ProtaStructure Design Guide

RC Staircase Module

Version 1.0 March 2025

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Publisher

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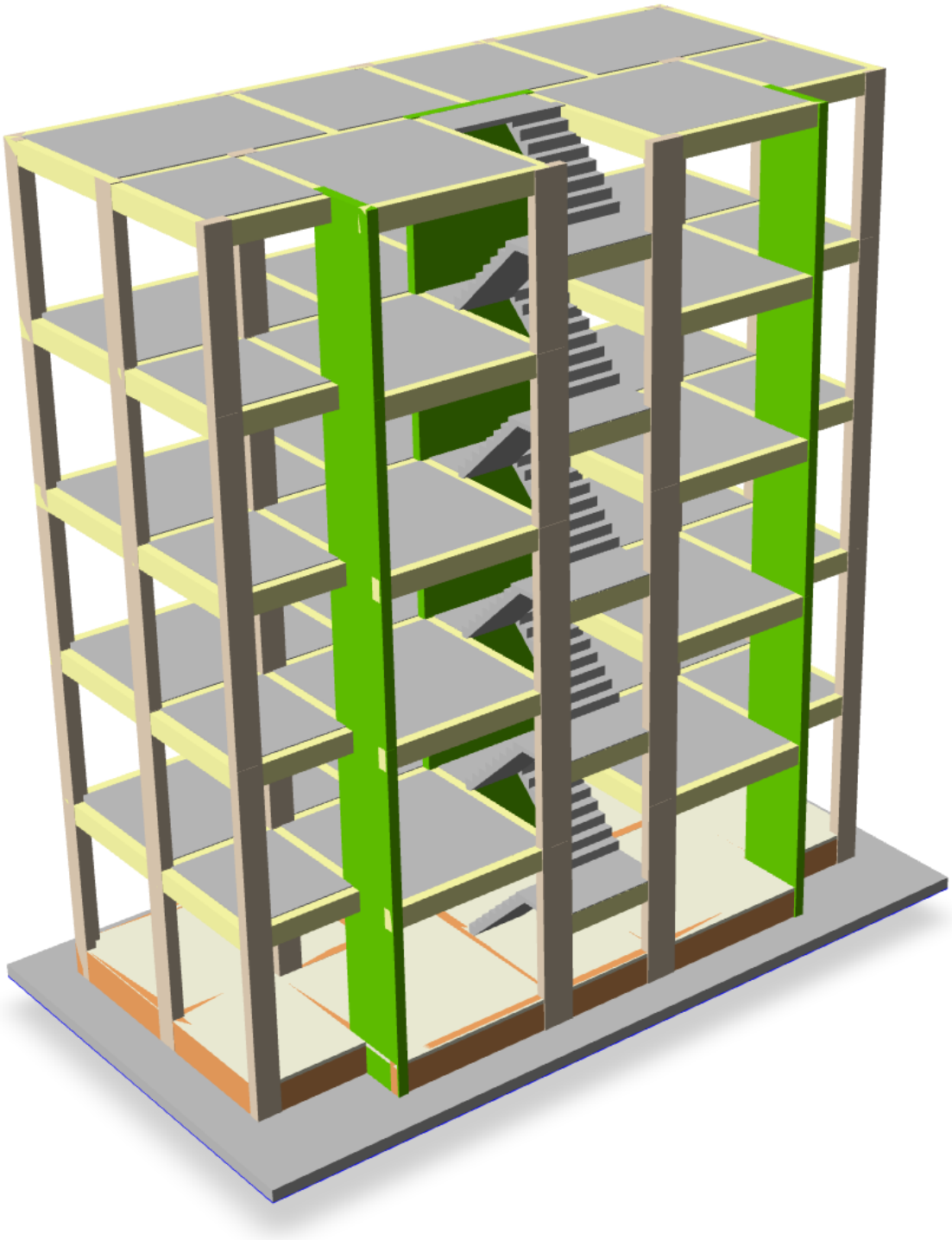
New RC Staircase Module

We are thrilled to present our new RC stairs module, a result of our dedicated efforts. This innovative module allows you to interactively model RC stairs, seamlessly integrate them into the building model using a library of frequently used stair types.

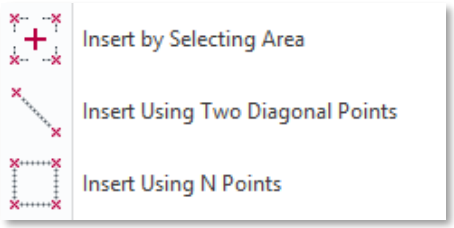


Staircase Interface

To insert a staircase click on **Staircase** command on the **Modeling > RC Members** ribbon tab.

You can select one of three alternative insertion methods for inserting a staircase.

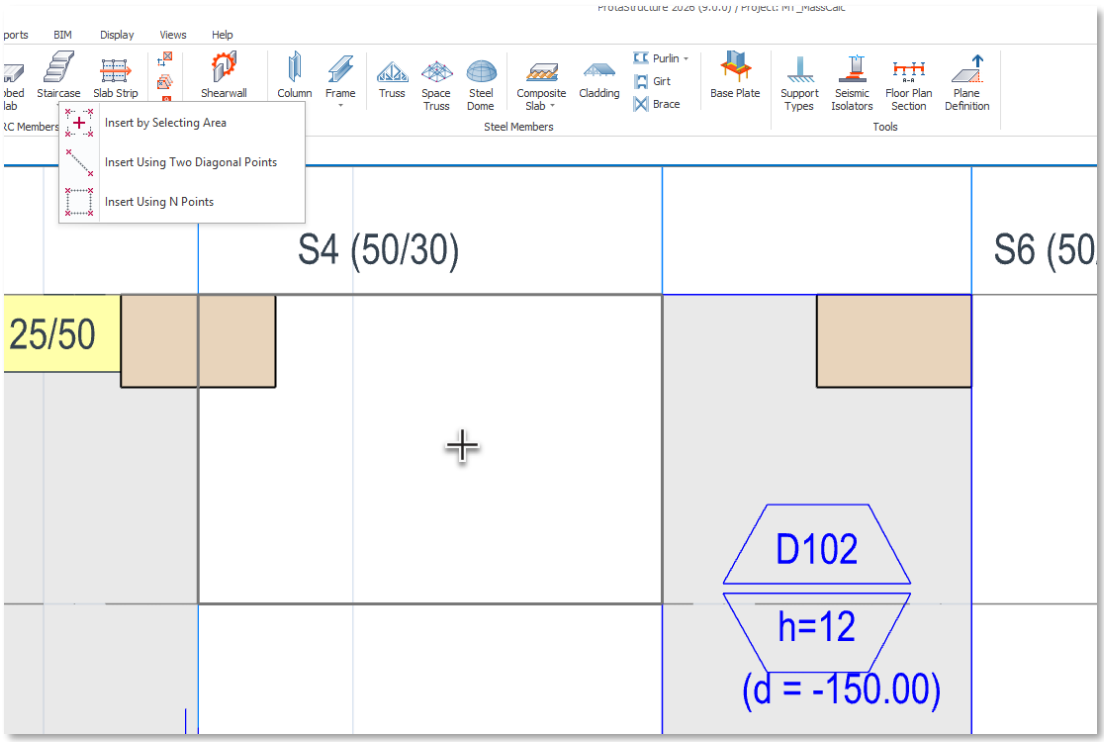
1. Insert by Selecting Area
2. Insert Using Two Diagonal Points
3. Insert Using N Points



In each insertion method, ProtaStructure will expect you to specify the area that the staircase will be inserted.

