Comparative Study of Concrete by Using Glass Powder and Coconut Shell Ash by Partial Replacement of Cement

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Abstract— On the earth's surface, the amount of waste material from industrial and agricultural activities has begun to cause a sustainability issue for the environment as well as the ecology of the earth. The production of waste accounts for global warming because it releases CO_2 and other harmful gases during disposal or manufacturing. In this research work, we use waste materials like coconut shell ash (CSA) and glass powder (GP) in place of cement. More than 108 specimens were prepared and tested by using CSA and GP with 0%, 2.5%, 5%, 7.5%, 10%, and 12.5% as replacements with cement. After design mixing, we find the ratio of concrete mixed is 1:2.03:3.10 by weight of cement sand and coarse aggregate at a 0.55 water-to-cement ratio. The properties of concrete and cement that were studied include initial setting, final setting time, compressive strength, split tensile strength, and flexural strength. The workability of CSA and GP mixed concrete was tested immediately after preparing the concrete mix, and compressive strength was tested at 7 days and 28 days of curing. The addition of waste CSA and GP increases the strength of concrete at a certain point, after that it decreases. The compressive strength of CSA and GP mixed concrete increases up to 10% of replacement cement with an amount of 28.44 kg/cm^2 and 29.02 kg/cm^2 respectively, then decreases. In the case of split tensile strength and flexural strength, the strength also increases up to 7.5% of the replacement of cement in CSA and GP mixed concrete with an amount of 3.81 kg/cm^2, 3.90 kg/cm^2 and 9.20 kg/cm^2, 9.22 kg/cm^2 respectively. Finally, we clearly say that the replacement of CSA & GP with cement is up to 10% for compressive strength and up to 7.5% for split tensile and flexural strength.

Keywords— **Polyethylene Terephthalate (PET), Compressive Strength, Split Tensile Strength, Flexural Strength.**

I. Introduction

Concrete is a blend of coarse aggregate, fine aggregate(sand), admixtures and water. Today Global Warming (GW) and environmental pollution have become manifest harms in early and recent years, concern about environmental issues. It can happen due to use and production of the mass-waste, mass consumption, mass-production. Normally it can see that glass does not harm to environment due to not produced pollutants matter but it can harm animal as well as human shortly when we do not take care off that time it harmful and it is not non-biodegradable. For that we required new technologies to overcome them from this problem. The glass has many chemical diversities like Soda-lime Silicate Glass, Alkali-Silicate Glass & Boro-Silicate Glass. These all types of glasses generally used in Civil Engineering work as Pozzolana. The Alkali contents increases the properties of cement. It also used in brick manufacturing & ceramic manufacture. The useful and recycled materials, glasses and glass powder are mainly used in various Civil Engineering project because glass powder as supplementary cementitious material and coarse aggregate. All type of glass is near to 100% recyclable. It also increases concrete durability without affects any property in concrete. In recently glass & glass powder has used as a construction material for reducing environmental pollution. In concrete mixed the coarse & fine glass aggregate produced Alkali Silica Reaction (ASR) but this problem cannot happen in the case of glass powder because it has Supplementary Cementitious Material (SCM). Therefore, glass powder used as replacement of SCM.

This work is based on utilization of waste material like coconut shell and glass powder used in concrete construction industry for their valuable application. Use of such waste material not only reduction in land fill cost, saving in energy and protecting environment from possible pollution effect but also getting them utilized in cement and other construction material. Different effort made by many researchers in using coconut shell ash, coconut shell, coconut husk ash as replacement material for cement, coarse aggregate & cement respectively. This research set out the effect of coconut shell ash.

II. Literature Reviews

Tajamul Magrey et al 2016 It also helps in reducing the cost of concrete manufacturing. 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. In this research, the effect of coconut shell as partial replacement of coarse aggregate and waste glass as partial replacement of fine aggregate on the properties of concrete were studied. The characteristic properties of concrete such as compressive strength, flexural strength, and water absorption of various mixes were reviewed in this work.

