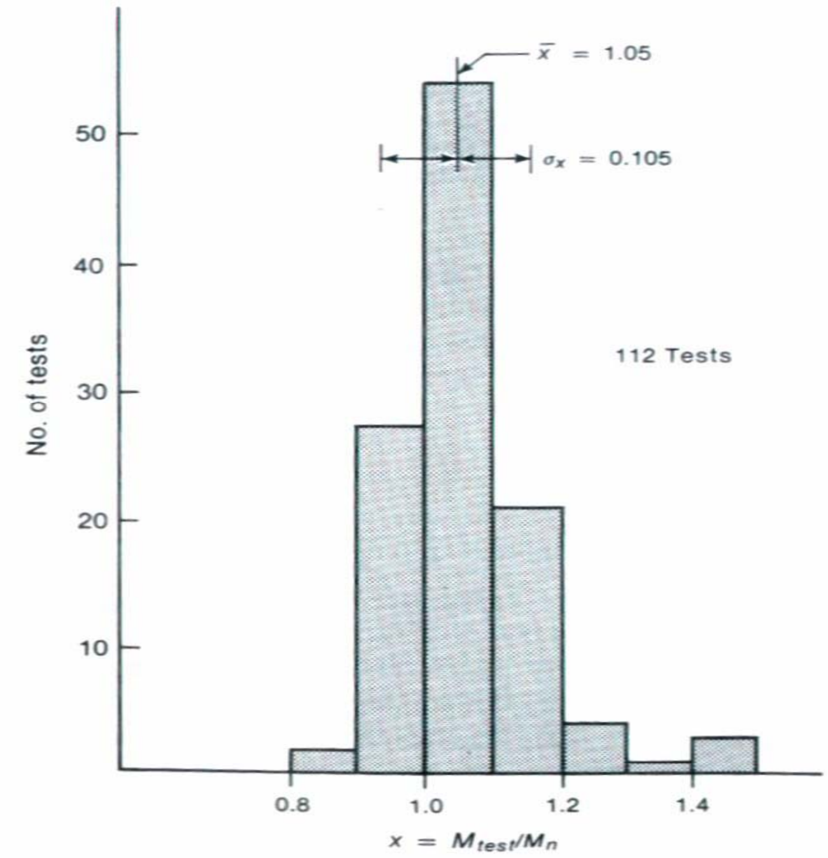
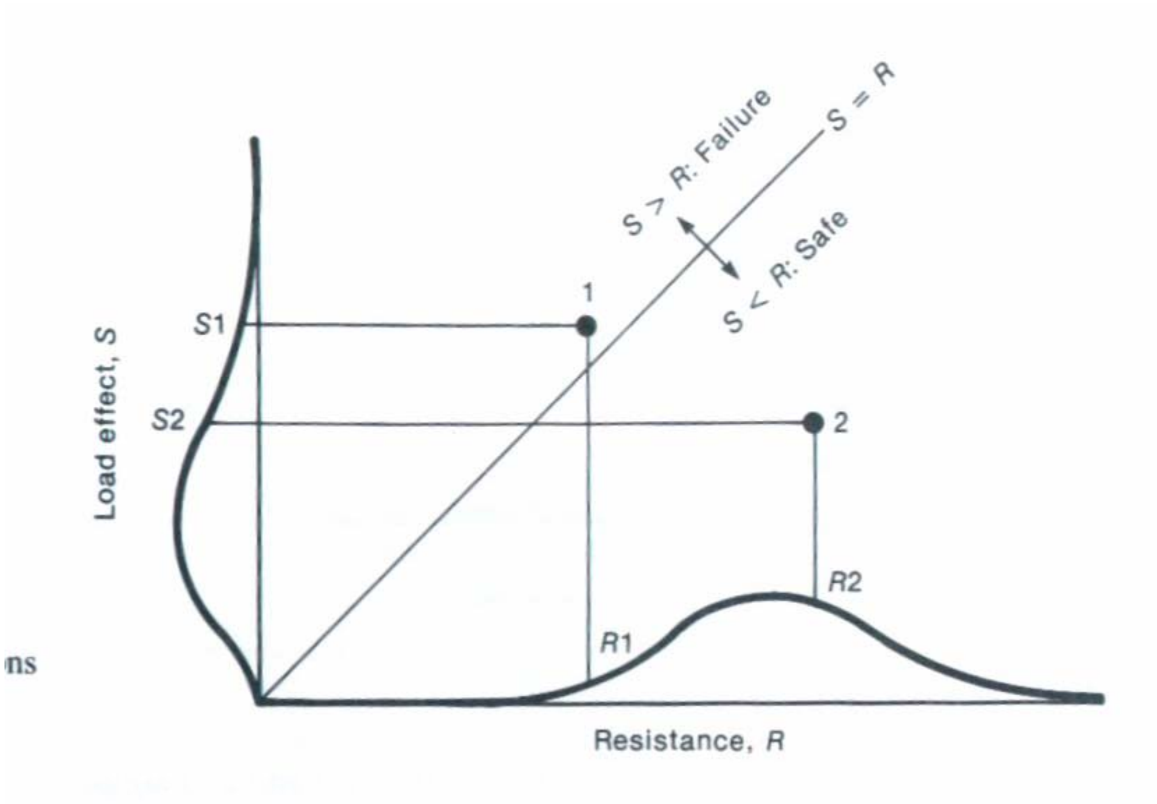
Variability in Resistance

