PERFORMANCE OPTIMIZATION OF SUSTAINABLE M40 CONCRETE INCORPORATING RECYCLED COARSE AGGREGATE, FLY ASH, GGBS AND NANO-SILICA

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Abstract *The most widely used material in this world is concrete. After water, concrete is placed in second position. The use of natural sand in conventional concrete has become of vital importance which is scarce to obtain. Aggregates are basic concrete making construction material required in large quantities. Recycled coarse aggregates, fly ash, GGBS and nano silica are materials to replace coarse aggregates and cementious materials which can be used as an alternative coarse aggregates and cement in concrete. In general concrete is a combination of cement, fine and coarse aggregate. These days, coarse aggregates are difficult to acquire and extraction. In addition, government has connected limitation on extraction of coarse aggregates from rocks. Subsequently, insufficiency of coarse aggregates and increase in demand contemplate research seek towards alternate coarse aggregates. Fly ash, GGBS and nano silica are using as alternative materials for the cement materials.*

In the present study an attempt had been made to discuss the properties of concrete such as workability and strength of concrete which is prepared by replacing coarse aggregates with recycled aggregates, cement with fly ash, ggbs and nano silica in M40 grade concrete. The fresh properties of concrete like workability, hardened concrete properties like compressive strength, split tensile strength and flexural strength, durability properties like percentage loss of strength, percentage loss of weight are carried out for acid attack test, alkaline attack test and sulphate attck test in M40 grade concrete.

KEY WORDS: GGBS, Nano Silica, fly ash, Strength, Recycled coarse aggregates, compressive strength, split tensile strength, flexural strength, durability

I. INTRODUCTION

For a long time concrete was considered to be very durable material requiring. We build concrete structures in highly polluted urban and industrial areas, aggressive marine environments, harmful sub-soil water in area and many other hostile conditions where other materials of construction are found be non –durable. Since the use of concrete in recent years have spread to highly harsh and hostile conditions, the earlier impression that concrete is a very durable material is being threatened, particularly on account of premature failures of number of structures.

In the past only strength of concrete was considered in the concrete mix design procedure assuming strength of concrete in all pervading factor for all other desirable properties of concrete including durability. In the recent revision of IS 456 of 2000, one of the points discussed, deliberated and revised is the durability aspects of concrete, in line with codes of practice of other countries, which have better experiences in dealing with durability of concrete structures. One of the main reasons for deterioration of concrete in the past is that too much emphasis is placed on concrete compressive strength. As a matter of fact advancement in concrete technology has been generally on the strength of concrete. It is now recognized that strength of concrete alone is not sufficient, the degree of harshness of the environment condition to which concrete is exposed over its entire life is equally important. Therefore, both strength and durability have to be considered explicitly at the design state. It is interesting to consider yet another view point regarding strength and durability relationship. Durability of concrete is its Resistance to deteriorating agencies to which the concrete may be exposed during its service life. When one deals with the durability aspects of concrete, the chemical attack, which results in loss of weight, cracking of concrete and the consequent deterioration of concrete, becomes an important part of investigation. Ordinary Portland cement concrete usually does not have good resistance to acid attack. The addition of FA improves the micro structural properties of concrete like porosity, permeability and sorptivity. The reduction of porosity and permeability implies the improvement in chemical attack and corrosion resistance. The experimental investigation of this aspect is to find compressive strength and durability of concrete by partial replacement of cement with quarry dust.

Durability is an important engineering property of concrete, which determines the service life of concrete structures significantly. Due to the interactions of concrete with external influences, the mechanical and physical properties of concrete may be threatened and lost. ACI Committee Report 201(2001) has classified chemical attacks into several types that include acidic attack, alkali attack, carbonation, chloride attack, and leaching and sulfate attack. Acidic attack usually originates from industrial processes, but it can even be due to urban activity. Even natural exposure conditions may cause acid attacks. Free acids in natural waters are rare. Exceptions are carbonic waters and sulfurous and sulfuric acids in peat waters. Soils may contain huminous acids. Several organic and inorganic acids may occur in shallow regions of sea-water as a consequence of bacteriological activity. Significant quantities of free acids in plants and factories may be found. In these cases, the concentration of acid, which comes in contact with concrete structures, may reach to high value. The degree of aggressive of an acid is dependent on the chemical character of anions present. The strength of acid, its dissociation degree in solutions and, mainly, the solubility of the calcium salts formed are dependent on the chemical character of anion. The acidic attack is affected by the processes of decomposition and leaching of the constituent of cement matrix.

