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Experimental Study on Exploring the Potential of Low Cement Content Concrete through Alkaline Binder

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ABSTRACT
This paper describes the experimental study of using low cement content for concrete manufacturing by the application of polymerization. This geopolymer concrete technology will help us to reduce the carbon emission, economical and helps in growth of concrete industries. In this study industrial wastes like fly ash and GGBS are use for cementicious material whereas calcium hydroxide is used as alkaline activator for the process of polymerization. The paper reveals the experimental study about complete replacement of cement with flyash,GGBS and calcium hydroxide as binder activator. The concrete has good range of workability and there is no delay in setting time since accelerating admixture was used. The cube of size 150mmx150mmx150mm and cylinder of size 150mmx300mm are casted for M25 grade of concrete which is cured under normal temperature. The slump test revealed that the fresh concrete was cohesive and flow was from 80 mm to 120 mm .The compressive and tensile strength are evaluated which is ranges from 10.22 N/mm^2 to 34.22 N/mm^2 and 2.22 N/mm^2 to 4.52 N/mm^2 vice versa. The result of M2 and M3 are superior to conventional mix.

KEYWORDS: *Geoploymer Concrete, Alkaline solution, industrial waste, calcium hydroxide powder*

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I. INTRODUCTION

The global cement industry contributes around 1.35 billion tons of the green house gas emissions annually (e.g. [10]). In order to protect the global environment from the impact of cement production, it is now believed that new binders are helps to replace Portland cement. For that geopolymer concrete is one of the new technologies related to low cost materials and environmental friendly.

The geopolymer technology was first introduced by Davidovits in 1978. His work considerably shows that the adoption of the geopolymer technology could reduce the CO2 emission caused due to cement industries. Davidovits proposed that an alkaline liquid could be used to react with aluminosilicate in a source material of geological origin or in by-product materials such as fly ash to make a binder (e.g. [10]). The geoplolymer concrete is ecofriendly and greener concrete which has the potential to reduce the carbon emission. In this study compressive strength and split tensile strength of geoploymer concrete were carried out .The strength of concrete is basically depend on the (2006) reviewed the development of the ecological risk assessment paradigm in the United States, and identified ways it is being applied and adapted in other countries. Linkov, Satterstrom, Steevens, Ferguson and Pleus (2007) combined state-of-the-art research in multi-criteria decision attribute (MCDA) methods applicable to nanotechnology with a hypothetical case study for nanomaterial management. The example shows how MCDA application can balance societal benefits against unintended side effects and risks, and how it can also bring together multiple lines of evidence to estimate the likely toxicity and risk of nanomaterials given limited information on physical and chemical properties. Burger (2008) studied method for variation of different parameters like cement, flyash and GGBS proportions, addition of calcium hydroxide as alkaline activator etc.

The principal objective of the research were

1. The development of structural grade concrete with different combinations of FA and GGBS.
2. To evaluate the fresh and hardened state behaviours of concrete mixtures with reduced cement content, the so-called low cement content (LCC) concrete towards a greener and more sustainable future in the construction industry
3. To help the concrete industry use less cement with an appropriate water-to-cement ratio (w/c) to meet given workability, strength, and durability requirements; and so as to reduce carbon dioxide emissions, energy consumption, and costs.
4. To develop a mixture proportioning process to manufacture low-cement Based concrete.
5. To study the short-term engineering properties of fresh and hardened low cement concrete.

II. MATERIAL

2.1 Cement

Ordinary Portland cement (OPC – 53 grades) is used in this experimental work. Various properties of the cement have been tested according to IS 12269-1987 and IS 4031-1988 is given below

Table-1: Properties of cement

Properties	Values
Standard consistency (%)	30
Initial setting time (Min)	130
Final setting time (Min)	365
Fineness (%)	98.6
Specific gravity	3.15
Compressive strength (N/mm^2)	63.26

2.2 Fine Aggregate

The Fine aggregate are used in concrete to fill the voids present between Coarse aggregate and they mix with cementaneous materials and from paste to coat aggregate particles affect the compatibility of the mix.

Table-2: Properties of fine aggregate

Properties	Values
Type	M.sand
Specific gravity	2.68
Water absorbtion	0.93
grading	Zone-II
Fineness modulus (%)	4.03
Silt content (%)	1.2
Bulk density (kg/mm^3)	1596.78

2.3 Coarse Aggregate

Coarse Aggregate should be selected carefully since it depends on the project Application, Workability, Segregation, Strength and availability. The maximum size of aggregate used was 20mm.

