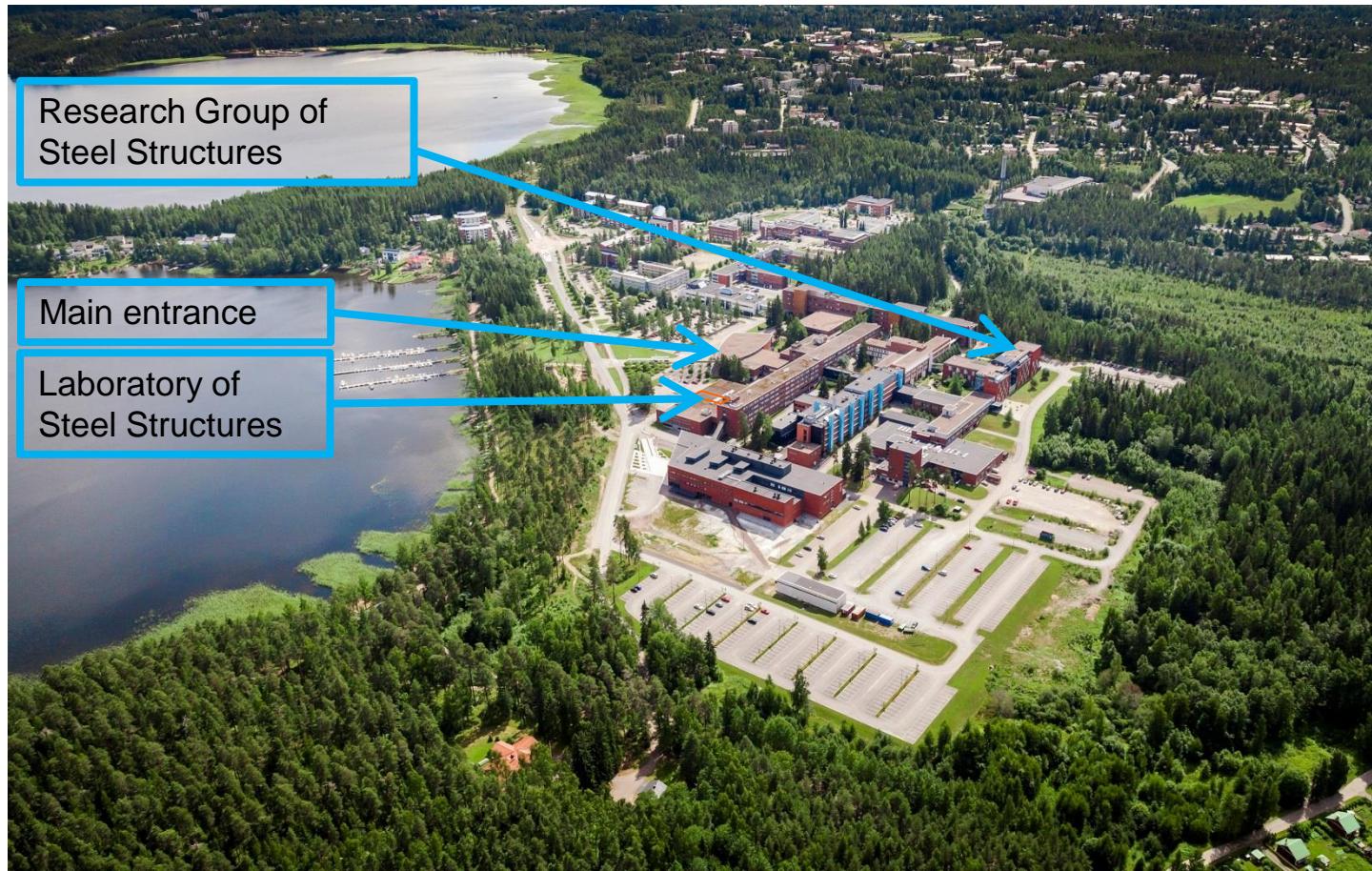


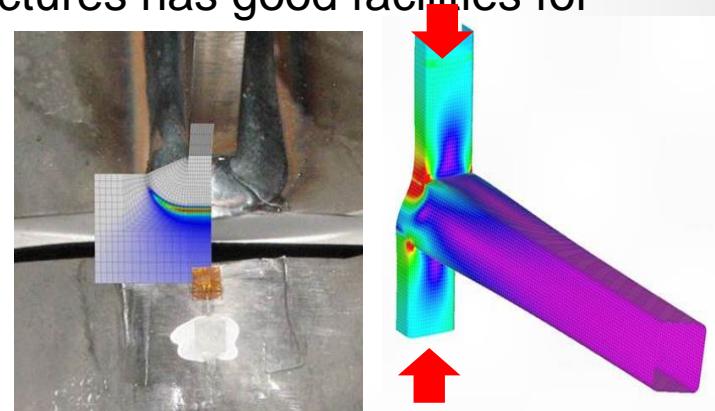


Mechanical Engineering
Laboratory of Steel Structures



STEEL STRUCTURES

- Research group of Steel Structures is working on design and fabrication of metal structures for demanding energy-efficient applications
- We are creating novel ideas and rules for design and fabrication procedures especially for design with high- and ultra-high strength steels (UHSS)
- The investigation includes theoretical analyses, numerical simulation and experimental testing. Laboratory of Steel Structures has good facilities for testing, also at low ambient temperatures
- Current main research topics include
 - Fatigue and static strength of welded joints
 - Performance of welded structures made of UHSS
 - Simulation and measurement of residual stress and their effect on structural behavior of structures
 - Digitized life cycle control including design, fabrication and service of metal constructions



RESEARCH TOPICS – STEEL STRUCTURES

a) Design of steel structures

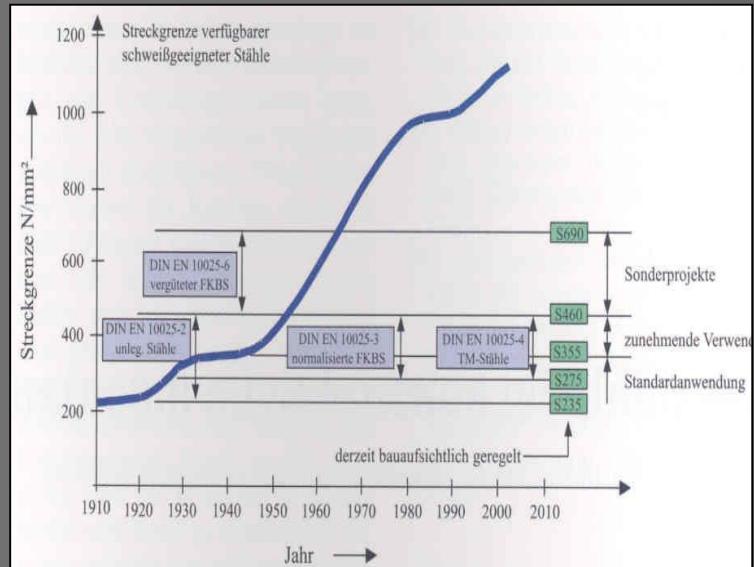
b) Analyzing the behavior of steel structures imposed to different load conditions

- Especially capacity of welded joints
- Static and **fatigue** strength made of high or ultra-high strength steels
→ ENERGY EFFICIENCY
- Digitization of the production (design and fabrication)
- supporting topics: FEA, simulations, experimental static/fatigue testing, arctic conditions

