
# *Analysis of Wide Plate Tests using SINTAP Failure Assessment Diagrams*

# UNIVERSITY OF CANTABRIA

## Report/SINTAP/UC/14

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# 1. MATERIALS

| **Plate** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Material | S275J0 | 355EMZ | 450EMZ | S690Q | ABR.400 | S690Q | S690Q |
| Thickness (mm) | 25 | 25 | 25 | 25 | 25 | 12 | 40 |
| LYS or 0.2%PS (MPa) | 303 | 436 | 471 | 713 | 991 | 820 | 746 |
| UTS (MPa) | 467 | 548 | 565 | 792 | 1408 | 864 | 859 |
| LYS/UTS | 0.649 | 0.796 | 0.834 | 0.900 | 0.704 | 0.949 | 0.868 |
| Type of curve | Discont. | Discont. | Discont. | Contin. | Contin. | Discont. | Contin. |
| N (measured) | 0.231 | 0.282 | 0.151 | 0.092 | 0.157 | 0.071 | 0.068 |
| Charpy T27J (°C) | -65 | -115 | -115 | -50 | -45 | -85 | -85 |
| Charpy at -20°C (J) | 70 | 220 | >250 | 100 | 35 | 180 | 170 |
| CTOD at -20°C (mm) | 0.974 | 0.765 | 1.450 | 0.083 | 0.022 | 0.140 | 0.235 |
| CTOD R-curve (mm) | $1.03\Delta a^{0.50}$ | $1.04\Delta a^{0.63}$ | $1.31\Delta a^{0.71}$ | - | - | - | $0.44\Delta a^{0.62}$ |

# 2. CALCULATIONS TO DERIVE THE DIFFERENT FAILURE ASSESSMENT LINES

| **Plate** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| FS (MPa) | 385 | 492 | 518 | 752.5 | 1199.5 | 842 | 802.5 |
| Cut-off | 1.271 | 1.128 | 1.100 | 1.055 | 1.210 | 1.027 | 1.076 |
| $\Delta\varepsilon$ | 0.0261 | 0.0212 | 0.0198 | - | - | 0.0068 | - |
| $\mu$ | - | - | - | 0.295 | 0.212 | - | 0.282 |
| $\lambda$ | 19.12 | 11.19 | 9.84 | - | - | 2.73 | - |
| N | 0.105 | 0.061 | 0.050 | 0.030 | 0.089 | 0.015 | 0.040 |
| $L_{r\,max}^{est}$ | - | - | - | 1.020 | 1.009 | - | 1.018 |

Three different Failure Assessment Lines have been drawn for each material (Default, Basic and SS in SINTAP Procedure Rev 5 and noted herein as FAD 0, 1 and 3 respectively).

## 3. TOUGHNESSES CONSIDERED

From the Charpy values, different toughnesses can be taken into acount depending upon the test temperature (-20°C for all plates) whether this is higher than the transition one or not, thus depending if the material is either on the lower or transition regime or on the upper shelf.

If the material is above or near the transition temperature (T27J), two different equations from Section CH can be used (Eq. 2 -lower bound- and Eq. 3 -Master curve- of SINTAP Revision 5). Only Plate 5 can be said that behaves on the lower shelf. If the material is on the upper shelf, Equation 11 from Section CH should be used instead the previous ones.

These three options have been noted as Toughness 1*, 1** and 1 respectively in the following tables and figures.

On the other hand, if CTOD-values are considered, these can be translated into K-values by means of Equations 5 and 6 in the mentioned Section CH. Factors 1.5 and 1.3 have been used for yield and flow stress respectively and plane strain has been supposed (E=210 GPa, ν=0.3).

| **Plate** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| l≈B | 135 | 135 | 135 | 135 | 135 | 135 | 135 |
| $K_{mat25}$ | - | - | - | - | 71.0 | - | - |
| $P_f$ | - | - | - | - | 0.05 | - | - |
| $K_{mat}$ (1*) (MPam$^{1/2}$) | - | - | - | - | 53.5 | - | - |
| $K_{mat}$ (1**) (MPam$^{1/2}$) | - | - | - | - | 59.9 | - | - |
| $K_{mat}$ (1) (MPam$^{1/2}$) | 106.5 | 189.8 | 201.9 | 128.1 | - | 172.1 | 167.3 |
| $K_{mat}$ (2) (MPam$^{1/2}$) | 319.6 | 336.0 | 474.7 | 136.9 | 86.9 | 188.1 | 237.9 |

