Strength Properties of Concrete by Partial Replacement of Coconut Shell as Coarse Aggregate and Waste Glass Powder as Fine Aggregate

A Review

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Abstract : Now a day's global consumption of natural aggregates have been increased. At the same time production of solid wastes from the manufacturing units and demolitions are also very high. Concrete is a composite material made with cement, aggregates and water in construction industry. In civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete as sustainable and environment friendly. Hence there is a necessity in innovation of new natural products for the replacement of fine and coarse aggregate. Research was carried on glass powder and coconut shell and was found that glass posses a pozzolana properties due to increase in silica content, so it can replace fine aggregate to some degree whereas coconut shell can replace coarse aggregate. It was further investigated that by applying this replacement there will be improvement in the strength and durability of concrete. This paper explains about the study of sustainability of glass powder and coconut shell as a partial replacement of fine aggregate and coarse aggregate.

***IndexTerms* – Concrete,coconut shell,glass powder,partial replacement,coarse aggregate,fine aggregate.**

I. INTRODUCTION

Concrete is one of the highly used construction material in the world. Due to increase in demand of construction material and degradation of environment, there is a need in investigation of a alternative construction material. It is recommended that the material to be investigated should be such of environment friendly, economical and easily to available to all. The best way of finding out such material is by recycling and reuse of the industrial or household waste. The reuse of such waste will be reducing the environmental impact. The disposal of the waste generated from industries has become serious issue solid waste management is one of the major environmental impact and is more economical. In India, 0.7% of total urban waste generated from glass. UK produces over 3million tons of waste glass annually. The using of river sand as fine aggregate leads to lowering of water table, exploitation of natural resources, erosion of river bed and sinking of bridge piers. Generally waste glass is being dumped into land fill sites. The using of waste glass powder in concrete creates a problem due to ASR (Alkali Silica Reaction). The reaction between alkalis in Portland cement and silica in aggregates (waste glass powder) forms silica gel. This gel is prone to swelling. It absorbs water and the volume of the gel increases. The swelling of the ASR gel generates hydrostatic pressure and if the reaction continues, the cracks will form around the reactive aggregate particles. The chance of ASR occurrence by using of larger size particles of waste glass. The general size of the waste glass is the range of 0-1.18mm.

II. LITERATURE REVIEW

Kumar Animesh.et.al (2017) studied and conclude that the waste glass powder and coconut shell is used as a partial replacement of fine aggregate and coarse aggregate in concrete due to its enhanced workability, compressive strength, flexural strength and also its enhanced durability measured by density check and water absorption check. In between of 35%,45%,55% the strength is achieved at 35% by the comparison of waste glass powder and coconut shell itself. This waste glass powder and coconut shell concrete are used for non structural elements like flooring and surface coatings.

M. Vijaya Sekhar Reddy.et.al (2015) studied the waste glass powder as partial replacement of fine aggregate in cement concrete. The 20% replacement of fine aggregate by waste glass powder showing the result of 35% increase in 7 days compressive strength and 30% increase in 28 days compressive strength. The water absorption percentage decreases and making of light weight concrete was done by increasing of waste glass content. The 5% of average weight of concrete decreases with the content of 30% of waste glass. Workability of this concrete mix increases with the increasing of waste glass content.

Bashar Taha.et.al (2009) The replacement of cement up to about 20% by waste glass powder can be done with out sacrificing the compressive strength. On one hand the waste disposal problem is solved and on other hand the waste glass powder and coconut shell is gainfully utilized. The reaction between alkalis in portland cement and silica in waste glass powder forms silica gel. This reaction is called alkali silica reaction.

Abubakar Mikailu.et.al(2017) studied that fresh and hardened concrete and characteristics of partial replacement of coarse aggregate with coconut shell. Concrete produced with 0%,5%,10%,15% and 20% replacement attained at28 days compressive strength of 38.17,35.11,32.14,31.18 and 29.14 N/mm^2 respectively. The aggregate crushing value of coarse aggregate and coconut shell were 23.47% and 28.25%. The aggregate impact value of the coarse aggregate and coconut shell were 17.44% and 20.2% respectively. The results obtained in this study coconut shell satisfies the requirements for coarse aggregate and can be used as partial replacement of coarse aggregate (up to 20%)in concrete pavement production.

