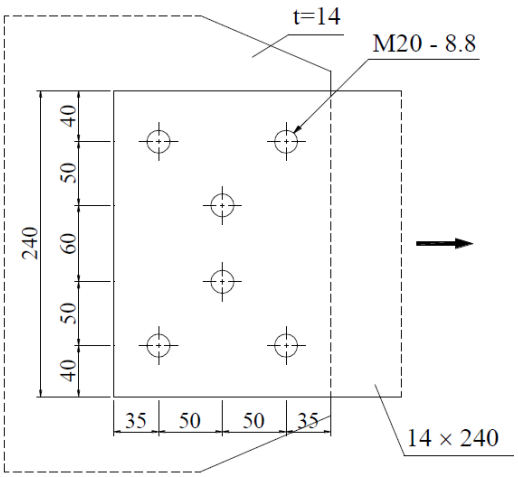

Figure 1.

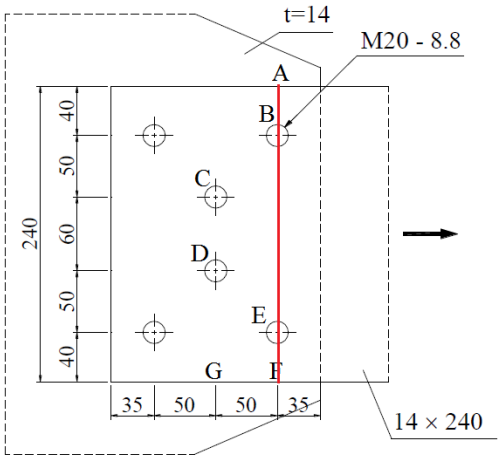

Figure 2.

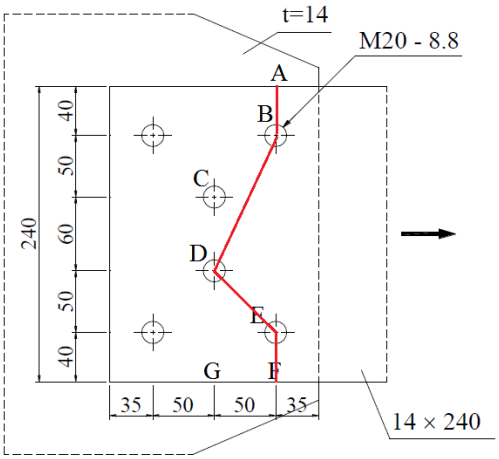

Figure 3.

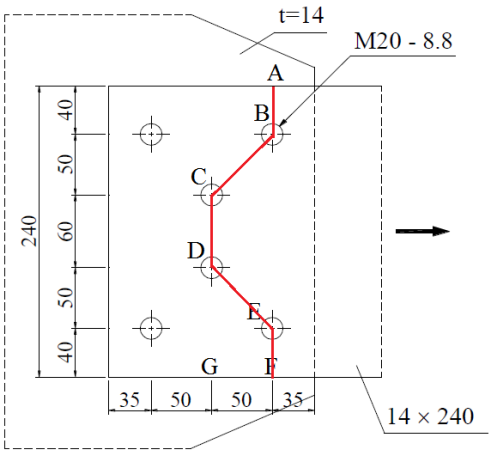

Figure 4.

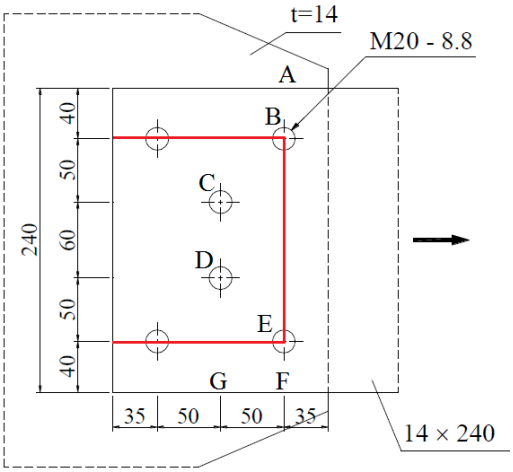

Figure 5.

