

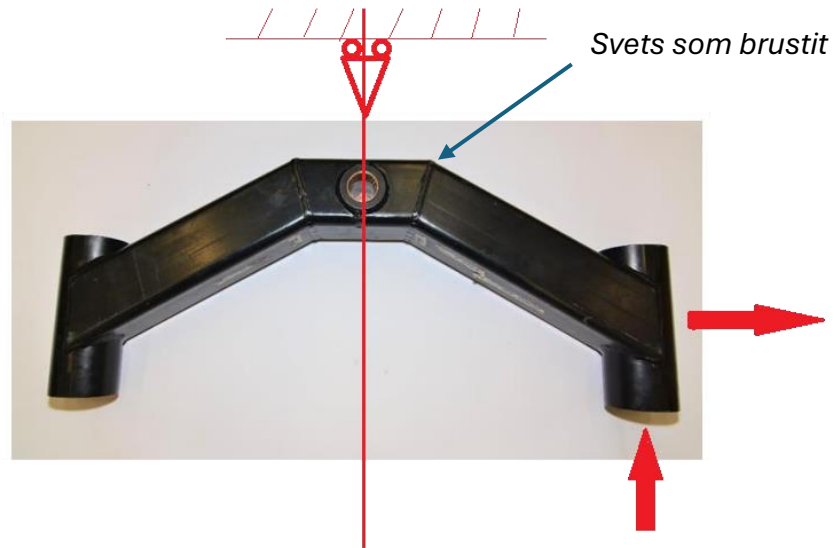
Gröna Lund Haveriet

(Enkla överslag med Nominell Metod resp ENS / APP)

5 sept 2024

Bertil Jonsson

Främre bärarm



Nominell Metod:

Med rotstöd ger FAT 71

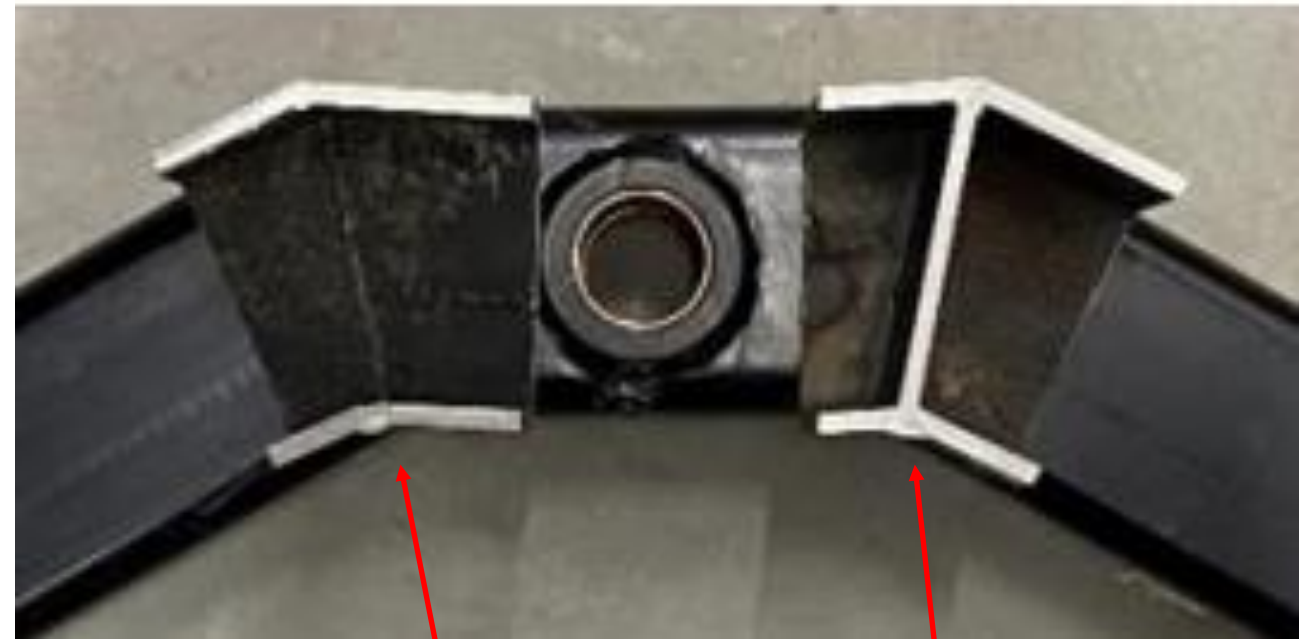
Utan rotstöd ger FAT 36

Livslängd = $(36/71)^3 \approx 0.13$

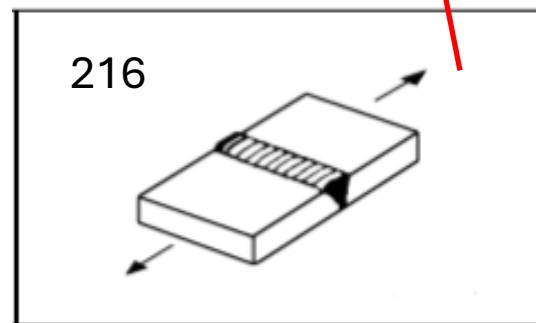
→

Livslängden sjunker till ca **1/8-del** !

