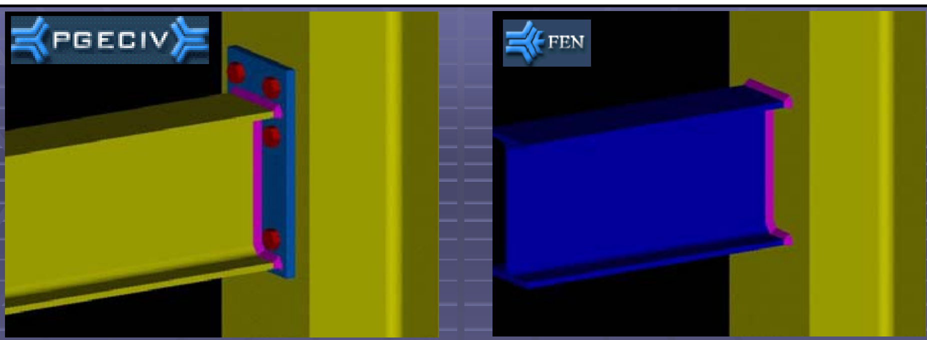


Ligações Soldadas

Segunda Parte

Programa de Pós-Graduação em Engenharia Civil

PGECIV - Mestrado Acadêmico

Faculdade de Engenharia – FEN/UERJ

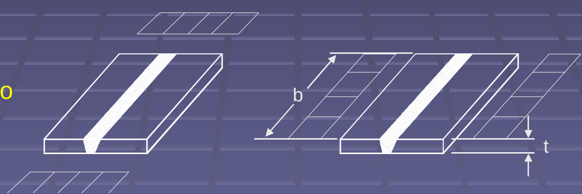
Disciplina: Tópicos Especiais em Projeto (Ligações em Aço e Mistas)

Professor: Pedro Vellasco

13. Dimensionamento de Soldas

- Soldas de Entalhe – Penetração Total
  - ✓ metal base controla

tração ou compressão // ao eixo da solda



tração ou compressão ⊥ ao eixo da solda

  - ✓ todos os casos exceto cisalhamento

$V_r = V_m = \phi \, . \, A_m \, . \, F_y$ onde $A_m = b \, . \, t$ com $\phi = 0{,}9$

  - ✓ cisalhamento

V_r é o menor de $0{,}67 . \, \phi \, . \, A_m \, . \, F_y$ e $0{,}67 . \, \phi_w \, . \, A_w \, . \, F_w$

$A_m = A_w = b \, . \, t$ | **$\phi = 0{,}9$ e $\phi_w = 0{,}67$**

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13. Dimensionamento de Soldas

- Soldas de Entalhe –Penetração Total

  Eurocode 3 pt 1.8

  - ✓ Metal base controla
    - Full penetration butt weld resistance is equal to the resistance of the weaker of the parts connected, provided that the weld have both minimum yield and tensile strength not less than the parent metal.

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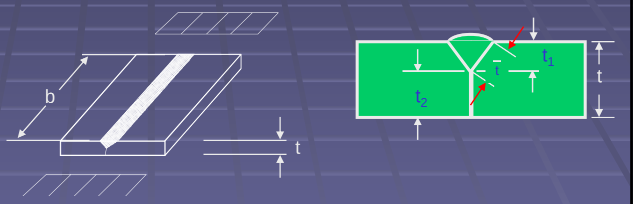
13. Dimensionamento de Soldas

- Soldas de Entalhe – Penetração Parcial
  - ✓ metal base controla

tração ou compressão // ao eixo da solda



$V_r = V_m = \phi \cdot A_m \cdot F_y$ onde $A_m = b \cdot t$ com $\phi = 0{,}9$

compressão ⊥ ao eixo da solda

$V_r = V_m = \phi \cdot A \cdot F_y$ onde $A = A_m + A_{contato}$

$A_m = b \cdot \bar{t}$

$A_{contato} = t_2 \cdot b$

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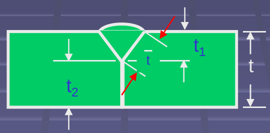
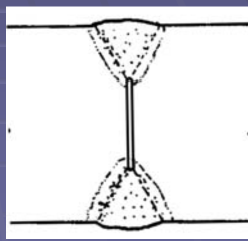
13. Dimensionamento de Soldas

- Soldas de Entalhe – Penetração Parcial
  - ✓ metal base controla



tração

$V_r = V_m = \phi \cdot A_n \cdot F_u$ onde $A_n = t \cdot \bar{b} \leq t \cdot b$



cisalhamento

V_r menor de $0{,}67 \cdot \phi \cdot A_m \cdot F_y$
$0{,}67 \cdot \phi_w \cdot A_w \cdot F_w$

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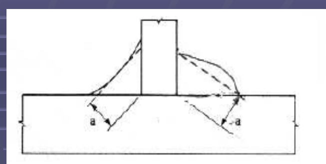
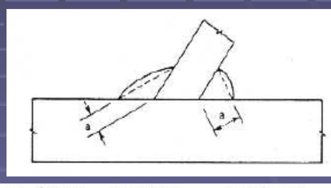
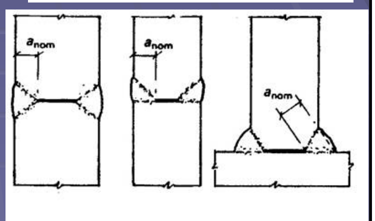
13. Dimensionamento de Soldas

- Soldas de Entalhe –Penetração Parcial - Eurocode 3 pt 1.8
  - ✓ Partial penetration butt weld → deep penetration fillet weld.
  - ✓ Partial penetration butt weld throat thickness ≤ depth of penetration that can be consistently achieved
    - Effective throat thickness, a, of a fillet weld = largest triangle height (equal/unequal legs) inscribed within the fusion faces and weld surface, ⊥ triangle outer side.
    - Fillet weld effective throat thickness, a ≥ 3 mm.







