



# Structural Analysis & Design Software

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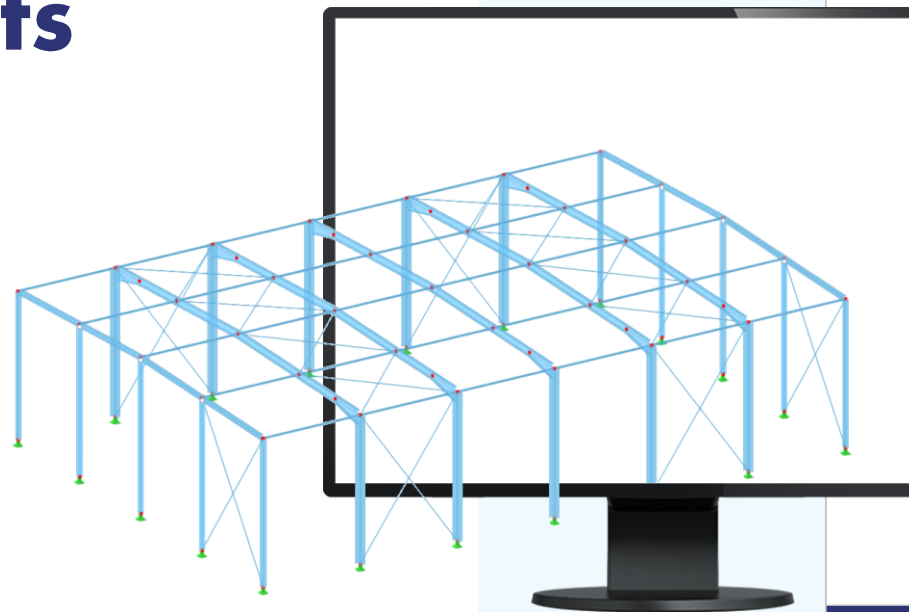
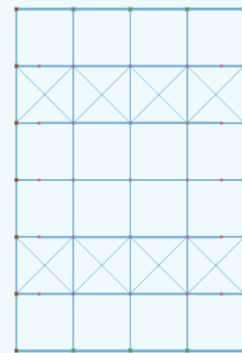
Co-Organizer

Customer Support  
Dlubal Software GmbH



Part 6 | Introduction to Steel Design

# RFEM 6 for Students



# Questions During the Presentation



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2

Adjust audio settings

Questions

No questions yet

Question from your attendees will appear here.

Submit a question

Enter your question

Your question will be sent to the staff

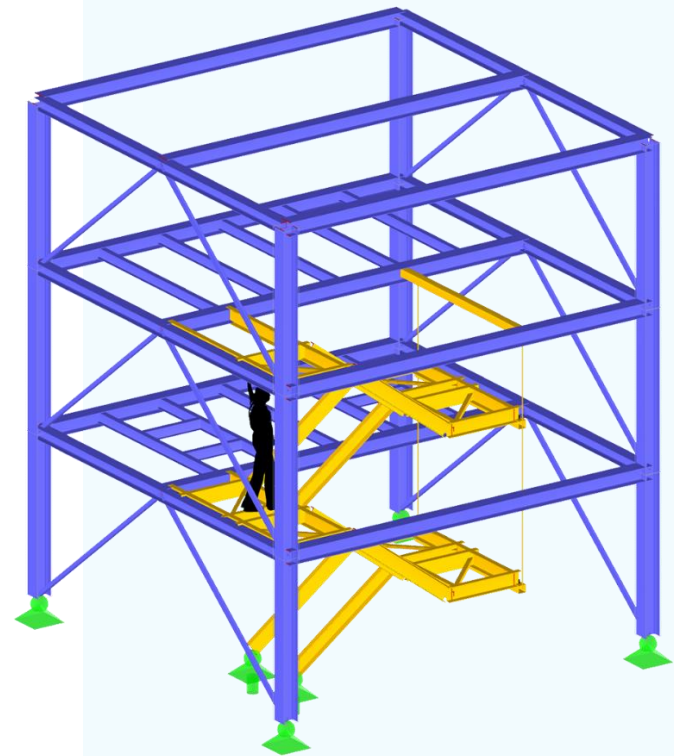
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Ask questions



