In this video, the T-Stub definition is introduced according to Eurocode 1993-1-8. The following topics are covered:

a) Equivalent T-Stub.
b) Different failure modes.
c) Prying force and its definition.
d) Stress area of a bolt.
e) Individual and group bolt rows in general.
f) The effective length of a T-Stub for column flange.

### 6.2.4 Equivalent T-stub in tension

#### 6.2.4.1 General

(1) In bolted connections an equivalent T-stub in tension may be used to model the design resistance of the following basic components:

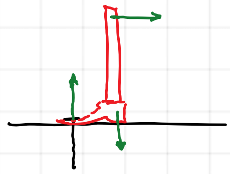
- column flange in bending;
- end-plate in bending;
- flange cleat in bending;
- base plate in bending under tension.

(2) Methods for modelling these basic components as equivalent T-stub flanges, including the values to be used for $e_{min}$, $\ell_{eff}$ and $m$, are given in 6.2.6.

(3) The possible modes of failure of the flange of an equivalent T-stub may be assumed to be similar to those expected to occur in the basic component that it represents.

(4) The total effective length $\sum \ell_{eff}$ of an equivalent T-stub, see Figure 6.2, should be such that the design resistance of its flange is equivalent to that of the basic joint component that it represents.

**NOTE:** The effective length of an equivalent T-stub is a notional length and does not necessarily correspond to the physical length of the basic joint component that it represents.



### 6.2.4 Equivalent T-stub in tension

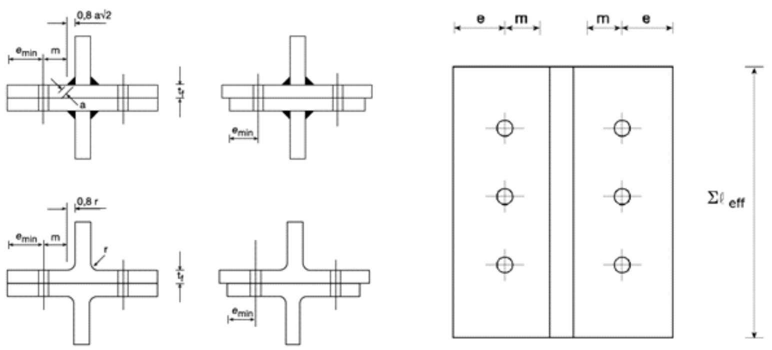
#### 6.2.4.1 General

(5) The design tension resistance of a T-stub flange should be determined from Table 6.2.

**NOTE:** Prying effects are implicitly taken into account when determining the design tension resistance according to Table 6.2.

(6) In cases where prying forces may develop, see Table 6.2, the design tension resistance of a T-stub flange $F_{T,Rd}$ should be taken as the smallest value for the three possible failure modes 1, 2 and 3.

(7) In cases where prying forces may not develop the design tension resistance of a T-stub flange $F_{T,Rd}$ should be taken as the smallest value for the two possible failure modes according to Table 6.2.



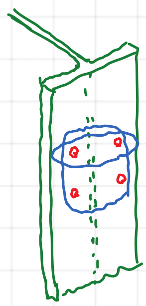



Figure 6.2: Dimensions of an equivalent T-stub flange

### Table 6.2: Design Resistance $F_{T,Rd}$ of a T-stub flange

| | Prying forces may develop, i.e. $L_b \leq L_b^*$ | | No prying forces |
|---|---|---|---|
| **Mode 1** | Method 1 | Method 2 (alternative method) | |
| without backing plates | $F_{T,1,Rd} = \frac{4M_{pl,1,Rd}}{m}$ | $F_{T,1,Rd} = \frac{(8n - 2e_w)M_{pl,1,Rd}}{2mn - e_w(m+n)}$ | $F_{T,1\text{-}2,Rd} = \frac{2M_{pl,1,Rd}}{m}$ |
| with backing plates | $F_{T,1,Rd} = \frac{4M_{pl,1,Rd} + 2M_{bp,Rd}}{m}$ | $F_{T,1,Rd} = \frac{(8n - 2e_w)M_{pl,1,Rd} + 4nM_{bp,Rd}}{2mn - e_w(m+n)}$ | |
| **Mode 2** | $F_{T,2,Rd} = \frac{2M_{pl,2,Rd} + n\Sigma F_{t,Rd}}{m+n}$ | | |
| **Mode 3** | $F_{T,3,Rd} = \Sigma F_{t,Rd}$ | | |

Mode 1: Complete yielding of the flange
Mode 2: Bolt failure with yielding of the flange
Mode 3: Bolt failure

