Aalto-yliopisto
Insinööritieteiden
korkeakoulu

MEC-E8007 Thin-Walled Structures
Lecture 9. Fatigue Analysis and Sub-modelling

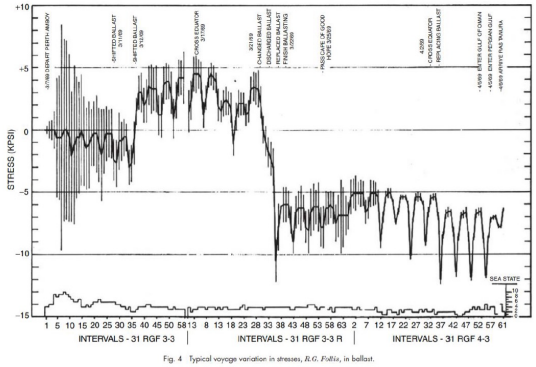
Heikki Remes, 30.9.2024

Fatigue design of thin-walled structures

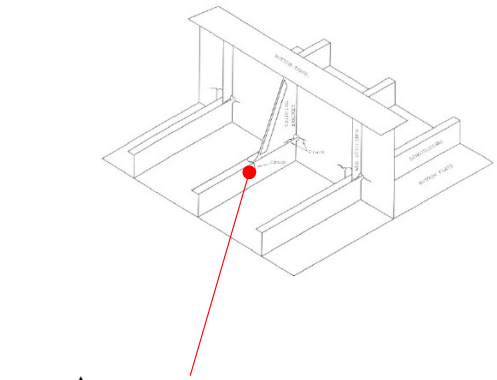
What are the aspects that need to be considered in fatigue analysis?

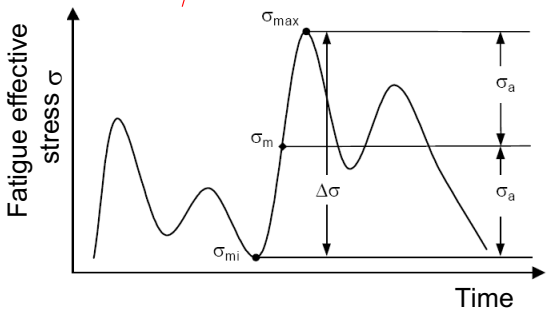
Fatigue design of thin-walled structures

