Flexural Strength Behavior of RC Beams using Environmental Wastes

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Abstract— The concrete is made with wastes which are freely available in present environment and named as eco-friendly concrete or Green concrete. This Green Concrete is an environmental friendly and the overall impact on the environment per ton of concrete is limited. Some of the environmental waste materials are fly ash, marble powder, ceramic, crushed stone dust, Blast furnace slag, copper slag, demolition wastes, rice husk ash(RHA) etc. It has been observed that 1.71 tons of CO2 is produced per ton of cement production causes environment pollution. Now we have to reduce the production of cement for better environment. This focus of study goes on cement replacements only. Lot of research work showed and over and above all eco-friendly concrete has greater strength and durability than the normal concrete and having low flexural strength. The research papers showed compressive and tensile strengths results only so, in practical way no one can using these environmental wastes in concrete. In another study using glass fibres in concrete to improve and increase the flexural strength. There are lot of research work and plenty of journals about using 1% optimum of glass fibres in concrete for increasing the flexural strength behaviour and increasing the load carrying capacity of structural members comparative with normal concrete. So this experimental research is about how to improve the flexural strength in eco-friendly concrete with adding of glass fibres and study the strength parameters.
Key words: RC Beams, Environmental Wastes

I. INTRODUCTION

A. Green Concrete

As the resources are limited and constructions are heavy and cost of material is high. On the other hand, wastes are large in quantity, it requires large amount of area to disposal those wastes. There are several wastes like GGBS, Fly Ash, Rice husk ash, ceramic waste , marble waste etc.,

The concrete which is made with wastes which are freely available in environment as eco-friendly so called as Green concrete. The other name for green concrete is resource saving structures with reduced environmental impact for e.g. Energy saving, CO_2 emissions, waste water. Green concrete is a revolutionary topic in the history of concrete industry. This was first invented in Denmark in the year 1998 by Dr.WG. It has been observed that 1.71 tons of CO_2 is produced per ton of cement production causes environmental pollution. We have to reduce the production of cement for better environmental pollution by using wastes.

B. Why Green Concrete?

- Huge impact on sustainability.
- Most widely used material on Earth.
  - 30% of all materials flow on the planet
- 70% of all materials flow in the built environment.
  - 2.1 billion tonnes per annum.
  - 15 billion tonnes poured each year.
  - Over 2 tonnes per person per annum

C. Characteristics of Green Concrete:

- Optimizes use of available materials
- Better Performance
- Enhanced cohesion workability / consistency
- Reduced shrinkage / creep.
- Durability - Better service life of concrete
- Reduced carbon footprint
- No increase in cost
- LEED India Certification

Green concrete mix is designed with the principle of "Particle-Packing Optimization" to meet requirements of plastic and hardened properties.

D. Environmental Benefits to Using Green Concrete

1) Lasts Longer
2) Uses Industrial Waste
3) Reduces Energy Consumption
4) Reduces CO_2 Emissions

1) Advantage of Green Concrete:

1) Optimized mix designs mean easier handling, better consistency and easier finishing
2) Reduction in shrinkage & creep
3) Green Concrete uses local and recycled materials in concrete
4) The heat of hydration of green concrete is significantly lower than traditional concrete
5) This result in a lower temperature rise in large concrete pours which is a distinct advantage for green concrete.

2) Improved Engineering Properties

Mix can result in a reduced paste volume within the concrete structure resulting in a higher level of protection against concrete deterioration.

6) Higher strength per kilogram of cement
7) Increased durability & lower permeability
8) More aggregates typically mean higher Modulus of elasticity.

E. Cement Replacement Materials:

Cement replacement materials are naturally occurring materials or industrial by products which can be used as a replacement material of cement in concrete mix. They are called as pozzolans or fine minerals.

Some of the cement replacement materials are:

1) Ceramic waste
2) Rice husk ash
3) Marble powder

F. Ceramic Waste Powder:

The ceramic industry inevitable generates wastes, irrespective of the improvements introduced in the manufacturing process. In the ceramic industry, about 15%-

30% production goes as waste. These wastes pose a problem in present-day society, requiring a suitable form of management in order to achieve sustainable development. Utilization of Ceramic waste and its application are used for the development of the construction industry, Material sciences. It is the possible alternative solution of safe disposal of Ceramic waste.

Fig. 1: Ceramic waste powder

G. Rice Husk Ash:

The substitution of Rice Husk Ash and Bone Powder can be used as used as one of the replacement materials. There is abundance of this material in developing countries and it will help in removing thousands of tones of waste from the environment annually

Fig. 2: Rice husk ash

H. Marble Powder:

Marble powder is the one which, is the most commonly used replacement material. Utilization of marble powder will avoid the disposal problems and related to Environmental issues. Utilization of marble powder will reduce the usage of cement and conserve natural resources. Also we can say that some amount of cost of cement can be reduced. There is best possible way of disposal of waste material like marble powder by using it in concrete, which will reduce environmental burden.

