

## TALAT Lecture 2406 – Annex 1

### An Update of TALAT Chapter 2400

# Fatigue and Fracture in Aluminium Structures Proposal for a National Application Document (Updated from the TAS project)

TAS



Leonardo da Vinci program  
Training in Aluminium Alloy Structural Design

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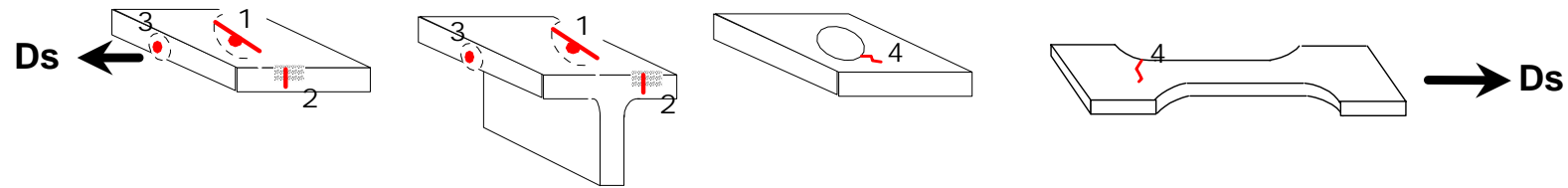
6 pages

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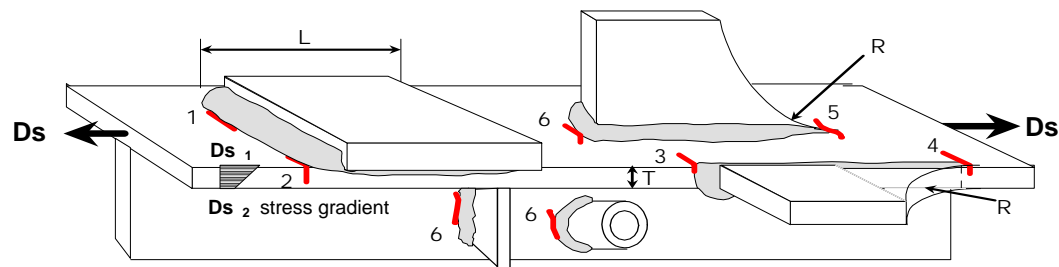
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**Table 5.1.1\* Detail Categories for Plain Material**



