Progetto DPC-ReLUIS 2024-2026 W12

Task 12.2 – Costruzioni in Legno

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

Sub task 12.2.1 - Edifici

UR11: UNINA/Faggiano – Responsabile scientifico: Prof. Beatrice Faggiano
Componente di Unità di ricerca: Dott. Giacomo Iovane

SEISMIC-RESISTANT TIMBER FRAME STRUCTURES WITH DISSIPATIVE STEEL LINKS

Iovane et al., 2025 - WCTE

GENERAL CONTEXT OF THE RESEARCH

OBJECTIVES AND ACHIEVEMENTS

Goals of the research
- Definition of seismic-resistant timber frame structural types;
- Design criteria for dissipative seismic timber frame structures;
- Evaluation of structural seismic performance.

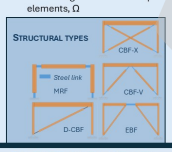
Methodology
- Incremental-static analysis.

Main issues
- Reduction of structural mass respect to Non-Dissipative structures;
- Reduction of construction costs;
- High dissipative and ductile capacity;
- Re-centering of the structures.

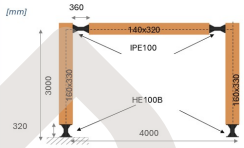
FUTURE IMPROVEMENTS

- Cyclic behaviour;
- Non-Linear Dynamic analysis;
- Experimental tests;
- Design rules calibration:
  - Behaviour factor, q_0, for different ductility classes.
  - Material overstrength factor, γ_{Rd}
  - Overstrength factor for dissipative elements, Ω

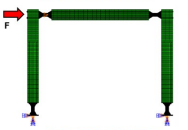
STRUCTURAL TYPES



ANALYSIS OF THE BEHAVIOR OF MRF FRAMES WITH SINGLE DIAGONAL AND STEEL LINKS

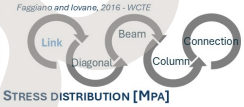


NUMERICAL MODEL

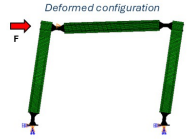


APPLICATION OF THE CAPACITY DESIGN: HIERARCHY CRITERION

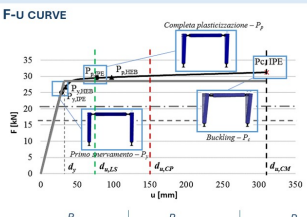
Faggiano and Iovane, 2016 - WCTE



Deformed configuration



F-U CURVE



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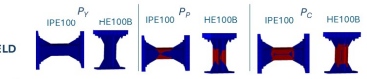
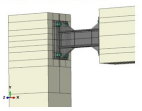
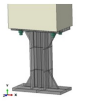


CONSTRUCTION DETAIL

Beam-to-column joint



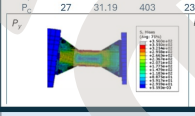
Column-to-foundation joint

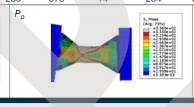


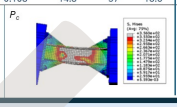
STRESS DISTRIBUTION [MPa]

Beam-to-column joint (IPE100)

Point	Inc	time	σ [MPa]				θ	M	u	F
	[-]	[s]	IPE100	Piastra	Barra	Trave	Irrig.	[rad]	[kNm]	[mm]	[kN]
P_Y	14	2.90	355	158	279	7.2	215	0.007	9	9	12.5
P_P	21	7.73	368	230	350	9.6	279	0.021	13.3	23	14.7
P_C	27	31.19	403	235	375	14	284	0.103	14.3	97	15.6

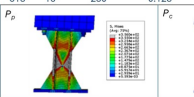


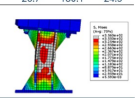




Column-to-foundation joint (HEB100)

Point	Inc	time	σ [MPa]					θ	M	u	F
	[-]	[s]	HHEB100	Piastra	barra	Legno	Irrig.	[rad]	[kNm]	[mm]	[kN]
P_Y	14	2.90	232	203	440	10.5	187	0.007	24.0	9.1	18.4
P_P	21	7.73	242	276	605	11.2	277	0.025	25.2	33.1	23.3
P_C	27	31.19	303	278	618	16	280	0.128	26.7	130.1	24.9





A MECHANICAL CLASSIFICATION METHOD FOR TIMBER BEAM-TO-COLUMN JOINTS

Iovane et al., 2025 - ANIDIS
Iovane et al., 2023 - WCTE

GENERAL CONTEXT OF THE RESEARCH

OBJECTIVES AND ACHIEVEMENTS

Goals of the research
- Proposal of timber beam-to-column joint classification method;
- Classification in terms of stiffness of joints from literature;
- Definition of most current timber joint typologies.