$L_b$ is
- the bolt elongation length, taken equal to the grip length (total thickness of material and washers), plus half the sum of the height of the bolt head and the height of the nut or
- the anchor bolt elongation length, taken equal to the sum of 8 times the nominal bolt diameter, the grout layer, the plate thickness, the washer and half the height of the nut

$L_b^* = \frac{8,8m^3 A_s}{\Sigma \ell_{eff,1} t_f^3}$

**16) Modification to 6.2.4.1**

*Paragraph "(7)", "Table 6.2", last row, replace the formula for "$L_b^*$" with:*

"$L_b^* = \frac{8,8m^3 A_s n_b}{\sum l_{eff,1} t_f^3}$";

*then add to the list:*

"$n_b$ is the number of bolt rows (with 2 bolts per row)".

$F_{T,Rd}$ is the design tension resistance of a T-stub flange
Q is the prying force

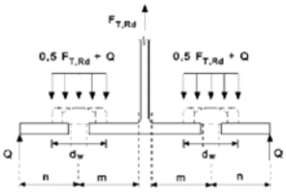
$M_{pl,1,Rd} = 0,25\Sigma\ell_{eff,1} t_f^2 f_y / \gamma_{M0}$

$M_{pl,2,Rd} = 0,25\Sigma\ell_{eff,2} t_f^2 f_y / \gamma_{M0}$

$M_{bp,Rd} = 0,25\Sigma\ell_{eff,1} t_{bp}^2 f_{y,bp} / \gamma_{M0}$

$n = e_{min}$ but $n \leq 1,25m$

$F_{t,Rd}$ is the design tension resistance of a bolt, see Table 3.4;
$\sum F_{t,Rd}$ is the total value of $F_{t,Rd}$ for all the bolts in the T-stub;
$\sum \ell_{eff,1}$ is the value of $\sum \ell_{eff}$ for mode 1;
$\sum \ell_{eff,2}$ is the value of $\sum \ell_{eff}$ for mode 2;
$e_{min}$, $m$ and $t_f$ are as indicated in Figure 6.2.
$f_{y,bp}$ is the yield strength of the backing plates;
$t_{bp}$ is the thickness of the backing plates;
$e_w = d_w / 4$;
$d_w$ is the diameter of the washer, or the width across points of the bolt head or nut, as relevant.




**NOTE 1:** In bolted beam-to-column joints or beam splices it may be assumed that prying forces will develop.
**NOTE 2:** In method 2, the force applied to the T-stub flange by a bolt is assumed to be uniformly distributed under the washer, the bolt head or the nut, as appropriate, see figure, instead of concentrated at the centre-line of the bolt. This assumption leads to a higher value for mode 1, but leaves the values for $F_{T,1\text{-}2,Rd}$ and modes 2 and 3 unchanged.

### Table 3.4: Design resistance for individual fasteners subjected to shear and/or tension

| Failure mode | Bolts | Rivets |
|---|---|---|
| Tension resistance [2)] | $F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}}$<br>where $k_2 = 0,63$ for countersunk bolt,<br>otherwise $k_2 = 0,9$. | $F_{t,Rd} = \frac{0,6 f_{ur} A_0}{\gamma_{M2}}$ |

**Proof Load**

Proof load is defined as the maximum tensile force that can be applied to a bolt that will not result in plastic deformation. A material must remain in its elastic region when loaded up to its proof load typically between 85-95% of the yield strength. Acceptable clamp load is typically 75% of proof load.

