MADE EASY PUBLICATIONS

POSTAL BOOK PACKAGE 2024

CONTENTS

MECHANICAL ENGINEERING

Objective Practice Sets

Machine Design

1 CHAPTER
Static and Variable Loading

MCQ and NAT Questions

Q.1 If the size of a standard specification for a fatigue testing machine is increased, the endurance limit for the material will
(a) have same value as that of standard specimen
(b) increases
(c) decreases
(d) None of these

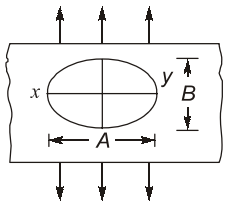
Q.2 Failure of a material is called fatigue when it fails
(a) at the elastic limit
(b) below the elastic limit
(c) at the yield point
(d) below the yield point

Q.3 The design of the pressure vessel is based on
(a) longitudinal stress
(b) hoop stress
(c) longitudinal & hoop stress
(d) none of these

Q.4 Stress concentration in a machine component of ductile material is not so harmful as it is in brittle material because
(a) In ductile material local yielding may distribute stress concentration
(b) Ductile material has larger Young's Modulus
(c) Poison's ratio is lager in ductile materials
(d) Modulus of rigidity is larger in ductile materials

Q.5 The design calculations for members subject to fluctuating loads with the same factor of safety yield the more conservative estimates when using
(a) Gerber relation (b) Soderberg relation
(c) Goodman relation (d) none of the above

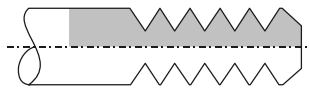
Q.6 A loaded semi-infinite flat plate is having an elliptical hole ($A / B = 2$) in the middle as shown in the below figure. The stress concentration factor at point either X or Y is

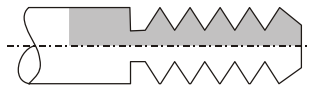


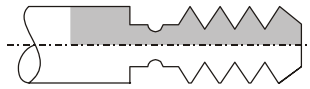
(a) 1 (b) 3
(c) 5 (d) 7

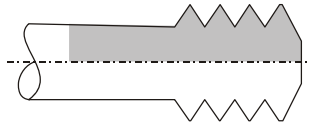
Q.7 The severity of stress-concentration can be reduced
(a) by using multiple notches
(b) by removal of undesired materials
(c) by drilling additional holes
(d) by all of the above

Q.8 Which of the following threaded joint will give the minimum stress concentration result.

(a) 

(b) 

(c) 

(d) 

Q.9 S-N curve is valid for
(a) Ferrous material only
(b) Non-ferrous materials
(c) Both the ferrous & non-ferrous materials
(d) None of the above

Q.10 The maximum stress due to stress concentration in a bar having circular transverse hole as compared to its static stress without hole will be
(a) remain same (b) 2 times
(c) three time (d) four times

Q.11 Surface fatigue failure which occurs when the load on the gear tooth exceeds the surface endurance strength of the material, is known as

(a) Destructive pitting (b) initial pitting
(c) Scoring (d) Corrosive wear

Q.12 Consider the following statements

1. Stress concentration factor (SCF) are used for ductile material under static loading.
2. SCF are used for brittle materials under static loading.

Which of the above statements is/are correct

(a) 1 only (b) 2 only
(c) Both 1 & 2 (d) Neither 1 nor 2

Q.13 Consider the following surface finish on steel components:

1. Polished 2. Machined & cold drawn
3. Hot rolled 4. Forged

Correct sequence of surface finish factor in ascending order for above finish is

(a) 1-2-3-4 (b) 2-3-4-1
(c) 3-4-1-2 (d) 4-3-2-1

Q.14 Match **List-I** (Component) with **List-II** (FOS) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Cast iron components where ultimate tensile strength is failure criterion	1. 3 to 6
B. Ductile material subjected to external static forces	2. 3 to 5
C. Ductile material subjected to external fluctuating force	3. 1.5 to 2
D. Component designed on basis of buckling consideration	4. 1.3 to 1.5

