Study on Effect of Curing for Red Soil Based Geopolymer Bricks

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ABSTRACT
The main problem facing the world today is pollution. In the construction industry, especially during the production of Portland cement, pollutants are emitted which lead to environmental pollution. in the present study, to make the geopolymer bricks, the ordinary Portland cement is fully replaced with fly ash and the fine aggregate is replaced with stone dust and alkaline liquids are used for the binding of materials. In this study an attempt is made to identify the optimum methodology of curing, by curing the red soil based geopolymer bricks with various curing temperature from 60^0c to 120^0c with a variation of 10^0c for 24 hours in oven. From the optimum elevated temperature obtained, specimens are cured for 24 hours,48 hours and 72 hours in oven and also comparative study is carried out between elevation curing and ambient curing. The specimens are tested for physical and durable aspects.

Keywords*: *red soil, class c fly ash, geopolymer bricks, compressive strength, sem analysis

I. INTRODUCTION

Geopolymer brick is relatively new material that does not require OPC as a binder; instead, product components rich in silicon and aluminium are activated by alkaline solutions to generate bricks. Because of fly ash is high in aluminium oxide (Al_2O_3) and silica oxide (SiO_2) , it can react with an alkaline activator solution to make geopolymer mortar.

The ideal temperature for geopolymer synthesis is between 25^0C to 80^0C. Geopolymers, on other hand, offer good mechanical qualities such as stiffness and compressive strength, as well as exceptional resistance to heat, acids and organic solvents. Despite recent advancements in the construction sector, bricks and blocks remain the most common building materials. When it comes to product selection, the traditional burnt bricks continue to reign supreme, with cost being the primary determining element.

1.1 Objectives

Study the effect of elevation curing for geopolymer bricks by varying temperature of 10^0C from 60^0C to 120^0C in oven for 24 hours. By using above optimum temperature, study the effect of curing for 24hrs, 48hrs and 72hrs. And then Study the effect of ambient curing of geopolymer bricks for 7 days, 14 days, 21 days and 28 days. Arriving a design chart for optimum method of curing for geopolymer composites.

II. MATERIALS AND METHODOLOGY

2.1 Materials

2.1.1 Geopolymer

Geopolymer was created by combining an aluminosilicate source with a strong alkali solution such as sodium hydroxide (NaOH) or potassium hydroxide (KOH) and a silicate solution such as sodium silicate or potassium silicate.

Geopolymer solution

2.1.2 Red Soil

Red soil is a type of soil that grows well in warm, humid environment. They grow in deciduous forests and are most commonly seen in mixed forest. The features of red soil have a significant impact on strength, imperviousness, and anti- pest control. After conducting the tests, it was determined that red soil is suitable for use as an additive in concrete and can be utilised in the construction of structures.

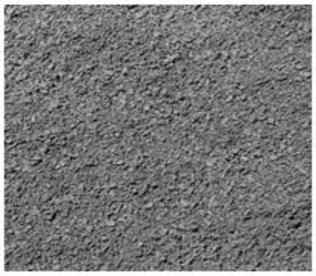
Characterization of red soil

Sl. No	**Test**	**Results**
1	Specific Gravity	2.62
2	Liquid Limit	34.12%
3	Plastic Limit	17.78%
4	pH	7.24
5	Dry Density	1.91gm/cc

Red soil

2.1.3 Stone Dust

Quarry dust and rock dust are other names for stone dust. Stone dust is a by-product produced by stone crusher operations. The use of stone dust in concrete can help to preserve natural river sand for future generations while also improving concrete quality.



Stone dust

2.1.4 Fly Ash

Fly ash is a rich source of silica and alumina for geopolymers and is widely available across the world.

