...power transmission shaft 1500 mm long is supported at two points A and ... A is at a distance of 50 mm from the left extreme end of the shaft, B is at the right extreme end of the shaft. The shaft receives power of 40 KW through a gear drive located at the left extreme end of the shaft at a rated speed of 500 rpm. The gear mounted on the shaft to be designed here has a pitch diameter of 200mm and weighs 500 N. The gear meshing with this gear is placed behind such that the line of centers is directed away from the observer below the horizontal and inclined at 30^0 to it. The gear tooth is having a pressure angle of 20^0. This power is given out through a belt drive locating at a distance of 400mm from the right support. The belt pulley has a pitch diameter of 350mm and weighs 800N ; the belt moving on the pulley is directed towards the observer below the horizontal and inclined at 45^0 to it. The ratio of the belt tension may be taken to be 3. Selecting carbon steel C40 as a material for the shaft and choosing a value of 2.5 for the factor of safety, determine the diameters of the hollow circular shaft, assuming its inner diameter to be 0.6 times outer diameter. **(20 Marks)**

Design a flexible flanged coupling to transmit a power of 45 KW at a rated speed of 500 rpm **(12 Marks)**

Determine the diameter of a solid circular shaft to transmit a power of 50 KW at a rated speed of 1000 rpm selecting a suitable material and choosing an appropriate value for factor of safety. Replace this solid circular shaft by a hollow circular shaft assuming the value of 0.6 for the ratio of diameters, selecting the same material and the same factor of safety. As the consequence of this replacement determine :

i) Percentage of reduction in weight assuming same length for the shafts.

ii) The ratio of the torsional stiffness of the hollow shaft to that of the solid shaft. **(8 Marks)**

A cover plate is bloted on to flanged end of a pressure vessel through 6 bolts. The inner diameter of pressure vessel is 200mm and is subjected to an internal pressure of 10 MPa. Selecting carbon steel C40 as the material for the bolts. Determine the size of the bolts also considering the initial tension for the following cases.

i) Metal to metal joint ii) A gasket joint. **(10 Marks)**

A power screw for a jack has square threads of proportion 50 × 42 × 8. While he coefficient of friction at the threads is 0.1 that at the collar is 0.12. Determine the weight that can be lifted by this jack through a human effort of 400 N through a hand liver of span 400 mm. **(10 Marks)**

Design a cotter joint to sustain an axial load of 100 kN.

Allowable stresses for the material of the joint are as follows :
Allowable stress in tension 80 MPa
Allowable stress in compression 120 MPa
Allowable shear stress 60 MPa
Allowable bearing pressure 40 MPa. **(10 Marks)**

Design a double riveted butt joint with equal widths of cover plates to join two plates of thickness 10 mm. The allowable stress for the material of the rivets and for the plates are as follow :

For plate material in tension, $\sigma_t = 80MPa$
For rivet material in compression, $\sigma_c = 120MPa$
For rivet material in shear ; $\tau = 60MPa$. **(10 Marks)**

Contd.... 3

NEW SCHEME

USN

Fourth Semester B.E. Degree Examination, July/August 2005

ME/IP/IM/MA/AU

Design of Machine Elements - I

Time: 3 hrs.] [Max.Marks

Note: *1. Answer any FIVE full Questions.*
2. Use of design data hand book is permitted.
3. Missing data may be suitably assumed.

1. (a) Discuss factors to be considered for selection of an appropriate material for a machine element in the design process. **(8 Marks)**

(b) Derive an expression for impact/shock factor. **(5 Marks)**

(c) A machine element in the form of a cantilever beam is made of a rod of circular cross section with a span of 800mm. The material of the rod is carbon steel C30. Determine a safe value for a transverse load that falls on to the free end of the beam from a height of 25mm, if the diameter of the rod is 40mm. Use a value of 2.5 for the factor of safety. **(7 Marks)**

2. (a) A round rod of diameter 1.2d has a semi circular grove of radius 0.1d. Determine a safe value for d to sustain a bending moment of 2 kN-m. Select a suitable material and choose appropriate value for factor of safety. **(6 Marks)**

(b) Explain the following theories of failure.

i) Maximum normal stress theory

ii) Maximum shear stress theory

iii) Distortion energy theory. **(6 Marks)**

(c) A round rod of diameter 50 mm is to sustain an axial tensile load of 25 kN together with a twisting moment of 1.5 kN-m. The material for the rod is carbon steel C40. Determine the factor of safety as per the following theory of failure. Maximum normal stress theory. **(8 Marks)**

3. (a) Derive Soderberg's equation for designing of a machine element, with change in cross section, to sustain loads that fluctuate between two limits. **(6 Marks)**

(b) Determine the diameters of a hollow rod to sustain a twisting moment that fluctuates between +2.5 kN-m and +1.5kN-m together with a bending moment that fluctuates between +2 kN-m and -2kN-m Assume the inner diameter to be 0.6 times the outer diameter. Select a suitable material and assume an appropriate value for factor of safety. **(14 Marks)**

Contd.... 2

8. (a) Determine safe value of P for a joint loaded as shown in figure , limiting the maximum normal stress induced to 80 MPa and maximum shear stress induced to 60 MPa. (10 Marks)

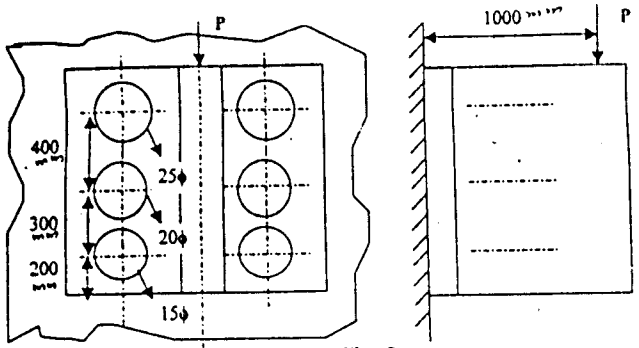

Fig: 8.a

(b) Determine the size of the weld for a welded joint loaded as shown in figure : 8.b. (10 Marks)

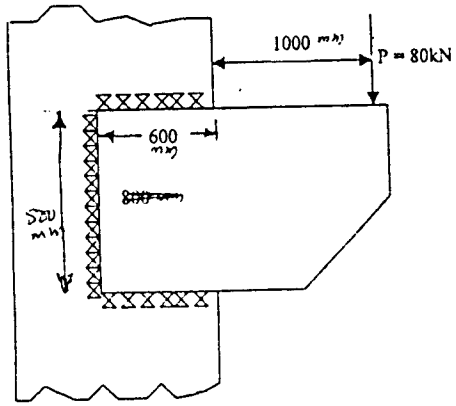

Fig: 8.b

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AU46

USN | | | | | | | | | | |

NEW SCHEME

C-42

Fourth Semester B.E. Degree Examination, July 2006
ME / AU / IP / IM / MA
Design of Machine Elements - I

Time: 3 hrs.] [Max. Marks:100

Note: *1. Answer any FIVE questions.*
2. Missing data, if any, may be assumed suitably.
3. Use of Data Hand Book is permitted.

