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Partial Replacement of Fine Aggregate and Coarse Aggregate by Waste Glass Powder and Coconut Shell

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Abstract:

Concrete is the mixture of various materials coarse aggregate, fine aggregate, cement & water, each of them is mixed in various proportions to achieve specific strength.coarse aggregate and fine aggregate being the most important material plays an important role in the manufacturing of concrete. The cost of conventional construction materials is high .This is necessity research for some new kind of alternative materials in the constructions field. Waste glass in the form of fine aggregate and coconut shell as coarse aggregate can be used. The proportion of the mineral and mixtures is applied in testing cubes for their workability, compression strength and flexural strength.

Keywords —coconut shell, waste glass powder, compression, flexural, workability.

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1. INTRODUCTION

1.1 GENERAL

Concrete is the second largest of widely used material; but there are environmental issues related with its use which are needed to be taken under considerations. Use of such waste materials not only helps in getting them utilized in fine and coarse aggregate. concrete and other construction materials, but also has benefits such as reduction in land fill cost, saving in energy, and protecting environment,reducing the cost of concrete manufacturing. In addition use of such wastes can improve the properties of construction materials as well. Moreover, the production of cement and other concrete raw materials has increased dramatically over the past 80 years due to a continuous increase in demand for concrete. In view of this, the significance of this study is to show that the replacement of aggregates in concrete by coconut shells and waste glass leads to economy in the concrete utilization sector. The use of such waste materials in concrete can be an important step towards sustainability of the construction industry by ensuring a scenario having less environmental impacts. Further we know pozzolanic materials like glass are materials of current use in concrete. Their

main purpose is usually the mitigation of Alkali Silica Reaction (ASR), especially deleterious in concrete structures, which is achieved by the development of a faster pozzolanic reaction, conferring additional strength to mortars and concretes. Similarly Coconut shell being a hard and not easily degrade material if crushed to smaller size can be a potential material to partially substitute coarse aggregates in concrete. The concrete with ground coconut shell was found to be durable in terms of its resistance in water, acidic and alkaline surrounding. Due to various factories and industries large volume of waste produced daily .The disposal of the waste generated from industries has become serious issue solid waste management is one of the major environmental concerns in the world. The recycling and reuse of the waste has become the best alternatives as their disposal problem of waste. In light of this in the contemporary civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete as sustainable and environmentally friendly construction material.

1.2 OBJECTIVE

The main objective of the study is to use the waste materials (coconut shells and glass waste) in place of coarse and fine aggregates respectively for the positive variations in the properties of the concrete and also its impact on the economic growth of the construction industry and to explore the use of replaced materials. Further, the effects of materials used as aggregates are to be determined by testing workability, tensile strength, compressive strength, durability, etc. of cement concrete. These tests will enable a complete characterization and an evaluation of application possibilities. The main objectives of the study are summarized below,

1. To investigate the influence of partial replacement of coarse aggregates& fine aggregates by coconut shells and waste glass respectively on mechanical properties of concrete. Study on effect of change in percentage of coconut shells and waste glass (separately and in combination) on properties of concrete will also be deemed as an important part of present experimental investigation.
2. To find economical solution for high cost aggregate material like sand and gravel and hence making concrete construction more sustainable.
3. To prepare lightweight concrete by using coconut shell as course aggregate and waste glass as fine aggregate.
4. Utilization of waste glass in the concrete construction sector, hence eliminating the need of land fill disposal of this non- biodegradable waste.

2. MATERIAL AND MIX DESIGN

2.1 MATERIALS

2.1.1 CEMENT

Cement is a binder, a substance used in construction that sets, hardens and adheres to other materials, binding them together. Cement is seldom used solely, but is used to bind sand and gravel (aggregate) together. Cement is used with fine aggregate to produce mortar for masonry, or with sand and gravel aggregates to produce concrete. Cements used in construction are usually inorganic, often lime or calcium silicate based, and can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to set in the presence of water. Cement used in construction is characterized as hydraulic or non-hydraulic. Hydraulic cements (e.g., Portland cement) harden because of hydration, chemical reactions that occur independently of the mixture's water content; they can harden even underwater or when constantly exposed to wet weather. Non-hydraulic cement will not set in wet conditions or underwater; rather, it sets as it dries and reacts with carbon dioxide in the air. It is resistant to attack by chemicals after setting.

2.1.2 FINE AGGREGATE

Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end

product in their own right. They are also the raw materials that are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of concrete. Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. As with coarse aggregates these can be from Primary, Secondary or Recycled sources.

2.1.3 COARSE AGGREGATES

Coarse aggregates are particles greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter. They can either be from Primary, Secondary or Recycled sources. Primary, or 'virgin', aggregates are either Land- or Marine-Won. Gravel is a coarse marine-won aggregate; land-won coarse aggregates include gravel and crushed rock. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. Secondary aggregates are materials which are the by-products of extractive operations and are derived from a very wide range of materials .Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular sub bases, soil-cement, and in new concrete. Recycled aggregates are classified in one of two ways,

- Recycled Aggregate (RA), or as
- Recycled Concrete Aggregate (RCA)

Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into several distinct categories, and are either coarse or fine.