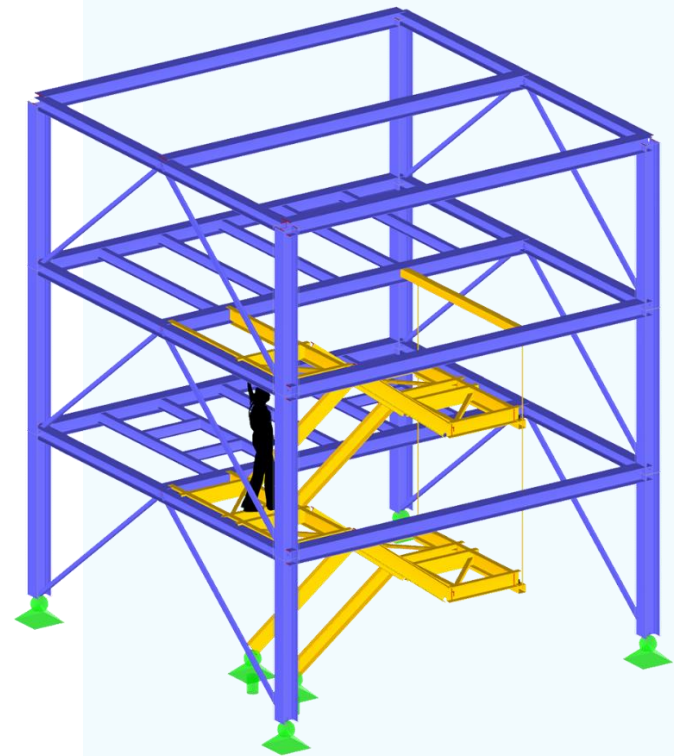
# Training Series

- 01 Introduction to Member Design
- 02 Introduction to Strength of Materials
- 03 Introduction to FEM / FEA
- 04 Introduction to Timber Design
- 05 Introduction to Reinforced Concrete Design
- 06 Introduction to Steel Design



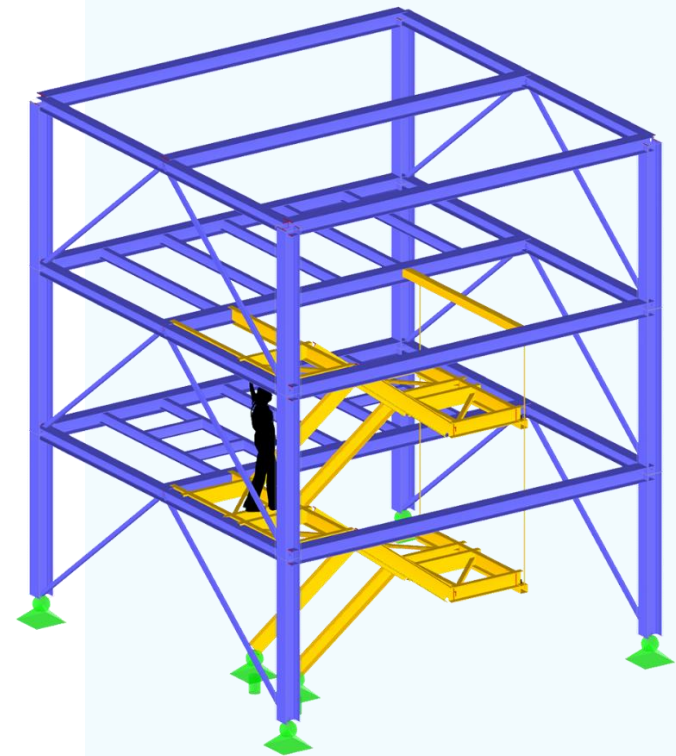
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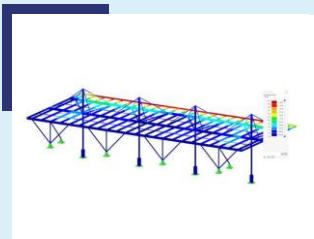
# CONTENT

- 01 Theoretical Background
- 02 Introductory Example: Two-span beam
- 03 Imperfections
- 04 Stability proofs in the ULS
- 05 Example: Flat hall frame





# Products for Design according to Eurocode 3



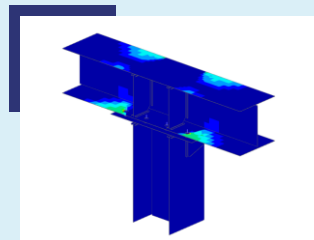
## Steel Design

- Add-On | RFEM/RSTAB
- Design of steel members acc. to international standards, like EC, AISC,...



