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The Effect of Crack Size, Orientation and Number on the Elastic Modulus of a Cracked Body

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Abstract : Osteoporosis is a disease affecting bone quality which in turn can increase the risk of low energy fractures. Treatment of osteoporosis using Bisphosphonates has the beneficial effect of increasing bone mass while at the same time has been linked to the formation of atypical femoral fractures. This has led to the increased study of micro-fractures in bones of patients using Bisphosphonate treatment. One of the mechanics related issues which have been identified in this regard is the loss in stiffness of bones containing one or many micro-fractures. Different theories have been put forth using fracture mechanics to determine the effect of crack presence on elastic properties such as modulus. However, validation of these results in a deterministic way has not been forthcoming. The present analysis seeks to provide this deterministic evaluation of fracture's effect on the elastic modulus. In particular, the effect of crack size, crack orientation and crack number on elastic modulus is investigated. In particular, the Finite Element method is used to explicitly determine the elastic modulus reduction caused by the presence of cracks in a representative volume element. Single cracks of various lengths and orientations are examined as well as cases of multiple cracks. Cracks in tension as well as under shear stress are considered. Although the focus is predominantly two-dimensional, some three-dimensional results are also presented. The results obtained show the explicit reduction in modulus caused by the parameters of crack size, orientation and number noted above. The present results allow the interpretation of the various theories which currently exist in the literature.

Keywords : cracks, elastic, fracture, modulus
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