International Journal For Technological Research In Engineering
Volume 5, Issue 3, November-2017 *ISSN (Online): 2347 - 4718*

EXPERIMENTAL STUDY ON GREEN CONCRETE

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ABSTRACT: Construction industry is growing rapidly and new technologies have evolved very fast to cater different difficulties in the construction industry. Among all materials used in the construction industry concrete is main material for construction purpose. Billions of tons of naturally occurring materials are mined for the production of concrete which will leave a substantial mark on the environment. Nowadays recycling of waste and industrial by products gaining popularity to make concrete environment friendly material and the concrete can be called as Green Concrete. This review paper will give us a brief idea about as well as advantages and disadvantages about green concrete. This paper proposed the guidelines for the design of fly ash based green concrete of ordinary and standard grade on the basis of quantity and fineness of fly ash, quantity of water and grading of fine aggregate by maintaining water- to-green binder ratio of 0.35, solution-to-fly ash ratio of 0.40, and sodium silicate-to-sodium hydroxide ratio of 1 with concentration of sodium hydroxide as 11M, 13 M, 15M. Heat curing was done at 60°C for duration of 24 h and tested after 1, 3 and 7 days after oven heating.

I. INTRODUCTION

Unfortunately concrete is not an environmental friendly material, either to make, or to use, or even to dispose of. To gain the raw materials to make this material, much energy and water must be used, and quarrying for sand and other aggregates causes environmental destruction and pollution .claimed to be a huge source of carbon emissions into the atmosphere. Some claim that concrete is responsible for up to 5% of the world's total amount of carbon emissions, which contribute to greenhouse gases. The reason for the huge popularity of concrete is the result of a number of well-known advantages, such as low cost, general availability, and wide applicability. But this popularity of concrete also carries with it a great environmental cost. Cement-based materials are the most abundant manufactured materials in the world. Today’s exciting trend is the Green building is in our country. The potential environmental benefit to society of being able to build with green concrete is huge. Green Concrete as the name suggests is eco friendly and saves the environment by using waste products generated by industries in various forms like rice husk ash, micro silica, etc to make resource-saving concrete structures . Use of green concrete helps in saving energy with emissions, waste water. Green concrete is very often also cheap to produce as it uses waste products directly as a partial substitute for cement, thus saving energy consumption in production of per unit of cement. Over and above all green concrete has greater strength and durability than the normal concrete. It is realistic to assume that the technology can be developed, which can reduce the CO_2 emission related to concrete production.

Objectives

- Replacement of fly ash instead of cement in conventional concrete.
- Getting the same or more strength then that of conventional concrete.
- Fixing out the mix design for green concrete.

Workability of Green Concrete
A fly ash particle is generally spherical in shape and reduces the water requirement for a given slump. The spherical shape helps to reduce friction between aggregates and between concrete and pump line and thus increases workability and improve pump ability of concrete. Fly ash use in concrete increases fines volume and decreases water content and thus reduces bleeding of concrete. Different concrete types are tested for workability, changes in workability after 30 min., air-content, compressive strength development, E-modulus, heat development, homogeneity, water separation, setting time, density and pump ability. Furthermore, frost testing, chloride penetration and an air void analysis are carried out for the concretes in the aggressive environmental class.

Advantages of Green Concrete
• Much change is not required for the preparation of green concrete compared to conventional concrete.
• Reduces environmental pollution.
• Have good thermal and acid resistance.
• Compressive and split tensile strength is better with some materials compared to conventional concrete.
• Reduces the consumption of cement overall.
• Green concrete is economical compared to conventional concrete.
Disadvantages of Green Concrete
• Structures constructed with green concrete have comparatively less
• Life than structures with conventional concrete.
• Compressive strength and other characteristics are less compared to conventional concrete.
• Water absorption is high.
• Shrinkage and creep are high compared to conventional concrete.
• Flexural strength is less in green concrete.

Applications of Green Concrete

Cement-based materials are the most abundant manufactured materials in the world. Today's exciting trend is the Green building is in our country. The potential environmental benefit to society of being able to build with green concrete is huge. Green Concrete as the name suggests is eco friendly and saves the environment by using waste products generated by industries in various forms like rice husk ash, micro silica, etc to make resource-saving concrete structures . Use of green concrete helps in saving energy with emissions, waste water. Green concrete is very often also cheap to produce as it uses waste products directly as a partial substitute for cement, thus saving energy consumption in production of per unit of cement. Over and above all green concrete has greater strength and durability than the normal concrete. It is realistic to assume that the technology can be developed, which can reduce the CO_2 emission related to concrete production. Generally the construction industry accounts for a massive environmental impact due to its high demand of energy. As a result of the awareness built during the past few years about green house effect and damage to the nature, more people and countries became conscious about their future.

