UNIT- III

TEMPORARY AND PERMANENT JOINTS

PART - A

1. **How is a bolt designated? Give example. (Dec 2006,Apr 2009)**

   A thread is designated with Letter M followed by Nominal diameter in mm and Pitch in mm [for fine pitches only].If coarse pitches are used then P value is omitted.

   Thus M20×2.5 means, Nominal diameter is 20mm, 2.5mm pitch, fine thread.

   M20 means, 20mm nominal diameter with coarse threads

2. **Why are ACME threads preferred over square thread for power screw?(Nov 2014)**

   ACME threads is easier to machine and it is stronger than square threads. ACME threads are thicker and wider and operate better in environments with dirt and debris.

3. **What are the various initial stresses developed due to screwing up in bolted joints? (Dec 2010)**

   - Tensile stresses
   - Torsional shear stress
   - Shear stress
   - Compressive and bending stress

4. **Under what force, the big end bolts and caps are designed.(Dec 2011)**

   The big end bolts and caps are designed for inertia force due to reciprocating parts

5. **What is gib? Why it is provided in a cotter joint?(Dec 2013)**

   Gib is an element made of mild steel with thickness equal to the cotter. A gib is used in combination with the cotter to provide the following advantages

   - Reduce bending of socket end
   - Increase the bearing area of contact between the mating surfaces.

6. **What are the different types of cotter joints? (May 2014)**
   - Socket and spigot cotter joint
   - Sleeve and cotter joint
   - Gip and cotter joint
7. **Why are welded joints preferred over riveted joints? (Nov 2003, Apr2008, Apr 2009)**

Material is saved in welded joints and hence the machine element will be light if welded joints are used instead of riveted joints. Leak proof joints can be easily obtained by welded joints compared riveted joints.

8. **Define the term self locking of power screws? (Apr 2004,Dec 2012, May 2013)**

If the friction angle is greater than helix angle of the power screw, the torque required to lower the load will be positive, indicating that an effort is applied to lower the load. This type is screw is known as self locking screw. The efficiency of the self locking screw is less than 50%.

9. **What is the minimum size for fillet weld? If the required weld size from strength consideration is too small how will you fulfill the condition of minimum weld size? (Nov 2008)**

It is the defined as the minimum size of the weld for a given thickness of the thinner part joined or plate to avoid cold cracking by escaping the rapid cooling

10. **Name the possible modes of failure of riveting joint. (Nov 2008, Dec 2012,May 2012)**

1. Crushing of rivets
2. Shear of rivets
3. Tearing of the plate at the edge
4. Tearing of the plate between rivets.

11. What is meant by the efficiency of the riveted joint? (Dec 2010)

The efficiency of a riveted joint is defined as the ratio of the strength of riveted joint to the strength of the un-riveted or solid plate.

$$\eta = \frac{\text{Least of Tearing Resistance, Shearing resistance and Crushing Resistanace}}{p \times t \times \sigma_t}$$

Where, p = Pitch of rivets, t= thickness of plate and σ_t = Permissible Tensile stress of the plate material.

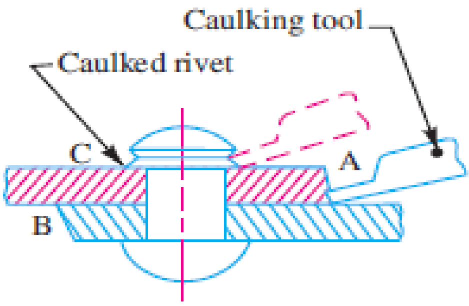
12. What are the reason of replacing riveted joint by welded joint in modern equipment.(Dec 2010)

Material is saved in welding joints and hence the machine element will be light if welded joint are used instead of riveted joints. Leak proof joints can be easily obtained by welded joints compared riveted joints.

13. State the two types of eccentric welded connection (Dec 2013)

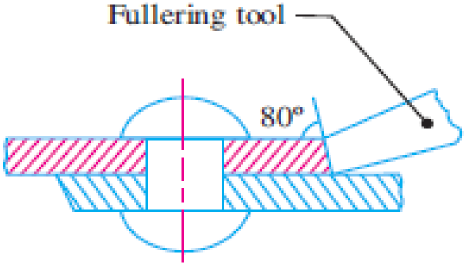
- Welded connections subjected to moment in a plane of the weld
- Welded connections subjected to moment in a plane normal to the plane of the weld.

