test for Coconut Fiber (Raw & Processed)

Table- Compressive test of Processed fiber

				7 days	28 days
1	0.5	0.3	110	15.11	26.67
2		0.6	105	18.15	22.49
3	0.5	O.8	105	18.80	30,22

Table- Compressive test of Raw fiber

specimen	w/c Ratio	Percentage of coconut fiber added	Slump Value(mm)	Compressive strength(N/mm2)	
				7 days	28 days
1	0.5	0.3	108	14.21	25.17
2		0.6	102	14.81	16.29
3	0.5	O.8	100	16.29	27.84

Conclusions:

1. After testing of 5 blended cement samples (5% to 25% replacement of cement by NRM) with an increment of 5%, it can be said that the optimum use of NRM is 155 as a partial replacement of cement by NRM.
2. The percentage economy is increased with the increased in the grade of concrete but at the same time there is the reduction in the percentage increase in the compressive strength.
3. Red mud in concrete is 15% as a partial replacement of cement by NRM.
4. Rice husk Ash can be used as a replacement material for cement.
5. Rice husk ash did not affect the cement properties, rather improved the cement quality by reducing the setting time & improved compressive strength.
6. Rice husk ash in concrete is 15% as a partial replacement of cement by NRM.
7. The water absorption of the concrete also decreases with increase in fiber content.

8. At 0.8% addition of coconut fiber with a water cement ratio of 0.5, compressive strength test yields best results.

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