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Experimental Study on Properties of Concrete by Partial Replacement of Coarse Aggregate by Coconut Shell and Fine Aggregate by GGBS

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***Abstract**: - Depletion of natural resources is a common phenomenon in developing nations like India due to rapid urbanization and Industrialization involving construction of Infrastructure and other conveniences. In prospect of this, people have begun researching for suitable other viable alternative materials for concrete so that the existing natural resources could be preserved to the possible extent, for the future generation. Lately, on the environmental issues, restrictions on local & natural access or sources and dispose of waste material are gaining great importance.*
Concrete is the most widely used construction material in civil engineering because of its high structural strength and stability. To find a suitable and effective material from the waste product that would considerably minimize the use of material and ultimately reduce the construction cost.
Aggregate is a major ingredient for making concrete, occupy almost 70-80% part of concrete. The roles of structural grade lightweight concrete reduce considerably the self-load of a structure and permit larger precast units to be managed. Coconut Shell is a waste from the agrarian sector and is used in large quantities in the tropical areas. The waste coconut shell may be utilized to replace natural coarse aggregate.
In this project Coconut shell and GGBS were used as replacement of coarse aggregate and fine aggregate respectively. In this project, experimental investigations were carried to find out the workability, strength and Durability characteristics of M30 grade concrete with different replacement level of fine aggregate as (i.e.,5%,10%,15%,20 %) and coarse aggregate as (i.e.,0%,5%,10%,15%). The tests were conducted to determine the performance level of steel slag and coconut shell in concrete. The specimen were subjected to compressive strength, split tensile strength at 7, 14, 28 days and flexural strength at 7,14, 28 days of curing period. Workability of concrete is increased by combination of steel slag and coconut shell. In this project GGBS is used to increase strength of the coconut shell concrete. GGBS along with cement and Coconut shell with coarse aggregate was indicated an increase in strength with 20 % steel slag and 5% Coconut shell at 28 days. From the durability test, the weight loss due to acid attack and sulphate attack of concrete is lower than the conventional concrete.
The main objective of this thesis is to encourage the use of these 'seemingly' waste products as construction materials in low-cost housing. It is also expected to serve the purpose of encouraging housing developers in investing these materials in house construction
***KEYWORDS:** - Coconut shell, GGBS, Infrastructure, Industrialization, lightweight, waste material*

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I. INTRODUCTION

Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non- decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the Waste Hierarchy. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal. Far more concrete is produced than any other man-made material. Annual production represents one ton for every person on the planet. It is incredibly versatile, and is used in almost all major construction projects. Aggregates are used in concrete for very specific purposes. Aggregates typically make up about 60 % to 75 % of the volume of a concrete mixture, and as they are the least expensive of the materials used in concrete, the economic impact is significant. 80 % of buildings CO2 emissions are generated not by the production of the materials used in its construction, but in the electric utilities of the building over its life-cycle. Compared to other comparable building materials, concrete is less costly to produce and remains extremely affordable. Use of waste materials as a construction material has several benefits such as decrease in cost, saving in energy, and protection of environment. Coconut shell is one of the main contributors of pollution problem as an agricultural waste. Coconut shell used as coarse aggregate in concrete encouraged sustainable and environmentally helpful material in the construction field for the production of lightweight structural concrete. The concrete with ground coconut shell was found to be durable in terms of its resistance in water, acidic, alkaline and salty. Density of coconut shell is in the range of 550 - 650 kg/m3 and these are within the specified limits for lightweight aggregate. Density, workability, compressive strength and split tensile strength of the concretes decreases with increase in percent of Coconut shells. Permeable voids, absorption and adsorption are increased with increase in coconut shells percent. Replacement of coarse aggregate with equivalent weight of fly ash had no effect when it is compared with properties of coconut shell replaced concrete. Rising populations and the need for infrastructure development boost the growth of construction industry. It is a major source of pollution responsible for around 5% of CO2 emission from cement manufacturing. "According to World Commission on Environment and Development, 1987, the sustainable development is the one which meets the needs of the present without compromising the ability of future generations to meet their own needs". In order to reduce the environmental unsustainability of construction activity worldwide, it is required to find the alternative of natural resource used in construction. Industrial byproduct such as fly ash has been extensively used in concrete input ingredient. But there are many other industrial wastes such as steel slag, GGBS, coconut shell and others can also be served as alternative of natural resource. It is required to do research and laboratory trials to find the suitability of another industrial waste as construction material. Industrial Solid waste and its management is one of a most critical problem, the gradual accumulation of which results in severe environmental concerns. Rather than disposing-off these materials on scarcely available land fill areas, the utilization of waste materials in construction industry can be an attractive alternative. The Indian integrated iron and steel industry poses serious challenges to environment through its inherent complexity and may hazardous to environment. Presently, India is the following to China, Japan and the US in the steel manufacturing industry. To meet the present need of the country, steel production will be expected to increase to about 155MT in 2021 (Indian steel). Aggregate, which makes up 70% of the concrete volume, is one of the main constituent materials in concrete production. Due to the high cost of natural sand used as a fine aggregate and the rising emphasis on sustainable construction, there is a need for the construction industry to search for alternative materials. Ground Granulated Blast Furnace Slag (GGBS) one of the most common industrial wastes, is a byproduct of steel production. One ton of steel implies the production of 130 – 200 kg of GGBS, depending on the composition of the steel and on the steel production process. Slag often appears as granulated materials containing large clusters, coarse and very fine particles. Serious environmental problems formerly originated from unrestrained sand and gravel taken from rivers. Fortunately, it has been considered for some decades the chance to use different recycled materials as concrete aggregates, even if just in partial replacement of natural counterparts. Among the ingredients of concrete, aggregates play a significant role in concrete occupying the largest volume which is about 60–75% of total concrete volume. Engineering properties of GGBS have shown that, it can be the good alternative of fine aggregate. Although a large number of investigations have been carried out to investigate the properties of concrete made with GGBS.

