Prediction of fretting fatigue lifetime of dovetail joints using a Modified Theory of Critical Distances

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Introduction

The traditional Theory of Critical Distances (TCD) is unable to effectively address the complex stress distribution in stress concentration areas. To overcome this limitation, a Modified TCD (MTCD) is proposed, integrating the effects of stress gradients and maximum principal stress into the original TCD framework. The MTCD method significantly improves the accuracy of predicting the initiation lifetime of both dovetail joints compared to the traditional TCD method. This study not only enhances the understanding of fretting fatigue behavior in dovetail joints but also provides a reliable predictive tool for evaluating more complex models of dovetail joints.
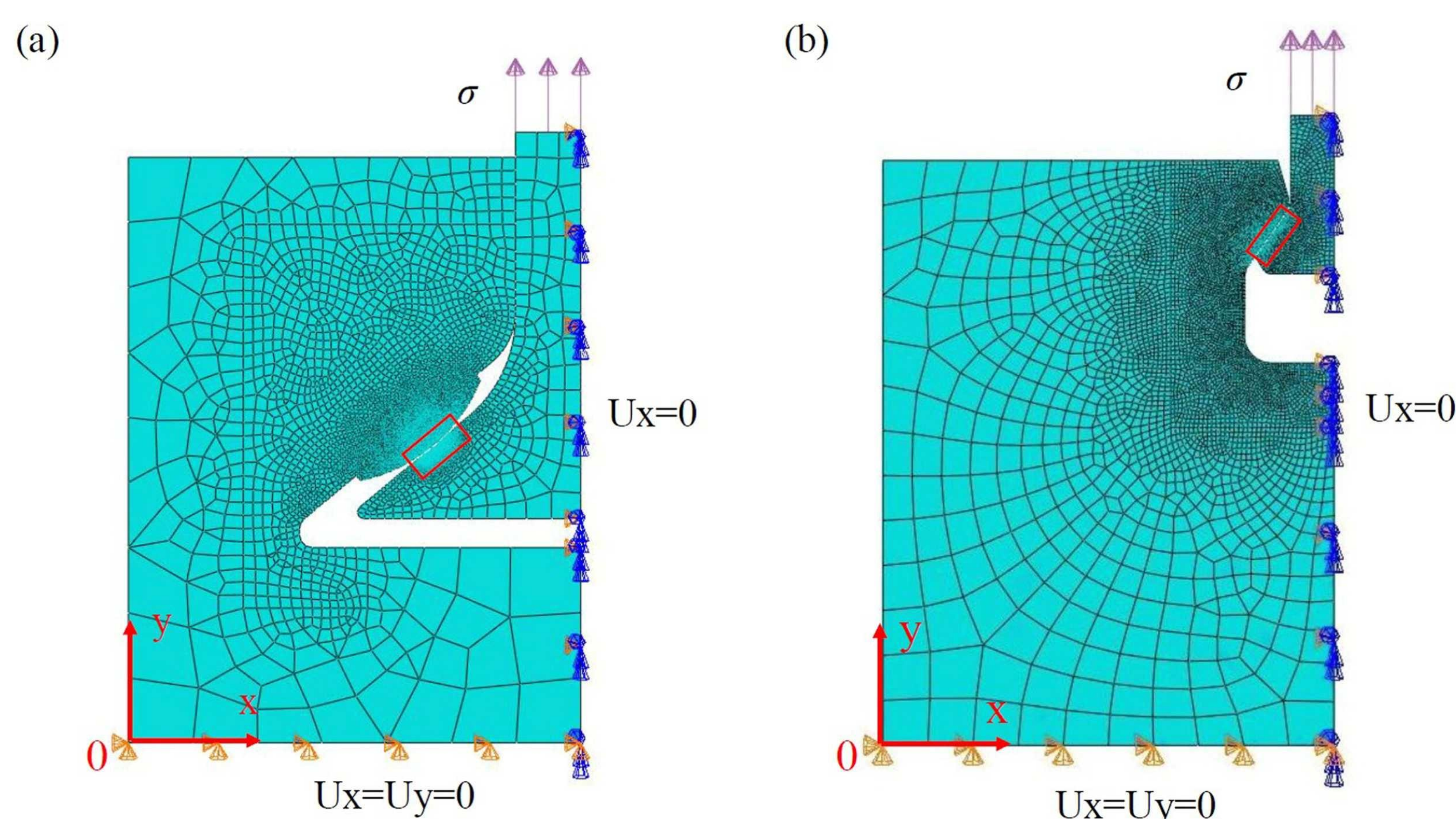
Methods

