THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF MECHANICAL ENGINEERING

EXAMINATION FOR THE DEGREE OF B.E.

4109: SOLID MECHANICS

JUNE 1999

TIME: 3 HOURS

[In addition, candidates are allowed ten minutes before the exam begins, to read the paper.]

[The use of notes, textbooks and calculating devices is permitted in the examination room.]

[Answer all questions.]

[All questions carry unequal marks].

[Appropriate engineering assumptions may be made for inadequate data].

QUESTION ONE

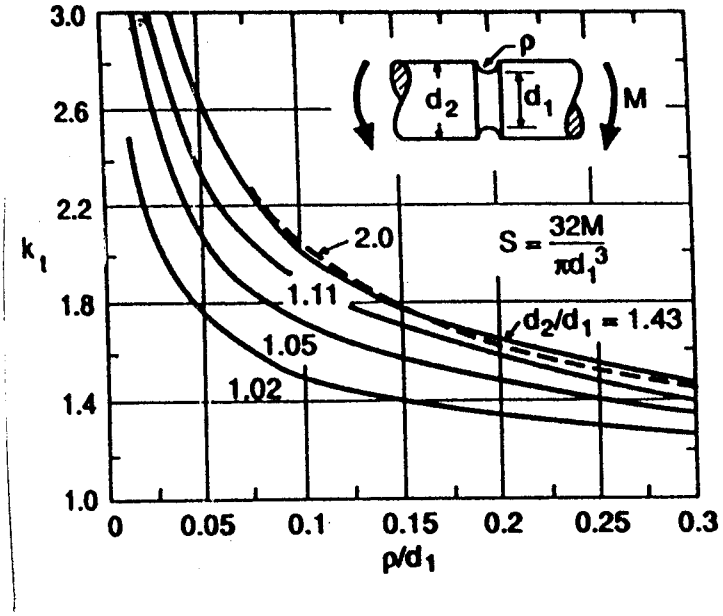
An aircraft quality AISI 4340 steel round bar is subjected to an applied bending moment M and contains a circumferential groove with a ground surface. The dimensions as defined in the figure below, K_t vs ρ/d_1 are d_1 = 30mm, d_2 = 33.3mm, and ρ, groove root radius = 2.25mm.

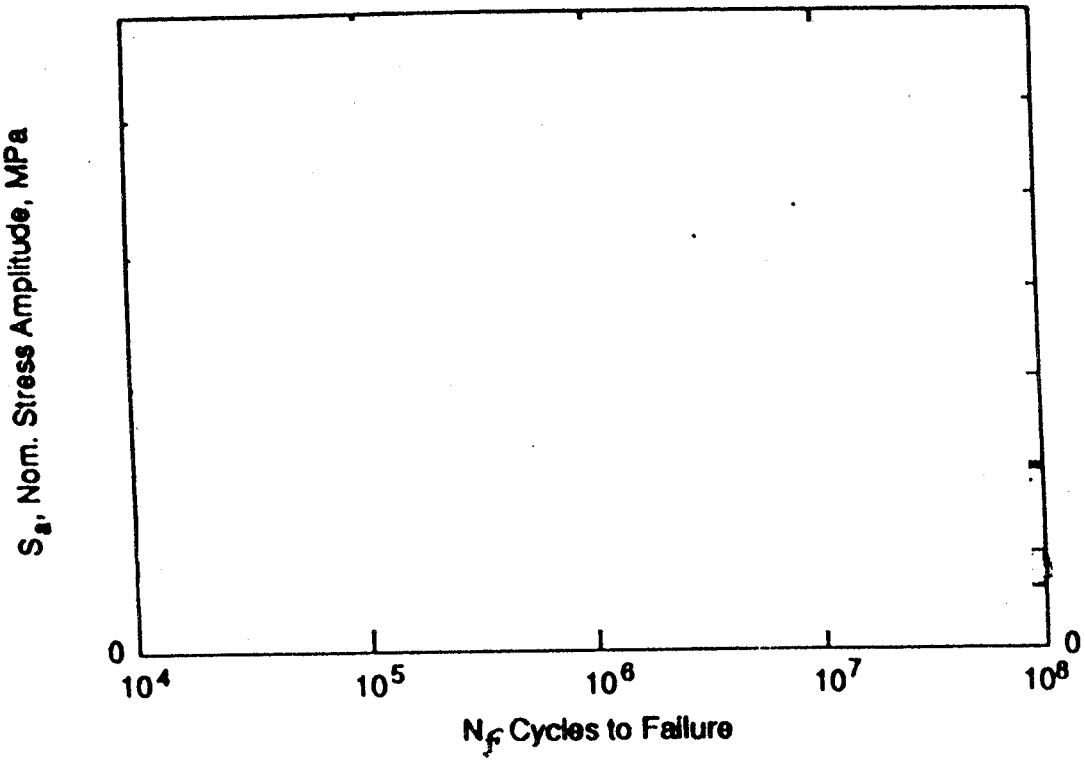
Estimate the completely revised stress-life (S-N) curve, and also estimate the life for cyclic loading at a nominal stress amplitude of S_a=250 MPa with a mean stress amplitude, S_m=300 MPa. For the estimation of life use only the "Collins approach". For AISI 4340 aircraft steel, σ_y = 1103 MPa and σ_u=1172 MPa.

