Tensile fracture in concrete is characterised by a quasi-brittle response in the form of a gradual reduction of stress with increasing displacements. This softening response is caused by the development of a fracture process zone in the heterogeneous concrete, involving mechanisms such as branching and bridging of micro-cracks. The fracture process zone evolves from distributed and disconnected micro-cracks to a strongly localised tortuous macroscopic crack, whereby the tortuosity is governed by the presence of aggregates, which represent the dominant heterogeneity of the material. For the analysis of concrete structures, it is important to include this quasi-brittle softening response, since it strongly influences the load capacity of structures and is the source of a particular size effect on nominal strength, which neither follows the strength theory nor linear elastic fracture mechanics [1].

For many structures, the heterogeneities in concrete are too small to be modelled explicitly and too large to allow for the use of linear elastic fracture mechanics. Therefore, concrete is often assumed to be homogeneous on the scale studied and the fracture process zone caused by interactions on the lower scale are modelled by localised but regular strain profiles using nonlocal models [2]. In these models the stress at a point is evaluated by the weighted spatial averaging of history variables in the vicinity of this point. Nonlocal approaches do not rely on the assumption that strains localise in a mesh dependent zone. Therefore, they are capable of describing the simultaneous occurrence of distributed and localised failure mesh-independently. Additionally, fracture patterns obtained with nonlocal models are less sensitive to the alignment of the finite element mesh than those obtained by other models.

The spatial averaging in nonlocal models requires the input of a length parameter, which should be related to the width of the fracture process zone. Calibration approaches to determine this parameter have been proposed in literature [3, 4]. However, more research is required to provide simple procedures which would allow for the determination of this length parameter.

Here, a recent approach based on the meso-scale analysis of the fracture process of a unit cell subjected to tension [5] is further developed to determine this parameter. The tortuosity of the final localised crack is linked to the width of the fracture process zone and the length parameter used in the nonlocal model. The influence of aggregate size and volume fraction on the nonlocal length will be investigated with this method. Furthermore, suggestions for experimental techniques to determine the length parameter will be proposed.

References