



DESIGN AND PRODUCTION OF HIGH-TECH COMPONENTS OF CABLEWAY VEHICLES

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INTRODUCTION

Vehicles

European Directive 2000/9 CE

- Risk analysis

Safety components according EN 13796

- Structural verification
- Quality requirements for material and welding process
- Traceability



MM PisaMover, IT



GD10 Castelir Le Fassane, IT






GD10 Genting Highlands, MY



CD8C Enzian, Racines, IT

3S EISGRATBAHN – STUBAIER GLETSCHER

TD32 Eisgratbahn I - II

-  4686 m
-  1188 m
-  3014 p/h
-  997 kW
-  48
-  7

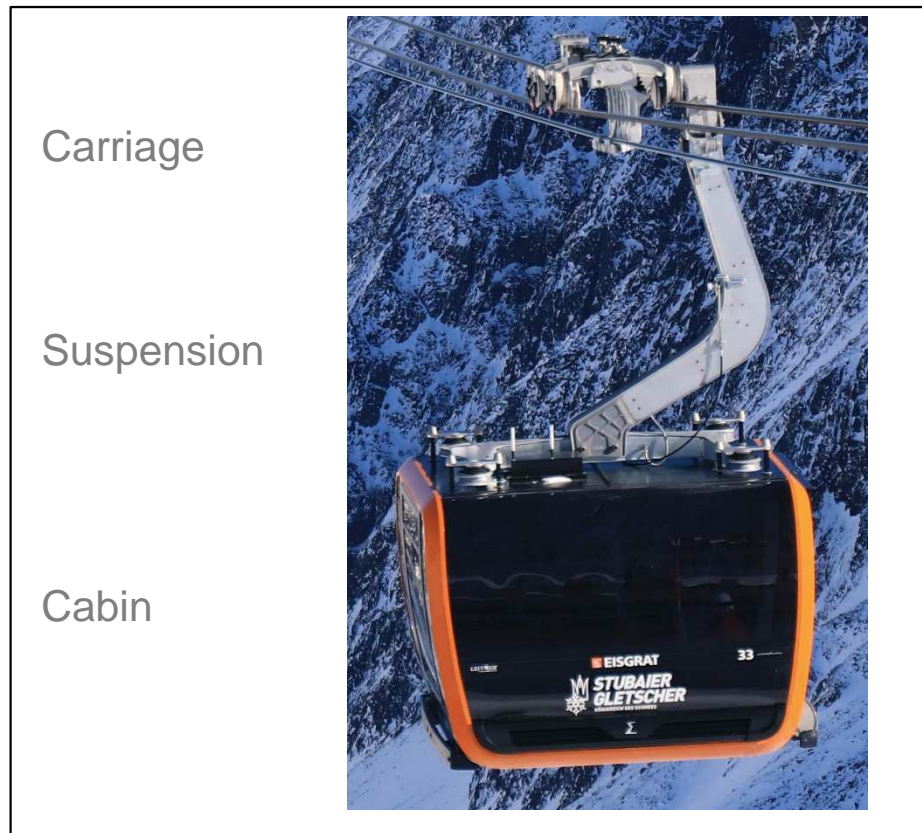


Neustift (Stubai) / AT

2016

DESIGN

3S Vehicle – Safety components



3S Vehicle

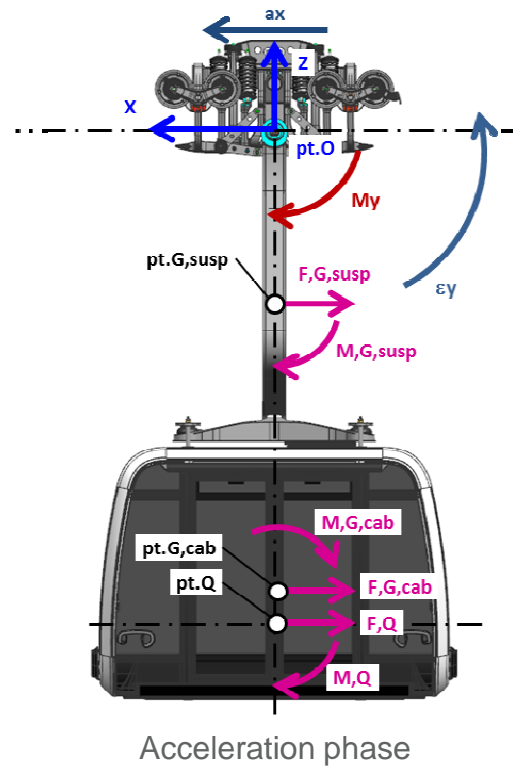
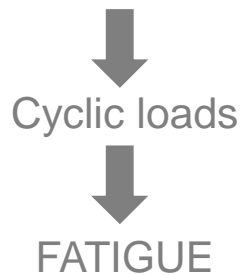
DESIGN