Table-3: Properties of coarse aggregate

Properties	Values
Type	Crushed stone
Specific gravity	2.86
Water absorbtion	0.53
Fineness modulus (%)	3.075
Impact value (%)	11
Bulk density (kg/mm^3)	1703.61
Flakiness and elongation index (%)	18 & 20

2.4 Flyash

Low calcium flyash of class F (IS 3812-1987) specifications are collected from Ennore thermal power plant station is used for casting the specimen. Table no 4 shows the properties of flyash

Table-4: Properties of flyash

Properties	Values
Type	Crushed stone
Residue test (%)	28
Specific gravity	2.11

2.5 GGBS

GGBS is used to make durable concrete structures in combination with ordinary Portland cement and/or other pozzolanic materials. The GGBS used is having specific gravity of 2.88**.**

2.6 Calcium hydroxide powder

Calcium hydroxide with its chemical formula $Ca(OH)_2$. It is a white powder and is produced when calcium oxide is mixed, or slaked with water.

2.7 Admixture

A cement accelerator is an admixture for the use in concrete for an accelerator speeds the setting time. In this STP Limited brand admixture of shali plast is used according with IS 9103 specification.

2.8 Water

Bore well water of PH 8.2 is used for mixing concrete.

III. METHODOLOGY

3.1 Mix proportion

The aim of the experiment is to investigate the behavior of the calcium hydroxide powder as alkaline binder for polymerization process .The Mix adopted is M25 (1: 2.5: 3.3), designed as per IS 10262:2010.

Table-5: Mix proportion for different trials

Trial Mix	Cement %	Flyash %	GGBS %
M1	100	0	0
M2	80	10	10
M3	60	20	20
M4	40	30	30
M5	20	40	40
M6	0	50	50
M7	0	0	100
M8	10	10	80
M9	20	20	60
M10	30	30	40
M11	40	40	20
M12	50	50	0

IV. RESULTS

4.1 Workability

The concrete were found to have cohesive with high slump at initial stage . The workability of concrete is decreased with increase adding of calcium hydroxide .the slump values are ranging from 120 mm to 80 mm after one and half an hour.

Table-6: Slump test results

Trial Mix	Initial Slump (mm)	30 min Slump (mm)	60 min Slump (mm)	90 min Slump (mm)
M1	Collapse	170	140	100
M2	Collapse	170	150	110
M3	Collapse	160	140	120
M4	Collapse	150	130	90
M5	Collapse	140	120	85
M6	Collapse	140	120	80
M7	Collapse	150	130	80
M8	Collapse	150	130	85
M9	Collapse	140	120	90
M10	Collapse	150	130	95
M11	Collapse	150	120	100
M12	Collapse	150	120	100

4.2 Compressive strength

The compressive streength is the important property of hardened concrete.The cube specimens of variou mixes ,when tested under compression from that it is clear the result is maximum fo M2 which is 34.22 N/mm^2 and M3 which is 32.88 N/mm^2 which can be used for high strength concrete required applications like footing,pile etc.Whereas M11 attain 25.03 N/mm^2 strength which can be used for flooring ,roofing purpose.
The compressive strength of the cube are plotted as graph as shown in chart -1

Table -7: Compressive strength at 7, 14 & 28 day

Trial Mix	Compressive strength at 7 days N/mm^2	Compressive strength at 14 days N/mm^2	Compressive strength at 28 days N/mm^2
M1	19.704	25.185	32.148
M2	22.519	29.481	34.222
M3	20.444	26.074	32.889
M4	13.778	18.815	24.593
M5	9.481	12.296	18.963
M6	4.593	8.000	10.222
M7	6.667	9.778	12.889
M8	8.000	11.111	14.963
M9	10.963	14.370	18.963
M10	12.444	17.481	23.259
M11	11.259	14.667	25.037
M12	9.778	12.296	18.519

