



# Structural Analysis & Design Software



[www.dlubal.com](http://www.dlubal.com)



Webinar

# NBC 2020 Response Spectrum Analysis in RFEM 6



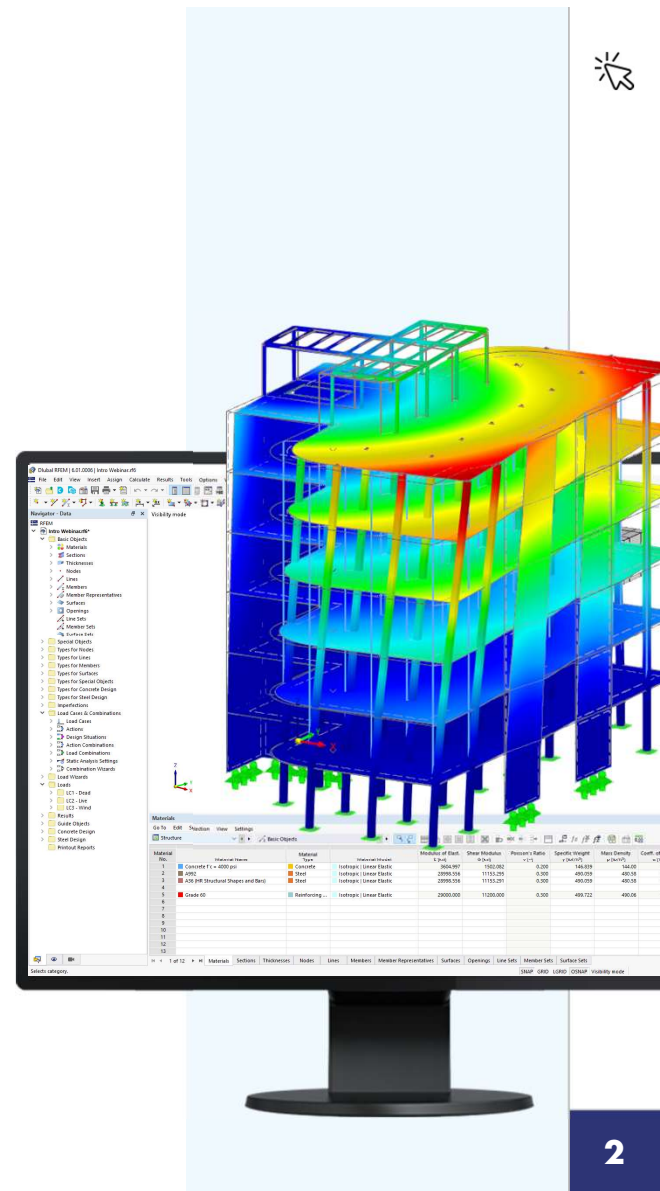
**Amy Heilig, PE**  
Presenter

CEO – USA Office



**Alex Bacon, EIT**  
Moderator

Technical Support Engineer



# Questions During the Presentation



GoToWebinar Control Panel  
**Desktop**



Email: [info-us@dlubal.com](mailto:info-us@dlubal.com)



The screenshot shows the GoToWebinar control panel interface. Three dark blue callout boxes with white text and blue arrows point to specific features:

- Show or hide control panel**: Points to the vertical toolbar on the left side of the window.
- Adjust audio settings**: Points to the 'Audio' section, which includes a 'Sound Check' indicator, radio buttons for 'Computer audio' (selected) and 'Phone call', a 'MUTED' status, and a volume slider.
- Ask questions**: Points to the 'Questions' section, which contains a text input field with the placeholder '[Enter a question for staff]', a 'Send' button, and the 'Webinar ID: 373-901-987'.



