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EXPERIMENTAL STUDY ON STRENGTH OF GREEN CONCRETE

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ABSTRACT

There are many choices in regard to selection of materials in any type of constructions. Due to growing interest in sustainable construction, engineers and architects are motivated to choose the materials which are more sustainable. Green concrete capable for sustainable construction is characterized by application of industrial wastes to reduce consumption of natural resources and energy and pollution of the environment. Replacement of materials over nominal concrete is what makes green concrete more environmental friendly concrete. Marble sludge powder, quarry rocks, crushed concrete and fly ashes are some of the materials used for making green concrete, a sustainable construction.

Keywords: Construction Industry, Environmental Impact, Fly Ash, Marble Powder, Recycled Aggregate.

1. INTRODUCTION

Concrete is the primary construction material in the world, It is widely used in all types of civil engineering works, like low and high-rise buildings, environment protection and local/domestic developments. Concrete is a manufactured product, essentially consisting of cement, aggregates, water and admixture(s). The production of raw materials used in concrete such as Portland cement requires a significant amount of energy input and causes various environmental problems (e.g., emission of greenhouse gases). The most widely used fine aggregate for making of concrete is the natural sand mined from the riverbeds, but the availability of river sand for the preparation of concrete is becoming scarce due to lowering of water table, sinking of bridge piers, etc. are. The present scenario demands identification of substitute materials for the river sand for making concrete.The major part of the concrete is the coarse aggregate since it forms the shape and structure for the concrete, but due to the enormous need of the coarse aggregate it depleted abruptly day to day. Thus the production of concrete by using these raw materials is not environmentally friendly. So we are in need to find an alternate source of concrete which reduces an adverse environmental effect.

2. MATERIAL COLLECTION

2.1 Cement

Ordinary Portland cement, 53Grade conforming to IS: 269 – 1976.Ordinary Portland cement, 53Gradewas used for casting all the Specimens. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strengths at early ages can be considerably influenced by the particular cement used. It is also important to ensure compatibility of the chemical and mineral admixtures with cement.

2.2 Fine Aggregate

Locally available river sand conforming to Grading zone II of IS: 383 –1970. Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens.

2.3 Coarse Aggregate

Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12.5 mm as per IS: 383 – 1970. Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

2.4 Fly ash:

Fly ash, also known as flue-ash, is one of the residues generated in combustion of coal, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal-fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata. About 43 percent is recycled and often used to supplement Portland cement in concrete production.

Figure 2.1 Fly Ash

2.5 Marble powder:

In India the extractive activity of decorative sedimentary carbonate rocks, commercially indicated as Marble and Granite is one of the most thriving industry. Marble waste powder is an industrial waste containing heavy metals in constituent. Marble powder has a very high Blaine fineness value of about 1.5m2/g with 90% of particles passing 50 µm sieves and 50% under 7 µm. The maximum compressive and flexural strength were observed for specimens containing a 6% waste sludge when compared with control and it was also found that waste sludge up to 9% could effectively be used as additive material in concrete.

Figure 2.2 Marble Powder

2.6 Recycled aggregate:

The use of recycled aggregate in concrete is gaining momentum these days. In the years to come the recycled aggregate concrete may become the need of the day. The waste concrete can be produced from a number of different sources. The most common are demolition projects. Many concrete structures like building, bridges, side walls and roads are razed after a period of time into their service life for purpose of replacement or landscape changes. Other sources of waste include natural disasters like earthquakes, avalanches, and tornadoes. All these contribute to vast quantities of waste concrete that must be managed in some way. Recycled aggregate utilizes demolition material from concrete and burnt clay brick masonry construction as aggregate. Reuse of demolition waste disposal is also helpful in reducing the gap between the demand and supply of crushed granite fresh aggregate. While the amount of demolition waste materials generated in India has not yet been quantified properly, it is thought that presently the yearly rate of demolition of buildings and other structures in the major cities has reached 1 to 2 percent.

Figure 2.3 Recycled Aggregate

2.7 Water

Casting and curing of specimens were done with the potable water that is available in the college premises.