Fig. 3: Marble powder

I. Glass Fiber:

It is a material consisting of numerous extremely fine fibers of glass. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling. Glass fiber has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass". This structural material product contains little or no air or gas, is more dense, and is a much poorer thermal insulator than is glass wool.

Fig. 4: Glass fibers

1) Types of Glass Fiber:

1) A-glass: With regard to its composition, it is close to window glass. In the Federal Republic of Germany it is mainly used in the manufacture of process equipment.
2) C-glass: This kind of glass shows better resistance to chemical impact.
3) E-glass: This kind of glass combines the characteristics of C-glass with very good insulation to electricity.
4) AE-glass: Alkali resistant glass

II. EXPERIMENTAL INVESTIGATION

The experimental program carried out check out the cement properties for ceramic powder, rice ash husk and marble powder. The major tests are specific gravity , consistency and initial setting time ceramic powder, rice ash husk and marble powder.

A. Tests on Cement:

1) Specific Gravity Test:

Specific gravity is the ratio of the density of solids to the density of liquids.

Formula used:

$$G=\frac{W2-W1}{(W4-W1)-(W3-W2)}$$

Fig. 5: Specific gravity test

2) Standard Consistency Test:

The standard consistency of cement paste is defined as that consistency which will permit a vi-cat plunger having 10mm diameter and 50mm length to penetrate to a depth of 33-35 from the top of the mould.

Fig. 6: Vicat apparatus

Fig. 7: Plunger

3) Initial Setting Time:

This time interval for which the cement product remains in plastic condition is known as "Initial setting time".

Fig. 8: Initial setting time test

S No	Name of the Test	Cement	Marble powder	Ceramic powder	Rice ash husk
1	Specific Gravity	3.15	1.6	2.3	1.8
2	Standard Consistency	30%	27%	30%	45%
3	Initial setting time	30 min	60 min	35 min	120 min

Table 1: Tests on Cement and waste materials

From the above table of results, final conclusion is ceramic powder properties is equal to cement. Because this ceramic powder of above results are similar to cement results comparative to with other marble powder and rice husk ash. Then now ceramic powder is taking to replace with cement in Green concrete.

From the above results cement is replaced with ceramic waste powder, marble powder and rice ash husk and same tests conducted on these above materials and we got the below results.

Type of material	Specific Gravity	Consistency	Initial setting time
Cement	2.6	30%	30 min
Cement with ceramic(30%)	2.3	30%	30 min
Cement with marble(20%)	1.6	27%	60 min
Cement with Rice husk ash(30%)	1.8	45%	120 min

Table 2: Tests on cement with replcements

From the above results we cement with ceramic values are better results among those materials. From now remain compressive strength and flexural strength tests are goes on with ceramic waste powder material.

III. Results and Discussions

A. Compressive Strength Test:

This test meant for conducting to know the compressive strength of hardened concrete the cubes were taken out from the curing tank and then dried, placed in compressive testing machine of 1000 tons capacity. the cube will be placed in testing machine in such a way that the load exerted on specimen should be perpendicular on the cube, applied at a constant rate up to failure of specimen and the ultimate load at failure is noted the cube compressive strength of the concrete mix is then computed a sample calculation for the determination of cube compressive strength is presented in I. This test has been carried out on cube specimens at 7 and 28 days of age the values are represented in a table.

Compressive strength = P/A.

Where,
P = maximum load in kg applied to the specimen
A = cross-sectional area of the cube on which the load is applied (150× 150mm)

Fig. 9: Compressive Strength testing machine

Fig. 10: Cube after testing

CEMENT %	CERAMIC %	7DAYS	28 DAYS
100	0	20.54	31.28
90	10	21.2	32.1
80	20	22.36	33.07
70	30	25.5	37.5
60	40	23.34	35.5

Table 3: compressive strength results for 7 & 28 days

Graphical representation of compressive strength for 7 & 28 days.