Objectives of the study

Most of the published research studied on the concrete properties with rice husk ash. The present study deals with the replacement of fine aggregates and coarse aggregates is made for M40 grade and M60 grade concrete.

1. To make a concrete by using fly ash, GGBS and nano silica as a partial replacement of cement and Recycled aggregates as coarse aggregates in M40 concrete.

2. To investigate the strength properties (Compressive, split, flexural strength) of concrete using fly ash, GGBS and nano silica and Recycled coarse aggregates.

3. To study the properties of concrete by using Recycled coarse aggregates as coarse aggregates and fly ash, GGBS and nano silica as cement in M40 grade concrete.

4. Recycled coarse aggregates are used as 10%, 20%, 305, 405 and 50%, fly ash fixed as 2.5%, GGBS and nano silica replaced at 2.5%, 5%, 7.5%, 10% and 12.5% in M40 grade concrete.

5. To study the strength of concrete using recycled waste materials

II. LITERATURE REVIEW

Mohd Monish[1], Vikas Srivastava[2], V.C. Agarwal[3], etc., This study is a part of comprehensive program wherein experimental investigations have been carried out to assess the effect of partial replacement of coarse aggregate by demolished waste on workability and compressive strength of recycled concrete for the study at 7 and 28 d. The compressive strength thus, observed was compared with strength of conventional concrete. Test results showed that the compressive strength of recycled concrete up to 30% coarse aggregate replacement (C. A. R.) by demolished waste at the end of 28 d has been found to be comparable to the conventional concrete. From this experimental study it was concluded that the recycled aggregate concrete may be an alternative to the conventional concrete. Water required producing the same workability increases with the increase in the percentage of demolished waste. Up to 30% replacement of coarse aggregate with recycled aggregate concrete was comparable to conventional concrete. Up to 30% of coarse aggregate replaced by demolished waste gave strength closer to the strength of plain concrete cubes and strength retention is in the range of 86.84-94.74% as compared to conventional concrete

Vikas Srivastava[1], Mohd Monish[2], Raushan Ranjan[3],etc., The present work presents the results of experimental investigations carried out to evaluate the effect of partial replacement of cement, fine aggregate and coarse aggregate by different parts of demolished wastes on strength and workability of concrete made. For the study, design mix concrete of grade M25 (Referral concrete) was prepared using IS: 10262-2009. Thereafter, the replacement of different constituents of concrete, one at a time was carried out by replacing these with the different sieved fractions of crushed demolition waste. The compressive strength at 7 and 28 days, and workability in terms of slump value were measured. From this paper it was concluded that the water required for producing the same workability in recycled concrete increases with the increase in the percentage of use of demolition waste, irrespective of types of replacement viz., Cement, Fine Aggregate and Coarse Aggregate. The strength of recycled concrete is marginally affected up to 10% replacement of cement by demolition waste powder. However, with further increase in demolition waste powder content, the strength decreases.

III. MATERIALS AND MIX DESIGN

The properties of materials utilized for making concrete blend are resolved in research facility according to applicable codes of training. Distinctive materials utilized in show consider were Cement, Coarse aggregates, Fine aggregates, Silica fume, Steel fibers and super-plasticizer. The point of an investigation of different properties of material is utilized to check the appearance with codal necessities and to empower an architect to outline a solid blend for a specific quality. The portrayal of different materials which were utilized in this examination is given beneath:

Portland cement

Portland cement is the most widely recognized sort of concrete all in all utilization around the globe as a fundamental element of solid, mortar, stucco, and non-forte grout. A few sorts of Portland bond are accessible. The most well-known, called common Portland bond (OPC), is dark in shading, however white Portland concrete is additionally accessible.

