Lateral load carrying capacity of timber walls filled with hemp concrete

Husam WADI , Sofiane AMZIANE , Evelyne TOUSSAINT, Mustapha TAAZOUNT
Université Clermont Auvergne, Institut Pascal, BP 10448, F 63000 CLERMONT-FERRAND, FRANCE

Introduction

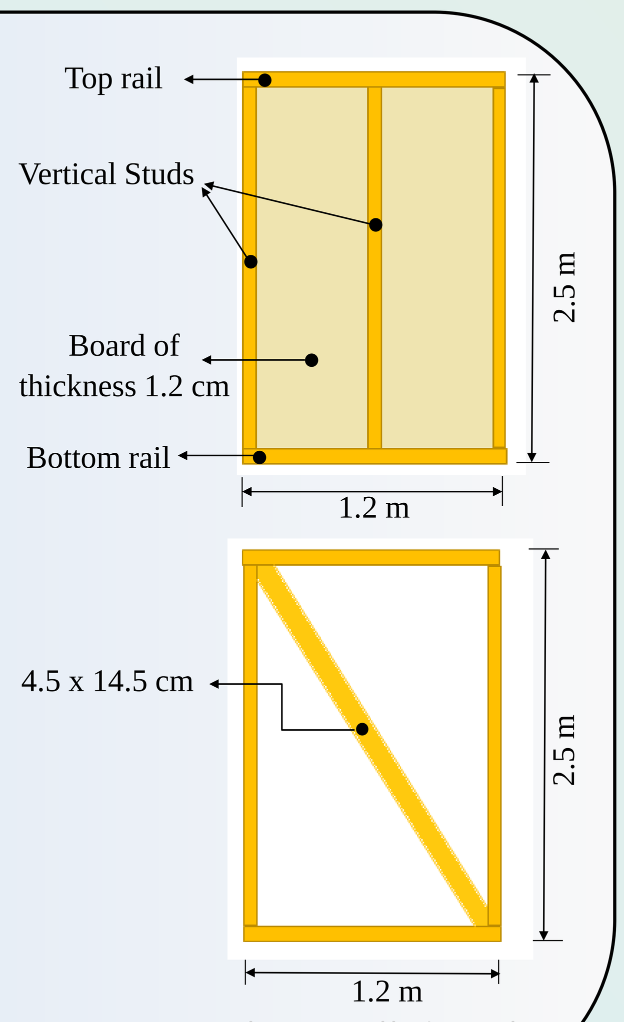
Hemp concrete is now used in construction as a sustainable and carbon neutral infill wall material around timber-framed construction. In-plane racking strength of timber walls is important in construction for resisting lateral loads. As limited studies are published on the lateral strength of hemp walls, the aims of this study are to study the contribution of hemp concrete in lateral strength of the wall on one side-and to investigate the most effective parameter that plays a main role in the in-plane racking strength of hemp walls on the other side.

Hemp concrete as infill material in timber walls.

Theoretical analysis

Two different shapes of timber walls were considered in this study in order to investigate the participation of hemp concrete as infill material, vertical and diagonal bracing struts. The dimensions of all tested walls were 2.5 m high, 1.2 m width and 140 mm thickness. We assume a linear elastic behaviour of the wall-unit and the deformations are caused by external force only. By applying the virtual work transformation by unit-load theorem (F), the total displacement of the wall unit (Δ) can by calculated as:

$$\Delta = \frac{\partial W}{\partial F} \qquad (1)$$



Timber wall details.

By taking the material characteristics into account in vertical strut wall, the total horizontal displacement (Δ_1) can be calculated as a function of the internal forces (equation 4) and the term F/Δ = 0.0083 (kN/mm). For the diagonal bracing strut wall, equation (5) is used to calculate the lateral displacement of the wall (Δ_2), also the term F/Δ = 2.7 (kN/mm).

