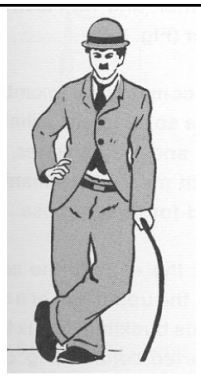
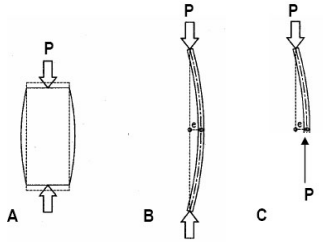
Compression Members





Buckling

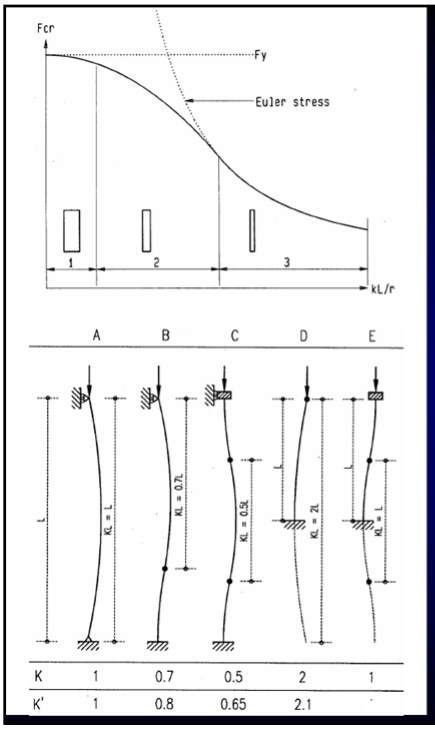
Buckling is a tendency of slender compression members to bow out, which causes bending.
When the combined bending and compressive stress exceeds the buckling capacity failure occurs.
Buckling effects all compression members, such as columns, truss bars, bracing, etc

A Short columns fail in compression.

B Slender columns fail in buckling

C Free-body diagram of half column shows bending moment M = P e (force times lever arm)

Buckling bends a column progressively.
Increasing offset e increases bending, which in turn increases e further ……
which finally causes buckling failure ☹



Euler formula, developed by the 18th century Swiss Mathematician Euler defines critical buckling load as:

$$P_{cr} = \pi^2 E I / L^2$$

P_{cr} = critical buckling load
E = Elastic modulus
I = Moment of inertia
L = Length (un-braced)

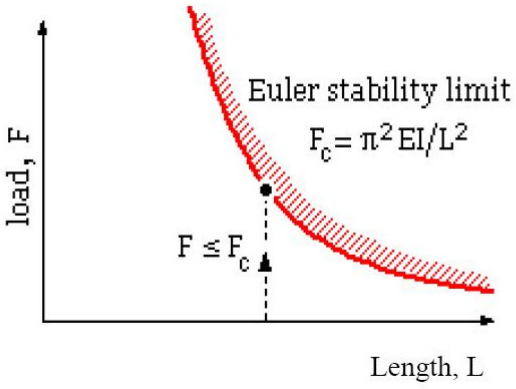
Since f=P/A, critical buckling **stress** $F_{cr}=\pi^2 EI/(A L^2)$, or

$$F_{cr} = \pi^2 E / (KL/r)^2$$

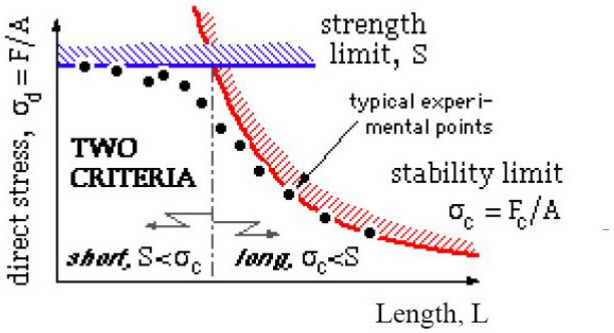
A = cross section area)
KL/r = slenderness ratio
r = radius of gyration, $r =(I/A)^{1/2} \rightarrow I / A = r^2$
K = support factor defined as follows

