# **Composite Section**

1. My and Mp



2. Lateral-torsional buckling and lateral bracing



 $\star$  stress distribution when a composite beam has reached the plastic limit state



To determine which of the three cases governs, compute the compressive resultants as the smallest of

(1)  $A_s F_y$ 

(2)  $0.85 f_c' A_c$ 

 $\Im \sum Q_n$ 

A<sub>s</sub> cross-sectional area of steel shape

 $A_c$  area of concrete=*tb* (see Fig.(a))

 $\sum Q_n$  total shear strength of the shear connectors When (1) controls, the steel is being fully utilized.  $\Box$  stress distribution (a) □ normal case for full composite behavior exists.

When (2) controls, the concrete is being fully utilized.  $\Box$  stress distribution (b) or (c) When (3) controls, partial composite behavior

# **Composite Section Strength for LRFD Method**

### Classification of Composite Sections

#### 1. Composite Sections in Positive Flexure

- Composite sections in kinked continuous or horizontally curved steel girder bridges shall be considered as noncompact sections
- Composite sections in straight bridges that satisfy the following requirements shall qualify as compact sections
  - □ The specified minimum yield strengths of the flanges do not exceed 70.0ksi,

$$\Box \quad \text{the web satisfies the requirement:} \quad \frac{D}{t_w} \le 150$$

$$\Box \quad \text{the section satisfies the web slenderness limit:} \quad \frac{2D_{cp}}{t_w} \le 3.76 \sqrt{\frac{E}{F_{yc}}}$$

D depth of the web

 $D_{\rm cp}~$  depth of the web in compression at the plastic moment assuming steel

beam is fully yielded

 $F_{vc}$  compression flange steel yield stress (ksi)

#### 2. Composite Sections in Negative Flexure and Noncomposite Sections

For composite sections in negative flexure and noncomposite sections, the provisions of Article 6.10.8 limit the nominal flexural resistance to be less than or equal to the moment at first yield. As a result, the nominal flexural resistance for these sections is conveniently expressed in terms of the elastically computed flange stress.

## Flexural Resistance of Composite Sections in Positive Flexure

#### 1. For compact sections

□ Strength limit state

$$M_u + \frac{1}{3} f_l S_{xt} \le \phi_f M_n$$

- $\phi_{f}$  the resistance factor for flexural (=1.0)
- $f_l$  flange lateral bending stress
- $M_n$  nominal flexure resistance of the composite section
- $S_{\scriptscriptstyle xt}\,$  elastic section modulus about the major axis of the section to the tension flange

taken as  $M_{vt}/F_{vt}$ 

 $M_{_{\it Vt}}\,$  yield moment with respect to the tension flange

#### Nominal flexural resistance

- $\Box \quad \text{If} \quad D_p \leq 0.1 D_t \text{ , then } M_n = M_p$
- $\Box \quad \text{Otherwise,} \quad M_n = M_p \left( 1.07 0.7 \frac{D_p}{D_t} \right)$ 
  - $D_p$  distance from the top of the concrete deck to the neutral axis of the composite

section at plastic moment (in)

- $D_t$  total depth of the composite section (in)
- $\Box \quad \text{In continuous span,} \quad M_n \leq 1.3R_h M_y$ 
  - $R_h$  hybrid factor

=1.0 if a higher-strength steel in the web than in both flanges

$$=\frac{12+\beta(3\rho-\rho^3)}{12+2\beta}, \text{ otherwise}$$
$$\beta=\frac{2D_n t_w}{A_{fn}}$$

- $\rho$  = the smaller of  $F_{yw}/f_n$  and 1.0
- $f_{_{\it Y\!W}}\,$  specified minimum yield strength of a web

 $A_{_{f\!m}}\,$  sum of the flange area and the area of any cover plates on the side of

the neutral axis corresponding to  $D_n$ . For composite sections in negative flexure, the area of the longitudinal reinforcement may be included in calculating  $A_{fn}$  for the top flange

 $D_{\scriptscriptstyle n}\,$  larger of the distances from the elastic neutral axis of the cross-

#### section

to the inside face of either flange. For sections where the neutral axis

is

at the mid-depth of the web, the distance from the neutral axis to the inside face of the flange on the side of the neutral axis where yielding occurs first.

 $f_n$  for sections where yielding occurs first in the flange, a cover plate or

the

longitudinal reinforcement on the side of the neutral axis corresponding

to  $D_n$  the largest of the specified minimum yield strengths of each

component included in the calculation of  $A_{fn}$  . Otherwise, the largest

of

the elastic stresses in the flange, cover plate or longitudinal

reinforcement on the side of the neutral axis corresponding to  $D_n$  at

first yield on the opposite side of the neutral axis.

#### 2. For Noncompact sections

□ Strength limit state for compression flange

# $f_{bu} \leq \phi_f F_{nc}$

- $\phi_{f}$  resistance factor for flexure (=1.0)
- $f_{\rm bu}~$  flange stress calculated without consideration of flange lateral bending
- ${\cal F}_{\it nc}~$  nominal flexural resistance of the compression flange

### □ Strength limit state for tension flange

$$f_{bu} + \frac{1}{3}f_l \le \phi_f F_{nt}$$

- $f_l$  flange lateral bending stress
- ${\cal F}_{\rm nt}$   $\,$  nominal flexural resistance of the tension flange  $\,$
- □ Nominal flexural resistance of the compression flange

$$F_{nc} = R_b R_h F_{yc}$$

□ Nominal flexural resistance of the tension flange

$$F_{nc} = R_h F_{yt}$$

### 3. Ductility Requirement

Compact and noncompact sections shall satisfy  $D_p = 0.42D_t$  to ensure significant yielding of the bottom flange when the crushing strain is reached at the top of concrete deck.

# Flexural Resistance of Composite Sections in Negative Flexure and Noncomposite Sections

#### Strength Limit State

$$F_{bu} + \frac{1}{3}f_l = \phi_f F_n$$

- $\phi_{f}$  the resistance factor for flexure (=1.0)
- $f_{\scriptscriptstyle bu}~$  flange stress calculated without consideration of flange lateral bending
- $f_l$  flange lateral bending stress
- $F_{\it nc}$  nominal flexural resistance of the flange

### Application of Design Vehicular Live Loads

#### AASHTO LRFD 3.6.1.3.1

Unless otherwise specified, the extreme force effect shall be taken as the larger of the following:

- □ The effect of the design tandem combined with the effect of the design lane load(=0.64klf), or
- □ The effect of one design truck with the variable axle spacing (14~30ft) combined with the effect of the design lane load, and
- For negative moment between points of contraflexure under a uniform load on all spans, and reaction at interior piers only, 90 percent of the effect of two design trucks spaced a minimum of 50.0ft between the lead axle of one truck and the rear axle of the other truck, combined with 90 percent of the effect of the design lane load. The distance between the 32.0-kip axles of each truck shall be taken as 14.0ft. The two design trucks shall be placed in adjacent spans to produce maximum force effects.

