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COMPARISON OF WELD STRENGTH ACCORDING TO EUROCODE NO. 3 WITH WELD STRENGTH ACCORDING TO NATIONAL CODES - PART A

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1. INTRODUCTION

In [1] design functions for welded connections have been derived. These design functions will be included in the 1988 revision of Eurocode No. 3 [2]. In order to find out whether these design functions lead towards more economic design than the design functions of national codes of practice, a comparison of weld strength according to Eurocode No. 3 [2] with weld strength according to national codes of practice should be made. The concluding table of [1], which is used for the examples considered in this report, is given here as table 1.

In chapter 2 three examples are presented, covering weld failure:
- lap joint with parallel welds;
- lap joint with transverse welds;
- lap joint with parallel and transverse welds.

In chapter 2 only the examples to be analysed are presented. The analyses should be carried out using:
- Eurocode No. 3 [2], method 1: stress component method;
- Eurocode No. 3 [2], method 2: mean stress method;
- National codes of practice;
- Draft-revision of national codes if available.

In this report the national code of practice considered is the Dutch code: Arc welding, NEN 2062 [3] and no draft-revision of the national code is considered since a commonly used draft revision is not available. The analyses are presented in the appendix given in part B of this report. A summary of the analyses is given in chapter 3. Finally the conclusions are presented in chapter 4.

Readers are invited to make analyses for comparison using their national codes of practice. For this purpose chapter 2 is given in a general form.

Table 1: Summary of design functions for welded connections.

method	EC No. 3 draft 1984	EC No. 3 draft 1984 reformatted	EC No. 3 revision 1988
1: stress component method	$\beta \sqrt{\sigma_\perp^2+3(\tau_\perp^2+\tau_{//}^2)} \leq f_y$ and $\sigma_\perp \leq f_y$ where: $\beta = 0.7$ if $f_y \leq 240$ N/mm^2 $\beta = 1.0$ if $f_y \geq 340$ N/mm^2	$\sqrt{\sigma_\perp^2+3(\tau_\perp^2+\tau_{//}^2)} \leq \frac{f_u}{\beta \gamma_M}$ and $\sigma_\perp \leq \frac{f_u}{\gamma_M}$ where: $\beta = 0.7$ if $f_y \leq 240$ N/mm^2 $\beta = 1.0$ if $f_y \geq 340$ N/mm^2 ($\gamma_M = 1.5$; $f_u = 1.5\ f_y$)	$\sqrt{\sigma_\perp^2+3(\tau_\perp^2+\tau_{//}^2)} \leq \frac{f_u}{\beta \gamma_M}$ and $\sigma_\perp \leq \frac{f_u}{\gamma_M}$ where: $\beta = 0.8$ if $f_u = 360$ N/mm^2 $\beta = 0.9$ if $f_u = 510$ N/mm^2 ($\gamma_M = 1.25$)
2: mean stress method	$\sigma_w \leq \frac{f_y}{\beta \sqrt{3}}$ where: $\sigma_w = \frac{F}{\Sigma\ a\ell}$ $\beta = 0.7$ if $f_y \leq 240$ N/mm^2 $\beta = 1.0$ if $f_y \geq 340$ N/mm^2	$\sigma_w \leq \frac{f_u}{\beta \gamma_M \sqrt{3}}$ where: $\sigma_w = \frac{F}{\Sigma\ a\ell}$ $\beta = 0.7$ if $f_y \leq 240$ N/mm^2 $\beta = 1.0$ if $f_y \geq 340$ N/mm^2 ($\gamma_M = 1.5$; $f_u = 1.5\ f_y$)	$\sigma_w \leq \frac{f_u}{\beta \gamma_M \sqrt{3}}$ where: $\sigma_w = \frac{F}{\Sigma\ a\ell}$ $\beta = 0.8$ if $f_u = 360$ N/mm^2 $\beta = 0.9$ if $f_u = 510$ N/mm^2 ($\gamma_M = 1.25$)

- β-values relevant for FeE235 and FeE355 have been given only. β-values for other steel grades for the 1988 revision of EC 3 can be obtained by linear interpolation and extrapolation. This results in approximately: $\beta = 0.85$ if $f_u = 430$ N/mm^2 and $\beta = 1.00$ if $f_u = 650$ N/mm^2.

2. EXAMPLES TO BE ANALYSED

Three examples to be analysed are as follows:
- a lap joint with parallel welds;
- a lap joint with transverse welds;
- a lap joint with parallel and transverse welds.

2.1 Lap joint with parallel welds

Calculate the allowable tensile load on the welded connection of figure 1 according to:
- Eurocode No. 3 [1,2], method 1: stress component method;
- Eurocode No. 3 [1,2], method 2: mean stress method;
- National code of practice;
- Draft-revision of national code if available.

