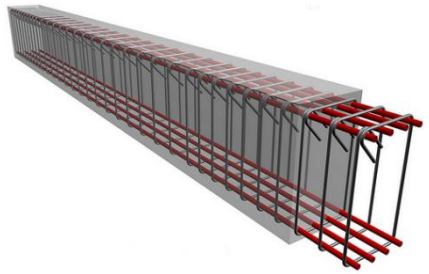
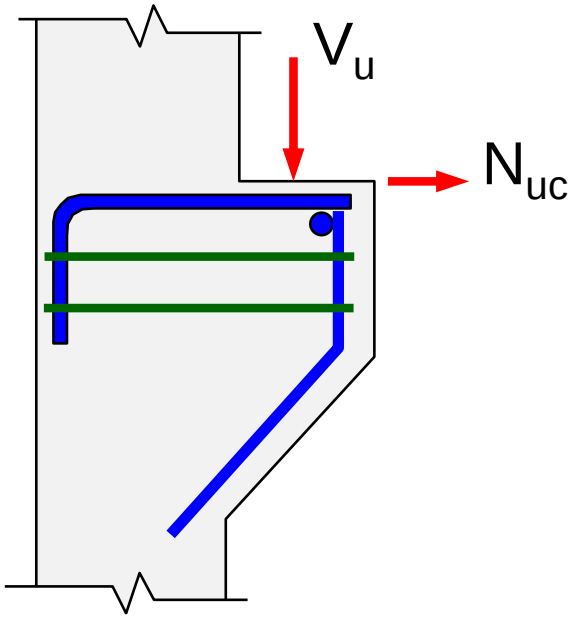
4



Advanced RC Structures

Bracket & Corbel



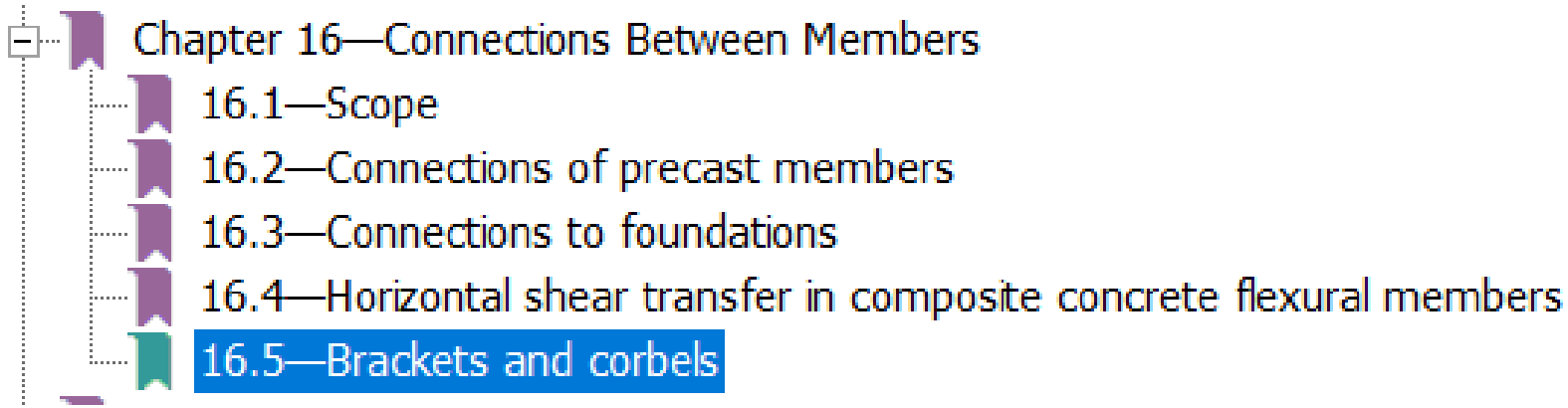
- Shear Friction
- Structural Action
- Types of Failiure
- Design Steps
- Examples