## Torsional Warping (7 DOF)

- Add-On | RFEM/RSTAB
- Consideration of torsional warping in global solver



## Steel Joints

- Add-On | RFEM
- Analysis of steel joints based on finite element method



## Other Add-Ons & Stand-Alone Programs

- RSECTION
- Structure Stability
- Nonlinear Material Behavior
- Stress-Strain Analysis

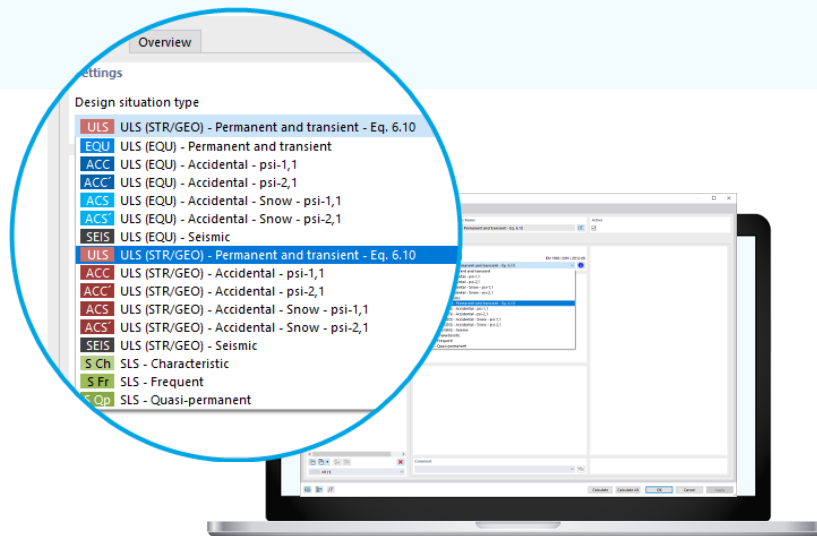
More information:  
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# Safety Concept

## Limit State Designs

- $E_d < R_d = R_k / \gamma_M$
- $R_k$  – characteristic resistance
- $R_d$  – design resistance



Factor of safety	Usage	EN 1993-1-1		DIN EN 1993-1-1/NA	
		FUN	ACC	FUN	ACC
$\gamma_{M0}$	Cross-section design	1.0	-	1.0	1.0
$\gamma_{M1}$	Stability analysis	1.0	-	1.1	1.0
$\gamma_{M2}$	Failure due to tension	1.25	-	1.25	1.15