Fly ash

2.2 Methodology

After obtaining all of the necessary ingredients and characterising them for physical and chemical parameters in accordance with IS guidelines, prepare NaOH solution 8M using NaOH pellets. By preparing the geopolymer precursor of NaOH to Na2SiO3 in a 1:2 ratio prior to use. And gently dry combine the red soil, fly ash, and stone dust in the proportions of 60:10:30. These dry mixes are completely blended with geopolymer precursor. Bricks are cast using geopolymer composite and given a day to achieve green strength. The casted specimens are then cured at a range of increased temperatures ranging from 60°C to 120°C with a 10°C variance and tested for compressive strength. From the above optimum temperature specimens are cured for various days from 1 to 3 days and tested for compressive strength.

The specimens are cured at ambient curing and specimens are tested for various days (7, 14, 21, 28 and 90 days). Arriving at design chart for optimum curing methodology for geopolymer composites. And the Structural integrity is carried out for the strength varied specimens, to identify the formation of chemical composition with the effects of curing.

Preparation of geopolymer solution

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Dry mixing of materials

Placing of mixed materials in mould

Removing the specimen from the mould

Brick specimen

2.3 Tests On

The various tests carried out to obtain the properties of bricks are listed below. The characteristics of the bricks is obtained by conducting different tests on it which includes

1. Compressive strength
2. Water absorption tests
3. Alternative wetting and drying test

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4. Durability test
5. sulphate resistance test
6. Chloride – ion diffusion test
7. Scanning Electron Microscope (SEM)

2.3.1 Compressive Strength Test

After a certain curing time, the dimensions of the sample were measured with vernier callipers and the total mass was determined with an electronic balance. The specimen was then mounted in a tri axial testing frame to determine the unconfined compressive strength. The load was applied at strain rate of 1.2mm/minute until failure. As previously mentioned, three identical specimens were prepared for each mix proportions. The reported compressive strength for each sample is the average of three measurements.

2.3.2 Water Absorption Test

The specimen was selected in random which are cured at 28 days and oven dried at 110^0c at which it gains the substantial constant mass. Once it attains the room temperature after cooling, the mass of specimens was taken as M_1. The dried specimen is then immersed in water for 24 hours. After which the brick is taken out from the water and wiped with a damp cloth and mass of that brick is taken as M_2

The percentage of water absorption is obtained as

Water absorption = $(M_2-M_1) / M_1$ x 100%

2.3.3 Alternate Wetting and Drying Test

The dry weight of the brick specimen subjected to testing is measured. After which the specimen is immersed in water for 24 hrs and then the mass of the brick is noted. The brick specimen is then oven dried at 110^0c for 24 hrs and again the mass is noted which completes one cycle, the same procedure is carried up to 7 cycles. The compressive strength of the brick after 7 cycles is obtained by compressive testing machine.

2.3.4 Durability Test

Among several deterioration process, destructive attack by various chemical considered are

i) Sulphate resistance test

ii) Chloride-ion diffusion test

i) Sulphate Resistance Test

As per the experiment 5% MgSO4 solution is formed by diluting 5g of MgSO4 particles in 100 ml of distilled water. To submerge the entire brick in the solution, prepare the required amount of MgSO4 solution. After 28 days, the bricks are removed from the solution, cleaned with a damp cloth and tested for compressive strength.

ii) Chloride-ion Diffusion Test

The chloride solution is prepared by diluting 5g of NaCl in 100ml of distilled water i.e, 5% solution and the brick is immersed in the solution completely. After 28 days of soaking in the solution the compressive strength check is done on the brick.

2.3.5 Scanning Electron Microscope (SEM)

Surface morphology of Red soil and geopolymer composite blocks were examined utilizing SEM instrument at Siddaganga Institute Of Technology, Tumkur. On the basis of results, we concluded that, it show agglomeration of sodium silicates.