2.1.4 COCONUT SHELL

A Coconut shell is an item obtained by removing coconut milk from coconut opened with a hammer. It can be used to generate super compost. Coconut shells are one of the by-products from splitting a Coconut. The freshly discarded shells were collected from the local temples and they were well seasoned. The seasoned CS is crushed, which was developed and erected for this purpose. The crushed edges were rough and spiky and the lengths were restricted to a maximum of 12 mm. The surface texture of the shell was fairly smooth on concave and rough on convex faces.

Fig -1: Coconut Shell aggregate

2.1.5 WASTE GLASS POWDER

Waste glass is not just waste, but a new resource. Generally, beer, wine bottles and other food jars etc., are among the few normal household glass items put into landfills every day. Glass is generally produced from sand, lime and soda and uses about 40 percent more power to produce from raw materials than it does with recycled materials The glass in light bulbs, cook ware and window panes are not recyclable due to some special additives used to the glass. These additives are ceramics and other impurities that generally contaminate the recycling process. The glass that cannot be recycled only plays a small part of the glass that is put into the landfills though. The process of glass recycling is less extensive than the process of making it from raw materials. Once glass is picked up and taken to the recycle centre it is separated by colour and then broken into small pieces. The broken glass pieces are then crushed and sorted before being cleaned and added to raw

materials to make the final glass product. Crushed glass melts at a lower temperature than the raw materials and therefore the more recycled material that is in the mixture the less energy it takes to melt the materials into glass.

Fig -2: Waste Glass Powder

2.1.6 WATER

Water to be used in the concrete work should have following properties: It should be free from injurious amount of oil, acids, alkalis or other organic or inorganic impurities. It should be free from iron, vegetable matter or other any type of substances, which are likely to have adverse affect on concrete or reinforcement. It should be quite satisfactory for drinking purpose which is used in mixing of concrete.

2.1.7 BENTONITE

Bentonite is used as a coating material for coconut shell to increase the durability of the coconut shell. Bentonite is a clay material it has various type like sodium bentonite, potassium betonies, calcium bentonite.

Fig -3: Bentonite

2.2 MIXING RATIO

M20 mix with 1:1.5:3 ratio of cement, fine aggregate and coarse aggregate respectively was prepared for each sample. For replaced samples, different percentages of fine and coarse aggregates were replaced by waste glass and the coconut shell respectively. The water/cement ratio was kept as 0.45 for all mixes. The proportioned mix was blended together by hand, and then water was added to it in small quantities. The concrete was mixed continuously by hand using trowels till the appropriate mortar consistency is reached.

2.2.1 MIXING PROCEDURE

The concretes were mixed in a planetary mixer of capacity. The mixing time kept to about 3 to 4 min. Mixing of the materials was in a sequence: (i) portion of design water poured into mixture drum; (ii) cement gently placed; and (iii) aggregate of coconut shell and waste glass powder was spread over the cement and started mixing. During mixing, the remaining design water was poured into the mix for thorough mix of concretes. Specimens were then prepared and left for 24 hours. The specimens were de moulded after 24 hours and immersed in normal water for curing until the test age.

2.2.3 MIX PRECENTAGE

Fine aggregates and Coarse aggregates partially were replaced by waste glass powder and coconut shell as 10%, 20%, 30% ,40%,50% by weight for M-20 mix.

2.2.4 PREPARATION OF SAMPLES

All samples were prepared in the Concrete technology laboratory at our college campus. The samples for compression testing were cubes of size (15cm x15cm x15cm) while the beams of size (50cm x 10cm x 10cm) were used for flexure testing. The various steps involved in the sample preparation process are given below.

3. RESULTS AND INTERPRETATIONS

The results show the variation in Compressive strengths and Flexural strengths of various concrete mixes in which the fine and coarse aggregates were replaced by various percentages of glass waste and coconut shells respectively. The results of various tests on materials used in the project are also mentioned in this chapter.

3.1 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/mm2. 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.

Fig -3: Compression Test

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.

Table -1:*Compression Test*

3.2 FLEXURAL TEST

The test is held for determine the strength of the concrete by using flexure test ,the apparatus consists of prism mould, felexural or compression testing machine. The specimens are stored in water at a temperature of 24°c and 30°c for 48 hours before testing .they are tested immediately on removal from the water whilst they are still wet condition. The dimension of each specimen shouldbe noted before testing. The bearing surface of the supporting and loading rollers is wiped and clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers.

