

# Experimental Investigation on Concrete with Glass Powder and Concrete Debris Using ANSYS Software

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**Abstract**—This study explores the feasibility of using concrete debris, glass powder and glass fiber as partial replacement of coarse aggregate, fine aggregate and cement to ensure sustainability in construction practices. Construction by-products such as concrete debris and glass powder were integrated into concrete mixtures at different proportions. M30 grade concrete is used for this experiment. Cement is replaced with glass fiber by 1%. The percentage of glass powder and concrete debris used in concrete varied from 0%, 10%, 20% and 30%. The compressive strength of cube specimen, tensile strength of a cylindrical specimen and the flexural strength of a beam specimen were tested after 7, 14 and 28 days. The flexural strength of the beam was analysed using ANSYS software and compared with experimental results. The results demonstrate promising outcomes, highlighting the potential of construction by-product to reduce dependency on conventional aggregates, lower environmental impact, and offer cost-effective alternatives for eco-friendly construction. This research emphasizes the benefits of waste management and sustainable material development in modern construction.

**Index Terms**—ANSYS analysis, concrete debris, glass fiber, glass powder, partial replacement, sustainable concrete.

## I. INTRODUCTION

The construction industry operates with a massive environmental footprint. It has led to two interconnected environmental crises such as rapid depletion of natural resources and the generation of overwhelming amounts of waste. In response, researchers and engineers are exploring sustainable alternatives to traditional materials, focusing on reducing the ecological footprint of construction practices. One promising approach involves the partial replacement of fine and coarse aggregates with

construction debris and glass powder, which not only alleviates environmental strain but also provides an effective waste management solution.

Concrete debris and waste glass are generated in large quantities globally and is often end-up in landfill or discarded illegally which contributes to pollution. Using these materials in concrete could help mitigate environmental issues, reduce landfill waste, and promote a circular economy. This study aims to investigate the potential of construction debris and glass powder as partial substitutes for coarse and fine aggregate, analyzing how they impact the mechanical and structural properties of concrete.

Ansys software, a powerful engineering simulation tool. It works based on the principle of finite element analysis. It is utilized to simulate various concrete mixtures with concrete debris, glass fiber and glass powder substitutions. By examining factors like compressive strength, durability, and load-bearing capacity, we can able to identify optimal replacement ratios that maintain or enhance concrete performance. The results are expected to provide valuable insights into the viability of incorporating concrete debris and waste glass powder into concrete, thereby supporting sustainable development and eco-friendly construction practices.

## II. OBJECTIVE

This study explores the use of concrete debris and glass powder as partial concrete replacement, evaluating its mechanical properties and durability. Using ANSYS software, the study aims to optimize replacement levels, promote sustainable concrete production, and contribute to reduce pollution,

ultimately promoting sustainable production and improved concrete quality. The scope of the work includes, knowing the strength parameters of concrete such as compression strength, split tensile strength, flexural strength in which construction debris and glass powder by (10%+10%), (20%+20%) and (30%+30%), Cement is replaced with glass fiber by 1% using M30 grade of concrete.

### III. MATERIALS USED

#### A. Cement:

Cement is a binder substance that sets and hardens and can bind other materials together. It is a material with adhesive and cohesive properties. It produces high compressive strength and good durability when combined with fine aggregate and coarse aggregate and can be used as a load bearing member or structure for long term use. The grade of cement used is OPC53 grade.

Table I. Properties Of Cement

Properties	Results
Specific Gravity	3.12
Fineness	2.9%
Initial Setting time	30 min
Final Setting time	10 hours

#### B. Aggregate:

Fine aggregate is used to fill voids between coarse aggregates, improving concrete workability, density and strength. Sand is used as fine aggregate for preparing concrete. An individual particle in sand is termed as Sand grain. These sand grains are between coarse aggregate (2mm to 64mm) and silt (0.004mm to 0.0625mm). Aggregate most of which passes through 4.75mm sieve is used. Crushed stone is generally used as coarse aggregate. Angular Shape aggregate of size is 20mm and below. The aggregate which are retained on 4.75mm sieve are known as coarse aggregate.

Table II Properties of Fine Aggregate

Properties	Results
Specific Gravity	2.59
Water Absorption	0.9%
Fineness Modulus	2.4

Table III Properties of Coarse Aggregate

Properties	Results
Specific Gravity	2.74
Water Absorption	0.6%
Fineness Modulus	7.6

#### C. Concrete Debris

Concrete debris is a byproduct of construction industry. It can be reused as a partial replacement for natural coarse aggregate in concrete. This practice of using concrete debris as partial replacement of coarse aggregate comes under sustainable construction methods, aiming to reduce the demand for virgin materials while managing construction and demolition waste effectively. Concrete debris is partially replaced in 10%,20% and 30% of total weight of coarse aggregate.



