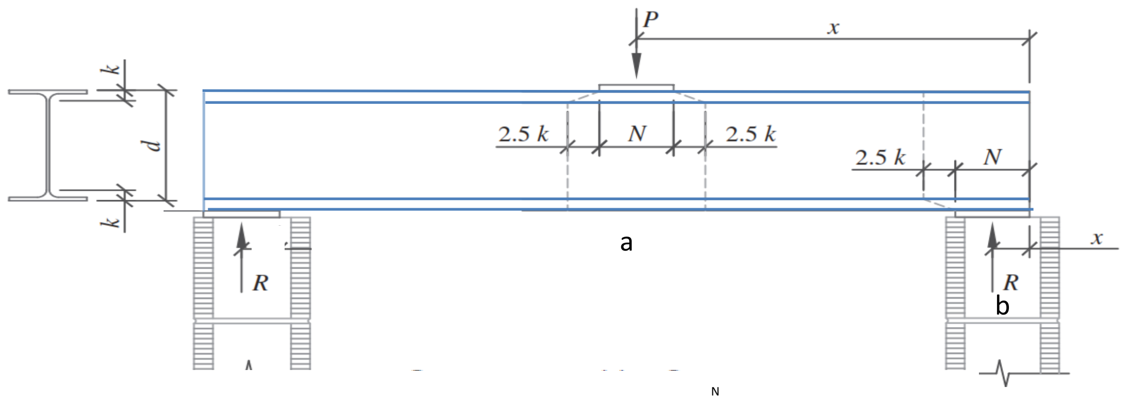
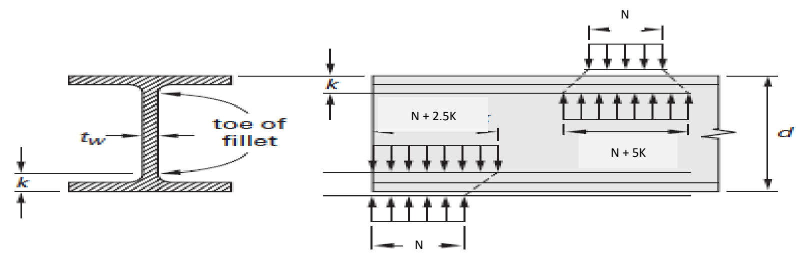
The basic design checks for beam bearing are yielding and web crippling in the beam as follows:

Web Yielding

Web yielding is the compressive crushing of a beam web caused by the application of a compressive force to the flange directly above or below the web. This force could be an end reaction from a support of the type shown in Figure below, or it could be a load delivered to the top flange by a column or another beam. Yielding occurs when the compressive stress on a horizontal section through the web reaches the yield point. When the load is transmitted through a plate, web yielding is assumed to take place on the nearest section of width t_w. In a rolled shape, this section will be at the toe of the fillet, a distance k from the outside face of the flange (this dimension is tabulated in the dimensions and properties tables in the Manual). If the load is assumed to distribute itself at a slope of 1: 2.5, as shown in Figure, the area at the support subject to yielding is $t_w(2.5k + N)$. Multiplying this area by the yield stress gives the nominal strength for web yielding at the support:





The nominal strength, Rn, shall be determined as follows

(a) When the concentrated force to be resisted is applied at a distance from the member end that is greater than the depth of the member, d, (at X > d)

Where

X: is the distance from end of the beam to the applied load

d: is the overall depth of the beam

$$R_n = (5k + N) F_{yw} t_w \quad \text{(AISC Equation J10-2)}$$

(b) When the concentrated force to be resisted is applied at a distance from the member end that is less than or equal to the depth of the member, d, (at X< d) The bearing length N at the

$$R_n = (2.5k + N) F_{yw} t_w \quad \text{(AISC Equation J10-3)}$$

Where

Rn = Nominal design strength, kip
Fy_w = specified minimum yield stress of the web material, ksi
k = distance from outer face of the flange to the web toe of the fillet, in.
N = length of bearing (not less than k for end beam reactions), in.
t_w = thickness of web, in.
d = Beam depth,
x = Distance from the end of the beam to the concentrated load,