Mahammad Iqbal Malik.et.al (2014) the 30% replacement of fine aggregates by waste glass showed 30% increase in 7 days compressive strength and 25% increase in 28 days compressive strength. With increase in waste glass content, water absorption percentage decreases and average weight decreases by 5.31% for mixture with 40% waste glass content thus making waste glass concrete lightweight. The grounding glass finer (<600 micron) has lead to increase in the optimum value for fine aggregate replacement from 20% to 27%. The greener concrete (or) environment friendly concrete are made by using of waste glass (or) coconut shell (or) by products used in concrete production.

Aniketh Deshmukh.et.al (2016) The accompanying conclusions can be gotten from the present examination. The workability really diminishes as there is an expansion in the measure of CSA added to the blend because of the non-appearance of super plasticizers the workability of the solid was on the lower side. The compressive qualities of the CSA concrete were observed to be lower than the ordinary cement by5-55% following 7 days, 9 half following 14 days and by 12-52% following 28 days, contingent upon the curing environment.

Sandhya R.Mathapati.et.al (2014) prepared three different mix designs for M20,M35,M50 grades of concrete and the percentage replacement by coconut shell varied as 0%,10%,20%,30% and 40% respectively. It is concluded that M20,M35,M50 grade concrete cubes with all 30% replacement of coconut shell aggregates had given strength of 23Mpa, 42Mpa, 51Mpa at all 28 days respectively.

Sreenivasulu Dandagala.et.al (2014) It was observed that coconut shell concrete is showing 65% of compressive strength to that of normal concrete. The 28 days air dry densities of coconut shell aggregate concrete are less than 2000kg/m^3.The coconut shell exhibits more resistance against crushing, impact and abrasion when compared to normal concrete. From this study we can conclude that coconut shell can be used instead of crushed granite for light weight structures. Hence, the present study is only at the initial stage and it requires more study to explore coconut shell aggregate as a coarse aggregate in concrete.

Palak Patel.et.al (2015) Based on results from this study , the addition of CSA increases as decreased compressive strength, split tensile strength and flexural strength as compared to conventional concrete. The replacement of CSA up to 20% as to good result of compressive strength as compared to conventional concrete. The various sizes 8mm,10mm, and 12.5mm of 10% replace coconut shell aggregate increase as decrease the split tensile strength, flexural strength and compressive strength.

R.Ranjith.et.al (2017) concluded that use of coconut shells in cement concrete can help in waste reduction and pollution reduction. It is also expected to encourage hosing developers in investigating these materials in house construction. It is also concluded that the coconut shells are more suitable as low strength and giving light weight aggregate when used to replace the common coarse aggregate in concrete production.

MH.Rahman.et.al (2016) Conclude that by considering the similar performance with replaced material, glass addition can reduce the cost of cement production up to 14%. In addition, production of every six ton glass powder concrete results in the reduction of each tone CO@ emission from cement production and save the environment significantly by reducing green house gas and particulate production. The optimum range of glass content is 20% considering mortar and concrete compressive strength calculated at 90 days.

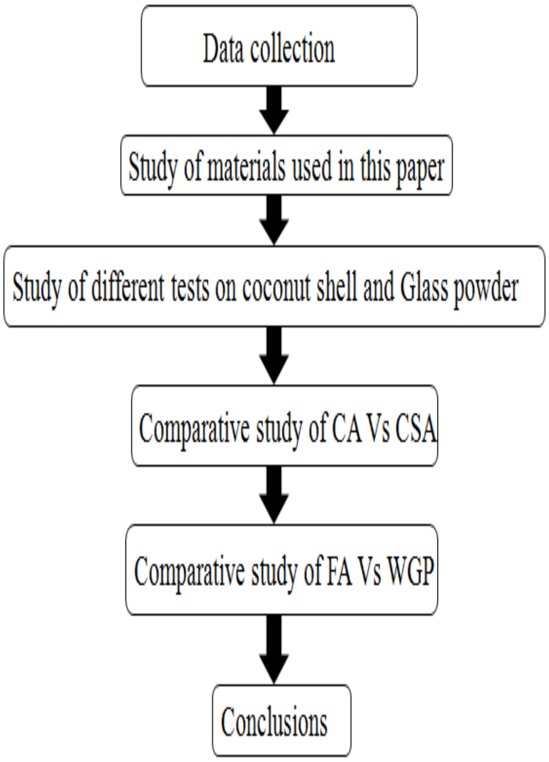
P.Kara.et.al (2016) It can be concluded that this waste glass powder can be applied in concrete technology. The study has identified important effects on mechanical and durability properties when special glass cullet was used in composition to soda lime cullet, the use of waste glass powder in concrete industry may moderate the problem of dumped waste glass and reduce CO2 emissions into the atmosphere by decreasing the proportion of Portland cement in unit volume of concrete produced.

