11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

STRUCTURAL ANALYSIS OF FROST DAMAGED CONSTRUCTIONS BY MEANS OF A COUPLED ENVIRONMENTAL-MECHANICAL DAMAGE MODEL

Luisa Berto[1], Anna Saetta[1], Diego A. Talledo[1] and Renato Vitaliani[2]

[1] Department of Architecture Construction and Restoration - University IUAV of Venice - Campus Terese, Dorsoduro 2206 – 30123 Venice, saetta@iuav.it
[2] Department of Civil, Environmental and Architectural Engineering – University of Padova Via Marzolo 9 – 35131 Padova, renato.vitaliani@dicea.unipd.it

Key Words: *Freezing-and-thawing, reinforced concrete, coupled damage model.*

Reinforced concrete structures have been extensively used during the last century due to its relatively low cost in comparison with other construction materials. Moreover it was considered an intrinsically durable material and durability was considered a marginal issue. During the last decades durability issues gained more interest: the demand for designing durable structures has increased together with the necessity of reliable and suitable models for the prediction of concrete's behaviour on time. One of the most severe deterioration process that may affect concrete structures is caused by freezing-and-thawing cycles.

The causes and mechanisms of frost damaging process have been studied during the last decades and different theories have been developed to describe the physical process of damaging due to frost action. Nevertheless very little attention has been given to the effect of frost attack on the material characteristics and on the bond properties of concrete, see e.g. [1] where it has been shown the effects of frost action on mechanical properties of concrete: reduction of compressive and tensile strength, an increasing of peak strain and fracture energy and a reduction of bond strength.

An innovative formulation able to accounting for the physical deterioration mechanism due to freezing-and-thawing cycles was developed within the framework of the coupled environmental-mechanical damage approach by the authors [2], [3]. In particular the coupled model was calibrated by using a limited number of tests carried out on concrete specimens under mono-axial and bi-axial compressive stresses, subjected to freeze-thaw cycles with different levels of frost deterioration, [4].

In this paper the model was reorganized and further enhanced in order to be more general considering additional experimental tests carried out during the last years by different research groups, e.g. [1], [5].

Finally the proposed coupled model was used as a predictive tool to evaluate the load carrying capacity of some frost damaged beams [6], Figure 1. Figure 2 shows the damage contour maps for both the sound beam R1 and the frost-degraded beam D1.

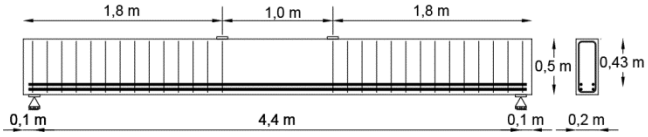

Figure 1: Beams R1 (Sound) and D1 (Degraded): geometry and reinforcement, [6]

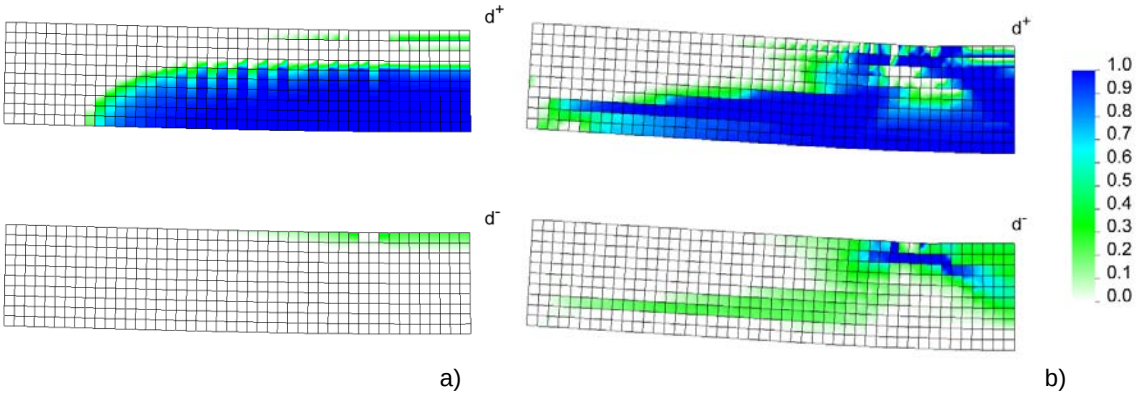

Figure 2: Damage contour maps for a) beam R1 and b) beam D1

REFERENCES

[1] K. Zandi Hanjari, Load-Carrying Capacity of Damaged Concrete Structures, *Licentiate thesis*, Civil and Environmental Engineering, Chalmers University of Technology, Gothenburg, Sweden, 2008.

[2] D.A. Talledo, A coupled environmental-mechanical damage model for structural analysis of RC constructions, *PhD Thesis*, Department of Architecture, University of Florence and University of Braunschweig, Italy and Germany, 2013.

[3] L. Berto, A. Saetta, R. Scotta, D.A. Talledo, A coupled damage model for r.c. structures: proposal for a frost deterioration model and enhancement of mixed tension domain, *submitted* 2013.

[4] HS Shang, YP Song, Experimental study of strength and deformation of plain concrete under biaxial compression after freezing and thawing cycles, *Cement and Concrete Research*, 36:1857-642, 006

[5] A. Duan, W. Jin, J. Qian, Effect of freeze-thaw cycles on the stress-strain curves of unconfined and confined concrete, *Materials and Structures*, 44:1309-1324, 2011

[6] M. Hassanzadeh, G. Fagerlund, Residual Strength of the Frost-Damaged Reinforced Concrete Beams, *III European Conference on Computational Mechanics*, 2006