Retrofitting masonry infill walls with novel fibrous structures
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Presentation overview

- **INTRODUCTION;**
  - Seismic behaviour,
  - Retrofitting techniques,
  - Braided fibrous materials,
- **Materials and Methods;**
  - Production of Braided Structures,
  - Fabrication of Masonry Wall Specimens,
- **RESULTS and DISCUSSION;**
- **CONCLUSION.**
INTRODUCTION

• Turkey (Kocaeli 1999, Duzce 1999, Bingol 2003), Italy (L’Aquila, 2009) and Spain (Lorca, 2011);
• Different solutions have been proposed to improve the seismic behaviour of masonry infill’s using pre-stressing, jacketing or fibre reinforced polymers;
• Retrofitting of masonry walls using laminates glass and carbon fibre reinforced composites;
• Main problem with these retrofitting materials is the delamination between the composite materials and masonry walls.

Seismic behaviour

• Damage was concentrated at the non-structural elements;
• Out-of-plane vulnerability of masonry

Failure patterns of masonry infill walls found in the recent earthquake of L’Aquila
Retrofitting techniques

- Fiber reinforced polymer (FRP):
  - GFRP
  - CFRP
  - BFRP
- Fiber reinforced shotcrete (FRS);
- Textile reinforced mortar (TRM).

Textile reinforced mortar (TRM)

<table>
<thead>
<tr>
<th>Monaxial structure</th>
<th>Biaxial structure</th>
<th>Triaxial structure</th>
<th>Multiaxial structure</th>
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<tbody>
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<td>Warp reinforced</td>
<td>Warp and Weft</td>
<td>Warp and diagonal</td>
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Fibrous architectures oriented directionally
Retrofitting techniques
Textile reinforced mortar (TRM)

Fibrous architectures oriented directionally

Braided fibrous materials
Braided fibrous materials

• The technique consists in the braiding in the transverse and longitudinal directions forming a tubular structure.

Schematic representation of the diameter and angle of braided structure.
Braided fibrous materials

Advantage this technique.

- Possibility to combine different material and different kinds of structure;

- The braided structure protect the fibers and keeps the reinforcement in said the braided structure;

- Is possible to increase the adherence between the mortar and reinforcement.
Production of Braided Structures

- Braided fibrous structures were produced in a vertical braiding machine;
- Speed of take off system was 0.54 m/min;
- 2 yarns of carbon fibre (each yarn 1200 Tex) and 4 yarns of glass fibre (each yarn 600 Tex)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Picture</th>
<th>Angle of braided (°)</th>
<th>Diameter (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced by simple braided structure</td>
<td><img src="image1.png" alt="Image" /></td>
<td>21</td>
<td>1.8</td>
</tr>
<tr>
<td>Reinforced by braided structure with glass core</td>
<td><img src="image2.png" alt="Image" /></td>
<td>25</td>
<td>2.2</td>
</tr>
<tr>
<td>Reinforced by braided structure with carbon core</td>
<td><img src="image3.png" alt="Image" /></td>
<td>33</td>
<td>2.5</td>
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</table>
Fabrication of Masonry Wall Specimens

- Masonry walls specimens were built with traditional horizontally perforated clay bricks (30×20×15 cm);
- Four distinct solutions were used for retrofitting purposes:
  - (1) glass/epoxy laminate,
  - (2) simple braided structure made of polyester yarns,
  - (3) braided structure made of polyester yarns and axially reinforced with glass fibers
  - (4) braided structure made of polyester yarns and axially reinforced with carbon fibers
Fabrication of Masonry Wall Specimens

- The masonry walls specimens were tested under flexural loading (four point load configuration) in the direction perpendicular to the horizontal joints. The flexural tests were performed according to NP EN 1052-2 standard using a loading rate of 0.03N/mm²/min.

RESULTS and DISCUSSION

Flexural behavior of masonry walls

- Desirable flexural behavior;
- Carbon and glass give much higher ductile deformation;
- Capable of sustaining the structure of masonry walls after occurrence of a seismic event.
RESULTS and DISCUSSION

Flexural behavior of masonry walls

Unreinforced

Simple braided structure

Reinforced with glass core

Reinforced with Carbon core
RESULTS and DISCUSSION

Flexural behavior of masonry walls

Glass laminate

CONCLUSION

• It was observed that the developed braided structures with carbon fiber core were found very much helpful in improving the ductility of reinforced masonry walls;

• Braided structures can be used as an alternative material to more common glass fiber composite based materials;
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