Load as a function of time

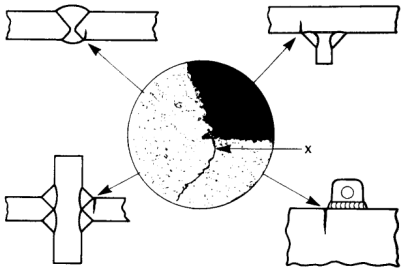


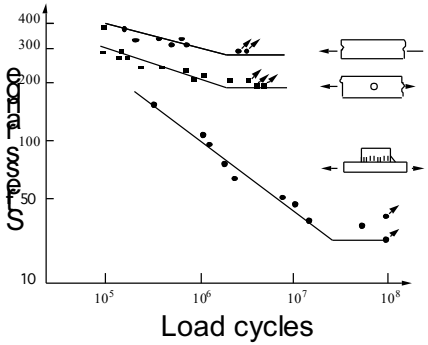
Cyclic Load





Fatigue response

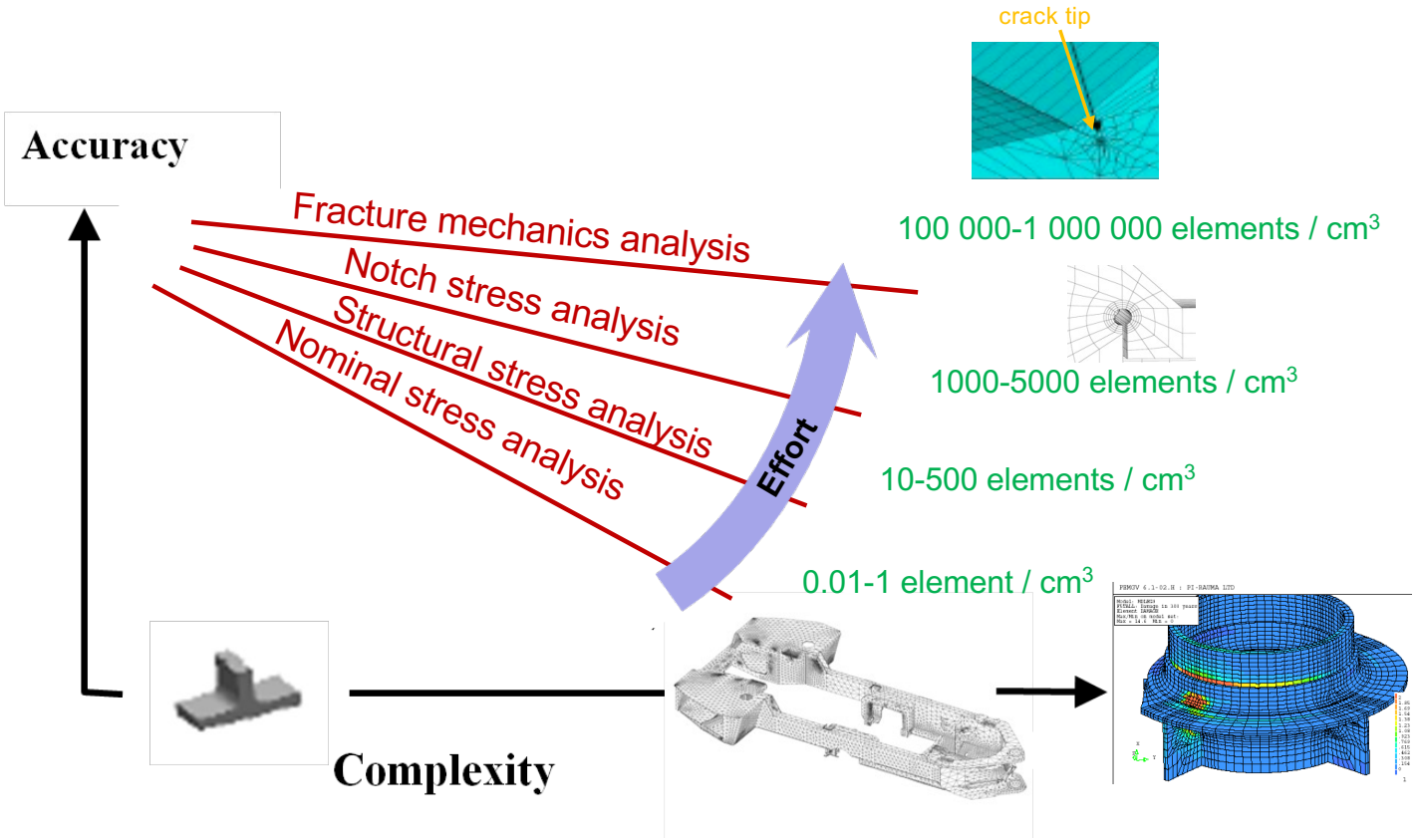




Fatigue strength

Fatigue design of thin-walled structures

Fatigue assessment methods for welded structures



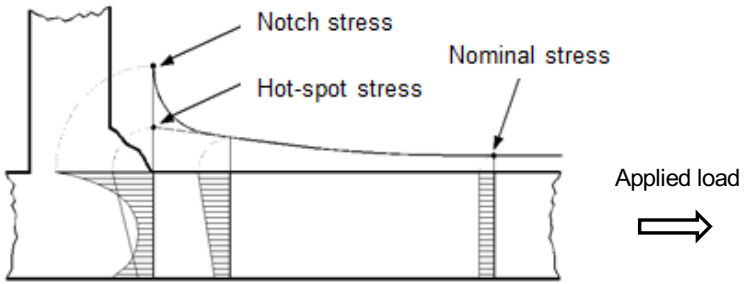
Fatigue design of thin-walled structures