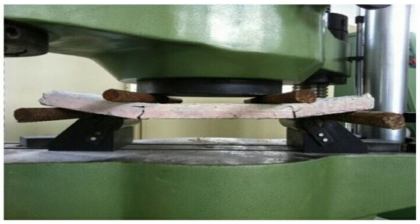

Fig -4: Flexural Test

The specimen is then placed in the machine in such manner that the load is applied to the upper most surface of the cast in the mould. The axis of specimen is carefully aligned with the axis of the loading device. No packing is used between the

Mix ratio	7days strength (N/mm2)	28 days strength (N/mm2)
Mix 0%	2.63	3.68
Mix 10%	2.91	3.96
Mix 20%	3.98	4.12
Mix 30%	4.56	4.63
Mix 40%	4.98	5.32
Mix 50%	5.11	5.56

bearing surfaces of the specimen and rollers. The load is applied without shock and increasing continuously at a rate of the specimen. The rate of loading is 4 kN/min for the 15cm specimen and 18 kN/min for the 10cm specimen. The load is increased until the specimen fails and the maximum load applied to the specimen during the test is recorded. The strength of concrete is calculated.

Table -2: Flexural Test

Mix ratio	7days strength (N/mm2)	28 days strength (N/mm2)
Mix 0%	17.20	26.53
Mix 10%	17.88	34.55
Mix 20%	19.57	28.96
Mix 30%	19.81	27.87
Mix 40%	20.13	29.56
Mix 50%	22.58	28.50

3.3 SLUMP CONE TEST

Slump cone test is used to determine the flow and workability of concrete mix prepared at the laboratory or the construction site during the progress of the work. concrete slump test is carried out from batch to check the uniform quality of concrete during construction. Generally concrete slump value is used to find the workability, which indicates water cement ratio, but there are various factors including properties of materials, mixing methods, admixtures ect, also affect the concrete slump value.

Table -3: *Slump Cone Test*

Mix ratio	Slump value	% Change in slump
Mix 0%	60	-
Mix 10%	64	Slump>60mm
Mix 20%	68	Slump>60mm
Mix 30%	75	Slump>60mm
Mix 40%	78	Slump>60mm
Mix 50%	82	Slump>60mm

4. CONCLUSIONS AND RECOMMENDATIONS

In civil engineering construction, Economy of any construction project depends upon its construction, advancement and sustainability. Using alternative materials in place of natural aggregates in concrete production makes concrete as sustainable and environmental friendly construction material. Use of solid waste can achieve economy in construction. This study concluded that the utilisation of coconut shells and glass waste as aggregates in concrete not only helps in getting them utilized in concrete but also has numerous indirect benefits such as reduction in land fill cost and protecting environment from possible pollution effect. With increasing concern over the excessive exploitation of natural aggregates, this environmental waste compromising of coconut shells and waste glass is a viable new source of structural aggregate material.

The study concluded that up to 10% replacement of coarse aggregates by coconut shells and up to (20-30) percent replacement of fine aggregates by waste glass, compressive strength increases. Also there is an increase in the flexural strength of concrete up to 10% replacement of fine aggregates in combination with replacement of coarse aggregates from 10% to 30%.Hence, Coconut Shell and waste Glass can be effectively used as coarse and fine aggregate replacement up to 20% to improve the strength of concrete. Among various mixes compressive strength is maximum for the mix in which fine aggregates are

replaced by 10% waste glasses. Its strength has increased by about 39% compared to the conventional M20 concrete. Flexural strength is also maximum for the mix in which fine aggregates are replaced by 10% waste glasses. Its flexural strength has increased by 13.5 percent compared to conventional M20 concrete. When both the coarse aggregates and fine aggregates are replaced by coconut shells and waste glasses respectively, compressive strength is maximum for the mix in which there is 10% replacement by coconut shells and 30% replacement by waste glass. Its strength has increased by about 30%. Also flexural strength is maximum for the mix in which there is 20% replacement by coconut shells and 10% replacement by waste glass. Its flexural strength has increased by 5.5%.

Partially replaced concrete is relatively light weight than conventional concrete which is economical, eco friendly and used in light weight structure where we have to minimize dead loads especially in earthquake prone zones. Coconut shells possesses sound absorbing property up to certain extent hence study is helpful for sound absorbing structures. Also coconut shell exhibits more resistance against crushing, impact and abrasion, compared to crushed granite aggregate. Coconut shell can be grouped under lightweight aggregate. There is no need to treat the coconut shell before use as an aggregate except for water absorption. Coconut shell is compatible with the cement. Due to the replacement of course aggregates by coconut shells workability decreases but due to the replacement of fine aggregates by waste glasses workability increases. So the study concluded that when both the course aggregates and fine aggregates are replaced by coconut shells and waste glasses respectively there is not much effect on workability compared to conventional concrete as the effects are counter balanced in these mixes. When the percentage replacement by coconut shells is higher, some plasticizers or super plasticizers can be used to have good workability.

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