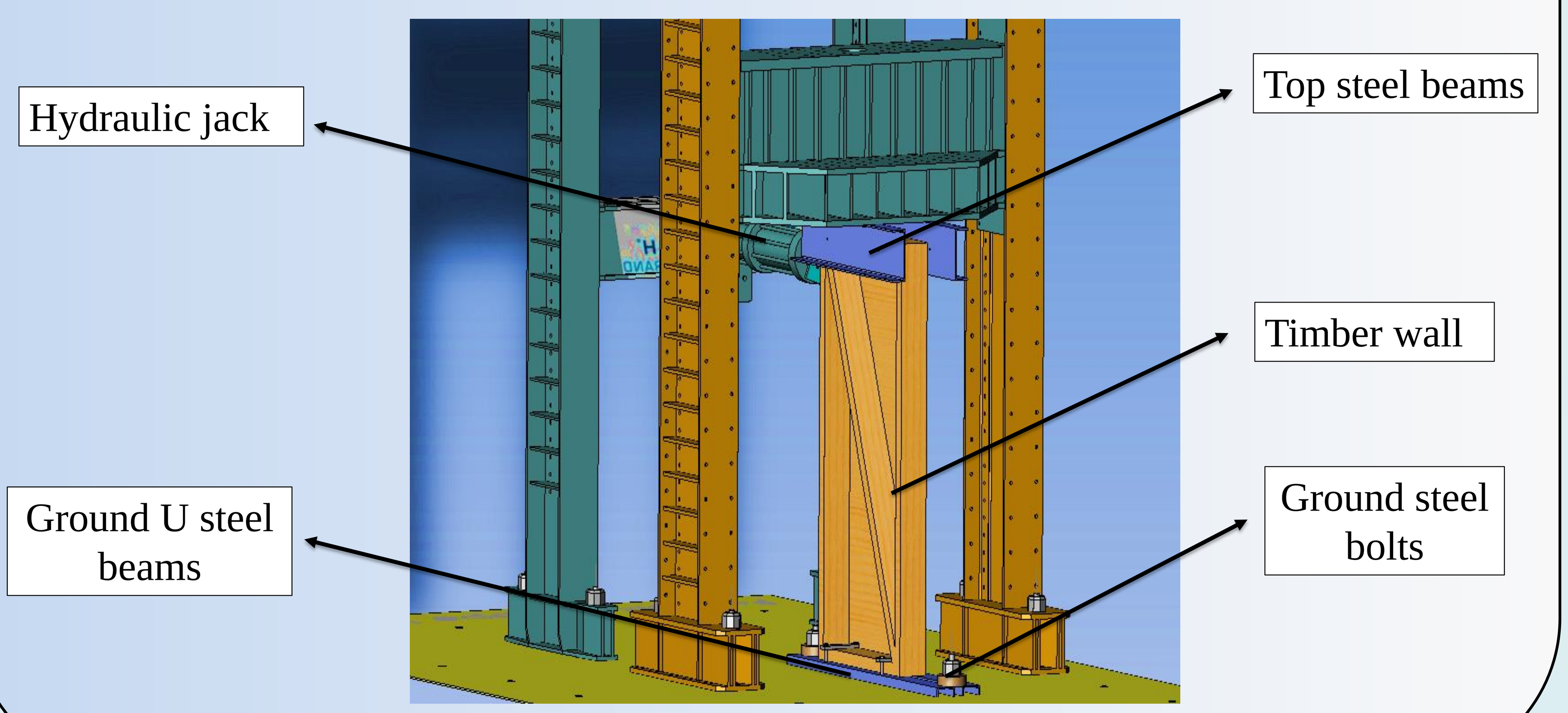
$$W = \frac{1}{2}\left[\frac{1}{E_{0,05}\,I}\int M^2(x)\,dx + \frac{1}{E_{0,mean}\,A}\int N^2(x)\,dx + \frac{1}{G_{mean}\,\acute{A}}\int V^2(x)\,dx\right] \qquad (2)$$

$$\Delta_i(m) = (a_M + a_V + a_N)F(N) \qquad (3)$$

$$\Delta_1(m) = \left[\left(\frac{0.964}{E_{0,05}\,I}\right) + \left(\frac{5.72}{E_{0,mean}\,A}\right) + \left(\frac{3.85}{G_{mean}\,A'}\right)\right]F(N); \quad A' = \frac{2}{3}A \qquad (4)$$

$$\Delta_2(m) = \left[\left(\frac{1.26\times10^{-5}}{E_{0,05}\,I}\right) + \left(\frac{25.5}{E_{0,mean}\,A}\right) + \left(\frac{1.0\times10^{-4}}{G_{mean}\,A'}\right)\right]F(N) \qquad (5)$$