Codes:

	A	B	C	D
(a)	1	2	3	4
(b)	2	3	4	1
(c)	3	4	1	2
(d)	4	1	2	3

Q.15 Consider following statements about low cycle and high cycle fatigue:

1. Low cycle fatigue corresponds to stress cycle less than 1000.
2. High cycle fatigue corresponds to stress cycle more than 10000.
3. The machine components such as springs, ball bearings, gears etc. are subjected to high cycle fatigue.
4. A greater factor of safety is taken in low cycle fatigue to ignore the fatigue effect.

Which of the above statements are valid?

(a) 1, 2, 3 and 4 (b) 2, 3 and 4
(c) 1, 3 and 4 (d) 1 and 3

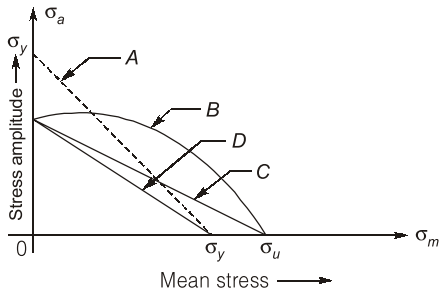
Q.16 Increase of actual stress over nominal stress due to stress raising notches in fatigue loading is given by

(a) $K_f\sigma_0$ (b) $K_t\sigma_0$
(c) $(K_f - 1)\,\sigma_0$ (d) $(K_t - 1)\,\sigma_0$

(All symbols have their usual meaning)

Q.17 Consider the following figure and match the following:

List-I



List-II

1. Gerber line
2. Soderberg line
3. Failure line
4. Fatigue line
5. Goodman line
6. Yield line

Codes:

	A	B	C	D
(a)	3	2	5	1
(b)	6	1	5	2
(c)	3	1	5	4
(d)	6	5	2	4

Q.18 Notch sensitivity factor is defined as the ratio of

(a) Actual stress to theoretical stress.
(b) Increase of actual stress over nominal stress to increase of theoretical stress over nominal stress.
(c) Theoretical stress to actual stress.
(d) Increase of theoretical stress over nominal stress to increase of actual stress over nominal stress.

Q.19 A high factor of safety is chosen under the following conditions:

1. Exact mode of failure of the component is unpredictable.
2. There is stress concentration in a machine component.
3. High reliability is demanded in applications like components of aircraft.
4. There is possibility of residual stresses in the machine component.

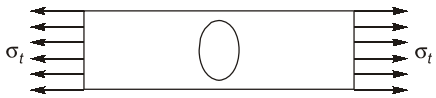
Which of the above statements are correct?

(a) 1, 2 and 3 only (b) 1, 3 and 4 only
(c) 2, 3 and 4 only (d) 1, 2, 3 and 4

Q.20 A fatigue stress concentration factor of 1 means

(a) material is fully sensitive to notches.
(b) material has no sensitivity to notches
(c) theoretical stress concentration factor is equal to zero
(d) theoretical stress concentration factor is equal to fatigue stress concentration factor

Q.21 What is the maximum stress induced at the edge of an elliptical hole of major axis 20 and minor axis 15 in a flat plate, as shown in figure,



(a) $2.67\,\sigma_t$ (b) $2.33\sigma_t$
(c) $3\sigma_t$ (d) $3.67\sigma_t$

Q.22 Consider the following statement:

1. Maximum principal stress theory is used in brittle material.
2. Maximum shear stress theory is used in ductile material.
3. Distortion energy theory is the most conservation theory.

Which of the above statements is/are correct?