#### Local Buckling Resistance

 $\Box \quad \text{If} \quad \lambda_f \leq \lambda_{pf} \text{ , then } \quad \overline{F_{nc} = R_b R_h F_{yc}}$ 

 $\Box \quad \text{Otherwise} \quad F_{nc} = \left[ 1 - \left( 1 - \frac{F_{yc}}{R_h F_{yc}} \right) \left( \frac{\lambda_f - \lambda_{pf}}{\lambda_{rf} - \lambda_{pf}} \right) \right] R_b R_h F_{yc}$ 

 $F_{\rm yc}~$  yield stress of the compression flange steel

$$\lambda_{_{f=}}rac{b_{_{fc}}}{2t_{_{fc}}}$$
 slenderness ratio for the compression flange

$$\lambda_{pf} = 0.38 \sqrt{\frac{E}{F_{yc}}}$$

•

 $\lambda_{rf} = 0.56 \sqrt{\frac{E}{F_{yr}}}$  limiting slenderness ratio for a noncompact flange

# R<sub>b</sub> web load-shedding factor <u>AASHTO LRFD 6.10.1.10.2</u>

$$R_{b} = 1.0$$

if the section is composite and is in positive flexure

or longitudinal stiffeners are provided, and  $\frac{D}{t_w} \le 0.95 \sqrt{\frac{Ek}{F_{yc}}}$ 

or web satisfy 
$$\frac{2D_c}{t_w} \le \lambda_{rw} = 5.7 \sqrt{\frac{E}{F_y}}$$

• Otherwise, 
$$R_b = 1 - \left(\frac{a_{wc}}{1200 + 300a_{wc}}\right) \left(\frac{2D_c}{t_w} - \lambda_{rw}\right) \le 1.0$$

$$\lambda_{rw} = 5.7 \sqrt{\frac{E}{F_y}}$$
: limiting slenderness ratio for a noncompact web

$$a_{wc} = \frac{2D_c t_w}{b_{fc} t_{fc}}$$
 : ratio of two times the web area in compression to

the

# area of the compression flange

- D web depth
- $D_c$  depth of the web in compression in the elastic range
- *k* bend-buckling coefficient for webs

 $F_{\rm vc}$  specified minimum yield strength of a compression flange

*R*<sub>h</sub> hybrid factor <u>AASHTO LRFD 6.10.1.10.1</u>

#### **Lateral-Torsional Buckling Resistance of Compression Flange**

$$\Box \quad \text{if} \quad L_b \leq L_p = 1.0r_t \sqrt{\frac{E}{F_y}} \quad \text{then} \quad F_{nc} = R_b R_h F_y$$
$$\Box \quad \text{if} \quad L_p \leq L_b \leq L_r \quad \text{then} \quad F_{nc} = C_b \left[ 1 - \left( 1 - \frac{F_{yr}}{R_h F_{yc}} \right) \left( \frac{L_b - L_p}{L_r - L_p} \right) \right] R_b F_y \leq R_b F_y$$

$$\Box \quad \text{if} \quad L_b \ge L_r = \pi r_t \sqrt{\frac{E}{F_y}} \quad \text{then} \quad F_{nc} = F_{cr} \le R_b F_y$$

$$r_{t} = \frac{b_{fc}}{\sqrt{12\left(1 + \frac{1}{3}\frac{D_{c}t_{w}}{b_{fc}t_{fc}}\right)}}$$

$$c_{\scriptscriptstyle b}=1.0\,\text{, if}~f_{\scriptscriptstyle mid}\geq f_{\scriptscriptstyle 2}\,\text{, or}~f_{\scriptscriptstyle 2}=0$$

Otherwise  $c_b = 1.75 - 1.05 \left(\frac{f_1}{f_2}\right) + 0.3 \left(\frac{f_1}{f_2}\right)^2 \le 2.3$ 

$$F_{cr} = \frac{C_b R_b \pi^2 E}{\left(\frac{L_b}{r_t}\right)^2}$$

 $f_{\it mid}~$  factored maximum stress at the middle of the unbraced compression flange

(compression as positive)

- $f_2$  factored maximum stress at either end of the unbraced compression flange (compression as positive) if it is in tension,  $f_2 = 0$ .
- $f_0$  factored maximum stress at the braced point opposite to the one corresponding

to  $f_2$  (compression as positive)

$$f_1 = 2f_{mid} - f_2 \ge f_0$$

□ Flexural Resistance of Tension Flange

$$F_{nt} = R_h F_{yt}$$

# Shear Resistance of Composite Sections

□ Strength Limit State of straight and curved web panels

 $V_u \leq \phi_v V_n$ 

- $V_{\scriptscriptstyle n}$   $\,$  nominal shear resistance for unstiffened and stiffened webs
- $V_{\scriptscriptstyle u}~$  factored shear in the web
- $\phi_v$  the resistance factor for shear (=1.0)

## □ Nominal resistance of unstiffened webs

$$V_n = CV_p$$

$$V_p = 0.58 F_y Dt_w$$

the constant C

$$\Box \quad \text{for} \ \ \frac{D}{t_{_W}} \langle 1.12 \sqrt{\frac{Ek}{F_{_y}}} \ ,$$

$$C = 1.0$$





$$\Box \quad \text{for } 1.12 \sqrt{\frac{Ek}{F_y}} \le \frac{D}{t_w} \langle 1.40 \sqrt{\frac{Ek}{F_y}}, \qquad C = \frac{1.12}{\left(\frac{D}{t_w}\right)} \sqrt{\frac{Ek}{F_y}}$$

$$\Box \quad \text{for} \quad \frac{D}{t_w} \ge 1.40 \sqrt{\frac{Ek}{F_y}}, \qquad C = \frac{1.57}{\left(\frac{D}{t_w}\right)^2} \left(\frac{Ek}{F_y}\right)$$

 $k = 5 + \left[ 5/(d_0/D)^2 \right]$  buckling coefficient (k=5 for unstiffened beams)

- $D\ \ {\rm clear}\ {\rm distance}\ {\rm between}\ {\rm flanges}$
- $d_{\scriptscriptstyle 0}$   $\,$  distance between transverse stiffeners

**Nominal resistance of stiffened webs** 

$$V_n = V_p \left( C + \frac{0.87(1-C)}{\sqrt{1 + (d_0/D)^2} + d_0/D} \right)$$

□ Transverse stiffener



Typical shear-dominant failure mode of stiffened web



**Transverse stiffeners, longitudinal stiffeners, and bearing stiffeners** 





Transverse Web Stiffener Bearing Stiffener

Jacking Stiffeners

# **Design of Shear Connectors**

### How to design?

AASHTO requires that shear connectors be designed to account for <u>fatigue</u> and checked for <u>ultimate strength</u>. *Note that the ultimate strength method is not an alternative approach, but a required check*.

#### Fatigue Check

Fatigue is caused by the repetitive loading and unloading of a structural member.

- □ For fatigue load, use only one truck with a load factor of 0.75.
- □ Range of horizontal shear at slab-beam interface(k/in)

$$S_r = \frac{V_r Q}{I}$$

 $V_r$  range of shear due to live load plus impact, k

Q statical moment about neutral axis, in<sup>3</sup>

- *I* moment of inertia of composite beam, in<sup>4</sup>
- □ Allowable range of horizontal shear for on one stud(k)

 $Z_r = \alpha \cdot d^2$ 

- $\alpha = 34.5 4.28 \log N$  constant based on number of stress cycles d diameter of stud, in (5/8, 6/8, 7/8in, typically)
- □ Fatigue check

 $S_r \leq Z_r$ 

Pitch of shear connectors

$$p = \frac{n \cdot Z_r}{S_r}$$

*n* number of shear connectors, in

## Geometric Constraints

- □ Maximum pitch of shear connectors: 24 in
- □ Minimum spacing between shear connectors in a row:  $s \ge 4 \cdot d$

- Minimum spacing between the edge of the stringer flange to the edge of the shear connector: 1 in
- □ Minimum concrete cover over the top of the shear connector: 2 in.
- □ The shear stud should extend at least 2 in above the bottom of the concrete deck slab.
- □ The ratio of the length of the connector to its diameter should not be less than 4.

