Eindhoven University of Technology
Department of the Built Environment
Unit Structural Design

Intermediate test Dimensioning of Structures (7PPX2)
Date: December 15, 2017
Time: 13:45 – 15:15

Part Applied Mechanics

Consists of this these assignments and the AMMC answer sheet

First read the terms and conditions below

- Use for your answers only the additionally given Applied Mechanics Multiple Choice (AMMC) answer sheet. First fill in your ID NUMBER on the sheet following the examples there, and completely fill in the bubbles with the correct answers with a dark/black colour. Hint: use a pencil (Dutch: potlood), not a pen, so you can firmly erase a possibly incorrect answer. Note that the AMMC sheets will be processed automatically: A missing or incorrect ID.NR., corrections, notes, and creased or folded paper will all result in 0 points. Only a single sheet per student is handed out.

- Multiple Choice (MC) questions require a single correct answer. A multiple Response (MR) question may have zero, a single, or multiple correct answers: Each correct answer yields t/c points, with t the total number of points for the question, and c the number of correct answers. Marking an incorrect answer as correct reduces your result with $(1/2)*t/c$, however an overall negative result for the question is not possible (minimum = 0 points).

- "Complex" formulae are given to you on page 5.

- The course book, notes, laptop, mobile phone, and similar items are not permitted. Although a non-graphical pocket calculator is permitted.

- Pages 6 and 7 are scrap paper and will not be graded: as mentioned only the AMMC sheet will be used for the assessment.

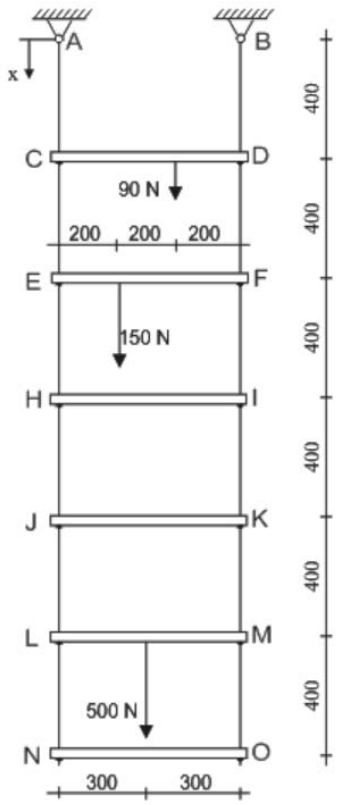
- Assessment of this part Applied Mechanics can yield up to 25 points in total. See the questions themselves for the maximum achievable points for each question.

- Assessment of the total intermediate test is calculated as follows: total number of points (Part Applied Mechanics part + Part Materials) divided by 5. The intermediate test contributes a 15% to the final mark.

- These assignments and the scrap paper should be taken home, only submit the AMMC answer sheet.

Assignment 1

A person is using a rope ladder as shown in the figure below. He or she applies vertical downwards loads on the rungs as indicated. All distances are in mm, and each of the two ropes has a cross-section equal to 100 mm^2 and a Young's Modulus (E) equal to 1000 N/mm^2.



Calculate (e.g. on the scrap paper) the tensile forces in rope parts EL and FM due to the 500 N load on rung LM. Hint: regard the rung LM as a beam on two supports L and M. Use the AMMC sheet to answer the multiple choice question below.

MC 1 (2 points)
The tensile forces in rope parts EL and FM are equal to:

A) $N_{EL} = 380\text{N}, N_{FM} = 360\text{N}$ B) $N_{EL} = 370\text{N}, N_{FM} = 370\text{N}$
C) $N_{EL} = 380\text{N}, N_{FM} = 360\text{N}$ D) $N_{EL} = 360\text{N}, N_{FM} = 380\text{N}$
E) $N_{EL} = 250\text{N}, N_{FM} = 250\text{N}$ F) $N_{EL} = 740\text{N}, N_{FM} = 740\text{N}$

Using the same approach for rung CD and EF, calculate the tensile forces in rope parts AC and BD, and answer the question below on the AMMC sheet.

MC 2 (3 points)
The tensile forces in rope parts AC and BD equal:

A) $N_{AC} = 380\text{N}, N_{BD} = 360\text{N}$ B) $N_{AC} = 370\text{N}, N_{BD} = 370\text{N}$
C) $N_{AC} = 380\text{N}, N_{BD} = 380\text{N}$ D) $N_{AC} = 360\text{N}, N_{BD} = 380\text{N}$
E) $N_{AC} = 250\text{N}, N_{BD} = 250\text{N}$ F) $N_{AC} = 740\text{N}, N_{BD} = 740\text{N}$

MC3 (2 points)
Assume that the forces in rope part AC and BD equal $N_{AC} = 100\text{N}$, $N_{BD} = 110\text{N}$ respectively (note that these need not to be the correct answers for MC2), give on the AMMC sheet the correct statement below:

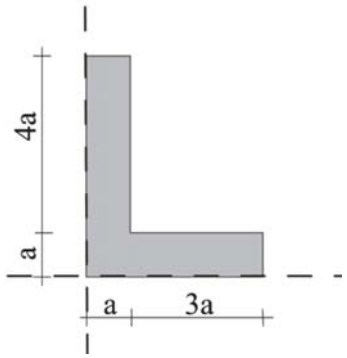
A) $\Delta l_{AC} = 2.4\text{ mm}, \Delta l_{BD} = 2.64\text{ mm}$ B) $\Delta l_{AC} = 0.40\text{ mm}, \Delta l_{BD} = 0.44\text{ mm}$
C) $\Delta l_{AC} = 0.240\text{ m}, \Delta l_{BD} = 0.264\text{ m}$ D) $\Delta l_{AC} = 2.40\text{ mm}, \Delta l_{BD} = 2.41\text{ mm}$
E) $\Delta l_{AC} = 0.0040\text{ m}, \Delta l_{BD} = 0.0044\text{ m}$ F) $\Delta l_{AC} = 2.41\text{ mm}, \Delta l_{BD} = 2.40\text{ mm}$

