Technological analysis of prefabricated timber-based panels for the integrated renovation of RC framed buildings

C. Tardo[1], G. Fiore[2], G. Margani[3]

[1*] Department of Civil Engineering and Architecture, University of Catania, Catania, carola.tardo@unict.it
[2] Department of Civil Engineering and Architecture, University of Catania, Catania, giulia.fioreg@libero.it
[3] Department of Civil Engineering and Architecture, University of Catania, Catania, margani@unict.it

ABSTRACT

In earthquake-prone countries, the need for interventions aimed at improving both the seismic resistance and energy efficiency of the existing building stock is widely recognized, although the implementation of such interventions is currently limited by economic and technical barriers, as well as socio-cultural ones.
In order to overcome these barriers, a new holistic design approach to the building renovation is strongly needed, which can result in innovative and integrated retrofitting interventions able to specifically meet the current needs of cost-effectiveness, quick installation, reduced users' disturbance and low environmental impact.
To this purpose, the use of Cross Laminated Timber (CLT) has been recently investigated as an alternative and sustainable solution to seismic strengthen the existing buildings, thanks to its high mechanical performance. In this research context, an innovative integrated (seismic-energy-architectural) renovation technology for reinforced concrete (RC) framed buildings is currently under development within the ongoing multidisciplinary Horizon 2020 innovation project, called e-SAFE (energy and Seismic AFfordable rEnovation solutions). The proposed technology consists in the application of prefabricated timber-based panels on the existing outer walls, combining structural CLT panels (called e-CLT), equipped with innovative friction dampers for seismic energy dissipation, with non-structural wooden framed panels hosting high-performing windows (called e-PANEL).
This paper illustrates a possible technical and functional application solution of this new renovation system, aimed at ensuring a correct and easy installation and operation. To this end, the proposed solution has been applied to a specific case study, i.e. a typical apartment building located in the city of Catania, in Southern Italy.

1. INTRODUCTION

In earthquake-prone countries, a recent issue in the building renovation sector is the need to combine the energy-efficient measures promoted by the current environmental and energy policies [1] with anti-seismic interventions. In fact, in most European seismic countries – such as Italy, Greece, Bulgaria, Turkey, Romania and the Balkan peninsula [2] – the building stock designed without anti-seismic and energy-efficient criteria is extremely wide, including mainly masonry or reinforced concrete (RC) framed buildings.
However, many barriers currently hinder the combined use of current seismic and energy retrofitting techniques: i) economic barriers (mainly due to the excessive costs of combined renovation interventions); ii) technical and management barriers (high occupants' disturbance and long time for implementation, resulting in the building operativity interruption); iii) social and cultural barriers (lack of information, as well as community rejection to changing the original building appearance, if required) [3]. These barriers limit the spread of combined retrofitting actions, which are further opposed by the insufficient spread of a seismic risk and environmental protection culture.
Considering the current needs of cost-effectiveness, quick installation, and less users' disturbance, as well as environmental sustainability, an innovative and holistic design approach to the building renovation is strongly needed, which can result on new and integrated retrofitting technologies.
In this framework, wood has shown great potential as sustainable and renewable retrofitting material to upgrade the seismic and thermal performance of the existing buildings, thanks to the recent advancement of engineered timber products, such as cross laminated timber (CLT), as well as wood-based insulating materials.
In this research context, this paper firstly explores recent research on this topic, and then investigates the technical feasibility of an innovative integrated renovation solution for RC framed buildings based on the use of prefabricated timber-based panels. This solution is currently under development within the ongoing multidisciplinary Horizon 2020 innovation project, called e-SAFE (energy and Seismic AFfordable rEnovation solutions).

2. THE POTENTIAL USE OF CLT IN THE BUILDING RENOVATION SECTOR

CLT is a plate-like engineered wood product, commonly composed of an uneven number of layers made of side-by-side placed timber boards, which are arranged crosswise to each other at an angle of 90° and quasi rigidly connected by adhesive bonding [4]. The result is a monolithic element having considerable mechanical performance. In fact, the crosswise build-up provides the CLT panel high capacity of bearing loads both in-plane and out-of-plane, allowing its application as a full-size wall and floor element, as well as linear structural member [5]. The recent use of CLT in mid-rise and high-rise buildings with low environmental impact has shown the great potential of timber-based or hybrid timber-based constructions, to which is expected that building industry will be addressed in the coming decades [6].

The high mechanical performance of this engineered wood product together with the increasing attention to the environmental sustainability issue have led research community to investigate further application fields, such as building renovation sector. Specifically, recent studies have investigated the use of reinforcement CLT walls in order to increase the seismic performance of the existing historical or modern buildings, with potential results in terms of strength and stiffness capacity increase under seismic loads [7-13]. Other advantages of such potential use are also low building mass increase, compared to other seismic upgrading techniques, as well as the well-known benefits of dry interventions, such as quick and easy installation and materials reversibility and recyclability. Furthermore, CLT is a good insulating material thanks to its low thermal conductivity (0.10 ÷ 0.13 W m-1 K-1) [14]. Consequently, if applicated on the building envelope can also improve its thermal insulation performance, in view of an integrated and sustainable approach to buildings renovation.

Different applications of reinforcement CLT panels to the building envelopes have been investigated.