3. MATERIAL PROPERTIY

3.1. Physical Properties of Cement

Ordinary Portland cement, 53Grade conforming to IS: 269 – 1976.Ordinary Portland cement, 53Gradewas used for casting all the Specimens. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strengths at early ages can be considerably influenced by the particular cement used. It is also important to ensure compatibility of the chemical and mineral admixtures with cement.

3.1.1 Specific Gravity

The density bottle was used to determine the specific gravity of cement. The bottle was cleaned and dried. The weight of empty bottle with brass cap and washerW_1 was taken. Then bottle was filled by 200 to 400g of dry cement and weighed as W_2.The bottle was filled with kerosene and stirred thoroughly for removing the entrapped air which was weighed as W_3.It was emptied, cleaned well, filled with kerosene and weighed as W_4.

3.1.2 Fineness (By Sieve Analysis)

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster development of strength.

100 grams of cement was taken on a standard IS Sieve No.9 (90 microns). The air-set lumps in the sample were broken with fingers. The sample was continuously sieved giving circular and vertical motion for 15 minutes. The residue left on the sieve was weighed.

3.1.3 Consistency

The objective of conducting this test is to find out the amount of water to be added to the cement to get a paste of normal consistency. 500 grams of cement was taken and made into a paste with a weighed quantity of water (% by weight of cement) for the first trial. The paste was prepared in a standard manner and filled into the vicat mould plunger, 10mm diameter, 50mm long and was attached and brought down to touch the surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight. The depth of penetration of the plunger was noted. Similarly trials were conducted with higher water cement ratios till such time the plunger penetrates for a depth of 33-35mm from the top. That particular percentage of water which allows the plunger to penetrate only to a depth of 33-35mm from the top is known as the percentage of water required to produce a cement paste of standard consistency.

3.1.4 Initial Setting Time

The needle of the Vicat apparatus was lowed gently and brought in contact with the surface of the test block and quickly released. It was allowed to penetrate into the test block. In the beginning, the needle completely pierced through the test block. But after sometime when the paste starts losing its plasticity, the needle penetrated only to a depth of 33-35mm from the top. The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth equal to 33-35mm from the top was taken as the initial setting time.

3.2 Property of Fine Aggregate

Clean and dry river sand available locally will be used. Sand passing through IS 4.75mm Sieve will be used for casting all the specimens.

3.2.1 Absorption, Porosity, and Permeability

The internal pore characteristics are very important properties of aggregates. The size, the number, and the continuity of the pores through an aggregate particle may affect the strength of the aggregate, abrasion resistance, surface texture, specific gravity, bonding capabilities, and

3.2.3 Strength and Elasticity

Strength is a measure of the ability of an aggregate particle to stand up to pulling or crushing forces. Elasticity measures the "stretch" in a particle. High strength and elasticity are desirable in aggregate base and surface courses. These qualities minimize the rate of disintegration and maximize the stability of the compacted material. The best results for Portland cement concrete may be obtained by compromising between high and low strength, and elasticity. This permits volumetric changes to take place more uniformly throughout the concrete.

3.2.4 Hardness

The hardness of the minerals that make up the aggregate particles and the firmness with which the individual grains are cemented or interlocked control the resistance of the aggregate to abrasion and degradation. Soft aggregate particles are composed of minerals with a low degree of hardness. Weak particles have poor cementation. Neither type is acceptable. The Mohs Hardness Scale is frequently used for determination of mineral hardness.

3.3 Property of Coarse Aggregate

Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be

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restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability. 20mm down size aggregate was used.

3.3.1 Specific Gravity

A pycnometer was used to find out the specific gravity of coarse aggregate. The empty dry pycnometer was weighed and taken as W_1. Then the pycnometer is filled with 2/3 of coarse aggregate and it was weighed as W_2. Then the pycnometer was filled with part of coarse aggregate and water and it weighed as W_3. The pycnometer was filled up to the top of the bottle with water and weighed it as W_4.

3.3.2 Bulk Density

Bulk density is the weight of a material in a given volume. It is expressed in Kg/m^3.A cylindrical measure of nominal diameter 250mm and height 300mm was used. The cylinder has the capacity of 1.5 liters with the thickness of 4mm. The cylindrical measure was filled about 1/3 each time with thoroughly mixed aggregate and tampered with 25 strokes. The measure was carefully struck off level using tamping rod as straight edge. The net weight of aggregate in the measure was determined. Bulk density was calculated as follows.

