UNECE

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REGULATIONS AND STRUCTURAL REQUIREMENTS FOR SEISMIC RESISTANCE

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design & research of timber structures

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Introduction

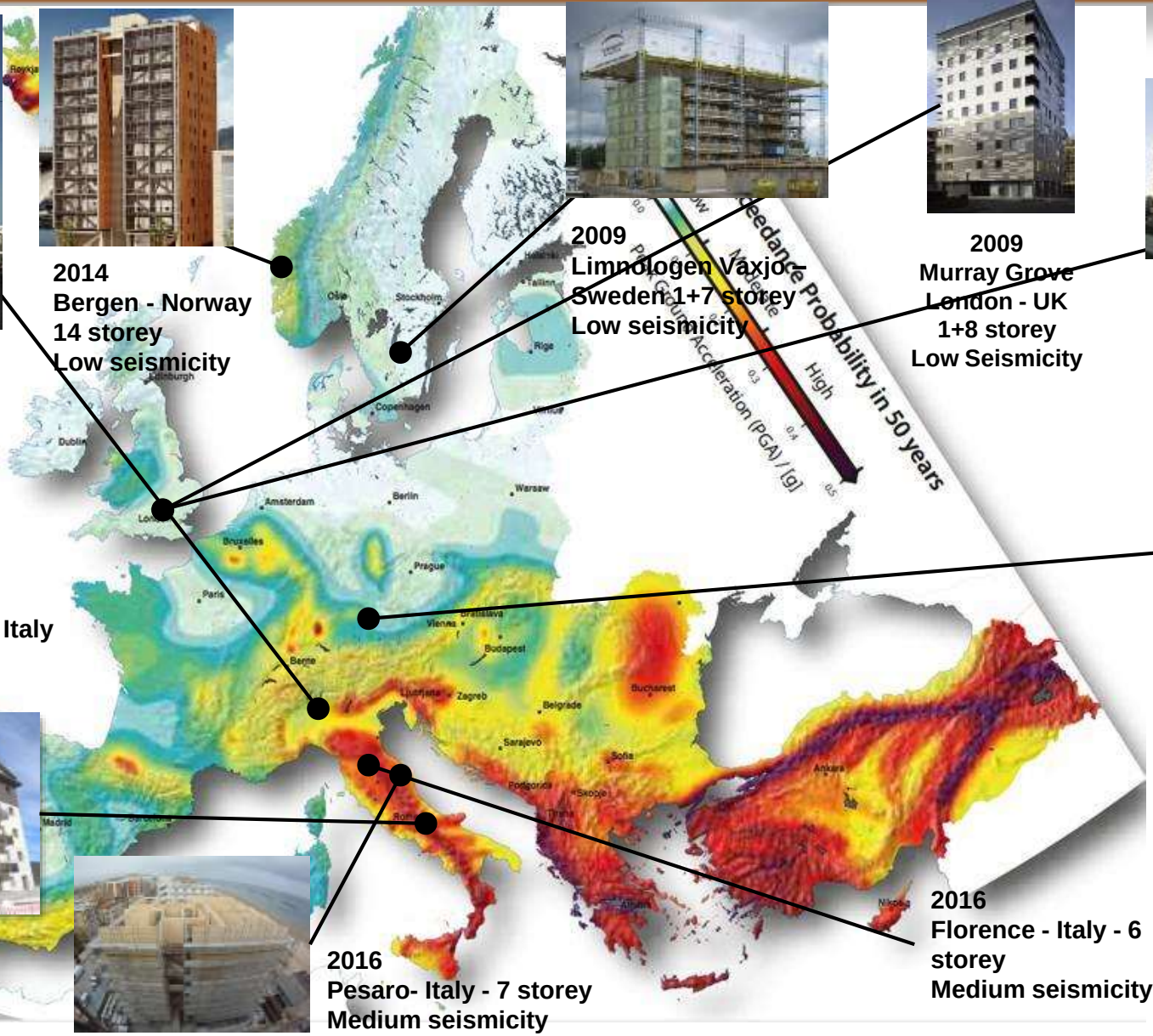
2012
Via Cenni
Milan - Italy
9 storey
Low-moderate seismicity

2014
Bergen - Norway
14 storey
Low seismicity

2009
Limnologen Växjö
Sweden 1+7 storey
Low seismicity

2009
Murray Grove
London - UK
1+8 storey
Low Seismicity

2011
Bridport House
London - UK
8 storey
Low seismicity



2012
Roccaraso (AQ)- Italy
- 6 storey
High seismicity

2016
Pesaro- Italy - 7 storey
Medium seismicity

2016
Florence - Italy - 6 storey
Medium seismicity

2011
Holz8 - Bad Aibling
Germany- 8 storey
Low seismicity

Tall Wood Buildings

CLT = Cross Laminated Timber

4 CLT buildings, 9 Storeys, Milan, Italy, 2012

6 Storey CLT building Florence, Italy, 2016

Hybrid Wood Buildings

Photo from Acton Ostry Architets INC website

Brock Commons, @ UBC Vancouver: 18 storeys, 53.5m tall. 17 storeys of mass timber construction on top of 1 concrete storey, in addition to two concrete shafts.

