Experimental Study on Partial Replacement of Fine Aggregate by Waste Glass Powder and CNC Lathe Waste

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Abstract— In this paper an attempt is made replacement of natural sand by by-products and recyclable materials. This paper aims to deal with the current and future trends of research on the use of Manufactured Fine Aggregate (MFA) in Portland cement concrete. Advancements in technology enhance not only human comforts but also damage the environment. Hence an attempt has been made in the present investigation to study the influence of addition waste materials like CNC waste from workshop at a dosage of 1.5% to 2% of total weight of concrete as fibers. If natural fine aggregate is replacement of 10%, 20%, 30% with waste glass powder in concrete. Experimental investigation was done using M25 mix and testes were carried out as per recommended procedures by relevant codes. The results were compared with convectional concrete it was observed that concrete blocks incorporated with steel lathe waste Compression strength. The investigation reported in this paper was carried out to study the feasibility of using steel scrap obtained from lathe machine in fiber reinforced concrete by checking the compressive strength, splitting tensile strength and Flexural strength of M25 concrete and thus optimizing the fiber proportions. The natural fine aggregate replacement by (10-30%) of glass powder.

Key words: Binding Material, GPC, M-Sand, Degradation, Deteriorated

I. INTRODUCTION

The present day world is witnessing the construction of very challenging And difficult civil engineering structures. Concrete is the most important and widely used construction material is called upon to possess very high strength and sufficient workability

Concrete is a composite material which composed of cement, water and aggregates. Researchers all over the world are attempting to develop high performance concretes by using fibers in concrete up to certain proportions. If fiber provided to the improvements of concrete in tensile strength, toughness, ductility, durability, post cracking resistance, fatigue characteristics, shrinkage characteristics, impact capitations, erosion resistance and serviceability of concrete.

It is associated with every human activity that it touches every human being in his day to day living. Cement concrete is one of the seemingly simple but actually complex materials. Many of its complex behaviours are yet to be identified to employ this material more advantageously and economically.

The glass waste is cannot be replaced in any work. So I decided to replace glass waste as fine aggregate in concrete. The whole demand for sand mainly depends on river sand extracted for construction work such as manufacture of cement concrete. In addition, from the abundant of glass waste powder, it can make the aesthetic values for environmental view.

Therefore, the glass waste powder can be utilized in construction work for making concrete. This study signifies to propose an alternative way in replacing glass waste powder as fine aggregate and adding of CNC waste of concrete.

A. Objectives of the Research

1) To evaluate the utility o glass powder as a partial replacement of sand in concrete.
2) To reduce the usage of river sand.
3) To reduce the glass wastages from shops and other buildings (hotel, hospital, etc.)
4) To Increase the Compressive strength, tensile strength and flexural strength of the concrete in CNC wastes adding.
5) The waste glass recycled material can be effectively used in concrete a as Replacement of sand.
6) Collecting the required information and documents related to the Waste glass and CNC lathe waste
7) Developing an adequate experimental program to study the use of waste glass and CNC waste in concrete mixtures as explained.

II. EXPERIMENTAL PROGRAM

A. MATERIAL SELECTION

1) Concrete Materials used:

The ingredients of concrete consist of Cement, fine aggregate and coarse aggregates, water. When the reaction of water with cement takes place hydration process is done and a hard material is formed. In this research we used waste glass powder as a partial replacement of fine aggregate with an addition of CNC waste. The ingredients are used in proper proportion. Also the sand is replaced at 10%, 20%, and 30% by glass powder and addition adding CNC waste. They are described in details with their properties are as follows

2) Cement:

In this work, Ordinary Portland cement (OPC) of 43 grades has been used. The physical properties of OPC as determined are given in Table 1. The cement satisfies the requirement of IS: 8112-1989. The specific gravity was2.96 and fineness was 2800 cm2/g.

Fig. 1: Cement

Cements and cement-containing materials comprised some of the first structural materials exploited by humanity, as cement's components are common materials: sand, lime, and water. On a molecular level, cement is a paste of calcium silicate hydrates polymerized into a densely cross linked matrix. Its most important property is called hydraulicity-the ability to set and remain insoluble under water.

Cements of this period, if still in existence, are inconsistent in composition and are composed almost exclusively of un reacted starting materials. There was no significant breakthrough in the development of cement chemistry until 1756, when Smeaton was commissioned to rebuild the Eddystone lighthouse in cornwall, England.

