Investigations of geopolymer on cupola slag concrete

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Abstract

Inventive studies on cupola slag geopolymer concrete has carried out and presented in this work. The experiments were conducted by varying replacement levels at 50 % and 100% and molarity of Sodium hydroxide solution at 8M, 10M and 12M respectively in cupola slag concrete and the properties such as Compressive Strength were measured. Cupola slag geopolymer concrete attained maximum compressive strength at 50% at the time of 12 M of NaOH solution. However compressive strength increases by increasing the molarity of sodium hydroxide solution with cupola slag replacements. It can be figured by saying that use of cupola slag for fine aggregates exhibits enriched good properties when replaced under the optimal molarity and it concludes that increases in molarity increase in strength. The value of compressive strength and split tensile strength of cupola slag geopolymer concrete is high computed to conventional concrete.

Keywords: *Cupola slag, Geopolymer, Compressive strength, Split tensile strength*

1. Introduction

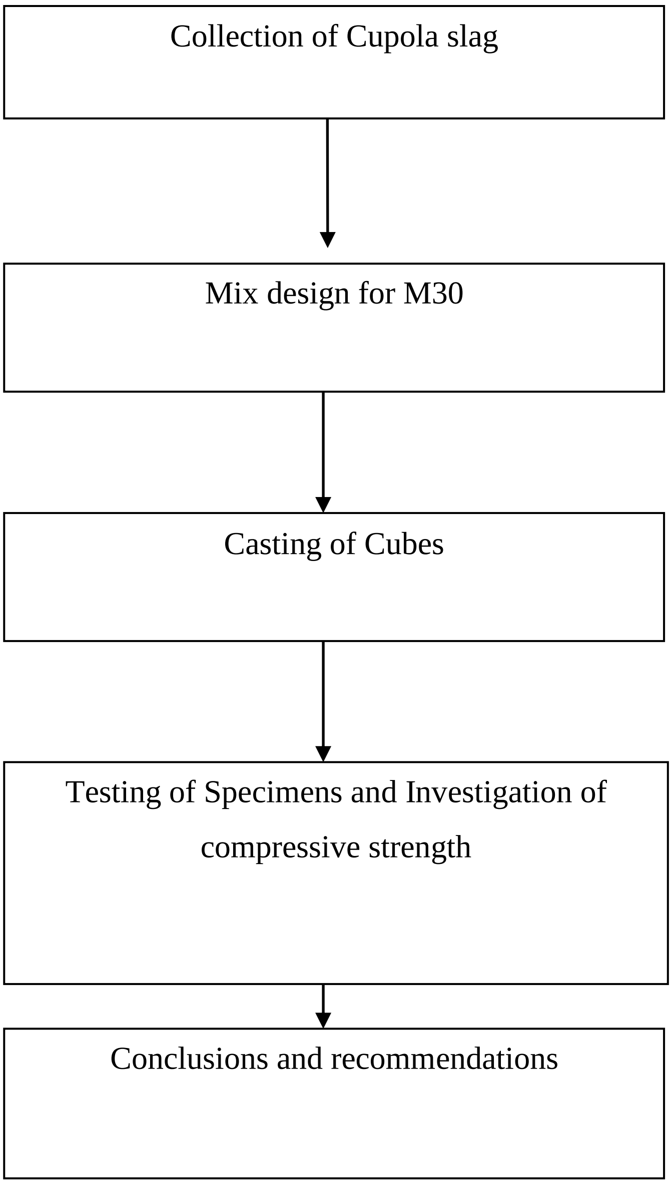
Concrete is a adaptable material used for construction in all over countries. Pyro processing is required for the production of cement requires of materials at temperatures between 1400°C – 1500°C, which makes it an energy intensive process and costly. Moreover due to the calcinations of limestone and combustion of fossil fuel during the manufacture of cement CO is the primary green house gas is released to the atmosphere. Therefore the usage of cement concrete should be decreased and there should be environmental friendly concrete used in construction.

Iron slag, steel slag, cupola furnace slag, induction furnace slag, blast furnace slag, electric arc furnace slag are some common types of foundry slags. The types of slag depend upon the composition of raw material and the type of furnace used during the manufacturing process of pig iron and steel. High strength concrete (HSC) has been frequently used in civil engineering structures to reduce the size of structural elements, i.e. beams and columns of high rise buildings.