SOFIE Project NIED/CNR-IVALSA 2006-07

Miki, Kobe, October 2007, JMA Kobe 100%

SOFIE Project NIED/CNR-IVALSA 2006-07

Miki, Kobe, October 2006

NIED

6 storey concrete JMA Kobe 60%

SAFER WITH RESPECT TO OTHER MATERIALS

SAFE EVEN FOR STRONG EVENTS

LIMITED DAMAGE EASILY REPAIRABLE

POST DISASTER IMMEDIATE OCCUPANCY

RESILIENT

LESS EXPENSIVE WITH RESPECT TO OTHER MATERIALS

DRY CONTRUCTION PROCESS = LESS TIME

EASE IN THE ASSEMBLY OF CLADDINGS AND INSTALLATIONS

LIGHTNESS OF CONSTRUCTION MATERIAL AND TOOLS = LESS DANGER FOR SITE OPERATORS

CHEAPER AND SAFER CONSTRUCTION

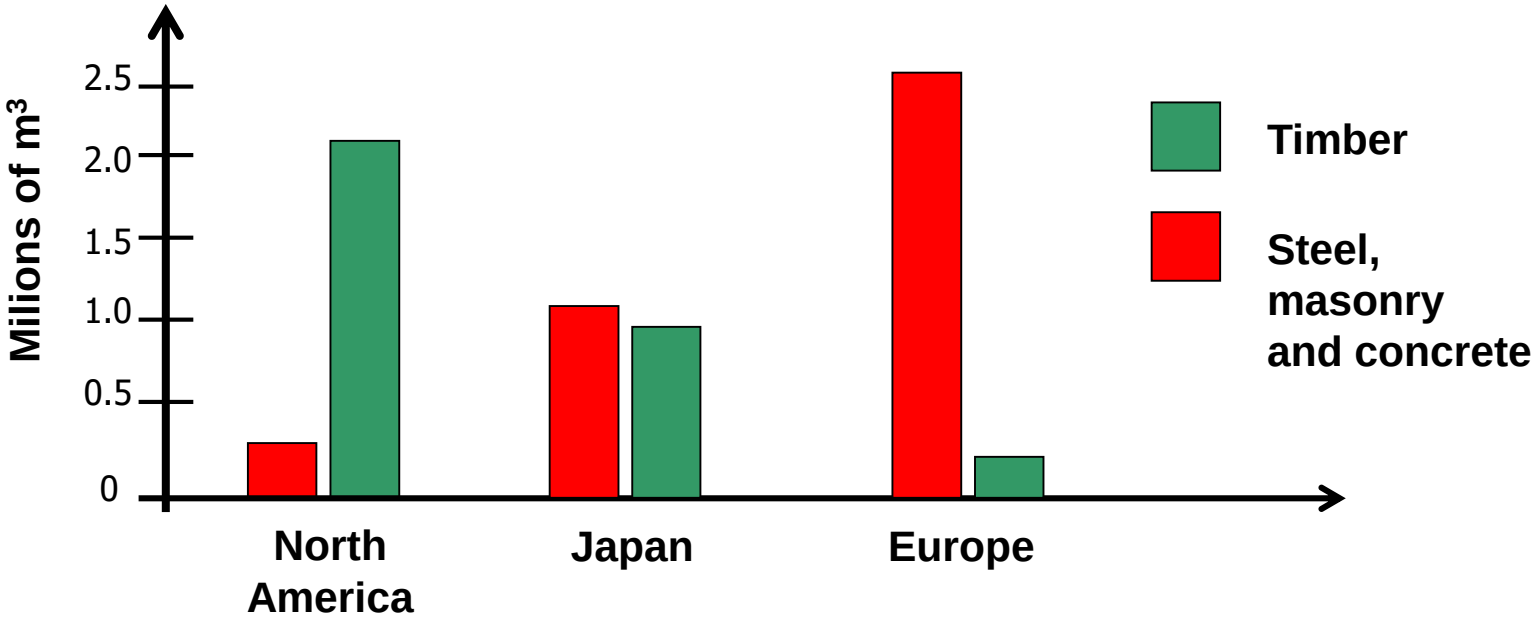
EXPECIALLY FOR HIGH SEISMICITY AREAS !!!

Concrete floor
Contruction time: 1 month

Timber floor
Contruction time: few hours

However…

Residential buildings



The share for timber construction is 90% in North America, 45% in Japan and 8-10% in Europe