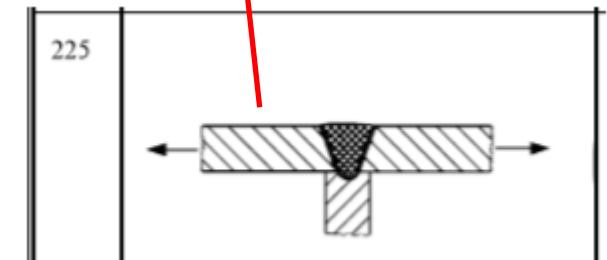
Dagens bärarm
(utan rotstöd)



Ursprunglig bärarm
(med rotstöd)

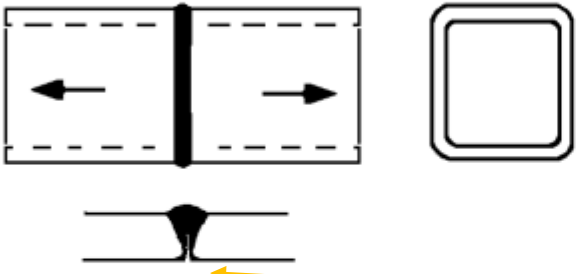
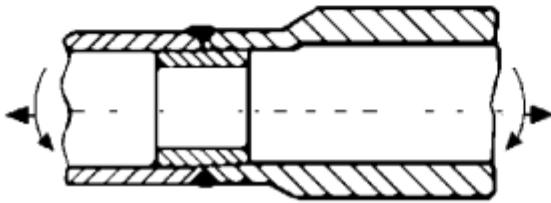


Single symmetry
2 choices of BC at right end
Nominal FAT 71/63/**36**



Symmetry assumed
Nominal FAT **71**

Det finns FAT-värden för rekt. profiler

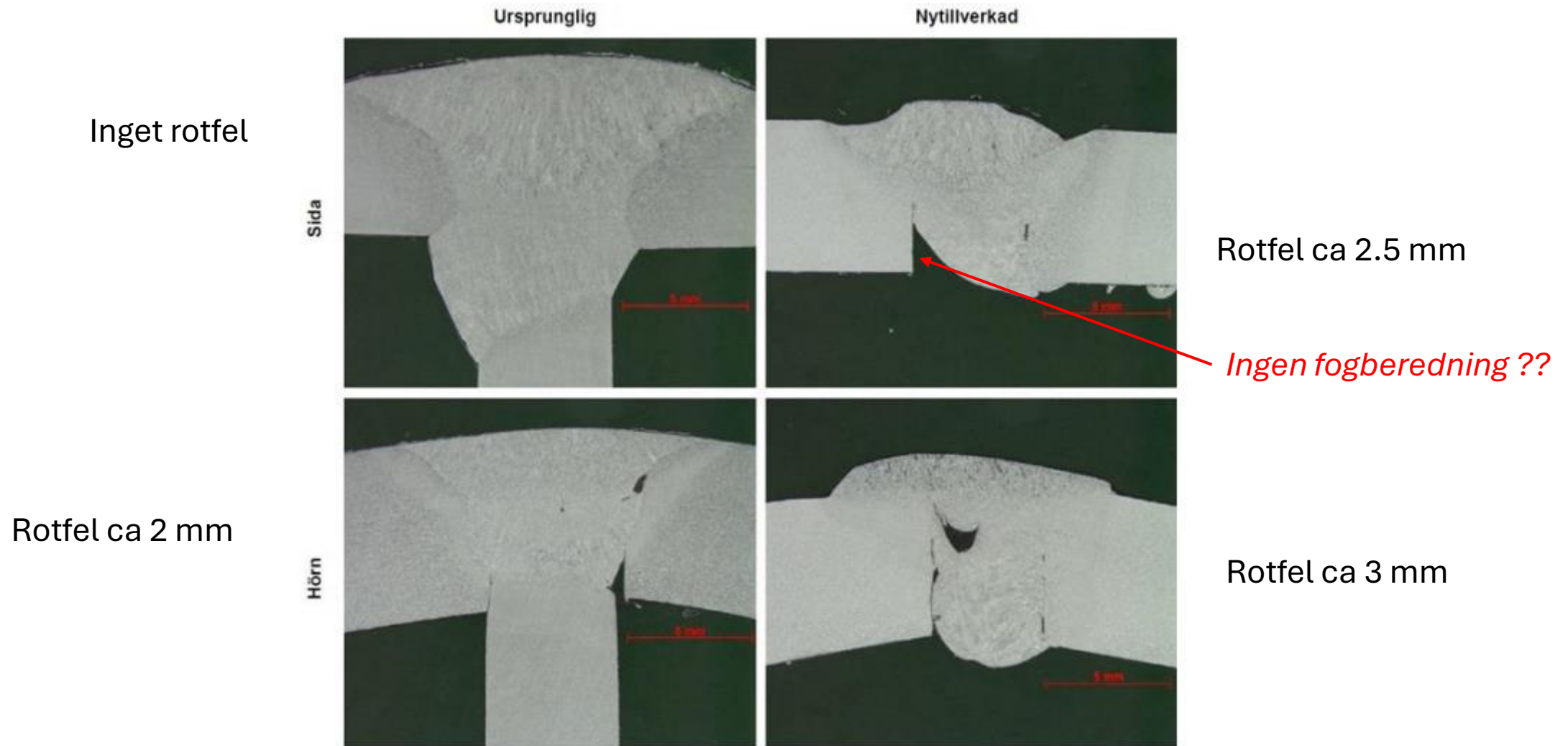
No.	Structural Detail	Description (St.= steel)	FAT St.
234		Transverse butt weld splice in rectangular hollow section, welded from one side, full penetration, root crack <i>Obs!</i> root inspected by NDT no NDT	56 36
233		Tubular joint with permanent backing	71