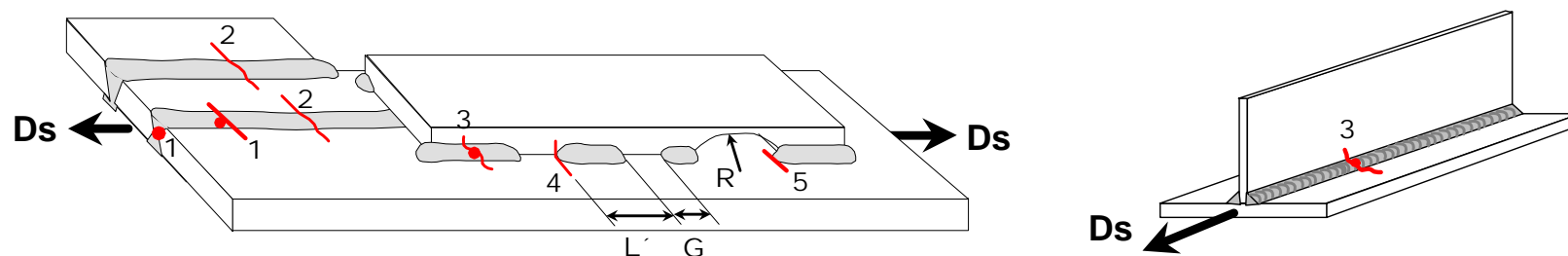
|   |   |  |                              |   |                              |  |                              |  |               |
|---|---|--|------------------------------|---|------------------------------|--|------------------------------|--|---------------|
| Product Forms   |   | Simple Extruded Rod and Bar, Machined Parts  |                              | Sheet, Plate, Extrusions, Tubes, Forgings                       |                              | Notches, Holes                             |                              | Castings   |               |
| Initiation Site   | Reference No.                             | 1, 2   |                              | 1, 2  |                              | 4  |                              | 1  | 3             |
|   | Location                                  | Small surface irregularity   |                              |   |                              |  |                              | Cast material  |               |
| Stress orientation (see 4.3.4)  |   | PARALLEL or NORMAL <sup>1)</sup> to rolling or extrusion direction                               |                              |   |                              |  |                              | -  | -             |
| Alloys  |   | 7020   | As table 1.1.1 (except 7020) | 7020  | As table 1.1.1 (except 7020) | 7020                                       | As table 1.1.1 (except 7020) | As Table 1.1.2   |               |
| Particular Requirements   | Dimensional                               | Surfaces free of sharp corners unless parallel to stress direction; Edges free of stress raisers |                              |   |                              |  |                              |  |               |
|   |   | No re-entrant corners in profile, No contact with other parts                                    |                              | -   |                              |  |                              |  |               |
|   | Fabrication                               | Machining only by high speed milling cutters   |                              | Hand grinding not permitted unless parallel to stress direction |                              | Holes drilled and reamed                   |                              | Casting as per Table 1.1.2<br>Machining only by high speed milling cutters |               |
|   | Inspection/Testing                        | Visual   |                              |   |                              |  |                              | Dye Penetrant  | Radiography   |
|   | Quality Standard                          | Surface finish ( $R_a < 0.5\text{mm}$ )  |                              | No score marks transverse to stress direction                   |                              | -  |                              | see Chapter 6*   |               |
| Stress Analysis   | Stress parameter                          | Principal structural stress at initiation site   |                              |   |                              | Account for stress concentration Annex A.4 |                              | Principal structural stress at initiation site                             |               |
|   | Stress concentrations already allowed for | Surface texture  |                              |   |                              |  |                              | Permitted internal porosity  |               |
| Type Number   |   | 1.1  | 1.2                          | 1.3   | 1.4                          | 1.5  | 1.6                          | 1.7  | 1.8           |
| Detail Category $\Delta\sigma - m_1$ <sup>2)</sup>  |   | <b>130 - 7</b>   | <b>95 - 7</b>                | <b>85 - 7</b>   | <b>70 - 7</b>                | as Types 1.1 to 1.4                        |                              | <b>70 - 7</b>  | <b>70 - 7</b> |
| <sup>1)</sup> The manufacturer shall be consulted concerning the quality assurance in case of extrusions by port hole or bridge die<br><sup>2)</sup> $m_1 = m_2$ , constant amplitude fatigue limit at $2 \times 10^6$ cycles |   |  |                              |   |                              |  |                              |  |               |

