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Tension Members

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Where to Use ?

CHAPTER 3 Analysis of Tension Members

Where to use tension members

Mccormac

Structural steel design

3.1 Introduction

Tension members are found in bridge and roof trusses, towers, and bracing systems, and in situations where they are used as tie rods. The selection of a section to be used as a tension member is one of the simplest problems encountered in design. As there is no danger of the member buckling, the designer needs to determine only the load to be supported, as previously described in Chapter 2. Then the area required to support that load is calculated as described in Chapter 4, and finally a steel section is selected that provides the required area. Though these introductory calculations for tension members are quite simple, they serve the important tasks of starting students off with design ideas and getting their "feet wet" with the massive Steel Manual.

CM#15

Chapter D

CHAPTER D

DESIGN OF MEMBERS FOR TENSION

Chapter D for tension members

This chapter applies to members subject to axial tension.

The chapter is organized as follows:

Strength

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

Tensile yielding

D2. TENSILE STRENGTH

The design tensile strength, $\phi_t P_n$, and the allowable tensile strength, P_n/Ω_t, of tension members shall be the lower value obtained according to the limit states of tensile yielding in the gross section and tensile rupture in the net section.

(a) For tensile yielding in the gross section

Equations for tensile strength

$$P_n = F_y A_g \tag{D2-1}$$

$$\phi_t = 0.90 \text{ (LRFD)} \qquad \Omega_t = 1.67 \text{ (ASD)}$$

(b) For tensile rupture in the net section

$$P_n = F_u A_e \tag{D2-2}$$

$$\phi_t = 0.75 \text{ (LRFD)} \qquad \Omega_t = 2.00 \text{ (ASD)}$$

Tensile rupture

where

A_e = effective net area, in.^{2} (mm^2)
A_g = gross area of member, in.^{2} (mm^2)
F_y = specified minimum yield stress, ksi (MPa)
F_u = specified minimum tensile strength, ksi (MPa)

Effective net area

D3. EFFECTIVE NET AREA

A_n : net area

The gross area, A_g, and net area, A_n, of tension members shall be determined in accordance with the provisions of Section B4.3.

A_e = Effective area

The effective net area of tension members shall be determined as

$$A_e = A_n U \qquad \text{(D3-1)}$$

U shear Lag Factor

where U, the shear lag factor, is determined as shown in Table D3.1.

For open cross sections such as W, M, S, C, or HP shapes, WTs, STs, and single and double angles, the shear lag factor, U, need not be less than the ratio of the gross area of the connected element(s) to the member gross area. This provision does not apply to closed sections, such as HSS sections, nor to plates.

D3. EFFECTIVE NET AREA

The gross area, A_g, and net area, A_n, of tension members shall be determined in accordance with the provisions of Section B4.3.