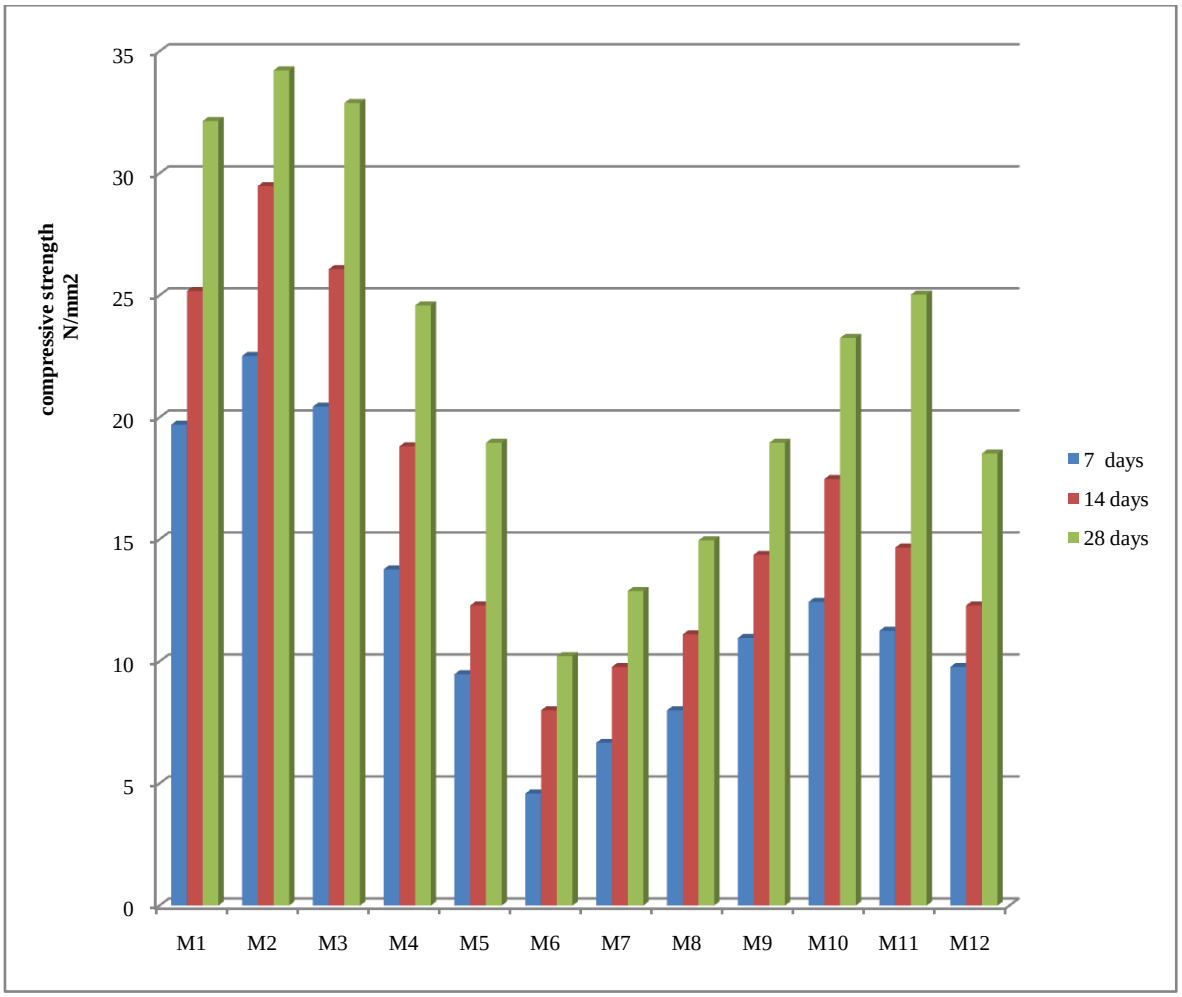

Chart -1: Compressive strength test values

4.3 Split tensile strength

The result of split tensille are tabulated in table no and plottes as graph as shown in .From the chart-2 it is clear that the split tensile strength results are in match with compressive strength.

Table -8: Tensile strength at 7, 14 & 28 days

Trial Mix	Tensile strength at 7 days N/mm^2	Tensile strength at 14 days N/mm^2	Tensile strength at 28 days N/mm^2
M1	3.112	3.725	4.056
M2	3.490	4.103	4.527
M3	3.348	3.773	4.386
M4	2.264	3.018	3.867
M5	2.028	2.358	3.160
M6	1.509	2.028	2.216
M7	1.886	2.264	2.782
M8	1.933	2.311	2.877
M9	2.311	2.782	3.207
M10	1.698	2.971	3.537
M11	2.452	2.877	3.725
M12	1.226	2.499	3.112

