# Analysis of strength characteristic of concrete using vernacular material

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**Abstract:** *Concrete is the world's most versatile, durable and reliable construction material. Next to water, concrete is the most used material, which required large quantities of Portland Cement. Ordinary Portland Cement production is the second only to the automobile as the major generator of carbon dioxide, which polluted the atmosphere. In addition to that large amount energy was also consumed for the cement production. Hence, it is inevitable to find an alternative material to the existing most expensive, most resource consuming Portland Cement. Geopolymer concrete is an innovative construction material replaced with normal cement concrete. In geopolymer concrete mostly sodium hydroxide (NaoH) and sodium silicate are used but in our project we have replaced sodium hydroxide with potassium hydroxide. It is an excellent alternative construction material. In this project strength of normal geopolymer concrete and strength of using potassium hydroxide using sodium silicate is compared.*

***Key Words -*** Potassium hydroxide ,Sodium silicate,Fly Ash, Strength, Curing, Applications

## 1. INTRODUCTION:

Concrete is the widely used construction material that makes best foundations, architectural structures, bridges, roads, block walls, fences and poles. The production of one ton of Portland cement emits approximately one ton of $CO_2$ into the atmosphere. Among the green house gases, $CO_2$ contributes about 65% of global warming. The overall evaluated sharing of normal Portland concrete (OPC) generation to ozone harming substance discharges is assessed to be roughly 1.35 billion tons yearly or around 7% of the aggregate green house gas outflows to the earth' s atmosphere. However, the cement industry is extremely energy intensive.

After aluminium and steel, the manufacturing of Portland cement is the most energy intensive process as it consumes 4GJ of energy per ton. After thermal power plants and the iron and steel sector, the Indian cement industry is the third largest user of coal in the country. The industry's capacity at the beginning of the year 2008-09 was about 198 million tones. For housing, infrastructure and corporate capital expenditures the demand of cement in India is expected to grow at 10% annually. Considering an expected production and consumption growth of 9 to 10 percent, the demand-supply position of the cement industry is expected to improve from 2008-09 onwards (Ragan & Hardjito,2006 2005)

In future use of Portland cement is unavoidable. Efforts are being taken to reduce the use of Portland cement in production of concrete. The effort include the utilisation of supplementary cementing material such as fly ash, silica fume, granulated blast furnace slag, rise-husk ash and metakaolin, and finding alternative binders to Portland cement.

The geopolymer technology has shown considerable good results for construction industry as an alternative binder to Portland cement. In construction industry applications a water resistant binder with sufficient strength is desirable. In addition the production technology necessitates an adequate processing time. Nevertheless after the shaping procedure the material should be demoulded immediately to enable feasible production. Therefore the binder should show a rather a late beginning of setting, but it should be possible to accelerate strength evolution when the material is shaped.

The form of cementitious material using silicon and aluminium activated in a high alkali solution was developed. This material is usually based on fly ash as a source material and is termed geopolymer or alkali-activated fly ash cement. The mortar and concrete made from this geopolymer possess similar strength and appearance to those from ordinary Portland cement.

Geopolymer exhibit many excellent properties such as high compressive strength, low creep, good acid resistance, low shrinkage, fire resistance and other mechanical properties. The work on geopolymer has been based on the normally used low calcium fly ash. Low calcium fly ash has been successfully used to manufacture geopolymer concrete when the silicon and aluminium oxides constituted about 80% by mass, with the Si-to Al ratio of about 2. It is also known that high calcium fly ash contains a reasonable amount of silica and alumina. This high calcium fly ash could also be suitable for use as base material for making geopolymer.

## 1.1 Material:

### 1.1.1 Fly ash:

As according to ASTM C- 618, two major classes of fly ash are recognized. These two classes are related to the type of coal burned and are designated Class F and Class C in most of the current literature. Class F fly ash is normally produced by burning anthracite or bituminous coal while Class C fly ash is generally obtained by burning subbituminous or lignite coal. The important characteristics of these two types of ashes are discussed below.

Present Class C fly ash is collected in ichalkarangi. Class F fly ashes with calcium oxide (CaO) content less than 6%, designated as low calcium ashes, are not self hardening but generally exhibit pozzolanic properties. These ashes contain more than 2% unburned carbon determined by loss on ignition (LOI). Quartz, mullite and hematite are the major crystalline phases identified fly ashes, derived from bituminous coal. Essentially, all the fly ashes and, therefore, most research concerning use of fly ash in cement and concrete are dealt with Class C fly ashes.

Findings and majority of current industry practices indicate that satisfactory and acceptable concrete can be produced with the Class F fly ash replacing 15 to 30% of cement by weight. When Class F fly ash is used for producing air entrained concrete to improve freeze-thaw durability, the demand for air entraining mixtures is generally increased. Use of Class F fly ash in general reduces water demand as well as heat of hydration. The concrete made with Class C fly ash also exhibits improved resistance to sulphate attack and chloride ion ingress. The test material is taken from ichalkaranji.

