

# CE 415

# DESIGN OF STEEL STRUCTURES

## LECTURE 5

## BLOCK SHEAR

SEMESTER: SUMMER 2020

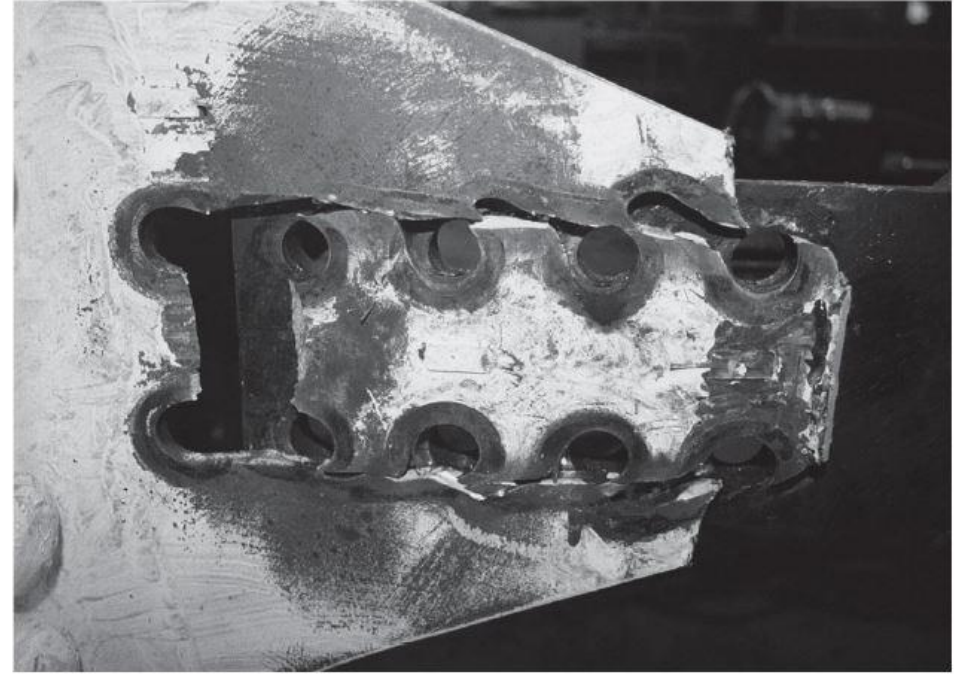
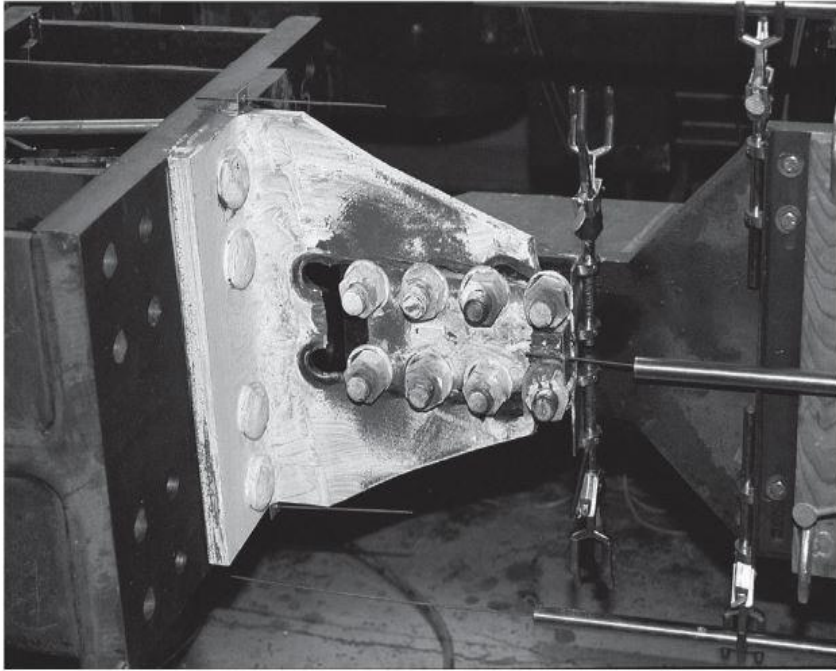
COURSE TEACHER: SAURAV BARUA

