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EXPERIMENTAL STUDY ON THE STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF FINE AGGREGATE BY WASTE GLASS POWDER

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ABSTRACT: The concrete is a composite material which is mostly used all over the world. The strength characteristics depends upon the properties of materials used and their action. Fine aggregate is one of the important constituent materials as far as strength characteristics of concrete. River sand is most commonly used as fine aggregates in the production of concrete. Availability of raw materials required for manufacturing of cement and production of concrete are limited in nature. This increases the demand will lead to fast depletion of natural resources and will cause big threat to environment. So as to overcome this problem, this is very much essential to utilize the industrial waste materials and by-products generated in manufacturing of cement and in concrete construction. The use of river sand as fine aggregate leads to exploitation of natural resources, lowering of water table , sinking of bridge piers and erosion of river bed. If fine aggregates is replaced by waste glass by specific percent and by specific size range, it will decrease fine aggregate content and thereby reducing the ill effects of river dredging and thus making concrete manufacturing industry sustainable. Most waste glass is being dumped into landfill sites. The land filling of waste glass is undesirable because waste glass is non-bio degradable which makes them environmentally less friendly. Glass material contents contributes greater strength and better thermal insulation due to its better thermal properties of the glass aggregate. When the waste glasses are reused in making concrete products, the production cost of concrete will go down. Using crushed glass material for the replacement of natural sand can be justified both as remedial for waste disposal and reducing environmental degradation.

INTRODUCTION

1) To investigate the utilization of waste material as partial of sand.
2) The development of alternate low-cost and environmentally suitable building materials from industrial wastes is an economical way.
3) To determine the percentage of replacement to give high strength concrete.
4) To study and compare the performance of conventional concrete and glass powder concrete.
5) To understand the effectiveness of glass powder in strength enhancement.

SCOPE

1) It reduces the amount of waste glass to be disposed.
2) It is a remedy to the increasing impact of sand dredging on the ecological environment.
3) It reduces waste disposal crisis.
4) Concrete workability can be studied by using glass powder as partial material of sand in it.

NEED FOR THE RESEARCH

1). To judge the utility of glass powder as a partial replacement of fine aggregate in concrete.

2). To check and compare the performance standard concrete and glass powder concrete.

3). To know the effectiveness of glass powder in strength improvement. Literature pertaining to studies on the strength of concrete by partial replacement of fine aggregate by waste glass powder is presented in this chapter. A detailed review of literature has been carried out to study the strength of concrete. The use of recycled waste glasses in the concrete industry has been rising lately due to its environment-friendly advantage. Various researches support the use of waste glasses as a replacement of fine and coarse aggregate.

REVIEW OF LITERATURE

Shayan and Xu (2004) studied the twenty-eight-day mechanical properties of the concrete comprising waste glass (Size 4.75 – 0.15mm) as the fine aggregate replacement at levels of 10%, 20%, 30% and 40% by weight. Result obtained from the experiment showed positive growth in the mechanical properties of concrete.

De Castro and Brito (2013) studied the twenty-eight-day mechanical properties of the

concrete by replacing the fine aggregate with a waste glass of size <4mm at levels of 5%, 10% and 20% by volume.workability of the mixture was studied with the help of the slump. Workability was found to be reduced with an increment of the percentage of the waste glass. The reduction in the workability was found to be 1.97%, 1.57% and 4.33% after the addition of 5%, 10% and 20% of waste glass.

M.Vijaya Sekhar Reddy (2015) In this paper, the issues of environmental and economic concern are addressed by the use of waste glass as partial replacement of finer aggregates in concrete. Fine aggregates were replaced by waste glass powder (GP) as 10%, 20% and 30% by weight for M20 mix. The concrete specimens were tested for compressive strength seven and 28 of age and the result obtained were compared with those of normal concrete. The study indicates that waste glass can effectively be used as fine aggregate replacement (upto 20%) without substantial change in strength.

B.V.Kavyateja (2016) The study provides details regarding exploratory examination on the suitability of squashed glass as partially replaced for fine total in solid generation. The control blending proportion of 1:1.5:3 grouped by volume with water – bond proportion of 0.5 were utilized. The compressive qualities of cured solid 3D shapes of of sizes 150mm x 150mm x 150mm were assessed at 3 days, 7 days, 28 days,56 days and 90 days.