Load assessment and project life

Loads:

- Gravity loads
 - Self-weight
 - Pay load
- Dynamic loads
 - Passages on Towers
 - Acceleration
 - Deceleration
- Environmental loads
 - Wind

The load cases repeat at each travel of the vehicle



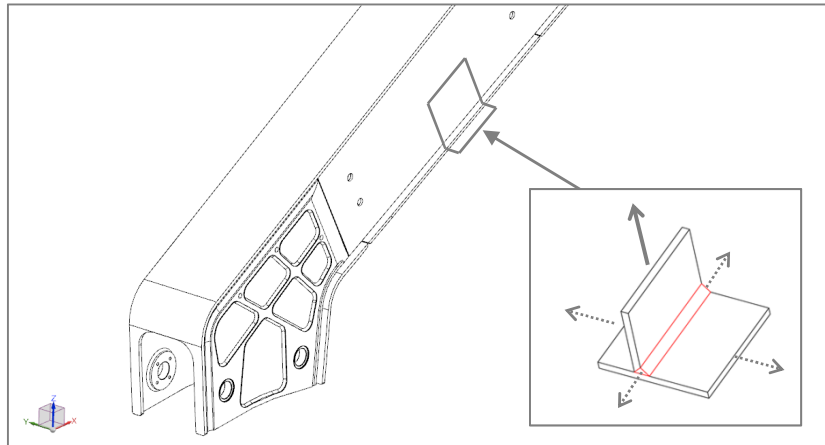
3S Eisgratbahn

| Operation mode | |
|----------------------------|------------------|
| Operating days: | 310 d/y |
| Operating hours at day: | 12 h/d |
| Operating hours at year: | 3720 h/y |
| Design length of the line: | 4100 m |
| Operational speed: | 7 m/s |
| Travel time: | 586 s |
| Time into stations | 150 s |
| Number of travel for hour: | 4.89 travel/h |
| Total travels at year | 18203 travel/y |
| Fatigue design life | |
| Operational year: | 40 y |
| Total travels: | 728.11E+3 travel |
| Total number of event | |
| Event: | Ni |
| acceleration | 1.5E+6 |
| braking | 1.5E+6 |
| entering station | 436.9E+3 |
| tower | 6.6E+6 |
| deviation | 1.5E+6 |
| boarding | 728.1E+3 |

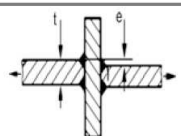
Resistance criteria and local FEM model

Resistance criteria:

- Use of classes FAT IIW-FKM for welded details



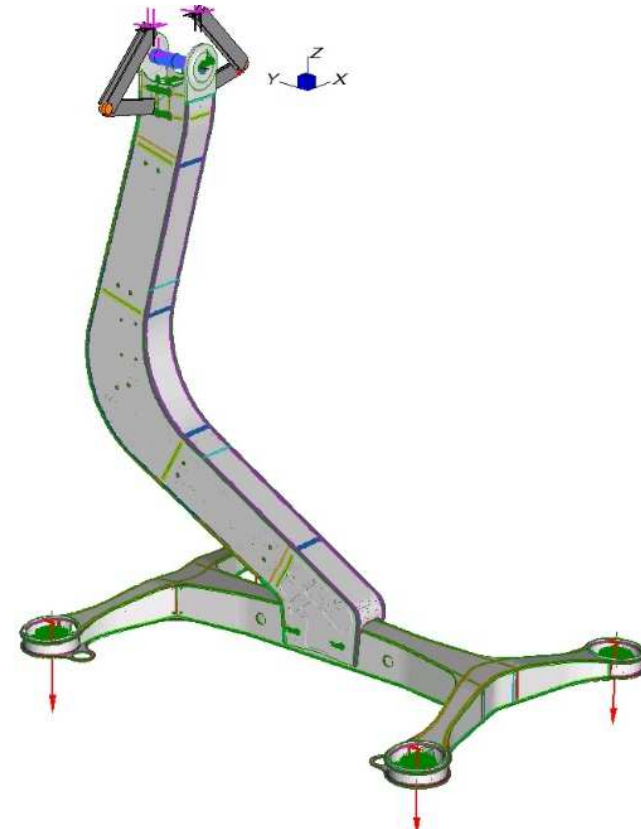
Structural detail identification

| No. | Structural Detail | Description (St. = steel; Al. = aluminium) | FAT St. |
|-----|---|--|------------|
| 412 |  | Cruciform joint or T-joint, K-butt welds, full penetration, potential failure from weld toe Single sided T-joints | 71 80 |

Detail reference
A.F. Hobbacher – IIW-2259-15

Stress calculation:

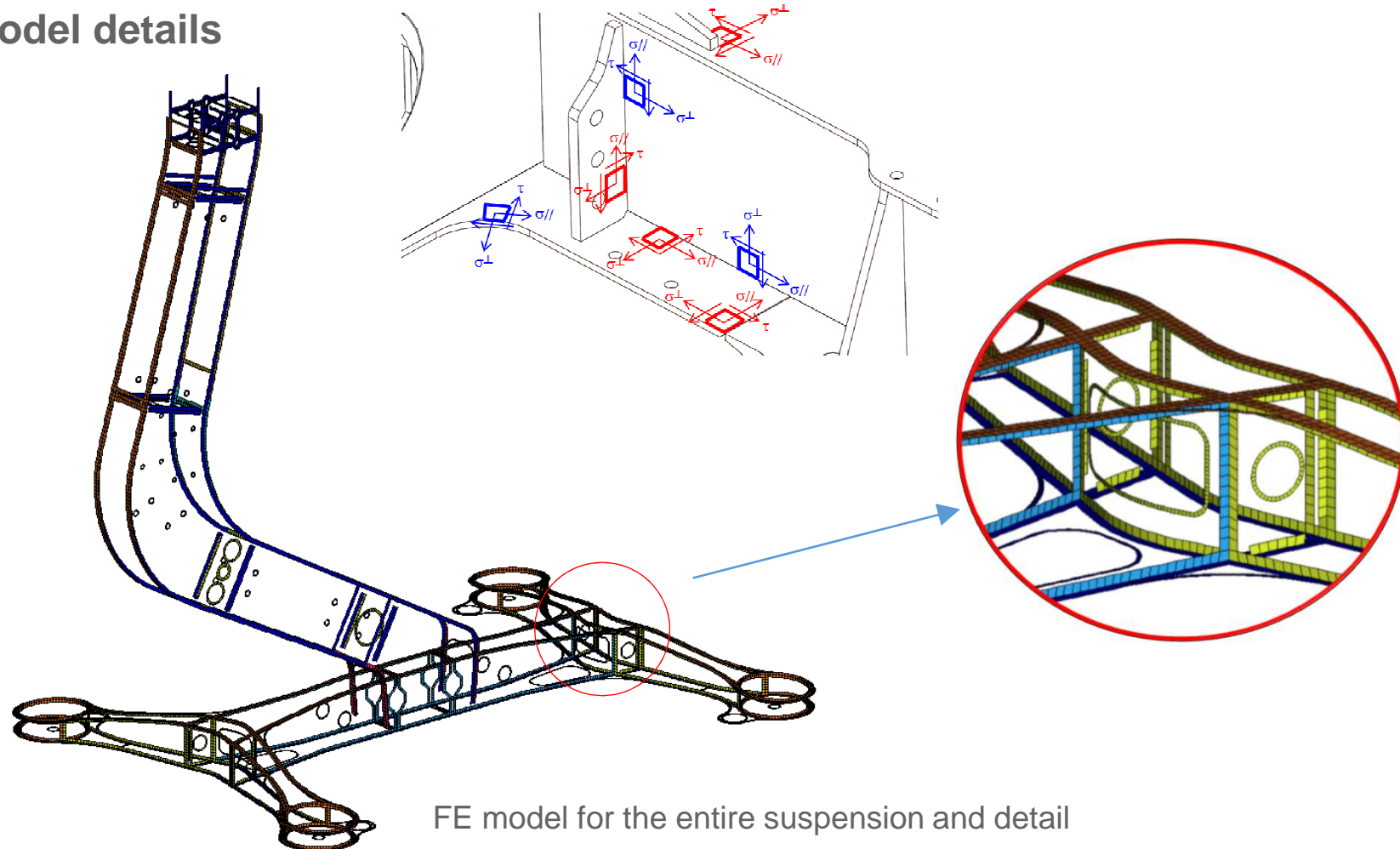
- «Nominal» local stress
- Shell-brick FE model