1 a. Draw the stress strain diagrams for a ductile material and a brittle material and show the salient points on them. (06 Marks)

b. Determine a stress at extreme for fibers for the cross section X-X of the C-Clamp loaded as shown in Fig. 1(b). (14 Marks)

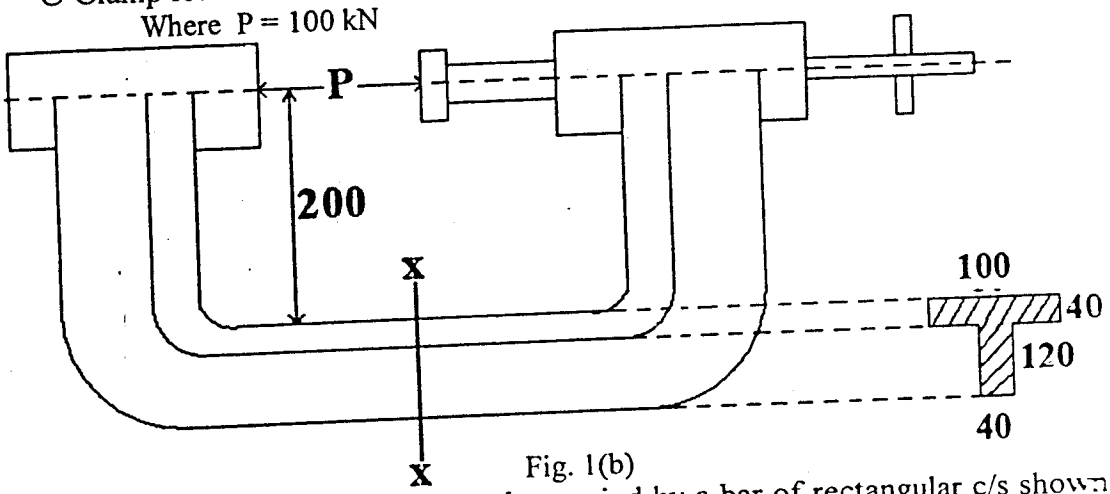


Fig. 1(b)

2 a. Determine the safe load that can be carried by a bar of rectangular c/s shown in the Fig. 2(a) limiting the maximum stress to 130 MPa taking stress concentration into account. (10 Marks)

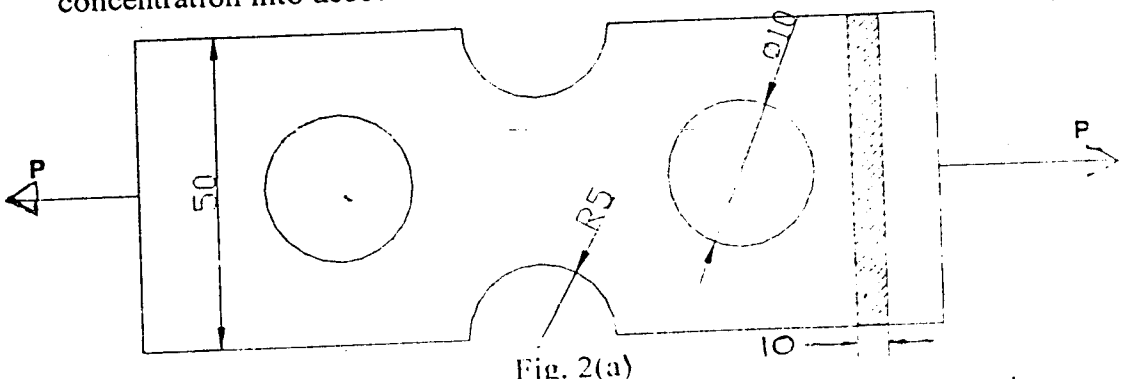


Fig. 2(a)

b. A machine element in the form of a cantilever beam has a rectangular cross section of 40mm width and 120mm depth. The span of the beam is 600mm. A transverse load of 5kN falls from a height of 'h' at the free end of the beam. Determine a safe value for 'h' limiting the maximum normal stress induced in the machine element, due to impact, to 120 MPa. The modulus of the elasticity of the material of the beam is 210 MPa. (10 Marks)

Contd... 2

3 a. A round rod of diameter 1.2d has a semicircular groove of diameter 0.2d. This rod is to sustain a twisting moment that fluctuates between 2.5 kNm and 1.5 kN-m together with a bending moment that fluctuates between +2kNm and -1kNm. Selecting carbon steel C30 as material for the rod and choosing 2.5 as a value for the factor of safety, determine a safe value for 'd'. **(12 Marks)**

b. A rod of circular cross section with a diameter of 50mm is subjected to a compressive load of 20 kN together with a twisting moment of 1.5 kNm. The material of the rod is carbon steel C40. Determine the factor of safety as per the following theories of failure.

i) Maximum normal stress theory for failure.

ii) Maximum shear stress theory for failure. **(08 Marks)**

4 A power transmission shaft 1500mm long is supported at two points A and B. Where as A is at the left extreme end of the shaft, B is at a distance of 400mm from the right extreme end of the shaft. The shaft receives a power of 50kW at a rated speed of 500 rpm through a belt drive located at the right extreme end of the shaft. The belt pulley has a diameter of 400mm and weighs 1 kN. The belts moving on the pulley is directed away from the observer below the horizontal and inclined at 45^0 to it. The ratio of belt tensions is 3. This power is given out through a gear drive located at a distance of 500mm from the right support B. The gear mounted on the shaft has a pitch diameter of 200mm and weighs 400N. The other gear, which meshes, with this gear is placed exactly in front. The gear teeth have a pressure angle of 20^0. Selecting a suitable material and choosing an appropriate value of the factor of safety, determine the diameter of the solid circular shaft required for power transmission. **(20 Marks)**

5 a. Design a flexible flanged coupling to transmit a power of 50kW at a rated speed of 500rpm. **(12 Marks)**

b. A shaft of a motor is supported at two points which are 800mm apart. The armature of the motor can be considered as a uniformly distributed load of 15 N/mm, centrally spread over a length of 500mm. selecting a suitable material and choosing appropriate value for the factor of safety determine the diameter of the motor shaft. **(08 Marks)**

6 a. Prove that a square key is equally strong in shear and compression. **(05 Marks)**

b. The square thread of a screw jack with a specification of 80×16, with a double start is to raise a load of 100kN. The mean collar diameter is 130mm. The coefficient of friction for the threads and the collar are respectively 0.1 and 0.12. Determine :

i) The torque required to raise the load.

ii) The efficiency of the screw.