Utan rotstöd: FAT **36**

Med rotstöd: FAT **71**

*Dessa FAT stämmer
med stumfogar ovan*

Snitt genom svetsar, man hittade rotfel



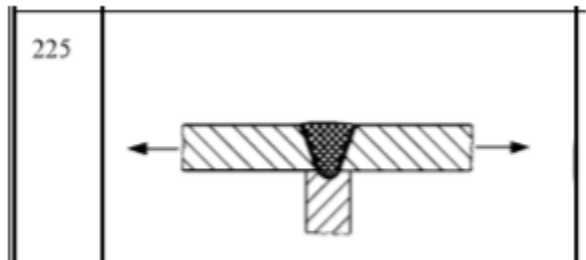
Figur 20. Tvärsnitt av svetsen på en ursprungligt tillverkad och en nyttillverkad bärarm. Bild: Element Materials Technology AB.

Case 225 (med rotstödet)

ENS (R=0.3 mm)

Draglast = 71 Mpa (=Fat)

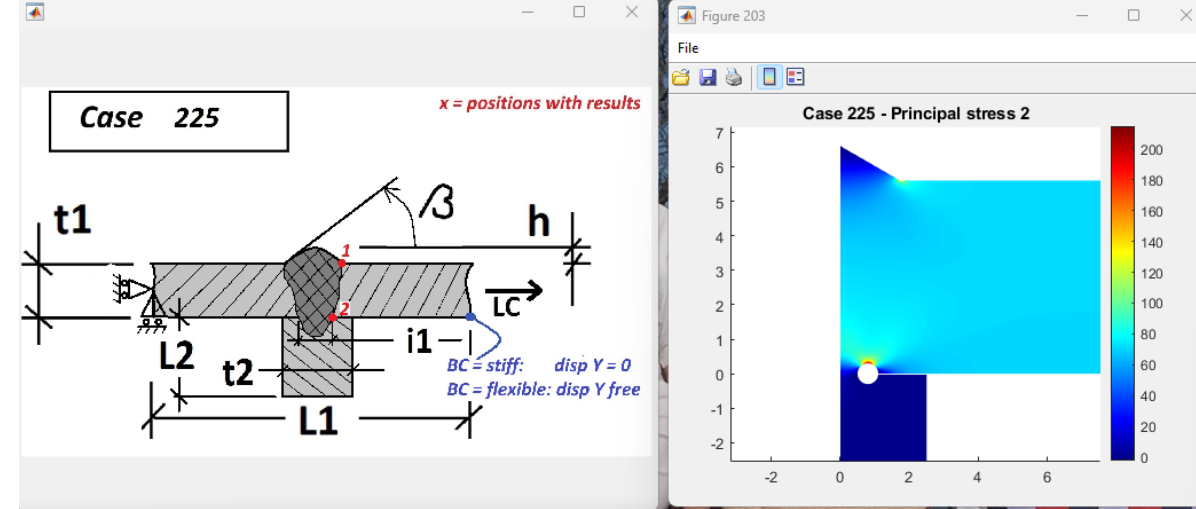
Rotfel = 2.0 mm



Symmetry assumed
Nominal FAT **71**



Livslängd $N \approx 19E6$ cykler



Weld Joint Analyzer Ver. 1.6

Weld Joint CASE: CASE 225

Read me! This APP computes Effective Notch Stress range for fatigue from nominal tension loads. It is done for different weld joint types according to IIW Recommendations nomenclature. Choose CASE no (above), give appropriate parameter values at left (according to EXPLANATION - see below), then click SOLVE to start the 2D FE-analysis!

