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A FINITE ELEMENT METHOD FOR THE PREDICTION OF COMPRESSIVE STRENGTH OF LIGHTWEIGHT CONCRETE

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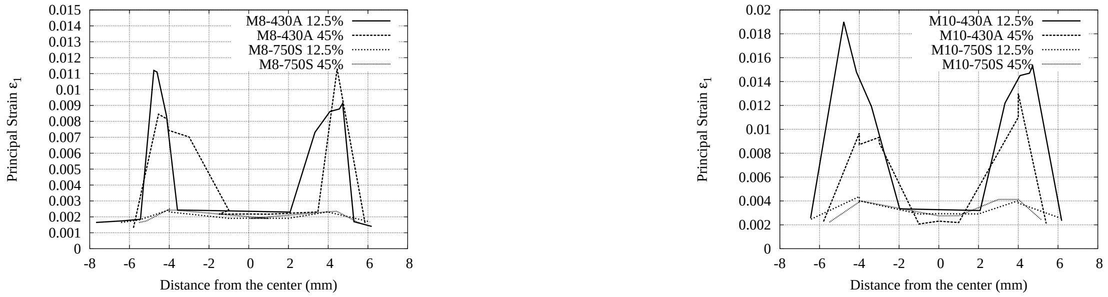
Constituted by low rigid coarse aggregates, coated with a more rigid mortar, lightweight concretes are useful to reduce thermal bridge in the concrete structure. At mesoscopic level concrete could be described as a granular skeleton based on coarse aggregates only, embedded in a mortar compounded by a cement paste and sand. In order to realize a finite element model describing the elastic behavior of lightweight concrete, the granular skeleton has to be generated in a realistic way, using a granular model [1]. The numerical model proposed here, will be used to propose a rupture mode, not solved in literature, and to predict the concrete compressive strength, still remaining in the elastic domain. All the experimental data used for calibrated and validated the numerical model come from the study on lightweight concrete of [2]

The granular model used to generate the concrete takes into account a granular curve, the real compacity for a concrete sample, the maximum density called virtual compacity, and the minimum and maximum aggregates' diameters. Since only coarse aggregates are represented, diameters are included between 2 mm and 10 mm. The granular model allows to define a thickness between aggregates. When the cylindrical sample is generated, mortar and aggregates are meshed separately, and the mechanical link between them is supposed perfect. Came from the work of [2], two mortars are considered, called M8 and M10, with Young's modulus about 28 GPa and 35 GPa respectively. In this mortar two types of aggregates called 430A and 750S, are included, with Young's modulus equal to 4.3 GPa and 20 GPa, and with the compacities of 12.5% and 45%. Each numerical concrete sample is loaded until its compressive strength determined experimentaly. Stress and strain distribution inside and around aggregates are calculated. Evolution of principal elastic strains, along the axis perpendicular to the loading one, is represented by Figures 1(a) and 1(b). One can notice a convergence of strains inside aggregate and inside mortar, and peaks of strain in a transition zone between aggregate and mortar. Since the mechanical behavior in the mortar is purely compressive, it is possible to approximate the experimental maximum admissible strain with the Hooke's law, knowing the compressive strength of mortar and the Young's modulus. These values equal to 1.45×10^{-3} for M8, and 2.45×10^{-3} for M10. A correlation is observed between experimental and numerical strains in mortar, far from the aggregate center as shown by Figures 1(a) and 1(b). Differences between them are included between 0.8% and 16%. Thus if the maximum strain is reached in mortar when concrete is loaded until its compressive strength, it is allowed to consider that the concrete compressive strength is only induced by the failure of mortar.



(a) Concrete with mortar M8

(b) Concrete with mortar M10

Figure 1: Principal strain values inside and around the aggregate with the maximum diameter

Now the numerical model is used as a prediction tool for lightweight concrete compressive strength. The numerical simulation is stopped when the exact values of maximum admissible strain of mortar, given previously, are reached in each concrete. Then the stresses in lower and upper faces of the numerical sample are picked up, providing the loading stresses. Comparisons between experimental and numerical predicted compressive strengths are presented in Figure 2, and show a strong correlation.

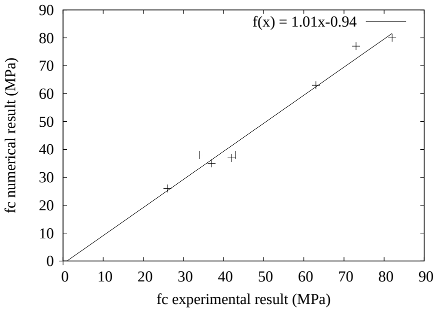


Figure 2: Correlation between f_c and f_{cnum}

REFERENCES

[1] Francois De Larrard. *Concrete Mixture Proportioning*. E&FN Spon, London and New York, 1999.

[2] Y Ke, A L Beaucour, S Ortola, H Dumontet, and R Cabrillac. Influence of volume fraction and characteristics of lightweight aggregates on the mechanical properties of concrete. *Construction and Building Materials*, 23(8):2821–2828, 2009.