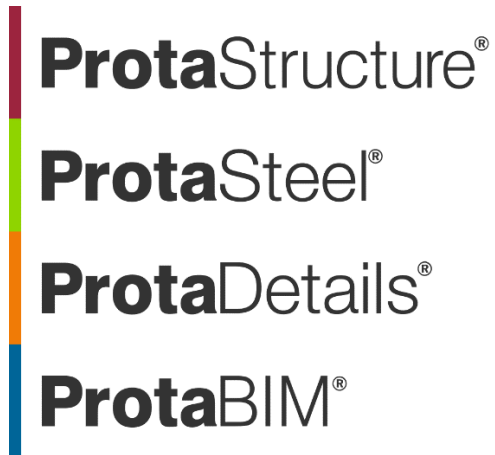




ProtaStructure Design Guide

Ribbed and Waffle Slab Loads

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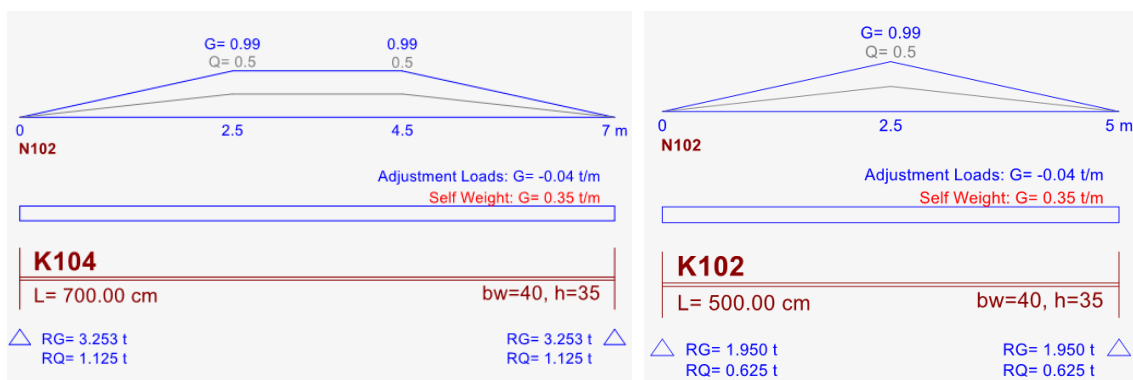
Scope

In this document, calculation and decomposition of loads on ribbed and waffle slabs are explained. Modelling and design of ribbed and waffle slabs are out of scope of this document.

Alternative Methods for Load Decomposition

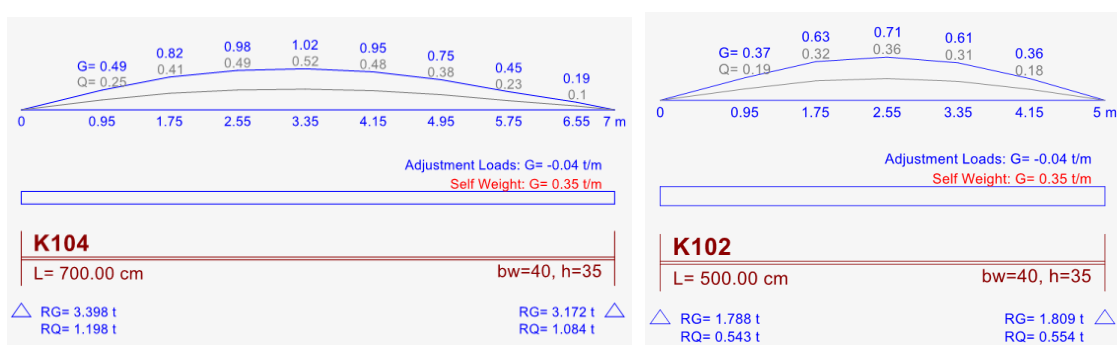
Yield Line Load Decomposition

Default method of load decomposition for waffle and ribbed slabs is the **Yield Line method**. Similar to regular slabs, yield lines are calculated and loads are decomposed on the surrounding frame girders. Distribution is done in two directions since waffle slabs are considered as two-way slabs. **If ribbed slabs are considered, load decomposition is one-way.**



Finite Element Load Decomposition

In this, method, a floor is isolated from the building and meshed and analyzed under G and Q load cases with beams modelled as support points. Support reactions are calculated and decomposed on the frame girders.



Automatic Decomposition in Building Analysis

Stiffness of slabs in a floor level can optionally be included in the entire building analysis. Load decomposition can also be done automatically using the connectivity information.