- The applications of green concrete are same as cement concrete. However, this material has not yet been popularly used for various applications.
- This concrete has been used for construction of pavements, retaining walls, water tanks, precast bridge decks.
- Recently world's first building Structural Building, The University of Queensland's Global Change Institute (GCI) has been constructed with the use of green concrete. It is a four storey high building for public use.
- Green concrete is composed of alkaline liquid and source materials which is either natural mineral or by product material for example fly ash.
- Green concrete is a binder that is used instead of Portland cement and it produced because of efforts which were conducted to reduce detrimental environmental impact of Portland cement.

II. LITERATURE REVIEW

Green concrete. No doubt you've heard about it and its "Green" possibilities. But how much do you know about green concrete and its presence in today's concrete industry?

Green Concrete is a type of concrete which resembles the conventional concrete but the production or usage of such concrete requires minimum amount of energy and causes least harm to the environment. Green concrete is very low energy & resource consumption, no environmental pollution & sustainable development. Green cement concrete is produced by using recycled waste materials such as activated fly ash and recycled concrete aggregates. Other concrete alternatives can be equally used to significantly increase the sustainability and durability. Secondly, one must plan for structural designs involving environmentally friendly maintenance strategies which will need less of energy and resources. Although green concrete seems to be providing lot of benefits, still one needs to consider the potential barriers on its way. They are increase in cost of recycling and reusing along with use of additional energies and resources for the same and the fear of failure of the green concrete as it is made from reused products. One can conclude that overcoming the above demerits would help to use green cement concrete with a potentially new environmental friendly world.

S.S. Jain Subodh P.G. Autonomous College University of Rajasthan Jaipur says In order to estimate the environmental impact of a construction material, it is necessary to consider all stages in the life of the material. Each construction material is manufactured from some combination of raw materials, with some expenditure of energy, and with associated wastes. Therefore manufacture is an essential element in computing the environmental impact, and manufacture is probably the element most widely cited when considering the environmental impact of construction materials. Are the raw materials renewable? Are they scarce? Are they important to the global environment? How much energy is required in the manufacture? How much waste is produced during the manufacture? What impact do these wastes have on the environment? These questions are very important and this phase probably receives the most attention, both from the general public and from the government.

The construction process also involves some expenditure of energy and produces some waste. There are several important questions. How much of each manufactured material is used? Can materials be used that have less environmental impact? How much energy is used? How much waste is produced? What is the impact of the waste on the environment? Some of these questions can only be answered for a specific structure. Increasing attention is being given to the construction phase as part of global and regional efforts to make development more sustainable. The lifetime of the structure has a direct impact on sustainability. When the structure deteriorates, it must be destructed and rebuilt. The lifetime is directly controlled by the durability of the construction materials. It is further influenced by the adaptability of the design to repair and renovation, and repair and renovation themselves have environmental impacts. Finally, the lifetime of a structure is influenced by cultural and market forces. When a structure no longer serves an important function (not necessarily the function for which it was constructed), it is likely to be destructed. And if it is not aesthetically pleasing, it may be destructed. So materials and design considerations directly affect the lifetime of a structure and the lifetime must be considered when computing environmental impact.

Literature review by Anita Bhatia*, Rashmy Nair*, Neeru Gakkhar* on green concrete says, Green concrete is a new development in the world of concrete in which cement is totally replaced by pozzolanic materials like fly ash and activated by highly alkaline solutions to act as a binder in the concrete mix. For the selection of suitable ingredients of green concrete to achieve desire strength at required workability, an experimental investigation has been carried out for the gradation of green concrete and a mix design procedure is proposed on the basis of quantity and fineness of fly ash, quantity of water, grading of fine aggregate, fine to total aggregate ratio. Sodium silicate solution with Na2O = 16.37 %, SiO2 = 34.35 % and H2O = 49.28 % and sodium hydroxide solution having 13 M concentration were maintained constant throughout the experiment. Water-to-alkaline binder ratio of 0.35, alkaline solution-to-fly ash ratio of 0.35 and sodium silicate-to-sodium hydroxide ratio of 1.0 by mass were fixed on the basis of workability and cube compressive strength. Workability of green concrete was measured by flow table apparatus and cubes of 150 mm side were cast and tested for compressive strength after specified period of oven heating. The temperature of oven heating was maintained at 60 °C for 24 h duration and tested 7 days after heating. It is observed that the results of workability and compressive strength are well match with the required degree of workability and compressive strength. So, proposed method is used to design normal and standard green concrete.

