# EFFECT OF HIGH TEMPERATURE ON PHASE BEHAVIOUR AND MECHANICAL PROPERTIES OF ALKALI-ACTIVATED MATERIALS

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## Chapter 1 - Introduction

During the service life of built infrastructure, they might be subjected to natural and man-made hazards that can cause partial or complete damage and collapse of the structures. Such catastrophic disasters can cause tremendous loss of life along with a considerable amount of direct or indirect monetary losses. Fire accidents can cause one such disaster. During a fire hazard, the temperature can rise to 1000℃ leading to strength loss and physio-chemical changes in structural materials such as concrete, steel, wood, etc., thereby leading to structural impair and instability. Alongside this, it also poses a direct threat to the safety of life from the released chemical gases and smoke.

Over the years with the increasing urgency in urbanization and rise in construction activities, there is larger inflation in the usage of concrete and its binder i.e., ordinary Portland cement (OPC), worldwide. An increase in the production of cement involves the emission of a substantial amount of greenhouse gases that impact global warming by increasing the carbon footprint. Thus, it becomes crucial to perceive alternative binding material to produce concrete. From past research, geopolymers synthesized from industrial by-products that are available in huge quantities have proven to be beneficial in this regard.

From past research, AAMs are proven to have better thermal and fire resistance compared to conventional concrete because of their ceramic-like properties. The performance of AAMs at high temperatures is majorly credited to the nature of the precursors used, water/binder ratio, sodium content ($Na_2O$), activator modulus ($Ms = SiO_2/Na_2O$), curing temperature and curing period.

Even though there are several kinds of research supervised to interpret the mechanism of AAMs, there are very few of them oriented to comprehend its behaviour at elevated temperatures. In the current study, an attempt was made to understand the behaviour of alkali-activated materials at the macro and micro levels when exposed to high temperatures. To get a better understanding of the behaviour of AAMs at high temperatures and to correlate the phase changes to compressive strength, microstructural analysis (i.e., XRD, FTIR and TGA) was performed. Also, an attempt as being made to study the effect of calcium content in the AAMs when exposed to elevated temperature.

## Chapter 2 - Objectives

The main aim of this study is to evaluate the behaviour of low calcium fly ash-based alkali activated materials when exposed to elevated temperature.

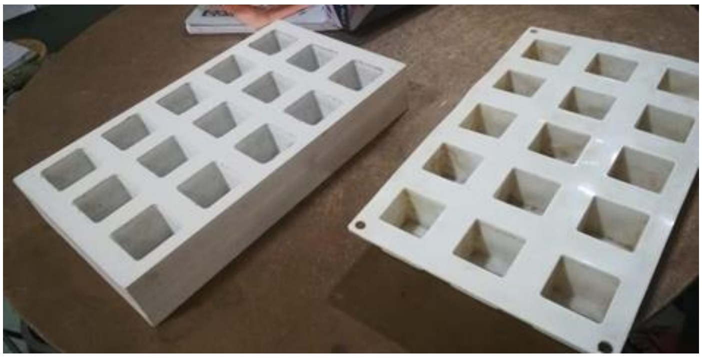
Based on literature review following objectives are defined:

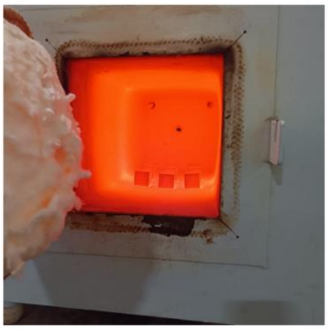
- Effect of curing temperature on the mechanical properties of low calcium based alkali activated materials at high temperature.
- Effect of variation of alumina content on mechanical properties of low calcium based alkali activated materials at high temperature.
- Partial replacement of slag and calcium hydroxide content on mechanical properties alkali activated materials of fly ash based alkali activated materials at high temperature.
- To observe the phase changes that occurs due to all these effects through microstructural analysis and the correlation of microstructural studies to mechanical properties.