Effective weld throat = a_{nom} − 2 mm

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13. Dimensionamento de Soldas

- Soldas de Entalhe –Penet. Parcial - Eurocode 3
  - ✓ Account may be taken of the additional throat thickness, provided that preliminary tests → required penetration can consistently be achieved

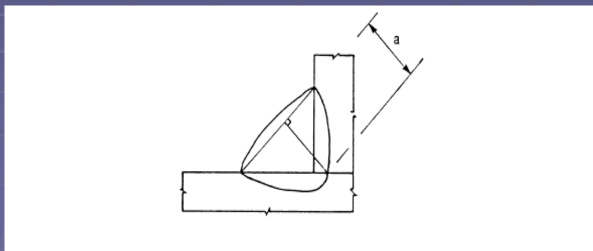

Figure 4.4: Throat thickness of a deep penetration fillet weld

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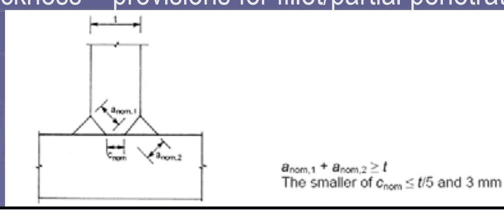
13. Dimensionamento de Soldas

- T-Butt Joints - Eurocode 3 pt 1.8
- Pair of partial penetration butt welds reinforced by superimposed fillet welds = full penetration butt weld
  - ✓ If the total nominal throat thickness, exclusive of the unwelded gap, ≥ thickness t of the part forming the tee joint stem, provided that the unwelded gap is not more than:
    - (t / 5) or 3 mm, whichever is less.
  - ✓ Otherwhise = fillet/deep penetration fillet weld depending on the amount of penetration.
    - Throat thickness = provisions for fillet/partial penetration butt welds



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13. Dimensionamento de Soldas

Recomendações Gerais - Eurocode 3

- ✓ Full penetration butt weld has complete penetration and fusion of weld and parent metal throughout the joint thickness.
- ✓ Partial penetration butt weld has joint penetration less than the full thickness of the parent material.
- ✓ Intermittent butt welds should not be used.
- ✓ For eccentricity in single-sided partial penetration butt welds see the case for fillet welds

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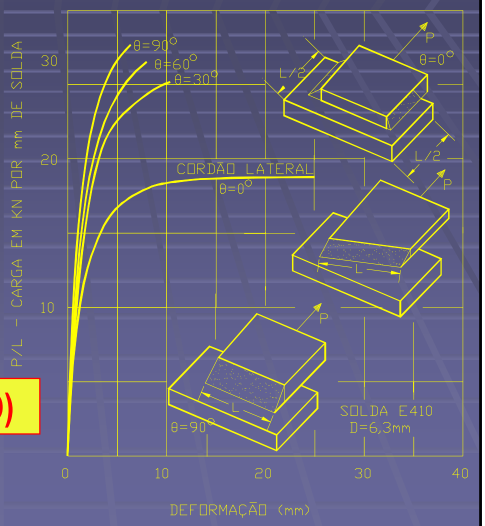
13. Dimensionamento de Soldas

Soldas de Filete

- ✓ $\theta = 90^\circ \rightarrow$ V da solda com pouca ductilidade
- ✓ $\theta = 0^\circ \rightarrow$ menor resistência (cisalhamento puro) com maior ductilidade $\rightarrow V = 0{,}5\ V_m$



$$0{,}67 \cdot \phi_w \cdot A_w \cdot F_w\ (1 + 0{,}5\ \mathrm{sen}^{1,5}\ \theta)$$

$$0{,}67 \cdot \phi_w \cdot A_m \cdot F_u$$

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13. Dimensionamento de Soldas

- Soldas de Filete
  - ✓ metal base controla

tração ou compressão // ao eixo da solda ($\theta = 0º$)

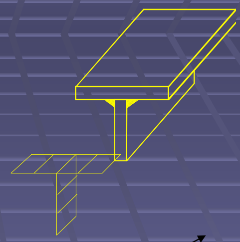
$V_r = V_m = \phi \, . \, A_m \, . \, F_y$

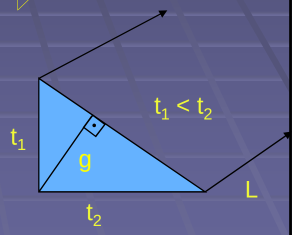
tração e compressão $\perp$ ao eixo da solda ($\theta = 90º$)

cisalhamento

V_r menor de $0{,}67 \, . \, \phi \, . \, A_m \, . \, F_y$

$0{,}67 \, . \, \phi_w \, . \, A_w \, . \, F_w$





$A_m = t_1 \, . \, L$

$A_w = g \, . \, L$

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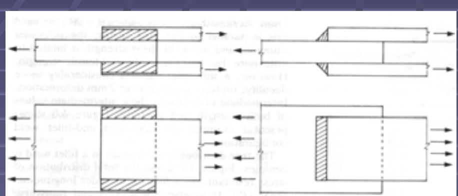
13. Dimensionamento de Soldas

- Soldas de Filete (exemplos práticos)



P_s → cisalhamento longitudinal

P_t → cisalhamento transversal

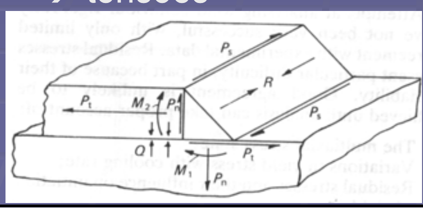
P_n → tração direta

M_1, M_2 → equilíbrio

Q → resfriamento → retração na solda

R → tensões residuais longitudinais (auto-equilibradas)