III. RESULTS AND DISCUSSION

Red temperature Soil Based Specimen
Specimen Type and Ratio : Brick and 1:2(NaOH : Na_2SiO_3)

3.1 Compressive Strength after 24 Hours Oven Curing at Elevated

Trial No.	**Temperature (^{0}C)**	**Avg. compressive strength (N/mm^2)**
1	60^{0}C	4.23
2	70^{0}C	5.46
3	80^{0}C	3.56
4	90^{0}C	3.47
5	100^{0}C	1.27
6	110^{0}C	2.18
7	120^{0}C	1.50

Table 3.1

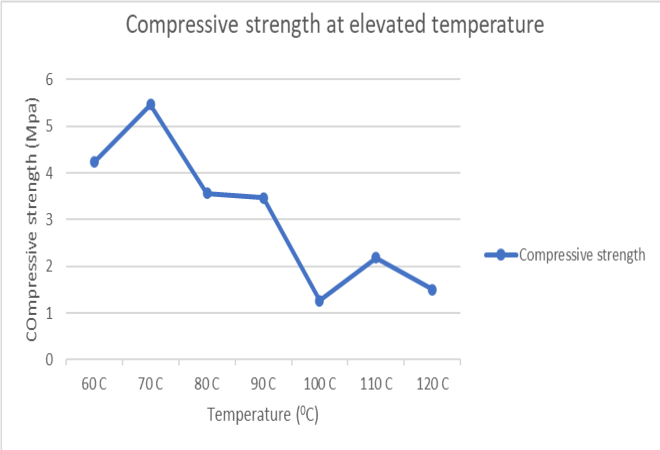

Figure 3.1: Graph on compressive strength after 24 hours oven curing at elevated temperature

Observation

The strength increased by 29.07% when the temperature was raised from 60^{0}c to 70^{0}c, and then fell by 15.83% when the temperature was raised by 10^{0}c to 80^{0}c. The strength has been reduced as the temperature has been raised. As a result, 70^{0}c is regarded as the optimum curing temperature.

3.2 Water Absorption Test

Compressive strength after 24 hours of water absorption

Trial no	**Temperature (^{0}C)**	**Avg. compressive strength (N/mm^2)**
1	60^{0}C	4.17
2	700C	4.80
3	800C	4.00
4	900C	3.62
5	1000C	3.55
6	1100C	3.44
7	1200C	3.40

Table 3.2

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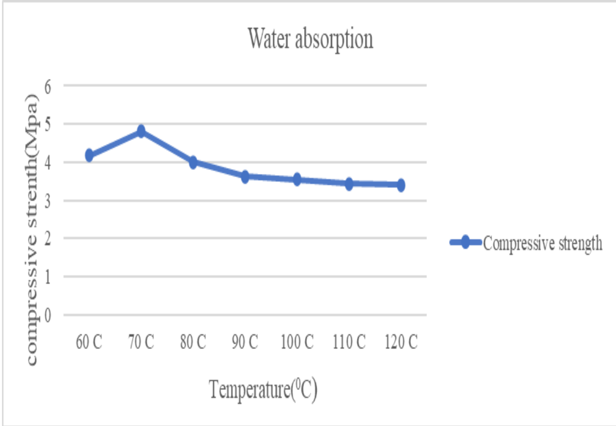

Figure 3.2: Graph on compressive strength after 24 hours of water absorption

Observation

The strength increased by 15.10% when the temperature was raised from 60^0c to 70^0c.When the temperature was raised again by 10^0c to 80^0c, the strength decreased by 4.07%. The strength has decreased as the temperature has been raised. As a result, 70^0c is regarded as the optimum curing temperature.

Compressive strength after Alternative drying and wetting test

Trial no	**Temperature (^{0}C)**	**Avg. compressive strength (N/mm^2)**
1	60^0C	5.64
2	70^0C	5.77
3	80^0C	5.56
4	90^0C	3.37
5	100^0C	3.96
6	110^0C	3.44
7	120^0C	3.40

Table 3.3

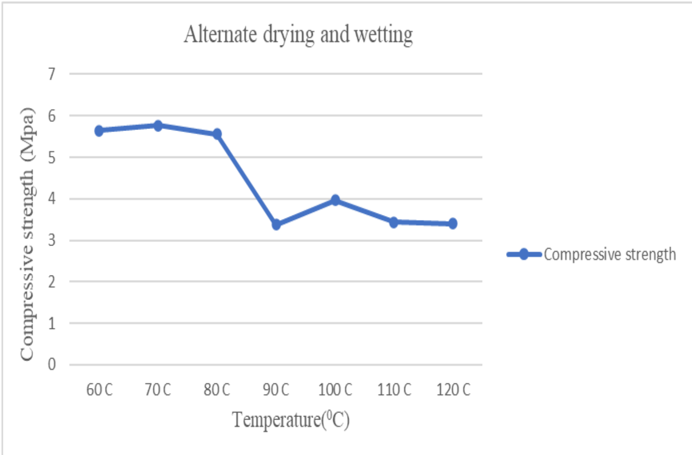

Figure 3.3: Graph on compressive strength after alternative drying and wetting test