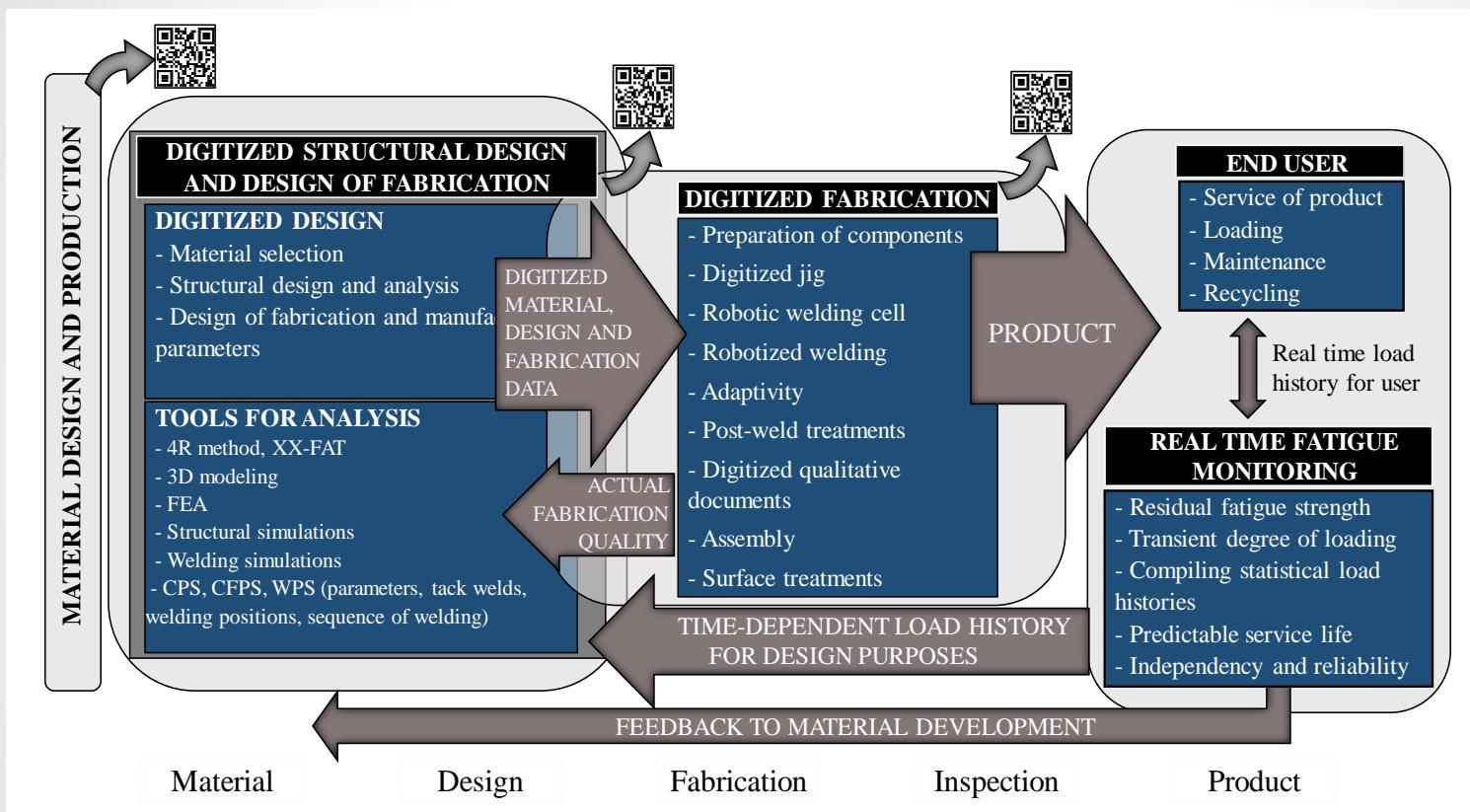
c) Collaboration with Finnish industrial companies

d) International cooperative universities

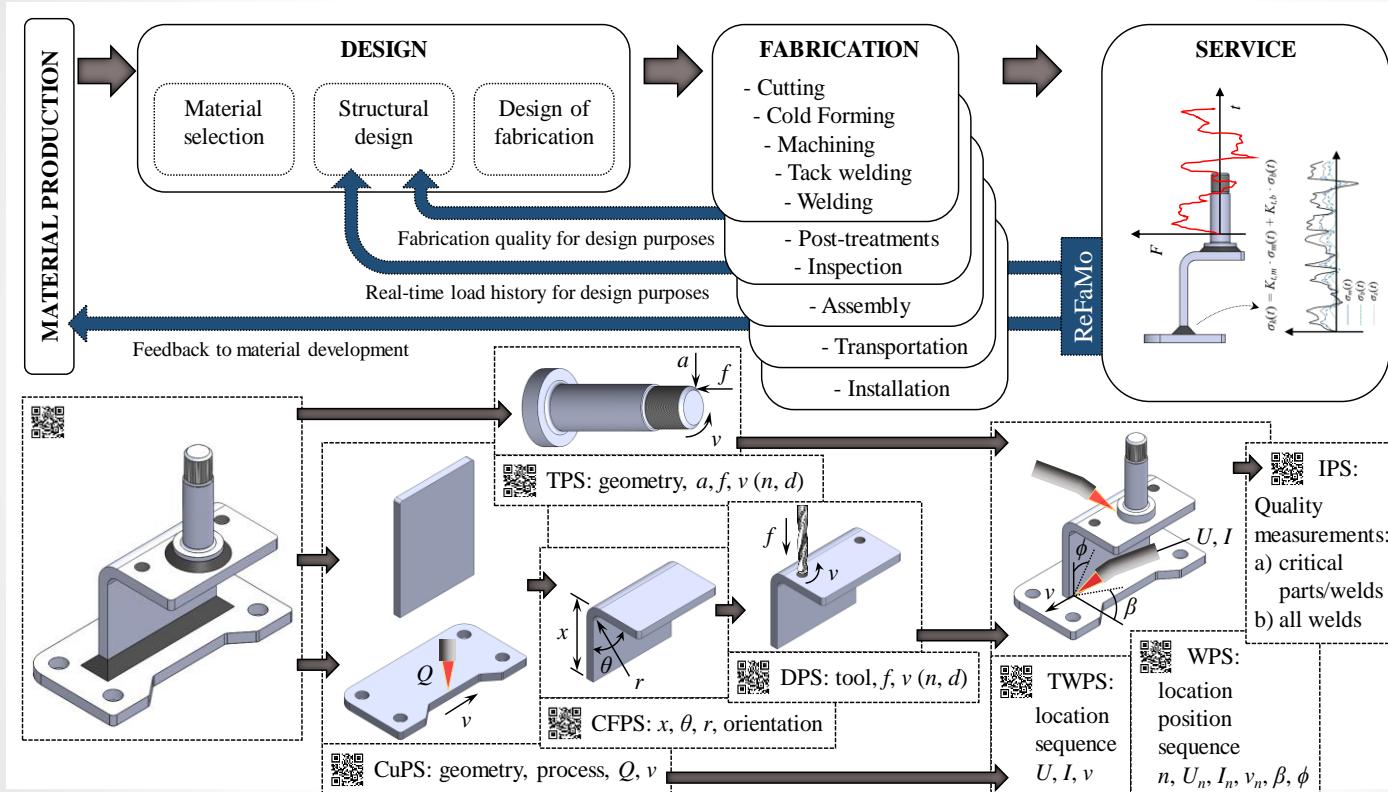
Increase of material strength in structural steels