FE model for the entire suspension

DESIGN

FE model details



FE model for the entire suspension and detail

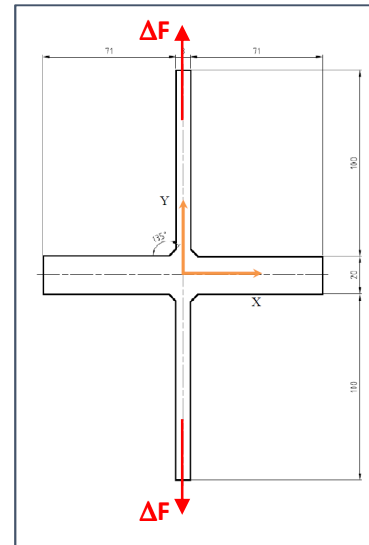
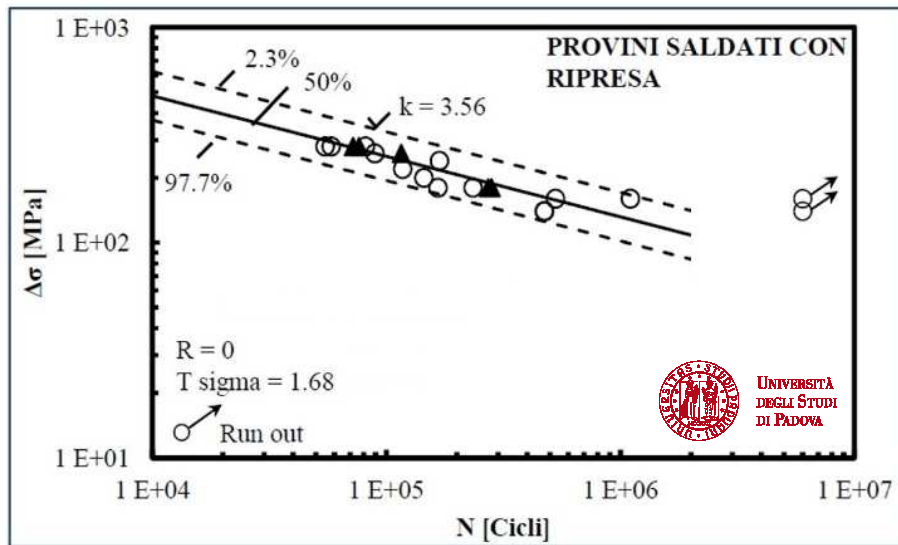
DESIGN – Experimental evaluation of resistance category

Evaluation of design FAT class:

- FAT class IIW-FKM
- Correlation between FAT class and quality level (B, C, D) secondo ISO 5817
- Experimental evaluation