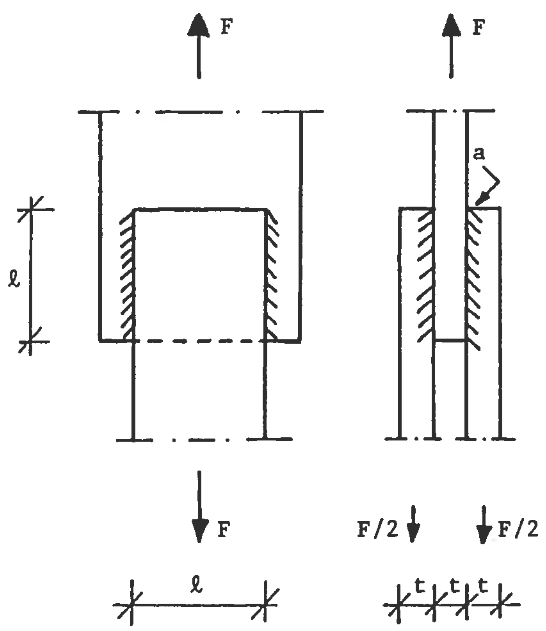

Figure 1: Lap joint with parallel welds.

Data:
. Weld length ℓ = 55 mm;
. Weld size a = 5 mm;
. Plate thickness t = 10 mm;

- Steel grades to be considered: FeE235 and FeE355;
- Deformation capacity not required;
- Note that for Eurocode No. 3:

$$F_{t,all} = \frac{F_{td}}{\gamma}$$

where:

$F_{t,all}$ = the allowable tensile load
F_{td} = the design tensile strength
γ = the load factor:
$\gamma = 1.41$

- Summary of results to be provided in the form of table 2.

Table 2: $F_{t,all}$(kN); results for lap joint with parallel welds.

Grade	Eurocode No. 3 [1,2] method 1: stress component method	Eurocode No. 3 [1,2] method 2: mean stress method	National code *	Draft national code **
FeE235 FeE355				

* =

** =

2.2 Lap joint with transverse welds

Calculate the allowable tensile load on the welded connection of figure 2 according to:

- Eurocode No. 3 [1,2], method 1: stress component method;
- Eurocode No. 3 [1,2], method 2: mean stress method;
- National code of practice;
- Draft - revision of national code if available.

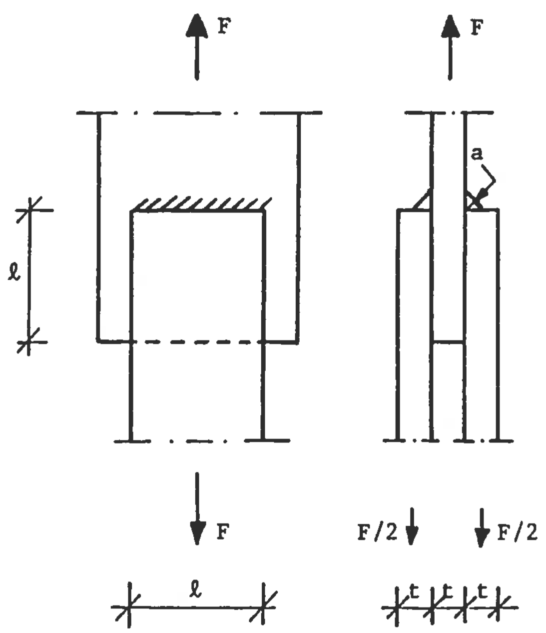

Figure 2: Lap joint with transverse welds.

Data:

. Weld length ℓ = 55 mm;

. Weld size a = 5 mm;

. Plate thickness t = 10 mm;

. Consider steel grades FeE235 and FeE355;

. Deformation capacity not required;

. Note that for Eurocode No. 3

$$F_{t,all} = \frac{F_{td}}{\gamma}$$

where:

$\gamma = 1.41$

. Summary of results to be provided in the form of table 3.

Table 3: $F_{t,all}$ (kN); results for lap joint with transverse welds.

Grade	Eurocode No. 3 [1,2] method 1: stress component method	Eurocode No. 3 [1,2] method 2: mean stress method	National code *	Draft national code **
FeE235 FeE355				

* =

** =

2.3 Lap joint with parallel and transverse welds

Calculate the allowable tensile load on the welded connenction of figure 3 according to:

- Eurocode No. 3 [1,2], method 1: stress component method;
- Eurocode No. 3 [1,2], method 2: mean stress method;
- National code of practice;
- Draft - revision of national code if available.