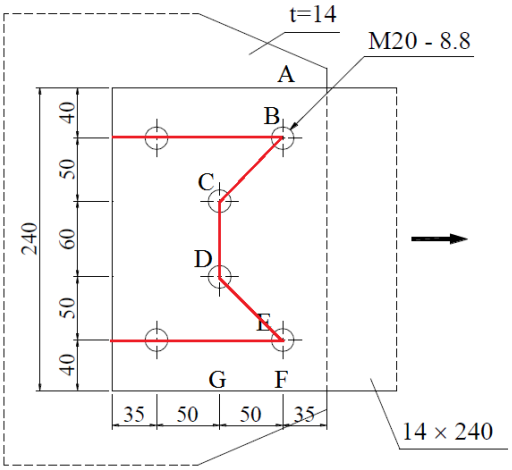

Figure 6.

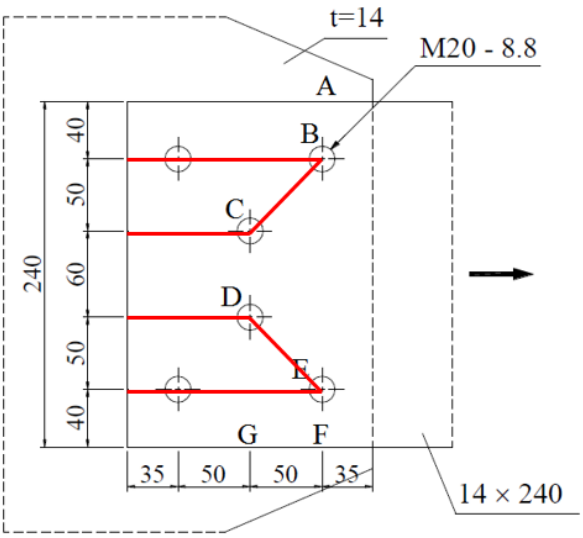

Figure 7.

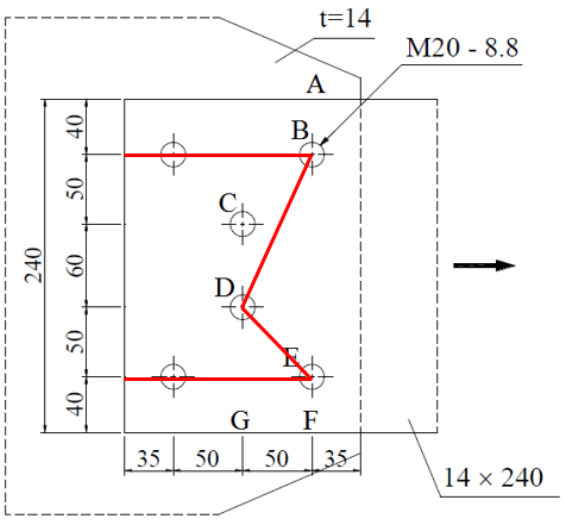

Figure 8.

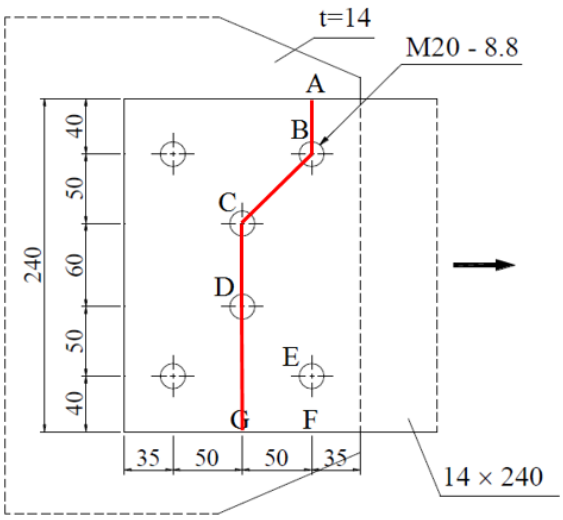

Figure 9.