Bulk density = (Net weight of coarse aggregate in Kg)/ (Volume)

3.3.3 Surface Moisture

100g of coarse aggregate was taken and their weight was determined, say W_1. The sample was then kept in the oven for 24 hours. It was then taken out and the dry weight is determined, says W_2. The difference between W_1 and W_2 gives the surface moisture of the sample.

3.3.4 Water Absorption

100g of nominal coarse aggregate was taken and their weight was determined, say W_1. The sample was then immersed in water for 24 hours. It was then taken out, drained and its weight was determined, says W_2. The difference between W_1 and W_2 gives the water absorption of the sample.

3.3.5 Fineness Modulus

The sample was brought to an air-dry condition by drying at room temperature. The required quantity of the sample was taken (3Kg). Sieving was done for 10 minutes. The material retained on each sieve after shaking, represents the fraction of the aggregate coarser then the sieve considered and finer than the sieve above. The weight of aggregate retained in each sieve was measured and converted to a total sample.

3.4 Properties of Water

Water used for mixing and curing shall be clean and free from injurious amounts of Oils, Acids, Alkalis, Salts, Sugar, Organic materials Potable water is generally considered satisfactory for mixing concrete Mixing and curing with sea water shall not be permitted. The pH value shall not be less than 6.

FLY ASH

Fly ash is a by-product from coal-fired electricity generating power plants. The coal used in these power plants is mainly composed of combustible elements such as carbon, hydrogen and oxygen (nitrogen and sulphur being minor elements), and non-combustible impurities (10 to 40%) usually present in the form of clay, shale, quartz, feldspar and limestone. As the coal travels through the high-temperature zone in the furnace, the combustible elements of the coal are burnt off, whereas the mineral impurities of the coal fuse and chemically recombine to produce various crystalline phases of the molten ash.

PROPERTIES	VALUES
Specific gravity	3.2
Fineness of fly ash	9.7
Initial setting	30 minutes
Final setting	600 minutes

Table No 3.1 physical properties of fly ash are given below

The molten ash is entrained in the flue gas and cools rapidly, when leaving the combustion zone (e.g. from 1500ºC to 200ºC in few seconds), into spherical, glassy particles. Most of these particles fly out with the flue gas stream and are therefore called fly ash. The fly ash is then collected in electrostatic precipitators or bag houses and the fineness of the fly ash can be controlled by how and where the particles are collected.

3.7 Fresh Concrete Properties

3.7.1 Workability

With the addition of furnace slag, the slump loss with time is directly proportional to increase in the slag content due to the introduction of large surface area in the concrete mix by its addition. Although the slump decreases, the mix remains highly cohesive.

3.7.2 Segregation and Bleeding

Furnace slag reduces bleeding significantly because the free water is consumed in wetting of the large surface area of the furnace slag and hence the free water left in the mix for bleeding also decreases. Furnace slag also blocks the pores in the fresh concrete so water within the concrete is not allowed to come to the surface.

3.8 Hardened Concrete Properties

3.8.1 Compression Test on Concrete Cubes

The determination of the compressive strength of concrete is very important because the compressive strength is the criterion of its quality. Other strength is generally prescribed in terms of compressive strength. The strength is expressed in N/mm^2. This method is applicable to the making of preliminary compression tests to ascertain the suitability of the available materials or to determine suitable mix proportions. The concrete to be tested should not have the nominal maximum size of aggregate more than 20mm test specimens are either

15cm cubes or 15cm diameter used. At least three specimens should be made available for testing. Where every cylinder is used for compressive strength results the cube strength can be calculated as under. Minimum cylinder compressive strength = 0.8 x compressive strength cube (10 cm x 10 cm) The concrete specimens are generally tested at ages 7 days and 28 days.

3.8.2 Split Tensile Test on Cylinder

Concrete is strong in compression but weak in tension. Tension stresses are likely to develop in concrete due to drying shrinkage, rusting of reinforcement, temperature gradient etc. In concrete road slab this tensile stresses are developed due to wheel loaded and volume changes in concrete are available to determine this. Split test is one of the indirect methods available to find out the tensile strength.