Observation

The strength increased by 2.30% when the temperature was raised from 60^0c to 70^0c. When the temperature was raised again by 10^0c to 80^0c, the strength decreased by 1.42%. The strength has decreased as the temperature has been raised. As a result, 70^0c is considered as the optimum curing temperature.

3.4 Compressive Strength after Sulphate Attack Test

Trial No	Temperature (^{0}C)	Avg. compressive strength (N/mm^2)
1	60^0C	2.00
2	70^0C	3.15
3	80^0C	1.45
4	90^0C	1.55
5	100^0C	1.39
6	110^0C	2.15
7	120^0C	1.61

Table 3.4

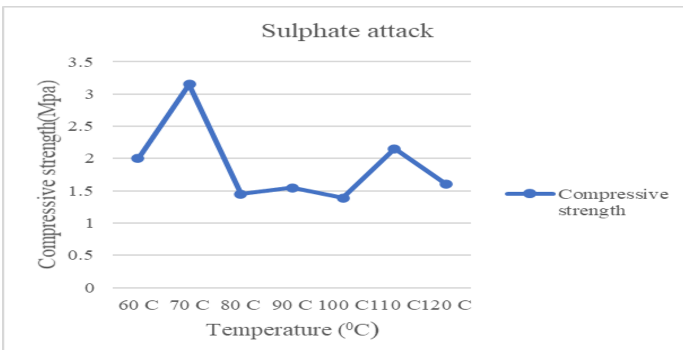

Figure 3.4: Graph on results of compressive strength after sulphate attack test

Observation

The strength increased by 57.5% when the temperature was raised from 60^0c to 70^0c. When the temperature was raised again by 10^0c to 80^0c, the strength decreased by 27.5%. The strength has decreased as the temperature has been raised. As a result, 70^0c is regarded as the optimum curing temperature.

3.5 Compressive Strength after Chloride Attack Test

Trial No	Temperature (^{0}C)	Avg. compressive strength (N/mm^2)
1	60^0C	2.79
2	70^0C	3.72
3	80^0C	2.21
4	90^0C	1.78
5	100^0C	1.84
6	110^0C	2.49
7	120^0C	2.34

Table 3.5

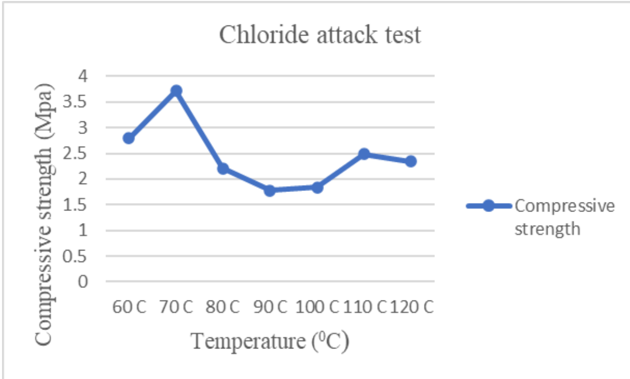

Figure 3.5: Graph on results of compressive strength after chloride attack test

Observation

The strength increased by 33.33% when the temperature was raised from 60^0c to 70^0c. when the temperature was raised again by 10^0c to 80^0c, the strength decreased by 26.24%. The strength has decreased as the temperature has been raised. As a result 70^0c is regarded as the optimum curing temperature.