Mongkol JIRAVACHARADET

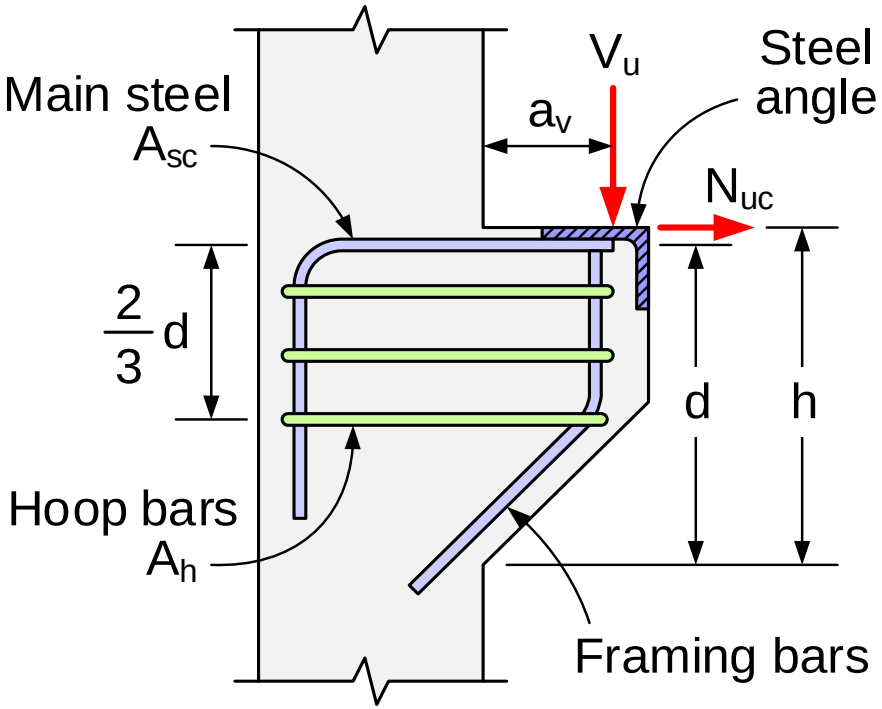
ACI 318-19

An ACI Standard

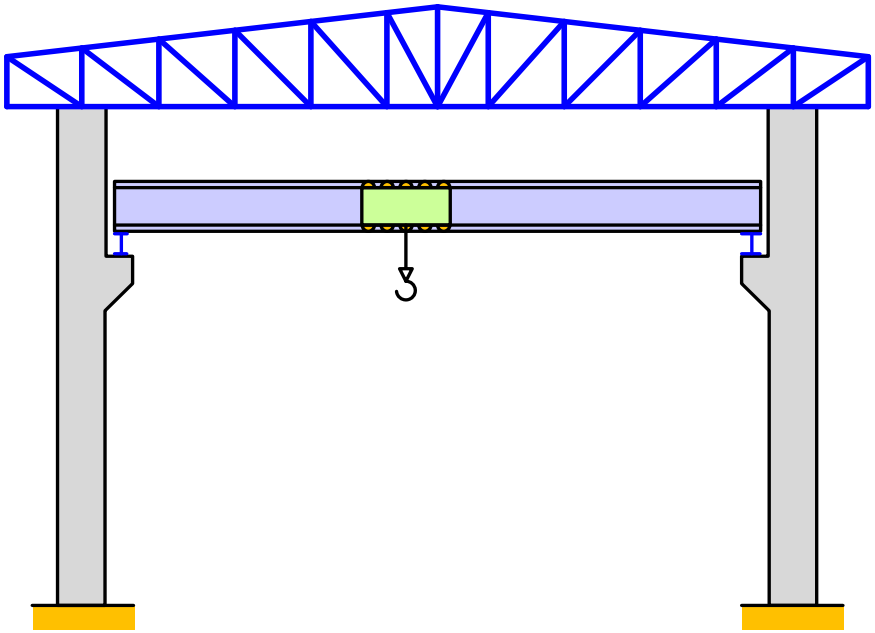
Building Code Requirements For Structural Concrete