For this, you have to check the "Include Slabs in Building Model" option. All of your floors must be selected from storeys to be meshed menu.

Storey Diaphragm Model

☒ Slabs to Define Rigid Diaphragm
☐ Single Diaphragm per Floor Level
☐ No Rigid Diaphragm Floor Levels

☒ All Storeys

Storeys with Diaphragm Definition

Finite Elements Mesh

☒ Include Slabs in Building Model

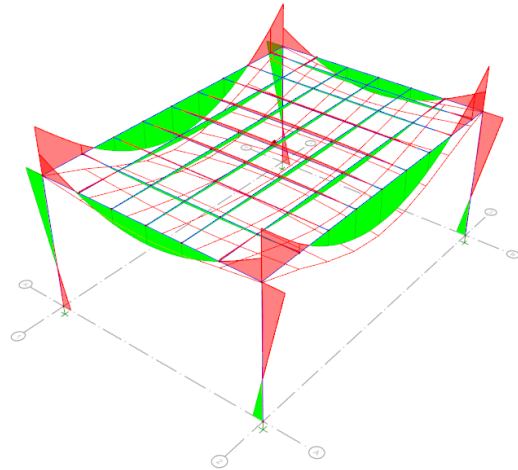
Storeys to be Meshed

☒ 1 (+3.00m)

☐ Use Decomposed Slab and Ribbed Slab Loads
☐ Include Columns Sections in FE Model

Shell Element Size

Min: 100.0 cm Max:



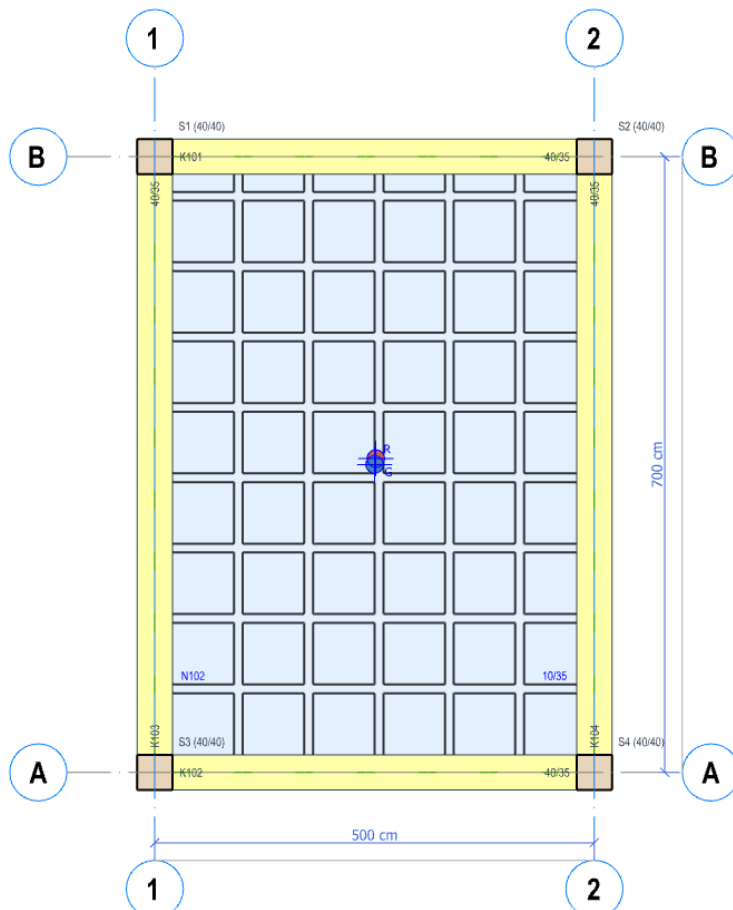
In this case, all load decompositions done before using the first two methods are ignored and loads are distributed automatically during the building analysis. 'Use Decomposed Slab and Ribbed Slab Loads' option must be unchecked.

