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Structural Analysis & Design Software

www.dlubal.com

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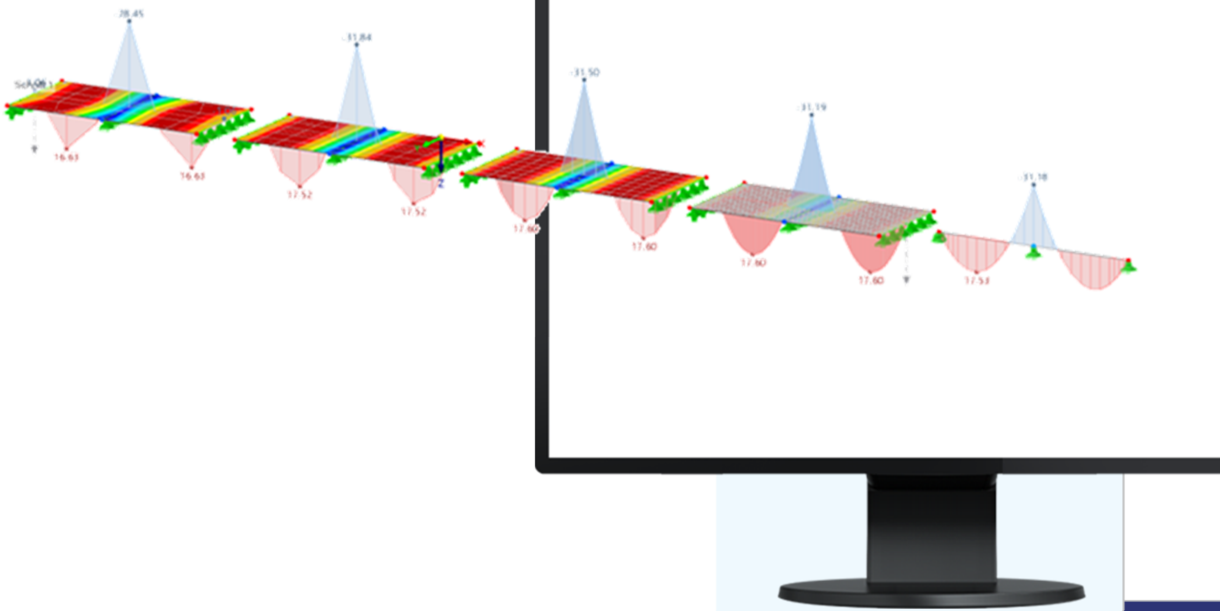
Part 3 | Introduction to FEM

RFEM 6 for Students



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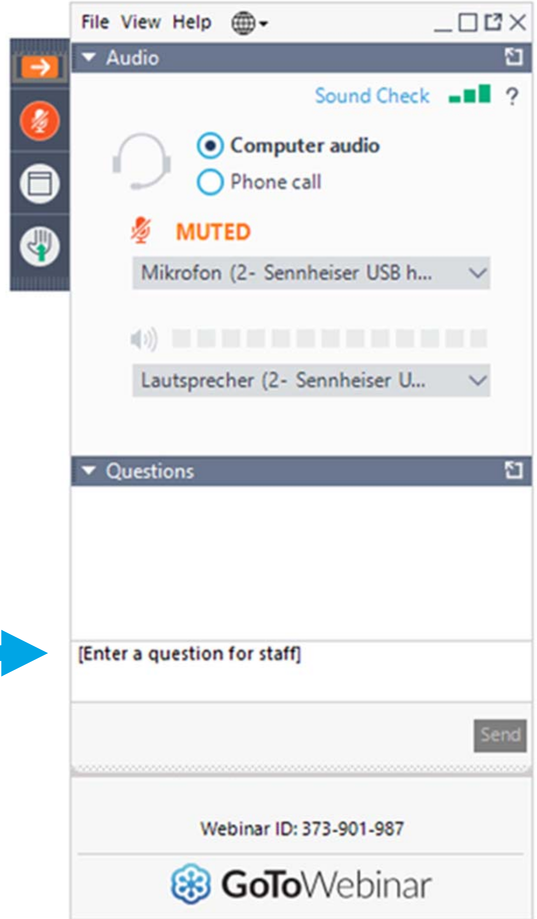