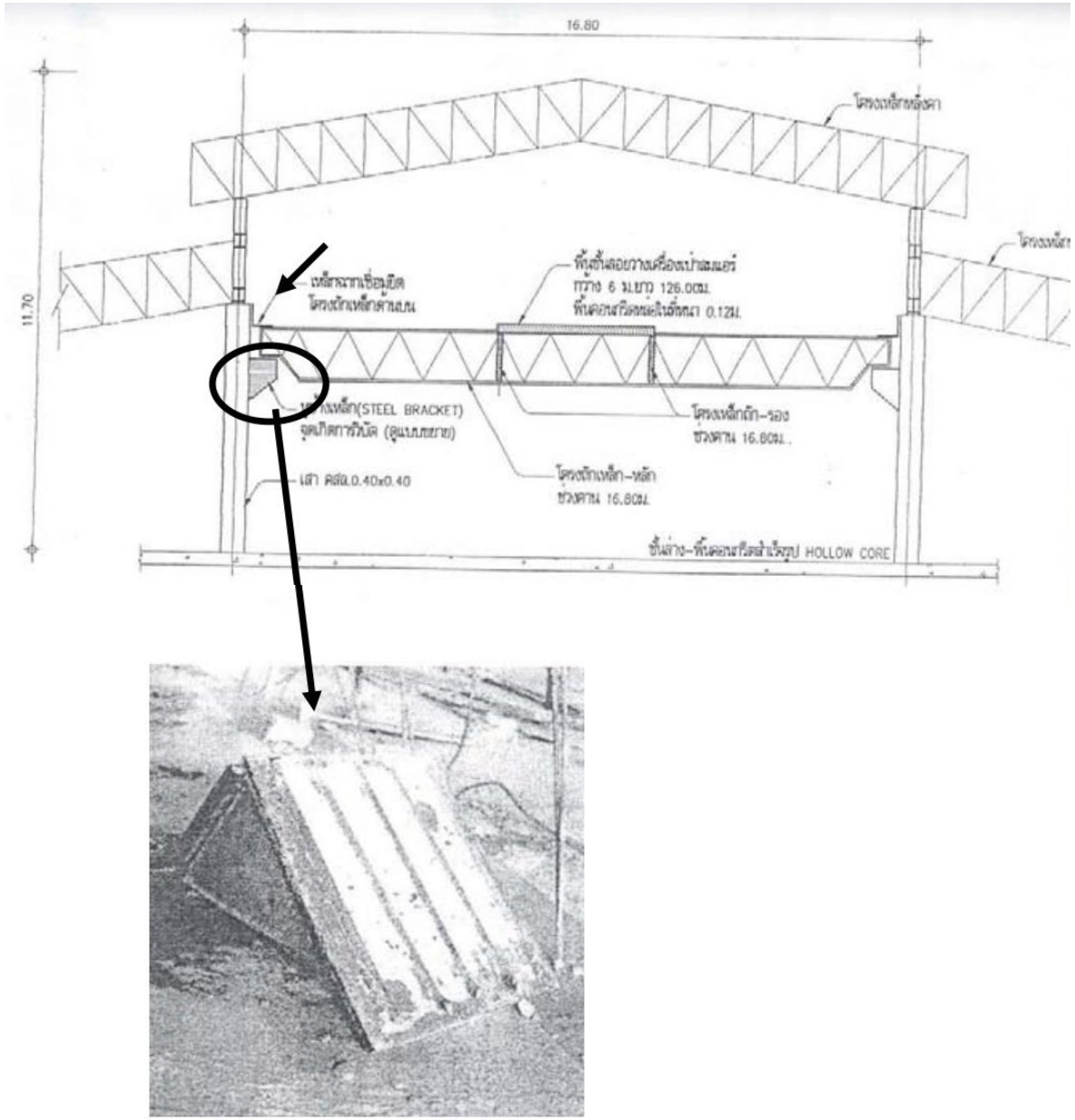
Bracket & Corbel

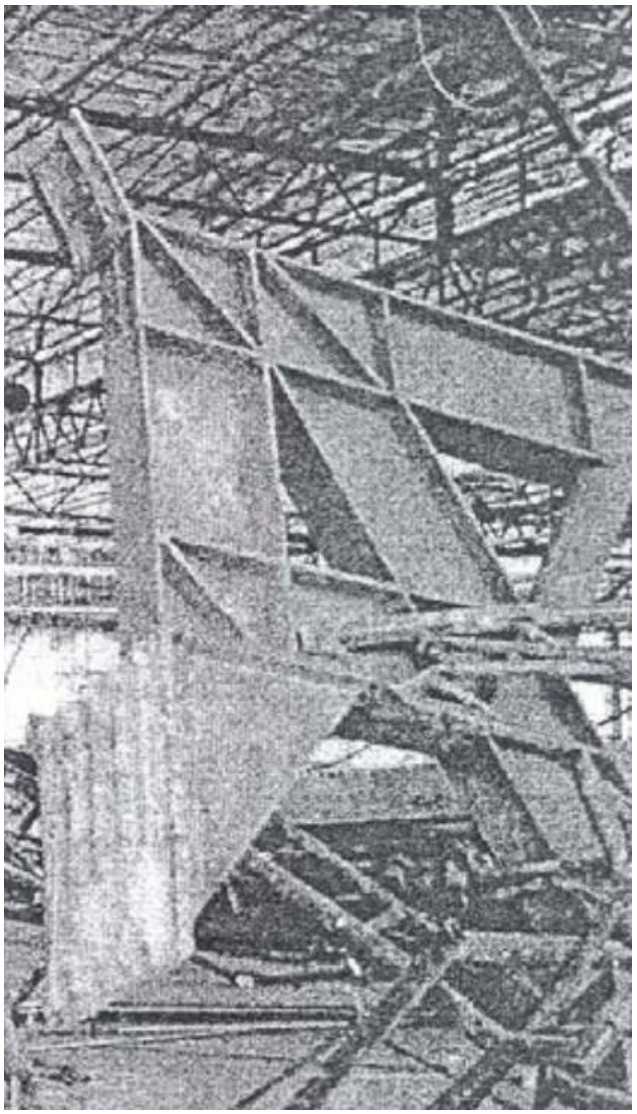


- Short cantilevers that tend to act as simple trusses or deep beams
- Used to support truss, crane or precast beams
- Design for vertical force **V_u** and horizontal force **N_{uc}**