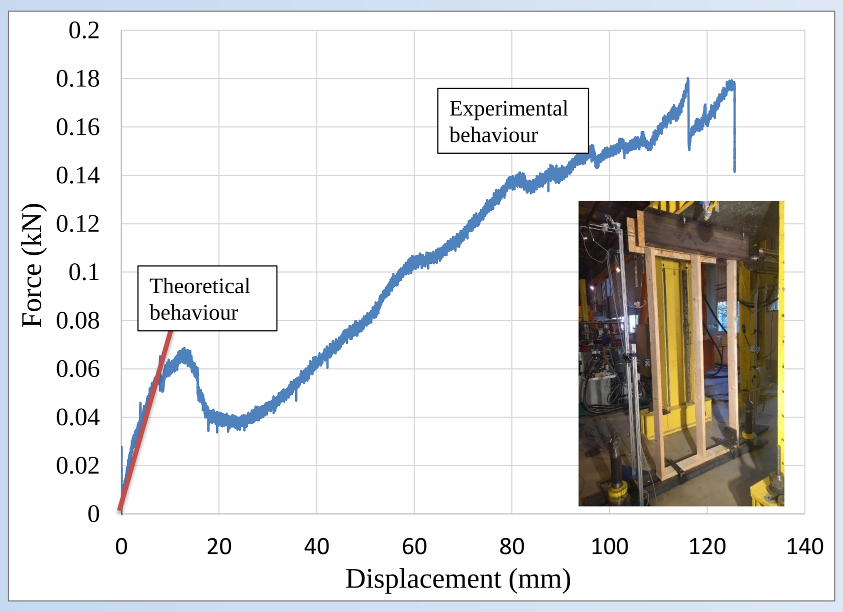
Test set up



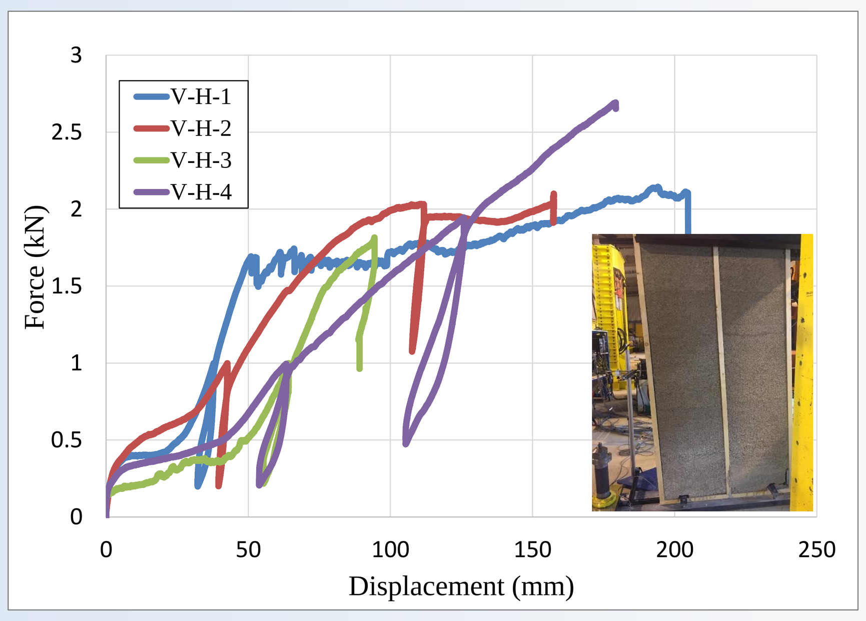
The test set up of timber walls.

Experimental results

A small participation of hemp concrete was noticed in the vertical strut timber frame. Hemp concrete does not completely work against lateral loads due to the absence of the diagonal compression zone.