Hamdule Abdul Rehman et al 2021 We did the project work for the determination of the effect of the use of „Glass Powder" as a partial replacement of cement to assess the pozzolanic nature of fine glass powder when mixed in concrete and compare the performance when other pozzolanic materials are mixed. The present study shows that waste glass, if ground finer than 600µm shows a pozzolanic behavior. It reacts with lime at early stage of hydration forming extra CSH gel thereby forming denser cement matrix. Thus, early consumption of alkalis by glass particles helps in the reduction of alkalisilica reaction hence enhancing the durability of concrete. Number of tests were conducted to study the effect of 0%,10%,20%,30% and 40% replacement of cement by glass powder on workability and compressive strength. The results showed that the maximum increase in strength of concrete occurred when 20% replacement was done with glass powder.

K.I.M. Ibrahim 2021 The WGP replacement ratios from cement weight were 0 %, 5 %, 10 %, 15 %, and 20 %. Some mechanical and other concrete properties have been investigated at both hardened and fresh stages. This reduction was about 13 %– 14 %, respectively, at a 20 % WGP ratio. Additionally, the water absorption and density of plain, SF, and FA concrete mixes incorporating the proportions 5 %–20 % WGP as a partial replacement of cement weight decreased compared to reference concretes [0%WGP]. The fresh and dry density of ordinary concrete (group 1) lessened by around 3 % compared to control concrete at a 20 % WGP ratio. The decreasing ratios in water absorption of groups 1,2, and 3 specimens made of 20 % WGP compared to control concrete [0%WGP] are 27.78 %, 14.75 %, and 18.75 % respectively. The workability increased by increasing the WGP content for all concrete types utilized in this study.

M.J. Garba, A.S.J. Smith, et al 2020 The result of oxide composition of CSA showed that CSA is a good pozzolana and can be used as a mineral admixture. The inclusion of CSA in cement decreased linear drying shrinkage but increased consistency, initial and final setting times and could be used as a retarder. The use of CSA in concrete showed a decrease in workability but increase in compressive and splitting tensile strengths respectively with addition of CSA up to 2%. Therefore, up to 2% addition of CSA is recommended for use as a retarding admixture and strength improver in concrete in normal environment.

A Gupta, N Gupta et al 2020 It is evident that the exploitation of waste increases insignificantly every year worldwide and is not recycled as per the need of the environment. All these cause a problem to dispose of after they have been used once. In order to deal with such a situation, the application of such waste in concrete production has become a great means of managing them. These wastes can be utilized as a partial or complete replacement of certain ingredients of the concrete. The recycling of these waste materials in concreting not only helps in managing solid waste but also renders the occurrence of natural resources. This review paper will provide an understanding of the adoption of waste materials as a resource during concrete production.

III. Methodology

3.1 Properties of OPC

It was fresh and free from any lumps. For best result cement stored in moisture less storage. To find out physical properties of cement the following test performs which shown in table 1 and the corresponding standard for that parameter as per BIS: 8112-2013 is also listed in Table 3.1.

Table 1: Properties of OPC 43 grade cement

S. No	Particulars	Result Values After Test	Requirements of IS:1489-1991 (Part-1)	
1	Normal Consistency (%)	32%	---	---
2	Setting Time (Minutes)	---	---	---
	I. Initial Setting Time	150-170 Minutes	30 Minutes	Minimum
	II. Final Setting Time	210-300 Minutes	600 Minutes	Maximum

3.2 Test Performed on Coconut Shell Ash: -

The Coconut Shell Ash (CSA) was obtained by burning the coconut shell to a temperature of 600–650ºC in an incinerator and controlling the firing at that temperature for about three hours to produce the ash. The ash was collected after cooling, and then sieved through 75µm sieve. The CSA is of specific gravity of 2.30, bulk density of 505 kg/m3 and moisture content of 1.46 %.

