Fatigue strength of repaired welded connections made of S690 and S890

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Content

- My expertise
- Test results of research project
- Challenges for future

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My background

- MSc from TU Delft
- Master thesis; Fracture mechanic analysis based on BS 7910:2005
- Currently working on fatigue strength of repaired welded connections .

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Master thesis

- Fracture mechanic analysis based on BS 7910:2005
  - Clarifying the standard with help of literature
  - Application of facture mechanic theories on fatigue problems.
  - Calculation on remaining fatigue life of crack contains sections.
  - Combining failure assessment diagrams (FAD) with fatigue crack growth assessment.
  - The calculation procedure is implemented in a simple math program for practical use.

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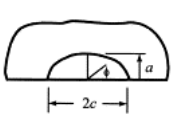
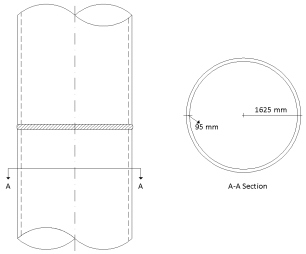
An example from master thesis

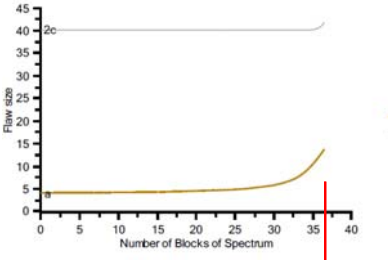
Stress ranges (Δσ)	Number of cycles (N)
13.55228	5069230
11.7044	8483657
11.467325	9238397
12.90413	4597449
14.6247	2381229
13.57925	3084120
15.637235	1182115
11.710925	5170956
11.49009	5620646
12.96213	2790997
14.690385	1445586
14.30541	1542039
15.310115	1094103
9.103535	1432958
11.18356	501000
13.849385	1714541
9.394115	10852100
16.34527	669219
15.66841	719198
11.714985	2907381
12.39141	1983626
15.40944	662956
14.302655	939902
16.765045	413624
13.943345	1038902
9.101795	8734216
11.23373	3041448
8.368095	1199347
9.401075	6602473
16.41864	406266
1.5921	9400

a = 3 mm
2c = 12 mm

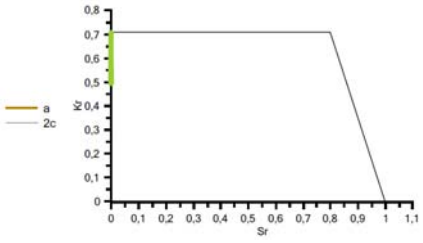




Fatigue crack growth



Failure assessment diagram



Remaining fatigue life 36,5 years

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Fatigue strength of repaired welded connections

- Concentrated on fatigue strength of repaired welded connections made of S690 and S890.
- V-shape welded connections are manufactured for hot rolled-hot rolled steel connection and hot rolled- cast steel connections.
- 4 point bending test setups are used
- Fatigue cracks are repaired by welding

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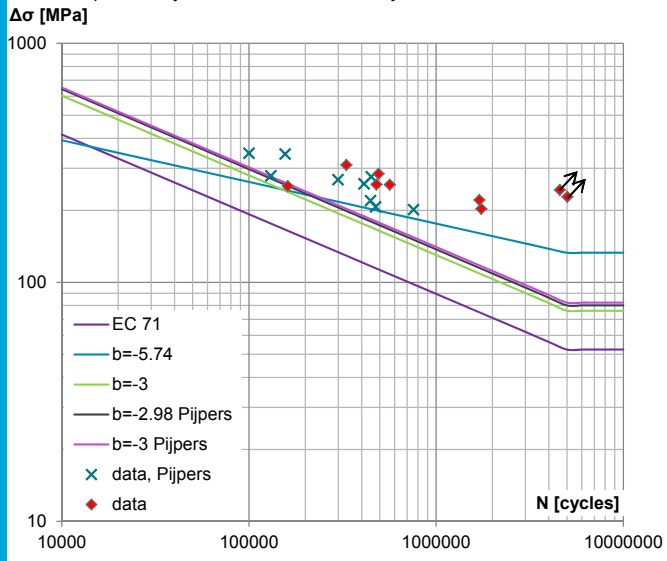
Test results

- Detail categories of EN 1993-1-9 are determined based on stress range of a 75% confidence level of 95% probability of survival at 2 million cycles.



