
Subject Code

- Any -

Chapter Name

- Any -

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Examination: 2017 SUMMER

Que.No	Marks	
Q 1a)(ii)	8	

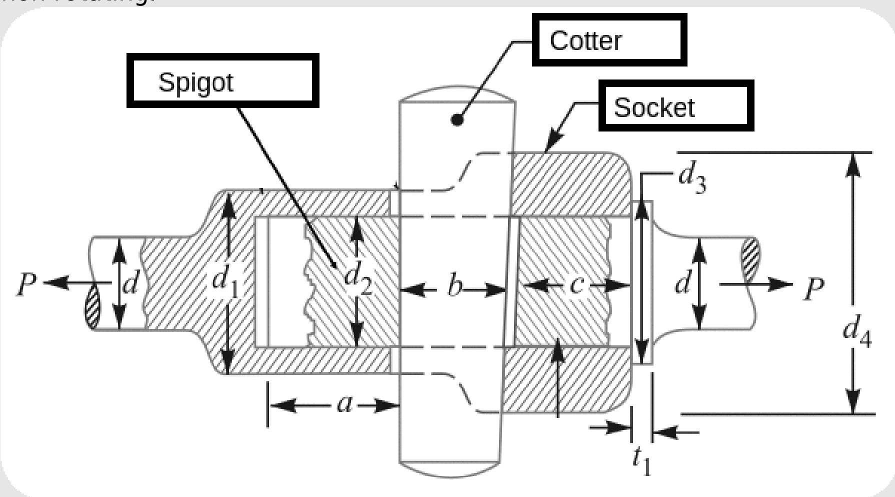
Question:

What is a cotter joint? State any four applications of a cotter joint? Why taper is provided on cotter joint?

Answer:

COTTER JOINT

Cotter Joint: " A cotter joint is temporary joint and used to connect two coaxial rods or bars which are subjected to axial tensile and or compressive forces."
It consist of
1) spigot : It is the male part of the joint , it has a rectangular slot for passing the cotter through it. Spigot has a collar which rests against the socket end.
2) socket :It is the female part of the joint, it also has a rectangular slot for passing the cotter through it. It has a circular hole in which spigot fits.
3) cotter : is a wedge shaped piece of metal which actually connects two parts which are non rotating.



Cotter Joint Applications:

1) Lewis foundation bolt
2) connection of the piston rod to cross head of a reciprocating steam engine.
3) valve rod & its stem 4) piston rod to the trail end in an air pump.
5) Cycle pedal sprocket wheel.

Cotter joint taper why and how much?

Cotter is a flat wedge shaped metal piece which is used to connect two rods which transmit the force but without rotation. The force may be axial and of tensile or compressive nature. Cotter is fitted in the tapered slot and remains in its position because of wedge action. This happens because of taper.
Because of taper,
i) It is simple to remove the cotter and dismantle the joint parts.
ii) Taper ensures tightness of the joint in operation and it prevents slackening of the parts.
Generally the value of taper on cotter is 1 in 48 to 1 in 24.
1 in 48 means that there will be reduction of 1 mm in size after the length of 48 mm, and 1 in 24 means there will be reduction in size of cotter by 1 mm after 24 mm.

Link to other chapters in machine design
http://mechdiploma.com/elements-machine-design-syllabus22564