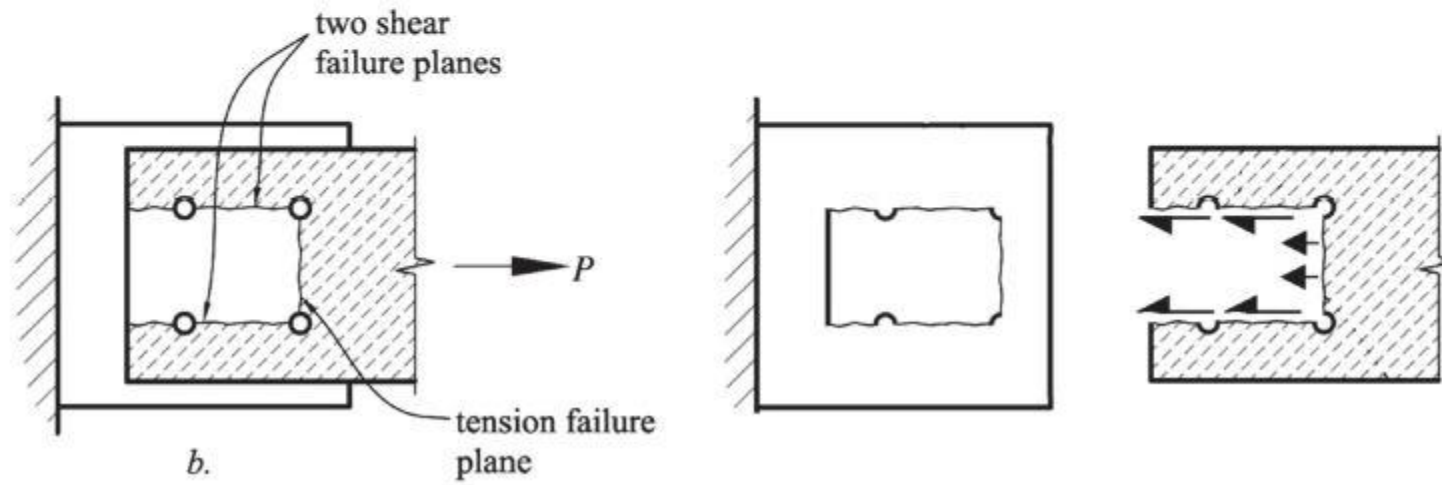
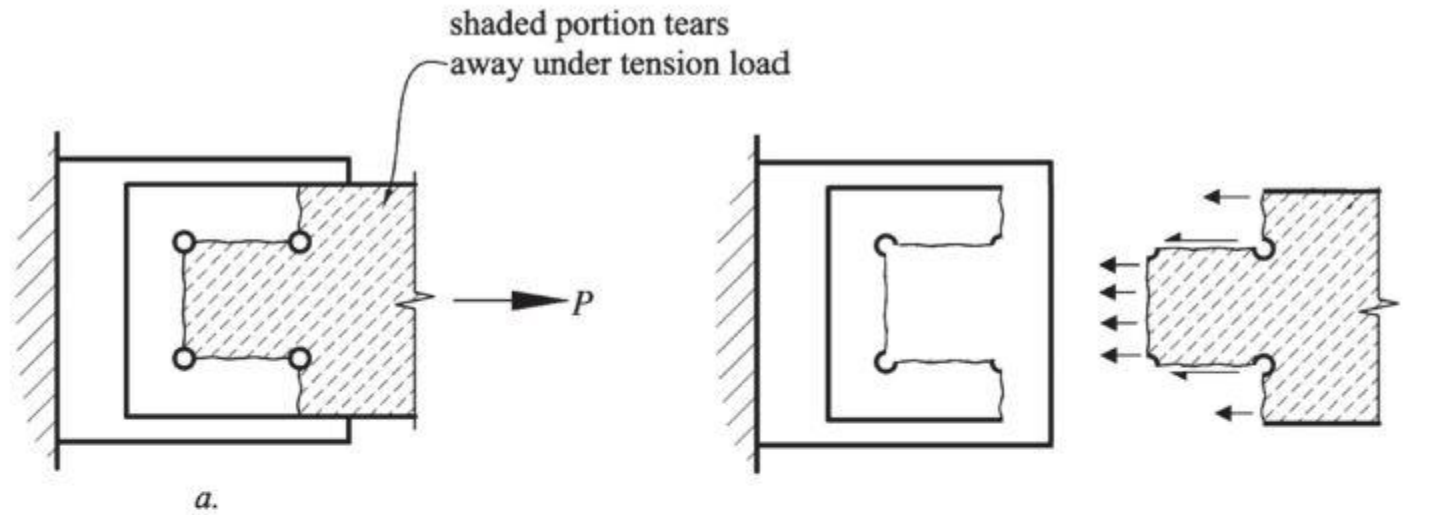
CONTACT NO: +8801715334075

