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Experimental Investigation of Strength and Durability of Concrete by Partial Replacement of Cement with Glass Powder and Fine Aggregate with Copper Slag

Pavan B Kamble[1], Prof.V.G. Patwari[2]

[1]M.Tech student, civil Engineering Department, M.S. Bidve Engineering college Latur, Affiliated to Dr. Babasaheb Ambedkar Technological University, Lonere Approved by AICTE, Accredited by NAAC, Maharashtra. India
[2]Prof. Civil Engineering Department, M.S. Bidve Engineering College Latur, Affiliated to Dr. Babasaheb Ambedkar Technological University, Lonere Approved by AICTE, Accredited by NAAC, Maharashtra. India

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Abstract - *This experimental study is to investigate the effect of using glass powder as replacement of cement and copper slag as a replacement of fine aggregate on the strength and durability properties of concrete. The importance of this alternatively glass powder and copper slag replacement is to reduce wastage of the locally available waste products and to reuse it in construction industry. In the present study experimental investigation has been carried out on M30 grade concrete is used and tests were conducted for various percentage replacement of cement with glass powder and fine aggregate with copper slag in concrete. The results obtained were compared with those of conventional concrete made with ordinary Portland cement (53 Grade) and fine aggregate. The use of glass powder and copper slag in concrete provides potential atmosphere likewise as economic advantages for all connected industries, notably in areas where ever a substantial quantity of glass powder and copper slag is created.*

This study reviews the characteristics of glass powder and copper slag and its effect on the engineering properties of M30 grade concrete. Now a day's use of glass powder and copper slag as substitute for cement and fine aggregate is to increase the strength of cement concrete. The Glass Powder and copper slag was replaced by 0%, 10%, 15% & 20% for 7 & 28 days for Cubes for Compressive strength and beams are casting for flexural Strength and other properties like compacting factor and slump were also determined for four mixes of concrete. There are two trial mixes to be made i.e. 1) Ordinary Concrete, 2) Concrete with addition of glass powder and copper slag for M-30 grade of concrete.

Key Words: Waste glass powder, copper slag, compressive strength, flexural strength, workability, pozzolanic properties.

1. INTRODUCTION:

The study, various investigations have been found the solution on concrete composite materials. Natural resources are decreasing from the world and increasing waste from industries generated simultaneously. The eco-friendly and reliable development for construction consists of the use of non-conventional and different waste materials. Concrete is a blend with cement, sand, coarse aggregate and water. The key issue adds price to concrete that it is can be designed to resist harshest atmosphere vital role. Sand is an important material for the making of concrete. Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Slag that is quenched in water produces angular granules which are disposed of as waste. At present, across the world around 33 tonnes of slag is generated while in India three copper producers Sterlite, Birla Copper and Hindustan Copper produce around 6-6.5 tonnes of slag at different sites. Slag's containing <0.8% copper are either discarded as waste or sold cheaply the potential use of granulated copper slag, a relatively heavy material, as a replacement for sand in concrete mixes is explored..

Cement industry emits 8% of greenhouse gases to the environment. 1 ton of co2 is released to the environment for the production of one ton cement in industry. To reduce the emissions of greenhouse gasses alternative materials is used in concrete. There are many alternatives like rice husk ash, fly ash, egg shell, glass powder. When we are going for an alternative in construction it should be economical and easily available. In India 5200 tons per day of glass is produced. Glass is an amorphous material produced by melting a mixture of silica, soda ash, caco3 at high temperature followed by cooling where the solidification occurs without crystallization. Glass is non-biodegradable material so it is not suitable for landfill. It is an inert material which could be recycled and used many times without changing their chemical properties. In glass powder the main concern is alkali silica reaction, the chemical reaction takes place between silica rich glass particle and the alkali in pore solution of concrete. The finely grounded glass does not contribute to the alkali silica reaction. The waste glass contains high silica sio2-72%. The amorphous silica in glass would dissolve in alkaline environment due to OH- ions in pore solution of cement paste. Then it reacts with calcium hydroxide (CH) to form secondary calcium silicate hydrate (C-S-H) this process is known as pozzolanic reaction. It leads to studies on partial use of waste glass as raw material in concrete batching. The finely ground glass powder reacts with alkali and cementatious product for increase the development in strength.