## 4. CRACKS CONSIDERED

All the flaws analysed within this work have been considered as Finite surface crack in a plate. For some plates two different crack sizes have been studied; the real one and a nominal one of 5 mm.
The dimensions are summarised in the following table:

| **Plate** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| l (mm) | 135 | 135 | 135 | 135 | 135 | 135 | 135 |
| t (mm) | 25 | 25 | 25 | 25 | 25 | 12 | 40 |
| a real (mm) | 5 | 6.5 | 6.8 | 5.5 | 5 | 3.1 | 8.4 |
| a nominal | - | 5 | 5 | 5 | - | - | - |

## 5. $L_r$ AND $K_I$ SOLUTIONS

From Stress Intensity Factor and Limit Load Handbook, Issue 1, September 1998,

*$L_r$ (AII.42):*

$$L_r = \frac{\sigma}{(1-\zeta)\sigma_Y}$$

where

$$\zeta = \frac{al}{t(l+2t)}$$

*$K_I$ (AI.3) -deepest point of the crack-:*

$$K_I = \sigma f_0 \sqrt{\pi a}$$

(Linear interpolation has been used for $f_0$ determination)

The following table details the corresponding factor $\zeta$ and $f_0$ values for the plates.

| **Plate** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| ζ (real a) | 0.1459 | 0.1897 | 0.1985 | 0.1605 | 0.1459 | 0.2193 | 0.1319 |
| $f_0$ (real a) | 1.2151 | 1.2904 | 1.3026 | 1.2421 | 1.2151 | 1.3991 | 1.1753 |
| ζ (nominal a) | - | 0.1459 | 0.1459 | 0.1459 | - | - | - |
| $f_0$ (nominal a) | - | 1.2151 | 1.2151 | 1.2151 | - | - | - |

## 6. RESULTS

The maximum acceptable applied stress for each plate, crack, toughness and FAD considered are pointed out in the table where the results are in MPa.

| Plate | Crack size | Toughness | FAD 0 | FAD 1 | FAD 3 |
|---|---|---|---|---|---|
| 1 | 5 | 1 | 259 | 259 | 259 |
| | | 2 | 259 | 291 | 329 |
| 2 | 5 | 1 | 372 | 372 | 419 |
| | | 2 | 372 | 398 | 420 |
| | 6.5 | 1 | 353 | 353 | 398 |
| | | 2 | 353 | 371 | 398 |
| 3 | 5 | 1 | 402 | 404 | 412 |
| | | 2 | 402 | 438 | 441 |
| | 6.8 | 1 | 378 | 378 | 378 |
| | | 2 | 378 | 405 | 413 |
| 4 | 5 | 1 | 558 | 589 | 604 |
| | | 2 | 572 | 606 | 610 |
| | 5.5 | 1 | 537 | 566 | 589 |
| | | 2 | 551 | 583 | 595 |
| 5 | 5 | 1* | 337 | 338 | - |
| | | 1** | 374 | 375 | - |

| | | | | | |
|---|---|---|---|---|---|
| | | 2 | 513 | 519 | - |
| 6 | 3.1 | 1 | 640 | 647 | 629 |
| | | 2 | 640 | 651 | 633 |
| 7 | 8.4 | 1 | 589 | 623 | 639, 658 |
| | | 2 | 659 | 661 | 672 |

# 7. ANNEX

The following pages present all the assessment graphics needed to perform the calculations.