Lucchini et al. [7] and Riccadonna et al. [8] propose to add CLT panels to the internal side of the existing outer walls in unreinforced masonry (URM) buildings, investigating possible connection systems between the new timber-based envelope and the existing one. Despite this solution includes high occupants' disturbance, the aim is to not modify the building façades, especially those protected by historical and architectural constraints. Pozza et al. [9] analyse CLT panels application on both the external and internal side of the existing masonry walls, performing experimental tests on masonry wall samples with CLT jacketing. Instead, referring to RC framed buildings Sustersic e Dujic [10] propose CLT panels in addition to the existing outer walls, realizing the connection to the structure through special energy dissipation devices. The external application of CLT panels has been recently investigated also within the AdESA project [11], resulting in a real application on a case study, while Stazi et al. [12] proposed CLT shear walls in replacement of the existing masonry infill walls of RC framed buildings. CLT infilled shear walls have been also analysed by Japanese researchers [13], who investigated narrow CLT elements bonded onto the RC frame with epoxy resin.

The recent and rich literature on the topic of buildings retrofitting through reinforcement CLT walls shows not only that these studies are of great interest, but also that they are still at a preliminary stage. Consequently, further investigations on the versatility and effective replicability of this intervention, as well as possible connection systems between the CLT panels and the existing building envelope are required, in order to make this renovation solution concretely and widely applicable [6].

3. PROPOSED RETROFIT TECHNOLOGY

3.1 Materials and components

The proposed retrofit technology consists of cladding the envelope of the existing RC framed buildings with prefabricated timber-based panels (Figure 1). Specifically, structural CLT-based panels (e-CLT) are connected to the RC beams by means of innovative friction dampers for seismic energy dissipation. These dampers make available the additional lateral stiffness of the CLT panels and dissipate seismic energy in occurrence of moderate and strong ground motions, respectively. Both these effects reduce the drifts demanded by earthquake, reduce damage to non-structural and structural components and improve the seismic performance of the existing RC frame.

The mechanical characterization of the proposed friction damper is currently under investigation. Basically, it is made by two steel profiles, which connect the CLT panels of two consecutive floors with the existing interposed RC beam (Figure 2a). One profile (named "anchor profile") is connected to the RC beam by anchor bolts and to the other profile (named "free profile") by slotted holes and pretensioned high-strength bolts. The shear force is transmitted from the upper to the bottom profile by means of the friction exerted in the contact surface. During an earthquake, when the force transmitted by the damper attains the value of the friction force, the upper profile slides on the bottom one and thus dissipates seismic energy (Figure 2b).

The e-CLT panels are combined with prefabricated non-structural panels (e-PANEL) that integrate high-performing windows to replace the existing ones. These panels are made of lightweight wooden frame in order to ensure easier manufacture and cost savings.