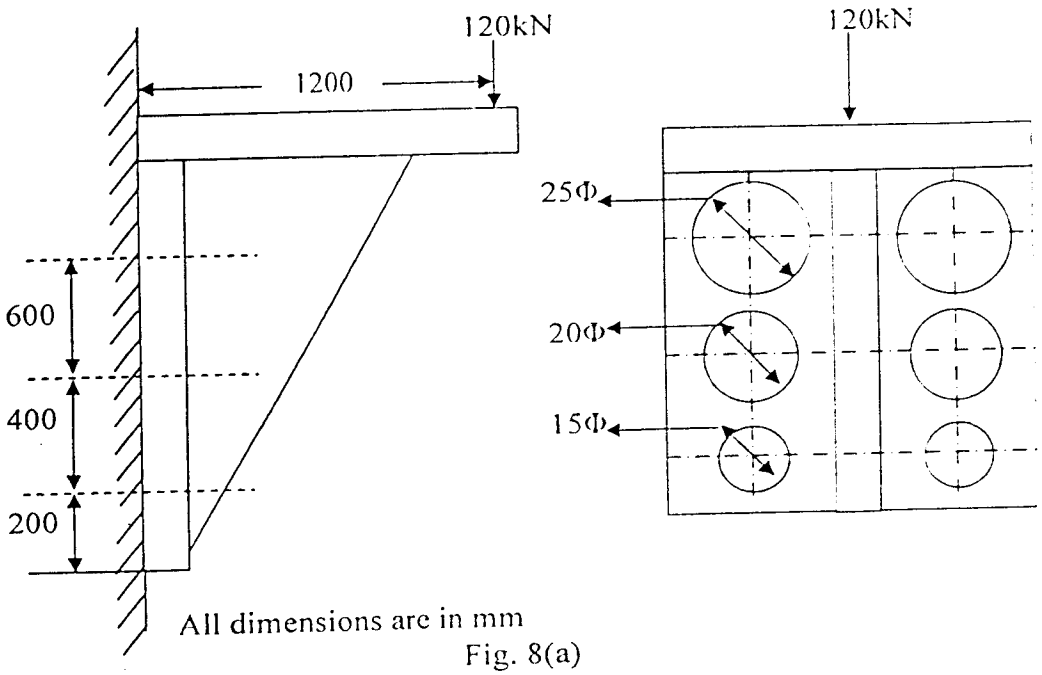
iii) Whether self locking exists. **(15 Marks)**

7 a. Design a cotter joint to join two round rods capable of sustaining an axial load of 100kN. **(10 Marks)**

b. Design a double riveted butt joint to join two plates of thickness 10mm. The allowable stresses for plate material in tension are equal to 120 MPa, in compression 160 MPa, in shear 80 MPa. The width of cover plates are equal. **(10 Marks)**

Contd... 3

8 a. **Determine the maximum stresses induced in the worst stressed rivet in a riveted joint loaded as shown in Fig. 8(a).** **(10 Marks)**



All dimensions are in mm

Fig. 8(a)

b. Determine the weld size for a welded joint as shown in Fig. 8(b). **(10 Marks)**

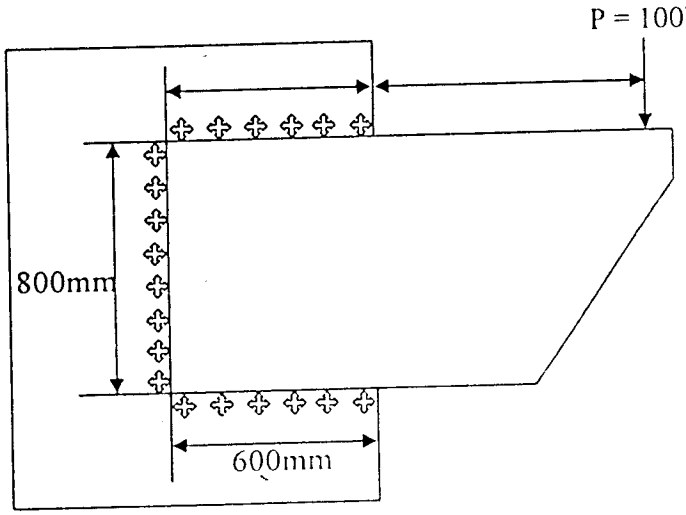


Fig. 8(b)

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AU46

USN

NEW SCHEME

Fourth Semester B.E. Degree Examination, Dec. 06 / Jan. 07
ME/IP/IM/MA/AU
Design of Machine Elements - I

Time: 3 hrs.] [Max. Marks:100

Note : *1. Answer any FIVE full questions.*
2. Use of design data hand book is permitted.
3. Wherever necessary data may be assumed giving reasons.

1 a. A circular shaft 50mm diameter fixed at one end is subjected to an axial load of 20 kN and a torque of 1.5 kN-m. If the length of the shaft is 300 mm, determine the nature and magnitude of stresses at the critical point. **(10 Marks)**

b. A weight of 5kN is being lowered with a velocity of 2m/sec with the help of a wire rope and a sheave. When the sheave stops suddenly after the weight has reached a distance of 15m, find the maximum stress in the rope. The area resisting the stress is 707 mm^2 and modulus of elasticity is 190 GPa. Neglect the inertia effect. **(10 Marks)**

2 a. A hot rolled bar has an yield strength of 390 MPa. Compute the factor of safety for the following theories of failure.
i) Maximum normal stress theory ii) Maximum shear stress theory and
iii) Distortion energy theory for the following state of stress.
a) $\sigma_1 = 225$ MPa , $\sigma_2 = 225$ MPa , $\sigma_3 = 0$
b) $\sigma_1 = 225$ MPa , $\sigma_2 = 120$ MPa , $\sigma_3 = 0$
c) $\sigma_1 = 225$ MPa , $\sigma_2 = 0$, $\sigma_3 = -120$ MPa. **(10 Marks)**

b. A rectangular plate with semi-circular groove of radius 12 mm (shown in fig.2 (b)) is subjected to i) A tensile force of 10 kN and ii) A bending moment of 15 N-m. Determine the maximum stress induced in the plate in each case. **(10 Marks)**

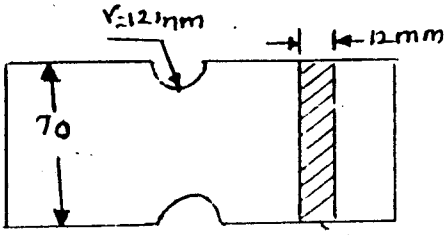

Fig. 2(b)

3 a. Derive the Soderberg relations. **(06 Marks)**

b. A SAE1025 water quenched steel rod ($\sigma_u = 620.8$ MPa, $\sigma_y = 400.1$ MPa, $\sigma_{-1} = 345.2$ MPa) of circular cross section, shown in fig. 3(b), is subjected to load varying from P to 3P. Determine the value of P. The stress concentration factor may be taken as 1.4. Analyse the member at the change of cross section. Use factor of safety = 3. Assume the surface to be rough finished. **(10 Marks)**

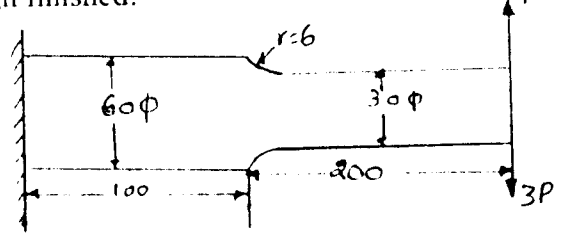

Fig. 3(b)