DIGITIZED DESIGN AND FABRICATION



DIGITIZED PRODUCTION

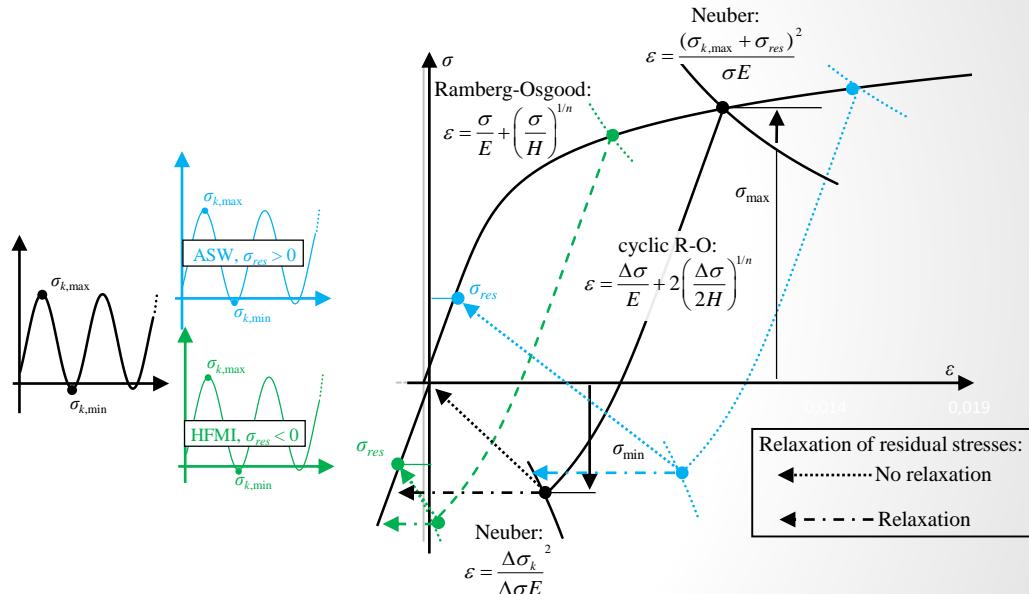


4R METHOD FOR FATIGUE DESIGN OF WELDED JOINTS AND COMPONENTS

Novel multi-parametric fatigue assessment approach that considers:

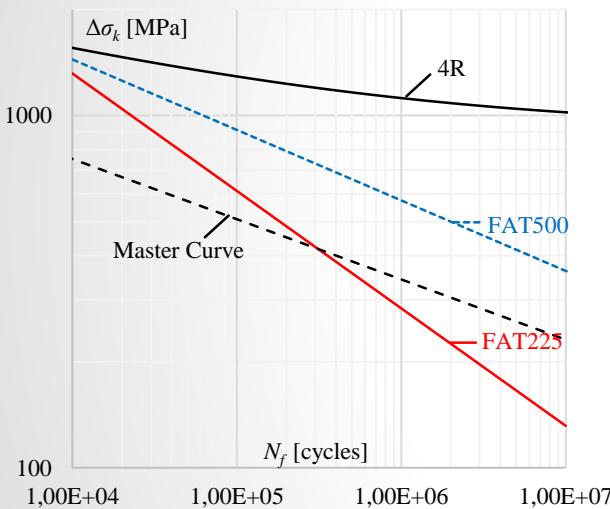
- Material ultimate strength (R_m)
- Residual stresses (σ_{res})
- External stress ratio (R)
- Weld toe radius (r_{true})

Acting stress ratio (R_{local}) at notch root is obtained using well-known material models (Ramberg-Osgood and Neuber's notch theory) considering the four essential parameters

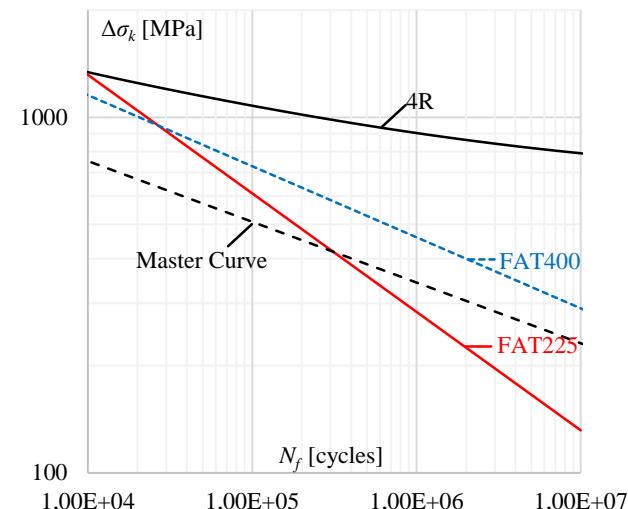


S-N CURVES OF 4R METHOD

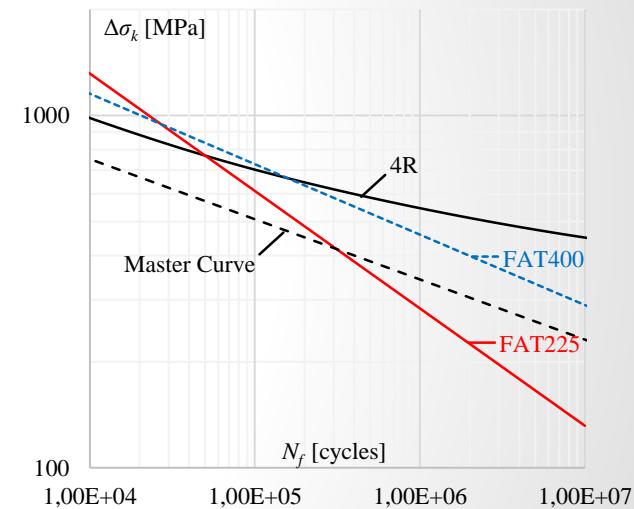
Material S1100 | Loading $R = -1$ | $\sigma_{res} = -460$ MPa



Material S700 | Loading $R = -1$ | $\sigma_{res} = -330$ MPa



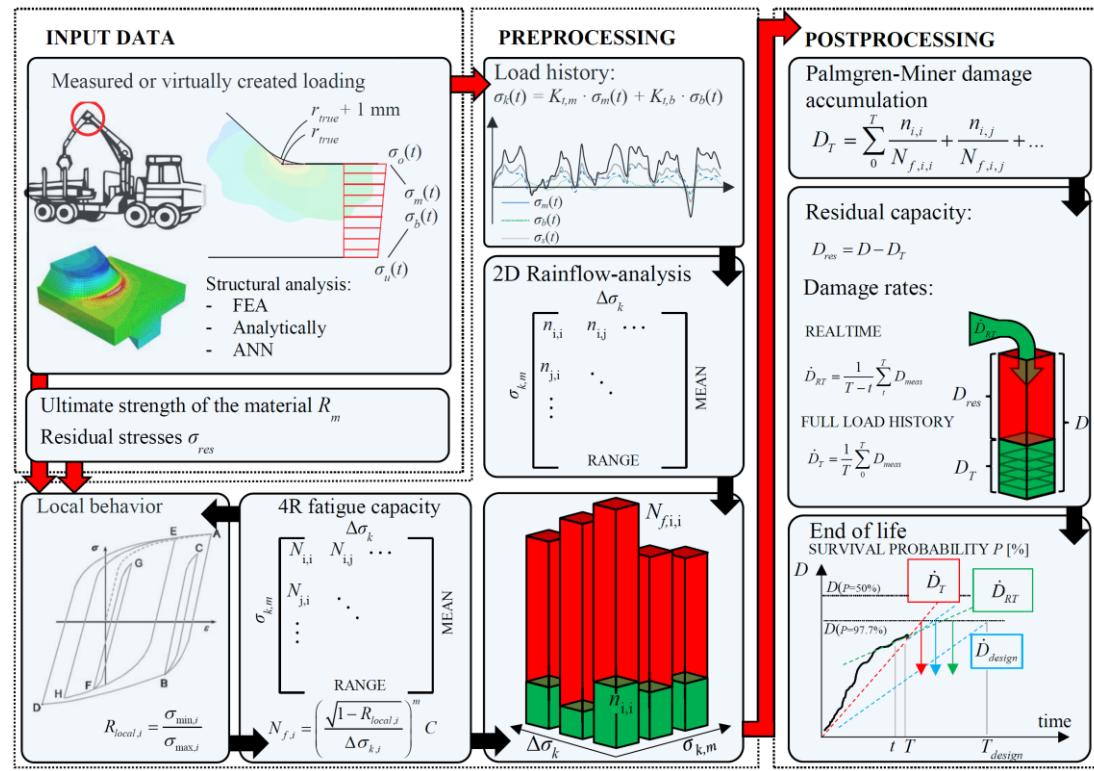
Material S700 | Loading $R = 0$ | $\sigma_{res} = -330$ MPa