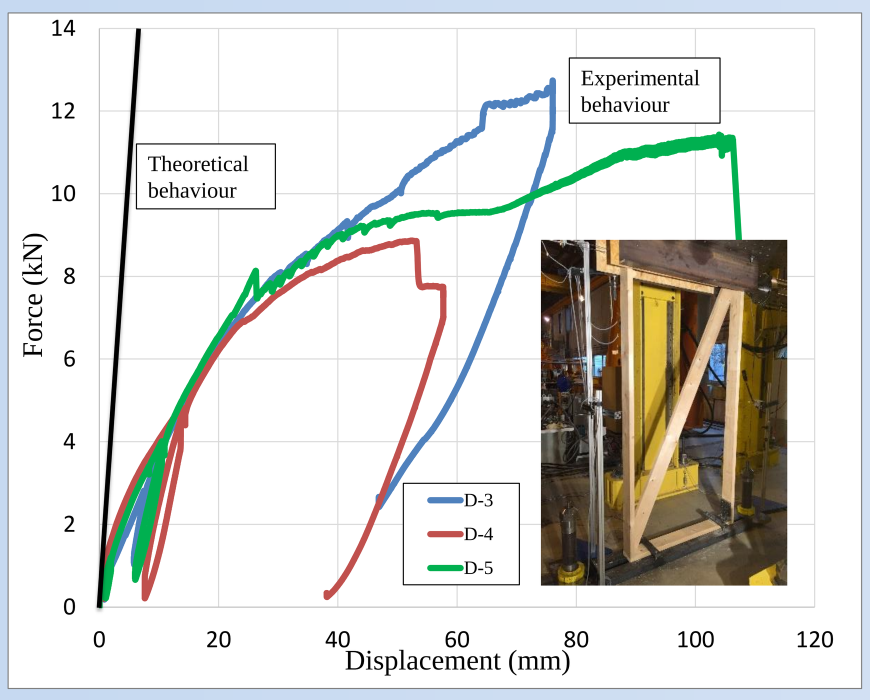


Force-displacement behaviour for frame only.

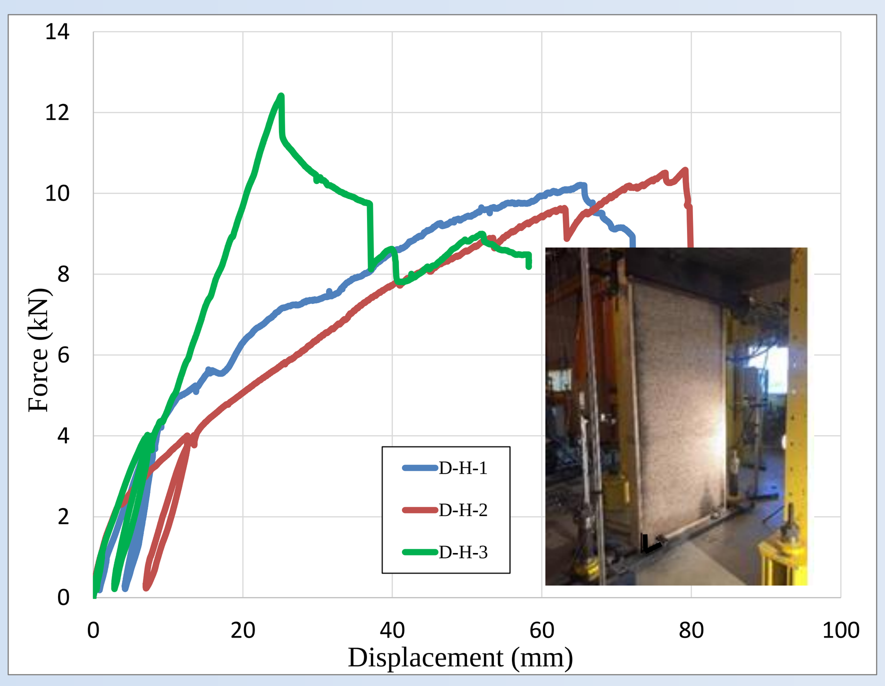


Force-Displacement behaviour for vertical stud hemp walls.

The diagonal strut increases the rigidity of the overall system preventing the hemp concrete to participate in the lateral strength of timber frame wall.