14. What is caulking and fullering?

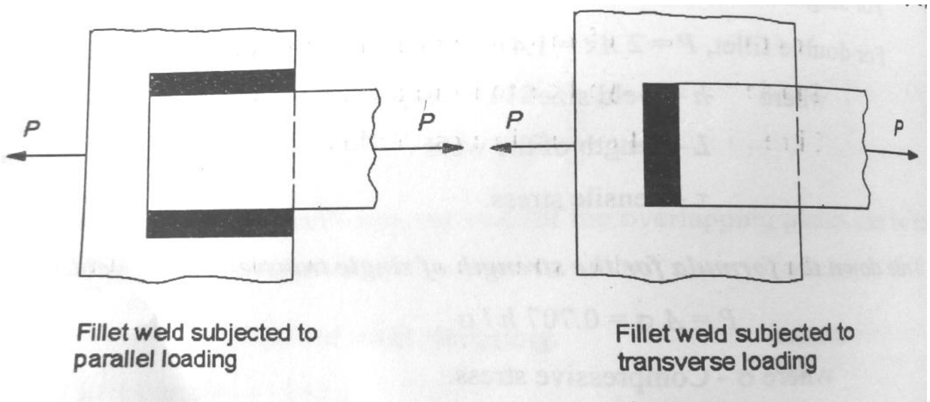


In order to make the joints leak proof or fluid tight in pressure vessels like steam boilers, air receivers and tanks etc. a process known as caulking is employed. In this process, a narrow blunt tool called caulking tool, about 5 mm thick and 38 mm in breadth, is used. The edge of the tool is ground to an angle of 80°. The tool is moved after each blow long the edge of the plate, which is planed to a bevel of 75° to 80° to facilitate the forcing down of edge. It is seen that the tool burrs down the plate at A in Fig. forming a metal to metal joint. In actual practice, both the edges at A and *B* are caulked. The head of the rivets as shown at *C* are also turned down with a caulking tool to make a joint steam tight. A great care is taken to prevent injury to the plate below the tool.

Fullering: A more satisfactory way of making the joints staunch is known as fullering which has largely superseded caulking. In this case, a fullering tool with a thickness at the end equal to that of the plate is used in such a way that the greatest pressure due to the blows occur near the joint, giving a clean finish, with less risk of damaging the plate. A fullering process is shown in Fig.

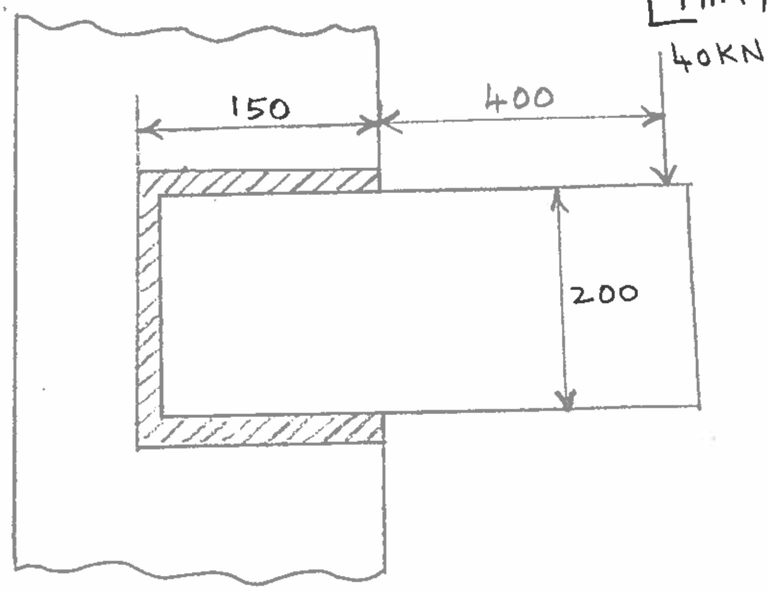


15. Differentiate with a neat sketch the fillet welds subjected to parallel loading and transverse loading. (Apr-04, May-14)



TEMPORARY AND PERMANENT JOINT

1. A rectangular steel plate is welded as a cantilever to a vertical column and supports a single concentrated load P, as shown in figure. Determine the weld size if shear stress in the same is not to exceed 80N/mm². [MAY/JUNE 2013]



GIVEN DATA:

$P = 40\,KN = 40\times10^3 N$; $b = 150mm$; $d = 200mm$

$[\tau] = 80 N/mm^2$

TO FIND: Weld size, h.