Show active KNOBS

Press to SOLVE!

Message: Input Ok - CASE solved!

Note: BC active!

RESULTS:

Position	Principal stress (MPa)
Pos 1: Toe	135
Pos 2: Root	216
Pos 3: N/A	0
Pos 4: N/A	0
Pos 5: N/A	0
Pos 6: N/A	0

Stress in critical point (MPa): 216 (Root)

Shortest char. Life: $1.934e+07$

Shortest median Life: $4.857e+07$

Input parameters:

- Thickness t_1 (mm): 5.6
- Thickness t_2 (mm): 5
- Length L_1 (mm): 270
- Length L_2 (mm): 100
- Length L_3 (mm): 0
- Throat a_1 (mm): 0
- Throat a_2 (mm): 0
- Penetration i_1 (mm): 1
- Penetration i_2 (mm): 0
- Angle Beta (degr): 30
- Height h (mm): 1
- Off (mm): 0
- Tension (MPa) Load 1, LC: 71
- Tension (MPa) Load 2, non-LC: 0
- Notch Radius (mm, def =1): 0.3
- FAT - Toe (Mpa, def 225): 300
- FAT - Root (Mpa, def 225): 340
- Inclination (def m=3): 5
- Stand deviation (def s=0.2 in Log N): 0.2
- Scale factor deform plot: 100

Boundary Conditions (BC): Stiff

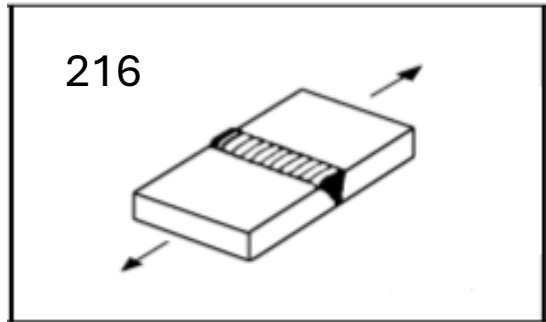
Active parameters: Active t_1 , Active t_2 , Active L_1 , Active L_2 , Active L_3 , Active a_1 , Active a_2 , Active i_1 , Active i_2 , Active Beta, Active h , Active Off, Active BC.

Case 216 (utan rotstödet)

ENS (R=0.3 mm)

Draglast = 71 MPa (=Fat)

Rotfel = 0.5 mm

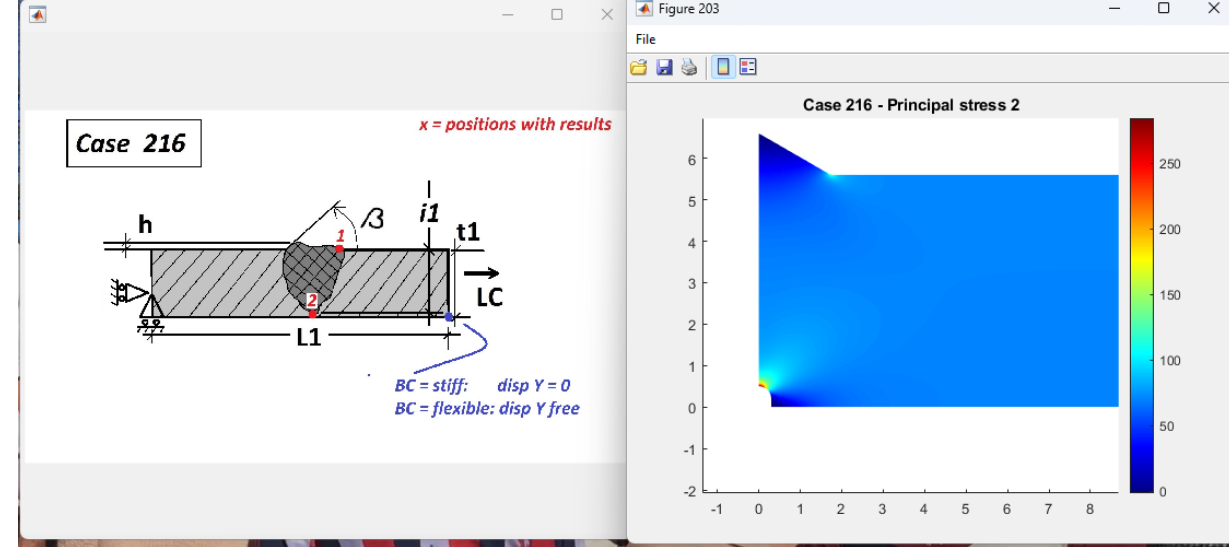
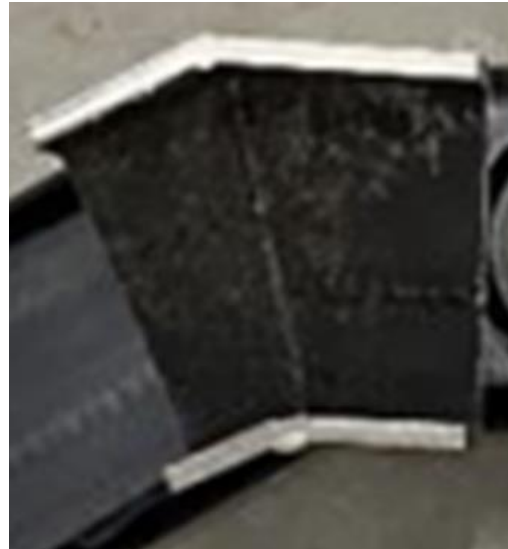