EMAIL: [saurav.ce@diu.edu.bd](mailto:saurav.ce@diu.edu.bd)

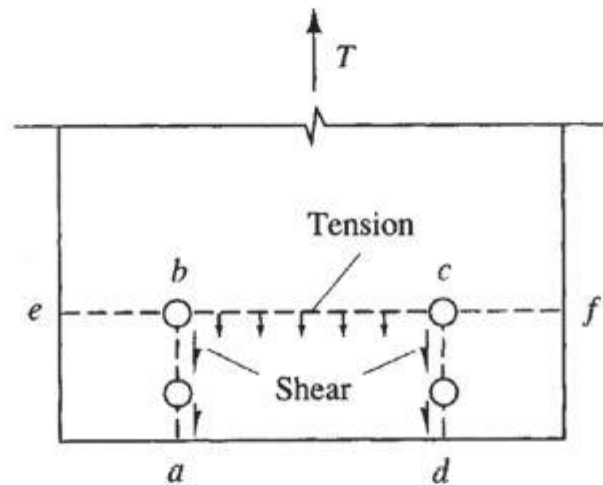
# OUTLINE

- Block Shear theory ASD and LRFD
- Shear yielding tension rupture
- Shear fracture tension rupture
- Calculation of block shear capacity

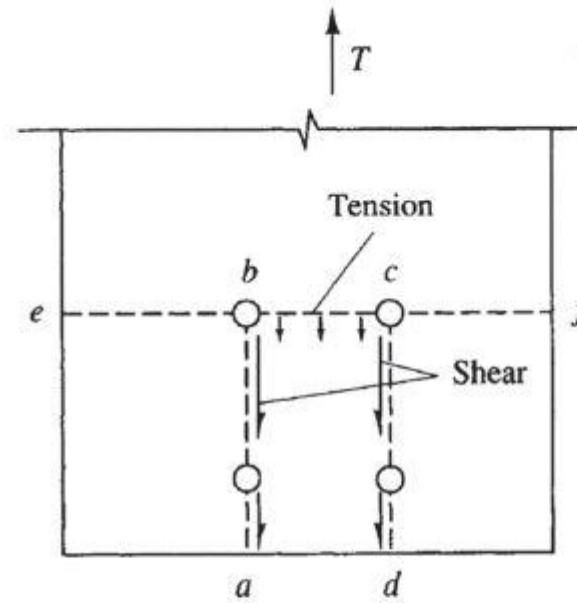




## Block Shear Failure



Large tension, small shear



Large shear, small tension

AISC-J4.3. defines two block shear failure modes:

1. Rupture along the tensile plane ( $b$ - $c$  in left fig.) accompanied by yielding along the shear planes ( $a$ - $b$  and  $c$ - $d$  in left fig.).
2. Rupture along the shear planes ( $a$ - $b$  and  $c$ - $d$  right fig.) accompanied by rupture along the tensile plane ( $b$ - $c$  in right fig.).

