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Hemp FRP for Seismic Retrofitting of Existing Masonry Buildings

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THE RESEARCH STEPS

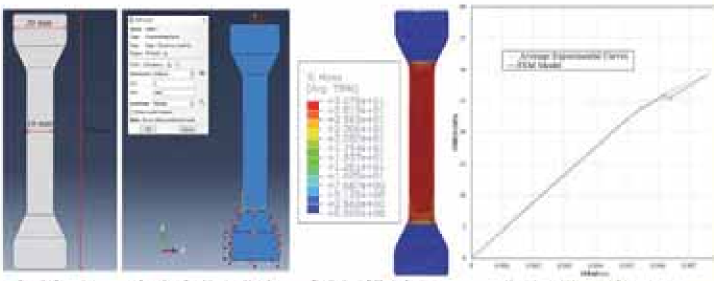
- Analysis of Hemp FRP (H-FRP) sheets mechanical properties
- Investigation on masonry seismic behaviour
- Numerical calibration of experimental tests by the ABAQUS CAE v.6.14.4 non-linear FEM software
- Development of intervention techniques based on H-FRP sheets for seismic strengthening of masonry walls
- Parametric FEM analysis to identify the optimal configuration of the proposed reinforcing system

"In the last few years the scientific community has turned its interest towards the use of natural composite materials to replace those made of carbon and glass fibres. Due to both environmental pollution produced for the realization of thermoplastic polymers and the disposal of natural fibres at the end of their life cycle, in the current work, starting from an experimental research performed at the University of Brasov in Romania (Scutaru et al., 2013) on hemp fabrics laminated with thermoplastic resin, the use of composite materials with hemp fibres for seismic retrofitting of existing masonry buildings has been investigated."

FEM CALIBRATION OF EXPERIMENTAL TESTS

- Tensile tests on Hemp Fiber Materials (Scutaru et al., 2013)

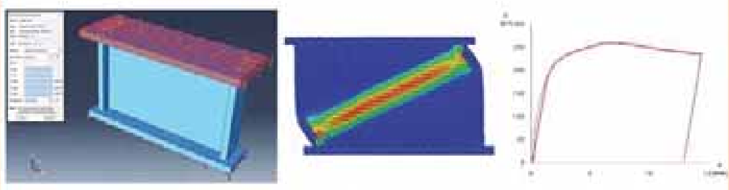
H-FRP Samples — Test Set-up for Tensile Testing — Experimental Test Results



Sample Geometry — Boundary Conditions and Loads — Distribution of Plastic Strains — Experimental-Numerical Comparison

- Shear test on masonry wall (Ganz et al., 1986)

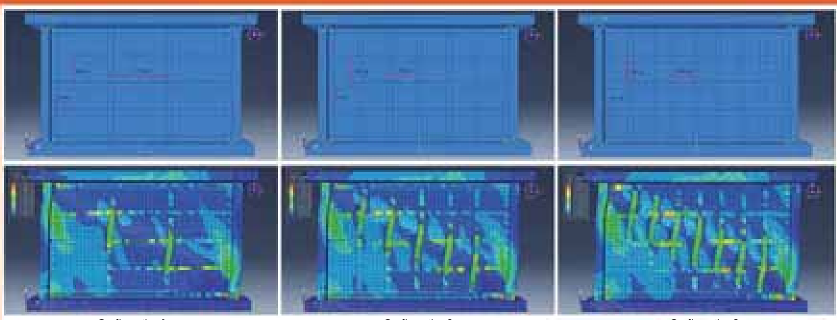
Wall Geometrical Dimensions — Final Crack Pattern — Force-Displacement Experimental Curve



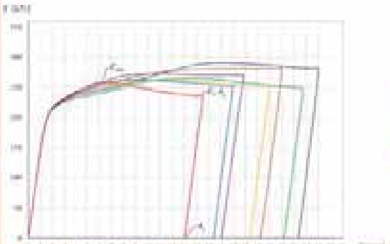
FEM Model — Final Deformed Shape — Experimental-Numerical Comparison