## Geometric Constraints

Ultimate tensile strength of the steel stringer

$$P_1 = A_s F_y$$

- *A<sub>s</sub>* total area of steel stringer
- $F_{v}$  minimum yield point of steel used



□ Ultimate compressive strength of the concrete slab

$$P_2 = 0.85 f_c' b_{eff} t$$

□ Ultimate strength of a single shear connector, kips

$$Q_r = \phi_{sc} Q_n$$
$$Q_n = 0.5 A \sqrt{f_c' E_c} \le A F_u$$

- $\phi_{sc}$  resistance factor for shear conncetors= 0.85
- A cross-sectional area of stud, in<sup>2</sup>
- $E_c$  modulus of elasticity of concrete, ksi
- $F_u$  specified tensile strength of shear stud, ksi



 Minimum number of shear connectors required between points of maximum positive moment and the adjacent end supports

$$n = \frac{P}{Q_r}$$

P smaller of  $P_1$  and  $P_2$ 



 Minimum number of shear connectors in areas between maximum positive moment and adjacent maximum negative moment in continuous spans

$$n = \frac{P + P_3}{Q_r}$$

 $P_3$  force in slab at points of maximum negative moment

 $P_3$  =0 reinforcement of the concrete slab is ignored for negative bending

 $P_3$  lesser of  $A_s F_y$  and  $0.45 f_c b_{e\!f\!f} t$ 

-> represents the combined contribution of deck reinforcement and the tensile strength of the concrete-> more conservative in AASHTO LRFD!

