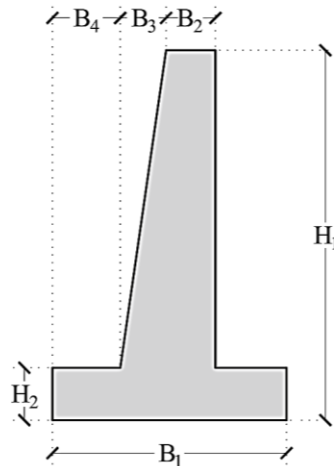


PHASE I

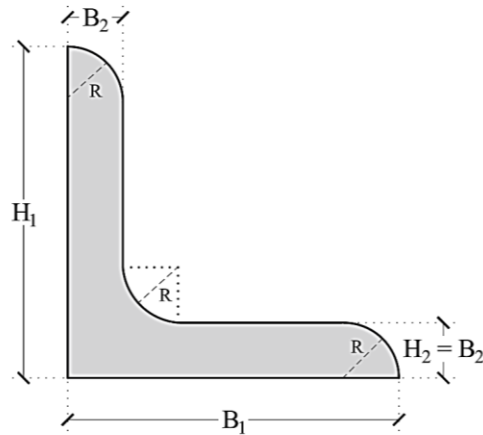
SECTION PROPERTIES

CPMK-1: Students are able to calculate cross-sectional properties or characteristics.

A.



B.



Given Dimensions:

$B_1 =$

$B_2 =$

$B_3 =$

$B_4 =$

$H_1 =$

$H_2 =$

Based on the given cross-sectional profile, calculate and determine the following parameters:

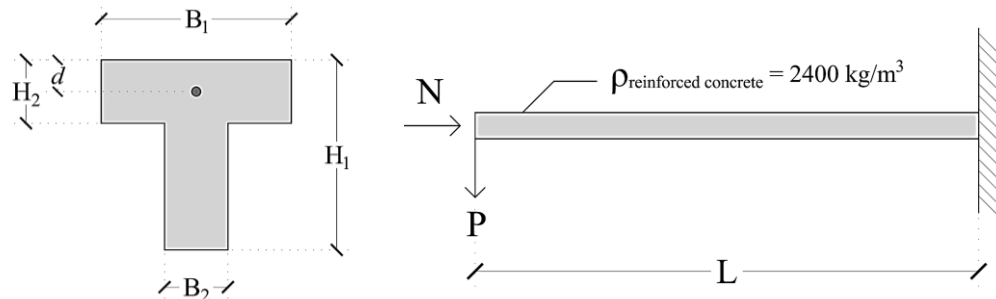
1. Total cross-sectional area (A).
2. Centroid location of the cross-section (coordinates $\bar{x}$ and $\bar{y}$).
3. First moment of area with respect to the specified axes (S_x and S_y).
4. Moment of inertia values of the cross-section about the centroidal axes. Use the Parallel Axis Theorem to calculate:
 - a. Moment of inertia I_x
 - b. Moment of inertia I_y
 - c. Product of inertia I_{xy}
5. Radius of gyration of the cross-section (r_x and r_y).
6. Maximum ($I_{\max}$) and minimum ($I_{\min}$) principal moments of inertia, along with the orientation of the principal axes (θ_p) calculated both analytically and graphically using Mohr's Circle. Subsequently, draw the orientation of these principal axes ($x' - y'$) on the cross-section sketch.*

***Note:** Mohr's Circle must be drawn manually and precisely using graph paper (millimeter block), complete with defined axis scales (I and I_{xy}) and indication of key coordinate points.

PHASE II

STRESS ANALYSIS OF CROSS-SECTION

CPMK-2: Students are able to analyze normal, bending, and shear stresses on a cross-section.



