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PARTIAL REPLACEMENT OF CEMENT BY GLASS AND SEASHELL POWDER IN CONCRETE

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Abstract - *Concrete is most commonly used construction material in worldwide due to its ductility, versatility and economy. It is a composite material composed of cement, fine aggregate, course aggregate and it is mixed with water. Cement is used as binder material in construction. During the manufacture of cement greenhouse gases such as CO_2 is released this causes global warming and cement have higher cost compared to other ingredients in the concrete. There are many researches are carried out to use waste material as replacement in concrete. Rubber Latex, coconut shell etc. are used as coarse aggregate replacement material and quarry dust or lime stone, filtered sand and copper slag are used for fine aggregate. Recent researches are carried out to find out on glass powder and seashell powder as partial replacement material for cement in concrete. Waste glass is one material when grounded to fine powder shows pozzolanic properties so this material can be used as replacement material for cement. Seashells are rapidly accumulating waste material mainly in coastal areas; these are mainly generated from aquaculture and by product of seafood. Fine powdered seashell can be used as partial replacement material for cement in concrete because it contains high silicon content and this react with alkalis in cement and forms high cementitious material. This project investigates the effect of using combination of glass powder and seashell powder as partial replacement for cement in M35 grade concrete. Various tests conducted on the laboratory casted concrete specimens and their behavior will be observed and documented for of 7 days and 28 days testing.*

Key Words*: *Seashell powder, Glass powder, Super plasticizer, Workability test, Strength test.

1. INTRODUCTION

Concrete is the most widely and commonly used material for construction and it is the second mostly consumed material in the world. Concrete is a composite material which is composed of cement, fine aggregate and coarse aggregate and it is mixed with water which hardens with time. During the manufacture of the cement large amount of greenhouse gases such as CO_2 are released to the atmosphere that causes global warming. Many research works are carried out to find the effect of using waste material as partial replacement for coarse or fine aggregate and cement.

In this paper cement is replaced with Glass Powder (GP) and Seashell Powder (SP).Waste glass shows pozzolanic properties when it ground to fine powdered form there for it can be used as a partial replacement material in concrete. The main sources of waste glasses are waste containers, window glasses, windscreen, medicinal and liquor bottles, electronic equipments, etc. Seashells are rapidly accumulating waste materials in coastal areas and waste dumped from the fishery industries it makes environmental problems. Oyster shells, mussel shell and scallop shells are some of seashells used for powdering.

Goal of this project is to evaluate and compare the properties of normal concrete and replaced concrete.

1.1 Objective

In this project the impact of using combination of seashell powder and glass powder as partial replacement material for cement in concrete is evaluated. Physical properties of 53 grade Ordinary Portland Cement is evaluated by conducting fineness test, consistency test, setting time test and specific gravity test. Main objective of the project is to find out the mechanical properties of replaced concrete such as compressive strength, split tensile strength and flexural strength and its comparison with the conventional concrete. The replacement by the rate of 5%, 10%, 15 %, 20% 25% and 30% is carried out on M35 concrete and the test is conducted at 7 days and 28 days.

2. LITERATURE SURVEY

Abhishek Tiwari et.al (2019), [1] conducted an experimental study to evaluate the compressive strength of concrete which uses glass powder as partial replacement of cement. They replaced cement by 5%, 10%, 15%, 20% and 25% of glass powder by weigh of cement in M25 grade concrete. Optimum 7 days and 28 days compressive strength obtained at 20 % replacement.

Er.Manoj Kumar Meena et.al (2018), [2] performed an experimental investigation to evaluate the performance of concrete by using glass powder as partial replacement material for cement in M35 concrete. They tested at 7 days and 28 days of M35 grade concrete with partial replacement

of cement by glass powder at the rate of 0, 10%, 15%, 20%, 25% and 30%. Up to 15% replacement of glass powder the strength, increases then strength of concrete gradually decreases.

Vipin Kumar and Dr. Hemant Sood (2017), [3] conducted an experimental study to find the effect of using waste glass powder as partial replacement for cement in M20, M25, and M30 grade concrete. In this project they evaluated the flexural strength and split tensile strength of the concrete by replacing cement by waste glass powder at a rate of 5%, 10%, 15% and 20% by weight of cement. From this test maximum flexural strength and tensile strength obtained for M30 at 20 % replacement of cement by glass powder.

L. Senthil Nathan (2018), [4] conducted an experimental study for increasing the compressive strength in concrete with partial replacement of cement in concrete by seashell powder. The cement is partially replaced with the seashell powder by 5%, 10%, 15%, and 20 % by weight of cement at the curing date 7, 14, and 28 days. Finally they concluded that as the curing date increases the strength of concrete increases and the maximum compressive strength is obtained when 20% replacement of cement by seashell powder.

Monita Oliviaa et. al (2015), [5] conducted an experimental study to find out the properties of concrete with seashell powder used as partial replacement for cement in concrete and it is compared with the ordinary Portland cement. Cement at the rate of 2, 4, 6, and 8% of seashell powder by weight of cement. Compressive strength of the conventional concrete and replaced concrete increases from 7, 28 and 91 days but compared to replace concrete conventional concrete shows higher value of compressive strength.

