

5.3 Strength curve for all ideal strut

We will assume that the stress-strain relationship of the material of the column is as shown in Fig. 5.5. Such a strut under compression can therefore resist only a maximum force given by $f_y.A$, when plastic squashing failure would occur by the plastic yielding of the entire cross section; this means that the stress at failure of a column can never exceed f_y , shown by A-A' in Fig. 5.6(a).

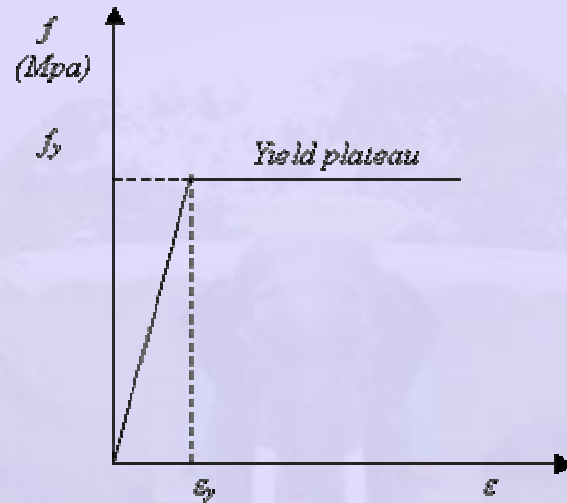


Fig 5.5 Idealised elastic-plastic relationship for steel

From Fig. 5.4, it is obvious that the column would fail by buckling at a stress given by $(\pi^2 EI / \lambda^2)$

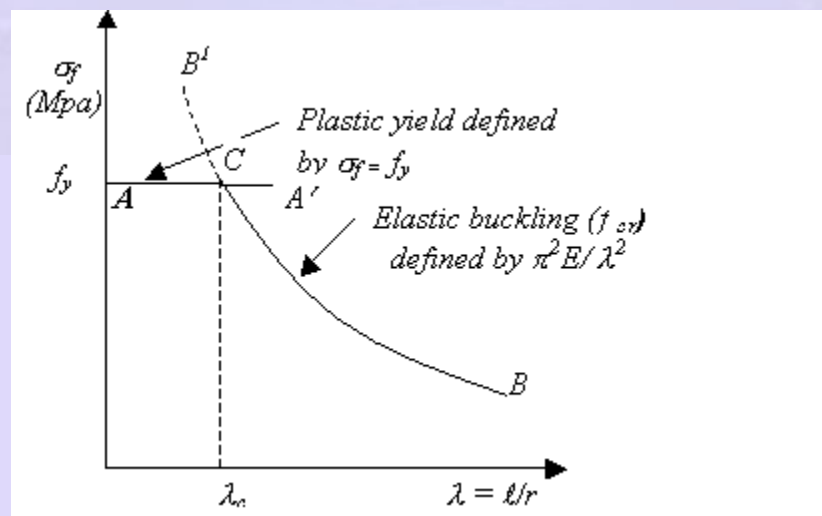


Fig 5.6(a) Strength curve for an axially loaded initially straight pin-ended column

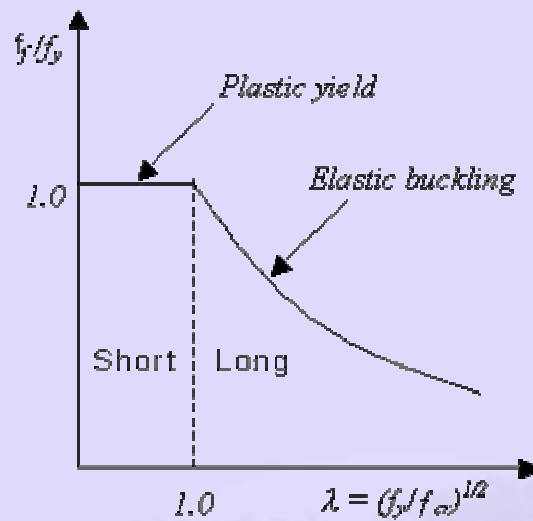


Fig 5.6(b) Strength curve in a non-dimensional form

This is indicated by B-B¹ in Fig. 5.6(a), which combines the two types of behaviour just described. The two curves intersect at C. Obviously the column will fail when the axial compressive stress equals or exceeds the values defined by ACB. In the region AC, where the slenderness values are low, the column fails by yielding. In the region CB, the failure will be triggered by buckling. The changeover from yielding to buckling failure occurs at the point C, defined by a slenderness ratio given by λ_c and is evaluated from

$$f_y = \frac{\pi^2 E}{\lambda_c^2} \quad (5.6)$$

$$\lambda_c = \pi \sqrt{\frac{E}{f_y}}$$

Plots of the type Fig. 5.6(a) are sometimes presented in a non-dimensional form as illustrated in Fig. 5.6(b). Here (f_f / f_y) is plotted against a generalized slenderness given by

$$\lambda_g = \lambda / \lambda_c = \sqrt{\frac{f_y}{f_{cr}}} \quad (5.7)$$

This single plot can be employed to define the strength of all axially loaded, initially straight columns irrespective of their E and f_y values. The change over from plastic yield to elastic critical buckling failure occurs when $\lambda_g = 1$ (i.e when $f_y = \sigma_{cr}$), the corresponding slenderness ratio is $\pi \sqrt{E / f_y}$. This slenderness ratio demarcates short and long columns.

