ARCHITECTURAL STRUCTURES I:
STATICS AND STRENGTH OF MATERIALS
ENDS 231

DR. ANNE NICHOLS

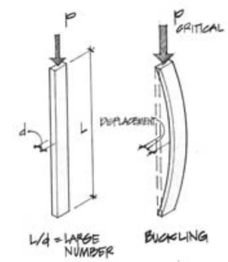
FALL 2007

lecture
twenty three

stability and columns

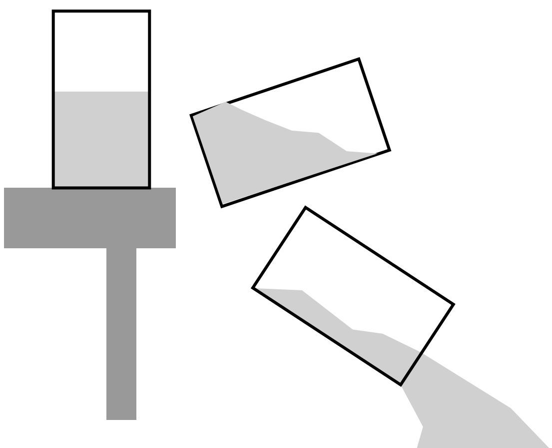
Additional Design Criteria

- designed for strength & stresses
- designed for serviceability & deflection
- need to design for <u>stability</u>
  - ability to support a specified load without sudden or unacceptable deformations



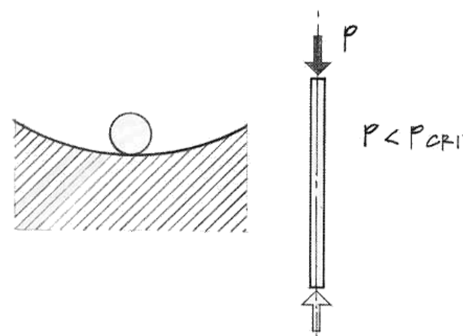
Column Behavior

- objects like lowest energy state



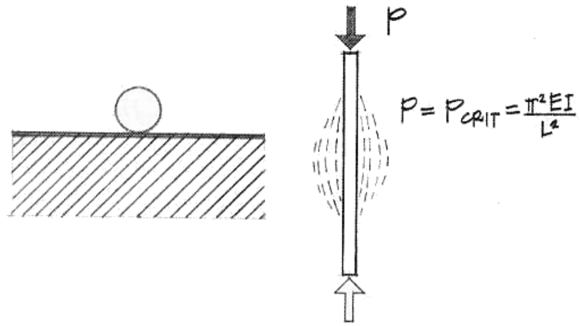
Stable Equilibrium

- energy added
- things don't change



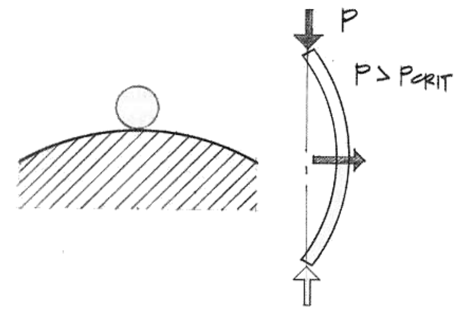
Neutral Equilibrium

- *energy added*
- *things change, but not much*



Unstable Equilibrium

- *energy added*
- *things change drastically*



Column Buckling

- *axially loaded columns*
- *long & slender*
  - *unstable equilibrium = buckling*
  - *sudden and not good*

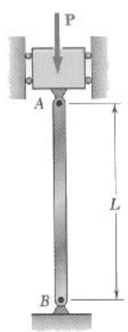
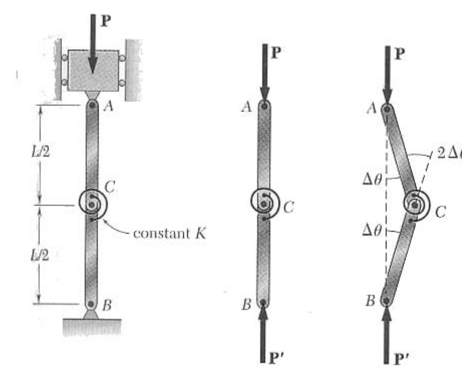