Baricova et al. made a deep investigation on the blast furnace and cupola furnace slag utilization in the concrete production. Pilot experiments of the concrete production were performed, by that the blast furnace and cupola furnace slag with a fractions of 0–4mm; 4–8mm; 8–16mm were used as a natural substitute. A cupola furnace slag and combination of the blast furnace and cupola furnace slag were used in the experiments. Their analysis results showed that such concretes are suitable for less demanding applications.

According to Mehta (1999) concluded that for sustainable development environmentally-friendly concrete technology are the conservation of primary materials, the enhancement of the durability of concrete structures.
According to Davidovits geopolymers are inorganic polymeric materials primarily made from the polymerization of industrial waste materials such as kaolin, metakaolin, fly ash, granulated blast furnace slag and rice husk ash etc. which are rich in silica and alumina.The strength attain 90 % is higher compared to conventional concrete within 4 hours of the polymerization reaction.
Geopolymer concrete yields more strength in short time and the fact that more byproduct from iron-steel industries waste slag is a abundantly available so I carried out trial investigation to study the properties of concrete by varying geopolymer solution. Likely geopolymer concrete can be prepared by cupola slag. Experimental studies in geopolymer concrete prepared using cupola slag is also conducted and presented in our work.

2. Methodology and Mix design



2.1 Mix design

Characteristic strength = 30 MPa
Specific gravity of sand = 2.25
Specific gravity of Cement = 3.15
Target strength = f_{CK}+ks
= 30+1.65x5
= 38.25N/mm^2

From table 11.24, for 20mm sieve (coarse aggregate)
Sand as percent of total aggregate by absolute volume = 35
Therefore required sand concrete as percentage of total aggregate by absolute volume = 35-3.5 = 31.5%
Required water content =186+5.58 = 191.l/m^3

2.2 Determination of cement content

Water cement ratio = 0.45
Volume of Water = 195.6 lit
Weight of Cement =195.6/0.45 = 434.66 kg

2.3 Determination of coarse and fine aggregate content

The Absolute volume of fresh concrete is determined as follows:

$V= [W+(C/S_c) + (1/P) x (F_a/S_{Fa})] 1/1000$

V- Absolute volume of fresh concrete, which is equal to gross volume (m^3) minus the volume of entrapped air.

W- Mass of water (kg) per m^3 of concrete
C- Mass of cement (kg) per m^3 of concrete
S_c - specific gravity of cement
P- Ratio of FA to total aggregate by absolute volume
F_a, C_a- total masses of FA and CA (kg) per m^3 of concrete respectively and
S_{Fa}, S_{ca}- specific gravities of saturated, surface dry fine aggregate and coarse aggregate

0.98 = [191.61+ (425.80/3.15) + (1/0.315) x (F_a/2.1)] 1/1000
980 = 1.512F_a+326.784
F_a = 440.020kg/m^3
C_a = [(1-P)/P*F_a*S_{ca}/S_{Fa}]
C_a = [(1-0.315)/0.315x432.020x2.6/2.25]
C_a = 1180.158kg/m^3

3. Experimental work

3.1 Compressive strength

The compressive test on both conventional concrete and cupola slag concrete is carried out in accordance with IS 516- 1999 standards, The test is conducted on concrete specimens of size 150mm x 150mm x 150mm. The specimen is placed at the centre of the compressive testing machine platform, the load is applied gradually till the specimen fails. The experimental set up for the measurement of compressive strength is shown in **Figure 1.**The compressive strength of the specimen are calculated as follows

Compressive strength = P/A

Where, P – Load at which cube fails, kN

A – Area of cube under loading, mm^2

Figure 1. Compressive strength

4. Results and discussions

An trial study were conducted for conventional and cupola slag geopolymer concrete by changing the molarity of sodium hydroxide solution with partial replacements to obtain compressive strength. The following outcome where made from the experimental investigations.