## Block Shear Strength

The tensile failure is defined by *rupture along the net area* in both modes,

The failure along the shear planes can either be *Rupture along the net shear area* or *Yield along the gross shear area*, whichever is smaller.

Consistent with the limit states discussed earlier, the *gross area* is used for the yielding limit state and the *net area* is used for the fracture limit state.

Following the energy-of-distortion theory,

- Shear yield stress  $\tau_y$  is taken as  $0.6F_y$
- Shear strength/rupture  $\tau_u$  is taken as  $0.6F_u$

## The nominal block shear strength $T_n$ in tension

Shear yielding - tension rupture ( $\tau_y A_{gv} < \tau_u A_{nv}$ ) or ( $0.6F_y A_{gv} < 0.6F_u A_{nv}$ )

$$T_n = 0.6F_y A_{gv} + F_u U_{bs} A_{nt}$$

Shear fracture - tension rupture ( $\tau_y A_{gv} \geq \tau_u A_{nv}$ ) or ( $0.6F_y A_{gv} \geq 0.6F_u A_{nv}$ )

$$T_n = 0.6F_u A_{nv} + F_u U_{bs} A_{nt}$$

where

$A_{gv}$  : gross area acted upon by shear

$A_n$  : net area acted upon by tension

$A_{nv}$  : net area acted upon by shear

$F_u$  : specified (ASTM) minimum tensile strength

$F_y$  : specified (ASTM) minimum yield stress

When the tension stress is uniform, use  $U_{bs} = 1$ , where the tension is non-uniform use  $U_{bs} = 0.5$ .

## ASD Design

### Block Shear Strength

Shear yielding - tension rupture ( $0.6F_y A_{gv} < 0.6F_u A_{nv}$ )

$$T_n / \Omega = (0.6F_y A_{gv} + F_u U_{bs} A_{nt}) / \Omega = (0.6F_y A_{gv} + F_u U_{bs} A_{nt}) / 2.0$$

Shear fracture - tension rupture ( $0.6F_y A_{gv} \geq 0.6F_u A_{nv}$ )

$$T_n / \Omega = (0.6F_u A_{nv} + F_u U_{bs} A_{nt}) / \Omega = (0.6F_u A_{nv} + F_u U_{bs} A_{nt}) / 2.0$$