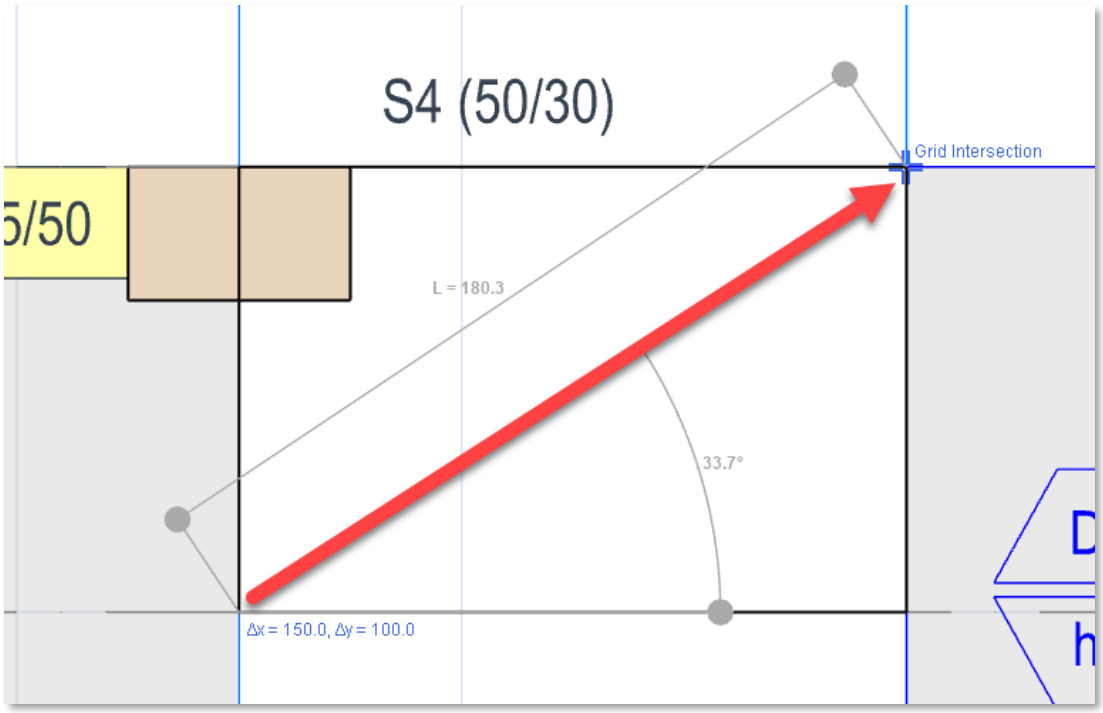
Insert By Selecting Area

In this method, you can pick an area enclosed by beams/shearwalls or axes.



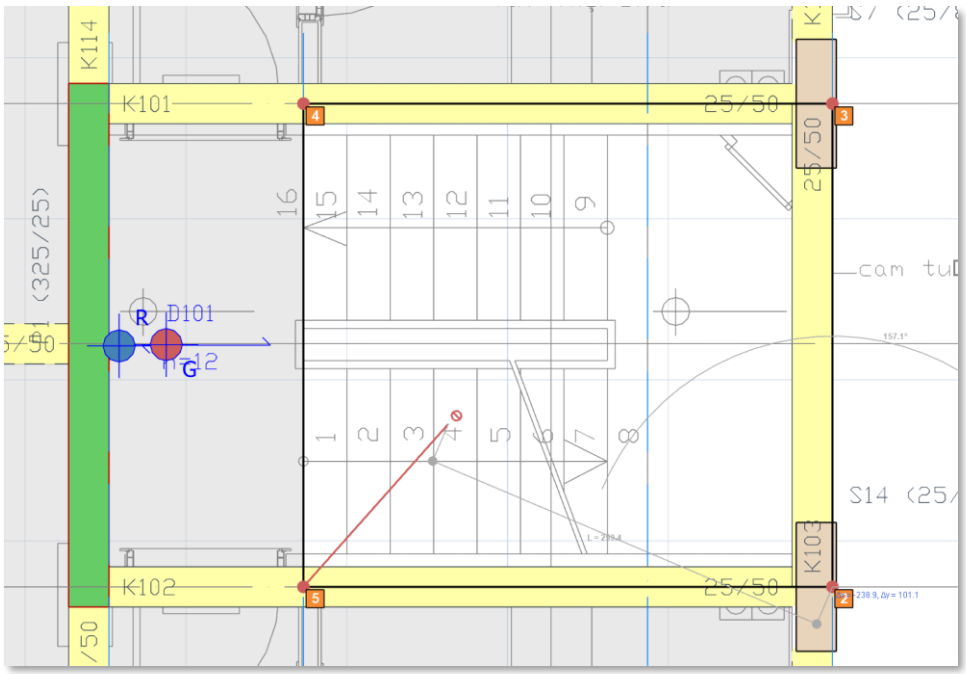
Insert Using Two Diagonal Points

In this method, you can show the two diagonal points of a rectangular area.

