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Green Concrete for better Sustainable Environment

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Abstract:-*The purpose of this study is to investigate the effects of concrete on the environment .There is a huge growth in Construction industry . Many new technologies have evolved very rapidly to cater different difficulties in the construction industry. Concrete is one of the most important materials in a construction industry, among all the material used for construction purposes. The process of manufacturing of cement emits near about eight to ten parent of total world's carbon dioxide . The global warming gas is released when limestone and clays are crushed and heated to high temperatures. In recent year , the recycling of waste and industrial by products gaining popularity to make concrete environment friendly material and the concrete can be called as Green Concrete. Green concrete is defined as a concrete which uses waste material as at least one of its components, or its production process does not lead to environmental destruction, or it has high-performance and life cycle sustainability. This review paper will help to give us a brief idea about advantages and disadvantages of green concrete.*

Key Words **— Concrete, Green Concrete, Recycled Aggregates, Fly Ash, Recycled Aggregate Concrete, Cement, Fine Aggregate, Coarse Aggregate, Admixture.**

1.INTRODUCTION:-

Environmental protection and conservation has become a major world issue in the global context.All over the world the size of construction industry is growing at faster rate. The demand for construction materials increases very much, due to huge growth in a construction . When the raw material of cement, limestone and clay is crushed and heated in a furnace at high temperature (±15000C),the global warming gas is released in large amount.Approximately 1.89 billion tons of cement (which is one of the major component of concrete) have beenproduced worldwide ,each year . In traditional cement CO2 emission is very high and in some cases can be equal to more than 1t per 1t of cement production . Due to this fact ordinary cement, which is often called as Portland cement, unfortunately is being serious environment and atmospheric pollutant. This is happening because of fact that producing cement clinker involves very well-known reaction called calcinations of calcium carbonate which can be written is this equation (1):

$$5CaCO3 + 2SiO2 \rightarrow (3CaO,SiO2)(2CaO,SiO2) + 5CO2.$$

Aggregates are the main constituent of concrete. The availability of aggregates has emerged problems in recent times due to continuously mining ., There is need to find replacement to some extent to cater this problem . Nowadays, there is a solution to some extent and the solution is known as "Green Concrete.."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 mix design to structural design, construction, and service life. The production cost of Green concrete is less i.e green concrete is cheap to produce because, waste products are used as partial substitute for cement, charges for the disposal are avoided, energy consumption in production is lower, and durability is greater. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits.

IMPACT ON ENVIRONMENT DUE TO CONCRETE:-

I. Cement production produces carbon dioxide which is one of the greenhouse gases which is responsible for global warming. About0.9 tons of carbon dioxide is produced for every 1 ton of cement produced.

II. Aggregates are one of the major ingredients in the production of concrete. Without the use of aggregates it is not possible to produce concrete. Aggregates are mined from the rock mines and the rate with which concrete is produced there will be significant reduction in naturally occurring materials.

III. According to the report of Technology, Information, Forecasting, Assessment Council, disposal of construction and demolition waste has become a major problem these days. The total amount of waste from construction industry is estimated to be 12 to 14.7 million tons per annum. Out of which 7.8 million tons are concrete and brick waste. Because of increasing problems of these wastes many countries have started researches to use these materials as source.

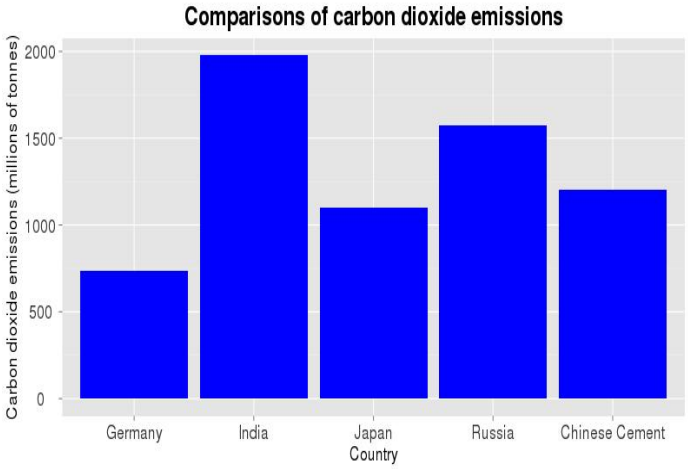


Chart -1: Comparisons of carbon dioxide emissions

1.2 Need For The Study

- To determine an alternative for the ordinary Portland cement.
- To produce eco-friendly concrete and reduce CO2 emission .
- To develop a product which will be a cost efficient .
- To provide high strength concrete than ordinary Portland concrete .