SOLUTION:

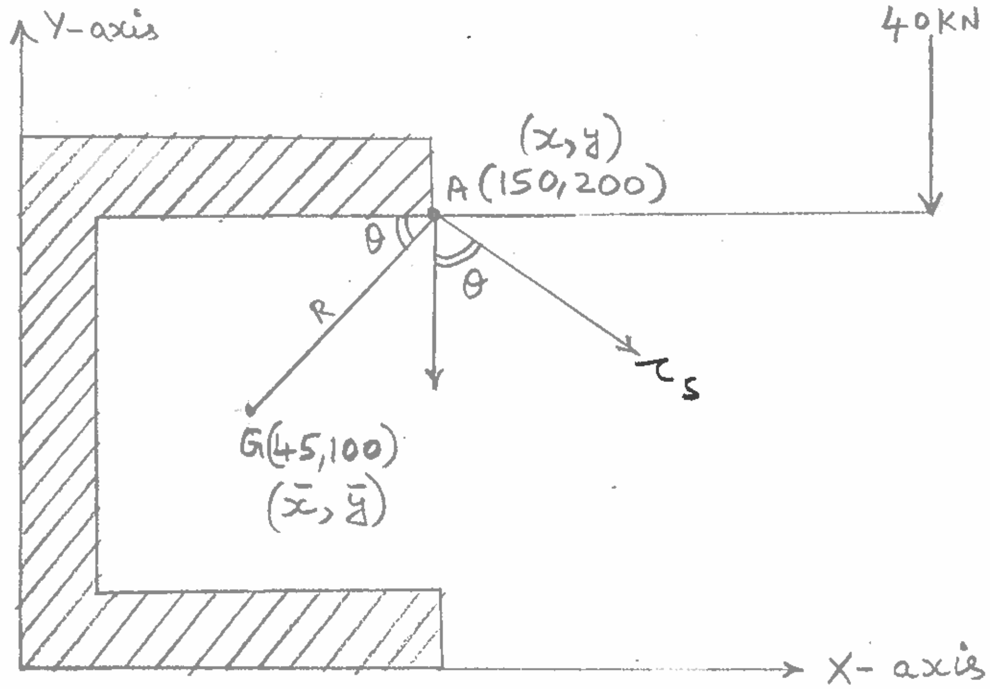
I Location of the Centroid:

From DDB.P.NO: 11.5

$$\bar{x} = N_y = \frac{b^2}{2b+d} = \frac{150^2}{2\times150+200} = 45mm$$

$$\bar{y} = \frac{200}{2} = 100mm$$

$$\text{Centroid} = (\bar{x},\bar{y}) = (45,100)$$



II Polar Moment of Inertia:

J_u = Unit Polar Moment of Inertia.

$$= \frac{(2b+d)^3}{12} - \frac{b^2(b+d)^2}{(2b+d)} \quad (\text{DDB. P.No: } 11.5)$$

$$J_u = \frac{(2\times150+200)^3}{12} - \frac{150^2(150+200)^2}{(2\times150+200)}$$

$$= 4.904 \times 10^6 \ mm^3$$

$$J = J_u \times t$$

$$= 4.904 \times 10^6 \times t \ mm^4.$$

III Secondary Shear Stress (τ_s):

