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Visco-elasto-plastic behavior of unstabilized rammed earth wallet

Taini Chitimbo*, Feras Abdul Samad, Noémie Prime, Olivier Plé

Université Savoie Mont Blanc, CNRS, LOCIE, 60 rue du lac Léman, 73000 Chambéry, France.

*taini.chitimbo@univ-smb.fr; noemie.prime@univ-smb.fr

Extended Abstract

Currently, the buildings exploitation and construction are responsible for over one-third of global final energy consumption and nearly 40% of total direct and indirect CO₂ emissions [1]. Concerning the manufacture of the material a large part of this energy demand is used cement/lime production and to transport building materials.

Develop alternative construction materials to minimize the energy consumption in building construction sector is a must. One of these alternatives is the use of rammed earth because of its low embodied energy and reduction of carbon footprint. However, rammed earth structures are very sensitive to hydric conditions (more generally weather conditions such as rainfall, freeze-thaw, capillarity, etc.).

Studies on apparent mechanical behavior (stiffness, compression and shear strength) of rammed earth at different hydric state i.e. water content have been done. However, there are few effective stress approaches as well as large-scale studies involving mechanical behavior over time. Moreover, there are no studies on the behavior of these materials with both fluid and elastic properties at the same time.

This paper presents experimental results of determining dynamic viscosity and stiffness on unstabilized rammed earth wallet. The aim is to evaluate the link between the apparent mechanical performance and the varying hydric state inside the drying wallet after manufacture.

In this study, rammed earth wallet of 1.5m x 0.75m x 0.2m were manufactured with initial water content equal to 10%. The wallet was then left to dry for 8 weeks. While drying, the wallet was periodically mechanically tested at each week. Compression test followed by apparent stress relaxation test were performed for 8 weeks. Alongside, the hydric state inside the wallet was monitored by humidity sensors.

The compression test was done with loading-unloading cycle. The cycles were done at 0.1MPa to avoid damage on the wallet and in order to be representative of a classical vertical apparent stress for a one-story building. The strain was calculated using fields displacement coming from Digital Image Correlation technique in the central part of the wallet in order to avoid border effects. The total strain calculated varied from 0.18 to 0.1%. The apparent rigidity of a wallet was determined from the

unloading path. Results show that the apparent stiffness of the wallet increased from 100 MPa to 1500 MPa. These results are very comparable to those obtained at structural scale [2].

The dynamic viscosity was calculated from stress relaxation test. Figure 1 shows the dependency of stress with time, during stress relaxation of a wallet, while displacement is fixed. It was observed that, the stress reduces exponentially until it reaches an asymptotic value. This behavior was modeled using the combination of Maxwell and Kelvin Voight viscoelastic model; the combination is known as Three-Element model [3]. Figure 1 is showing the experimental curves with their respective model curves. Figure 2 shows the model adapted. Using this model, the coefficient of viscosity increased from 10^{10} to 10^{12} Pa.s during 8 weeks of drying. The apparent relaxation modulus of rammed earth structure increases as the sample dries. This means, the viscous behavior of rammed earth is highly dependent on the hydric state. That means creep effect can be considered in the same time that the hydro-mechanical coupling behavior. It is a significant factor to consider when constructing rammed earth wall.

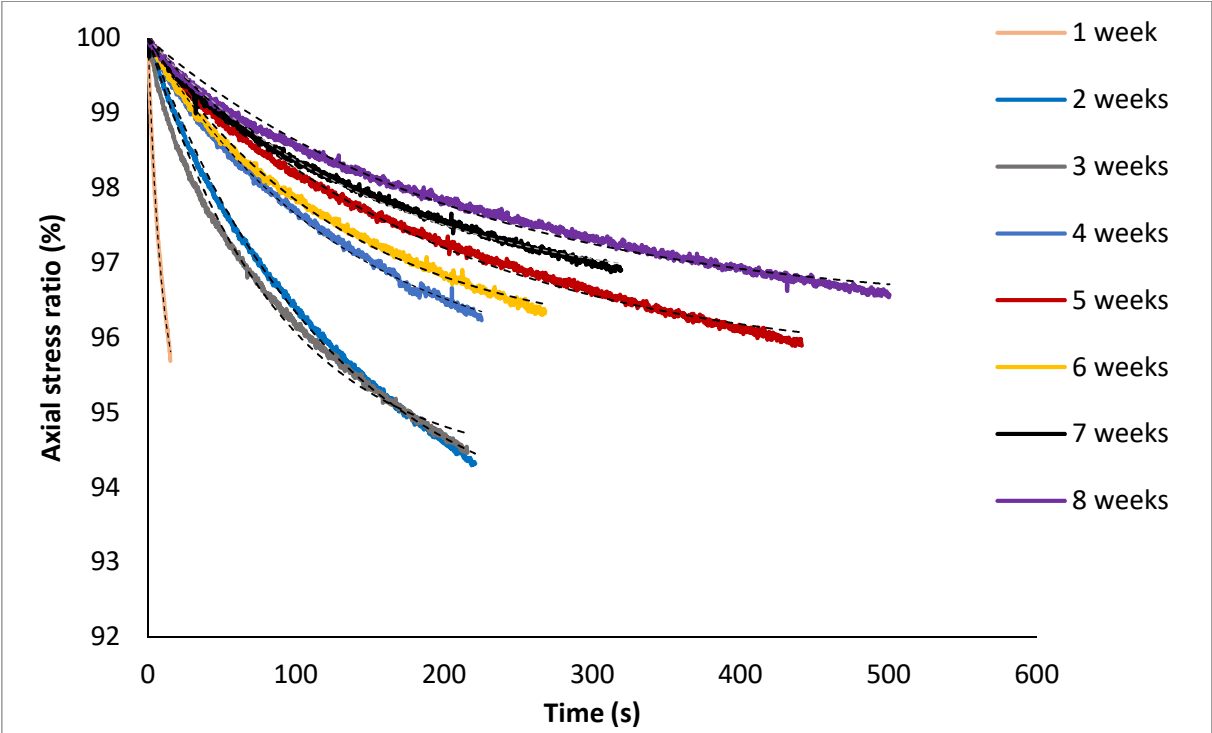


Fig 1: Stress relaxation test results showing experimental and modelled curve at each week on a drying wallet

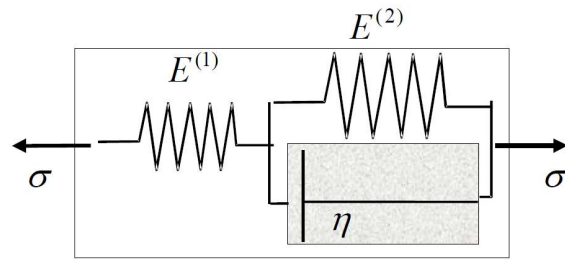


Fig 2: Three element model for viscoelastic material

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