Single symmetry

2 choices of BC at right end

Nominal FAT 71/63/36

Livslängd $N \approx 5E6$ cykler



Weld Joint Analyzer Ver. 1.6

Weld Joint CASE CASE 216

Read me! This APP computes Effective Notch Stress range for fatigue from nominal tension loads. It is done for different weld joint types according to IIW Recommendations nomenclature. Choose CASE no (above), give appropriate parameter values at left (according to EXPLANATION - see below), then click SOLVE to start the 2D FE-analysis!

[Show active KNOBS](#) [Click here to get an EXPLANATION of input parameters for the CASE chosen](#)

Message: Input Ok - CASE solved!
Note: BC active!

RESULTS:

Position	Principal stress (MPa)
Pos 1 Toe	133
Pos 2 Root (if not full penetr.)	285
Pos 3 N/A	0
Pos 4 N/A	0
Pos 5 N/A	0
Pos 6 N/A	0

Stress in critical point (MPa) 285
Shortest char. Life 4.874e+06
Shortest median Life 1.224e+07

Root (if not full penetr.) 6

Input Parameters:

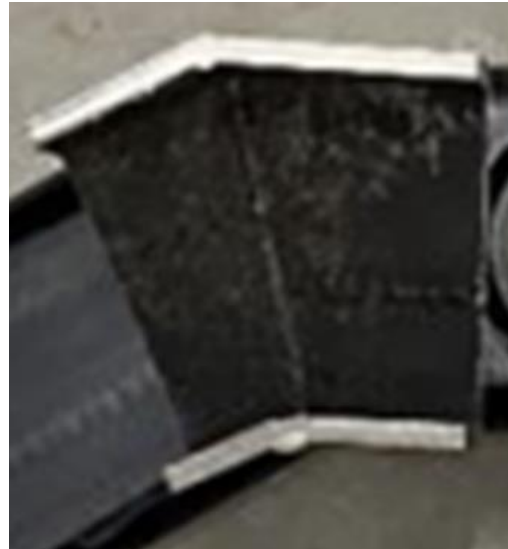
- Thickness t1 (mm): 5.6
- Thickness t2 (mm): 0
- Length L1 (mm): 270
- Length L2 (mm): 0
- Length L3 (mm): 0
- Throat a1 (mm): 0
- Throat a2 (mm): 0
- Penetration i1 (mm): 5.1
- Penetration i2 (mm): 0
- Angle Beta (degr): 30
- Height h (mm): 1
- Off (mm): 0
- Tension (MPa) Load 1, LC: 71
- Tension (MPa) Load 2, non-LC: 0
- Notch Radius (mm, def=1): 0.3
- FAT - Toe (Mpa, def 225): 300
- FAT - Root (Mpa, def 225): 340
- Inclination (def m=3): 5
- Stand deviation (def s=0.2 in Log N): 0.2
- Scale factor deform plot: 100
- Boundary Conditions (BC): Stiff
- Active BC: Yes

Case 216 (utan rotstödet)