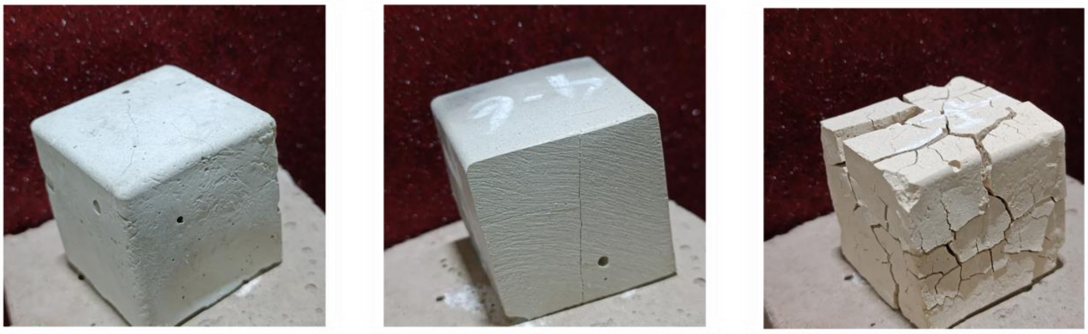
## Chapter 3 – Methodology and work carried out

- Pure AAM binder paste or single precursor system with class F flyash and blended precursor system by incorporating GGBFS and calcium hydroxide at varying percentages with flyash was prepared.
- Alkali solution of sodium hydroxide and sodium silicate was used to activate or increase the reactivity of precursors. Modulus ($SiO_2/Na_2O$) of 1.5 and 1 was maintained for high and low calcium geopolymer paste respectively. Water/binder ratio of 0.5 was maintained for all the mixes. This binder paste was casted into silicon moulds of size 35 mm and later subjected to accelerated curing at a temperature of 60 °C for a period of 6 days.

- Following the accelerated curing, 3 cubes of each mix were tested for compressive strength at ambient temperature. These test specimens were then exposed to elevated temperatures of 400 °C and 800 °C. Temperature was raised at a rate of 5 °C/ min in the muffle furnace. After achieving the target temperature, it was maintained for a period of 2 hours. Later, specimens were cooled to room temperature and then tested for compressive strength.
- To correlate the phase changes to compressive strength, microstructural analysis (i.e., XRD, FTIR) was performed.