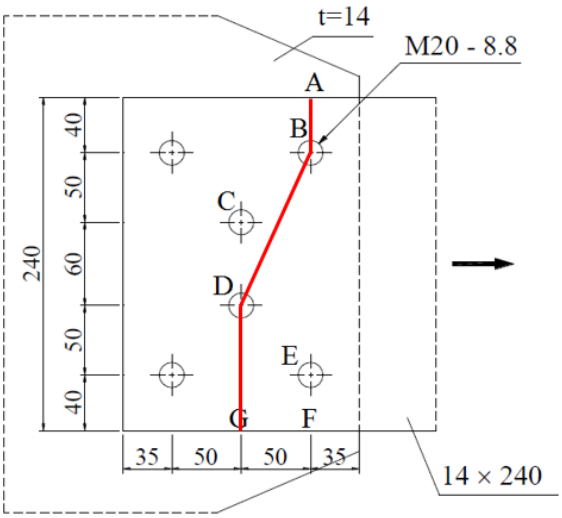

Figure 10.

A tension member, a 14x240 plate, is connected to a gusset plate with staggered bolts as shown in Figure 1. Determine the design strength of the member.

Bolt: M20 (standart bolt hole)

Steel: S275 (F_y= 27,5 kN/cm², F_u =43 kN/cm²)

Şekil 1'de görüldüğü gibi, 14x240 boyutlarındaki çekme çubuğu şaşırtmalı yerleştirilmiş bulonlar ile mesnet levhasına bağlanmıştır. Çekme çubuğunun tasarım dayanımını hesaplayınız.

Bulon: M20 (standart bulon deliği)

Çelik: S275 (F_y=27,5 kN/cm², F_u=43 kN/cm²)

$d=20$ $\quad d_h=22$ $\quad d_e=22+2=24$

$$A_n = A_g - \sum d_e\, t + \sum \frac{s^2 t}{4g}$$

→ Akma (Yielding)

$A_g = 24.1,4 = 33,6$ cm²

$T_n = 27,5.33,6 = 924$ kN $\qquad \phi_t T_n = 0,90.924 = 831,6$ kN

→ Kopma (Fracture)

$A_n = ?$

- Case-1 (Figure-2) (A-B-E-F)

$A_n = 24.1,4 - 2.2,4.1,4 = 26,88$ cm²

- Case-2 (Figure-3) (A-B-D-E-F)

$$A_n = 24.1,4 - 3.2,4.1,4 + \frac{5^2.1,4}{4.5} + \frac{5^2.1,4}{4.11} = 26,07 \text{ cm}^2$$

- Case-3 (Figure-4) (A-B-C-D-E-F)

$$A_n = 24.1,4 - 4.2,4.1,4 + 2.\frac{5^2.1,4}{4.5} = 23,66 \text{ cm}^2$$

$\min A_n = 23,66$ cm² $\quad U=1 \quad A_e = 23,66$ cm²

$T_n = F_u.A_e = 43.23,66 = 1017,38$ kN $\qquad \phi_t T_n = 0,75.1017,38 = 763,04$ kN

→ Blok Kırılma (Block Shear)

• Case-1 (Figure-5)

$A_{gv} = 2.(5+5+3,5).1,4 = 37,80\ cm^2$

$A_{nv} = 2.(5+5+3,5-2,4-1,2).1,4 = 27,72\ cm^2$

$A_{nt} = (5+6+5-1,2-1,2).1,4 = 19,04\ cm^2$

$R_n = 0,60 F_u A_{nv} + U_{bs} F_u A_{nt} \leq 0,60 F_y A_{gv} + U_{bs} F_u A_{nt}$

$0,60.43.27,72 + 1.43.19,04 = 1533,9\ kN$
$0,60.27,5.37,80 + 1.43.19,04 = 1442,4\ kN$ } $R_n = 1442,4\ kN$

