

Information: 2018-02-04

*Syllabus for Advanced Steel Engineering  
Course for PhD students*

*LTU, KTH, Chalmers, LTH*

Course credits: 7.5 ECTS

Course dates:

Session 1	Chalmers	1 <sup>st</sup> & 2 <sup>nd</sup> of March
Session 2	Chalmers	5 <sup>th</sup> and 6 <sup>th</sup> of April
Session 3	Chalmers	17 <sup>th</sup> & 18 <sup>th</sup> of May

Course Teachers

Mohammad Al-Emrani	(MA)
Mikael Möller	(MM)
Bert Norlin	(BN)
Zuheir Barsoum	(ZB)

**Session 1**      1<sup>st</sup> & 2<sup>nd</sup> of March, 2018  
**Location:**      Chalmers university of Technology, Department of Architecture and Civil Engineering

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**Teachers:**  
**Mikael Möller (MM)**

**General notes about this session:**

1. During the lectures teacher will give you some numerical examples that should be solved during the lectures therefore you should have a calculator with you.
2. In order to pass the course, students will need to solve numerical assignments, for this part of the course, provided by Mikael Möller. The assignments can be solved in group of two students and send to the teacher and cc to Mohammad.Al-Emrani@chalmers.se, until **April 2nd**.

**Course contents:**

**Thursday, March 1<sup>st</sup>:**

- 10:00-10:15    Gathering and coffee
- 10:15-10:30    **Welcome**, course planning and presentation of participants (MA)
- 10:30-12:00    **Basic constitutive modelling-1** (MM)  
- Typical stress-strain curves for different steels  
- von Mises & Tresca yield criteria  
- the concepts of plastic potential, normality, convexity & consistency  
- isotropic & kinematic hardening  
- more advanced hardening models  
- a stress-driven constitutive model based on isotropic hardening
- 12:00-13:00    lunch
- 13:00-13:45    **Basic constitutive modelling-2** (MM)  
- analytical solutions to some classical multi-axial elasto-plastic constitutive problems  
- exercises
- 13:45-13:50    short break

- 13:50-15:00 **Limit analysis-1** (MM)
- Requirement on deformation capacity
  - Principle of virtual work
  - Lower bound theorem of plasticity
  - Upper bound theorem of plasticity
  - Slacking the requirements on equilibrium & compatibility
- 15:00-15:30 Coffee break
- 15:30-18:00 **Limit analysis-2** (MM)
- Energy methods & equilibrium methods
  - Yield hinge method for indeterminate beam structures
  - Yield line method & strip method for plates
  - The concept of limit resistance interaction
  - Some useful limit interaction relationships
- 18:00-18:30 **Social gathering**
- 18:30 **Dinner**

**Friday, March 2<sup>nd</sup>:**

- 09:00-11:30 **Limit analysis-3** (MM)
- Convexity and normality of deformations to the limit interaction surface
  - Finite element limit analysis
  - Normative references
- 11:30-12:30 Lunch
- 12:30-14:30 **Shakedown analysis** (MM)
- The concept of shakedown and progressive deformation
  - Shakedown theorems
  - The fundamental mechanics of progressive deformation
  - The Bree-diagram
  - Progressive deformation in piping
  - Finite element shake-down analysis
  - Normative references
- 14:30-15:00 Break

- 15:00-17:00 Limit analysis *interactions of combined loading* (MM)
- Axial force + bending of rectangular section
  - Axial force + strong axis bending of H-beams
  - Axial force + strong axis+ weak axis bending of H-beams
  - Axial force + bending of tubes
  - Axial force + internal pressure of tubes
  - Internal pressure + bending of tubes

**Session 2**

5<sup>th</sup> and 6<sup>th</sup> of April, 2018

**Location:**

Chalmers university of Technology

Department of Architecture and Civil Engineering

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**Teachers:**

**Bert Norlin (BN)**

**General notes about this session:**

1. During the lectures teacher will give you numerical examples that will refer to EN1993-1-1, part1-5 and part 1-8. It would be good to have these codes with you. Let me know if you need them.
2. In order to pass the course, students will need to solve numerical assignments, for this part of the course, provided by Bert Norlin. The assignments could be solved in a group of two students and send to the teacher (and cc Mohammad.Al-Emrani@chalmers.se) until May 2<sup>nd</sup>, 2018.

**Course contents:**

**Thursday, April 5<sup>th</sup>**

10:00- 10:15 Gathering and coffee

10:15-12:00 **Stability of columns, beam-columns and plates (BN)**

- General about classic theory, behaviour and design
- General method for lateral and lateral-torsional buckling of structural components

12:00-13:00 **Lunch**

kl 13:00-kl.14:50 **Beams and girders (BN)**

- Interaction formulae in EN 1993-1-1 – background and simplifications

kl 15:00-kl.16:30 **Beam-columns (BN)**

- Bending and axial resistance of sections in class 4
- Shear resistance
- Interaction shear and bending

kl. 18:00 **Dinner**

**Friday, April 6<sup>th</sup>**

09:00 – 10:00 **Stability Design with FEM (BN)**

10:10 – 11:00 **Connections (BN)**

- Basic failure criteria for bolts

11:10 – 12:00 **Design models for bolted and welded connections (BN)**

- Design models according SS-EN11993-1-8

kl. 12:00 -13:00 **Lunch**

13:00 – 14:20 **Rigid and simple connections (BN)**

- Design models for rigid connection and moment free connection, typical examples

14:30 – 16:00 **Semi rigid connections (BN)**

- Classification of connections according to SS-EN1993-1-8
- Structural modelling of connection

**Session 3**

**Location:**

17<sup>th</sup> & 18<sup>th</sup> of May, 2018

Chalmers university of Technology

Department of Architecture and Civil Engineering

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**Teachers:**

*Mohammad Al-Emrani (MA), Zuheir Barsoum (ZB)*

**Thursday, May 17th**

10:00-10:15 *Gathering and coffee*

10:15-11:45 *Fatigue of metals*

- The nature of fatigue damage process
- Fatigue crack initiation and propagation
- Representation of fatigue data - definitions
- Factors affecting the fatigue strength of metals

12:00 Lunch

13:00- 15:00 *Fatigue of welded details*

- Fatigue damage in welded details
- Fatigue design concept (Eurocode)
- Fatigue design variable amplitude loading (Palmgern-Miner)
- Fatigue strength of basic weld details
- Fatigue strength of some bridge details
- Examples and exercises

15:00 – 17:00 *Fatigue assessment with local approaches*

- Hot Spot Stress Approach
- Effective Notch Stress Approach
- FE-modeling for fatigue assessment – hints and recommendations
- Practical examples

19:0 *Dinner*

**Friday, May 18<sup>th</sup>**

09:00-11:45 *Fracture mechanics applied to fatigue*

- Historical overview
- Brittle failure in fatigue loaded structures
- Factors affecting the risk for brittle failure (steel type, Size and notch effects, temperature and loading rate)
- Measuring “material toughness”
- Fatigue crack growth under constant and variable amplitude loading
- Linear and nonlinear fracture mechanics (FM)
- Examples of the application of FM in fatigue analysis and design

12:00 Lunch

13:00-14:00 *Fatigue-life improvement techniques*

14:00 – 16:00 *Fatigue damage in steel Bridges*

- Deformation controlled fatigue cracking
- Learning from failure

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