Comparison of measured and computed failure moments based on all data for reinforced concrete beams with f_c > 2000 psi.



Margin of Safety

The distributions of the resistance and the loading are used to get a probability of failure of the structure.



Margin of Safety

The term

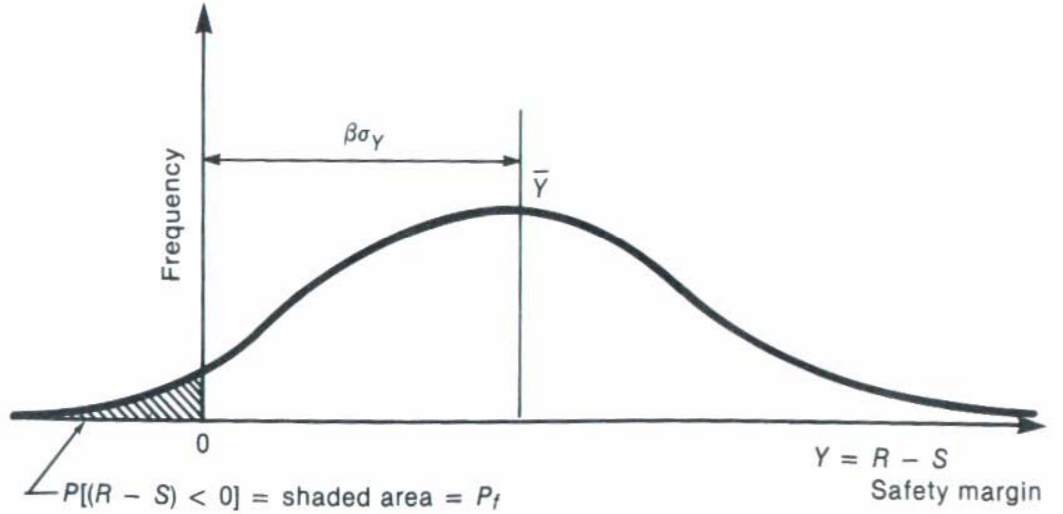
$$Y = R - S$$

is called the safety margin.
The probability of failure is defined as:

$$P_f = \text{Probability of } [Y < 0]$$

and the safety index is

$$\beta = \frac{\bar{Y}}{\sigma_Y}$$



Loading

SPECIFICATIONS

Cities in the U.S. generally base their building code on one of the three model codes:

- Uniform Building Code
- Basic Building Code (BOCA)
- Standard Building Code

Loading

These codes have been consolidated in the 2000 *International Building Code*.