Support type:	Theoretical K	Recommended K'
A Pin supports:	K = 1	K' = 1
B One fixed support:	K = 0.7	K' = 0.8
C Both fixed supports:	K = 0.5	K' = 0.65
D Cantilever:	K = 2	K' = 2.1
E Moment frame	K = 1	K' = 1.2 - 1.5

Buckling vs. length of column

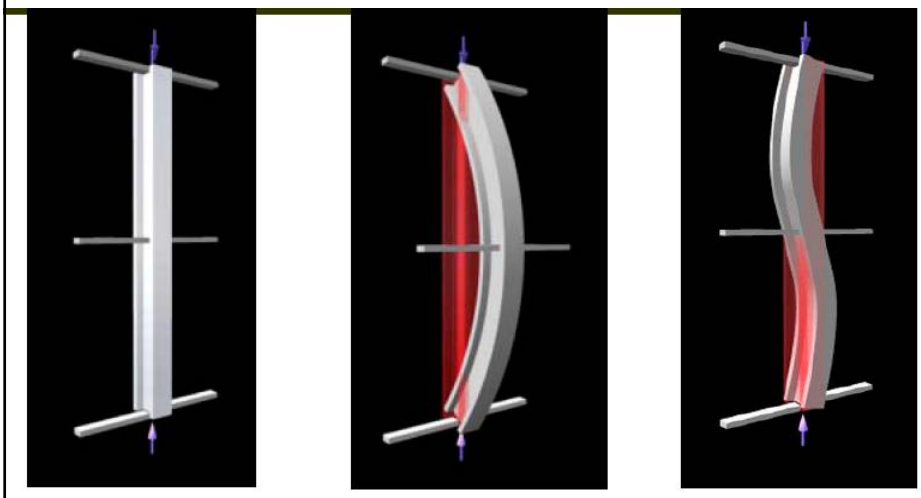


Failure of Compression Members



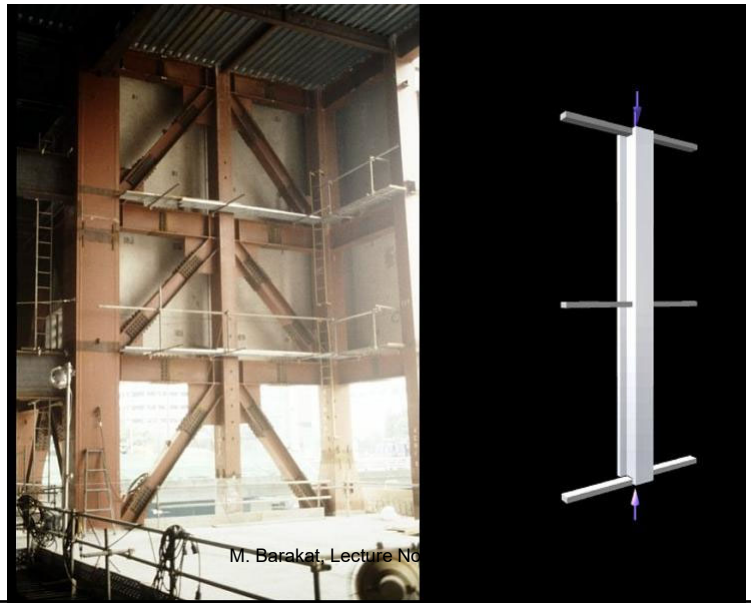
Failure by buckling or crushing
Reality may be in between the two modes