(a) 1 only (b) 3 only
(c) 1, 2 and 3 (d) 1 and 2

Q.23 If theoretical and fatigue stress concentration factor are 2 and 1.5 respectively. The notch sensitivity is

(a) 0.4 (b) 0.1
(c) 0.5 (d) 0.75

Q.24 A cast steel machine component having a theoretical stress concentration factor of 3.1 and notch sensitivity of 0.7 then its effect on endurance limit is:

(a) 59.515% increment
(b) 59.515% reduction
(c) 40.485% increment
(d) 40.485% reduction

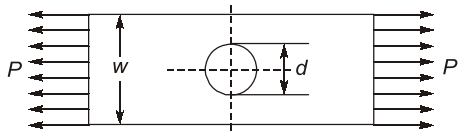
Q.25 Consider the following statements regarding fatigue:

1. It is the phenomenon of failure or fracture under fluctuating stresses.
2. It is phenomenon of failure or fracture under static stresses.
3. It is phenomenon of decrease in resistance of material under variable or cyclic loading.

Which of the above statements is/are correct?

(a) 1 only (b) 1 and 2
(c) 3 only (d) 1 and 3

Q.26 Which of the following statements is true regarding given geometry?



(a) Theoretical stress concentration factor (k_t) is independent from $\left(\frac{d}{w}\right)$ ratio.

(b) Theoretical stress concentration factor (k_t) value increases as the $\left(\frac{d}{w}\right)$ ratio increases.

(c) Theoretical stress concentration factor (k_t) value decreases as the $\left(\frac{d}{w}\right)$ ratio increases.

(d) None of these

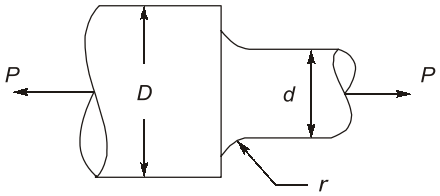
Q.27 The S-N curve is the graphical representation of stress amplitude versus the number of stress cycles before the fatigue failure on a

(a) log-log graph paper
(b) cartesian co-ordinate system
(c) semilog graph paper
(d) cylindrical co-ordinate system

Q.28 A machine component that is subjected to fluctuating stress which varies from 50 to 100 N/mm^2. The corrected endurance limit and ultimate strength are 270 MPa and 600 MPa respectively. The factor of safety, using Gerber theory is

(a) 2.5 (b) 5.5
(c) 7.5 (d) 9.5

Q.29 In figure, a round shaft is subjected to tensile force (P) if P = 10 kN, r = 3 mm, d = 20 mm and D = 28 mm then the nominal stress will be

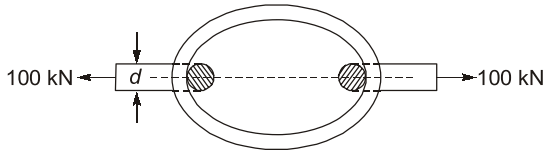


(a) 16.8 N/mm^2 (b) 21.8 N/mm^2
(c) 26.8 N/mm^2 (d) 31.8 N/mm^2

Q.30 A rectangular plate of a width 10 mm & thickness 3 mm with a transverse hole of 2.5 mm in tension of 15 kN. The nominal stress is

(a) 6.67 N/mm^2 (b) 66.67 N/mm^2
(c) 666.67 N/mm^2 (d) 6666.67 N/mm^2

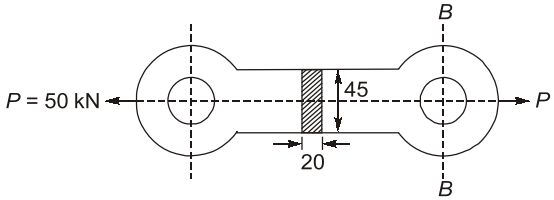
Q.31 A coil chain of a crane required to carry a maximum load of 100 kN, is shown in following figure.



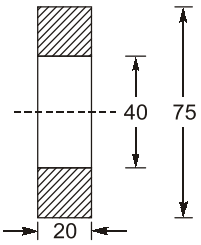
What is the diameter of the link stock, if the permissible tensile stress in the link material is not to exceed 150 MPa?

