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## An experimental study on partial replacement of perlite powder and GGBS with cement in ternary blended concrete

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### ABSTRACT

*In the present scenario in the world, the cost and environmental pollution of cement are very high which is obtained from the cement industries. Alternately we want to decrease the cost and environmental pollution by adding waste industrial materials. Among the many types of admixtures, Perlite Powder (PP) is a material with very low thermal conductivity & GGBS from industries which can be made blended concrete with perlite and GGBS powder. For the strength purpose, partial replacement of cement is carried out by GGBS at 20%. In this work different tests have been performed on M30 grade of concrete like compression test, tensile test, water absorption test. The Present work describes the comparative study of partial replacement of Perlite and GGBS powder in cement. And the Compression and Tensile tests were performed for 7days and 28days and 56 days of curing at 4% PP + 20% constant of GGBS, the compressive strength and tensile strength both are observed to be increased by 0.54% and 1.68% respectively as compared to the conventional concrete of M30 grade. And also did water absorption at 1050C and by taking of perlite powder in Mix which controls the thermal properties of concrete.*

**Keywords**— Perlite powder, GGBS, Blended concrete, Compressive strength, Tensile strength

### 1. INTRODUCTION

Concrete is the most versatile building materials being utilized all around the world. For construction materials, concrete has high resistant to elevated temperature when compared to other building materials like steel and wood etc., However, it is pertinent up to a possible temperature level in a given period of time. Concrete materials are highly susceptible to high temperatures due to a fire accident or when it is nearest to reactors or furnaces. When it surpasses its time under high

exposures, it leads to severe changes resulting in the collapse of a structure such as spalling, causing cracks, forming large pores and deplete the bond between aggregate – cementations materials

#### 1.1 Ternary blended concrete

Ternary blended concrete incorporates three diverse cementitious materials. The utilization of suitably proportioned ternary mixes permits the impacts of one supplementary cementitious material to adjust for the inborn weaknesses of another. Such cement have been found to display fabulous crisp and mechanical properties of the concrete.

#### 1.2 Introduction to perlite powder

Perlite, a hydrated volcanic glass, commonly has a pearly, vitreous lustre characterized by concentric onion skin fractures. Relatively high water content of 2% to 5% distinguishes perlite from other hydrous volcanic glasses, such as obsidian, hydrated volcanic ash, and pumicite. Upon rapid heating, perlite transforms into a cellular material of low bulk-density. As the chemical water held within the perlite boils, generally at temperatures in the range of 900– 1100°C, the resultant steam forms bubbles within the softened rock to produce a frothy-like structure. The formation of these bubbles allows perlite to expand up to 15–20 times of its original volume.

#### 1.3 Objective

- To examine the outcome of the ternary blended concrete containing GGBS and PERLITE under elevated temperatures.
- The dosage of GGBS content 20% constant with varying proportions of PERLITE as 2%, 4% and 6% replacement of cement are examined.
- To analyze the difference between replaced cement in concrete and conventional concrete and find the difference in their strength.

- By examining the parameter like Compressive strength and Tensile strength by using CTM and UTM.

### 1.4 Materials and its Properties

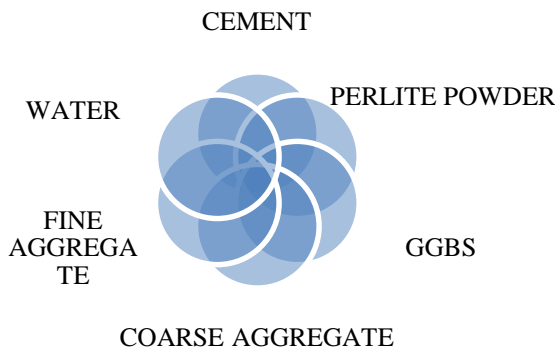


Fig. 1: Materials used

### 1.5 Cement

Cement took up in this study named (chakra-cement) of 53 grade ordinary Portland cement conforming to IS 12269:1987. The physical and chemical properties are shown in table 1 and 2.

Table 1: Properties of Cement

S.no	Properties	Value
1	Specific gravity	3.05
2	Initial Setting time	39 min
3	Final Setting time	200 min
4	Consistency	32 %

### 1.6 Aggregates

Aggregates are the main components of the concrete broadly classified into two categories, they are fine aggregate and coarse aggregate. They constitute 70-75% of the aggregate volume; give inflexible skeleton structure to concrete, goes about as efficient space fillers. They add to both weight and firmness of the solid. In India, river sand is utilized as fine aggregate and crushed rock is preferred for coarse aggregate. Aggregate with grain sizes above 4.75mm is termed as coarse aggregate and below 4.75mm is called as fine aggregate.