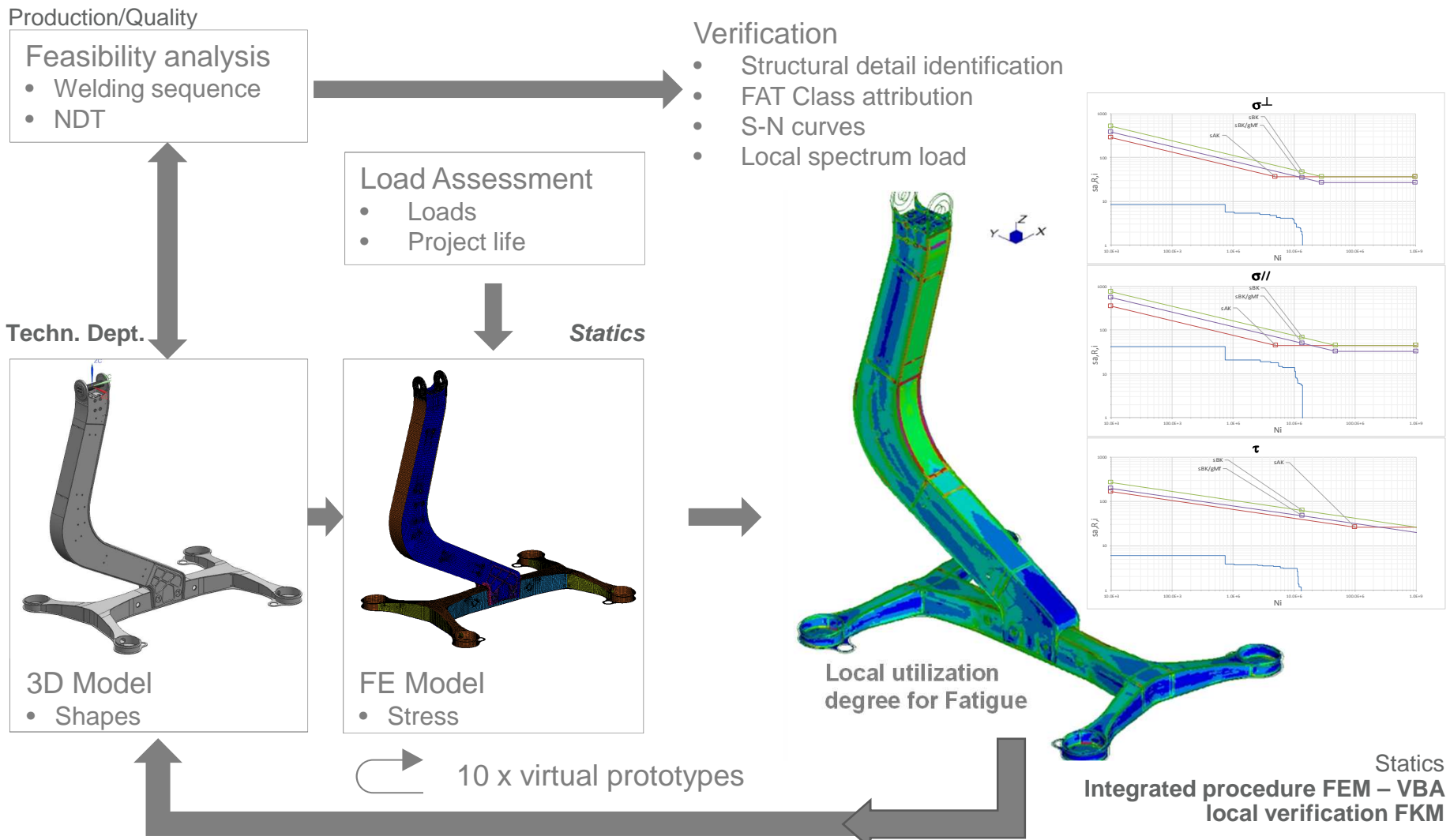


- A. Hobbacher and M. Kassner (2012)
On relation between fatigue properties of welded joints vs. quality criteria and groups in ISO 5817
IIW doc. XIII-2323r1-10. Weld World 11–12
- A. Hobbacher (2016)
Raccomandazioni for fatigue design of welded joints and components – Second edition
IIW doc. IIW-2259-15



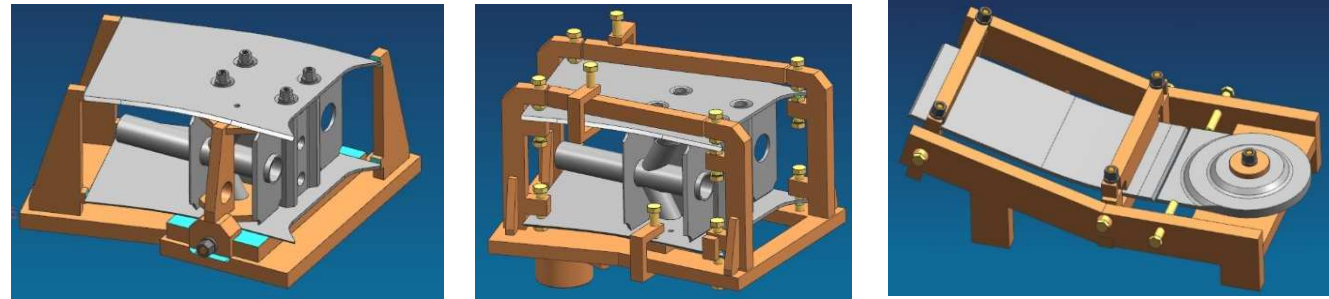
L. Pierobon - Determinazione delle classi di resistenza di dettagli strutturali con approcci locali e prove sperimentali a fatica - Tesi di Laurea Magistrale – Università degli Studi di Padova

