RES9 - Advances in seismic resilience research - commemorating 70th anniversary of IEM, CEA
14:45 – 15:00

WHY TRADITIONAL TIMBER FRAMES WITH INFILLS STAND UP

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Universitatea Tehnică de Construcții București

1. Introduction

Petit-Trou-de-Nippes 2021,(**Haiti** – kayi pey buildings)

Dutu, A., Miyamoto K., Sechi G., Kishiki S. (2022) 'Timber framed masonry houses: resilient or not?', in *3rdEuropean Conference on Earthquake Engineering and Seismology (3ECEES), September, Bucharest, Romania*.

Port-au-prince, 2010 (**Haiti** – GingerBread and kayi pey buildings)

Langenbach, R. *et al*. (2010) *Preserving Haiti's Gingerbread houses: 2010 earthquake mission report*.

Vieux-Champagne, F., Sieffert, Y., Grange, S., Polastri, A., Ceccotti, A., & Daudeville, L. (2014). Experimental analysis of seismic resistance of timber-framed structures with stones and earth infill. *Engineering Structures*, *69*, 102–115. https://doi.org/10.1016/j.engstruct.2014.02.020

Port-au-prince, 2010 (**Haiti** – GingerBread and kayi pey buildings)

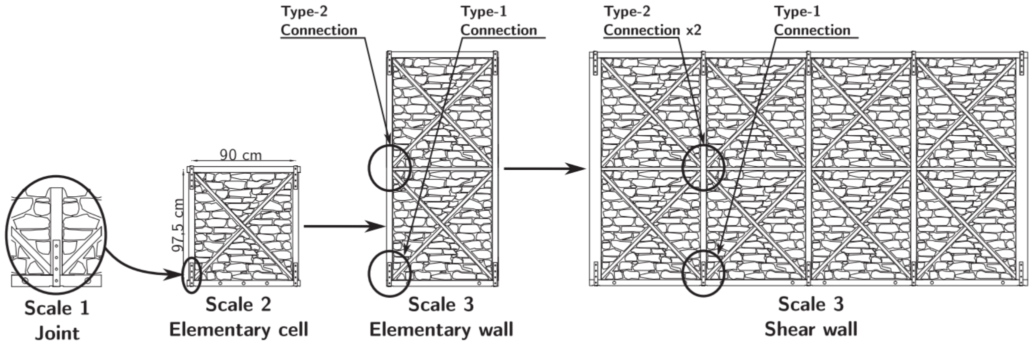
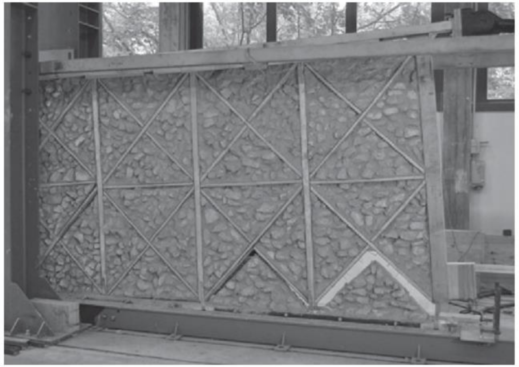


Fig. 3. The three scales of this experimental study.



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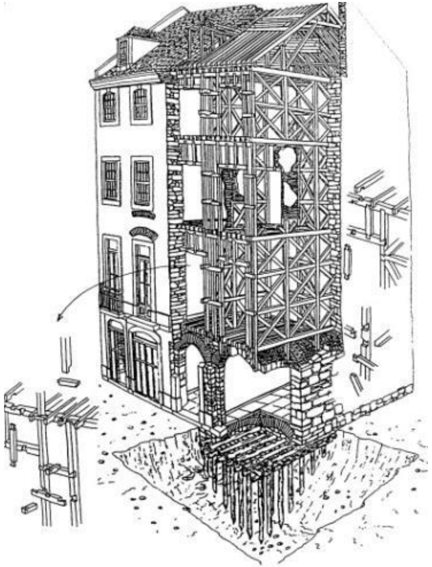
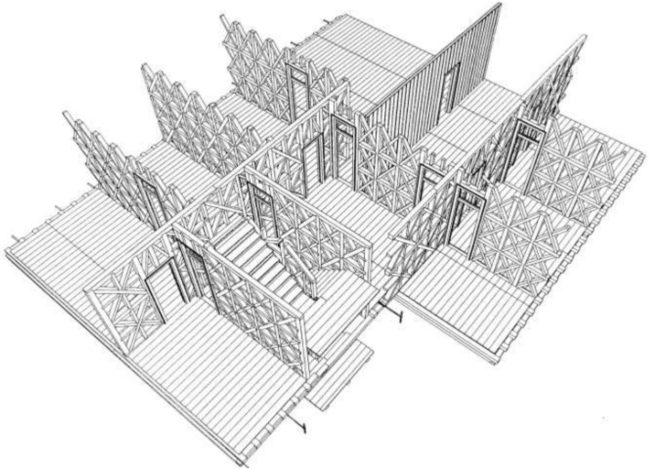
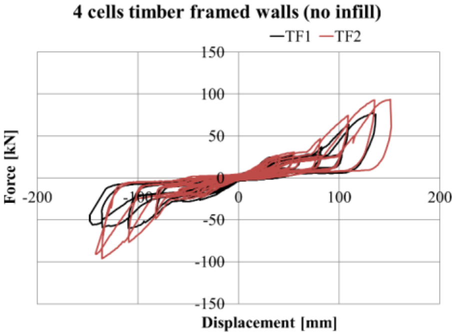
Lisbon, 1755 (**Portugal** – Pombalino buildings)