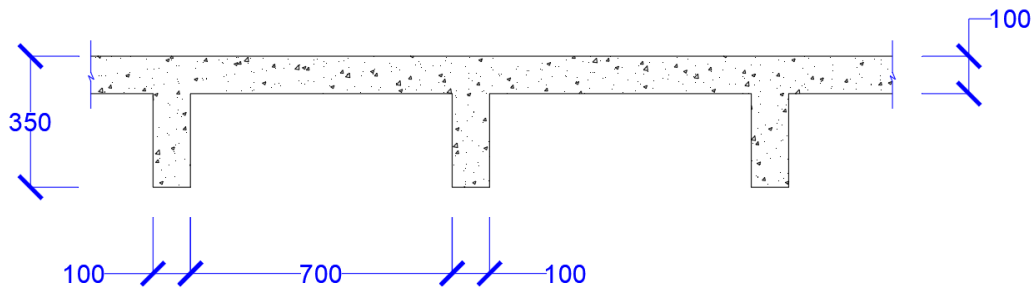
Self Weight of Waffle Slabs

The waffle slab dimensions is given below:

$s = 700 \text{ mm}$, $b_w = 100 \text{ mm}$, $h = 350 \text{ mm}$, $h_{top} = 100 \text{ mm}$, $L_x = 5000 \text{ mm}$, $L_y = 7000 \text{ mm}$, $n_x = 8$, $n_y = 5$

$\gamma_{con} = 25 \text{ kN/m}^3$, $\gamma_{spacer} = 0$ (no spacer)





The self weight calculation depends on calculation of a single waffle cell.

Weight of a single waffle cell

Gross volume of cell

$$V_{gross} = h \cdot (b_w + s)^2 = 0,35 \times (0,1 + 0,7)^2 = 0,224 \text{ m}^3$$

Volume of spacing

$$V_{spacing} = s^2 \cdot (h - h_{top}) = 0,7^2 \times (0,35 - 0,1) = 0,1225 \text{ m}^3$$

Weight of concrete

$$W_{concrete} = (V_{gross} - V_{spacing}) \cdot \gamma_{concrete} = (0,224 - 0,1225) \times 25 = 2,5375 \text{ kN}$$

Weight of spacer blocks (No spacer blocks in this example)

$$W_{spacer} = V_{spacing} \cdot \gamma_{spacer} = 0,1225 \times 0 = 0$$

Plan Area of One Cell

$$A_{cell} = (b_w + s)^2 = (0,1 + 0,7)^2 = 0,64 \text{ m}^2$$

Distributed Self Weight of Waffle Slab,

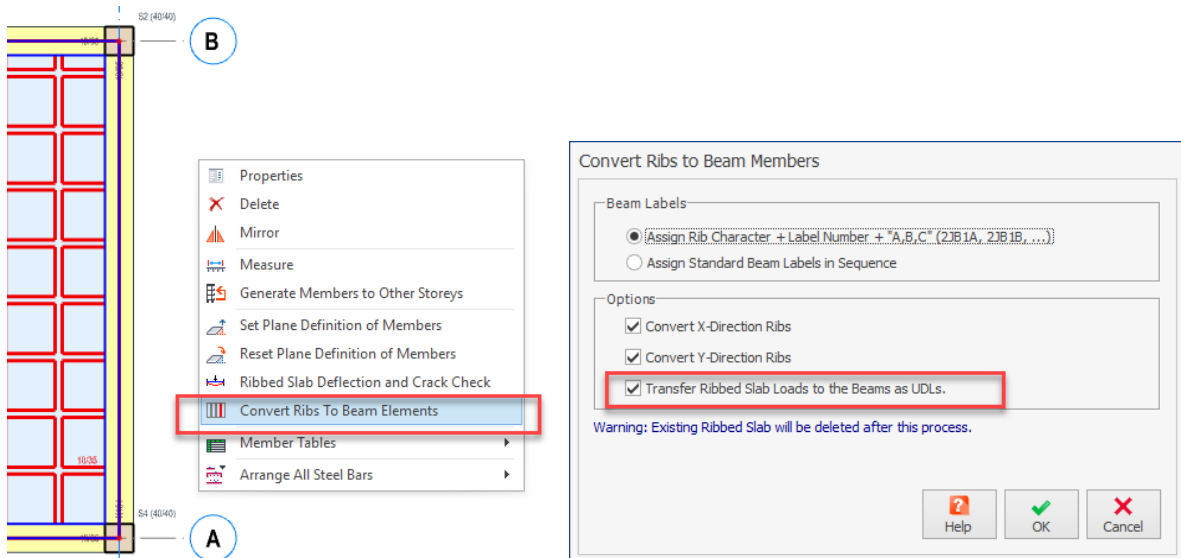
$$g = \frac{(W_{concrete} + W_{spacer})}{A_{cell}} = \frac{2,5375 + 0}{0,64} = \mathbf{3,965 \text{ kN/m}^2}$$

Converting Rib Beams to Regular Beams (for Waffle Slabs)

In order to model beams quickly, you can also convert rib beams to regular beams. This allows you to consider rib beam stiffnesses in building analysis and load decomposition is done similar to regular beams. The waffle or ribbed slab is automatically deleted after conversion.