Contd...2

c. How is cumulative fatigue failure predicted? **(04 Marks)**

4 A steel shaft 950 mm long, supported between bearings 750 mm apart, has a cast iron pulley 600 mm diameter, weighing 800 N over hanging to the right of the bearing by 200 mm as in fig. 4. The pulley receives 25 kW at 1000 rpm from a belt drive, the belt inclined at 60^0 to the horizontal (inclined upwards). The power from the shaft is transmitted through a $14\frac{1}{2}^0$ spur pinion of diameter 200 mm to a spur gear mounted directly above the pinion. The pinion is keyed to the shaft at a distance of 150 mm to the right of the left bearing. Taking the ratio of the belt tension as 3:1, ultimate stress and yield stress for the material of the shaft as 500 MPa and 310 MPa respectively. Determine the diameter of the shaft. Use $K_b = 2$ and $K_t = 1.5$. **(20 Marks)**

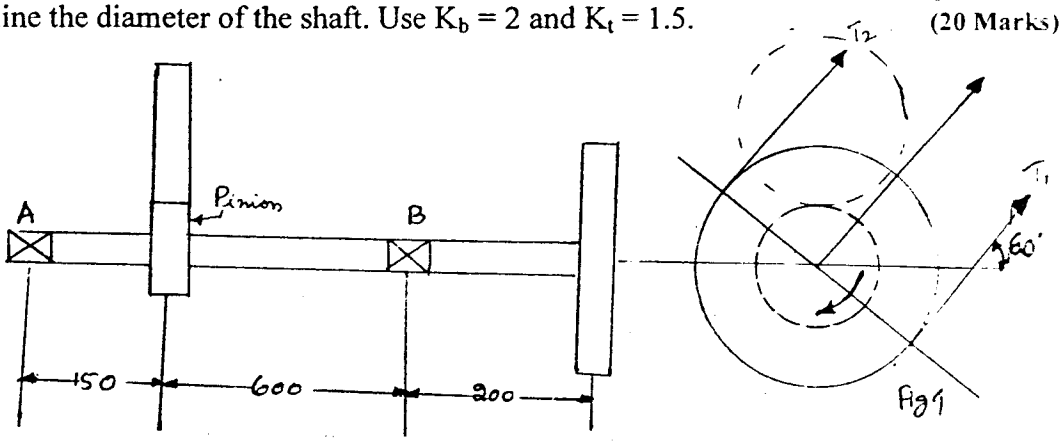

Fig. 4

5 Design a protected type C.I. flange coupling for a steel shaft transmitting 30 kW at 200 rpm. The allowable shear stress in the shaft and the key material is 40 MPa. The maximum torque transmitted is to be 20% greater than the full torque. The allowable shear stress in the bolts is 60 MPa and the allowable shear stress in C.I. flange is 40 MPa. Sketch the coupling indicating the salient dimensions. **(20 Marks)**

6 a. A bracket is bolted as shown in the fig. 6(a). All the bolts are identical and have a yield strength of 400 MPa. Determine size of the bolts, assuming a factor of safety of 3. **(10 Marks)**

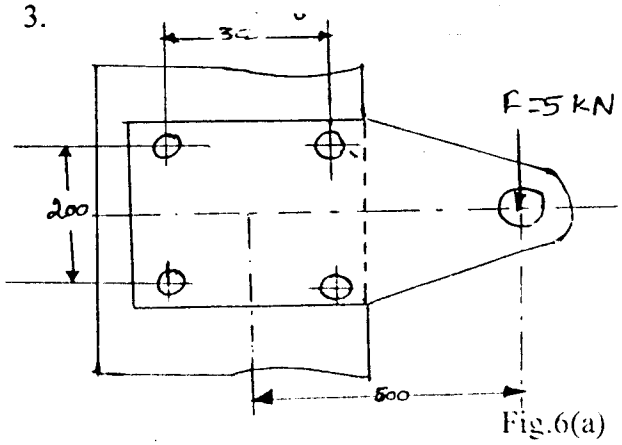

Fig.6(a)

b. A single threaded power screw has a major diameter restriction of 36 mm. Design the screw, if the frictional coefficient for thread and collar are 0.13 and 0.1 respectively. Estimate the power input to rotate the screw at 1 rpm, if the load to be lifted is 5 kN. **(10 Marks)**

Contd.. 3

7 a. Design and sketch the assembly of a Knuckle joint to connect two mild steel rods, subjected to an axial pull of 100 kN. The material selected for the joint has the following design stresses. $\sigma_t = 100$ MPa, $\sigma_c = 130$ MPa , $\tau = 60$ MPa. **(12 Marks)**

b. For the riveted joint shown in fig. 7(b), determine the size of the rivet taking permissible shear stress in rivets as 60 MPa. **(08 Marks)**

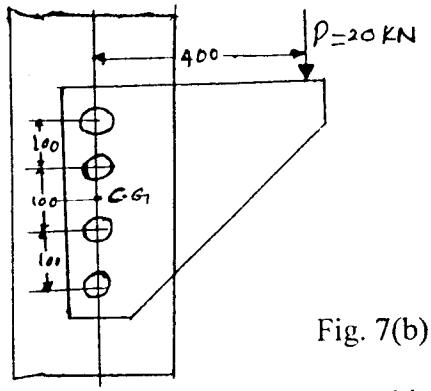

Fig. 7(b)

8 a. A 80 mm wide and 12 mm thick plate subjected to axial tensile load is welded to a vertical support by a single transverse fillet weld and a double parallel fillet weld as shown in fig. 8(a). The maximum tensile and shear stresses in the weld are 100 MPa and 70 MPa respectively. Find the length of each parallel weld, if the joint is subjected to i) Static loading and ii) Fatigue loading. **(10 Marks)**

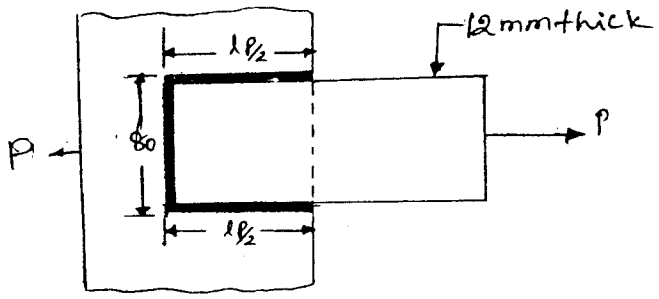

Fig.8(a)

b. Design triple riveted butt joint with double straps of equal width longitudinal butt joint for a boiler shell of 1.5 m diameter. The maximum steam pressure in the boiler is limited to 2.4 N/mm^2. The rivet pitch is to be same in all rows and chain riveting is to be used. The allowable stresses in tension, shear and crushing are 124 N/mm^2, 93 N/mm^2 and 165 N/mm^2 respectively. Assume that the rivets in double shear are 1.875 times stronger than in single shear. Take the corrosion allowance in thickness of plate as 1 mm. Sketch the joint with all the dimensions. **(10 Marks)**

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06ME/AU52

Fifth Semester B.E. Degree Examination, Dec 08 / Jan 09
Design of Machine Elements - I

Time: 3 hrs. Max. Marks:100

Note : ***1. Answer any FIVE full question, choosing atleast TWO questions from each Part.***
2. Use of design data hand book is permitted.