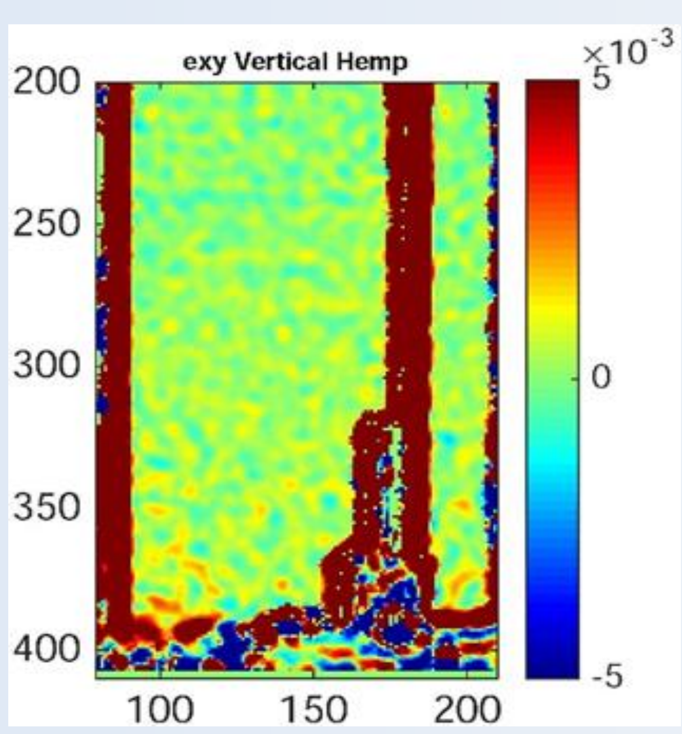


Force-displacement diagram for diagonal bracing wall

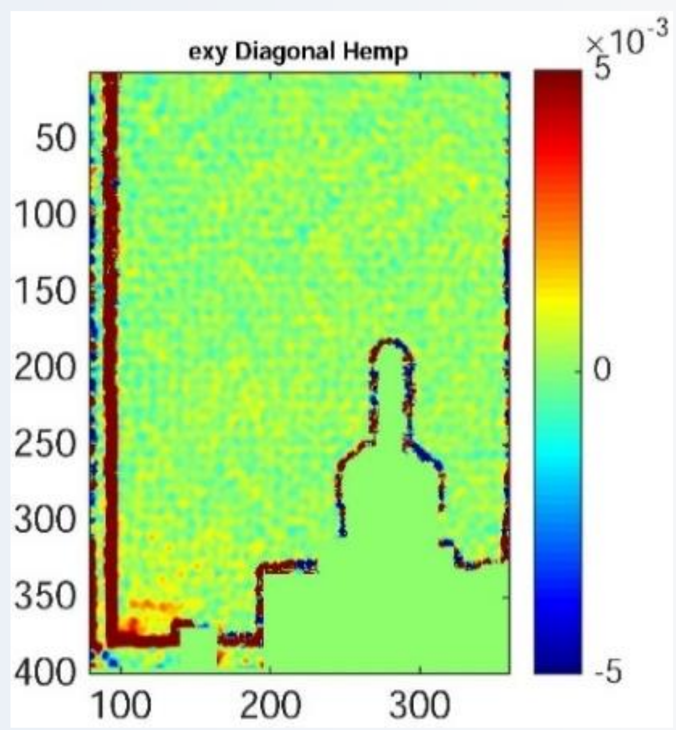


Force-displacement diagram for diagonal bracing hemp wall

Digital Image Correlation (DIC) technique



Shear strain field of hemp concrete in vertical stud timber wall (V-H-2)



Shear strain field of hemp concrete in diagonal bracing timber wall (D-H-2)

Discussion and conclusions

- The hemp concrete in wall dimensions (2.5 m x 1.2 m) has not any contribution in the lateral load carrying capacity of diagonal bracing wall due to the high rigidity of the diagonal element in timber wall.
- Small participation of hemp concrete was observed in the vertical strut wall, the hemp concrete can not participate totally in the lateral strength without existence of diagonal compression strut zone which make the material loaded under shear forces.
- The diagonal compression zone depends totally on to the external dimemensions of wall.