Que.No	Marks	
Q 2 a)	8	Question: **Design a knuckle joint to transmit 150 KN. The design stresses may be taken as 75 MPa in tension, 60 MPa in shear and 150 MPa in compression.** Answer: Design of knuckle joint: Step 1) Diameter of Rod: d : =? Consider tensile failure of Rod 1. P =σt x A , 150 x 103 = 75 x π/4 xd2 , d = 50.4 mm 52 mm (say) Using Imperial relations Diameter of Knuckle pin Outside $d_1 = d = 52\text{ mm}$ Outer diameter of eye, $d_2 = 2d = 2 \times 52 = 104\text{ mm}$ Diameter of knuckle pin head and collar, $d_3 = 1.5d = 1.5 \times 52 = 78\text{ mm}$ Thickness of single eye or rod end, $t = 1.25d = 1.25 \times 52 = 65\text{ mm}$ Thickness of fork, $t_1 = 0.75d = 0.75 \times 52 = 39$ say 40 mm Thickness of pin head, $t_2 = 0.5d = 0.5 \times 52 = 26\text{ mm}$ *2. Failure of the knuckle pin in shear* Since the knuckle pin is in double shear, therefore load (*P*), $150 \times 10^3 = 2 \times \frac{\pi}{4} \times (d_1)^2 \tau = 2 \times \frac{\pi}{4} \times (52)^2 \tau = 4248\,\tau$ $\tau = 150 \times 10^3 / 4248 = 35.31$ MPa *3. Failure of the single eye or rod end in tension* The single eye or rod end may fail in tension due to the load. We know that load (*P*), $150 \times 10^3 = (d_2 - d_1)\,t \times \sigma_t = (104 - 52)\,65 \times \sigma_t = 3380\,\sigma_t$ $\therefore \quad \sigma_t = 150 \times 10^3 / 3380 = 44.4\text{ N/mm}^2 = 44.4\text{ MPa}$ *4. Failure of the single eye or rod end in shearing* The single eye or rod end may fail in shearing due to the load. We know that load (*P*), $150 \times 10^3 = (d_2 - d_1)\,t \times \tau = (104 - 52)\,65 \times \tau = 3380\,\tau$ $\therefore \quad \tau = 150 \times 10^3 / 3380 = 44.4\text{ N/mm}^2 = 44.4\text{ MPa}$ *5. Failure of the single eye or rod end in crushing* The single eye or rod end may fail in crushing due to the load. We know that load (*P*), $150 \times 10^3 = d_1 \times t \times \sigma_c = 52 \times 65 \times \sigma_c = 3380\,\sigma_c$ $\therefore \quad \sigma_c = 150 \times 10^3 / 3380 = 44.4\text{ N/mm}^2 = 44.4\text{ MPa}$ .... *6. Failure of the forked end in tension* The forked end may fail in tension due to the load. We know that load (*P*), $150 \times 10^3 = (d_2 - d_1)\,2\,t_1 \times \sigma_t = (104 - 52)\,2 \times 40 \times \sigma_t = 4160\,\sigma_t$ $\therefore \quad \sigma_t = 150 \times 10^3 / 4160 = 36\text{ N/mm}^2 = 36\text{ MPa}$ *7. Failure of the forked end in shear* The forked end may fail in shearing due to the load. We know that load (*P*), $150 \times 10^3 = (d_2 - d_1)\,2\,t_1 \times \tau = (104 - 52)\,2 \times 40 \times \tau = 4160\,\tau$ $\therefore \quad \tau = 150 \times 10^3 / 4160 = 36\text{ N/mm}^2 = 36\text{ MPa}$ *8. Failure of the forked end in crushing* --------- The forked end may fail in crushing due to the load. We know that load (*P*), $150 \times 10^3 = d_1 \times 2\,t_1 \times \sigma_c = 52 \times 2 \times 40 \times \sigma_c = 4160\,\sigma_c$ $\therefore \quad \sigma_c = 150 \times 10^3 / 4180 = 36\text{ N/mm}^2 = 36\text{ MPa}$ From above, we see that the induced stresses are less than the given design stresses, therefore --

Que.No	Marks	
Q 2c)(i)	8	Question: **Why are bushes of softer material inserted in the eyes of levers?** Answer: Explain with neat sketches and equations. How the screw spindle and nut of a screw jack is designed. the forces acting on the boss of lever & the pin are equal & opposite .There is a relative motion between the pin & the lever and bearing pressure becomes design criteria. The projected area of the pin is d1 x l1therefore Reaction R= P (d1 x l1). A softer material like phosphorous bronze bush with 3 mm thick is fitted in eyes to reduce the friction. & bear a bearing pressure upto5 to 10 N/mm2. Bushes are cheaper and can be easily replaceable. --

Que.No	Marks	
Q 3 b)	4	Question: **Design a foot brake lever from the following data: Length of lever from C.G. of the spindle to the point of application of the load = 1 meter. Max. load on the foot plate = 800 N Overhang from the nearest bearing = 100 mm Permissible tensile and shear stress = 70 MPa.** Answer: Methods of reducing stress concentration in cylindrical members with holes . Stress concentration can be reduced in cylindrical members with holes by providing additional holes in vicinity of holes as shown in fig. (ii). Fig (i) Showing cylindrical member with hole at center having stress line in disturb manner at vicinity of hole and component will fail at hole so for fig (i) ,stress concentration is more . fig. (ii) members shoulder having additional hole in vicinity of hole and therefore stress line maintain spacing between them so here stress concentration is less. Design of foot lever : Given data: L=1 m =1000 mm , P=800 N , σt =70 N/mm2 , Ʈ =70 N/mm2 , Assume B=3t Step 1) Considering shaft is under pure torsion , therefore $T = \frac{\pi}{16} x\ d^3\ x\ \tau$ But Twisting Moment on shaft T= P X L = 800 X 1000 = 800 X 10^3 $800 \text{ X } 10^3 = \frac{\pi}{16} x\ d^3\ x70$ **d = 38.75 mm ≅ 40 mm (say)** Step 2) Using the imperical relation fix the other dimensions d_2 =1.6 d =1 .6 x 40 = 64 mm, t_2 = 0.3 X d =0.3 x 40 = 12 mm, l_2 = 1.25 x d = 50 mm, l =2 x l_2 =100 mm Step 3) Considering shaft supported at center of bearing under combined twisting & bending moment. M=P X l = 800 x 100 = 80 x 10^3 N-mm T= P X L = 800 X 1000 = 800 X 10^3 N-mm Equivalents twisting moments $Te = \sqrt{M^2 + T^2} = \sqrt{(80 \text{ x } 10^3)^2 + (800 \text{ x } 10^3)^2} = 804 \text{ X } 10^3 N - mm$ Also ,Equivalents twisting moments $Te = \frac{\pi}{16} x\ d1^3\ x\ \tau_{max}$ $804 \text{ X } 10^3 = \frac{\pi}{16} x\ d1^3\ x\ 70$, **d_1 = 38.81 mm ≅ 44 *mm*** (***assume diameter more than* 40 *mm***) **Step 4) Design of key : Consider Key is rectangular** **W= d/4 =40/4 = 10mm t = d/6 =40/6 =6.67 mm** $T = W\ x\ l\ x\ \tau\ x\ \frac{d}{2}$ $800 \text{ X } \mathbf{10^3} = 10\ x\ l\ x70\ x\ \frac{40}{2}$ $\boldsymbol{l = 57.14\ mm}$ Length of key l may be taken as boss length $l2 = 50\ mm$- **Step 5)** Considering bending failure of lever , we can determine cross section of lever. --

