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Nonlinear mesoscopic elasticity of concrete:

in search of the physical sources for improving the respective NDE methods

In the last 20 years there has been an increase in the experimental evidence about the nonlinear elastic behavior of cementitious materials at large strains. The type of nonlinear elastic phenomenology observed is similar to the one observed also for rocks, soils and sintered ceramics. It is usually classified under the common umbrella name of nonlinear mesoscopic elasticity.

The physical source of such nonlinear elastic behavior is usually identified with the structural features that lead to the spatial heterogeneity at the above-micron scale, e.g., interfaces between different material phases (aggregates and cement paste, for cementitious materials), cracks and dislocation networks in (poly)crystalline phases. The larger the amount of such features, the stronger and more variegated the nonlinear mesoscopic elastic response. At least, this is what has been used as working hypothesis.

Several non-destructive evaluation (NDE) methods have been developed and successfully applied to such materials based upon that working hypothesis.

Despite the success of such methods, there is still lack of basic physical understanding of why such working hypothesis seems to be valid for such a large variety of materials and damage processes.

In this talk, I will review the recent developments in the application to cementitious materials (mortars and concretes) of NDE methods based upon nonlinear mesoscopic elasticity. I will then present results of some efforts towards a better understanding of the physical sources of such nonlinear elastic behavior.

These efforts include complementing nonlinear mesoscopic elasticity measurements with other non-destructive techniques, e.g., X-ray tomographic microscopy, in search of correlations between the damage processes' features and the observed nonlinear elastic response.

The focus of my presentation will be on the nonlinear elastic behavior of cementitious materials affected by specific types of damage processes, e.g., the alkali-silica reaction, and how a better understanding of the damage process itself could lead to a more efficient use of the nonlinear elasticity NDE methods and, in the future, to their standardization.