

① Slenderness Value For Tension members

① a Recommendations.

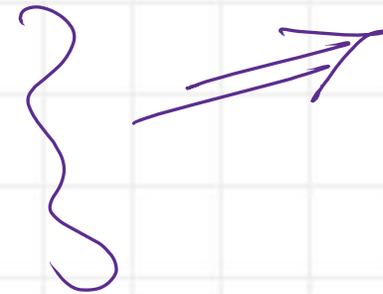
① b Code Provision.

② Introduction to Block shear strength

- shear rupture

shear yielding

- Tensile rupture



What will be the value of $\frac{L}{r}$ For Tension Members ?

It turns out that very slender members are difficult to handle without inadvertent bending during fabrication, transportation, and erection. Experience has shown that if you limit the slenderness (L/r) to 300 or less, then you are less likely to have problems handling the member.

Also, recalling that this is not a strength based limit state, the limit state is the same for both LRFD and ASD.

Slenderness, as you will recall from your mechanics course, relates the overall length of a member, "L", to its radius of gyration, "r".

The limit state is written as:

Recommendations

$$L/r \leq 300 \text{ or } L/(300r) \leq 1.00$$

Where "r" is the least radius of gyration. "r" is a section property that equals the square root of the moment of inertia divided by the cross section area. Every member has an "r" for each of the of the principle axes.

For better handling of slender members

ALAN

Williams

A **mandatory slenderness ratio is not specified** for tension members. However, American Institute of Steel Construction, *Specification for Structural Steel Buildings* (AISC 360) Sec. D1 recommends a maximum slenderness ratio of

$$L/r = 300$$

Maximum ratio

This limit is based on practical considerations for ease of handling during fabrication, transportation, and erection. It also reduces the possibility of undesirable vibration or slapping in service. This recommendation does not apply to rods and hangers.

Prepared by Eng. Maged Kamel.

Code Provision

CHAPTER D DESIGN OF MEMBERS FOR TENSION

This chapter applies to members subject to axial tension.

The chapter is organized as follows:

- D1. Slenderness Limitations
- D2. Tensile Strength
- D3. Effective Net Area
- D4. Built-Up Members
- D5. Pin-Connected Members
- D6. Eyebars

→ D1. Slenderness Limitations

User Note: For cases not included in this chapter, the following sections apply:

- B3.11 Members subject to fatigue
- Chapter H Members subject to combined axial tension and flexure
- J3 Threaded rods
- J4.1 Connecting elements in tension
- J4.3 Block shear rupture strength at end connections of tension members

D1. SLENDERNESS LIMITATIONS

There is no maximum slenderness limit for members in tension.

User Note: For members designed on the basis of tension, the slenderness ratio, L/r , preferably should not exceed 300. This suggestion does not apply to rods or hangers in tension.

Prepared by Eng. Maged Kamel.

$$L/r < 300$$

New specification 2022

CM#16

16.1-32

CHAPTER D DESIGN OF MEMBERS FOR TENSION

This chapter applies to members subjected to axial tension.

The chapter is organized as follows:

- D1. Slenderness Limitations
- D2. Tensile Strength
- D3. Effective Net Area
- D4. Built-Up Members
- D5. Pin-Connected Members
- D6. Eyebars

→ D.1

User Note: For cases not included in this chapter, the following sections apply:

- B3.11 Members subjected to fatigue
- Chapter H Members subjected to combined axial tension and flexure
- J3 Threaded rods
- J4.1 Connecting elements in tension
- J4.3 Block shear rupture strength at end connections of tension members

D1. SLENDERNESS LIMITATIONS

There is no maximum slenderness limit for members in tension.

User Note: For members designed on the basis of tension, the slenderness ratio of the member as fabricated—taken as the fabricated length of the member divided by the least radius of gyration of the section—preferably should not exceed 300. This suggestion does not apply to rods.

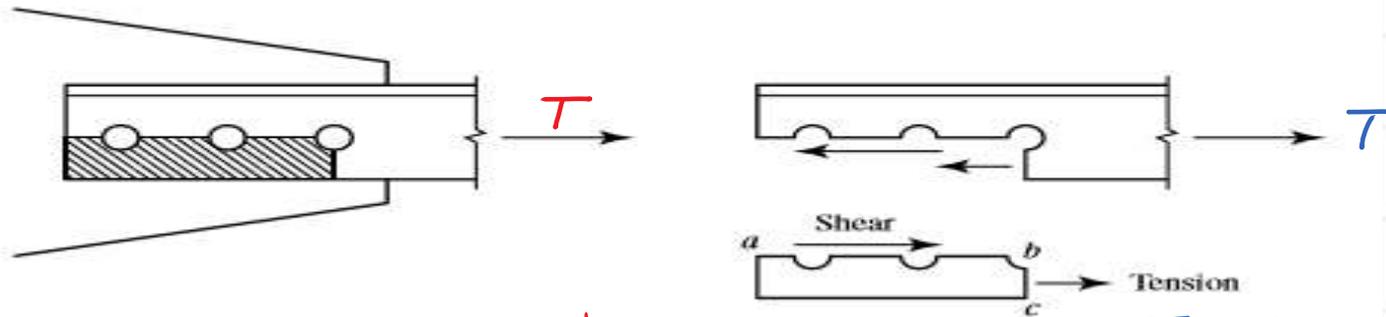
3.5 BLOCK SHEAR

Prof. SEGUi
Chapter 3.50

For certain connection configurations, a segment or "block" of material at the end of the member can tear out. For example, the connection of the single-angle tension member shown in Figure 3.21 is susceptible to this phenomenon, called *block shear*.