OPC 53 Grade Cement

Aggregates

Aggregates constitute the main part of a concrete blend and give dimensional soundness to concrete. To build the thickness of coming about blend, the totals are oftentimes utilized in at least two sizes. The most critical capacity of the fine total is to help with creating usefulness and consistency in blend.

Coarse aggregates

Those particles that are prevalently held on the 4.75 mm (No. 4) sifter and will go through 3-inch screen are called coarse total. The coarser the aggregate, the more temperate the blend. Bigger pieces offer less surface region of the particles than a comparable volume of little pieces.

Coarse aggregates

Fine aggreagtes:

Those particles passing the 9.5 mm (3/8 in.) Sieve, essentially passing the 4.75 mm (No. 4) strainer, and transcendently held on the 75 µm (No. 200) strainer are called fine total. For expanded usefulness and for economy as reflected by utilization of less concrete, the fine total ought to have an adjusted shape.

Fine aggregates

Recycled coarse aggregates

The recycled aggregate is obtained by breaking the tested laboratory concrete specimens of grades M20, M25 and M30. The concrete specimens were made into smaller fragments manually and the recycled aggregate obtained. The following process of crushing was used to obtain Recycled Coarse Aggregate.

1. Primary crushing
2. Secondary crushing

Fly ash

Fly ash, also known as "pulverised fuel ash" in the United Kingdom, is a coal combustion product that is composed of the particulates(fine particles of burned fuel) that are driven out of coal-fired boilers together with the flue gases. Ash that falls to the bottom of the boiler is called bottom ash. In modern coal-fired power plants, fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys. Together with bottom ash removed from the bottom of the boiler, it is known as coal ash.

Fly ash

GGBS

Granulated Blast Furnace Slag is obtained by rapidly chilling (quenching) the molten ash from the furnace with the help of water. During this process, the slag gets fragmented and transformed into amorphous granules (glass), meeting the requirement of IS 12089:1987 (manufacturing specification for granulated slag used in Portland Slag Cement). The granulated slag is ground to desired fineness for producing GGBS.

The chemical composition of JSW's GGBS contributes to the production of superior cement. Over the period of time, its load-bearing properties continue to increase as it absorbs surplus lime released during hydration to form more calcium silicate hydrates. These hydrates add to the strength of the cement.

GGBS

Nano Silica

Silicon dioxide nano particles, also known as silica nano particles or nano silica, are the basis for a great deal of biomedical research due to their stability, low toxicity and ability to be functionalized with a range of molecules and polymers. Nano-silica particles are divided into P-type and S-type according to their structure. The P-type particles are characterized by numerous nano pores having a pore rate of 0.61 ml/g. The S-type particles have a comparatively smaller surface area. The P-type nano-silica particles exhibit a higher ultraviolet reflectivity when compared to the S-type.

Nano silica

Mix design of concrete

Mix design is a methodology of choosing the appropriate elements of cement and their relative extents with a goal to get ready cement of certain base quality, wanted usefulness and sturdiness as financially (esteem built) as would be prudent.

Final for M40 grade concrete is 1:1.63:2.54 at w/c of 0.45

Mix Trials used in the study

1. M0 - %0FA+%0GGBS+%0Nano Silica+%0RCA
2. M1 - 2.5FA+2.5GGBS+5Nano Silica+10RCA
3. M2 - 2.5FA+5GGBS+7.5Nano Silica+20RCA
4. M3 - 2.5FA+7.5GGBS+10Nano Silica+30RCA
5. M4 - 2.5FA+10GGBS+12.5Nano Silica +40RCA
6. M5 - 2.5FA+12.5GGBS+15Nano Silica+50 RCA

IV EXPERIMENTAL INVESTIGATION

Casting of cubes and cylinders

Casting of concrete shapes and chambers as improved the situation M40 and M60 review concrete, the blend extent is for which we are casting cubes and cylinders for typical cement, with the incomplete substitution

Compaction with compacting bar

150 mm molds ought to be filled in three roughly break even with layers (50 mm profound). A compacting bar is accommodated compacting the solid. It is a 380 mm long steel bar, weighs 1.8 kg and has a 25 mm square end for smashing.

