# DEM analyses of effect of interfacial transitional zones on fracture in concrete


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## ABSTRACT


At the meso-scale level, concrete may be described as a four-phase material composed of aggregate, cement matrix, macro-voids and interfacial transitional zones [1], [2]. The presence of aggregate and ITZs is particularly important since the volume fraction of aggregate can be as high as 70-75% in concrete and ITZs with the thickness of about 5-50 μm are always the weakest regions in usual concretes wherein cracking starts. ITZs are porous regions of the cement paste around aggregate particles which are perturbed by their presence. Their origin lies in the packing of the cement grains against the much larger aggregate that leads to a local increase in porosity (micro-voids) and a presence of small cement particles. A paste with the lower *w/c* (higher packing density) or made of finer cement particles or smooth aggregates lead to ITZs of a smaller extent. These layers are highly heterogeneous and damaged and thus critical for the concrete behaviour. Two different types of failure exist for ITZs: the ITZ-aggregate separation (related to some delamination processes directly at the aggregate surface) and the ITZ-failure (related to cracking). The accurate understanding of the properties and behaviour of ITZ is one of the most important issues in meso-scale analyses because damage is initiated in the weakest region and ITZs are just the weakest link in concrete and acts as attractors for cracks.

The aim of the paper is to determine in numbers the effect of ITZs on both the concrete strength and fracture. For numerical analyses the discrete element method (DEM) was used. The calculations were performed with the 3-dimensional open-source code YADE which was developed at Grenoble University. A linear contact under compression was used. The normal and tangential contact forces satisfied the cohesive-frictional Mohr-Coulomb equation [3]. The cohesive force and tensile force were a function of the cohesive stress, tensile normal stress and element radius. The internal structure of concrete (size, shape and location of aggregate and macro-voids, micro-porosity) was directly taken from 3D x-ray images using the micro-tomography SkyScan 117 [1], [2]. The ITZs were assumed to exist around all aggregate particles. They were taken into account in calculations by means of two different methods. First they were solely simulated as contacts between aggregate and cement matrix grains (thus they had a no physical width) [1]. Second they were assumed as thin cement zones with a higher porosity. The DEM calculations were carried out for concrete during three-point bending by assuming a different elastic modulus, cohesive stress, tensile normal stress, inter-granular friction angle and porosity in ITZs. The width of ITZs was also varied. Numerical outcomes of the concrete strength and fracture were directly compared with corresponding experimental results [1].


## REFERENCES


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