Where,

$A_{gv}$  : gross area acted upon by shear

$A_n$  : net area acted upon by tension

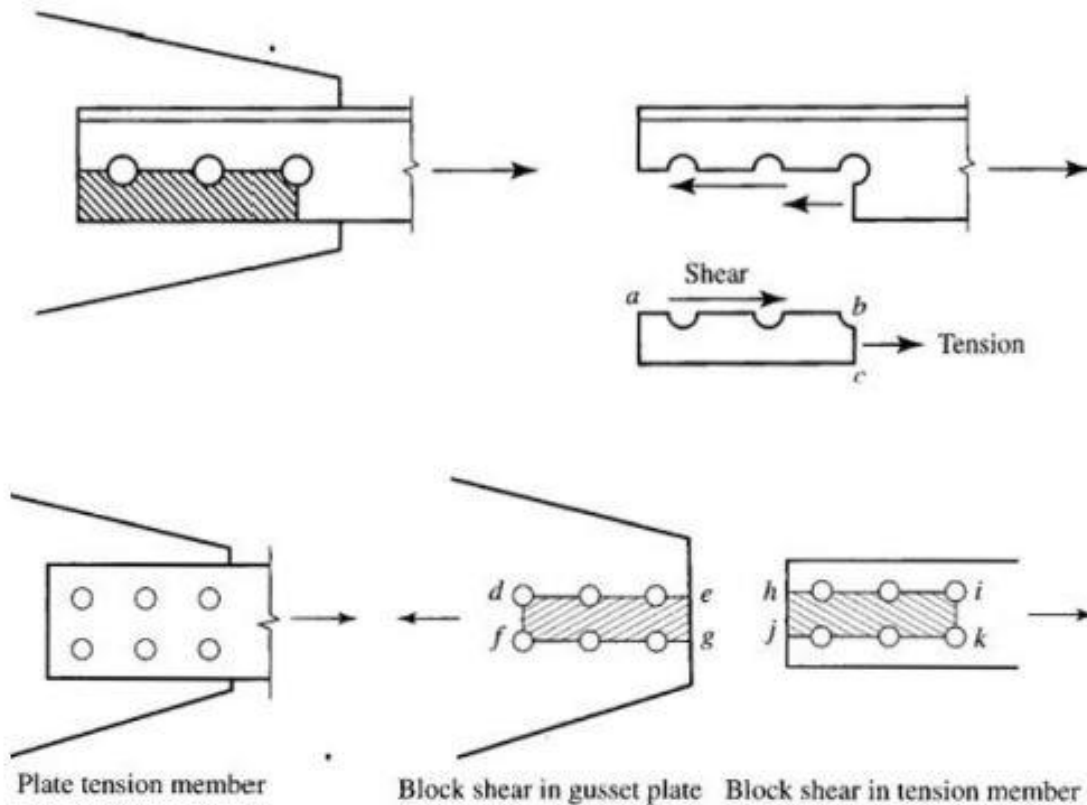
$A_{nv}$  : net area acted upon by shear

$F_u$  : specified (ASTM) minimum tensile strength

$F_y$  : specified (ASTM) minimum yield stress

Safety factor  $\Omega = 2.00$  for block shear which is essentially a fracture limit state





Two types of failure occurs during block shear.

**Tensile Failure** Occurs at cross sections that are transverse to applied load.

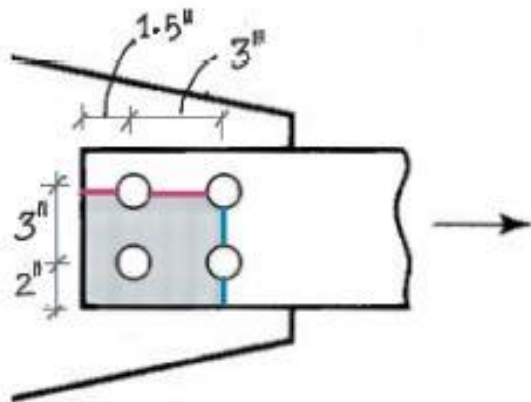
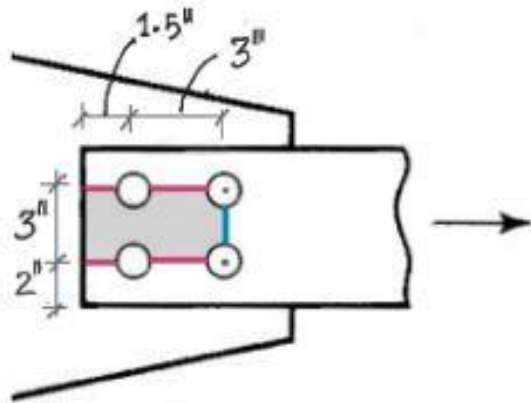
**Shear Failure** Occurs at cross sections that are along the direction of applied load.

**Nominal Capacity** The minimum of the following two expressions.

$$R_n = \begin{cases} 0.60F_y A_{gv} + F_u A_{nt} \\ 0.60F_u A_{nv} + F_u A_{nt} \end{cases}$$

$A_{gv}$	Gross area for shear
$A_{nv}$	Net area for shear
$A_{nt}$	Net area for tension
$F_y$	Yield Strength
$F_u$	Ultimate Strength

**Ques.** Determine block shear strength of the following plate which is 1/2 inch thickness. Bolts have 5/8 inch diameter. Assume A36 steel.