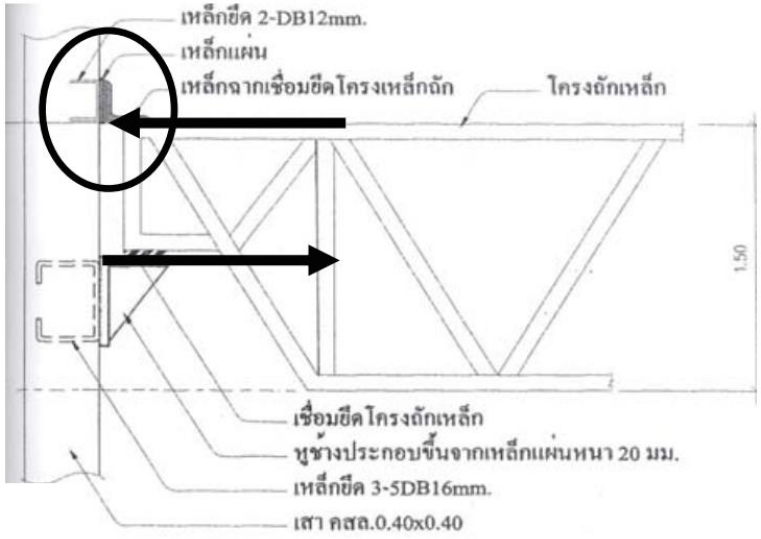


Failure of Steel Corbel on RC Column

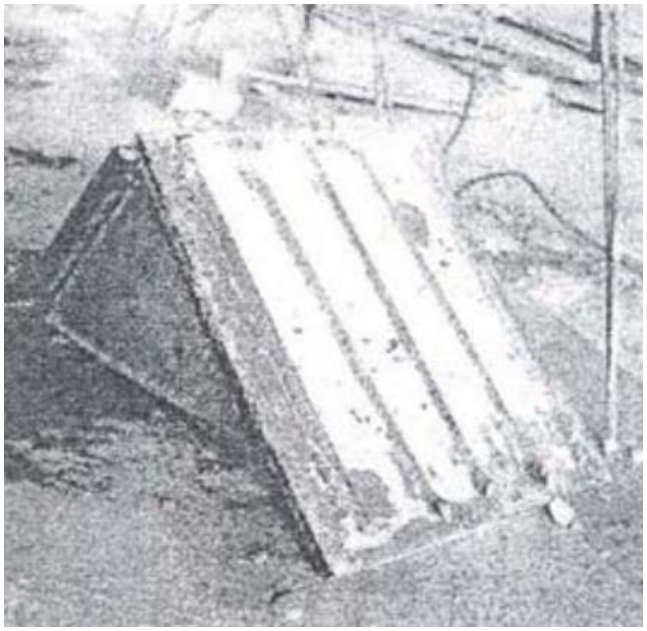


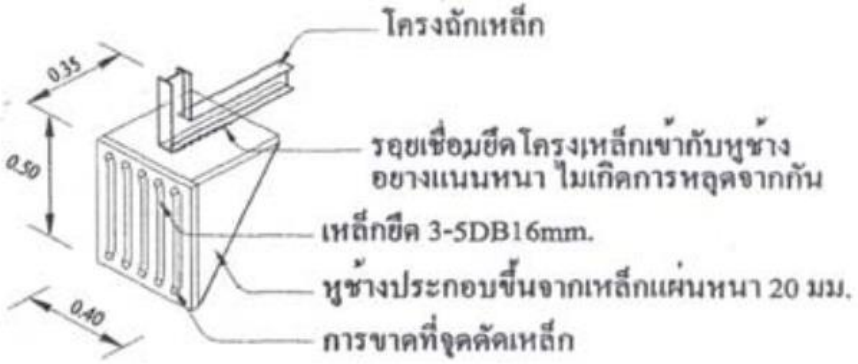


Failure of Steel Corbel on RC Column



แบบขยายหูช้างเหล็ก (STEEL BRACKET)



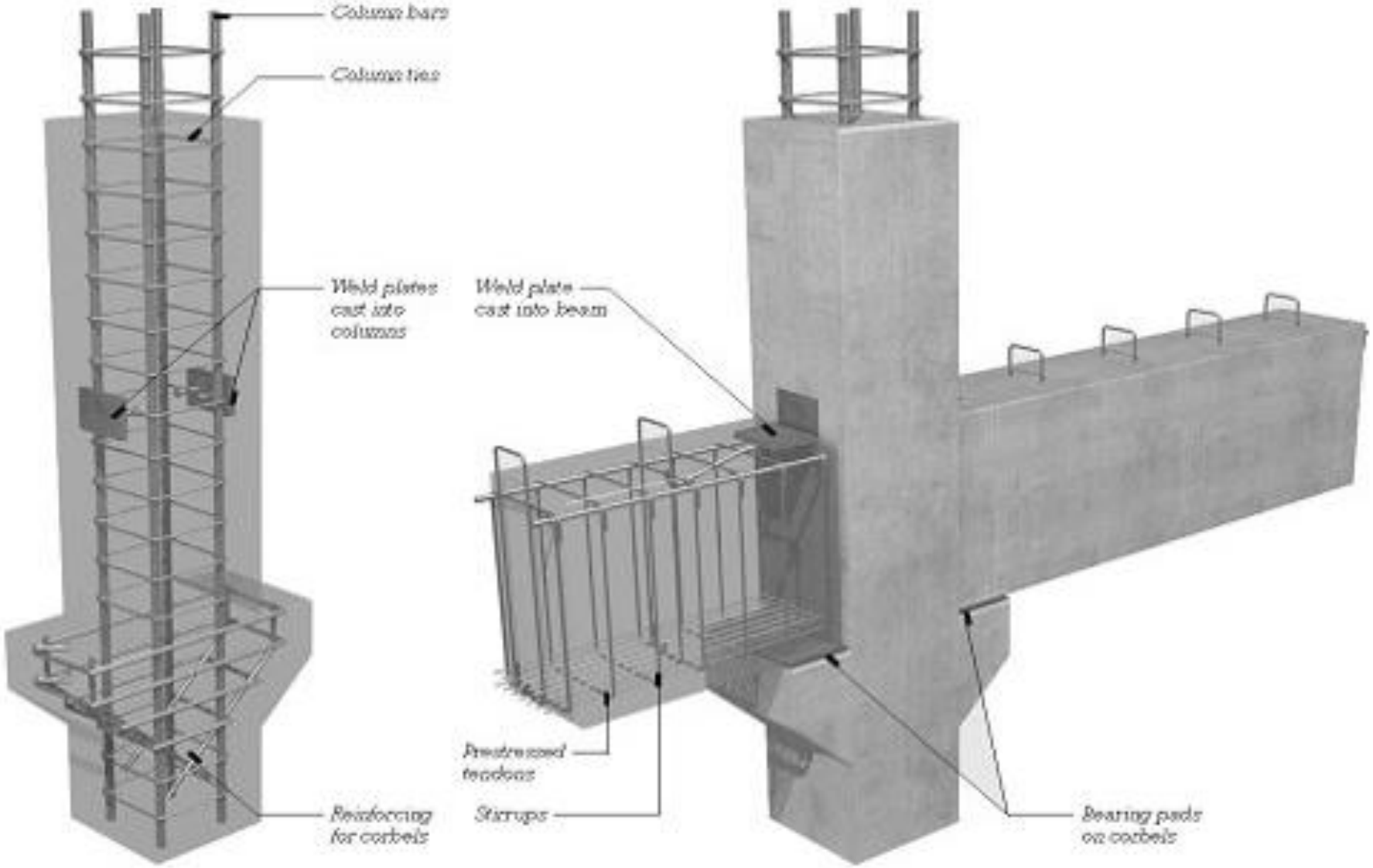


การวิบัติของเหล็กยึดเกิดการขาดที่จุดดัดเหล็ก

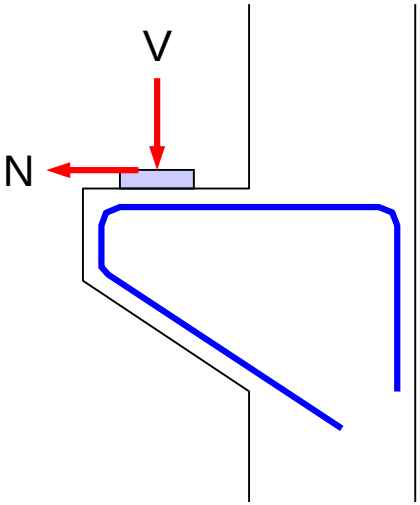
(หูช้างวิบัติ 13ตัวจากทั้งหมด 14ตัว)