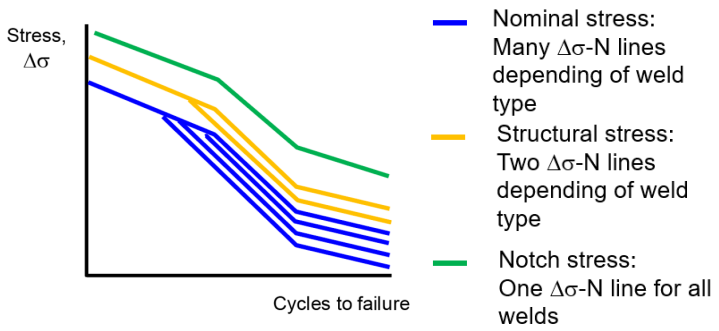
Fatigue assessment methods for welded structures

Commonly used methods for large thin-wall structures are

- Nominal stress approach based on the applied load and cross-section of the structure
- Structural hot-spot stress approach for fatigue critical detail. This is the most common in ship structural design
- Notch stress approach for weld toe or root, considering also notch effect in peak stress.

Note: Each approach has its own S-N curve(s) to describe fatigue strength



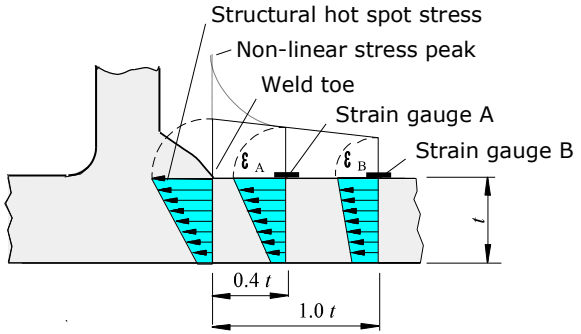


Fatigue design of thin-walled structures

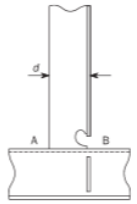
Fatigue assessment methods for welded structures

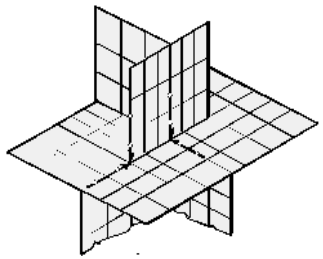
Structural Stress approach

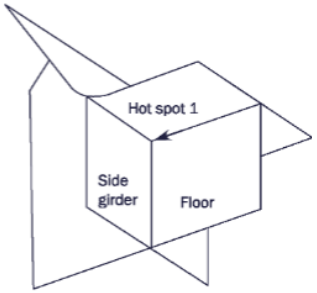
- Experiments with the help of strain gauges
- FE models with fine mesh
- Pre-calculated solution (Stress concentration factor)



$$\sigma_{hs} = K_s \cdot \sigma_{nom}$$

No.	Geometry Connection type	Point A	
		K_a	K_b
2(1)		1.28 for $d \le 150$ 1.36 for $150<d<250$ 1.45 for $d > 250$	1.40 for $d <$ 1501.50 for $150<d<250$ 1.60 for $d>250$