# CONTENT

01

Modal analysis to determine natural frequencies and mode shapes

02

Response spectrum analysis acc. to NBC 2020

03

Review of tabular and graphical results

04

New Building Model Add-on features for story results

05

NBC 2020 base shear considerations



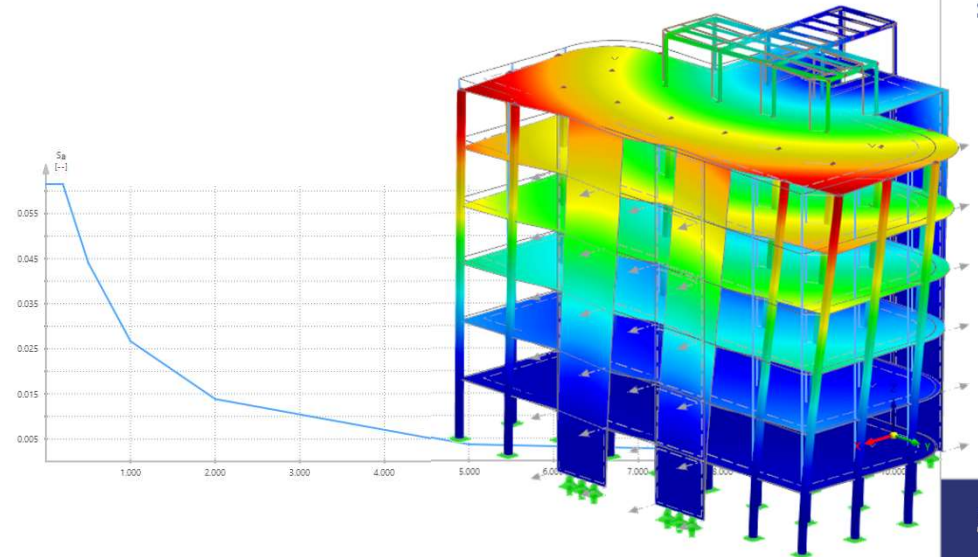
Webinar





# NBC 2020 Earthquake Method of Analysis

- **Method of Analysis [4.1.8.7]**
- **Equivalent Static Force Procedure (ESFP) [4.1.8.11]**
  - Seismic Category is SC1 or SC2 [Table 4.1.8.5.-B]
  - Regular,  $H < 60$  m, and  $T_a < 2$  sec
  - Irregular structures [Table 4.1.8.6] w/  $H < 20$  m and  $T_a < 0.5$  sec
- **Dynamic Analysis Procedure [4.1.8.12]**
  - Response Spectrum Method, Time History Method, or Non-linear Dynamic Analysis
  - All structures not satisfying Article 4.1.8.7



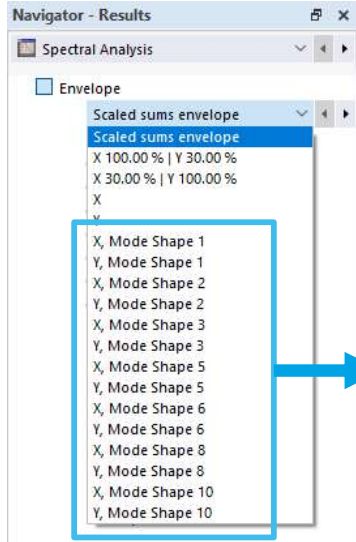
# Modal Combination Method

Modal Combination Method

Combination rule for periodic responses

SRSS

- Use equivalent linear combination
- Signed results using dominant mode
- Save results of all selected modes



## 1. Square Root Sum of the Squares (SRSS)

$$E_{SRSS} = \sqrt{E_1^2 + E_2^2 + \dots + E_p^2}$$

## 2. Complete Quadratic Combination (CQC)

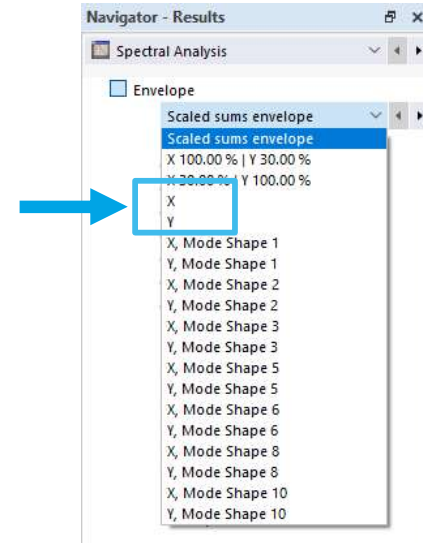
$$E_{CQC} = \sqrt{\sum_{i=1}^p \sum_{j=1}^p E_i \cdot \varepsilon_{ij} \cdot E_j}$$