- Distribuição real de esforços → tensões



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13. Dimensionamento de Soldas

- Boa análise
  - ✓Estado multiaxial de tensões
  - ✓Variação na F_y com a razão de resfriamento
  - ✓Tensões residuais aceleram o início do escoamento
  - ✓Encruamento
  - ✓Plasticidade
- Análise Simplificada
  - ✓Ductilidade do aço
  - ✓Equilíbrio é possível com as forças assumidas
    - Não é válido p.ex. Para momentos na região da solda

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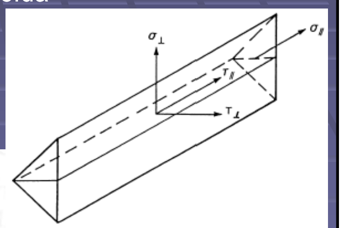
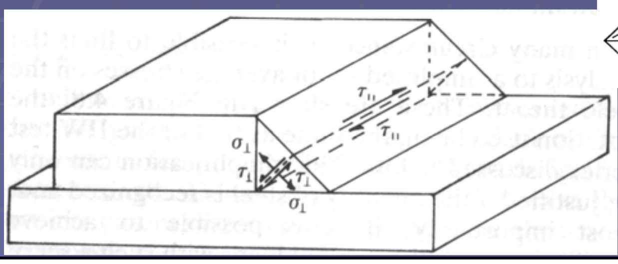
13. Dimensionamento de Soldas

- $\tau_{\parallel}$ é o cisalhamento longitudinal, no plano da garganta, $\perp$ ao eixo da solda
- $\tau_{\perp}$ é o cisalhamento transversal, no plano da garganta, $\parallel$ ao eixo da solda
- $\sigma_{\perp}$ é o esforço normal transversal, $\perp$ a garganta
- $\sigma_{\parallel}$ é o esforço normal longitudinal, $\parallel$ ao eixo da solda





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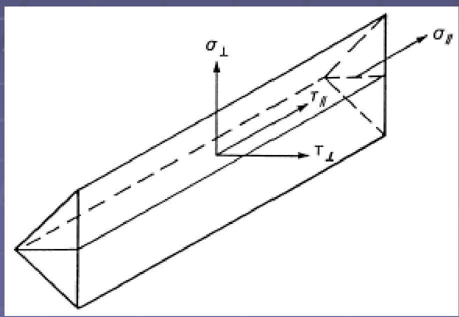
13. Dimensionamento de Soldas

- $\tau_{\parallel}$ é o cisalhamento longitudinal
- $\tau_{\perp}$ é o cisalhamento transversal
- $\sigma_{\perp}$ é o esforço normal transversal
- $\sigma_{\parallel}$ é o esforço normal longitudinal



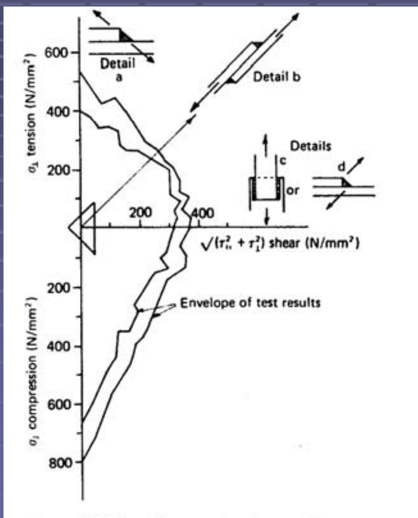


Figure 4.9 Fillet weld strength under combined stresses. Classification of details: a – pure tension weld; b – nominal 'tension' weld; c – longitudinal shear weld; d – transverse shear weld

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13. Dimensionamento de Soldas

- Soldas de Filete – Método Direcional - Eurocode 3
  - ✓Forces transmitted by a unit length of weld are expressed into components parallel and transverse to the longitudinal axis of the weld and normal and transverse to the plane of its throat.
  - ✓Design throat area should be taken as $A_w = \sum L_{eff}$.
  - ✓Design throat location area is assumed to be concentrated in the root

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13. Dimensionamento de Soldas

- Soldas de Filete – Método Direcional - Eurocode 3
  - ✓Uniform distribution of stress is assumed on the weld throat section leading to normal and shear stresses
  - ✓Normal stress parallel to the weld axis, $\sigma_{\parallel}$ is not considered
  - ✓Welds between parts with different material strength should be designed using properties of the lower strength material

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13. Dimensionamento de Soldas

- Soldas de Filete – Método Direcional - Eurocode 3 pt 1.8
  - ✓Design resistance of the fillet weld will be sufficient if the following are both satisfied:

$$[\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} \leq f_u / (\beta_w \gamma_{M2}) \quad \text{and} \quad \sigma_{\perp} \leq f_u / \gamma_{M2} \qquad (4.1)$$

where:

f_u is the nominal ultimate tensile strength of the weaker part joined;

β_w is the appropriate correlation factor taken from Table 4.1.

