Aalto University
School of Engineering

MEC-E8006 Fatigue of Structures

Teacher in charge: Heikki Remes
Email: heikki.remes@aalto.fi

Co-teacher and teaching assistant: Yuki Ono
Email: yuki.ono@aalto.fi

Today agenda

10:15 Welcome and course organization

10:30 Lecture 1: Fatigue phenomena

11:00 A short break

11:10 Lecture 1: Fatigue phenomena continue

12:00 End

Aalto University
School of Engineering

MEC-E8006 Fatigue of Structures

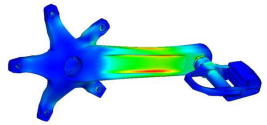
Course organisation

Teacher in charge: Heikki Remes
Email: heikki.remes@aalto.fi

Course scope

The fatigue assessment of engineering structures and components

- Fatigue phenomena
- Main methods for fatigue assessment
- Machined components and welded structures
- Structural design aspects



Learning objectives

After the course, you

- understand the material behavior under cyclic loading and fatigue phenomenon.
- can identify the main affecting factors and requirements for fatigue assessment.
- understand the main modelling principles and assumptions used in common fatigue approaches.
- can apply selected fatigue approach for structural design.

Course contents

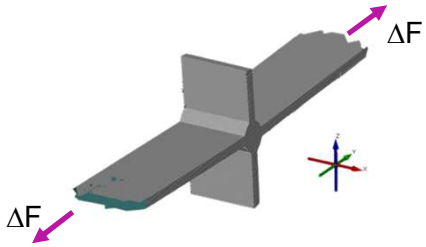
Week		Description
43	**Lecture 1-2**	**Fatigue phenomenon and fatigue design principles**
	Assignment 1	Fatigue Damage process, design principle and Rainflow counting – dl after week 43
44	**Lecture 3-4**	**Stress-based fatigue assessment**
	Assignment 2	Fatigue life estimation using stress-based approach – dl after week 44
45	**Lecture 5-6**	**Strain-based fatigue assessment**
	Assignment 3	Fatigue crack initiation life by strain-based approach – dl after week 46
46	**Lectures 7-8**	**Fracture mechanics -based assessment**
	Assignment 4	Fatigue crack propagation life by fracture mechanics – dl after week 46
47	**Lectures 9-10**	**Fatigue assessment of welded structures and residual stress effect**
	Assignment 5	Fatigue life estimation of welded joint – dl after week 48
48	**Lecture 11-12**	**Multiaxial fatigue and statistic of fatigue testing**
	Assignment 6	Fatigue life estimation for multiaxial loading and statistical analysis – dl after week 48
49	**Exam**	**Course exam**
	Project work	Delivery of final project (optional) – dl on week 50

Assignment are delivered in pdf format using MyCourse and the following naming ***AssignmentNumber_FirstName_Surname.pdf.***

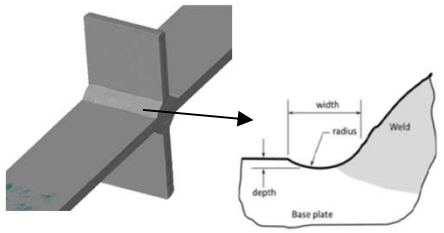
Optional project work

- **With optional project work, you can replace two last assignment round (Assignment 5-6)**
- The project work is real life application case:
  - A. Fatigue life analysis of welded cruciform joint in low strength steel
  - B. Fatigue life analysis of post-weld-treated joint in high strength steel
  - C. Fatigue life analysis of cut-plate edge in high strength steel
  - D. Fatigue life analysis of team own project work (upon approval)