1.1 Objectives of the study are stated below;

- To study the properties of concrete like workability, compressive strength, and Flexural strength with partial replacement of cement with glass powder and fine aggregate with copper slag in concrete.
- Study the influence of partial replacement to fine aggregate with copper slag by using V.S.I. sand.
- Find the percentage of copper slag replaced to fine aggregate that makes the strength of concrete maximum using V.S.I. sand.
- Determine the suitability of glass powder as partial replacement with cement and copper slag with of fine aggregate in concrete.
- Find the alternative of basic materials which are used in construction from past many years.
- To manage the industrial waste and to determine the suitability of cooper slag and glass powder as partial replacement with fine aggregate and cement.
- Compare the mechanical properties of glass powder and copper slag in concrete with control concrete.

1.2 SIGNIFICANT OF STUDY:

- To reduce the space required for landfill of glass powder and copper slag.
- To diminish the pressure of exploiting the natural resources.
- To introduce the potential of cement as glass powder and fine aggregate as copper slag.

2. METHODLOGY

2.1 MATERIAL USED:

a) Cement:

- The Cement used for this experiment is Parasakti Ordinary Portland cement of 53 grade with specific gravity of 3.15.
- OPC 53Grade at PARASAKTI CEMENT is produced conformed to the Indian standards specification as per IS: 12269-1987
- 53Grade ordinary Portland cement is high strength OPC and can provides numerous advantages where ever concrete for special high strength applications is required. The rate of development of strength is higher than 43 grade OPC.

b) Fine aggregate(VSI sand)

- Vertical Shaft Impactor (V.S.I.) Sand is also known as Artificial Sand or Crushed Sand. Only sand manufactured by V.S.I. Crusher is cubical and angular in shape. Generally the size of the aggregate lesser than
- Specific gravity of V.S.I sand is 2.60.

c) Coarse aggregate:

- Locally available coarse aggregate from quarry was used with specific gravity 2.68 and water absorption of 0.705% and maximum size of 20mm aggregate used.
- Testing is done as per Indian Standard Specification IS: 383-1970.

d) Water:

- Water should be free from acids, oils, alkalies, vegetable or other organic impurities.
- Water is used for mixing curing purpose should be clean and portable, fresh and free from any bacteria and desire matter confirming to IS 3025-1964 is used for mixing.

e) **Glass powder:**

- Physical and chemical properties of copper slag as obtained given in following table.

TABLE 1: Physical properties of glass powder:

Sr. no	Physical property	Test result of cement	Test result of glass powder
1	Specific Gravity	3.15	2.68
2	Fineness passing 90µm	<90µm	<75µm
3	Colour	Grey	White

TABLE 2: Chemical properties of glass powder:

Composition (% by mass)/Property	Cement %	Glass Powder %
Silica (Sio2)	17-25	72.5
Alumina (Al2O3)	3-8	0.4
Iron Oxide (Fe2O3)	3-4	0.2
Calcium Oxide (Cao)	3-8	9.7
Magnesium Oxide (MgO)	3-4	3.3
Sodium Oxide (Na2O)	0.19	13.7
Potassium Oxide (K2O)	0.82	0.1
Fineness % passing (sieve size)	97.4 (45µm)	(45µm)

f) Copper slag:

- Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on molten metal.

- Copper slag is mixed in the concrete as replacement material of fine aggregate. It is the waste product of copper produces from iron or steel plant.
- A physical property of copper slag is as follows.

TABLE 2: physical properties of copper slag:

Sr. no	Property	Value
1	Specific gravity	3.35
2	Fineness modulus	3.18
3	Bulk density	3.0
4	Water absorption	0.40%
5	Particle shape	Irregular
6	Appearance	Black and Glassy
7	Type	Air cooled
8	Moisture content	0.1%

2.2 Casting of specimen:

Test specimens of Cubes of size 150mm x 150mm x 150mm, beam with 700mm x 150mm x 150mm will prepared using the standard moulds. The samples are cast. The samples are remoulded after 24hrs of casting and kept in a water tank for 7 and 28 days curing. A total of 24 specimens cast for testing the properties such as compressive strength, and flexural strength.