3.6 Compressive Strength Test at Optimum Temperature of 70^0C

Trial No	No of hours	Avg. Compressive strength (N/mm^2)
1	24	5.45
2	48	4.45
3	72	3.46

Table 3.6

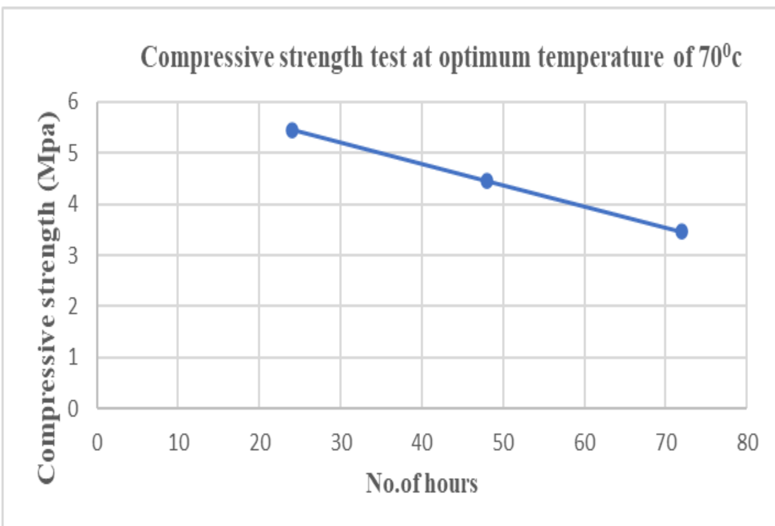

Figure 3.6: Graph on results of compressive strength test at optimum temperature of 70^0C

Observation

The specimens are cured for 70^0c for 24hrs, 48hrs and 72hrs, but as the number of hours in the oven increases, the strength decreases, with a compressive strength of 36.51%. As a result, 24hrs of 70^0c curing in the oven is regarded optimum temperature Curing.

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3.7 Ambient Curing Brick Specimens Test Results

3.7.1 Compressive Strength for Ambient Curing

Trial No	No of days	Avg. compressive strength(N/mm^2)
1	7	2.58
2	14	3.62
3	21	4.56
4	28	6.22

Table 3.7.1

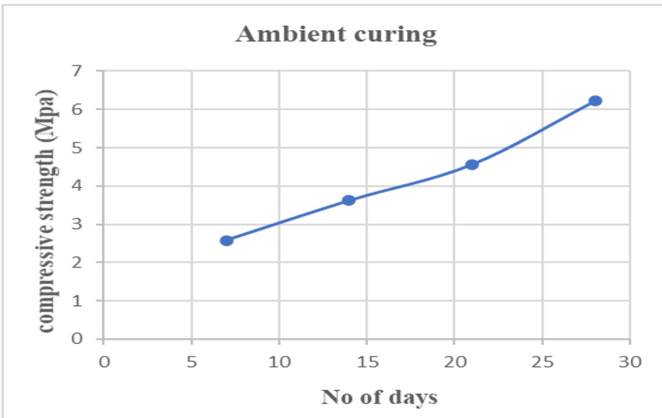


Figure 3.7.1: Graph on results of compressive strength of ambient curing

Observation

The strength has gradually increased as the number of days of curing has increased, at the end of 28 days, the strength has increased to 141.08%.

3.7.2 Water Absorption of Ambient Curing Bricks after 28 Days

Trial No	Compressive strength	Avg. compressive strength(N/mm^2)
1	4.98	4.97
2	4.96	
3	4.98	

Table 3.7.2

Observation

- Compressive strength was decreased by 20.09% after water absorption.

3.7.3 Alternate Drying and Wetting Test of Ambient Curing Bricks after 28 Days

Trial No	Compressive strength	Avg. compressive strength(N/mm^2)
1	4.30	4.25
2	4.20	
3	4.25	

Observation:

- Compressive strength was decreased by 31.67% after alternate drying and wetting test.

3.7.4 Sulphate Attack Test of Ambient Curing Bricks after 28 Days

Trial No	Compressive strength	Avg. compressive strength(N/mm^2)
1	3.20	3.12
2	3.00	
3	3.15	

Table 3.7.4

Observation
Compressive strength was decreased by 49.89% after sulphate attack test.