Hatched part is split as a block due to T

FIGURE 3.21



3.5 Block Shear 00

Notes: There will be a combination between - Tension Fracture + Shear Failure by Fracture
upper limit Tension + Shear Failure by yielding .

- Normally shear stress $\tau < \sigma$ due to yielding

$\tau_{vy} = 0.6 F_y$, $\tau_{vu} = 0.60 F_{ult}$
 ↘ shear due rupture

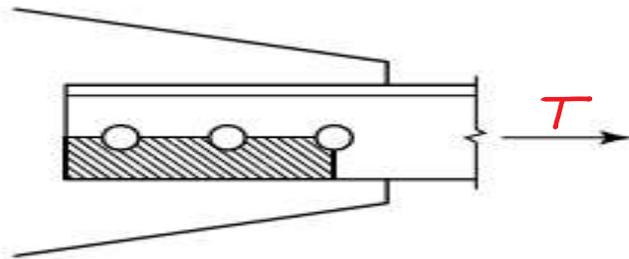
Prepared by Eng. Maged Kamel.

3.5 BLOCK SHEAR

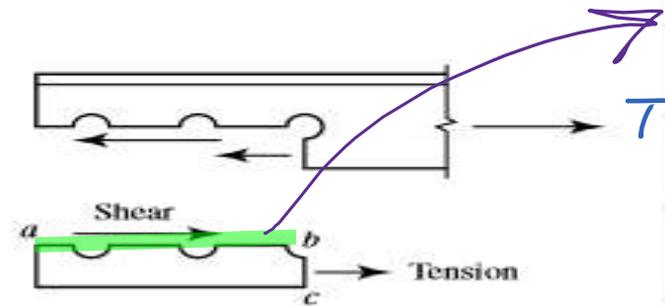
For certain connection configurations, a segment or "block" of material at the end of the member can tear out. For example, the connection of the single-angle tension member shown in Figure 3.21 is susceptible to this phenomenon, called *block shear*.

Prof. SEGUi
Chapter 3.50

FIGURE 3.21



3.5 Block Shear



Shear in ab

Case No. 1

Investigate the case of part a b c

For net Area Under shear stresses

R_n $\hat{=}$ Nominal Block shear Rupture strength

Case - 1 $R_n = (0.6 F_u A_{net}) + A_{net} \cdot F_u \cdot U$

AB

BC

Prepared by Eng. Maged Kamel.

$0.6 F_u A_{net} \rightarrow \rightarrow \rightarrow = 0.60 F_u A_{net}$



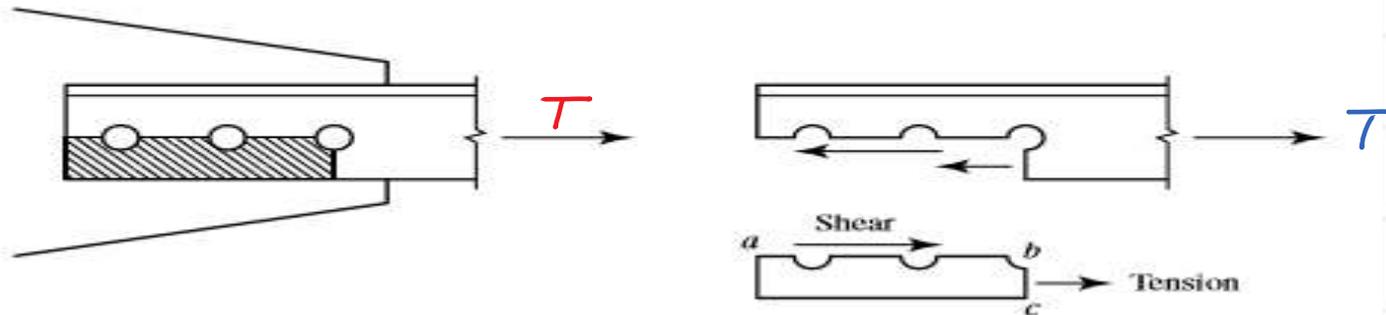
$A_{net} F_u \cdot U =$

\rightarrow Uniformity stress Factor

3.5 BLOCK SHEAR

For certain connection configurations, a segment or "block" of material at the end of the member can tear out. For example, the connection of the single-angle tension member shown in Figure 3.21 is susceptible to this phenomenon, called *block shear*.