| Thread d (mm) | Pitch P (mm) (in) | Nominal Stress Area $A_{s,nom}$ ($mm^2$) (in2) | Property Class | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 4.6 | 4.8 | 5.6 | 5.8 | 6.8 | 8.8 | 9.8 | 10.9 | 12.9 |
| | | | Proof Load - $F_p$ (N) (kgf, lbf) | | | | | | | | |
| M3 | 0.50 | 5.03 | 1130 | 1560 | 1410 | 1910 | 2210 | 2920 | 3270 | 4180 | 4880 |
| M3.5 | 0.60 | 6.78 | 1530 | 2100 | 1900 | 2580 | 2980 | 3940 | 4410 | 5630 | 6580 |
| M4 | 0.70 | 8.78 | 1980 | 2770 | 2460 | 3340 | 3860 | 5100 | 5710 | 7290 | 8520 |
| M5 | 0.80 | 14.2 | 3200 | 4400 | 3980 | 5400 | 6250 | 8230 | 9230 | 11800 | 13800 |
| M6 | 1.00 | 20.1 | 4520 | 6230 | 5630 | 7640 | 8840 | 11600 | 13100 | 16700 | 19500 |
| M7 | 1.00 | 28.9 | 6500 | 8920 | 8090 | 11000 | 12700 | 16800 | 18800 | 24000 | 28000 |
| M8 | 1.25 | 36.6 | 8240 | 11400 | 10200 | 13900 | 16100 | 21200 | 23800 | 30400 | 35500 |
| M10 | 1.50 | 58.0 | 13000 | 18000 | 16200 | 22000 | 25500 | 33700 | 37700 | 48100 | 56300 |
| M12 | 1.75 | 84.3 | 19000 | 26100 | 23600 | 32000 | 37100 | 48900[d)] | 54800 | 70000 | 81800 |
| M14 | 2.00 | 115 | 25900 | 35600 | 32200 | 43700 | 50600 | 66700[d)] | 74800 | 95500 | 112000 |
| M16 | 2.00 | 157 | 35300 | 48700 | 44000 | 59700 | 69100 | 91000[d)] | 102000 | 130000 | 152000 |
| M18 | 2.50 | 192 | 43200 | 59500 | 53800 | 73000 | 84500 | 115000 | | 159000 | 186000 |
| M20 | 2.50 | 245 | 55100 | 76000 | 68600 | 93100 | 108000 | 147000 | | 203000 | 238000 |
| M22 | 2.50 | 303 | 68200 | 93900 | 84800 | 115000 | 133000 | 182000 | | 252000 | 294000 |
| M24 | 3.00 | 353 | 79400 | 109000 | 98800 | 134000 | 155000 | 212000 | | 293000 | 342000 |
| M27 | 3.00 | 459 | 103000 | 142000 | 128000 | 174000 | 202000 | 275000 | | 381000 | 445000 |
| M30 | 3.50 | 561 | 126000 | 174000 | 157000 | 213000 | 247000 | 337000 | | 466000 | 544000 |
| M33 | 3.50 | 694 | 156000 | 215000 | 194000 | 264000 | 305000 | 416000 | | 570000 | 673000 |
| M36 | 4.00 | 817 | 184000 | 253000 | 229000 | 310000 | 359000 | 490000 | | 678000 | 792000 |
| M39 | 4.00 | 976 | 220000 | 303000 | 273000 | 371000 | 429000 | 586000 | | 810000 | 947000 |

engineeringtoolbox.com/metric-bolts-minimum-ultimate-tensile-proof-loads-d_2026.html

**6.2.4.2 Individual bolt-rows, bolt-groups and groups of bolt-rows**

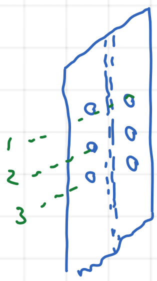
(1) Although in an actual T-stub flange the forces at each bolt-row are generally equal, when an equivalent T-stub flange is used to model a basic component listed in 6.2.4.1(1), allowance should be made for the different in forces at each bolt-row.

(2) When using the equivalent T-stub approach to model a group of bolt rows it may be necessary to divide the group into separate bolt-rows and use an equivalent T-stub to model each separate bolt-row.

(3) When using the T-stub approach to model a group of bolt rows the following conditions should be satisfied:

a) the force at each bolt-row should not exceed the design resistance determined considering only that individual bolt-row;

b) the total force on each group of bolt-rows, comprising two or more adjacent bolt-rows within the same bolt-group, should not exceed the design resistance of that group of bolt-rows.




(4) When determining the design tension resistance of a basic component represented by an equivalent T-stub flange, the following parameters should be calculated:

a) the design resistance of an individual bolt-row, determined considering only that bolt-row;

b) the contribution of each bolt-row to the design resistance of two or more adjacent bolt-rows within a bolt-group, determined considering only those bolt-rows.

(5) In the case of an individual bolt-row $\sum \ell_{eff}$ should be taken as equal to the effective length $\ell_{eff}$ tabulated in 6.2.6 for that bolt-row taken as an individual bolt-row.

(6) In the case of a group of bolt-rows $\sum \ell_{eff}$ should be taken as the sum of the effective lengths $\ell_{eff}$ tabulated in 6.2.6 for each relevant bolt-row taken as part of a bolt-group.