REFAMO – REAL-TIME FATIGUE MONITORING

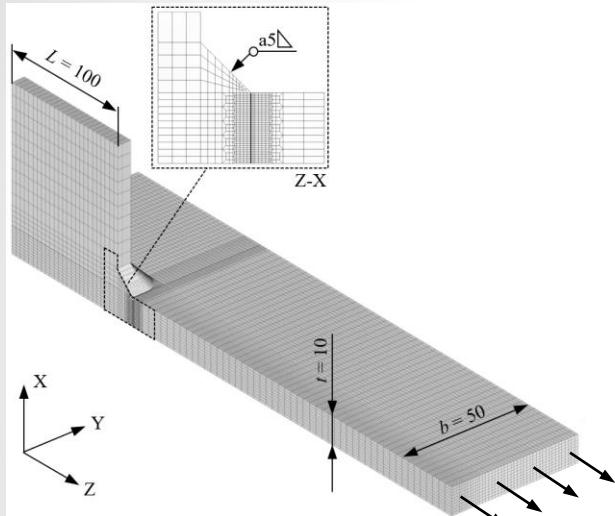
ReFaMo measures, analyses the measured loading, and calculates and visualizes the remaining 4R fatigue life and current degree of loading

ReFaMo solves the problems related to processing of large amount of measured data, structural health monitoring and inaccuracy of design loads



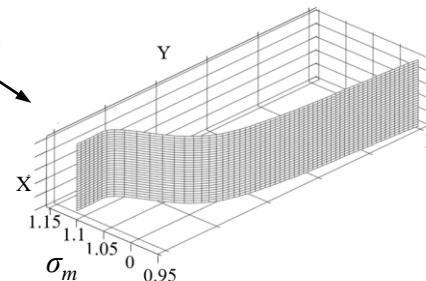
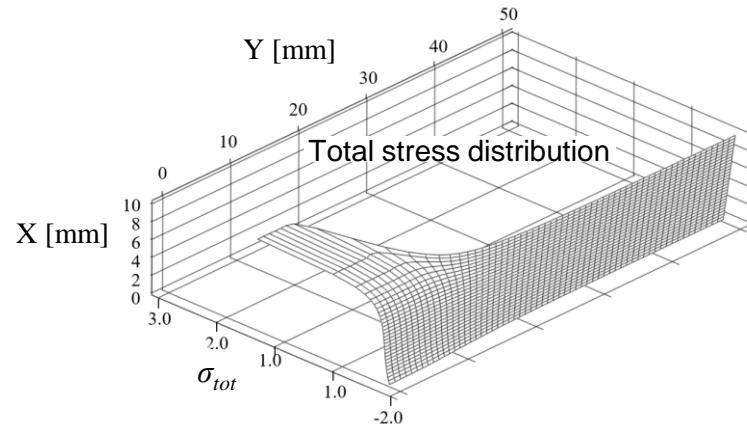
CATEGORIZATION OF STRESS COMPONENTS

UNDER AXIAL LOADING

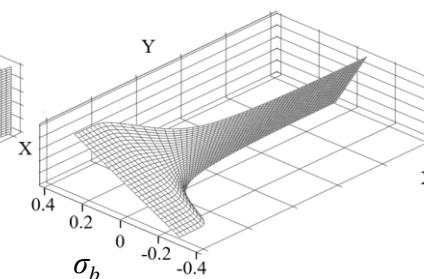


$$\sigma_s = \sigma_m + \sigma_b$$

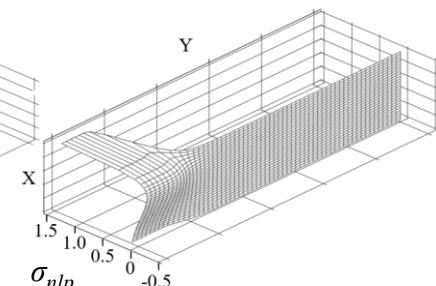
$$\sigma_{tot} = \sigma_m + \sigma_b + \sigma_{nlp}$$



Membrane stress distribution



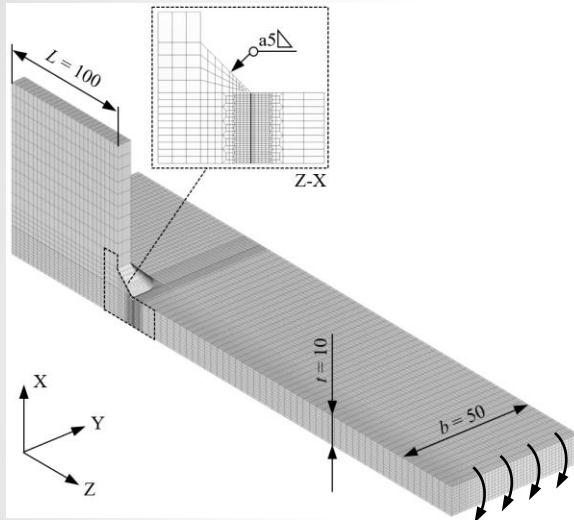
Bending stress distribution



Non-linear stress peak

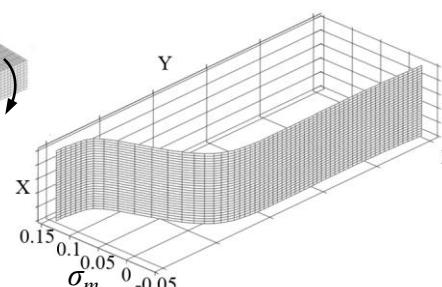
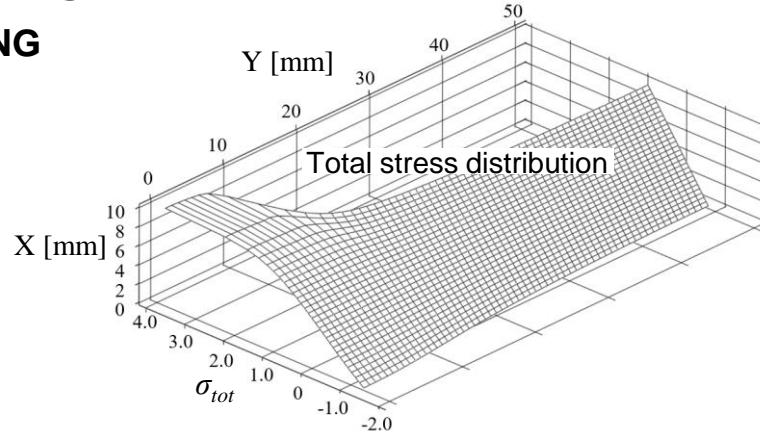
CATEGORIZATION OF STRESS COMPONENTS

UNDER BENDING LOADING

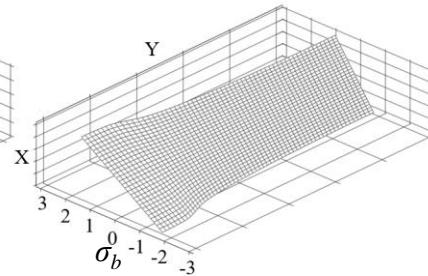


$$\sigma_s = \sigma_m + \sigma_b$$

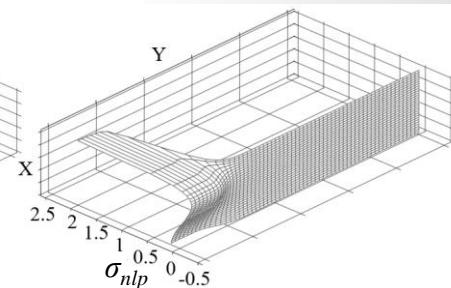
$$\sigma_{tot} = \sigma_m + \sigma_b + \sigma_{nlp}$$



σ_m



σ_b



σ_{nlp}

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Laboratory Technician

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Laboratory Technician

No. of Master Thesis Workers at LUT: 5 (04/2019)

"Theory and experiments should be thought of as completing each other, and the engineer who takes this attitude will, in general, be a more effective problem solver than one who neglects one or the other of these two approaches."