**Table 5.1.2\*** Detail Categories for Members with Welded Attachments - Transverse Weld Toe



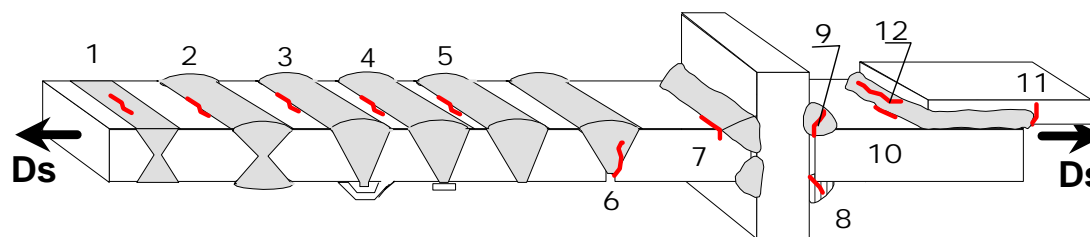
| Product Forms                                    |   | Rolled, extruded and forged products  |  |                 |           |   |         |                          |                            |   |                           |                                  |   |           |  |
|--|---|---|--|-----------------|-----------|---|---------|--------------------------|----------------------------|---|---------------------------|----------------------------------|---|-----------|--|
| Initiation Site                                  | Reference No.                             | 1   |  |                 | 2         |   | 3       |                          | 4                          |   | 5                         |                                  | 6 |           |  |
|  | Location                                  | At transverse weld toe on stressed member   |  |                 |           |   |         | At longitudinal weld end |                            | At transverse weld toe on stressed member               |                           |                                  |   |           |  |
|  |   | On surface away from edge   |  |                 | At corner |   | On edge |                          | In ground weld toe on edge |   | On surface away from edge |                                  |   |           |  |
| Stress orientation (see 4.3.4)                   |   | Normal to transverse weld toe   |  |                 |           |   |         | Parallel to weld axis    |                            |   |                           | Normal to weld toe               |   |           |  |
| Alloys   |   | As table 1.1.1  |  |                 |           |   |         |                          |                            |   |                           |                                  |   |           |  |
| Particular Requirements                          | Dimensional                               | Attachment on member surface  |  |                 |           | Attachment on member edge               |         |                          |                            | Attachment on member surface                            |                           |                                  |   |           |  |
|  |   | Weld on surface away from corner  |  |                 |           | Welded round corner                     |         | Weld on edge             |                            |   |                           | Weld on surface away from corner |   |           |  |
|  |   | Length L (mm)   |  | L > 20          |           | L and T as for                          |         | No radius                |                            | R ≥ 50  |                           | R ≥ 50                           |   | No radius |  |
|  |   | Thickness T (mm)  |  | see table below |           |   |         | Types 2.1 and 2.2        |                            |   |                           |                                  |   |           |  |
|  |   | Fabrication   |  |                 |           | Grind undercut smooth                   |         |                          |                            | Grind radius parallel to stress direction <sup>1)</sup> |                           |                                  |   |           |  |
|  |   | Inspection/Testing  |  |                 |           | see chapter 6*                          |         |                          |                            |   |                           |                                  |   |           |  |
|  | Quality in acc. to EN 30 042              | internal  |  | C               |           |   |         |                          |                            |   |                           |                                  |   |           |  |
|  |   | geometrical   |  | C               |           |   |         |                          |                            |   |                           |                                  |   |           |  |
| Stress Analysis                                  | Stress parameter                          | Nominal stress at initiation site   |  |                 |           |   |         |                          |                            |   |                           |                                  |   |           |  |
|  | Stress concentrations already allowed for | Discontinuities permitted as given in EN 30042  |  |                 |           |   |         |                          |                            |   |                           |                                  |   |           |  |
|  |   | Stiffening effect of attachment   |  |                 |           |   |         |                          |                            |   |                           |                                  |   |           |  |
| Type Number                                      |   | 2.1   |  | 2.2             |           | 2.3                                     |         | 2.4                      |                            | 2.5   |                           | 2.6                              |   | 2.7       |  |
| <b>Detail Category <math>\Delta\sigma</math></b> |   | T ≤ 4   |  | 25              |           | As Types 2.1 to 2.2, but reduced by 12% |         | 18                       |                            | 35  |                           | 35                               |   | 23        |  |
| $m_1 = 3,4$ , $m_2 = 5,4$ for all Types          |   | 31  |  | 22              |           |   |         |                          |                            |   |                           |                                  |   |           |  |
|  |   | 31  |  | 20              |           |   |         |                          |                            |   |                           |                                  |   |           |  |
| Adjustment for stress gradient                   |   | Where $\Delta\sigma_1$ and $\Delta\sigma_2$ are of opposite sign increase by 2 Categories where T ≤ 15 mm |  |                 |           |   |         |                          |                            |   |                           |                                  |   |           |  |
| <sup>1)</sup> Weld toe shall be fully ground out |   |   |  |                 |           |   |         |                          |                            |   |                           |                                  |   |           |  |