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13. Dimensionamento de Soldas

Table 2.1: Partial safety factors for joints

Resistance of members and cross-sections	γ_{M0} , γ_{M1} and γ_{M2} see EN 1993-1-1
Resistance of bolts	γ_{M2}
Resistance of rivets	
Resistance of pins	
Resistance of welds	
Resistance of plates in bearing	
Slip resistance - for hybrid connections or connections under fatigue loading - for other design situations	 γ_{M3} γ_{M3}
Bearing resistance of an injection bolt	γ_{M4}
Resistance of joints in hollow section lattice girder	γ_{M5}
Resistance of pins at serviceability limit state	$\gamma_{M6,ser}$
Preload of high strength bolts	γ_{M7}
Resistance of concrete	γ_c see EN 1992

NOTE: Numerical values for γ_M may be defined in the National Annex. Recommended values are as follows: γ_{M2} = 1,25 ; γ_{M3} = 1,25 for hybrid connections or connections under fatigue loading and γ_{M3} = 1,1 for other design situations; γ_{M4} = 1,0 ; γ_{M5} = 1,0 ; $\gamma_{M6,ser}$ = 1,0 ; γ_{M7} = 1,1 .

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13. Dimensionamento de Soldas

- Fator β
- Resistência da solda → Ruptura e não o escoamento
- β é função dos metais base e de solda
- Metal base ↓ → β ↓
- Gera descontinuidades

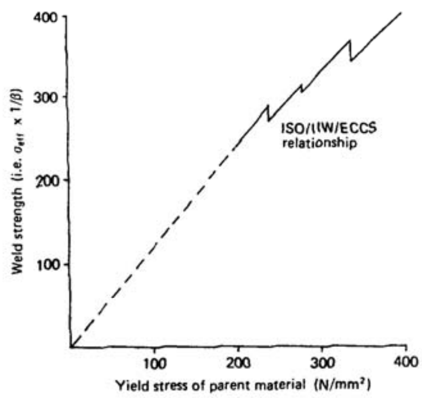

Figure 4.10 Relationship between weld 'strength' and material strength

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13. Dimensionamento de Soldas

Table 4.1: Correlation factor β_w for fillet welds

Standard and steel grade			Correlation factor β_w
EN 10025	**EN 10210**	**EN 10219**	
S 235 S 235 W	S 235 H	S 235 H	0,8
S 275 S 275 N/NL S 275 M/ML	S 275 H S 275 NH/NLH	S 275 H S 275 NH/NLH S 275 MH/MLH	0,85
S 355 S 355 N/NL S 355 M/ML S 355 W	S 355 H S 355 NH/NLH	S 355 H S 355 NH/NLH S 355 MH/MLH	0,9
S 420 N/NL S 420 M/ML		S 420 MH/MLH	1,0
S 460 N/NL S 460 M/ML S 460 Q/QL/QL1	S 460 NH/NLH	S 460 NH/NLH S 460 MH/MLH	1,0

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13. Dimensionamento de Soldas

- Soldas de Filete – Método Simplificado - Eurocode 3 pt 1.8
  - ✓ Fillet weld design resistance is adequate if, at every point along its length, all the force resultant/unit length transmitted by the weld satisfy:

$$F_{w,Ed} \leq F_{w,Rd} \qquad (4.2)$$

  - ✓ where: $F_{w,Ed}$ is the design value of the weld force per unit length;
    $F_{w,Rd}$ is the design weld resistance per unit length.
  - ✓ Independent of the weld throat plane orientation to the applied force, the design resistance per unit length $F_{w,Rd}$ is determined by:

$$F_{w,Rd} = f_{vw.d}\ a \qquad (4.3)$$

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13. Dimensionamento de Soldas

- Soldas de Filete – Método Simplificado - Eurocode 3

$$F_{w,Rd} = f_{vw.d}\ a \qquad (4.3)$$

a is the weld throat

$f_{vw.d}$ is the weld design shear strength

✓Design shear strength $f_{vw.d}$ is:

$$f_{vw.d} = \frac{f_u / \sqrt{3}}{\beta_w \gamma_{M2}} \qquad (4.4)$$

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13. Dimensionamento de Soldas

✓Distribuição de Forças em Soldas - Eurocode 3 pt 1.8

- Distribution of forces in a welds may assume:
  - Elastic or plastic behaviour
- Acceptable to assume a simplified load distribution within the welds.
- Residual stresses and stresses not subjected to transfer of load need not be included when checking the weld resistance.
  - This applies specifically to the normal stress parallel to the weld axis

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13. Dimensionamento de Soldas

✓ Distribuição de Forças em Soldas - Eurocode 3 pt 1.8

- Welded joints should be designed to have adequate deformation capacity.
  - However, weld ductility should not be relied upon.
- In joints where plastic hinges may form:
  - Welds should be designed to provide at least the same resistance as the weakest of the connected parts
- In joints where deformation capacity for joint rotation is required due to the possibility of excessive straining:
  - Welds require sufficient strength not to rupture before general yielding in the adjacent parent material

PGECIV FEN

13. Dimensionamento de Soldas

- Distribuição de Forças em soldas
  - ✓ Intermittent weld resistance is determined by:
    - Using the total length l_{tot},
    - Weld shear force per unit length $F_{w,Ed}$ should be multiplied by (e+l)/l
- Recomendações Gerais
  - ✓ Fillet welds may be used for fusion faces with angles between 60° and 120°.
  - ✓ Angles smaller than 60° are also permitted
    - In such cases the weld should be considered as a partial penetration butt weld.
  - ✓ For angles greater than 120°
    - Fillet welds resistance should be determined by testing in accordance with Annex D: Design by testing.

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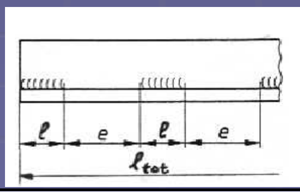
13. Dimensionamento de Soldas

- Recomendações Gerais
  - ✓ Fillet welds finishing at the ends or sides of parts should be:
    - Returned continuously, full size, around the corner for a distance of at least twice the leg length of the weld, unless access/joint configuration renders this impracticable.
    - In intermittent welds this rule applies only to the last intermittent fillet weld at corners.
  - ✓ End returns should be indicated on the drawings.