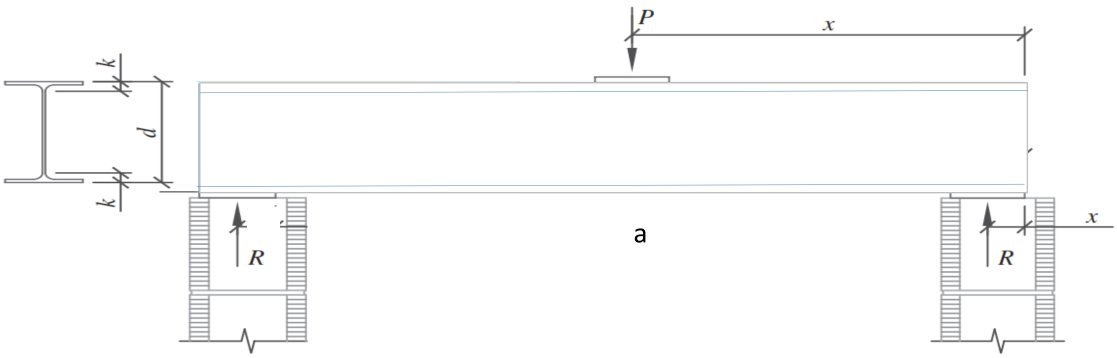
Note
The bearing length (N) should not be less than K (N≥ K)
The available strength for the limit state of web local yielding shall be determined as follows:

ϕ = 1.00 (LRFD Ω = 1.50 (ASD
ϕRn ≥ Ru Rn/Ω ≥ Ra

If not we should be provided a pair of transverse stiffeners or a doubler plate to increase the web resistance.

Web Crippling

Web crippling is buckling of the web caused by the compressive force delivered through the flange. For an interior load, the nominal strength for web crippling is



a

a) When the concentrated compressive force to be resisted is applied at a distance from the member end that is greater than or equal to d/ 2:(X> d/2)

$$R_n = 0.80\, t_w^2 \left[1 + 3\left(\frac{N}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{E F_y t_f}{t_w}}$$ (AISC Equation J10-4)

(b) When the concentrated compressive force to be resisted is applied at a distance from the member end that is less than d/ 2 :(X< d/2)
(i) For N /d ≤ 0.2

$$R_n = 0.40\, t_w^2 \left[1 + 3\left(\frac{N}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{E F_y t_f}{t_w}}$$ (AISC Equation J10-5a)

(ii) For N /d > 0.2

$$R_n = 0.40\, t_w^2 \left[1 + \left(\frac{4N}{d} - 0.2\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{E F_y t_f}{t_w}}$$ (AISC Equation J10-5b)

The available strength for the limit state of web local crippling shall be determined as follows:

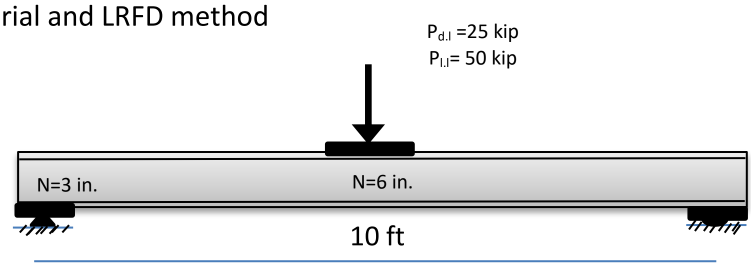
$\phi = 0.75$ (LRFD) $\Omega = 2.00$ (ASD)

$\phi R_n \geq R_u$ $R_n/\Omega \geq R_a$

If not we should be provided, a transverse stiffener, a pair of transverse stiffeners, or a doubler plate extending at least one-half the depth of the web to increase the web resistance.