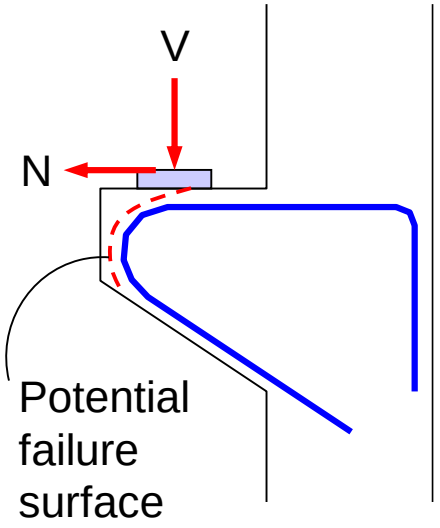
Beam-Column Connection

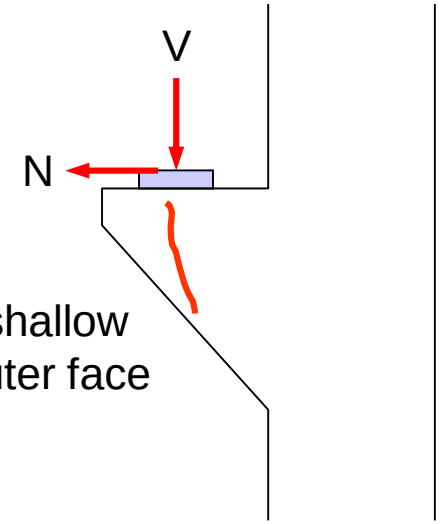
Precast Concrete Structure

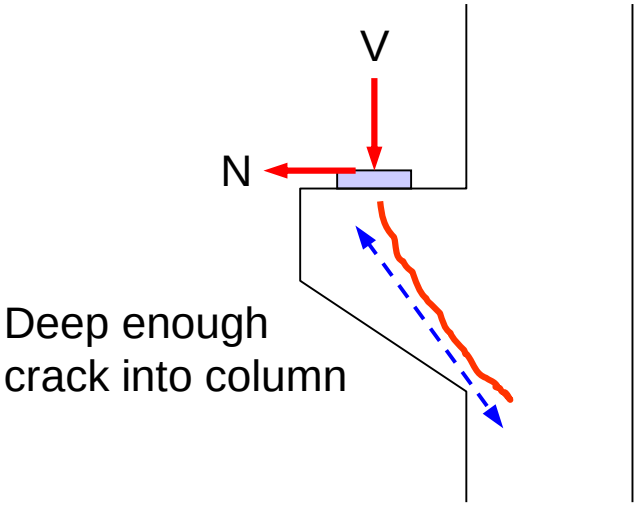


Types of Failure









Structural Action

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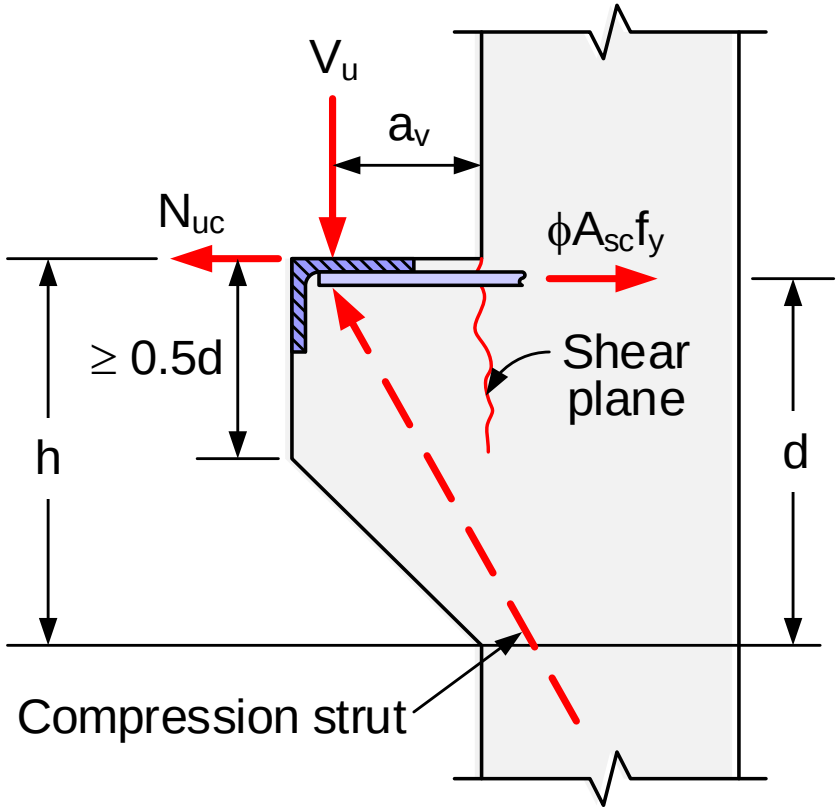
The bracket may fail by

- Shearing along interface between column and bracket
- Yielding of tension tie
- Crushing or splitting of compression strut
- Localized bearing or shearing failure under loading plate



The method of design is valid for

- $a_v/d \leq 1.0$
- $N_{uc} \leq V_u$

For normal weight concrete, V_u/ϕ shall not exceed the least of :