To obtain the test results the workability is increased. Compressive strength is increased upto 20% replacement levelit goes to decreasing, and splittensile strength is slightly decreasing as compared to normal concrete.

Rakesh Sakale (2015) investigated the effects of replacing fine aggregate with waste glass powder by volume of cement in steps of 10%, 20%, 30% and 40 % and the effects on compressive strength split tensile strength, workability and flexural strength. The compressive, flexural and split tensile strengths of concrete arev found to increase initially as glass powder increases, peaking at around 20% and then decreasing.

S.M. Chikhalikar and S.N. Tande (2012) there is a need to replace a portion of fine aggregate with waste glass powder to reduce fine 9111aggregate consumption and to reduce environmental pollution to some extent. Recently, research has revealed that waste glass can be used as fine aggregate in concrete. Because of its high silica content, waste glass has cementitious properties when ground to a fine powder.

Veena V. Bhat, N. Bhavanishankar Rao (2014) Glass is an indeterminate material with high silica content (SiO2) i.e., 72% of waste glass when grounded to very fine powder (600 micron) reacts with alkali in cement & cementations product that help to contribute to the strength development.

Park and Lee (2004) used waste glasses instead of natural sand (Glass size 4.75 – 0.3 mm) 10%, 20%, 30%, 50% and 100% by weight as a replacement of sand. With the increase in the replacement percentage, the flexural and compressive strength was found to be decreased. When the glass content was morethan twenty percent then the strength was found to be reduced significantly.

Chen CH (2004) noticed with the increase in the percentage replacement of sand with glass aggregate. The strength parameters of concrete were found to have deteriorated.

Seung et al.(2004) noticed the decrement in workability with the increase in glass percentage and concluded it to be due to the angular shape of waste glasses. With 30% replacement of the sand with waste glass maximum mechanical properties of concrete was obtained.

Ibrahim (2017) discovered that waste glass may replace sand upto 40% by weight without affecting the tensile and compressive strengths when compared to control concrete. He observed that 15% partial replacement was the optimum dosage.

Malik et al. (2013) used waste glasses as a partial replacement of fine aggregates (sand) in concrete. Several samples were made by replacing sand with glass contents of 10%, 20%, 30% and 40% by weight in M25 grade concrete. The samples were tested for compressibility, splitting tensile

strength, and density 28 days after curing. The experiments findings were compared to those of conventional concrete. Specimens containing crushed waste glass had higher compressive strength for particle sizes of 0.1 – 1.18 mm, with upto 30% weight replacement of small aggregate. Specimens made of glass were also shown to be more cost-effective and environmentally friendly.

Ramana and Samdani (2013) studied the effects of replacing fine sand aggregates with waste glass in the rabges of 0%, 5%, 10%, 15%, 20%, 25% and 30%. The research work investigated compressive strength and flexural strength among other mechanical properties. The results of the laboratory tests were recorded and compared to traditional concrete results. The results showed that mechanical properties improved when fine aggregates were replaced with crushed glass at 15% but reduced when fine aggregates were replaced at a rate of 30%.

Dabiri et al. (2018) assessed the effects on compressive strength and more importantly, the effects on the weight of the concrete by replacing fine aggregates with waste glass particles. 27 cube samples were produced to achieve the objectives with 6 specimens produced of normal concrete and the test incorporating glass particles mixed in varying amounts. Micro-Silica was added to the glass cubes to prevent the Alkali-Silica reaction(ASR). According to the results of the testing, replacing aggregates with glass particles increased the compressive strength by more than 30%. The weight of the concrete was observed to be nearly constant for the most part. The optimum proportion for replacing aggregates with waste glass particles, according to the research is 50%.

Waste glass powder

Glass powder partially replaces the fine aggregate in mix proportion.

It is a transperant material produced by melting a mixture of materials such as Silica, Soda ash and $CaCO_3$ at high temperature followed by cooling during which solidification occurs without crystallization. It is widely used in our day today life. It can be found in many forms, including container glass, flat glass such as windows, bulb glass and cathode ray tube glass. The use of glass as aggregates in concrete has a great potential for high quality concrete development. Its shape and size have potential benefits in obtaining a good particle size distribution in glass concrete.