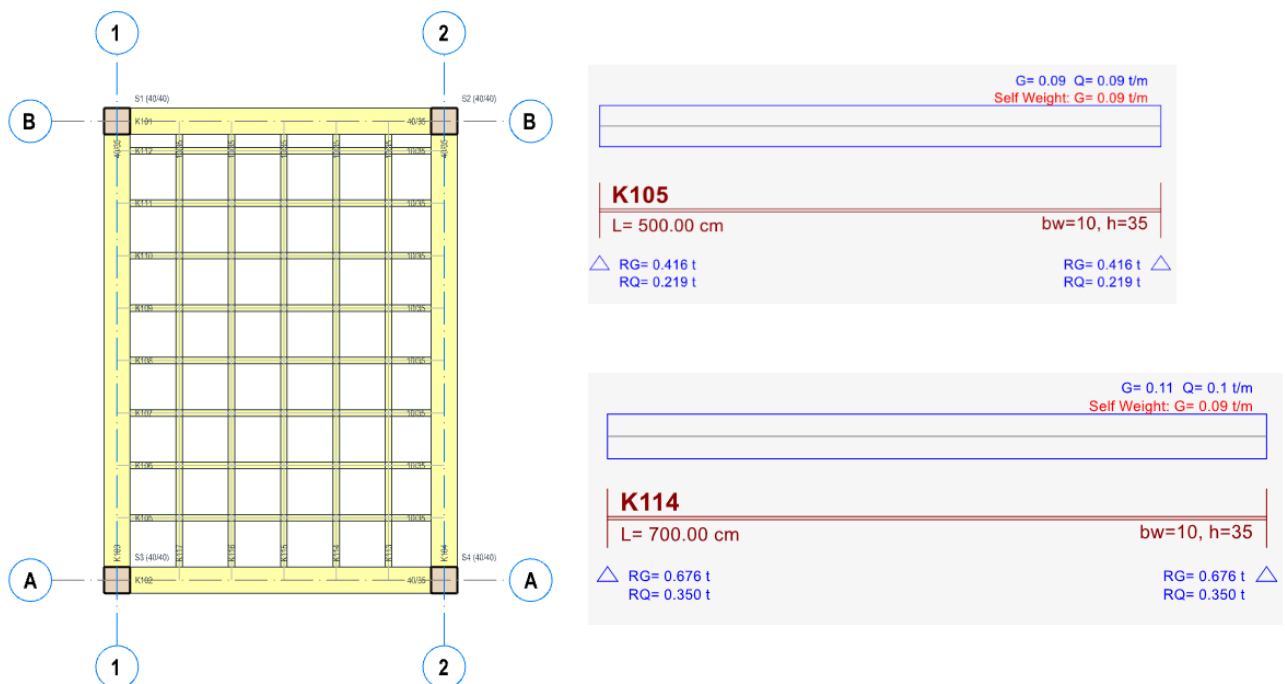
To convert rib beams to regular beams,

- Select waffle or ribbed slab
- Right Click and select "Convert Ribs to Beam Elements"



You can optionally decompose the slab loads as uniformly distributed load on the newly generated beam elements by selecting “**Transfer Ribbed Slab Loads to the Beams as UDLs**”

Result is as follows.



UDL Loads on Converted Ribs

When the ribs are converted to regular beam members – if **Transfer Ribbed Slab Loads as UDLs** option is selected- it is assumed that weight of the slab is equally shared between Direction-1 and Direction-2 ribs.

Tributary Length for Direction-1 Rib Beams

$$L_{eff1} = \frac{L_y}{n_x} = \frac{7}{8} = 0,875 \text{ m}$$

Uniformly distributed load on direction-1 beams

$$g_x = 0.5 \cdot g \cdot L_{eff1} = 0.5 \times 3,965 \times 0,875 = 1,735 \frac{kN}{m}$$

