INVESTIGATING RESIDUAL PROPERTIES OF MASONRY UNITS AT ELEVATED TEMPERATURES

T.D.C.M. Rajapaksha [1, *], I.E. Ariyaratne [1], C. Jayasinghe [1]

[1] Department of Civil Engineering, University of Moratuwa, Moratuwa

Masonry structures are renowned globally for their strength, durability, affordability, and thermal and sound insulation properties. However, there is limited information on the residual properties of masonry units after exposure to elevated temperatures. This research addresses the aforementioned gap by investigating the residual properties of four representative masonry units; clay bricks, concrete blocks, compressed stabilized earth blocks and lightweight foam blocks. The study aimed at determining variations in physical and mechanical properties, including visual appearance, density, and compressive strength of these masonry units after exposure to elevated temperatures. Additionally, conventional cement-sand mortar (1:6) was also tested both in their ambient state and after exposure to elevated temperatures.

The study involved an experimental approach where four types of masonry units named clay bricks, concrete blocks, compressed stabilized earth blocks (CSEB), and lightweight foam blocks were subjected to controlled elevated temperatures up to 1200°C using a muffle furnace. Physical and mechanical properties, including density and compressive strength were measured both prior and post stages of exposure to these temperatures. Variations in these properties were then analyzed to assess the residual performance of each masonry unit. Visual observations and Scanning Electron Microscopy (SEM) were examined to document surface alterations and microstructural changes after exposure to elevated temperatures. Further, characteristic compressive strength values of the masonry assembly were also calculated using an empirical equation in the ambient and residual states. Finally, a comparative analysis between ambient and elevated temperature conditions was conducted to assess the impact of elevated temperatures on the masonry units and mortar.

The results indicate that the compressive strength values of masonry units and mortar decrease after exposure to temperatures up to 1200°C. The reduction factor in compressive strength of each unit after full heating process were observed as 0.57, 1, 0.68, 0.88 for clay brick, CSEB, lightweight foam block and CMU respectively. Clay bricks exhibited better resistance than other types, retaining most of their initial strength after exposure to elevated temperatures. Compressed stabilized earth block was observed to fail into a brittle failure after exposure to 1200°C. Dry density of all four types decreased significantly after exposure to elevated temperature conditions. Additionally, residual compressive strength of generally used mortar (1:6) exhibited a clear reduction after exposure to elevated temperature conditions.

The study's primary contributions include the investigation of the residual state behaviour of masonry structures after exposure to elevated temperatures which simulates the close behavior of a masonry structure at post-fire condition. This understanding aids in selecting appropriate masonry materials in a fire-prone area in future masonry construction.

Keywords: Compressive strength, Elevated temperature, Masonry units, Physical properties, Residual properties

[*] Correspondence: indunile@uom.lk

INVESTIGATING RESIDUAL PROPERTIES OF MASONRY UNITS AT ELEVATED TEMPERATURES

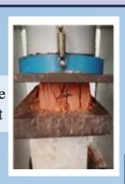
Background

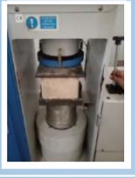
- Masonry structures are known for their strength, durability, and insulation properties in ambient condition.
- Understanding the residual state behavior after exposure to elevated temperatures is crucial for safety assessments.
- This study examines the behavior of masonry materials after elevated-temperature exposure, offering insights into their post-fire performance.

Objectives

- Investigate the physical and mechanical properties of masonry materials before and after exposure to elevated temperatures.
- Conduct a comparative analysis of residual and ambient behavior of selected masonry unit types.
- Provide a calculated compressive strength value for the masonry assembly using empirical equation.

Methodology


Compressive strength test


Residual compressive strength test


SEM test setup

Testing ambient properties

Testing residual properties

Sample preparation

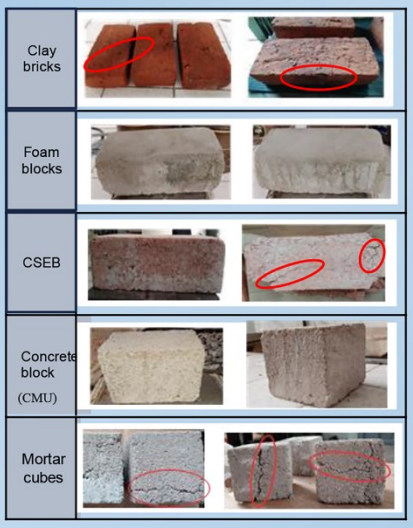
Exposure to elevated temperatures


Collected masonry units


Casting mortar cubes

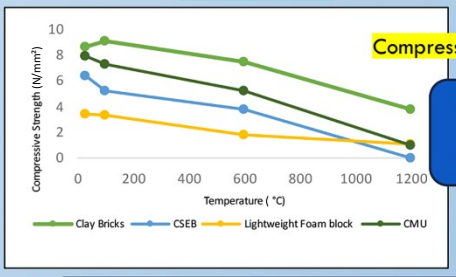

Heated in muffle furnace

Visual observations



Residual Compressive strength of generally used mortar (1:6) has a clear reduction after exposure to elevated temperature conditions.

Results



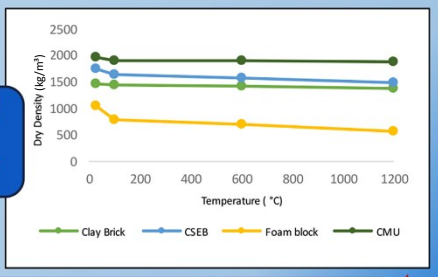
Compressive strength

CSEB block is observed to fail after exposure to 1200 ° C.

Clay brick > Lightweight foam block > CMU > CSEB

Dry density

Clay brick and CMU shows a smaller reduction in dry density



CMU > CSEB > Clay brick > Lightweight foam block