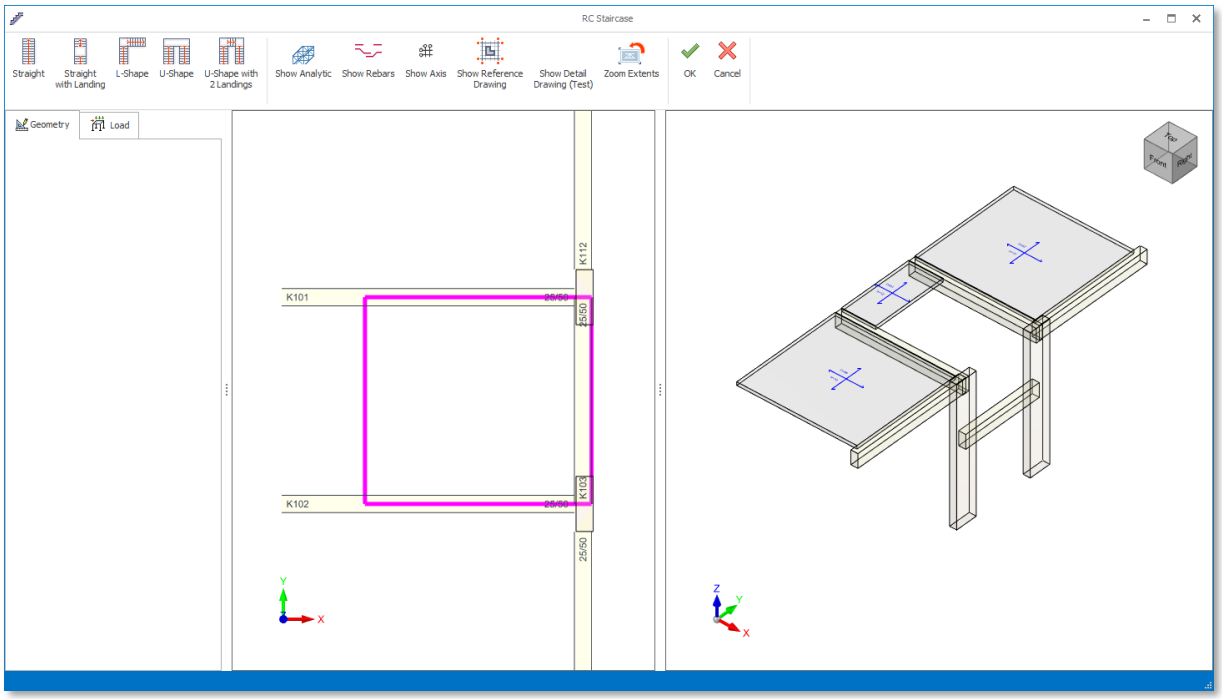


Insert Using N Points

This Method allows you to specify more complex areas rather than rectangular ones. You may also use this method to specify rectangular areas where the other two methods are not applicable. The points will be numbered on the screen as you pick them. Pick the first point again to finish the command.



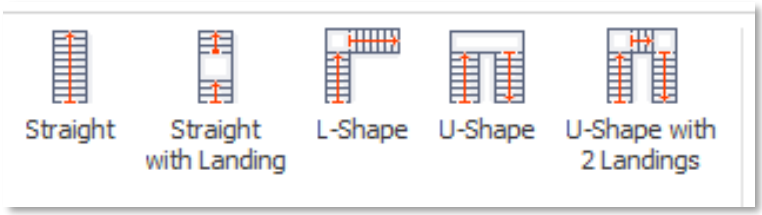
The staircase editor will be loaded. Neighboring members and the enclosed area will be shown on the editor.



Staircase Types

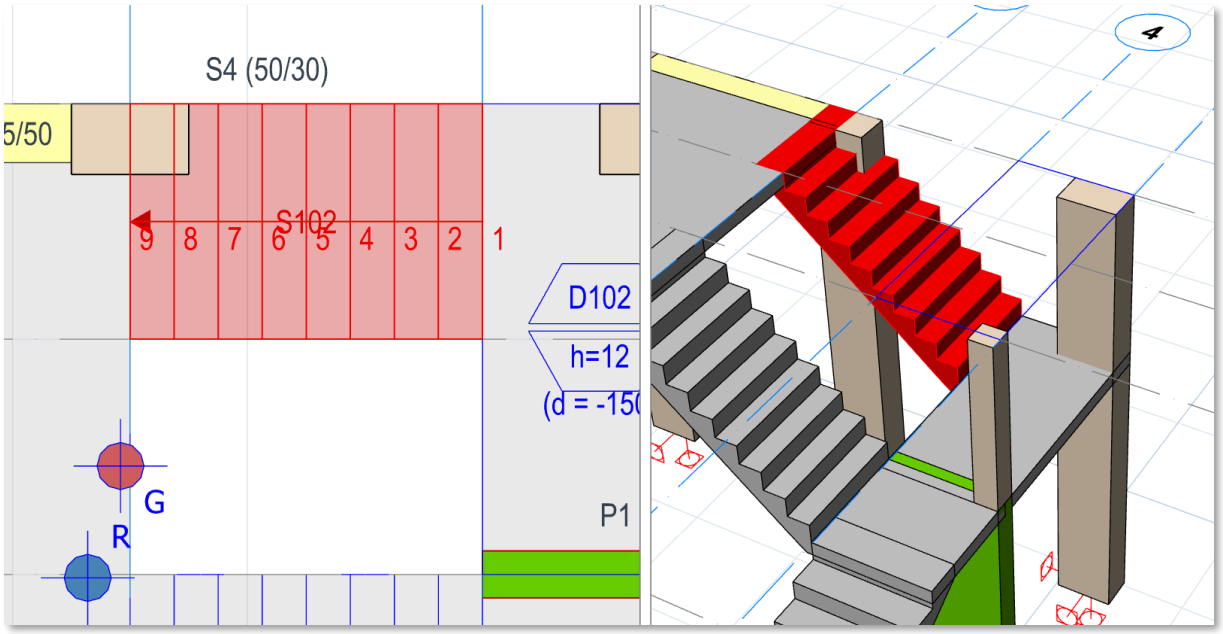
The new staircase module currently supports the following stair types. We will introduce more types in the future. Also, a Do-It-Yourself staircase editor is also among our plans.