Examination: 2017 WINTER

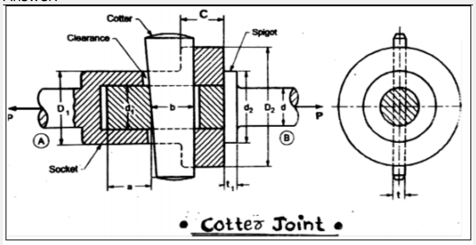
Que.No	Marks	
Q 1 f)	2	Question: **Give two applications of knuckle joint.** Answer: (i) A knuckle joint is used to connect two rods which are under the action of tensile loads. However, if the joint is guided, the rods may support a compressive load. (ii) Its use may be found in the link of a cycle chain, tie rod joint of roof truss, valve rod joint with eccentric rod, pump rod joint, tension link in bridge structure and lever and rod connections of various types. --

Que.No	Marks	
Q 2 a)	8	See below

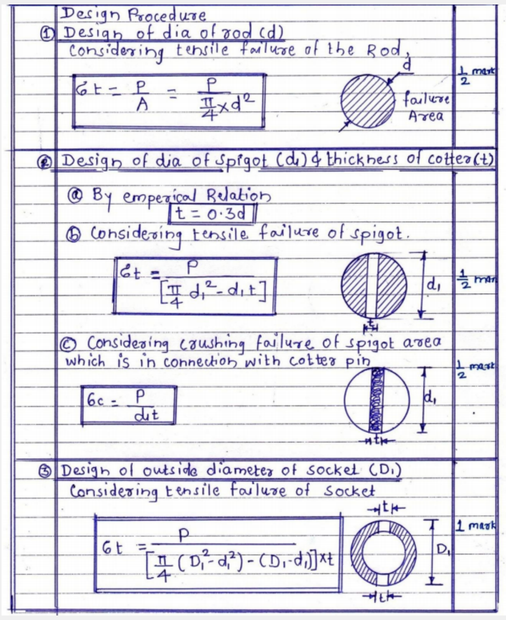
Question:

Explain various failures to be considered in designing a cotter joint along with the necessary sketches and strength equations.

Answer:



It consist of 3 elements: i. Socket ii. Spigot iii. Cotter Where, d= End diameter of rod d1= Diameter of spigot/Inside diameter of socket d2= Diameter of spigot collar D1= Outer diameter of socket D2= Diameter of socket collar C=Thickness of socket collar t1= Thickness of spigot collar t= thickness of cotter b= Mean width of cotter a= Distance of end of slot to the end of spigot P= Axial tensile/compressive force σt , σc , τ= Permissible tensile,
compressive, shear stress for the component materia



Design Procedure

① Design of dia of rod (d)

Considering tensile failure of the Rod.

$$\boxed{\sigma_t = \frac{P}{A} = \frac{P}{\frac{\pi}{4} \times d^2}}$$ 1/2 mark

d, failure Area

② Design of dia of spigot (d_1) & thickness of cotter (t)

ⓐ By emperical Relation $\boxed{t = 0.3d}$

ⓑ Considering tensile failure of spigot.

$$\boxed{\sigma_t = \frac{P}{\left[\frac{\pi}{4} d_1^2 - d_1 t\right]}}$$ 1/2 mark

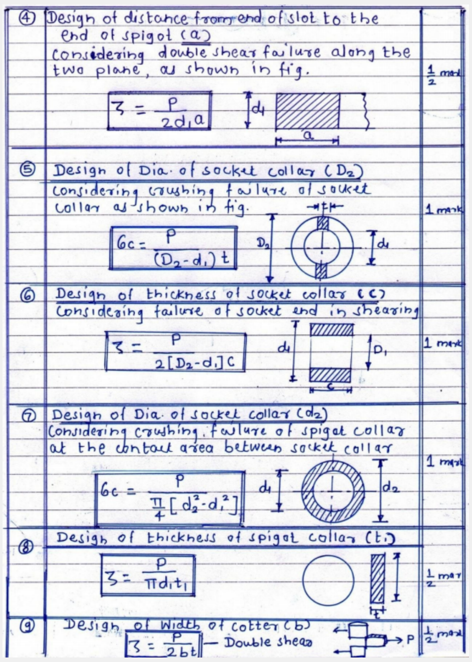
ⓒ Considering crushing failure of spigot area which is in connection with cotter pin

$$\boxed{\sigma_c = \frac{P}{d_1 t}}$$ 1/2 mark

③ Design of outside diameter of socket (D_1)