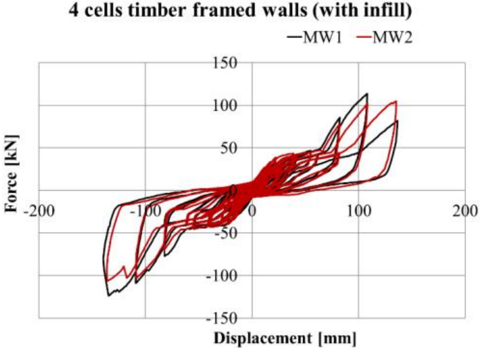




Poletti, E., Vasconcelos, G. and Oliveira, D. V. (2013) 'Influence of Infill on the Cyclic Behaviour of Traditional Half-Timbered Walls', *International Conference on Rehabilitation and Restoration of Structures*, pp. 179–189. Available at: https://repositorium.sdum.uminho.pt/handle/1822/26476

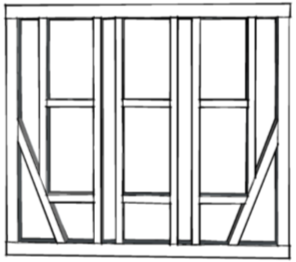
Lisbon, 1755 (**Portugal** – Pombalino buildings)

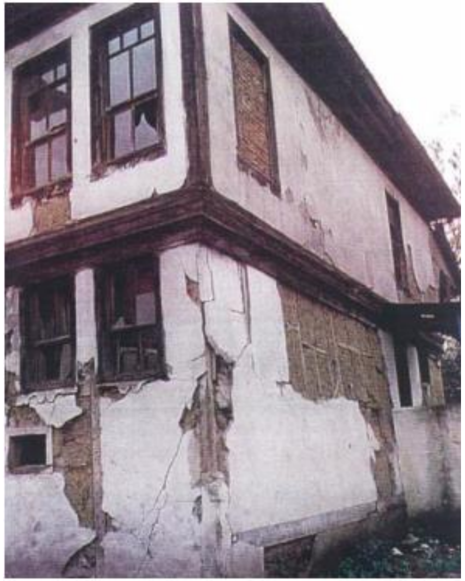




Dutu A., Gomes Ferreira J., & Gonçalves, A. M. (2012). THE BEHAVIOUR OF TIMBER FRAMED MASONRY PANELS IN QUASI-STATIC CYCLIC TESTING. *9th International Conference on Urban Earthquake Engineering/ 4th Asia Conference on Earthquake Engineering*, 8–13.

Kocaeli, 1999 (Turkey – himis buildings – earthquake Kocaeli 1999)

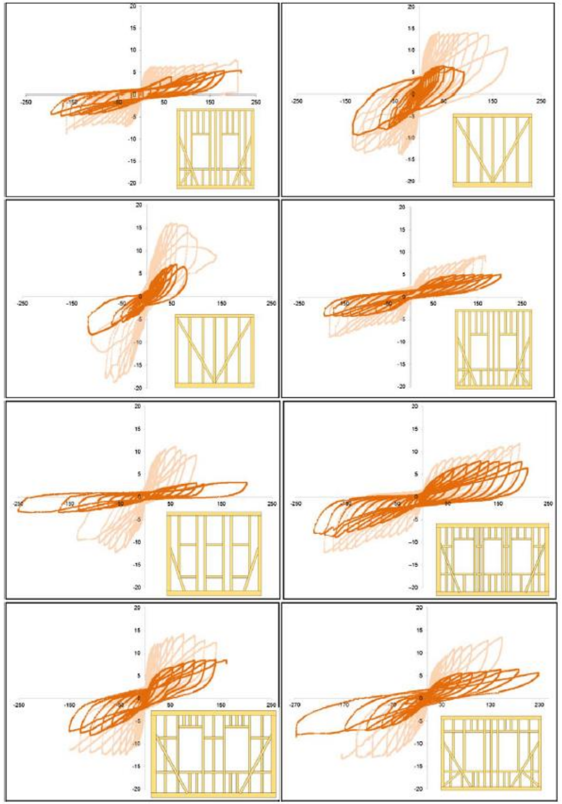




Koca, G. (2018) 'Seismic Resistance of Traditional Wooden Buildings in Turkey', in *VI Convegno Internazionale*. Messina, p. 11

Kocaeli, 1999 (Turkey – himis buildings)



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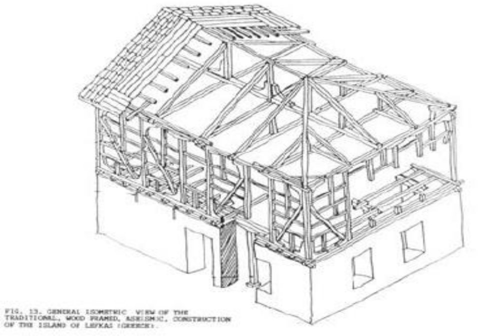
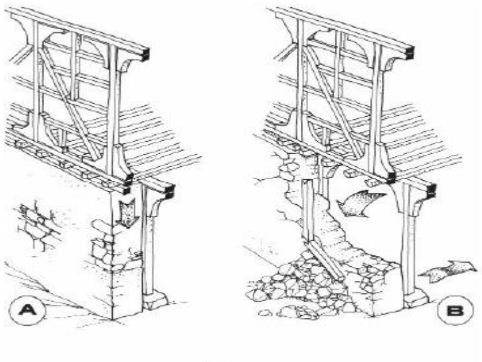
Lefkada, 2003 (Greece - Ξυλοπηκτη Τοιχοποιια (Xylopikti Toichopoiia)