Table 2: Properties of Coconut Shell Ash

S No.	Specification	Obtained
1	Type	Burn
2	Colour	Dark Black
3	Shape	Powder Form
4	Maximum Size	75 microns
5	Specific Gravity	2.30
6	Water Absorption	1.46%

3.3 Test Performed on Glass Powder: --

This waste glass was collected and washed with clean water, to remove the dust and dirt. Waste flat glass after washing it by clean water.

Table 3: Properties of Glass Powder

S No.	Specification	Obtained
1	Type	Crushed
2	Colour	Radish
3	Shape	Powder Form
4	Maximum Size	68 microns
5	Specific Gravity	2.55
6	Water Absorption	0.9 %

3.4 Workability of concrete as per IS: 1199-1959

The slump value for each mix is given in Table 3 In order to determine the Degree of workability, the slump of each of the mix is compared with slump value v/s degree of workability. Based on this, the Degree of workability of each mix is specified in Table 4.

Table 4: Test results for workability of concrete

Mix	Hypo sludge %	Polypropylene fibre%	Slump (mm)	Degree of workability
Mix1	0	0	100	Medium
Mix2	10	0	90	Medium
Mix3	20	0	70	Medium
Mix4	0	0.25	90	Medium
Mix5	10	0.25	80	Medium
Mix6	20	0.25	60	Medium
Mix7	0	0.50	84	Medium
Mix8	10	0.50	70	Medium
Mix9	20	0.50	54	Medium
Mix10	0	1.00	55	Medium
Mix11	10	1.00	45	Low
Mix12	20	1.00	40	Low

3.5 BIS Mix Design Method: -

The following steps used to design mixed of concrete summarized below: -

i) In first step we have to find out target mean strength from the specified characteristics strength on the level of quality controlled.

ii) In second step select W/C ratio (Water Cement Ratio) for target strength.

iii) In third step with the help of slump cone test determine water content.

iv)The cement content can be determined from the water/cement ratio determined by slump cone test and water content obtained in step (ii) and (iii) respectively and is checked for the water requirements.

v) With the help of characteristics of course and fine aggregate find out proportion of fine and coarse aggregate.

vi) The trial mix proportions are determined.

vii) After verifying compressive strength with the trial mixes tested are made to get there the final mix composition.

Table 5: Mix proportions of different concrete mixes for Coconut Shell Ash (CSE)

Mix	W/C Ratio	CSE %	CSE kg/m3	Cement kg/m3	Fine aggregates kg/m3	Coarse Aggregate kg/m3	Water l/m3
Mix 1	0.55	0	0	359	730.89	1113.77	197
Mix 2	0.55	2.5	8.9	359	730.89	1113.77	197
Mix 3	0.55	5	17.9	359	730.89	1113.77	197
Mix 4	0.55	7.5	26.9	359	730.89	1113.77	197
Mix 5	0.55	10	35.9	359	730.89	1113.77	197
Mix 6	0.55	12.5	44.8	359	730.89	1113.77	197

Table 6: Mix proportions of different concrete mixes for Glass

Mix	W/C Ratio	GP %	GP kg/ m3	Cement kg/ m3	Fine aggregates kg/m3	Coarse Aggregate kg/m3	Water l/m3
Mix 1	0.55	0	0	359	730.89	1113.77	197
Mix 2	0.55	2.5	8.97	359	730.89	1113.77	197
Mix 3	0.55	5	17.95	359	730.89	1113.77	197
Mix 4	0.55	7.5	26.92	359	730.89	1113.77	197
Mix 5	0.55	10	35.90	359	730.89	1113.77	197
Mix 6	0.55	12.5	44.87	359	730.89	1113.77	197

3.5 Compressive Strength of CSA and GP mixed Concrete:

The compressive strength of all the prepared mixes was determined at the ages of 7,14 and 28 days for the various addition levels of CSE and GP with cement concrete. The values of average compressive strength for different mixes prepared by addition of CSE and GP (**0%, 2.5%, 5%, 7.5%, 10% and 12.5%**) at the completion of different curing periods (7 days, 14 days and 28 days) are given in the various Tables below.

