Integrated structural and thermal upgrading of existing masonry walls using textile-strengthened mortars with jute fibers: a cross-scale experimental study.

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Abstract

In last few years, scientist and researchers are working to find the best solution for integrated reinforcement techniques to achieve integrated (Structural and Thermal) upgrading or retrofitting of masonry walls using Textile Reinforcement Mortar (TRM)-system. Majority of masonry buildings are constructed without following seismic and thermal standards; therefore, they are vulnerable to natural disaster (earthquake) and mostly energy inefficient, and urgently they need retrofitting or upgrading.

This thesis presents an Integrated (Structural and Thermal) upgrading of the masonry walls with Natural Fiber (NF) TRM system and the experimental results based on the in-plane cyclic compression tests and thermal conductance test in a Climate Chamber (CC). It contains a total of eleven chapters.

Chapter 1 starts with initial introductive remarks and it highlights the motivations, visions and structure of the thesis.

Chapter 2 contains the state of the art literature review: various reinforcement strategies have been highlighted, including latest works done on TRM retrofitting or upgrading.

Chapter 3 mainly underlines latest available guidelines and recommendations on TRM reinforcement/upgrading, and rules and regulations on the thermal transmittance or heat transfer coefficient (U) calculations.

Chapter 4 presents the physical characteristics and mechanical behaviors of the raw jute fibers and its derived products (threads and diatons) obtained through water absorption tests, aging test, tensile strength tests.

Chapter 5 presents the composite mortars prepared using two different types (lime based and cement based) of mortars, three different fiber lengths (30 mm, 10 mm and mm) and four different fiber percentages (0.5%, 1%, 1.5% and 2%) with respect to the mortar masses. The mechanical behavior and thermal performances of these composite samples were evaluated through flexural, compression and thermal conductivity tests, respectively.

Chapter 6 contains some special cases, where composite samples were prepared using only 0.5% and 1.0% of fiber with respect to the mortar mass, in these cases particular attention was made on the amount of water used for the mortar mix.

Chapter 7 presents the masonry Integrated (Thermo-Structural) upgrading. Masonry walls were upgraded using various combinations of the jute fiber products to improve the structural and thermal performances of the masonry walls. The integrated behavior has been determined through the in-plane cyclic compression test and the thermal conductance test.

Chapter 8 highlights the innovative approach to recycle scrap jute net fibers for composite mortar preparation and investigates its thermo-mechanical behavior.

Chapter 9 presents the observation on crack patterns in the prismatic samples and masonry wall specimens. This was done using Digital Image Correlation (DIC) procedure and analysis.

Chapter 10 reports the outcome the carbon-footprint analysis conducted on the masonry wall upgrading process with jute fiber products, on the basis of on-field survey, jute mill visit and literature review

Chapter 11 includes the conclusive remakes based on results and observations.

The novelties of this reserchwork can be listed as:

(1) a natural fiber has been used for dual purpose (structural and thermal) or integrated upgarating of a masonry wall/structure with a NFTRM system, with the aim to study both structural and thermal properties.

(2) jute fiber productes like nets, diatons and chopped raw fibers (for composite mortar) have been used for NFTRM integrated upgrading

(3) the thermal properties have been evaluated expermentally in a dedicated CC with pre-set desired enviromental (i.e., room/internal and ambient/external) conditions.

(4) a TRM-system-package composded of jute fiber nets, jute fiber diatons and jute fiber composite mortar, has been created with the aim not only to improve the stuctural behavior but also to enhance the thermal performance of the upgraded masonry wall/structure. It has been nominated as TRM system package, as a unique TRM-system was fabricated with the capability to improve both structural and thermal performances.

This is the first time when a natural (jute) fiber has been used to create a TRM system for Integrated upgrading. Therefore, further research on mesh configurations, number of net-layers, thickness of the TRM system package etc. should be conducted to improve the dual performances i.e., both structural and Thermal behaviors of the NFTRM system package.