### Web Local Yielding / Web Crippling / Web Sideways Buckling

- \( d_t = 32.4 \text{ in} \) distance of applied force from the member end
- \( l = 299 \text{ in} \) largest laterally unbraced length along either flange at the point of load
- \( N = 2.25 \text{ in} \) length of bearing (not less than \( k \) for end beam reactions)

#### Section properties

- **Section**: W14x30
- \( F_y = 50 \text{ ksi} \) minimum yield stress of the type of steel being used
- \( F_{yw} = 50 \text{ ksi} \) yield stress of web
- \( k = 0.785 \text{ in} \) distance from outer face of the flange to the web toe of the fillet
- \( d = 13.8 \text{ in} \) overall depth of the member
- \( t_w = 0.27 \text{ in} \) web thickness
- \( t_f = 0.385 \text{ in} \) flange thickness
- \( b_f = 6.73 \text{ in} \) flange width
- \( h = 13.03 \text{ in} \) clear distance between the flanges less the filler or corner radius for rolled shapes
- \( S_x = 42 \text{ in}^3 \) elastic section modulus - major axis

#### Steel properties

- \( E = 29000 \text{ ksi} \) modulus of elasticity of steel

### Local Web Yielding

Transverse stiffeners shall be provided adjacent to a concentrated tensile or compressive force when the required strength of the web at the toe of the fillet exceeds \( \phi R_n \)

- \( \phi = 1 \) resistance factor

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 \( d_t \),

\[
R_n = \frac{(5k + N)F_{yw}t_w}{k} = 83.36 \text{ kip} \\
\phi * R_n = 83.36 \text{ kip} \quad \text{allowable concentrated force}
\]

### References

- Manual of Steel Construction - American Institute of Steel Construction Inc., Load and resistance factor design (LRFD)
## Web crippling

Transverse stiffeners shall be provided adjacent to a concentrated tensile or compressive force when the required strength of the web at the toe of the fillet exceeds $\phi R_n$.

- $\phi = 0.75$ resistance factor
- $d_i = 32.4$ in
- $d/2 = 6.90$ in

$R_n = \frac{0.80t_w^2 + (1+3(N/d)^2)^{1.5}}{t_f} \times (1 + 0.4 \times \frac{(h/t_w)/(l/b_f)}{1.5})^{0.5}$

$R_n = 107.95$ kip

$\phi \times R_n = 80.96$ kip allowable concentrated force

## Web Sidesway Buckling

Compressive single concentrated force applied to the member, lateral movement between the loaded compression flange and the tension flange is not restrained at the point of application of the concentrated force.

- $\phi = 0.85$ resistance factor

Restraint at compression flange: YES

- $C_i = 960000$ ksi $C_i$ is 960000 ksi when $M_y < M_u$ per Manual of Steel Construction (LRFD)
- $C_j = 480000$ ksi when $M_y > M_u$ per Manual of Steel Construction (LRFD)

$M_y = 2100$ kip*in $(F_y*S_y)$ moment corresponding to onset of yielding at the extreme fiber from an elastic stress distribution

Compression flange is restrained against rotation.

$(h/t_w)/(l/b_f) = 1.09 < 2.3$

$R_n = \frac{(C_i^*t_w^2 + t_f^2)^{1.5}}{1 + 0.4 \times ((h/t_w)/(l/b_f))^{1.5}}$

$R_n = 64.82$ kip

$\phi \times R_n = 55.09$ kip allowable concentrated force

When the required strength of the web exceeds $\phi R_n$, local lateral bracing shall be provided at the tension flange or either a pair of transverse stiffeners or a doubler plate, extending at least one-half the depth of the web, shall be provided adjacent to the concentrated compressive force.

## References

- Manual of Steel Construction - American Institute of Steel Construction Inc., Load and resistance factor design (LRFD)