**Table 5.1.3\*** Detail Categories for Members with Welded Attachments - Longitudinal Welds



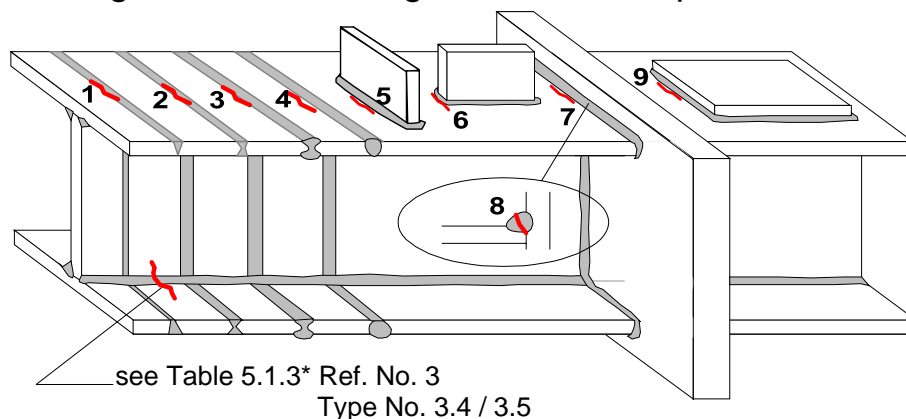
|   |   |  |                 |                 |                        |                          |                                |                       |
|---|---|--|-----------------|-----------------|------------------------|--------------------------|--------------------------------|-----------------------|
| Product Forms   |   | Rolled, extruded and forged products                     |                 |                 |                        |                          |                                |                       |
| Initiation Site   | Reference No.                             | 1  |                 |                 | 2                      | 3                        | 4                              | 5                     |
|   | Location                                  | A weld discontinuity                                     |                 |                 |                        | Weld toe or crater       |                                |                       |
| Stress orientation (see 4.3.4)  |   | Parallel to weld axis                                    |                 |                 |                        |                          |                                |                       |
| Alloys  |   | As Table 1.1.1   |                 |                 |                        |                          |                                |                       |
| Particular Requirements   | Dimensional                               | Full penetration butt weld                               |                 |                 | Continuous fillet weld | Intermittent fillet weld | Cope hole centred on weld axis |                       |
|   | Fabrication                               | Continuous automatic welding                             |                 |                 |                        | $G \leq 2.5L$            | $R \leq 25\text{mm}$           |                       |
|   |   | Weld caps ground flush in direction of $\Delta\sigma$    |                 |                 | 2)                     |                          |                                |                       |
|   |   | Any backing bars (and attachment welds) to be continuous |                 |                 |                        |                          |                                |                       |
|   | Inspection/Testing                        | see Chapter 6*   |                 |                 |                        |                          |                                |                       |
| Quality in acc. to EN 30 042  | internal                                  | B  | C               | C               | B                      | C                        | C                              | C                     |
|   | geometrical                               | C  | C               | D               | C                      | D                        | D                              | D                     |
|   | add. requirements                         |  |                 | 1)              | 3)                     |                          |                                |                       |
| Stress Analysis   | Stress parameter                          | Nominal stress at initiation site                        |                 |                 |                        |                          |                                |                       |
|   | Stress concentrations already allowed for | Weld discontinuities as permitted by EN 30 042           |                 |                 |                        |                          |                                | Presence of cope hole |
| Type Number   |   |  |                 |                 |                        |                          |                                |                       |
| <b>Detail Category <math>\Delta\sigma - m_1</math> (<math>m_2 = m_1 + 2</math>)</b>   |   | <b>60 - 4,3</b>  | <b>55 - 4,3</b> | <b>45 - 4,3</b> | <b>45 - 4,3</b>        | <b>40 - 4,3</b>          | <b>35 - 4,3</b>                | <b>28 - 3,4</b>       |
| <sup>1)</sup> Ripple/imperfection no. 504/EN 30 042:B <sup>2)</sup> imperfection due to stop-start effect shall be checked <sup>3)</sup> Discontinuity in direction of longitudinal weld shall not be higher than $1/10$ of plate thickness or exhibit slope steeper than 1:4 |   |  |                 |                 |                        |                          |                                |                       |