[20 marks]

PLEASE SEE NEXT PAGE

QUESTION ONE CONTINUED





PLEASE SEE NEXT PAGE

QUESTION TWO

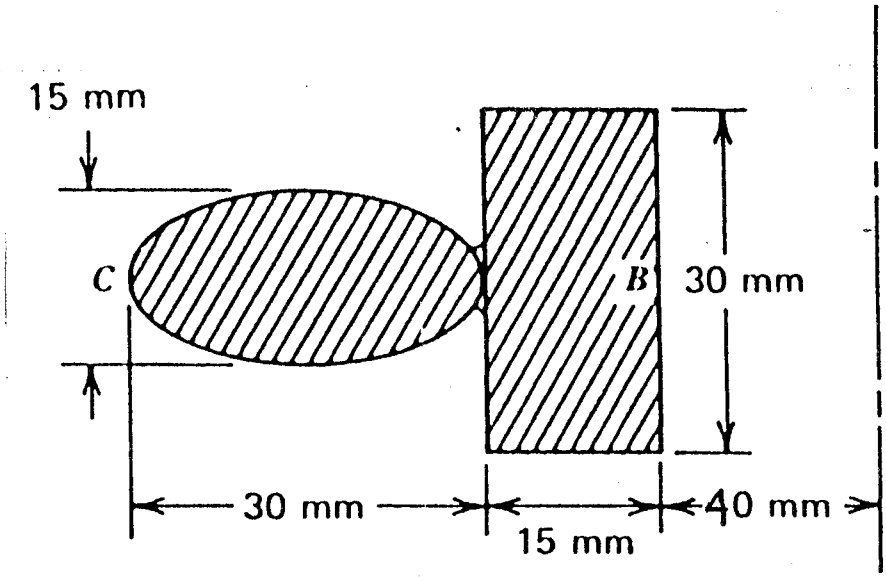
A machine component in a Turbine Generator System is subjected to reversed cyclic loading at 210 cycles/day in a continuous sequence involving three stages:
1000 cycles at ± 180 MPa, 1000 cycles at ± 160 MPa, and another 1, 500 cycles at ± 140 MPa. If the fatigue limit at these stages are $1.1x10^4$, $1.1x10^5$ and $3.1x10^5$ cycles respectively, estimate the life of the component in "days" according to the non-linear fatigue damage law, where $D_1=R_1^{½}$, $D_2=R_2^2$ and $D_3=R_3^3$. D is given as damage under cyclie ratio R. The above fatigue loading is applied to semi-stress ranges of 180MPa, 160MPa and 140MPa respectively.

[20 marks]

QUESTION THREE

A curved beam which is used in the Australian Mining Industry is built up by welding together rectangular and elliptical cross section curved beams. The beam cross section is shown in the following figure where the centre of curvature is located 40mm to the right hand side of B. The curved beam is subjected to a positive bending moment $M_x=2000Nm$. Determine the stresses at points B and C.