Table 1. Compressive strength of conventional concrete in M30

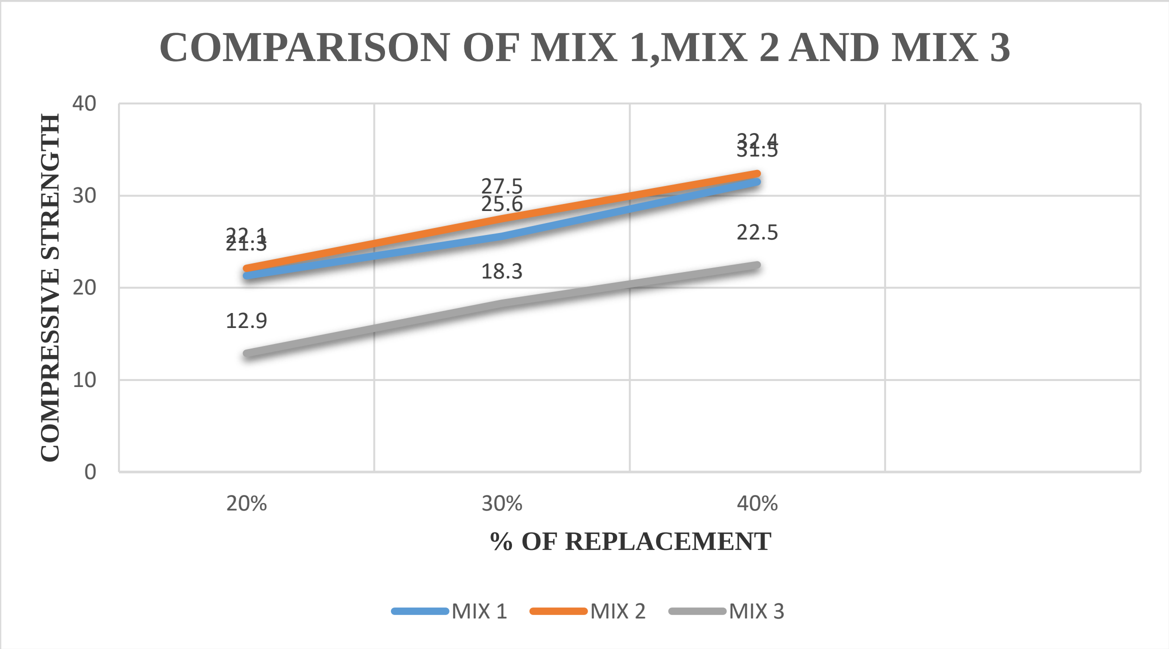
Trial No.	MOLARITY	Ult. load (KN)	Comp. strength (N/mm^2)	Avg. comp. strength (N/mm^2)
1.	8 M	544	24.2	24.8
2.		573	25.5	
3.	10 M	669	28.6	28.4
4.		655	28.3	
5.	12 M	808	35.9	36.7
6.		845	37.6	

Table 2. Compressive strength of 50 % replacements

Trial No.	MOLARITY	Ult. load (kN)	Compressive strength (N/mm^2)	Avg. comp. strength (N/mm^2)
1.	8 M	487	21.6	21.3
2.		473	21.0	
3.	10 M	581	25.8	25.6
4.		572	25.4	
5.	12 M	705	31.3	31.5
6.		713	31.7	

Table 3. Compressive strength of 100% replacements

Trial No.	MOLARITY	Ult. load (KN)	Compressive strength (N/mm^2)	Avg. comp. strength (N/mm^2)
1.	8 M	291	12.9	12.9
2.		288	12.8	
3.	10 M	405	18.0	18.3
4.		417	18.5	
5.	12 M	505	22.4	22.5
6.		509	22.6	



5. Conclusions

- It is observed that the compressive strength for cupola slag replacement at 50 % and 100 % at 28 days increase its strength for 50 % with decrease in compressive strength for 100 % compared to conventional concrete.
- It can be concluded by saying that use of cupola slag for fine aggregates exhibits good mechanical properties when replaced under the usage of molarity`
- The maximum compressive strength attained at 12 M for 50 % replacements is 31.5 N/mm^2
- From the present investigations it is concluded that cupola slag fit to use as aggregates it reduce the waste obtained from cupola furnace and it can be reuse give enrich mechanical properties compared to conventional methods.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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