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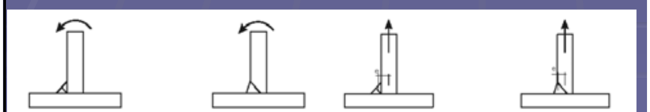
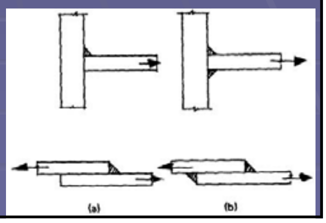
13. Dimensionamento de Soldas

- Local eccentricity should be avoided whenever possible
- Local eccentricity (relative to the line of action of the force to be resisted) has to be considered when:
  - ✓ Bending moment transmitted about the longitudinal axis of the weld produces tension at the root of the weld, (a)
  - ✓ Tensile force transmitted perpendicular to the longitudinal axis of the weld produces a bending moment, resulting in a tension force at the root of the weld, (b)
  - ✓ Local eccentricity can be disregarded if a weld is used as part of a weld group around the perimeter of a structural hollow section



(a) Bending moment produces tension at the root of the weld

(b) Tensile force produces tension at the root of the weld



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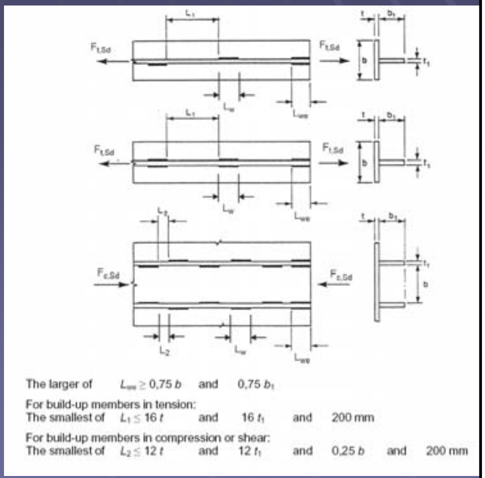
13. Dimensionamento de Soldas

- Soldas Intermitentes
  - ✓Intermittent fillet welds shall not be used in corrosive conditions
  - ✓Gaps (L_1 or L_2) between the ends of each length of weld L_w should fulfil →
  - ✓Gaps (L_1 or L_2) should be taken as the smaller of:
    - Distances between the ends of the welds on opposite sides
    - Distance between the ends of the welds on the same side.



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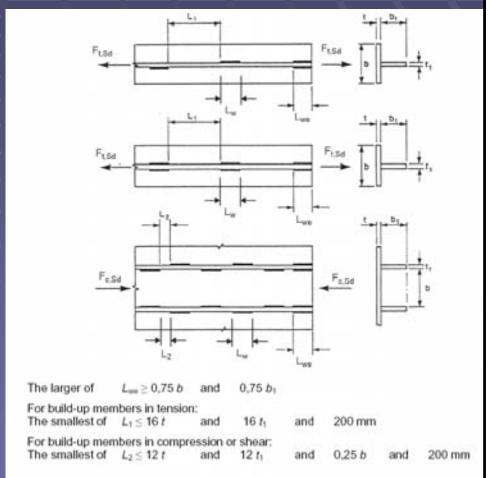
13. Dimensionamento de Soldas

- Soldas Intermitentes
  - ✓Any run of intermittent fillet weld should always have a length of weld at each end of the part connected.
  - ✓In a built-up member in which plates are connected by means of intermittent fillet welds:
    - Continuous fillet weld should be provided on each side of the plate for a length at each end equal to at least ¾ of the narrower plate width



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13. Dimensionamento de Soldas

- Recomendações Gerais
  - ✓Fillet welds all round, comprising fillet welds in circular or elongated holes, may be used only to transmit shear or to prevent the buckling or separation of lapped parts.
  - ✓Diameter of a circular hole, or width of an elongated hole, for a fillet weld all round should not be less than four times the thickness of the part containing it.
  - ✓Ends of elongated holes should be semi-circular except:
    - For ends which extend to the edge of the part concerned.
  - ✓Centre to centre spacing of fillet welds all round should not exceed the value necessary to prevent local buckling.

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13. Dimensionamento de Soldas

- Garganta mínima para se atingir a máxima tensão suportada pela placa (Métodos: direcional e simplificado)

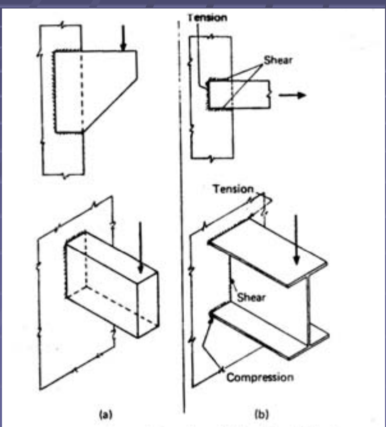
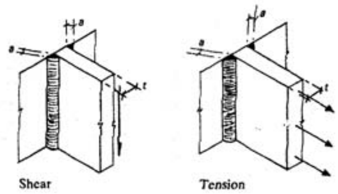


Figure 4.11 Connections where (a) simple weld design and (b) direction-dependent weld design methods are likely to be used

Table 4.4 Ratios of minimum throat size to attached plate thickness (a/t) to develop full strength of attached plate, with symmetric fillet welds



	Simple		*Direction dependent*		*Simple*		*Direction dependent*	
Grade	43	50	43	50	43	50	43	50
Code								
BS 449	0.50	0.50	–	–	0.67	0.67	–	–
BS 5950[d]	0.38	0.42	–	–	0.50	0.50	–	–
BS 5400	0.43	0.51	0.39[c]	0.46[c]	0.49[a] 0.68[b]	0.57[a] 0.79[b]	0.56[c]	0.65[c]
ECCS / Eurocode 3	0.40	0.50	0.40	0.50	0.70	0.87	0.57	0.71

[a]Value for end fillets in end connections.
[b]Value for other tension connections.
[c]Discounting k in equation 14.6.3.11.2 (code error).
[d]Based on design strengths of 275 N/mm² for Grade 43 and 355 N/mm² and E51 electrodes for Grade 50.