Given Dimensions and Parameters:

$P =$	$L =$
$N =$	$d =$
$B_1 =$	$H_1 =$
$B_2 =$	$H_2 =$

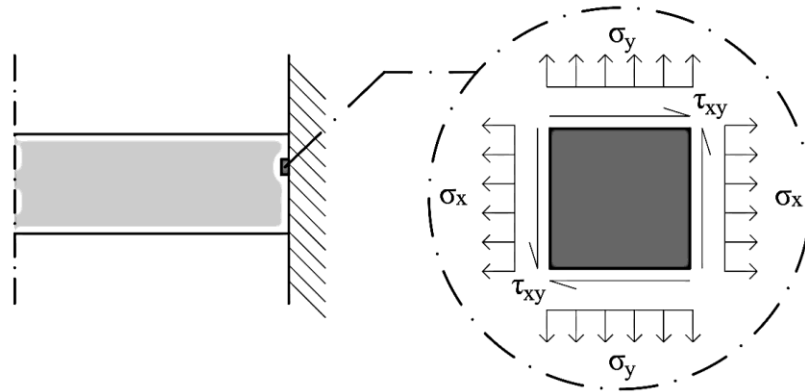
A cantilever beam of length L with a reinforced concrete T-beam section ($\rho_{\text{reinforced concrete}} = 2400 \text{ kg/m}^3$) is rigidly fixed at its support. The beam carries a uniformly distributed load originating from its self-weight, as well as a concentrated load (P) applied at the free end. To reduce tensile stresses induced by external loads, the beam is subjected to a prestressing force in the form of an eccentric compressive axial force N applied at the free end. The point of application of the prestressing force N is located on the web of the beam at a distance d from the top fiber of the section (indicated by the point in the T-beam sketch). Based on these conditions:

1. Determine the critical section location along the beam span that experiences the maximum bending stress (σ) due to external loads (excluding the prestressing force). At this critical section, calculate and plot the bending stress distribution diagram, indicating the maximum stress values at the top and bottom fibers.
2. Determine the total normal stress (σ_{total}) resulting from the combination of external loading and the eccentric normal force acting at the cross-section at the most critical stress location.
3. Calculate and plot the shear stress (τ) distribution diagram at the cross-section location that yields the maximum shear stress along the span of the beam.

PHASE III

PRINCIPAL STRESSES AND MOHR'S CIRCLE

CPMK-3: Students are able to determine plane stresses and strains along the principal axes (principal stresses and principal strains).



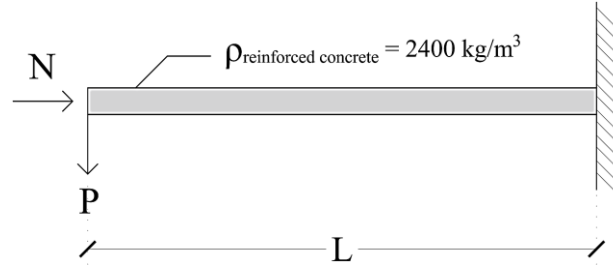
Using the stress analysis results from Stage II, consider a stress element at the critical cross-section located at a distance of $H/3$ from the top fiber (with stress parameter σ_x from bending stress, $\sigma_y = 0$, and τ_{xy} from shear stress). Based on the stress state on this element, complete the following instructions:

1. Calculate the principal stresses at that point, including:
 - a. Maximum principal normal stress ($\sigma_{\max}$)
 - b. Minimum principal normal stress ($\sigma_{\min}$)
 - c. Maximum shear stress ($\tau_{\max}$)
2. Draw Mohr's Circle to represent the stress state graphically.
3. Determine the principal plane orientation angle (θ_p) analytically, then sketch the stress element rotated according to its principal axis orientation.**

****Note:** Mohr's Circle must be drawn manually and precisely using graph paper (millimeter block), complete with defined axis scales (σ and τ) and indication of key coordinate points.

PHASE IV BEAM DEFORMATION

CPMK-4: Students are able to analyze deflection and slope in statically determinate beams.



Using the same structural configuration and loading condition as in Stage II and Stage III, perform a structural deformation analysis to calculate the deflection and rotation responses of the beam. Calculate the magnitude of deflection (δ) and slope/rotation (θ) at the free end of the beam. Use the following two separate analysis methods to complete the calculation:

1. Double Integration Method
2. Conjugate Beam Method

Plot the elastic curve (deflection curve), compare the deflection and rotation values obtained from both methods, and provide an analysis regarding the degree of agreement between the results.