DESIGN – CAE design and optimization



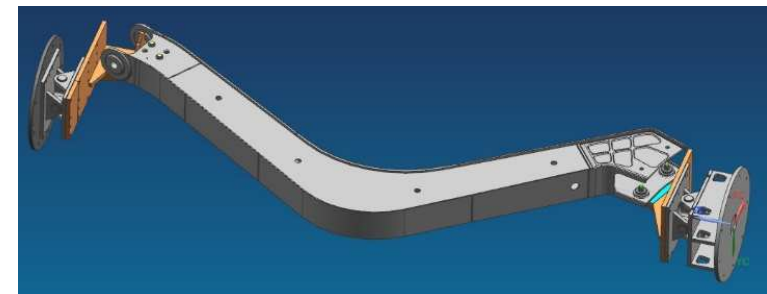
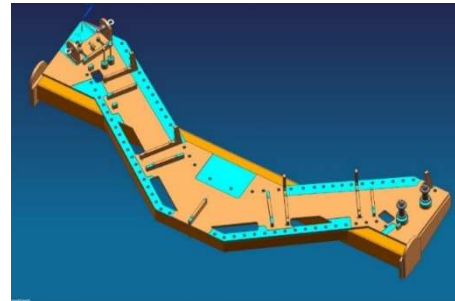
PRODUCTION

Welding



Respect of dimensional tolerances:

- Welding deformation control
- Jig for intermediate assembly
- Jig for manual welding
- Jig for automatic welding
- Stress-relieved heat treatment