Where the correlation coefficient  $\varepsilon$  is:

$$\varepsilon_{ij} = \frac{8 \cdot \sqrt{D_i \cdot D_j} \cdot (D_i + r \cdot D_j)^{\frac{3}{2}}}{(1-r^2)^2 + 4 \cdot D_i \cdot D_j \cdot r \cdot (1+r^2) + 4 \cdot (D_i^2 + D_j^2) \cdot r^2}$$

## 3. Absolute Sum

$$E_{AbsSum} = \sum_{i=1}^p |E_i|$$



## Modal Combination Method (cont'd)

- Standard SRSS/CQC combinations, corresponding internal forces are lost (e.g., corresponding moment at max axial force)
- Equivalent linear combination gives more realistic results and correct signage

Modal Combination Method

Combination rule for periodic responses

SRSS

Use equivalent linear combination

Signed results using dominant mode

Save results of all selected modes

### 1. Square Root Sum of the Squares (SRSS) linear combination

$$E_{SRSS} = \sum_{i=1}^p f_i \cdot E_i \quad \text{where} \quad f_i = \frac{E_i}{\sqrt{\sum_{j=1}^p E_j^2}}$$

### 2. Complete Quadratic Combination (CQC) linear combination

$$E_{CQC} = \sum_{i=1}^p f_i \cdot E_i \quad \text{where} \quad f_i = \frac{\sum_{j=1}^p \varepsilon_{ij} \cdot E_j}{\sqrt{\sum_{i=1}^p \sum_{j=1}^p E_i \cdot \varepsilon_{ij} \cdot E_j}}$$





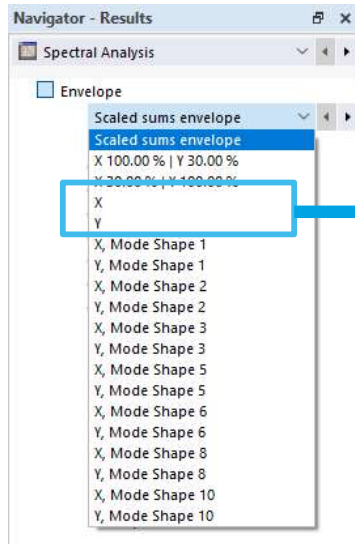
# Directional Component Combination

Combination of Directional Components

Combination rule for directional components

Scaled Sum 100% / 30.00 [%]

Consider independent directions in envelope results



## 1. Square Root Sum of the Squares (SRSS)

$$E_{SRSS} = \sqrt{E_1^2 + E_2^2 + \dots + E_p^2}$$

## 2. Scaled Sum (100%/30%)

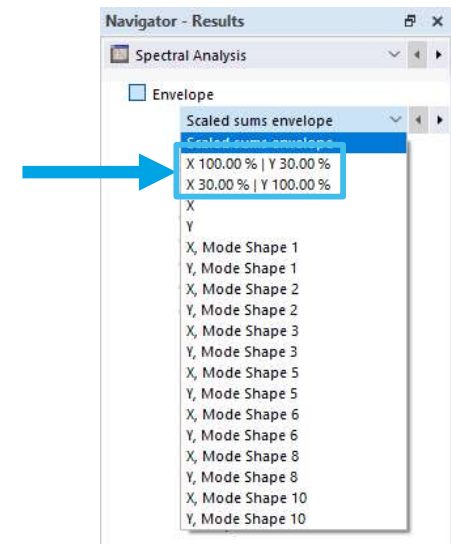
$$E_{Ed} = 1,0 \cdot E_{EdX} \oplus 0,3 \cdot E_{EdY} \oplus 0,3 \cdot E_{EdZ}$$

$$E_{Ed} = 0,3 \cdot E_{EdX} \oplus 1,0 \cdot E_{EdY} \oplus 0,3 \cdot E_{EdZ}$$

$$E_{Ed} = 0,3 \cdot E_{EdX} \oplus 0,3 \cdot E_{EdY} \oplus 1,0 \cdot E_{EdZ}$$

## 3. Absolute Sum

$$E_{Ed} = 1,0 \cdot E_{EdX} \oplus 1,0 \cdot E_{EdY} \oplus 1,0 \cdot E_{EdZ}$$





# NBC 2020 Base Shear Considerations

- $V_e$  = elastic base shear from dynamic analysis [4.1.8.12(5)]
- $V_{ed}$  = adjusted elastic base shear [4.1.8.12(6)]