**Table 5.1.4\* Detail Categories for Welded Joints between Members**



| Product Forms                        |   | Rolled, extruded and forged products   |  |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               | Castings |  |  |
|--------------------------------------|---|--|--|---------------|---------------|---------------|---------------|---------------|------------------|------------------|------------------|---|-----------------------------|---------------|------------------|---------------|---------------------------|---------------|---------------|----------|--|--|
| Initiation Site                      | Reference No.                             | 1  | 2  |               | 3, 4          |               | 5             |               | 6                | 7                | 8                | 9                                       | 10                          | 11            | 12               |               |                           |               |               |          |  |  |
|                                      | Location                                  | weld, base material  |  |               |               |               |               | weld          | base material    |                  | weld             |   |                             | base material |                  | weld          |                           |               |               |          |  |  |
| Stress orientation (see 4.3.4)       |   | Normal to weld axis  |  |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               |          |  |  |
| Alloys                               |   | As table 1.1.1   |  |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               |          |  |  |
| Particular Requirements              | Dimensional                               | Joint type   | In-line-butt   |               |               |               |               |               |                  |                  |                  | Cruciform or Tee                        |                             |               |                  |               | Lap                       |               |               |          |  |  |
|                                      |   | Weld type  | Butt   |               |               |               |               |               |                  |                  |                  |   | Double fillet <sup>1)</sup> |               | One sided fillet |               |                           | Fillet        |               |          |  |  |
|                                      |   | Preparation  | Double sided   |               |               |               | Single sided  |               |                  |                  |                  | edge preparation                        |                             |               |                  |               |                           |               |               |          |  |  |
|                                      |   | Penetration  | Full   |               |               |               |               |               |                  |                  | Partial          |   | Full                        |               | Partial          |               |                           |               |               |          |  |  |
|                                      |   | Transition   | Taper slope < 1:4 at width or thickness change   |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               |          |  |  |
|                                      | Manufacturing                             | Root   | Ground   |               |               |               | Backed        |               | Unbacked         |                  |                  |   | Ground                      |               |                  |               |                           |               |               |          |  |  |
|                                      |   | Cap  | Ground flush   |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               |          |  |  |
|                                      |   | Ends   | Extension plates used on ends, cut off and ground flush in direction of $\Delta\sigma$ |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               |          |  |  |
|                                      | Inspection/Testing                        |  | see Chapter 6*   |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               |          |  |  |
|                                      | Quality in acc. to EN 30 042              | internal   | B  | C             | B             | B             | C             | C             | C                | B                | C                | C                                       | D                           | B             | C                | C             | C                         | C             | C             | C        |  |  |
| geometrical                          |   | B  | C  | C             | B             | C             | C             | C             | B                | C                | C                | C                                       | B                           | C             | C                | C             | C                         | C             | C             |          |  |  |
| add. requirements                    |   |  | <sup>3)</sup>  | <sup>3)</sup> | <sup>3)</sup> | <sup>3)</sup> | <sup>3)</sup> | <sup>3)</sup> | <sup>2) 3)</sup> | <sup>2) 3)</sup> | <sup>2) 3)</sup> | <sup>3)</sup>                           | <sup>2) 3)</sup>            | <sup>3)</sup> | <sup>3)</sup>    | <sup>3)</sup> | <sup>3)</sup>             | <sup>3)</sup> | <sup>3)</sup> |          |  |  |
| Stress Analysis                      | Stress parameter                          | net section  |  |               |               |               |               |               |                  |                  | net throat       | net section                             |                             |               | net throat       |               |                           | net section   | net throat    |          |  |  |
|                                      | Stress concentrations already allowed for |  |  |               |               |               |               |               |                  |                  |                  | Stiffening effect of transverse element |                             |               |                  |               | stress peaks at weld ends |               |               |          |  |  |
| Type Number                          |   | 4.1 fl   | 4.1 op   | 4.2 fl        | 4.2 op        |               | 4.3 fl        | 4.3 op/ho     | 4.4 fl           |                  | 4.4 op/ho        | 4.5                                     | 4.6                         | 4.7           | 4.8              | 4.9           |                           | 4.10          | 4.11          | 4.12     |  |  |
| Detail Category $\Delta\sigma - m_1$ |   | 55-7   | 45-7   | 50-4,3        | 40-3,4        | 35-3,4        | 40-4,3        | 30-3,4        | 45-4,3           | 40-4,3           | 30-3,4           | 18-3,4                                  | 35-3,4                      | 30-3,4        | 25-3,4           | 12-3,4        | 23-3,4                    | 18-3,4        | 14-3,4        |          |  |  |
| Footnote 1)                          |   | Round tubes one sided fillet   |  |               |               |               |               |               |                  |                  |                  |   |                             | Footnote 2)   |                  |               |                           |               |               |          |  |  |
| Footnote 2)                          |   | Imperfection no. 402 / EN 30 042 not allowed   |  |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               |          |  |  |
| Footnote 3)                          |   | Discontinuity in direction of longitudinal weld shall not be higher than $1/10$ of plate thickness or exhibit slope steeper than 1:4 |  |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               |          |  |  |
| Footnote 3)                          |   | fl: Flats, Solids / op: Open Shapes / ho: Hollow, Tubular  |  |               |               |               |               |               |                  |                  |                  |   |                             |               |                  |               |                           |               |               |          |  |  |

