

### GLOSSARY OF VARIABLES

The following is an alphabetical listing of variables commonly used in this course. There is no single standard of variable names used in structural engineering, and the definitions here will be different than some in Schodek and in other textbooks.

This is a first edition, please let me know if you find errors or inconsistencies.

A	<b>Cross section area.</b>
c	<b>Distance from neutral axis to extreme fiber.</b> Bending stress is zero at the neutral axis, and increases with increasing distance from it, so bending stress is maximum at the distance $c$ .
$c_x, c_y$	<b>Distance <math>c</math> for strong axis and weak axis.</b> The distance $c$ depends on the orientation of bending. $c_x$ corresponds to the orientation where $c$ is maximum, and $c_y$ to the orientation where $c$ is minimum.
$\Delta$	<b>Deflection,</b> change in position of a structure or structural element from its original position.
E	<b>Modulus of elasticity</b> (a.k.a. <b>E-modulus</b> ), ratio of stress divided by strain in the elastic range. $E = \frac{f}{\varepsilon}$
$\varepsilon$	<b>Strain,</b> deformation intensity. Calculated as change in length divided by original length for a loaded bar of material. $\varepsilon = \frac{\Delta L}{L}$
$\varepsilon_y$	<b>Yield strain.</b> The strain which is the upper limit of a material's elastic range.
f	<b>Stress,</b> force intensity in a material. Stress can result from axial force, shear, or bending moment.  For an axial load P on a bar with cross section A, calculated as $f = \frac{P}{A}$ .
$f_a$	<b>Axial stress,</b> stress due to axial load. $f_a = \frac{P}{A}$ , may be tension or compression.
$F_a$	<b>Allowable axial stress.</b> a stress that defines the upper limit of safe levels of axial stress.
fb	<b>Bending stress,</b> maximum stress at a cross section due to bending moment.
$F_b$	<b>Allowable bending stress,</b> a stress that defines the upper limit of safe levels of bending stress. In steel, this is calculated as a fraction of the yield stress of the material.
$F_c$	<b>Allowable crushing stress,</b> a stress that defines the upper limit of safe levels of compression stress as governed by material failure (not buckling).

$f_{cr}$	<b>Critical buckling stress.</b> The stress that causes buckling in a compression member. $f_{cr} = \frac{\pi^2 E}{\left(\frac{kL}{r}\right)^2}$
$F_{cr}$	<b>Allowable buckling stress,</b> a stress that defines the upper limit of safe levels of compression stress as governed by buckling.
$F_t$	<b>Allowable tension stress,</b> a stress that defines the upper limit of safe levels of tension stress in a member.
$f_v$	<b>Shear stress,</b> stress due to internal shear force. For a rectangular cross section, $f_v = \frac{3V}{2A}$
$F_v$	<b>Allowable shear stress,</b> a stress that defines the upper limit of safe levels of shear stress.
$F_X, F_Y$	<b>Force components</b> in X and Y direction respectively
$F_1, F_2, \text{etc.}$	<b>Unknown forces,</b> used to represent unknown forces in statics problems.
$f_y$	<b>Yield stress.</b> The stress which is the upper limit of a material's elastic range.
$f_u$	<b>Ultimate stress.</b> The highest stress that a material can resist.
$k$	<b>Effective length factor,</b> a unitless factor that accounts for the effect of support conditions on the buckled shape and buckling load of a column.
$\frac{kL}{r}$	<b>Slenderness ratio,</b> a unitless ratio that combines effective length factor, member length, and radius of gyration. This ratio accounts for the geometry and support conditions of a compression member.
$I$	<b>Moment of inertia,</b> a cross section property that measures size and "spread-outness" with respect to an axis through the centroid of the section (for a symmetric shape, the centroid is the center).  For a rectangular section $I = \frac{bd^3}{12}$ .  For a general section $I = \sum_i A_i y_i^2$ where $A_i$ is the $i^{\text{th}}$ small area increment of the total area, and $y_i$ is the distance from the center of the section to the center of $A_i$ .  Moment of inertia is always calculated with respect to an axis, and a given cross section shape will have different values of $I$ depending on the orientation of the axis.
$I_x, I_{xx}$	<b>Strong axis moment of inertia,</b> moment of inertia when section is oriented for maximum bending resistance.
$I_y, I_{yy}$	<b>Weak axis moment of inertia,</b> moment of inertia when section is oriented for minimum bending resistance.
$L$	<b>Original length</b> of a beam or bar.
$\Delta L$	<b>Change in length</b> of a bar resulting from loading.

M	1. the <b>moment</b> , as in sum of the moments. 2. The internal <b>bending moment</b> at a section.
$M_A, M_B$ , etc	A <b>moment reaction</b> at point A, or B respectively.
P	The internal <b>axial force</b> at a section.
$P_{cr}$	<b>Critical buckling load</b> , the load which causes buckling in a compression member, also called the Euler buckling load.
r	<b>Radius of gyration</b> , a section property that describes the “spread-outness” of a section.  Defined as $r = \sqrt{\frac{I}{A}}$
$r_x, r_{xx}$	<b>Strong axis radius of gyration</b> , radius of gyration when the cross section is oriented for maximum bending resistance. $r_x = \sqrt{\frac{I_x}{A}}$
$r_y, r_{yy}$	<b>Weak axis radius of gyration</b> , radius of gyration when the cross section is oriented for minimum bending resistance. $r_y = \sqrt{\frac{I_y}{A}}$
$R_{AX}, R_{BY}$ , etc.	The <b>unknown reaction force</b> in the X direction at point A; the unknown reaction force in the Y direction at point B, etc.
S	<b>Section modulus</b> , a cross section property that defines the relation between bending moment and bending stress in a beam, according to $f_b = \frac{M}{S}$ . This formula assumes the material is linear elastic and that plane sections remain plane.  The general definition is $S = \frac{I}{c}$ .  For a rectangle, this becomes $S = \frac{bd^2}{6}$
$S_x, S_{xx}$	<b>Strong axis section modulus</b> , section modulus when section is oriented for maximum bending resistance. $S_x = \frac{I_x}{c_x}$
$S_y, S_{yy}$	<b>Weak axis section modulus</b> , section modulus when section is oriented for maximum bending resistance. $S_y = \frac{I_y}{c_y}$
V	The internal <b>shear force</b> at a section.
w	A <b>distributed load</b> (force per unit length).