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Experimental Studies on Strength Parameters of Geopolymer Concrete

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ABSTRACT: As the infrastructure development growing worldwide, the demand for Ordinary Portland Cement (OPC) increases exponentially. Studies revealed that the production of one ton cement releases around one ton of CO₂ to the atmosphere due to the calcinations of lime stone and combustion of fossil fuel. The production of cement is highly energy intensive and it consumes a substantial amount of natural resources. Davidovits (1978) proposed that binders can be produced by polymeric reaction of alkaline liquid with alumino-silicate materials such as fly ash, metakaolin, blast furnace slag, rice husk ash etc. Geopolymer also has the ability to form a strong chemical bond with rock-based aggregates. In this project work, Metakaolin is used as a replacement for cement in the percentages 0, 25%, 50%, 75% & 100%. The mechanical strength properties of Geopolymer concrete are studied for 7 days and 28 days compressive strength and compared with conventional concrete.

KEYWORDS: carbon foot print, replacement of cement, alternative to OPC, metakaolin, Eco friendly concrete.

I. INTRODUCTION

Geopolymer are inorganic, typically ceramic alumino-silicate forming long-range, covalently bonded, non-crystalline (amorphous) networks geopolymers is a new environment-friendly Cementous material, and the development of geopolymer can reduce the CO₂ emission caused by the development of cement industry. Since the early 1980's, geopolymer material have been considered substitute for ordinary Portland cement (OPC), mainly because of their low carbon dioxide emission and performance advantages. In addition, the production of cement is highly energy intensive and it consumes a large number of natural resources. To reduce these problems, it is necessary to find out an alternative material for cement. Many researches were carried out to find out a replacement for cement. In 1978, Davidovits proposed that binders can be produced by polymeric reaction of alkaline liquid with alumino-silicate materials such as fly ash, rice husk ash, blast furnace slag etc. and termed these binders as geopolymers. Geopolymers can be considered as green material, because it relies on minimally processed natural materials or industrial by-products, thus reducing its carbon foot print.

Geopolymers have gained considerable attention for their rapid strength attainment, corrosion resistance, chemical stability, low rate of shrinkage and freeze thaw resistance. The existing Portland cement standard are not adopted for mix design for geopolymer concrete, presently the findings based on different experimental investigation on geopolymer concrete have been considered as reference. To produce the geopolymer concrete of desired strength, various mix proportioning by trial-and-error methods are being used on the basis of type of work, availability and properties of materials, field conditions and also workability and durability requirements.

II. RELATED WORK

Using Geopolymer concrete in place of normal concrete represents the reduction in generation of greenhouse gases, that is 80% less greenhouse gasses are produced. To Decrease the cement content in a concrete by adding



geopolymer as a binding material. To study the durability properties of a concrete by addition of admixtures and fibres in concrete. The demand for concrete as a construction material increases exponentially and thereby, there is an increase in the demand for the production for OPC. The production of cement is highly energy intensive and it consumes a large number of natural resources. The production of 1-ton cement releases around 1 ton of carbon dioxide to the atmosphere due to the calcination of lime stone and combustion of fossil fuels and cause the global warming conditions.

III. METHODOLOGY

The methodology to carry out the research work is as follows.

Collection of materials – Testing of materials as per IS specifications- Mix proportioning as per IS 10262:2019 – Casting and curing of specimens – Testing – Result & Discussion – Conclusion

MATERIALS USED

Cement: Portland Pozzolana cement (PPC) of 43 grade will be used throughout the course of the investigation. The physical properties of the cement as determined from various tests conforming to Indian Standard IS: 4031; 2017.

Aggregates: Are those chemically inert materials which when bonded by cement paste form concrete. Aggregates constitute the bulk of the total volume of concrete and hence they influence the strength of concrete to great extent. The properties of concrete are directly related to those of its constituents and as such aggregate used in a concrete mix should be hard, strong, dense, durable, and free from lumps of clays, loam, vegetable and other such foreign matter. The presence of all such debris prevents adhesion of cement on the surface of aggregates and hence reduces the strength of concrete.