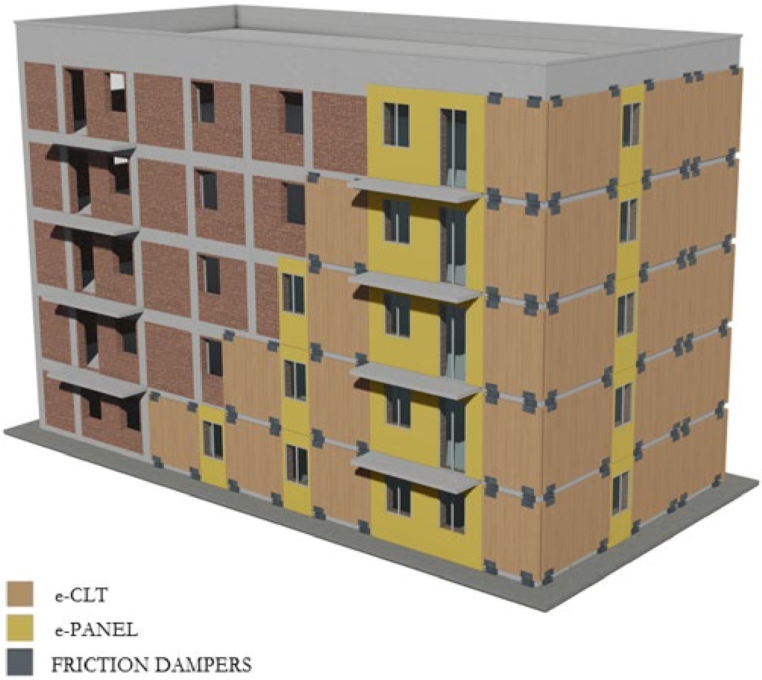


Fig. 1 Components of the proposed retrofit technology

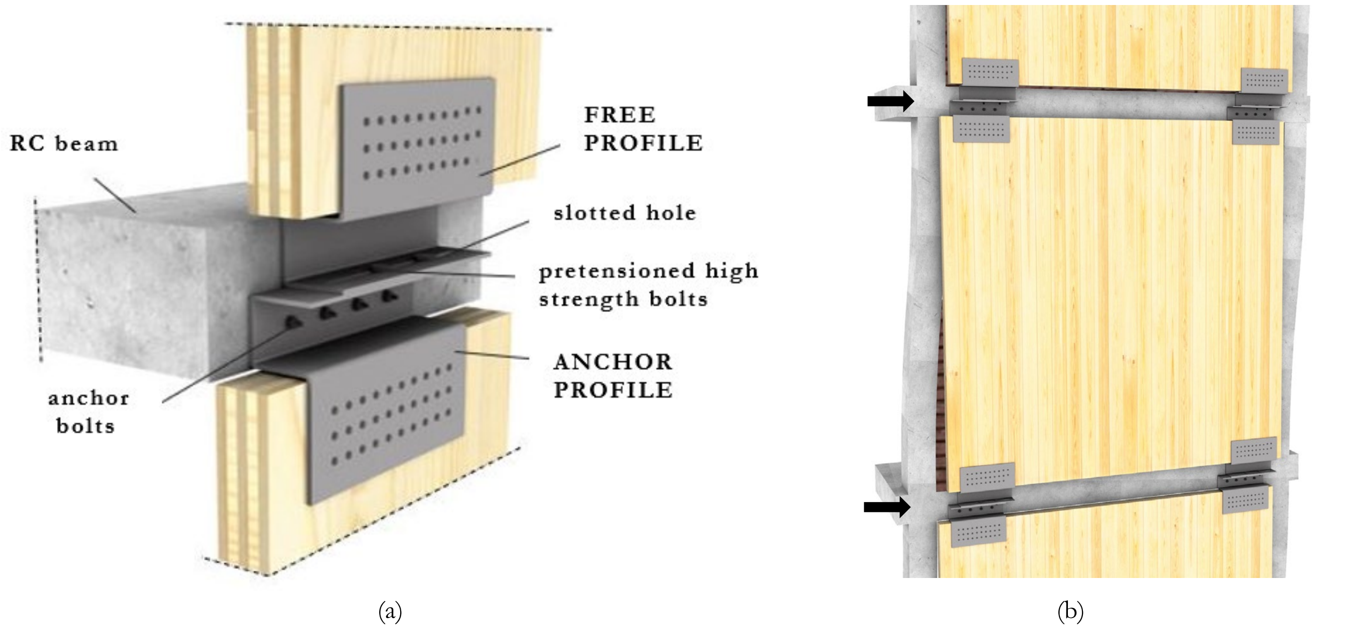


Fig. 2 (a) Friction damper under investigation and (b) e-CLT behaviour system under seismic loads.

Both e-CLT and e-PANEL integrate insulation materials, waterproof breather membranes and finishing layer (Figure 3). Insulation materials can be chosen based on the local availability of low-cost bio-materials (e.g., wood fibre, hemp, cork, cellulose fibre, etc.) and their thickness are set according to the climate zone and the required level of thermal insulation performance. Instead, cladding materials can be chosen according to the users' aesthetic preferences, contributing to renovate the building architectural image.

Thanks to the use of prefabricated components and their dry installation, the proposed solution allows to significantly reduce costs and installation time. Furthermore, this intervention is carried out from the outside, minimizing the occupants' disturbance, while maintaining the building operativity.

In the followings Sections we will investigate the main technological measures aimed at ensuring the operation of the proposed technology in the event of dampers activation, as well as the quick and easy installation of the main components and their architectural integration.

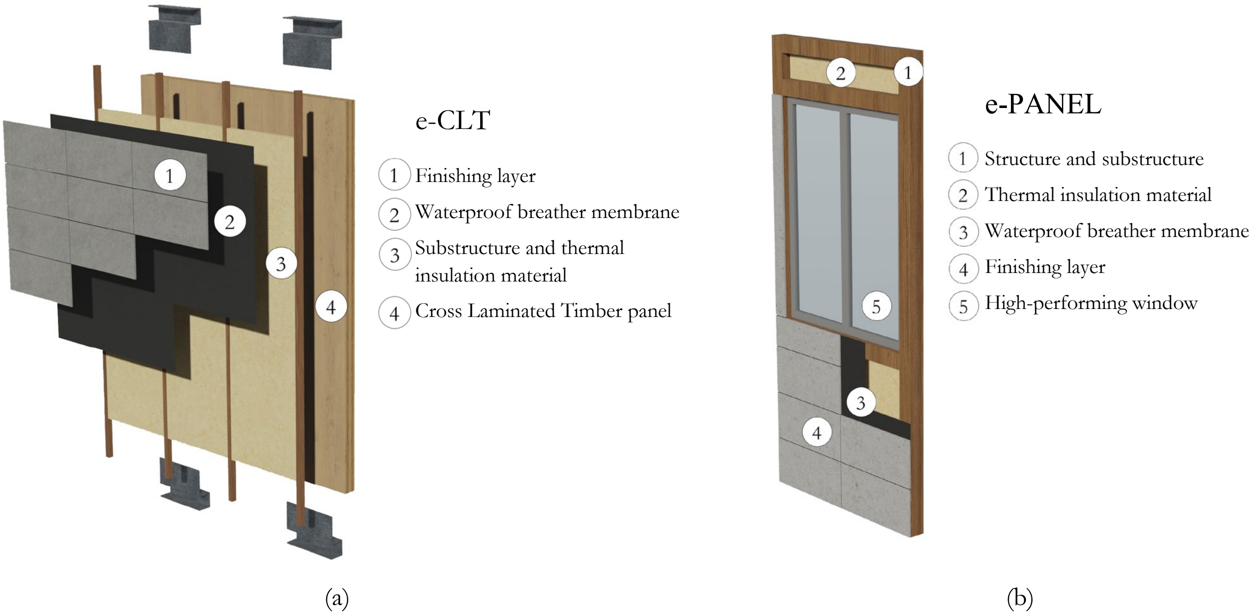


Fig. 3 Stratification of (a) e-CLT and (b) e-PANEL.