### Block Shear - Mode 1

#### Areas

$$A_{gv} = \frac{1}{2} \times [4.5] \times 2 = 4.5 \text{ in}^2$$

$$A_{nv} = \frac{1}{2} \times \left[ 4.5 - 1.5 \times \left( \frac{5}{8} + \frac{1}{8} \right) \right] \times 2 = 3.375 \text{ in}^2$$

$$A_{nt} = \frac{1}{2} \times \left[ 3 - 1 \times \left( \frac{5}{8} + \frac{1}{8} \right) \right] = 1.125 \text{ in}^2$$

#### Capacity

$$\begin{aligned} R_n &= 0.60F_y A_{gv} + F_u A_{nt} \\ &= 0.60 \times 36 \times 4.5 + 58 \times 1.125 \\ &= 162.4 \text{ (←)} \end{aligned}$$

$$\begin{aligned} R_n &= 0.60F_u A_{nv} + F_u A_{nt} \\ &= 0.60 \times 58 \times 3.375 + 58 \times 1.125 \\ &= 182.7 \text{ kip} \end{aligned}$$

$$\phi_t R_n = 0.9 \times 162.4 = 146.1 \text{ kip}$$

### Block Shear - Mode 2

#### Areas

$$A_{gv} = \frac{1}{2} \times [4.5] \times 1 = 2.25 \text{ in}^2$$

$$A_{nv} = \frac{1}{2} \times \left[ 4.5 - 1.5 \times \left( \frac{5}{8} + \frac{1}{8} \right) \right] = 1.687 \text{ in}^2$$

$$A_{nt} = \frac{1}{2} \times \left[ 5 - 1.5 \times \left( \frac{5}{8} + \frac{1}{8} \right) \right] = 1.936 \text{ in}^2$$

#### Capacity

$$\begin{aligned} R_n &= 0.60F_y A_{gv} + F_u A_{nt} \\ &= 0.60 \times 36 \times 2.25 + 58 \times 1.936 \\ &= 160.9 \text{ (←)} \end{aligned}$$

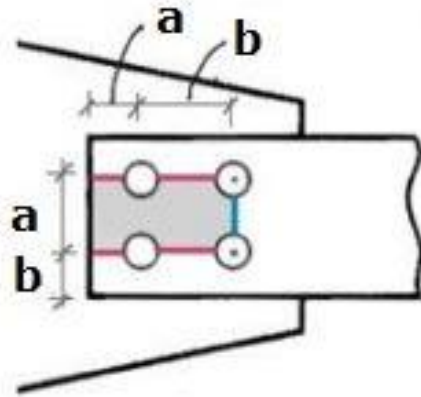
$$\begin{aligned} R_n &= 0.60F_u A_{nv} + F_u A_{nt} \\ &= 0.60 \times 58 \times 1.687 + 58 \times 1.936 \\ &= 171 \text{ kip} \end{aligned}$$

$$\phi_t R_n = 0.9 \times 160.9 = 144.8 \text{ kip}$$

**Ans.** Block shear strength is 144.8 kip

# QUIZ-1

Determine block shear strength of following plate which is  $\frac{3}{4}$  inch thickness. Bolts have  $\frac{7}{8}$  inch diameter. Assume A36 Steel.



Example: 172-47- Xba

$b = (\text{roll no 2nd last digit} + 1)$  inch

$a = (\text{roll no last digit} + 1)$  inch

if some one roll no. 172-47-123, then  $b = 3''$  and  $a = 4''$

  SB- Quiz-1 on 9.6.20 (Block Shear) 

 Edit  

Not available unless any of:

- You belong to 172DE1
- You belong to 172DE2

This quiz opened at Saturday, 6 June 2020, 11:29 AM

This quiz will close on Friday, 12 June 2020, 11:29 AM.

Time limit: 2 hours

Grading method: Highest grade