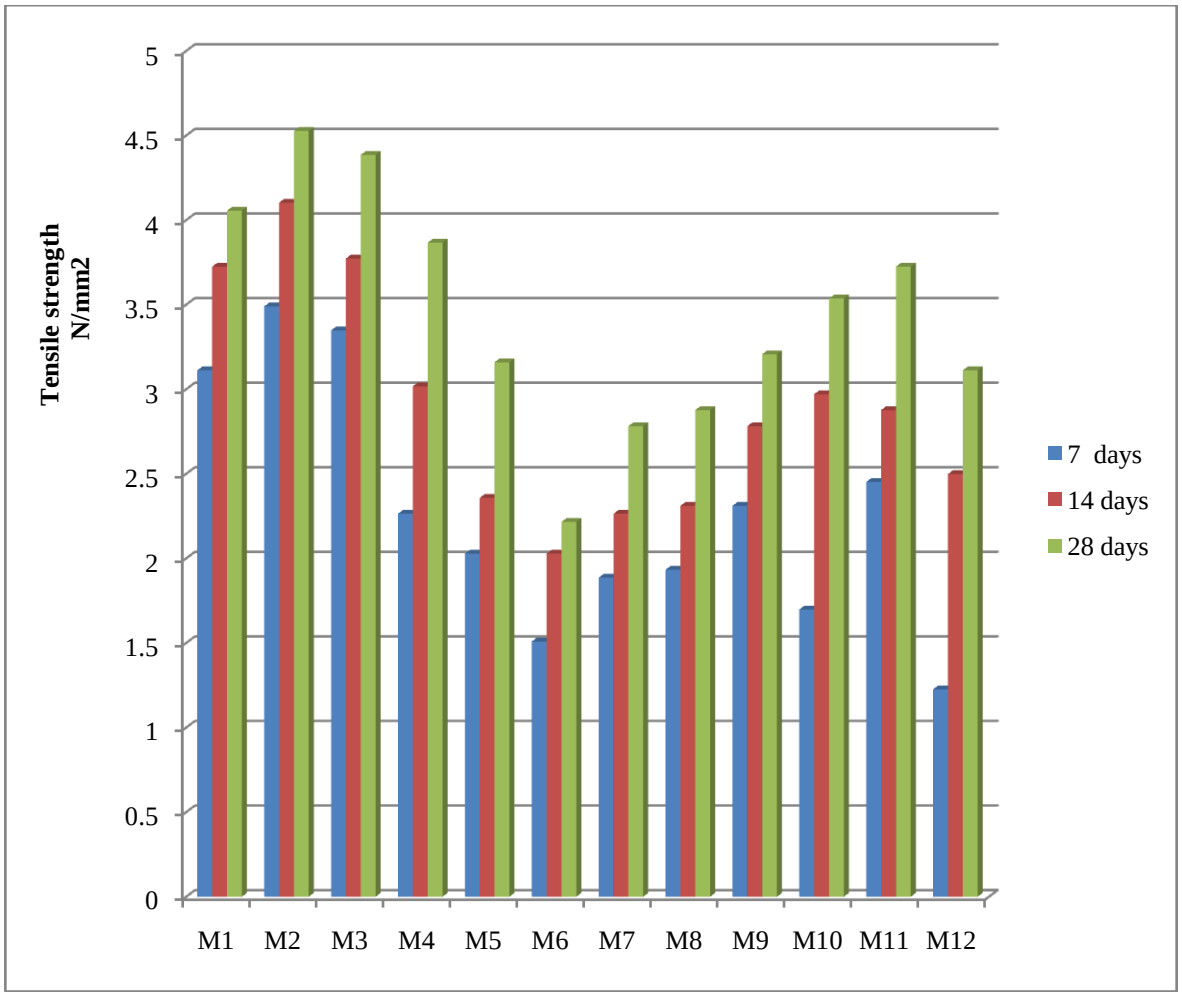

Chart -2: Split tensile strength test values

V. DISCUSSION AND CONCLUSION

The following results are obtained during the experimental studies

- The lean concrete mix will leads to less energy consumption and production cost is low which make concrte for greater application in civil engineering.
- This concrete is economic benefits when it is utlized in infra structure applications.
- In this industrial wastes like flyash and GGBS are used to produce geopolymeric binder which helps for binding coarse and fine aggregates to form a geopolymer concrete.Hence it can be consider as eco friendly materials.
- The geopolymer concrete mix were produced as easily like convential concrete mix.

On complete replacing of cement results are lower in compression strength .So this is contrary to the behaviour in the case of calcium hydroxide based geoploymers. Howevere investigation are required.

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