a) Powder type of self-compacting concrete: This is proportioned to give the required self-compatibility by reducing the water-powder (material<0.1mm) ratio and provide adequate segregation resistance. Super plasticizer and air entraining admixtures give the required deformability.
b) Viscosity agent type self-compacting concrete: This type is proportioned to provide self-compaction by the use of viscosity modifying admixture to provide segregation resistance. Super plasticizers and air entraining admixtures are used for obtaining the desired deformability.
c) Combination type self-compacting concrete: This type is proportioned so as to obtain self-compact ability mainly by reducing the water powder ratio, as in the powder type, and a viscosity modifying admixture is added to reduce the quality fluctuations of the fresh concrete due to the variation of the surface moisture content of the aggregates and their gradations during the production. This facilitates the production control of the concrete.

OBJECTIVE OF THE STUDY

The objective of the present work is to study the partial replacement of one of the slags viz. Iron slag. It is proposed to partially replace fine aggregate with Iron slag and find its effect on the strength characteristics of concrete. Five percentage levels of replacement i.e., 10, 20 ,30,40 and 50% are considered for partially replacing sand with Steel slag. M20 concrete grade is initially designed without replacement and subsequently sand is partially replaced with Steel slag.

- To study the strength and durability properties of concrete.
- To study the fresh properties of the concrete
- To determine the performance level and optimum replacement of the combination of steel slag and coconut shell based on the strength and durability criteria

Scope of the study

M40 grade of concrete designed to carried out according to the recommendation of IS 10262-2009. The aim of the present study is to determine the performance level of the combination of steel slag and coconut shell. Partially replacing Portland cement with GGBS and fine aggregate with steel slag, reduces temperature rises and help to avoid early age thermal crack and also gives better workability, strength, and durability. Replacing coarse aggregate with coconut shell is good for construction because light weight concrete gives more advantage and it is easier to handle. The strength of the concrete decreased, when the percentage of CS increased. In order to attain the target strength, the steel slag was used as replacement of cement at proportion of (i.e., 5%,10%,15%, and 20%) and coconut shell were used as replacement of coarse aggregate at proportion of (i.e., 0%,5%,10% and 15%).

II. LITERATURE REVIEW

It was studied that palm kernel shell and coconut shell, both of which belongs to the family of palm shells. These are agricultural waste products and are available in large quantities in the tropical regions of the world. Research showed that coconut shell is more suitable as low strength giving light weight aggregate when used to replace common coarse aggregate in concrete production. The researcher suggested that one of the alternatives for coarse aggregate is coconut shell. It is one of the most common agricultural solid wastes in many tropical countries. Density of coconut shell concrete of the typical mixes ranged from 1930 kg/cum to 1970 kg/cum. There was researched on the coconut shell use as aggregate in the study which showed that with global economic recession coupled with the market inflator trends. The average compressive strength for concrete cubes with coconut shell 15.6 N/mm2 for 28 days.

