Name: **Rafik Abdallah**

Email: rafik.abdallah@univ-pau.fr

Supervisors: Hélène Carre, Céline Perlot, Chrisitian La Borderie, Hayssam El Ghoche

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High temperature behavior of compressed earth bricks

Abstract:

The present PhD thesis addresses the high temperature behavior of a compacted raw earth material and a cement stabilized earth material, both of which are likely to be used in fire-prone buildings. A complete campaign of laboratory tests was carried out on the two materials. Residual tests, which included mechanical, thermal and permeability tests were performed after slowly heating at a rate of 2 °C.min^{-1} using an electric furnace to attain temperatures of 80 °C, 120 °C, 200 °C, 350 °C, 450 °C and 600 °C. Then, fire tests were performed, which allowed for the exposure of these materials' bricks to a high heating rate using a mobile gas furnace designed to follow an ISO 834-1 fire curve in order to simulate a real-life fire accident in a building. Besides the effect of the material composition on the high temperature behavior, the effect of the water content on this behavior was also studied after subjecting the samples of the two materials to different relative humidities (RH): dry condition, 50 % RH, 75 % RH and 100 % RH, at an ambient temperature of 23 °C. As a result, the behavior of these materials is better characterized, allowing for a better understanding of real-world applications in a variety of environments. The material's composition and water content influence significantly its behavior at high temperatures. Following the fire tests, the samples were classified into two categories based on their composition and water state: thermally stable and unstable. The observed differences in behaviors have been ascribed to thermomechanical phenomena. They are caused, on the one hand, by the formed thermal gradients induced as a result of the consequent thermal stresses, which decrease as the water content increases, and, on the other hand, by the intrinsic mechanical properties of the materials (which decrease with the water content). These factors were subsequently demonstrated to play a major role in the material's fire behavior and load-bearing capacity at high temperatures, as assessed by mechanical loading of the samples during fire tests.

Results and Discussion:

The picture on the right illustrates an example of one of the findings. After testing the fire behavior of two different types of earthen materials, raw earth (SW50) and cement stabilized (SWC3.5), a pessimum was found for the compacted raw earth one. This pessimum reflects the effect of water content on the thermal instability of SW50 and the relative percentage mass of its broken pieces during its fire test. SWC3.5, on the other hand, demonstrated a thermal stable behavior.