3.2 The installation process

The installation of both e-CLT and e-PANEL is performed by means of a mobile lifting equipment (cranes, lifting platforms, etc.), proceeding to apply panels from the first floor of the building to the top one (Figure 4a).

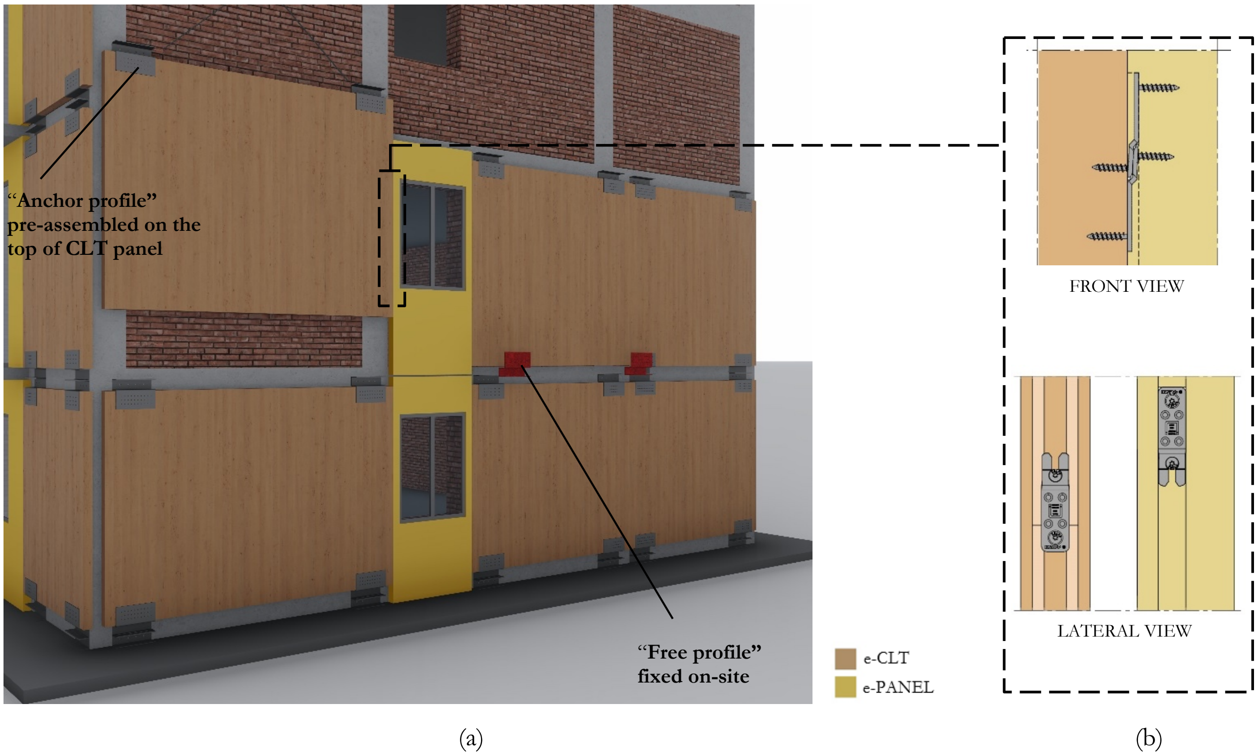


Fig. 4 (a) Installation of the proposed retrofit technology; (b) example of concealed wood connector between e-CLT and e-PANEL [15]. (e-CLT and e-PANEL are reported without insulation and cladding layers)

The "anchor profiles" of each damper are pre-assembled on the top of CLT panels off-site. In this way, the e-CLT installation results quick and easy, since it involves: 1) to lift and place the panel next to the existing outer wall, by means of harness accessories (e.g. tie rods and sling bars); 2) to connect the panel to the existing RC beams through chemical anchors, which are inserted into holes previously arranged in the steel profiles. Instead, the "free profiles" of the same dampers are installed on-site in order to properly align and connect the friction surfaces of the two steel profiles.

Unlike e-CLT, e-PANEL is not connected to the existing RC structure but is coupled to the adjacent e-CLT panels by means of connection systems on its lateral sides, in order to ensure the operation of the e-CLT system in the event of dampers activation. In fact, during severe earthquakes, the e-CLT panels will slide horizontally following the building inter-storey drift. Otherwise, seismic vertical joints between e-CLT and e-PANEL would be required to let a free horizontal shift of the e-CLT.

Common concealed wood connectors could be used as lateral connecting systems between e-CLT and e-PANEL (Figure 4b). These connectors are made of two brackets pre-installed in the side edge of both panels, into proper recesses. Nowadays, concealed connectors are widely used in the wood construction sector that offers a wide choice in terms of sizes and mechanical resistance capacity.

The same installation process of both e-CLT and e-PANEL elements can be applied also if the façade has balconies, preserving the existing railings, where possible (Figure 5). In this case, the friction dampers are located at the lower edge of the e-CLT panels, and the "anchor profiles" are fixed directly to the balcony RC slab.

