CHAPTER 1 Introduction

1) What is the difference between a total life approach and a defect-tolerant approach?
2) What is HCF and LCF and what characterizes them?
3) What is the difference between dimensioning Safe-life or Fail-safe?
4) What is RFC?
5) What is ”Leak-before-break”?
6) What is the influence from hydrostatic pressure on plasticity in metals?
7) Consider a beam, clamed in one end and of length L and bending stiffness EI. The material is ideally elastic-plastic. Determine maximum load P_{el} that can be applied at its free end without causing plasticity. At what load P_{max} is the beam fully plastic?
8) What are the flow surfaces according to von Mises and Tresca?
9) Consider a thin walled pressure vessel of length L, radius R and wall thickness t. The vessel is subjected to an inner pressure p, a torque M_v and an axial force P. Determine the effective stress.
10) If the low surface is given by the function $f(\sigma_{ij})$, what are the implications $f(\sigma_{ij})>0$, $f(\sigma_{ij})=0$ and $f(\sigma_{ij})<0$?
11) What is a Maxwell element and a Kelvin-Voigt element and when are they useful?
12) Define resolved shear stress. Why is it important?
13) What is Schmid´s law and the Schmid-factor?
14) What is meant by hardening and softening of a metal?
15) What is the critical plane approach?

CHAPTER 7 Stress-life approach

Not 7.5, 7.7, 7.8

1) How is a S-N-curve constructed?
2) Define fatigue limit. How is the fatigue limit defined if the S-N curve do not approach a constant value?
3) Which is the Basquin equation and when does it apply? Detemine the number of cycles to fatigue as function of stress amplitude.
4) Define the diagram in which the Basquin equation is a straight line. What is the slope of the line?
5) The relation between stress amplitude σ_a and number of cycles to fatigue *N* is, for a specific material is in the interval 100MPa< σ_a <200MPa described by $\sigma_a = -50 \log N + 400 MPa$ assuming *R*=-1. Draw the Wöhler curve. Which amplitude can be allowed assuming a life of 10^5cycles? (Answer 150MPa). If σ_a =200MPa, determine the number of cycles to fatigue. (Answer 10^4cykler).
6) Define *R*.
7) How is a mean stress $\neq 0$, i.e. $R \neq -1$ compensated for? What are Soderberg, Gerber, Goodman and Haigh-diagrams?
8) Assume $R = 0, \sigma_e = 380 MPa$ and $\sigma_{TS} = 1200 MPa$. Determine maximum σ_a for infinite life. Compare Gerber and Goodman. (Answer: Gerber 348MPA, Goodman 289MPa.)
9) How did Morrow modify the Basquins equation?
10) What is the Palmgren-Miner rule? Which objections can be raised against?
11) Assume, according to Wöhler, $\sigma_a = -55 \log N + 430 MPa$ and σ_m =0. A load sequence with amplitudes σ_a =200, 180, 150 and 100MPa during *N*=15, 20, 250 and 3000, respectively. Assume the Palmgren-Miner rule to apply. How many such load sequences can be applied? (Answer: 152).
12) How can residual stresses be enforced? Why is this useful? Compare example 7.6.1, Example problem: Effects of surface treatments.
13) Define K_t, K_f and *q*. What are the implications of *q*=1 and *q*=0?
14) How is K_f used at HCF? Why is it applied to the stress range, only?
15) How is a multi axial stress state treated?
16) What is proportional and non- proportional loading?
17) How is the critical plane-approach applied at non-proportional loading?

CHAPTER 8 Strain-life approach
Not Example 8.1.3

1) A Ramberg-Osgood-material follows, assuming monotonic loading, the relation

$$\varepsilon = \frac{\sigma}{E} + \varepsilon_f \left(\frac{\sigma}{\sigma_f} \right)^{1/n}$$

Assume $\sigma_f = 1227 MPa, \varepsilon_f = 1.0, E = 200000 MPa, n = 0.13$.

Draw the stress-strain diagram and mark $\sigma_f, \varepsilon_f, E$. What is the influence from *n*?

2) A Ramberg-Osgood-material under cyclic loading is described by

$$\varepsilon = \frac{\sigma}{E} + \varepsilon'_f \left(\frac{\sigma}{\sigma'_f} \right)^{1/n'} = \frac{\sigma}{E} + \left(\frac{\sigma}{A'} \right)^{1/n'}$$

Assume $\sigma'_f = 1355 MPa, A' = \sigma'_f / (\varepsilon'_f)^{n'} = 1344 MPa, E = 200000 MPa, n' = 0.13$. Draw the hysteresis loop if $\sigma = \pm 600 MPa$.

3) Assume load control. Draw the strain amplitude for a hardening/softening material?

4) Assume displacement control. Draw the stress amplitude for a hardening/softening material?

6) Which is the Coffin-Manson relation? When should it be applied?