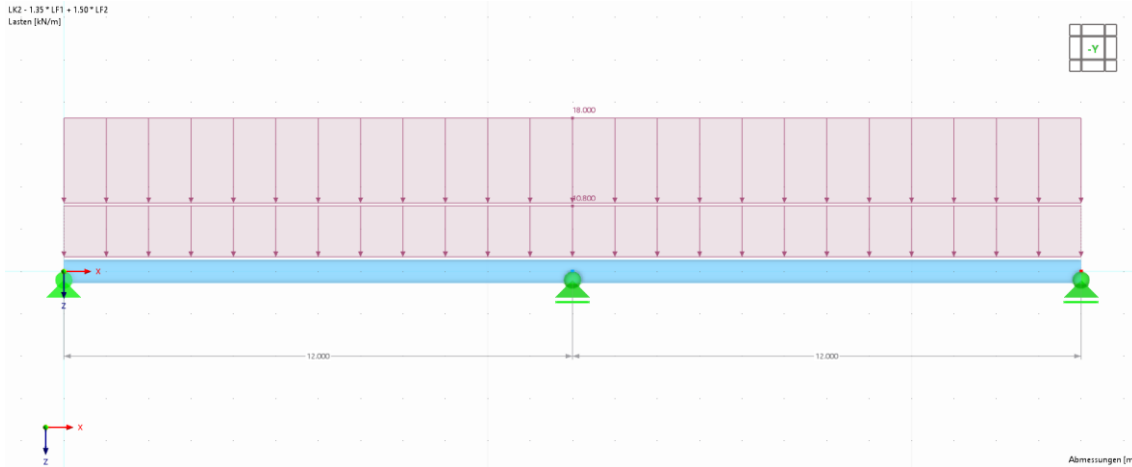
# Elastic or Plastic global analysis

CC	1	2	3	4
Moment-Rotation Behavior				
Rotation capacity	high	low	-	-
<b>Global Analysis</b>	<b>P</b>	<b>E</b>	<b>E</b>	<b>E</b>
Cross-Section Resistance	P	P	E	E*

\* reduced



# Two-span beam



## Information

- Beam: IPE 550, S235
- Geometry: see image
- Self-Weight: LC1:  $g_k = 8,00$  kN/m
- Imposed Load: LC2:  $q_k = 12,00$  kN/m

## Tasks

- Cross-Section Classification
- Cross-Section Design Checks
- Difference between elastic and plastic cross-section resistance
- Design check: EL-EL and EL-PL

# Effects of deformed geometry of the structure

## Criterion

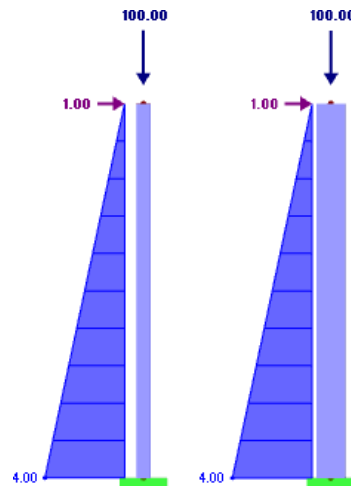
$$\alpha_{cr} = \frac{F_{cr}}{F_{Ed}}$$

Geometrically linear analysis is sufficient if

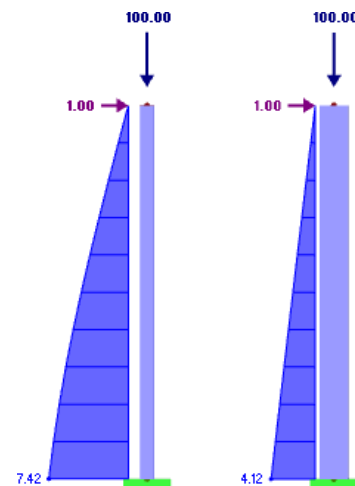
$\alpha_{cr} > 10$  for elastic global analysis