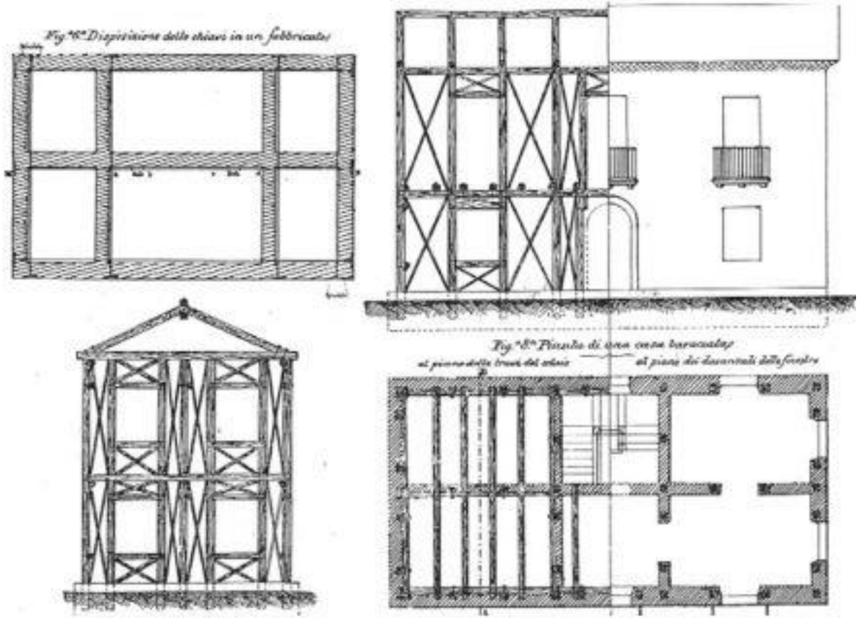
(a)

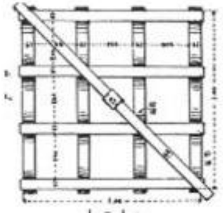


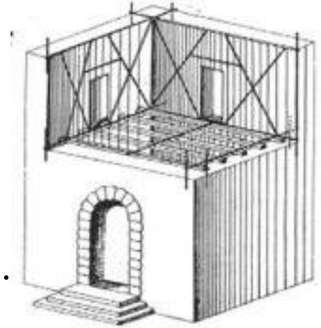
(β)

Σχολη, Π., Προγραμμα, Δ. and Σπουδων, Μ. (2014) *Ανελαστική Ανάλυση Ξυλόπηκτων τοιχοποιιών με απλή διαγώνια δικτύωση.*

Italy – casa baraccata buildings – Messina earthquake 1908







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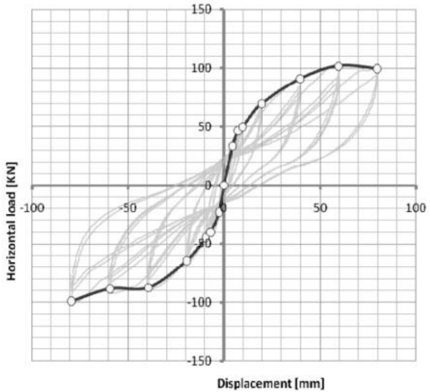
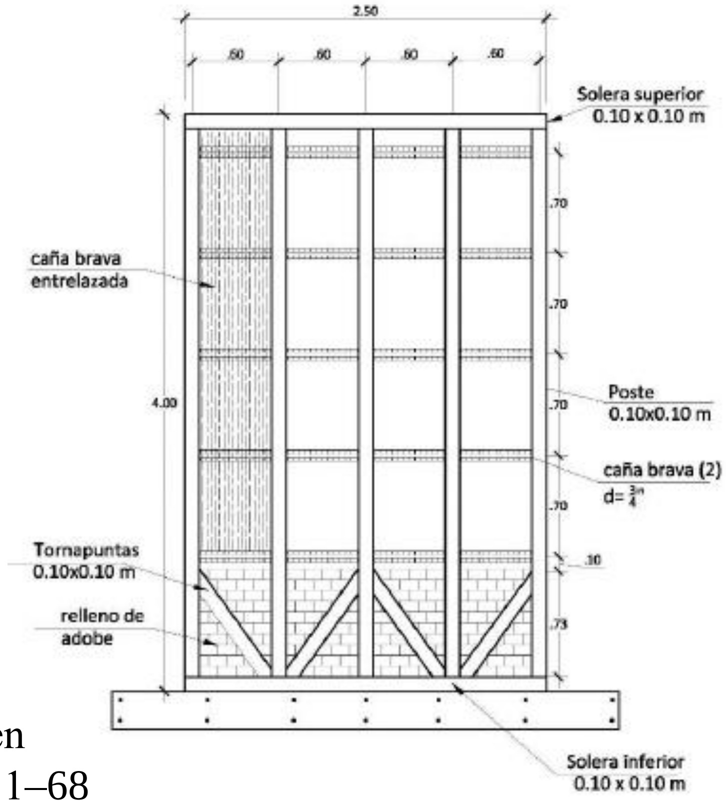
Italy – casa baraccata buildings



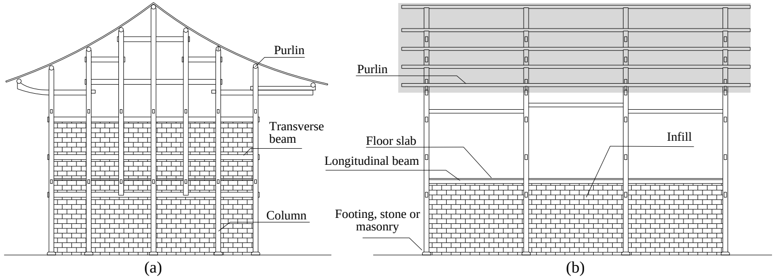
Ruggieri, Nicola, & Zinno, R. (2014). Seismic Assessment of “ Baraccato ” System : Constructive Analysis and Experimental Investigations. *Second European Conference on Earthquake Engineering and Seismology, Istanbul Aug 25-29*.