Fig.1 Concrete Debris

Table IV Properties of Concrete Debris

Properties	Results
Specific Gravity	2.52
Water absorption	1.6%

#### D. Glass Powder:

Glass powder is a finely crushed material produced from waste glass. Finely crushed glass powder can enhance compressive strength. Smooth, non-porous glass particles improve the flow and ease of placing concrete. It helps in promoting recycling of waste glass and reduces the need for natural sand. Glass powder is partially replaced in 10%,20% and 30% of total weight of fine aggregate.



Fig.2 Glass powder

Table V Properties of Glass Powder

Properties	Results
Specific Gravity	2.51
Water Absorption	0.2%

#### E. GLASS FIBER

Glass fiber are thin, strong filaments of 5cm in length made from glass. When mixed into concrete, they act like tiny reinforcement that help hold the material together. Adding glass fibers to concrete significantly changes its behavior mainly by improving tension, crack resistant and durability. Glass fiber is partially replaced in 1% of total weight of cement.



Fig.3. Glass powder

### IV. EXPERIMENTAL METHODS

#### A. Concrete Mix Design

The mix design is done by the various proportions of materials for M30 grade concrete which is used in the present study. Then the mix design is designed as per IS 10262-2009 standards.

Table VI Mix Design Proportion

Cement (kg/m <sup>3</sup> )	Fine Aggregate (kg/m <sup>3</sup> )	Coarse Aggregate (kg/m <sup>3</sup> )
415	640	1281
1	1.54	3.08

#### B. Casting of Specimen

Cubes of Size 150mm x 150mm x 150mm, Cylinder of size 150mm x 300mm, Beam of size 700mm x 150mm x 150mm were casted. The specimen containing coarse aggregate, fine aggregate, cement, concrete debris, glass powder, glass fiber and water were casted. After casting and compaction, demoulding was done after 24 hours of casting and specimens were allowed to cured in a water tank.

### V. CONCRETE TESTS AND RESULTS

#### A. Fresh Concrete Tests

##### 1) Slump Cone Test

Table VII Slump Cone Test

S.NO	% Replacement	Slump (mm)
1	0% GP + 0% GF + 0% CD	74
2	10% GP + 1% GF + 10% CD	69
3	20% GP + 1% GF + 20% CD	65
4	30% GP + 1% GF + 30% CD	62

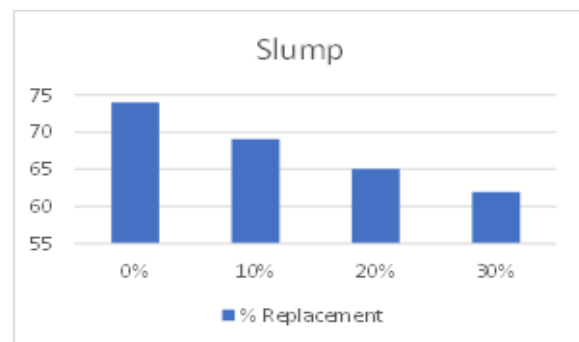


Fig.4 Slump Cone Test

##### 2) Compaction Factor Test

Table VIII Compaction Factor Test

S.NO	% Replacement	Compaction factor
1	0% GP + 0% GF + 0% CD	0.93
2	10% GP + 1% GF + 10% CD	0.91
3	20% GP + 1% GF + 20% CD	0.88
4	30% GP + 1% GF + 30% CD	0.86

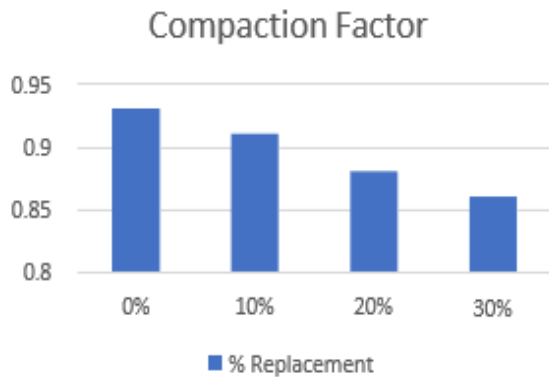


Fig.5 Compaction factor test

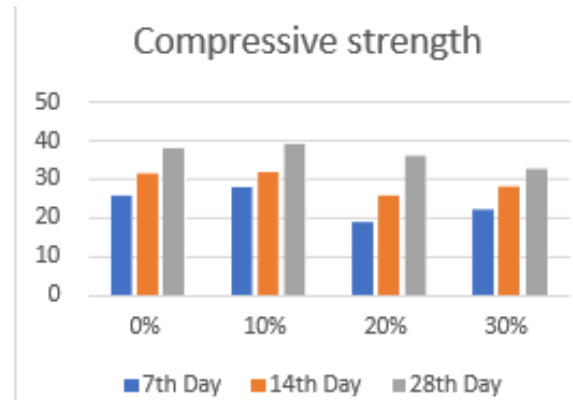


Fig.6 Compressive strength

**B. Hardened Concrete Test**

The individual variations of specimen were not more than  $\pm 10$  percent of the average. The specimen stored in water was tested immediately on the removal from the tank. The specimen is wiped off and the dimensions of the specimen were recorded before testing. The bearing surface of the testing machine were wiped clean. While placing the specimen in the machine, care was taken such that the load was applied to opposite side of the cube as casted and not to the top and the bottom. The maximum load applied to the specimen was recorded and any usual appearance in the type of failure was noted.