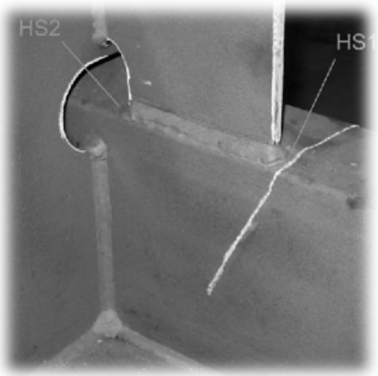


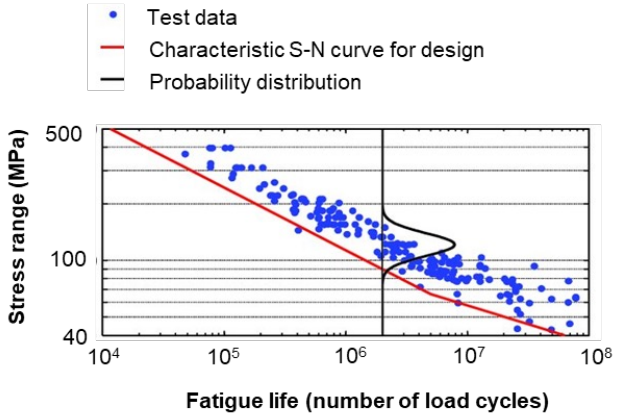
Fatigue design of thin-walled structures

Fatigue assessment methods for welded structures

Fatigue strength

- S-N curves are defined for different kinds of fatigue critical structural details and component-based large experimental database
- Design S-N curves defined for selected survival probability level (97.7%) using the statistical approach
- Standards (e.g., ISO) and rules (e.g. DNV, IACS) define acceptable quality for welds, surface, distortions, and workmanship





Assignment 5. Fatigue

The idea of the assignment is to demonstrate how fatigue assessment affects the FE-modeling of thin-walled structures.

In assignment, you need to:

- Create a direct mesh refinement to the stiffened panel (from Assignment 1) and compute the structural stress at some critical location with the t/2 and 3t/2 extrapolation rule.

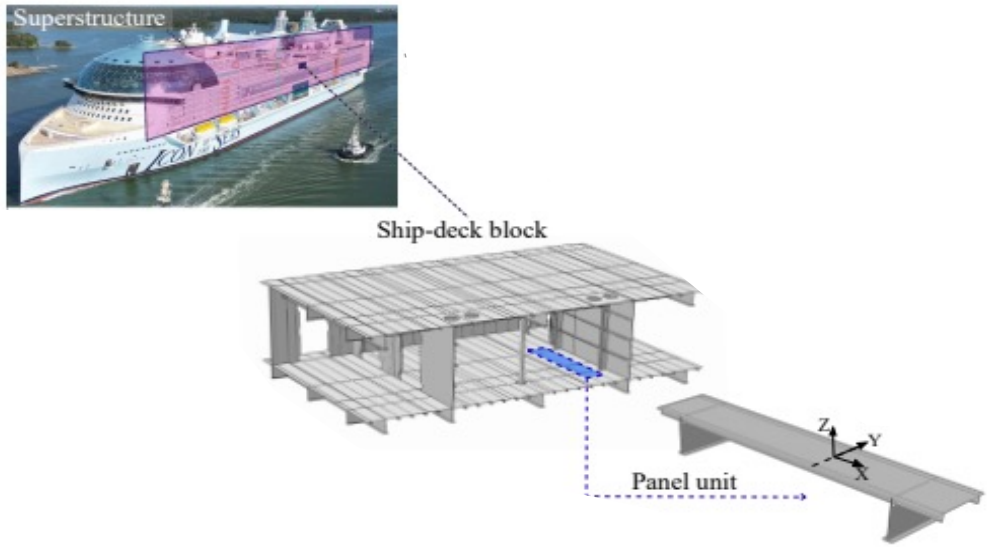
In the report, you need to:

- Discuss how you selected the mesh size and location for the fatigue assessment.
- Discuss the lessons learned from the assignment.

Bonus, 25%:

- consider an intersection between the stiffener web and the plate and perform extrapolation to the hot spot based on the structural stress approach from different from both plate and the stiffener web. How does the extrapolated stress change? Why does it change?

An example of a stiffened panel model



(Federica Mancini, 2024)

—

Kiitos
aalto.fi