Zainib Z.Ismail (2009) studied the replacement of fine aggregate by waste glass powder by using different mixing percentages of 10%,20%,30% and 40% by volume of cement. The above mixing percentages are effects on compressive strength, tensile strength, workability, and flexural strength. This study conclude that the compressive strength, flexural strength and tensile strengths are maximum at 20%. He concluded that the workability of concrete reduces monotonically by the increasing of replacement percentage of waste glass powder.

G.Vizaya kumar.et.al (2013) studied by divide the waste glass powder into two types, those are recycled glass sand (RGS) and pozzolanic glass powder (PGP) and also studied about alkali silica reaction (ASR). It can be concluded that the properties of fresh concrete were considerably affected when RGS was used in concrete as sand replacement. There is no major impact on the properties of fresh concrete when the PGP as cement replacement in concrete. It can enhance the handling, placing and properties of fresh concrete. The ground granulated blast furnace slag (GGBS), met kaolin, pozzolanic glass powder (PGP), lithium nitrate (LiNo3) were used to mitigate the potential risk of ASR.

Ahmad shayan.et.al (2002) investigated the test results at 7,14,28 days of curing of specimens containing waste glass powder as partial replacement of fine aggregate and his results showed that the mixing of 20% of glass powder shows a positive value of compressive strength at 28 days. Compared to other ratios of 10% and 15% is not achieve even very little increment in 14 days results.

III. METHODOLOGY



3.1 Coconut Shell Aggregate

The coconut shells were collected from the local oil mills and household wastes. They were well seasoned. Seasoning was done by getting rid of the fibers and immersing them in water for 24 hours and then drying them in the air for one day. Coconut shells were sun dried for one month before they were broken into small pieces. The seasoned CS is crushed manually by applying a hammer to the required size range. The different sizes of the aggregates were maintained in a range of 4.75 to 12.5mm and 2.36 to 10 mm. CSA were tested for their physical and mechanical properties.

3.1.1 Crushing of coconut shell aggregate

Figure 1 crushing of coconut shell aggregate

3.1.2 Water Absorption of CS Aggregate

The measured water absorption of CS was 17.67%. The absorption capacity signifies the porosity of an aggregate. This value implies that the CSA has a high water absorption compared to conventional aggregates that usually have water absorption of 1.5%. This high water absorption takes place due to the high pore content. Because of the high water absorption, shells may have a chance to absorb water from the concrete mix during the manufacture of concrete. Mannan et al (2006) have reported that the water absorption capacity of CS aggregate can be reduced by using pre-treatment methods such as 20% PVA solution.

3.1.3 Physical and Mechanical properties of coconut shell aggregate (CSA)

Table 1 physical and mechanical properties of coconut shell aggregate

Physical and mechanical Properties of CSA	Aggregate of size 20mm	CSA of size 4.75 to 12.5mm	CSA of size 2.36 to 10mm
Water absorption (24h) (%)	1.5	17.67	20.1
Specific gravity	2.78	1.16	1.14
Impact value (%)	19.8	7.8	-
Crushing value (%)	8.4	2.3	-
Fineness modulus (%)	7.68	6.56	5.803
Shell thickness (mm)	-	3-8	3-8
Loose Bulk density (kg/m3)	1460	570	586
Compacted bulk density (kg/m3)	1644	695	712
Abrasion value (%)	1.71	1.92	-
Flakiness index (%)	13	71.43	52.39
Elongation index	21	14.9	12.28

3.1.4 Unit Weight and Specific Gravity of CS Aggregate

The average unit weight of CS was 570 kg/m3 while that of coarse aggregate was found to be 1644 kg/m3. The percentage of reduction in unit weight of CSA is found to be 65% when compared to conventional aggregate. The unit weight of CS is within the range of 480 to 1040 kg/m3. The specific gravity of CS and CA were 1.16 & 2.78 respectively. This figure fall in the range of 1/3 to 2/3 of specific gravity of normal weight aggregate. This meant that CSA can be classed as LWA.