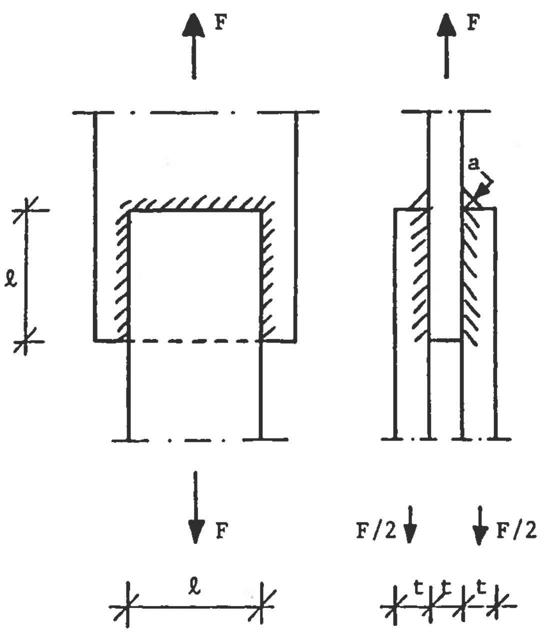

Figure 3: Lap joint with parallel and transverse welds.

Data:

. Weld length ℓ = 55 mm;
. Weld size a = 5 mm;
. Plate thickness t = 10 mm;
. Consider steel grades FeE235 and FeE355;
. Deformation capacity not required;

. Note that for Eurocode No. 3

$$F_{t,all} = \frac{F_{td}}{\gamma}$$

where:

$\gamma = 1.41$

. Summary of results to be provided in the form of table 4.

Table 4: $F_{t,all}$ (kN); results for lap joint with parallel and transverse welds.

Grade	Eurocode No. 3 [1,2] method 1: stress component method	Eurocode No. 3 [1,2] method 2: mean stress method	National code *	Draft national code **
FeE235				
FeE355				

* =

** =

3. SUMMARY OF CALCULATION RESULTS

3.1 Lap joint with parallel welds

A summary of results is given in table 5.

Table 5: $F_{t,all}$ (kN); results for lap joint with parallel welds.

Grade	Eurocode No. 3 [1,2] method 1: stress component method	Eurocode No. 3 [1,2] method 2: mean stress method	National code *	Draft national code **
FeE235	162.15	162.15	145.16	-
FeE355	204.19	204.19	179.32	-

* = NEN 2062; Arc welding [3]
** = -

3.2 Lap joint with transverse welds.

A summary of results is given in table 6.

Table 6: $F_{t,all}$ (kN); results for lap joint with transverse welds.

Grade	Eurocode No. 3 [1,2] method 1: stress component method	Eurocode No. 3 [1,2] method 2: mean stress method	National code *	Draft national code **
FeE235	99.30	81.08	88.89	-
FeE355	125.04	102.09	109.81	-

* = NEN 2062; Arc welding [3]
** = -

3.3 Lap joint with parallel and transverse welds

A summary of results is given in table 7.

Table 7: $F_{t,all}$ (kN); results for lap joint with parallel and transverse welds.

Grade	Eurocode No. 3 [1,2] method 1: stress component method	Eurocode No. 3 [1,2] method 2: mean stress method	National code *	Draft national code **
FeE235	261.45	243.23	234.05	-
FeE355	329.23	306.28	289.13	-

* = NEN 2062; Arc welding [3]

** = -

4. CONCLUSIONS

- For the examples considered it can be concluded from the tables 5 to 7 that in general the design functions for welded connections according to the 1988 revision of Eurocode No. 3 [1,2] lead to a more economic design than the design functions according to the Dutch national code [3]. However, this is not true for transverse welds calculated according to method 2 of Eurocode No. 3 [1,2].

- For the lap joint with parallel welds (table 5), the allowable tensile loads according to both methods of Eurocode No. 3 [1,2] are equal. They are greater than those according to the Dutch national code [3]. This is partly caused by more favourable design functions and partly by a more favourable load factor γ.

- For the lap joint with transverse welds (table 6), the allowable tensile loads according tot method 2 of Eurocode No. 3 [1,2] are conservative compared with those according to method 1 of Eurocode No. 3 [1,2] and those according to the Dutch national code [3]. Method 1 of Eurocode No. 3 [1,2] gives greater allowable tensile loads than method 2 of Eurocode No. 3 [1,2] and the Dutch national code [3].

- For the lap joint with parallel and transverse welds (table 7), the allowable tensile loads according to method 2 of Eurocode No. 3 [1,2] are slightly greater than those according to the Dutch national code. They are conservative when compared to the allowable tensile loads according to method 1 of Eurocode No. 3 [1,2].

REFERENCES

[1] Snijder, H.H., Ungermann, D., Stark, J.W.B., Sedlaced, G., Bijlaard, F.S.K., Hemmert-Halswick, A., "Evaluation of test results on welded connections in order to obtain strength functions and suitable model factors - Part A: Results - Part B: Evaluations", Report No. BI-88-139/63.5.5960, RWTH - Aachen, BRD, University of Technology, Eindhoven and TNO-IBBC, Rijswijk (Z.H.), The Netherlands, 1988.

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[3] Booglassen - Het berekenen van gelaste verbindingen in ongelegeerd en zwakgelegeerd staal tot en met Fe510 (Fe52) die overwegend statisch worden belast (Arc welding - Calculation of welded joints in unalloyed and low-alloy steel up to and including Fe510 (Fe52) which are predominantly statically loaded), NEN 2062, NNI, 1977.