ProtaStructure®

ProtaSteel®

ProtaDetails®

ProtaBIM®

ProtaStructure Design Guide

Ribbed and Waffle Slab Loads

Version 1.0 24 September 2020

Please contact us for your training and technical support queries

asiasupport@protasoftware.com

globalsupport@protasoftware.com

PROTA

Limitation of Responsibilities

Prota shall not be held responsible for any losses caused by documentation, software or usage errors.

In addition to Prota License Agreement Terms, it is the responsibility of the user

- to check of results generated by documentation and software,
- make sure that the users of the software and their supervisors have the adequate technical capabilities,
- make sure that the software is properly used in accordance with the reference manual and documentation,

Intellectual Property

ProtaStructure is registered trademark of **Prota Software Inc.** and all intellectual property rights belongs to **Prota Software Inc**. Documentation, training and reference manuals and any program component can not be copied, distributed and used in violation of license agreement.

Trademarks

ProtaStructure®, ProtaDetails®, ProtaSteel® ve **ProtaBIM®** are registered trademarks of Prota Software Inc. Prota logo is a trademark of Prota Software Inc.

Table of Contents

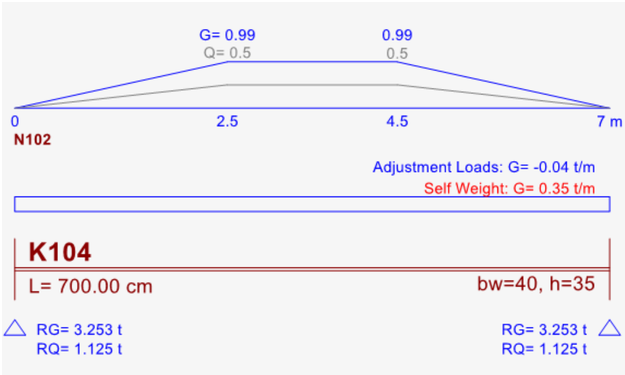
Scope

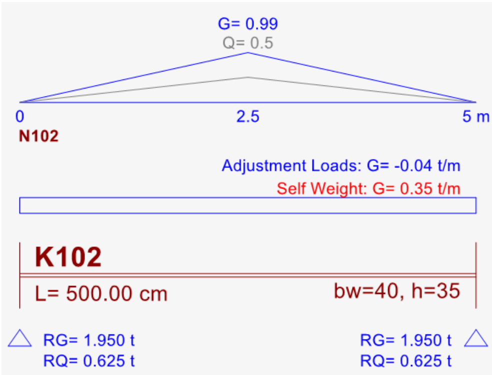
In this document, calculation and decomposition of loads on ribbed and waffle slabs are explained. Modelling and design of ribbed and waffle slabs are out of scope of this document.

Alternative Methods for Load Decomposition

Yield Line Load Decomposition

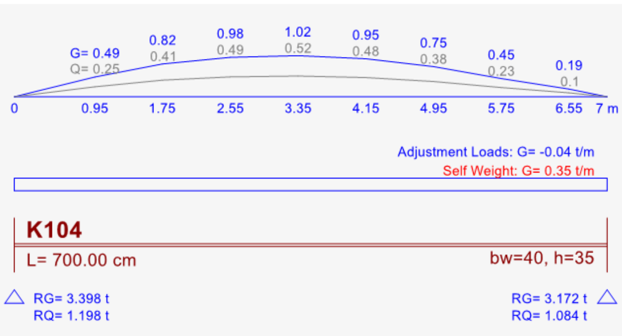
Default method of load decomposition for waffle and ribbed slabs is the **Yield Line method**. Similar to regular slabs, yield lines are calculated and loads are decomposed on the surrounding frame girders. Distribution is done in two directions since waffle slabs are considered as two-way slabs. **If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

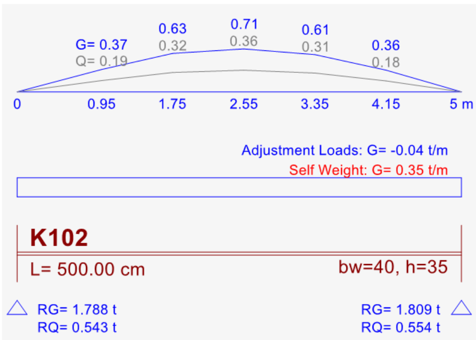




Finite Element Load Decomposition

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.