$$\tau_s = \frac{T \times R}{J}$$

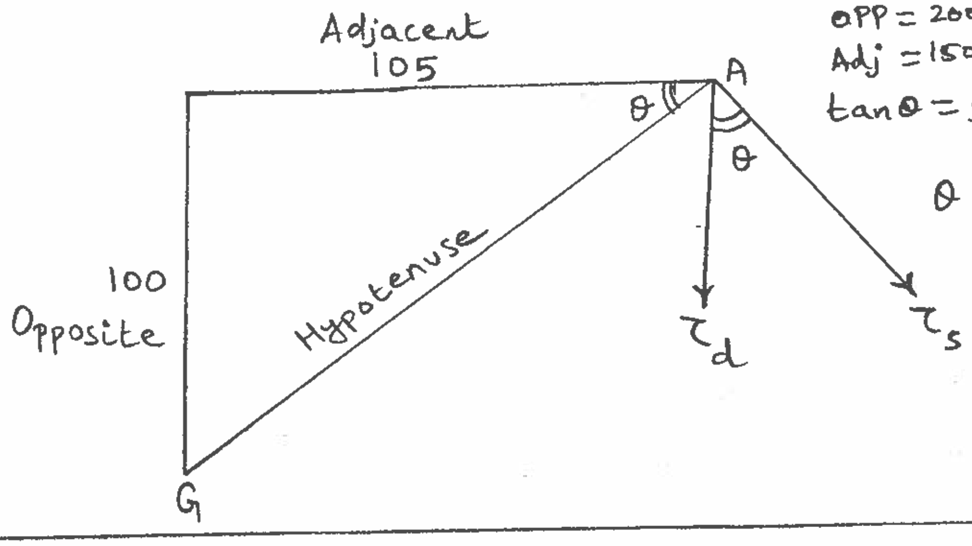
T = Torque = $P \times l$

where l = distance between line of action of load and centroid.

$l = (550 - 45) = 505\,mm$

$T = 40 \times 10^3 \times 505 = 20\,200\,000$ N-mm

Resultant Shear Stress (τ_R):



$OPP = 200 - 100 = 100$

$Adj = 150 - 45 = 105$

$\tan\theta = \frac{OPP}{Adj} = \frac{100}{105}$

$\theta = 43.6^\circ$

III Secondary Shear Stress

$R = GA = \sqrt{(x - \bar{x})^2 + (y - \bar{y})^2}$

$= \sqrt{(150 - 45)^2 + (200 - 100)^2}$

$= 145\,mm$

$\tau_s = \frac{TR}{J}$

$= \frac{20{,}200\,000 \times 145}{4.904 \times 10^6}$

$= \frac{597.26}{t}\ N/mm^2$

IV Primary Shear Stress, τ_d:

A = Total Throat Area.

$= 2 \times (b + d)t = 2 \times (150 + 200) \times t$

$= 500t\ mm^2.$

$$\tau_d = \frac{P}{A} = \frac{40{,}000}{500t} = \frac{80}{t}\ N/mm^2$$

V Resultant Shear Stress, τ_R:

$$\tau_R = \sqrt{\tau_d^2 + \tau_s^2 + 2\tau_d\tau_s\cos\theta}$$

$$= \sqrt{\left(\frac{80}{t}\right)^2 + \left(\frac{597.2}{t}\right)^2 + 2\left(\frac{80}{t}\right)\left(\frac{597.2}{t}\right)\cos 43.6^\circ}$$

$$= \frac{657.45}{t}$$

VI Weld Size:

$$\frac{657.45}{t} \leq [\tau]$$

$$\frac{657.45}{0.707 \times h} \leq 80$$

$$h \geq \frac{657.45}{0.707 \times 80}$$

$$h \geq 11.62\,mm$$

$$\boxed{h = 12\,mm}$$

2. A mild steel plate of 10mm thickness is joined with another plate by a single transverse weld and double parallel fillet welds as shown in fig. Find the width of the plate and the length of the welds if the joint is subjected to a static load of 65KN. [APRIL/MAY 2010]

GIVEN DATA:

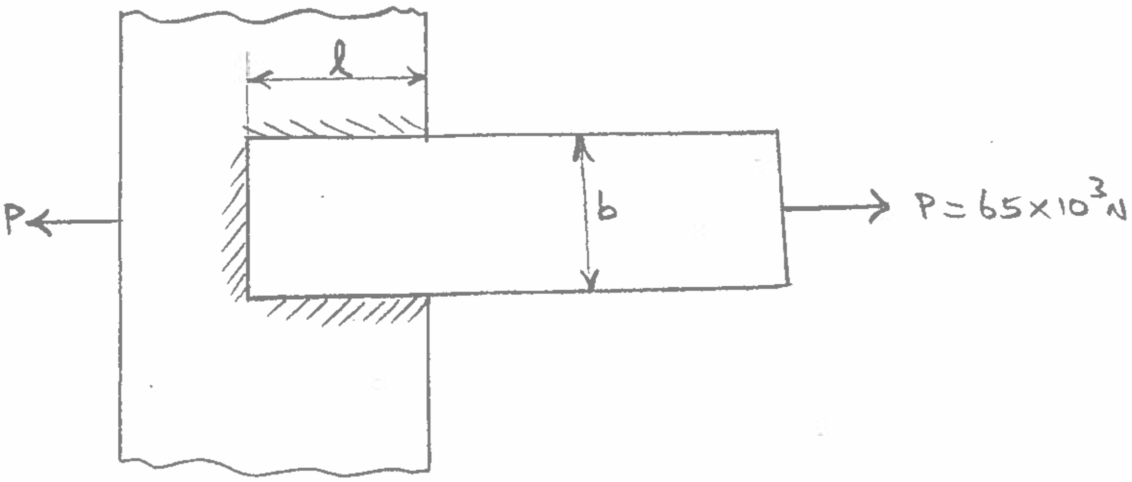
t = plate thickness = 10mm

P = 65 KN

TO FIND: ① Width of the plate, b

② Length of the weld, l.