Example

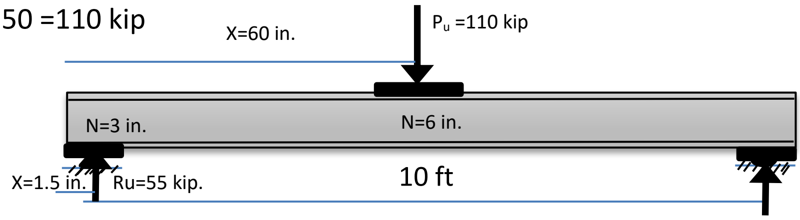
Check the web yielding and web crippling for W18x50 simply supported beam subjected to $P_{d.l}$ =25 kip, and $P_{l.l}$= 50 kip, the bearing plate width (N= 6 in.) at mid span and (N= 3 in.) at end span, used A992 steel material and LRFD method



Solution

Steel	fy	fu
A992	50	65

Section	d	t_w	t_f	k
W18x50	18	0.355	0.57	0.972



Pu= 1.2 P $_{d.l}$ +1.6 P $_{l.l}$= 1.2 x25+1.6x 50 =110 kip

Ru at mid span =110 kip

Ru at end span= 55 kip

1- Web yielding

a-X > d, N=6 in

5x12 > 18

60 > 18 Ok

Rn =(5K+N) Fytw =(5x0.972+6)x50x0.355 =192.765 kip

ϕ= 1 (LRFD method)

ϕ Rn= 1x192.765= 192.765 kip >110 OK

b- X < d, N=3 in

3/2 < 18

1.5 < 18 Ok

Rn =(2.5K+N) Fytw =(2.5x0.972+6)x50x0.355 =96.38 kip

ϕ= 1 (LRFD method)

ϕ Rn= 1x63.38= 63.38 kip > 55 OK

No web yielding occur

2- Web crippling

a- X> d/2, N=6 in

60 > 18/2

60 > 9

$$R_n = 0.80\, t_w^2 \left[1 + 3\left(\frac{N}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{E F_y t_f}{t_w}}$$

$$= 0.8 x(0.355)^2\left[1+3(6/18)x(0.355/0.57)^{1.5}\right]\sqrt{\frac{29000x50x0.57}{0.355}} = 229.44 \text{ kip}$$

ϕ= 0.75 (LRFD method)

ϕ Rn= 0.75x229.44= 172.08 kip >110 OK

b- X< d/2, N=3 in
1.5 < 18/2
1.5 > 9

N/d=3/18= 0.166< 0.2

$$R_n = 0.40\, t_w^2 \left[1 + 3\left(\frac{N}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{E F_y t_f}{t_w}}$$

$= 0.4\,x(0.355)^2\left[1+3(3/18)x(0.355/0.57)^{1.5}\right]\sqrt{\frac{29000x50x0.57}{0.355}}$ =95.733 kip

ϕ= 0.75 (LRFD method)

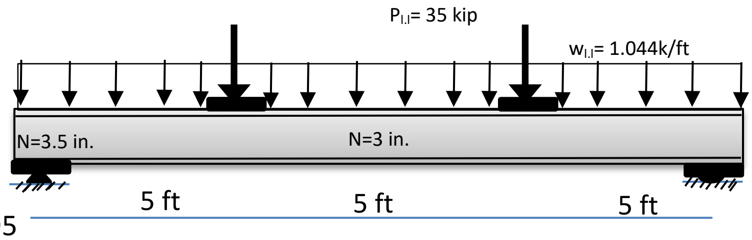
ϕ Rn= 0.75x95.733= 71.8 kip >55 OK

No web crippling occur

Example

Check the web yielding and web crippling for W21x44 simply supported beam subjected to $P_{l.l}$= 35 kip, and service uniform dead load ($W_{l.l}$= 1.044 k/ft), including to self-weight of beam, the bearing plate width (N= 3 in.) at mid span and at end span (N=3.5 in), used A992 steel material and LRFD method

