2.3 Section Properties of Built-Up Steel Sections


Description

This document calculates the moment of inertia and section modulus for a steel section that has at least one axis of symmetry built-up from plates or from a combination of plates and sections with known section properties. Any number of plates or sections may be used.

Built-up sections are used when reinforcing existing members, as plate girders, and for composite steel beams using bottom plates. The application may also be used to calculate section properties for nonstandard T sections cut from I-shaped members. The properties of fillets or continuous welds may also be included when required. The required input includes the overall depth of the built-up section, plate dimensions (in the horizontal and vertical directions) and the area and moment of inertia of any sections with known properties making up the built-up section, and the dimensions from the centroids of plates or sections to the bottom of the built-up section.

Input

Notation
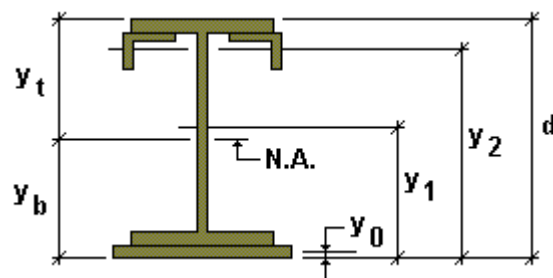
Input Variables

Enter depth of the built-up section, moments of inertia and areas of individual sections, horizontal and vertical dimensions of plates, and distances from the centroids of individual plates and sections to the bottom of the built-up section. Moments of inertia, areas, or plate dimensions referring to a given section or plate must have the same corresponding subscript number.

Depth of the built-up section:	$d := 17.81 \cdot in$

Moments of inertia of individual sections: $\quad I_0 := 704.5 \cdot in^4 \qquad I_1 := 3.6 \cdot in^4$

Areas of individual sections: $\quad A_0 := 13.24 \cdot in^2 \qquad A_1 := 4.22 \cdot in^2$

Horizontal plate dimensions: $\quad h_2 := 9 \cdot in$

Vertical plate dimensions: $\quad v_2 := 0.25 \cdot in$

Distances from the bottom of the built-up section to area centroid of any sections or plates: $\quad y_0 := 9.03 \cdot in \qquad y_1 := 16.42 \cdot in \qquad y_2 := 0.125 \cdot in$

Note $\Rightarrow$ $\qquad$ Section must be symmetrical about the vertical axis.

Computed Variables

The following variables are calculated in this document:

d   depth of the built-up section

As   cross section area of built-up section

Is   moment of inertia of the built-up section about the horizontal centroidal axis

St   section modulus of the built-up section about the horizontal centroidal axis referred to the top of the section

Sb   section modulus of the built-up section about the horizontal centroidal axis referred to the bottom of the section

yt   dimension form the horizontal centroidal axis to the top of the built-up section

yb   dimension form the horizontal centroidal axis to the bottom of the built-up section

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Calculations

Areas of all sections and plates:

$$i := 0 .. \operatorname{last}(y)$$

$$A_i := \operatorname{if}\left(h_i = 0 \cdot in, A_i, h_i \cdot v_i\right)$$

$$A^{\mathrm{T}} = \begin{bmatrix} 13.24 & 4.22 & 2.25 \end{bmatrix} \, in^2$$

Moments of inertia of all sections and plates:

$$I_i := \mathbf{if}\left(h_i = 0 \cdot in, I_i, \frac{1}{12} \cdot h_i \cdot \left(v_i\right)^3\right)$$

$$I^{\mathrm{T}} = \begin{bmatrix} 704.5 & 3.6 & 0.012 \end{bmatrix} \, in^4$$

Area of the built-up section:

$$A_s := \sum A \qquad\qquad A_s = 19.71 \, in^2$$

Dimension form the horizontal centroidal axis to the bottom of the built-up section:

$$y_b := \sum_i \frac{A_i \cdot y_i}{A_s} \qquad\qquad y_b = 9.596 \, in$$

Dimension form the horizontal centroidal axis to the top of the built-up section:

$$y_t := d - y_b \qquad\qquad y_t = 8.214 \, in$$

Moment of inertia of the built-up section about the horizontal centroidal axis:

$$I_s := \sum I + \sum_i \left(A_i \cdot \left(y_i - y_b\right)^2\right)$$

$$I_s = 1110.691 \, in^4$$

Section modulus of the built-up section about the horizontal centroidal axis referred to the top of the built-up section:

$$S_t := \frac{I_s}{y_t}$$

$$S_t = 135.214 \, in^3$$

Section modulus of the built-up section about the horizontal centroidal axis referred to the bottom of the built-up section:

$$S_b := \dfrac{I_s}{y_b}$$

$$S_b = 115.749 \ in^3$$