3) Fine Aggregate:

Fine aggregate/sand is an accumulation of grains of mineral matter derived from the disintegration of rocks. It is distinguished from gravel only by the size of grain or particle, but is distinct from clays which contain organic minerals. Sands that have been sorted out and separated from the generally quite uniform in size of grains

Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds. Much of the earth's surface is sandy, out and separated from the organic material by the action of currents of water which contain organic across arid lands and the sand is usually quartz and other siliceous materials. Sand is used to make mortar and concrete and for making molds in foundries.

Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions, and economy. Consequently, selection of aggregate is an important process. Although some variation in aggregates properties is expected, characteristics that are considered when selecting aggregates include:

- Grading
- Durability
- Particle Shape and Surface Texture
- Abrasion and Skid Resistance
- Unit Weights and Voids
- Absorption and Surface Moisture

Fig. 2: Fine Aggregate

4) Course aggregate:

Course aggregate are the crushed stone used for making concrete. The commercial stone is quarried, crushed and graded. Much of the crushed stone used is granite, limestone and trap rock. Crushed angular granite metal of 10 mm size from a local source was used as coarse aggregate. The specific gravity of 2.6 and fineness modulus 6.05 was used.

Grading refer to the determination of the particle-size distribution for aggregates. Grading limits and maximum aggregates size are specified because grading and size affect the amount of aggregates used as well as cement and water requirements, workability, pumpability, and durability of concrete. In general, if the water-cement ratio is chosen correctly, a wide range in grading can be used without a major effect on strength

Fig. 3: Corse Aggregate

5) Water:

Potable water is generally considered satisfactory for mixing concrete. Tap water, potable without any salts or chemicals was used in the study.

6) Waste glass powder (WGP):

Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, and CaCO3 at high temperature followed by cooling during which solidification occurs without crystallization. The potential use of waste recycled glass in concrete as recycled glass sand (RGS) and pozzolanic glass powder (PGP) was examined in this study. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing.

The amount of waste glass is gradually increased over the recent years due to an ever-growing use of glass products.

Most waste glasses have been dumped into landfill sites. The Land filling of waste glasses is undesirable because they are not biodegradable, which makes them environmentally less friendly.

Sowed use the waste glass in concrete to become the construction economical as well as eco-friendly.

The glass powder is (GLP) divided in two categories wise

- Glass powder (GLP) particle size less than 90 microns.
- Glass powder (GLP) particle size from 90 micron to 150 microns.

Fig. 4: Waste Glass Powder (WGP)

7) CNC Lathe Waste (Computer Numerical Controlled):

To make concrete more economical and eco-friendly with a remarkable quality, application of CNC lathe machine waste can have tremendous importance.By using this large amount (according to ICI 1200 million tons annually) CNC waste can help to produce large quantity of eco-friendly concrete and reduce large amount of land pollution. To Increase the compressive strength and tensile strength and flexural Strength of the concrete in CNC wastes adding. Steel scraps of length 20-30mm, width 1.5 -2mm and thickness 0.3-0.6mm which obtained from the lathe machines as waste. Aspect ratio will be with 50-70.so the value of CNC waste which is taken for lathe machine will vary from 50-70.

Fig. 5: CNC WASTE

B. Mix Design

The design of concrete mix involves the determination of the most rational proportions of ingredients of concrete to achieve a concrete which is workable in its plastic state and will develop the required qualities when hardened. In general, a fresh concrete must be workable and a hardened concrete must be durable & have the desired strength and appearance. So, Mix design can be defined as a process of selecting suitable materials/ingredients of concrete and determining their relative quantities with the object of producing an economical concrete having certain minimum properties, i.e., workability, strength and durability.

In the present study, M25 grade with nominal mix as per the Bureau of Indian Standards recommended a set of procedure for design of concrete mix mainly based on the work done in National laboratories. The concrete mixed proportion (1:1:2) by volume and water cement ratio of 0.45-0.5

III. MATERIAL TESTING

A. Analysis:

A laboratory study were performed to determine the compressive strengths cubes for 7 days,14 days, 28 days of casting of different trail of concrete with 0, 10, 20, 30 percent replacement of fine aggregate by glass powder and adding CNC waste. The various test results are analyzed below

B. Specific Gravity Test:

It is defined as the ratio of the mass of void in a given volume of sample to the mass of an equal volume of water at the same temperature. If the volume of aggregates includes the voids, the resulting specific gravity is called as "apparent specific gravity", it refers the volume of aggregate includes impermeable voids. The specific gravity most frequently and easily determine and it is based on the saturated dry condition of the aggregate because the water absorbed aggregate in the pores of the aggregate does not take part in the chemical reaction of the cement. Therefore it is considered as a part of the aggregate. The specific gravity is required for the calculation of the yield of concrete or the required quantity of aggregate for the given volume of concrete. This test is done to determine the specific gravity of fine- grained soil by density bottle method as per IS: 2720 (Part III/Sec 1) – 1980. Specific gravity is the ratio of the weight of a given volume of solids to the weight of an equivalent volume of water.

