Crack propagation in structures with uncertain-but-bounded parameters via interval perturbation method

Zhiping Qiu, Zesheng Zhang

PII: S0167-8442(18)30121-6
DOI: https://doi.org/10.1016/j.tafmec.2018.09.009
Reference: TAFMEC 2103

To appear in: *Theoretical and Applied Fracture Mechanics*

Received Date: 18 March 2018
Revised Date: 1 August 2018
Accepted Date: 14 September 2018

Please cite this article as: Z. Qiu, Z. Zhang, Crack propagation in structures with uncertain-but-bounded parameters via interval perturbation method, *Theoretical and Applied Fracture Mechanics* (2018), doi: https://doi.org/10.1016/j.tafmec.2018.09.009

Crack propagation in structures with uncertain-but-bounded parameters via interval perturbation method

Zhiping Qiu†, Zesheng Zhang

Institute of Solid Mechanics, Beihang University, Beijing 100191, China

ABSTRACT

Fatigue crack growth prediction plays a crucial role in structure design. This paper presents a method for crack propagation analysis in structures with uncertain-but-bounded parameters. Although the parameters of engineering structures are uncertain due to many factors, the range across which they vary can be determined from practical experience and engineering knowledge. The crack growth boundary over the life of the structure has great significance in preventing structural failure. Uncertain-but-bounded parameters are regarded as interval numbers in the proposed method, and expressed alongside time-varying crack length under Paris law as a perturbation series after introducing a small parameter. By combining the perturbation method with interval mathematics, boundaries of each term in the perturbation series of time-varying crack length are determined to obtain the upper and lower boundaries of time-varying crack length. The proposed method is verified based on two examples; both the Monte-Carlo method and probabilistic method are applied for the sake of validation. The results demonstrate the feasibility and efficiency of the proposed method for predicting crack propagation in structures with uncertain-but-bounded parameters.

Keywords: crack propagation; Paris law; uncertain-but-bounded parameters; interval perturbation method

1. Introduction

At present, with the development of mechanical engineering and aircraft engineering, structural safety has become a problem which attracts much attention[1][2]. Small cracks and defects frequently emerge in engineering structures due to manufacturing and environmental factors, so fatigue crack propagation prediction plays a crucial role in estimating structural safety under dynamic loads. Many researchers and practicing engineers have explored this subject[3]-[9]. Paris[10], for example, pioneered the extant research on crack growth rate calculation; da/dN was

†Corresponding author: Zhiping QIu. Email: zpqiu@buaa.edu.cn; Fax: +86-10-82339628; Tel: +86-10-82339628.