(a) $0.2 f'_c b_w d$

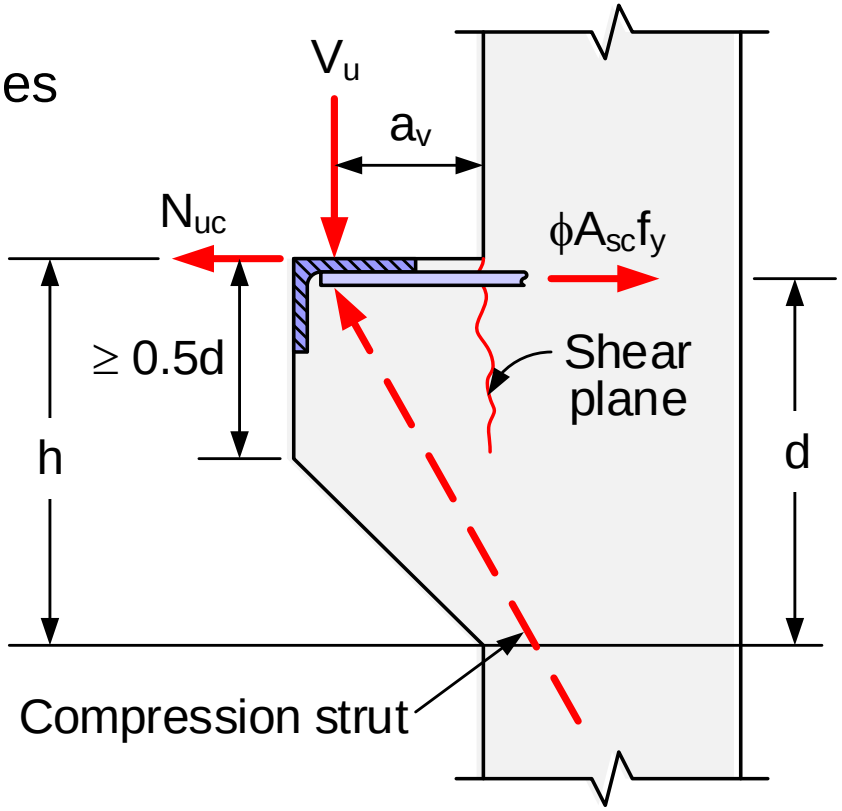
(b) $(33.8 + 0.08 f'_c) b_w d$

(c) $112.7 b_w d$

Required Strength

ACI 318-19

- V_u and N_{uc} shall be the maximum values of the factored load combinations
- Horizontal tensile force acting on bracket shall be treated as a live load when computing N_{uc}
- Unless tensile forces are prevented from being applied to the bracket, N_{uc} shall be at least $0.2V_u$
- The factored moment M_u is given by



$$M_u = V_u a_v + N_{uc}(h - d)$$

Design Strength

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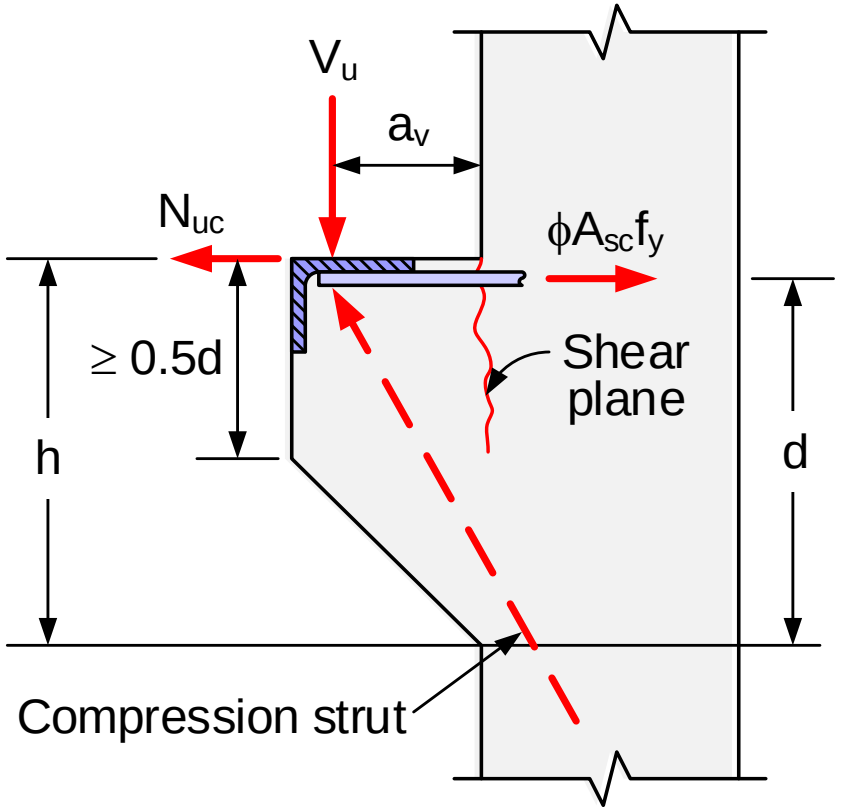
- Design strength $\phi S_n \geq U$:
  - $\phi N_n \geq N_{uc}$
  - $\phi V_n \geq V_{uc}$
  - $\phi M_n \geq M_u$
- Strength reduction factor $\phi = 0.75$
- Nominal tensile strength $N_n = A_n f_y$
- Nominal shear strength $V_n = \mu A_{vf} f_y$
  for concrete momolithically $\mu = 1.4$



- Nominal moment strength $M_n = A_f f_y \left(d - \frac{a}{2} \right) \approx A_f f_y (0.9d)$

Steel Reinforcements

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- Steel to resist tensile force: $A_n = \dfrac{N_{uc}}{\phi f_y}$

- Steel to resist bending moment:

$$A_f = \frac{M_u}{\phi f_y (d - a/2)}$$

- Steel to resist shear force:

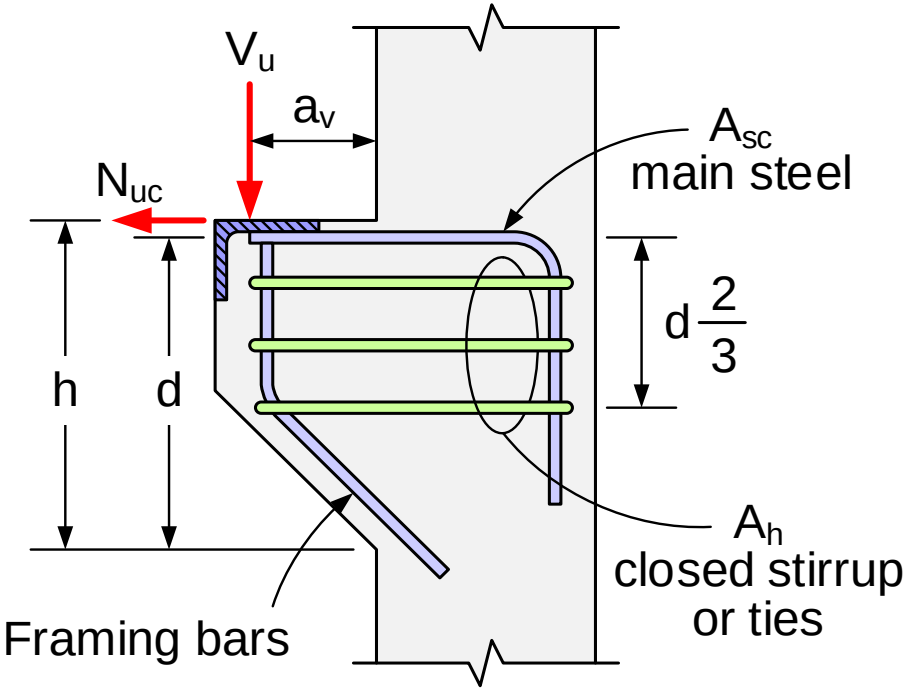
$$A_{vf} = \frac{V_u}{\phi \mu f_y}$$

- Total steel A_{sc} @ top of bracket shall be at least the greatest of :

  (a) $A_f + A_n$

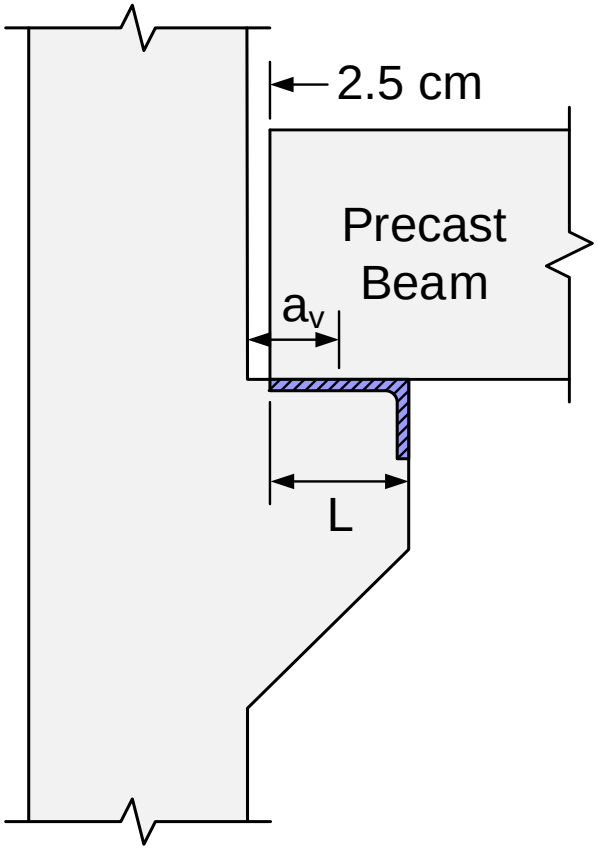
  (b) $(2/3)A_{vf} + A_n$

  (c) $0.04(f'_c / f_y) b_w d$



- Total steel A_h of ties shall be at least : $A_h = 0.5(A_{sc} - A_n)$

ตัวอย่างที่ 1 ออกแบบหูช้างซึ่งยื่นจากเสากว้าง 35 ซม. รับน้ำหนักคงที่ 14 ตัน น้ำหนักจร 18 ตัน สมมุติให้มีการจัดเตรียมจุดรองรับของคานเสริมเหล็กอัดแรงอย่างเหมาะสมทำให้สามารถขจัดแรงที่จะเกิดในแนวนอน ช่องว่างระหว่างปลายคานและผิวของเสาเท่ากับ 2.5 ซม. กำหนด $f'_c = 240$ กก./ซม.^{2} และ $f_y = 4{,}000$ กก./ซม.^{2}



วิธีทำ **(1) Factored loads:**

$$V_u = 1.4\times 14 + 1.7\times 18 = 50.2 \text{ ton}$$

$$N_{uc} = 0.2V_u = 0.2\times 50.2 = 10.0 \text{ ton}$$

Bearing length $V_u/\phi = (0.85f'_c)A_1 = (0.85f'_c)bL$

$$L = \frac{50.2\times 1{,}000}{0.70\times 0.85\times 240\times 35} = 10.0 \text{ cm}$$

$$a_v = 5.0 + \frac{1}{2}L = 10.0 \text{ cm}$$

(2) Depth of Bracket : from max. V_u/ϕ criteria

(a) $0.2f'_c b_w d = 48 b_w d$ → control

(b) $(33.8 + 0.08f'_c)b_w d = 53 b_w d$

(c) $112.7 b_w d$

From $V_u / \phi = 48\, b_w d$

$$\min d = \frac{V_u}{\phi(48 b_w)} = \frac{50.2 \times 1{,}000}{0.75 \times 48 \times 35} = 39.8 \text{ cm}$$

ใช้ความลึก h = 45 ซม. → d = 40 ซม.