Solution



Steel	fy	fu
A992	50	65

Section	d	t_w	t_f	k
W21x44	20.7	0.35	0.45	0.95

Pu= 1.6 P $_{l.l}$= 1.6x 35 =56 kip

Wu=1.2 $Wu_{d.l}$ =1.2x 1.044= 1.2528 k/ft

Ru at mid span =56 kip

Ru at end span= 56 + 1.2528x15/2= 65.4 kip

Web yielding

a- X> d ,N=3 in

60> 20.7 Ok

Rn =(5K+N) Fytw =(5x0.95+3)x50x0.35 =135.625

ϕ= 1 (LRFD method)

ϕ Rn= 1x135.625= 135.625 kip > 56 OK

b- X < d, N=3.5 in

3/2 < 20.7

1.5 < 20.7 Ok

Rn =(2.5K+N) Fytw =(2.5x0.95+3.5)x50x0.35 = 102 kip

ϕ= 1 (LRFD method)

ϕ Rn= 1x 102= 102 kip > 65.4 OK

No web yielding occur

Web crippling

a- X> d/2, N=3 in
60 > 20.7/2
60 > 10.35

$$R_n = 0.80\, t_w^2 \left[1 + 3\left(\frac{N}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{E F_y t_f}{t_w}}$$

$= 0.8 \times (0.35)^2\left[1+3(3/20.7)\times(0.35/0.45)^{1.5}\right]\sqrt{\frac{29000\times50\times0.45}{0.35}} = 173.733$ kip

ϕ= 0.75 (LRFD method)

ϕ Rn= 0.75x173.733= 130.3 kip >65.4 OK

b- X< d/2, N=3.5 in

1.5 < 20.7/2

1.5 > 10.35

N/d=3.5/20.7= 0.169< 0.2

$$R_n = 0.40\, t_w^2 \left[1+3\left(\frac{N}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\right]\sqrt{\frac{E F_y t_f}{t_w}}$$

$= 0.4 \times(0.35)^2\left[1+3(3.5/20.7)\times(0.35/0.45)^{1.5}\right]\sqrt{\frac{29000\times50\times0.45}{0.35}} = 90.18$ kip

ϕ= 0.75 (LRFD method)

ϕ Rn= 0.75x90.18= 67.64 kip >65.4 OK

No web crippling occur

Home work

Resolve the above example by use ASD method

Beam Bearing Constants by using Table 9-4.

At beam ends and at any location on beams or columns where concentrated loads occur, the available strength for web local yielding and web local crippling, ϕRn or Rn/Ω, at concentrated loads is determined per AISC Specification Sections J10.2 and J10.3. Values of Rn are given for a bearing length, $N = 3^{1/4}$ in. The web local yielding (Equations J10-2 and J10-3) and web local crippling (Equations J10-4, J10-5a and J10-5b) equations can be simplified using the bearing length, N, and the constants R1 through R6 as follows

Limitation of using table (9.4)

- The W shape is available in table
- Yielding strengthen for steel material must be equal to $(fy = 50)$

$$R_1 = 2.5kF_{yw}t_w \qquad (9\text{-}39)$$

$$R_2 = F_{yw}t_w \qquad (9\text{-}40)$$

$$R_3 = 0.40t_w^2\sqrt{\frac{EF_{yw}t_f}{t_w}} \qquad (9\text{-}41)$$

$$R_4 = 0.40t_w^2\left(\frac{3}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\sqrt{\frac{EF_{yw}t_f}{t_w}} \qquad (9\text{-}42)$$

$$R_5 = 0.40t_w^2\left(1-0.2\left(\frac{t_w}{t_f}\right)^{1.5}\right)\sqrt{\frac{EF_{yw}t_f}{t_w}} \qquad (9\text{-}43)$$

$$R_6 = 0.40t_w^2\left(\frac{4}{d}\right)\left(\frac{t_w}{t_f}\right)^{1.5}\sqrt{\frac{EF_{yw}t_f}{t_w}} \qquad (9\text{-}44)$$