$\alpha_{cr} > 15$  for plastic global analysis

## Geometrically Linear Analysis



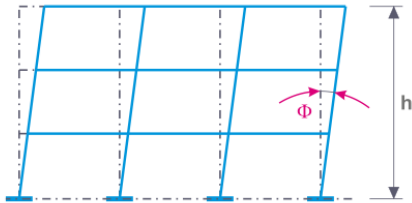
## Second-Order Analysis





# Equivalent geometric imperfections

## Initial sway imperfection

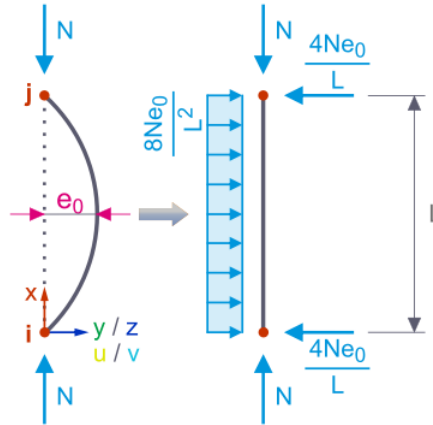


$$\Phi = \Phi_0 \cdot \alpha_h \cdot \alpha_m$$

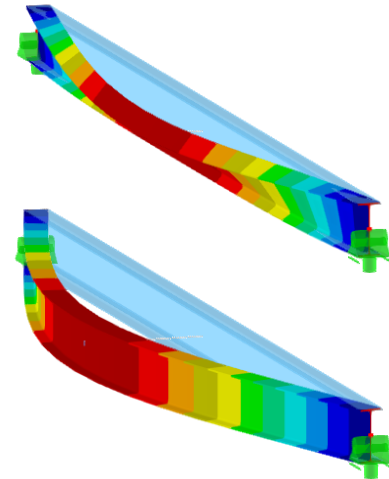
$$\Phi_0 = 1/200$$

$$\alpha_m = \sqrt{0.5(1 + \frac{1}{m})} \quad \alpha_h = \frac{2}{\sqrt{h}}$$

## Initial bow imperfection



## Scaled Mode Shape



↪ Application of equivalent horizontal forces ←

↪ Pre-deformation

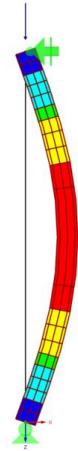


# Stability Analysis

$$\alpha_{cr} = \frac{N_{cr,min}}{N_{Ed}}$$

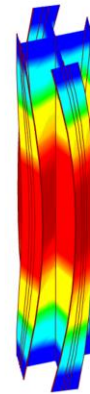
or

$$\alpha_{cr} = \frac{M_{cr}}{M_{Ed}}$$



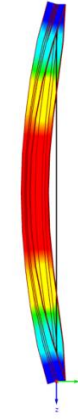
**Flexural Buckling**

$N_{cr,y/z}$  ;  $N_{cr,u/v}$



**Torsional Buckling**

$N_{cr,T}$



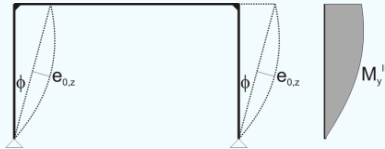
**Lateral-torsional Buckling**

$N_{cr,FTB}$  ;  $M_{cr}$

# Methods for Stability Analysis

## Method A

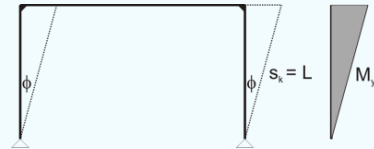
Global and local imp + structural analysis acc. to second-order analysis



Cross-section design checks with internal forces acc. to second-order analysis

## Method B

Global imp + structural analysis acc. to second-order analysis



Structural component design on equivalent member according to Section 6.3 but with  $s_k$ =member length