It was studied that the compressive strength, split tensile strength, water absorption and adsorption for different coconut shell replaced concrete. By replacement of coconut shells in place of aggregates, 10% & 20% replacement will have been decreased marginally the strength properties of concrete compared to the normal concrete. The researcher experimented three different concrete mixes namely M20, M35 and M50 grade with different combination of natural material CS content in the proportion 0%, 10%, 20%, 30% and 40% replaced. It was studied that coconut shells are suitable as low strength giving lightweight aggregate. Also, the researcher experimented to determine the compressive strength, split tensile strength and flexural strength cube, cylinder and beam section. It was concluded that when coconut shell aggregates in proportions of 15% was used in the conventional concrete comparable compressive strength results were obtained. There was study on experimentation that coconut shell can be grouped under lightweight aggregate because 28 days air dry densities of coconut shell aggregate concrete are less than 2000 kg/cum. It was concluded that this type of concrete can be used in rural areas and wherever the natural aggregates are costly. The experimentation conducted that density of concrete decreases with increases in CS percentage. Workability decreases with increase in CS percentage. Compressive and split tensile strength of CS concrete were lower than normal concrete. Olanipekun et al. (2006) were investigated the comparative cost analysis and strength characteristics of concrete produced using crushed, granular coconut and Palm kernel shell as substitutes for conventional coarse aggregate. The main objective is to encourage the use of these 'seemingly' waste products as construction materials in low-cost housing. It is also expected to serve the purpose of encouraging housing developers in investing in house construction incorporating these materials. The conclusions for the research are the compressive strength of the concrete decreased as the percentage shell substitution increased. In all cases, the Coconut shell concrete exhibited a higher compressive strength than Palm kernel shell concrete in the twomix proportion tested. Both types of concrete performed fairly equally well in terms of their water absorption capacities. In terms of cost, the Palm kernel shell concrete appears to be cheaper. However, considering the strength per economy ratio and expecting further studies on the durability performance of both types of shell concrete, it could reasonably be concluded that Coconut shell would be more suitable than Palm kernel shell when used as substitute for conventional aggregates in concrete production. Madheswaran et al (2015), have discussed about the Design Analysis of Concrete with Partial Replacement of Cement with GGBS. The replacement level at 0%, 10%, 20%, 30% by wt of cement for M25 grade of concrete with OPC 53 grade of cement were used. The compressive strength attained for conventional mix 27.77 Mpa, 31.11 Mpa strength attained for 10 %, 34.44 Mpa, attained for 20 % replacement, 36.67 % attained for 30 % of replacement by wt of cement. Workability of concrete increases as percentage of GGBS increases in cement. The replacement levels of GGBS 30% gives 26.24% more Split Tensile Strength than conventional control concrete in 28 days. The replacement level of GGBS by 30% given minimum curvature compared with other replacement level.

Kaviya et al (2017) have studied on partial replacement of cement by GGBS the replacement percentages of cement by GGBS used are 30, 40 and 50 % for M35 grade of concrete. Water cement ratio adopted in this work is 0.46. The optimum replacement of GGBS is 30 percentages. This increases strength at age of 7 and 28 days for both compression and split. The replacement of cement by GGBS not only increases the compressive strength but also reduces the cement content which decrease in emission of CO2. However, beyond 40% of replacement, the strength decreases. The cost of GGBS in the market including packaging and transporting is three times less than that of OPC. Therefore, they conclude that the partial replacement of OPC in concrete by GGBS, is not only economical but also facilitates environmental friendly disposal of the waste slag into a useful product, which is generated in huge quantities from the iron and steel industries.

III. Materials

For the production of concrete, the constituent materials are cement, fine aggregate, coarse aggregate and water. To get better workability and strength, the material used should have better quality. To maintain the safety of any structure, provisions are provided as per IS 456:2000.

1. Cement: In the experimental work cement used is Ordinary Portland cement. Various properties were evaluated such as fineness of cement, setting time, soundness test and compressive strength

2.. Fine Aggregate

The various properties of fine aggregate such as specific gravity, fineness modulus, bulk density were determined as per IS 456:2000. Locally available sand was used as fine aggregate in the experimental work. The test is carried out for deciding the fineness modulus. Also the sieve analysis is carried out. Fineness modulus of sand is found to be 3.25 and it confirms to grading zone II as per grading limit for fine aggregate as per IS 383:1970. Fineness modulus is well within 2.5 to 3.37.the bulk modulus is found to be 2.65. Sieve analysis of sand Coarse Aggregates: Locally available well graded granite aggregates of normal size greater than 4.75 mm and less than 16mm. The code to be referred to understand the specification of the coarse aggregates from natural sources is: IS 383:1970. Coarse aggregate may be further classified as:

- **Uncrushed Stone**– it results from natural disintegration of rock.
- **Crushed Stone**– it results from crushing of gravel or hard stone.
- **Partially Crushed Stone**– it is a product of the blending of the above two aggregate. In this project Crushed stone used as coarse aggregate of following properties

3. Coconut shell Coconut shells used in the study are brought from local temple. The coconut shells are sundried for five days before using it as an aggregate. The cleaning of coconut shell is carried with the help of sand paper, the smaller extractions on the outer face of coconut is cleaned with the help of water. The outer shell is then broken in smaller parts up to 20 mm. The broking of coconut shell is done with the help of 30 kg hammer. Then the broken pieces are passed through IS 20 mm sieve and pieces are retained on a IS 16mm sieve are used.