A As welded joint

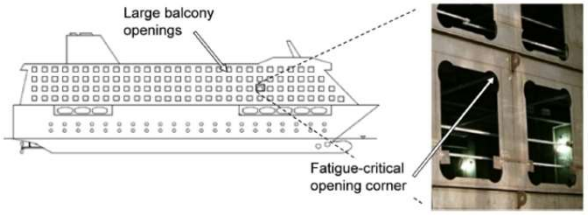


B Post-weld- treated joint



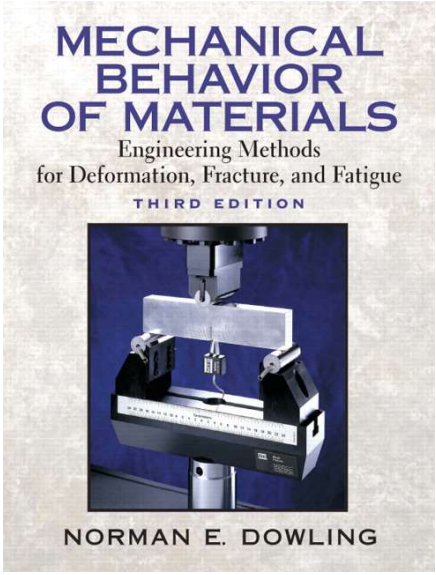
C

Sandblasted surface



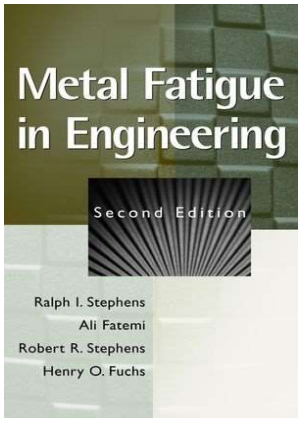
Study material

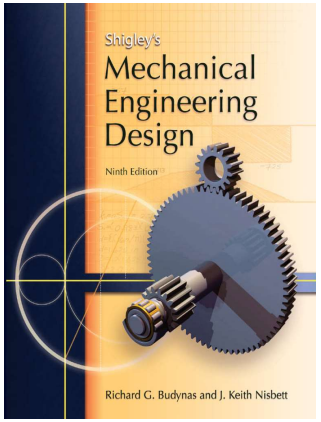
- **Course material**
  - **Mechanical Behavior of Materials by Dowling, N. E., *Chapter 8-14***
  - **Selected parts of textbooks, papers and reports**
- Optional reading
  - Metal Fatigue in Engineering by Stephens, R. I. et al.
  - Selected scientific papers, standards, and guidelines
  - Shigley's Mechanical Engineering Design by Richard, G. et al., *Chapter 6*



Important note

- Textbooks are always the best reading material for self-studies since lecture slides do not include all the details.
- Readings material related to each week are specified in pdf-copy of lecture slides (MyCourses)





Course organisation

Course

- Teaching period II: 24.10.2023-1.12.2023
- Exam: 8.12.2023, 13:00 – 17:00
- Assignments (weekly basis) and optional project work (on week 50)

Lectures and exercises

- Lectures: Monday 10:15 – 12:00
Tuesday 12:15 – 14:00
- Question hour: Thursday 13:15 – 15:00

Grading

- 50% on assignments (and optional project report)
- 50% on the examination

Materials, assignments delivery, information, etc.

- MyCourses: https://mycourses.aalto.fi/

Course organisation

- The assignments are delivered by each student every week. In addition to numerical results, please briefly describe the calculation steps in the assignment report.
- The question hour is organized to support assignment works based on student requests and questions.
- The optional project work can be done alone or as a group.

Weekly routine (suggested)

- *Sunday* — *Get familiar with the textbook or watch the video (~0.5 hours)*
- *Monday 10:15-12* — *Lecture 1 (~2 h.)*
- *Tuesday 12:15-14* — *Lecture 2 (~2 h.)*
- *Wednesday* — *Reading of textbook chapter and assignment solving (~7 h)*
- *Thursday 13:15-15* — *Question hour (if needed) (~2 h)*
- *Friday - Saturday* — *Finalization and delivery of assignment (~6 h)*

In this course, 5 credits really means in average 135 hours, i.e. ~20 hours / week!

Aalto University
School of Engineering

MEC-E8006 Fatigue of Structures

Optional project work options

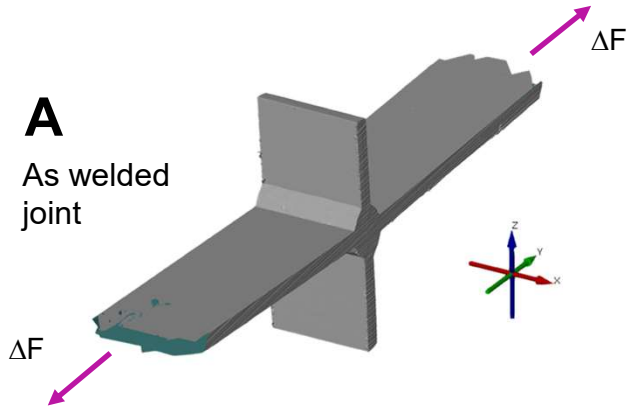
Project work cases

A. **Welded cruciform joint in low-strength steel**
B. **Post-weld-treated joint in high-strength steel**
C. **Cut-plate edge in high-strength steel**
D. **Own project work**

For option A-C, the reference material (e.g., geometry measurements, material data) is in my course folder.