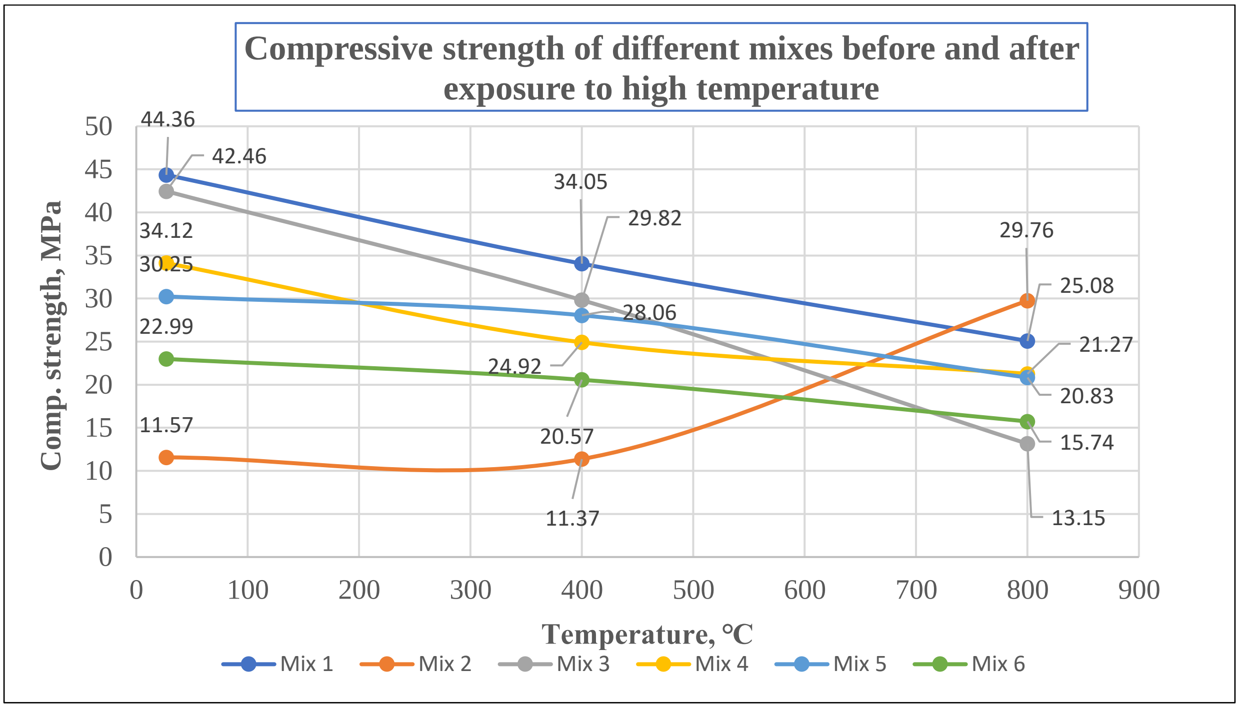


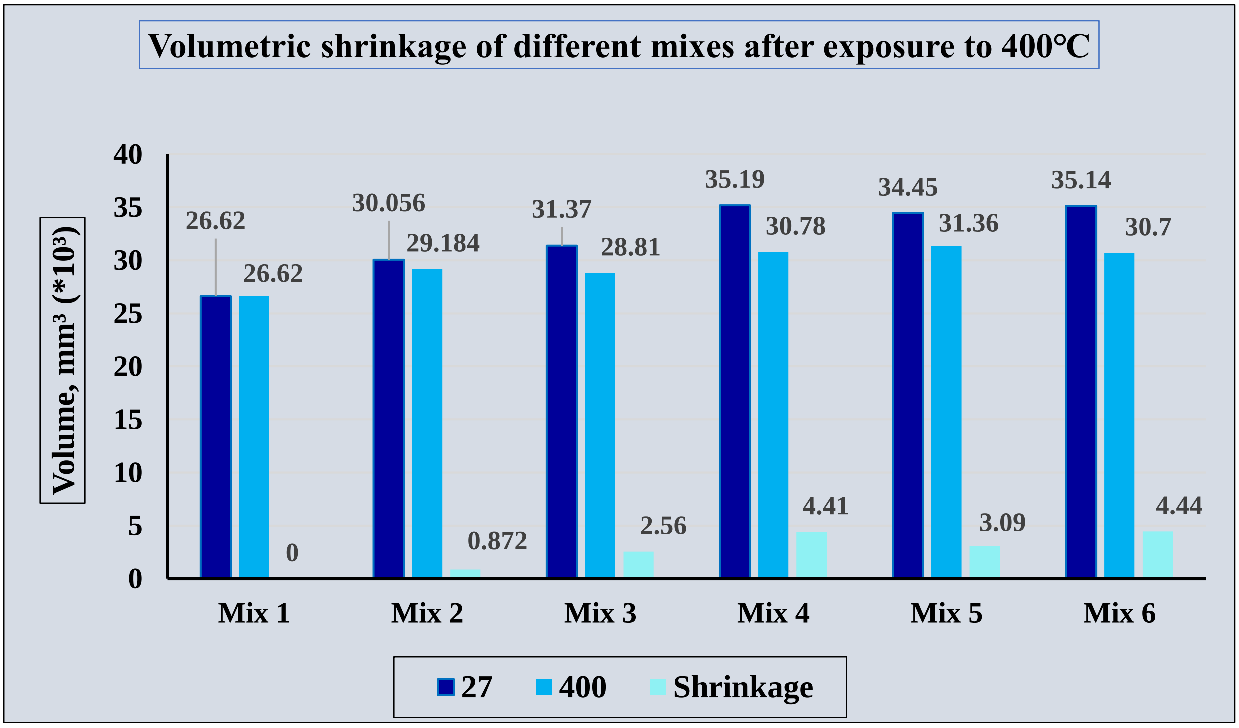
Above fig shows the cubes at ambient temperature (left), exposed to 400°C (centre) and 800°C (right) of one of the mix proportion.