FIGURE 3.21



3.5 Block Shear 55

Prof. SEGUi
Chapter 3.50
Case 2
Upper Limit
Case

Investigate the case of part a b c

R_n \neq Nominal Block shear yielding strength

$$R_n = 0.60 F_y A_g + A_{net} F_u \cdot U$$

$$R_n = 0.60 F_y A_{gv} + A_{nt} \cdot F_u \cdot U$$

$$T_y \cdot A_g = 0.60 F_y A_g$$

ab

$$A_{nt} F_u \cdot U =$$

Uniformity
stren
Factor

Prepared by Eng. Maged Kamel.

$a \rightarrow b$
Case 1
 shear rupture $\rightarrow A_{nv}$
 Tension rupture $\Rightarrow A_{nt}$

$A_{gv} \rightarrow ab$ gross area
Case 2
 shear yielding
 Tension rupture $\Rightarrow A_{nt}$ net area

$A_{net} \left\{ \begin{array}{l} \rightarrow A_{nt} \\ \rightarrow A_{nv} \end{array} \right.$
 $R_{n1} = (0.60 F_u) \cdot A_{nv} + F_u A_{nt} U_{bs}$

$R_{n2} = 0.60 F_y A_{gv} + F_u A_{nt} \cdot U_{bs}$
 upper limit

$R_{n1} < R_{n2}$

Then Multiply by ϕ which = 0.75 LRFD
 2.00 ASD

$\phi R_n = \phi (0.60 F_u) \cdot A_{nv} + F_u \cdot A_{nt} U_b \leq \phi (0.60 F_y A_{gv} + F_u A_{nt} \cdot U_{bs})$

U_{bs} values

Prof. SEGUi

where $U_{bs} = 1.0$ when the tension stress is uniform (angles, gusset plates, and most coped beams) and $U_{bs} = 0.5$ when the tension stress is nonuniform. A nonuniform case is illustrated in the Commentary to the Specification.

$$U_{BS} = 0.5$$

B. Shear For LRFD, the resistance factor ϕ is 0.75, and for ASD, the safety factor Ω is 2.00. Recall that these are the factors used for the fracture—or rupture—limit state, and block shear is a rupture limit state.

$$\phi = 0.75$$
$$\Omega = 2$$

Although AISC Equation J4-5 is expressed in terms of bolted connections, block shear can also occur in welded connections, especially in gusset plates.

16.1 - 113

AISC-A360-16

CHAPTER J

DESIGN OF CONNECTIONS

This chapter addresses connecting elements, connectors and the affected elements of connected members not subject to fatigue loads.

The chapter is organized as follows:

- J1. General Provisions
- J2. Welds
- J3. Bolts and Threaded Parts → J3 Bolts
- J4. Affected Elements of Members and Connecting Elements
- J5. Fillers
- J6. Splices
- J7. Bearing Strength
- J8. Column Bases and Bearing on Concrete
- J9. Anchor Rods and Embedments
- J10. Flanges and Webs with Concentrated Forces

User Note: For cases not included in this chapter, the following sections apply:

- Chapter K Additional Requirements for HSS and Box-Section Connections
- Appendix 3 Fatigue

Prepared by Eng. Maged Kamel.

3. Block Shear Strength

The available strength for the limit state of block shear rupture along a shear failure path or paths and a perpendicular tension failure path shall be determined as follows:

$$R_n = 0.60F_u A_{gv} + U_{bs}F_u A_{nt} \leq 0.60F_y A_{gv} + U_{bs}F_u A_{nt} \quad (J4-5)$$

$$\phi = 0.75 \text{ (LRFD)} \quad \Omega = 2.00 \text{ (ASD)}$$

where

A_{nt} = net area subject to tension, in.² (mm²)

A_{net} in Tension

Where the tension stress is uniform, $U_{bs} = 1$; where the tension stress is nonuniform, $U_{bs} = 0.5$.

User Note: Typical cases where U_{bs} should be taken equal to 0.5 are illustrated in the Commentary.

CM #16 specification 2022 J4-5

16.1-146 AFFECTED ELEMENTS OF MEMBERS AND CONNECTING ELEMENTS [Sect. J4.

(b) For shear rupture of the element

$$R_n = 0.60F_u A_{nv} \quad (J4-4)$$

$$\phi = 0.75 \text{ (LRFD)} \quad \Omega = 2.00 \text{ (ASD)}$$

where

A_{nv} = net area subjected to shear, in.² (mm²)

3. Block Shear Strength

The available strength for the limit state of block shear rupture along a shear failure path or paths and a perpendicular tension failure path shall be determined as follows:

$$R_n = 0.60F_u A_{nv} + U_{bs} F_u A_{nt} \leq 0.60F_y A_{gv} + U_{bs} F_u A_{nt} \quad (J4-5)$$

$$\phi = 0.75 \text{ (LRFD)} \quad \Omega = 2.00 \text{ (ASD)}$$

where

A_{nt} = net area subjected to tension, in.² (mm²)

Where the tension stress is uniform, $U_{bs} = 1$; where the tension stress is nonuniform, $U_{bs} = 0.5$.

User Note: Typical cases where U_{bs} should be taken as equal to 0.5 are illustrated in the Commentary.