Fine Aggregates: the material which passed through I.S. 2386 (4.75mm) is termed as fine aggregates. Function of fine aggregates is to make concrete dense, by filling voids of coarse aggregates, reduces the shrinkage of cement and makes an economical mix. Natural sand or crushed stone dust is used as a fine aggregate in concrete mix. Sand may be obtained from sea, river, lake or pit, but when used in a concrete mix, it should be properly washed and tested to ascertain that total percentage of clay, silt, salts and other organic matter does not exceed specified limit. Sand as obtained from the above sources may be round or angular in grains. Angular grained sand has good interlocking property which results in a strong mix while rounded grained sand does not afford sufficient interlock in the matrix. But for our project m-sand is used.

Coarse Aggregates: The material whose particles size such that they are retained on I.S 2386 (4.75mm) is termed as coarse aggregates. Coarse aggregates, like fine aggregates, must consist of sound durable inert particles to make the concrete strong and weather resistant. It should be free chemicals or coating or clay or other fine material that may affect bonding of cement paste. The size of the coarse aggregates used depends upon the nature of work. Crushed hard stone and gravel are the common materials used as coarse aggregates for structural concrete. Coarse aggregates are usually obtained by crushing granite, gneiss, crystalline lime stone and good variety of sand stone etc. As far as possible flaky and elongated pieces of stone should be avoid.

Metakaolin:

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Metakaolin is commonly used in the production of ceramics, but is also used as cement replacement in concrete. Metakaolin has a smaller particle size ($\sim 1-2 \mu\text{m}$) and higher surface area compared with Portland cement, but a larger particle size than SF. In this project we have used ALTIUS (calcinated kaolin) of brand SURYAM MINECHEM RAYS OF TRUST.

Type of metakaolin - ALTIUS (calcinated kaolin)

BRAND: Suryaminechem Rays of trust

Following are the physical properties of Metakaolin

Properties of Metakaolin

Whiteness (AIMIL) %	92.0 – 94.0
500 mesh residue %	Max. 0.4
Average particle size D50	1.25
Particle size (-2 micron)	57 ± 1
Moisture %	Max. 0.5
Specific gravity	2.6
pH	6.0 ± 0.5
Bulk density (untapped) (g/l)	300 ± 40
Oil absorption (g/100 gram)	45 - 60
Flow point (g/100 gram)	60 – 80
LOI (900°C) %	Max. 0.5

Tests on Cement

Tests as per IS 4031-2017

1. Specific Gravity- 2.95, 2. Initial Setting Time- 33 min, 3. Final Setting Time-520 min

Test on Fine Aggregate- sand

Tests as per IS 2386

1. Specific Gravity- 2.55, Sieve Analysis- 2.57

Test on Coarse Aggregate Gravel

Test as per IS 2386

1. Specific Gravity-2.72, Sieve Analysis-8.94

Mix Proportion: Mix proportion for M25 grade obtained using IS 10262:2019 is **1:1.33:2.48****IV. EXPERIMENTAL RESULTS****Test results of conventional concrete at 7 days**

Sl. No.	Cube name	Area in mm ²	Failure load kN	Crushing strength N/mm ²	Average crushing strength N/mm ²
1	Z1	22500	410	18.22	19.55
2	Z2	22500	440	19.55	
3	Z3	22500	470	20.88	