### 6.2.6.4 Column flange in tranverse bending

6.2.6.4.1 Unstiffened column flange, bolted connection

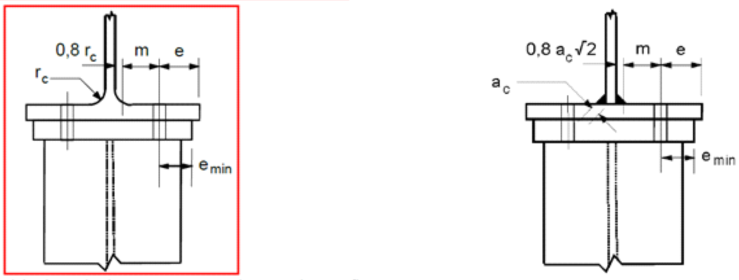
(1) The design resistance and failure mode of an unstiffened column flange in tranverse bending, together with the associated bolts in tension, should be taken as similar to those of an equivalent T-stub flange, see 6.2.4, for both:

- each individual bolt-row required to resist tension;
- each group of bolt-rows required to resist tension.

(2) The dimensions $e_{min}$ and $m$ for use in 6.2.4 should be determined from Figure 6.8.

(3) The effective length of equivalent T-stub flange should be determined for the individual bolt-rows and the bolt-group in accordance with 6.2.4.2 from the values given for each bolt-row in Table 6.4.

**6.2.6.4 Column flange in tranverse bending**

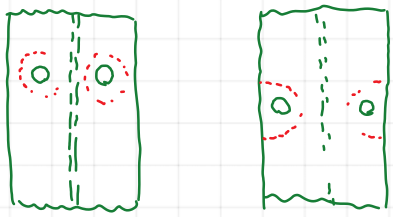



a) Welded end-plate narrower than column flange.

**Figure 6.8: Definitions of $e$, $e_{min}$, $r_c$ and $m$**

**Table 6.4: Effective lengths for an unstiffened column flange**

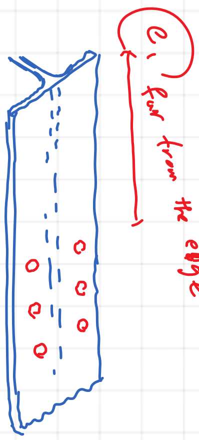
| Bolt-row Location | Bolt-row considered individually | | Bolt-row considered as part of a group of bolt-rows | |
|---|---|---|---|---|
| | Circular patterns $\ell_{eff,cp}$ | Non-circular patterns $\ell_{eff,nc}$ | Circular patterns $\ell_{eff,cp}$ | Non-circular patterns $\ell_{eff,nc}$ |
| Inner bolt-row | $2\pi m$ | $4m + 1{,}25e$ | $2p$ | $p$ |
| End bolt-row | The smaller of: $2\pi m$ $\pi m + 2e_1$ | The smaller of: $4m + 1{,}25e$ $2m + 0{,}625e + e_1$ | The smaller of: $\pi m + p$ $2e_1 + p$ | The smaller of: $2m + 0{,}625e + 0{,}5p$ $e_1 + 0{,}5p$ |
| Mode 1: | $\ell_{eff,1} = \ell_{eff,nc}$ but $\ell_{eff,1} \leq \ell_{eff,cp}$ | | $\sum\ell_{eff,1} = \sum\ell_{eff,nc}$ but $\sum\ell_{eff,1} \leq \sum\ell_{eff,cp}$ | |
| Mode 2: | $\ell_{eff,2} = \ell_{eff,nc}$ | | $\sum\ell_{eff,2} = \sum\ell_{eff,nc}$ | |

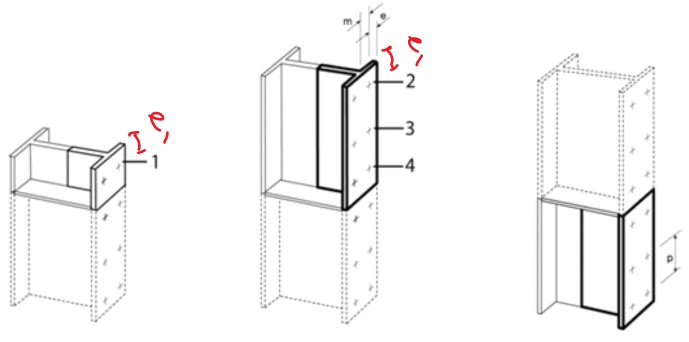


**19)Modification to 6.2.6.4.1**

*Paragraph* "(3)", "Table 6.4", *add a row at the bottom of the table containing the following paragraph:*

"$e_1$ is the distance from the centre of the fasteners in the end row to the adjacent free end of the column flange measured in the direction of the axis of the column profile (see row 1 and row 2 in Figure 6.9).".






*1 End bolt row adjacent to a stiffener*
*2 End bolt row*
*3 Inner bolt row*
*4 Bolt row adjacent to a stiffener*

**Figure 6.9: Modelling a stiffened column flange as separate T-stubs**