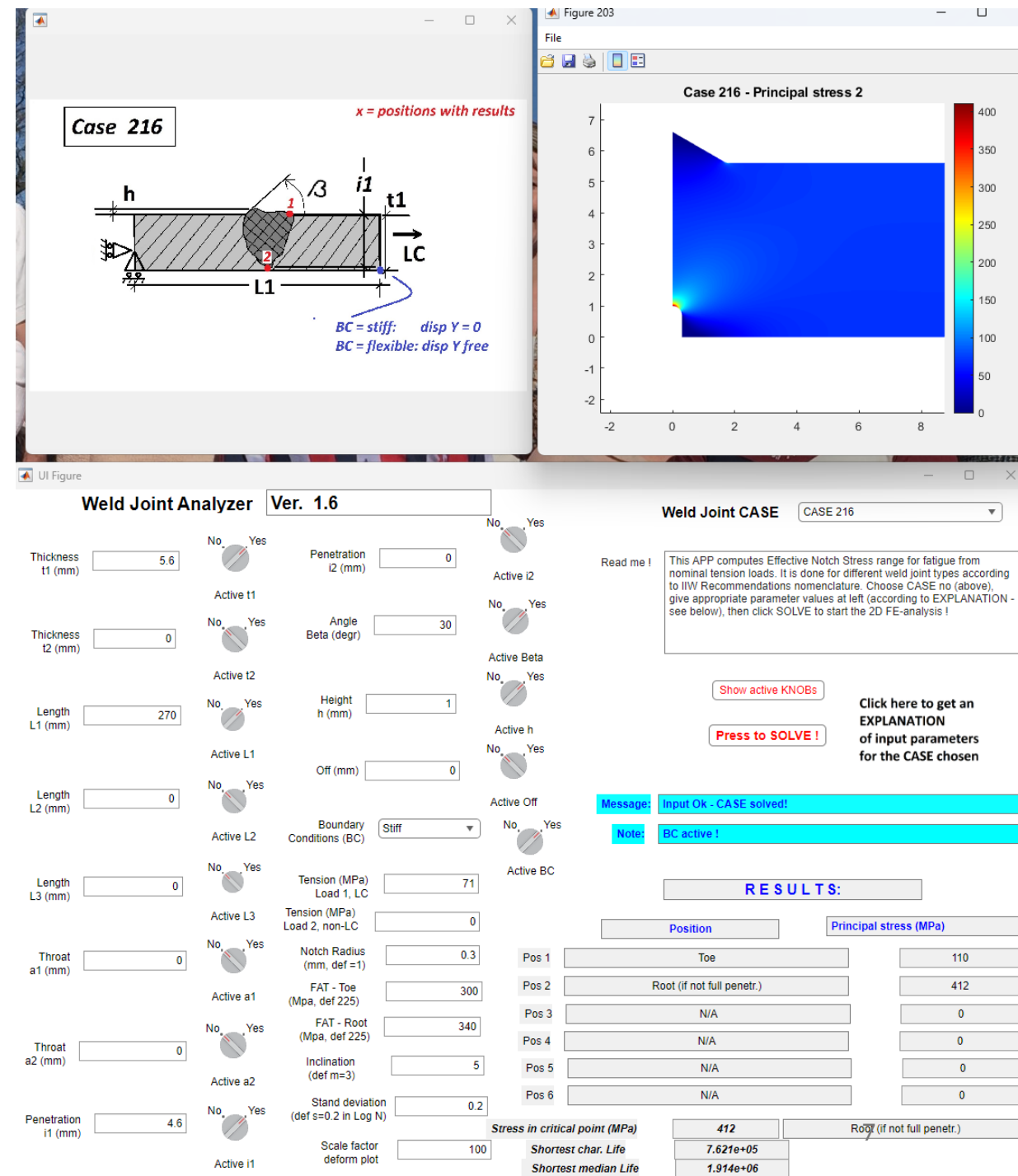
ENS (R=0.3 mm)

Draglast = 71 Mpa (=Fat)

Rotfel = 1.0 mm



Livslängd $N \approx 1E6$ cykler

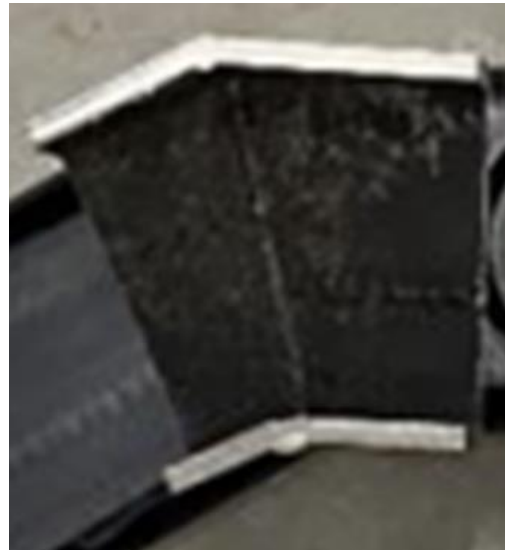


Case 216 (utan rotstödet)

