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ARCHETYPE-BLENDING CONTINUUM THEORY FOR MULTISCALE FATIGUE PREDICTIONS

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Fatigue accounts for approximately 80% of all structural failures [3] but is difficult to predict due to an extensive array of driving factors on multiple length and time scales. The need for predictive tools is highlighted for biomedical devices (such as stents and artificial heart valves) where design lives are on the order of billions of cycles (i.e. 20 years of heartbeats) and failures can be expensive if not fatal. This work outlines a method for fatigue prediction based on the Archetype-Blending Continuum (ABC) theory [1] which has the power to not only predict fatigue but also allow for concurrent device and material microstructure design.

The ABC theory captures the response of microstructural constituents (such as non-metallic inclusions) using extra computational degrees-of-freedom. Strain gradients on both the macro and microscale, which are critical for predicting fatigue, are also included. Fatigue is predicted based on a *fatigue indicator parameter* as in the work of Owolabi et al. [2], but advances their approach by allowing for implicit microstructures without the cost of an explicit finite element mesh for grains or inclusions.

An agreement between ABC predictions for simple linear elastic microstructures and direct numerical simulations using finite element is shown. Plasticity is then included and fatigue is predicted. The reduction in fatigue life due to notching of test specimens is predicted and compared to experimental data, illustrating that the ABC method can capture the notch sensitivity of fatigue specimens. Thus, this work can not only predict notching effects, but also link these effects to the material's microstructure. The result is a tool which can help improve the design of both biomedical devices and their materials for fatigue resistance and ultimately decreased healthcare cost and improve patient care.

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