$$\frac{a}{d} = \frac{10}{40} = 0.25 < 1.0$$ **OK**

(3) Steel Reinforcement :

$$A_{vf} = \frac{V_u}{\phi f_y \mu} = \frac{50.2}{0.75 \times 4.0 \times 1.4} = 12.0 \text{ cm}^2$$

$$A_n = \frac{N_{uc}}{\phi f_y} = \frac{10.0}{0.75 \times 4.0} = 3.33 \text{ cm}^2$$

$$M_u = V_u a_v + N_{uc}(h - d) = 50.2 \times 10 + 10.0(45 - 40)$$

$$= 542 \text{ ตัน-ซม.} = 5.42 \text{ ตัน-เมตร}$$

$$A_f = \frac{M_u}{\phi f_y jd} = \frac{542}{0.75 \times 4.0 \times 0.9 \times 40} = 5.02 \text{ cm}^2$$

- Total steel A_{sc} @ top of bracket shall be at least the greatest of :

  (a) $A_f + A_n = 5.02 + 3.33 = 8.35\ cm^2$

  (b) $(2/3)A_{vf} + A_n = (2/3)(12.0) + 3.33 = 11.33\ cm^2 \rightarrow$ control

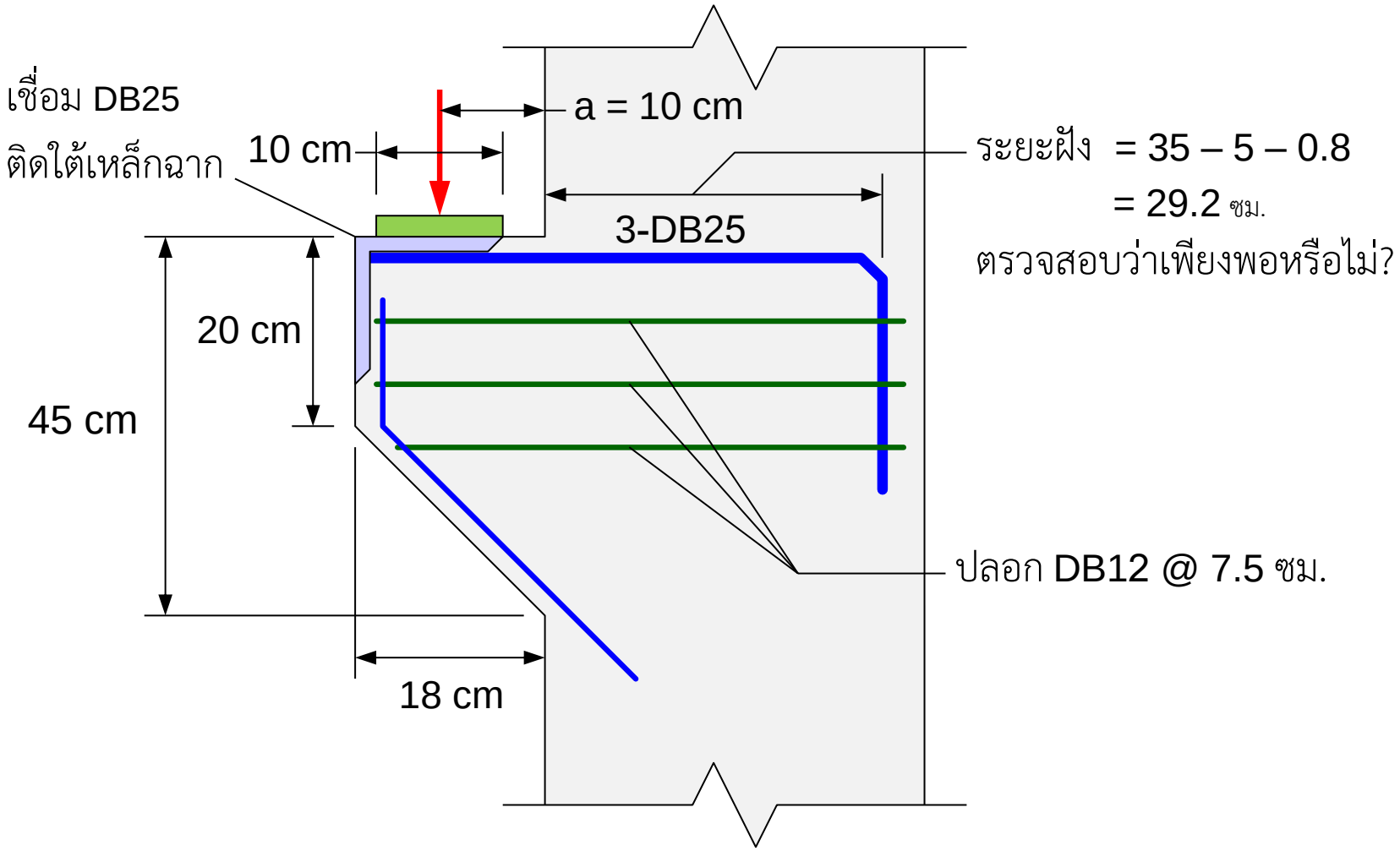
  (c) $0.04(f'_c / f_y)b_w d = 0.04\left(\frac{240}{4{,}000}\right)(35)(40) = 3.36\ cm^2$

  ดังนั้นใช้ A_{sc}: **3-DB25** ($A_s = 14.73$ ซม^2)

- Total steel A_h of ties shall be at least :

  $A_h = 0.5(A_{sc} - A_n) = 0.5(14.73 - 3.33) = 5.90\ cm^2$

  เลือกใช้ปลอกปิด **3-DB12** ($A_h = 2(3)(1.13) = 6.79$ ซม^2)


เชื่อม DB25
ติดใต้เหล็กฉาก
10 cm
a = 10 cm
ระยะฝัง = 35 – 5 – 0.8
= 29.2 ซม.
ตรวจสอบว่าเพียงพอหรือไม่?
3-DB25
20 cm
45 cm
ปลอก DB12 @ 7.5 ซม.
18 cm

End of Lecture