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13. Dimensionamento de Soldas

- Soldas muito espaçadas
  - ✓Concentração de tensões nas bordas
  - ✓Contração transversal ↑ momento fletor
  - ✓Ruína (b)
  - ✓Eficiência b/l
  - ✓Evitar usar b/t> 1

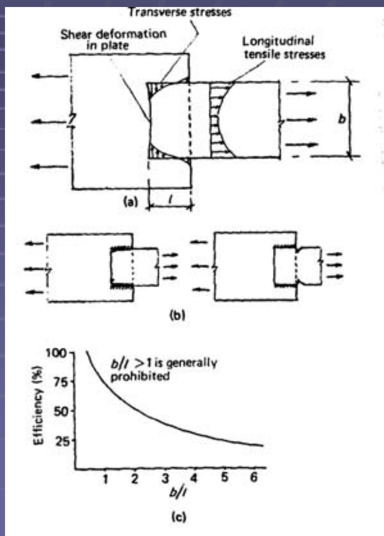

Figure 4.14 Behaviour of short, widely spaced fillet welds. (a) Stress distribution; (b) modes of failure; (c) loss of efficiency

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13. Dimensionamento de Soldas

- Soldas muito longas
  - ✓Variação nas τ_w
  - ✓Redução na resistência
    - Se lw > 1,5 metros
  - ✓Unzziping effect → incompatibilidade entre deformações/deslocamentos dos elementos das ligações
  - ✓η = (1 – 0.06 L) e L_w > 1.9 metros

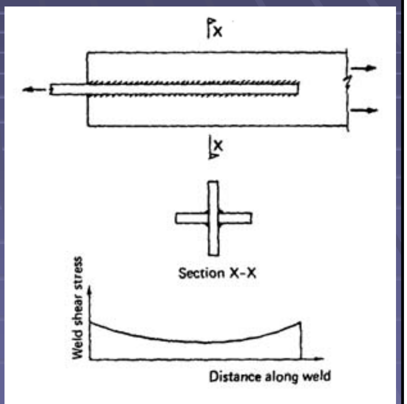

Figure 4.15 Behaviour of long fillet welds: effect of plate extensions on distribution of weld shear

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13. Dimensionamento de Soldas

- Soldas muito longas – Eurocode 3
- In lap joints the fillet weld resistance should be reduced by multiplying it by a reduction factor β_{Lw} to allow for the effects of non-uniform distribution of stress along its length.
- This provisions do not apply when the stress distribution along the weld corresponds to the stress distribution in the adjacent base metal
  - ✓ I.e. weld connecting the flange and the web of a plate girder.
- For joints longer than 150a the reduction factor should be:

$$\beta_{Lw.1} = 1{,}2 - 0{,}2L_j/(150a) \quad \text{but} \quad \beta_{Lw.1} \leq 1{,}0 \qquad (4.9)$$

where: L_j is the lap overall length in the direction of the force transfer.

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13. Dimensionamento de Soldas

- Soldas muito longas – Eurocode 3
- For fillet welds longer than 1.7 metres connecting transverse stiffeners in plated members, the reduction factor is:

$$\beta_{Lw.2} = 1{,}1 - L_w/17 \quad \text{but} \quad \beta_{Lw.2} \leq 1{,}0 \quad \text{and} \quad \beta_{Lw.2} \geq 0{,}6 \qquad (4.10)$$

where: L_w is the length of the weld (in metres).

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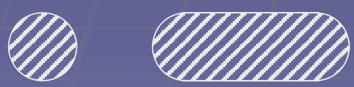
13. Dimensionamento de Soldas

- Soldas de Bujão

cisalhamento

V_r menor de $0{,}67 \cdot \phi \cdot A_m \cdot F_y$
$0{,}67 \cdot \phi_w \cdot A_w \cdot F_w$

A_w = área do furo ou rasgo = A_m



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13. Dimensionamento de Soldas

- Solda de Bujão/ Tampão – Eurocode 3
- Design resistance of a plug weld should be taken as:

$$F_{w,Rd} = f_{vw,d} A_w, \qquad (4.5)$$

Where : $f_{vw.d}$ is the design shear strength of a weld
A_w is the design throat area and is the area of the hole

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13. Dimensionamento de Soldas

- Recomendações Gerais – Eurocode 3
  - ✓Plug welds may be used to:
    - Transmit shear,
    - Prevent the buckling or separation of lapped parts
    - Inter-connect the components of built-up members
  - ✓Should not be used to resist externally applied tension.
  - ✓Diameter of a circular hole, or width of an elongated hole, for a plug weld ≥ 8 mm + thickness of the part containing it.