C. Water Absorption of Aggregate:

Some of the aggregates are porous and absorptive. Porosity and absorption of aggregate will affect the water / cement ratio and hence the workability of concrete. The water absorption of aggregate is determined by measuring the increase in weight of an oven dried sample when immersed in water for 24 hours. The ratio of increase in weight of the dry sample expressed as percentage is known as absorption of aggregate

D. Consistency Test:

The determination of consistency of concrete using a vee-bee Consistometer, Which determines the time required for transforming, by vibration, a concrete specimen in the shape of a conical frustum into cylinder.

This is a good laboratory test to measure indirectly the workability of concrete. This test consists of a vibrating table, a metal pot, a sheet metal cone, as standardiron rod. A sheet metal cone open at both ends is placed in the metal pot and the metal pot is fixed on to the vibrator table by means of twowing-nuts.

When water is mixed with cement to form a paste, reaction starts. The action of changing of the cement paste from fluid state is called setting time. For the initial setting time test, a needle of 1 mm square section is to be fitted to the moving rod, while for the final setting time test, the needle with annular attachment is to be used.

E. Slump cone test:

The internal surface of the mould is cleaned thoroughly and freed From any old set concrete before commencing the test.

The mould is placed on a smooth horizontal rigid and non – absorbent Surface.

The mould is then filled in four layers each approximately one – fourth of the height of the mould.

Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section. After the top layer has been rodded the concrete is struck off level with a trowel and a tamping rod.

Raise the mould a distance of 300 mm in 5±2 sec by steady upward lift with no lateral or torsional motion.

The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction.

Complete the entire from the start, conventional concrete 90mm.

Fig. 6: Slump Cone Apparatus

F. Workability:

Workability is the property of concrete which determines the amount of useful internal work necessary to produce full compaction. Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work.

G. Sieve Analysis on Recycled Aggregate:

Sieve analysis is conducted determine the partial size distribution in a sample of aggregate which we call as grading. Aggregate fraction from 40mm to 4.75mm is termed as recycled aggregate.

From the sieve analysis practical size distribution in a sample of aggregate is found out.

Recycled aggregate obtained by carefully breaking the demolished concrete structure and sieved through standard set of sieves order to produce a sample having various proportion of size fraction as given in IS code

H. Summary of Material Properties:

Finess modulus of sand is more than that of glass powder . This means glass powder is finer than sand.

Sand particles rounded and globular where as glass powder particles are angular , flaky and irregular in shape.

The reasons with the fact that glass powder is finer than sand

IV. EXPERIMENTAL INVESTIGATION

A. General

The most common of all the tests on hardened concrete is the comprssive strength test. This is partly because it is easy to make and partly because many through not all, of the desirable characteristics of concrete are qualitatively related to its strength, but mainly because of the intrinsic importance of the compressive strength of concrete in construction.

The concrete samples are casted with the mix 1:1:2 as per the design, with the parial replacement of fine aggregate. The tests are carried out after 7, 14 & 28 days of casting of concrete,

- Compressive strength (cube specimen)
- Tensile strength (cylinder specimen)

B. Curing

In all but the least critical applications, care needs to be taken to properly cure concrete, to achieve best strength and hardness. This happens after the concrete has been placed. Cement requires a moist, controlled environment to gain strength and harden fully. The cement paste hardens over time, initially setting and becoming rigid though very weak and gaining in strength in the weeks.

Fig. 7: Curing of Specimen

V. RESULTS & DISCUSSIONS

A. General

The result of the experimental investigationon cube and cylinder specimen,the influence of material on internal curing is investigated.

1) Compressive Strength Test

The compressive strength of a material is that value of uniaxial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of compressive test. An uniaxial compressive load is applied on testing material to extract the strength of the specimen.

Compressive strength o concrete is usually found by testing cubes o size 150mm x 150mm x 150mm. Specimens with nominal and partially replaced glass powder and cnc waste concrete were casted. During casting the cubes were manually compacted using damping rod. After 24 hours, the specimens was removed rom the mould and subjected to water curing or 28 days. After curing, the specimens were tested or compressive strength using a compression testing machine.