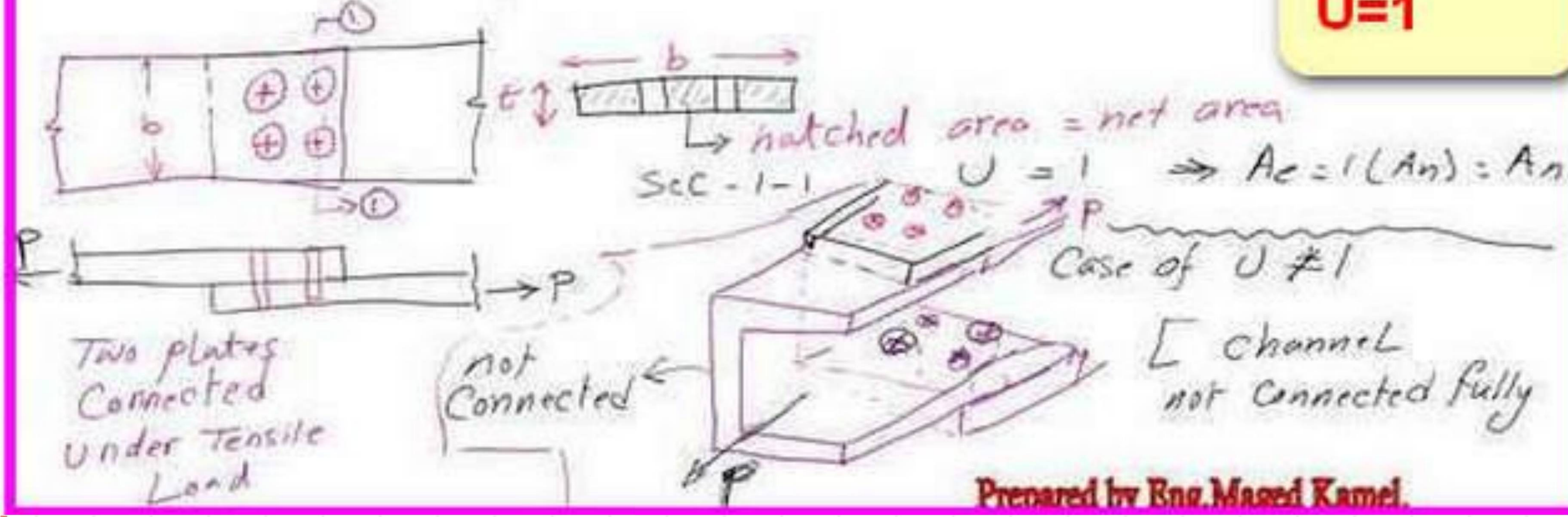
Case of U=1

The effective net area of tension members shall be determined as

$$A_e = A_n U$$

where U, the shear lag factor, is determined as shown in Table D3.1.

case of U=1



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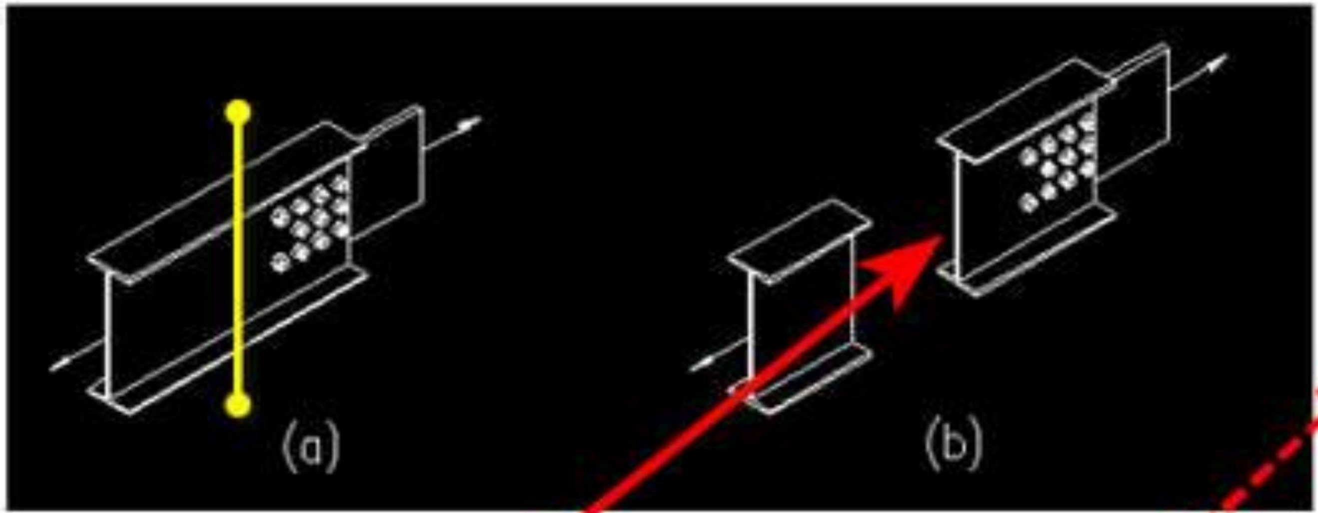