[15 marks]



PLEASE SEE NEXT PAGE

QUESTION FOUR

A compound cylinder which is to be used in the Australian Pressure Vessels Industry is formed by shrinking a tube of 300 mm internal diameter and 30 mm wall thickness onto another tube of 300 mm external diameter and 30 mm wall thickness. Both tubes are made of steel having a σ_y=450MPa and E=200 GN/m^2. The stress set up at the junction owing to shrinkage is 15MN/m^2. The compound tube is then subjected to an internal pressure of 100MN/m^2. Compare the hoop stress distribution now obtained with that of a single cylinder of 360mm external diameter and 60mm thickness subjected to the same internal pressure.

[15 marks]

QUESTION FIVE

(i) In a photoelastic experiment the stress fringe value f_σ for a material was determined to be 40 kN/m when sodium light with λ=590nm was used in its determination. What would be the stress fringe value for the same material if mercury light with λ=545nm were used in place of the sodium light?

[5 marks]

(ii) The following observations are made with a rectangular rosette mounted on a steel (E=210 GN/m^2, and Poisson's ratio μ=0.30) specimen. Determine the principal stresses and the principal anglies $\varnothing_1$ and $\varnothing_2$.

Case #	ε_A, $\mu\varepsilon$	ε_B, ε	ε_C, ε
1	1800	600	-400
2	-1000	400	400

[5 marks]

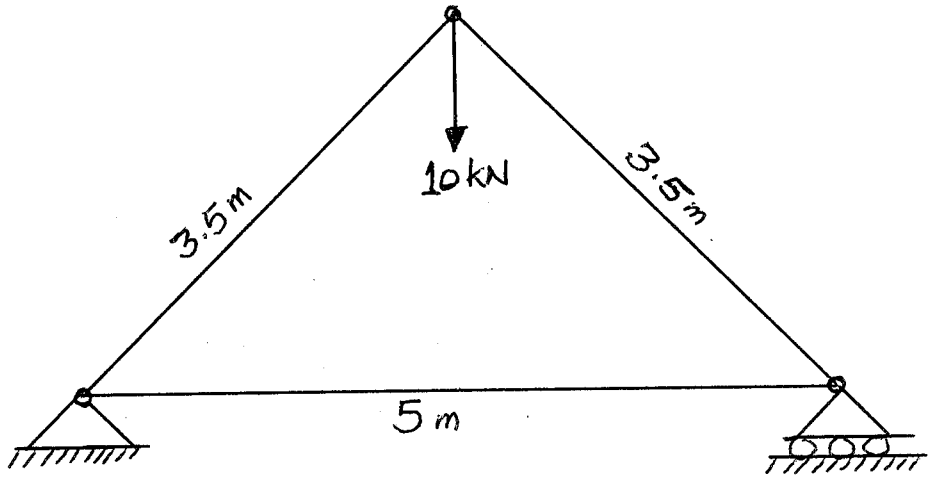
(iii) In a cylindrical pressure vessel a pressure of 1.5 MN/m^2 acts on a circular cover plate of area 0.15m^2. The cover plate is held in position by thirty 20mm diameter steel bolts, equispaced around its rigid rim. What should be the initial tightening stress in the bolts in order that a safety factor of 2.2 be maintained after 10,000h of creep relaxation at 460°C. After what time should the bolts be retightened to

PLEASE SEE NEXT PAGE

prevent leakage around the plate? Ignore primary creep but account for elasticity with $E=172GN/m^2$ and a secondary creep rate of $\dot{\varepsilon}_s=44.5x10^{-16}\ \sigma^4$, $\dot{\varepsilon}_s$ in h^{-1} and σ in MPa.

[10 marks]

(iv) For a simple pin-jointed framework shown in the following figure use the stiffness matrix approach to calculate the vertical deflection at the 10 kN load. For each member the product AE=250MN, where A= Area of the X-section of each member and E is the modulus of Elasticity.



[10 marks]

END OF EXAMINATION PAPER