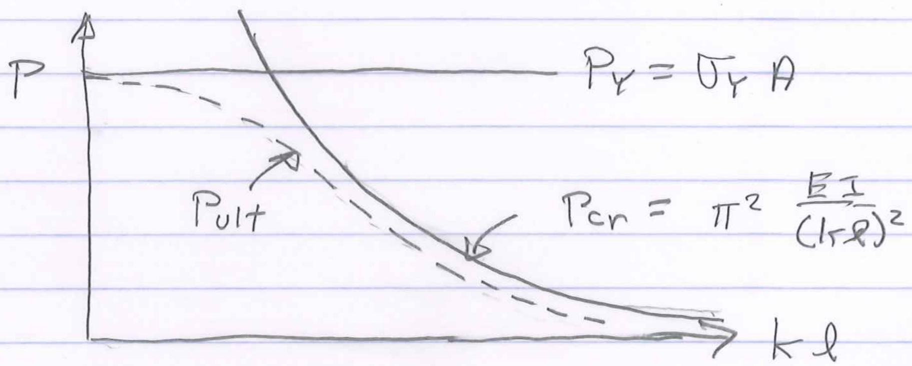
37. Ultimate strength design for "beam-columns"

<u>Column subjected to axial force only without eccentricity.</u>

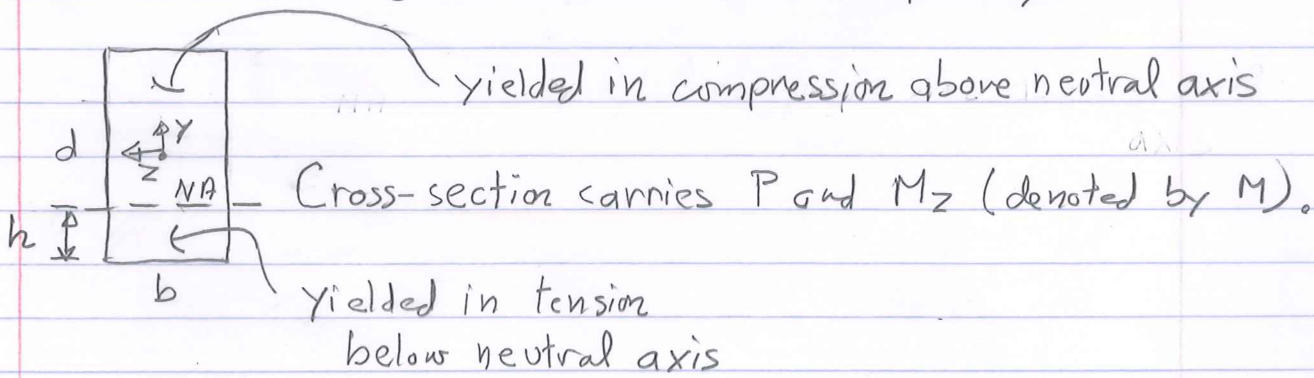
The ultimate capacity P_{ult} for a column with given A and EI can be plotted as follows.



Theoretically, P_{ult} would be controlled by P_Y for lower values of the effective length $k\ell$ and by P_{cr} for higher values of $k\ell$. Practically, P_{ult} should be reduced by the presence of imperfections, and so it is given by some empirical formula that might look like the P_{ult} plot above.

<u>Ultimate capacity of a cross-section where both P and M are present</u>

Consider a rectangular section for simplicity.

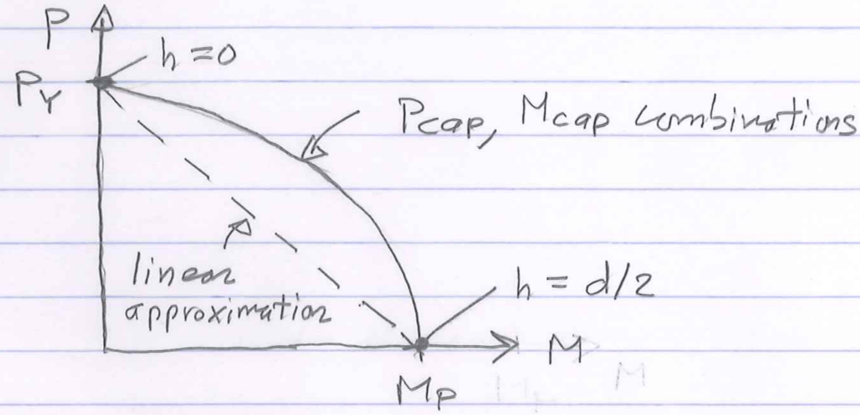


Since the entire cross-section is at yield, the values of P and M on the cross-section will be denoted by P_{cap} and M_{cap}, which are found as

$$P_{cap} = \sigma_Y \cdot (d-2h) \cdot b$$

$$M_{cap} = \sigma_Y \cdot 2bh \cdot \left(\frac{d}{2} - \frac{h}{2}\right) = \sigma_Y \cdot bh \cdot (d-h)$$

A plot of all possible P_{cap}, M_{cap} combinations appears as



All P, M combinations within the capacity curve can be carried by the cross-section.

A linear approximation to the capacity curve is simple and conservative.

$$\frac{P_{cap}}{P_Y} + \frac{M_{cap}}{M_P} = 1$$

where $P_Y = \sigma_Y \cdot A$ and $M_P = \sigma_Y \cdot Z$.

<u>Approximate ultimate strength design formula for beam-columns</u>

A beam-column carries axial load plus other loads that cause primary bending. An analysis is performed that finds the axial force P and the maximum, amplified bending couple M_{max} for the column. The (somewhat ad hoc) design formula is

$$\frac{P \cdot L.F.}{P_{ult}} + \frac{M_{max} \cdot L.F.}{M_p} \leq 1$$

where L.F. = load factor (>1). This formula is a modification of the capacity equation for a cross-section. Note that this design formula applies to the entire column (and not just a cross-section) due to the use of P_{ult} and the maximum, amplified bending couple.