Fatigue & Fracture Mechanics in FE Analysis

January 10th-31st 2013

sessions take place at

12:30 PST, 15:30 EST, 20:30 GMT, 21:30 CET

Four-Week Training Course

(one 2.5 hour session per week)

Engineering Board PDH Credits: 10 hours*

EARLYBIRD PRICE OF $288 FOR MEMBERS AND $432 FOR NON MEMBERS IS AVAILABLE UNTIL *JANUARY 5TH 2013*. THEREAFTER, PRICES WILL REVERT TO $360 FOR MEMBERS AND $540 FOR NON-MEMBERS.

BOOK TODAY TO SECURE YOUR DISCOUNT!

Course Overview

Fatigue failure occurs when a material is subjected to repeated loading and unloading cycles. The level of stresses present to cause failure may be well below values considered safe for a single static load application. The critical fatigue initiation is usually at a very localized site and may be a result of additional factors such as stress concentration due to component shape, surface finish or corrosion pitting.

Fatigue has been cited as one of the major causes of in-service failure throughout engineering history. The earliest application of rotating machinery with its attendant cyclic nature produced documented fatigue failures. Textile loom machinery, pumping machinery and above all steam railway operations were beset by a mode of failure that was not understood. The early railway axle failures and mining equipment failures prompted fundamental testing and research. The theories on which much of modern fatigue analysis is based on were developed all through the industrial revolution and into the 1920's.

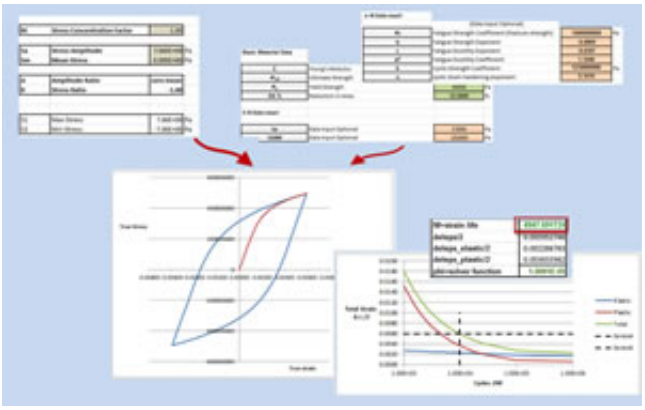
The advent of more complex structures with more complex loading histories was typified by the introduction of the first jet powered airliners. Sadly new fatigue lessons had to be learned in the period from 1954 as a result of the DH Comet crashes.

The nature and prediction of fatigue is much more understood, and is a requirement for most design products today. However the application of fatigue analysis is not easy and a good background is essential to be able to use the powerful FEA method as a basis for fatigue analysis.

Much of the terminology used in setting up the fatigue problem through a modern GUI is confusing and the choice of options is not always clear.

The objective of this course is to break down the fatigue analysis process into clearly defined steps, give an overview of the physics involved and show how to successfully implement practical solutions using Finite Element Analysis.

Free Fatigue Life Calculator



All attendees on the course will be able to download a fully functioning Fatigue Life Calculator. As well as forming a useful tool for many of the homework tasks set, attendees will be able to explore the implications of both High Cycle and Low Cycle Fatigue as discussed in the class.

A tutorial guide is also available for download. Basic Material Data and Strain Life Material data is input, or derived from fundamentals. Neuber notch and Plastic material intersection points are found allowing a hysteresis cycle to be plotted. The strain life curve is plotted and the number of cycles to failure is calculated.

The Calculator has been steadily developed over the last few years of delivering this course and attendees will be entitled to future upgrades.

Course Process and Details

In the current climate travel and training budgets are tight. To help you still meet your training needs the following e-learning course has been developed to complement the live class. The e-learning course runs over a three week period with a single two hour session per week.

The course is completely code independent. No software is required.