18 cube samples of size 150mmx150mmx150mm for different percentages of waste glass powder in partial replacement with cement and copper slag with replacement of fine aggregate will casted. The concrete mixes are 0%, 10%, 15%, 20% with partial replacement of cement with glass powder and copper slag with fine aggregate. All cubes will casted in one lift and consolidated using machine vibrator. After final setting of cubes, the cube moulds will be removed and cubes will kept in water tank for curing up to 7 and 28 days.

All specimen beams size 700mm × 150mm × 150mm will casted with optimum compressive strength for the specific mix in single lift and consolidated using tamping rods. After setting, the beams will covered with wet gunny bags. The burlap will be kept for 3days. At the end of the third day, the forms will stripped and beams will kept for curing up to 28 days.

Fig-1. Mixing of glass powder and copper slag in concrete

2.3. Testing of specimen:

After 24hrs, the specimens were remove from mould and subjected to water curing for 7 days and 28 days. After the curing the specimens were tested for compressive strength and flexural strength using a compressive testing machine of capacity 200KN in accordance with the provision of Indian standard specification IS;516-1959. Strength of cube tested at 7 days and 28 days. Strength of beam was tested at 28 days.

3. WORKABILITY:

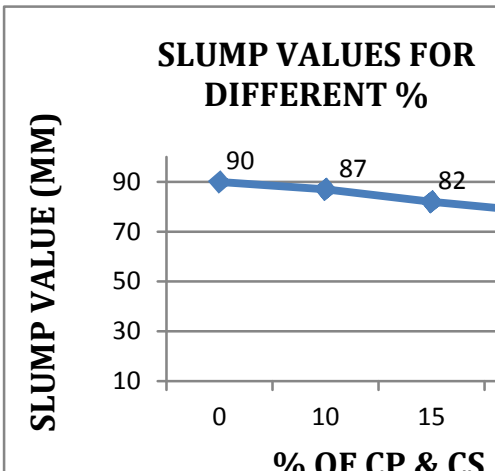
It is the amount of useful internal work necessary to produce the full compaction of concrete on field and laboratory methods are available to determine the workability of concrete.

Workability of concrete is measured by slump cone test with w/c ratio of 0.40 for addition of different % of glass powder and copper slag.

The value obtained for different percentage mix is as given below.

Table 3: Slump values for different percentage of mix

% of glass powder and cooper slag replaced	Slump value (mm)
0	90
10	87
15	82
20	78



4. EXPERIMENTAL METHODLOGY:

4.1 Compressive Strength Test:

Compressive strength is measured at 7 days and 28 days. The result indicate that as we increase the percentage of glass powder and copper slag from 0% to 15% its compressive strength increases after the further increments in percentage of glass powder and copper slag there is loss in strength. That mean we replace up to 15%.

4.2 Flexural Strength Test:

Testing of all beam specimens with two point loading is carried out to measure its flexural strength. The load was applied by using a hydraulic jack via a load cell. The load was transferred from the jack to the main specimen by using a loading beam Two roller supports carried the reactions; therefore, the loading states were two incremental bending points loads. The deflection at the Centre of web is measured by using dial gauge.