Compressive strength is also used as a qualitative measure for other properties of hardened concrete. In practical, the compressive strength increases as the specimen size decreases. At least three cubes of size 150mm x 150mm x 150mm were casted for each age, usually 7, 14 & 28 days. In most structural applications, concrete is used primarily to resist compressive stress. In those cases, where strength in tension or in shear is of primary importance.

The specimens were kept in moistureFor one day and then subjected to water curing for the rest of the days. Specimens were tested in saturated condition.

Fig. 8: Universal Testing Machine

2) Compressive Strength Test Result After 7 Days Curing

Compressive strength of conventional, replaced of 10%,20%,30% concrete of M25 grade after 7 days.

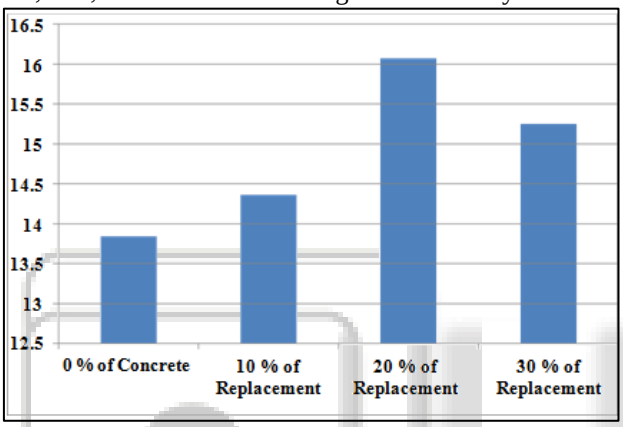

Fig. 9: Compressive Strength Test result after 7 days

3) Compressive Strength Test Result after 14 Days Curing

Compressive strength of conventional, replaced of 10%,20%,30% concrete of M25 grade after 14 days.

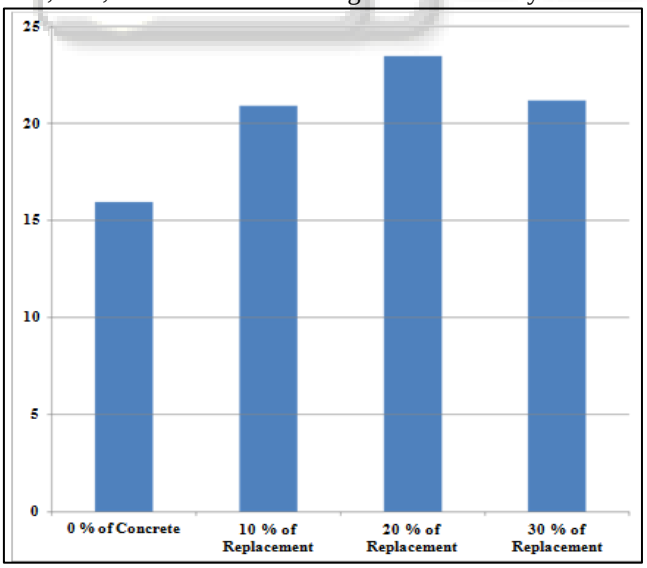

Fig. 10: Compressive Strength Test result after 14 days curing

4) Compressive Strength Test Result after 28 Days Curing

Compressive strength of conventional, replaced of 10%, 20%, 30% concrete of M25 grade after 28 days.

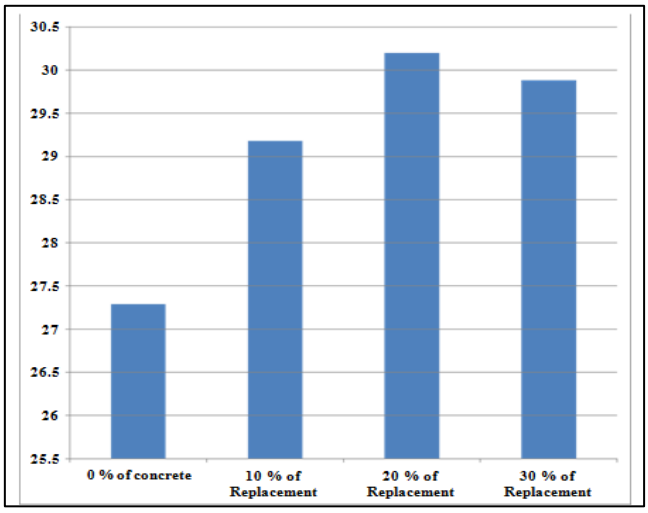

Fig. 11: Compressive Strength Test result after 28 days

5) Split Tensile Strength

Split tensile strength is usually formed by testing plain concrete cylinders. Cylinders o size 100mm x 200mm were casting using M25 grade concrete. specimens with nominal and partially replaced glasspowder and cnc waste concrete were casted.