Curing

The concrete specimens were relieved utilizing six unique strategies until when their compressive qualities were resolved at ages 7,28 days and 56.

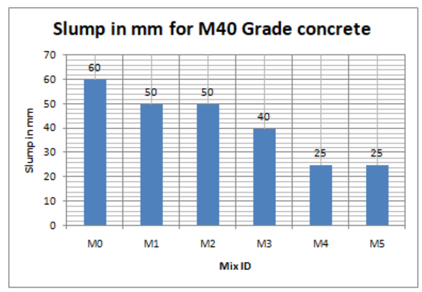
Curing of specimens

Tests to be conducted on concrete

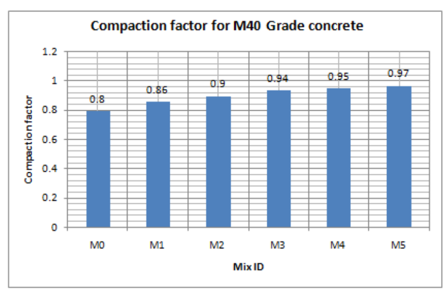
1. Slump Cone test
2. Compaction factor test
3. Compressive strength
4. Split tensile strength
5. Flexural strength
6. Durability

V. RESULTS AND ANALYSIS

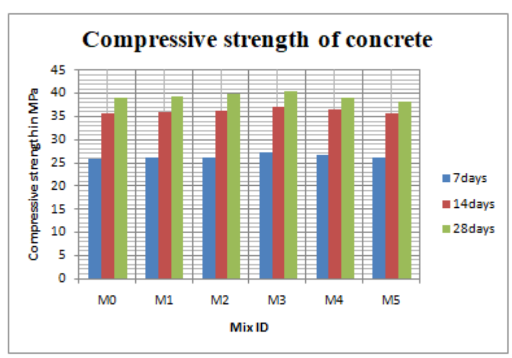
Slump cone test



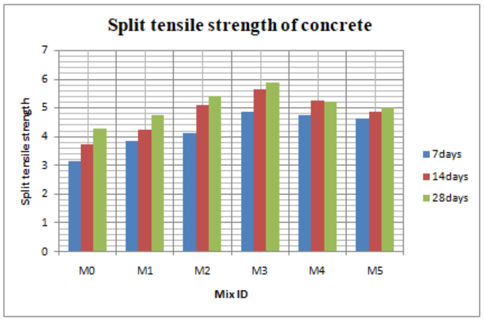
Compaction factor test



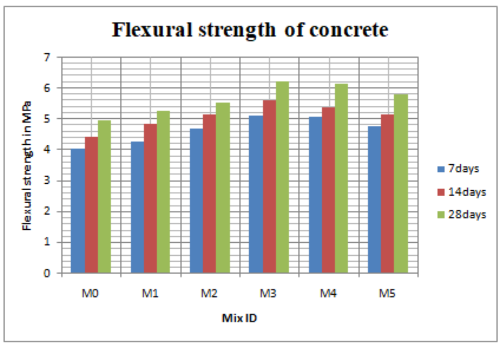
Compressive strength of concrete



Split tensile strength



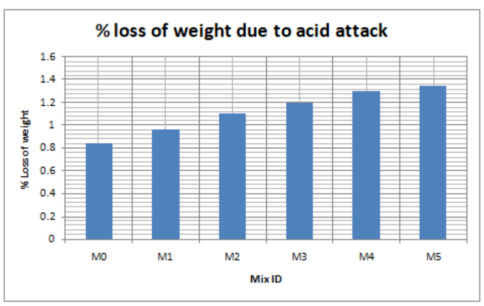
Flexural strength



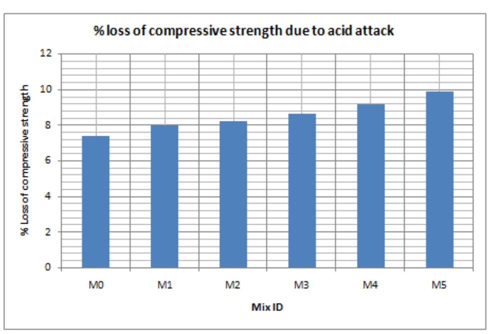
Durability of concrete

ACID ATTACK

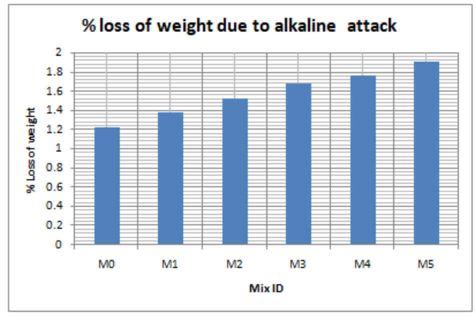
Percentage of loss of weight due to acid attack

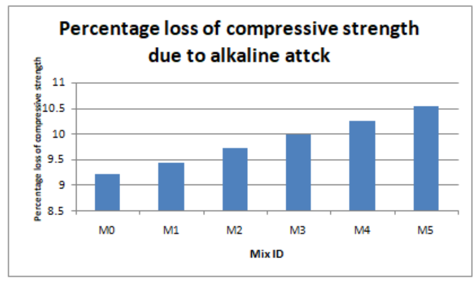


Percentage of loss of compressive strength due to acid attack



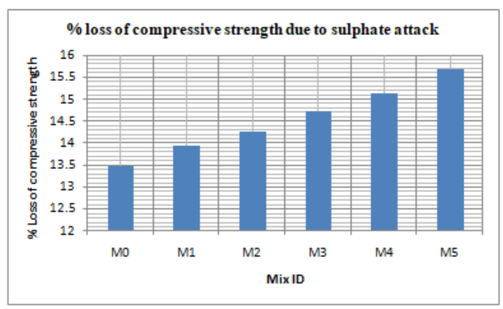
Alkaline attack test





SULPHATE ATTACK

Percentage of loss of weight due to sulphate attack



VI. CONCLUSIONS

From the above study the following conclusions were made

1. The value of slump for the concrete decreases with increasing the percentage of Recycled Coarse aggregates and fly ash, GGBS and Nano silica in M40 Grade concrete. The value of compaction factor for the concrete increases with increasing the percentage of Recycled Coarse aggregates and fly ash, GGBS and Nano silica in M40 Grade concrete.