Table 7 Combine Compressive Strength of Coconut Shell Ash (CSA) mix Concrete for all Mixes

S. No.	CSA %	Compressive Strength After 7 Days (kg/cm²)	Compressive Strength After 28 Days (kg/cm²)
1	0%	14.48	25.38
2	2.5%	15.71	25.83
3	5%	17.16	27.17
4	7.5%	18.32	27.97
5	10%	19.44	28.44
6	12.5%	18.26	26.98

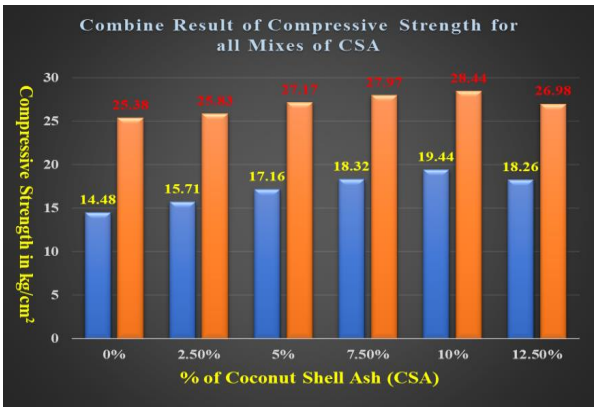

Figure 1: Combine Compressive strength at 7 day and 28 days for all mixes of Coconut Shell Ash

By these test results we can say that compressive strength of coconut shell ash concrete can be increased approximately 28.44kg/cm² by adding waste coconut shell ash 10% of the weight of the cement content. It is also clear by these results that more than 10% waste coconut shell ash start reducing the compressive strength of coconut shell ash concrete

Figure-2 Cube Casting

Table-8 Combine Compressive Strength of Coconut Shell Ash (CSA) mix Concrete for all Mixes

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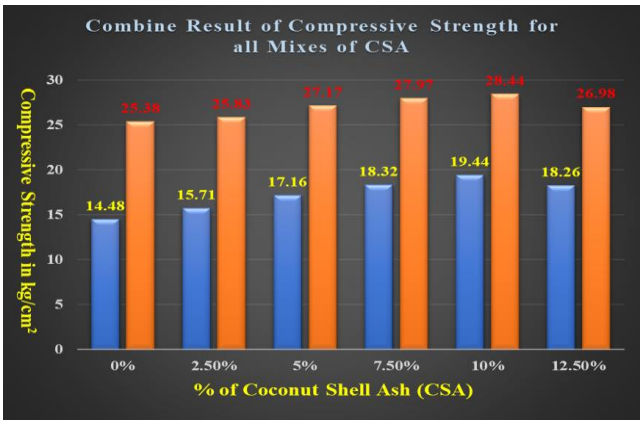

Figure 3: Combine Compressive strength at 7 day and 28 days for all mixes of Coconut Shell Ash

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Table-9 Combine Compressive Strength of Glass Powder (GP) mix Concrete for all Mixes

S. No.	GP %	Compressive Strength After 7 Days (kg/cm²)	Compressive Strength After 28 Days (kg/cm²)
1	0%	13.47	25.10
2	2.5%	15.05	26.39
3	5%	16.96	27.16
4	7.5%	18.06	27.90
5	**10%**	**19.48**	**29.02**
6	12.5%	18.21	27.18

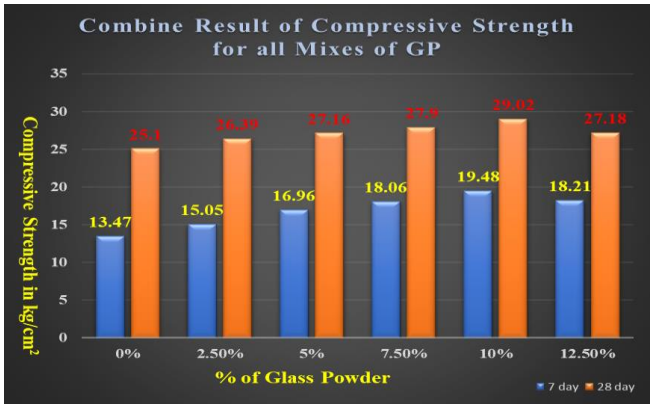

Figure 4: Combine Compressive strength at 7 day and 28 days for all mixes of Glass Powder