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Training Series

01 **Introduction to Member Design**

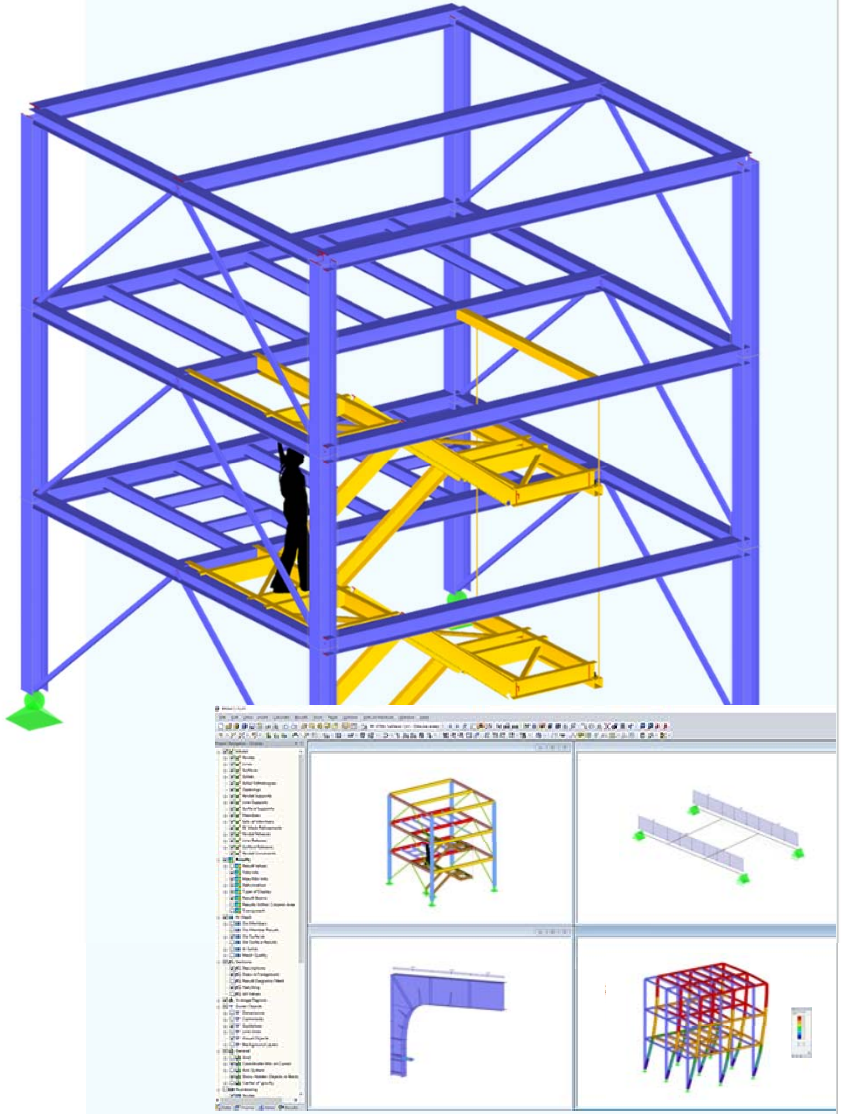
02 **Introduction to Strength of Materials**