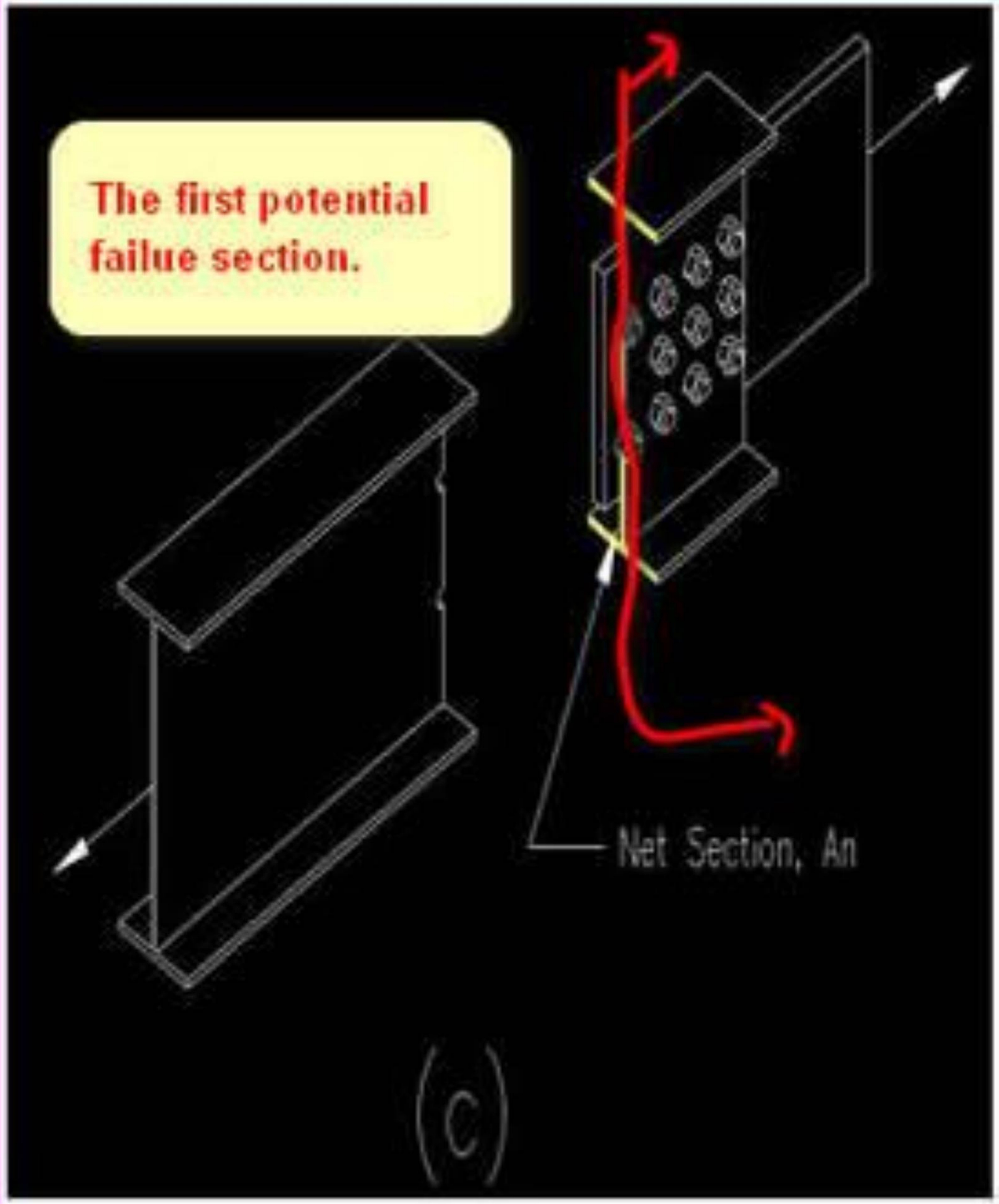
a - original shape

Section is away from connection

Tensile Yielding

1

Tension yielding is illustrated in Figure 3.1.1(b). This failure mode looks at yielding on the gross cross sectional area, A_g, of the member under consideration. Consequently, the critical area is located away from the connection as shown. Strength of the section equals the *gross area*, A_g, times the *minimum yield stress*, F_y, of the member.



1

Tensile rupture occurs in the next section of the W section at the connection. In this case we have two potential failure paths that see the full force of the member. These are shown in Figures 3.1.1(c) and 3.1.1(d). It is common to have multiple potential failure paths. Each valid path must be investigated. Tensile rupture is complicated by the need to get the forces out of the flanges, through the web, and into the bolts. This means that we need to account for the stress concentrated in and around the bolts. This will be discussed in further detail later. The capacity of each failure path equals the *effective net area*, A_e, times the *tensile stress*, F_u, of the member.