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s S	tige Distance North-	tr kates kates kates kates able with the second sec	in. in. in. in. in. in.	2.72 2 <sup>3</sup> / <sub>4</sub> 3.22 3 <sup>5</sup> / <sub>8</sub> 1 <sup>9</sup> / <sub>16</sub> 20 <sup>3</sup> / <sub>4</sub> 5 <sup>1</sup> / <sub>2</sub> 37 2.48 2 <sup>1</sup> / <sub>2</sub> 2.98 3 <sup>3</sup> / <sub>8</sub> 1 <sup>1</sup> / <sub>2</sub> 1	2.28 2 <sup>1</sup> /4 2.78 3 <sup>3</sup> /16 1 <sup>7</sup> /16 30 30 21/4 2.78 3 <sup>3</sup> /16 30	1.89 17/8 2.39 2 <sup>13</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>8</sub> 2.39 2 <sup>13</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>8</sub>	1.73 13/4 2.23 25/6 15/16 2 1.57 19/16 2.07 21/5 11/4	1.46 17/16 1.96 2 <sup>3/6</sup> 1 <sup>1/4</sup>	1.22 11/4 1.72 21/8 13/18 1.22 11/4 1.72 21/8 13/18	1.109 11/16 1.59 2 11/8 1 3.960 <sup>15</sup> / <sub>16</sub> 1.46 17/ <sub>8</sub> 11/ <sub>8</sub>	0.850 7/8 1.35 13/4 17/8 9.750 3/4 1.25 15/6 17/16 V	0.980 1 1.48 17/8 17/8 203/4 51/2	0.875 7/8 1.38 1 <sup>3/4</sup> 1 <sup>1/16</sup> 9.770 <sup>3</sup> /4 1.27 1 <sup>11/16</sup> 1 <sup>1/16</sup>	0.680 11/36 1.18 19/16 11/36 V	0.590 <sup>9</sup> / <sub>16</sub> 1.09 1 <sup>1</sup> / <sub>2</sub> 1 <sup>1</sup> / <sub>16</sub> 20 <sup>3</sup> / <sub>4</sub> 3 <sup>1</sup> / <sub>2</sub> <sup>9</sup> 2.505 <sup>1</sup> / <sub>2</sub> 1.01 1 <sup>7</sup> / <sub>16</sub> 1 20 <sup>3</sup> / <sub>4</sub> 3 <sup>1</sup> / <sub>2</sub> <sup>9</sup>	1.63 1 <sup>5</sup> / <sub>8</sub> 2.13 2 <sup>1</sup> / <sub>2</sub> 1 <sup>5</sup> / <sub>16</sub> 18 5 <sup>1</sup> / <sub>2</sub>	1.48 11/2 1.98 23/8 11/4 1.36 13/6 1.86 21/2 1.3/4	1.15 1 <sup>1</sup> / <sub>16</sub> 1.65 2 1 <sup>3</sup> / <sub>16</sub>	1.04 11/16 1.54 11 <sup>3</sup> /16 11/8 1.960 <sup>15</sup> / <sub>18</sub> 1.46 11 <sup>3</sup> / <sub>16</sub> 11/ <sub>8</sub>	0.875 7/8 1.38 1 <sup>-3/4</sup> 1 <sup>1/8</sup>	0.000 <sup>12</sup> /16 1.30 1.1/16 1 //16 <b>1</b> //16		
continued) apes sions	Flange Distance Nork-	hr tr Kees Keer ki T able WL	1. in. in. in. in. in. in.	13% 2.72 234 3.22 3% 19/16 203/4 51/2 31 13/2 2.48 21/2 2.98 33% 11/2 1	13 <sup>3</sup> /s 2.28 2 <sup>3</sup> /s 2.78 3 <sup>3</sup> /16 1 <sup>7</sup> /16 13 <sup>1</sup> /s 2.00 2 <sup>1</sup> /s 2.60 2 1 <sup>7</sup> /s 2	13 <sup>1/8</sup> 1.89 17 <sup>1/8</sup> 2.39 2 <sup>13</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>18</sub>	13/8 1.73 13/4 2.23 25/6 15/16 13 1.57 19/16 2.07 21/5 11/4	13 1.46 17/16 1.96 23/8 17/4 137/6 1.24 15/6 1.96 23/8 17/4	12./8 1	127/8 1.09 11/16 1.59 2 11/8 1 127/8 0.960 <sup>15</sup> /36 1.46 17/8 11/8 11/8	12 <sup>2</sup> / <sub>4</sub> 0.850 <sup>7</sup> / <sub>8</sub> 1.35 1 <sup>3</sup> / <sub>4</sub> 1 <sup>3</sup> / <sub>8</sub> 1 <sup>3</sup> / <sub>8</sub> 1 <sup>3</sup> / <sub>8</sub> 1 <sup>3</sup> / <sub>8</sub>	9 0.980 1 1.48 17/8 11/8 203/4 51/2	9/8 0.875 //s 1.38 1 <sup>3</sup> /4 1 <sup>1</sup> / <sub>16</sub> 9 9 0.770 <sup>3</sup> /4 1.27 1 <sup>1</sup> / <sub>16</sub> 1 <sup>1</sup> / <sub>16</sub>	9 0.680 <sup>11</sup> / <sub>16</sub> 1.18 1 <sup>9</sup> / <sub>16</sub> 1 <sup>1</sup> / <sub>16</sub> V	7 0.590 <sup>9</sup> / <sub>16</sub> 1.09 1 <sup>1</sup> / <sub>2</sub> 1 <sup>1</sup> / <sub>16</sub> 20 <sup>3</sup> / <sub>4</sub> 3 <sup>1</sup> / <sub>2</sub> <sup>9</sup> 7 0.505 <sup>1</sup> / <sub>2</sub> 1.01 1 <sup>1</sup> / <sub>16</sub> 1 20 <sup>3</sup> / <sub>4</sub> 3 <sup>1</sup> / <sub>2</sub> <sup>9</sup>	12 <sup>5</sup> / <sub>6</sub> 1.63 1 <sup>5</sup> / <sub>8</sub> 2.13 2 <sup>1</sup> / <sub>2</sub> 1 <sup>5</sup> / <sub>16</sub> 18 5 <sup>1</sup> / <sub>2</sub>	12/2 1.48 11/2 1.98 23/8 11/4 123/s 136 13/s 186 21/s 13/s	12 <sup>1/2</sup> 1.15 1 <sup>1/8</sup> 1.65 2 1 <sup>3/16</sup>	12/2 1.04 1/16 1.54 1 <sup>10</sup> /16 1/8 12 <sup>3</sup> /8 0.960 <sup>15</sup> / <sub>16</sub> 1.46 1 <sup>13</sup> / <sub>16</sub> 1 <sup>1</sup> / <sub>8</sub>	123/s 0.875 7/s 1.38 13/4 11/8	12/4 U.SUU 12/16 1.3U 11/16 1/16 1		
-1 (continued) Shapes nensions	Flange Distance North-	br tr kaas kaar ki T able Wt.	in. in. in. in. in. in. in.	13.7 13 <sup>3</sup> / <sub>6</sub> 2.72 2 <sup>3</sup> / <sub>6</sub> 3.22 3 <sup>5</sup> / <sub>6</sub> 1 <sup>3</sup> / <sub>16</sub> 20 <sup>3</sup> / <sub>4</sub> 5 <sup>1</sup> / <sub>2</sub> 37   13.5 13 <sup>3</sup> / <sub>2</sub> 13 <sup>3</sup> / <sub>6</sub> 1 <sup>1</sup> / <sub>2</sub> 1 1 1 32	13.4 13 <sup>4</sup> /s 2.28 2 <sup>4</sup> /4 2.78 3 <sup>3</sup> / <sub>15</sub> 1 <sup>4</sup> / <sub>16</sub> 38 13.3 13 <sup>4</sup> /s 2.00 2 <sup>14</sup> /s 56 5 3 <sup>4</sup> / <sub>16</sub> 5	13.2 13/8 1.89 17/8 2.39 2 <sup>13/16</sup> 1 <sup>3/6</sup> 2.	