03 **Introduction to FEM / FEA**

04 **Steel Design**

05 **Concrete Design**

06 **Timber Design**



ONLINE TRAINING

Training Series

01 Introduction to Member Design

02 Introduction to Strength of Materials

03 **Introduction to FEM / FEA**

04 Steel Design

05 Concrete Design

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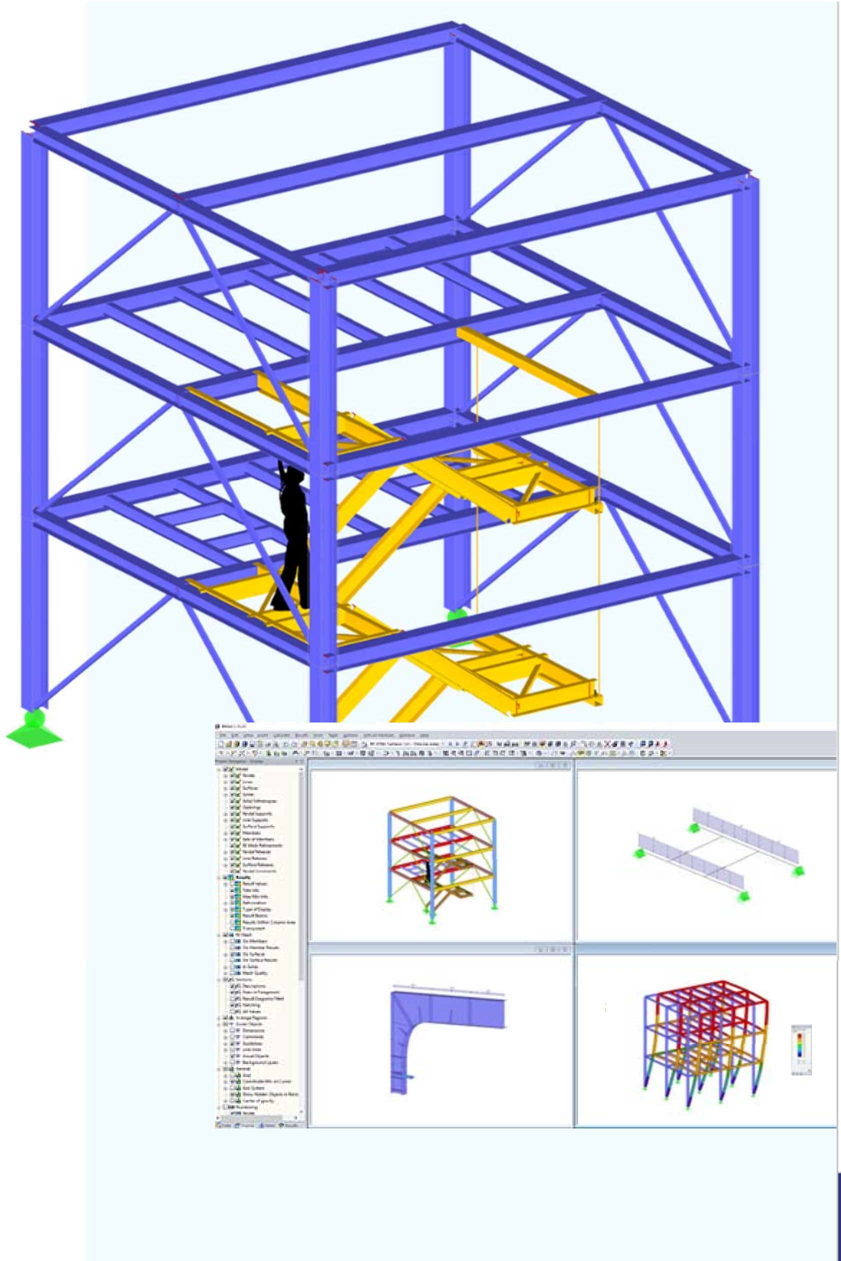


