Princípios de Fadiga e Fratura de Estruturas Navais e Oceânicas (PNV 3631)

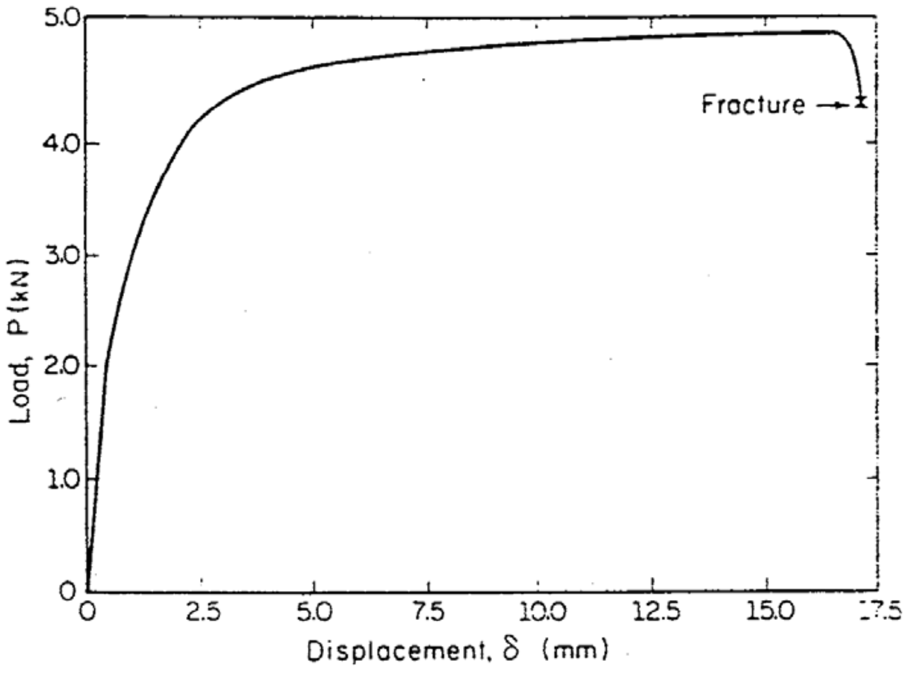
Lista 2 – Strain-Based Approach

Deadline: 10-05-2018

1.

Shown below is the load–deflection curve ($P - \delta$) for an engineering brass. The modulus of elasticity, E, of the material is 100 GPa. Given the following values for the test specimen:

Initial length, $l_0 = 167$ mm
Initial diameter, $d_0 = 3.17$ mm
Final diameter at necked section, $d_f = 2.55$ mm



Determine:

(a) 0.2% offset yield strength, S_y

(b) Ultimate strength, S_u

(c) Percent reduction in area, % RA

(d) True fracture ductility, ϵ_f

(e) True fracture strength, σ_f

(f) Strength coefficient, K (H)

(g) Strain hardening exponent, n

(h) True stress at ultimate load

(i) True strain at ultimate load

Also plot the engineering and true stress–strain curves.

2.

Given below are the results of constant amplitude strain-controlled tests. The material has a modulus of elasticity, E, of 200 GPa.

Total Strain Amplitude. $\Delta\epsilon/2$	Stress Amplitude, $\Delta\sigma/2$ (MPa)	Reversals to Failure, $2N_f$
0.00202	261	416,714
0.00510	372	15,894
0.0102	428	2,671
0.0151	444	989

Determine:

(a) The cyclic stress–strain properties (K', n')

(b) The strain–life properties (ϵ_f', σ_f', b, c)

(c) The transition life ($2N_t$)

(d) The fatigue life at strain amplitude, $\Delta\epsilon/2$, of 0.0075

3.

Determine the lives to failure for a nickel alloy under the following load histories:

History	Description	Strain Amplitude $\Delta\epsilon/2$	Mean Strain ϵ_0
A	Fully reversed ($R = -1$)	0.005	0
B	Fully reversed ($R = -1$)	0.010	0
C	Zero to maximum ($R = 0$)	0.005	0.005
D	Zero to maximum ($R = 0$)	0.010	0.010

Use the Morrow [Eq. (2.49)], Manson–Halford [Eq. (2.50)], and Smith–Watson–Topper [Eq. (2.52)] relationships for these predictions. Compare the predictions made using the three methods.