**1) Compressive Strength of Concrete**

Table IX Compressive Strength Test

S.NO	% Replacement	Compressive Strength		
		7 days	14 days	28 days
1	0% GP + 0% GF +0% CD	25.62	31.74	38.19
2	10%GP + 1%GF +10% CD	27.8	32.1	39.3
3	20%GP + 1%GF +20% CD	18.8	25.9	36.1
4	30%GP + 1%GF +30% CD	22	28.24	32.84

**2) Split Tensile Strength Test**

Table X Split Tensile Strength Test

S.NO	% Replacement	Tensile Strength		
		7 days	14 days	28 days
1	0%GP + 0%GF +0% CD	2.25	2.93	3.58
2	10%GP + 1%GF +10% CD	2.4	2.86	3.97
3	20%GP + 1%GF +20% CD	7 days	14 days	28 days
4	30%GP + 1%GF +30% CD	2.25	2.93	3.58

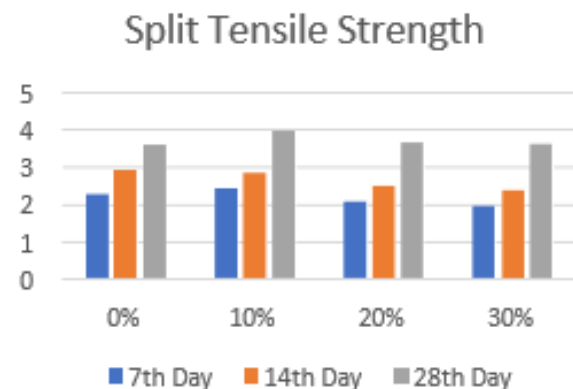


Fig.7 Split Tensile strength

## 3) Flexural Strength Test

Table XI Flexural Strength Test

S. No	% Replacement	Flexural Strength		
		7th Day	14th Day	28th Day
1	0% GP + 0% GF + 0% CD	2.54	3.15	3.79
2	10% GP + 1% GF + 10% CD	2.84	3.51	4.28
3	20% GP + 1% GF + 20% CD	2.61	3.26	3.91
4	30% GP + 1% GF + 30% CD	2.58	3.13	3.67

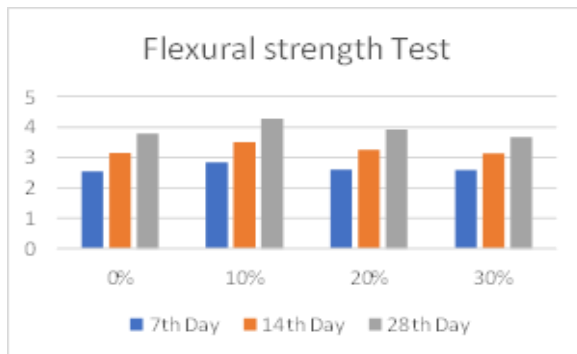


Fig.8 Flexural strength

C. Flexural Strength Result by using ANSYS Software  
ANSYS software has been used to model and analyze the beam of dimension 4000mm X 400mm X 250mm

Table XI Split Tensile Strength Test

S. No	% Replacement	Flexural Strength (28 days)
1	0% GP + 0% GF + 0% CD	3.68
2	+ 1% GF + 10% CD	4.12
3	+ 1% GF + 20% CD	4.84
4	30% GP + 1% GF + 30% CD	4.59

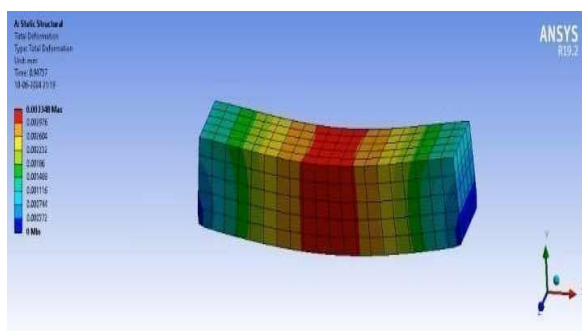


Fig 9 Flexural strength of Beam

## VI. CONCLUSION

The experimental investigation on partial replacement of fine and coarse aggregates with glass powder and concrete debris at 10%, 20%, and 30%, Alongside 1% replacement of cement with glass fiber shows that the mechanical properties such as compressive, split tensile, and flexural strength increases slightly at 10% replacement and decrease with increase replacement but remains within acceptable limits for structural and semi-structural applications. The 20% replacement mix showed compressive strength of 36.1 MPa, split tensile strength of 3.64 MPa, and flexural strength of 4.28 MPa at 28 days, closely matching the control mix. At 30% replacement, the strengths were adequate but lower than 0% replacement. This study concludes that up to 10% replacement offers a sustainable and environmentally beneficial alternative to conventional aggregates with minimal compromise in strength, making it suitable for sustainable concrete applications.

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