

FOUR LECTURES ON FATIGUE CRACK GROWTH

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Abstract—During the course year 1976–1977 the author presented a series of eight lectures on fatigue crack growth at the Department of Aerospace Engineering of the Delft University of Technology. Four of these lectures in a slightly modified version were presented in August 1977 as part of a Seminar on Fatigue, Fundamental and Applied Aspects, organized by the Linköping Institute of Technology (Prof. T. Ericsson). These lectures are reproduced here. Titles and summaries are given below.

I. FATIGUE CRACK GROWTH AND FRACTURE MECHANICS

Summary

Aspects of the technical meaning of fatigue considerations in practice are indicated. The fatigue life is subdivided into a crack nucleation period and a crack propagation period. The significance of recognizing these periods for practical problems is illustrated by several examples. The similarity approach for correlating fatigue data is introduced. The meaning of the stress intensity factor for fatigue crack growth is discussed.

II. FATIGUE CRACKS, PLASTICITY EFFECTS AND CRACK CLOSURE

Summary

Concepts introduced are residual plastic deformation, residual stress, reversed plastic deformation, plastic deformation in the wake of the crack and crack closure under tensile load. COD measurements as a method to determine the crack closure level are discussed. The significance of crack closure for fatigue crack growth is analysed and illustrated by several examples, including effects of yield stress, stress ratio and delayed crack growth after a peak load. Finally some attention is paid to three dimensional aspect following from thickness effects, shear lips and curved crack fronts.

III. FATIGUE CRACK PROPAGATION, PREDICTION AND CORRELATION

Summary

Two prediction techniques are introduced, (1) cycle-by-cycle prediction and (2) prediction by correlation. Attention is paid to the problem of describing variable-amplitude loading in terms of load cycles. Aspects of fatigue damage are reviewed with reference to interaction effects and weaknesses in cycle-by-cycle prediction methods. The discussion on prediction by correlation is restricted to constant-amplitude loading. The validity of the similarity concept based on K -factors is reconsidered. Application of simple specimen data to complex structures is shown. Finally a variety of crack growth equations is reviewed, including aspects of curve fitting, a comparison between formulas of Walker and Elber and asymptotic values in the $da/dn - \Delta K$ relation.

IV. FATIGUE CRACK GROWTH UNDER VARIABLE-AMPLITUDE LOADING

Summary

Stationary and non-stationary types of variable-amplitude loading are specified. Some attention is paid to the description of stationary random load. The stress intensity factor is then applied to crack growth under stationary variable-amplitude loading by defining first characteristic stresses and characteristic stress intensity factors. This is done for random loading, non-random loading and flight-simulation loading. It is discussed how and why this concept may break down if the stationarity is lost. Attention is paid to truncation of high loads in a flight-simulation test and the analogous problem of the crest factor under random loading. The significance of crack closure for understanding crack growth under variable-amplitude loading is emphasized.

CONTENTS

- I. Fatigue crack growth and fracture mechanics**
 1. Introduction
 2. Fatigue crack initiation
 3. Fatigue crack growth
 4. The stress intensity factor K
 5. K and cyclic loading
 6. References

- II. Fatigue cracks, plasticity effects and crack closure**
 1. Introduction
 2. Residual stress after local plastic deformation
 3. Crack closure
 4. How to measure crack closure
 5. Crack closure and fatigue crack growth
 6. Some consequences of crack closure
 7. Crack closure and the effect of thickness
 8. Crack closure and shear lips
 9. Crack closure and crack front curvature
 10. References

- III. Fatigue crack propagation, prediction and correlation**
 1. Introduction
 2. Cycle-by-cycle prediction for variable-amplitude loading
 3. Crack growth prediction by correlation
 4. Crack growth equations for constant-amplitude loading
 5. References

- IV. Fatigue crack growth under variable-amplitude loading**
 1. Introduction
 2. Different types of variable-amplitude loading
 3. How to describe random load
 4. K -concept and random load
 5. K -concept and stationary non-random load
 6. Crack growth under flight-simulation loading
 7. Truncation of high loads
 8. Crack closure and non-stationary variable-amplitude loading
 9. References