The stress–strain and strain–life properties for the alloy are

$$E = 208.5\ \text{GPA} \qquad K' = 1530\ \text{MPa} \qquad n' = 0.073$$

$$\sigma'_f = 1640\ \text{MPa} \qquad b = -0.06$$

$$\epsilon'_f = 2.67 \qquad c = -0.82$$

Listed below are actual test results for the four histories. Two tests were run for each history. Compare the predictions to these values. Discuss the effect of mean strain on fatigue life at high and low strain amplitudes. (Data taken from Ref. 27.)

History	Test Results: Lives in Reversals, $2N_f$	
A	2.8×10^4	2.6×10^4
B	2.4×10^3	2.6×10^3
C	1.6×10^4	1.4×10^4
D	1.8×10^3	1.9×10^3

4.

For a given material, assume that constants E, H, and n are known for its uniaxial stress–strain curve of the Ramberg–Osgood form, Eq. 12.12. An estimate is needed of the stress–strain curve $\gamma = f_\tau(\tau)$ for a state of pure planar shear stress.

(a) Show that the appropriate estimate is

$$\gamma = \frac{\tau}{G} + \left(\frac{\tau}{H_\tau}\right)^{1/n}$$

where $G = E/[2(1+\nu)]$ and $H_\tau = H/3^{(n+1)/2}$. Note that the principal stresses and strains for pure shear are given in Fig. 4.41.

(b) For the Fig 12.9 material, calculate a number of points on both the uniaxial and the pure shear stress–strain curves, covering strains from zero to 0.04. Then plot the two curves on the same graph and comment on the comparison.

E = 69,000 MPa
H = 690 MPa
n = 0.15
v = 0.30

$$\tau_f = \frac{T_f r_2}{J}, \qquad \tau_f = \frac{2T_f r_2}{\pi(r_2^4 - r_1^4)} \qquad \text{(a, b)}$$

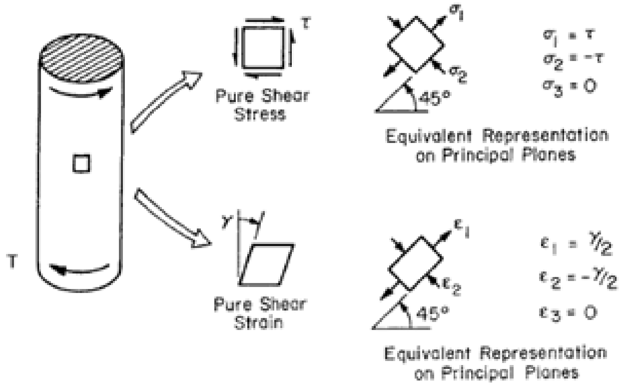


Figure 4.41 A round bar in torsion and the resulting state of pure shear stress and strain. The equivalent normal stresses and strains for a 45° rotation of the coordinate axes are also shown.

5.

Consider a material with a uniaxial stress–strain curve of the Ramberg–Osgood form, Eq. 12.12, subjected to the state of stress

$$\sigma_1 = \sigma_2, \qquad \sigma_3 = \alpha\sigma_1 \qquad (-1 \le \alpha \le 1)$$

where σ_1, σ_2, and σ_3 are the principal normal stresses and α is a constant.

(a) Derive an equation for the principal normal strain ε_1 as a function of σ_1, α, and materials constants.

(b) Assume that the material is the 7075-T651 aluminum of Ex. 12.1, with Poisson's ratio $\nu = 0.33$. Plot the family of curves resulting from $\alpha = -1, -0.5, 0, 0.5$, and 1, covering strains from zero to 0.04. Then comment on the trends observed.

$$\sigma = 585.5\varepsilon_p^{0.04453}\ \text{MPa}$$

$$\varepsilon = \frac{\sigma}{71{,}000} + \left(\frac{\sigma}{585.5}\right)^{1/0.04453}$$