1. Straight
2. Straight with Landing
3. L-Shape
4. U-Shape
5. U-Shape with 2 Landings



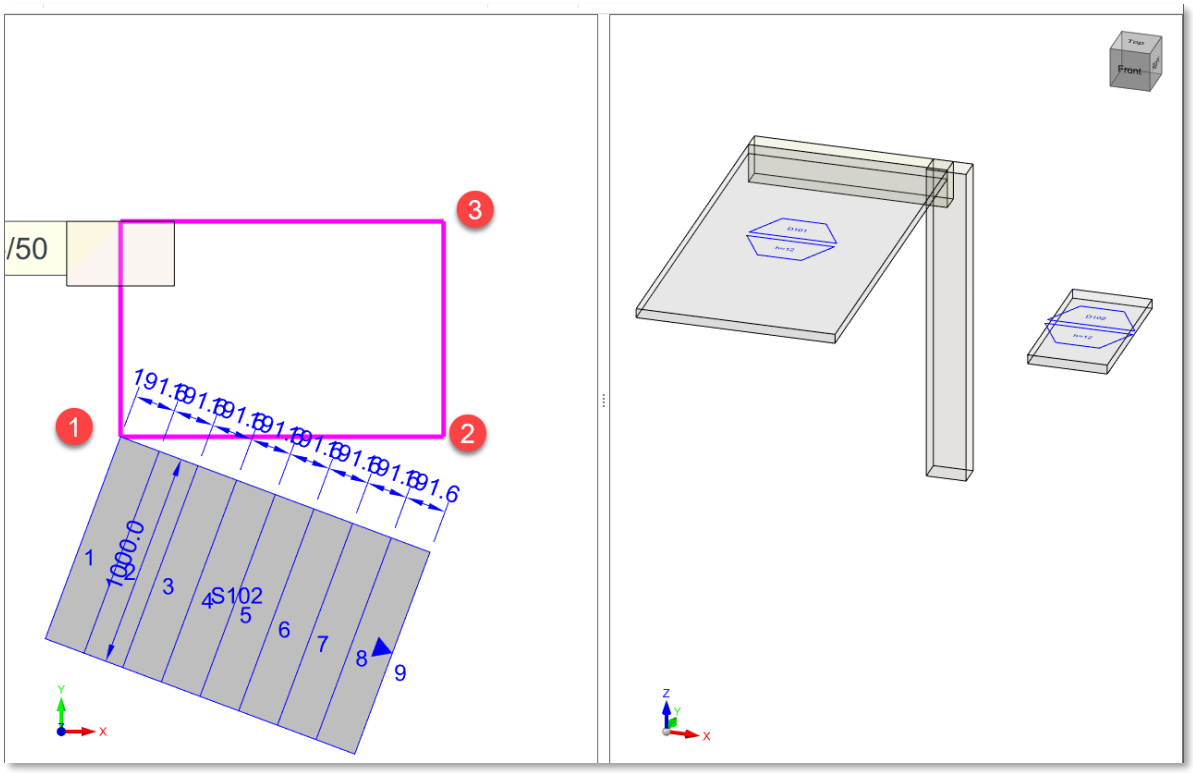
Straight

This type is used to connect two existing levels with a single stair flight.



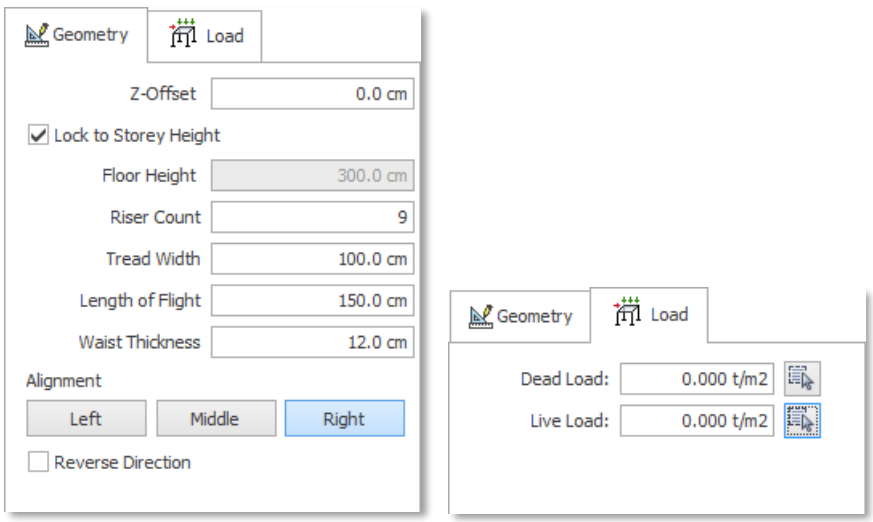
To insert a straight staircase,

1. Specify the enclosed area on the screen. This is explained in detail in insertion methods.
2. In the staircase editor, snap to the points where you want to insert the stair. The obivous snap points are the corners of the pink guide rectangle.



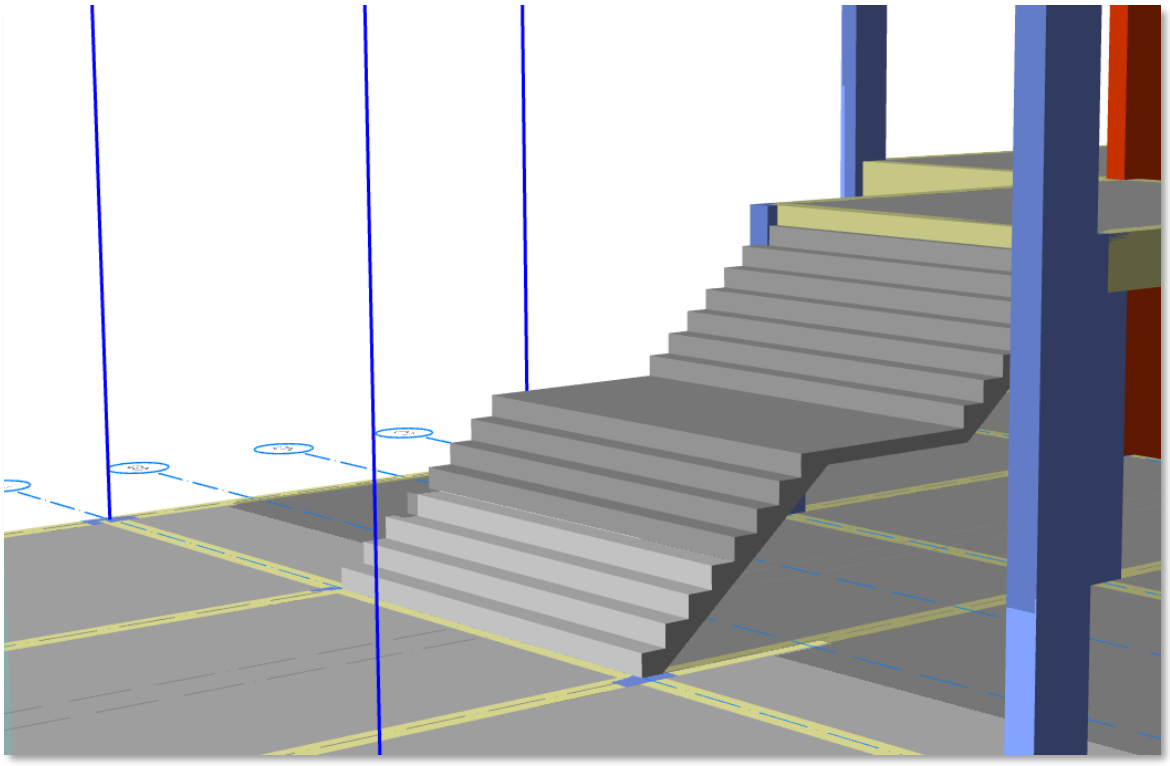
Note:
You can snap to end points and intersections of members shown in the staircase editor. The pink guide rectangle is provided for convenience, which also shows the initially picked enclosed area.

