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ENHANCED COATING MORTARS FOR BUILT HERITAGE'S RETROFITTING

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Abstract

Conservation and retrofitting of Building Heritage, when considered under an architect perspective, involves a cluster of actions, from the recognition of the particular and specific values of each building to the architectural intervention. Among the measurements included in building retrofitting are environmental control, maintenance, repair, restoration, renovation and rehabilitation (The Charter of Krakow 2000). It is common to retrofit building facades by repairing or replacing the traditional lime coating mortars. However, when conventional cement mortars are used as repairing materials, some problems related to physical and chemical compatibility arise.

Consequently, it is necessary to improve our knowledge of traditional materials and techniques (Alejandre, 2002; *Historia, caracterización y restauración de morteros*. Sevilla: IUCC, US) and to list conservation policies and materials selection criteria: using respectful materials with their original function, ensuring compatible materials and considering previous structures and architectural values as the principles of any intervention. Additionally, the functional issues related to the building use after the architectural intervention will affect the habitability conditions regarding the external walls and facades.

Concerning habitability conditions, buildings often require repairs due to the loss of materials' performance. In addition, the Built Heritage shows deficiencies according to nowadays thermal and acoustic standards (CTE-DB-HE, 2013; CTE-DB-HR, 2009) that involve high energy consumption and low noise control. Besides, traditional binders are replacing which have shown a good thermal performance (Stefanidou et al., 2010; *Int J Thermophys,* 31:844-851). For those reasons, coating mortars for retrofitting the Built Heritage should be designed to fulfill the nowadays thermal and acoustic requirements but learning from the traditional compositions. As well, other aspects should be taken into account: functional requirements (conservation, aesthetic, structural, service-life and construction issues); technical requirements based on exterior or interior applications; and performance requirements (general and specific technical requirements for renders and plasters) (RILEM TC-RHM, 2012; *Mater Struct* 45:1277-1285).

Therefore, the opportunity to fulfill the nowadays habitability requirements, besides the technical or functional requirements, through the design of new mortar coatings for using in the Built Heritage arises. Material compatibility; aesthetic values like colour, texture and shape and the cast in-place will be considered.

This paper presents a scientific methodology for research on mortars and construction techniques involved in their use for Built Heritage's retrofitting. The aim is to design and characterize a pigmentable lime-cement coating mortar, for both indoors and outdoors application, with improved thermal and acoustic performance, and meeting the technical, functional and other performance

requirements. Figure 1 outlines the general approach.

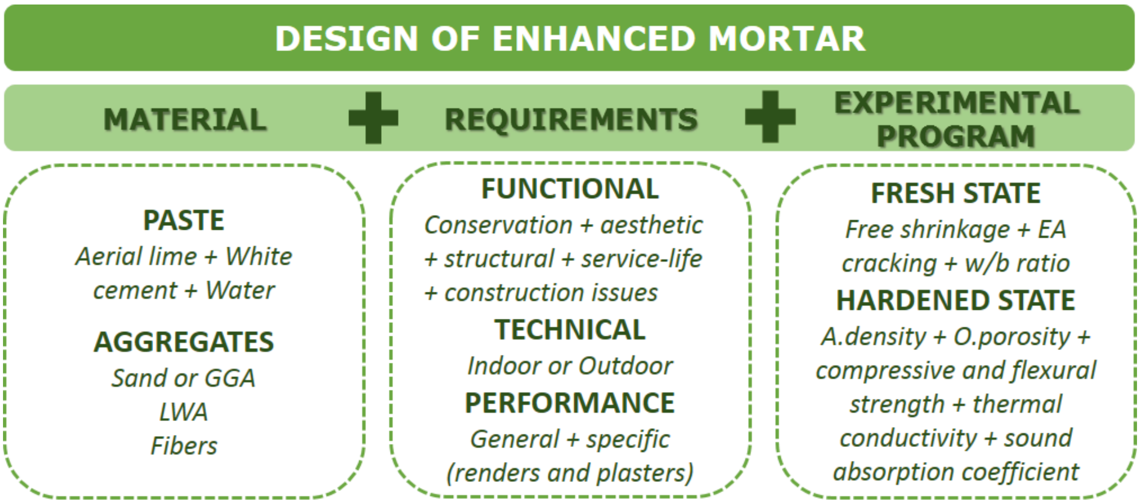

Figure 1. *Methodology for designing an enhanced mortar for Built Heritage's retrofitting*