Tensile rupture

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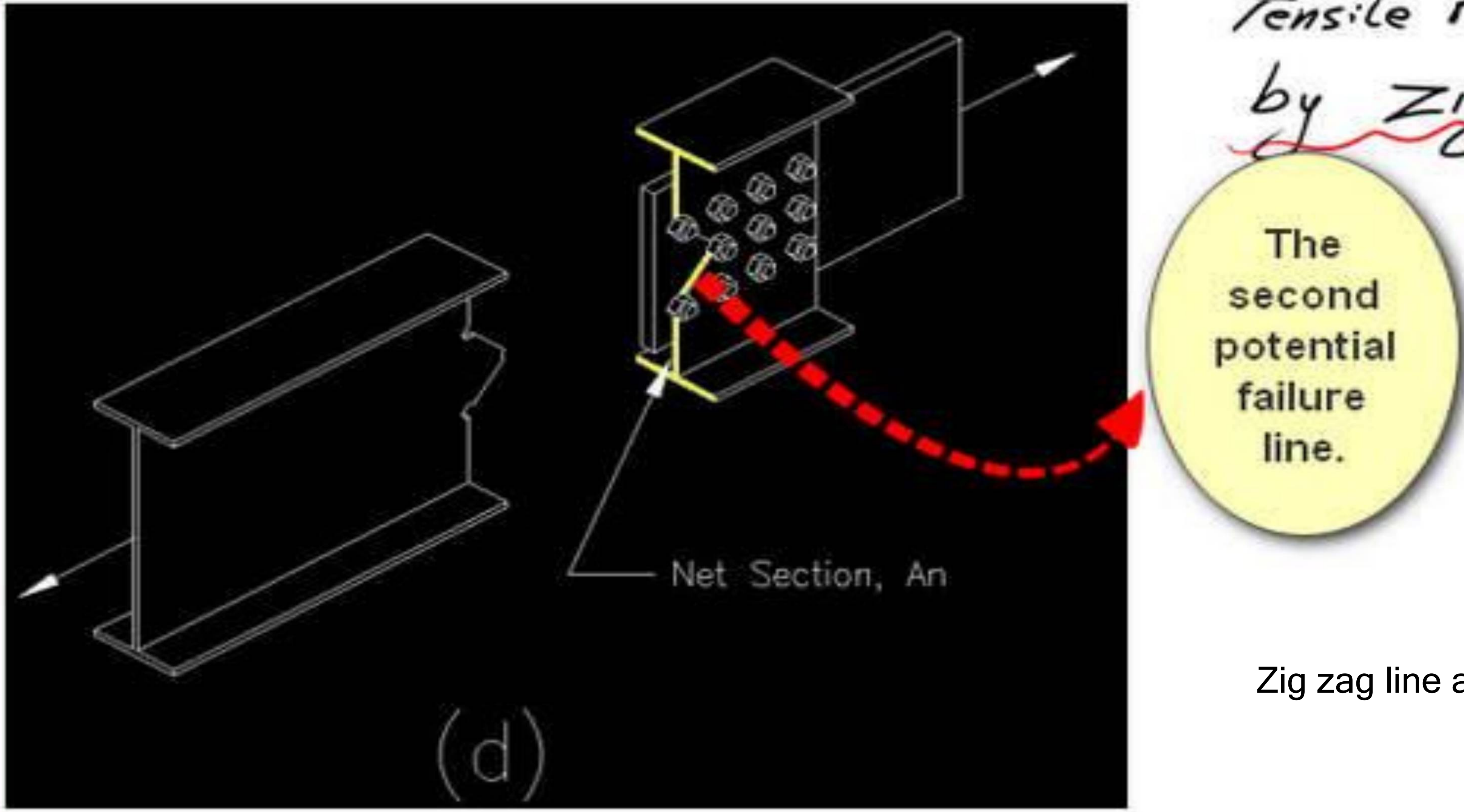
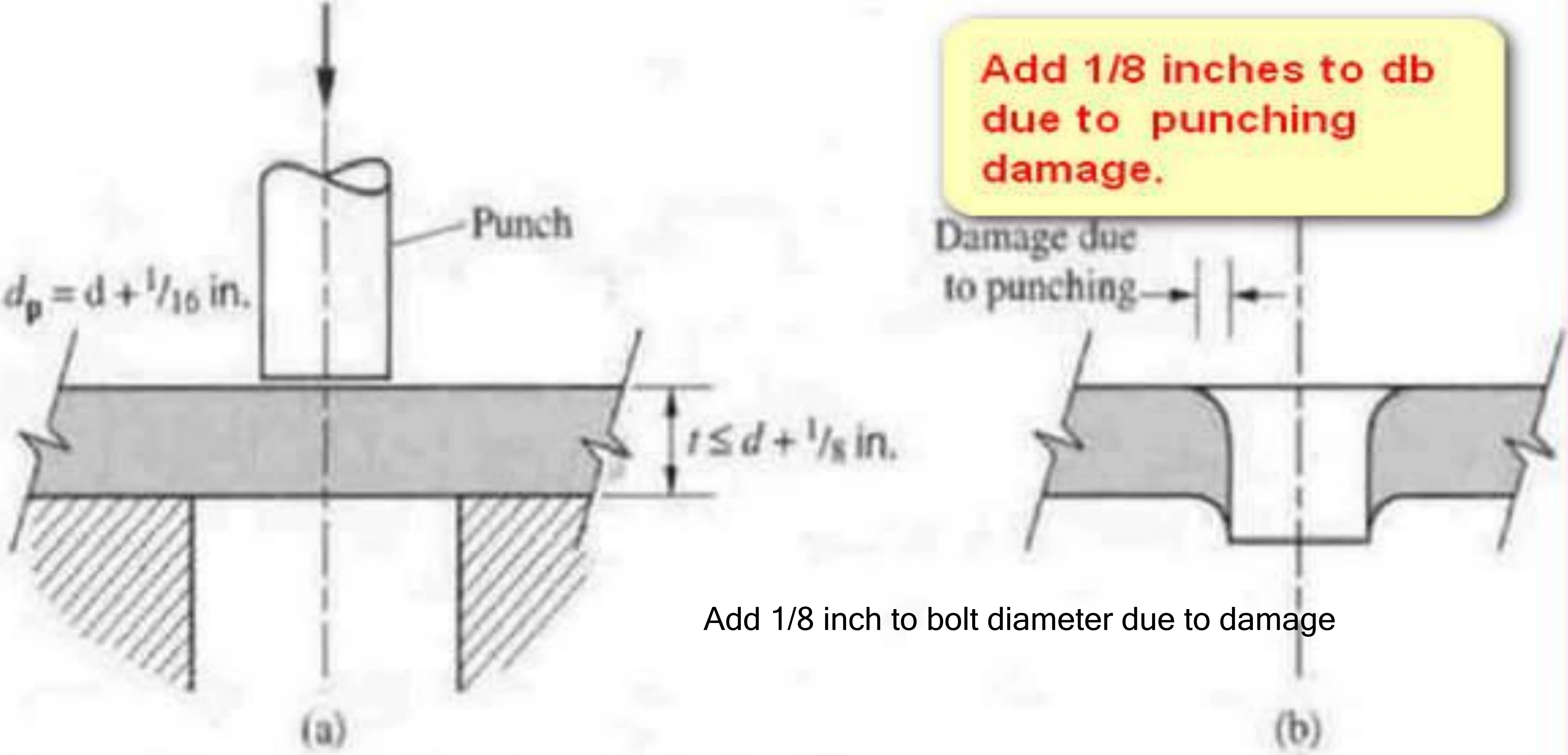