Pisco, 2007 (**Peru** – Quincha buildings)



Cancino, C. *et al.* (2011) 'Damage assessment of historic earthen buildings after the august 15, 2007 pisco, peru earthquake', pp. 1–68

Lushan, 2013 (**China** –ChuanDou buildings)



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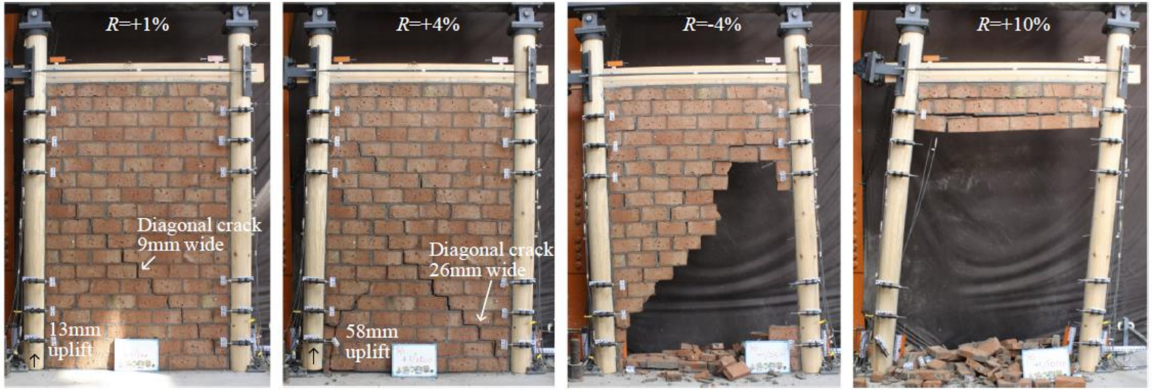
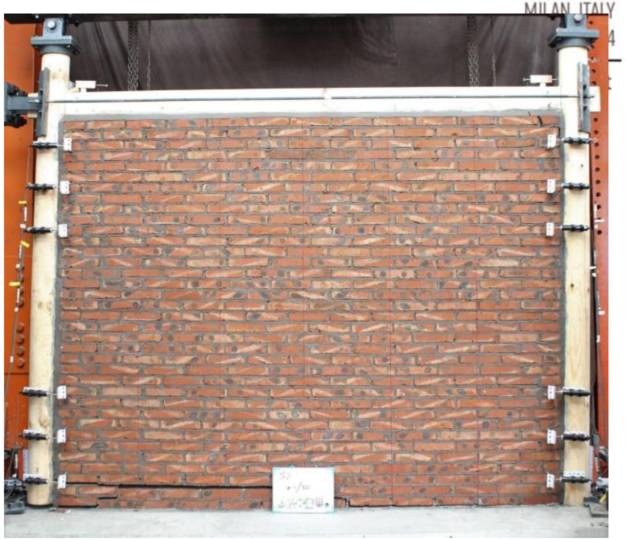
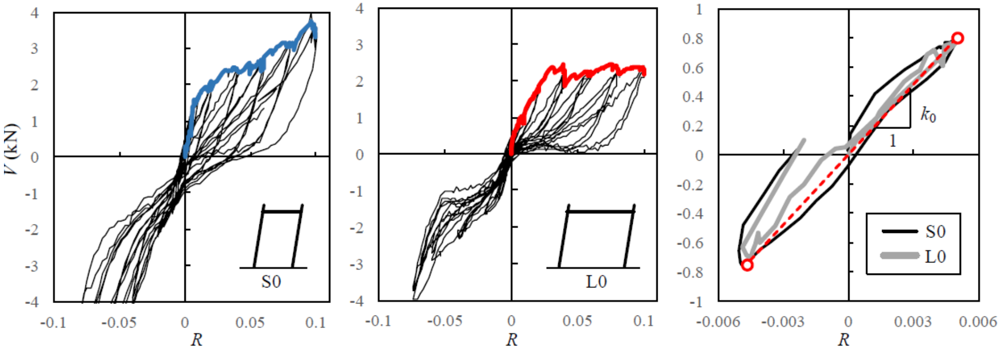
Lushan, 2013 (**China** –ChuanDou buildings)







Qu, Z., Fu, X., Kishiki, S., & Cui, Y. (2020). Behavior of masonry infilled Chuandou timber frames subjected to in-plane cyclic loading. Engineering Structures, 211, 110449. https://doi.org/10.1016/j.engstruct.2020.110449.

2.Timber frames with infills around the world

Bulgaria

Paianta house, type 1 – with fired mud brick infill - **Romania**

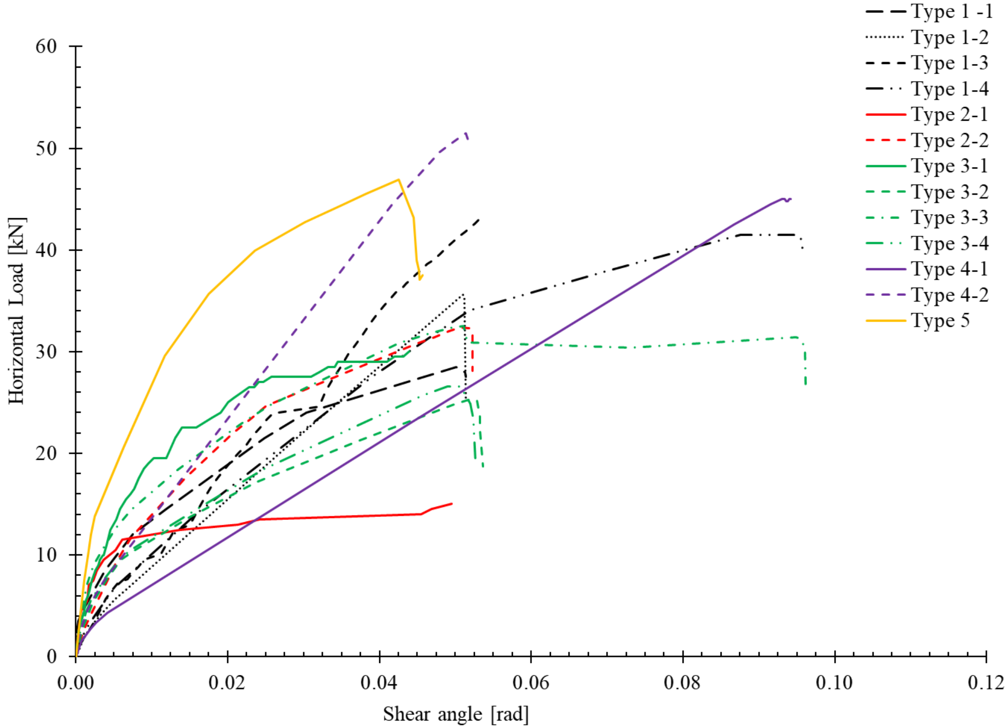
Paianta house, type 2 – with wattle and daub infill - **Romania**