4. Water The water used in the study was clean and clear. It was free from bacteria and other impurities. There was no acid content in it. The water cement ratio for the concrete mix is 0.6.

IV. EXPERIMENTAL INVESTIGATIONS

The concrete mix design was carried out for the present work. The concrete mix design is a process of selecting the suitable ingredient of concrete and determining their most optimum proportions economically. The approximate value for the coarse aggregate volumes are given in IS 10262- 2009 for the water cement ratio. For more workable concrete that can flow around any congested reinforcement bars, it may be desired to reduce the coarse aggregate content. The value for the coarse aggregate for different zone of fine aggregate. Testing of workability

Slump test:

- This is most commonly used test for determination of consistency of concrete.
- It can be used on the site as well as in the laboratory because of its handy apparatus and simple test procedure.
- The slump test indicates the behavior of compacted concrete cone under the action of gravitational force.
- Which is a slump cone its dimensions are top diameter 10cm, bottom diameter 20cm and height 30cm.
- The thickness of the metallic sheet for the mould should not be less than 1.6mm. For tamping, a steel rod of 16mm diameter, 0.6m long with bullet end is used.
- The test is suitable for concrete of medium to high workability that is slump value of 25mm to 125mm.
- The slump test is limited to concrete with maximum size of aggregate less than 38mm.

4.2 Compressive strength

Compressive Strength Test of Concrete Cubes, For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used. This concrete is poured in the mould and put over VEE BEE CONSISTOMETER so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine (CTM) after 7 days curing, 14 days and 28 days curing.

- Clean the bearing surface of the testing machine
- Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
- Align the specimen centrally on the base plate of the machine.
- Rotate the movable portion gently by hand so that it touches the top surface of the specimen. Apply the load gradually without shock and continuously at the rate of 140 kg/cm2/min, till the specimen fail
- Record the maximum load and note any unusual features in the type of failure.

4.3 Splitting tensile strength

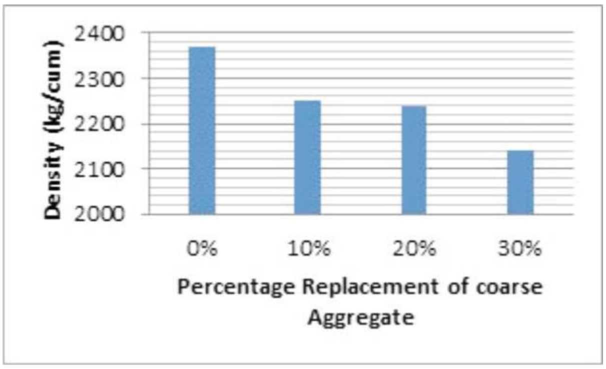
indicates splitting tensile strength of BFRC cylinders of size 150mmx300mm using two different diameters (D1) 700 µ and (D2) 1.156 mm for M30 grade of concrete for 28 days for the aspect ratio of 30, 40 and 50. It is shown that the diameter of 1.156 mm fibers at 1% gave the maximum split tensile strength of 4.8N/mm2with an aspect ratio (l/d) of 40 when mixed with concrete. Both the diameters of fibers showing the lesser decrement in the strength at the 1.25% addition of fibers.

• Flexural strength

indicates the flexural strength of BFRC beam of size 150mmx150mmx1200mm using two different diameters (D1) 700 µ and (D2) 1.156 mm for M30 grade of concrete for 28 days for the aspect ratio of 30, 40 and 50. It is shown that the diameter of 1.156 mm fibers at 1% gave the maximum split tensile strength of 8.5N/mm2with an aspect ratio (l/d) of 40 when mixed with concrete. Both the diameters of fibers showing the very less decrement in the strength, at the 1.25% addition of fibers.

