

Finite element numerical simulation of the mechanical behaviour of recycled aggregate concrete at the meso-scale

Summary

This PhD conducts an efficient mesoscale numerical modelling approach to assess the mechanical behaviour of RAC and investigate the influence of material composition and mix design. Despite the growing interest in RAC, a comprehensive mesoscale model and a clear understanding of its behaviour remain lacking. This research addresses this gap through a three-stage methodology. First, a mesostructural model of concrete is generated using an adapted generation–separation method, accurately representing the shape and spatial distribution of coarse aggregates. The model is calibrated to reflect realistic geometry and aggregate packing. Second, both 2D and 3D simulations of RAC under quasi-static loading are implemented and validated. Results show that the 2D model is suitable for parametric studies with lower computational cost, while the 3D model offers a more detailed representation. Third, a series of parametric analyses are conducted to examine the effects of mortar quality, recycled aggregate content, and interfacial transition zone (ITZ) characteristics on RAC behaviour. Numerical results are benchmarked against experimental observations, confirming the model's reliability. The main innovation lies in the development of a robust numerical tool capable of capturing mesoscale features such as aggregate geometry and distribution within concrete. The study demonstrates that mesoscale modelling is a powerful tool for optimising RAC mix design and understanding failure mechanisms. It highlights that the RAC strength is strongly influenced by mortar and ITZ properties, while its stiffness correlates closely with the amount and quality of coarse and recycled aggregates used in the mix.

Keywords

Mesoscale modelling; recycled aggregate concrete; mechanical behaviour; parametric analysis; finite element method.



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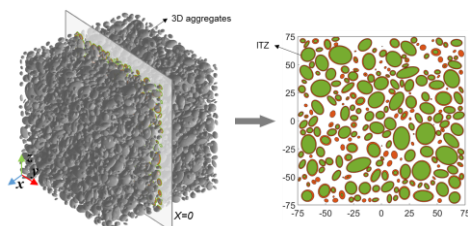
João Pacheco (CERIS, IST, University of Lisbon)

Period

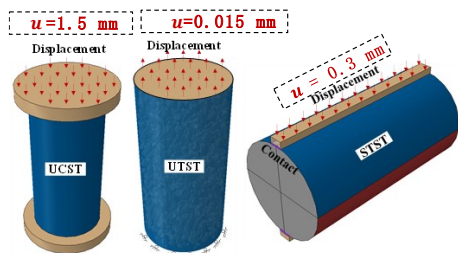
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Funding

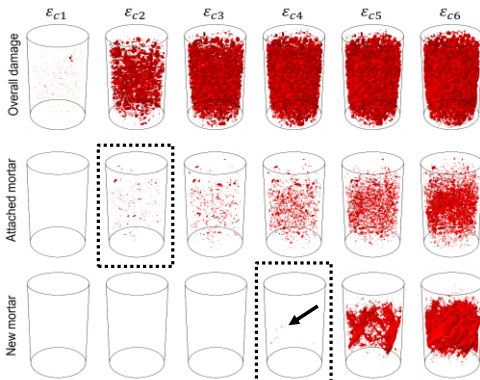
Financial support from China Scholarship Council



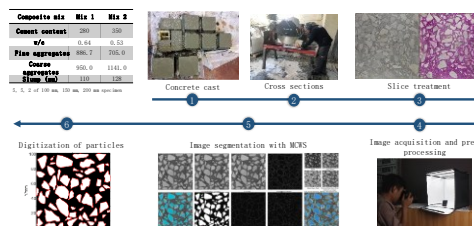
(a) generation and separation method



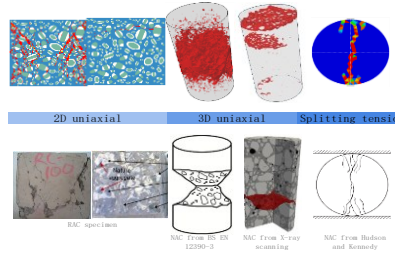
(c) 3D modelling of recycled concrete



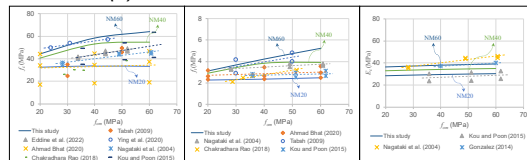
(e) results of mesoscale modelling of RAC



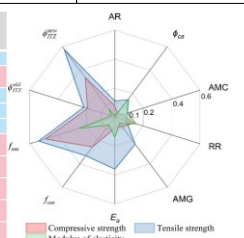
(b) calibration of the mesoscale model



(d) validation of numerical results



Type	Parameters	Δf_c (%)	Δf_t (%)	ΔE_c (%)
Mix design	AR	-7.7	-11.1	-0.6
	ϕ_{ca}	-3.1	-14.8	15.9
	AMC	-5.3	-8.7	-8.8
	FR	-13.3	-8.0	-15.0
Phase properties	AMG	8.3	23.2	-5.5
	E_a	-7.7	-36.0	13.8
	f_{om}	25.5	33.0	6.9
	f_{rm}	52.8	58.6	25.9
	ϕ_{ITZ}^{old}	19.2	21.8	2.5
	ϕ_{ITZ}^{new}	33.8	57.7	6.5



(e) parametric analysis of RAC