3.8.3 Flexural Test on Beams

It is the ability of a beam or slab to resist failure in bending. It is measured by loading un-reinforced 6x6 inch concrete beams with a span three times the depth (usually 18 in.). The flexural strength is expressed as "Modulus of Rupture" (MR) in psi. Flexural MR is about 12 to 20 percent of compressive strength

4. MIX DESIGN

4.1 Definition

Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportions with the object of certain minimum strength and durability as economically as possible.

4.2 Objective Of Mix Design

- The objective of concrete mix design as follows.

- The first objective is to achieve the stipulated minimum strength.
- The second objective is to make the concrete in the most economical Manner. Cost wise all concrete's depends primarily on two factors, namely cost of material and cost of labour. Labor cost, by way of formwork, batching, mixing, transporting and curing is namely same for good concrete.

4.3 Factors To Be Considered In Mix Design

1.Grade of concrete

2.Type of cement

3.Type & size of aggregate
4.Type of mixing & curing

5.Water /cement ratio

6.Degree of workability

7.Density of concrete

8.Air content

5. TESTING PROCEDURE

5.1 Compressive Strength Test

At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block will be noted. From the noted values, the compressive strength may calculated by using below formula When a specimen of material is loaded in such a way that it extends it is said to be in tension (Figure.5.1) On the other hand if the material compresses and shortens it is said to be in compression.

Compressive Strength = Load / Area

Size of the test specimen=150mm x 150mm x 150mm

Figure 5.1 Compression Test

5.2 Split Tensile Test

The size of cylinders 300 mm length and 150 mm diameter are placed in the machine such that load is applied on the opposite side of the cubes are casted. Align carefully and load is applied, till the specimen breaks. The formula used for calculation.

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Split tensile strength = 2P/ µdl

Figure.5.2 Split Tensile Test

The tensile strength is one of the basic and important properties of the concrete. The concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. Figure.5.2 Shows Split Tensile Test

5.3 Flexural Strength Test

During the testing, the beam specimens of size 1500mmx150mmx150mm were used. Specimens were dried in open air after 7 days of curing and subjected to flexural strength test under flexural testing assembly. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicates in the tension surface within the middle third of span length. The flexural strength was obtained using the formula (R)

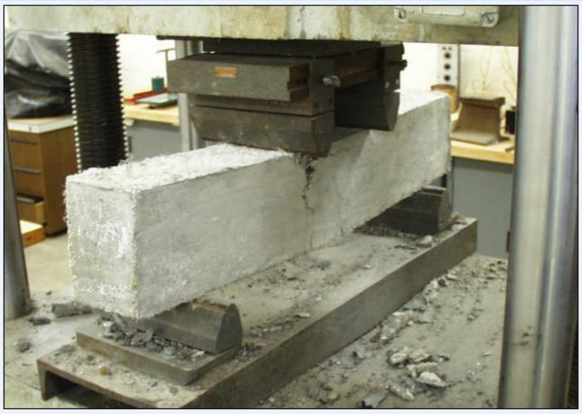

Figure 5.3 Flexural Strength Test

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Flexural strength, also known as modulus of rupture, bend strength, or fracture strength,[a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibres are at the largest stress so, if those fibres are free from defects, the flexural strength will be controlled by the strength of those intact 'fibres'. However, if the same material was subjected to only tensile forces then all the fibres in the material are at the same stress and failure will initiate when the weakest fibre reaches its limiting tensile stress. Therefore it is common for flexural strengths to be higher than tensile strengths for the same material. Conversely, a homogeneous material with defects only on its surfaces (e.g., due to scratches) might have a higher tensile strength than flexural strength. If we don't take into account defects of any kind, it is clear that the material will fail under a bending force which is smaller than the corresponding tensile force. Figure 5.3 shows Flexural Strength Test.