Paianta house, type 3 – with mud mixed with straw infill - **Romania**

Paianta house, type 4 – with horizontal logs infill - Romania

Paianta house, type 5 – with AAC brick infill - **Romania**

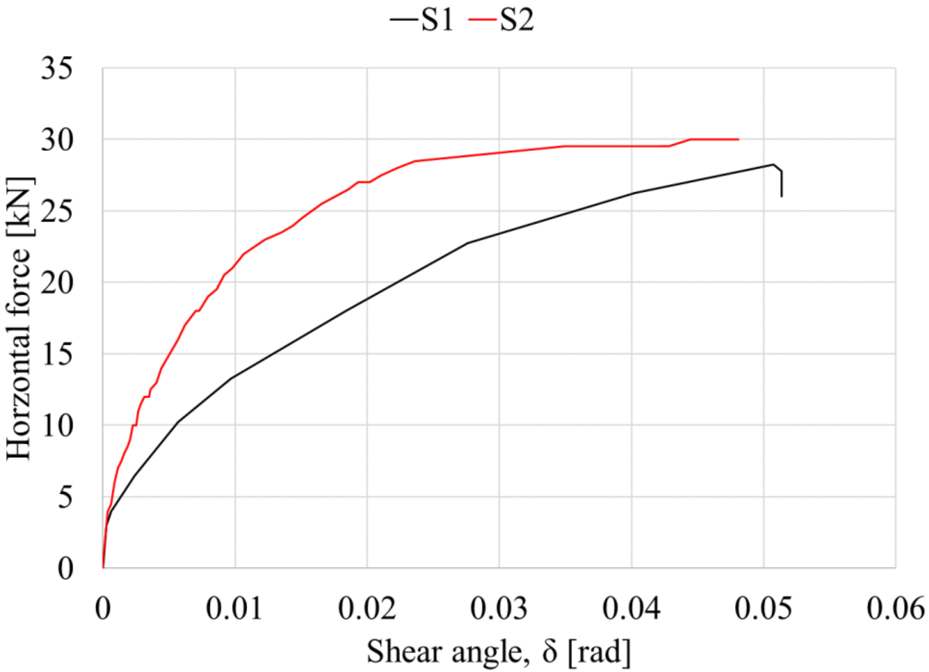
Static cyclic tests on *paianta* walls

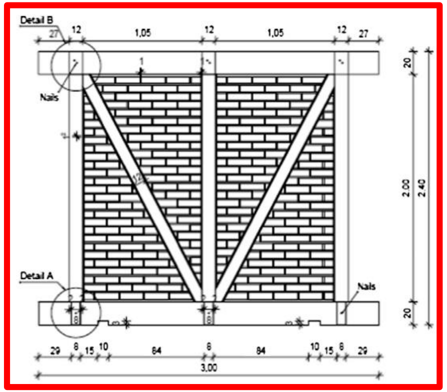


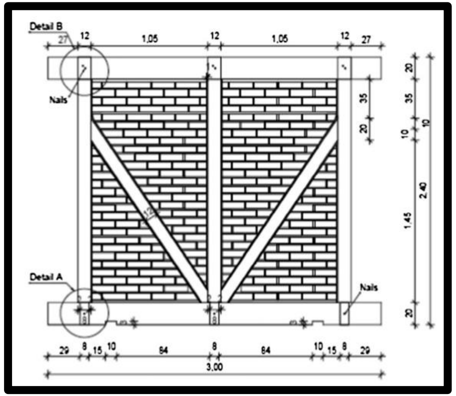