CONTENT

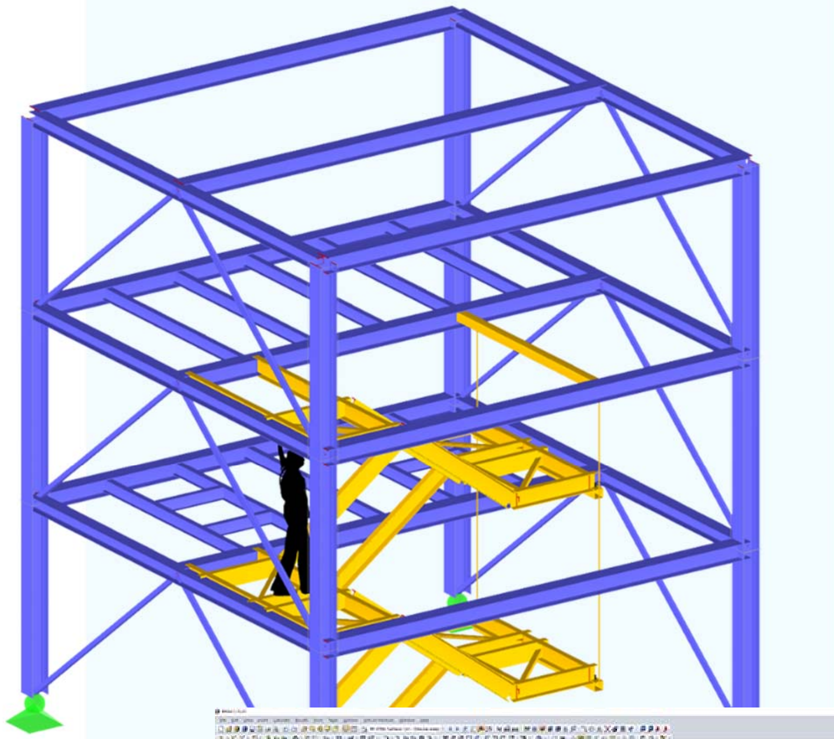
01 Basic principle of FEA

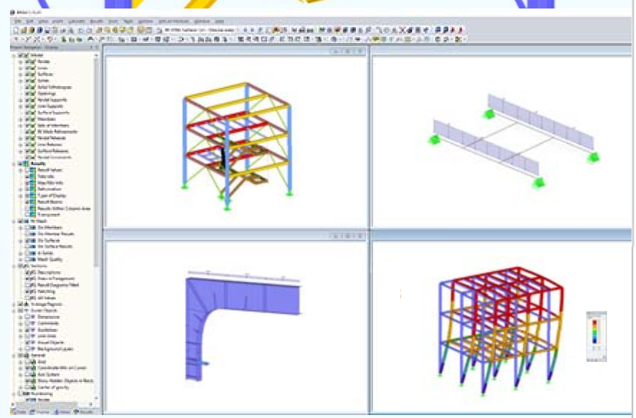
02 Introductory Example: Continuous slab