III. METHODOLOGY

1) Collection of Fly ash
Fly ash produced in modern power stations of India is of good quality as it contains low sulphur & very low unburnt carbon. For the project green concrete, we brought fly ash from TNR ready mix concrete plant, Hayath Nagar, Hyderabad.

2) Collection of aggregates
Coarse aggregates are particles greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter. They can either be from Primary, Secondary or Recycled sources. For the project green concrete, we brought aggregates from Gopala aggregate suppliers, Nagole, Hyderabad.

3) Collection of alkaline materials
a) Sodium hydroxide (NaOH)
Sodium hydroxide is also a strong base, which is a compound that splits apart in water to make many hydroxide (OH-) ions. When dissolved in water, sodium hydroxide has a very high pH and feels very slippery. Generally, sodium hydroxide is most corrosive when it is dissolved in water.

b) Sodium silicate (Na2Sio3)
Sodium silicate is a white powder that is readily soluble in water, producing an alkaline solution. All are glassy, colorless and dissolve in water. Sodium silicate is stable in neutral and alkaline. In acidic solutions, the silicate ion reacts with hydrogen ions to form silicic acid, which when heated and roasted forms silica gel, a hard, glassy substance. Liquids and solids based on sodium silicate and produced have a density from 1.6g/cubic cm. to about 1.4 g/cubic cm.

Initially, Fly ash doesn't have any binding property to hold the aggregates. To generate the binding property in fly ash, the alkali solutions (i.e. mixture of both sodium hydroxide + sodium silicate) is added to fly ash at different molarities.
4)Preparation of alkaline activator
Alkaline activator for the present work is prepared using commercially available sodium silicate liquid and sodium hydroxide pallets. Commercially available sodium silicate liquid contains Na2O = 14.61 %, SiO2 = 25.18% and water = 59.99 %. The alkaline solution is prepared with NaOH molar concentration varying from 8 to 16; the mass ratio of sodium silicate to sodium hydroxide varied from 1.75 to 3.0; and the mass ratio of alkaline liquid to fly-ash also varied from 0.25 to 0.40. Water to polymer solid ratio by mass is maintained constant as 0.3 throughout investigation.
a) Preparation of alkaline activator
Preparation of alkaline activator is done in different concentrations of NaOH (i.e. 11M, 13M, and 15M) and sodium silicate solution.
b) Preparation of alkaline activator with 11M of NaOH & Na2Sio3
The sodium hydroxide pellets are dissolved in distilled water to make solution. The mass of NaOH 11 x 40 = 440 grams is added per one liter of solution along with sodium silicate which contains Na2O of 16.37 %, SiO2 of 34.35 % and H2O of 49.72 %. The mass of NaOH varies depending upon concentration.
c) Preparation of alkaline activator with 13M of NaOH & Na2Sio3
The concentration of sodium hydroxide was maintained at 13 M while concentration of sodium silicate contains Na2O of 16.37 %, SiO2 of 34.35 % and H2O of 49.72 % is used as alkaline solutions.
d) Preparation of alkaline activator with 15M of NaOH & Na2Sio3
The concentration of sodium hydroxide was maintained at 15 M while concentration of Sodium silicate contains Na2O of16.37 %, SiO2 of 34.35 % and H2O of 49.72 % is used as alkaline solutions.

IV. MIX DESIGN

Mix design for M 30 grade of green concrete using proposed method
Design steps
1. Target mean strength
F_{ck} = 38.25 MPa

2. Selection of quantity of fly ash

From Fig. 1, the quantity of fly ash required is 405 kg/m^3 for the target mean strength of 38.25 MPa at solution-to-fly ash ratio of 0.35 and for 430 m^2/kg fineness of fly ash.

3. Calculation of the quantity of alkaline activators
Solution/fly ash ratio by mass=0.35
i.e. Mass of (Na_2SiO_3+NaOH)/Fly ash= 0.35
Mass of (Na_2SiO_3+NaOH)/405 =0.35
Mass of (Na_2SiO_3+NaOH) = 141.75kg/m^3
Take the sodium silicate-to-sodium hydroxide ratio by mass of 1
Mass of sodium hydroxide solution (NaOH) = 70.88 kg/m^3
Mass of sodium silicate solution (Na2SiO3) = 70.88 kg/m^3
4. Calculation of total solid content in alkaline solution
Solid content in sodium silicate solution = (50.32/100)x70.88

=35.67 kg/m^3
Solid content to sodium hydroxide solution = (38.50/100)x70.88 =27.29 kg/m^3
Total solid content in both alkaline solutions = 62.96 kg/m^3

5. Selection of water content
For medium degree of workability and fineness of fly ash of 430 m^2/kg, water content per cubic meter of green concrete is selected from Table 2 Water content = 110 kg/m^3

6. Adjustment in water content
Adjustment in water content = -1.5%
Total quantity of water required = 110-(1.5/100) x 110 =108.35 kg/m^3
Water content in alkaline solutions = 141.75-62.69 =78.79 kg/m^3

7. Calculation of additional quantity of water
= [Total quantity of water] − [Water present in alkaline solutions]
= 108.35 − 78.79 = 29.46 kg/m^3

8. Selection of wet density of green concrete
Wet density of green concrete is 2,528 kg/m^3 for the fineness of fly ash of 430 m^2/kg.