**Plate 1. S275J0**

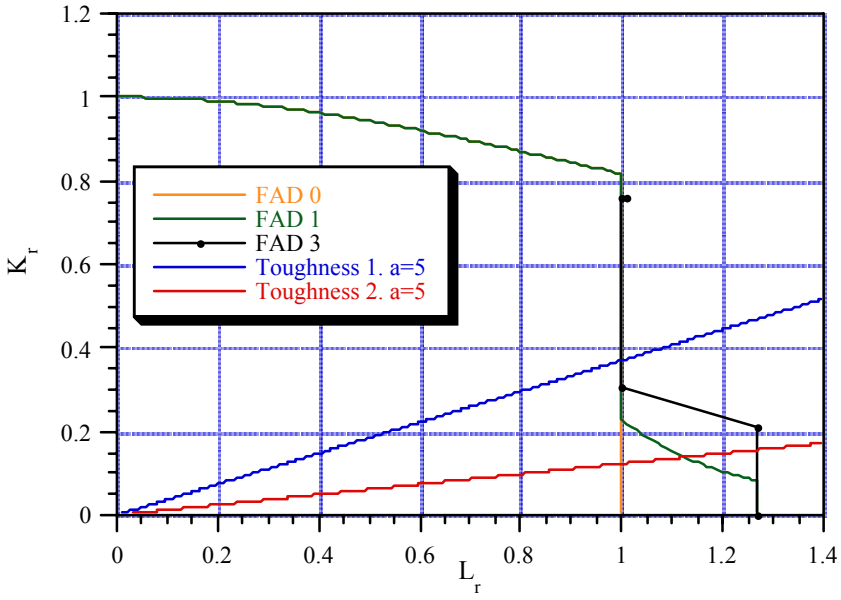


**Plate 2. 355EMZ**

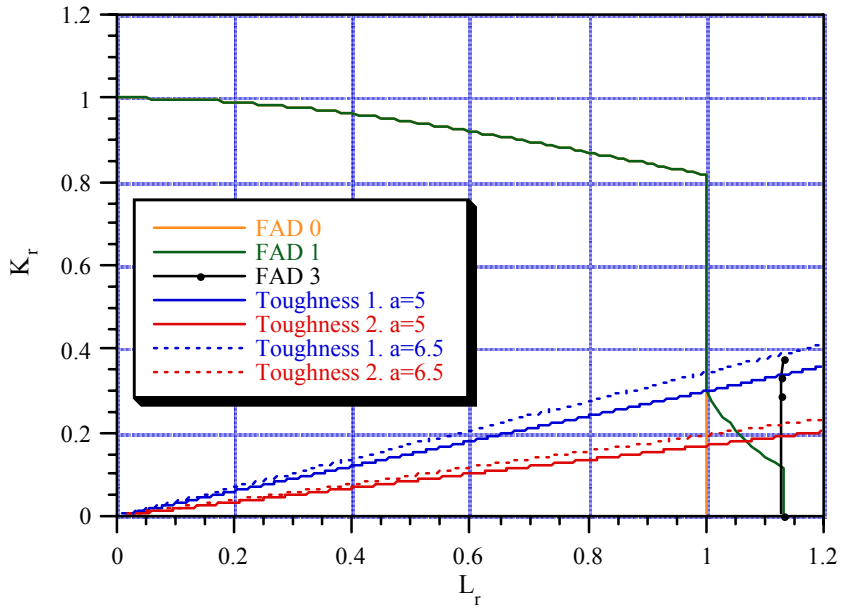

**Plate 3. 450EMZ**

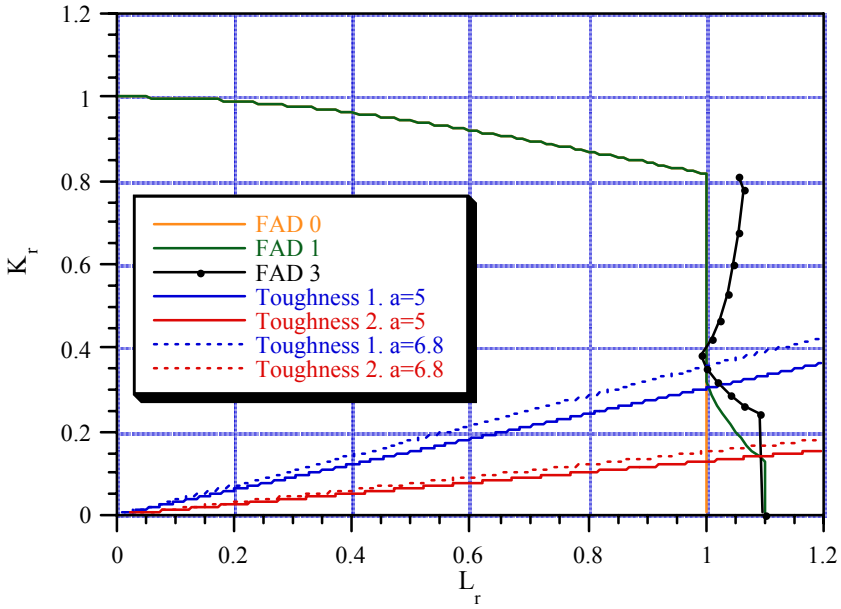