Considering tensile failure of socket

$$\boxed{\sigma_t = \frac{P}{\left[\frac{\pi}{4}(D_1^2 - d_1^2) - (D_1 - d_1)\right] \times t}}$$ 1 mark



④ Design of distance ~~from end~~ of slot to the end of spigot (a)

Considering double shear failure along the two plane, as shown in fig.

$$\boxed{\tau = \frac{P}{2 d_1 a}}$$ 1/2 mark

⑤ Design of Dia. of socket collar (D_2)

Considering crushing failure of socket collar as shown in fig.

$$\boxed{\sigma_c = \frac{P}{(D_2 - d_1)\, t}}$$ 1 mark

⑥ Design of thickness of socket collar (c)

Considering failure of socket end in shearing

$$\boxed{\tau = \frac{P}{2[D_2 - d_1]c}}$$ 1 mark

⑦ Design of Dia. of socket collar (d_2)

Considering crushing failure of spigot collar at the contact area between socket collar

$$\boxed{\sigma_c = \frac{P}{\frac{\pi}{4}[d_2^2 - d_1^2]}}$$ 1 mark

⑧ Design of thickness of spigot collar (t_1)

$$\boxed{\tau = \frac{P}{\pi d_1 t_1}}$$ 1/2 mark

⑨ Design of width of cotter (b)

$$\boxed{\tau = \frac{P}{2bt}}$$ — Double shear 1/2 mark

In practice, sometimes the following proportions in terms of the diameter of the rod (d), are used when all components of the cotter joint are made of steel.

$d_1 = 1.21$ d; $d_2 = 1.5$ d;

$D_1 = 1.75$ d; $D_2 = 2.4$ d;

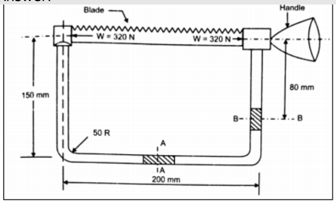
$t = 0.3$ d; $b = 1.6$ d;

$t_1 = 0.45$ d; $a = c = 0.75$ d

Knowing the dimensions, the various stresses induced in the components are calculated and ensured that all are within the permissible limits.

Que.No	Marks	
Q 3)	8	Question: **Fig.1Show of hacksaw The belt is assembled with tensoion**

Answer:



Solution :- Given data ⇒ $W = 320\ N$, $\sigma_{yt} = 360\ N/mm^2$, $FOS = 4$

$b = 2.5t$

$$\begin{bmatrix}\text{Allowable stress} \\ \text{in tension}\end{bmatrix} = \frac{\text{Yield pt stress}}{FOS} = \frac{\sigma_{yt}}{FOS} = \frac{360}{4} = 90\ N/mm^2$$

At Section A - A :-

Direct stress, $\sigma_o = \frac{W}{A} = \frac{320}{b \times t} = \frac{320}{2.5t \times t} = \frac{128}{t^2}$

Bending stress, $\sigma_b = \frac{M}{Z} = \frac{W \times e}{(1/6)tb^2} = \frac{320 \times 150 \times 6}{6.25t^3} = \frac{46080}{t^3}$ ...[$\because b = 2.5t$]

Resultant stress,

$$\sigma_{tR} = \sigma_b + \sigma_o \geq 90$$

$$\therefore \frac{46080}{t^3} + \frac{128}{t^2} = 90$$

$$\therefore 90t^3 - 128t - 46080 = 0$$

$$\therefore t = 8.0592\ mm \approx \underline{9\ mm\ (say)}$$

$$\therefore b = 2.5t = 2.5(9) = \underline{22.5\ mm}$$

At section B - B :-

Frame is uniform in section throughout.

∴ Using same section at B - B, we should find the stresses induced at section B - B. These induced stresses should be within the permissible stress limit.

Use $b = 22.5\ mm$ & $t = 9\ mm$

Bending stress induced at section B - B,

$$\sigma_{b\,ind} = \frac{M}{Z} = \frac{W \times e}{\frac{tb^2}{6}}$$

$$\therefore \sigma_{b\,ind} = \frac{320 \times 80 \times 6}{9 \times (22.5)^2} = 33.71\ N/mm^2 < 90\ N/mm^2$$

It is less than permissible stress.

In addition to bending stress, there is transverse shear stress.

We know, $\tau = 1.5\,\sigma_o$

$$\therefore \tau = 1.5 \times \frac{W}{A} = 1.5 \times \frac{W}{(b \times t)} = 1.5 \times \frac{320}{(22.5 \times 9)} = 2.37\ N/mm^2$$

which is less than $90\ N/mm^2$

Hence, design is safe

∴ At section B - B :- Use, $\underline{b = 22.5\ mm}$, $\underline{t = 9\ mm}$

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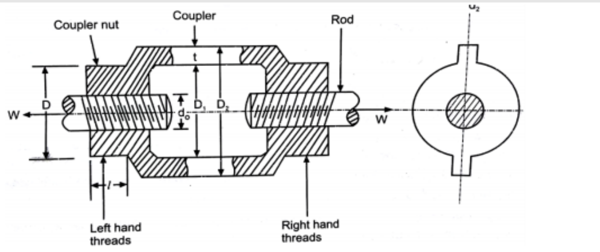
<tr><th>Que.No</th><th>Marks</th><th></th></tr>
<tr><td>Q 1 ii)</td><td>4</td><td>
Question:
Write the design procedure for turn buckle. (Any four steps)