PARAMETRIC FEM ANALYSIS FOR SELECTING THE OPTIMAL REINFORCING SYSTEM

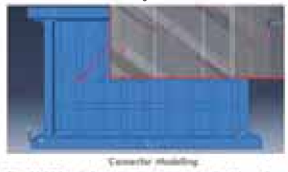
After numerical calibration of experimental tests, a parametric analysis on a masonry wall strengthened with H-FRP sheets on either one side or both sides has been done aiming at understanding the advantages in terms of strength and ductility provided by the used composite natural materials. Three different configurations of H-FRP sheets having width of 10 cm, fixed vertical pitch (30 cm) and variable horizontal pitch (40 cm, 30 cm and 110 cm) have been examined. The achieved results have shown that all reinforcing solutions attain more or less the same resistance, while in terms of ductility the best system is that with H-FRP sheets on both sides and horizontal pitch of 40 cm.



Configuration 1 — Configuration 2 — Configuration 3



CURVE
[illegible]
H-FRP 1 (1 side)
H-FRP 2 (1 side)
H-FRP 3 (1 side)
H-FRP 4 (2 sides)
H-FRP 5 (2 sides)
H-FRP 6 (2 sides)



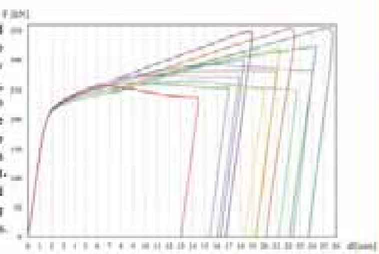
Connector Modelling

The H-FRP reinforcing systems on both sides of the wall have been connected to each other in the intersection zones between horizontal and vertical sheets through a "TIE" constraint able to simulate the presence of appropriate connectors.

COMPARISON BETWEEN H-FRP AND C-FRP

The herein inspected reinforcing solutions with H-FRP have been compared with analogous in geometry systems made of C-FRP.

From comparison it has been observed that both solutions provide almost the same increment of ductility, whereas C-FRP allow to achieve a higher resistance increase, which however does not represent the main prerequisite for seismic retrofitting purpose by means of this technique. This outcome clearly identifies that hemp fibre sheets represent an effective structural-environmental solution to be used instead of C-FRP for seismic retrofitting of existing masonry walls.



CURVE	F_{max} [kN]	d_{max} [mm]
[illegible]	258.2	24.5
[illegible]	262.4	26.8
[illegible]	262.9	25.6
[illegible]	264.6	22.6
[illegible]	272.7	37.8
[illegible]	285.4	21.0
[illegible]	290.7	23.9

ΔF_{max} [%]	Δd_{max} [%]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

The obtained results have shown that, referred to the seismic performance of the unreinforced wall, a maximum strength increase of 2.42% and 11.18% and a maximum ductility increase of 35.84% and 39.33% have been attained with H-FRP and C-FRP, respectively.

CONCLUSIONS

In the current research work the use of H-FRP sheets as seismic retrofitting system of existing masonry buildings has been investigated through FEM simulations carried out in the ABAQUS non linear software environment. Parametric analyses on different configurations of H-FRP systems (variable pitch among sheets and application on one side or both sides of the wall) have shown that the best system is that applied on both wall sides having sheets at horizontal and vertical pitches of 40 cm and 30 cm, respectively. The comparison with analogous in geometry C-FRP systems has shown that hemp fibres sheets allow to attain almost the same ductility increase provided by carbon fibres ones. This means that H-FRP systems can effectively replace C-FRP sheets as seismic retrofitting systems of existing masonry constructions.

REFERENCES

M. L. SCUTARU, C. COFARU, T. D. HORATIU, I. TIMAR - "Properties of Hemp Fibers Used in Automotive Engineering" - Faculty of Mechanical Engineering - Brasov, Transilvania
H. R. GANZ, B. THURLIMANN, - "Plastic Strength of Masonry Shear Walls" - Institute of Structural Engineering - Swiss Federal Institute of Technology - Zurich, Switzerland

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