SOLUTION:



I Width of the plate:

From DDB. P.No: 1.9, Take C20 Material

$\sigma_y = 260\ N/mm^2$

Assume Factor of Safety, $n = 2.5$

$$[\sigma_t] = \frac{\sigma_y}{n} = \frac{260}{2.5} = 104\ N/mm^2$$

$$= \frac{P}{A} = \frac{P}{b \times t} = \frac{65{,}000}{b \times 10}$$

$$\therefore \quad b = \frac{65{,}000}{10 \times 104} = 62.5mm$$

$$\boxed{b \simeq 65mm}$$

II Load Carried by Transverse Weld, P_1

DDB. P-No: 11.4

Corresponding to ① Fillet weld, ② Covered Electrodes and ③ Steady load.

$$[\tau] = 950 \ kgf/cm^2$$
$$= \frac{950 \times 10}{100} \ N/mm^2$$
$$= 95 \ N/mm^2$$

A = Welded Area
$$= b \times t$$
$$= b \times 0.707 \times h$$

where h = weld size = Thickness of plate
$$= 10mm$$

$$[\tau] = \frac{P_1}{A} = \frac{P_1}{65 \times 0.707 \times 10}$$

$$\therefore P_1 = 95 \times 65 \times 0.707 \times 10$$
$$= 43,657N.$$

III Load Carried by each parallel Weld, P_2:

$$P = P_1 + 2P_2$$

$$\therefore P_2 = \left(\frac{P - P_1}{2}\right) = \left(\frac{65,000 - 43657}{2}\right)$$

$$P_2 = 10,672 \ N$$

IV Length of parallel Weld:

$$[\tau] = \frac{P_2}{A} = \frac{P_2}{l \times t} = \frac{P_2}{l \times 0.707 \times h}$$

$$95 = \frac{10,672}{l \times 0.707 \times 10}$$

$$\therefore l = 15.9\,mm$$

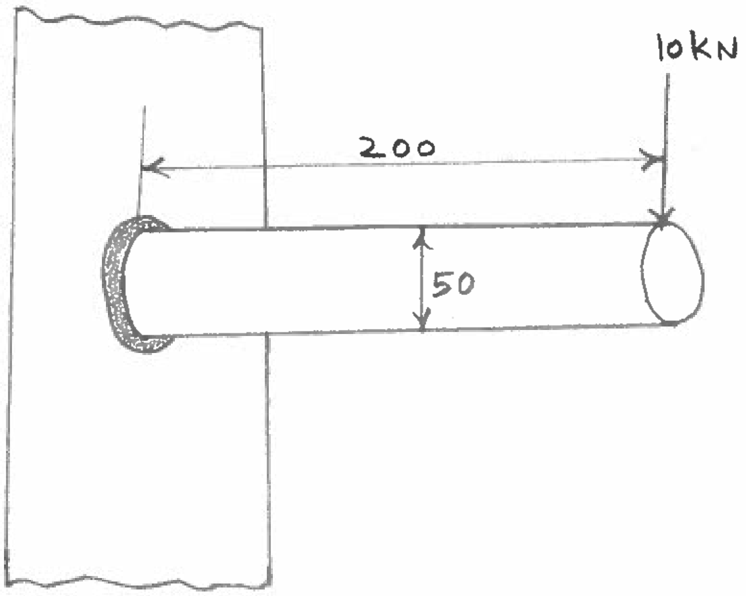
$$l = 16\,mm$$

Starting & stopping allowance = 10mm

$$l = 16 + 10 = 26\,mm$$

$$\boxed{l = 26\,mm}$$

3. A 50mm diameter solid shaft is welded to a flat plate as shown in fig. If the size of the weld is 15mm, find the maximum normal and shear stress in the weld [MAY/JUNE 2009]



GIVEN DATA:

$d = 50\,mm$

$h = 15\,mm$

$l = 200\,mm$

$P = 10 \times 10^3\,N$

To FIND:

1. Max. Normal Stress, σ_1
2. Max. Shear Stress, τ_{max}

SOLUTION:

I Bending Stress:

M = Bending Moment $= P \times l = 10 \times 10^3 \times 200$

$= 2 \times 10^6$ N-mm

σ_b = Bending Stress

$= \frac{M}{Z}$

From DDB. P.No: 11.6; $Z = \frac{\pi}{4} d^2 \times t$

$Z = \frac{\pi}{4} \times 50^2 \times 0.707 \times h$

$= \frac{\pi}{4} \times 50^2 \times 0.707 \times 15$

$= 20822.86 \text{ mm}^3$

$\sigma_b = \frac{2 \times 10^6}{20822.86} = 96.04 \text{ N/mm}^2$

II Shear Stress

A = Area $= \pi d t = \pi \times d \times 0.707 \times h$

$\tau = \frac{P}{A} = \frac{10 \times 10^3}{\pi \times 50 \times 0.707 \times 15} = 6 \text{ N/mm}^2$

III Maximum Normal Stress:

$\sigma_1 = \frac{\sigma_b}{2} + \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + \tau^2}$

$= \left(\frac{96}{2}\right) + \sqrt{\left(\frac{96}{2}\right)^2 + 6^2}$

$= 48 + 48.37$

$\boxed{\sigma_1 = 96.37 \text{ N/mm}^2}$

IV Maximum Shear Stress, τ_{max}:

$$\tau_{max} = \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + \tau^2}$$

$$\boxed{\tau_{max} = 48.4\ N/mm^2}$$

3. Design a Cotter joint to support a load varying from 120kN in compression to 120kN in tension. The material used is carbon steel for which the following allowable stresses may be used. Tensile stress = 85 N/mm^2; Shear stress = 70MPa, Crushing stress = 165 N/mm^2. The load is applied statically. [MAY/JUNE 2013]

GIVEN DATA:

$P = 120\ kN = 120 \times 10^3 N$; $[\sigma_t] = 85\ N/mm^2$; $[\tau] = 70\ N/mm^2$

$[\sigma_c] = 165\ N/mm^2$.

TO FIND: Design Cotter Joint

SOLUTION:

I. Failure of Rod in Tension

$$[\sigma_t] = \frac{P}{A} = \frac{P}{\frac{\pi}{4} d^2}$$

$$85 = \frac{120 \times 10^3 \times 4}{\pi \times d^2}$$

$$\therefore \quad d = 42.4mm$$

$$\boxed{d \simeq 45mm}$$

d = diameter of rod

II Tearing of rod across Cotter slot:

$$[\sigma_t] = \frac{P}{A} = \frac{P}{\left(\frac{\pi}{4} d_1^2 - d_1 t\right)}$$

$$P = [\sigma_t] \times \left[\frac{\pi}{4} d_1^2 - d_1 t\right]$$, where $t = 0.25 d_1$

$$120 \times 10^3 = 85 \times \left[\frac{\pi}{4} d_1^2 - d_1 \times (0.25 d_1)\right]$$

$$= 85 \times \left[\frac{\pi}{4} d_1^2 - 0.25 d_1^2\right]$$

$d_1 = 51.35\,mm$

$d_1 \simeq 52\,mm$

= Diameter of Spigot = Inside diameter of Socket.

$t = 0.25 \times d_1 = 0.25 \times 52 = 13\,mm$

$t = 13\,mm$

= Thickness of Cotter

III Failure of Cotter & Rod in Crushing:

σ_c = Induced Crushing stress

$$= \frac{P}{A} = \frac{P}{d_1 \times t} = \frac{120 \times 10^3}{52 \times 13} = 177.51\,N/mm^2$$

$\sigma_c = 177.51\,N/mm^2$

$> [\sigma_c] = 165\,N/mm^2$

∴ Design is not Safe.

Trial 2: Take $d_1 = 56\,mm$; ∴ $t = 0.25 \times d_1 = 14\,mm$

$$\sigma_c = \frac{120 \times 10^3}{56 \times 14} = 153\,N/mm^2$$

$= 153\,N/mm^2$

$< [\sigma_c] = 165\,N/mm^2$

∴ Design is Safe and Satisfactory.