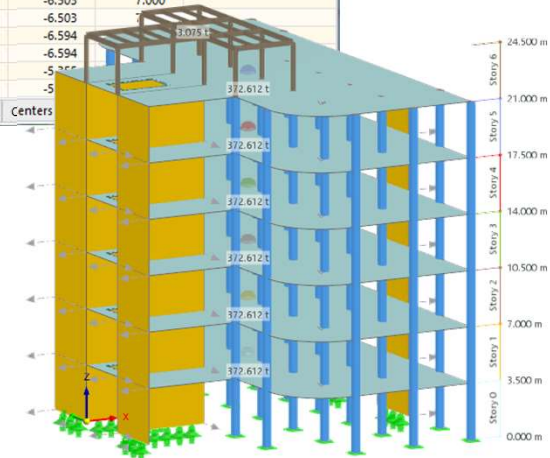
$$V_{ed} = \text{Max} \left[ \left( \frac{2}{3} \right) \frac{S(0.2)}{S(T_a)} \leq 1, \frac{S(0.5)}{S(T_a)} \leq 1 \right] \times V_e$$

- $V_d$  = specified lateral earthquake force [4.1.8.12(7)]

$$V_d = V_{ed} \left( \frac{I_e}{R_d R_o} \right)$$

- $V$  = ESFP lateral earthquake force [4.1.8.11]
- $V_d/V < 0.8$  [4.1.8.12(8)] or  $V_d/V < 1.0$  (irregular or timber structures) [4.1.8.12(9)/(12)], scale  $V_d$  to min  $0.8V$  or  $1.0V$

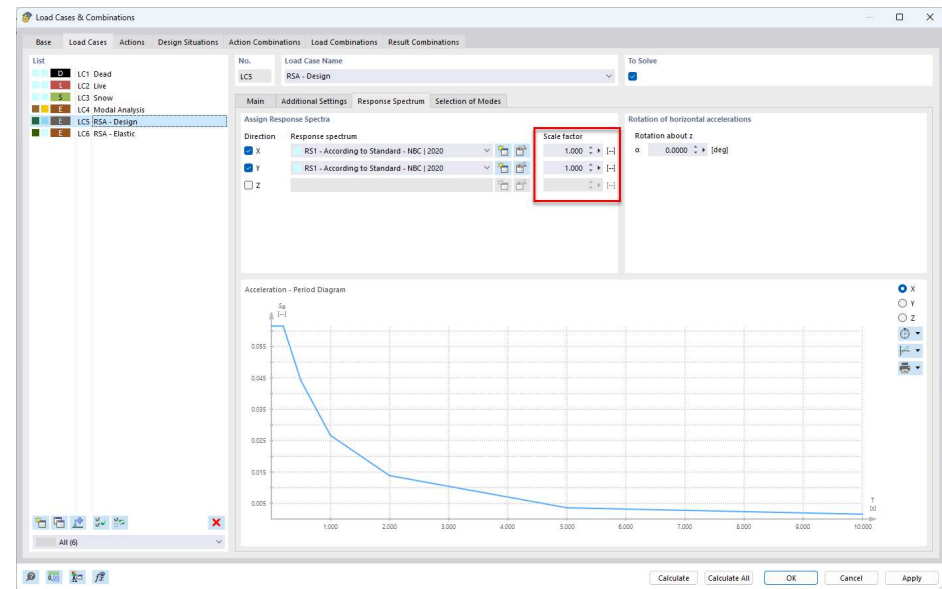
Story No.	Story Forces		Location of Resultant Story Forces		
	F <sub>x</sub> [kN]	F <sub>y</sub> [kN]	X <sub>M</sub> [m]	Y <sub>M</sub> [m]	Z <sub>M</sub> [m]
5	863.96	-74.96	10.863	-6.007	17.500
4	-363.96	74.96	10.863	-6.007	17.500
	628.56	-122.12	10.969	-6.325	14.000
	-628.56	122.12	10.969	-6.325	14.000
3	805.21	-156.26	10.987	-6.422	10.500
	-805.21	156.26	10.987	-6.422	10.500
2	945.97	-183.58	11.003	-6.503	7.000
	-945.97	183.58	11.003	-6.503	7.000
1	1058.68	-204.31	11.016	-6.594	
	-1058.68	204.31	11.016	-6.594	
0	944.64	-165.06	10.715	-5.255	
	-944.64	165.06	10.715	-5.255	