Loadings in these codes are mainly based on *ASCE Minimum Design Loads for Buildings and Other Structures* has been updated to ASCE 7-98.

Loading

The loading variations are taken into consideration by using a series of "load factors" to determine the ultimate load, U.

$$U = 1.4(D + F)$$

$$U = 1.2(D + F + T) + 1.6(L + H) + 0.5(L_r \text{ or } S \text{ or } R)$$

$$U = 1.2D + 1.6W + 0.5L + 1.0(L_r \text{ or } S \text{ or } R)$$

$$U = 1.2D + 1.0E + 1.0L + 0.2S$$

$$\vdots = \text{etc.}$$

Loading

The equations come from ACI code 9.2 on loading (4.6 in your book),

D – Dead Load	W – Wind Load
L – Live Load	L_r – Roof Load
F – Fluid Pressure	R – Rain Load
E – Earthquake Load	T – Temperature Load
S – Snow Load	H – Soil Load

Loading

The most general equation for the ultimate load, U (M_u) that you will see is going to be:

$$U = 1.2D + 1.6L$$

Resistance

The load factors will generate the ultimate load, which is used in the design and analysis of the structural member.

$$M_u = \phi M_n$$

M_u – Ultimate Moment

M_n – Nominal Moment

ϕ – Strength Reduction Factor

Resistance

The strength reduction factor, ϕ, varies from member to member depending whether it is in tension or compression or the type of member. The code has been setup to determine the reduction.

Three possibilities in Inelastic Behavior

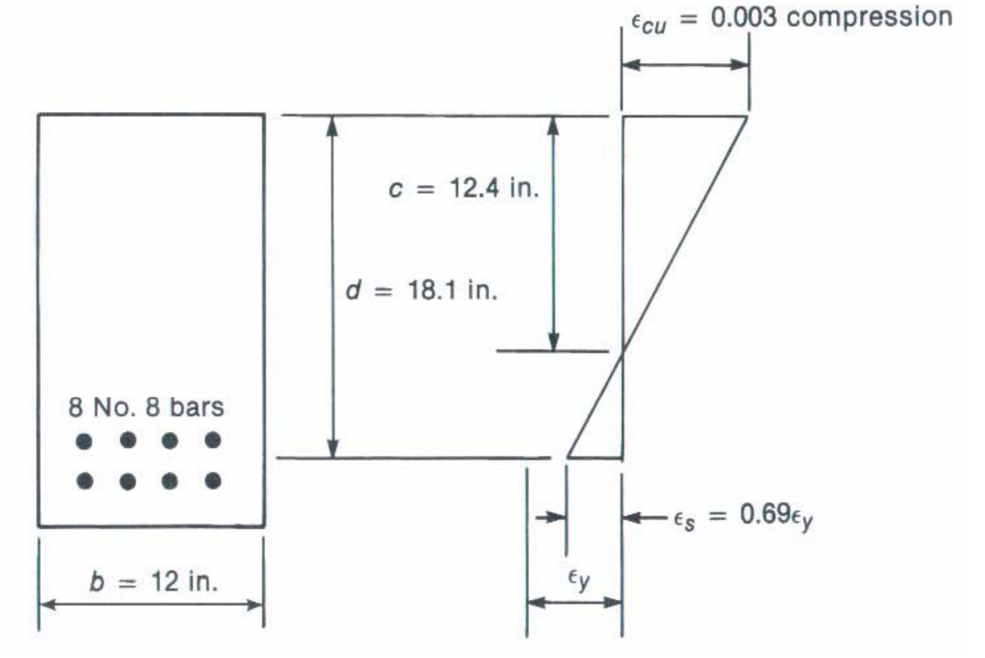
- Compression Failure - (over-reinforced beam)
- Tension Failure - (under-reinforced beam)
- Balanced Failure - (balanced reinforcement)

Inelastic Behavior

Compression Failure

The concrete will crush before the steel yields. This is a sudden failure.

The beam is known as an ***over-reinforced beam***.