1.3 Objectives:

- To produce a concrete with the use of locally available materials (i.e. Green concrete).
- To study the strength properties of green concrete with percentage replacement of cement with fly ash , partial replacement of natural aggregates .
- To compare the cost variation of green concrete with normal concrete.

2. REVIEW OF LITERATURE

2.1 General

In this research paper , the production of green concrete and applications of green concrete are discussed .

2.2 Green Concrete

Green concrete was first invented in Denmark in the year 1998 by Dr.WG. . This is a revolutionsary topic in the history of concrete industry. The concrete which is made with concrete wastes which are 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, co2 emissions, waste water.

2.3 Literatures On Green Concrete :

Prof. Pratap Krishnan discussed the results of an experimental investigation FLY ASH and BLAST FURNACE SLAG are used in equal proportion (50% each). The green concrete gains about 60-70% of the total compressive strength within 7days.

Palaniappan. A, S. Vasantha concluded the experimental investigation and compare on the mechanical properties of different binder composition (17 TO 20 % replacement of cement by ground granulated blast furnace slag (GGBS)) of Green Concrete Composites (GPCC). The test results show that GGBS concrete shown increase in compressive strength of 13.82% as compared with conventional concrete.

Gokulram .H, R. Anuradha presented the results of an experimental investigation and compare on the mechanical properties of different binder composition (100% replacement of cement by ASTM class F Fly ash (FA) and ground granulated blast furnace slag (GGBS)) of Green Concrete Composites (GPCC).

Ganapati Naidu. P, A. S. S. N. Prasad reported in this paper that an attempt is made to study strength properties of green concrete using low calcium fly ash replacing with slag in 5 different percentages. Higher concentrations of G.G.B.S (Slag) result in higher compressive strength of green concrete. 90% of compressive strength was achieved in 14 days.

REPLACEMENT MATERIALS FOR GREEN CONCRETE

Sl. No	TRADITIONAL INGREDIENTS	REPLACEMENT MATERIALS FOR GREEN CONCRETE
1	C E M E N T	ECO-CEMENT, SLUDGE ASH, MUNCIPAL SOLID WASTE, FLY ASH
2	COARSE AGGREGATE	RECYCLED AGGREGATES, WASTE READY MIX CONCRETE, WASTE GLASS, RECYCLED AGGREGATES WITH CRUSHED GLASS, RECYCLED AGGREGATES WITH SILICA FUME
3	FINE AGGREGATE	RECYCLED AGGREGATE, BOILER BRICK WASTE, QUARY DUST, WASTE GLASS POWDER, MARBLE SLUDGE POWDER, FOUNDRY SAND POWDER, ARTIFICIAL SAND, WASTE GLASS, FLY ASH AND MUNICIPAL BOTTOM ASH OF MUNICIPAL SOLID WASTE

II EXPERIMENTAL MATERIALS

This experiment studies the strength characteristic of green concrete that contains locally available material as its key ingredients . The studies were carried out using demolished concrete coarse aggregates, artificial fine aggregate and fly ash as a supplementary cementitious material . Compressive strength is conducted at 7 ,14 and 28 days.

Materials

a. **Cement –**

Cement is one of the key ingredient in the concrete .An ordinary Portland cement is the most commonly used cement in the construction .. The Ordinary Portland Cement of 53 grades conforming to IS: 8112-1989 is being used. Various tests were conducted on cement; some of them are consistency tests, setting tests, soundness tests, etc.

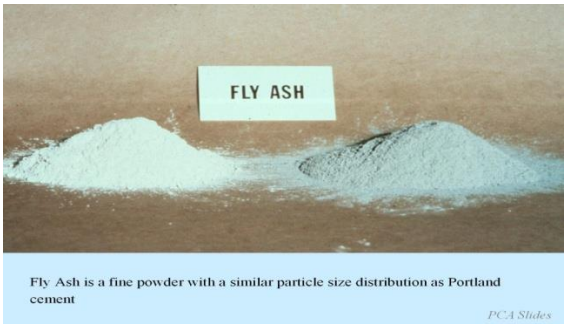
Sr. No	Physical properties of OPC 53Cement	Results	Requirements as per IS:8112 1989
1	Specific Gravity	3.15	3.10-3.15
2	Standard consistency (%)	31.5	30 - 35
3	Initial Setting Time (min)	30	30 minimum
4	Final Setting Time (min)	211	600 minimum
5	Compressive Strength (At 28 days in N/mm2)	58	53 N/mm2 Minimum