Tributary Length for Direction-2 Rib Beams

$$L_{eff2} = \frac{L_x}{n_y} = \frac{5}{5} = 1 \text{ m}$$

Uniformly distributed load on direction-2 beams

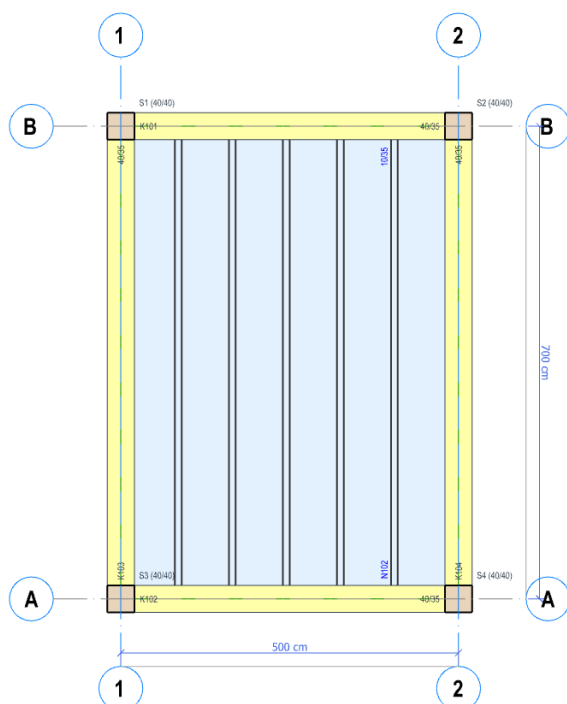
$$g_x = 0.5 \cdot g \cdot L_{eff1} = 0.5 \times 3,965 \times 1 = 1,983 \frac{kN}{m}$$

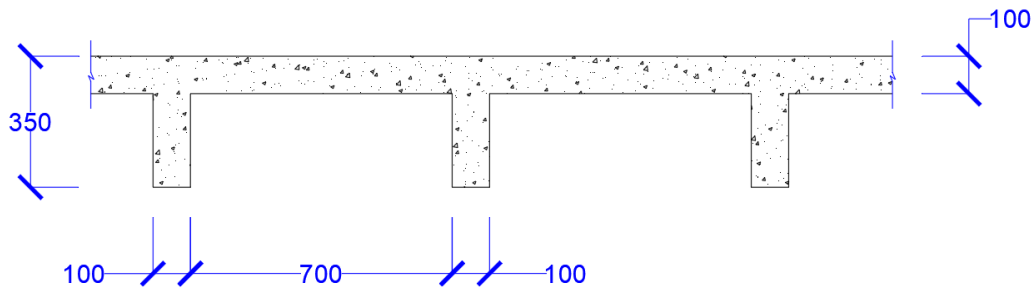
Self Weight of Ribbed Slabs

The ribbed slab dimensions is given below:

$s = 700 \text{ mm}$, $b_w = 100 \text{ mm}$, $h = 350 \text{ mm}$, $h_{top} = 100 \text{ mm}$, $L_x = 5000 \text{ mm}$, $L_y = 7000 \text{ mm}$, $n_y = 5$

$\gamma_{con} = 25 \text{ kN/m}^3$, $\gamma_{spacer} = 0$ (no spacer)





Weight of Rib Beams without topping for unit length

$$W_{rib} = b_w \cdot (h - h_{top}) \cdot \gamma_{concrete} = 0,1 \times (0,35 - 0,1) \times 25 = 0,625 \text{ kN/m}$$

Weight of Spacer for unit length (no spacer block)

$$W_{spacer} = s \cdot (h - h_{top}) \cdot \gamma_{spacer} = 0,7 \times (0,35 - 0,1) \times 0 = 0$$

Weight of topping

$$W_{topping} = h_{top} \cdot (b_w + s) \cdot \gamma_{concrete} = 0,1 \times (0,1 + 0,7) \times 25 = 2 \text{ kN/m}$$

Distributed Self Weight of Ribbed Slab,

$$g = \frac{(W_{rib} + W_{spacer} + W_{topping})}{(b_w + s)} = \frac{0,625 + 0 + 2}{0,1 + 0,7} = \mathbf{3,281 \text{ kN/m}^2}$$

Converting Rib Beams to Regular Beams (for Rib Slabs)

Steps for converting rib beams to regular beams are identical with waffle slabs.

UDL Loads on Converted Ribs

When the ribs are converted to regular beam members – if **Transfer Ribbed Slab Loads as UDLs** option is selected- it is assumed that weight of the slab is uniformly distributed on the rib beams.

Tributary Length for Rib Beams

$$L_{eff} = s + b_w = 0,7 + 0,1 = 0,8 \text{ m}$$

Uniformly distributed load on rib beams

$$g_{rib} = g \cdot L_{eff} \cdot \frac{L_{clear}}{L} = 3,281 \times 0,8 \times \frac{6,6}{7} = 2,475 \frac{\text{kN}}{\text{m}}$$

Thank You...

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