03 Plate theory

04 Nonlinear calculations

05 Singularities





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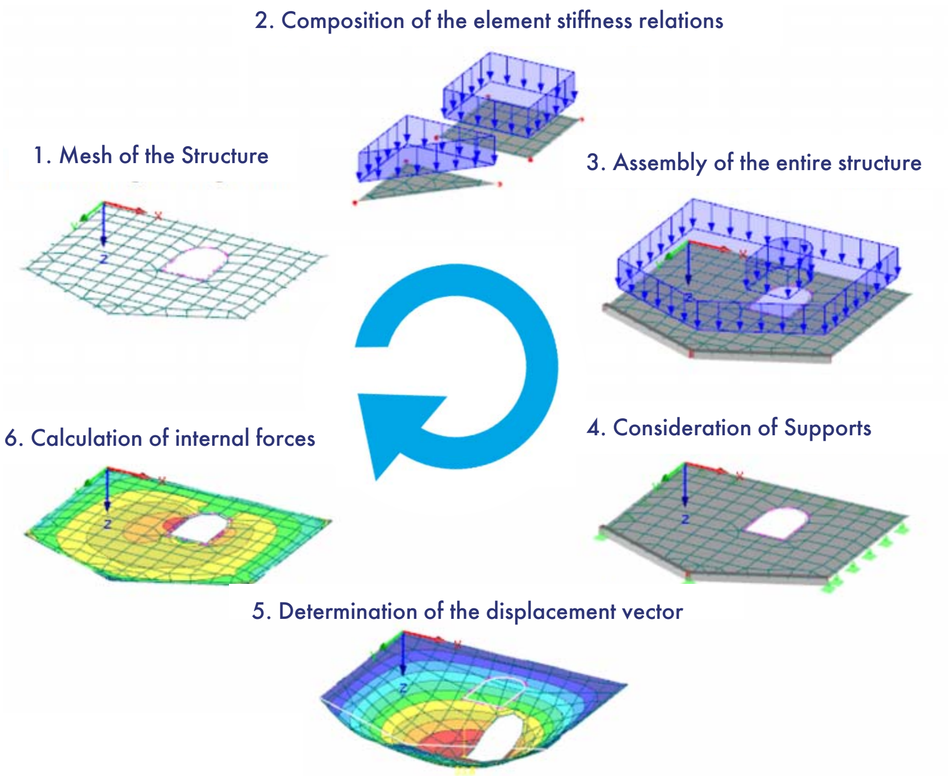
Basics of FEA

- Computer programs are based on the displacement method
- Analytical solution of structures is hardly possible
  - Real structure is decomposed into a mesh of finite interconnected elements
  - Properties of the element continuum are described at the nodes
  - The mechanical behavior is described by approximation sets
- Discretization: Decomposition of structure into finite elements

Procedure of a FEA calculation

1. Determination of the local element stiffness relations
2. Transformation of the stiffness relations to the global Coordinate System
3. Composition of the total stiffness relation
4. Consideration of Support Conditions
5. Solution of Equation System
6. Determination of Support Forces and Internal Forces



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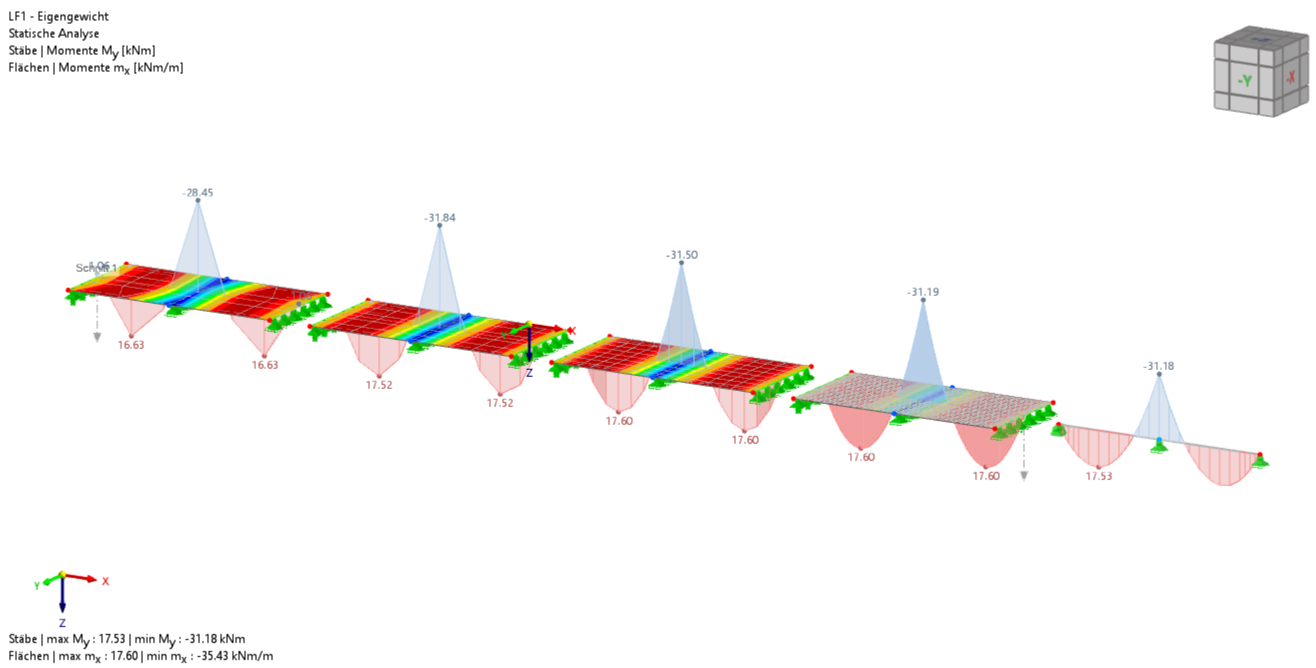
Durchlaufplatte mit Flächenlast