3.7.5 Chloride Attack Test of Ambient Curing Bricks after 28 Days

Trial No	Compressive strength	Avg. compressive strength(N/mm^2)
1	4.12	4.15
2	4.18	
3	4.16	

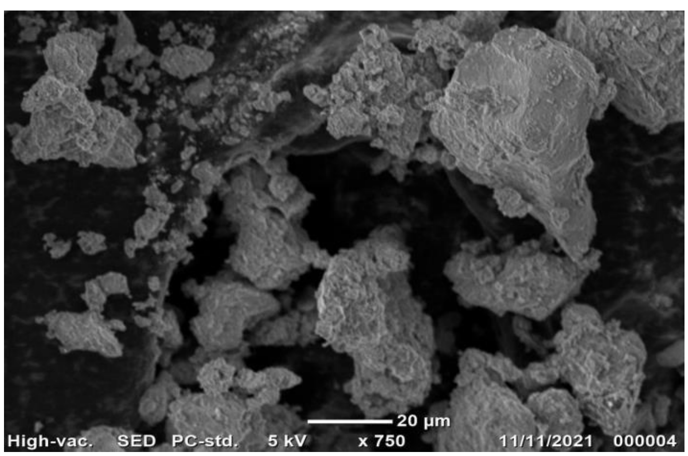
Table 3.7.5

Observation
Compressive strength was decreased by 33.27% after chloride attack test.

IV. SCANNING ELECTRON MICROSCOPE (SEM)

Surface morphology of red soil and geopolymer composite blocks were examined utilizing SEM instrument at Siddaganga Institute of Technology, Tumkur.
On the basis of results, we concluded that, it show agglomeration of sodium silicate.