7) Which is the Morrow relation? Draw, schematically, the elastic and plastic contributions to the total strain and define the limit between ”long” and ”short” life.

8) How is $\sigma_m \neq 0$ compensated for?

9) Draw a $(\log(2N), \log(\Delta\varepsilon/2))$-diagram for Morrows relation if $\sigma_m = 0, \sigma_m = -100 MPa, \sigma_m = 100 MPa$. Determine $(N_f)_t$ for each case and determine corresponding strain amplitudes. Assume for the steel SAE1045 that $\sigma'_f = 1227 MPa, \varepsilon'_f = 1.0, E = 200000 MPa, b = -0.095, c = -0.66$.

10) The Neuber rule reads: $K_f = \sqrt{K_\sigma K_\varepsilon}$. What is the rational for this?

11) What is the Neuber hyperbola and how is it used?

12) A plate contains a small, centrally placed circular hole. The plate is loaded by the remote stress $S = \sigma_\infty = \pm 400 MPa.$ Determine number of cycles to failure according to the Neuber method. Assume a Ramberg-Osgood material model and use Morrows relation.

Material data: $q = 1, E = 200000 MPa, A' = 1344 MPa, n' = 0.18,$

$\sigma'_f = 1227 MPa, \varepsilon'_f = 1.0, b = -0.095, c = -0.66$

(Answer: 600 cycles)

Draw the hysteresis loop for $S = \sigma_\infty = \pm 400 MPa.$

Draw the hysteresis loop for $S = \sigma_\infty = 200 \pm 200 MPa.$

Determine number of cycles to fatigue using the Neuber method if $S = \sigma_\infty = 200 \pm 200 MPa.$

13) The stress levels in a load sequence are (MPa) 1,8,3,11,1,5,3,8,6,10,3,8,1,11,2,7,6,7,6, 7,6,10,1,8,3,11. Identify load cycles using rain flow count.

14) How can an effective strain be determined?

CHAPTER 9 Fracture mechanics and its implications for fatigue Overview 9.3.2, 9.7.6. Not 9.5.3. Overview 9.9 – 9.11.

1) What is the Griffith fracture theory.
2) Define the energy release rate *G*.
3) (Show that $G = \frac{F^2}{2B}\frac{dC}{da}$ applies to load control as well to displacement control.)
4) The fracture criterion is G=G_c What holds for dG/da?
5) Define mode I, II and III. Which is most common?
6) By solving a boundary value problem the stress- and strain state in a crack tip vicinity can be determined. What singularity applies to the stress field? What about the strain field?
7) Define the stress intensity factors.
8) Why is, always, $K_I \geq 0$?
9) In mode I the principal stresses are $\sigma_1 = \frac{K_I}{\sqrt{2\pi r}}\cos\frac{\theta}{2}(1+\sin\frac{\theta}{2}), \sigma_2 = \frac{K_I}{\sqrt{2\pi r}}\cos\frac{\theta}{2}(1-\sin\frac{\theta}{2}), \sigma_3 = 0$ at plane stress and $\sigma_3 = 0.6\frac{K_I}{\sqrt{2\pi r}}\cos\frac{\theta}{2}$ in plane deformation Draw the contour of $\sigma_{effMises} =$constant about the crack tip in plane stress and in plane strain.
10) What is the *T*-stress?
11) What is *K*-dominance?
12) What is the fracture toughness K_{Ic}?
13) State the Paris law.
14) For an edge crack in a large plate $K_I = 1.12\sigma_\infty\sqrt{\pi a}$. A crack of initial length $a = a_0$ is discovered as its length is $a = 0.1a_c$. Critical crack length is a_c where $a_c / a_0 = 400$. What portion of life remains as the crack is discovered? The exponent in Paris´ law is n=3.
15) What is the relation between *G* and *K*?
16) Solve Example 9.4.1 in Suresh.
17) The fracture criterion reads K_I=K_{Ic} . How do K_{Ic} vary with specimen width and temperature?
18) What is the *J*-integral measuring?
19) What is the relation between *K* –*J* – *G* ?
20) What is the HRR-singularity?
21) How is Crack Tip Opening Displacement, CTOD, defined? How can CTOD be used as a fracture criteria?
22) What is *J*-dominance?
23) Which is, according to ASTM, the limit for the use of LEFM? How is this limit defined?
24) Solve Example 9.7.5 in Suresh.
25) How is a hydrostatic stress state in the vicinity of a crack tip compensated for?

CHAPTER 13 Fretting fatigue

Overview. Focus on phenomena.

1) Name some of the concepts of Table 13.1.
2) Illustrate the stick-slip-region as a sphere is pressed against a flat surface at the same time as cyclically varying shear forces are applied (Fig. 13.6).
3) Illustrate schematically the stress field emerging as a cylinder rolls over a flat surface (Fig. 13.7).
4) Name some different types of damage emerging due to fretting fatigue (Table 13.2).
5) What is a fretting map?