Covered Topics

- FE mesh design
- Convergence behavior
- Comparison of beam / surface elements
- FE mesh size

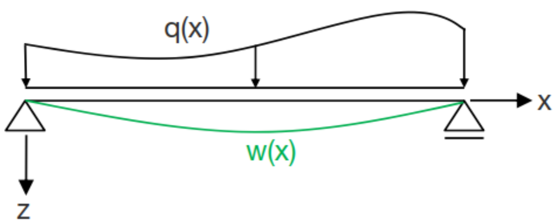
Result Interpretation

- Distribution of internal forces
- Shear stiffnesses
- Result smoothing

Plate Theory

Analogy to beam element:

Bernoulli	Timoshenko
▪ Cross-Section remain in plane, Cross-Sections remain perpendicular to the member axis ▪ No consideration of shear deformations, rigid shear stiffness	▪ Cross-Section remain in plane, Cross-Sections don't remain perpendicular to the member axis ▪ Consideration of shear deformations, shear stiffness is limited, isn't rigid



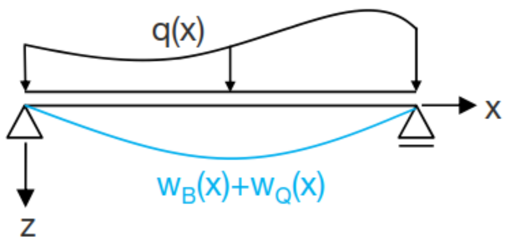


Plate Theory

Analogy to beam element:

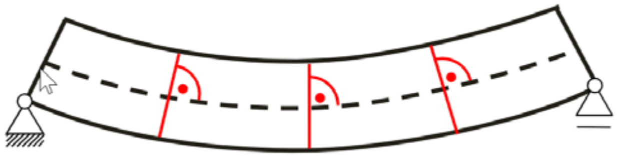
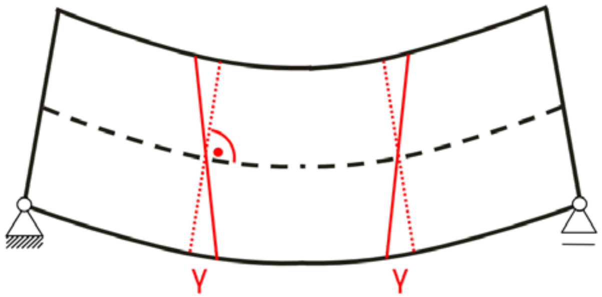
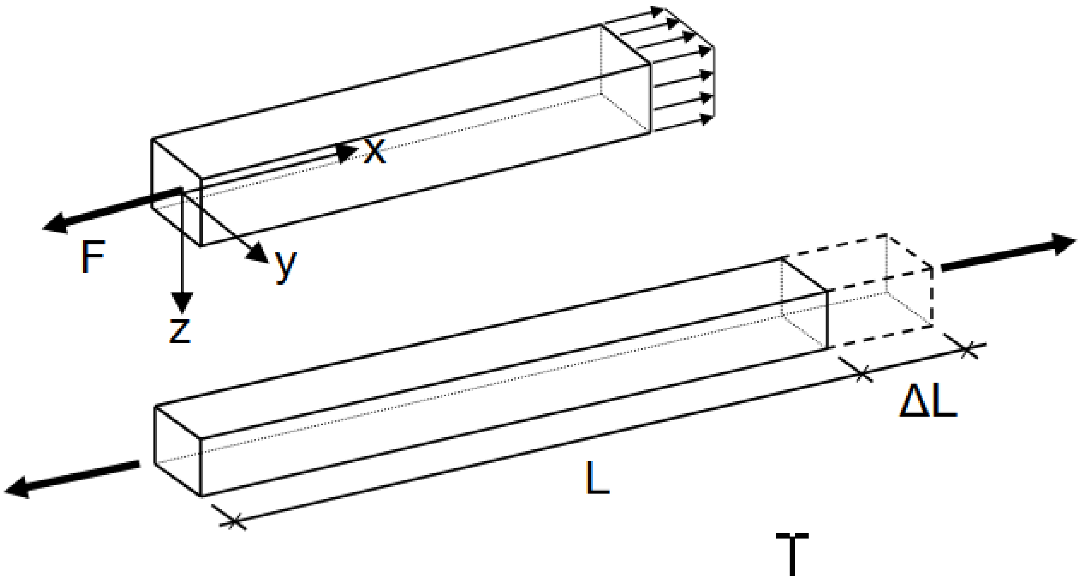
Bernoulli	Timoshenko
	

Plate Theory

Transfer to plate elements:

Kirchhoff	Reissner/Mindlin
▪ Geometrically linear: small deformations ▪ Linear elastic material law: Hooke ▪ The cross-sections remain flat, no warping ▪ Constant thickness ▪ **No consideration of shear deformations**	▪ Geometrically linear: small deformations ▪ Linear elastic material law: Hooke ▪ The cross-sections remain flat, no warping ▪ Constant thickness ▪ **Consideration of shear deformations** ▪ **Consideration of transverse/lateral strains**

Transverse/Lateral Strain



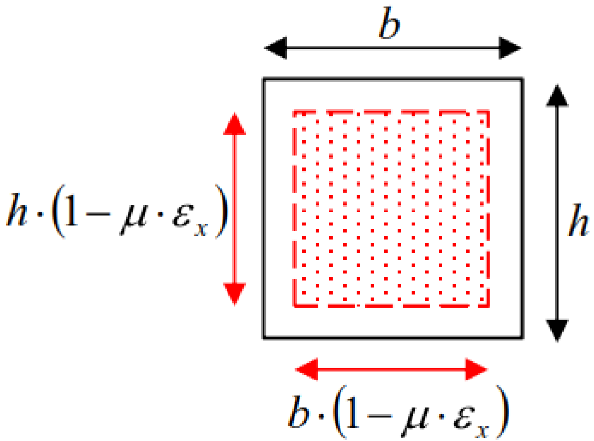


Plate Theory

Transfer to plate elements:

Kirchhoff	Reissner/Mindlin
▪ **No consideration of shear deformations** ▪ Theory of thin plates ▪ Pure bending load bearing capacity ▪ Simplified approach	▪ **Consideration of shear deformations** ▪ Theory of thick plates ▪ The component of the shear influence is relatively high ▪ Error in neglecting shear force would be too high ▪ Higher-value approach ▪ More accurate shear forces

Nonlinear Calculation

- Disadvantage of all nonlinear calculations: Superposition law is no longer valid
- Typical application areas in RFEM 6:
  - Geometrically nonlinear calculation, e.B. Second-order analysis
  - Nonlinear material behavior
  - Nonlinear behavior for structural object elements such as members, hinges, supports, etc.
- More precise analyzes, but increased calculation effort

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Coffee Break

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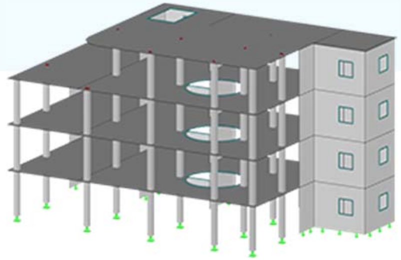
What are singularities? Where do they occur?