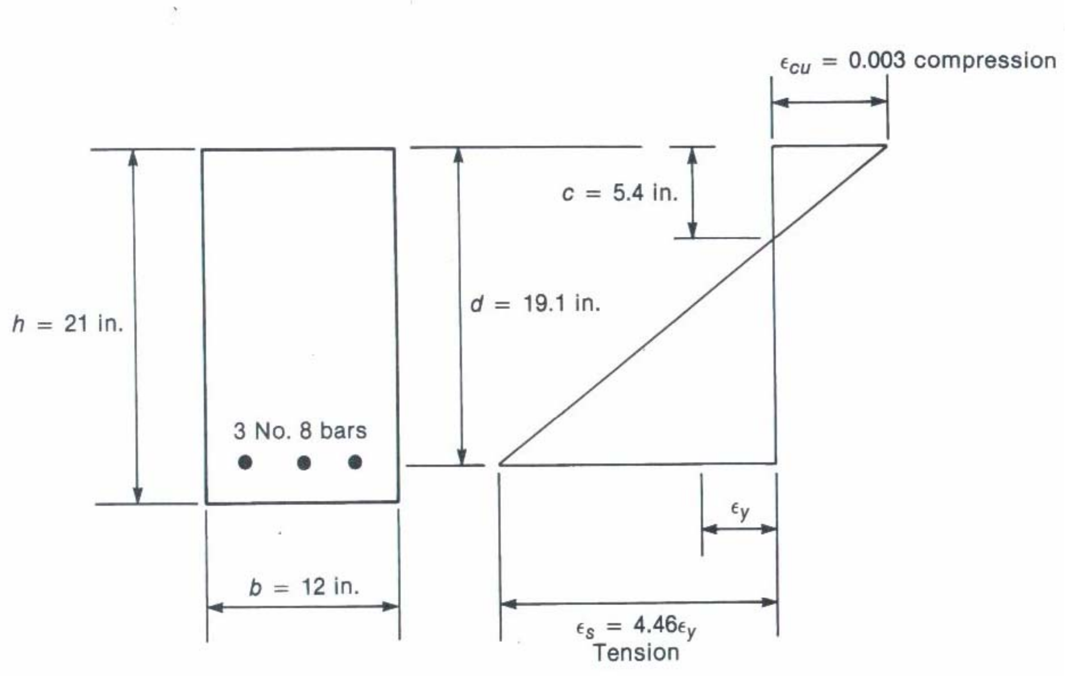


Inelastic Behavior

Tension Failure

The reinforcement yields before the concrete crushes. The concrete crushes is a secondary compression failure.

The beam is known as an ***under-reinforced beam***.

