2005-12-11

Analysis of Indentation Loading of Cortical Bone Using Acoustic Emission Techniques

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Recommended Citation

Safari, A., O'Reilly, G., McCormack, B.: Analysis of Indentation Loading of Cortical Bone Using Acoustic Emission Techniques. 1st International Conference on the Mechanics of Biomaterials and Tissues, Hawaii, USA. December 11-14, 2005. doi:10.21427/hjpr-wb81

Funder: Council of Directors (Strand 1)

Analysis of indentation loading of cortical bone using acoustic emission techniques

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In this study, we recorded the number of Acoustic emission (AE) hits and related AE energy during indentation fracture of cortical bone using a PAC PCI-2 card and pico sensor. A threshold value of 43dB was used to filter premature trigger due to background noise. Registered AE hits had more than one count (threshold crossing) [1]. Amplifier gain was set at 40dB with a (0.1-1) MHz band pass filter. 8mm cubes of cortical bones were indented in the longitudinal direction at constant crosshead speed of 1 mm min^{-1} using a large 2D, 50° wedge indenter. We hypothesised that signals occurring as a result of microcracking would have low AE energy and occur prior to and during the period of maximum load whereas those associated with main crack propagation would have high AE energy and occur at fracture only.

Figure 1 shows the force and AE activity during indentation loading of a typical bone specimen. The cumulative number of AE hits did not increase substantially until just prior to maximum load as previously established for monotonic tensile loading of deer antler [1]. During fracture toughness testing of cortical bone the increase in cumulative total of AE hits is associated with advance of the crack front [2]. Figure 2 shows AE energy distribution during the fracture process. It was observed that only high amplitude and high duration signals produced high AE energy. High energy signals occurring at time 30s and 34s were associated with main crack initiation and propagation. Signals in the intervening time period were assumed to be associated with microcracking prior to main crack propagation.

We conclude that acoustic emission analysis can be used to distinguish between different stages in the indentation fracture of cortical bone by evaluating the AE energy of the AE signals in conjunction with the force/time graph.

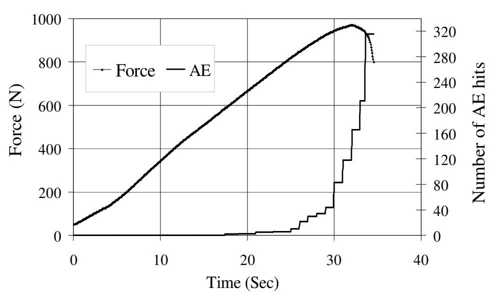

Figure 1: Force & number of AE hits vs. time

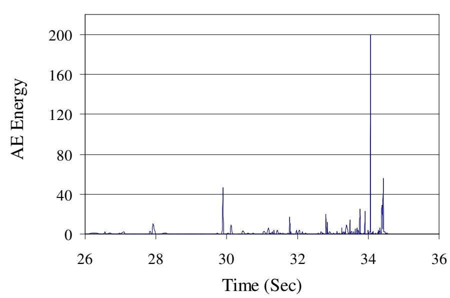

Figure 2. AE energy vs. time at fracture

[1] Zioupos, P., et al, Med. Eng. Phys., 16: 203-212, 1994,
[2] Akkus, O., et al, J. Materials Science, 35: 6065-6074, 2000

Keywords: Acoustic emission, Cortical bone, Microcracks, Crack propagation.