evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Recommended teaching texts

Theory:

M. Sochor: Strength of materials II. Czech Technical University Prague, 2006.

In Czech:
Ondráček, Vrbka, Janíček, Burša: Mechanika těles, Pružnost a pevnost II. CERM, Brno, 2006.

Theory and problems:

Timoshenko's Strength of Materials, Part II: Advanced Theory and Problems: 3rd Edition, 1963

A.P. Boresi, R.J. Schmidt, O.M. Sidebottom: **Advanced Mechanics of Materials.** John Wiley and Sons, New York, 1993.

A.C. Ugural, S.K. Fenster: **Advanced Strength and Applied Elasticity.** Prentice Hall, New Jersey, 2003.

Problems in Czech:
Janíček, Petruška: Pružnost a pevnost II, Úlohy do cvičení. CERM, Brno, 2007.

Backgrounds for these lectures available at: http://www.old.umt.fme.vutbr.cz/~jbursa/

Objectives of the course in Strength of materials II

The course enlarges and completes the knowledge acquired in Strength of materials I

1. Topics presented but not exercised in the previous course
   - combined loads of bars
   - evaluation of multiaxial stress states (Mechanics of materials I - Chapt. 16)

2. Enlargement of the knowledge on failures (limit states) for
   - repeated loading – fatigue fracture
   - bodies with cracks – fracture mechanics

3. Analytical solutions of stress-strain states in some axisymmetric bodies

4. Fundamentals of finite element method (FEM)

5. Overview of capabilities and methods of experimental mechanics

Overview of analytically soluble model bodies

- **Rod-like bodies (beams, bars, columns)**
- **Thick-wall cylindrical and spherical body**
- **Axisymmetric plate**
- **Rotating disc**
- **Axisymmetric membrane shell**
- **Cylindrical momentum shell**

Assumptions used in the stress analysis

(simple theory of elasticity)

Categories of assumptions:
A. on elasticity
B. on failure conditions
C. on calculations

ad A:

1. small strains ($\varepsilon<0.01$)
2. free body diagram created in the undeformed state –small distortion (displacements negligible in comparison with the dimensions of the body)
3. primary loads independent of the body deformation
4. supports (and reactions) not influenced by deformations
5. body fixed to the frame (not moving as a whole)
6. static behaviour – no inertial effects
7. isotropic material meets Hooke’s law
8. the body keeps continuous deformability up to a crack initiation
9. initial state is undeformed and stress-free

ad B:

1. crack propagation without branching
2. plastic deformation occurs in the near surroundings of the crack root

ad C:

1. availability of all material parameters needed
2. the mathematical solution exploits a computational model that can be
    a. in the form of an explicit analytical formula
    b. in the form of complex equations or their systems – solved using a mathematical software
    c. in the numerical form under use of a special software, **Finite Element Method** (FEM) being the most frequent (ANSYS, Abaqus, Adina, MSC Marc, LS-DYNA, Nastran, Pam-Crash, and other softwares). In a simpler form included in most CAD systems as well.

A computational model (in all its forms) consists of the following partial models:

- Model of geometry
- Model of material behaviour
- Model of body supports
- Model of loads

These four models represent a complete system of input data for forward problems in both analytical and numerical approaches.

Outputs of a forward problem: field of displacements, strains and stresses in the investigated body.

Attention! FEM and other computer methods are not able to solve backward (inverse) problems; i.e. they cannot start calculations without having defined all of the above input data!

5. Main applications of experimental mechanics

a) Acquiring input data for computational modelling on
- operational conditions (acting loads),
- material data (mechanical properties).

b) Verification of the results of computational modelling, specifically
- verification of the principle of the computational theory,
- validation of the applicability of computational modelling for a specific technical product (using the product itself or its physical model).

c) Replacement of calculations if not feasible

d) Monitoring and diagnostics

e) Gaining new information on mechanical behaviour