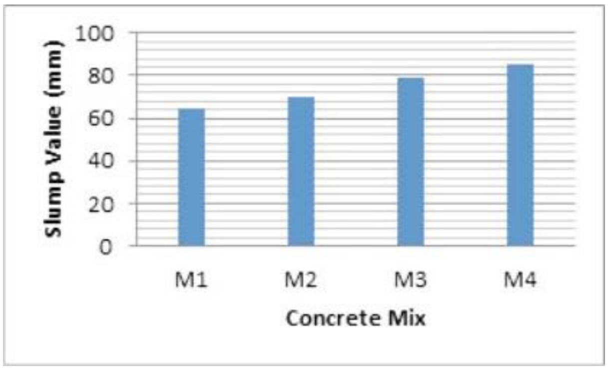
V. Results

In the present work coarse aggregate is replaced with the coconut shell, by volume. Specimens were casted by replacing 0%, 10%, 20% and 30% of coarse aggregate with coconut shell. Tests were conducted on the cast specimens after 7, 14, 21 and 28 days as mentioned in the IS code. There is no need to treat the coconut shell before use as an aggregate except for water absorption. Tests for workability and compression were conducted and results were obtained. Coconut shell concrete has better workability because of the smooth surface on one side of the shell and the smaller size of coconut shell. The table is mentioned below detailing the properties of concrete.



Percentage replacement of coarse aggregate v/s Density(Kg/cum)

From the above graph it is observed that as the percentage replacement of coarse aggregate by coconut shell is increased, the density is decreased. This can lead to light weight concrete up to some extent and therefore the applications are filler materials in framed structure, flooring tiles, thermal insulating concrete, etc. Also the slump Value of different mix



From the above graph the slump value is increased as the percentage of the replacement of coarse aggregate by coconut shell is increased. Therefore, the construction work requiring the more slump value, this type of concrete is suitable. The compressive strength of concrete is detailed in the table below.

Mix name	Compressive strength (MPa)			
	7 day	14 day	21 day	28 day
M1	16.8	19	23.68	24.2
M2	12.5	16.23	22.7	23.4
M3	10.1	15.1	20.12	21.3
M4	9.2	12.4	14.8	16.7

VI. CONCLUSIONS

Use of coconut shell in cement concrete can help in waste reduction and reduction in pollution. The need of the hour is to encourage such a use of the wastes as construction material in low-cost housing. The construction industries have identified many artificial and natural lightweight aggregate that have replaced conventional aggregates thereby reducing the size of the members in the structure.

From the experimental work it is clear that the with CS percentage increase the 7 days' strength gain also increased with the corresponding 28 days curing strength.

Workability of concrete is increases as the replacement increases. Specific gravity of the concrete reduces as the replacement of coarse aggregate increases. The density of concrete is decreases as the replacement increases. Density of concrete should not be less than 2000 kg/cum.

REFRENCES

[1]. Doh Shu Ing., Chin Siew Choo., (2014), "Eggshell Powder: Potential Filler in Concrete", Malaysian Technical Universities Conference on Engineering and Technology.
[2]. IS 456-2000, Indian Standard, Plain and Reinforced Concrete - code of practice.
[3]. IS 383-1970, Indian Standard Specification for Coarse and Fine Aggregates from Natural Sourcesfor Concrete.
[4]. IS 10262-2009, Indian Standard Recommended Guidelines for Concrete Mix Design.
[5]. M.F.M. Zain, M.N. Islam, S.S. Radin, S.G. Yap "Cementbased solidification for the safe disposal of blasted copper slag" (2004)
[6]. C. K. Madheswaran, P. S. Ambily,J. K. Dattatreya, N. P. Rajamane "Studies on use of Copper Slag as Replacement Material for River Sand in Building Constructions" (2014)
[7]. D.Gowsika, S.Sarankokila, K.Sargunan "Experimental Investigation of Egg Shell Powder as Partial Replacement with Cement in Concrete" (2014)
[8]. M. C.Nataraja, G.N. Chandan, T. J. Rajeeth "Concrete Mix Design Using Copper Slag as Fine Aggregate" (2014)
[9]. Praveen Kumar, Vijaya Sarathy, Jose Ravindraraj "Experimental Study on Partial Replacement of Cement with Egg Shell Powder" (2015)
[10]. P. Pliya , D. Cree "Limestone derived eggshell powder as a replacement in Portland cement mortar" (2015)
[11]. J. S. Patel , Dr K. B. Parikh , Prof. A. R. Darji "Study on Concrete Using Fly Ash, Rise Husk Ash and Egg Shell Powder" (2017)
[12]. Ambrish E, Dhavamani Doss S, ShanmugaNathan N, Ganapathi Raj S "Partial Replacement of Copper Slag as Fine Aggregate" (2017)
[13]. R. Elamaran, K. Srinivasan, S. Vimala "Use of Copper Slag for Partial Replacement to Fine Aggregate in Concrete" (2019)