3. Pick three points on the screen. The staircase preview will be simultaneously shown on the screen as you pick the points.
4. After you pick the last point, the staircase is placed on the specified area and the 'Properties' dialog will be activated on the left of the screen as shown below.
    a. **Z-Offset** is used to adjust the lower end of the staircase with an offset value.
    b. **Lock to Storey Height** makes the staircase height to automatically adjust to the storey height. Uncheck this option if you want to enter different values.
    c. **Riser Count** is the number of stairs.
    d. **Tread Width** is the total with of the stair flight.
    e. **Length of Flight:** Normally the flight length is automatically calculated using the picked points. However, you can enter different values in this field.
    f. **Waist Thickness** is the thickness of the flight under the risers.
    g. **Alignment** options are used to insert the member to the left, middle or right of the designated area.
    h. **Reverse Direction** can be used to change the climbing direction of the staircase
    i. **Dead Load** is the value of additional dead loads on the staircase. This can be selected from the additional dead loads library or entered manually. This load is a uniform area load that is applied automatically on the entire staircase.
    j. **Live Load** is the value of imposed load on the staircase. This can also be picked from the imposed load library or entered manually. This load is a uniform area load that is applied automatically on the entire staircase.

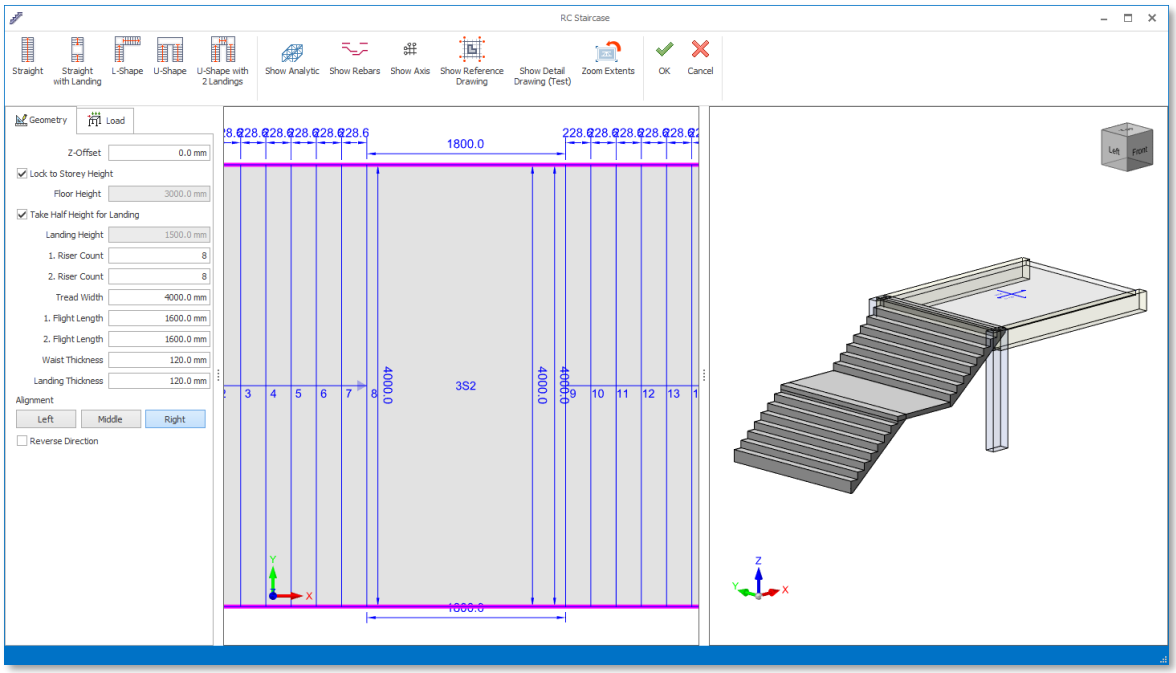


Note:
Self weight of the staircase is automatically calculated and applied on the staircase and can be reviewed using the load editor.

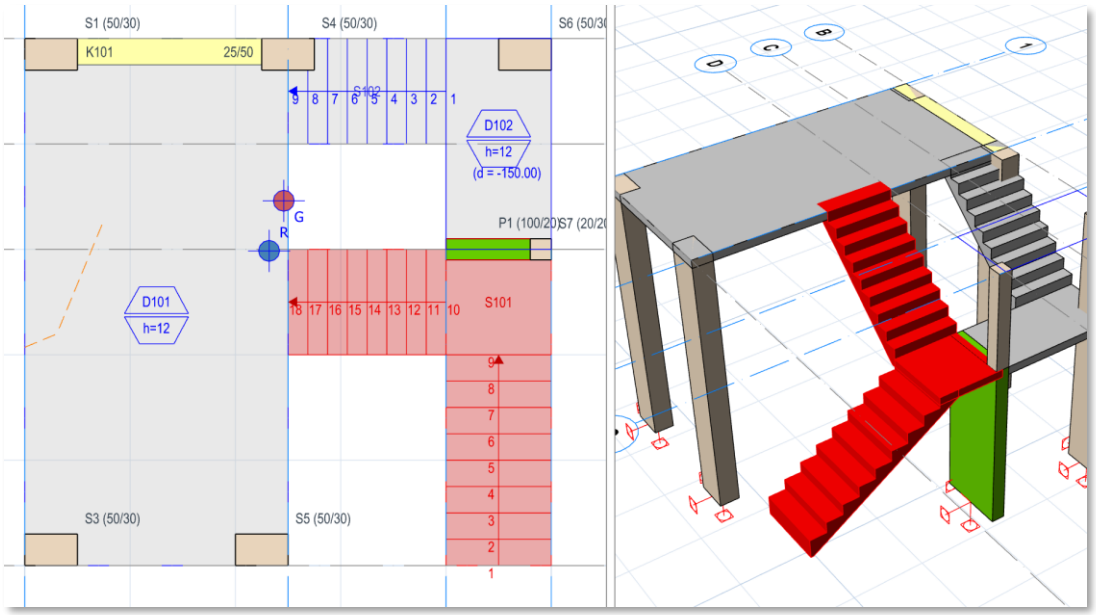
Straight with Landing



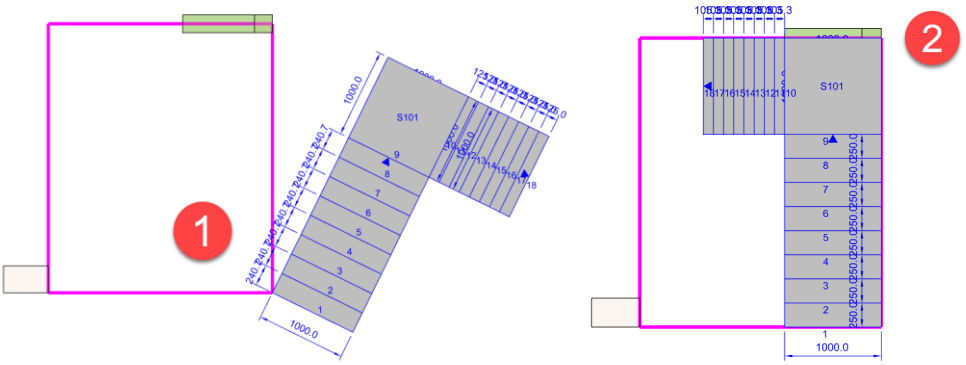
As the name implies, this type is similar to straight staircases, but with an additional landing. The insertion and loading procedure is exactly the same as straight types. There are additional fields that governs the landing and the second flight.