a. **Fly Ash**

Fly ash is obtained as a by-product after combustion of coal. Fly ash is one of the most abundant materials on the Earth. It is very crucial ingredient in the production of green concrete . A pozzolan is a material that exhibits cementations properties when combined with calcium hydroxide. Fly ash is the main by product created from the combustion of coal in coal-fired power plants. There are two “classes” of fly ash, Class F and Class C. Each class of fly ash has its own unique properties. The chemical composition of fly ash are shown in the table 1

Chemical Composition Of Fly Ash

OXIDES	PERCENTAGE
Sio2	52.0
Al2O3	33.9
Fe2O3	4.0
CaO	1.2
MgO	0.81
LOI	6.23



b. **Ground Granulated Blast Furnace Slag**

Chemical constitution of the Ground granulated blast furnace slag are calcium oxide, silicon di-oxide, aluminium oxide, magnesium oxide. It has almost the same chemical constituents as ordinary portland cement but the proportions of chemical constituents are different in GGBFS. The addition of G.G.B.S in Green Concrete increases the strength of the green concrete and also curing of Green concrete at room temperature is possible.

Chemical Composition

The chemical composition of the ordinary Portland cement and the chemical composition of GGBS is compared and discussed below in Table2.

Chemical constitution	Cement (%)	GGBS (%)
Calcium oxide (CaO)	62.91	37.02
Silicon di-oxide (SiO_2)	19.1	4.27
Aluminum oxide(Al_2o_3)	5.20	14.33
Magnesium oxide(MgO)	2.54	8.41

One of the most important and large used constituents in concrete are aggregates. They give bond to the concrete, reduce shrinkage and effect economy. Good gradation of aggregates is one of the most important factors for producing workable concrete. It indicates that fractions of aggregates in required proportion such that the sample contains minimum voids . The concrete with the well graded aggregate containing minimum voids and it requires minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, higher strength, lower shrinkage and greater durability.

i. **Coarse Aggregate (Recycled and Natural Coarse Aggregates)**: In this experiment , the coarse aggregates used are natural and recycled coarse aggregates .The fractions from 20 mm are used as a coarse aggregate. The Coarse Aggregates fromcrushed Basalt rock, conforming to IS: 383 is beingused. The Flakiness and Elongation Index weremaintained well below 15%.

Recycled Aggregate and Natural Aggregate

COMPARISON OF RECYCLED ANDNATURAL AGGREGATE:

Texture

Natural aggregate is smooth and rounded compact aggregate where recycled aggregate has the rough – textured, angular and elongated particles .A certain amount of mortar and cement paste from the original concrete remains attached to stone particles in recycled aggregate,when demolished concrete is crushed . The recycled coarse aggregates are of lower quality as compare to the natural coarse aggregate because of the attached mortar to the aggregates . Following properties recycled aggregates as compare to natural aggregates are obtained :

- increased water absorption
- decreased bulk density
- decreased specific gravity

Quality
Recycled aggregate and natural aggregates have the different qualities . The quality of natural aggregate is based on the physical and chemical properties of sources sites, where the recycled aggregate is depended on contamination of debris sources. It also stated that natural resources have suitable for multiple product and higher product larger marketing area, but recycled aggregate have limited product mixes and the lower product mixes may restrain the market.

Density
recycled concreteaggregate have lower specific gravity as compared to the natural aggregate. Density ofrecycled aggregate is lower than the fresh aggregatebecause of the porous and less dense residual mortarlumps that is adhering to the surfaces. When theparticle size is increased, the volume percentage ofresidual mortar will increase too.

Strength
The strength of recycled aggregate is lowerthan natural aggregate because of the weight ofrecycled aggregate is lighter than natural aggregate.This is the general effect that will reducethe strengthof reinforced concrete.