➢ Finite Element Method

➢ Critical Plane Method

➢ Modified Theory of Critical Distance
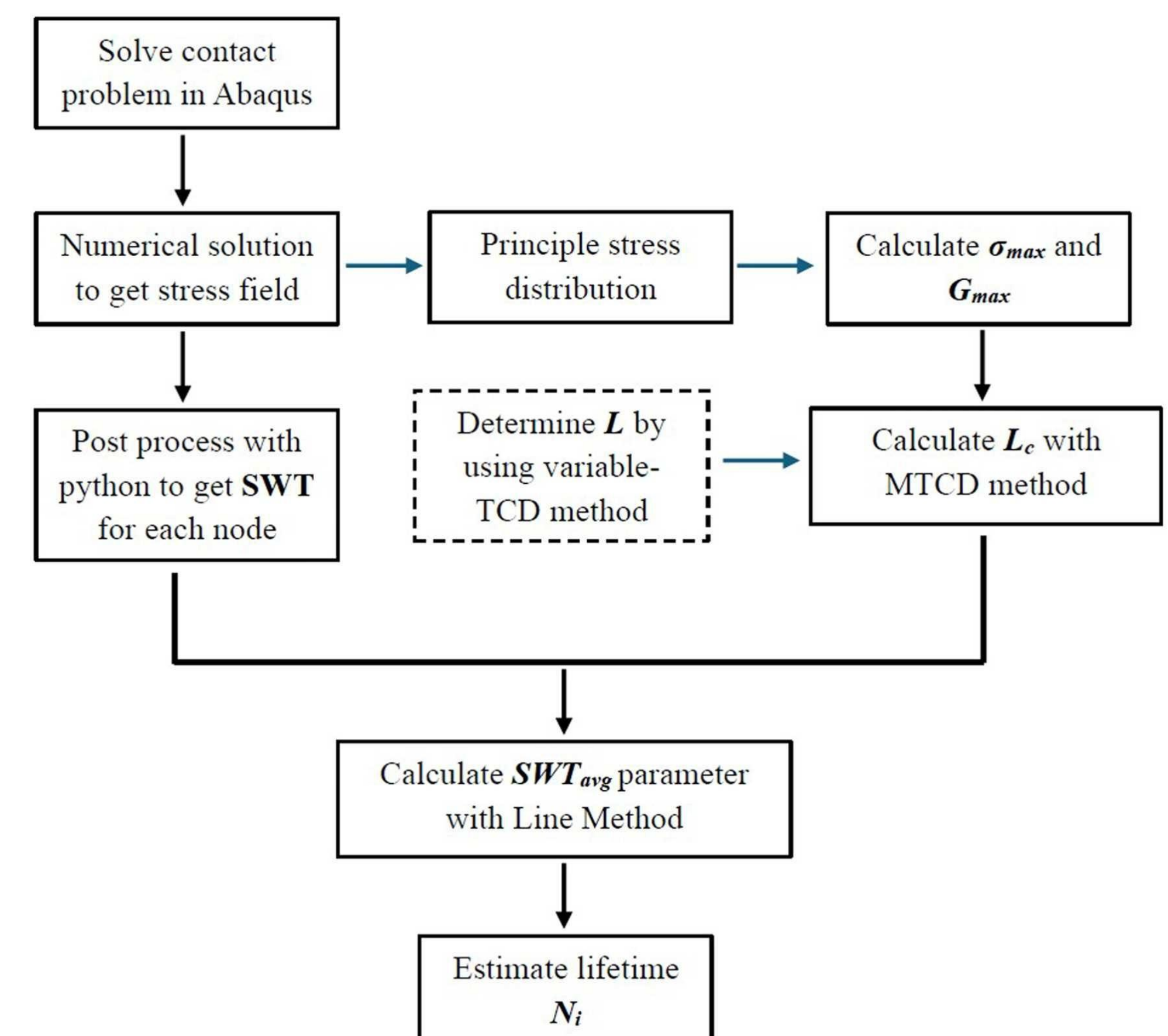
$$SWT = \sigma_{max} \frac{\Delta\varepsilon}{2} = \frac{\sigma_f'^2}{E}(2N_i)^b + \sigma_f'\varepsilon_f'(2N_i)^{b+c}$$

