ADVANCED TOPICS IN FINITE ELEMENT METHOD

Notation

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INTRODUCTION

- This presentation deals with the use of the finite element method (FEM is an abbreviation for the Finite Elements Method or FEA for Finite Elements Analysis) to solve linear problems of solid mechanics.
- We are interested in static analysis of bar structures (trusses, frames), surface structures (2D plates, slabs, 3D plates, shells); elements that are very often used in engineering structures.
- An understanding of the FEM basis is necessary for a contemporary designer who has to use sets of computer programmes in the design process and those calculated modules are just based on the finite element method.

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NOTATION

- **a, b, u** – column matrix – vectors
- **A, B, K** – two-dimensional matrix
- **u', K'**, u_x – vectors, matrices and scalars in the local coordinate system of an element
- **u, K**, u_X – vectors, matrices and scalars in the global coordinate system
- x, y, z – axes of the local coordinate system
- X, Y, Z – axes of the global coordinate system

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NOTATION

- $\mathbf{q}_i$ – lower index at vectors or matrices denotes the node number i
- $\mathbf{q}^e$ – upper index at vectors or matrices denotes the element number e
- $u_x, u_y, u_z, \varphi_x, \varphi_y, \varphi_z$ – components of the local vector $\mathbf{u}'$ in the local coordinate system
- $u_X, u_Y, u_Z, \varphi_X, \varphi_Y, \varphi_Z$ – components of the global vector $\mathbf{u}$ in the global coordinate system

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NOTATION

$$\mathbf{u}_i = \begin{bmatrix} u_{iX} \\ u_{iY} \\ u_{iZ} \end{bmatrix}$$ – displacement vector of node i

$$\mathbf{f}_i = \begin{bmatrix} F_{iX} \\ F_{iY} \\ F_{iZ} \end{bmatrix}$$ – force vector of node i

$$\mathbf{u}^e = \begin{bmatrix} \mathbf{u}_p \\ \mathbf{u}_k \end{bmatrix}$$ – nodal displacement vector of an element e

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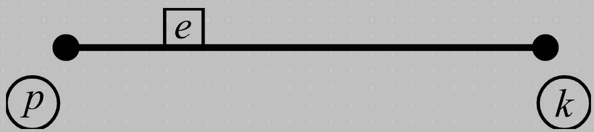
NOTATION

$$\mathbf{u} = \begin{bmatrix} u_x \\ u_y \\ u_z \end{bmatrix} \quad \mathbf{f} = \begin{bmatrix} F_x \\ F_y \\ F_z \end{bmatrix}$$

components of the vector are usually denoted by small letters just as a vector except for the nodal forces vector which is denoted by capital letters in accordance with tradition



Element numbers (e) are situated closer to the initial node of the element

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NOTATION

- det(**A**) is a determinant of the matrix **A**
- $\mathbf{A}^{\mathsf{T}}$ - transposition of the matrix **A** which means:

  if $\mathbf{B} = \mathbf{A}^{\mathsf{T}}$ *then* $B_{ij} = A_{ji}$
- N_N - number of nodes in a structure
- N_E - number of elements in a structure
- N_D - number of degrees of freedom of one node
- N^e_D - number of degrees of freedom of an element e
- N_K - number of degrees of freedom of the whole structure
- E - Young's modulus (modulus of elasticity)
- G - Kirchhoff's modulus (modulus of elasticity in shear)
- ν - Poisson's ratio

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NOTATION

- A - cross-section of a bar or the surface area of an element
- J_z - inertial moment with regard to the z axis
- C - torsional resistance characteristics
- L - length of an element
- $\mathcal{V}$ - volume of an element

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