PART - A

1 a. Sketch and explain Biaxial and Tri-axial stresses, Stress Tensor and Principal stresses. **(08 Marks)**

b. A rectangular bar of section 50 × 25mm is subjected to a tensile load of 25kN. Determine the values of normal and shear stresses on a plane 30^0 with the vertical. Also calculate the magnitude and direction of the maximum shear stress. **(08 Marks)**

c. Briefly explain design codes and standards. **(04 Marks)**

2 a. State and explain theories of failure. **(06 Marks)**

b. Briefly explain the impact strength of a bar subjected to axial, bending and torsional loading. **(06 Marks)**

c. An infinite plate with an elliptical cutout having major axis 50mm and minor axis of 25mm, is subjected to tensile load F. Determine the stress concentration factor when i) the load is perpendicular to major axis ii) the load is parallel to the major axis. **(08 Marks)**

3 a. Explain the significance of Goodman and Soderberg relations. **(08 Marks)**

b. A rough finished steel rod having σ_u = 620 MPa, σ_y = 400 MPa, and σ_{-1} = 345 MPa is subjected to completely reversed bending moment of 400 N-m. Determine the diameter of the rod required based on a factor of safety of 2.5. **(12 Marks)**

4 a. Explain the stresses induced in a screw fastening subjected to static, dynamic and impact loading. **(12 Marks)**

b. A bolt subjected to initial loading of 5kN and final tensile load of 9kN. Determine the size of the both, if the allowable stress is 80 MPa and k = 0.05. **(08 Marks)**

PART – B

5 a. Compare the strength of a hollow shaft with that of a solid shaft for the same diameter and material. The diameter ratio of hollow shaft is 0.75. **(06 Marks)**

b. A steel shaft (C45) transmitting 15 kW at 210 rpm is supported between two bearings 1000mm, apart. On this, two spur gears are mounted. The gear having 80 teeth of module 6mm is located 100mm to the left of the right bearing and receives power from a driving gear such that the tangential force acts vertical. The pinion having 24 teeth and module 6mm is located 200mm to the right of the left bearing and delivers power to a gear mounted behind it. Taking combined shock and fatigue factors 1.75 in bending and 1.25 in torsion, determine the shaft diameter. **(14 Marks)**

6 a. A rigid coupling has four bolts on a pitch circle of 125mm diameter and is transmitting 20 kW power at 720 rpm. The bolts are made of carbon steel (C45) and has the factor of safety 3. Determine the diameter of the bolt. **(06 Marks)**

b. Design a bush pin type flexible coupling to transmit 25 kW at 500 rpm. Select suitable materials for shaft, key and bolts. **(14 Marks)**

7 a. Design a double riveted lap joint with chain riveting for a mild steel plates of 20mm thick taking the allowable values of stress in shear, tension and compression to 60, 90 and 120 MPa respectively. **(12 Marks)**

b. A mild steel plate of 15mm thickness is welded to another plate by two parallel welds to carry a load of 50 kN. Determine the length of weld required : i) load is static ii) load is dynamic. **(08 Marks)**

8 a. Explain self locking and over haul of screw jack. **(06 Marks)**

b. Design a screw jack for a capacity of 10 kN, to lift 200mm height. Select suitable materials and factor of safety. **(14 Marks)**

USN | | | | | | | | | | |

06ME52

Fifth Semester B.E. Degree Examination, June-July 2009
Design of Machine Elements - I

Time: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, selecting at least TWO questions from each part.***
2. Use of design data hand book is permitted.
3. Missing data should be suitably assumed and clearly stated.

PART – A

1 a. Write brief note on general procedure used in design. **(05 Marks)**

b. Explain the following theories of failure:
i) Maximum normal stress theory. ii) Distortion energy theory. **(05 Marks)**

c. A steel rod 1.5 meter long resists an impact load of 2 kN dropped through a distance of 50mm along its axis. Limiting the maximum stress in the rod to 150 MPa, determine i) The diameter of rod required ii) Impact factor. Use E = 200 GPa. **(10 Marks)**

2 a. Explain the following:
i) Notch sensitivity ii) Stress concentration factor. **(05 Marks)**

b. A bolt in an assembly is subjected to a pull of 1000N along its axis and a shear force of 500N, what will be the maximum stress induced in the bolt. If the bolt is made of SAE 1045 annealed steel, is the bolt is safe given that the diameter of bolt is 12mm. **(07 Marks)**

c. A 50mm diameter steel rod supports a 9000N load and in addition is subjected to torsional moment of 100 N-m. Determine the maximum normal and the maximum shear stresses. **(08 Marks)**

3 a. Explain endurance limit and endurance strength with the help of S.N. diagram. **(05 Marks)**

b. A hot rolled steel rod is subjected to a torsional load that varies from +330 N-m clockwise to 110 N-m counter clockwise and an applied bending moment varies from +440 N-m to –220 N-m. The rod is of uniform cross-section. Determine the required rod diameter. The material has an ultimate tensile strength of 550 MPa and a yield strength of 410 MPa. Design based on a factor of safety of 1.5. Take the endurance limit as half the ultimate strength. **(15 Marks)**

4 a. A machine component is subjected to a bending load which is completely cyclic as shown in Fig.4(a). Determine the suitable value of load W. If the maximum stress induced is not to exceed 100 N/mm^2, take σ_y = 250 N/mm^2 and σ_{end} = 200 N/mm^2. **(10 Marks)**

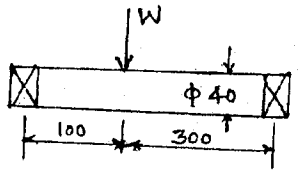

Fig.4(a)

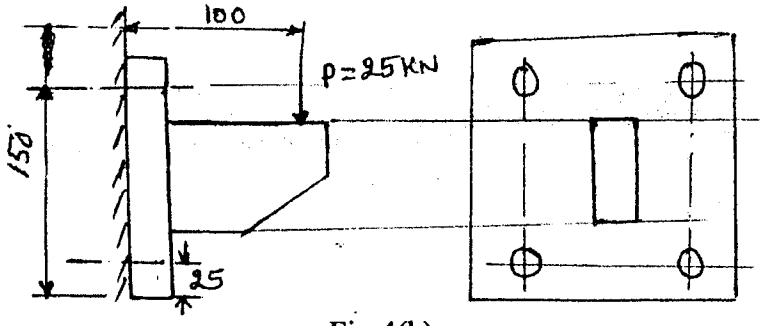

Fig.4(b)

b. A bracket is fixed to the wall by means of four bolts and loaded as shown in Fig.4(b). Calculate the size of the bolts if the load is 25 kN and the yield stress is 380 N/mm^2. The factor of safety is taken as 2.5. Use maximum shear stress theory. **(10 Marks)**