**Plate 4. S690Q**

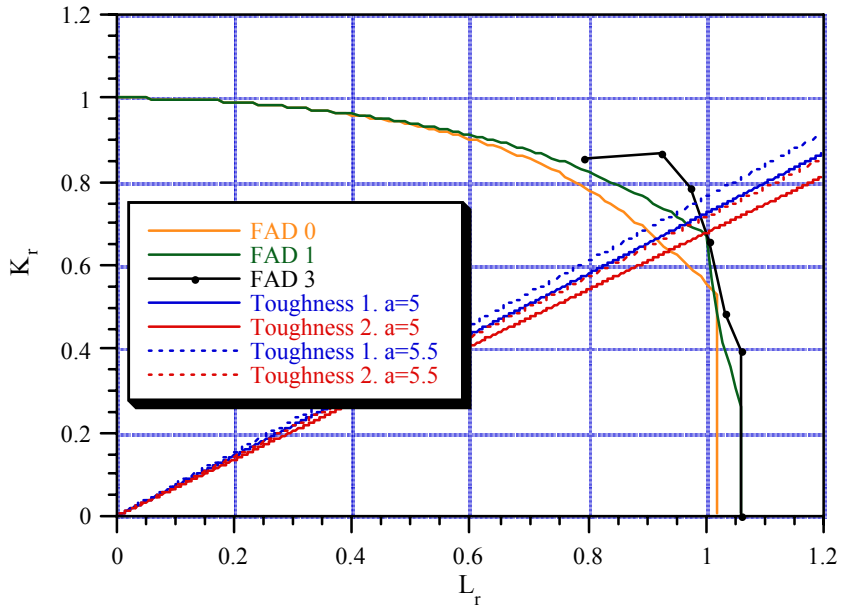

**Plate 5. ABRAZO400**

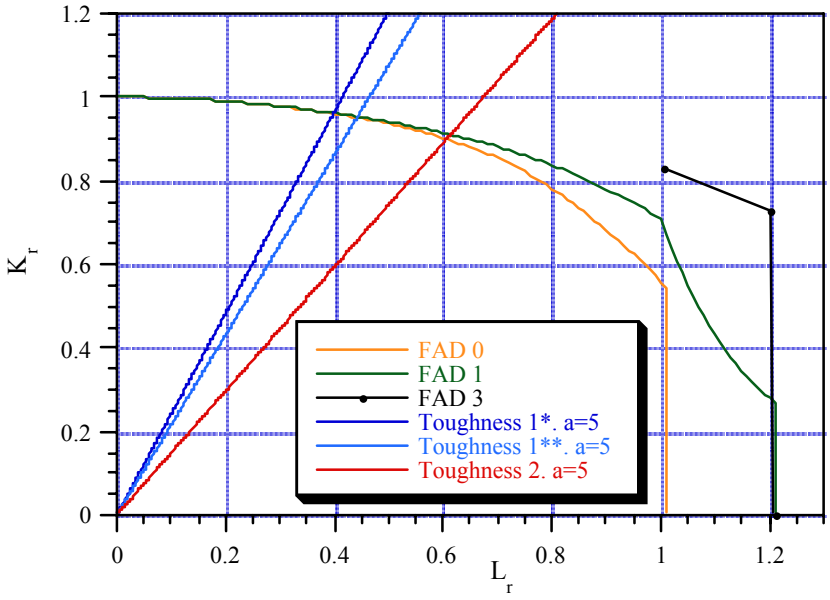


**Plate 6. S690Q (12mm)**

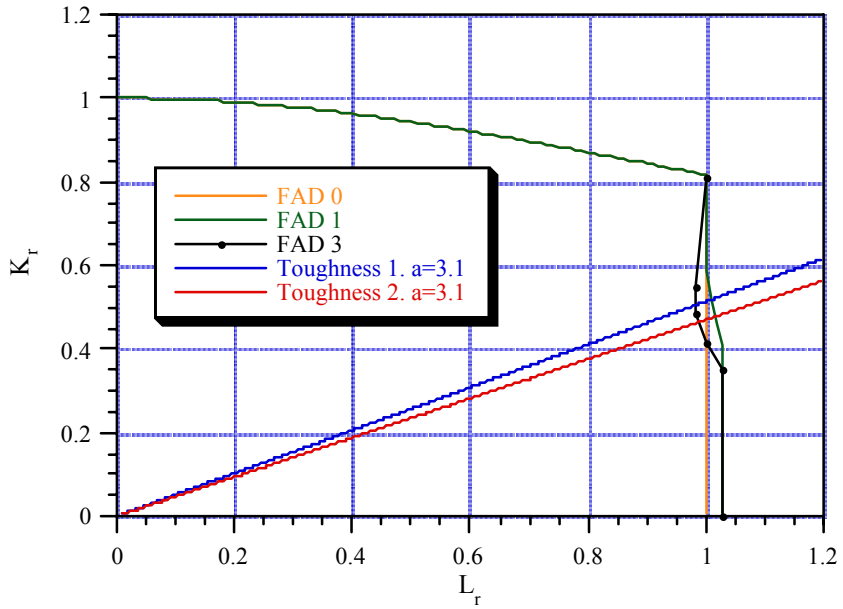

**Plate 7. S690Q (40mm)**