S.NO	DAYS	COMPRESSIVE STRENGTH (N/mm^2)	
		Conventional Concrete	Green Concrete
1	7	8.36	12.45
2	14	19.24	23.00
3	28	23.75	24.98

Table 6.1 Compressive Strength of Cube

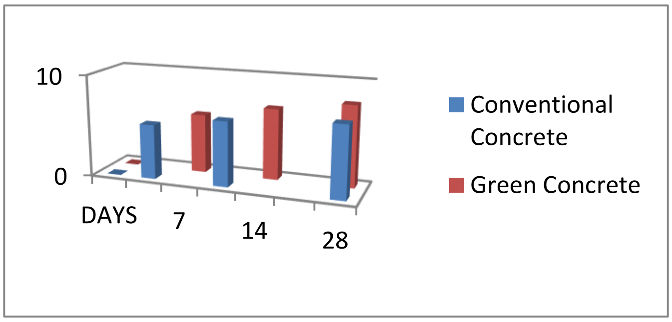

Figure 6.1 Compression Test Graph Result

S.NO	DAYS	SPLIT TENSILE STRENGTH (N/mm^2)	
		Conventional Concrete	Green Concrete
1	7	2.00	2.89
2	14	2.56	3.38
3	28	3.25	4.45

Table 6.2 Split Tensile Strength of Cylinder

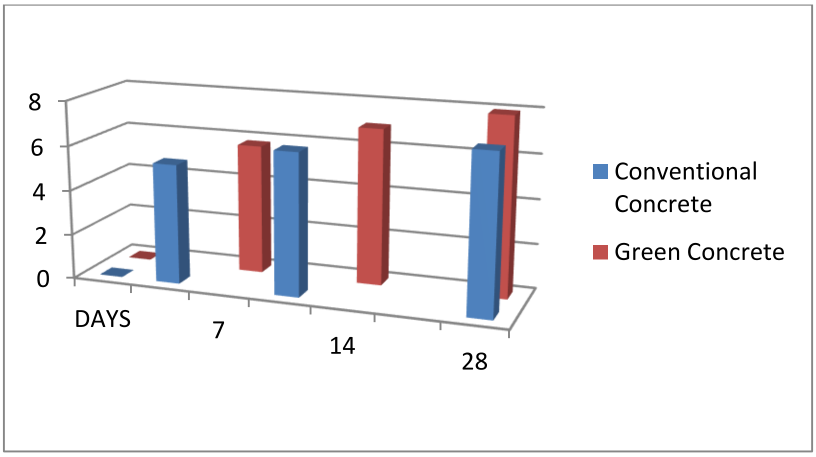

Figure 6.2 Split Tensile Test Graph Result

S.NO	DAYS	FLEXURAL STRENGTH (N/mm^2)	
		Conventional Concrete	Green Concrete
1	7	5.35	5.80
2	14	6.35	6.98
3	28	7.04	7.95

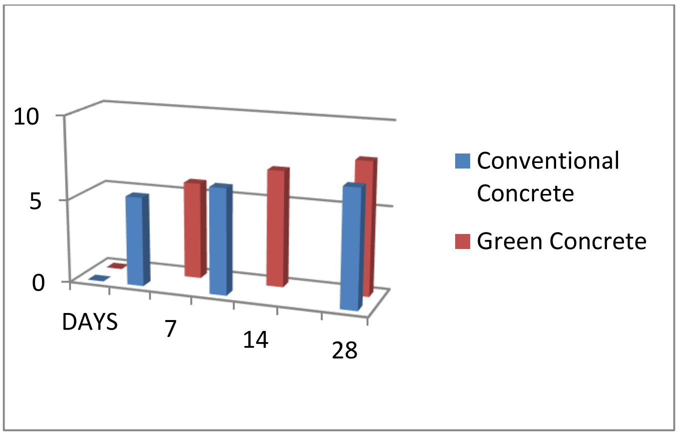

Figure.7.3 Flexural Test Graph Result

CONCLUSION

One must not forget to achieve the sustainable construction. There are various means to achieve sustainable construction and one of the means is through green concrete. Green concrete technology is one of the major steps that a construction industry can implement to achieve sustainable construction with various means as discussed above. With Green concrete Technology we can save the natural materials for future use or the generations to come and sustain it for good amount of time. With the time, the virgin material will deplete and so the cost for the material will increase which will add to more cost for the construction but if we use waste materials for construction the virgin materials will become a sustainable material and as well the cost will be reduced. With waste material as alternative we can help reduce the environmental problems and protect the naturally available materials for future generations as well. Our paper basically deals with the tools and strategies to ensure that green concrete can be used in place of Portland cement. The usage of green concrete ensures sustainable development and it's gaining its popularity ever since its inception.

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