13.1 13/8 1.73 13/4 2.23 25/6 15/16 13.0 13 1.57 19/6 2.07 21/5 11/4	13.0 13 1.46 17/16 1.96 2 <sup>3</sup> /6 1 <sup>1</sup> /4 12.0 127/6 1.24 15/6 1.96 2 <sup>3</sup> /6 11/4	13.0 13 1.22 1/4 1.72 2/6 13/6 1	12.9 127/s 1.09 11/s 1.59 2 11/s 12.9 127/s 0.960 15/s 1.46 17/s 11/s	12.8 12 <sup>9</sup> / <sub>4</sub> 0.850 <sup>7</sup> / <sub>8</sub> 1.35 1 <sup>3</sup> / <sub>4</sub> 1 <sup>3</sup> / <sub>6</sub> 1 <sup>3</sup> /	9.00 9 0.980 1 1.48 17/s 11/s 20 <sup>3/4</sup> 5 <sup>1</sup> /2	9.02 9 0.875 <sup>7/8</sup> 1.38 1 <sup>3/4</sup> 1 <sup>1/16</sup> 9.02 9 0.770 <sup>3</sup> /4 1.27 1 <sup>11/16</sup> 1 <sup>1/16</sup>	8 99 9 0.680 <sup>1</sup> / <sub>16</sub> 1.18 1 <sup>9</sup> / <sub>16</sub> 1.1 <sub>6</sub> 1.18 8 <sup>19</sup> / <sub>16</sub> 1.1 <sub>6</sub> 8 17 8 19/ <sub>16</sub> 1.1 <sub>6</sub> 1.1	Z/04 Z 0.590 9/se 1.09 1/yr 20/kr 3/yr   Z/01 Z 0.0505 ½ 1.01 17/yr 11/yr 20/kr 3/yr	12.6 12 <sup>5</sup> / <sub>6</sub> 1.63 1 <sup>5</sup> / <sub>8</sub> 2.13 2 <sup>7</sup> / <sub>2</sub> 1 <sup>5</sup> / <sub>16</sub> 18 5 <sup>7</sup> / <sub>2</sub>	12.5 12/2 1.48 11/2 1.98 23/8 11/4 12.4 123/8 1.36 1.36 1.86 21/2 1.30/2	12.5 12 <sup>1</sup> / <sub>2</sub> 1.15 1 <sup>1</sup> / <sub>8</sub> 1.65 2 1 <sup>3</sup> / <sub>16</sub>	12.4 12/2 1.04 1/16 1.54 1 <sup>10</sup> /6 1 <sup>7</sup> /8 1 <sup>10</sup> /6 1 <sup>7</sup> /8 1 <sup>10</sup> /6 1 <sup>7</sup> /8 1 <sup>10</sup> /6 1 <sup>15</sup> /6 1 <sup>3</sup> /6	12.3 12 <sup>3</sup> / <sub>12</sub> 0.875 <sup>7</sup> / <sub>18</sub> 1.38 1 <sup>3</sup> / <sub>14</sub> 1 <sup>1</sup> / <sub>18</sub>	12.3 12/4 0.8000 P/16 1.30 11/16 1/16 1/16 1/16 1		
le 1-1 (continued) W Shapes Dimensions	Flange Distance North	$\frac{t_{w}}{2}$ br $t_{f}$ keek keet $k_{1}$ T able W.	in. in. in. in. in. in. in. in.	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	5/s 13.4 133/s 2.28 33/s 17/s 30   5/s 13.3 131/s 2.00 21/s 2.78 33/s 17/s 30	<sup>9</sup> / <sub>16</sub> 13.2 13/ <sub>18</sub> 1.89 17/ <sub>18</sub> 2.39 213/ <sub>16</sub> 13/ <sub>16</sub> 2.39 22	5 <sup>1</sup> / <sub>2</sub> 13.1 13 <sup>1</sup> / <sub>8</sub> 1.73 1 <sup>3</sup> / <sub>4</sub> 2.23 2 <sup>5</sup> / <sub>8</sub> 1 <sup>5</sup> / <sub>16</sub> 2 <sup>7</sup> / <sub>16</sub> 13.0 13 1.57 1 <sup>9</sup> / <sub>16</sub> 2.07 2 <sup>1</sup> / <sub>2</sub> 1 <sup>1</sup> / <sub>4</sub>	7/16 13.0 13.1 1.46 17/16 1.96 23/6 17/4   3/6 17.0 1.37/6 1.36 1.24 13/6 1.44 1	<sup>76</sup> 12.2 12.18 1.34 1716 1.04 2.44 1716 1.04 2.44 1716 1.04 2.44 1716 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1.04	<sup>5</sup> / <sub>16</sub> 12.9 12/ <sub>18</sub> 1.09 1 <sup>1</sup> / <sub>16</sub> 1.59 2 1 <sup>1</sup> / <sub>16</sub> 1 <sup>5</sup> / <sub>16</sub> 12.9 12 <sup>1</sup> / <sub>16</sub> 0.960 <sup>15</sup> / <sub>16</sub> 1.46 1 <sup>7</sup> / <sub>16</sub> 1 <sup>1</sup> / <sub>16</sub> 1 <sup>1</sup> / <sub>16</sub>	<sup>5</sup> / <sub>16</sub> 12.8 12 <sup>9</sup> / <sub>1</sub> 0.850 <sup>7</sup> / <sub>6</sub> 1.35 1 <sup>3</sup> / <sub>4</sub> 1 <sup>1</sup> / <sub>6</sub> <sup>1</sup> / <sub>4</sub> 1 <sup>1</sup> / <sub>6</sub> <sup>1</sup> / <sub>4</sub> 12.8 12 <sup>9</sup> / <sub>4</sub> 0.750 <sup>3</sup> / <sub>4</sub> 1.25 1 <sup>5</sup> / <sub>6</sub> 1 <sup>1</sup> / <sub>16</sub> <sup>1</sup> / <sub>16</sub>	<sup>5</sup> / <sub>16</sub> 9.00 9 0.980 1 1.48 17/6 11/6 20 <sup>3</sup> /4 51/2	74 9.07 978 0.875 78 1.38 194 176 74 9.02 9 0.770 34 1.27 1176 176	Va 8.97 9 0.680 <sup>11</sup> / <sub>A6</sub> 1.18 19/ <sub>16</sub> 1. <sup>10</sup> Va 8.97 9 0.585 <sup>9</sup> / <sub>B</sub> 1.09 11/ <sub>2</sub> 11/ <sub>16</sub>	VA 7.04 7 0.590 9/46 1.09 11/46 20/34 3/26   Pire 7.01 7 0.505 1/2 1.01 11/16 1 3/26	<sup>1</sup> / <sub>2</sub> 12.6 12 <sup>5</sup> / <sub>8</sub> 1.63 1 <sup>5</sup> / <sub>8</sub> 2.13 2 <sup>1</sup> / <sub>2</sub> 1 <sup>5</sup> / <sub>16</sub> 18 5 <sup>1</sup> / <sub>2</sub>	7/16 12.5 12/2 1.48 17/2 1.98 2 <sup>3/8</sup> 17/4 3/8 12.4 123/8 1.96 13/8 1.86 27/2 1.3/2	<sup>3/8</sup> 12.5 12 <sup>1/2</sup> 1.15 1 <sup>1/6</sup> 1.65 2 1 <sup>3/16</sup>	7/16 12.4 12/2 1.04 17/16 1.54 11/9/6 17/8 17/8 17/8 12/4 12/3/6 12.4 12/3/6 0.960 15/48 14/6 11/2/4 12/4 12/4 12/4 12/4 12/4 12/4 12	<sup>5</sup> /18 12.3 12 <sup>3</sup> /9 0.875 <sup>7/8</sup> 1.38 1 <sup>3/4</sup> 1 <sup>1/8</sup>	74 12.3 12/4 0.800 19/6 1.30 11/16 17/6 A		
Table 1–1 (continued) W Shapes Dimensions	Web Flange Distance North Traincheanan & Work North	$t_w = \frac{t_w}{2}$ by tr $k_{des}$ $k_{des}$ $k_{des}$ $k_i$ T able WL	in	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	11/4 5/8 13.4 133/8 2.28 21/4 2.78 33/16 17/16 20 13/16 5/6 13.3 13/16 2.60 5 50 5 50 5 50 5 50 5 50 5 50 5 50 5	11/16 9/16 13.2 13/18 1.89 17/8 2.39 213/16 13/8 2.39 22	0 <sup>13</sup> / <sub>15</sub> <sup>1</sup> / <sub>2</sub> 13.1 13/ <sub>8</sub> 1.73 1 <sup>3</sup> / <sub>4</sub> 2.23 2 <sup>5</sup> / <sub>9</sub> 15/ <sub>16</sub> 2.2 2 <sup>3</sup> 2 <sup>5</sup> / <sub>9</sub> 15/ <sub>16</sub> 2.2 2 2 <sup>3</sup> / <sub>2</sub> 2 <sup></sup>	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	5 <sup>11</sup> / <sub>116</sub> <sup>3</sup> / <sub>3</sub> 13.0 13 1.22 11/ <sub>4</sub> 1.72 2 <sup>1</sup> / <sub>6</sub> 1.34 1 <sup>3</sup> / <sub>16</sub> 1.3 <sup>1</sup> / <sub>3</sub>	0 <sup>3</sup> / <sub>7</sub> <sup>3</sup> / <sub>16</sub> <sup>1</sup> / <sub>12</sub> <sup>1</sup> / <sub>2</sub> <sup>1</sup> / <sub>2</sub> <sup>1</sup> / <sub>16</sub> <sup>1</sup> / <sub>16</sub> <sup>1</sup> / <sub>15</sub> <sup>1</sup> / <sub>2</sub> <sup>1</sup> / <sub>2</sub> <sup>1</sup> / <sub>16</sub> <sup>1</sup> / <sub>1</sub>	0 9/16 5/16 12.8 129/4 0.360 7/8 1.35 13/4 17/8 1	0 <sup>9/16</sup> <sup>5/16</sup> 900 9 0.980 1 1.48 1 <sup>7/8</sup> 1 <sup>1/6</sup> 20 <sup>3/4</sup> 5 <sup>1/2</sup>	2 72 74 9.02 9 0.875 78 1.38 19/4 17/16 1 72 74 9.02 9 0.770 34 1.27 111/16 17/16	0 7/16 1/4 899 9 0.680 11/46 1.18 19/16 1.2/16 7 11/1/16 11/2 11/16 11/2 11/16 11/2 11/16 11/2 11/16 11/2 11/16	7/16 7/4 7.04 7 0.590 9/16 1/36 203/4 3/26   5 36 316 7.01 7 0.505 1/2 1/16 203/4 3/26	2 <sup>15</sup> /16 <sup>1</sup> /2 12.6 125/6 1.63 15/8 2.13 21/2 15/16 18 51/2	0 -2/16 /16 12.5 12/12 1.48 11/2 1.98 22/8 11/4 1 3/a 3/a 17.4 173/a 1.36 13/a 1.86 21/2 1.36/a	0 <sup>3</sup> / <sub>4</sub> <sup>3</sup> / <sub>8</sub> 12.5 12 <sup>1</sup> / <sub>2</sub> 1.15 1 <sup>1</sup> / <sub>8</sub> 1.65 2 1 <sup>3</sup> / <sub>16</sub>	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	0 <sup>9</sup> / <sub>16</sub> <sup>5</sup> / <sub>16</sub> 12.3 12 <sup>3</sup> / <sub>16</sub> 0.875 <sup>7</sup> / <sub>8</sub> 1.38 1 <sup>3</sup> / <sub>4</sub> 1 <sup>3</sup> / <sub>4</sub> 1 <sup>3</sup> / <sub>4</sub>	V V V 1.2.3 1.2.14 0.800 1.30 1.30 1.1/16 1.1/16		
Table 1–1 (continued) W Shapes Dimensions	Web Flange Distance   Thicknese 4 Work-	$t_w = \frac{1}{2}$ $b_t$ $t_t$ $k_{des}$ $k_{des}$ $k_{it}$ $T$ able $w_{max}$	in. in. in. in. in. in. in. in. in.	$ \begin{bmatrix} 1.52 & 1^{1}/2 & 3^{1}/4 & 13.7 & 13^{5}/6 & 2.72 & 2^{3}/4 & 3.22 & 3^{5}/6 & 19^{1}/6 & 20^{2}/4 & 5^{1}/2 & 31 \\ 2^{1}/2 & 1^{2}/8 & 1^{1}/6 & 13.5 & 13^{1}/2 & 2.48 & 2^{1}/2 & 2.98 & 3^{3}/6 & 1^{1}/2 & 1 & 1 \end{bmatrix} $	y <sub>10</sub> 1.26 1 y <sub>14</sub> = y <sub>18</sub> 13.4 133 <sup>16</sup> 2.28 2/4 2.78 3 <sup>3</sup> /16 17/16 13 <sup>1/16</sup> 2.78 2 <sup>3</sup> /16 17/16 13 <sup>1/16</sup> 2.78 2 <sup>3</sup> /16 12 <sup>1/16</sup> 2.78 2 <sup>3</sup> /16 12 <sup>1/16</sup> 2.00 2 <sup>3</sup> /16 12 <sup>1/16</sup> 2.00 2 <sup>3</sup> /16 12 <sup>1/16</sup> 2.00 2 <sup>3</sup> /16 12 <sup>1/16</sup> 2 <sup>1/16</sup>	Va 1.04 11/16 9/16 13.2 13/18 1.89 11/18 2.39 213/16 13/8 1.39 22	0.960 <sup>13</sup> / <sub>16</sub> <sup>1</sup> / <sub>2</sub> 113.1 13/ <sub>18</sub> 1.73 1 <sup>3</sup> / <sub>4</sub> 2.23 2 <sup>5</sup> / <sub>6</sub> 1 <sup>5</sup> / <sub>16</sub> 1 <sup>5</sup> / <sub>16</sub> 2 2 2 2 <sup>3</sup> / <sub>2</sub> 1 <sup>5</sup> / <sub>16</sub> 1 <sup>5</sup> / <sub>16</sub> 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	22 0.810 <sup>13</sup> / <sub>15</sub> <sup>7</sup> / <sub>16</sub> 13.0 13 1.46 17/ <sub>16</sub> 1.96 23/ <sub>16</sub> 11/ <sub>14</sub> (a) 750 3/ <sub>2</sub> 3/ <sub>6</sub> 12.0 127/ <sub>16</sub> 12.0 12/ <sub>16</sub> 12.4 12.6 12.6 23/ <sub>16</sub> 11/ <sub>14</sub>	0.705 <sup>1/1</sup> / <sub>16</sub> <sup>3/6</sup> 13.0 13 1.22 1/ <sub>1</sub> / <sub>1</sub> 1.72 2/ <sub>16</sub> 1.94 2.74 1.716 1.705 <sup>1/1</sup> / <sub>16</sub> <sup>3/6</sup> 13.0 13 1.22 1/ <sub>1</sub> / <sub>4</sub> 1.72 2/ <sub>16</sub> 1.916	140.0550 56 56 576 12.9 127/8 1.09 17/16 1.59 2 17/8 12/8 12/0 127/8 12/0 127/8 12/9 127/8 12/9 127/8 12/9 12/9 12/9 12/9 12/9 12/9 12/9 12/9	(4, 0.550) <sup>9</sup> / <sub>16</sub> <sup>9</sup> / <sub>16</sub> <sup>1</sup> / <sub>28</sub> <sup>1</sup> / <sub>28</sub> <sup>1</sup> / <sub>2</sub> <sup>0</sup> / <sub>2</sub> <sup>1</sup> / <sub>2</sub>	(20550 <sup>9</sup> /16 <sup>5</sup> /16 9.00 9 0.980 1 1.48 1 <sup>7</sup> /8 1 <sup>1</sup> /8 20 <sup>3</sup> /4 5 <sup>1</sup> /2	a <sub>1</sub> /1 b <sub>1</sub> /1 b <sub>1</sub> /1 8 1.3 8 0.48 0.875 0.876 0.876 0.470 0.47 0.00 0.47	[s] 0.440 7/m 1/s 8.99 9 0.680 11/s 1.18 12/m 11/s 12/m 12/m 12/m 14 0.415 7/m 1/s 8.97 9 0.585 9/m 1.09 11/5 11/m ♥	(a) 0.430 7/16 7/4 7 0.4 7 0.550 9/16 1.09 17/2 17/16 203/4 37/2 (b) 0.395 3/6 3/16 7.01 7 0.506 7/2 1.01 17/16 1 207/4 37/2	0.910 <sup>15</sup> / <sub>16</sub> <sup>1</sup> / <sub>12</sub> 12.6 125/ <sub>8</sub> 1.63 15/ <sub>8</sub> 2.13 2 <sup>1</sup> / <sub>2</sub> 15/ <sub>16</sub> 18 5/ <sub>2</sub>	74 0.0530 <sup>-3</sup> /16 <sup>-</sup> /16 12.5 12/2 1.48 1/2 1.98 2 <sup>-</sup> /8 1 <sup>-1</sup> /4 2 0.750 <sup>3</sup> /4 <sup>-3</sup> /8 12 4 12 <sup>3</sup> /8 1 36 1 <sup>-3</sup> /8 1 36 2 <sup>-1</sup> /8 2 <sup>-1</sup> /8 2 <sup>-1</sup> /8	0.720 <sup>3</sup> / <sub>4</sub> <sup>3</sup> / <sub>6</sub> 12.5 12 <sup>1</sup> / <sub>2</sub> 1.15 1 <sup>1</sup> / <sub>8</sub> 1.65 2 1 <sup>3</sup> / <sub>16</sub>	8 0.000 76 7/16 12.4 12.72 1.04 17/16 1.54 1.19/16 1.78 1.97 17/16 17/18 18 0.0600 5/16 5/16 1.24 1.23/18 0.960 15/18 1.46 1.13/16 17/18 1	2 0.550 <sup>9</sup> / <sub>16</sub> <sup>5</sup> / <sub>16</sub> 12.3 12 <sup>3</sup> / <sub>9</sub> 0.875 <sup>7</sup> / <sub>8</sub> 1.38 1 <sup>3</sup> / <sub>4</sub> 1 <sup>1</sup> / <sub>8</sub>			