### 1.1.2:Course Aggregate:

Locally available crushed granite stone aggregate of 20mm size was used as coarse aggregate. The coarse aggregate passing through 10mm and retaining 4.75mm was used for experimental work. The properties of coarse aggregates were determined as per IS: 2386:1963

### 1.1.3:Fine aggregate:

The locally available river sand, passing through 4.75 mm was used in this experimental work. The properties of fine aggregates were determined as per IS: 2386:1963

### 1.1.4 Potassium Hydroxide (KOH):

It is also a prime constituent in preparation of alkali activator. Here the pallets of KOH are with 84% purity.

### 1.1.5 Sodium Silicate ($Na_2Sio_3$):

This jelly like ingredient also contributes in preparation of alkali activator. It takes part in initiation of the polymerization process. (Na2O = 8%, SiO2 = 26.5% and 65.5% water).

**Table 1. Mixture proportion for 8 Molarity of KOH**

| Material | Quantity |
|---|---|
| Fly Ash | 1.5 kg |
| Fine Aggregate(Sand) | 2. 25 kg |
| Coarse Aggregate | 4.5 kg |
| Sodium Silicate Solution | 450 ml |
| Potassium Hydroxide Solution | 450 ml |
| Distilled Water | 100 ml |

Fig 1. Concrete mix

## 2. PREPARATION:

Fly ash, potassium hydroxide and sodium silicate are the main constituent of geopolymer. The preparation involves a few significant stages.

1. The first stage is of course preparing the alkali activator. The solution of KOH is prepared 24 hours before casting with some water.3
2. The required quantities of potassium hydroxide, sodium silicate is mixed together with a very little amount of water to prepare the main activator 3 hours of casting.
3. After that the sieved (by 75 micron) fly ash is weighted. The second stage is all about mixing the activator with the sieved fly ash.
4. Whole thing is mixed properly by Hobart mixture until the formation of a sticky solution.
5. After that it is casted in 0.15×0.15×0.15 m3 sized iron moulds properly followed by table vibration to eliminate the entrapped air.
6. Then it is time for the last stage of heat curing. The proposed heat curing was done for 72 hours at 90 degrees continuously to get the final geopolymer specimen .
7. Then these samples are tested within an of 3 days heat curing to get the result of development of compressive strength.

## 3. Methodology:

### 3.1Compressive strength :

Compressive strength of concrete is one of the most important and useful properties of concrete. In most structural applications concrete is implied primarily to resist compressive stress. In this experimental investigation, both geopolymer concrete cubes and hollow blocks were used for testing compressive strength. The load at which the specimen ultimately fails is noted. Compressive strength is calculated by dividing load

$$f_C = P/a$$

fc = Cube compressive strength in N/mm2

P = Cube compressive load causing failure in N

a=Cross sectional area of cube in mm2

Fig 2.Compressive strength test

### 3.2 Split tensile test:

The tensile strength is one of the basic and important properties of concrete. Concrete is not usually expected to resist direct tension due to its low tensile strength and brittle nature. The methods of determining the tensile strength of concrete can be broadly classified as (a) direct method, and (b) indirect method. The direct method suffers from a number of difficulties relating to holding the specimen properly in the testing machine without introducing stress concentration, and to the application of uniaxial tensile load which is free from eccentricity to the specimen. As concrete is weak in tension, even a small eccentricity of load can induce combined bending and axial force condition and the concrete fails at the apparent tensile stress other than the tensile strength.

The splitting tests are well known indirect tests used for determining the tensile strength of concrete sometimes referred to as split tensile strength of concrete. In these tests a compressive force is generally applied to a concrete specimen in such a way that the specimen fails due to tensile stresses

Fig 3.Split tensile strength

Table No. 1. Test results of compressive strength

| Molarity | Alkaline solution | Sample No | Comp strength ($N/mm^2$) | Avg. Comp Strength($N/mm^2$) |
|---|---|---|---|---|
| 8M | NaoH & Na2sio3 | 1 | 33.02 | 28.55 |
| | | 2 | 31.71 | |
| | | 3 | 35.92 | |
| | KoH & Na2sio3 | 1 | 15.10 | 14.13 |
| | | 2 | 16.85 | |
| | | 3 | 10.5 | |

Table No. 2 Test results of tensile strength

| Molarity | Alkaline solution | Sample No | Tensile strength ($N/mm^2$) | Avg. Tensile Strength ($N/mm^2$) |
|---|---|---|---|---|
| 8M | NaoH & Na2sio3 | 1 | 1.78 | 1.75 |
| | | 2 | 1.33 | |
| | | 3 | 2.15 | |
| | KoH & Na2sio3 | 1 | 1.2 | 1.14 |
| | | 2 | 1.05 | |
| | | 3 | 1.18 | |

## 4. CONCLUSION

1.The average compressive strength of M20 grade concrete using NaoH & Na2sio3 is 50.50% more than the Concrete made by KoH & Na2sio3

2.The average tensile strength of concrete made by using NaoH & Na2sio3 is 34.852% more that of concrete made by using KoH & Na2sio3

3.The NaoH is more economical and that of suitable than that of KoH

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