Table 2: Properties of fine aggregate

S. no	Properties	Values
1	Specific gravity	2.63
2	Water absorption	0.55%
3	Fineness modulus	4.475
4	Size of fine aggregate	Passing through 2.36mm

Table 3: Properties of coarse aggregate

S. no	Properties	Values
1	Specific gravity	2.74
2	Water absorption	1%
3	Fineness modulus	5.78
4	Max Size of aggregate	20mm

### 1.7 Water

Water plays a vital role in making the concrete after cement. The major functions of water are as follows.

- This spreads the cement uniformly.
- The reaction of cement with water transforms to calcium silicate hydrate (C-S-H) gel (a Strongest component of the concrete)
- It lubricates the mixes (thus enhances workability)

Two sources of water in concrete

- Mix water ( water added to the concrete) and
- Aggregate moisture (either sucks water from a mix or add water to the mix).

### 1.8 Perlite Powder

Perlite is a pozzolanic material formed naturally by hydration of obsidian and expands when heated. As the curing period is increased with increases in the strength of perlite. The Perlite expands nearly 15-17 times the original size of it when heated up to 900-1100°C. When perlite is blended along with concrete it offers very high thermal insulation to the concrete and also perlite is a waste material which is a volcanic glass which is relatively cheaper and makes the mix economical

Table 4: properties of PERLITE

Properties	Value
Color	White
Bulk density	40-50kg/m <sup>3</sup>
pH	Neutral
Thermal conductivity	0.40 w/m k @ 0°
Moisture content	0.5% max.
Organic content	0.1% max.

### 1.9 GROUND-GRANULATED BLAST-FURNACE SLAG (GGBS)

GGBS is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

## 2. METHODOLOGY

### 2.1 Selection and Procurement of Materials

Ternary blended concrete incorporates three diverse cementitious materials. The utilization of suitably proportioned ternary mixes permits the impacts of one supplementary cementitious material to adjust for the inborn weaknesses of another.

GGBS and PERLITE are effective materials to overcome the weakness of the cement concrete. PERLITE possesses esteemed pozzolanic activity. Besides its filling effect in concrete materials, the calcium hydroxide present in the cement reacts with PERLITE gives rise to the creation of CSH gel in the major bonding of the concrete. GGBS acts as a filler material and it has been used as an effective pozzolanic cementitious material to make the concrete high strength. GGBS content 20% by weight of the cement content makes the concrete more to gain more strength. Hence, these two materials are used in the study to get the best fire-resistant concrete at different temperatures

### 2.2 Testing of Materials

Concrete is mainly made up of cement, fine aggregate, coarse aggregate and water thus it is called as the composite material. For utilizing concrete in the major works it is important to test the materials to affirm the necessities of the Indian standard code specifications concerning its chemical and physical properties. The accompanying tests are typically directed in the laboratory.

Table 5: Test values of cement

S. no	Properties of cement	values
1	Specific gravity	3.05
2	Consistency	32 %
3	Initial setting time	39 min
4	Final setting time	200 min

**Table 6: Test values of Aggregates**

S.no	Properties	Fine aggregate	Coarse aggregate
1	Specific gravity	2.5	2.7
2	Fineness modulus	4.475	5.78
3	Water absorption	0.55 %	1 %

**2.3 Mix Design of M30 grade concrete**

The following mix proportions show the quantity for per cubic meter as per Indian standard code IS 10262:2009. The maximum water-cement ratio for M30 grade is 0.45; Grade of concrete is M30.

**Table 7: Mix proportions for w/c ratio 0.44**

S.no	Material	Weight
1	Cement	448.09 kg/m <sup>3</sup>
2	Fine aggregate	804.40 kg/m <sup>3</sup>
3	Coarse aggregate	1027.48 kg/m <sup>3</sup>
4	Water	197.16 kg/m <sup>3</sup>

Mix proportion ratio for M30 grade of concrete is 1:1.8:2.3

**2.4 Trial Mix: Workability Test on Concrete**

Workable cement is the one which displays next to no interior friction amongst molecule and molecule or which defeats the frictional resistance offered by the formwork surface or fortification contained in the concrete with simply the measure of compacting endeavours forthcoming, thus it's a complex property. For measuring the consistency of concrete, slump cone test is used. It is utilized for the sign of uniformity of cement from mix to mix. The maximum water-cement ratio adopted for M30 grade concrete is 0.45. Hence, the trial mixes have begun from 0.45 to the lower water-cement ratio. The slump value taken for each trail mix and the compressive strength of this mix was examined at 7 days curing of the concrete. Table5.4 shows the slump value and compressive strength of the concrete.