The proposed application system requires a cladding solution to cover the dampers after the panel installation and to inspect them for maintenance and/or replacement purposes. To this end, proper cladding systems should be designed according to the customer architectural preference, including insulation materials to avoid thermal bridges. A potential cladding solution is investigated in the following Section, referring to the selected case study but easily applicable to many other buildings.

Fig. 5 e-CLT installation in balcony façades.
(e-CLT and e-PANEL are reported without insulation and cladding layers)

3.3 Case study

The building selected as case study (Figure 6) is an RC framed apartment block belonging to a public housing compound located in Via Acquicella Porto, in the city of Catania (Southern Italy). It was built in 1964 by the Istituto Autonomo Case Popolari (IACP) of Catania and has five stories, with a total number of 10 apartments on a total area of around 1100 m^2. The case study is representative of the buildings erected in Italy between the 1950s and the 1980s, before the issue of the most recent and restrictive national regulations on seismic resistance and energy efficiency. The external infill walls have been assumed made of two leaves of hollow clay bricks (8-cm and 12-cm thick, internally and externally respectively) with an intermediate 10-cm thick layer (9-cm thick air cavity, plus 1 cm cement plaster on the inner face of the outer leaf), in accordance with the construction techniques of that period (Figure 9).

In order to investigate both the technical feasibility and the architectural integration of the proposed technology, the structural e-CLT panels have been designed on the outer blind walls of the building, with a uniform distribution on the opposite building fronts (Figures 7-8). Of course, the effective number of these panels depends on the level of seismic vulnerability of the building, as well as the expected level of seismic upgrading. Instead, the e-PANELs have been applied on all the windowed walls.


(a) (b)

Fig. 6 Multi-story apartment building selected as case study: (a) north-east view, (b) south-east view.

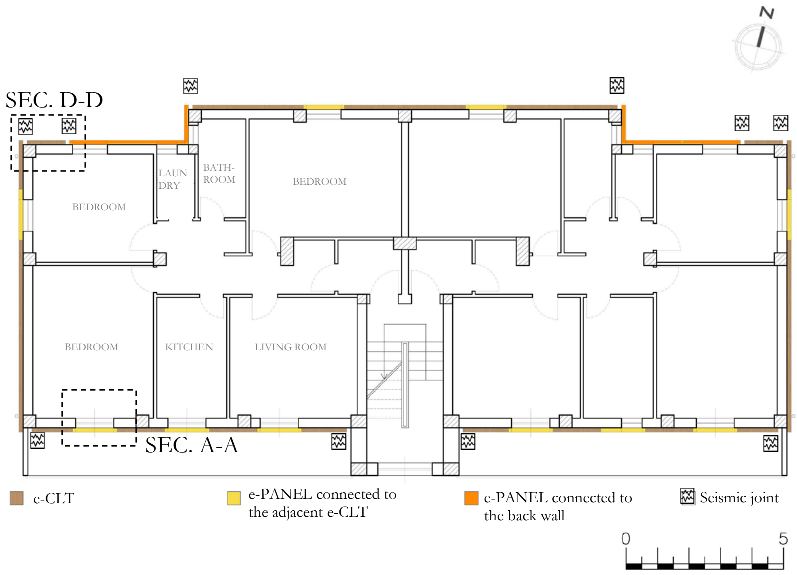
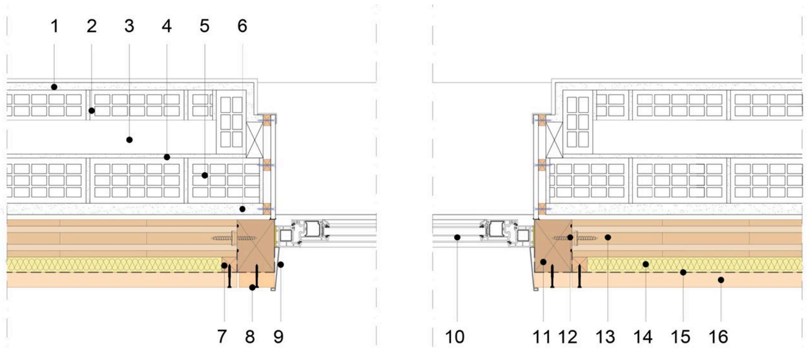


Fig. 7 Ground floor plan of the case study after the application of e-CLTs and e-PANELs.

Fig. 8 Application of e-CLTs and e-PANEs on the: (a) east front, (b) north front, (c) west front, (d) south front of the case study.