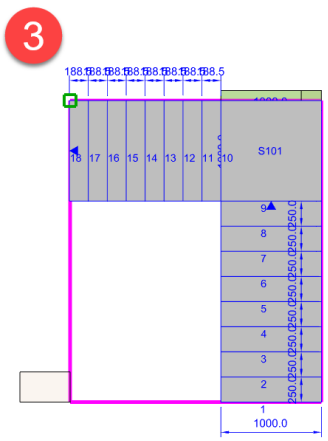


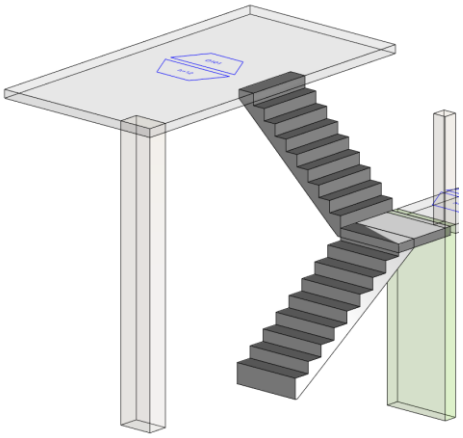
L-Shaped Staircase



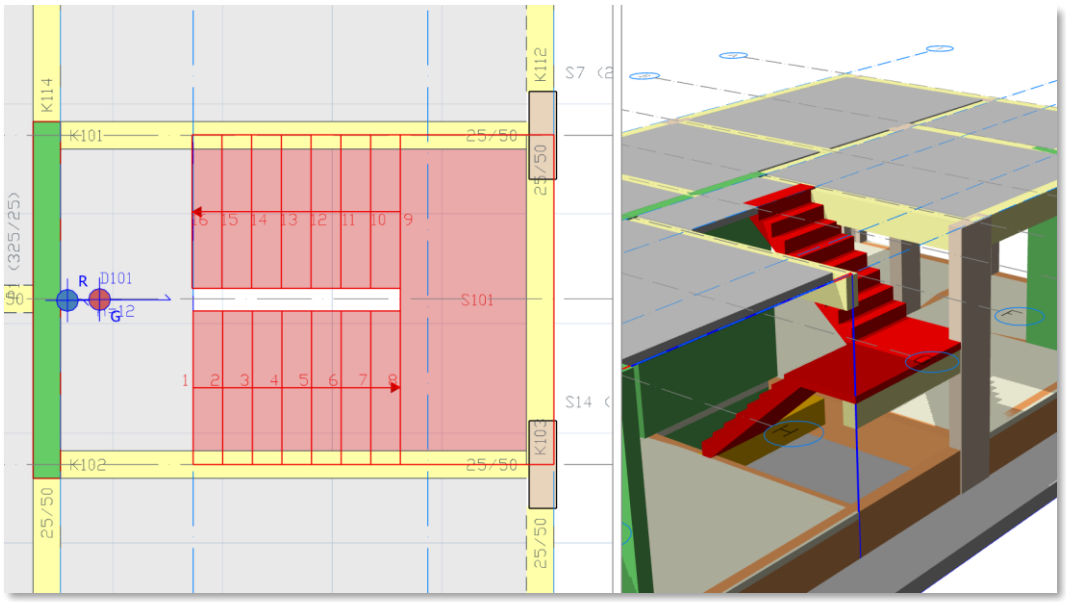
This type is similar to straight staircases with landing. Insertion procedure and the governing parameters are the same with straight staircases with landing.