(a) 20 mm (b) 25 mm
(c) 30 mm (d) 35 mm

Q.32 A cast iron link, as shown in following figure, is required to transmit a steady tensile load of 50 kN. What is the maximum tensile stress induced?



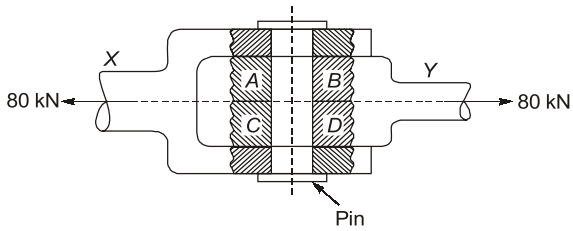
(All dimensions in mm)



(Section B-B)

(a) 55.55 MPa (b) 60 MPa
(c) 64.5 MPa (d) 71.42 MPa

Q.33 A pull of 80 kN is transmitted from a bar X to the bar Y through a pin as shown in following figure. If the maximum permissible tensile stress in the bars is 100 N/mm^2 and the permissible shear stress in the pin is 80 N/mm^2, what is the diameter of the pin?



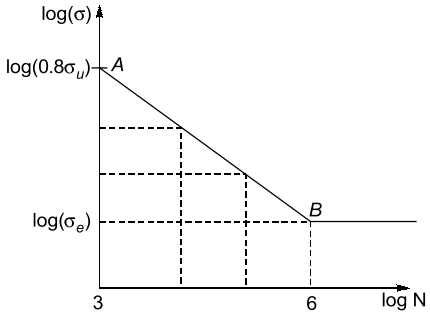
(a) 22 mm (b) 25 mm
(c) 27 mm (d) 30 mm

Q.34 A mild steel rod of 15 mm diameter was tested for tensile strength with the gauge length of 60 mm. Following observations were recorded:
Final length = 80 mm;
Final diameter = 10 mm;
Yield load = 4 kN and
Ultimate load = 6.5 kN.
Based on the above tensile test data, match the following:

List-I	List-II
A. Yield stress	1. 55.55%
B. Ultimate tensile stress	2. 22.6 MPa
C. Percentage reduction in area	3. 66.67%
D. Percentage elongation	4. 25 MPa
	5. 36.8 MPa
	6. 30%
	7. 25%
	8. 40 MPa

Codes:

	A	B	C	D
(a)	4	8	3	7
(b)	2	8	1	6
(c)	4	5	3	6
(d)	2	5	1	7



Which of the following options is/are correct, if the material is subjected to completely reversed stress?

(a) The maximum amplitude of stress for a life of 10000 cycles is 476.2 MPa.
(b) The maximum amplitude of stress for a life of 10000 cycles is 424.1 MPa.
(c) The maximum amplitude of stress for a life of 100000 cycles is 378 MPa.
(d) The maximum amplitude of stress for a life of 100000 cycles is 356 MPa.

Q.66 A circular bar is subjected to a combination of a steady load of 50 kN and a load fluctuating between – 40 kN and 110 kN. The ultimate, yield and corrected endurance limit of the material is 600 MPa, 450 MPa and 200 MPa respectively.

Which of the following statements is/are correct? Take factor of safety as 2.

(a) Diameter of bar as Soderberg's criterion is 37.9 mm.
(b) Diameter of bar as Goodman's criterion is 36.3 mm.
(c) Mean stress as per Soderberg's criterion is 75.4 MPa.
(d) Stress amplitude as per Soderberg's criterion is 66.5 MPa.

Q.67 A forged steel link with uniform diameter of 40 mm at the centre is subjected to an axial force that varies from 60 kN in compression to 200 kN in tension. The ultimate (σ_{ut}), yield (σ_{yt}) and corrected endurance (σ_e) strength of the steel material are 600 MPa, 400 MPa and 240 MPa respectively.

Which of the following options is/are correct?