Answer:
Write any four equation s in the design of turn buckle with relevant sketches



Where,
W=design load =1.3 or1.4 times load carried by rods
τ=permissible shear stress in N/mm2 σ_t=permissible tensile stress in N/mm2
σ_c=permissible crushing stress in N/mm2 d_c=core diameter of rod in mm,
d_o=nominal diameter of rod in mm p=pitch of the thread in mm ,n=no threads,
l=length of coupler nut in mm D=diameter of coupler nut,
D_1=inside diameter of coupler D_2=outside diameter of coupler,
t=thickness of coupler

Step 1: Design of rod (d_c)
Considering tensile failure,
$\sigma_t = \frac{W}{\frac{\pi}{4}\times d_c^2}$ ——— 1 mark
after calculating dc, do & pitch can be determine from std. table.
Step 2: Design of coupler nut (l)
Considering shear failure,
$\tau = \frac{W}{\pi d_c l}$
Step 3: Checking of crushing stress induced in thread (σ_c)
$\sigma_c = \frac{W}{\frac{\pi}{4}[d_o^2-d_c^2]\times n\times l}$
Where, $n = \frac{1}{\text{Pitch}}$
Step 4: Design of coupler nut (D)
Considering tensile failure,
$\sigma_t = \frac{W}{\frac{\pi}{4}\times[D^2-d_o^2]}$
Step 5: Design of outer dia. of coupler [D_2]
$\sigma_t = \frac{W}{\frac{\pi}{4}[D_2^2-D_1^2]}$
Where, $D_1 = d_o + (6 \text{ to } 8\text{ mm})$
$t = 0.75 d_o$

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<tr><td>Q 2a)(ii)</td><td>8</td><td>
Question:
Why taper is provided on cotter ? State recommended values of taper.

Answer:
a. When cotter is driven through the slots, it fit, fight due to wedge action. This ensures tightness of joint in operation and present loosening of the parts. b. Due to taper, it is easy to remove the cotter and dismantle the joint. The normal value of taper varies from 1 in 48 to 01 in 24 and it may increase to 1 in 8

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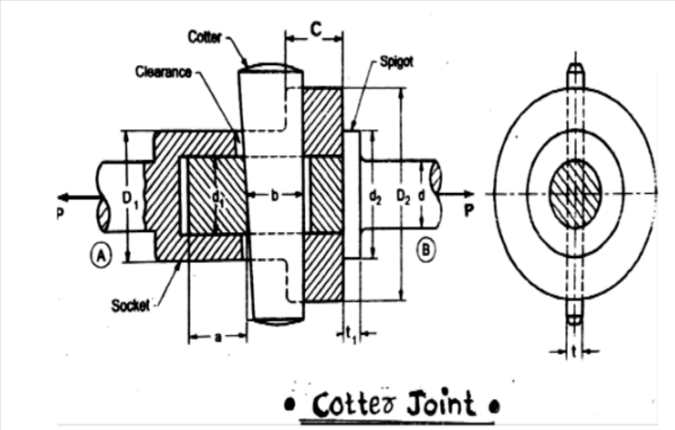
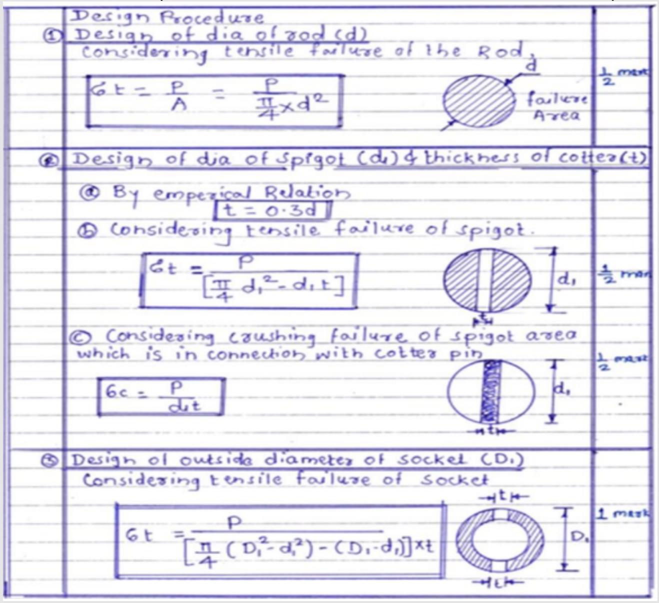
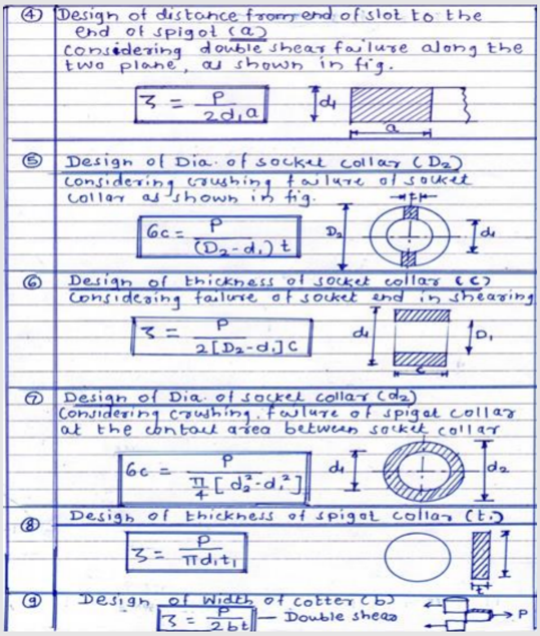
<tr><td>Q 2 b)</td><td>8</td><td>
Question:
Draw neat sketch showing the details of cotter joint. State strength equations for each component with suitable failure cross-sectional area.