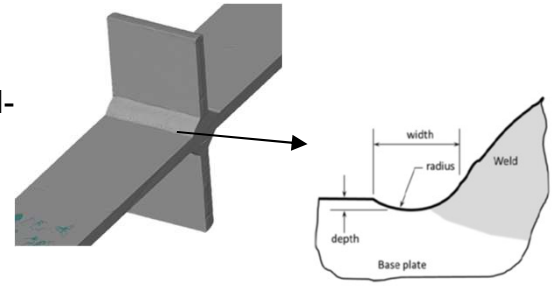
A

As welded joint



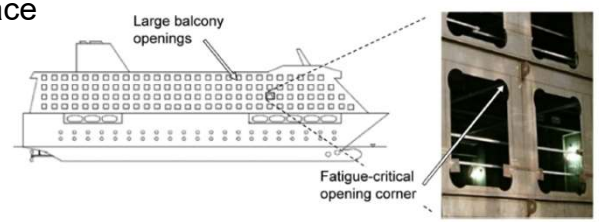
B

Post-weld-treated joint



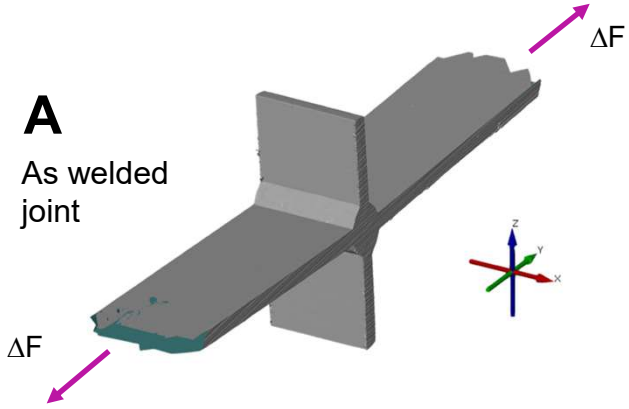
C

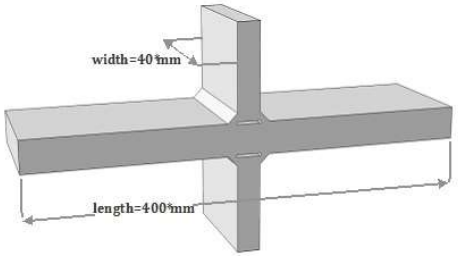
Sandblasted surface



A: Welded cruciform joint in low strength steel

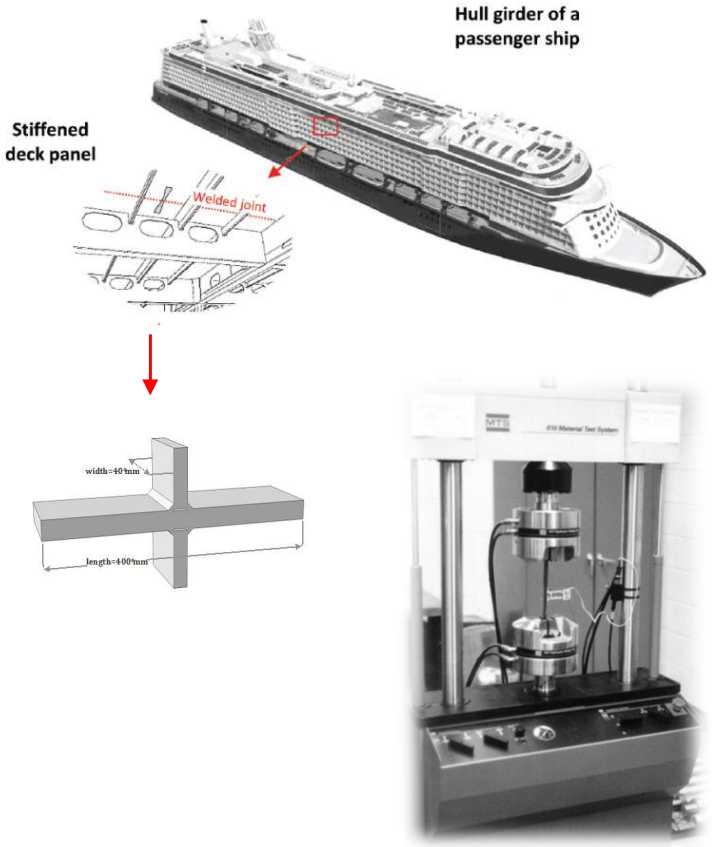
- Common fatigue critical detail in welded structures, such as ship, bridge, crane structures
- Fatigue test specimen including fillet welded cruciform joint
- A constant amplitude loading with load range of 39.6 kN and load ratio R=0.1