Type 1 Type 2 Type 3

Type 4 Type 5

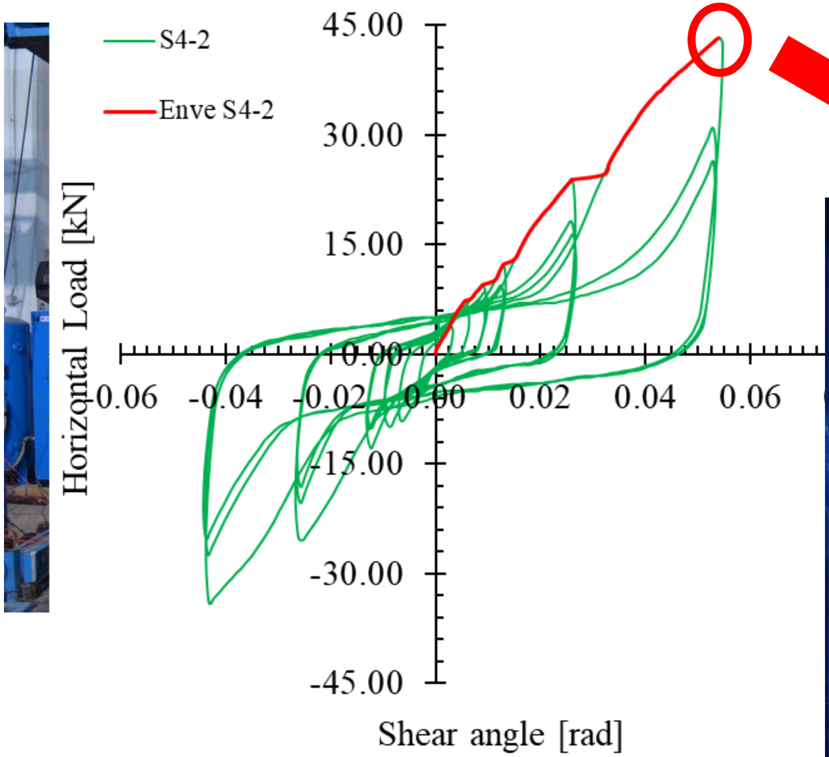
The lower diagonal

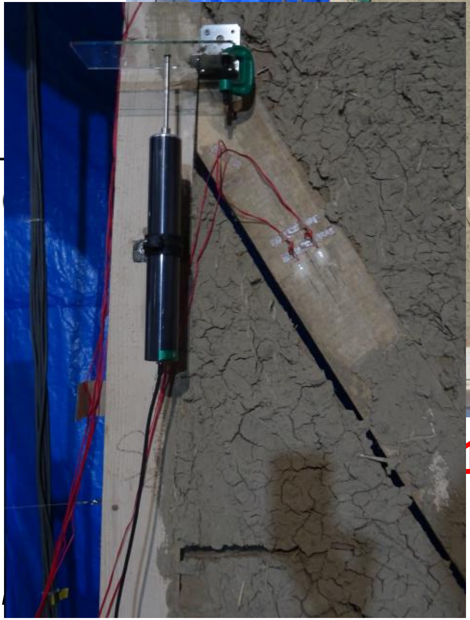






The poor connection between the timber frame and infill

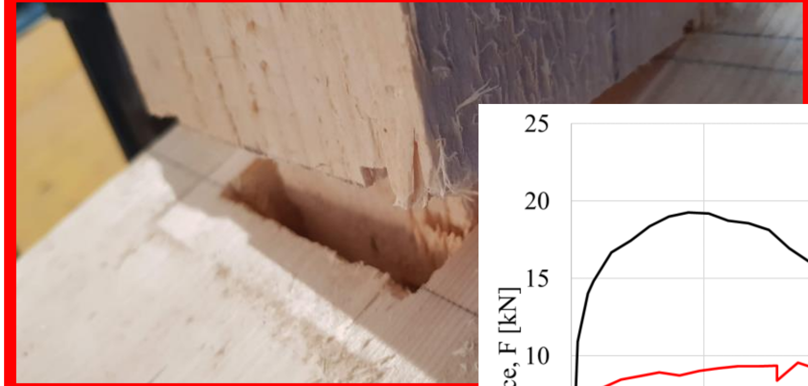
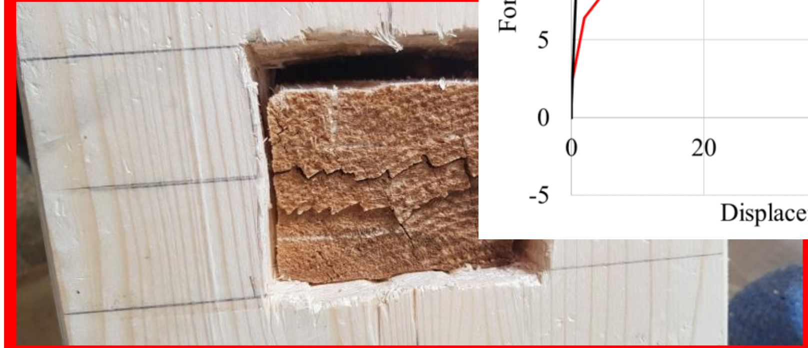
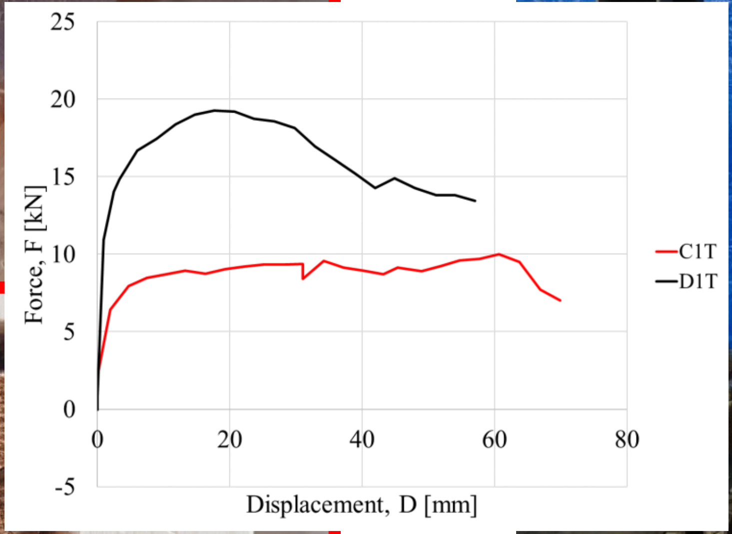