Source: Takle climate change: use wood. CEI – BOIS 2010

Which are the key barriers? – 1 Education…

1 – Lack of education on the use of wood for construction and consequently…

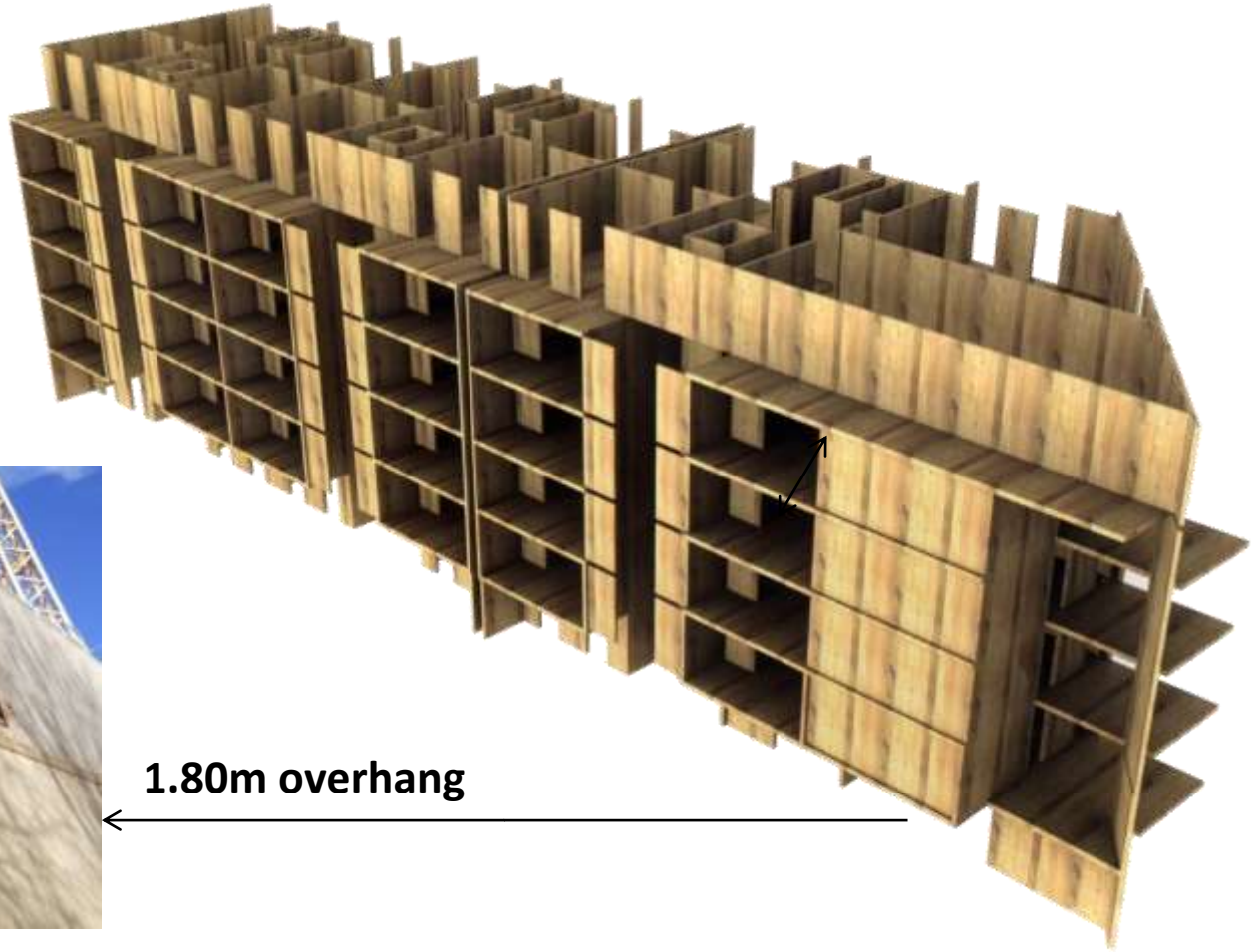
...lack of technical knowledge of wood by architects, engineers and contractors

In Germany the course of «design of timber structures» is mandatory at all universities