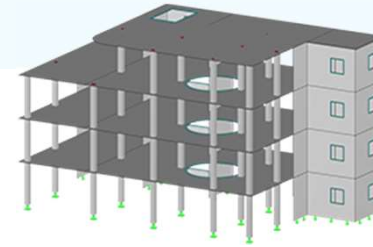


# RFEM 6 Base Shear Considerations

- **Type “Design Spectrum”**
  - Specified lateral earthquake force,  $V_d$  [4.1.8.12(7)]
  - Does not include  $\left[ \left( \frac{2}{3} \right) \frac{S(0.2)}{S(T_a)} \leq 1, \frac{S(0.5)}{S(T_a)} \leq 1 \right]$  factor [4.1.8.12(6)]
  - Does include  $I_e / (R_d R_o)$  [4.1.8.12(7)]
- **Type “Elastic Spectrum”**
  - Elastic base shear,  $V_e$  [4.1.8.12(5)]
  - Does not include  $I_e / (R_d R_o)$
  - Lateral deflections [4.1.8.13(2)]
- **Additional factors or scaling  $V_d/V$**



# Free Online Services



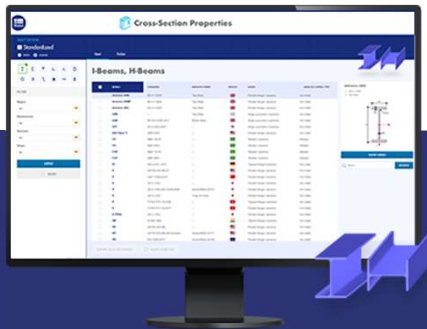
## Geo-Zone Tool

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.

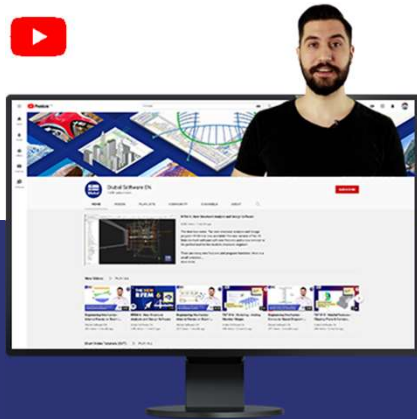




# Free Online Services

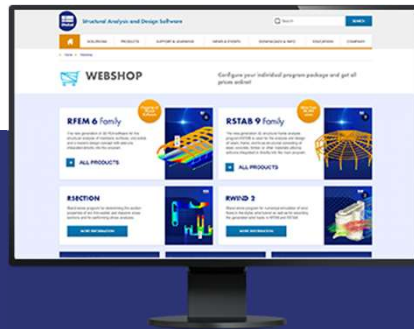
## Youtube Channel - Webinars, Videos

Videos and webinars about the structural engineering software.



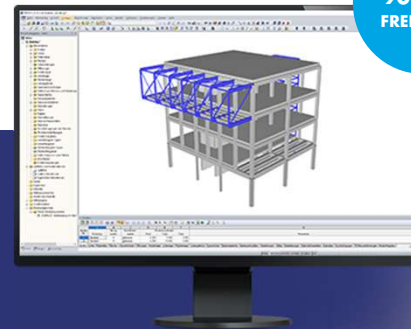
## Webshop with Prices

Configure your individual program package and get all prices online!

