STRENGTH OF MECHANICAL CONSTRUCTIONS

PROJECT – ANALYSIS OF A CURVED BAR (2025)

The project consist of two parts. The first part is obligatory and deals with analytical determination of the deformation of the curved bar as well as the stress distribution along the cross-section of the curved bar.

The second part is an optional one. It deals with the numerical analysis of selected curved actual structure in which the stress distribution on a cross-section needs to be analysed in elastic and plastic range.

Part I

A curved bar presented in figure below is clamped at one end (point A) and loaded with horizontal force F_x and vertical force F_y at the second end (point B). The radius of the centre line of the bar is R_0. The rectangular cross section has dimensions h and b. The mechanical properties of the material of the bar are: Young's modulus $E = 2 \cdot 10^5$ MPa, Poisson's ratio $\nu = 0.3$. Other data are given in the table (next page). A negative value of the force means that it is directed opposite to the vector in the figure.

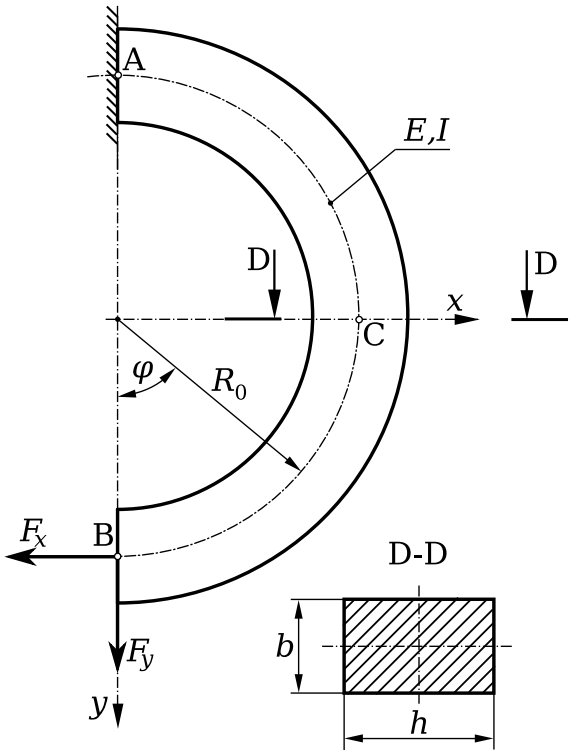
1. Treating the bar as a thin curved bar **loaded with the force F_x only** (neglect the influence of curvature, take into account only the energy due to bending moment) :
   (a) plot distribution of internal forces as functions of an angle φ ($N(\varphi), V(\varphi), M(\varphi)$),
   (b) determine the horizontal displacement of point B,
   (c) determine the angle of rotation of the cross section at point B.
2. Treating the bar as a thick curved bar **loaded with the force F_y only**:
   (a) determine the position of the neutral line,
   (b) determine the value of normal stress at inner and outer surface of the bar (for $\varphi = \pi/2$),
   (c) plot the stress distribution through the cross section of the bar (for $\varphi = \pi/2$),
   (d) calculate the maximum normal stress for $\varphi = \pi/2$ when the bar is treated as a straight one (the influence of curvature is neglected).

Part II (*only for experienced users of FEM*)

Prepare the numerical analysis, with the use finite element method, of a selected actual structure which can be treated as a highly curved bar, e.g. a hook crane, frame of micrometer, etc.

The goal of the analysis is to show the stress distribution in selected cross-sections before and after the yield strength has been exceeded. The report from the analysis should contain

- CAD model of the structure
- model of the material – e.g. bilinear with isotropic hardening
- FE model of the structure
  - assumptions made on the model – simplifications, symmetry, etc.
  - boundary conditions
  - description of the mesh
- results of the analysis
  - stress distribution in an elastic range
  - stress distribution in a plastic range



Data for the project

No	F_x [kN]	F_y [kN]	R_0 [mm]	h [mm]	b [mm]
1	10	10	80	80	40
2	8	-6	60	60	30
3	-8	8	50	50	50
4	-10	9	90	80	60
5	12	-10	80	70	30
6	11	12	70	60	40
7	5	5	40	40	20
8	8	7	65	60	40
9	16	-16	90	100	50
10	-12	12	100	100	60
11	7	10	75	80	50
12	-15	-12	70	80	60
13	-10	10	50	60	50
14	14	14	70	70	70
15	9	-9	80	90	70
16	7	-8	55	60	50
17	-12	10	100	80	60
18	10	18	90	70	60
19	8	-7	40	40	20
20	-12	-15	100	90	60
21	16	-16	90	100	50
22	-16	18	120	100	60
23	10	16	60	80	40

Guidelines for the preparation of project

- first page is a title page (where, what, who, when)
- start with defining the problem based on the provided information – drawing, what to do, etc.
- A4 paper printed on both sides (printout or handwriting)
- all pages must be clipped together
- calculations should be carried on using symbolic notations; values of parameters should be substituted after the final symbolic solution is known
- be sure that the project is readable