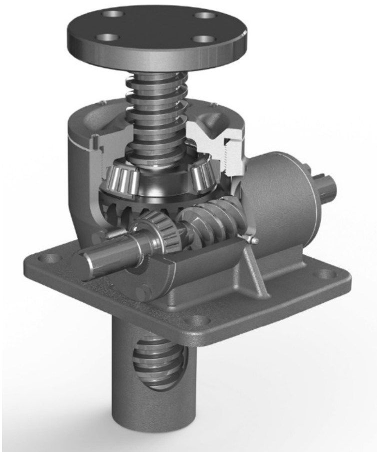
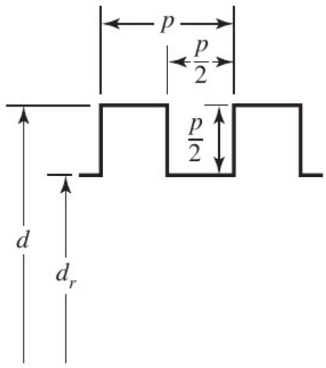
ME423 – Tutorial 7/ HW 7 – Due 22nd November

You have to submit all the problems by 11.00 pm, 22/11/2024 [Moodle].

1. A square-thread power screw has a major diameter of 32 mm and a pitch of 4 mm with double threads, and it is to be used in an application similar to that in the following figure.

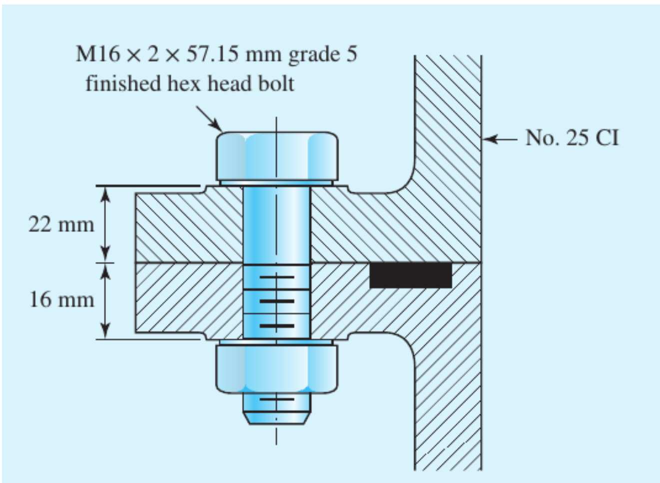




The given data include $\mu = \mu_c = 0.08$, $d_c = 40$ mm, and $F = 6.4$ kN per screw.
(a) Find the thread depth, thread width, mean diameter, minor diameter, and lead.
(b) Find the torque required to raise and lower the load.
(c) Find the efficiency during lifting the load.
(d) Find the body stresses, torsional and compressive.
(e) Find the bearing stress on the first thread.
(f) Find the thread bending stress at the root of the first thread.
(g) Determine the von Mises stress at the critical stress element where the root of the first thread interfaces with the screw body.

2. Find the bolt spring rate of M12 × 1.25 × 38.1 mm (property class 8.8) bolt.

3. The figure shown below is a cross section of a grade 25 cast-iron pressure vessel.



A total of N bolts are to be used to resist a separating force of 160 kN.

(a) Determine k_b, k_m, and C. You can estimate k_m using the following equation presented by Wileman et al.

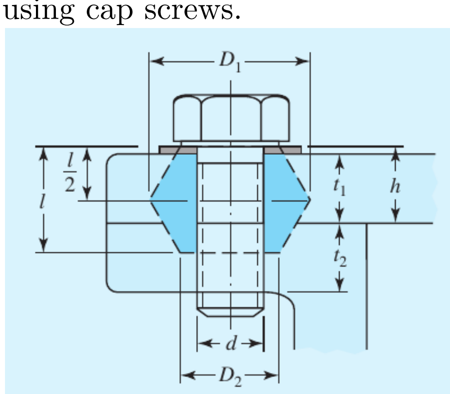
$$\frac{k_m}{Ed} = A\exp(Bd/l)$$

This equation is valid only if the entire joint is made of the same material. Here E is the Young's modulus, d is the mean bolt diameter and l is the grip length. For the given joint: E = 100 GPa, A = 0.77871, B = 0.61616.

(b) Find the number of bolts required for a load factor of 2 where the bolts may be reused when the joint is taken apart.

(c) With the number of bolts obtained in part (b), determine the realized load factor for overload, the yielding factor of safety, and the load factor for joint separation.

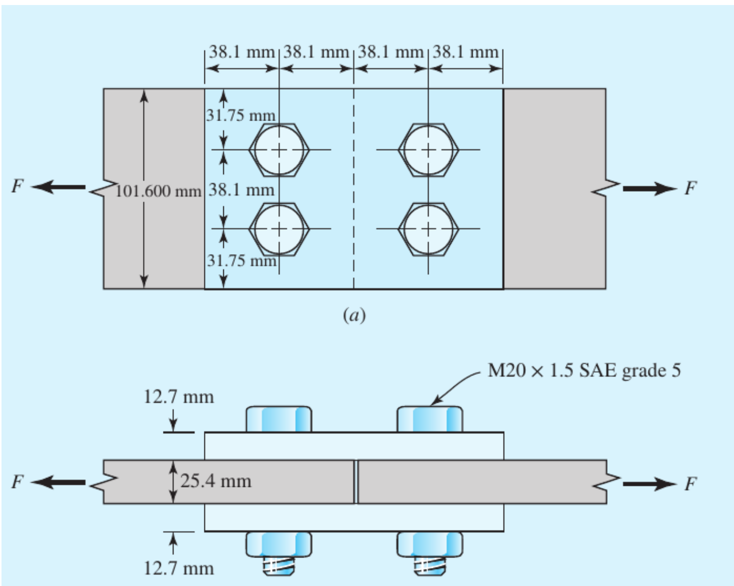
4. Figure shows a connection using cap screws.