**Table 5.1.5\* Detail Categories for Crossing Welds / Built-up Beams**



| Product Forms                        |                              |   |  |              |              |              |                                  |               |            |                           |            |
|--------------------------------------|------------------------------|---|--|--------------|--------------|--------------|----------------------------------|---------------|------------|---------------------------|------------|
| Initiation Site                      | Reference No.                | 1   | 2  | 3            | 4            | 5            | 6                                | 7             | 8          | 9                         |            |
|                                      | Location                     | Weld  |  |              |              |              |                                  | Base Material | Weld       | On surface away from edge |            |
| Stress orientation                   | (see 4.3.4)                  |   |  |              |              |              |                                  |               |            |                           |            |
| Alloys                               |                              |   |  |              |              |              |                                  |               |            |                           |            |
| Particular Requirements              | Dimensional                  | Joint type                                      |  |              |              | In-line-butt |                                  | Attachment    |            | Cruciform or tee          | Coverplate |
|                                      |                              | Weld type                                       |  |              |              | Butt         |                                  |               |            |                           | Fillet     |
|                                      |                              | Preparation                                     | Single sided                                   | Double sided | Double sided | Single sided |                                  |               |            | Double sided              |            |
|                                      |                              | Penetration                                     |  |              |              | Full         |                                  |               |            |                           |            |
|                                      |                              | Transition                                      | Taper slope < 1:4 at width or thickness change |              |              |              |                                  |               |            |                           |            |
|                                      | Manufacturing                | Root  | Ground flush                                   | Ground       |              |              |                                  |               |            |                           |            |
|                                      |                              | Cap   | Ground flush                                   | Ground       |              |              |                                  |               |            |                           |            |
|                                      |                              | Ends ??   |  |              |              | 1)           |                                  |               |            |                           |            |
|                                      | Inspection/Testing           |   | see Chapter 6*                                 |              |              |              |                                  |               |            |                           |            |
|                                      | Quality in acc. to EN 30 042 | internal  | B  | B            | B            | C            | C                                | C             | C          | C                         | C          |
| geometrical                          |                              | B   | B  | C            | C            | C            | C                                | C             | C          | C                         |            |
| add. requirements                    |                              | for web-to-flange fillet welds $\Rightarrow$ 2) |  |              |              |              |                                  |               |            |                           |            |
| Stress Analysis                      | Stress parameter             | net section                                     |  |              |              |              |                                  |               | net throat | net section               |            |
|                                      | Stress concentrations        | already allowed for                             |  |              |              |              | Stiffening effects of attachment |               |            |                           |            |
| Type Number                          |                              | 5.1   |  | 5.2          | 5.3          | 5.4          | 5.5                              | 5.6           | 5.7        | 5.8                       |            |
| Detail Category $\Delta\sigma - m_1$ |                              | 40-3,4  |  | 35-3,4       | 30-3,4       | 18-3,4       | 23-3,4                           | 30-4,3        | 25-4,3     | 20-4,3                    |            |

1) Transverse web and flange butt joint before final assembly of beam with longitudinal welds 2) see Table 5.1.3\* Reference No. 3 / Type No. 3.4 or 3.5