**Table 8: Slump value and compressive strength of the concrete**

Trial mix	w/c ratio	Slump value (mm)	Compressive strength for 7 days (MPa)
1	0.43	16	17.7
2	0.4	0	24.8



**Fig. 2: slum cone test**

**Table 9: Percentage of industrial waste materials are replaced with cement**

S.no	Series	% Perlite Replacement	% GGBS replacement
1	Type 1	0%	0%
2	Type 2	2%	20%
3	Type 3	4%	20%
4	Type 4	6%	20%

**2.5 Mix Proportions for ternary blended concrete**

The following mix proportions show the quantity for per cubic meter as per Indian standard code IS 10262:2009. The adopted water-cement ratio for M30 grade is 0.44 (based on trial mixes). The GGBS has 20% constant at a various dosage of PERLITE (blends of three materials) as 2%, 4%, and 6% of cement replacement carried out in this study. The mix ratio for M30 grade blended concrete is 1:1.8:2.3

**2.6 Testing of a ternary blended concrete**

Testing of hardened cement concrete assumes an essential part in controlling and affirming the nature of bond of concrete works. Deliberate testing of crude materials, crisp concrete and solidified cement are indivisible piece of any quality control program for concrete material, which accomplishes higher productivity of the material utilized and more prominent confirmation of the execution of the concrete with respect to both durability and quality of the concrete.

**2.7 Compressive strength test of the concrete**

Compression test is the most widely recognized test directed on hardened concrete, because of the fact that most of the alluring properties of cement are subjectively identified with its compressive quality utilized to decide the hardness of the concrete, where the primary utilization of concrete is to withstand compressive strengths.



**Fig. 3: Compressive strength testing machine**

**2.8 Tensile strength test of concrete**

The tensile test is the most widely recognized test directed on hardened concrete, because of the fact that most of the alluring properties of cement are subjectively identified with its tensile quality utilized to decide the hardness of the concrete, where the primary utilization of concrete is to withstand compressive strengths.



**Fig. 4: Tensile strength testing machine**

**3. RESULTS**

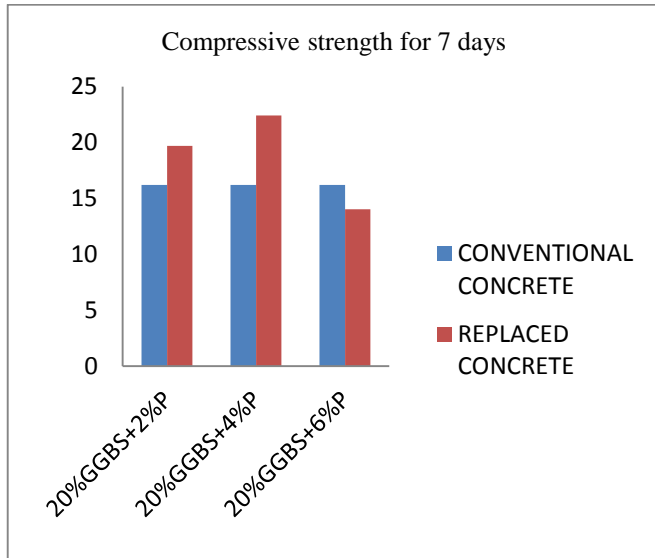
**3.1 Compressive strength test results**

At 7, 28 and 56 days strength of the concrete specimen of each mixture at respective curing age is tested in the compressive testing machine. For each mixture, three specimens are cast and the average value of the compressive strength are tabulated in the table and plotted in the graph given below.

This tabulation shows the compressive strength taken at temperatures (105°C) with the unheated sample for all the four types of mixtures given below.

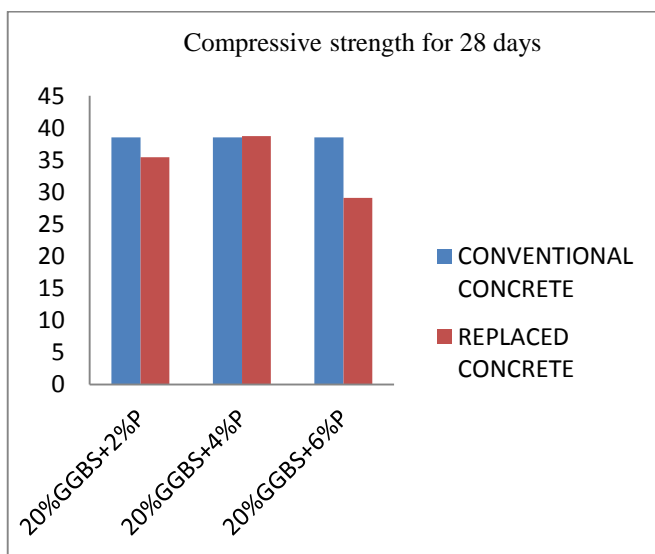
**Table 10: Compressive strength of the concrete (MPa) for 7, 28 and 56 days**