(a) Stress amplitude is 55.70 MPa.
(b) Stress amplitude is 103.45 MPa.
(c) Factor of safety as per Soderberg's criterion is 1.75.
(d) Factor of safety as per Soderberg's criterion is 1.91.

■■■■

Answers — Static and Variable Loading

1. (c)	**2.** (d)	**3.** (b)	**4.** (a)	**5.** (b)	**6.** (c)	**7.** (d)	**8.** (d)	**9.** (a)
10. (c)	**11.** (a)	**12.** (b)	**13.** (d)	**14.** (b)	**15.** (c)	**16.** (c)	**17.** (b)	**18.** (b)
19. (d)	**20.** (b)	**21.** (d)	**22.** (d)	**23.** (c)	**24.** (b)	**25.** (d)	**26.** (c)	**27.** (a)
28. (b)	**29.** (d)	**30.** (c)	**31.** (c)	**32.** (d)	**33.** (b)	**34.** (d)	**35.** (c)	**36.** (b)
37. (b)	**38.** (c)	**39.** (d)	**40.** (d)	**41.** (a)	**42.** (a)	**43.** (c)	**44.** (d)	**45.** (a)
46. (a)	**47.** (4)	**48.** (1.742)	**49.** (2.183)	**50.** (1.47)	**51.** (1.6)	**52.** (159.617)	**53.** (1.263)	
54. (281190)		**55.** (140)	**56.** (1000)	**57.** (9636.593)		**58.** (15.81)	**59.** (9.82)	
60. (a, b, c)		**61.** (a, c)	**62.** (a, b, d)	**63.** (a, c, d)		**64.** (a, c, d)	**65.** (a, c)	
66. (a, b, c, d)		**67.** (b, c)						

Explanations Static and Variable Loading

1. (c)

In fatigue testing machine, the rotating beam specimen is small with 7.5 mm diameter. The larger the machine part, the greater the probability that a flaw exists somewhere in the component. The chances of fatigue failure originating at any one of these flaws are more. The endurance therefore reduces with increasing size of the component.

2. (d)

It has been observed that materials fail under fluctuating stresses at a stress magnitude which is lower than the ultimate tensile strength of the material. Sometimes, the magnitude is even lower than the yield strength. Further, it has been found that the magnitude of the stress causing fatigue failure decreases as the number of stress cycles increase.

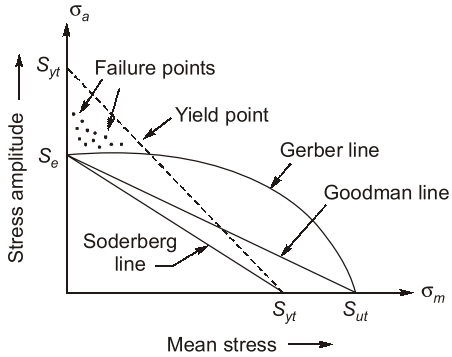
3. (b)

In pressure vessels, the maximum stress in circumferential (hoop) stress, so the permissible stress should be less than maximum one, hence the design of pressure vessel is based on hoop stress.

4. (a)

In ductile materials, when the stress in the vicinity of the discontinuity reaches the yield point, there is plastic deformation, resulting in a redistribution of stresses. This plastic deformation or yielding is local and restricted to a very small area in the component. The effect of stress concentration is more severe in case of brittle materials due to their in ability of plastic deformation. Brittle materials do not yield locally and there is no readjustment of stresses at the discontinuities. Once the local stress at the discontinuity reaches fracture strength, a crack is formed.

5. (b)



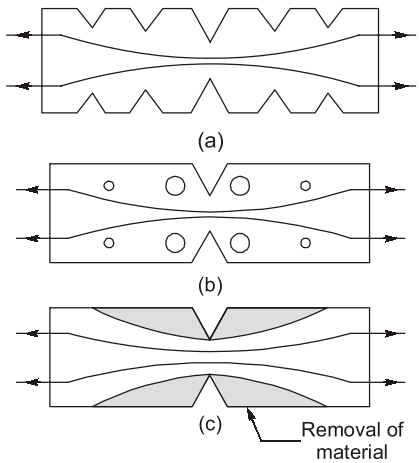
The Soderberg line is a more conservative failure criterion and there is no need to consider even yielding in this case.