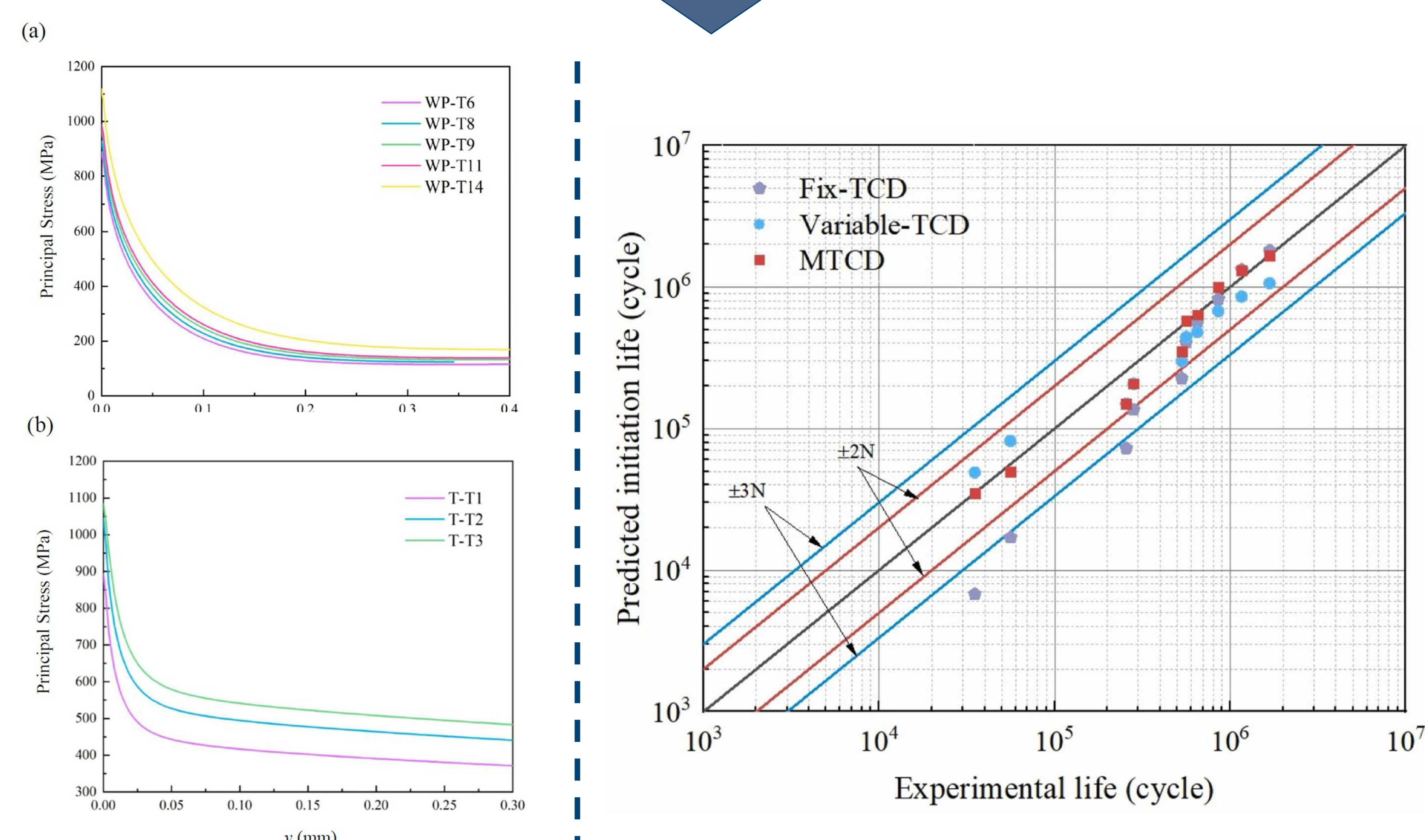$$L_C = 1.477\sqrt{\frac{\sigma_{max}}{G_{max}} \times L_0}$$

Graphics / Images

The finite element models: (a) dovetail joint with pads and (b) traditional dovetail joint.

Flowchart for the whole process of MTCD method.

The distribution of principal stress

Comparison of predicted crack initiation lifetimes.

Conclusions

1. As the load increases, the length of the contact area for the dovetail joint with pads increases, while it remains nearly unchanged for the traditional dovetail joint.

2. In both dovetail joints, the maximum principal stress shows a positive correlation with increasing load. However, the value of the stress gradient is not necessarily strongly correlated with the magnitude of the load.

3. For the dovetail joint with pads, the FP and FS parameters exhibit higher reliability in predicting the crack initiation angle. Conversely, the SWT parameter is more suitable for the traditional dovetail joint.

4. A pre-processing step has been added in the fatigue lifetime prediction to select a more accurate calibration group, allowing for better comparison of the test results with the simulation results.

5. A Modified Theory of Critical Distances (MTCD) has been proposed, integrating the effects of stress gradients and maximum principal stress, resulting in more precise predictions of fatigue initiation lifetime.