PART – B

5 A shaft supported between bearing 400mm apart gets its drive through a gear drive. A gear is mounted 200mm to the right of the left hand bearing and is driven by a pinion just above it. The gear has a module of 10mm, number if teeth is equal to 40 and pressure angle ϕ=20°, the power received is 20kW at 500 rpm. Overhanging to the right hand bearing by 200mm there is a pulley of diameter 200mm, the belt drive is inclined at an angle of 30° with the vertical and is away from the shaft. The ratio of belt tension is taken as 3:1. Design a shaft assuming that the allowable stress as 100 N/mm^2 in tension and 40 N/mm^2 in shear, for suddenly applied loads with minor shocks. **(20 Marks)**

6 a. A 45mm diameter, shaft is made of steel with a yield strength of 40 MPa. A parallel key of size 14mm wide and 9mm thick, made of steel with a yield strength of 340 MPa. Find the required length of key, if the shaft in loaded to transmit the maximum permissible torque. Design based on maximum shear stress theory and take factor of safety as 2. **(06 Marks)**

b. Design a bushed-pin type flexible coupling to connect a pump shaft to a motor shaft transmitting 32 kW at 960 rpm. The overall torque is 20 percent more than mean torque. The material properties are as follows:

i) The allowable shear and crushing stress for shaft and key material is 40 MPa and 80 MPa respectively.
ii) The allowable shear stress for cast iron is 15 MPa.
iii) The allowable bearing pressure for rubber bush is 0.8 N/mm^2.
iv) The material of the pin is same as that of shaft and key. **(14 Marks)**

7 a. A pulley has been fabricated by welding the rim of pulley to the annular web plate by a weld of size 3mm×3mm, where as hub is welded to the web plate by 5mm×5mm weld. Determine safe power that can be transmitted by this pulley and welded pulley considering only welded joint. [Refer Fig.7(a)]. **(10 Marks)**

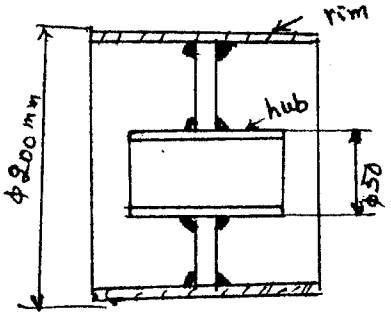

Fig.7(a)

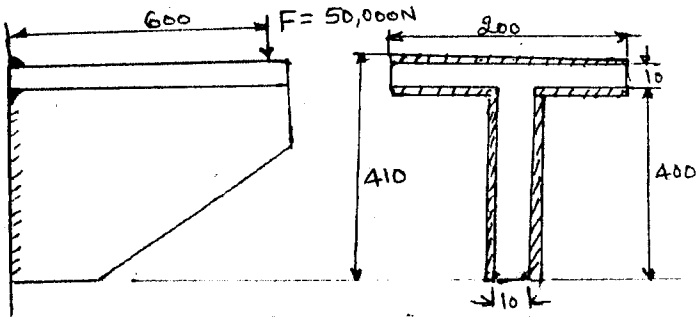

Fig.7(b)

b. An eccentric loaded connection is as shown in Fig.7(b). Determine the size of weld, if maximum shear stress induced in weld is not exceed 75 N/mm^2. **(10 Marks)**

8 a. A tie bar in a bridge consists of a plate 350mm wide and 20mm thick. It is connected by a plate of same thickness by a cover butt joint. Design an economical structural joint, if permissible stresses are, tensile stress 90 N/mm^2, shear stress 60 N/mm^2, Compressible stress 150 N/mm^2. **(10 Marks)**

b. A triple-threaded power screw is used in a screw jack, has a nominal diameter of 50 mm and a pitch of 8mm. The threads are square shape and the length of the nut is 48 mm. The screw jack is used to lift a load of 7.5 kN. The coefficient of friction at the threads is 0.12 and the collar friction is negligible. Calculate

i) The principle shear stresses in the screw rod.
ii) The transverse shear stress in the screw and nut.
iii) The bearing pressure for threads and
iv) State whether the screw is self locking. **(10 Marks)**

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06ME52

Fifth Semester B.E. Degree Examination, Dec.09/Jan.10
Design of Machine Elements - I

me: 3 hrs. Max. Marks:100

Note: ***1. Answer any FIVE full questions, choosing at least two from each part.***
2. Use of machine design data hand book is permitted.

PART-A

1.a. A point in a structural member subjected to plane stress is shown in Fig. Q1(a). Dtrmine the following :
i) Normal and tangential stress intensities on a plane inclined at 45°.
ii) Principle stresses and their directions.
iii) Maximum shear stress and the direction of plane on which they occur. **(10 Marks)**

b. A steel shaft is subjected to a bending moment of 9 kN m and a twisting moment of 12 kNm. The yield strength of steel is 360 MPa in tension and compression and the Poisson's ratio is 0.3. If a factor of safety of 2 with respect to failure is specified, determine the permissible diameter of the shaft according to –
i) Maximum shear stress theory of failure
ii) Maximum normal stress theory of failure
iii) Maximum distortion theory of failure. **(10 Marks)**

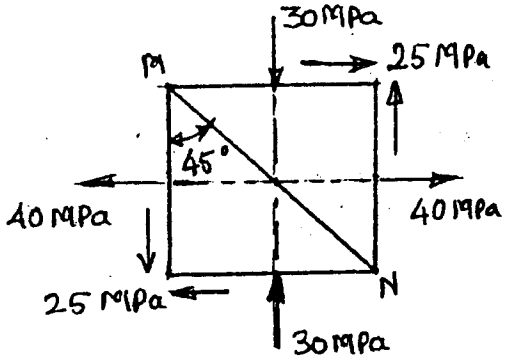

Fig. Q1(a)

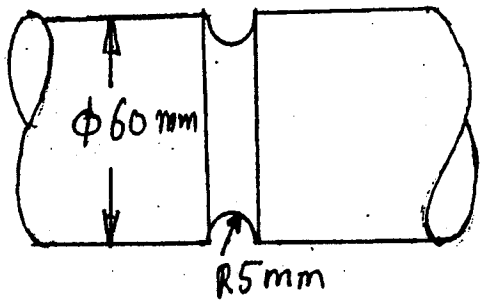

Fig. Q2(a)

2.a. Determine the maximum stress induced in the semi circular grooved shaft shown in Fig. Q 2(a), if it is subjected to –
i) An axial load of 40 kN ii) A bending moment of 400 N m iii) A twisting moment of 500 Nm. Take the stress concentration into account. **(10 Marks)**

b. A weight 600 N drops through a height of 20 mm and impacts the center of 300 mm long simply supported circular cross section beam. Find the diameter of the beam and the maximum deflection, if the allowable stress is limited to 90 MPa. Neglect the inertia effect and take E = 200 GPa. **(10 Marks)**

3. A ground steel cantilever member shown in Fig. Q3 is subjected to a transverse load at its free end that varies from 100 N up to 200 N down as an axial load varies from 500 N compressions to 1000 N tension. Determine the required diameter of the section using a factor of safety 2. The strength properties of the material are : ultimate strength = 550 MPa, yield strength = 480 MPa and endurance limit = 270 MPa. **(20 Marks)**