6. (c)

Stress concentration factor,

$$k = \left(1+\frac{2A}{B}\right) = [1 + 2 \times (2)] = 5$$

7. (d)



8. (d)

Options (d) will give better result, in this, shank diameter is reduced and made equal to the core diameter of the thread. The force flow line is almost straight and there is no stress concentration.

9. (a)

S-N curve is valid for ferrous material only.

10. (c)

For circular hole bar, ($a = b \Rightarrow a/b = 1$)

Stress concentration factor = $\left(1+2\times\frac{a}{b}\right)$

$= (1 + 2) = 3$

Thus, the maximum stress due to stress concentration in a bar having circular transverse hole as compared to its static stress without hole will be three times.

11. (a)

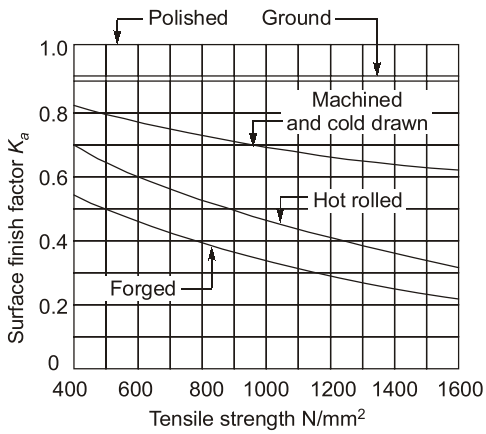
Destructive pitting is a surface fatigue failure, which occurs when the load on the gear tooth exceeds the surface endurance strength of the material. This type of failure is characterized by pits, which continue to grow resulting in complete destruction of the tooth surface and in some cases, even premature breakage of the tooth. It depends upon the magnitude of the Hertz contact stress and the number of stress cycles.

12. (b)

Under a static load, ductile materials are not affected by stress concentration. But stress concentration factors are used for components made of brittle materials subjected to both static load as well as fluctuating loads, because of their inability of plastic deformation. Brittle materials do not yield locally and there is no readjustment of stresses at discontinuities. Once the local stress at the discontinuity reaches the fracture strength, a crack is formed. This reduces the material available to resist external load and also increases the stress concentration at the crack. The part then quickly fails.

13. (d)

Forged < Hot rolled < Machined and cold drawn < Polished



14. (b)

- Cast iron components where UTS is failure criterion as FOS = 3 to 5.
- Ductile material subjected to external static forces has FOS = 1.5 to 2.
- Ductile material subjected to external fluctuating force has FOS = 1.3 to 1.5.
- Component designed on basis of buckling consideration has FOS = 3 to 6.

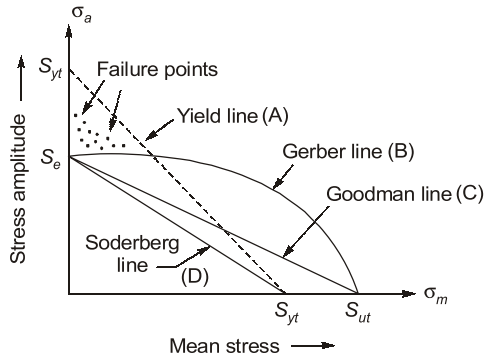
15. (c)

Low cycle fatigue: stress cycles $< 10^3$
High cycle fatigue: stress cycles $> 10^3$
Example of low cycle fatigue: studs on truck wheels, failure of set screws for locating gears on shafts, short-lived device such as missile
Example of high cycle fatigue: springs, gears, ball bearings.