3. EXPERIMENTAL INVESTIGATION

3.1 Materials

All the materials in concrete such as cement, fine aggregate, coarse aggregate and replacement materials are tested to determine the properties.

A) Ordinary port land cement (OPC)

OPC of grade 53 Dalmia cement used throughout the investigation. Testing on OPC 53 IS carried out as per IS 12269:2013

Table-1: Properties of cement

No.	Properties	Test result
1	Fineness test	1%
2	Consistency test	30%
3	Initial setting time test	123 min
4	Final setting time test	234 min
5	Specific gravity test	3.15

B) Fine aggregate

Natural river sand as per IS 383:1970 is used for this investigation. Properties of this aggregate are given in Table-2.

Table-2: Properties of fine aggregate

No.	Properties	Test result
1	Fineness modulus	2.35
2	Specific gravity	2.61
3	Water absorption (%)	0.29

C) Coarse aggregate

Naturally available coarse aggregate of size 12mm-20mm is used for investigation. Various test are conducted to determine the physical properties of coarse aggregate as per IS 2386:1963. Test result is given in Table-3

Table-3: Properties of coarse aggregate

No.	Properties	Test Result
1	Specific gravity	2.69
2	Water absorption (%)	0.06

D) Glass powder

The glass powder named AKSHAR CHEM is collected from Amazon, an online shopping site. Specification given by the manufactures is shown in Table-4.

Table-4: Properties of glass powder

Silica (SiO2)	72.5
Loss of ignition	0.36
Fineness percentage passing (sieve)	80 (45µm)
Unit weight .Kg/m^3	2579
Specific gravity	2.58

E) Seashell powder

Seashell powder is collected from AM Square Trade Links, Malapuram. Specifications o the powder is given by the distributors.

Table-5: Properties of seashell powder

Calcium oxide (CaO)	84.59 %
Lead (Pb)	52 ppm
Specific gravity	2.53
Loss on ignition	4.07

D) Super Plasticizers

An admixture is a material used to increase the properties of concrete. Generally used admixtures are accelerating admixtures, retarding admixtures, water reducing admixtures, super plasticizers etc. In these investigation super plasticizers is used as admixture. Super plasticizers are added to increase the workability and strength of the concrete. Super plasticizer Conplast SP 430 is used and it is manufactured by the company Fosroc.

Table-6: Properties of Super plasticizers

Appearance	Brown in color
Specific gravity	1.18
Chloride content	Nil
Air entrainment	Less than 2% additional air is entrained at normal dosages.

E) Mix proportioning

Mix design is done as per IS 10262:2019.All the samples prepared using design mix. M35 grade concrete is used for this investigation.

Table -7: Mix Proportioning

No	Material	Quantity (kg/m^3)
1	Cement	354
2	Fine aggregate	691
3	Coarse aggregate	1234
4	water	152

3.2 Workability of Fresh concrete

Workability is defined as the properties of freshly mixed concrete which determines the ease with which it can be mixed, placed, consolidated and finished. The workability was measured by conducting concrete slump test or slump cone test. In this investigation as the replacement percentage increases workability decreases super plasticizer is added to maintain the slump value.

4. TEST ON SPECIMEN

In this study compressive strength test, Split tensile strength test and flexural strength are conducted. Compressive strength, tensile strength and flexural strength are tested using the standard specimens of cube (150 mm×150mm×150mm), cylinder (300mm×150mm) and prism (100mm×100mm×500mm) size where used for testing. Water binder ratio of 0.43 is adopted for experiment and the super plasticizer added during mixing of concrete is 0.6 % by weight of cement. The materials are mixed using mixture machine in laboratory. Concrete is filled in different layers and compacted and kept 24 hrs in room temperature then remoulded and cured in water for 7 and 28 days then tested to determine compressive strength, tensile strength and flexural strength.

5. TEST RESULTS AND DISCUSSIONS

Compressive strength test, split tensile strength and flexural strength test is conducted on hardened concrete. Result of hardened concrete with replaced cement by the combination of glass powder and seashell powder is compared to the normal concrete.

5.1 Compressive strength of concrete

The results of compressive strength of normal concrete and replaced concrete were presented in Table-8.

Table-8: Compressive strength of concrete

(GP + SP)%	Compressive strength in MPa	
	7 days	28 days
0 %	27.95	35.3
5%	24.52	38.12
10%	25.89	38.23
15%	26.45	39.01
20%	30.67	47.165
25%	28.91	44.48
30%	26.68	41.65

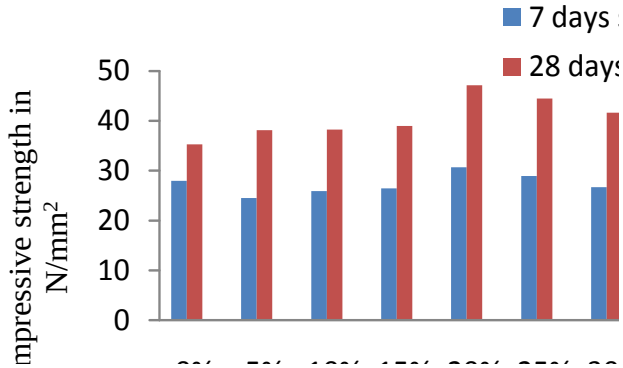

Chart 1: Compressive strength of concrete

The Table-8 gives the compressive strength results of test conducted on hardened concrete with 0-30% replacement of cement by the combination of glass powder and seashell powder for 7 and 28 days. The result shows that the compressive strength increases with increasing curing time. It seems the compressive strength obtained for 20% replacement shows higher compressive strength it is 30.67N/mm^2 and 47.165N/mm^2 for 7 and 28 days.