ENS (R=0.3 mm)

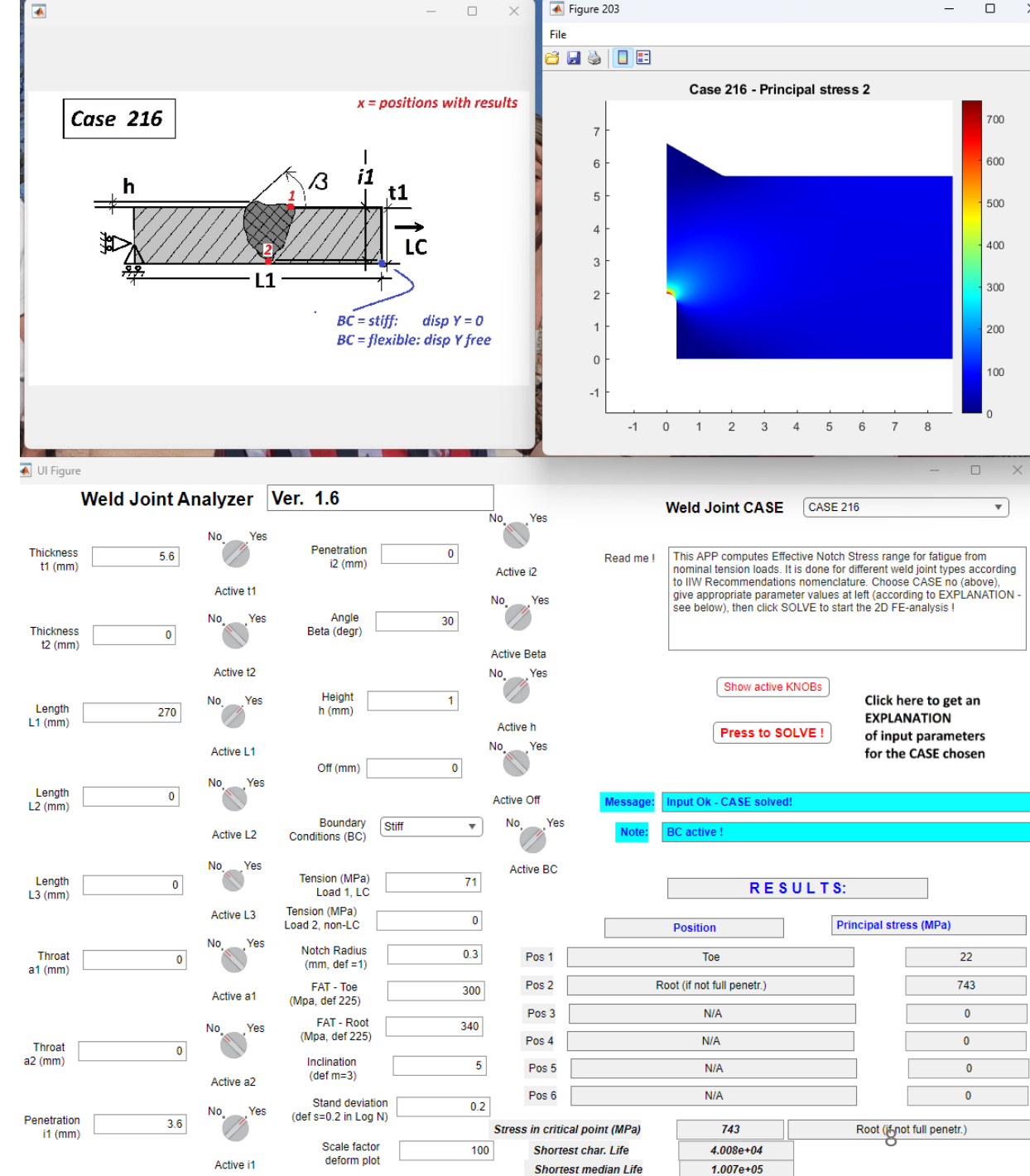
Draglast = 71 Mpa (=Fat)