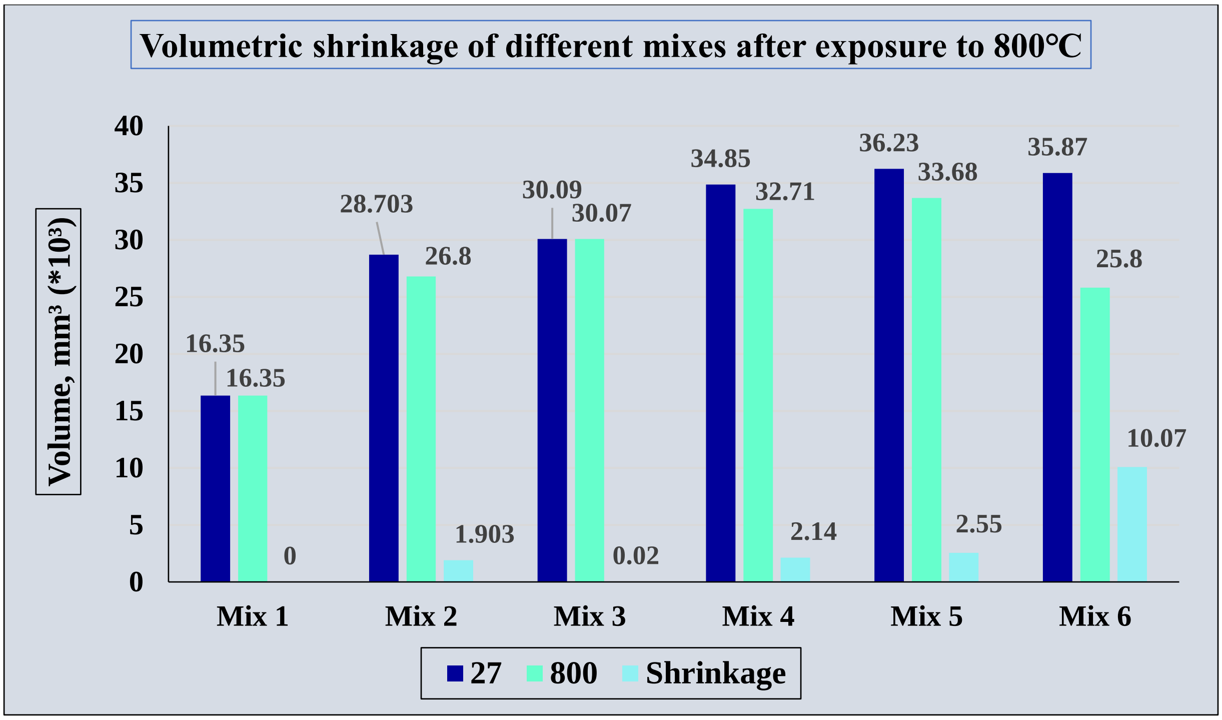
## Chapter 3 – Results obtained so far

- Compressive strength of different specimens of 6 mix proportions at 25°C and after exposed to 400°C and 800°C were determined. Below graph represents the corresponding values.
- It was observed that compressive strength of geopolymer paste decreased when exposed to high temperature. However, in pure geopolymer (mix 2), strength increased when exposed to 800°C which might be due to further geopolymerisation or due to formation of new phases.

- Specimens especially those with GGBFS and calcium hydroxide underwent volumetric shrinkage due to temperature exposure.
- At present, microstructural analysis (XRD, FTIR) is being carried out.






## Chapter 4 – Scope for future work

- Behaviour of alkali activated mortar and alkali activated concrete at elevated temperature and correlation of phase changes with the mechanical properties.
- To investigate the strength recovery of thermally damaged specimens by recuring with water or lime.
- Understanding the bond behaviour between alkali activated concrete and reinforcement when exposed to elevated temperature.
- Development of alkali activated material as a repair material for existing structures when damaged due to high temperature.