S.no	Replacement of Perlite powder and GGBS	Compressive strength (MPa) for 7days	Compressive strength (MPa) for 28 days	Compressive strength (MPa) for 56 days
1	Conventional Concrete	16.22	38.51	38.44
2	20%GGBS+2%P	19.70	35.41	36.59
3	20%GGBS+4%P	22.41	38.72	39.80
4	20%GGBS+6%P	14.02	29.10	31.72



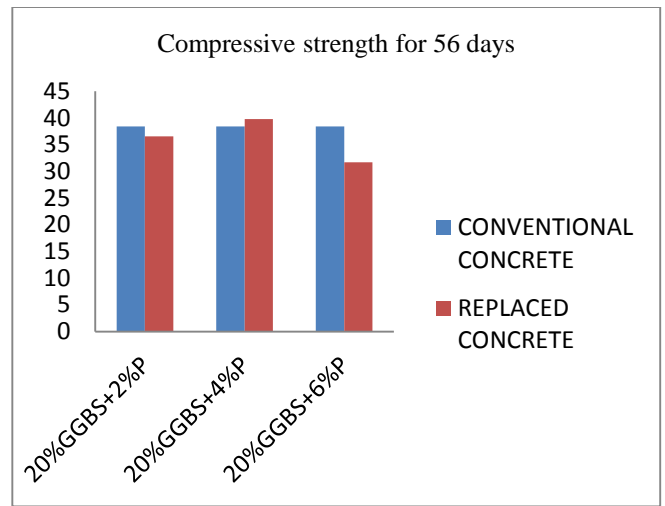
**Fig. 5: compressive strength for 7days**

From the above graph, we observed that the partial replacement of perlite and GGBS of 24% has the ultimate strength of 22.41MPa and then decreased the compressive strength for 26% of 7days respectively.



**Fig. 6: Compressive strength for 28 days Test**

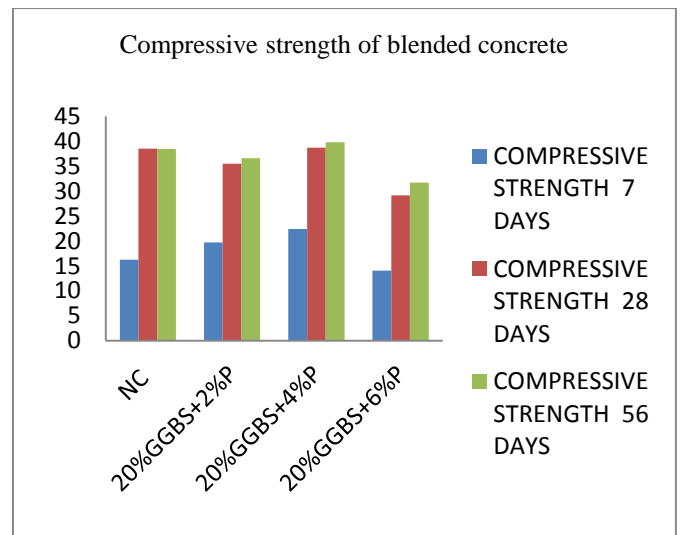
From the above graph, we observed that the partial replacement of perlite and GGBS of 24% has the ultimate strength of 38.72 MPa and then decreased the compressive strength for 26% of 28 days respectively



**Fig. 7: Compressive strength for 56 days**

From the above graph, we observed that the partial replacement of perlite and GGBS of 24% has the ultimate strength of 39.8 MPa and then decreased the compressive strength for 26% of 56days respectively.

**3.2 Comparative study of Compressive strength at 7, 28 and 56 days of curing**



**Fig. 8: Comparison of compressive strengths for conventional and replaced concrete at 7, 28 and 56 days curing**

**3.3 Tensile Strength Results**

At 7 and 28 days strength of the concrete specimen of each mixture at respective curing age are tested in the universal testing machine. For each mixture, one specimen is cast and the average value of the tensile strength are tabulated in the table and plotted in the graph given below.