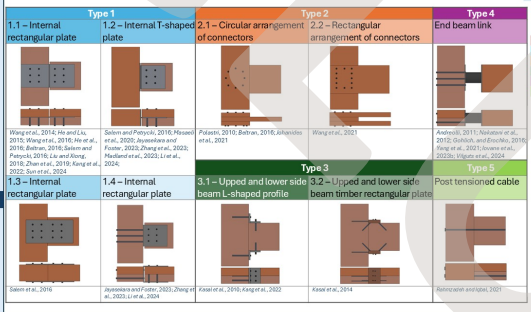
Methodology
- Analytical study.

Main issues
- Identification of 5 types of recurrent beam to column joints;
- Suitability of the proposed mechanical classification method.

FUTURE IMPROVEMENTS

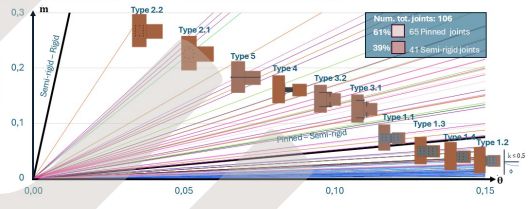
- Extension of the number of case studies
- Application of the component method for better understanding the contribution on the connection components to the overall mechanical behaviour of joint types

BEAM TO COLUMN JOINTS TYPOLOGICAL CATEGORIES



APPLICATION OF THE METHOD TO BEAM-TO-COLUMN JOINTS FROM LITERATURE

	k_{comp}	Reference	k_{comp}	Reference	Semi-rigid		Pinned	
					N. of joints	% of joints	N. of joints	% of joints
Type 1	0.0009	Massaeli et al., 2020	0.5780	Beltran, 2016	1	2%	58	98%
Type 2	0.1203	Wang et al., 2021	8.2898	Polastri, 2010	7	58%	5	42%
Type 3	0.8927	Kang et al., 2022	8.0000	Kasal et al., 2014	5	100%	-	-
Type 4	0.1745	Iovane et al., 2023b	5.0340	Andreolli, 2011	22	92%	2	8%
Type 5	0.9161	Rahmzadeh and Iqbal, 2021	2.0668	Rahmzadeh and Iqbal, 2021	Type 5	6	100%	-	-



CLT ENDOSKELETONS FOR HISTORIC MASONRY BUILDINGS

Zoccolillo et al., 2024

GENERAL CONTEXT OF THE RESEARCH

OBJECTIVES AND ACHIEVEMENTS

Goals of the research
- Design criteria proposal;
- Evaluation of the mechanical behaviour of consolidated structure.

Methodology
- Numerical analysis;

Main issues
- Proved effectiveness, convenience and feasibility of the proposed intervention.

FUTURE IMPROVEMENTS

- Improvement of the structural details;
- Definition of guidelines for the application of the proposed strategy in the recovery of historic centers.

CASE STUDY: PALAZZO DELLA VALLE IN PIEDIMONTE MATESE

Piedimonte Matese – Caserta

Northwest facade

Openings via Sorgente

Collapse in the stairwell area

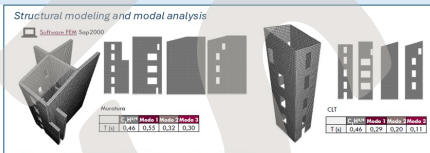
PREMIO DI LAUREA
PROF. ING. ALESSANDRA GUBANA

Existing building

Project

Focus on block 1

Structural modeling and modal analysis



Structural analysis and displacement verification

$u_{x,max} = 9,10\ cm < d_x = 15.00\ cm$
$u_{y,max} = 5,99\ cm < d_y = 22,00\ cm$

TIMBER-BASED SYSTEMS FOR THE RETROFITTING OF EXISTING STRUCTURES

Iovane et al, 2025 - PROHITECH

GENERAL CONTEXT OF THE RESEARCH

OBJECTIVES AND ACHIEVEMENTS

Goals of the research
- Definition of timber-based systems for the structural and energetic retrofitting of existing concrete and masonry constructions;
- Design rules proposal;
- Evaluation of overall integrated systems performance.

Methodology
- Numerical analysis.

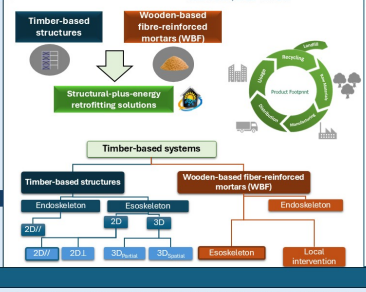
Main issues
- Suitability of timber-based systems for the retrofitting of existing r.c. structures.