Advantages of waste glass in concrete

- It is an environmentally friendly way to recycle glass
- It can help to improve the strength and durability of concrete
- It can add visual interest and variety to concrete projects
- It can help to reduce the overall cost of project
- It can helps to reduce the amount of heat transferred in concrete making
- Increase workability of the mix due to finness of particles
- Reduce dosage of super plasticizer to achieve target workability

Disadvantages of waste glass in concrete

- Waste glass is not as strong as other types of aggregates, so it may not be suitable for all applications
- It can absorbs moisture, which can lead to the concrete cracking or deteriorating over time

Classification of glass

Soda-Lime glass

- The glass has good chemical as well as physical properties.
- It is suitable for the products that resist the impact of chemical medium and limitedly temperature.
- Both types of pipettes are produced from the soda-lime glasses

Borosilicate glass

- Physical and chemical properties of this type of glass enable.
- These type of glasses are used in pharmacy (vial), medicine (glass syringes), production of brilliant lighting units, textile industries.

Optical glass

- Which are used for optical purpose like eyeglasses and camera lenses.

- These glasses are transperant, pure and hard.

Safety glasses

- That have additional features which prevent them from breaking easily and shattering even after breaking.
- Different safety glasses are toughened glass, wire mesh glass and laminated glass.

Potash glass

- It is a type of glass made using potash (Potassium carbonate) as a fluxing agent instead of soda ash (Sodium carbonate).
- It is harder, heavier and more chemically durable than soda-lime glass.

Flint glass

- It is a type of lead glass that is characterized by its high refractive index and high density.
- Historically, flint glass was widely used for the production of decorative items like chandliers, tableware and jewellery.

Crown glass

- It is a type of glass that has been used historically for its optical properties.

Crooks glass

- It is a type of glass with high electrical resistance developed by William Crookes in the late 19th century.

Xena glass

- It is a type of high-resistance glass developed in the early 20th century. It is known for its extremely high electrical resistivity.
- It will be used for high insulation, like in the electrical components of radio telegraphy, X-ray tubes and high voltage items in the early 20th century.

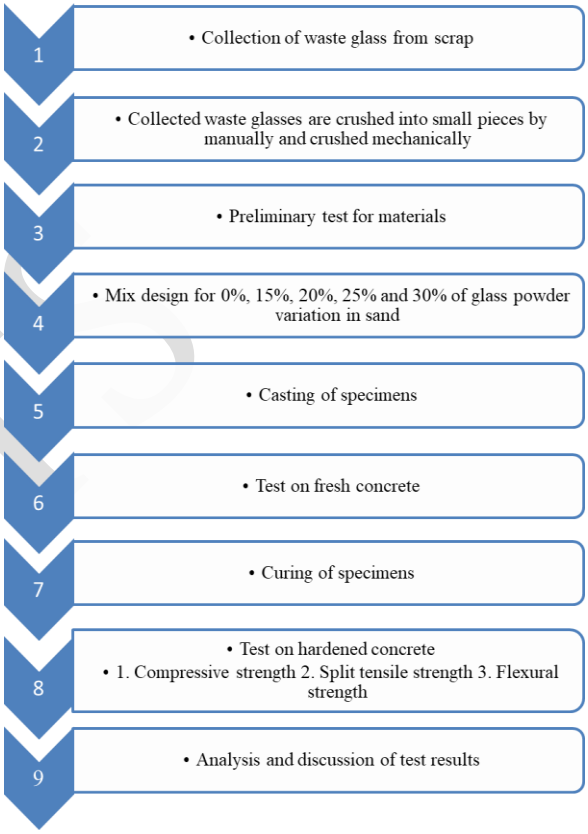
Lead Crystal glass

- It is a unique glass variety used in the creation of decorative objects.
- When these glasses are meticulously cut, they exhibit the optical phenomenon of total internal reflection with remarkable intensity, resulting in the creation of a delightful, radiant illumination.

Properties of glasses`

- It absorbs,refracts or transmits light
- It has no sharp melting point
- It is affected by alkalis
- It has no definite crystalline structure
- It is extensively brittle
- It is not usually affected by air and water
- It is available in beautiful colours
- It is available in clean and clear state
- It is cheap
- It is easily fustible at comparatively low temperature

METHODOLOGY



Collection of waste glass from scrap

Mixed waste glasses are collected from scrap for experiment. After collecting, all the unwanted materials, like labels are removed.