Rotfel = 2.0 mm



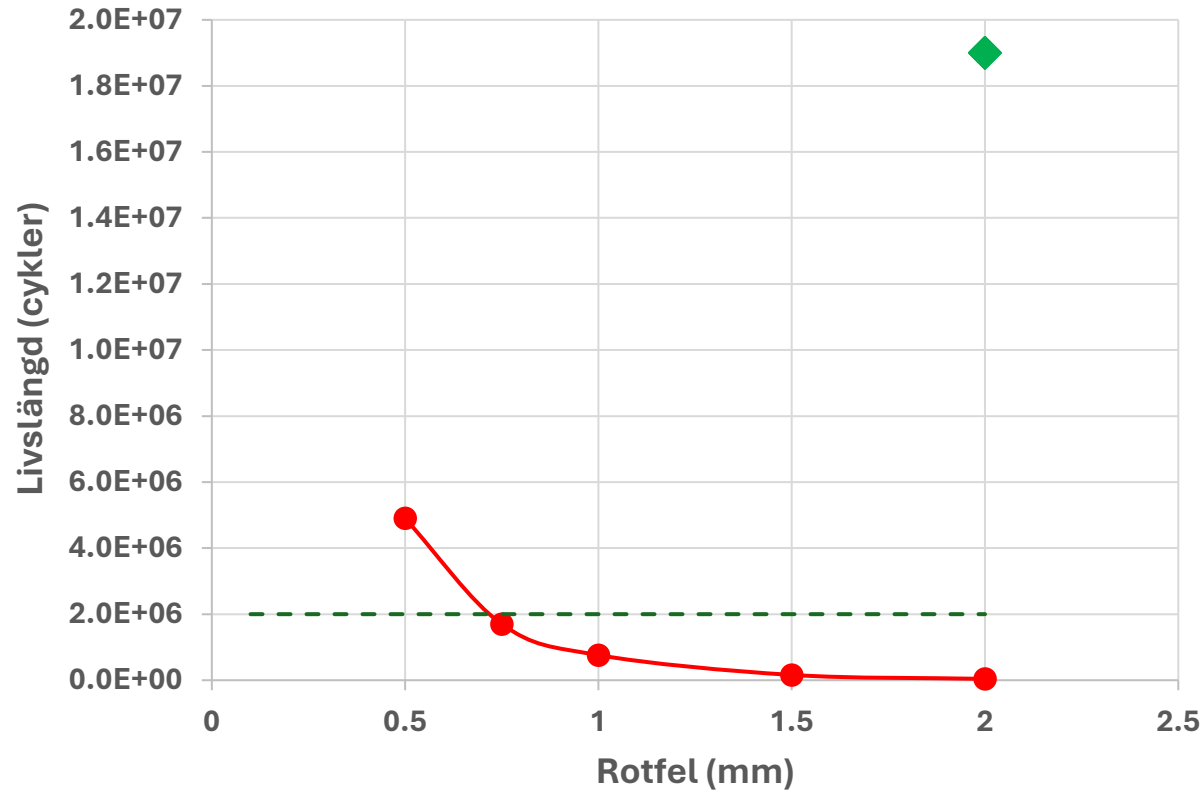
Livslängd $N \approx 0.04E6$ cykler

BerjoWeldDesign AB

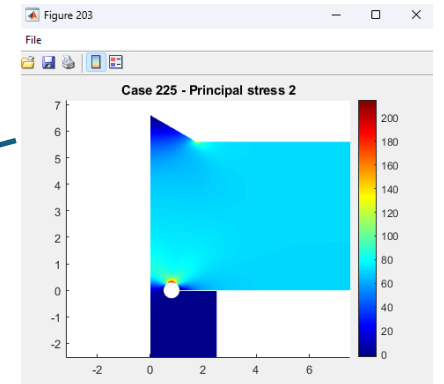
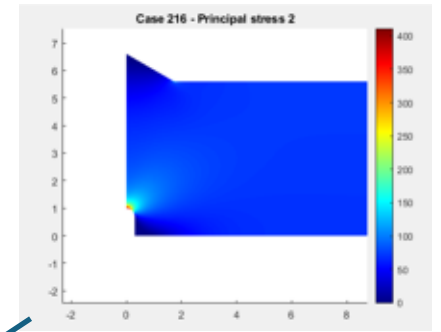


Livslängden för olika rotfel

Livslängd stumfog med o utan rotstöd, drag = 71 Mpa (Fat)



- Ej rotstöd
- ◆ Med rotstöd
- - - Karakt. Liv (FAT)



Slutsats:

Utan rotstöd faller livslängden **dramatiskt** om rotfelet ökar.
Med rotstöd fås mycket större livslängd

Summerat

- Haverikommissionen identifierade följande brister
 - Beställning (aningslös)
 - Tillverkning (slarvig)
 - Kontroller (fel punkt)
- Jag tycker också Konstruktion och design är en brist
 - Borde tydligt pekat ut rotsidan som kritisk
 - Borde beskrivit detta på ritningen (tex kvalitets- och inbränningskrav)
 - →
 - Då hade fokus hamnat på
 - Hur man ska svetsa för att undvika inre fel
 - Vad och hur som ska kontrollerats (förstörande provning?, ultraljud?)