16. (c)

Nominal stress = σ_0
Actual stress due to notch = $K_f \sigma_0$
$\therefore$ Increase in actual stress = $(K_f - 1)\,\sigma_0$
Theoretical stress due to notch = $K_t \sigma_0$
$\therefore$ Increase in theoretical stress = $(K_t - 1)\,\sigma_0$

17. (b)



18. (b)

Notch sensitivity factor,

$$q = \frac{\text{Increase of actual stress over nominal stress}}{\text{Increase of theoretical stress over nominal stress}}$$

Notch sensitivity is defined as the susceptibility of a material to succumb to the damaging effects of stress raising notches in fatigue loading.

19. (d)

A high value of factor of safety are chosen because:

- When there are notches and holes.
- High reliability is demanded in applications.
- Exact mode of failure is unpredictable.
- Possibility of residual stress in machine component.

20. (b)

Notch sensitivity, $q = \dfrac{k_f - 1}{k_t - 1}$

where,

$k_t \rightarrow$ Theoretical stress concentration factor

$k_f \rightarrow$ Fatigue stress concentration factor

when $k_f = 1$,

$$q = \frac{1-1}{k_t - 1}$$

$$q = 0;$$

this means material has no sensitivity to notches.

21. (d)

$$\sigma_{max} = \sigma_t\left(1+\frac{2a}{b}\right)$$

a is semi major axis = 10

b is semi minor axis = 7.5

So, $$\sigma_{max} = \sigma_t\left(1+\frac{2\times 10}{7.5}\right) = 3.67\sigma_t$$

22. (d)

Maximum shear stress theory is the most conservative one.

23. (c)

$$\frac{k_f - 1}{k_t - 1} = q$$

$$q = \frac{1.5-1}{2-1} = 0.5$$

24. (b)

Given:

Theoretical stress concentration factor,

$$k_t = 3.1$$

Notch sensitivity,

$$q = 0.7$$

As we know, $q = \dfrac{k_f - 1}{k_t - 1}$

Fatigue stress concentration factor,

$$k_f = 1 + 0.7(3.1 - 1)$$

$$k_f = 2.47$$

$$\frac{1}{k_f} = 0.40485\%$$

As we know,

$$k_f = \frac{\text{Endurance strength of unnotched specimen}}{\text{Endurance strength of notched specimen}}$$

So, % Reduction in endurance limit

$$= \left(\frac{k_f - 1}{k_f}\right) = \left(1 - \frac{1}{k_f}\right) \times 100\%$$

$$= (100 - 40.485)\% = 59.515\%$$

25. (d)

It is phenomenon of failure or fracture under fluctuating stresses or fatigue stresses having a magnitude less than yield strength (for ductile material) or ultimate strength (for brittle material)

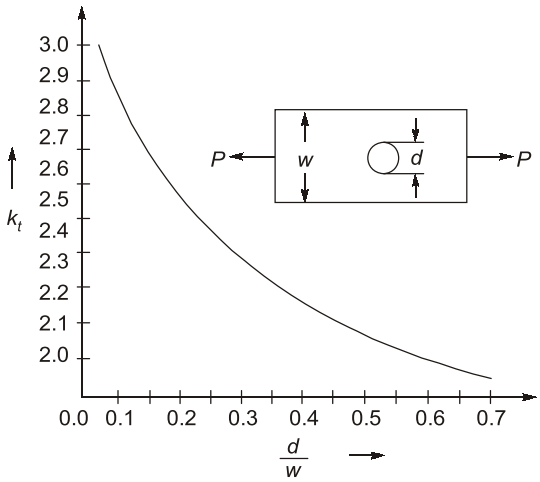
OR

It can also defined as the decrease in resistance of material under variable or cyclic loading.