Doebelin E.O.

LUT University
Mechanical Engineering
Laboratory of Steel Structures
Research Facilities

MATERIAL TESTING MACHINES (LOAD FRAMES)

- Laboratory have seven (7) servo hydraulic load frames for dynamic and static loading test set-ups.
- Biggest test rig in Finland for dynamic testing up to 5 MN compression and tension loading.
 - Equipped with movable environment chamber down to -60°C to determinate material and connections behaviour at sub zero temperatures.
 - Full-scale tests of components made of high- and ultra-high-strength steels (S700-S1100).



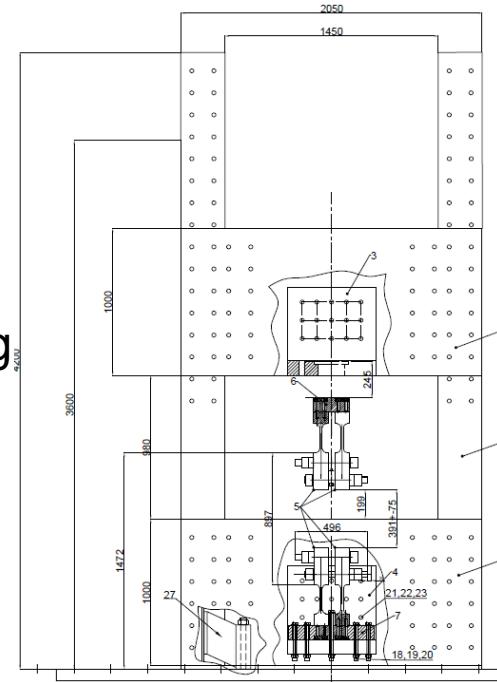
5MN load frame



Environment chamber + Cooling unit

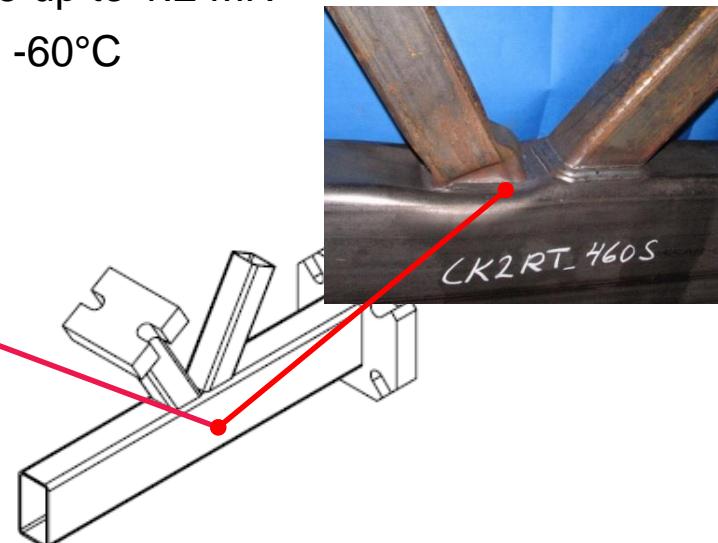
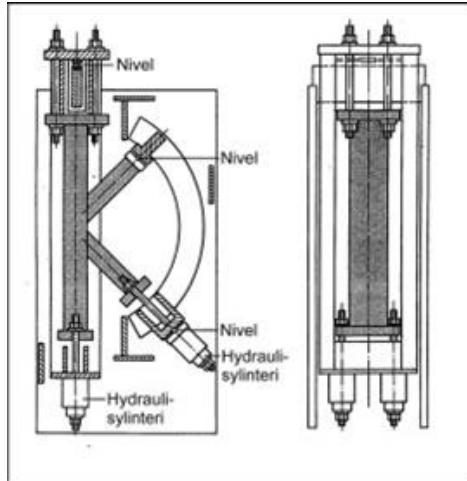
MATERIAL TESTING MACHINES (LOAD FRAMES)

- 5 MN for static and dynamic loading
- 1200 kN and 750 kN for dynamic and static loading
- 400 kN for dynamic and static loading
- Hz1 and Hz2 frames for 150 kN dynamic and static loading
- 150 kN for dynamic and static loading
- 1 MN compression up to 7 m length columns and beams
- Drop weight testing machine for impact tests



MATERIAL TESTING MACHINES (LOAD FRAMES)

- Load frame for RHS K-joints
 - Designed in Laboratory of Steel Structures based on the knowledge of 30 years of testing experience
 - Static chord force up to 2 MN and diagonal force up to 1.2 MN
 - Cooling capability for subzero tests down to -60°C

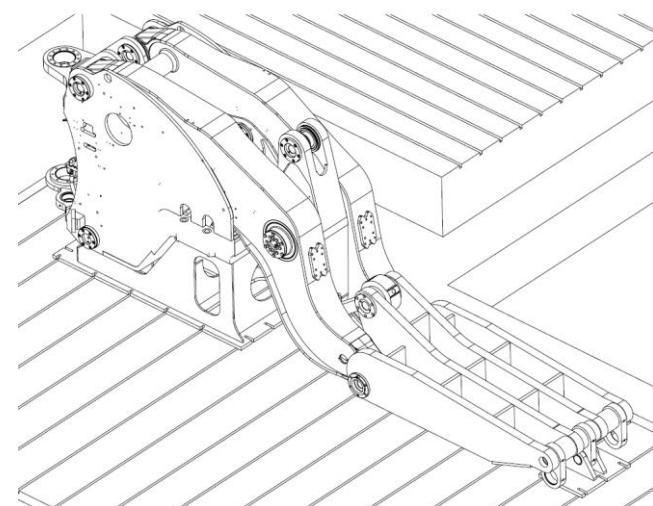


FULL-SCALE TEST SET-UPS DYNAMIC AND STATIC LOADING



FULL SCALE TEST SETUPS DYNAMIC AND STATIC LOADING

- Main frame of Underground Loading and hauling machine



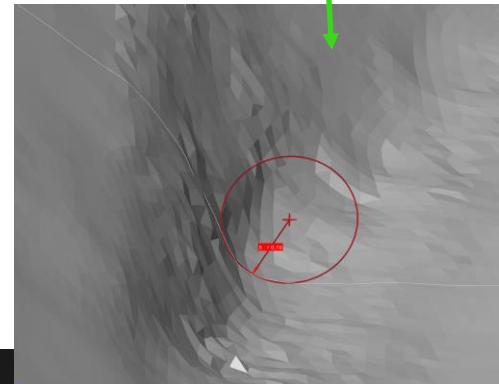
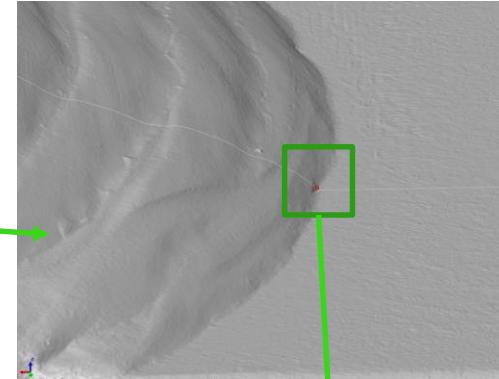
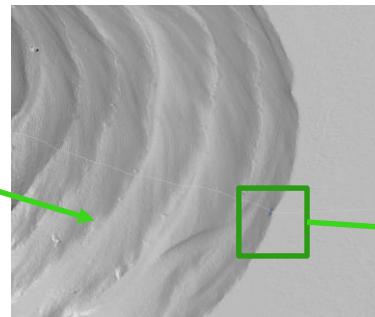
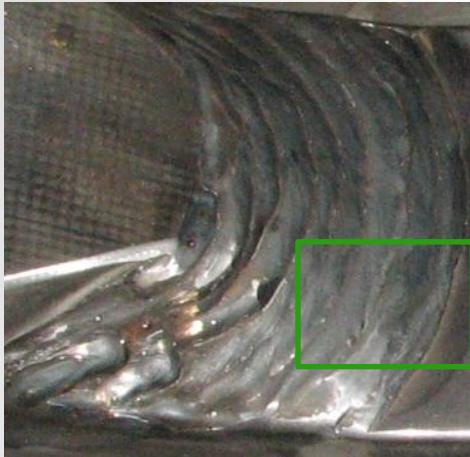
FULL SCALE TEST SETUPS DYNAMIC AND STATIC LOADING