Test results of conventional concrete at 28 days

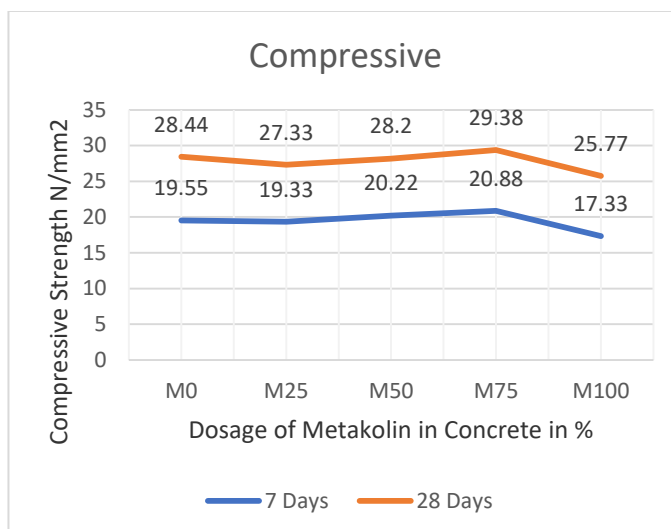
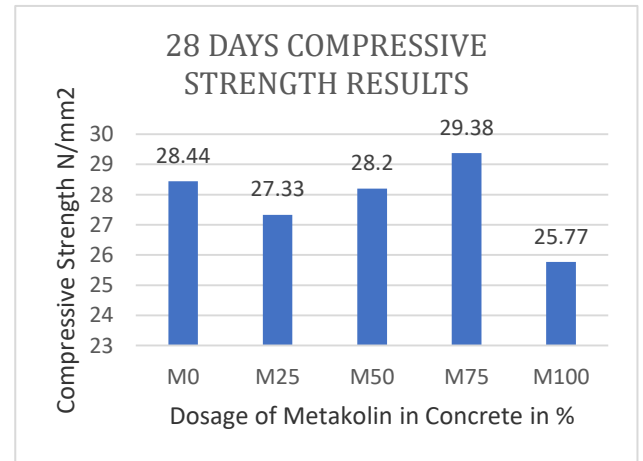
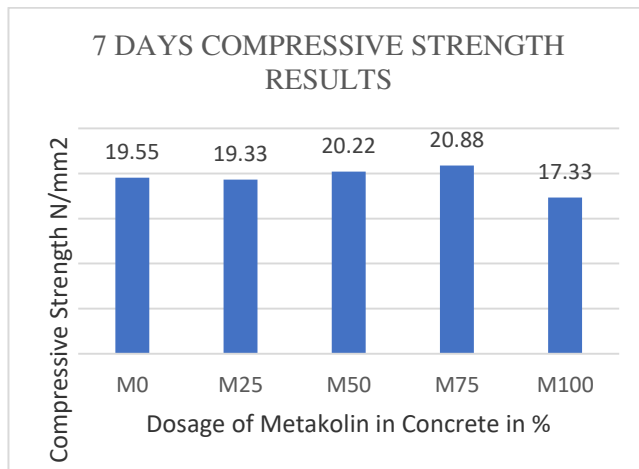
Sl. No.	Cube name	Area in mm ²	Failure load kN	Crushing strength N/mm ²	Average crushing strength N/mm ²
1	Z4	22500	610	27.1	28.44
2	Z5	22500	630	28.0	
3	Z6	22500	680	30.22	

Test results of geopolymer concrete at 7 days

Sl. No.	Cube name	% of metakaolin added	Area in mm ²	Failure load kN	Crushing strength N/mm ²
1	MK 25	25 %	22500	435	19.33
2	MK 50	50 %	22500	455	20.22
3	MK 75	75 %	22500	470	20.88
4	MK 100	100 %	22500	390	17.33

Test results of geopolymer concrete at 28 days

Sl. No.	Cube name	% of metakaolin added	Area in mm ²	Failure load kN	Crushing strength N/mm ²
1	MK 25	25 %	22500	620	27.33
2	MK 50	50 %	22500	635	28.2
3	MK 75	75 %	22500	665	29.38
4	MK 100	100 %	22500	580	25.77



V. CONCLUSION

From the test results and discussions carried out, following conclusion can be drawn:

- The test results on compressive strength of geopolymer concrete for 7 days and 28 days shows that there is a marginal increase in compressive strength of 3.3 % for 28 days with compare to conventional concrete and 6.8 % for 7 days with compare to conventional concrete respectively for the dosage of 75 % replacement of metakaolin with cement.
- From this project work we can conclude that metakaolin as a geopolymer can be a optimal replacement for a cement by which there is a gain in compressive strength as well as reducing the cement content and hence a step towards ecological environment.

VI. FUTURE SCOPE

- The mould dimensions can be varied.
- The Mix Proportion can be altered.
- The different chemical admixtures can be used according to requirement.
- As the main objective of the study was to determine the compressive strength of the geopolymer concrete block, various other parameters such as tensile strength, flexural strength can be studied.



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