Maximum compressive strength obtained is 34 % higher than conventional concrete.

5.2 Split tensile strength of concrete

The results of Split Tensile strength of normal concrete and replaced concrete were presented in Table-9.

Table-9: Split tensile strength of concrete

(GP+SP)%	Split tensile strength in MPa	
	7 days	28 days
0 %	1.485	2.456
5%	1.167	2.147
10%	1.20	2.223
15%	1.25	2.432
20%	1.77	3.76
25%	1.415	2.76
30%	1.32	2.54

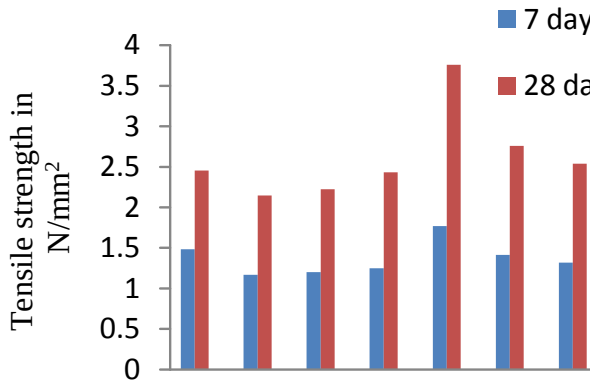

Chart 2: Tensile strength of concrete

Split tensile strength is tested at 7 and 28 days. Test result shows that the tensile strength increases as the curing days increases. From the test result increase in tensile strength is 1.77N/mm^2 and 3.76N/mm^2 at 7 and 28 days. The maximum increase in split tensile strength is observed at 20% replacement of cement by the combination of glass powder and seashell powder. Increasing tensile strength is due to the increasing the bond between the aggregate and Binder.

5.3 Flexural strength of concrete

The results of flexural strength of normal concrete and replaced concrete were presented in Table 10.

Table-10: Flexural strength of concrete

(GP+SP)%	Flexural strength in N/mm^2	
	7 days	28 days
0 %	4.6	5.8
5%	4.8	5.83
10%	5.1	6.1
15%	5.2	6.23
20%	6	7.63
25%	4.2	6.88
30%	4.1	6.12

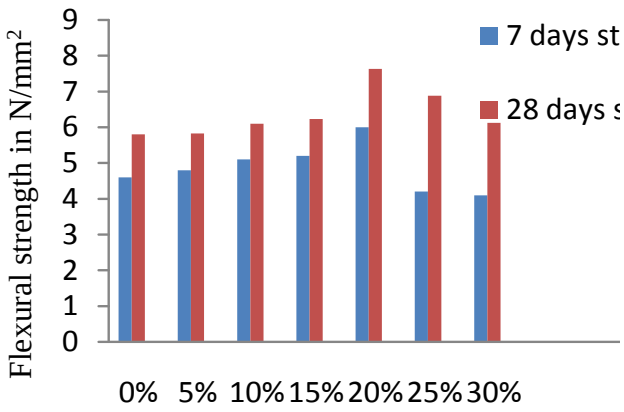

Chart 3: Flexural strength of concrete

A considerable strength gained after 28 days was probably due to better bonding between paste and aggregates.. The maximum increase in flexural strength is observed as 6 N/mm^2 and 7.63 N/mm^2 at 7 and 28 days when cement is replaced by the combination of glass powder and seashell powder by 20%. Maximum flexural strength obtained is 32% higher than the conventional concrete. Flexural strength increased due to the increasing the bonding between the aggregate and paste increases then the strength decreased due to the dilution effect of the concrete.

6. CONCLUSIONS

The following conclusions are made based on above study,

- As the percentage of replacement increases the workability decreases. Super plasticizer is necessary to maintain workability with restricted water cement ratio.
- Compressive strength of concrete increases up to 20 % then decreases in 28 days test.
- Split tensile strength of concrete initially decreases compared to conventional concrete then a sudden

increases in 20 % replacement. Then decreases slowly.

- Flexural strength increases gradually up to 20 % replacement then slowly decreases.
- Increase in tension properties enhances the composite action between concrete and steel reinforcement bars.
- Considering the strength criteria, the replacement of cement by the combination of glass powder and seashell powder is feasible. Therefore we can conclude that the utilization of waste glass powder and seashell powder in concrete as cement replacement is possible.
- Further durability investigation can be done to see the long term effect of glass powder and seashell powder replacement

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