9. Selection of fine-to-total aggregate content

Table: Materials required for M30 grade green concrete

Ingredients ofgreen concrete	flyash	NaOH	Na_2SiO_3	Sand	Coarse aggregate	Total water (W/GCB)	Extra water
Quantity (kg/m^3)	405	70.88	70.88	683.13	1.268.66	108.35	29.46
proportion	1	0.35	0.35	1.82	3.37	0.211	0.07

From Fig, Fine-to-total aggregate content is 35% for fineness modulus of sand of 3.35

10. Calculation of fine and coarse aggregate content
Total aggregate content = [wet density of GC]-[quantity of fly ash+ quantity of both solutions + extra water, if any]
=2,528-[405+141.75+29.46] = 1,951.79 kg/m^3
Sand content = [fine –to – total aggregate content in %] X [total quantity of all in aggregate]
= (35/100) x 1,951.79 = 683.13 kg/m^3
Coarse aggregate content = [total quantity of all in aggregate]-[sand content]
= 1,951.79-683.13 =1 268.66 kg/m^3
Quantity of materials required per cubic meter for M30 grade of green concrete is given.

V. RESULTS AND DISCUSSIONS

a) Tests Performed on Fly Ash

S.No	Test	Value
1	Specific gravity	2.89
2	Soundness (mm)	10
3	Standard consistency (%)	35
4	Initial & final setting time	30 min & 10 h

b) Tests Performed on Aggregates

S.No	Test	Value
1	Los angeles abration value	28.2%
2	impact value	8.8%
3	crushing value	31.5%
4	Shape test	16.65

c) Details of compressive strengths at different molarities:
Details of compressive strength of green concrete cubes

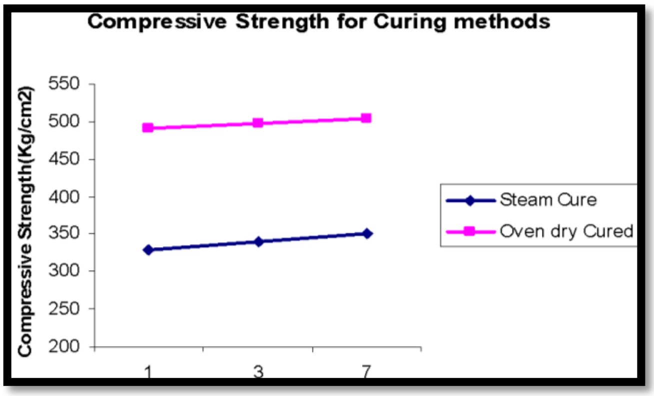
S.No	Curing details			Slump	Age at test day	Compressive strength in kg/cm^2	Special feature
	Time	Temp	Method				
1	20 Hrs	60^0C	Steam	Collapsible	1st day	435.556	NaOH-15M AL / FA= 0.40
	20 Hrs	60^0C	Steam	Collapsible	3rd day	442.445	
	20 Hrs	60^0C	Steam	Collapsible	7th day	451.112	
	20 Hrs	Room temp	Normal	Zero	28th day	463.52	
2	20 Hrs	60^0C	Steam	Collapsible	1st day	322.277	NaOH-13M AL / FA= 0.40
	20 Hrs	60^0C	Steam	Collapsible	3rd day	330.377	
	20 Hrs	60^0C	Steam	Collapsible	7th day	340.724	
	20 Hrs	Room temp	Normal	Zero	28th day	358.26	
3	20 Hrs	60^0C	Steam	Collapsible	1st day	337.788	NaOH-11M AL / FA= 0.40
	20 Hrs	60^0C	Steam	Collapsible	3rd day	348.889	
	20 Hrs	60^0C	Steam	Collapsible	7th day	357.778	
	20 Hrs	Room temp	Normal	zero	28th day	364.56	