Permanent courses of «Design of timber structures» for engineers in Italy

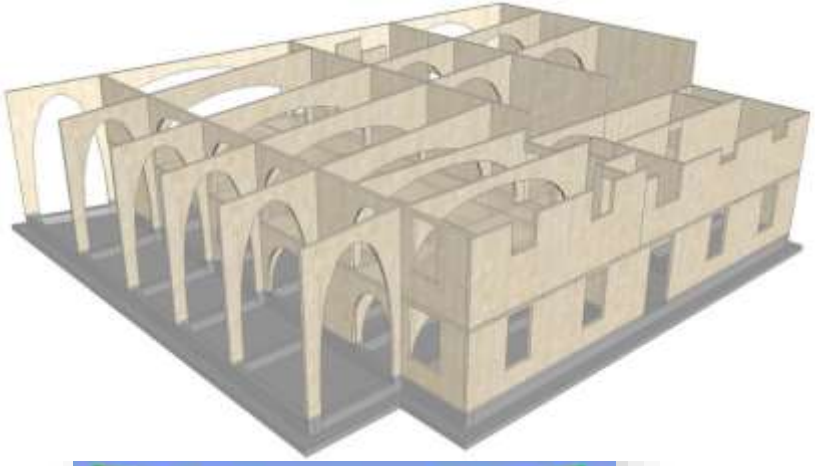
Which are the reasons? – 1 Education…

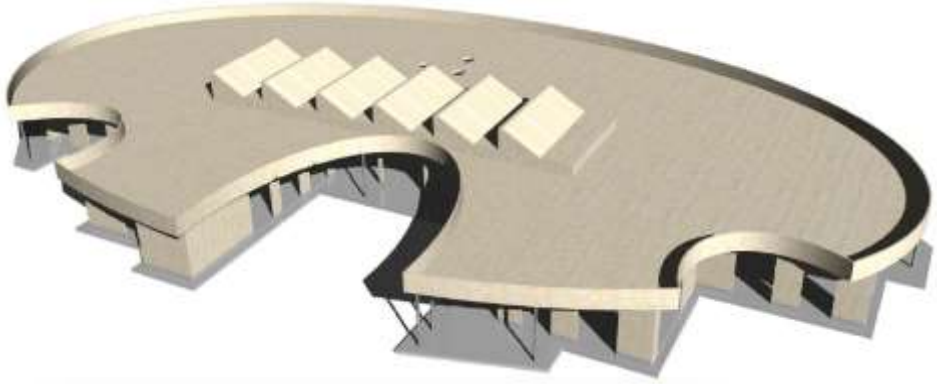
...often projects of timber structures are «adapted» on the base of a concrete project, resulting in very complicate design

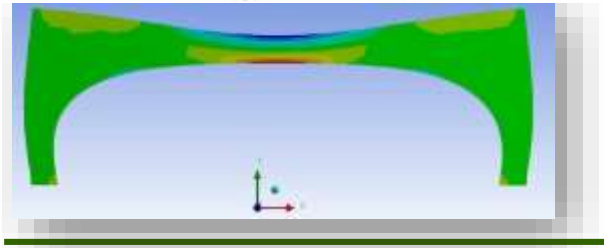


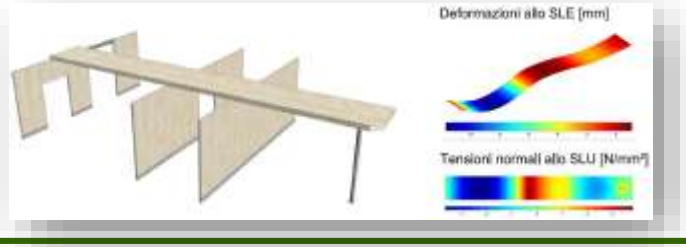
Which are the key barriers?– 1 Education…

…well trained architects and engineers, who knows hot to use wood-based products, make excellent design!