1. Crushing of waste glasses

Cleaned waste glasses are crushed manually and then ground into powder mechanically by Los Angle Abrasion pulverizer which was sieved ans passed through IS sieve 75µm size.

2. Primary tests for materials

a. Cement

Setting time of cement

The initial setting time of cement is the time when the cement paste starts losing its plasticity and final setting time of cement is the time when the cement

paste completely loses its plasticity. Vicat's apparatus is used for calculating the setting time of cement.

Normal Consistency of cement

The normal consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10mm dia and 50mm length to penetrate a depth of 33 to 35 mm from the top or 5 to 7 mm from the bottom of the mould.

Specific gravity of cement

Basically specific gravity defines that the substance is how much heavier than water or a reference substance of the same volume. The specific gravity of cement ranges from 3.1 to 3.16 g/cc. Le Chatelier flask is used for specic gravity test of cement.

Compressive strength of cement

Compressive strength is defined as, strength of cement to withstand applied loads. Universal Testing Machine is used for test. The test is typically conducted using a compression testing machine, which applies a gradually increasing loads to the test specimen until it fractures.

Finness of cement

(a) By Seiving
(b) By determination of specific surface (total surface area of all the particles in one gram of cement) by air- permeability apparatus. Expressed as cm^2/gm or m^2/kg.

b. Fine aggregate

Specific gravity

The ratio of weight of a given volume of aggregate to the weight of an equal volume of water. Standard pycnometer apparatus is used to find specific gravity of fine aggregate.

Seive analysis

It is calculated by sieving a known mass of given aggregates on a set of standard sieves and by adding the cumulative percentages of mass of materials retained on all the sieves and divide the total percentage by 100. IS sieve set from 4.75 mm to 75 micron was used.

C. Coarse aggregate

Crushing value

The aggregate crushing value is defined as a ratio of the weight of fines passing the specified IS sieve to the total weight of the sample expressed as percentage. Compressive testing machine is used for calculate crushing value of coarse aggregate.

Water absorption test

Perforated basket is used for water absorption test of coarse aggregate. Absorption capacity represents the maximum amount of water the aggregates can absorb. Water absorption gives an idea on the internal structure of the aggregate and strength of aggregate.

Seive analysis test (Gradation)

Seive analysis test indicates the size distribution of coarse aggregate particle in a given coarse aggregate sample. IS sieve set from 40mm to 2.36mm is used for sieve analysis.

d. Glass powder

Specific gravity test

The ratio of weight of a given volume of glass powder to the weight of an equal volume of water.

Seive analysis

It is calculated by sieving a known mass of given aggregates on a set of standard sieves and by adding the cumulative percentages 0 mass of materials retained on all the sieves and divide the total percentage by 100. IS sieve set from 4.75 mm to 75 micron was used.

4.Mix design

Mix design of concrete was prepared for M20 grade by adding glass powder as partially for fine aggregate into 0%, 15%, 20%, 25%, 30%.

5.Casting of specimens

Specimens are casted into the size of 150mm x 150mm x 150 mm for testing.

6.Test on fresh concrete

a. Slump cone test

This measures the consistency of a concrete batch to see how easily the concrete will flow

c. Compressive test

It is tested by pouring cubes of fresh concrete and measuring the force needed to break the concrete cubes at prescribed interval as they harden.

7. Curing of specimen

The process of maintaining satisfactory temperature and moisture conditions in concrete long enough for hydration to develop the desired concrete properties. 28 days curing period is considered as a standard benchmark for evaluating the concrete's strength.

8. Test on hardened concrete

a. Compressive strength test

Compression test is the most common testing conducted on hardened concrete, partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. For this test Universal Compressive Testing Machine was used.

b. Split Tensile Strength test

The split tensile strength test is performed on hardened concrete to determine its tensile strength. It is an indirect method of testing tensile strength of concrete.

c. Flexural strength of concrete

Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending. It denotes as (MR) in Mpa or Psi. It is conducted either three point load test (ASTM C78) or centre point load test (ASTM C293).

9. Analysis and discussion of test results

The mix with differ W/C ratio are compared with each other to find out the affect on the workability and strength of the concrete and as well as with the conventional concrete results and find out the optimum value of replacement for natural sand with crushed glass material.

CONCLUSION

The first phase of work primarily focused on literature review, data collection for future work such as properties of materials used for concreting, additive material properties. Testing of such materials and concrete will be conducted on second phase (Future work).

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