Buckling Modes of I-Section

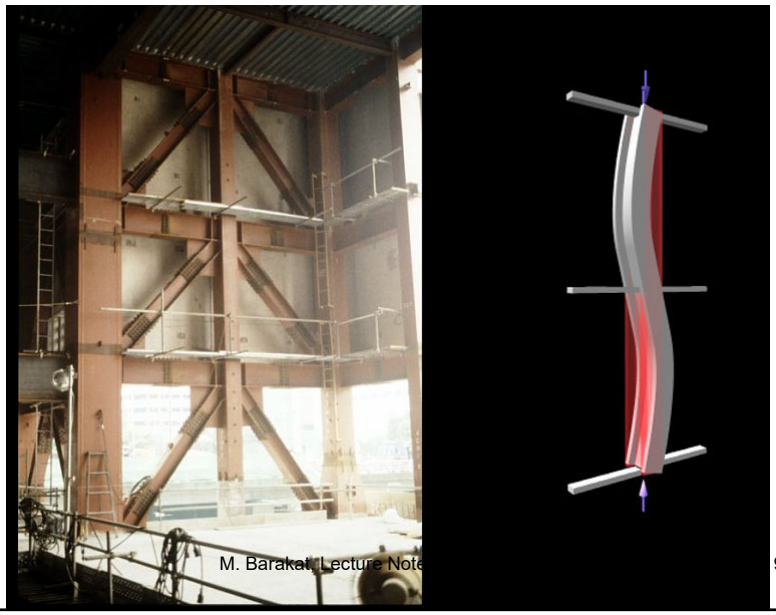


Unbuckled **Strong axis** **Weak axis**

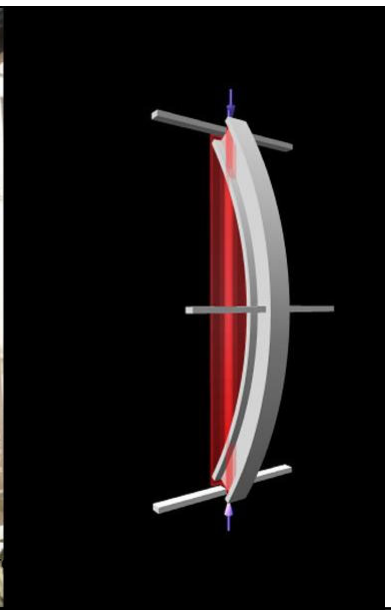
Column braced in the weak axis

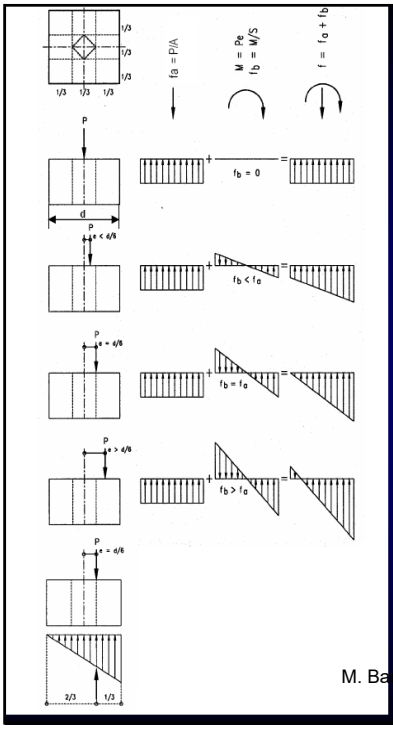


Buckling about the weak axis



Buckling about the strong axis





Kern, German for core denotes inner 1/3 of cross section (rhomboid for rectangular, circular for round posts).
Load within the kern causes compressive stress only
Load outside the Kern adds bending stress f_b=M/S (M=Pe)
Concentric load causes axial stress only $f_a = P/A$

load inside Kern causes $f_b < f_a$

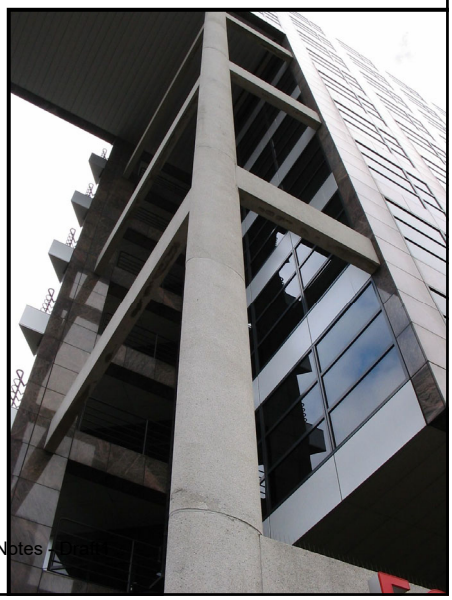
3 Load at Kern edge causes $f_b = f_a$

4 Laod outside the Kern causes $f_b > f_a$
(yields tensile bending stress)

Proof:
Triangular stress block has centroid @ d/3

Actual buckling of I-section

Actual vs. design length of column



Long (slender) columns