Tensile rupture by Zigzag Line

Zig zag line as second path

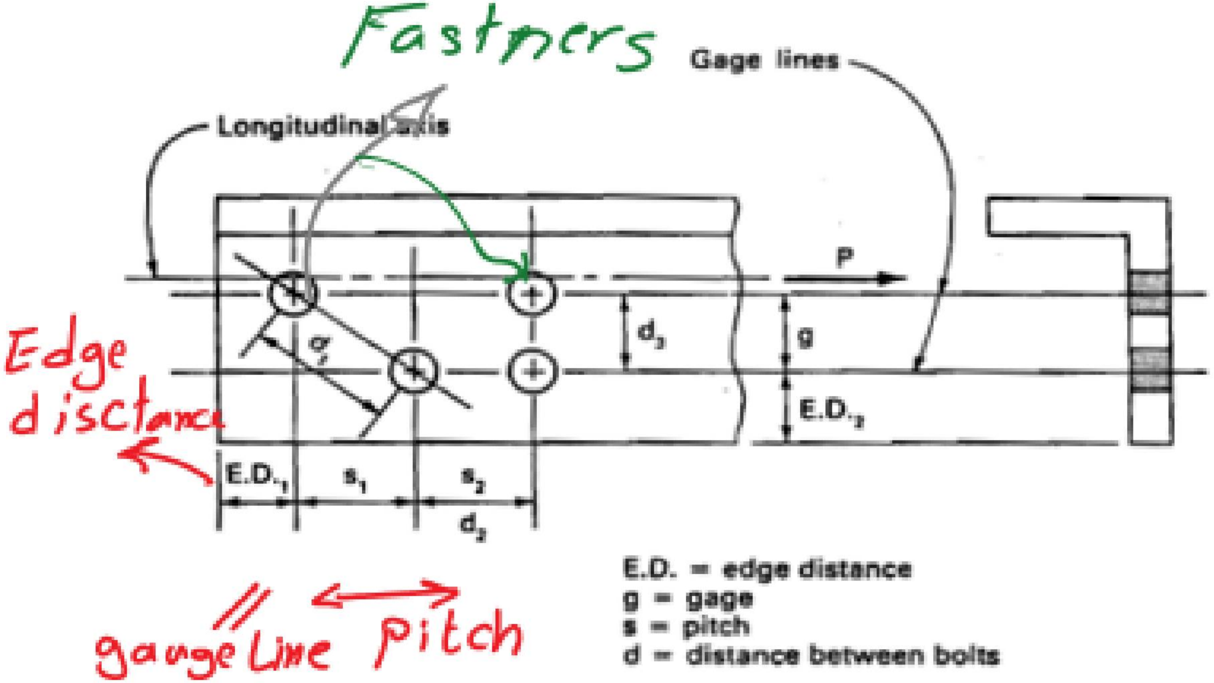
Add 1/8 inches to db due to punching damage.



Add 1/8 inch to bolt diameter due to damage

Figure 4.12 Damage Caused by Hole Punching.

Gauge lines and pitch



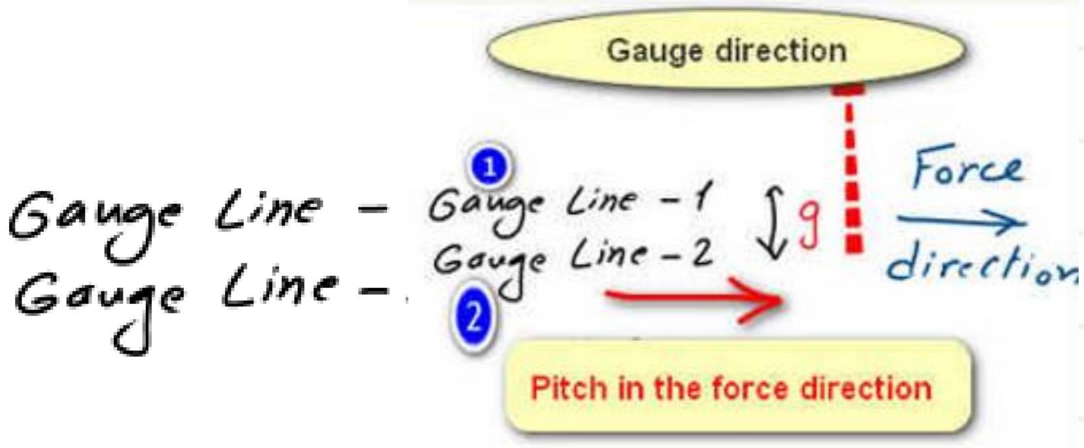


Figure 2-3 shows a tension member composed of a single steel angle with a 4-bolt connection. The tensile load *P* is assumed to be applied parallel to and coincident with the longitudinal axis of the member. The bolt holes are located on *gage lines* that are also parallel to the longitudinal axis. The dimension *g* between the gage lines is called the *gage*. The dimension *s* parallel to the gage line and taken between centers of bolt holes is called the *pitch* (or the *bolt spacing*). The *distance between bolts* is a straight line distance between any two bolts. The *edge distance* is the perpendicular distance from the *center of a hole* to the nearest edge.

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