# Literature

**English**

Zienkiewicz O. C., Taylor R. L., Zhu J. Z., The Finite Element Method, Sixth Edition, McGraw-Hill 2005.
Bathe J-K., Finite Element Procedures, Part 1-2, Prentice Hall 1995.
Banerjee P. K., Butterfield R., Boundary element methods in engineering science, McGraw-Hill 1981.
Brebbia C. A., Telles J. C. F., Wrobel L. C., Boundary Elements Techniques, Springer-Verlag, Berlin 1984.
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**Polish**

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Burczyński T., Metoda elementów brzegowych w mechanice, WNT, Warszawa 1995.

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Konderla P., Kasprzak T., Metody komputerowe w teorii sprężystości. Część I. Metoda elementów skończonych. Dolnośląskie Wydawnictwo Edukacyjne, Wrocław 1997.

Rakowski G., Kacprzyk Z., Metoda elementów skończonych w mechanice konstrukcji, Oficyna Wydawnicza Polit. Warszawskiej, Warszawa 1993.

# Lectures schedule

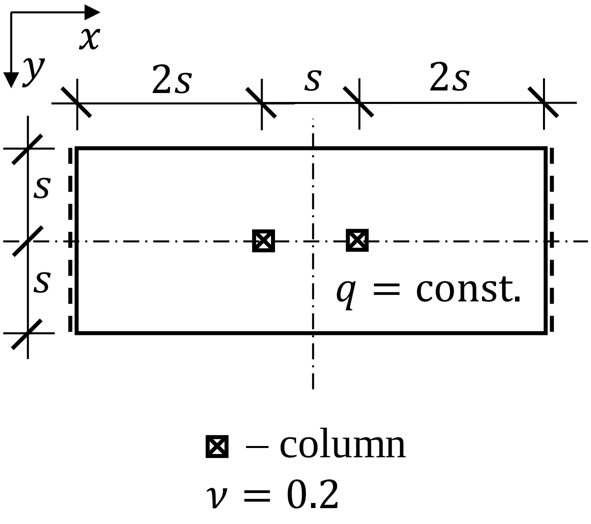
**Lecture 1**

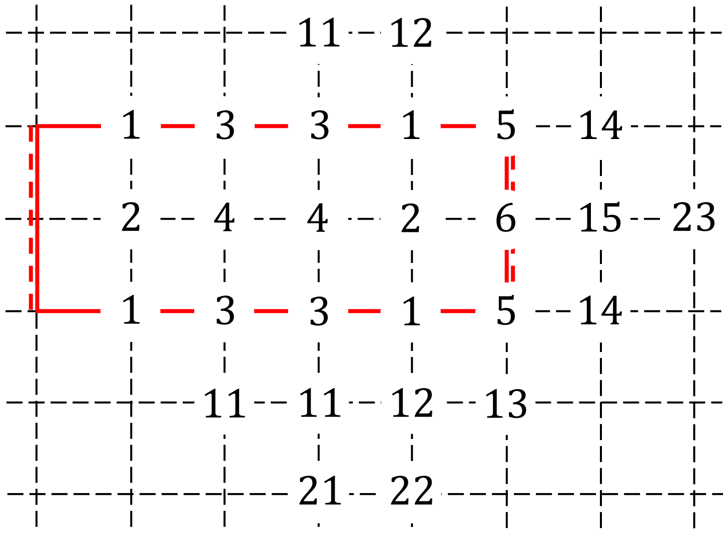
1. Introduction
   1.1. Place of numerical methods in structural analysis
   1.2. Boundary problems formulations and related numerical methods
2. *FDM* for thin plates
   2.1. Function approximation. Finite-difference operators
   2.2. Finite-difference operators for physical model equations