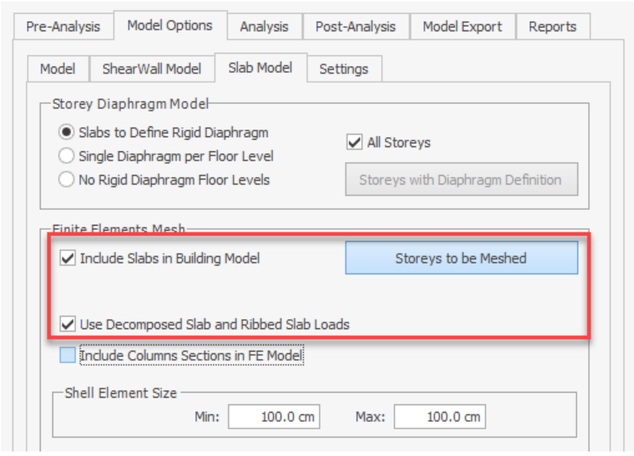


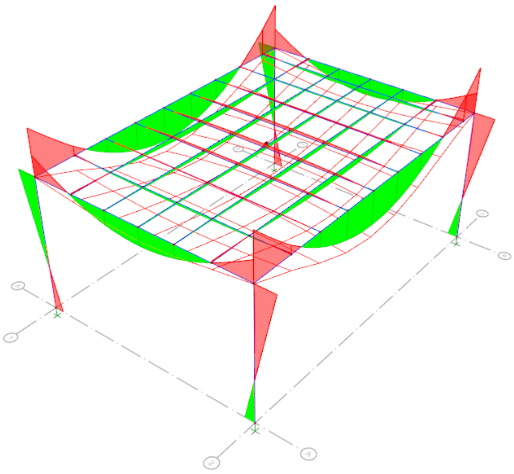


Automatic Decomposition in Building Analysis

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.

In order to do this, you must select "**Include Slabs in Building Model**" and "**Use Decomposed Slab and Ribbed Slab Loads**"





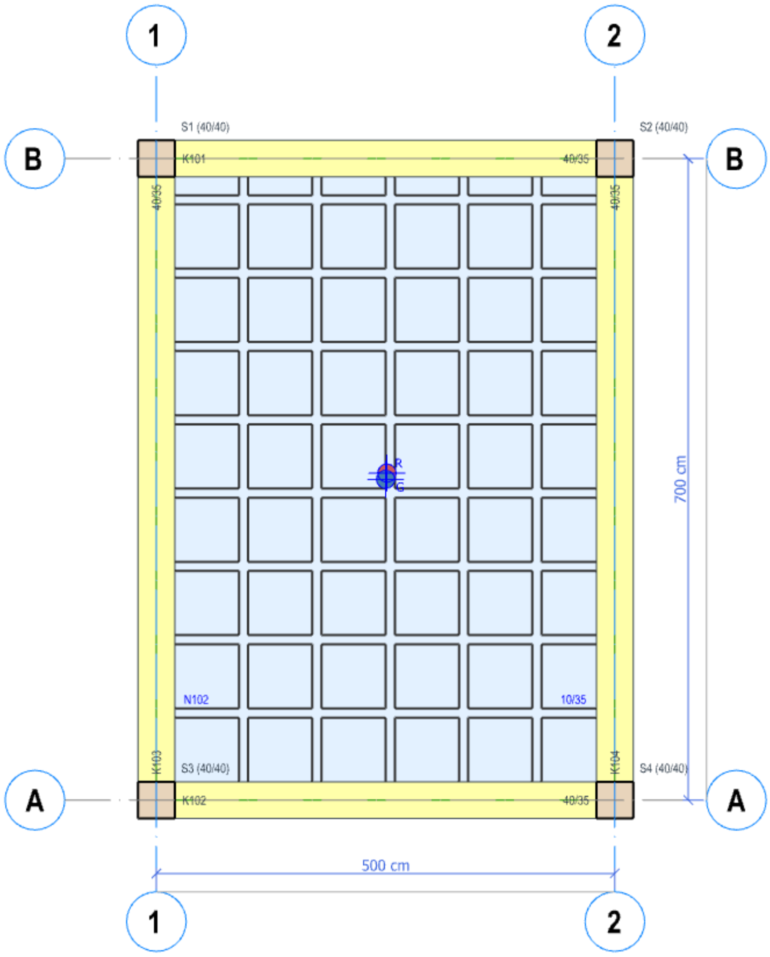
In this case, all load decompositions done before using the first two methods are ignored and loads are distributed automatically during the building analysis

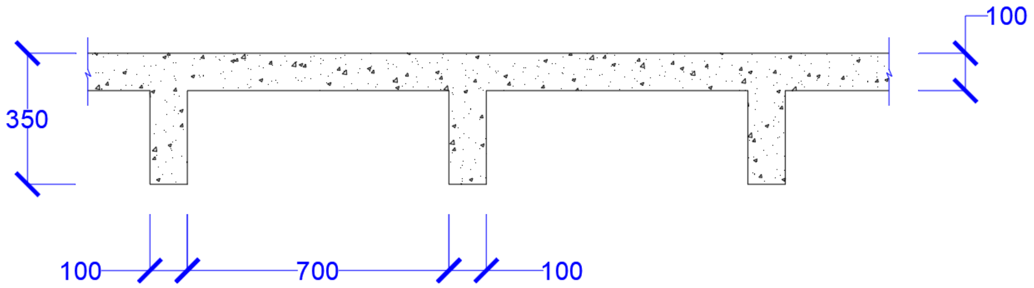
Self Weight of Waffle Slabs

The waffle slab dimensions is given below:

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

γ_{con} = 25 kN/m^3, γ_{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

$$V_{gross} = h.(b_w + s)^2 = 0.35 \times (0{,}1 + 0{,}7)^2 = 0{,}224\, m^3$$

Volume of spacing

$$V_{spacing} = s^2.\left(h - h_{top}\right) = 0.7^2 \times (0{,}35 - 0{,}1) = 0{,}1225\, m^3$$

Weight of concrete

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

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

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

Distributed Self Weight of Waffle Slab,

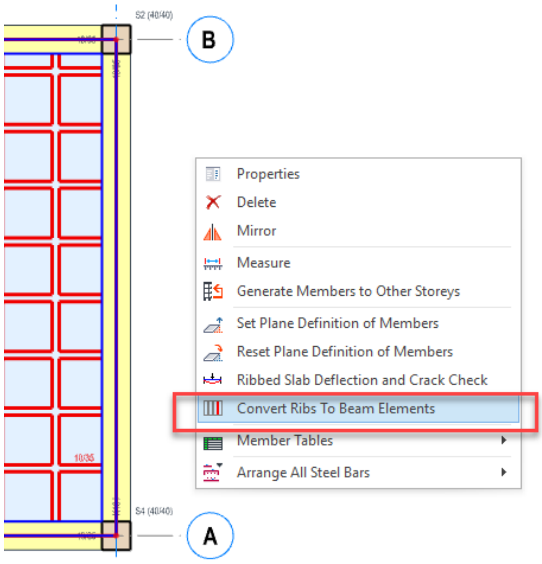
$$g = \frac{\left(W_{concrete} + W_{spacer}\right)}{A_{cell}} = \frac{2{,}5375 + 0}{0{,}64} = \mathbf{3{,}965\ kN/m^2}$$

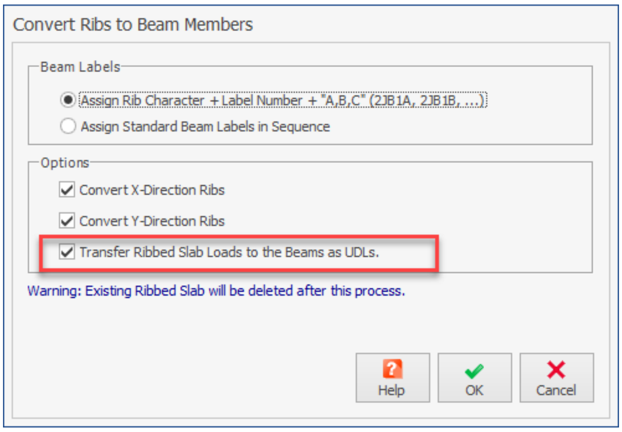
Converting Rib Beams to Regular Beams (for Waffle Slabs)

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,

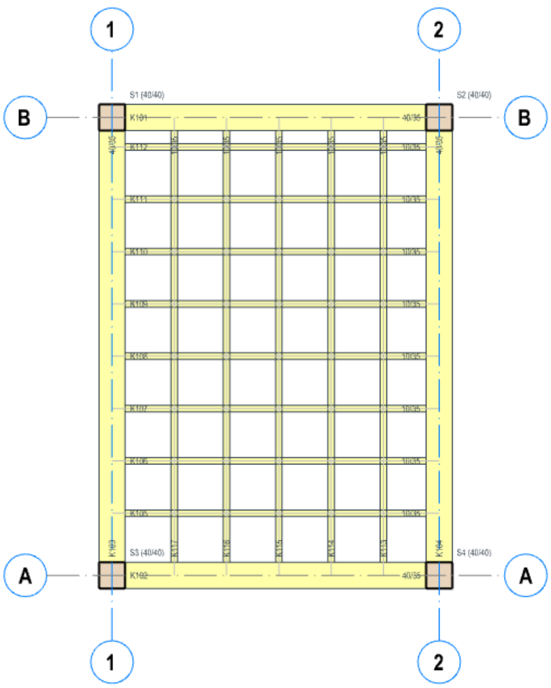
- Select waffle or ribbed slab
- Right Click and select “Convert Ribs to Beam Elements”