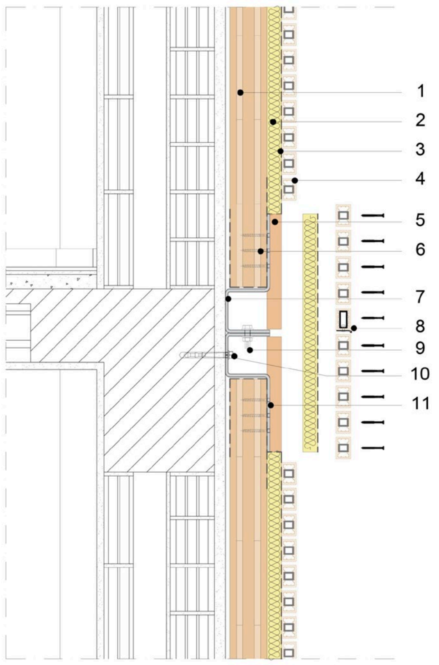
The prefabricated structural e-CLT panels are made of 10-cm thick CLT panel coupled with a 4 cm-thick wood fiber insulation layer (λ=0,037 W m^{-1}K^{-1}, ϱ=110 kg m^{-3}), which is interposed to a wooden framed substructure (wooden studs, 4x4 cm; Figure 9). This stratification allows to reduce the U-value of the existing infill wall from 1,3 W m^{-2} K^{-1} to 0,37 W m^{-2} K^{-1}, complying with the limits set by the current regulations [16] for the climate zone B (Catania).
Instead, the prefabricated non-structural e-PANELs are made of a lightweight wooden frame. They integrate 8-cm thick wood fiber insulation layer, that allows the existing infill wall to reach a U-value equal to 0,34 W m^{-2} K^{-1}. The e-PANELs also integrate PVC-framed double-glazing windows to replace the existing ones.
Both prefabricated panels are cladded with wood-plastic composite (WPC) staves. Specifically, 4x6-cm WPC staves have been used in the e-CLTs while 3x4-cm WPC staves in the e-PANELs, also varying the pitch. The use of different WPC stave formats in the two panels, as well as the different pitch allow to create different architectural effects on the building façades.



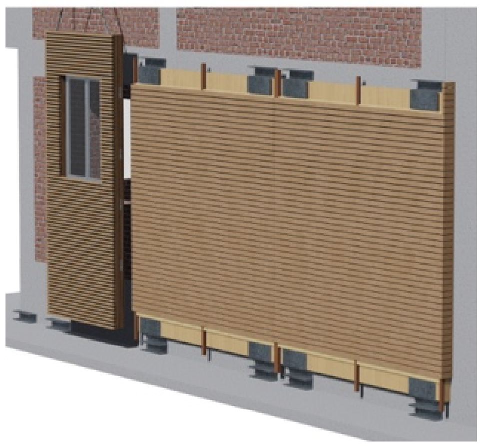
1. Lime plaster, 2 cm
2. Hollow clay brick, 8x25x25 cm
3. Air cavity, 9 cm
4. Cement mortar, 1 cm
5. Hollow clay brick, 12x12x25 cm
6. Lime render, 3 cm
7. Wooden stud, 4x4 cm
8. Wood screw
9. Metallic flashing
10. PVC-framed double-glazing window
11. Wooden stud, 10x14 cm
12. Concealed wood connectors between e-CLT and e-PANEL
13. CLT panel, 10 cm
14. Wood fiber thermal insulation, 4 cm
15. Waterproof breather membrane
16. WPC staves cladding

Fig. 9 Section A-A in Figure 7 (scale 1:20)

As mentioned in Section 3.2, we have analysed different technological solutions to clad the dampers after the e-CLTs and e-PANELs installation. The investigated solutions aim at providing a continuous and uniform cladding in each building fronts. However, other cladding options can be used as architectural motif, e.g. by marking the facades with string courses. In façades without balconies, the proposed solution consists in adding insulation material on-site to avoid thermal bridges, and then fixing the WPC staves directly on the wooden frame of the e-CLT (Figure 10a). To this end, the wooden frame must be left exposed during the e-CLT manufacturing process (Figure 10b).



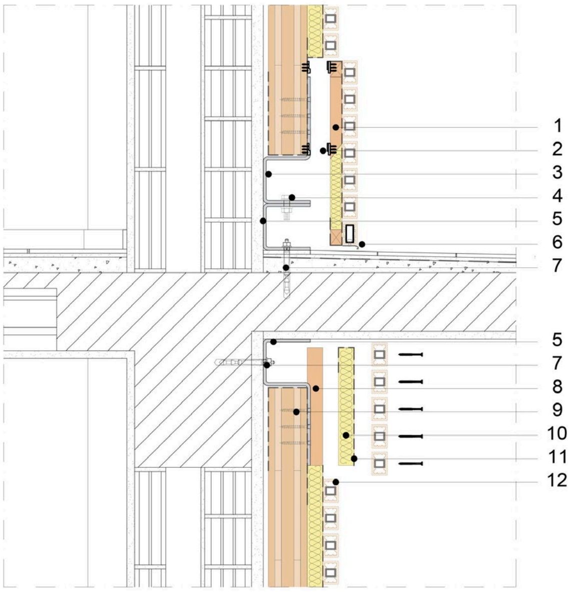
1. CLT panel, 10 cm
2. Wood fiber thermal insulation, 4 cm
3. Waterproof breather membrane
4. WPC staves cladding
5. Wooden framed, section 4x4 cm
6. Wood screw
7. "Free profile" of the friction damper
8. Drainer
9. Pretensioned high strength bolt
10. Chemical anchor
11. "Anchor profile" of the friction damper



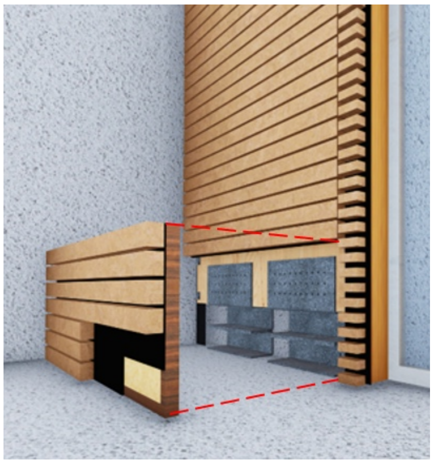
(a) (b)

Fig. 10 Cladding solution to cover the friction dampers in façades without balconies: (a) Section B-B in Figure 8 (scale 1:20); (b) wooden frame of e-CLT to be left exposed during manufacturing process.