Web Local Yielding

The available strength for web local yielding, ϕRn or Rn/Ω, is determined per AISC Specification Section J10.2 using Equations J10-2 or J10-3, which can be simplified using the constants R1 and R2 from Table 9-4 as follows, where ϕ = 1.00 and Ω = 1.50.
When the compressive force to be resisted is applied at a distance, x, from the member end that is less than or equal to the depth of the member (x ≤ d),

LRFD		ASD	
$\phi Rn = \phi R_1 + N\phi R_2$	(9-45a)	$Rn/\Omega = R_1/\Omega + NR_2/\Omega$	(9-45b)

When the compressive force to be resisted is applied at a distance, x, from the member end that is greater than the depth of the member (x > d),

LRFD		ASD	
$\phi Rn = 2(\phi R_1) + N\phi R_2$	(9-46a)	$Rn/\Omega = 2(R_1/\Omega) + NR_2/\Omega$	(9-46b)

Note that the minimum length of bearing, N, is k, per AISC Specification Section J10.2 for end beam reactions, where $k = k_{des}$ for W-shapes
.

Web Local Crippling

The available strength for web local crippling, ϕRn or Rn/Ω, is determined per AISC Specification Section J10.3 using Equations J10-4, J10-5a or J10-5b, which can be simplified using constants R3, R4, R5 and R6 from Table 9-4 as follows, where ϕ = 0.75 and Ω =2.00.
When the compressive force to be resisted is applied at a distance, x, from the member end that is less than one-half of the depth of the member (x < d/2),
For N/d ≤ 0.2:

LRFD		ASD	
$\phi Rn = \phi R_3 + N\phi R_4$	(9-47a)	$Rn/\Omega = R_3/\Omega + NR_4/\Omega$	(9-47b)

For N/d > 0.2:

LRFD		ASD	
$\phi Rn = \phi R_5 + N\phi R_6$	(9-48a)	$Rn/\Omega = R_5/\Omega + NR_6/\Omega$	(9-48b)

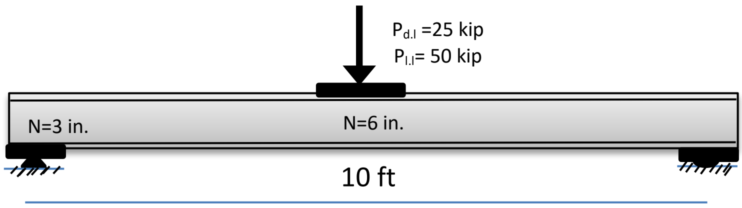
When the compressive force to be resisted is applied at a distance, x, from the member end that is greater than or equal to one-half of the depth of the member (x ≥ d/2),

LRFD		ASD	
$\phi Rn = 2[\phi R_5 + N\phi R_6]$	(9-49a)	$Rn/\Omega = 2[R_5/\Omega + NR_6/\Omega]$	(9-49b)

Example

Check the web yielding and web crippling for W18x50 simply supported beam subjected to $P_{d.l}$ =25 kip, and $P_{l.l}$= 50 kip, the bearing plate width (N= 6 in.) at mid span and (N= 3 in.) at end span, used A992 steel material and LRFD method

Solution



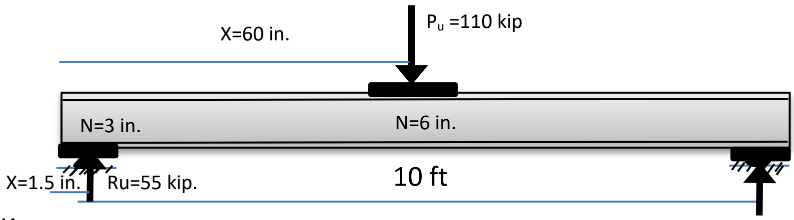
Steel	fy	fu
A992	50	65

Section	d	t_w	t_f	k	ϕR_1	ϕR_2	ϕR_3	ϕR_4	ϕR_5	ϕR_6
W18x50	18	0.355	0.57	0.972	43.1	17.8	57.7	4.73	52	6.3