Table 1–1 (continued) W Shapes Dimensions	Depth, Web Flange Distance North Thickness & Width Thickness & Width Thickness & Width Thickness & Work-	d two the second secon	in.	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	1.1 27/16 1.26 11/4 5/6 13.4 13/9 2.28 21/4 2.78 33/16 17/16 38/16 13/16	1.3 26 <sup>3</sup> / <sub>8</sub> 1.04 11/ <sub>16</sub> <sup>9</sup> / <sub>16</sub> 13.2 13/ <sub>8</sub> 1.89 17/ <sub>8</sub> 2.39 2 <sup>13</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>8</sub> 2.39 2 <sup>13</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>8</sub>	2.0 26 0.960 <sup>13</sup> / <sub>16</sub> <sup>1/2</sup> 13.1 13/ <sub>18</sub> 1.73 1 <sup>3</sup> / <sub>4</sub> 2.23 2 <sup>5</sup> / <sub>8</sub> 15/ <sub>16</sub> 25/ <sub>16</sub> 15/ <sub>16</sub> 201 2 .7 25 <sup>3</sup> / <sub>4</sub> 0.870 7 <sub>6</sub> <sup>3</sup> / <sub>16</sub> 13.0 13 1.57 1 <sup>9</sup> / <sub>16</sub> 2.07 2 <sup>1</sup> / <sub>5</sub> 1 <sup>1</sup> / <sub>4</sub>	2.5 25/2 (0.810 <sup>13</sup> / <sub>16</sub> <sup>7</sup> / <sub>16</sub> 13.0 13 1.46 17/ <sub>16</sub> 1.96 23/ <sub>16</sub> 17/ <sub>14</sub> 2. 25/ <sub>16</sub> (1750 <sup>3</sup> / <sub>16</sub> <sup>3/</sup> <sub>16</sub> 12.0 137/ <sub>16</sub> 1.24 15/ <sub>16</sub> 1.96 23/ <sub>16</sub> 1.14	20 25 0.705 <sup>11</sup> / <sub>16</sub> <sup>3</sup> / <sub>8</sub> 13.0 13 12.2 1 <sup>1</sup> / <sub>4</sub> 1.72 2 <sup>1</sup> / <sub>8</sub> 19 <sup>16</sup> 1.9 <sup>1</sup> / <sub>6</sub> 1	1.7 24 <sup>3</sup> /4 (1650 <sup>5</sup> / <sub>6</sub> <sup>5</sup> / <sub>6</sub> <sup>5</sup> / <sub>6</sub> <sup>1</sup> / <sub>6</sub> <sup>1</sup> / <sub>2</sub> 12 <sup>3</sup> / <sub>8</sub> 1.09 1 <sup>1</sup> / <sub>16</sub> 1.59 2 1 <sup>1</sup> / <sub>8</sub> 1.59 1 1 <sup>3</sup> / <sub>6</sub> 1.46 1 <sup>7</sup> / <sub>1</sub> 1 <sup>1</sup> / <sub>6</sub> 1.16 1 <sup>7</sup> / <sub>1</sub> 1 <sup>1</sup> / <sub>6</sub> 1 <sup>1</sup> / <sub>6</sub>	1.3 24/4 0.550 9/16 5/16 1/28 129/4 0.850 7/8 1.35 19/4 17/8 17/8 17/8 17/8 17/8 17/8 17/8 17/8	5 24/2 0.550 9/16 5/18 9.00 9 0.980 1 1.48 17/6 17/6 203/4 5/12	.3 24/4 (0.512) /2 /4 9.02 9/8 0.875 /8 1.38 13/4 11/16 .1 24/18 0.470 //2 /4 9.02 9 0.770 3/4 1.27 111/16	.9 23/5 0.440 7/16 7/4 8 99 9 0.680 17/16 1.18 1.9/16 1.1/6 7 23/4 0.415 7/16 7/4 8 97 9 0.585 9/16 1.09 117 17/16 V	7 23% 0.430 7/4 7 0.560 9/4 1.06 1.7/4 20%4 31/2   6 23% 0.336 3/6 7/1 7 0.560 9/4 1.01 1/1/6 20%4 31/2	.0 23 0.910 <sup>15/16</sup> <sup>1/2</sup> 12.6 125/8 1.63 15/8 2.13 22/2 15/16 18 5/2	./ 22/4 0.630 % 6 /16 12.5 12/12 1.48 11/2 1.98 23/8 11/4 5 22/12 0.750 3/4 3/8 12 4 173/8 13/6 13/6 13/6 13/6 23/12 63/6	1 22 0.720 <sup>3</sup> / <sub>4</sub> <sup>3</sup> / <sub>8</sub> 12.5 12 <sup>3</sup> / <sub>2</sub> 1.15 1 <sup>3</sup> / <sub>8</sub> 1.65 2 1 <sup>3</sup> / <sub>16</sub>	2 21/3 0.000 76 7/6 12.4 12/2 1.04 17/6 1.54 17/3 1.64 17/6 1/6 17 21/5 10/6 17/6 17/6 17/6 17/6 17/6 17/6 17/6	5 211/2 0.550 9/16 5/16 12.3 123/6 0.875 7/8 1.38 13/4 11/8			
Table 1-1 (continued) W Shapes Dimensions	rea, Depth, Thickness , wridth Trainkonnon k Distance North-	A d two two $\frac{1}{2}$ by tr kies kies to $\frac{1}{2}$ able with two $\frac{1}{2}$ by the form the f	n <sup>2</sup> in	9 28.0 28 1.52 11/2 34 13.7 1356 2.72 234 3.22 356 19/6 2034 51/2 38 84 27.5 271/51.38 136 11/6 13.5 131/2 248 21/5 298 33/6 11/5 1	9.8 27.1 27 <sup>16</sup> 1.26 1 <sup>1</sup> /4 <sup>5</sup> / <sub>6</sub> 13.4 13 <sup>3</sup> / <sub>8</sub> 2.28 2 <sup>1</sup> /4 2.78 3 <sup>3</sup> / <sub>16</sub> 1 <sup>7</sup> / <sub>16</sub> 3 <sup>3</sup> / <sub>16</sub> 1 <sup>7</sup> / <sub>16</sub> 3 <sup>1</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>16</sub> 5 <sup>1</sup> / <sub>13</sub> 1 <sup>3</sup> / <sub>16</sub> 5 <sup>1</sup> / <sub>16</sub>	3.5 26.3 26 <sup>3</sup> / <sub>8</sub> 1.04 1 <sup>1</sup> / <sub>16</sub> <sup>9</sup> / <sub>16</sub> 13.2 13 <sup>1</sup> / <sub>8</sub> 1.89 1 <sup>1</sup> / <sub>18</sub> 2.39 2 <sup>1</sup> / <sub>3</sub> / <sub>16</sub> 1 <sup>3</sup> / <sub>9</sub>	7.2 26.0 26 0.960 <sup>13</sup> / <sub>16</sub> <sup>1</sup> / <sub>2</sub> 13.1 13.16 1.73 13/ <sub>4</sub> 2.23 25/ <sub>8</sub> 15/ <sub>16</sub> 21.4 2.23 25/ <sub>8</sub> 15/ <sub>16</sub> 21.23 25/ <sub>8</sub> 25/	6.3 25.5 25/2 0.810 <sup>13</sup> / <sub>15</sub> 13.0 13 1.46 17/ <sub>16</sub> 1.96 2 <sup>3/6</sup> 17/ <sub>4</sub> 1.7 25.2 257/ <sub>6</sub> 0.760 <sup>3</sup> / <sub>6</sub> 120 13 12/ <sub>16</sub> 124 15/ <sub>6</sub> 1.96 2 <sup>3/6</sup> 17/ <sub>4</sub>	7.7 25.0 25 0.705 Tyte 36 13.0 13 1.22 1/4 1.72 2/6 1.34 1.916 1.04 1.72 2/6 1.91 1.17	3.0 24.7 24 <sup>3</sup> (4.0.660 <sup>5</sup> / <sub>6</sub> <sup>5</sup> / <sub>6</sub> 12.9 12/ <sub>18</sub> 1.09 17/ <sub>16</sub> 1.59 2 17/ <sub>8</sub> 3.5 24.5 24/2 0.605 <sup>5</sup> / <sub>6</sub> <sup>5</sup> / <sub>16</sub> 12.9 12/ <sub>18</sub> 0.990 <sup>15</sup> / <sub>66</sub> 1.46 17/ <sub>8</sub> 17/ <sub>6</sub>	4.4 24.3 24 <sup>3</sup> /4 0.550 <sup>9</sup> /6 <sup>5</sup> / <sub>16</sub> <sup>1</sup> / <sub>16</sub> 128 12 <sup>9</sup> /4 0.850 <sup>7</sup> / <sub>8</sub> 1.35 1 <sup>3</sup> / <sub>4</sub> 1 <sup>7</sup> / <sub>6</sub> 1.6 24.1 24 0.500 <sup>1</sup> / <sub>2</sub> <sup>1</sup> / <sub>4</sub> 128 12 <sup>9</sup> / <sub>4</sub> 0.750 <sup>3</sup> / <sub>4</sub> 1.25 1 <sup>3</sup> / <sub>9</sub> 1 <sup>7</sup> / <sub>16</sub> <sup>1</sup> / <sub>16</sub>	24.5 241/2 0.550 %/6 %/6 9.00 9 0.980 1 1.48 17/6 11/6 209/4 51/2	4.7 24.1 24/9 0.470 ½ 2 ½ 9.02 9 0.2770 34 1.25 ½ 1.38 1.34 1.1/16 4.7 24/19 0.470 ½ ½ 9.02 9 0.770 34 1.27 11/16	2.4 23.9 237/e 0.440 7/re 7/a 8.99 9 0.680 7/16 1.18 19/re 1//a 1//a 1/2.1 23.7 237/e 0.415 7/re 7/a 8.97 9 0.585 9/re 1.09 17/5 17/re V	2.2 23.7 2394, 0.430 7/16 7/4 7.04 7 0.590 9/16 1.09 11/2 11/16 20/14 31/2 13/20 12 23.6 2395, 0.395 3/6 3/16 7.01 7 0.505 7/2 11.01 17/16 1 20/14 37/2	3.2 23.0 23 0.910 <sup>15</sup> / <sub>16</sub> <sup>1</sup> / <sub>2</sub> 12.6 12 <sup>5</sup> / <sub>8</sub> 1.63 1 <sup>5</sup> / <sub>8</sub> 2.13 2 <sup>1</sup> / <sub>2</sub> 1 <sup>5</sup> / <sub>16</sub> 18 5 <sup>1</sup> / <sub>2</sub>	3.0 ZZ./ ZZ'4 U.830 '7/16 /7.6 12.5 12/2 1.48 17/2 1.98 22/6 17/4 3.8 22.5 22/2 0.750 3/4 3/6 12.4 123/6 136 13/6 136 37/2 13/4	3.2 22.1 22 0.720 <sup>3</sup> / <sub>4</sub> <sup>3/6</sup> 12.5 12 <sup>1/2</sup> 1.15 1 <sup>1/6</sup> 1.65 2 1 <sup>3/16</sup>	200 41.0 41.7 21 <sup>5</sup> /8 0.600 <sup>5/8</sup> <sup>5/16</sup> 12.4 12/2 1.04 17/6 1.54 1 <sup>10</sup> /6 1/8 1.9 21.7 21 <sup>5</sup> /8 0.600 <sup>5/8</sup> <sup>5/16</sup> 12.4 12 <sup>3/8</sup> 0.960 <sup>15/18</sup> 1.46 1 <sup>13/16</sup> 1 <sup>1/6</sup>	2.7 21.5 21.1/2 0.550 <sup>9</sup> /16 <sup>5</sup> /16 12.3 12 <sup>3</sup> /9 0.875 <sup>7/6</sup> 1.38 1 <sup>3/4</sup> 1 <sup>1/6</sup>			
the second secon	Area, Depth, Web Flange Distance North	$r_{tw} = \frac{1}{2} = \frac{1}{$	in <sup>2</sup> in	70" 109 28.0 28 1.52 1 <sup>1</sup> /s <sup>3</sup> /4 13.7 13 <sup>5</sup> /8 2.72 2 <sup>3</sup> /4 3.22 2 <sup>5</sup> /8 1 <sup>3</sup> /8 1 <sup>3</sup> /8 5 <sup>1</sup> /8 5 <sup>1</sup> /8 37 35" 98.4 27.5 27 <sup>1</sup> /21.138 1 <sup>3</sup> /8 <sup>11</sup> /1613.5 13 <sup>1</sup> /2 2.48 2 <sup>1</sup> /2 2.98 3 <sup>3</sup> /8 1 <sup>1</sup> /2 1	06 <sup>th</sup> 89.8 27.1 27 <sup>1</sup> / <sub>16</sub> 12.6 1 <sup>1</sup> / <sub>14</sub> <sup>5</sup> / <sub>16</sub> 13.4 13 <sup>3</sup> / <sub>16</sub> 2.28 2 <sup>1</sup> / <sub>14</sub> 2.78 3 <sup>3</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>16</sub> 3 <sup>3</sup> / <sub>16</sub>	50 73.5 26.3 26% 1.04 11/16 % 13.2 131/8 1.89 17/8 2.39 21% 1.89 17/8 2.39 21% 13/8 13/8 2.39 2.5% 13/8 13/8 13/8 2.5% 13/8 13/8 13/8 13/8 13/8 13/8 13/8 13/8	29 67.2 26.0 26 0.960 <sup>15</sup> / <sub>16</sub> <sup>1</sup> / <sub>2</sub> 13.1 13 <sup>1</sup> / <sub>8</sub> 1.73 1 <sup>3</sup> / <sub>8</sub> 1.73 2 <sup>3</sup> / <sub>8</sub> 1 <sup>3</sup> / <sub>8</sub> 2.23 2 <sup>5</sup> / <sub>8</sub> 1 <sup>5</sup> / <sub>16</sub> 1 <sup>5</sup> / <sub>16</sub> 2 17 60.7 25.7 25 <sup>3</sup> / <sub>8</sub> /40.870 7 <sup>6</sup> 7/ <sub>16</sub> 13.0 13 1.57 1 <sup>3</sup> / <sub>16</sub> 2.07 2 <sup>1</sup> / <sub>9</sub> 1 <sup>1</sup> / <sub>6</sub>	22 563 255 2512 0.810 <sup>19</sup> / <sub>16</sub> 7/ <sub>16</sub> 13.0 13 1.46 17/ <sub>16</sub> 1.96 29/ <sub>8</sub> 17/ <sub>4</sub> 16 517 252 2514 0750 34 36 12 0 12/ <sub>16</sub> 134 14/ <sub>16</sub> 1.96 29/ <sub>8</sub> 17/ <sub>4</sub>	22 47.7 25.0 25 0.705 <sup>11</sup> / <sub>16</sub> 38 13.0 13 1.22 11/ <sub>4</sub> 1.72 21/ <sub>8</sub> 13/ <sub>8</sub> 13/ <sub>8</sub> 1	46 43.0 24.7 24/4 0.650 3/s 3/s 12.9 12/s 1.09 13/s 1.59 2 11/s 1.59 1 1/s 1.58 1 1/s 1.58 2 12/5 0.58 3/s 3/s 12/5 0.9960 15/s 1.48 17/s 11/s 1/s 11/s 1	17° 344 24.3 24/4.0550 9/6 5/16 128 129/4 0.850 7/6 1.35 13/4 17/6 14° 30.6 24.1 24 0500 7/2 7/4 12.8 129/4 0.750 3/4 1.25 15/6 17/16 V	13 <sup>3</sup> 30.3 24.5 24/5 0.550 <sup>9</sup> /16 <sup>5</sup> /16 <sup>9</sup> /10 <sup>9</sup> 200 <sup>9</sup> 0.980 <sup>1</sup> 1.48 <sup>17</sup> /6 <sup>17</sup> /6 <sup>5</sup> /2 <sup>2</sup> /2	F 24.7 24.1 24/8 0.312 72 74 9.02 9 0.375 7/8 1.38 1.4 17/6 F 24.7 24.1 24/8 0.470 7/2 7/4 9.02 9 0.770 3/4 1.27 11//6 11//6	2 <sup>6</sup> 22.4 23.9 23/6 0.440 7/6 1/6 1/2 0.0630 1/36 1.13 19/6 1.14 19/6 1/16 1 1/6 1/16 1/2 10 12 23.7 23/4 0.415 7/6 1/2 837 9 0.555 9/6 109 11/2 11/6 V	2° 18.2 23.7 23% 0.430 7% 7% 7.04 7 0.590 9% 1.08 17% 17% 20% 37% 37% 16.2 236 23% 0.395 3% 7.01 7 0.555 72 1.01 17% 1.2 20% 37%	11 59.2 23.0 23 0.910 <sup>15</sup> / <sub>16</sub> <sup>1</sup> / <sub>2</sub> 12.6 125/ <sub>6</sub> 1.63 15/ <sub>6</sub> 2.13 2/ <sub>2</sub> 15/ <sub>16</sub> 18 5/ <sub>2</sub>	22 33.0 22.7 22/9 0.350 3/16 12.5 12/2 1.48 172 1.98 23/6 174 56 48.8 22/5 22/9 0.750 3/4 3/6 174 173/6 13/6 13/6 13/6 13/6 13/6 13/6 13/6 1	7 43.2 22.1 22 0.720 34 36 12.5 12/2 1.15 11/6 1.65 2 13/6	2 35.9 21.7 21 <sup>5</sup> /9 0.600 <sup>5</sup> /8 <sup>5</sup> /18 12.4 12 <sup>3</sup> /8 0.960 <sup>15</sup> / <sub>16</sub> 1.46 1. <sup>5</sup> / <sub>16</sub> 1. <sup>5</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>16</sub> 1 <sup>3</sup> / <sub>16</sub>	1 32.7 21.5 211/2 0.550 9/16 9/16 12.3 123/9 0.875 7/6 1.38 13/4 11/6			