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13. Dimensionamento de Soldas

- Recomendações Gerais – Eurocode 3
  - ✓Ends of elongated holes should either be semi-circular or else should have corners which are rounded to a radius ≥ thickness of the part containing the slot
    - Except →ends which extend to the edge of the part concerned.
  - ✓Plug weld thickness in a parent material up to 16 mm thick should be equal to the parent material thickness
  - ✓Parent material over 16 mm thick should be:
    - ≥ ½ parent material thickness and
    - ≥ 16 mm.
  - ✓Plug weld centre/centre spacing →prevent local buckling

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13. Dimensionamento de Soldas

- Soldas de Filete
  - ✓ dimensões mínimas

Espessura de placa mais grossa a ser soldada	Perna mínima $D_{mín}$ (em mm)
t < 12 mm	5
$12 \leq t \leq 20$ mm	6
t > 20 mm	8

  - ✓ dimensões máximas para perna
    - $D_{máx} \leq t$ quando $t \leq 6$mm
    - $D_{máx} \leq t - 2$ quando $t > 6$mm

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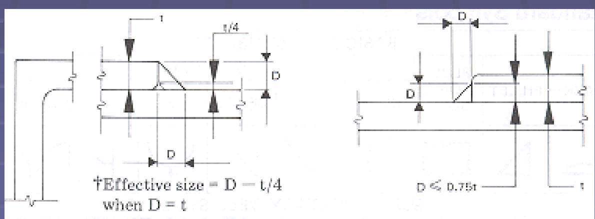
13. Dimensionamento de Soldas

- Soldas de Filete
  - ✓ Dimensões mínimas para o comprimento
  - ✓ $l_{mín} \geq 4D$ ou 40 mm (início e fim de solda)
  - ✓ Material com borda arredondada



  - ✓ Filete em furos e rasgos
    - ϕ ou $L_{rasgo} \geq t + 8$

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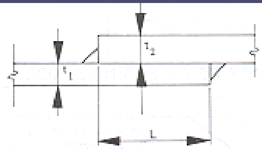
13. Dimensionamento de Soldas

- Soldas de Filete
  - ✓ Juntas sobrepostas



$L_{min} = 5t_1 \geq 25$ mm when $t_1 \leq t_2$
$L_{min} = 5t_2 \geq 25$ mm $t_2 < t_1$

  - ✓ Soldas de Entalhe com Penetração Parcial

Thickness of Thicker Part Joined (Millimetres)	Minimum Groove Depth*, mm	
	Groove Angle, α, at Root $45° \leq \alpha < 60°$ (V-, Bevel Grooves)	Groove Angle, α, at Root $\alpha \geq 60°$ (V-, Bevel, J-, U- Grooves)
Total 12 incl.	8	5
Over 12 – 20	10	6
Over 20 – 40	12	8
Over 40 – 60	14	10
Over 60	16	12

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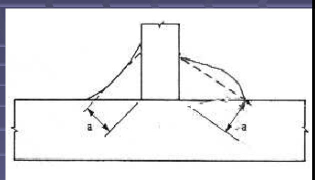
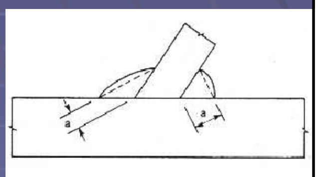
PGECIV FEN

13. Dimensionamento de Soldas

- Recomendações – Eurocode 3
- Comprimentos de soldas de filete
  - ✓ Effective length of a fillet weld should be taken as the length over which the fillet is full-size.
  - ✓ This can be taken as the weld overall length reduced by 2 x effective throat thickness a.
  - ✓ Provided that the weld is full size throughout its length including starts and terminations,
    - No reduction in effective length is made for either the weld start /end
  - ✓ Fillet welds with an effective length ≤ 30mm or 6 x its throat thickness, whichever is larger, should not be used to carry load





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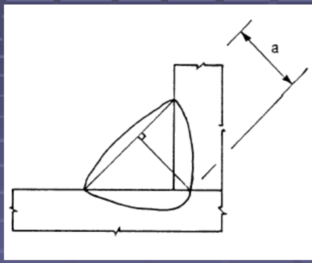
13. Dimensionamento de Soldas

- Recomendações – Eurocode 3
- Garganta efetiva de soldas de filete
  - ✓ Fillet weld efective throat thickness, a, is the largest triangle height (equal/unequal legs) that can be inscribed within the fusion faces/weld surface,⊥ outer side of this triangle.
  - ✓ The fillet weld effective throat thickness ≥ 3mm.
  - ✓ Deep penetration fillet weld resistance can consider its additional throat thickness, provided that preliminary tests show that the required penetration can consistently be achieved.



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13. Dimensionamento de Soldas

- Garganta efetiva da solda
  - ✓ Arco submerso → grande penetração
  - ✓ a´ = a + (0.2 a ou 1mm) o maior
  - ✓ Defeitos no início e fim do cordão → resfriamento rápido
  - ✓ L_{eff} = L – 2 t
  - ✓ Importante para soldas intermitentes

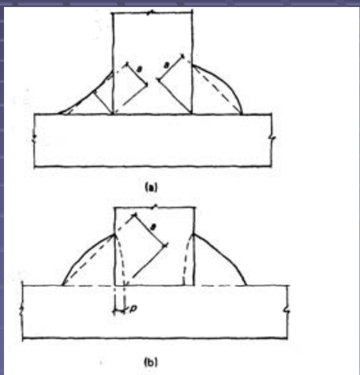

Figure 4.12 Definitions of effective throat for (a) normal welding and (b) deep-penetration and submerged arc welding. *p* is penetration of deep-penetration weld, demonstrated by procedure trials. For submerged arc welding, *a* may be increased by the lesser of 0.2*a* and 2 mm

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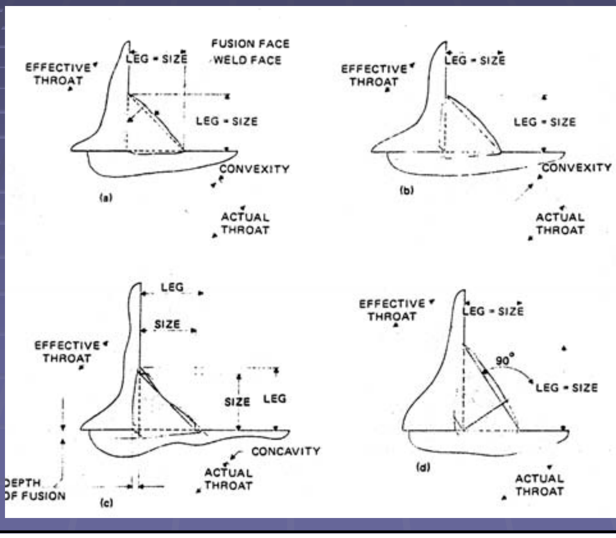
13. Dimensionamento de Soldas