The joint is subjected to a fluctuating force whose maximum value is 22.24 kN per screw. The data for the cap screw is M16 × 2, (property class 8.8). The bolt stiffness k_b is 1.28 MN/mm while the member stiffness, k_m, is 3.07 MN/mm.

(a) Find all factors of safety – yield, overload, separation, fatigue.

5. Two 25.4 by 101.6 mm 1018 cold-rolled steel bars are butt-spliced with two 12.7 by 101.6 mm 1018 cold-rolled splice plates using four M20 × 1.5 mm (property class 8.8) bolts as depicted in Figure 8–26. For a design factor of nd = 1.5 estimate the static load F that can be carried if the bolts lose preload.

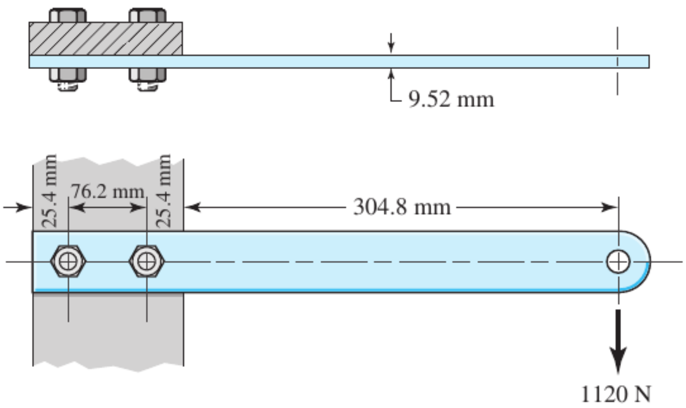


6. A M20 $\times$ 1.5 $\times$ 63.5 mm (property class 5.8) bolt is subjected to a load P of 26.69 kN in a tension joint. The initial bolt tension is $F_i = 111.205$ kN. The bolt and joint stiffnesses are $k_b = 1.14$ and $k_m = 2.42$ MN/mm, respectively.

(a) Determine the preload and service load stresses in the bolt. Compare these to the SAE minimum proof strength of the bolt.

(b) Specify the torque necessary to develop the preload. Specify the torque necessary to develop the preload.

7. A 9.52 $\times$ 50.8 mm AISI 1018 cold-drawn steel bar is cantilevered to support a static load of 1120 N as illustrated. The bar is secured to the support using two M10x1.5 (property class 5.8). Assume the bolt threads do not extend into the joint. Find the factor of safety for the following modes of failure: shear of bolt, bearing on bolt, bearing on member, and strength of member.



Nominal Major Diameter d mm	Coarse-Pitch Series: Pitch p mm	Coarse-Pitch Series: Tensile-Stress Area A_t mm^2	Coarse-Pitch Series: Minor-Diameter Area A_r mm^2	Fine-Pitch Series: Pitch p mm	Fine-Pitch Series: Tensile-Stress Area A_t mm^2	Fine-Pitch Series: Minor-Diameter Area A_r mm^2
1.6	0.35	1.27	1.07			
2	0.40	2.07	1.79			
2.5	0.45	3.39	2.98			
3	0.5	5.03	4.47			
3.5	0.6	6.78	6.00			
4	0.7	8.78	7.75			
5	0.8	14.2	12.7			
6	1	20.1	17.9			
8	1.25	36.6	32.8	1	39.2	36.0
10	1.5	58.0	52.3	1.25	61.2	56.3
12	1.75	84.3	76.3	1.25	92.1	86.0
14	2	115	104	1.5	125	116
16	2	157	144	1.5	167	157
20	2.5	245	225	1.5	272	259
24	3	353	324	2	384	365
30	3.5	561	519	2	621	596
36	4	817	759	2	915	884
42	4.5	1120	1050	2	1260	1230
48	5	1470	1380	2	1670	1630
56	5.5	2030	1910	2	2300	2250
64	6	2680	2520	2	3030	2980
72	6	3460	3280	2	3860	3800
80	6	4340	4140	1.5	4850	4800
90	6	5590	5360	2	6100	6020
100	6	6990	6740	2	7560	7470
110				2	9180	9080

Table 8–11 **Metric Mechanical-Property Classes for Steel Bolts, Screws, and Studs**

Property Class	Size Range, Inclusive	Minimum Proof Strength,* MPa	Minimum Tensile Strength,* MPa	Minimum Yield Strength,* MPa	Material	Head Marking
4.6	M5–M36	225	400	240	Low or medium carbon	4.6
4.8	M1.6–M16	310	420	340	Low or medium carbon	4.8
5.8	M5–M24	380	520	420	Low or medium carbon	5.8
8.8	M16–M36	600	830	660	Medium carbon, Q&T	8.8
9.8	M1.6–M16	650	900	720	Medium carbon, Q&T	9.8
10.9	M5–M36	830	1040	940	Low-carbon martensite, Q&T	10.9
12.9	M1.6–M36	970	1220	1100	Alloy, Q&T	12.9