By these test results we can say that compressive strength of glass powder concrete can be increased approximately **29.02kg/cm²** by adding waste coconut shell ash **10%** of the weight of the cement content. It is also clear by these results that more than **10%** waste glass powder start reducing the compressive strength of glass powder mixed concrete.

3.6 Split Tensile Strength of CSA and GP mixed Concrete (IS:5816-1970) [38]: -

The splitting tests are well known indirect tests used for determination the tensile strength of concrete sometime referred to as split tensile strength of concrete. Uniform tensile stress is developed nearly 2/3 of the loaded diameter, due to compression loading. The magnitude of this tensile stress Fsp acting in a direction perpendicular to the line of action of applied loading is given by the formula (IS:5816-1970).

Table-10 Combine Split Tensile Strength of Coconut Shell Ash (CSA) mix Concrete for all Mixes

S. No.	GP %	Split Tensile Strength After 7 Days (kg/cm²)	Split Tensile Strength After 28 Days (kg/cm²)
1	0%	1.11	2.55
2	2.5%	1.43	2.78
3	5%	1.63	2.89
4	7.5%	1.91	3.81
5	10%	1.73	3.24
6	12.5%	1.70	3.46

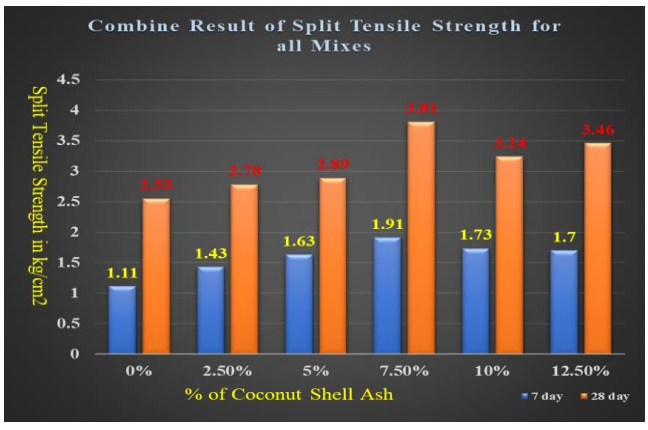

Figure 5: Combine Split Tensile strength at 7 day and 28 days for all mixes of Coconut Shell Ash

By these test results we can say that Split Tensile strength of Coconut Shell Ash concrete can be increased approximately **3.81 kg/cm²** by adding waste coconut shell ash **7.5%** of the weight of the cement content. It is also clear by these results that more than **7.5%** waste coconut

shell ash start reducing the split tensile strength of coconut shell ash mixed concrete.

Table-11 Combine Split Tensile Strength of Glass Powder (GP) mix Concrete for all Mixes

S. No.	GP %	Split Tensile Strength After 7 Days (kg/cm²)	Split Tensile Strength After 28 Days (kg/cm²)
1	0%	1.17	2.60
2	2.5%	1.51	2.79
3	5%	1.71	2.90
4	**7.5%**	**1.96**	**3.90**
5	10%	1.76	3.22
6	12.5%	1.72	3.47