IV Failure of Cotter in Double Shear:

A = Area Resisting Shear

$= 2 \times (b \times t)$

$$[\tau] = \frac{P}{A} = \frac{120 \times 10^3}{2 \times b \times t}$$

$$70 = \frac{120 \times 10^3}{2 \times b \times t}$$

$$b = \frac{120 \times 10^3}{70 \times 14 \times 2} = 61.2mm$$

$b = 62mm$

= Mean Width of Cotter.

V Failure of rod end in Double Shear:

A = Area resisting Shear of rod end.

$= 2ad_1$

$$[\tau] = \frac{P}{2ad_1} = \frac{120 \times 10^3}{2 \times a \times 56}$$

$$\therefore a = \frac{120 \times 10^3}{2 \times 56 \times 70}$$

$a = 15.3mm$

$a \simeq 16mm$

a = Distance from the end of the slot to the end of rod

VI Failure of Socket in Tension across the Cotter Slot:

$$A = \frac{\pi}{4}(D_1^2 - d_1^2) - (D_1 - d_1) \times t$$

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

$$85 = \frac{120 \times 10^3}{\frac{\pi}{4}(D_1^2 - 56^2) - (D_1 - 56) \times 14}$$

$$\frac{\pi}{4}(D_1^2 - 56^2) - (D_1 - 56) = \frac{120 \times 10^3}{85}$$

$$0.785 D_1^2 - 2463 - 14 D_1 + 784 = 1411.76$$

$$0.785 D_1^2 - 14 D_1 - 3090.76 = 0$$

$$D_1^2 - 17.83 D_1 - 3937.27 = 0$$

$$D_1 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$= \frac{17.83 \pm \sqrt{(-17.83)^2 - (4 \times 1 \times -3937)}}{2 \times 1}$$

$$= 74.13 \text{mm}$$

$$D_1 \simeq 75 \text{mm}$$

D_1 = outside Diameter of Socket.

VII Failure of Socket Collar in Crushing:

$$[\sigma_c] = \frac{P}{A} = \frac{P}{(D - d_1) \times t}$$

$$165 = \frac{120 \times 10^3}{(D - 56) \times 14}$$

$$D - 56 = \frac{120 \times 10^3}{165 \times 14} = 51.94$$

$$D = 107.94 \text{mm}$$

D = 110mm = Diameter of Socket Collar.

VIII Failure of Socket end in double Shearing

$$A = (D - d_1) \times c \times 2$$

$$[\tau] = \frac{P}{2(D - d_1) \times c}$$

$$70 = \frac{120 \times 10^3}{2 \times (110 - 56) \times c}$$

$$\therefore \; c = \frac{120 \times 10^3}{2 \times (110 - 56) \times 70}$$

$c = 15.87\,mm$

$c \simeq 16\,mm$

c = Thickness of Socket Collar.

IX Failure of Spigot Collar in Crushing:

$$A = \frac{\pi}{4}\left(d_2^2 - d_1^2\right)$$

$$[\sigma_c] = \frac{P}{\frac{\pi}{4}\left(d_2^2 - d_1^2\right)}$$

$$165 = \frac{120 \times 10^3}{\frac{\pi}{4}\left(d_2^2 - 56^2\right)}$$

$$d_2^2 - 56^2 = 926.46$$

$d_2 = 63.73\,mm$

$d_2 \simeq 65\,mm$

d_2 = outside diameter of Spigot Collar

X Failure of Spigot Collar in Crushing:

A = Shearing Area = $\pi d_1 t_1$

$$[\tau] = \frac{P}{\pi d_1 t_1} = \frac{120 \times 10^3}{\pi d_1 t_1}$$

$$70 = \frac{120 \times 10^3}{\pi \times 56 \times t_1}$$

$\therefore t_1 = 9.7mm$

$t_1 \simeq 10mm$

t_1 = Thickness of Spigot Collar

5. Design a knuckle joint to transmit a load of 120kN. The design stresses may be taken as 85MPa in tension, 70MPa in shear and 165MPa in Compression. [NOV|DEC 2012]

GIVEN DATA:

$P = 120kN = 120 \times 10^3 N$; $[\sigma_t] = 85 N/mm^2$; $[\tau] = 70 N/mm^2$

$[\sigma_c] = 165 N/mm^2$.