d) Details of Flexural strength of green concrete blocks

S.No	Curing details			Slump	Age at test day	Flexural strength in kg/cm^2	Special feature
	Time	Temp	Method				
1	20 Hrs	60^0C	Steam	Collapsible	1st day	106.667	NaOH-15M AL / FA= 0.40
	20 Hrs	60^0C	Steam	Collapsible	3rd day	113.333	
	20 Hrs	60^0C	Steam	Collapsible	7th day	120.000	
	20 Hrs	Room temp	Normal	Zero	28th day	124.32	
2	20 Hrs	60^0C	Steam	Collapsible	1st day	86.667	NaOH-13M AL / FA= 0.40
	20 Hrs	60^0C	Steam	Collapsible	3rd day	93.333	
	20 Hrs	60^0C	Steam	Collapsible	7th day	100.0	
	20 Hrs	Room temp	Normal	Zero	28th day	112.25	
3	20 Hrs	60^0C	Steam	Collapsible	1st day	73.333	NaOH-11M AL / FA= 0.40
	20 Hrs	60^0C	Steam	Collapsible	3rd day	80.000	
	20 Hrs	60^0C	Steam	Collapsible	7th day	84.000	
	20 Hrs	Room temp	Normal	zero	28th day	95.80	

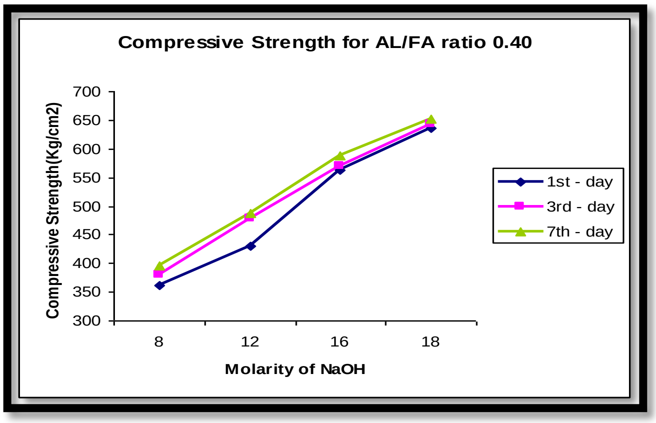
e) Discussions
Green concrete mix is prepared using mix proportion calculated in preceding section and shown in Table 4. It was found that the fresh fly ash-based green concrete was viscous, cohesive and dark in colour and glassy appearance. After making the homogeneous mix, workability of fresh green concrete was measured by flow table apparatus as per IS 5512-1983 and IS 1727-1967. Freshly mixed green concrete is viscous in nature and water comes out during polymerization process, methods like slump cone test is not suitable to measure workability as concrete subside for long time while in compaction factor test, concrete cannot flow freely. So, flow table test is recommended for workability measurement of green concrete.

Graph: plot between compressive strength and age of green concrete



The above graph show variation of compressive strength with respect to age of green concrete that is number of days from the 1st day of blocks prepared.

Graph: plot between compressive strength to concentration oh NaOH



The above graph show variation of compressive strength with respect to concentration of NaOH at different molarities. As the concentration of NAOH increases the compressive strength also increases.

VI. CONCLUSION

Experimental results of M_{30} grades of green concrete mixes using proposed method of mix design shows promising results of workability and compressive strength. So, these guidelines help in design of fly ash based green concrete of Ordinary and Standard Grades as mentioned in IS 456:2000. With the obtained results we can conclude that as the concentration of alkali solution increases the compressive strength of the green concrete blocks increases, and the also with steam curing the solution gets binding property which helps in getting required strength.

VII. FUTURE SCOPE FOR GREEN CONCRETE

Green concrete is a revolutionary topic in the history of concrete industry. This was first invented in Denmark in the year 1998. Green concrete has nothing to do with colour. It is a concept of thinking environment into concrete considering every aspect from raw materials manufacture over mixture design to structural design, construction, and service life. Green concrete is very often also cheap to produce, because, for example, waste products are used as a partial substitute for cement, charges for the disposal of waste are avoided, energy consumption in production is lower, and durability is greater. Green concrete is a type of concrete which resembles the conventional concrete but the production or usage of such concrete requires minimum amount of energy and causes least harm to the environment. Green Concrete as the name suggests is eco friendly and saves the environment by using waste products generated by industries in various forms like rice husk ash, micro silica etc. to make resource-saving concrete structures .Use of green concrete helps in saving energy, emissions, waste water Green concrete is very often also cheap to produce as it uses waste products directly as a partial substitute for cement, thus saving energy consumption in production of per unit of cement. Green Concrete is a term given to a concrete that has had extra steps taken in the mix design and placement to insure a sustainable structure and a long life cycle with a low maintenance surface.

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