NDT

Used devices



Phased Array Ultrasonic Testing



Conventional Ultrasonic Testing

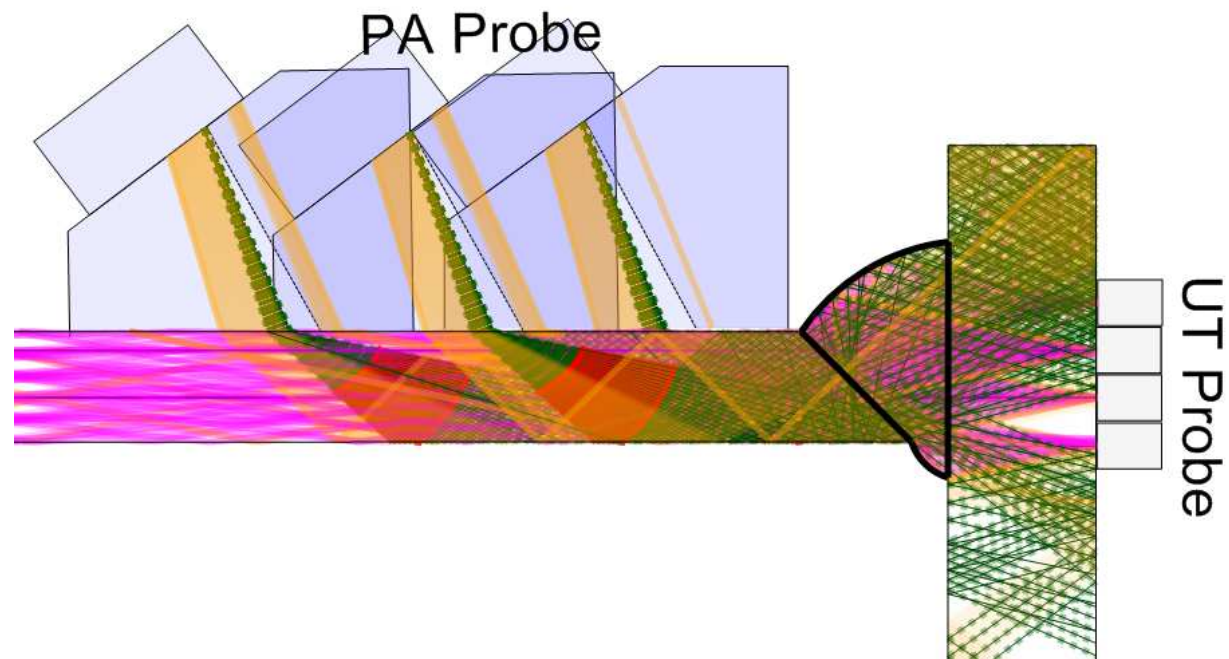


Magnetic Particle Testing



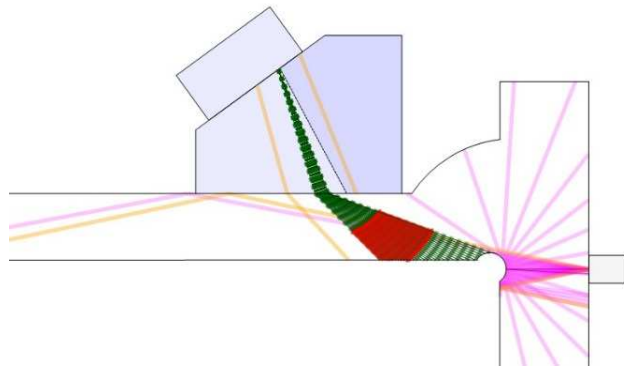
Remote Visual Inspection

Detail PAUT / UT

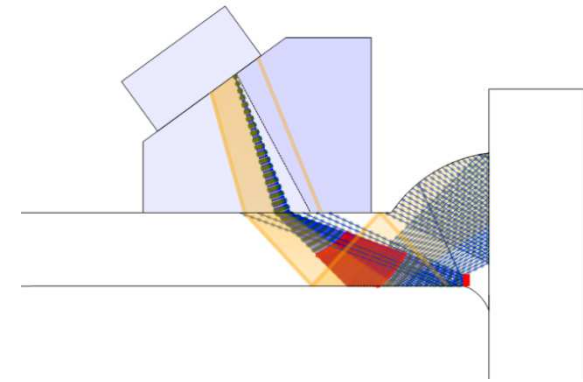


Probe path for one detail joint examination

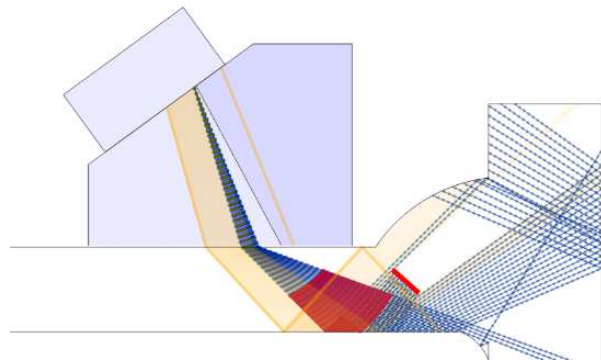
Defects investigation according ISO 58



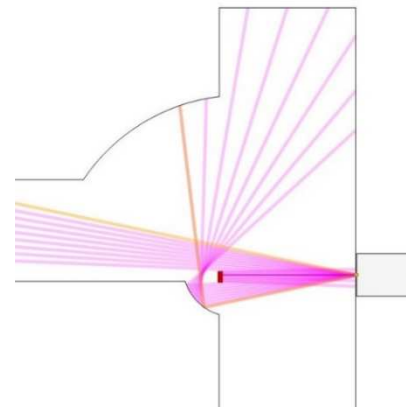
Imperfection 510 – Burn through



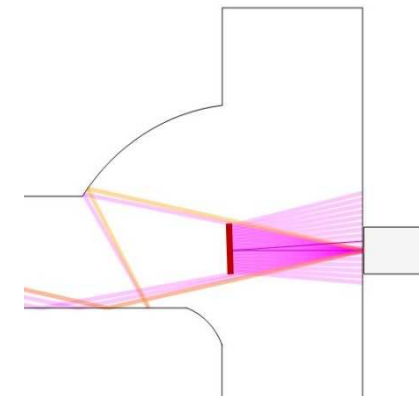
Imperfection 402 – Lack of penetration



Imperfection 4011 – Lack of side fusion



Imperfection 4013 – Lack of root fusion



Imperfection 401 – Lack of fusion



Thank you for your attention!