In façades with balconies, the above-described cladding solution is used to cover the steel profiles which are pre-assembled on the top of the e-CLT in order to connect them to the existing RC beams (Figure 11a). Whereas, at the bottom of the e-CLT, prefabricated cladding stave panels with integrated insulation material are used to cover the friction dampers that are connected to the balcony RC slab (Figure 11b). These prefabricated elements are fixed to CLT panel on-site through hook connectors, facilitating the e-CLT installation. In fact, the installation solution illustrated in Figure 10 would have been much more complex in this case, since the e-CLT with the exposed wooden frame would have been hardly handled and moved between two balconies.



1. Wooden frame 3x4 cm
2. Hook connector
3. “Free profile” of the friction damper
4. Pretensioned high strength bolt
5. “Anchor profile” of the friction damper
6. Drainer
7. Anchor bolt
8. Wooden frame 4x4 cm
9. Wood screw
10. Wood fiber thermal insulation
11. Waterproof breather membrane
12. WPC staves cladding

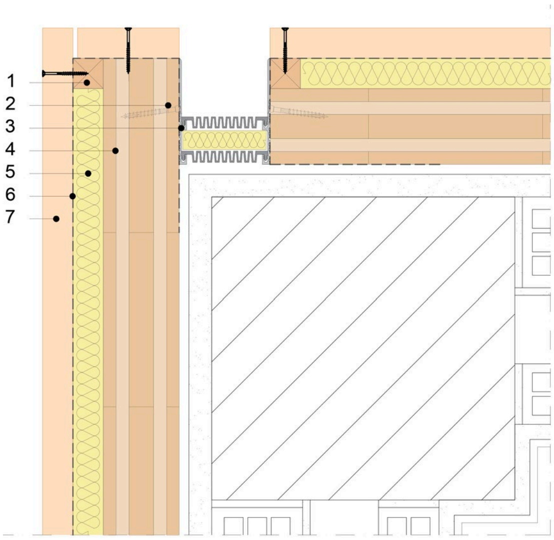


(a)

(b)

Fig. 11 Cladding solutions to cover the friction dampers in façades with balconies: (a) Section C-C in Figure 8 (scale 1:20); (b) prefabricated stave panel.

Then, as illustrated in Figure 7, seismic joints to allow the translation of the e-CLT panels in case of seismic dampers activation are required at the corner of the building, as well as between the e-CLT and the e-PANEL when the latter is connected directly to the existing wall. In particular, specific waterproof and thermal insulating expansion joints for walls have been selected (Figure 12a), not only to avoid thermal bridges and ensure waterproofness, but also to facilitate their installation and allow a proper architectural integration in the building façades (Figure 12b).
Figure 13 shows the potential of the proposed solutions to improve the architectural image of the case study.



1. Wooden frame, section 4x4 cm
2. Wood screw
3. Expansion joint
4. CLT panel, 10 cm
5. Wood fiber thermal insulation, 4 cm
6. Waterproof breather membrane
7. WPC staves cladding

(a)

(b)

Fig. 12 (a) Section D-D in Figure 7 (scale 1:10) and (b) architectural integration of expansion joints on the building façade.

(a) (b)

Fig. 13 (a) North front and (b) east front of the case study at post-renovation state.

4. APPLICATION OF THE PROPOSED RENOVATION INTERVENTION

The integrated retrofitting technology investigated in this paper can be effectively adopted in RC framed buildings with outer blind walls, where an adequate number of structural e-CLT panels should be applied to ensure the expected level of seismic upgrading. Buildings built in Europe between the 1950s and the 1990s are the main target of this innovative intervention, since they usually have regular openings on façades, which allows to uniformly apply the structural panels to each building storey, vertically aligned.

However, garages located at the ground floor of the building or commercial premises with many and large shop windows will preclude the e-CLT application, unless the surface of the openings will be reduced during the renovation works. Even a large use of bow-windows might limit the application of the structural panels, which in this case cannot be connected directly to the beams of the RC structure, reducing considerably the effectiveness of this solution.

Moreover, detached buildings are better suitable to this intervention, since the e-CLT panels can be externally added to each front. Otherwise, the internal application of the e-CLTs on the walls between two buildings might be required.

Another limitation to the effective use of the e-CLTs regards the number of floors. In fact, this solution is less efficient for high-rise buildings and specific simulations are ongoing to adequately investigate this point.

On the contrary, unlikely other anti-seismic renovation interventions (e.g. addition of exoskeletons or buttresses) the proposed application of e-CLTs on the building envelope turns out to be highly versatile, since the panel thickness is on average limited to around 20 cm, which are generally easily available around a building.