During moulding, the cylinders were manually compacted using tamping rod. After 24 hours, the specimens were removed rom the mould and subjected to water curing or 28 days.

After curing, the specimens were tested or compressive strength using a calibrated compression testing machine by placing the concrete cylinder in its longitudinal axis and there by providing indirect tension to the specimen .And the variation in their testing results are noted and a graph is plotted.

Fig. 12: Split Tensile Strength Testing Machine

6) Split Tensile Strength Test Result after 7 Days

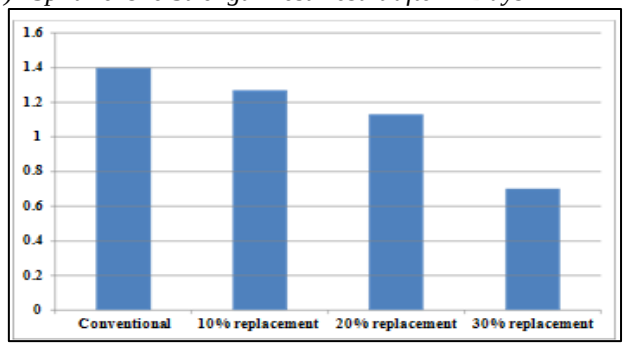

Fig. 13: Split Tensile Strength Test result after 7 days

7) Split Tensile Strength Test Result after 14 Days

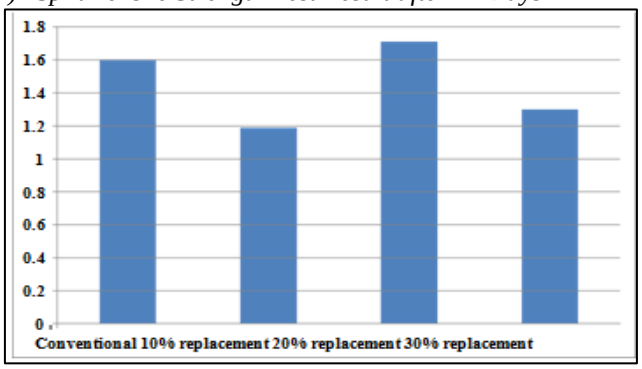

Fig. 14: Split Tensile Strength Test result after 14 days

8) Split Tensile Strength Test Result after 28 Days

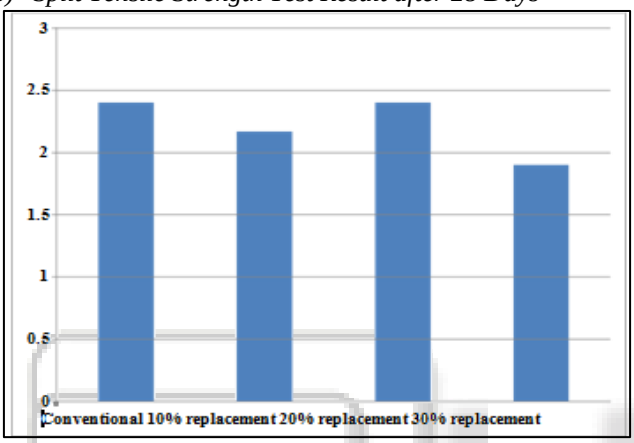

Fig. 15: Split Tensile Strength Test result after 14 days

VI. CONCLUSIONS

From the tests conducted on waste glass replaced in fine aggregate for concrete as Presented in various sections, the following conclusions are made.

The waste glass and CNC waste is suitable for making concrete. The fineness modulus, specific gravity, moisture content, un-compacted bulk density and compacted bulk density at 10% Sheet glass powder (waste glass) and 1.5% CNC waste were found to be 2.25,3.27,2.57%,1510kg/m^3 and 1620kg/m^3For a given mix.

The water requirement decreases as the waste glass content increases. The compressive strength of cubes of the concrete for all mix increases as the percentage of waste glass increases.

Partially (10%, 20% and 30%) replacement of waste glass and CNC waste (1.5% to 2%) in concrete showed better results than that of conventional concrete at 28 days curing to increases the compressive strength of 11%.

Waste glass and CNC is available in significant quantities as a waste and can be utilized for making concrete. This will go a long way to reduce the quantity of waste in our environment.

The optimum replacement level in fine aggregate with waste glass is 10%, 20% and 30%.

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