**Lecture 2**

   2.3. Boundary conditions

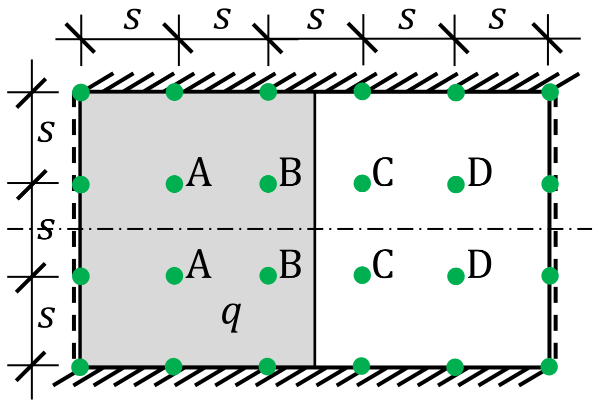
*Example 1*




$$\left.\begin{aligned} w_1 &= 0.3252 \\ w_2 &= 0.2226 \\ w_3 &= 0.2386 \end{aligned}\right\} \times \frac{qs^4}{D} \implies \begin{aligned} &\text{node 2} \longrightarrow \left\{\begin{aligned} M_x &= 0.404qs^2 \\ M_y &= -0.116qs^2 \\ M_{xy} &= 0 \\ Q_x &= 0.350qs \\ Q_y &= 0 \end{aligned}\right. \\ &\text{node 6} \longrightarrow \quad V_x = -0.576qs \\ &\text{node 4} \longrightarrow \quad R_4 = -3.201qs^2 \end{aligned}$$

*Example 2*




$$\implies \left.\begin{aligned} w_A &= 0.175 \\ w_B &= 0.197 \\ w_C &= 0.091 \\ w_D &= 0.029 \end{aligned}\right\} \times \frac{qs^4}{D}$$

**Lecture 3**

3. Finite element method (*FEM*) for thin plates
   - 3.1. Selected matrix operations
   - 3.2. Physical model equations in matrix notation
   - 3.3. *FEM* algorithm

**Lecture 4**

- 3.3. *FEM* algorithm (continuation)
- 3.4. Rectangular non-conforming element
- 3.5. Rectangular conforming element
- 3.6. Triangular non-conforming element

**Lecture 5**

3.7. Triangular shell element

4. *FEM* for geometrically nonlinear problems

4.1. Nonlinear equilibrium equation

4.2. Initial stability (buckling analysis)

**Lecture 6**

5. *BEM* for plane problems

5.1. Fundamental solution matrices

5.2. Somigliano identity

5.3. *BEM* discrete model

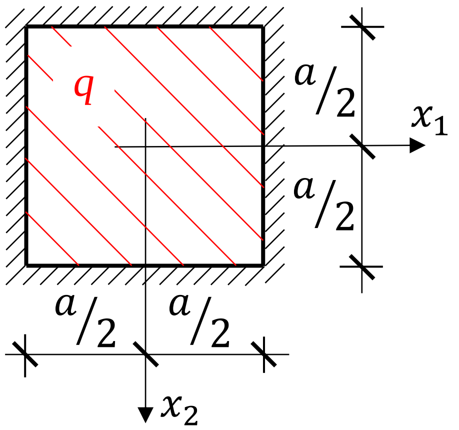
5.4. Post processing

**Lecture 7**

6. Ritz method for thin plate

6.1. Method equations system

6.2. <u>*Example 3*</u> *Square plate with constant load*




$$\Longrightarrow \quad w_{\max} \cong 0.00128\frac{qa^4}{D}$$

Test

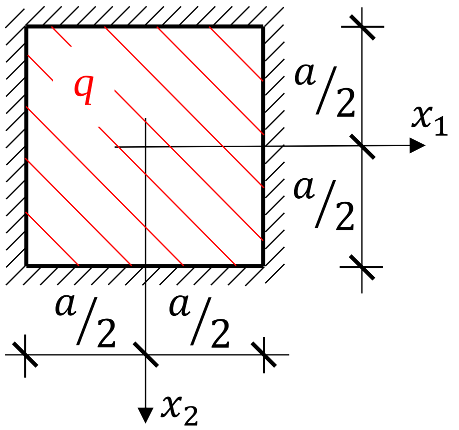
**Lecture 8**

7. Weighted residuals method (Galerkin) for thin plate

7.1. The concept of residuum. Error orthogonalization

7.2. Base and test functions. Method equations system

7.3. <u>*Example 4*</u> *Square plate with constant load*




$$\Longrightarrow \quad w_{\max} \cong 0.00133\frac{qa^4}{D}$$

Test 2nd attempt (retake, for volunteers only)