Answer:


It consist of 3 elements i. Socket ii. Spigot iii. Cotter Where, d= End diameter of rodd1= Diameter of spigot/ID of socket d2= Diameter of spigot collar D1= Outer diameter of socket D2= Diameter of socket collar C=Thickness of socket collar t1= Thickness of spigot collar t= thickness of cotter b= Mean width of cotter a= Distance of end of slot to the end of spigot P= Axial tensile/compressive force σt, σc, τ= Permissible tensile, compressive, shear stress for the component material

Design Procedure
① Design of dia of rod (d)
Considering tensile failure of the Rod
$\boxed{\sigma t = \frac{P}{A} = \frac{P}{\frac{\pi}{4} \times d^2}}$ d failure Area ½ mark
② Design of dia of spigot (d_1) & thickness of cotter (t)
ⓐ By emperical Relation $\boxed{t = 0.3d}$
ⓑ Considering tensile failure of spigot.
$\boxed{\sigma t = \frac{P}{[\frac{\pi}{4} d_1^2 - d_1 t]}}$ d_1 ½ mark
ⓒ Considering crushing failure of spigot area which is in connection with cotter pin
$\boxed{\sigma c = \frac{P}{d_1 t}}$ d_1 t ½ mark
③ Design of outside diameter of socket (D_1)
Considering tensile failure of socket
$\boxed{\sigma t = \frac{P}{[\frac{\pi}{4}(D_1^2 - d_1^2) - (D_1 - d_1)] \times t}}$ t D_1 t 1 mark

④ Design of distance ~~from end~~ of slot to the end of spigot (a)
Considering double shear failure along the two plane, as shown in fig.
$\boxed{\tau = \frac{P}{2 d_1 a}}$ d_1 a
⑤ Design of Dia. of socket collar (D_2)
Considering crushing failure of socket collar as shown in fig.
$\boxed{\sigma c = \frac{P}{(D_2 - d_1) t}}$ D_2 t d_1
⑥ Design of thickness of socket collar (c)
Considering failure of socket end in shearing
$\boxed{\tau = \frac{P}{2[D_2 - d_1] c}}$ d_1 D_1 c
⑦ Design of Dia. of socket collar (d_2)
Considering crushing failure of spigot collar at the contact area between socket collar
$\boxed{\sigma c = \frac{P}{\frac{\pi}{4}[d_2^2 - d_1^2]}}$ d_1 d_2
⑧ Design of thickness of spigot collar (t_1)
$\boxed{\tau = \frac{P}{\pi d_1 t_1}}$ t_1
⑨ Design of Width of cotter (b)
$\boxed{\tau = \frac{P}{2bt}}$ — Double shear P

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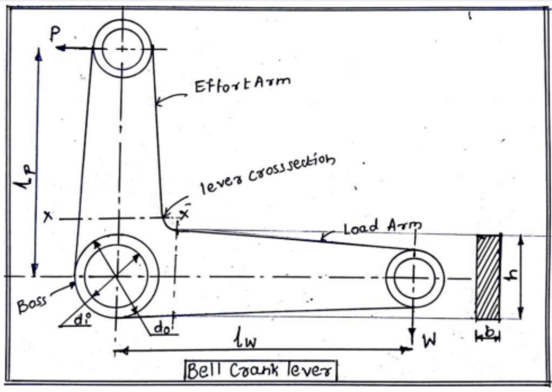
Que.No	Marks	
Q 3 b)	4	

Question:

Draw a neat sketch of bell crank lever. Enlist steps in designing the bell crank lever

Answer:



Where,

P=Effort ,W=Load

l_w= Length of load arm, l_p= Length of effort arm,

R_f= Fulcrum Reaction ,d= Diameter of pin

l_p= Length of fulcrum pin= 1.25dl_b= Length of boss= 1.25d

P_b= Bearing Pressure d_o= Outer diameter of boss

d_i= Inside diameter of boss

Consider a brass bush of 3mm thickness is fit into the boss

d_i= d+(3×2)

d_i=d+6

M=Bending Moment

b= Width of lever cross-section h= Depth of lever cross-section

Design Procedure

① Determination of effort (P)

$$\boxed{W \times l_w = P \times l_p}$$

② Determination of fulcrum reaction (Rf)

$$\boxed{R_F = \sqrt{W^2 + P^2}}$$

③ Design of fulcrum pin.