Pu= 1.2 $P_{d.l}$ +1.6 $P_{l.l}$= 1.2 x25+1.6x 50 =110 kip

Ru at mid span =110 kip

Ru at end span= 55 kip



Web yielding

a- X> d ,N=6 in

60> 18

$\phi R_n = 2\phi R_1 + N\,\phi R_2$

=2x43.1+6x17.8= 193 >110 OK

b- X< d ,N=3 in

1.5<18

$\phi R_n = \phi R_1 + N\,\phi R_2$

=43.1+3x17.8= 96.5 >55 OK

No web yielding occur

Web crippling

a- X> d/2, N=6 in

60>9

$\phi R_n = 2(\phi R_3 + N\,\phi R_4)$

=2x (43.1+6x17.8)= 172.16 >110 OK

b- X< d/2 ,N=3 in

1.5<9

N/d=3/18=0.166 <0.2

$\phi R_n = \phi R_3 + N\,\phi R_4$

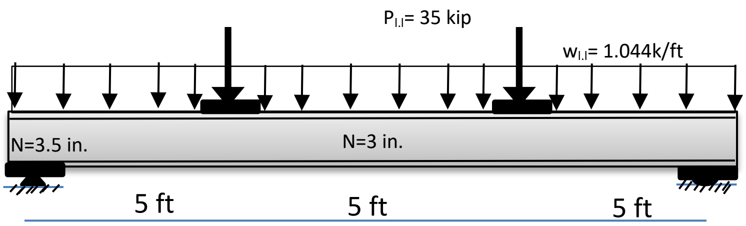
=57.7+3x4.73= 71.89 >55 OK

No web crippling occur

Example

Check the web yielding and web crippling for W21x44 simply supported beam subjected to $P_{l.l}$= 35 kip, and service uniform dead load ($W_{l.l}$= 1.044 k/ft), including to self-weight of beam, the bearing plate width (N= 3 in.) at mid span and at end span(N=3.5 in), used A992 steel material and LRFD method

Solution



Steel	fy	fu
A992	50	65

Section	d	t_w	t_f	k	ϕR_1	ϕR_2	ϕR_3	ϕR_4	ϕR_5	ϕR_6
W21x44	20.7	0.35	0.45	0.95	41.6	17.5	50.2	5	43.33	6.6

Pu= 1.6 P $_{l.l}$= 1.6x 35 =56 kip

Wu=1.2 $Wu_{d.l}$ =1.2x 1.044= 1.2528 k/ft

Ru at mid span =56 kip

Ru at end span= 56 + 1.2528x15/2= 65.4 kip

Web yielding

a- X> d ,N=3 in

60> 20.7

$\phi R_n = 2\phi R_1 + N\,\phi R_2$

=2x41.6+3x17.5= 135.7 >56 OK

b- X< d ,N=3.5 in

1.5<20.7

$\phi R_n = \phi R_1 + N\,\phi R_2$

=41.6+3.5x17.5= 102.85 >65.4 OK

No web yielding occur

Web crippling

a- X> d/2, N=3 in

60>10.35

$\phi R_n = 2(\phi R_3 + N\,\phi R_4)$

=2x (50.2+3x5)= 130.4 >56 OK

b- X< d/2 ,N=3.5 in

1.5<10.35

N/d=3.5/20.7=0.169 <0.2

$\phi R_n = \phi R_3 + N\,\phi R_4$

=50.2+3.5x5= 67.7 >65.4 OK

No web crippling g occur