MR4 (3 points)
Using the originally given properties in the figure and at the beginning of the assessment (so no assumed values like for MC3), calculate the displacement of point N and O and the stress along the ropes AN and BO. The maximal allowable stress in each rope equals 3.7 N/mm^2 Mark all possible correct answers below in the AMMC sheet. Note that this is a multiple response question, so 0, 1, or several answers may be correct.

A) The maximal allowable stress is reached (somewhere in the rope ladder).
B) Rung NO will be slightly inclined.
C) The stress in rope part DF equals 3.0 N/mm^2
D) The deformation of point N equals 5.64 mm
E) The deformation of point O equals 5.64 mm
F) The stress in rope part MO equals 2.5 N/mm^2

<u>Assignment 2</u>

Given is the cross-section of a beam below. All material has the same Young's Modulus and density.



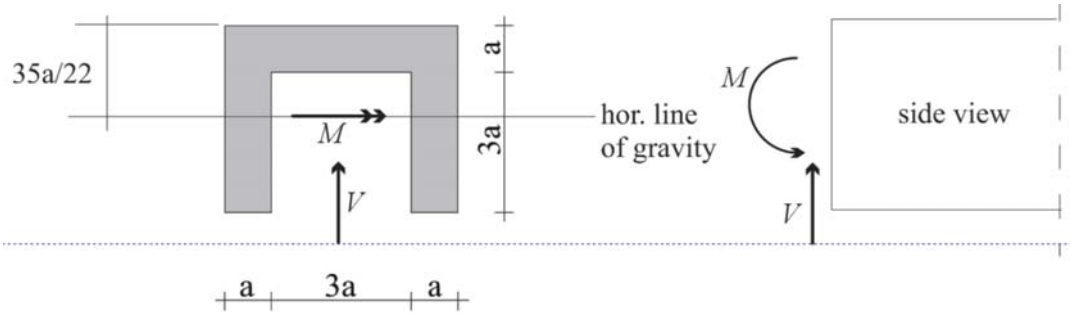
MC5 (3 points)
Calculate the (vertical) distance between the horizontal line of gravity and the dashed horizontal line at the bottom of the cross-section. This distance equals:

A) $1\frac{4}{3}a$ B) a C) $\frac{4}{7}a$ D) $\frac{7}{4}a$ E) $2\frac{1}{2}a$ F) $1\frac{1}{2}a$

MC6 (3 points)
Calculate the (horizontal) distance of the vertical line of gravity relative to the dashed vertical line at the left side of the cross-section. This distance equals:

A) $1\frac{4}{3}a$ B) a C) $\frac{5}{4}a$ D) $\frac{7}{4}a$ E) $2a$ F) $2\frac{1}{3}a$

Given is the U-shaped cross-section of a beam below. All material has the same Young's Modulus and density. The U-shaped cross-section has a horizontal line of gravity that has a distance of 35a/22 to the top of the section, as shown in the figure.



MC7 (4 points)
Calculate the second moment of area about the line of gravity and give on the AMMC sheet the correct answer. Note that the answers below may have been rounded.

A) $15.8a^4$ B) $10.9a^4$ C) $11.6a^3$ D) $10.9a^3$ E) $10.9a^5$ F) $11.6a^4$

MR8 (5 points)
Now assume that a bending moment M and a shear force V act on the cross-section, as shown in the above figure too. Indicate on the AMMC sheet only the statements below that are correct. Note that this is a multiple response question, therefore 0, 1, or several statements may be correct.

A) The maximum compression stress due to bending equals $\dfrac{M\left(35a/22\right)}{I}$

B) The shear stress in the webs (vertical parts) at the horizontal line with distance a from the top equals $\dfrac{V5a^2\left\{\frac{35}{22}a-\frac{1}{2}a\right\}}{aI}$

C) The shear stress in the flange (horizontal part) at the vertical line with distance a from the left side equals $\dfrac{V4a^2\left\{2a-\frac{35}{22}a\right\}}{aI}$

D) The shear stress in the flange (horizontal part) at the vertical line with distance a from the left side equals $\dfrac{V4a^2\left\{2a-\frac{35}{22}a\right\}}{5aI}$

E) The maximum compression stress due to bending equals $\dfrac{M\left(53a/22\right)}{I}$

F) Normal stresses due to the bending moment should be added up to the stresses due to the shear force, otherwise the stresses on the material are underestimated.

Formulae

Second moments of area

Rectangular cross-section

$$I = \frac{1}{12} b h^3$$

Triangular cross-section

$$I = \frac{1}{36} b h^3$$

Hollow circular cross-section

$$I = \frac{1}{4} \pi (R_u^4 - R_i^4)$$

Polar moment of area

$$I_p = \frac{1}{2} \pi (R_u^4 - R_i^4)$$

Stress

$$\sigma = \frac{N}{A}$$

$$\sigma = \frac{M\ z}{I}$$

$$\tau = \frac{V\ S}{b\ I}$$

$$\tau = \frac{M\ r}{I_p}$$

Elongation

$$\Delta l = \frac{Nl}{EA}$$

Scrap paper, will not be graded

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