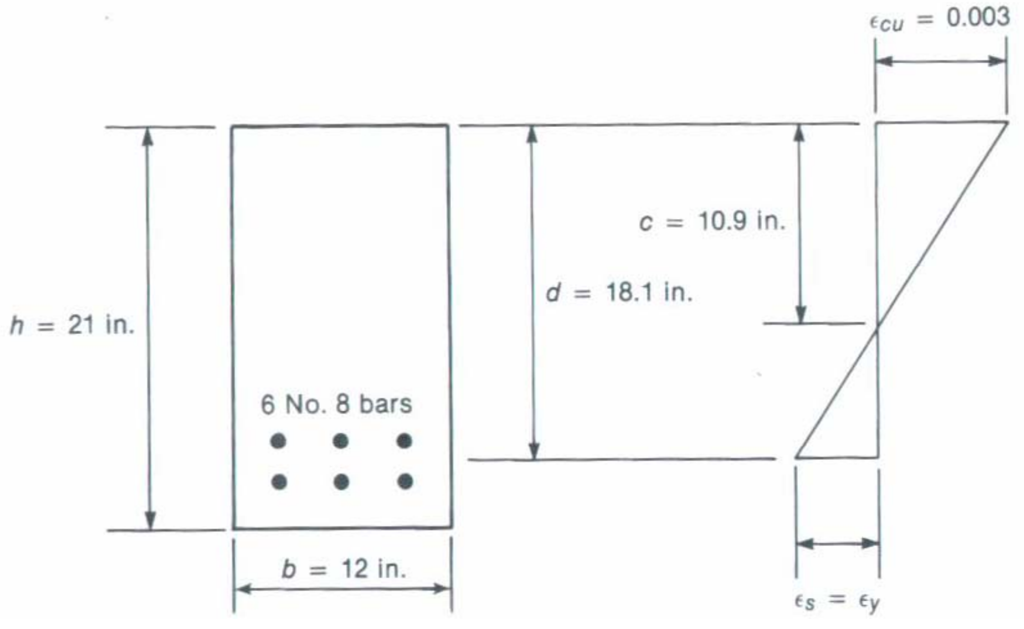


Inelastic Behavior

<u>Balanced Failure</u>

The concrete crushes and the steel yields simultaneously.

The beam is known as an ***balanced-reinforced beam***.



Inelastic Behavior

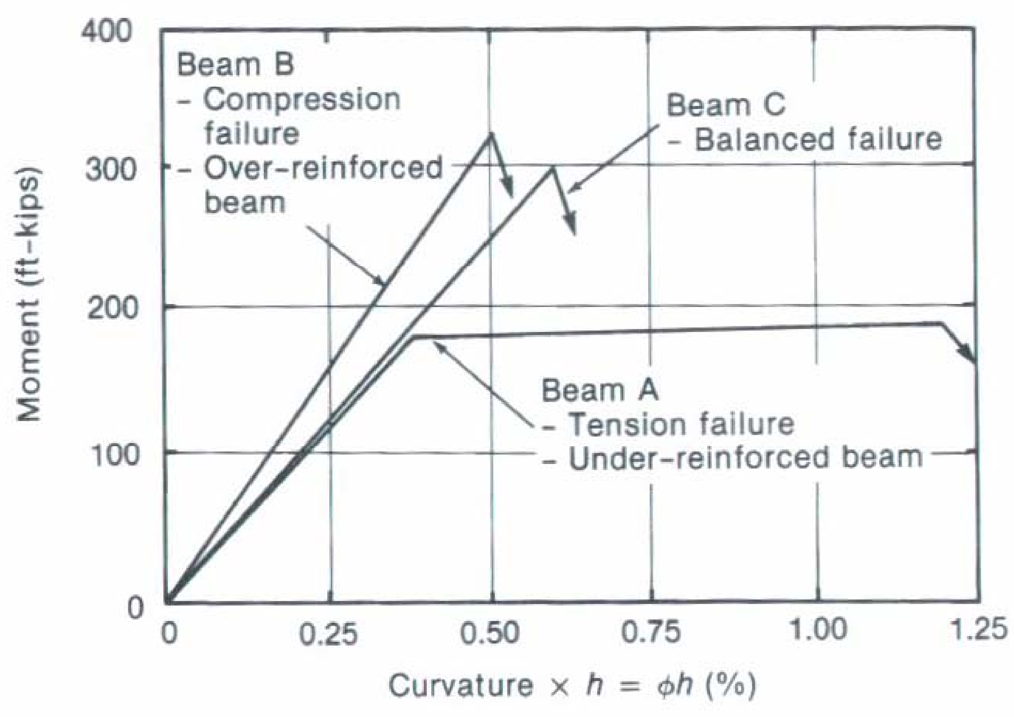
Which type of failure is the most desirable?

The ***under-reinforced beam*** is the most desirable.

$f_s = f_y$

$\varepsilon_s >> \varepsilon_y$

You want ductility ⟶ system deflects and still carries load.



Balanced Reinforcement Ratio, ρ_{bal}

ρ_{bal} = unique ρ value to get simultaneous $\varepsilon_c = 0.003$
& $\varepsilon_s = \varepsilon_y$

Use similar triangles:

$$\frac{0.003}{c_b} = \frac{\varepsilon_y}{d - c_b}$$