Each topic in the class is treated as a building block and is presented using an overview of the physics and theory involved. The math is kept simple and the emphasis is on practical examples from real life to illustrate the topic. The mapping to Finite Element analysis techniques is shown with numerous workshops. The tutor will be showing analysis results interactively and involving the students in the process via Q and A periods during each session, follow up emails and a Course Bulletin Board

Students are welcome to send in problems from industry and these will be discussed as time permits.

Full notes are provided for the students, together with personal passwords for e-learning backup material, bulletin board access etc.

Students will join the audio portion of the meetings by utilizing the VoIP (i.e. headset connected to the computer via headphone and microphone jacks) or by calling into a standard toll line. If you are interested in additional pricing to call-in using a toll-free line, please send an email to: **e-learning @ nafems.org** .

Who Should Attend?

This course is aimed at practicing engineers who wish to learn more about how to apply finite element techniques to fatigue analysis in the most effective manner. Ideally a student should have some experience of FEA analysis, but this is not essential. The material that is presented is independent of any particular software package, making it ideally suited to current and potential users of all commercial finite element software systems. This course is a must for all engineers aiming to use FEA as a reliable predictive tool for

fatigue analysis.

E-learning classes are ideal for companies with a group of engineers requiring training. E-learning classes can be provided to suit your needs and timescale. Contact us to discuss your requirements.

Special Note(s):

Telephony surcharges may apply for attendees who are located outside of North America, South America and Europe. These surcharges are related to individuals who join the audio portion of the web-meeting by calling in to the provided toll/toll-free teleconferencing lines. We have made a VoIP option available so anyone attending the class can join using a headset (headphones w/ microphone) connected to the computer. There is no associated surcharge to utilize the VoIP (listening through your computer speakers/headphones) option, and is actually encouraged to ensure NAFEMS is able to keep the e-Learning course fees as low as possible. Please send an email to the e-Learning coordinator (**e-learning @ nafems.org**) to determine if these surcharges may apply to your specific case.

Just as with a live face-to-face training course, each registration only covers one person. If you plan to register a large group (10+), please send an email to **e-learning @ nafems.org** in advance for group discounts.

For more information, please email **e-learning @ nafems.org** .

Course Programme

Session 1 - Thursday January 10th 2013

12:30 PST, 15:30 EST, 20:30 GMT, 21:30 CET

Finite Element Analysis Overview

Introduction to Fatigue analysis

High Cycle Fatigue methods

- S-N Curveo Definition and Usage
    - o Endurance Limit
    - o Data Sources
- Mean Stress Effects
- Fatigue Correction Factors
- Loading Environment

Low Cycle Fatigue methods – overview

- Strain Life
- True Stress and Strain
- Cyclic Stress Strain history

FEA application of Fatigue Analysis

Workshops and homework

Session 2: Thursday January 17th 2013

12:30 PST, 15:30 EST, 20:30 GMT, 21:30 CET

Homework Review

Notch Effects in High Cycle Fatigue

Low cycle fatigue

- Notch Effects
- Neuber Method
- Peterson Method

- Stress Gradient Method
- Worked example
- True stress strain definitions
- Mean Stress Effects

Loading History definition

- Cycle Counting Methods

More FEA implications

- Surface Stresses
- Stress Concentration Idealization

Workshops and homework

Session 3: Thursday January 24th 2013

12:30 PST, 15:30 EST, 20:30 GMT, 21:30 CET

Homework Review

Multiaxial Fatigue

- Proportional Loading
- Non-Proportional Loading
- Solution Methods
- Checking Methods

Vibration fatigue

- Review of Random Vibration Analysis

- Apparent Frequency and RMS values
- Stress components
- Von Mises results – caution
- Damage calculation methods

Homework

Session 4: Thursday January 31st 2013

12:30 PST, 15:30 EST, 20:30 GMT, 21:30 CET

Homework Review

Introduction to Fracture Mechanics methods

- Fracture mechanics
- Crack Loading Modes
- Stress Intensity Factor
- FEA Implementation Methods
- Virtual Crack Closure Method
- Crack growth and re-meshing

Fatigue in Composites

- Overview of Fatigue in Composites
- Micro-mechanical behaviour
- Fatigue Prediction
- Practical Applications

Workshops