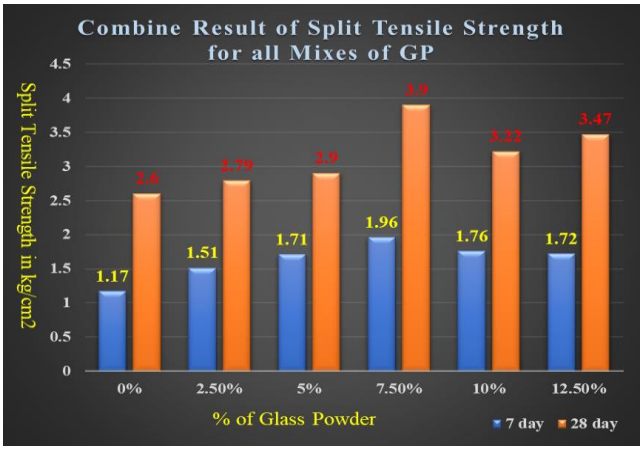

Figure 6: Combine Split Tensile strength at 7 day and 28 days for all mixes of Glass Powder

By these test results we can say that Split Tensile strength of Glass Powder concrete can be increased approximately **3.90 kg/cm²** by adding waste glass powder **7.5%** of the weight of the cement content. It is also clear by these results that more than **7.5%** waste glass powder start reducing the split tensile strength of glass powder mixed concrete.

3.7 Flexural Strength of CSA and GP mixed Concrete (IS: 516-1959): -

The flexural strength test of beam, a specimen of size (700*150*150) mm is placed over two-point loading arrangement and the stress produced during breakage of specimen. The flexural strength is reported as Modulus of Rupture ft (N/mm)

Table-12 Combine Flexural Strength of Coconut Shell Ash (CSA) mix Concrete for all Mixes

S. No.	CSA %	Flexural Strength After 7 Days (kg/cm²)	Flexural Strength After 28 Days (kg/cm²)
1	0%	5.77	7.45
2	2.5%	6.13	7.82
3	5%	6.40	8.12
4	7.5%	7.23	9.20
5	10%	6.61	8.52
6	12.5%	6.55	8.39

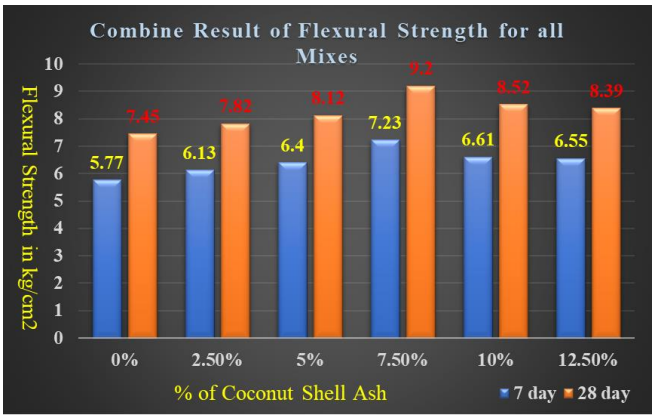

Figure 7: Combine Flexural strength at 7 day and 28 days for all mixes of Coconut Shell Ash

By these test results we can say that Flexural strength of Coconut Shell Ash concrete can be increased approximately **9.20 kg/cm²** by adding waste coconut shell ash **7.5%** of the weight of the cement content. It is also clear by these results that more than **7.5%** waste coconut shell ash start reducing the Flexural strength of coconut shell ash mixed concrete.

Table-13 Combine Flexural Strength of Glass Powder (GP) mix Concrete for all Mixes

S. No.	GP %	Flexural Strength After 7 Days (kg/cm²)	Flexural Strength After 28 Days (kg/cm²)
1	0%	5.08	6.35
2	2.5%	5.85	7.69
3	5%	6.33	8.03
4	**7.5%**	**7.18**	**9.22**
5	10%	6.48	8.41
6	12.5%	6.51	8.31