FUTURE IMPROVEMENTS

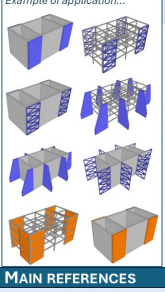
- Extension of numerical investigations;
- Guidelines for the design of timber-based system for the retrofitting of existing buildings.

SEISMIC RETROFIT STRATEGY

Iovane et al, 2022 - ANIDIS

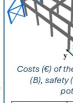


Example of application...

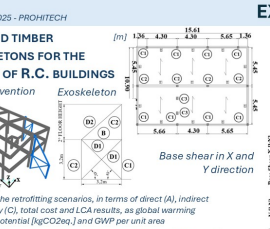


STEEL AND TIMBER EXOSKELETONS FOR THE RETROFIT OF R.C. BUILDINGS

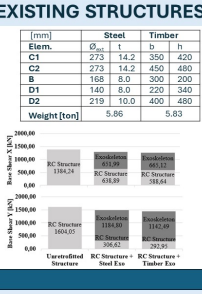
Post-intervention



Exoskeleton



Base shear in X and Y direction



Costs (€) of the retrofitting scenarios, in terms of direct (A), indirect (B), safety (C), total cost and LCA results, as global warming potential [kgCO2eq.] and GWP per unit area

Scenario	A	B	C	Total Cost	GWP_{tot}	GWP_{tot} / m²
1: Steel Exo	83.897	14.262	5.708	103.867	5098.6	14.74
2: Timber Exo	59.182	10.061	5.498	74.740	3613.0	10.44

[mm]	Steel		Timber	
Elem.	Ø	t	b	h
C1	273	14.2	350	420
C2	273	14.2	450	480
B	168	8.0	300	200
D1	140	8.0	220	340
D2	219	10.0	400	480
Weight [ton]	5.86		5.83	

MAIN REFERENCES

- Iovane G., Faggiano B. (2025). Seismic timber frames with steel link: mechanical characterization through numerical investigation. In: World Conference on Timber Engineering (WCTE 2025). https://doi.org/10.52202/080513-0166.
- Iovane G., Faggiano B. (2025). Mechanical classification of timber beam-to-column joints. In: Structural Integrity Procedia (ANIDIS 2025). 2452-3216© 2025 The Authors. Published by Elsevier B.V.
- Cucuzza R., Iovane G., Lazzurri T., Domaneschi M., Faggiano B. (2025). Structural, Economic and Environmental assessment of steel and timber exoskeletons for the retrofit of R. C. buildings. In: 5th International Conference on Protection of Historical Constructions.
- Zoccolillo A., Faggiano B., Iovane G., Mannarino D., Sandoli A. (2024). Endoscheletri in legno per il recupero degli edifici storici. RASSEGNA TECNICA DEL FRIULI VENEZIA GIULIA & NOTIZIARIO INGEGNERI. ANNO LXX - MARZO/APRILE 2024, rt nuova serie 396. ISSN 2421-0889. Associazione degli ingegneri della provincia di Udine. Associazione ingegneri e architetti della provincia di Pordenone.
- Iovane G., Novello C., Mazzolani F.M., Landolfo R., Faggiano B. (2023). A proposal for the mechanical classification of beam-to-column joints for timber structures. In: World Conference on Timber Engineering (WCTE 2023), 19-22 June 2023, Oslo, Norway, 2023, 5, pp. 2965-3000.
- Iovane G., Sandoli A., Mannarino D., Landolfo R., Prota A., Faggiano B. (2022). Timber based systems for the seismic and energetic retrofit of existing structures. In: (a cura di) Ferro G.A. Restuccia L., XIX ANIDIS Conference, Seismic Engineering in Italy. Procedia Structural Integrity, vol. 44 (223), p. 1870-1876. ISBN: 9781713870418, ISSN: 2452-3216, Torino, Italy, 11-15/09/2022, doi: 10.1016/j.prostr.2023.01.239.
- Faggiano B., Iovane G. (2016). First considerations on the design approach and criteria for seismic resistant and bracing timber frames. In: World Conference on Timber Engineering (WCTE2016). Eds: J. Eberhardsteiner, W. Winter, A. Fadai, M. Pöll. Publisher: Vienna University of Technology, Austria, ISBN: 978-3-903039-00-1. Full paper ID 1094. SCOPUS eid=2-s2.0-85010992280.

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