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Mechanical Behaviour of ETICE in Presence of Water

Fulvio Re Cecconi[1], Giuseppe Ccocchetti[2], Aram Cornaggia[3] and Tomaso VILLA[4]

[1] Architecture, Built environment and Construction engineering – ABC Department, Politecnico di Milano, via Ponzio 31, 20133-Milano, Italy, fulvio.rececconi@polimi.it

[2] Civil and Environmental engineering – DICA Department, Politecnico di Milano, piazza Leonardo da Vinci 32, 20133-Milano, Italy, giuseppe.cocchetti@polimi.it

[3] Civil and Environmental engineering – DICA Department, Politecnico di Milano, piazza Leonardo da Vinci 32, 20133-Milano, Italy, aram.cornaggia@polimi.it

[4] Chemistry, Materials and Chemical Engineering "Giulio Natta" – DCMIC Department, Politecnico di Milano, piazza Leonardo da Vinci 32, 20133-Milano, Italy, tomaso.villa@polimi.it

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1 Introduction

One of the most used technology to insulate new and refurbished buildings are the External Thermal Insulation Composite Systems (ETICS). Among ETICS defects found in literature cracks are not only a serious aesthetic deficiency, they are also a weak point for the entry of rainwater into the facade. The consequences of the excessive presence of water inside an ETICS system are its accelerated degradation and a decay in the thermal resistance of the insulating layer. The latter compromises the performance of the entire system. Thus, a study on the development of cracks in ETICS coatings is of utmost importance and understanding the causes may allow for better designed and longer life façades.

2 Methods and Tools

The research is divided mainly into two great stages as pictured in Figure 1, the first one dedicated to data gathering and pre-analysis, the second one to the actual FEM analysis when a nonlinear finite element model has been set-up for the mechanical analyses of ETICS. The model consists of seven insulating panels arranged in three rows so as to represent, considering the appropriate symmetries, the planar and central surface of the facade of a building. The chosen finite elements are of isoparametric kind, three-dimensional, with 8 nodes and incompatible shape modes. The total number of finite elements is about 70000, with about 75000 nodes. On the ETICS bottom, i.e. where the system adheres to the supporting wall, fixed boundary conditions are imposed on surface parts physically glued. Boundary conditions, consistent with a periodic repetition of insulations panels, are set to the lateral surface. In order to investigate particular configurations of the panels, i.e. different types of edge constraints, a second finite element model has been created to allow the analysis of troublesome point in an ETICS façade. Noteworthy, a double FEM analysis has been made, one in the case of a polystyrene foam (EPS) insulation panel and another with the insulation panel made of mineral wool (MW).

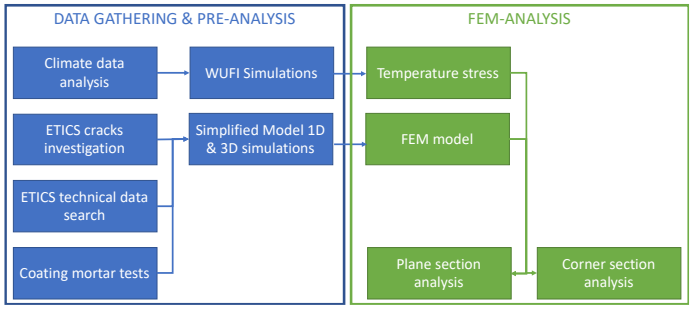

Figure 1. Research schema

3 Results, Discussion and Conclusions

All the analyses pointed out that a temperature increase cannot be the only cause of cracks (due to instability) on the base coat. If the model has no imperfections, *i.e.* there are no errors in construction or insulation panels have no thick tolerances, then there are no signs of possible cracks. In order to simulate the behavior of an ETICS near a corner some FEM analyses on a single insulation panel with two unconstrained edges have been done (Figure 2). The difference in the thermal expansion coefficient between the two insulation panel led to a huge difference in stresses in the coat layer, namely in the ETICS made of EPS stresses inside the coat are up to 6 times the stresses in ETICS made of mineral wool and with the given thermal stresses. Since the tensile strength of the coating play a crucial role in the development of cracks, 12 coat samples were tested to measure their tensile strength. Six of them were characterized by a high water content (immersed) and 6 with a standard water content (dry).

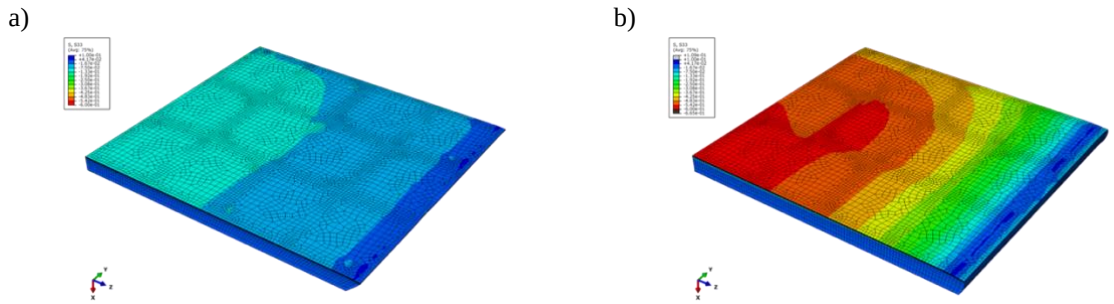

Figure 2. Comparison between mineral wool (a) and EPS (b). Stresses [MPa] when two edges of ETICS are unconstrained.

Experimental results proved that the average tensile strength applied to obtain a 2% strain varies significantly comparing the dry samples and the immersed ones with an average 42% reduction. By combining the results obtained in the two phases of the research, we can say that high water contents can easily halve the thermal variation causing cracks on the ETICS coat. This high reduction is all the more dangerous as the elastic modulus of the insulating material increases.

ORCID

Fulvio Re Cecconi: https://orcid.org/0000-0001-7716-8854
Giuseppe Cocchetti: http://orcid.org/0000-0002-9695-2967
Aram Cornaggia: http://orcid.org/0000-0001-7176-8664
Tomaso Villa: http://orcid.org/0000-0003-2663-6755