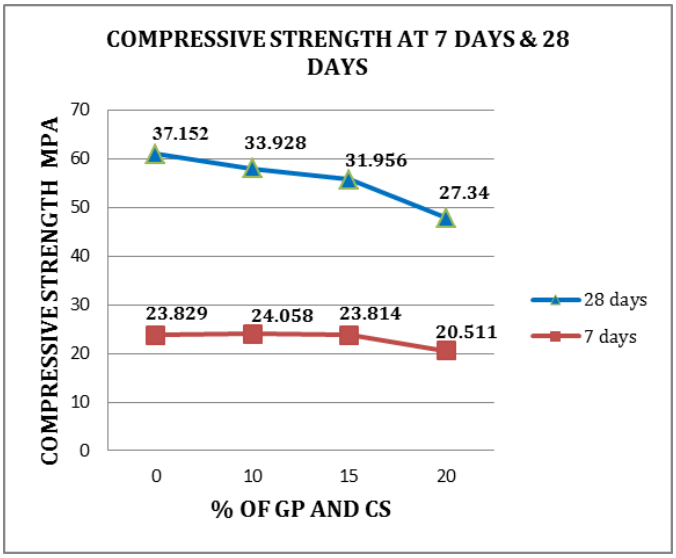
$$F_r = \frac{P \times L}{b \times d^2}$$

5. EXPERIMENTAL RESULTS:

5.1 Compressive strength test result:

Table 4: Compressive Strength at 7 days and 28 days

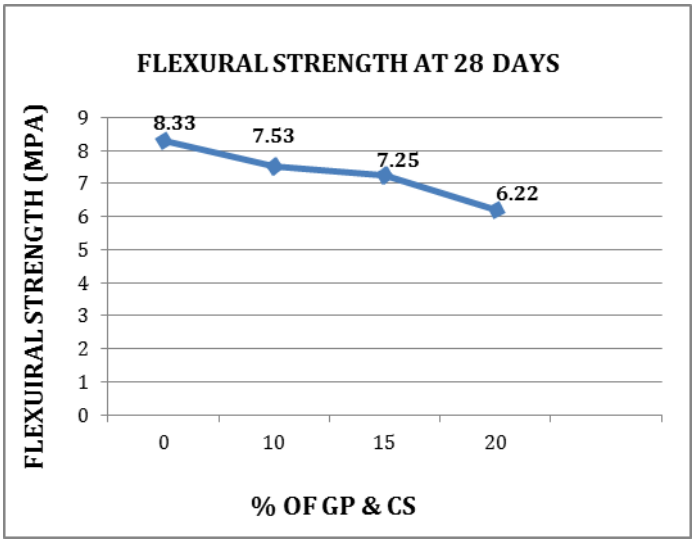
% of glass powder and copper slag replacement	Compressive strength at 7 days (N/mm²)	Compressive strength at 28 days(N/mm²)
0	23.829	37.152
10	24.058	33.928
15	23.814	31.956
20	20.814	27.340



5.2 flexural strength test results:

Table 5: Flexural Strength at 28 days:

%of glass powder and copper slag replacement	Flexural strength at 28 days(N/mm²)
0	8.33
10	7.53
15	7.25
20	6.22



6. CONCLUSIONS

Based on results and observation made in experimental research study the following conclusions are drawn.

1. It is observe that with increase in percentage of waste glass powder and copper slag workability decreases.

2. Concrete made by partial replacement of cement with glass powder and fine aggregate with copper slag is cheaper than conventional concrete.

3. Current study concluded that strength of concrete is achieved up to 15% replacement and strength of concrete decreases at 20%.

4. The use of waste glass powder and copper slag in concrete is possible to improve its compressive strength, and flexural strength.

5. Glass powder with 75micron size shows pozzolanic properties as per ASTM.

6. The results of the slump tests of waste glass powder as cement and fine aggregate as copper slag in concrete mixtures, these results indicate that the slump value of fresh concrete is prone to decrease with increasing copper slag aggregate ratio.

7. The slump was about 90 mm for concrete without any plastic aggregate and the slump was about 82 mm for replacement of 10% copper slag aggregate in concrete. The reasons for the lower slump value of the concrete mix containing plastic aggregate are the sharp edges and angular particle size of plastic aggregate.

8. Flexural strength of concrete increase up to 15% and at 20% flexural strength of concrete decreases

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BIOGRAPHIES

Kamble Pavan Blabhim
Student of M-TECH (M.S. Bidve Engineering college Latur)

Prof. V.G. Patwari completed his ME from P.D.A. College of Engineering Gulbarga
(Working as professor at M.S. Bidve Engineering college, Latur)