i) SEM Analysis for 70^{0}C Curing Bricks at 24hrs



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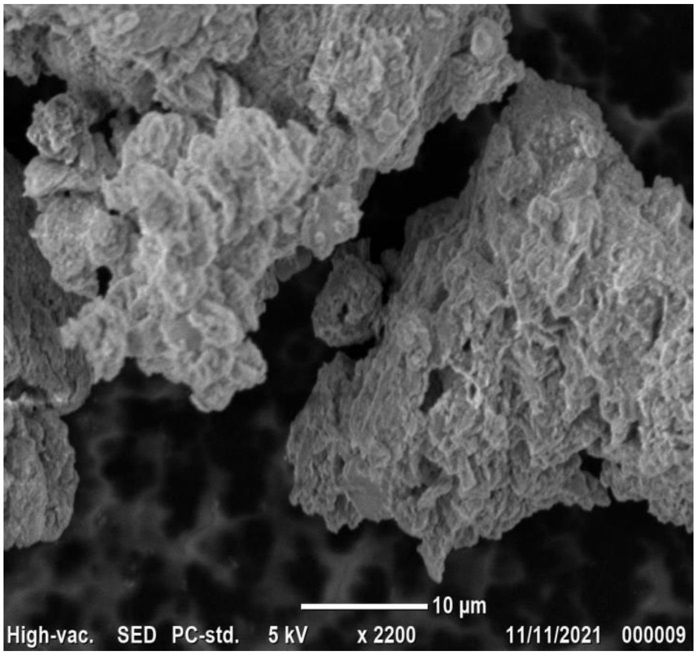
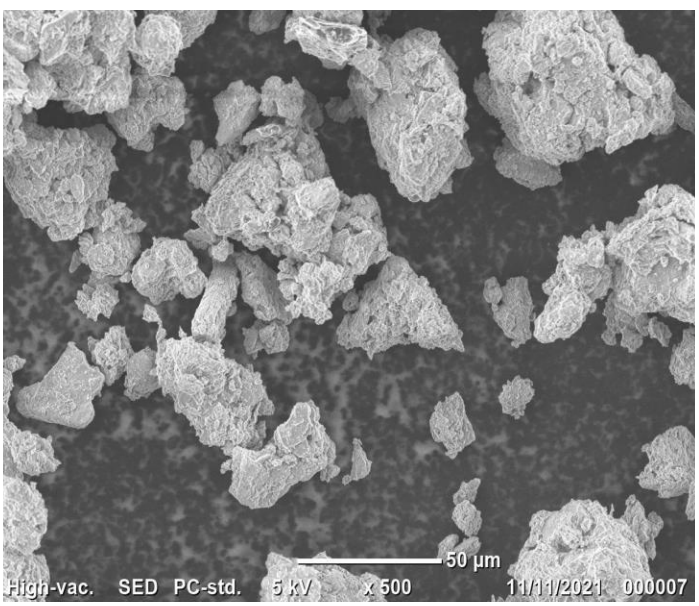
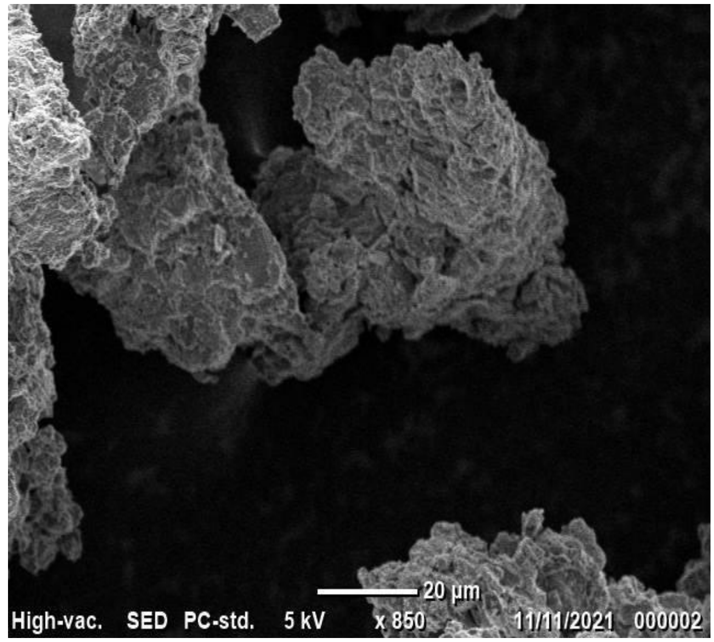
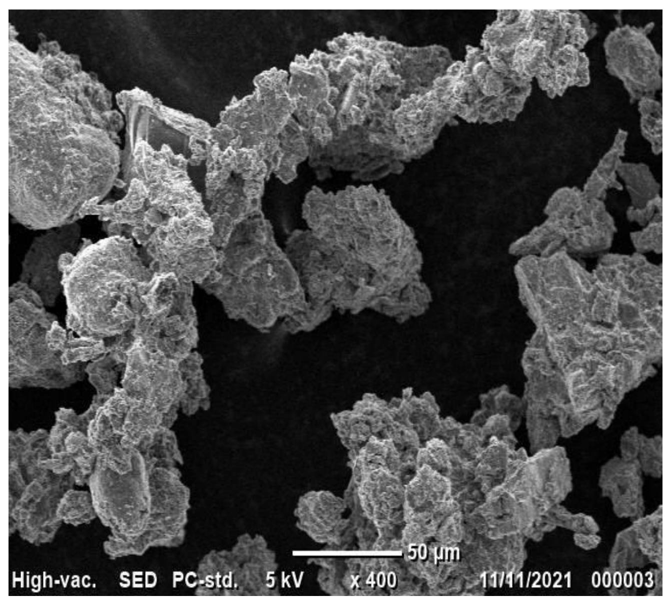
ii) SEM Analysis for 70^0c Curing Bricks at 72hrs



