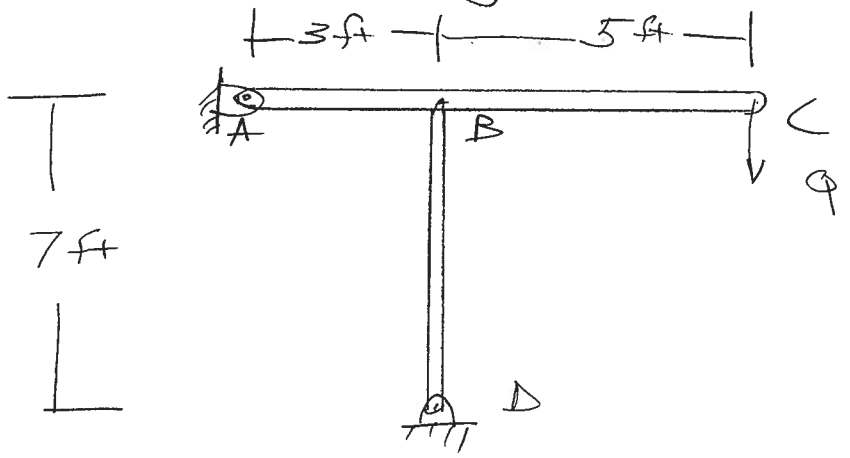
A horizontal beam ABC is pin-supported at A and carries a load, Q, at end C as shown. The beam is supported at B by a round steel column with a diameter of 4in. The modulus of elasticity of the steel is 30×10^6 psi and the yield strength is 40,000 psi. What is the maximum load that may be applied to point C if there is to be a factor of safety 2.0 against failure of the column by yielding or buckling.



First we will determine the maximum allowable compressive load on the column.

Check yielding criteria

(1) $A_{column} = \pi (2)^2 = 12.57 \text{ in}^2$

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(2) $\sigma_{Allow} = \frac{\sigma_{yield}}{F.S}$

(3) $\sigma_{Allow} = \frac{40000\ psi}{2}$

(4) $\sigma_{Allow} = 20,000\ psi$

(5) $P_{Allow} = \sigma_{Allow} A_{column}$

(6) $P_{Allow} = (20,000\ psi)(12.57 in^2)$

(7) $P_{Allow} = 251,400\ lb$

Check Buckling Criteria

(8) $I = \frac{\pi}{4} r^4$

(9) $I = \frac{\pi}{4}(2)^4$

(10) $I = 12.57\ in^4$

It is just a coincidence the $I = A$. Usually this will not happen.

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(11) $$P_{cr} = \frac{\pi^2 EI}{\ell^2}$$

(12) $$P_{cr} = \frac{\pi^2 \left(30 \times 10^6 \frac{lb}{in^2}\right)(12.57\ in^4)}{(84)^2}$$

(13) $$P_{cr} = 527{,}470\ lb$$

(14) $$P_{Allow} = \frac{P_{cr}}{F.S.}$$

(15) $$P_{Allow} = \frac{527\,470}{2}$$

(16) $$P_{Allow} = 263{,}735\ lb$$

Since $251{,}400\ lb < 263{,}735\ lb$ then failure by yielding controls.

Hence the maximum allowable compressive load or the column is 251,400 lb.

To determine the maximum allowable load Q that can be applied to the system it is necessary to examine a FBD of ABC

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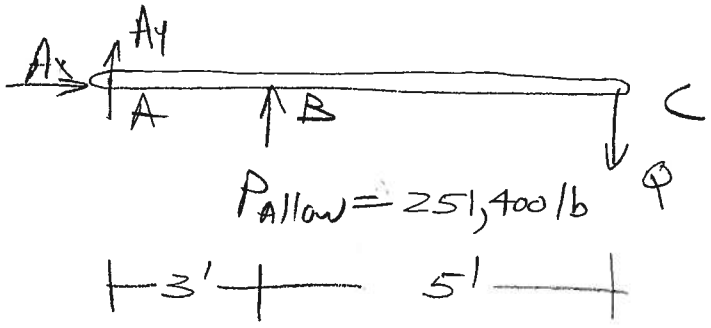

$\Sigma M_A = 0$

(17) $+(251{,}400\ \text{lb})(3\ \text{ft}) - Q_{Allow}(8\ \text{ft}) = 0$

(18) $Q_{Allow} = 94{,}275\ \text{lb}$

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