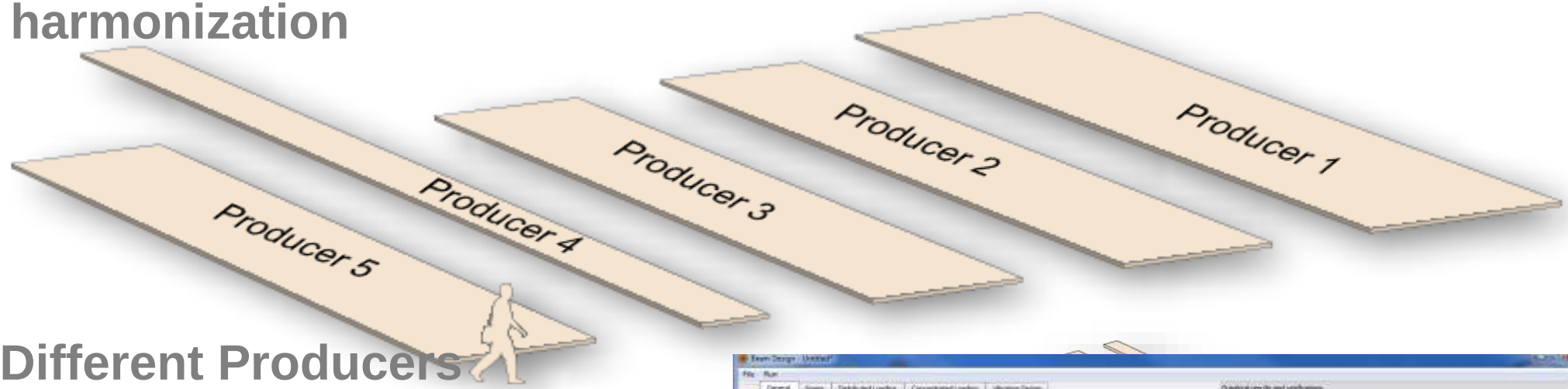






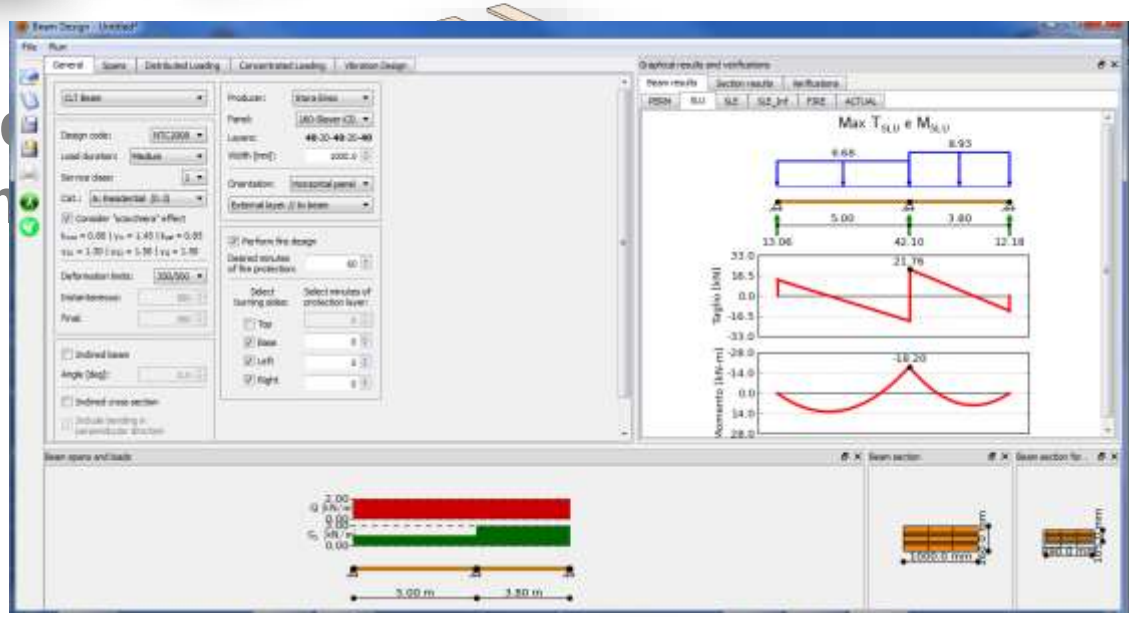
Which are the key barriers? – 2 Harmonization of some wood based products…

Some engineering wood-based product, like CLT, need a better harmonization



Different Producers

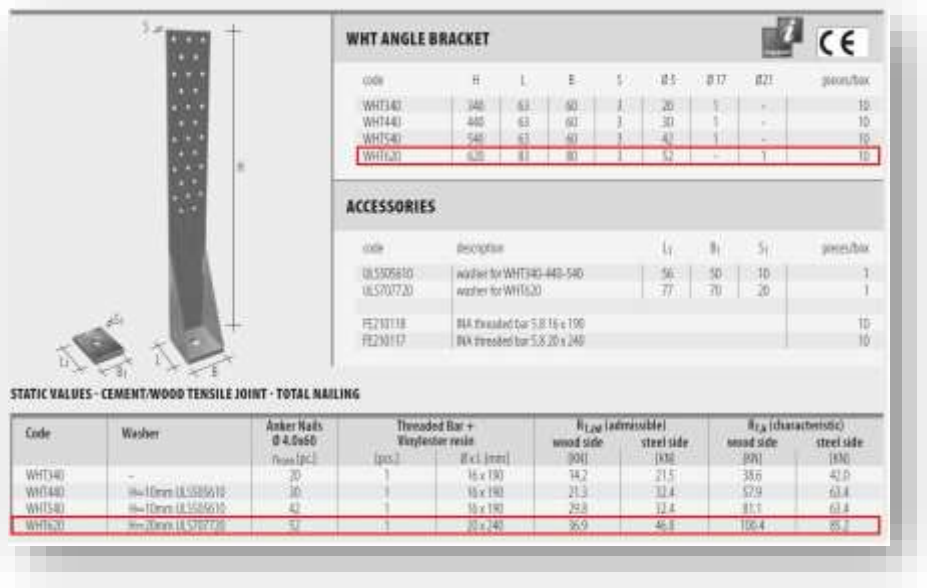
Different sizes, different thickne layer configurations, different m properties



Engineers have to change calculations according to the CLT producer

Which are the key barriers? – 3 Improvement of connection systems…

Commercially available connections are able to resist forces deriving from the seismic design for buildings up to a maximum of 3 or 4 storeys (depending on the seismic zone)



WHT ANGLE BRACKET

code	H	L	E	S	Ø 5	Ø 17	Ø 21	pieces/box
WHT340	340	63	60	3	20	1	-	10
WHT440	440	63	60	3	30	1	-	10
WHT540	540	63	60	3	42	1	-	10
WHT620	620	83	80	3	52	-	1	10

ACCESSORIES

code	description	L_1	B_1	S_1	pieces/box
ULS505610	washer for WHT340-440-540	56	50	10	1
ULS707720	washer for WHT620	77	70	20	1
FE210118	INA threaded bar 5.8 16 x 190				10
FE210117	INA threaded bar 5.8 20 x 240				10

STATIC VALUES - CEMENT/WOOD TENSILE JOINT - TOTAL NAILING

Code	Washer	Anker Nails Ø 4.0x60	Threaded Bar + Vinylester resin		$R_{1,d}$ (admissible) wood side	$R_{1,d}$ (admissible) steel side	$R_{1,k}$ (characteristic) wood side	$R_{1,k}$ (characteristic) steel side
		(pcs.)	(pcs.)	Ø x L (mm)	[kN]	[kN]	[kN]	[kN]
WHT340	-	20	1	16 x 190	14.2	21.5	35.6	42.0
WHT440	Wa=10mm ULS505610	30	1	16 x 190	21.3	32.4	57.9	63.4
WHT540	Wa=10mm ULS505610	42	1	16 x 190	29.8	32.4	81.1	63.4
WHT620	Wa=20mm ULS707720	52	1	20 x 240	36.9	46.3	100.4	85.2