- Lab floor space: $11 \text{ m} \times 29 \text{ m} = 319 \text{ m}^2$
 - height 4.5 m (hoist)
- T-slot floor with 400 mm spacing (M20)
 - T-slot areas:
 - $2 \times (9,6 \text{ m} \times 4 \text{ m})$, total length of 21 m
 - $4 \text{ m} \times 3,2 \text{ m}$
 - T-slot loading table $4 \text{ m} \times 3.5 \text{ m}$ (M24 - 250)



MEASUREMENTS of SPECIMENS

HP-L-20.8 Laser Scanner for ROMER Absolute Arm

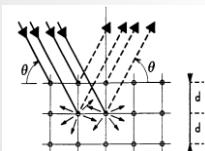
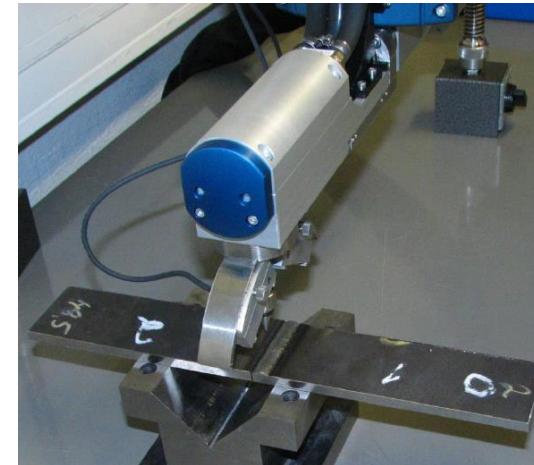


Detailed 3D-2D-
geometry for fatigue
analysis



MEASUREMENTS OF SPECIMENS

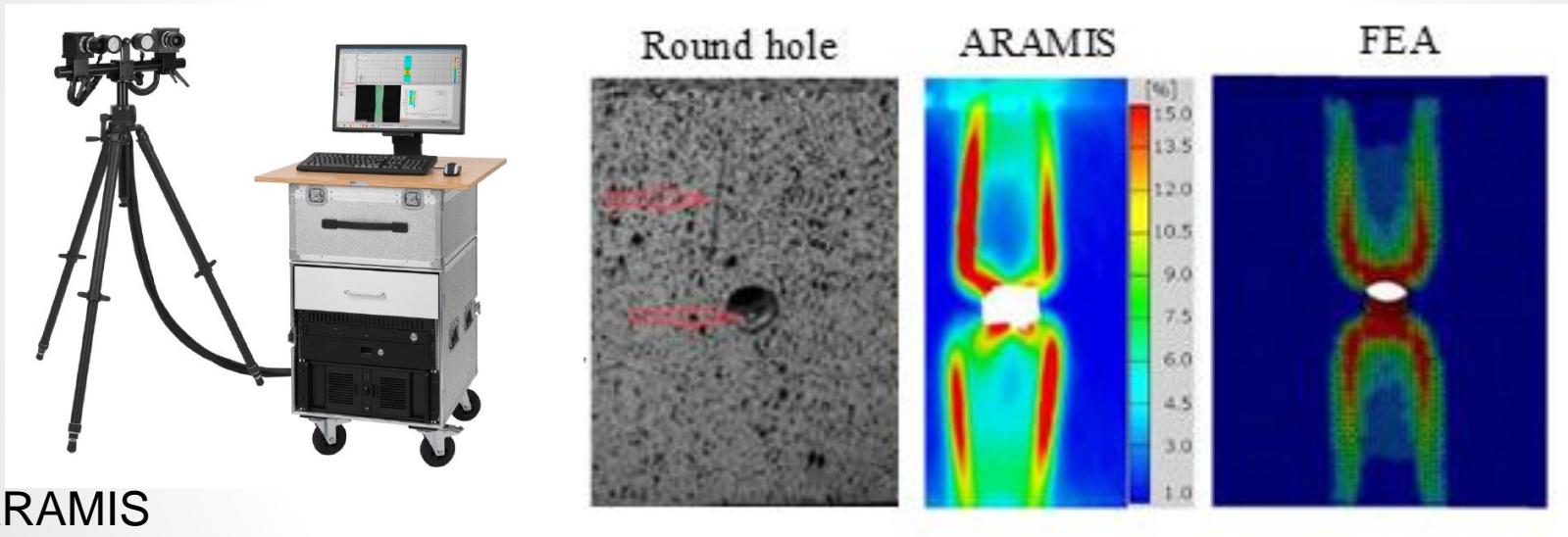
- X-ray diffraction device for residual stress measurements



$$\lambda = 2d \sin \theta$$

MEASUREMENTS OF SPECIMENS

Optical 3D Deformation Analysis, Digital image correlation (DIC)
device with 12MPa cameras

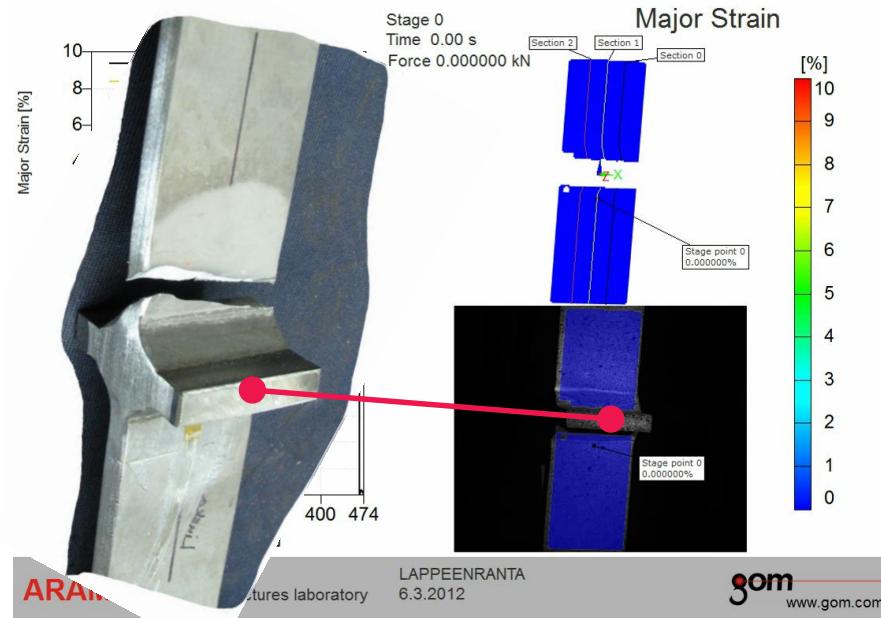


MEASUREMENTS OF SPECIMENS

Optical 3D Deformation Analysis, Digital image correlation (DIC)
device with 12MPa cameras