- Garganta efetiva de soldas de filete – Manual Canadense



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13. Dimensionamento de Soldas

- Recomendações – Eurocode 3 pt 1.8
- Soldas com Placas de Enchimento
  - ✓ In the case of welds with packing, the packing should be trimmed flush with the edge of the part that is to be welded.
  - ✓ When two parts connected by welding are separated by a packing plate
    - with a thickness less than the leg length of weld necessary to transmit the force, the required leg length should be increased by the thickness of the packing.
    - With a thickness equal to, or greater than, the leg length of weld necessary to transmit the force, each of the parts should be connected to the packing by a weld capable of transmitting the design force.

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13. Dimensionamento de Soldas

- Ligações a mesas não enrijecidas – Eurocode 3 pt 1.8
- Where a transverse plate (or beam flange) is welded to a supporting unstiffened flange of an I, H or other section, and provided that the condition given in eq. 4.7 is met, the applied force perpendicular to the unstiffened flange should not exceed any of the relevant resistances:
  - ✓ web of the supporting member of I or H sections
  - ✓ transverse plate on a RHS member
  - ✓ supporting flange calculated assuming the applied force is concentrated over an effective width, b_{eff}, of the flange as given in eqs. 4.6 or 4.8

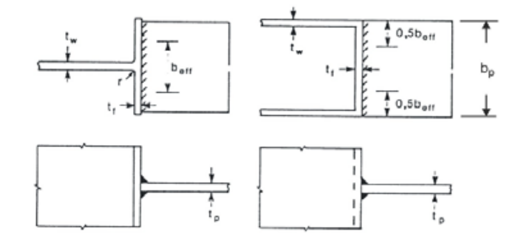

Figure 4.8: Effective width of an unstiffened T-joint

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13. Dimensionamento de Soldas

- Ligações a mesas não enrijecidas – Eurocode 3
- For an unstiffened I or H section the effective width eff should be:

$$b_{eff} = t_w + 2s + 7kt_f \qquad (4.6a)$$

- where: $k = (t_f / t_p)(f_{y,f} / f_{y,p})$ but $k \leq 1$ (4.6b)

$f_{y,f}$ is the yield strength of the flange of the I or H
$f_{y,p}$ is the yield strength of the plate welded to the I or H

- The dimension should be obtained from:
- Rolled I or H section: $s = r$ (4.6c)
- Welded I or H section: $s = \sqrt{2}\, a$ (4.6d)

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13. Dimensionamento de Soldas

- Ligações a mesas não enrijecidas – Eurocode 3
- For an unstiffened flange of an I or H section:

$$b_{\mathrm{eff}} \geq (f_{y,p} / f_{u,p}) b_p \qquad (4.7)$$

- where: $f_{u,p}$ is the ultimate strength of the plate welded to the I or H
  b_p is the width of the plate welded to the I or H
- Otherwise the joint should be stiffened.
- Other sections i.e.box/channel sections where the connected plate width is similar to the flange width, the effective width is:

$$b_{\mathrm{eff}} = 2t_{\mathrm{w}} + 5t_{\mathrm{f}} \quad \text{but} \quad b_{\mathrm{eff}} \leq 2t_{\mathrm{w}} + 5\,k\,t_{\mathrm{f}} \qquad (4.8)$$

- Even if $b_{eff} \leq b_p$, the welds connecting the plate to the flange need to be designed to transmit the design resistance of the plate $b_P t_P f y_{,P} / \gamma_{M0}$ assuming a uniform stress distribution

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13. Dimensionamento de Soldas

- Cantoneiras ligadas por uma perna – Eurocode 3
- Angles connected by one leg
  - ✓ Eccentricity of welded lap joint end may be allowed, using an effective cross-sectional area and treating the member as concentrically loaded.
- Equal or unequal-leg angles connected by its larger leg:
  - ✓ Effective area may be taken as equal to the gross area.
- Unequal-leg angle connected by its smaller leg,
  - ✓ Effective area = gross cross-sectional area of an equivalent equal-leg angle of leg size = smaller leg, for the cross-section design resistance.
  - ✓ However, when determining the buckling resistance of a compression member the actual gross cross-sectional area should be used.

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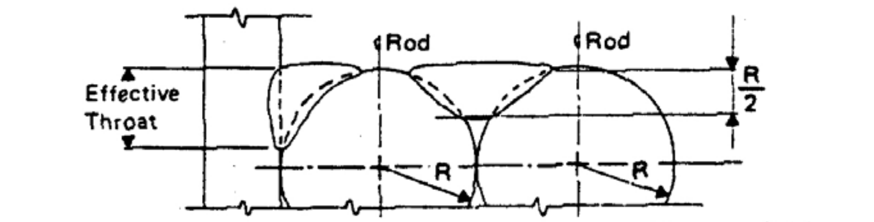
13. Dimensionamento de Soldas

- Soldas em barras redondas

Flare Bevel and Flare V-Welds



The effective throat thickness for flare groove welds on solid bars, when filled flush to the surface of the solid section of the bar is 5/16 R for Flare Bevel Groove welds and 1/2 R for Flare Vee Groove welds.

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13. Dimensionamento de Soldas

- Algumas recomendações