Engineers have to make a "special" connection design for taller buildings

Which are the key barriers? – 4 Revision and harmonization of structural building codes

The current version of the Chapter for the seismic design of timber buildings in very old (2004) and short (only 5 pages),

missing the provisions for the seismic design of some structural types widely used all over Europe

The seismic design of hybrid buildings with two types of Lateral Load Resisting Systems, made with different materials, and **working together** is rather complicate

Which are the key barriers? – 4 Revision and harmonization of structural building codes

Partial safety factors for timber and wood-based products

$$R_d = k_{mod} \frac{R_k}{\gamma_m}$$

Eurocode 5

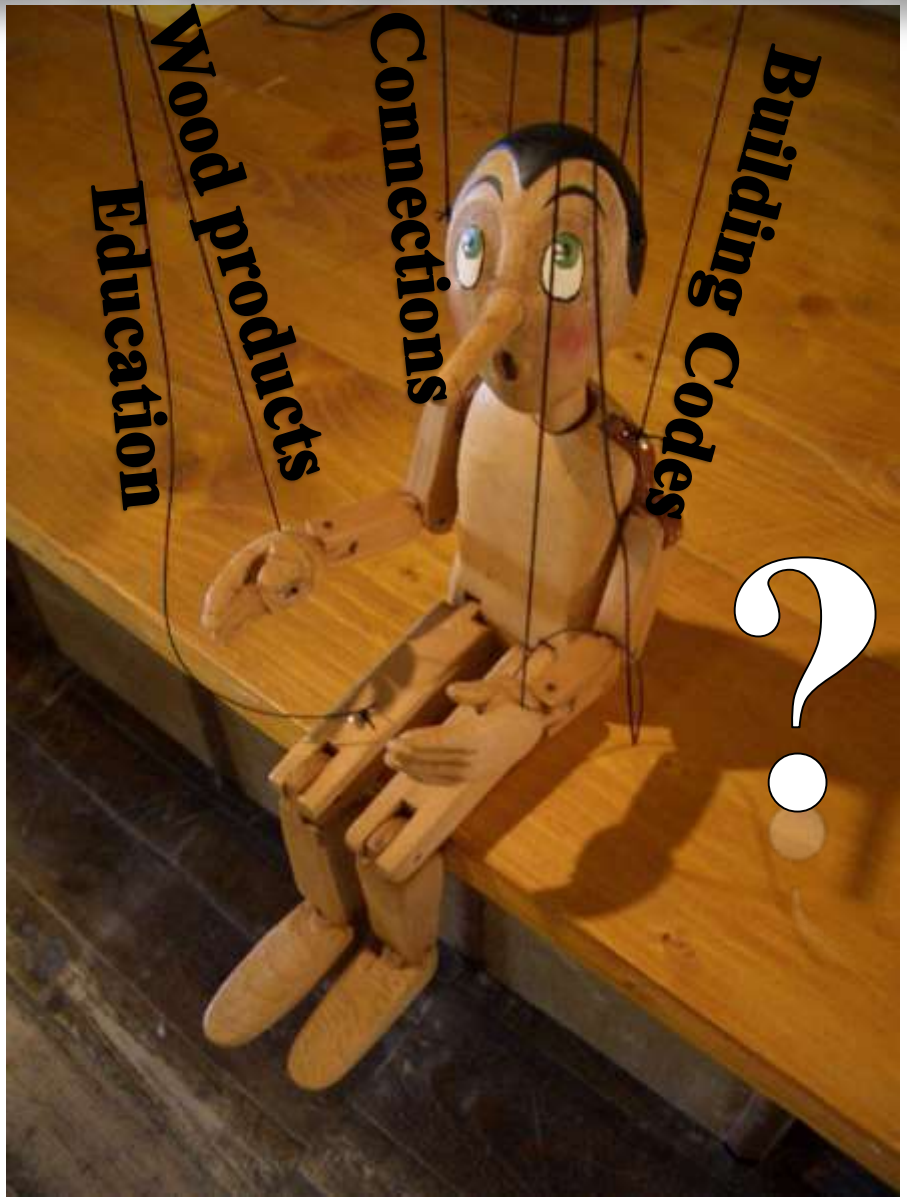
material	γ_m
Solid timber	1,3
Glued laminated timber	1,25
LVL, plywood, OSB	1,2
Particleboards and fibreboards	1,3
Connections	1,3

Italian Building Code (NTC 2008)

material	γ_m
Solid timber	**1,5**
Glued laminated timber	**1,45**
LVL, plywood, OSB	**1,4**
Particleboards and fibreboards	**1,5**
Connections	**1,5**

Timber structures in Italy are strongly penalized with respect to other construction materials!

What can be done to remove these hurdles?