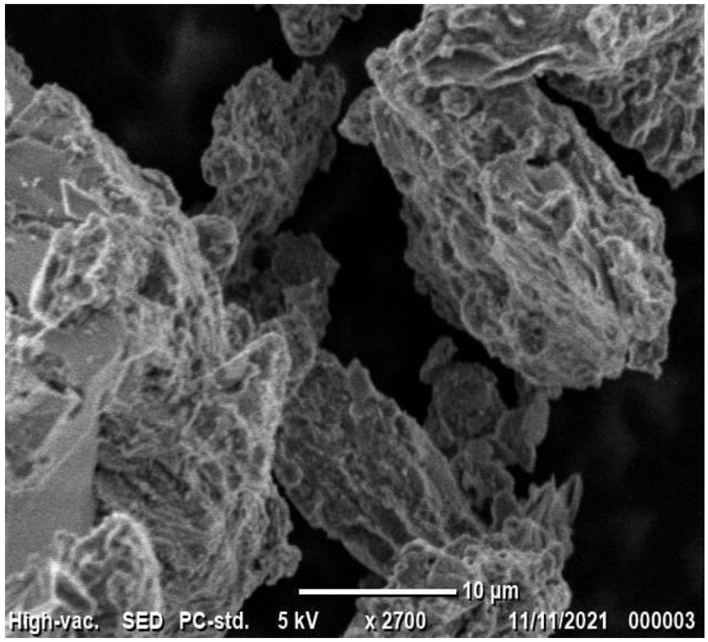


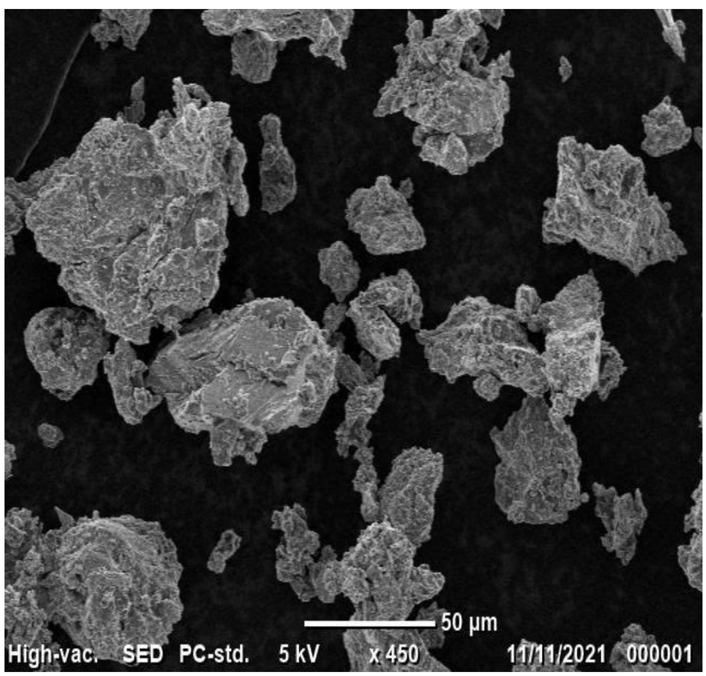
iii) SEM Analysis for 120^0C Curried Geopolymer Bricks





iv) SEM Analysis for 28 Days Ambient Curried Geopolymer Bricks





V. CONCLUSIONS

The following conclusions can be drawn for the project:

- Specific gravity of materials used are Red soil - 2.62, Stone dust – 2.41, Fly ash – 2.41.
- The Liquid limit and plastic limit of red soil obtained was 32.7% and 17.78% respectively.
- In this study, it observed that, the compressive strength increases in oven curing temperature 70^0c and decreases with further increases in the temperature gradually.
- The 70^0c of curing for 24 hrs given better strength compare to other curing temperature.
- The increasing the days of curing in oven 1 to 3 days shown decrease in strength.

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- 70^0c for 24 hrs oven curing is considered as optimum temperature.
- Ambient curing shows that strength increase gradually for 7 to 28 days.
- Ambient curing shows better strength than oven curing.

FURTHER SCOPE OF WORK

- The project is the study on geopolymer brick with red soil, stone dust and fly ash was carried out. Here geopolymer can be used in concrete and its behaviour can be identified.
- Both Stone dust and fly ash are major waste materials. Like this, many other materials are also present globally. Therefore, research is required to be carried for other waste materials.

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