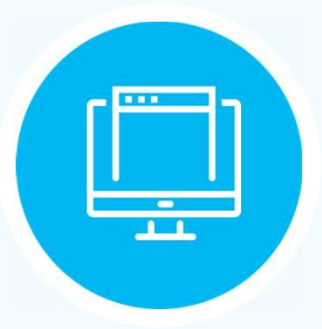


## Trial Licenses

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



# — Dlubal Software Information



- Videos and recorded webinars
- Events and conferences
- Knowledge Base articles
- FAQs

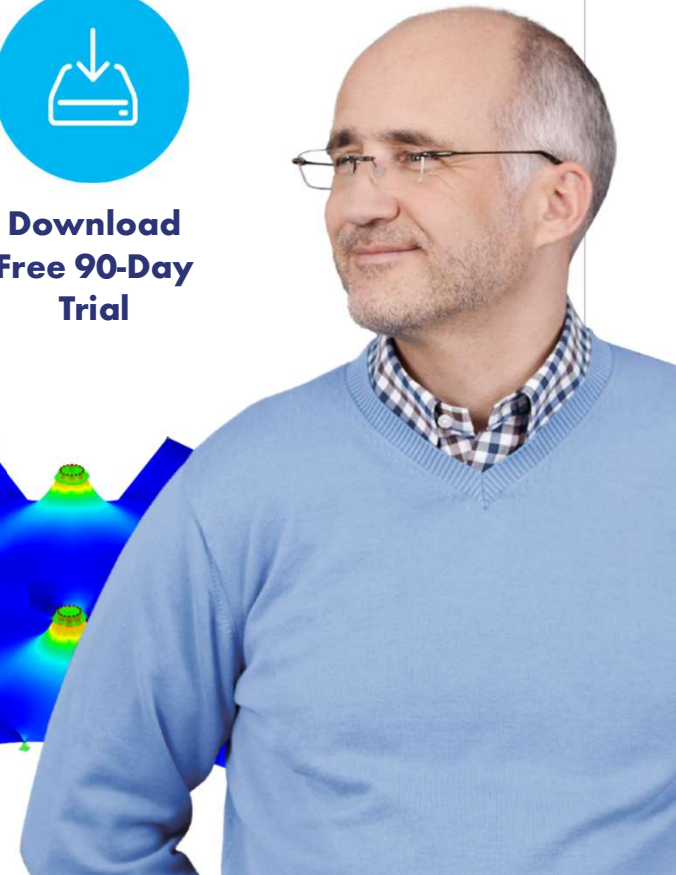
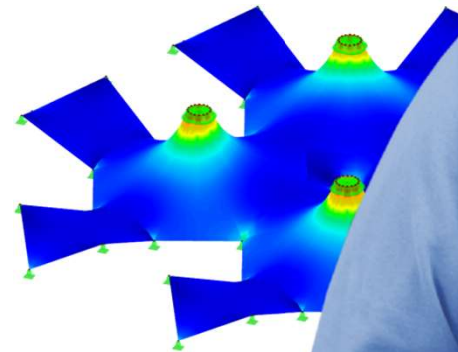
Visit website  
[www.dlubal.com](http://www.dlubal.com)



Register for  
Upcoming  
Webinars



Download  
Free 90-Day  
Trial



**Dlubal Software, Inc.**  
30 South 15th Street, 15th Floor  
Philadelphia, PA 19102

Phone: (267) 702-2815  
Email: [info-us@dlubal.com](mailto:info-us@dlubal.com)



# Webinars and PDH

## Upcoming Webinars

- 1 Register [www.dlubal.com](http://www.dlubal.com)
- 2 Support & Learning → Webinars
- 3 Registration through email



## PDH Certificates

- 1 Automatically emailed to participants
- 2 Available for the full presentation
- 3 Additional attendees request [info-us@dlubal.com](mailto:info-us@dlubal.com)







[www.dlubal.com](http://www.dlubal.com)