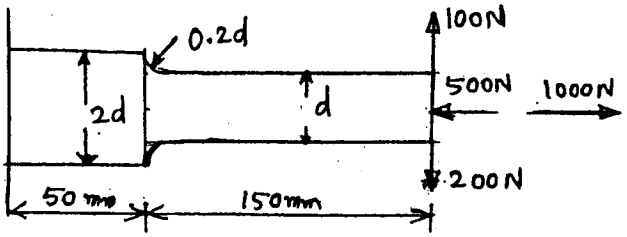

Fig. Q3

4 a. The cylinder head of a reciprocating air compressor is held in place by ten bolts. The total joint stiffness is four times the total bolt stiffness. Each bolt is tightened to an initial tension of 5 kN. The total external force acting to separate the joint is 20 kN. Find the size of the bolts so that the stress in bolts in not to exceed 100 MPa. **(08 Marks)**

b. A radial drilling machine with circular base is mounted to a base plate by means of three steel bolts equally spaced on a bolt circle diameter of 0.3m. The diameter of the circular base is 0.4m. The spindle is positioned at a radial distance of 0.335 m from the centre of the column. During drilling operation, the spindle is subjected to a force of 4.5 kN. Determine the size of the bolts, if the allowable stress in bolt material is limited to 100 MPa. **(12 Marks)**

PART-B

5 A shaft is supported between two bearings located 0.6 m apart. Gear 'A' of pitch circle diameter 0.1 m is keyed to the shaft 0.1m to the right of the left bearing. Gear 'B' of 0.15 m diameter is keyed to the shaft 0.3 m to the right of the left bearing. Another gear 'C' of pitch circle diameter 0.08 m is keyed to the shaft 0.1m to the left of the right bearing. Gear 'B' receives 10 kW power at 500 rpm from a mating gear mounted directly below it. Gear 'A' delivers 6 kW power to another gear mounted directly infront of it, such that the tangential force acts vertically upwards. The gear 'C' delivers the remaining power to its mating gear mounted directly behind it, such that the tangential force acts vertically downwards. All gears are of 20° full depth involute form. The shaft is made of steel which has an ultimate strength of 510 MPa and a yield strength of 330 MPa. Determine the required diameter of the shaft under steady load condition using ASME code. **(20 Marks)**

6 a. Design a knuckle joint to connect two mild steel rods to sustain an axial pull of 150 kN. The pin and the rods are made of same material. Assume the working stresses in the material as 80 MPa in tension, 40 MPa in shear and 120 MPa in crushing. **(10 Marks)**

b. Design a bushed pin type flexible coupling to connect a motor shaft to a pump shaft transmitting 20 kW power at 1440 rpm. The allowable shear and crushing stress for steel shafts, keys and pins are 40 MPa and 80 MPa respectively. The allowable shear stress for the cast iron flange is 10 MPa and the allowable bearing pressure for rubber bush is 0.5 MPa. **(10 Marks)**

7 a. Design a longitudinal double riveted double strap butt joint with unequal straps for a pressure vessel. The internal diameter of the pressure vessel is 1 m and is subjected to an internal pressure of 2.2 N/mm^2. The pitch of the rivet in the outer row is to be double the pitch in the inner row. The allowable tensile stress in the plate is 124 N/mm^2. The allowable shear and crushing of the rivets are 93 N/mm^2 and 165 N/mm^2 respectively. The resistance of the rivets in double shear is to be taken as 1.875 times that of single shear. **(10 Marks)**

b. One end of a rectangular bar of 120 mm × 70 mm cross section is welded to a vertical support by four fillet welds along its circumstance. A steady transverse load of 10 kN is applied at the free end of the bar of length 160 mm and is parallel to 120 mm side. Determine the size of the weld, if the allowable stress in the material is limited to 115 Mpa. **(10 Marks)**

8 a. Explain overhauling of screws. Derive the condition for self locking of square thread with collar friction. **(05 Marks)**

b. A single start square threaded power screw is used to raise a load of 120 kN. The screw has a mean diameter of 24 mm and four threads per 24 mm length. The mean collar diameter is 40 mm. The coefficient of friction is estimated as 0.1 for both the thread and the collar.

i) Determine the major diameter of the screw
ii) Estimate the screw torque required to raise the load
iii) Estimate over all efficiency
iv) If collar friction is eliminated, what minimum value of thread coefficient is needed to prevent the screw from overhauling? **(15 Marks)**

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06ME52

Fifth Semester B.E. Degree Examination, May/June 2010
Design of Machine Elements - I

Time: 3 hrs. Max. Marks:100

Note: ***1.Answer any FIVE full questions, selecting at least TWO questions from each part.***
2.Use of design data hand book is permitted.

PART – A

1 a. Sketch and explain, biaxial and tri-axial stresses, stress tensor and principal stresses. **(06 Marks)**

b. The state of stress at a point in a structural member is shown in Fig.Q1(b). The tensile principal stress is known to be 84 N/mm^2. Determine i) the maximum shearing stress at the point and orientation of its plane ii) the shearing stress τ_{xy}. **(10 Marks)**

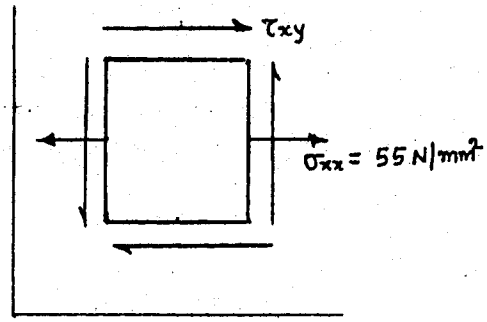

Fig.Q1(b)

c. Briefly discuss the factors influencing the selection of suitable material for machine element. **(04 Marks)**

2 a. A round rod of diameter 30mm is to sustain an axial compressive load of 20 kN and twisting moment of 1.5 kN.m. The rod is made of carbon steel C40 (σ_{yt}=328.6 MPa). Determine the factor of safety as per following theories of failure:
i) Maximum principal strain theory.
ii) Maximum elastic strain energy theory. **(08 Marks)**

b. A flat plate subjected to a tensile force of 5 kN is shown in Fig.Q2(b). The plate material is grey cost iron having σ_u value of 200 MPa. Determine the thickness of the plate. Factor of safety is 2.5 **(08 Marks)**

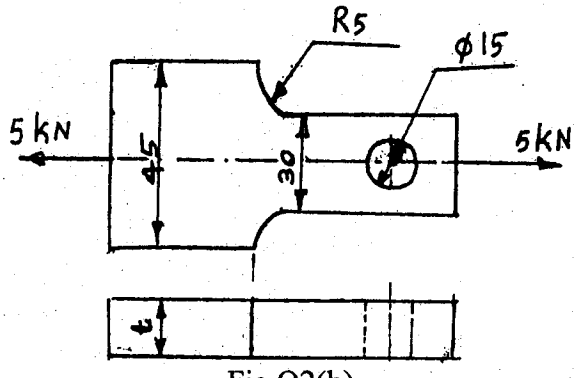

Fig.Q2(b)

c. Determine the maximum torsional impact that can withstand, without permanent deformation by a 100mm cylindrical shaft 5 m long and made of SAE 1045 annealed steel (τ_y = 180 MPa and G = 82 GPa). Factor of safety = 3. **(04 Marks)**