**Table 12: Tensile strengths of replaced concrete**

S.no	Partial replacement of perlite and GGBS	Tensile strength for 7 days	Tensile strength for 28 days
1	CC	1.16	2.37
2	20%GGBS+2%Perlite	1.36	2.06
3	20%GGBS+4%Perlite	2.28	2.41
4	20%GGBS+6%Perlite	2.17	2.36

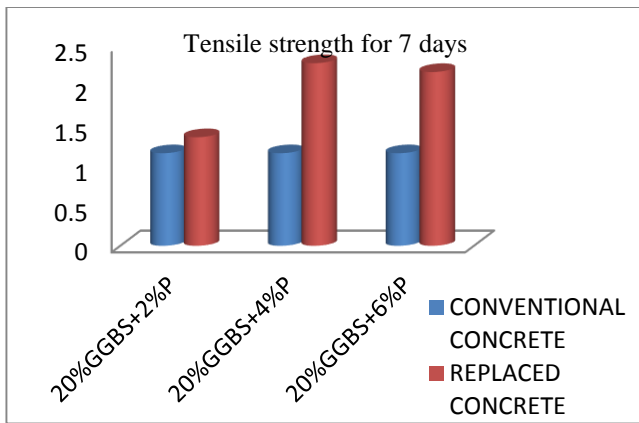


Fig. 9: Comparison of tensile strengths of conventional and replaced concrete

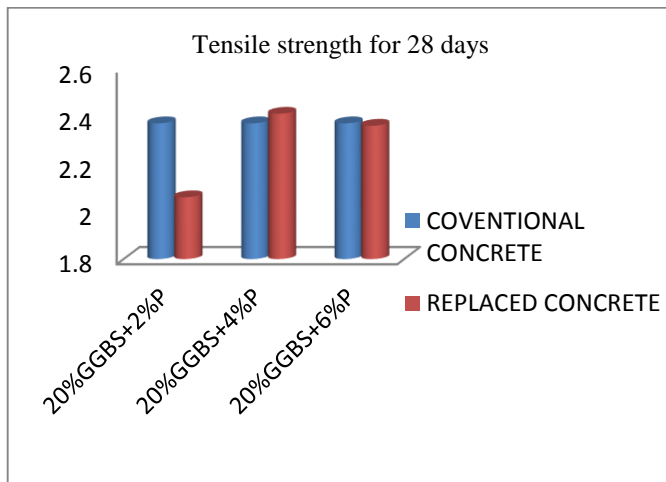


Fig. 10: Comparison of tensile strengths for conventional and replaced concrete

3.4 Comparative study of tensile strength at 7 and 28 days of curing

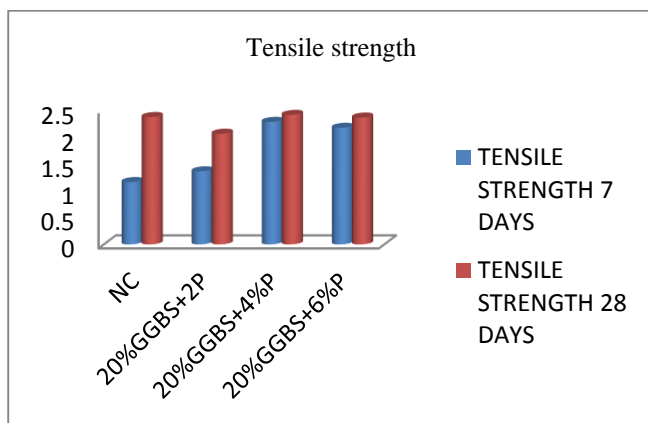


Fig. 11: Comparison of tensile strengths for conventional and replaced concrete at 7 and 28 days curing

4. CONCLUSIONS

- We concluded that on 7,28 and 56 days strength of the specimen at 105°C has maximum compressive strength obtained for the mix having 4% PP and 20%GGBS shows 22.41 MPa and 38.72 MPa respectively.
- As the percentage of perlite powder increases at 4%, both the compressive strength and tensile strength values increased by 0.54% and 1.68% respectively as compared to conventional concrete.
- Surface cracks observed at temperature 600°C and it gets more pronounced to further temperature and change of color also seen at this temperature.
- Increasing the target temperature lowers the strength of the concrete in all mixes.
- However, the increase in the temperature suppresses the concrete strength, blends of GGBS and PP makes the concrete more resistant to heat.
- The blends of GGBS and PP show excellent compressive strength than the conventional concrete.
- From all the mixes, a mix of 4% PP and 20% GGBS proven to be better at elevated temperatures than the others.

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