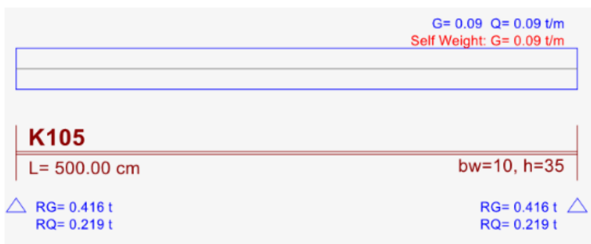


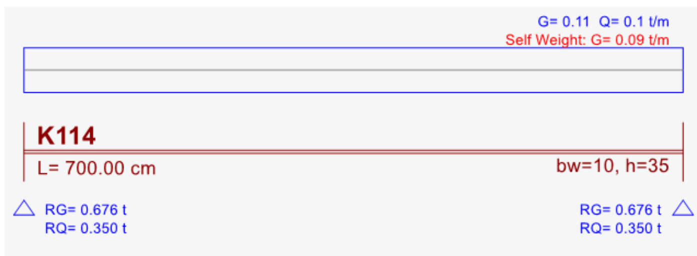


You can optionally decompose the slab loads as uniformly distributed load on the newly generated beam elements by selecting "**Transfer Ribbed Slab Loads to the Beams as UDLs**"

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.

Tributory Length for Direction-1 Rib Beams

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

Uniformly distributed load on direction-1 beams

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

Tributory Length for Direction-2 Rib Beams

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

Uniformly distributed load on direction-2 beams

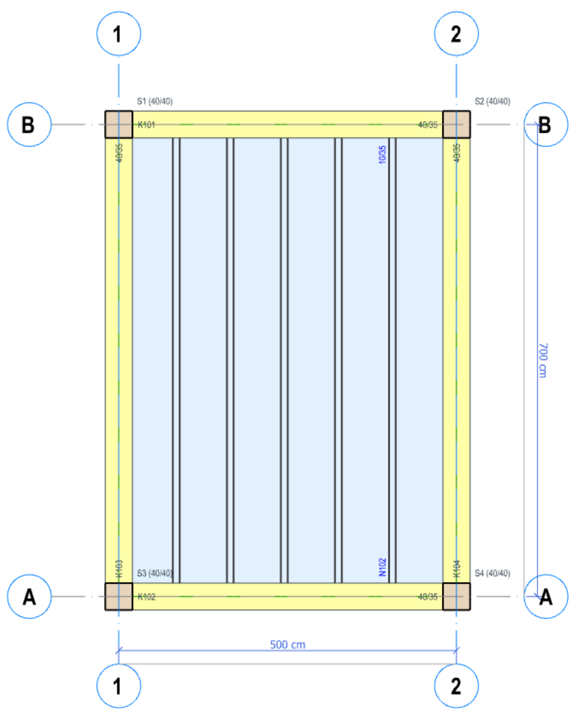
$$g_x = 0.5.\,g.\,L_{eff1} = 0.5 \times 3{,}965 \times 1 = 1{,}983\,\frac{kN}{m}$$

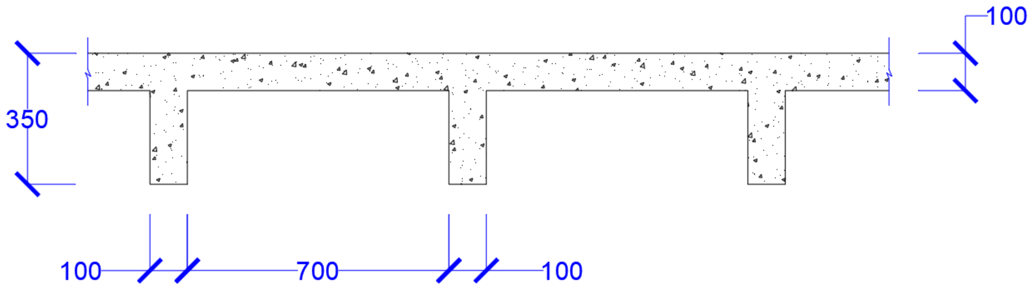
Self Weight of Ribbed Slabs

The ribbed slab dimensions is given below:

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

γ_{con} = 25 kN/m^3, γ_{spacer} = 0 (no spacer)





Weight of Rib Beams without topping for unit length

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

Weight of Spacer for unit length (no spacer block)

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

Weight of topping

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

Distributed Self Weight of Ribbed Slab,

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

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.

Tributory Length for Rib Beams

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

Uniformly distributed load on rib beams

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

Thank You…

Thank you for choosing the ProtaStructure Suite product family.

It is our top priority to make your experience excellent with our software technology solutions.

Should you have any technical support requests or questions, please do not hesitate to contact us at all times through globalsupport@protasoftware.com and asiasupport@protasoftware.com

Our dedicated online support center together with our responsive technical support team is available to help you get the most out of Prota's technology solutions.

The Prota Team

ProtaStructure®
ProtaSteel®
ProtaDetails®
ProtaBIM®