3.1.5 Thickness of CSA

Coconut shells were selected at random and their thicknesses were measured using Vernier calipers at different positions in a shell, and then the average was taken. The thickness of CS varied in the range 3-8 mm.

3.1.6 Grading of CSA

Grading refers to the particle size distribution of a material. The grading is determined by using the codal provision IS 2386 (Part I):1963. Using the sieve analysis test, the particle size distribution was performed and the results are presented in Figure 4.3. The fineness modulus was calculated from the results of the sieve analysis test

3.1.7 Fineness Modulus of CSA

The fineness modulus of the CS aggregate was found to be 6.56% and this value lies in the limiting values of fineness modulus of conventional aggregates, which is 6.00–6.90 (Shetty 2006). The Fineness modulus of conventional aggregate and fine aggregate is 7.68 and 2.8 respectively. This showed that the concrete produced using CS as coarse aggregate falls in the category of LWC.

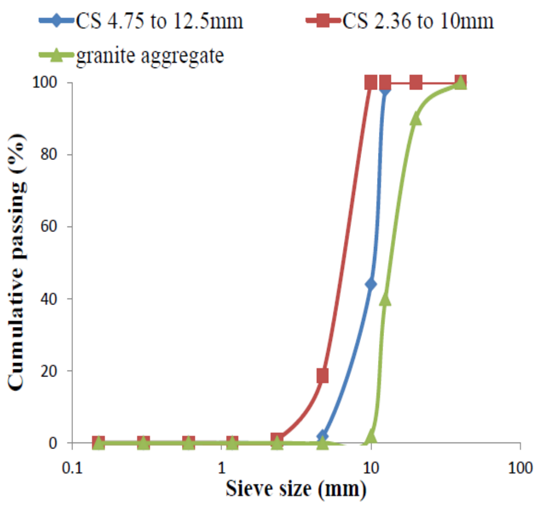


Figure 2 fineness modulus of CSA

3.1.8 Mechanical Properties of CSA

Above table shows the average crushing value (CV) and the average impact value (IV) of the CS were found to be 2.3% and 7.8% respectively, which satisfies the requirement as per IS 2386-1963 (Part IV). However, the crushing and impact value of the conventional aggregate were found to be 8.4% and 19.8% respectively. The low value of the IV and CV indicates that CS has good energy absorbing materials. Hence, CS can offer better resistance against crushing and impact, compared to conventional aggregate. When CS is used as aggregate in concrete, the good energy absorbing capacity would be advantageous to structures which are likely to be exposed to dynamic or shock loading (Gunasekaran et al 2011). These results satisfy the requirement as per IS 383-1970 (shall not exceed 30%). According to Indian Road Congress, an aggregate having an impact value lesser than 35% can be used as a wearing course and the one having the impact value lesser than 45% can be used as a wearing surface. Hence CSA with an impact value of 10% can be both practiced as a wearing course and wearing surface.

3.1.9 Durability of CSA

Durability of an aggregate is a measure of its resistance to wear, moisture penetration, decay and disintegration which relies on the hardness of the aggregate. The hardness of CS was measured by using the Los Angels abrasion method. The test outcomes (Above Table) showed that the abrasion value is higher in CS than CA, which implies that concrete with CS, will possess a high level of resistance to wear and is used to produce pavements and floors. Basri et al (1999) have reported that the Los Angeles abrasion value of the OPS aggregate was 4.8%. The average percentage loss in abrasion test on the CS was found to be 1.92%.

3.2. Waste Glass Powder

The waste glass is collected from the shops that are used. The collected glasses are crushed in to natural sand size and it could be used as an alternate material for partial replacement of fine aggregate. In brief, the successful utilization of glass as fine aggregate will turn this waste material into a valuable resource. Crushing of glass pieces were done by crusher. Glass material is sieved in 2.36mm sieve.