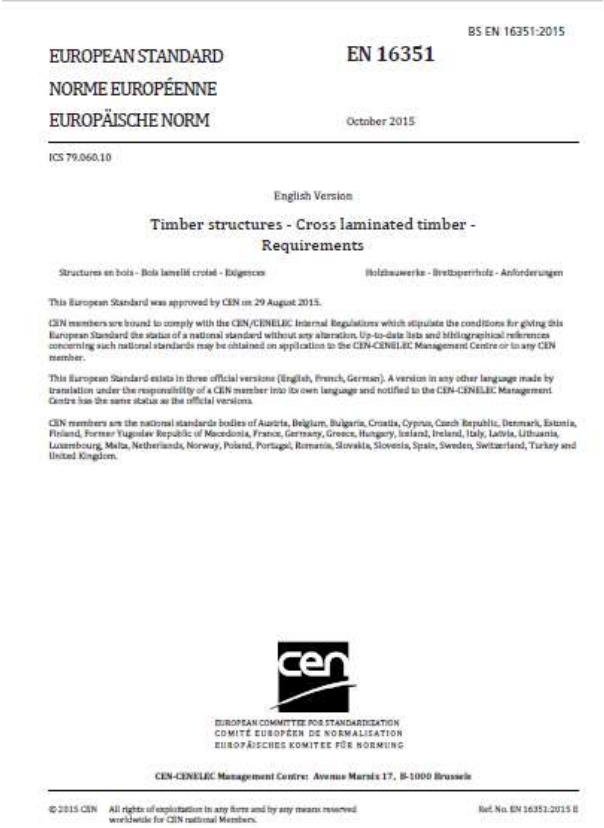
What can be done to remove these hurdles?
1 - Education

Architects and engineers decide upon structural material, envelope and finishing materials <u>therefore they need a comprehensive knowledge of wood products and of the design of structural timber systems in order to propose the use of wood as a structural material</u>

Teaching of «Timber construction» should be mandatory for Engineer and Architects at all European Universities

Also training regarding the use of wood-based materials and construction of timber buildings should be made for builders and constructors

What can be done to remove these hurdles?
2 – Harmonization of products



BS EN 16351:2015

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 16351

October 2015

ICS 79.060.10

English Version

Timber structures - Cross laminated timber - Requirements

Structures en bois - Bois lamellé croisé - Exigences

Holzbauwerke - Brettsperrholz - Anforderungen

This European Standard was approved by CEN on 29 August 2015.

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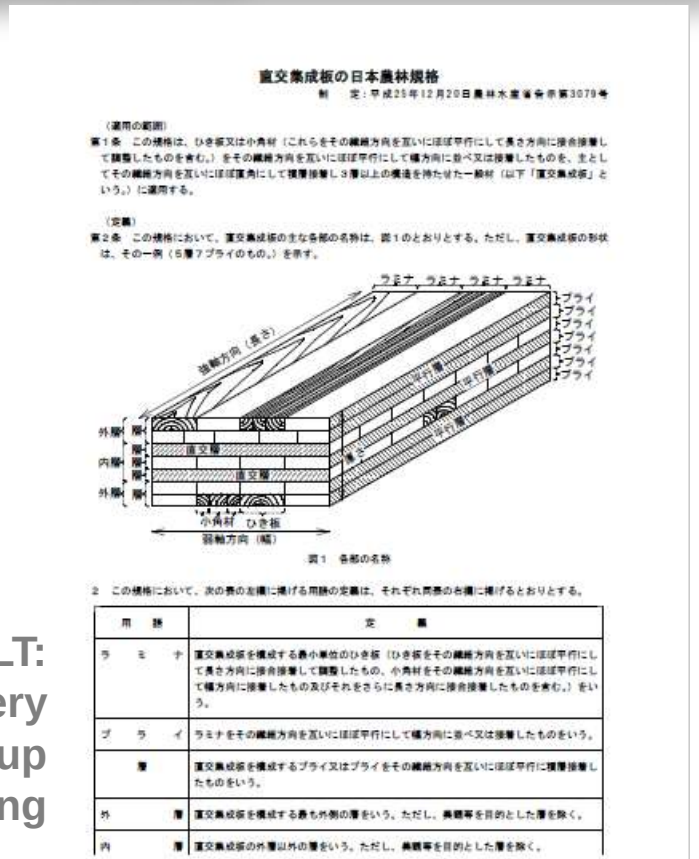
Ref. No. EN 16351:2015 E

European Standard for CLT:
102 pages in total,
complicate rules for panel composition and testing



直交集成板の日本農林規格

制　定：平成25年12月20日農林水産省告示第3079号

（適用の範囲）

第1条　この規格は、ひき板又は小角材（これらをその繊維方向を互いにほぼ平行にして長さ方向に接着接着して調整したものを含む。）をその繊維方向を互いにほぼ平行にして幅方向に並べ又は接着したものを、主としてその繊維方向を互いにほぼ直角にして複層接着し3層以上の構造を持たせた一般材（以下「直交集成板」という。）に適用する。