$$\boxed{l_p = l_b = 1.25\,d}$$

ⓐ Considering bearing pressure at fulcrum pin

$$\boxed{P_b = \frac{R_F}{l_b \times d}}$$

ⓑ considering double shear failure of pin

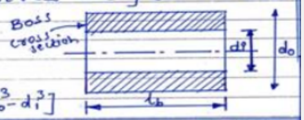
$$\boxed{\tau = \frac{R_F}{2 \times \frac{\pi}{4} \times d^2}} \longrightarrow \text{checking of value of } '\tau'$$

④ Design of boss of lever

$\boxed{d_i = d+6}$ — emperical relation

considering bending stress acting on the boss.

$$\boxed{\sigma_b = \frac{M \cdot Y}{I_{xx}}}$$



where,

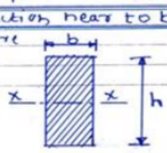
$M = l_p \times P$, • $Y = \frac{d_o}{2}$

• $I_{xx} = \frac{1}{12} \times l_b \times [d_o^3 - d_i^3]$

⑤ Design of lever arm crosssection near to boss

considering bending failure

$$\boxed{\sigma_b = \frac{M \cdot Y}{I_{xx}}}$$



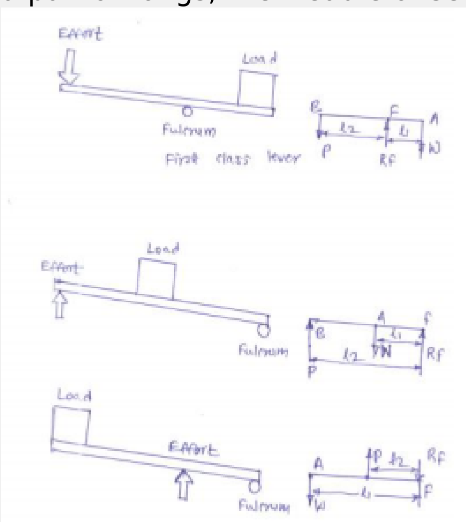
• $M = P \times [l_p - \frac{d_o}{2}]$

• $Y = \frac{h}{2}$

• $I_{xx} = \frac{1}{12} \cdot b h^3$

Examination: 2016 WINTER

Que.No	Marks	
Q 1a)(ii)	4	Question: **Write the design procedure of knuckle joint.** Answer: Design of Knuckle joint Failure of rod in tension Rod may fail in tension due to tensile load Tensile strength of rod , P = $\frac{\pi}{4}xd^2x\sigma_t$ From this equation diameter of rod may obtained **Diameter of knuckle pin in shearing** Since the pin is in double shear, Shearing strength of pin P = $\frac{\pi}{4}xd1^2\ x\sigma_t$ Value of d_1 can be found here d_1=d Fix the dimensions using empirical relations; Dia. Of pin = d_1 =d Outer dia. Of single or double eye = d_2 =2d Dia. Of knuckle pin head and collar =d_3 = 1.5d Thickness of single eye = t = 1.25d Thickness of fork =t_1 = 0.75d Thickness of collar pin =t_2 = 0.5d Checking the failure of single eye in tension σ_t = p/(d_2-d_1) x t Checking the failure of single eye in crushing σ_{ck} = p/d_1 x t Checking the failure of single eye in shear τ = p/(d_2-d_1) x t Checking the failure of double eye in tension σ_t= p/2(d_2-d_1) x t_1 Checking the failure of double eye in crushing σ_c= p/2d_1 x t_1 Checking the failure of double eye in shear τ = p/2(d_2-d_1) x t_1 --

Que.No	Marks	
Q 2 a)	8	Question: **Explain with the help of neat sketches three basic types of lever. State one application of each type.** Answer: In the first type of levers, the fulcrum is in between the load and effort. In this case, the effort arm is greater than load arm, therefore M.A. obtained is more than 1 Application: Bell crank levers used in railway signaling arrangement, rocker arm in I.C. Engines , handle of a hand pump, hand wheel of a punching press, beam of a balance, foot lever (any 1) In the second type of levers, the load is in between the fulcrum and effort. In this case, the effort arm is more than the load arm, therefore M.A. is more than 1. Application: levers of loaded safety valves, wheel barrow, nut cracker (any1) In the third type of levers, the effort is in between the fulcrum and load. Since the effort arm, in this case, is less than the load arm, therefore M.A. is less than 1 Application: a pair of tongs, the treadle of sewing machine  **---**

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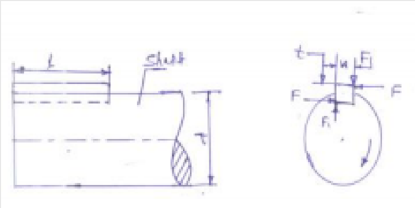
<tr><td>Q 2 b)</td><td>8</td><td>
Question:
Explain with the help of neat sketches, the design procedure of a square sunk key

Answer:


T= Torque transmitted by the shaft , F= tangential force acting at the circumference of the shaft,

d = dia. Of shaft,
l = length of key,
w = width of key
t = thickness of key
τ and σ_c = shear and crushing stress for the material of key
Consider shearing of key, the tangential shearing force acting at the circumference of the shaft ,F = Area resisting shearing X shear stress = lxw x τ
Torque transmitted by the shaft , T = F X d/2 = l x w x τ x d/2
Consider crushing of key, the tangential crushing force acting at the circumference of the shaft ,F = Area resisting crushing x crushing stress = lxt/2 x σ_c
Torque transmitted by the shaft , T = F X d/2 = lxt/2 x σ_c x d/2
The key is equally strong in shearing and crushing ,if
lxw x τ x d/2= lxt/2 x σ_c X d/2
w/t =σ_c/2 τ
as, w = t
$therefore \quad \sigma_c=2\tau$

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<tr><td>Q 2c)(ii)</td><td>8</td><td>
Question:
State two applications each of cotter joint and knuckle joint.

Answer:
Applications of cotter joint: cotter foundation bolt, big end of the connecting rod of a steam engine, joining piston rod with cross head, joining two rods with a pipe Applications of knuckle joint: link of bicycle chain, tie bar of roof truss, link of suspension bridge, valve mechanism, fulcrum of lever, joint for rail shifting mechanism
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Que.No	Marks	
Q 3 b)	4	Question: **Design single cotter joint to transmit 200 kN. Allowable stresses for the material are 75 MPa in tension and 50 MPa in shear.** Answer: Given : Load 200 KN= 200000N σ_t =75 MPa, τ= 50 MPa (i) **Dia of rod** P= π/4 xd^2 x σt 200000 = 0.7854x d^2 x 75 d = 58.27mm say 60 mm **failure of spigot in tension across the slot** p= π/4 $(d_2)^2$-$d_2$xt 200000 = 0.7854 xd2xd2 – d2x d2/4, t= d_2/4 = 60/4=15 D_2^2= 200000/(0.7854-0.25)x 75 D_2 =70.58mm **Failure of spigot end in shear** , P= 2Xaxd2x6s 200000 =2xax70.58x 50 a= 28.33mm **Failure of spigot collar in shear** P= π d_2x t1 x τ 200000 = 3.142x 70.58xt1x 50 t1= 18.03mm **failure of socket in tension across the slot**, P= π/4(d^2_1-d^2_2)- (d_1-d_2)x t x σ_t d_1xd_1 -19.09d1-7028.85 =0 solving by quadratic eq. method d_1= - (19.09)+- (-19,09x19.09- 4 x1x 7028.85)1/2/2 d_1 =84.925mm **failure of cotter in shearing** P= 2xbxtxτ 200000= 2xbx15x50 b =133.33mm --

Examination: 2015 WINTER

Que.No	Marks	
Q 1a)(ii)	4	Question: **Differentiate between Knuckle joint and Cotter joint. (any four points of difference)** Answer:

Sr.No	Knuckle Joint	Cotter Joint
1	Can take only tensile load	Can take tensile & compressive load
2	Can permit angular movement between rods	Cannot permit angular movement
3	Subjected to bearing failure	Not subjected to bearing failure
4	No taper or clearance provided	taper or clearance provided
5	Application: tie bar, links of bicycle chain, joint for rail shifting mechanism	Application: cotter foundation bolt, joining two rods with a pipe, joining piston rod with c/s head

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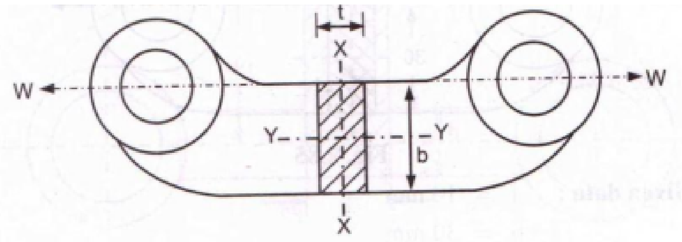
<tr><td>**Q 3 b)**</td><td>4</td><td>

Question:

Design an offset link for a load of 1000 N. Maximum permissible stress in tension for link material is 60 N/mm2. Assume b = 3t for rectangular cross section of the link.

Answer:



Step I : Direct Stress: $\sigma d = \frac{W}{A} = \frac{1000}{b\,X\,t} = \frac{1000}{3t\;X\,t}$

$\sigma d == \frac{1000}{3t^2}$ ....

Step II: Bending Stress:

$$\sigma b = \frac{M}{Zyy} = \frac{WXe}{\frac{1}{6}.t.b^2} = \frac{1000\;X\;\frac{B}{2}}{\frac{1}{6}.t.b(3t)^2}$$

$$\sigma b = \frac{1000\;X\;3t\;X\;6}{2.t.9.t^2}$$

$$\sigma b = \frac{1000}{t^2}$$ ....

Step III: Total Stress: $\sigma t = \sigma d + \sigma b$

$$60 = \frac{1000}{3t^2} + \frac{1000}{t^2}$$

$$60 = \frac{3000 + 1000}{3t^2}$$

$$3t^2 = \frac{4000}{60}$$

t=4.71 mm

b=3 t = 3 x 4.71 =14.14 mm

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