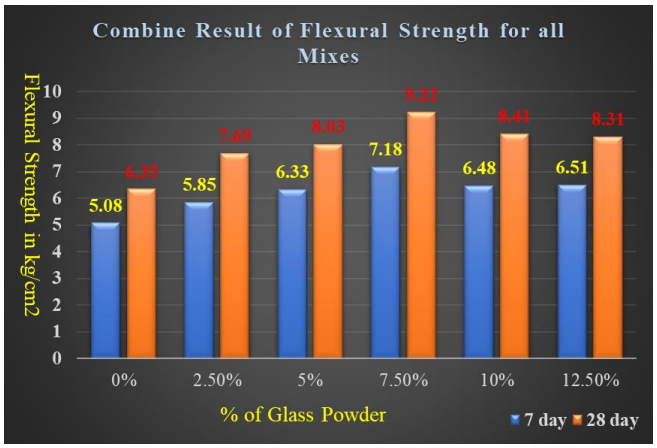

Figure 8: Combine Flexural strength at 7 day and 28 days for all mixes of Glass Powder

By these test results we can say that Flexural strength of glass powder concrete can be increased approximately 9.22 kg/cm^2 by adding waste glass powder ash 7.5% of the weight of the cement content. It is also clear by these results that more than 7.5% waste glass powder start reducing the Flexural strength of glass powder ash mixed concrete.

IV. Conclusion

After the detail analysis of the test results, we can say that the addition of waste coconut shell ash and glass powder significantly affect the 7 day and 28 days compressive strength, split tensile strength and flexural strength of the concrete. From the critical difference, it can be clearly seen that the addition of waste coconut shell ash and glass powder in certain amount i. e. (0-7.5) % of the weight of cement increases the compressive strength as well as split tensile strength and flexural strength increases. Experimental results also show similar trend. Hence, the results of statistical analysis are equivalent to the experimental results. From the experimental investigation this research work can be concluded as follows: -

[1] CSA & GP waste material improves the compressive strength, split tensile strength and flexural strength of concrete.

[2] The addition of waste CSA & GP does not affect very much the density of concrete mix.

[3] The addition of waste CSA & GP increases the strength of concrete for all curing ages up to a certain point. After that there is an abrupt reduction in the strength of the CSA & GP mixed concrete. Because at higher dosage, concrete loses its ability to make a proper bond.

[4] The gradual increase seen in the compressive strength of Coconut Shell Ash & Glass Powder mixed concrete at 7 days and 28 days curing with 10% addition of CSA and GP in the amount of 28.44 kg/cm^2 and 29.02 kg/cm^2 respectively but after that it starts reducing the compressive strength with increase of CSA and GP addition.

[5] The gradual increase seen in the Split Tensile Strength of Coconut Shell Ash & Glass Powder mixed concrete at 7 days and 28 days curing with 7.5% addition of CSA and GP in the amount of 3.81 kg/cm^2 and 3.90 kg/cm^2 respectively but after that it starts reducing the Split Tensile Strength with increase of CSA and GP addition.

[6] We also find that the Flexural Strength of Coconut Shell Ash & Glass Powder mixed concrete at 7 days and 28 days curing with 7.5% addition of CSA and GP in the amount of 9.20 kg/cm^2 and 9.22 kg/cm^2 respectively but after that it starts reducing the Flexural Strength with increase of CSA and GP addition.

[7] The mix which was prepared with the addition of 10% CSA & GP with 0.55 W/C ratio possess the maximum compressive strength. Therefore, this mix is recommended for maximum strength.

V. Recommendations

In the construction industries that is purely managed work has good communication and clear guideline on the scope of the work are essential in the construction to avoid undesirable and confusion.

[1] For the right and the accurate result, we have to prepare assessment report for every activity and every step of work to ensure the proper degree of control.

[2] We prepare for result new and accurate machine and updated IS codes for formulation.

[3] Allocation of financial and skilled human resources for the purpose of effective and efficient quality management should be provided.

[4] There should be training program and quality guidelines to assure desired quality.

VI. Scope for the future

[1] Further studies need to be conducted for the test of durability, soundness, thermal insulation, crack pattern and water absorption of the concrete.

[2] Further studies need to be conducted by using other waste materials (combination of artificial and natural material) with cement could increases strength of concrete.

[3] If we increase the plastic limit of CSA in concrete then we increase huge the strength in compressive strength and flexural strength.

[4] Experiments can be performed to study the behavior of soil reinforced with CSA & GP material.

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