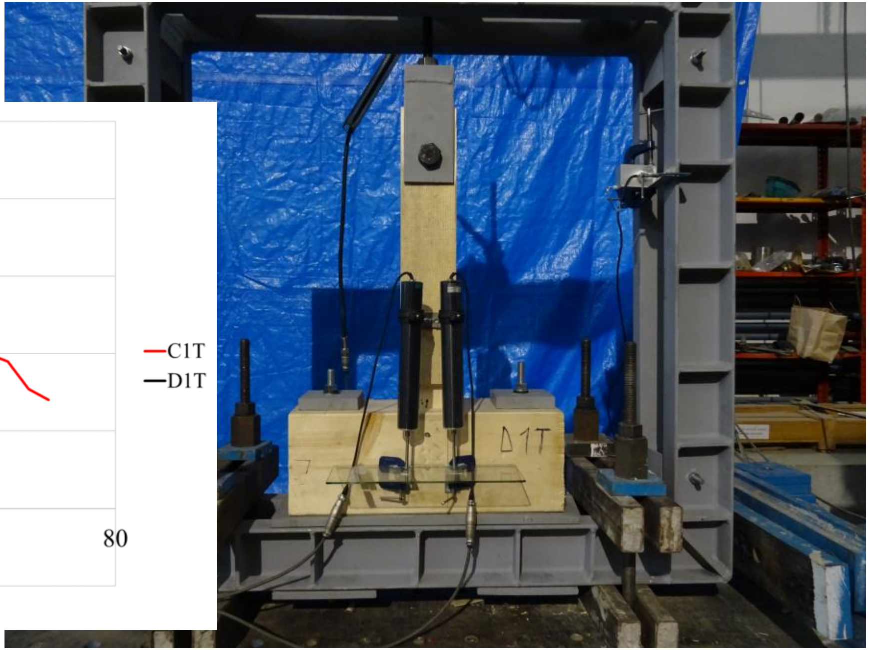


120 m

WHY TRADITIONAL TIMBER FRAMES WITH INFILLS STA

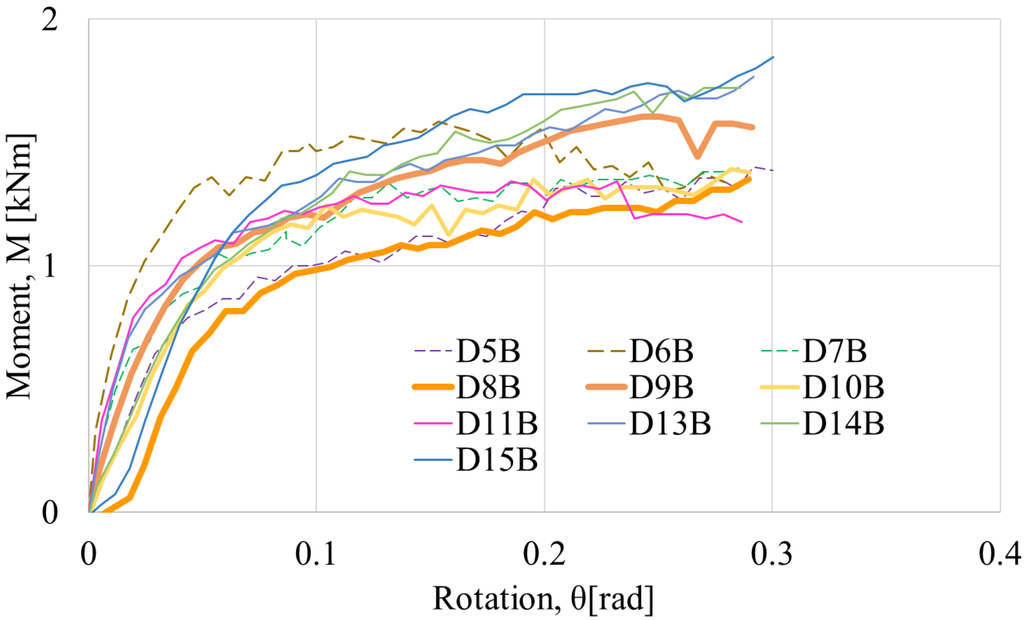
The gaps and different metal fasteners in the timber connections



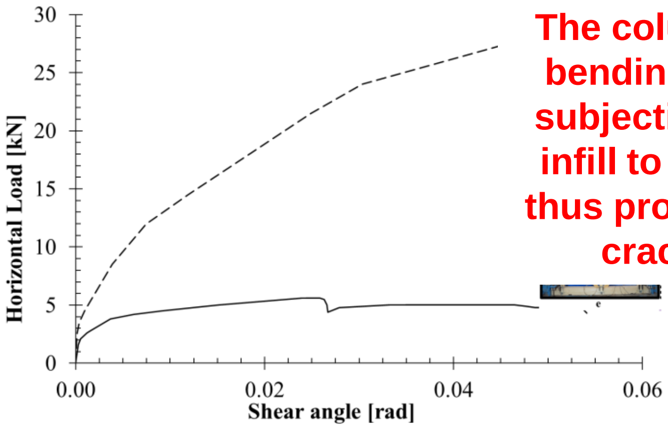
Black line = good workmanship skills
Red line = poor workmanship skills

The gaps and different metal fasteners in the timber connections



Orange thick line = gaps in the cross-halved connections

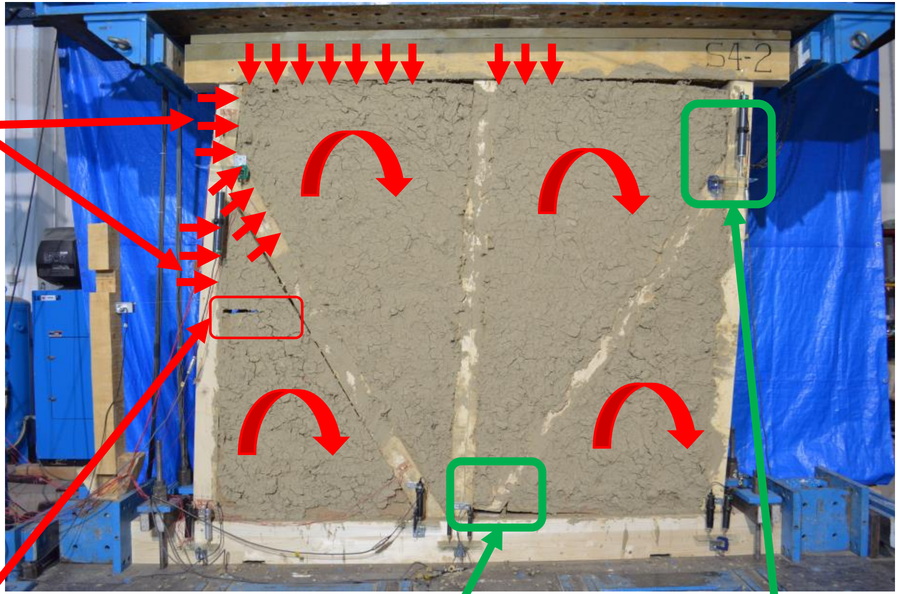
The mechanism of timber frames with infills