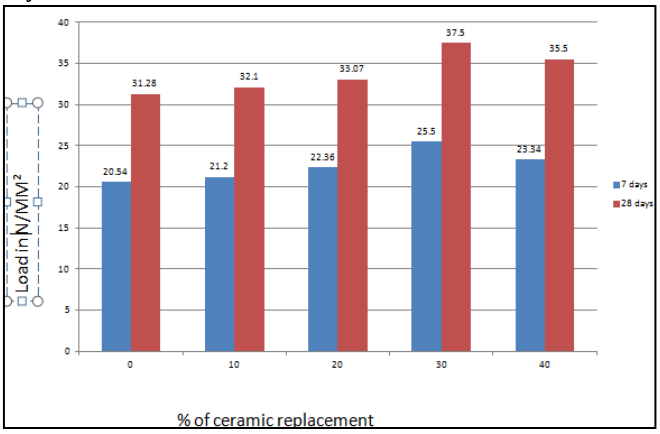

Fig. 11: Compressive strength results in graphical representation

B. Flexural Strength Test:

This test meant for conducting to know the flexural strength of hardened concrete the beams were taken out from the curing tank and then dried, placed in universal testing machine of 400 KN capacities. the beam will be placed in testing machine in such a way that the load exerted on specimen should be perpendicular on the cube, applied at a constant rate up to failure of specimen and the ultimate load at failure is noted the cube flexural strength of the concrete mix is then computed a sample calculation for the determination of beam flexural strength is presented in I. This test has been carried out on beam specimens at 28 days of age the values are represented in a table.

Fig. 12: UTM Machine for Flexural Strength testing

In this test, ceramic waste powder with cement and also added 1% of glass fibers to this flexural strength test because of improve in flexural strength results.

Fig. 13: beams after testing

Ceramic in %	Cement in %	Glass fibres in %	Ultimate load (n/mm²)	Deflection (mm)
0	100	1	27.34	5.8
5	95	1	32.33	4.3
10	90	1	44.63	4.2
15	85	1	45.09	4.2
20	80	1	40.76	4.5
30	70	1	29.18	4.7
40	60	1	24.26	5.3

Table 4: Flexural Strength Test Results

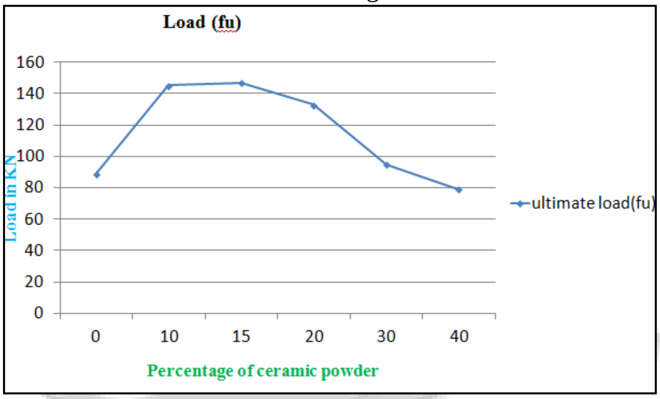

Fig. 14: Graphical representation of above flexural strength results

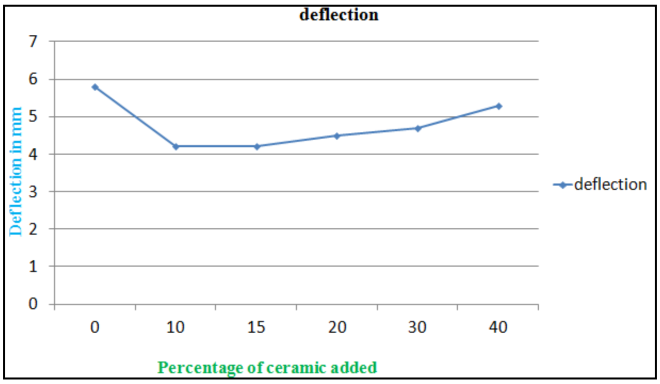

Fig. 15: Graphical representation of deflections from above results

IV. CONCLUSION

Results are analyzed to derive useful conclusions regarding the workability, strength characteristics of concrete on replacement of cement with ceramic powder in different proportions for M25 mix grades.

1) From the results it is clear that, compressive strength increases upto 30% replacement of cement with ceramic waste. further increases the ceramic waste , compressive strength will decreases.
2) Adding of glass fiber to this mix design getting 1% is optimum.
3) Flexural strength increases up to 15 % replacement of cement with ceramic waste and 1% glass fibers.
4) For 15% replacement of cement with ceramic waste and 1% glass fibers flexural strength increased up to 60% when compared to conventional concrete.
5) For 25% replacement of cement with ceramic waste and 1% glass fibers flexural strength increased up to 45% when compared to conventional concrete.
6) For 30% replacement of cement with ceramic waste and 1% glass fibers Flexural strength increased up to 9% when compared to conventional concrete.
7) For 40% replacement of cement with ceramic waste and 1% glass fibers flexural strength decreased up to 2% when compared to conventional concrete.
8) From above results 30% of ceramic waste powder added to cement we are getting similar values of normal conventional concrete.
9) Where 15% is the optimum and 30% is minimum for the flexural strength. So, from this we can reduce the cement content by replacing the material which is economical.

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