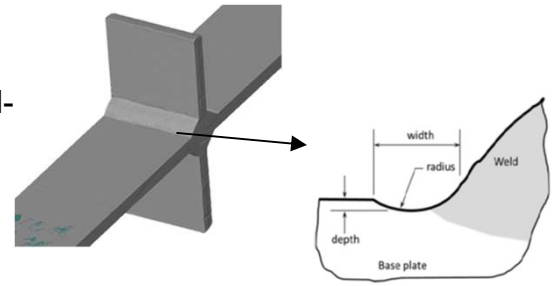
B: Post-weld treated joint in high strength steel

- Common fatigue critical detail in welded structures, such as ship, bridge, crane structures
- Fatigue test specimen including fillet welded cruciform joint, which is post-weld treated
- A constant amplitude loading with load range of 70.6 kN and load ratio R=-0.43



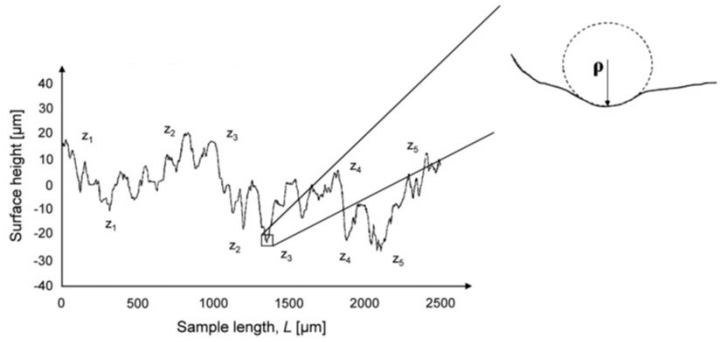
B

Post-weld-treated joint



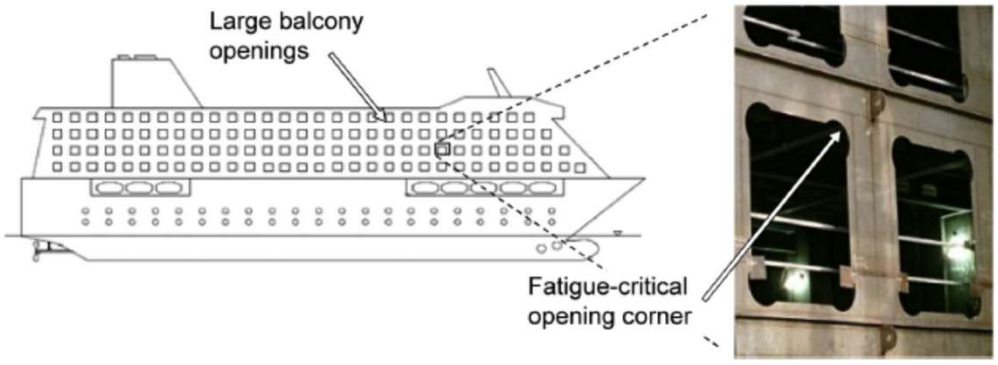
C: Cut-plate edge in high strength steel

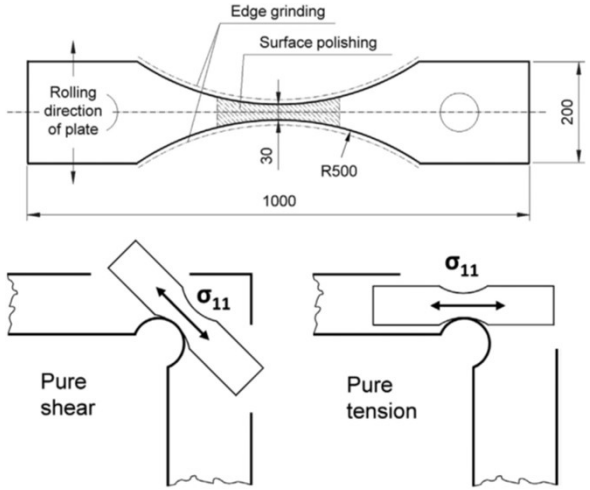
- Common fatigue critical detail in complex structures
- Fatigue test specimen including cut plate edge, which is sandblasted. The plate thickness is 15.3 mm.
- A constant amplitude loading with load range of 243 KN and load ratio R=0.1



C

Sandblasted surface





Project work description

- The project report should include:
  - *Case description (geometry, material, loading)*
  - *Description of analysed manufacturing-induced imperfections (e.g., residual stress, initial defect size)*
  - *Description of applied methods (at least methods)*
  - *Results from the analyses (fatigue life, sensitivity of input parameter)*
  - *Results discussion and conclusion*
- The report should not be longer than 10 pages, but the number of appendixes for numerical calculations is not limited.

- Send an email to heikki.remes@aalto.fi by the end of W45 if you are interested in optional project work.