Infills' influence

The column is bending, and subjecting the infill to shear, thus producing cracks

The crack does not propagate to the upper infill panel

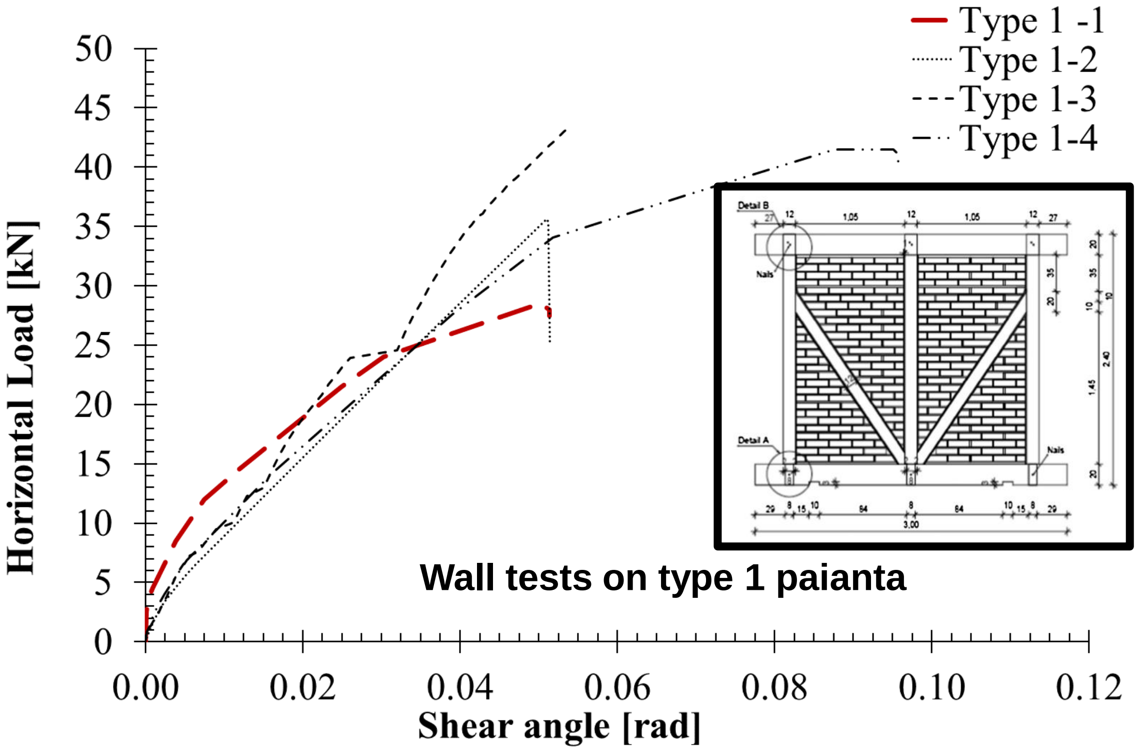


The brace detaches, but due to the infill, it goes back in the same place

The brace slides, but the infill is resisting it, being compressed

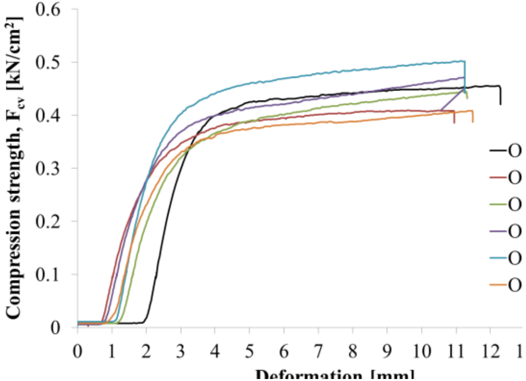
Fired earth brick behavior in compression

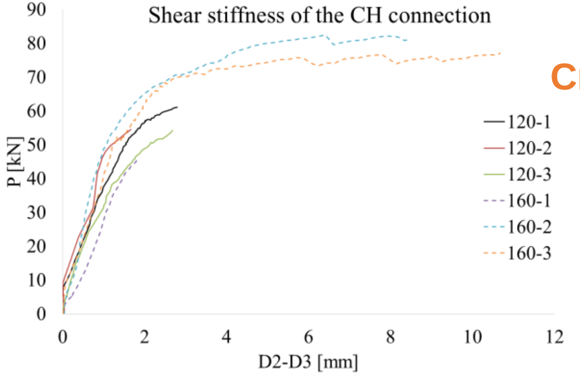
No.	Dimensions [mm]	F (crack)
1	115x150x50	20.5
2	115x150x50	20.5
3	115x145x50	6.8
4	115x150x55	18
Average		

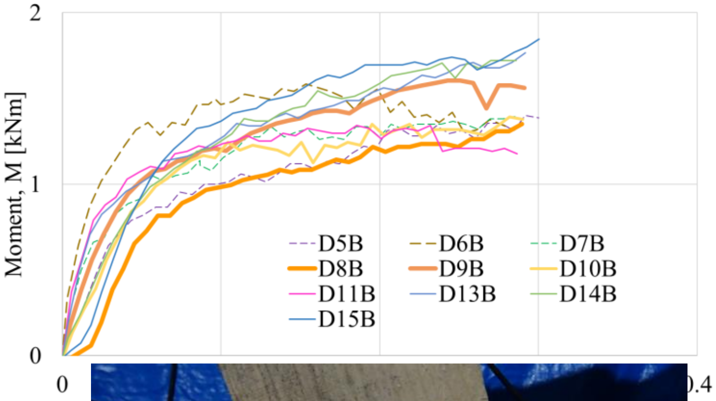


Wall tests on type 1 paianta

Timber behavior in compression perpendicular to the grain







- Traditional timber frames with infills are a category of houses which proved to be resilient both in real earthquakes and also in experimental tests.
- In some cases, even though the workmanship is not done by highly skilled workers, the system is “forgiving” and due to its layout and working principles, overcomes the execution mistakes and gives the inhabitants a resilient home.
- Key properties such as compression strength of earth, compression perpendicular to the grain of timber, bending of connections, are all contributing to the performance of the structure in earthquakes.

5.Acknowledgements

This paper was done based on the StrongPa project which is financially supported by the Romanian National Authority for Scientific Research and Innovation, CNCS – **UEFISCDI**, project number **PN-III-P2-2.1-PED-2021-1428** – Experimental Demonstrative Project (UEFISCDI Romania), 2022-2024” and also on the TFMRO project, funded by the same institution and having the project number **PN-II-RU-TE-2014-4-2169**” between 2015-2017.

The financial support of the Japan Society for Promotions of Science (**JSPS**) for the postdoctoral research grant no. **PE 13092** is acknowledged.