TABLE -2
PROPERTIES OF NATURAL & RECYCLED AGGREGATES

Property	Coarse Aggregate	Recycled Coarse Aggregate
Fineness modulus	7.54	7.476
Specific Gravity	2.76	2.74
Water absorption(%)	1.83	1.73
Bulk Density (gm/cc)	1741	1660

ii. **Fine aggregates :** The fine aggregate used in the project was artificial fine aggregate . It was first sieved through 4.75mm sieve to remove any particles greater than 4.75mm.Properties of the fine aggregate are tabulated below in Table 3

TABLE -3
PROPERTIES OF FINE AGGREGATE

S.No	Characteristics	Values
1.	Type	Crushed (Artificial)
2.	Specific gravity	2.6
3.	Water Absorption	3 %
4.	Grading zone	Zone 2

ARTIFICIAL SAND

c. **Water**
One of the most important ingredient in the concrete is water .It actually participates in the chemical reaction withcement .The quantity and quality of water arerequired to be looked into very carefully as it helps to form a strength .

III DESIGN MIX METHODOLOGY

A mix M25 grade was designed as per IS10262:1989 and the same was used to prepare the testsamples. The design mix proportion is shown in Table5

TABLE 5
CONCRETE DESIGN MIX PROPORTIONS

	FLY ASH	CEMENT	COARSE AGGREGATE	FIN
By weight, [kg]	6	4	33	

III EXPERIMENTAL WORK

This experimental study includes research work for the workability test and hardened concrete specimen test. The whole test program is as follows. The experimental study was divided into four major segments viz.
1) Materials and their testing
2) Concrete mix design
3) Checking the fresh properties of the mixes for M25 grade: slump cone test.
4) Tests on Hardened concrete specimens: Compressive Strength Test

IV EXPERIMENTAL METHODOLOGY

Concrete contains cement, water, fine aggregate, coarse aggregate (Recycled and Natural). With the control concrete, i.e. 100% of the natural fine aggregate is replaced with the artificial fine aggregates , 40% of the natural coarse aggregate is replaced with recycled coarse aggregates and 60% of the cement is replaced with supplementary cementitious material i.e. fly ash . Three cube samples were cast in the mould of size 150x150x150 mm for each 1:1.03:2.5 concrete mix with partial replacement ofcoarse aggregate and 100% replacement of natural fine aggregates with a w/c ratio as 0.50 were also cast. After about 24 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7,14 and 28 days for compressive strength and workability tests.

d. **RESULTS AND DISCUSSION**

Compressive strength
Compressive strength tests were performed on compression testing machine using cube samples. The cubes of size150 mm × 150 mm × 150 mm were casted for carrying out compression strength test and the test was performed at 7, 14 and 28 days . Three samples per batch were tested with the average strength values reported in this paper. The loading rate on the cube is 35 N/mm2 per min. The specimens were tested on a compression testing machine with capacity of 2000 kN . Green concrete specimens were casted with complete replacement of natural fine aggregate with artificial fine aggregate and partial replacement of natural coarse aggregates with recycled coarse aggregates and partial replacement of ordinary Portland cement with fly ash .
The results of compressive strength test are shown in Table

TABLE -8
COMPRESSIVE STRENGTH OF CUBES AT 3, 7 AND 28 DAYS

Sr . no	specimen	7 days strength	14 days strength	28 days strengt
1	150 mm × 150 mm	5.5 *(N/mm2)*	9.325 *(N/mm2)*	14.5 *(N/mm2)*

ADVANTAGES OF GREEN CONCRETE

- Much change is not required for the preparation of green concrete compared to conventional concrete.
- Reduces environmental pollution.
- Reduces the consumption of cement overall.
- Green concrete is economical compared to conventional concrete.

VIII. CONCLUSIONS

- Waste materials have a significantpotential toproduce a green concrete.
- To manufacture economical and environment friendly concrete , the replacement of traditional ingredients of concrete by waste materials and by products plays a very important role . It gives opportunity to produce environment friendly concrete .

- The utilization of waste demolition debris in new construction work is very important due to the materials waste is gradually increasing with the increase of population and urban development.

- Workability of green concrete with recycled aggregate decreases due to the rough surface of demolished concrete aggregates and the existence of adhering mortar to the aggregates in the case of demolished concrete aggregate. But the additional water is added during mixing, the same workability can be achieved.

- According to the test results , the performance of the green concrete with partial replacement of natural coarse aggregates with demolished concrete aggregate, replacement of natural fine aggregate with artificial fine aggregate, and partial replacement of OPC with fly ash is mainly satisfactory . Compressive strength is comparatively less than conventional concrete because of the use of some materials . The compressive strength can be improved by addition of some materials .

- So green concrete can be successfully produced with the locally available material and concrete waste materials .

- The production cost of green concrete is low as compare to conventional concrete .

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