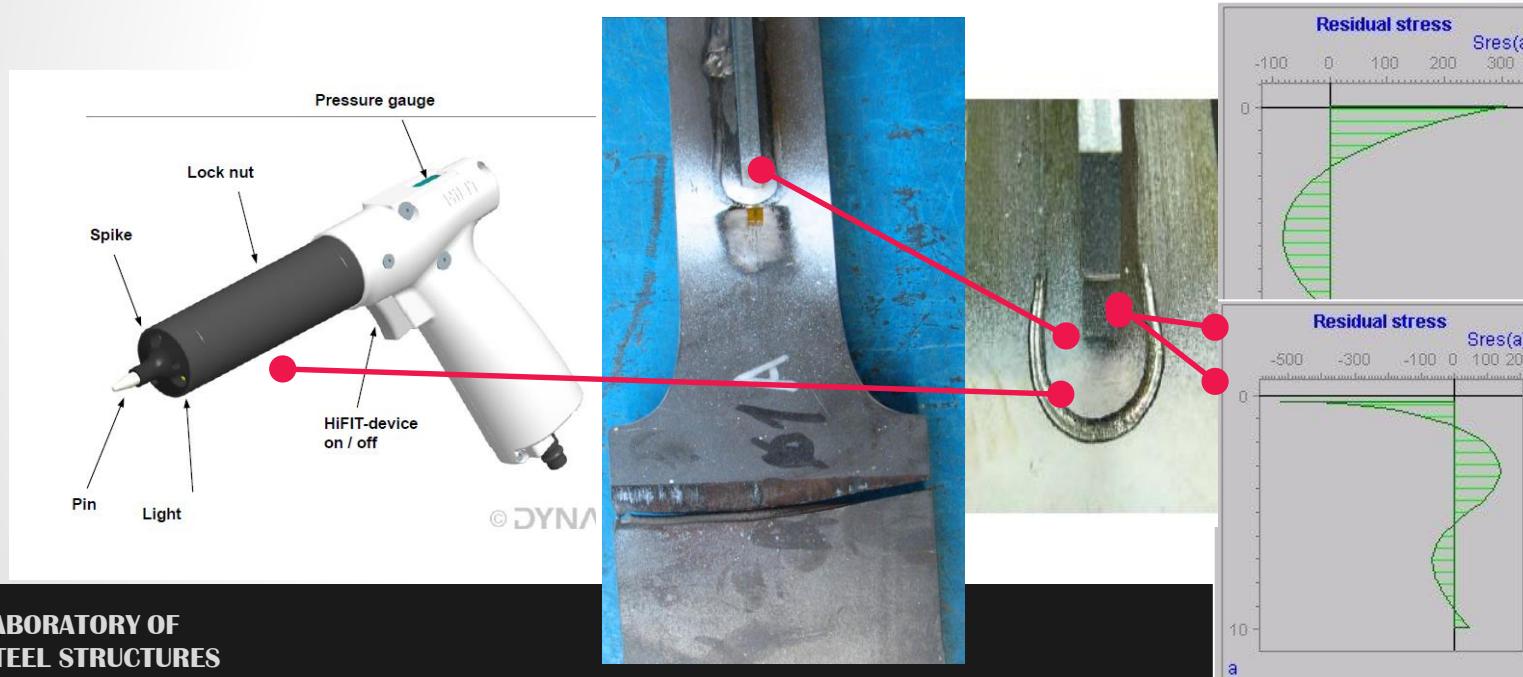


ARAMIS



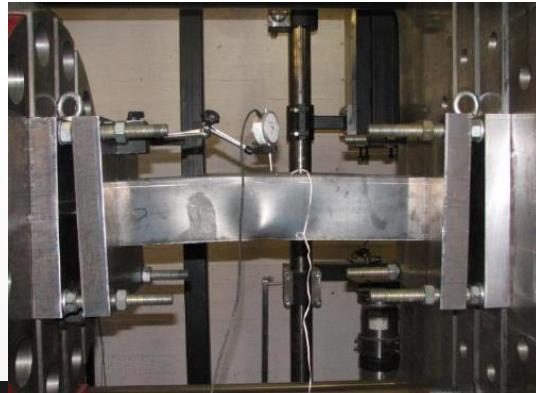
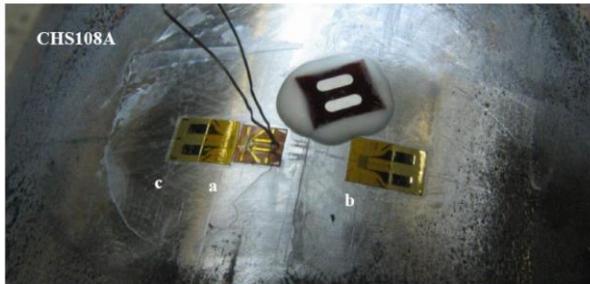
High Frequency Mechanical Impact Treatment (HFMI)

- Improvement of fatigue of welded structures as much as 5 times better fatigue life.
 - As welded condition FAT95% =97 vs. HFMI treated condition FAT 95% =175

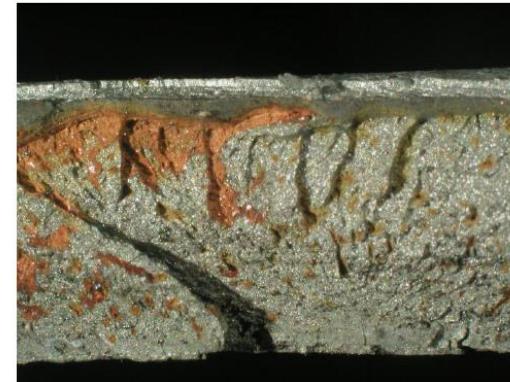
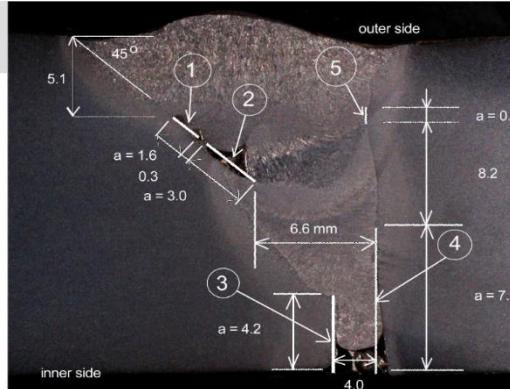
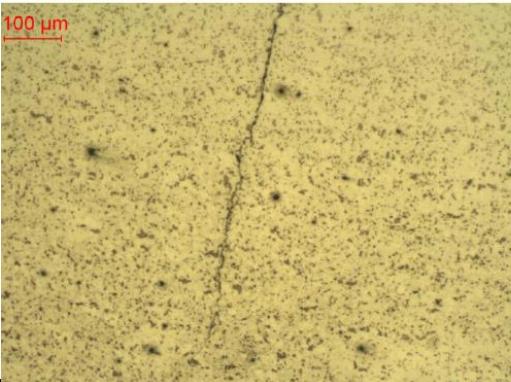
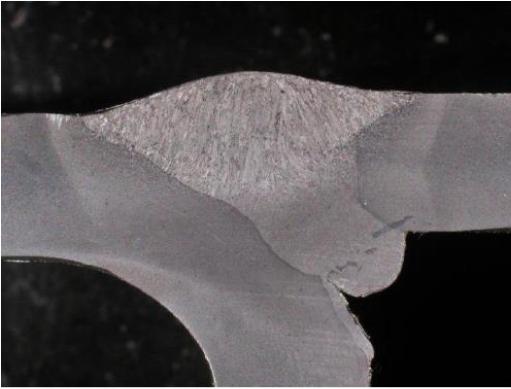


INSTRUMENTATION

- Strain Gauges, Transducers, Amplifiers, Data Acquisition.

