Cross Laminated Timber furniture providing shelter during earthquakes. Lifeshell public domain release.

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Earthquakes are an unpredictable potentially deadly phenomena. Buildings anti-seismic technology can effectively reduce the risk of injuries, however the anti-seismic performances of many buildings in Italy and other countries are still weak. Lack of funds, logistics and bureaucracy are still delaying the adoption of this technology on large scale. As a result citizens spend hours everyday in private and public buildings (including schools) which are still a dangerous place.

A wooden based furniture that can be used as an anti-seismic shelter is here released under the Creative Commons Licence: a low-cost, natural-based, open-source, copyright-free solution. The so-called *Life Shell* concept has been independently funded by former wood researchers and it is presented in its engineering characteristics. “Life in Shell” depicts an alive human being protected by wood during an earthquake.

Life Shell is a furniture in the shape of school desk, wardrobe, table or bed realized using Cross Laminated Timber panels. The design foresees as many closed sides as possible and the assembly uses metal connections and screws for wooden constructions. A 1300 x 700 x 500 mm school desk prototype has been successfully tested, resisting to a total impact energy of 40.000 Joule without major damages.

Life Shell is foreseen in various types, sizes, weights, finishing and accessories. A very low cost-version is thought for being assembled and finished by the final user, while a top-range version can include a surviving kit (torch, whistle, water, dust mask, a laminated emergency guide, energy bars, first aid kit) or even topped with fancy technology (oxygen masks, avalanche beacon, 2 way radio, hand crank power generator).

Authors desired to release this potential life-saving technology using the Creative Commons CC BY 4.0 License (public domain), which allows the production and selling of these furniture without any royalty fee for the authors.

**Keywords:** anti-seismic, furniture, Cross Laminated Timber, CLT, X-LAM, Crosslam, shelter, creative commons.

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REFERENCES

American earthquake guidelines [www.ready.gov](http://www.ready.gov) (last visited on October 2019)

Ario Ceccotti, Gabriele Bonamini, 2007. Progetto Sofie, Relazione scientifica finale 10.12.2007, CNR-IVALSA

Wanyu R. Chan, William W. Nazaroff, Phillip N. Price, Ashok J. Gadgil, 2007. Effectiveness of urban shelter-in-place—I: Idealized conditions, Atmospheric Environment 41 4962–4976.

Ching-Shan Chen, Min-Yuan Cheng, Yu-Wei Wu, 2012. Seismic assessment of school buildings in Taiwan using the evolutionary support vector machine inference system. Expert Systems with Applications 39 4102–4110.

Jianyu Chu, Youpo Su, 2012. The application of TOPSIS method in selecting fixed seismic shelter for evacuation in cities. Systems Engineering Procedia 3 391 – 397

Creative Commons licence 4.0, <https://creativecommons.org/licenses/by/4.0/> (last visited on October 2019)

P.L. Gould, B.J. Goodno , N.C. Gould, P. Caldwell, 2011, Behavior of Engineer Constructed Facilities in the Haitian Earthquake of January 12, 2010, Procedia Engineering 14 23–31.

Ki Young Koo, Sung Gook Cho, Jintao Cui, Dookie Kim, 2010. Seismic response prediction for cabinets of nuclear power plants by using impact hammer test. Nuclear Engineering and Design 240 2500–2511.

Lifeshell project main website: <https://www.lifeshell.net/> (last visited on October 2019)

Qiang Liu, Xuejing Ruan, Pilong Shi, 2008. Selection of emergency shelter sites for seismic disasters in mountainous regions: Lessons from the 2008 Wenchuan Ms 8.0 Earthquake, China. Journal of Asian Earth Sciences 40 926–934.

S. Molina, D.H. Lang, C.D. Lindholm, 2010. SELENA – An open-source tool for seismic risk and loss assessment using a logic tree computation procedure. Computers & Geosciences 36 257–269.

National Disaster Education Coalition earthquake guidelines <http://www.disastercenter.com/guide/earth.html> (last visited on October 2019)

Patricia J. Owens, Anthony Forgione, Susan Briggs, 2005. Challenges of International Disaster Relief: Use of a Deployable Rapid Assembly Shelter and Surgical Hospital, Disaster Manage Response 3:11-6.

Red Cross earthquake guidelines: <https://www.redcross.org/get-help/how-to-prepare-for-emergencies/types-of-emergencies/earthquake.html> (last visited on October 2019)

S. Russo, 2012. Experimental and finite element analysis of a very large pultruded FRP structure subjected to free vibration. Composite Structures 94 1097–1105