26. (c)

The variation of theoretical stress concentration can be observed from given graph,

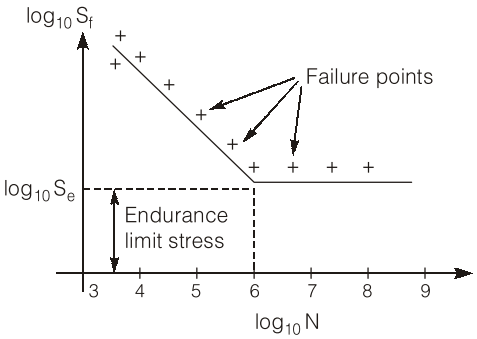
with respect to the $\dfrac{d}{w}$ ratio



as $\dfrac{d}{w} \uparrow \Rightarrow k_t \downarrow$

and $\dfrac{d}{w} \downarrow \Rightarrow k_t \uparrow$

27. (a)



S-N curve for steels

28. (b)

Given, $S_e = 270$ MPa, $S_{ut} = 600$ MPa

$$\sigma_m = \frac{1}{2}(100 + 50) = 75 \text{ N/mm}^2$$

$$\sigma_a = \frac{1}{2}(100 - 50) = 25 \text{ N/mm}^2$$

Gerber equations,

$$\left(\frac{\sigma_a}{S_e/N}\right) + \left(\frac{\sigma_m}{S_{ut}/N}\right)^2 = 1$$

$0.09259N + 0.015625N^2 - 1 = 0$

On solving, $N = 5.568$

29. (d)

$$\sigma_0 = \frac{P}{\frac{\pi}{4}d^2} = \frac{4P}{\pi d^2}$$

$$= \frac{4 \times 10 \times 10^3}{\pi (20)^2} = 31.8 \text{ N/mm}^2$$

30. (c)

$$\sigma_0 = \frac{P}{(w-d) \times t} = \frac{15 \times 10^3}{(10 - 2.5) \times 3}$$

$$= 666.67 \text{ N/mm}^2$$

31. (c)

Area, $A = \frac{\pi}{4}d^2 = 0.785 d^2$

$P = \sigma_{max} \times$ Area

$= 150 \times 0.785\, d^2$

$$\therefore \quad d^2 = \frac{100 \times 10^3}{150 \times 0.785} = 849.257$$

or $d = 29.14$ mm or 30 mm

32. (d)

There are two type of c/s area in the given cast iron link, one is solid c/s (20 mm × 45 mm) and other is hollow c/s at B-B

$A_s = 45 \times 20 = 900 \text{ mm}^2$

$A_h = 20\,(75 - 40) = 700 \text{ mm}^2$

$$\sigma_s = \frac{P}{A_s} = \frac{50 \times 10^3}{900} = 55.55 \text{ MPa}$$

$$\sigma_h = \frac{P}{A_h} = \frac{50 \times 10^3}{700}$$

$= 71.42$ MPa ← Maximum

33. (b)

$$\text{Resisting area} = 2 \times \frac{\pi}{4} D_P^2 = 2 \times 0.785 \times D_P^2$$

$$= 1.57\, D_P^2$$

$$\text{Permissible shear stress} = \frac{\text{Load}}{\text{Resisting area}}$$

or $$80 = \frac{80 \times 10^3}{1.57 \times D_P^2}$$

or $$D_P^2 = \frac{80 \times 10^3}{80 \times 1.57} = 636.942$$

or $D_P = 25.23$ mm

34. (d)

Original area, $A = \frac{\pi}{4} \times d^2$

$= 0.785 \times 225 = 176.625 \text{ mm}^2$

Final area, $a = \frac{\pi}{4} \times d^2 = 0.785 \times 100 = 78.5 \text{ mm}^2$

$$\sigma_y = \frac{4000}{176.625} = 22.646 \text{ MPa}$$

$$\sigma_{ult} = \frac{6500}{176.625} = 36.8 \text{ MPa}$$

% reduction in area

$$= 1 - \frac{a}{A} = 1 - \left(\frac{10}{15}\right)^2$$

$$= 1 - \frac{1}{1.5^2} = 0.5555 \text{ or } 55.55\%$$

% reduction in length

$$= 1 - \frac{l}{L} = 1 - \frac{60}{80}$$

$= 0.25$ or 25%