

School of Engineering

**1E10 Assignment.**

**A3. Structural Engineering Component**

**Design against failure under *static* actions**

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Question 1.

Given: d = 0.00604m, L=0.3m and P = 41N.

Formula: , where is the failure stress, P is the failure load, L is the span length, and d is the diameter of the timber beam.

Failure stress = 1.42 x 108 N/m2

Question 2.

Formula:

|  |  |  |  |
| --- | --- | --- | --- |
| **σf (N/m2)** | **d (m)** | **L (m)** | **P (N)** |
| 1.42E+08 | 0.00604 | 0.20 | 61.50 |
| 1.42E+08 | 0.00604 | 0.25 | 49.20 |
| 1.42E+08 | 0.00604 | 0.30 | 41.00 |
| 1.42E+08 | 0.00604 | 0.35 | 35.14 |
| 1.42E+08 | 0.00604 | 0.40 | 30.75 |
| 1.42E+08 | 0.00604 | 0.45 | 27.33 |
| 1.42E+08 | 0.00604 | 0.50 | 24.60 |
| 1.42E+08 | 0.00604 | 0.55 | 22.36 |
| 1.42E+08 | 0.00604 | 0.60 | 20.50 |
| 1.42E+08 | 0.00604 | 0.65 | 18.92 |
| 1.42E+08 | 0.00604 | 0.70 | 17.57 |
| 1.42E+08 | 0.00604 | 0.75 | 16.40 |
| 1.42E+08 | 0.00604 | 0.80 | 15.38 |

From this plot we observe that increasing the span length reduces the load that the timber beam is capable of supporting. Although the effects of increasing the span length are not linearly proportional to the reduction in failure load, instead the curve starts to level off, indicating that further increases in span length will not cause significant reductions in failure load.

Question 3.

Formula:

|  |  |  |  |
| --- | --- | --- | --- |
| **σf (N/m2)** | **d (m)** | **L (m)** | **P (N)** |
| 142145923.7 | 0.002 | 0.3 | 1.488548632 |
| 142145923.7 | 0.0025 | 0.3 | 2.907321546 |
| 142145923.7 | 0.003 | 0.3 | 5.023851632 |
| 142145923.7 | 0.0035 | 0.3 | 7.977690323 |
| 142145923.7 | 0.004 | 0.3 | 11.90838905 |
| 142145923.7 | 0.0045 | 0.3 | 16.95549926 |
| 142145923.7 | 0.005 | 0.3 | 23.25857237 |
| 142145923.7 | 0.0055 | 0.3 | 30.95715982 |
| 142145923.7 | 0.006 | 0.3 | 40.19081306 |
| 142145923.7 | 0.0065 | 0.3 | 51.0990835 |
| 142145923.7 | 0.007 | 0.3 | 63.82152258 |
| 142145923.7 | 0.0075 | 0.3 | 78.49768175 |
| 142145923.7 | 0.008 | 0.3 | 95.26711243 |

From this plot we observe that increasing the diameter of the timber beam increases the load that the timber beam is capable of supporting. Again the effects of increasing the diameter are not linearly proportional to the increase in failure load, but with this curve, further increases in diameter correspond to large increases in the failure load.

Question 4.

Given: d=0.009m, L = 0.5m, = 1.42 x 108 N/m2 (from Q.1)

Formula:

Theoretical Fail Load = 81.39 N.

Actual Fail Load = 80 N.

Difference 1.39 N.

This discrepancy can arise for a number of reasons. There may have been errors in the measurements, particularly when it came to the measurement of the diameter. It is given as 9 mm but it is very hard to measure in fractions of a millimetre, and in this case, an error of -0.05 mm (0.00005m), would case the failure load to drop to 80.04N.

Errors could also have arisen in the measurement of the span length. Or the load applied may not have been completely accurate, although personally I feel that the most likely cause was an error in the measurement of the diameter.

Question 5.

Given: L = 0.24 m, P = 120 N, = 1.42 x 108 N/m2 (from Q.1)

Formula:

Optimum diameter d = 12.73 mm (0.01273 m)

The diameter of the throwing arm provided = 28 mm  
So the diameter of the throwing arm provided is adequate to resist the peak static force of 120 N.

Question 6. (a)

Given: P = 120 N, d = 2.4mm

→ r = 1.2mm

Formulae: , where A is the cross sectional area of the cable.

, where σ is the axial stress.

Area A = 4.52 mm2

Axial Stress σ = 26.53 N/mm2

This axial stress is much lower than the axial failure stress (given as 75 x 106 N/mm2) and so it is clear that the cable can resist the force without breaking.

Question 6. (b)

Given: σ = 10 x 106 N/m2, P = 120 N.

Formulae: ,

,

d = 2r.

Area A = 0.000006 m2

Radius r = 1.382 mm (0.001382 m)

Minimum diameter d = 2.764 mm (0.002764 m)

The dowel diameter of our Mangonel is 28mm, which is much larger than the minimum diameter required to resist the force of 120N without failing in shear.

Question 7.

|  |  |  |
| --- | --- | --- |
| **Material** | **Modulus of elasticity E (GPa)** | **Shear modulus of elasticity G (GPa)** |
| Aluminium Alloys | 70-79 | 26-30 |
| Copper and Copper Alloys | 110-120 | 40-47 |
| Plastics - Nylon | 2.1-3.4 | - |
| Plastics - Polyethylene | 0.7-1.4 | - |
| Steel | 190-210 | 75-80 |
| Wood | 11-14 | - |