FRETTING FATIGUE: THE EQUIVALENCE OF CRITICAL PLANE AND CRITICAL ASYMPTOTE SOLUTIONS

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There is currently a great deal of interest in trying to devise a method for the avoidance of fretting fatigue in contacts, based on 'critical plane' approaches. The critical plane techniques were originally constructed to provide a means of specifying the boundary between infinite and finite life in complex components suffering plain fatigue, and may be sub-divided into those using simply the 'worst' state of stress at the critical point, measured using some composite stress parameter (the Fatemi-Socie and Smith-Watson-Topper rules), and one in which crystal-level plastic shakedown is allowed for (the Dang-Van approach). Several people have applied the critical-plane technique 'as is' to fretting problems, using the results of plain fatigue tests to provide a calibration. It has been shown that the results of a range of fretting fatigue tests can sometimes be successfully correlated using this approach, and a device which is sometimes employed to assist the correlation, by providing an additional degree of freedom in the solution, is to make a comparison not of the spot, worst state of stress, but by using an integrated value of the critical parameter over some representative element [1, 2]. Naturally, by using the size of the representative element as a parameter in the study, a better fit can be obtained than would otherwise be the case.

A recent, parallel approach has been advocated using the concept of a local solution (an asymptotic solution but, in the case of an incomplete contact, not a singular one [3]) and hypothesizing that cracks will nucleate when the range of stress intensity factor (the multiplicative factor on the asymptote) reaches a critical value. No attempt is made to speculate which components of stress are responsible for nucleation (in contradistinction to critical plane ideas), and it is intended that the calibration used for the technique be a simple fretting fatigue test where the stress intensity factors are known, although it would, in principle, be possible to use some plain fatigue tests of appropriate geometry. Note that the stress intensity factors are dimensional quantities (like the well-known crack-tip stress intensity factors), and therefore include information about the *size* of the contact and its slip zone.

In this paper we show that there is an equivalence between the two techniques, and also show explicitly how critical plane approaches, particularly when integrated over a particular volume, simply provide a means of describing the region over which the asymptote applies. Thus the two methods are interchangeable, but the asymptotic technique has the advantage that it can employ fretting tests directly to judge the fretting fatigue threshold condition, and it is argued that the presence of an interface, even when adhered, does have an influence on accelerating crack nucleation when compared with a monolithic specimen. This observation applies *a fortiori* in the case of a slipping contact, of course, and obviates the need for using the results from plain fatigue tests used by those advocating critical plane methods.

References

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Keywords: Asymptotics, fretting, fatigue