To achieve the main goal four stages were considered, that include:

1. **Designing mortar compositions.** Mortars can show different characteristics and performance due to wide variations in their **composition**. Also, coating mortars usually incorporate other **components** to vary physical and mechanical parameters in order to achieve thermal and acoustic improvement and satisfying the technical, functional and performance requirements of external coatings. In this study, the binder combined aerial lime (L) and white cement (C) in order to: obtain colored mortars by the inclusion of inorganic pigments; accelerate lime setting-time; improve lime mechanical performance and reduce pathologies related to cement's alkalis content (Stefanidou, 2014; *Constr Build Mater* 65:427-431). To achieve functional, technical and thermal and acoustic requirements on these lime-cement mortars, gap-graded aggregate without fines content (GGA), three lightweight aggregates (expanded clay, perlite and vermiculite) and two types of short fibers (cellulose and polypropylene) were used.
2. **Designing and carrying out an experimental program.** The **experimental techniques** evaluated material compatibility; taking into account aesthetic values like colour, texture and shape; the cast in-place and mechanical and physical properties necessary to improve thermal and acoustic features. The experimental program assessed different **parameters** in **fresh and hardened state** as consistency, free shrinkage and initial time, total cracked area, w/b ratio, apparent density, open porosity, capillary water absorption coefficient, compressive, flexural and adhesion strength, ultrasonic pulse velocity –UPV- and ultrasonic modulus. Besides, thermal conductivity (λ) and the noise reduction coefficient (α_{NRC}) were calculated. As a result, a **parametric analysis** was carried out to identify some relations linking physical parameters to performance issues as apparent density to thermal conductivity of samples or open porosity to sound absorption coefficient (Palomar, Barluenga & Puentes, 2014; Lime-cement mortars for coating with improved thermal and acoustic performance. *Constr Build Mater.* Accepted for publication, November 2014).
3. **Assessing requirements and for mortar compositions.** The results are compared to check the most suitable compositions according to the

requirements. For example, mixtures with vermiculite improved thermal properties (λ below 0.20 W/mK) yet these mortars showed high cracking risk, large horizontal shrinkage and lower mechanical properties. Another case in point, mechanical, physical, acoustic and thermal properties varied with the amount of cellulose fibers. However, the cellulose fiber showed a limit on the performance improvement and additional research on other fibers proportion are needed.

4. **Building predictive models and optimizing compositions**. To maximize the thermal and acoustic improvements, predictive models based on the parametric analysis will be made. According those models, an optimization of the mortar composition will be done to maximize sound absorption coefficient, reducing sound reflection and avoiding noise problems, and achieving a low thermal conductivity to enhance thermal insulation.

Currently, two stages have been completed and the third one is being implemented. Furthermore, the authors have registered a national patent (Palomar & Barluenga, 2014; Patent, Mezcla de cal y cemento con características térmicas y acústicas, *Application number P2014-00305*. Spain: OEPM). Patenting new materials is a preliminary step to market a product and to spread across the national and international building material sector. In addition, the results have been published: a research paper in a JCR (Q1) scientific magazine (Palomar et al., 2014) and two conference papers (Palomar, Barluenga & Puentes, 2014; International Conference On *Energy Efficiency In Historic Buildings: Experiences & Solutions*; Palomar, Barluenga & Puentes, 2013; International Research Conference / Third International Forum on Science Anthropic Areas *Heritage, Territory, Landscape*).

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