TO FIND: Design knuckle Joint

SOLUTION:

I Failure of rod in Tension:

$$[\sigma_t] = \frac{P}{\frac{\pi}{4} d^2} = \frac{120 \times 10^3}{\frac{\pi}{4} \times d^2}$$

$$d^2 = \frac{120 \times 10^3}{\frac{\pi}{4} \times 85}$$

$d = 42.4 \simeq 50mm$ = Diameter of rod

II Other dimensions of the Joint:

d_1 = Diameter of pin

= d = diameter of rod

= 45mm.

d_2 = Outer diameter of eye

= 2xd = 2x45 = 90mm

d_3 = Diameter of pin head

= 1.5xd = 1.5x45 = 67.5mm

≃ 68mm

t = thickness of eye

= 1.25xd = 1.25x45 = 56.25mm

t ≃ 58mm

t_1 = Thickness of fork

= 0.75d = 0.75x45 = 33.75mm

t_1 ≃ 35mm

t_2 = Thickness of Pin head

= 0.5xd = 0.5x45

= 22.5mm

t_2 ≃ 24mm

III Failure of knuckle Pin by double Shear

A = Area Resisting Shear

$= 2 \times \frac{\pi}{4} d_1^2$

$$\tau = \frac{P}{A} = \frac{120\times10^3}{2\times\frac{\pi}{4}\times(45)^2} = 37.7 N/mm^2 < [\tau] = 70 N/mm^2$$

∴ Design is Safe.

IV Failure of Single eye or rod end in Tension:

$A = (d_2 - d_1) \times t$

$$\sigma_t = \frac{P}{(d_2-d_1) \times t} = \frac{120 \times 10^3}{(90-45) \times 58} = 46 N/mm^2$$

$= 46 N/mm^2$

$< [\sigma_t] = 85 N/mm^2$

∴ Design is safe and satisfactory.

V Failure of Single eye or rod end in double shear:

Area Resisting shearing $= 2 \times \left(\frac{d_2-d_1}{2}\right) \times t$

$$\tau = \frac{P}{2 \times \left(\frac{d_2-d_1}{2}\right) \times t}$$

$$\tau = \frac{120 \times 10^3}{2 \times \left(\frac{90-45}{2}\right) \times 58}$$

$= 46 N/mm^2$

$< [\tau] = 70 N/mm^2$.

∴ Design is safe & satisfactory.

VI Failure of Single eye or rod end in Crushing:

$A = \text{Area} = d_1 . t$.

$$\sigma_c = \frac{P}{d_1 . t} = \frac{120 \times 10^3}{45 \times 58} = 45.97 N/mm^2$$

$= 45.97 N/mm^2$

$\leq [\sigma_c] = 165 N/mm^2$

VII Failure of Forked Ends in Tension

$$A = \text{Area} = 2\times(d_2-d_1)\times t_1$$

$$\sigma_t = \frac{P}{A} = \frac{P}{2\times(d_2-d_1)\times t_1} = \frac{120\times10^3}{2\times(90-45)\times35}$$

$$= 38\ N/mm^2$$

$$\leq [\sigma_t] = 85\ N/mm^2$$

VIII Failure of Forked Ends in Double Shear:

$$A = 2\times(d_2-d_1)\times t_1.$$

$$\tau = \frac{P}{A} = \frac{P}{2\times(d_2-d_1)\times t_1}$$

$$= \frac{120\times10^3}{2\times(90-45)\times35}$$

$$= 38\ N/mm^2$$

$$\leq [\tau] = 70\ N/mm^2$$

IX Failure of Forked Ends in Crushing:

$$A = 2\times d_1 t_1.$$

$$\sigma_c = \frac{P}{A} = \frac{P}{2\times d_1\times t_1} = \frac{120\times10^3}{2\times45\times35}$$

$$= 38\ N/mm^2$$

$$\leq [\sigma_c] = 165\ N/mm^2.$$

X Failure of Knuckle Pin by Bending:

$$\sigma_t = \frac{\frac{P}{2}\left(\frac{t_1}{3}+\frac{t}{4}\right)}{\frac{\pi}{32}d_1^3}$$

$$\sigma_t = \frac{\left(\frac{120\times10^3}{2}\right)\left(\frac{35}{3}+\frac{58}{4}\right)}{\frac{\pi}{32}(45)^3}$$

$$= 175.44\ N/mm^2$$

$$\geq [\sigma_t] = 85\ N/mm^2$$

Since $\sigma_t > [\sigma_t]$. Increase the value of 'd_1'. This will reduce the resistance to failures in step $\overline{IV}$, $\overline{V}$, $\overline{VII}$ and $\overline{VIII}$.

$\therefore$ Diameter d_2 also should be increased.