2. Compressive strength for 7days, 14days, and 28days for the concrete increases initially up to 2.5fly ash +7.5GGBS +7.5 nano silica +30

Recycled coarse aggregates and than decreases with increasing the percentage of fly ash, GGBS and nano silica and Recycled Coarse aggregates. The optimum value for the compressive strength was obtained at M3 mix 2.5fly ash +7.5GGBS +7.5 nano silica +30 Recycled coarse aggregates.

3. Split tensile strength for 7days, 14days, and 28days for the concrete increases initially up to 2.5fly ash +7.5GGBS +7.5 nano silica +30 Recycled coarse aggregates and than decreases with increasing the percentage of fly ash, GGBS and nano silica and Recycled Coarse aggregates. The optimum value for the compressive strength was obtained at M3 mix 2.5fly ash +7.5GGBS +7.5 nano silica +30 Recycled coarse aggregates.
4. Flexural strength for 7days, 14days, and 28days for the concrete increases initially up to 2.5fly ash +7.5GGBS +7.5 nano silica +30 Recycled coarse aggregates and than decreases with increasing the percentage of fly ash, GGBS and nano silica and Recycled Coarse aggregates. The optimum value for the compressive strength was obtained at M3 mix 2.5fly ash +7.5GGBS +7.5 nano silica +30 Recycled coarse aggregates.
5. The value of percentage loss of compressive strength, percentage loss of weight due to effect of fly ash, GGBS, nano silica and Recycled coarse aggregates increases from M0 to M5 mix in all the cases of concrete.

So the replacement of 2.5fly ash +7.5GGBS +7.5 nano silica +30 Recycled coarse aggregates is generally useful for better strength values in M40 grade of concrete.

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