Figure 3 stages of waste glass powder (Source Google)

The utilization of glass powder that can be called as manufactured sand has been accepted as a building material in the industrialized countries. The level of utilization of glass powder in the industrialized countries has been reached more than 60% of its total production by the results of sustained research and developmental works undertaken with respect to increasing application of industrial waste. The use of manufactured sand in India has not been much popular, when compared to other countries.

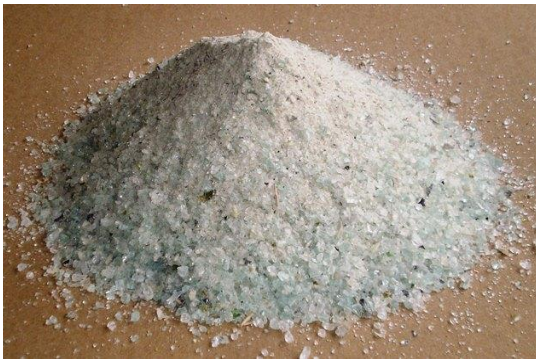


Figure 4 waste glass powder before sieving

3.2.1 Physical Properties of Glass Powder and Natural Sand

Table 2 physical properties of glass powder and natural sand

Property	Glass powder	Natural sand
Specific gravity	2.4-2.8	2.60
Bulk density	2.53	1.46
Moisture content (%)	Nil	1.50
Fine particles less than 0.075mm (%)	12-15	0- 6
Sieve analysis	Zone	Zone

3.2.2 Chemical Properties of Glass Powder and Natural Sand

Table 3 chemical properties of glass powder and natural sand

Constituent	Glass powder (%)	Natural sand (%)
Silica (SiO2)	72.5	80.78
Alumina (Al2O3)	01.06	10.52
Iron Oxide (Fe2O3)	0.36	01.75
Lime (CaO)	08	03.21
Magnesia (MgO)	4.18	00.77
Sodium Oxide (Na2O)	13.1	01.37
Potassium Oxide (K2O)	0.26	01.23
Sulphur Trioxide (SO3)	0.18	-

3.3. Mixing of Concrete

The materials used by replacing fine aggregate and coarse aggregate in different percentages. Glass powder and coconut shell is taken in 10%, 20%, 30% weight of fine aggregate and coarse aggregate respectively. The concrete samples are caste with mix 1: 1.626: 3.10 as per design, with partial replacement of fine aggregate. The numbers of concrete samples caste are laid down as per IS code. The tests are carried out at 7 and 28 days of casting of concrete cubes.

3.3.1 Curing of Specimens

To achieve good strength and hardness of concrete, care need to be taken about curing. This happens after the concrete has been placed. Concrete to gain strength and harden fully cement requires a moist and controlled environment. The cement paste hardens over time, initially setting and becoming rigid though very weak and gaining in strength in the weeks following.

3.3.2 Compressive Strength Test

The most common of all tests on hardened concrete is the compressive strength test. The compressive strength of a material is that value of uni-axial compressive stress reached when the material fails completely. The compressive strength is usually obtained experimentally by means of a cube by compressive testing machine. This CTM apparatus is also used for the experiment of tensile test.

Figure 5 Crushing Of Cube

Compressive strength of concrete is usually found by testing Cubes and cylinders. Cube of size 150 mm X 150mm X 150mm concrete specimens were casted by using M50 grade concrete. During casting the cubes were manually compacted using tamping rods. After 24 hours, the specimens has been removed from the mould and subjected to water curing for 28 days of testing. After curing, the specimens were tested for compressive strength using a compression testing machine.

IV. CONCLUSION

From the above mentioned work of assorted researchers, its clear that waste glass powder and coconut shell is used as a partial replacement of fine aggregate and coarse aggregate in concrete due to its enhanced workability and compressive strength.

- In comparison of waste glass powder and coconut shell concrete itself, in between 10%, 20%, 30% the strength is achieved in 10% replacement of both the materials.
- To comparison of conventional concrete to the waste glass powder and coconut shell concrete not attained target strength.
- The application of waste glass powder and coconut shell concrete to PCC (plain cement concrete) and DLC (dry lean concrete) to the sub-base of rigid pavements.

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