3 a. Derive the Soderberg's equation

$$\frac{1}{N}=\frac{\sigma_m}{\sigma_y}+K_{f_t}\frac{\sigma_a}{A\cdot B\cdot C\cdot\sigma_{en}}$$

where A is surface finish factor, B is size factor and C is the load factor. **(06 Marks)**

b. A hot rolled steel shaft is subjected to a torsional moment that varies from 330 Nm (clockwise) to 110 Nm (counter clockwise) as the applied bending moment at the critical section varies from +440 Nm to –220 Nm. The shaft is of uniform cross section and no key way is present at the critical section. Determine the required shaft diameter. The material has an ultimate strength of 550 MPa and yield strength of 410 MPa. Take the endurance limit as half the ultimate strength, factor of safety = 2, size factor of 0.85 and a surface finish factor of 0.62. **(14 Marks)**

4 a. An M20×2 steel bolt, 100mm long is subjected to an impact load. The energy absorbed by the bolt is 2 N.m. Take E = 206 GPa.

i) Determine the stress in the shank of the bolt if there is no threaded portion between the nut and the bolt head.

ii) Determine the stress in the shank if the entire length of the bolt is threaded. **(08 Marks)**

b. Determine the size of the bolts for the loaded bracket shown in Fig.Q4(b), if the allowable tensile stress in the bolt material is limited to 80 MPa. **(12 Marks)**

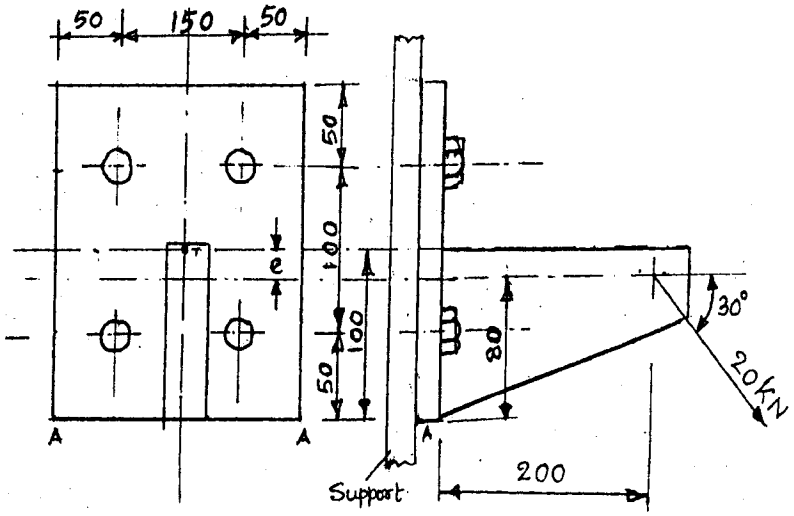

Fig.Q4(b)

PART – B

5 A power transmission shaft 1800 mm long, is supported at two points A and B. Whereas A is at a distance of 300 mm from the left extreme end of the shaft, B is at the right extreme end. A power of 50 kN is received at 500 rpm, through a gear drive located at the left extreme end of the shaft. The gear mounted on the shaft here, has a pitch diameter of 300 mm and weighs 700 N. The driver gear is located exactly behind. 30 kW of this power is given out through a belt drive located at a distance of 600 mm from the left support. The pulley mounted on the shaft has a diameter of 400 mm and weighs 1000N. The belt is directed towards the observer below the horizontal and inclined 45° to it. The ratio of belt tensions is 3. The remaining power is given out through a gear drive located at a distance of 400 mm from the right support. The driver gear has a pitch diameter of 200 mm and weighs 500 N. The driven gear is located exactly above. Selecting C40 steel (σ_y = 328.6 MPa) and assuming factor of safety 3, determine the diameter of a solid shaft for the purpose. Take k_b = 1.75 ; k_t = 1.5 & pressure angle ϕ = 20° for both the gears. **(20 Marks)**

6 a. Design a protected type cast iron flange coupling for a steel shaft transmitting 30 kW at 200 rpm. The allowable shear stress in the shaft and key material is 40 MPa. The maximum torque transmitted to be 20% greater than the full load torque. The allowable shear stress in the bolt is 60 MPa and allowable shear stress in the flange is 40 MPa. **(10 Marks)**

b. Design a sleeve type cotter joint, to connect two tie rods, subjected to an axial pull of 60 kN. The allowable stresses of C30 material used for the rods and cotters are $\sigma_t = 65$ N/mm^2; $\sigma_c = 75$ N/mm^2; $\tau = 35$ N/mm^2 ; cast steel used for the sleeve has the allowable stresses $\sigma_t = 70$ N/mm^2; $\sigma_c = 110$ N/mm^2; $\tau = 45$ N/mm^2 . **(10 Marks)**

7 a. The lengths of a flat tie bar, 15mm thick, are connected by a butt joint with equal cover plates on either side. If 400 kN is acting on the tie bar, design the joint, such that the section of the bar is not reduced by more than one rivet hole. Working stresses for the material of the bar are 85 MPa in tension, 60 MPa in shear and 110 MPa in crushing. **(10 Marks)**

b. A 16mm thick plate is welded to a vertical support by two fillet welds as shown in Fig.Q7(b). Determine the size of weld, if the permissible shear stress for the weld material is 75 MPa. **(10 Marks)**

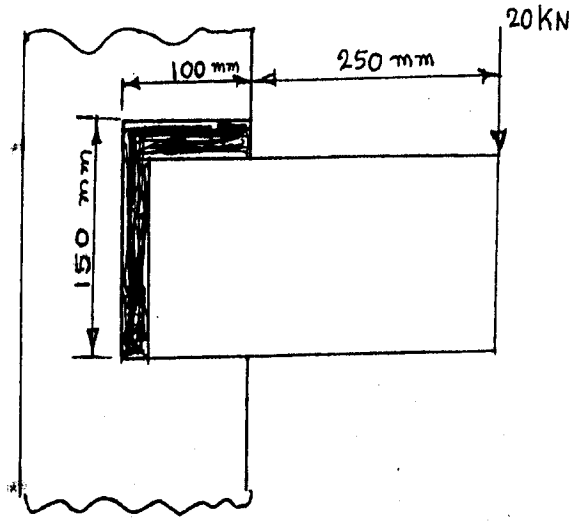

Fig.Q7(b)

8 a. Explain self locking and overhauling in power screws. **(04 Marks)**

b. A screw jack is to lift a load of 80 kN through a height of 400 mm. Ultimate strengths of screw material in tension and compression are 200 N/mm^2 and in shear it is 120 N/mm^2. The material for the nut is phosphor bronze for which the ultimate strength is 100 N/mm^2 in tension, 90 N/mm^2 in compression and 80 N/mm^2 in shear. The bearing pressure between the nut and the screw is not to exceed 18 N/mm^2. Design the screw and the nut and check for the stresses. Take FOS = 2. Assume 25% overload for the screw rod design. **(16 Marks)**

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