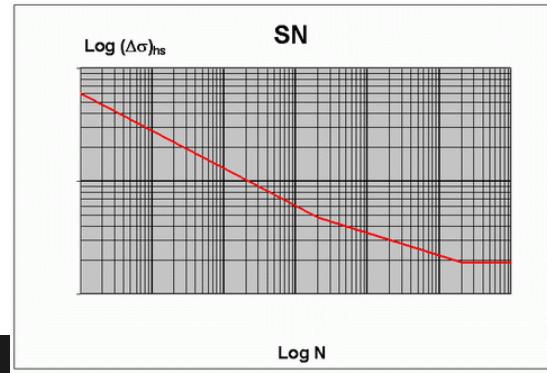
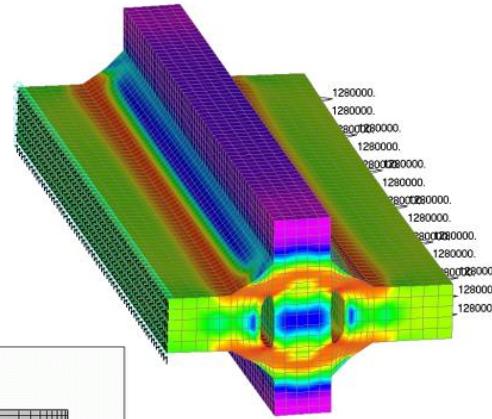
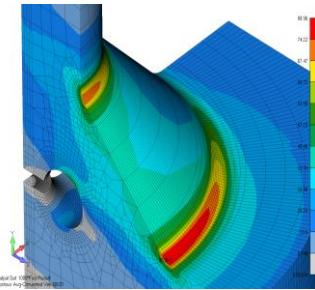
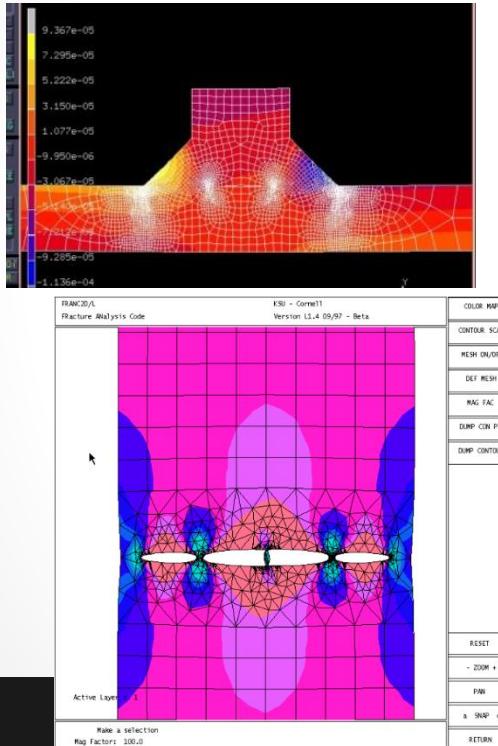


MICROSECTIONS and FIGURES



TOOLS for CALCULATION AND ANALYSIS

- FEA: ABAQUS, FEMAP/Nastran, Franc2D, LS/DYNA, tailor-made programs
- Others: Mathcad, Matlab, Solidworks, AutoCad, etc..



LUT SCOPUS: Welded UHSS (Weld+Ultra+High+Strength+Steel)

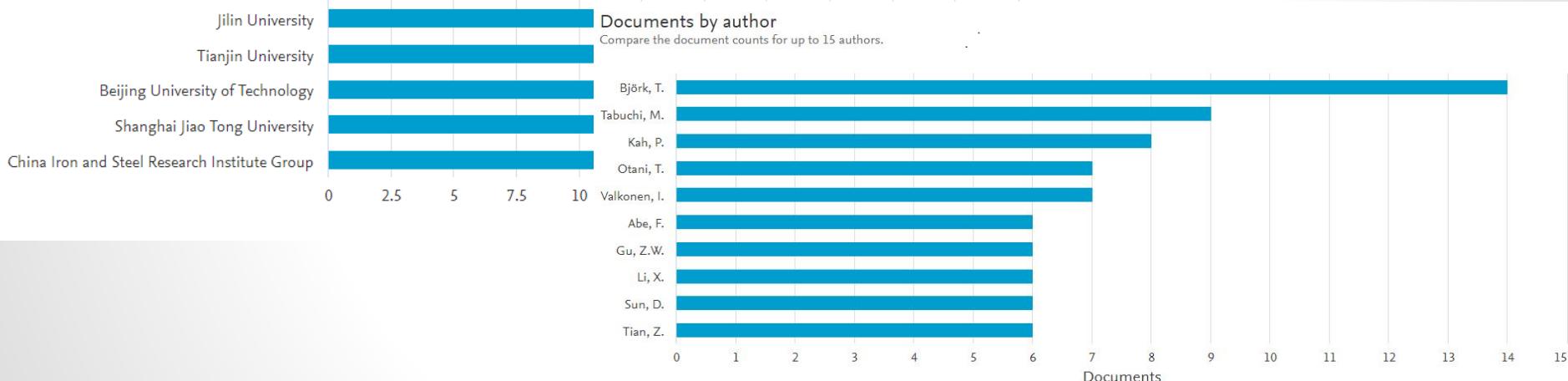
Documents by affiliation

Compare the document counts for up to 15 affiliations.



Documents by author

Compare the document counts for up to 15 authors.



HRO SUUNNITTELUFOORUMI

- Teräsrakenteiden laboratorion koordinoima foorumi vaativien rakenteiden suunnittelijoille, tuotekehittäjille ja tutkijoille sekä valmistuksesta, tarkastuksesta ja kunnossapidosta vastaaville
- SHY:n Suunnittelufoorumi
- Yhteensä 38 + jäsenyritystä
- Tavoitteet:
 - ✓ Tuottaa uutta tutkimustietoa (tutkimusprojektit + HRO diplomityöt)
 - ✓ Toteuttaa Suomen hitsaavan teollisuuden kannalta tärkeitä tutkimusprojekteja (BF, SA, EU..)
 - ✓ Välittää uusin tarpeellinen tutkimustieto maailmalta kotimaiselle teollisuudelle (IIW)
 - ✓ Luoda ja ylläpitää alan yritysten välisen yhteistyötä ja kontaktointia
 - ✓ Tuottaa palvelututkimusta ja koulutusta yrityksille (HRO alennus jäsenyrityksille)
- HRO Suunnitteluforumin teemapäivät
 - ✓ Alan viimeisimpien tutkimustulosten esittely (LUT + tutkimuslaitokset)
 - ✓ Jäsenyritysten ja kutsuvieraiden omat esitykset
 - ✓ Kansainvälinen vieraileva luennoitsija
 - ✓ Kaksipäiväiset vuosittain

ABB Oyj
Allu Finland Oy
Andritz Oy / Hollola / Savonlinna
Auramo Oy
BMH Technology Oy
Bronto Skylift Oy Ab
Cargotec Finland Oy
Deltamarin Oy
EDR & Medeso Oy
Eisto Oy
Elomatic Oy
Etteplan Design Center Oy
HT Laser Oy
John Deere Forestry Oy
Junttan Oy
Konecranes Global Oy
Mantsinen Group Ltd Oy
Metso Minerals Oy
Meyer Turku Oy
NDT Inspection & Consulting Oy
Neteram Oy
One Moment Engineering Oy
Outotec Oyj
Ponsse Oyj
Raahen Insiööri-suunnittelija Oy
Raute Oyj
Sandvik Mining and Construction Oy
SSAB Europe Oy
STALATUBE Oy
Stressfield Oy
The Switch
TMT Malinen Oy
Unisigma Oy
Valmet Technologies Oy
Valtra Oy Ab
Waratah OM Oy
Viafin Terästorni Oy
Wärtsilä Finland Oy

**NEED MORE INFORMATION?
WE ARE HERE FOR YOU,
DO NOT HESITATE TO ASK**

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- Laboratory Engineer Matti Koskimäki: Matti.Koskimaki@lut.fi