Fig. 10.1

Fig. 10.2

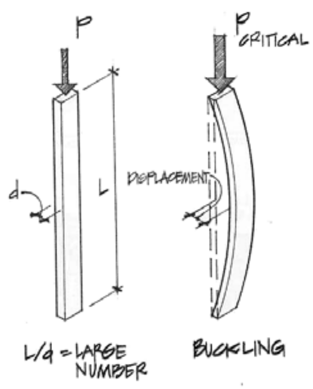
Modeling

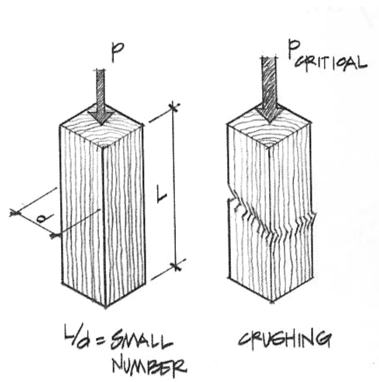
- *can be modeled with a spring at mid-height*
- *when moment from deflection exceeds the spring capacity ... "boing"*
- *critical load P*



Effect of Length

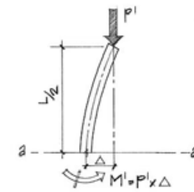
- *long & slender*
- *short & stubby*





Buckling Load

- *related to deflected shape (PΔ)*
- *shape of sine wave*
- *Euler's Formula*
- *I minimum*



$$P_{critical} = \frac{\pi^2 EI_{\min}}{(L)^2}$$

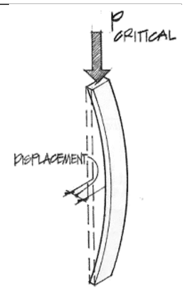
Figure 9.3 Leonhard Euler (1707–1783).

Critical Stress

- *short columns*

$$f_{critical} = \frac{P_{actual}}{A} < F_a$$

- *slenderness ratio = L_e/r (L/d)*
- *radius of gyration = $r = \sqrt{\frac{I}{A}}$*



weak axis

$$f_{critical} = \frac{P_{critical}}{A} = \frac{\pi^2 EAr^2}{A(L_e)^2} = \frac{\pi^2 E}{\left(\frac{L_e}{r}\right)^2} \qquad P_{critical} = \frac{\pi^2 EA}{\left(\frac{L_e}{r}\right)^2}$$

Critical Stresses

- *when a column gets stubby, F_y will limit the load*
- *real world has loads with eccentricity*
- *C_c for steel and allowable stress*

$$\frac{L_e}{r} > C_c = \sqrt{\frac{2\pi^2 E}{F_y}}$$

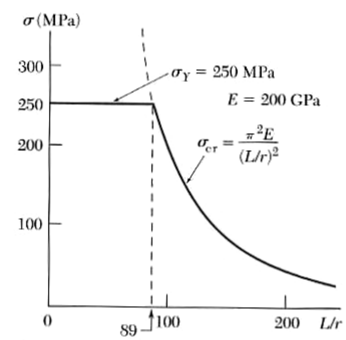
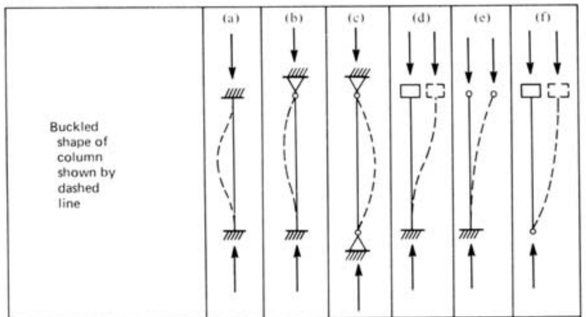


Fig. 10.9

Effective Length

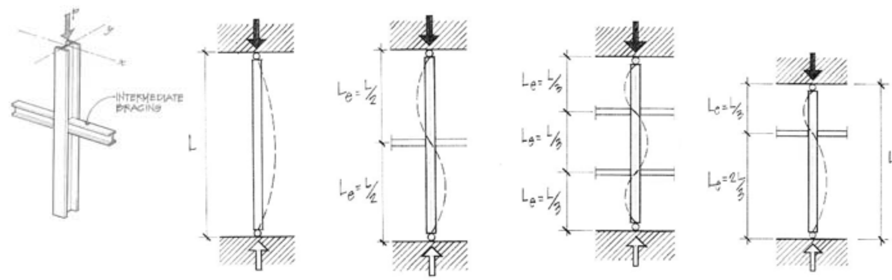
- end conditions affect shape
- effective length factor, K $\quad L_e = K \cdot L$



	(a)	(b)	(c)	(d)	(e)	(f)
Theoretical K value	0.5	0.7	1.0	1.0	2.0	2.0
Recommended design values when ideal conditions are approximated	0.65	0.80	1.0	1.2	2.10	2.0

Bracing

- bracing affects shape of buckle in one direction
- both should be checked!



(a) No bracing. (b) Braced at midpoint. (c) Third-point bracing. (d) Asymmetric bracing.