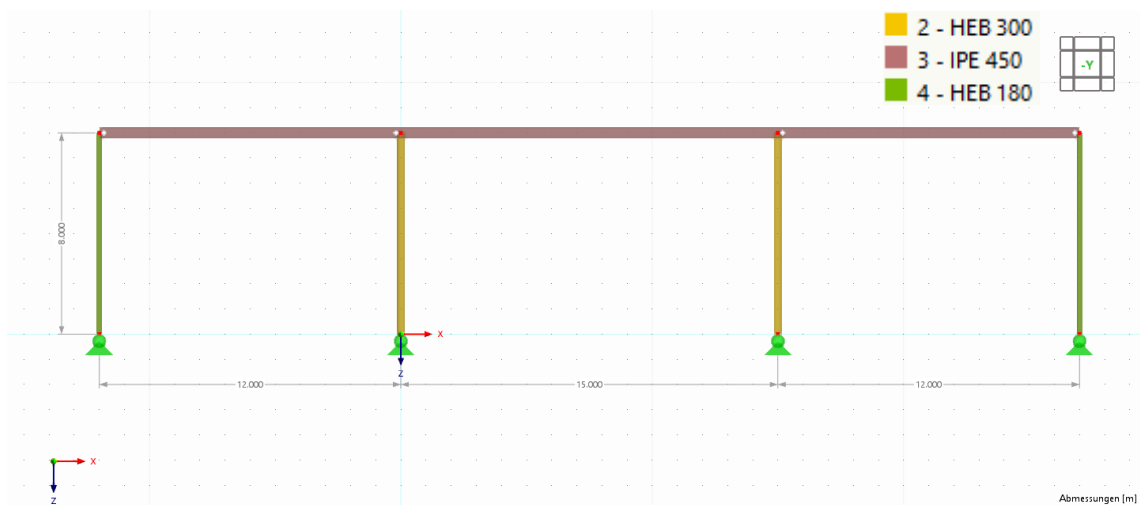
## Method C

Structural analysis acc. to geometrically linear analysis on ideal structure



Structural component design on equivalent member according to Section 6.3

# Flat Hall Frame



## Information

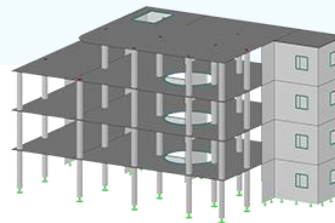
- Cross-Sections: see image
- Material: S235
- H= 8m; L1= 12m; L2= 15m; L3= 12m
- LC1 | Self-Weight: active
- LC2 | Snow:  $s_{kinner} = 20 \text{ kN}$ ;  $s_{kouter} = 10 \text{ kN}$
- LC3 | Wind:  $w_{kl} = 2 \text{ kN/m}$ ;  $w_{kr} = 1 \text{ kN/m}$

## Tasks

- Apply Imperfections
- Stability analysis according to method B and method C

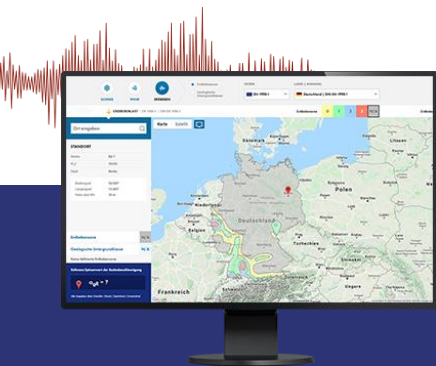


# Free Online Services



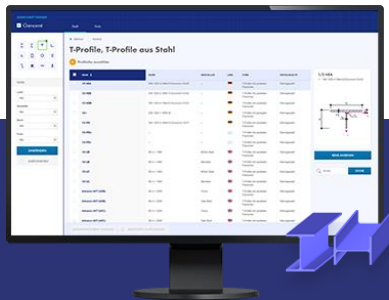
## Geo-Zone Tool

Dlubal Software provides an online tool with snow, wind and seismic zone maps.



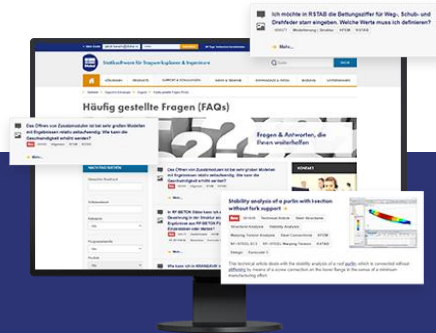
## Cross-Section Properties

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

Access frequently asked questions commonly submitted to our customer support team and view helpful tips and tricks articles to improve your work.



## Models to Download

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



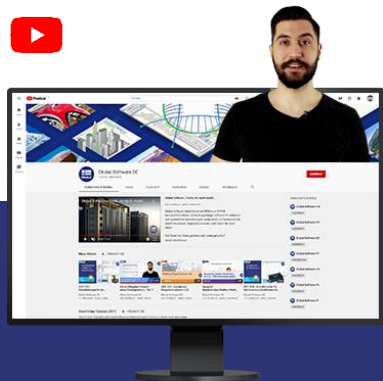




# Free Online Services

## Youtube Channel - Webinars, Videos

Videos and webinars about the structural engineering software.



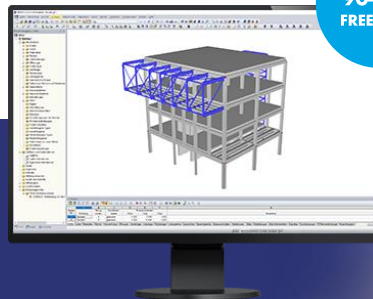
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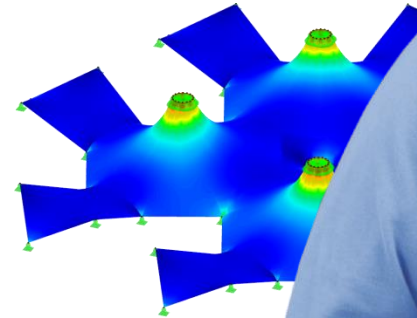
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