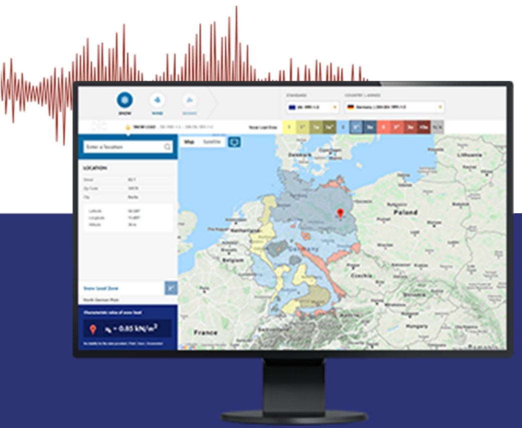
- Points of discontinuity in the calculation model
- No meaningful results
  - Model problem, no real occurring physical phenomenon
  - Infinite stresses and internal forces
  - Mesh refinement does not improve the result
- Typical singularity locations
  - Point and line loads, point and line supports
  - Openings, reentrant corners
  - Stiffness changes due to material or thicknesses



Free Online Services

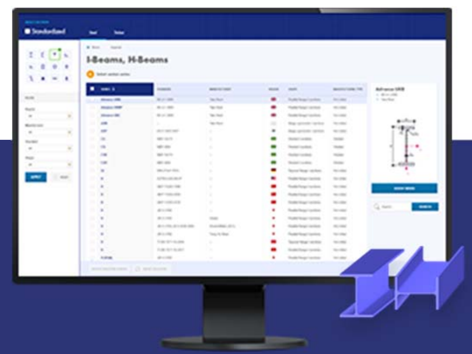
Geo-Zone Tool

Dlubal Software offers an online tool for determining the characteristic load values of the relevant load zone.



Cross-Section Properties

With this free online tool, you can select standardized sections from an extensive section library, define parametrized cross-sections and calculate its cross-section properties.



FAQs & Knowledge Base

Check out the frequently asked questions our customer support team is asked and get helpful tips and tricks with our technical articles to improve your work.

Models to Download

Download numerous example files that help you to get started and become familiar with the Dlubal programs.

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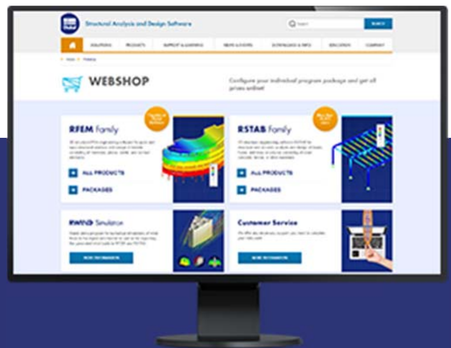
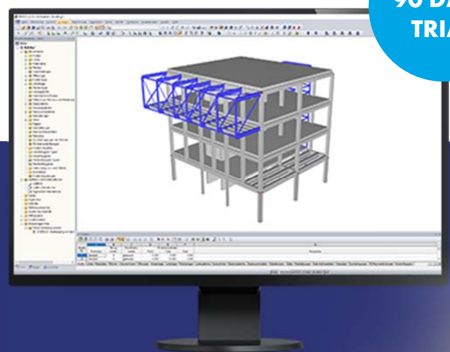
Customize your program package and get all prices online!



Trial Versions

The best way how to learn our programs is to simply test them yourself. Download the free 90-day free trial version of our structural analysis & design software.

90 DAYS TRIAL



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