$\phi R_n = 0,75.1442,4 = 1081,8\ kN$

• Case-2 (Figure-6)

$A_{gv} = 2.(3,5+5+5).1,4 = 37,80\ cm^2$

$A_{nv} = 2.(3,5+5+5-2,4-1,2).1,4 = 27,72\ cm^2$

$A_{nt} = 23,66 - 2.(4-1,2).1,4 = 15,82\ cm^2$

(from staggered case-3)

$R_n = 0,60.43.27,72 + 1.43.15,82 = 1395,44\ kN$
$0,60.27,5.37,80 + 1.43.15,82 = 1303,96\ kN$ } $R_n = 1303,96\ kN$

$\phi R_n = 0,75.1303,96 = 977,97\ kN$

• Case-3 (Figure-7)

$A_{gv} = 2.(5+5+3,5).1,4 + 2.(5+3,5).1,4 = 61,6\ cm^2$

$A_{nv} = 61,6 - 2.2,4.1,4 - 4.1,2.1,4 = 48,16\ cm^2$

$A_{nt} = 23,66 - 2.(4-1,2).1,4 - (6-2.1,2).1,4 = 10,78\ cm^2$

(from staggered case-3)

$R_n = 0,60.43.48,16 + 1.43.10,78 = 1706,07\ kN$
$0,60.27,5.61,6 + 1.43.10,78 = 1479,94\ kN$ } $R_n = 1479,94\ kN$

$\phi R_n = 0,75.1479,94 = 1109,96\ kN$

• Case-4 (Figure-8)

$A_{gv} = 2.(3,5+5+5).1,4 = 37,80\ cm^2$

$A_{nv} = 2.(3,5+5+5-2,4-1,2).1,4 = 27,72\ cm^2$

$A_{nt} = 26,07 - 2.(4-1,2).1,4 = 18,23\ cm^2$

(from staggered case-2)

$R_n = 0,60.43.27,72 + 1.43.18,23 = 1499,07\ kN$
$0,60.27,5.37,80 + 1.43.18,23 = 1407,59\ kN$
$\Rightarrow R_n = 1407,59\ kN$

$\phi R_n = 0,75.1407,59 = 1055,69\ kN$

Design strength: 763,04 kN

= Additional Information about Net-Section =
(Net Kesit Hakkında İlave Bilgi)

→ Kopma (Fracture)

• Case-4 (Figure-9) (A-B-C-D-G)

$A_n = 24.1,4 - 3.2,4.1,4 + \frac{5^2.1,4}{4.5} = 25,27\ cm^2$

Assume that the member is subjected to P load. Therefore, each bolt transfers $P/n = P/6$ load. (n is number of bolts)
Because P/6 of the load has been transferred from the gusset plate by the bolt at E, this potential failure line must resist only 5P/6 load. Therefore, the net area of Case-4 should be multiplied by 6/5 to obtain a net area that can be compared with previous lines that resist the full load.

$A_n = 25,27.\frac{6}{5} = 30,32\ cm^2$

Çekme çubuğunun P dış yüküne maruz kaldığı dikkate alınsın. Bu durumda, her bir bulon $P/n = P/6$ yükü aktaracaktır. (n bulon sayısıdır)

E noktasındaki bulonun üzerine düşen P/6 'lık kuvveti mesnet levhasına aktarmış olmasından dolayı, dikkate alınan olası kırılma çizgisi 5P/6 'lık kuvvete maruz kalacaktır. Bu nedenle, dış kuvvetin tamamına maruz kalan daha önceki kırılma durumlarıyla kıyaslama yapılabilmesi için, bu kırılma çizgisinin net alanı 6/5 ile çarpılmalıdır.

- Case-5 (Figure-10) (A-B-D-G)

$$A_n = 24.1,4 - 2.2,4.1,4 + \frac{5^2.1,4}{4.11} = 27,68 \text{ cm}^2$$

$$A_n = 27,68.\frac{6}{5} = 33,22 \text{ cm}^2$$