（定義）

第2条　この規格において、直交集成板の主な各部の名称は、図1のとおりとする。ただし、直交集成板の形状は、その一例（5層7プライのもの。）を示す。

図1　各部の名称

2　この規格において、次の表の左欄に掲げる用語の定義は、それぞれ同表の右欄に掲げるとおりとする。

用　語	定　義
ラ　ミ　ナ	直交集成板を構成する最小単位のひき板（ひき板をその繊維方向を互いにほぼ平行にして長さ方向に接着接着して調整したもの、小角材をその繊維方向を互いにほぼ平行にして幅方向に接着したもの及びそれをさらに長さ方向に接着したものを含む。）をいう。
プ　ラ　イ	ラミナをその繊維方向を互いにほぼ平行にして幅方向に並べ又は接着したものをいう。
層	直交集成板を構成するプライ又はプライをその繊維方向を互いにほぼ平行に複層接着したものをいう。
外　層	直交集成板を構成する最も外側の層をいう。ただし、美観等を目的とした層を除く。
内　層	直交集成板の外層以外の層をいう。ただし、美観等を目的とした層を除く。

Japanese Standard for CLT:
49 pages in total, very simple rules for panel layup and testing

Product standards should be simple and clear in order to «ease» the work of producers, builders and designers

What can be done to remove these hurdles?
3 – Improvement of connection systems





Connection producers should develop new types of connection systems for the seismic design of tall wood buildings which should be commercially available

What can be done to remove these hurdles?
4 – Updating of Building Codes

A proposal for a new Background Document of Chapter 8 of Eurocode 8

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Maurizio Piazza, Roberto Tomasi, Simone Rossi, Daniele Casagrande - Department of Civil, Environmental and Mechanical Engineering, University of Trento, Via Mesiano 77 - I 38123 Trento - Italy

Keywords: Eurocode 8, Multi-storey timber buildings, Background document

1 Introduction

Timber systems are becoming more and more popular in the construction of medium to high rise buildings in many European regions with different levels of seismicity, replacing day by day other materials like reinforced concrete, masonry or steel. Only considering the last decade, more than 20 buildings with a number of storeys ranging from 6 to 14 have been built in low to high seismicity areas.

Sustainability, energy efficiency and speed of construction together with the consequent costs reductions, and above all the excellent seismic performance demonstrated by recent research results based on extensive numerical simulations and full-scale tests on multi-storey buildings are just some of the advantages which explain this growing success.

However this progress and the growing diffusion have not been followed by a corresponding update of the provisions to be used in the seismic design, which for the case of timber buildings are included within Chapter 8 of Eurocode 8. This chapter, published in 2004, is very short and incomplete in many parts, especially when considering design provisions for modern construction systems that are nowadays widely used, thus causing real difficulties to structural engineers who have to apply these rules in the seismic design of timber buildings.

2 Seismic design according to Eurocode 8

The seismic design of structures according to Eurocode 8 (CEN, 2004) is founded on a force-based approach, according to which the energy dissipation capacity of the whole structure is implicitly taken into account by dividing the seismic forces

8.3.4 Rules for CLT buildings

8.3.4.1 General rules

(1) Cross laminated (CLT) timber buildings are structures in which walls are composed of cross laminated timber panels according to 8.3(5).

(2) The connection of the shear walls to the foundation shall be made by means of mechanical fasteners (e.g. hold-down anchors, steel brackets, anchoring bolts, nails and screws, etc.) and shall adequately restrain the wall against uplift and sliding. Uplift connections should be placed at wall ends and at opening ends, while shear connections should be distributed uniformly along the shear wall length (Figure 8-3).

(6) The upper walls bear on the floor panels (platform construction), and are connected to the lower walls using mechanical fasteners similar to those used for the wall-foundation connection. Tie-down connections nailed to the X-Lam walls may be used for the external walls uplift restraint.

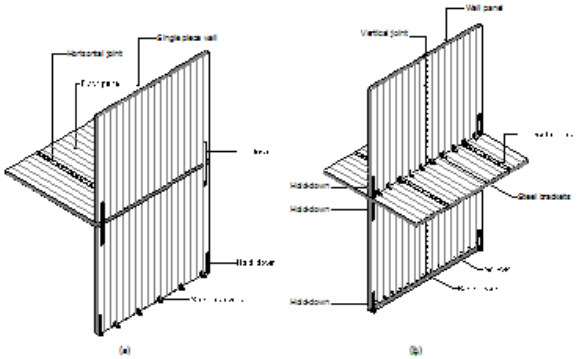

Figure 8-3: Walls and floors in monolithic (a) and segmented (b) Cross Laminated Timber buildings.

8.3.4.2 Capacity design rules for DCM

(1) In X-Lam buildings designed for DCM, each wall may be composed either by only one X-Lam panel or by more than one panel connected with rigid vertical joints.

Building codes for the static and seismic design should be updated, including provisions for all structural types and simple design rules, not too complicated.

What can be done to remove these hurdles?
4 – Harmonization of Building Codes

When I am in Italy and I want to use my laptop I just connect this plug to the electric socket....

When I travel to Germany, Austria or France I need this adapter....

Now I am in Switzerland and I need also this!

We need the same plug and the same socket as we need the same Structural Codes with the same safety coefficients for all European Countries!

In conclusion…

Wood buildings are ideal for seismic design…if we remove the hurdles… …and I'm not lying!

Thank you very much for your attention!

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