Grade		S690	
$b = m$	-5.74	-3	-5
a_N	19.71	13.15	17.95
$\Delta\sigma_{mean}$	217	192	213
$\Delta\sigma_c$	156	103	150
s	0.437	0.436	0.41
t	1.895	1.86	1.86
n	9	9	9

Results from Pijpers study

Grade		S690	
$b = m$	-2.98	-3	-5
a_N	12.69	12.72	17.57
$\Delta\sigma_{mean}$	138	139	179
$\Delta\sigma_c$	109	112	147
s	0.164	0.153	0.232
t	1.895	1.86	1.86
n	9	9	9

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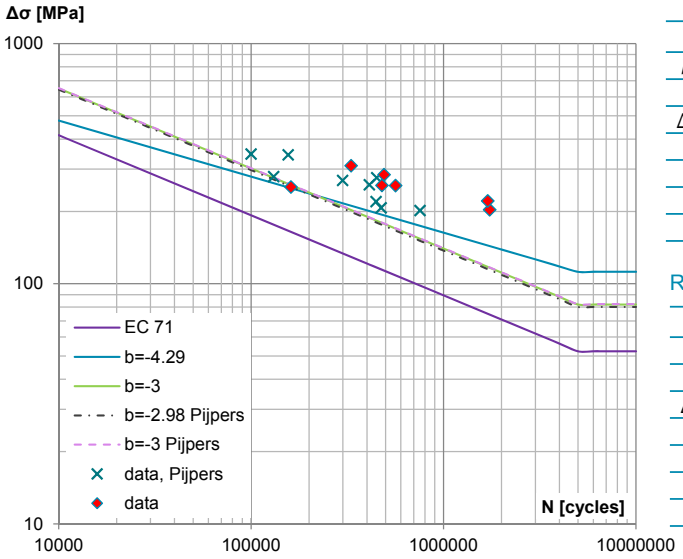
Test results



Runouts are excluded

Grade		S690	
$b = m$	-4.29	-3	-5
a_N	16.06	12.97	17.77
$\Delta\sigma_{mean}$	189	167	197
$\Delta\sigma_c$	139	111	156
s	0.285	0.272	0.264
t	2.015	1.943	1.943
n	7	7	7

Results from Pijpers study

Grade		S690	
$b = m$	-2.98	-3	-5
a_N	12.69	12.72	17.57
$\Delta\sigma_{mean}$	138	139	179
$\Delta\sigma_c$	109	112	147
s	0.164	0.153	0.232
t	1.895	1.86	1.86
n	9	9	9

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Test results

- Similar fatigue crack initiation and fatigue crack propagation is observed.
- Cracks are initiated at repaired side. Thus post weld impact treatment is effective.
- Fatigue strength curve of test results is located at above of detail category 71 of EN 1993-1-9 and even 3 detail category above of it.
- Fatigue strength curve of repaired welded connections is same as fatigue strength curve of the original joint.

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For future

- Further research on fatigue strength of very high strength steels
  - Welded connection under extreme (corrosive and low temperature) environment condition.
  - Fatigue strength of thick sections; challenges are, residual stress, material properties after thermal cycles, welding.
  - Reassessing surface quality requirements for base material for VHSS.
  - Testing under variable amplitude loading.
  - Repair weld under different preheat and cooling rate conditions which is representative to conditions of construction fields.

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For future

- Further research on fracture mechanics
  - Correlation between Charpy value and stress intensity factor
  - Effects of means stresses in fatigue crack growth
  - More detailed measurement and prediction model for residual stresses
  - FE modelling of crack propagation.
  - Fitness for purpose of existing structures

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Thank you for your attention

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