5. CONCLUSIONS

This paper describes and analyses the technical feasibility of an innovative integrated solution for the anti-seismic and energy-efficient renovation of RC framed buildings, which is currently under development within the Horizon 2020 e-SAFE project. The proposed retrofit technology consists in the application of prefabricated timber-based panels to the existing outer walls, combining structural CLT panels equipped with innovative friction dampers with non-structural wooden framed panels hosting high-performing windows. Specifically, this paper identifies the main technological issues related to this solution and investigates potential technical solutions aimed at: i) ensuring the correct operation of the retrofit technology during earthquakes; ii) making the installation and maintenance of the main components quick and easy; iii) providing a proper architectural integration of each component. The main technical solutions analysed concern lateral connecting systems between the two types of panels, as well as cladding options to cover the dampers after the panel installation, while allowing their inspection, maintenance, and possible replacement. Suitable expansion joints to allow the translation of the structural CLT panels in the event of dampers activation are also examined. The proposed solutions have been investigated referring to an apartment building selected as case study, but they can be effectively extended to many other buildings erected between the 1950s and the 1990s with similar construction techniques throughout Europe.

6. ACKNOWLEDGEMENTS

This paper was carried out in the framework of the "Energy and seismic affordable renovation solutions" (e-SAFE) project, which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135, and the "eWas - An early WArning System for Cultural Heritage" project - PON ARS01_00926 PNR2015-2020. Neither the Executive Agency for Small-and-Medium-sized Enterprises (EASME) nor the European Commission is in any way responsible for any use that may be made of the information it contains.
The authors would like to thank Sebastiano D'Urso for the solutions suggested to improve the architectural image of the considered case study.

7. REFERENCES

[1] Directive 2010/31/EC. Energy performance of buildings, directive of the European parliament and of the council of 19 May 2010 on the energy performance of buildings (recast)European parliament. 2016

[2] Seismic Hazard Harmonization in Europe (SHARE). *European seismic hazard map*. Available online: http://www.share-eu.org/sites/default/files/SHARE_Brochure_public.web_.pdf.

[3] La Greca, P.; Margani, G. Seismic and Energy Renovation Measures for Sustainable Cities: A Critical 490 Analysis of the Italian Scenario. *Sustainability* **2018**, 10(1), 254.

[4] Brandner, R. Production and technology of cross laminated timber (CLT): a state-of-the-art report. In: Harris R, Ringhofer A, Schickhofer G (eds) Focus solid timber solutions – European conference on cross laminated timber (CLT). The University of Bath, 2013.

[5] Brandner, R.; Flatscher, G.; Ringhofer, A.; Schickhofer, G.; Thiel, A. Cross laminated timber (CLT): overview and development. *Eur. J. Wood Prod.* 2016, *74*, 331–351.

[6] Stepinac, M.; Sustersic, I.; Gavric, I.; Rajcic; V. Seismic design of timber buildings: highlighted challenges and future trends. *Appl. Sci.* 2020, 10, 1380.

[7] Lucchini, A.; Mazzucchelli, E. S.; Mangialardo, S.; Persello, M. "Façadism and CLT technology: An innovative system for masonry construction refurbishment" Proceedings of the 40th IAHS World Congress on Housing, Funchal, Portugal, 2014.

[8] Riccadonna, D.; Giongo, I.; Shiro, G.; Rizzi, E.; Parisi, M.A. Experimental shear testing of timber-masonry dry connections for the seismic retrofit of unreinforced masonry shear walls. *Constr Build Mater.* 2019, 211, 52-72.

[9] Pozza, L.; Evangelista, F.; Scotta, R. CLT used as seismic strengthener for existing masonry walls. Proceedings of the 17th Conference ANIDIS – L'ingegneria sismica in Italia, Pistoia, Italy, 2017.

[10] Sustersic, I.; Dujic, B. Seismic shaking table testing of a reinforced concrete frame with masonry infill strenghtened with cross laminated timber panels. World Conference on Timber Engineering, Quebec City, Canada, 2014.

[11] Zanni, J.; Cademartori, S.; Marini, A.; Belleri, A.; Giuriani, E.; Riva, P.; Angi, B.; Franchini, G.; Marchetti, A.L.; Odorizzi, P.; G. Luitprandi, G. Riqualificazione integrata e sostenibile di edifici esistenti con esoscheletri a guscio prefabbricati: il caso studio AdESA. Convegno Ar.Tec. - Colloqui.AT.e 2020, Catania, Italia.

[12] Stazi, F.; Serpilli, M.; Maracchini, G.; Pavone, A. An experimental and numerical study on CLT panels used as infill shear walls for RC buildings retrofit. *Constr. Build. Mater.* 2019, 211, 605-616.

[13] Haba, R.; Kitamori, A.; Mori, T.; Fukuhara, T.; Kurihara, T.; Isoda, H. Development of clt panels bond-in method for seismic retrofitting of RC frame structure. J. Struct. Constr. Eng. 2016, 81, 1299–1308 (In Japanese).

[14] Presutti, A.; Evangelista, P. Edifici multipiano in legno a pannelli portanti in XLAM. Dario Flaccovio Editore: Palermo, 2014; p. 36.

[15] Knapp Connectors, Walco 40. https://www.knapp-verbinder.com/en/products/prefab-walls/

[16] Decreto interministeriale 26.6.2015. In Adeguamento Linee Guida Nazionali per la Certificazione Energetica degli Edifici; Allegato 1; Gazzetta Ufficiale della Repubblica Italiana n.162 del 15.7.2015: Roma, Italia, 2015.