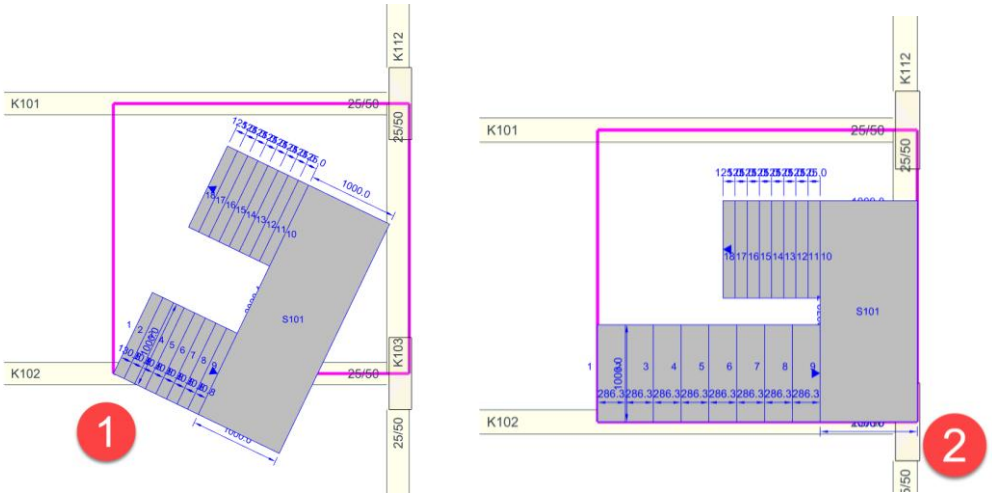


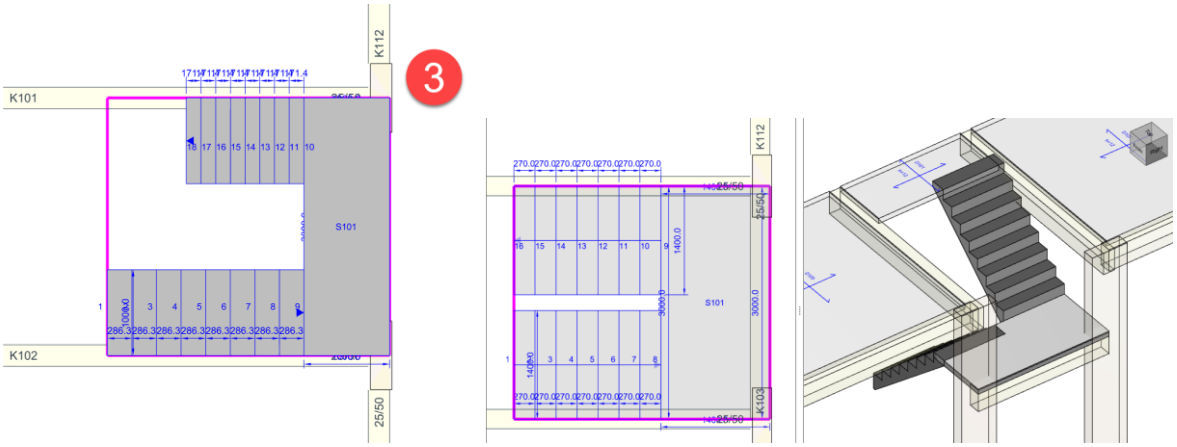


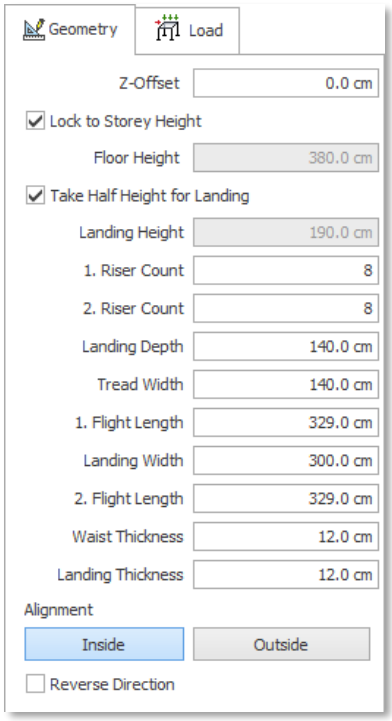
U-Shaped Staircase



This is one of the most frequently used types. . Insertion procedure and the governing parameters are similar with other types.







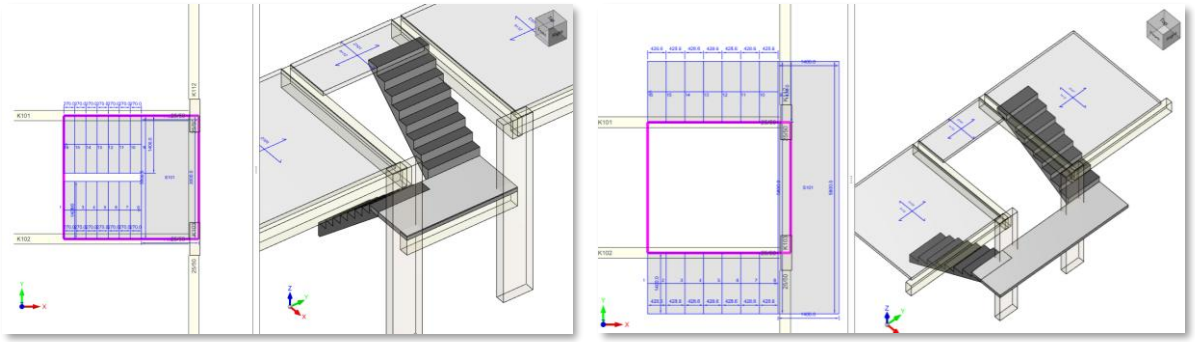
In addition to the common parameters, this stair type has additional parameters:

Landing Depth: Length (depth) of the landing. When this parameter is edited, flight lengths are automatically adjusted to fit into the designated area.

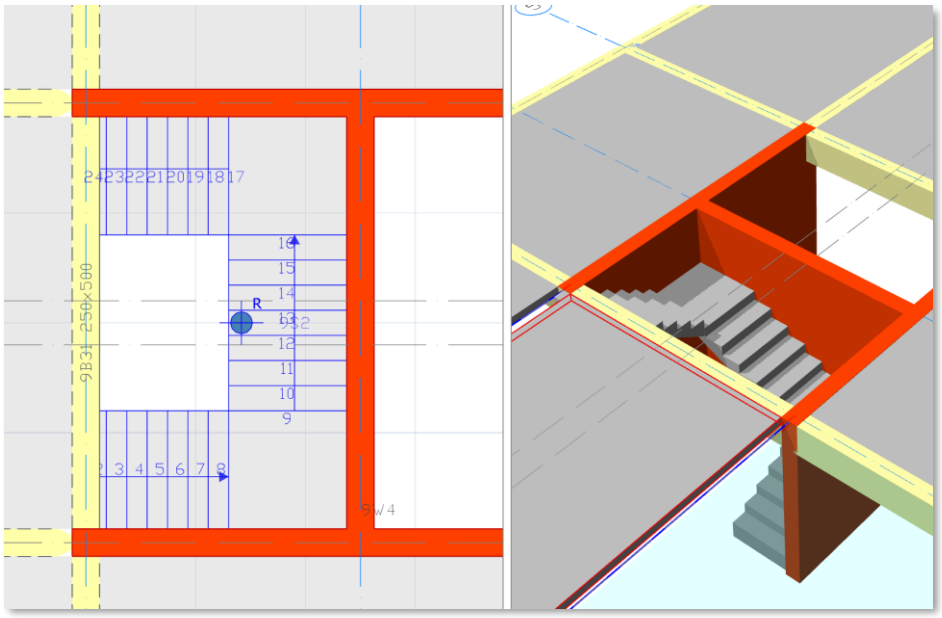
Landing Width: The width of the landing. This parameter also changes the entire width of the staircase. Initially this is automatically calculated using the designated area boundaries.

Landing Thickness: Thickness of the landing plate.

Alignment: You can specify whether the staircase will be placed inside the designated area or around it. Below you can see the '**Inside'** and '**Outside'** options.



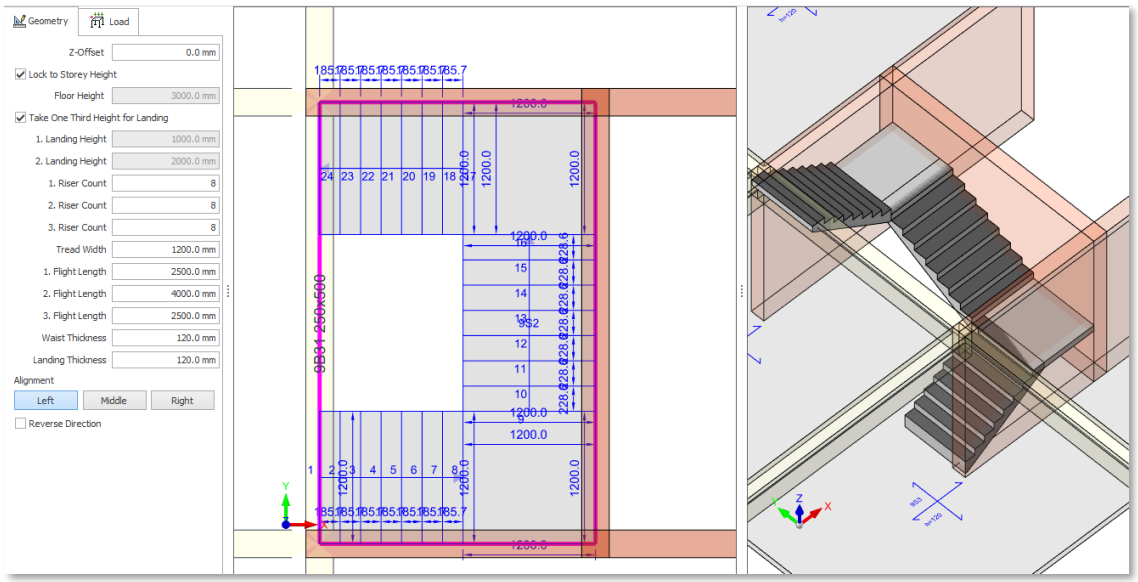
U-Shaped Staircase with Two Landings



These staircases consist of two parallel flights of stairs connected by two landings, creating a 180° turn. U-shaped staircases are necessary in spaces where:

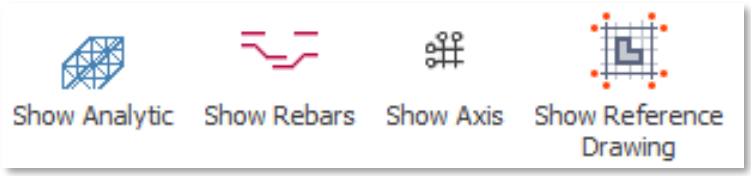
- **Limited Linear Space**: They fit well into architectural plans that require efficient use of floor space.
- **Safety Concerns**: The intermediate landings provide resting points, reducing fatigue and the risk of falls.
- **Directional Change**: They are ideal for buildings where stairs need to change direction, such as multi-story homes or commercial space

Insertion procedure and parameters are similar to other types of staircases. So, they are not explained here to avoid repetition.



Staircase Editor View Options

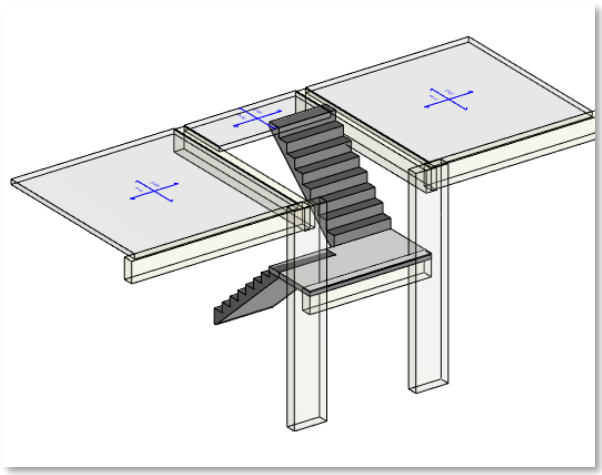
In order to increase productivity in the staricase editor, we have developed useful view tools.

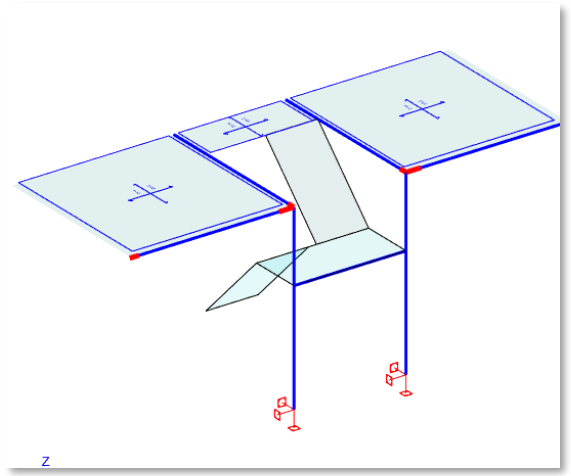


Show Analytic

You can toggle between the physical model view and pseudo-analytical view to see how the analysis lines and plates are connected.

Warning:
This is not a detailed analysis model. The actual analysis model and the FE mesh is created during building analysis.

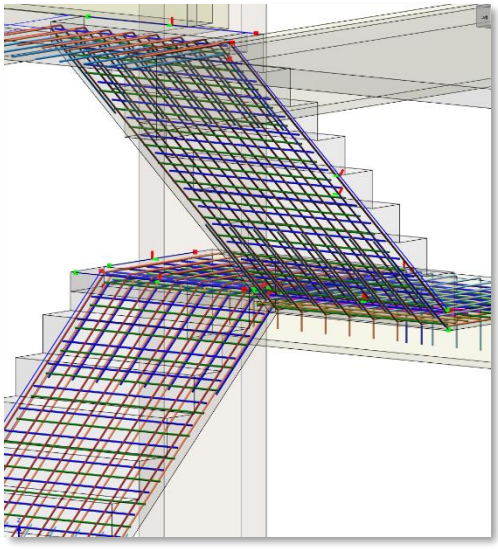




Show Rebars

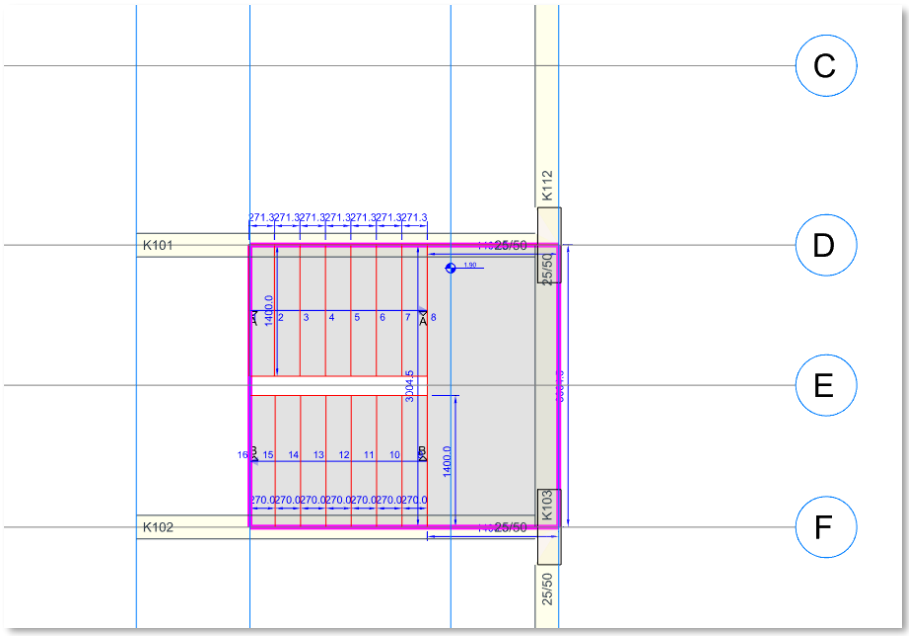
The new staircase module is based on ProtaStructure's 3D rebar technology. You can see how rebars are laid-out in 3D by toggling "Show Rebars" option.

Warning:
This feature is still under development and may not respond as expected in all cases.



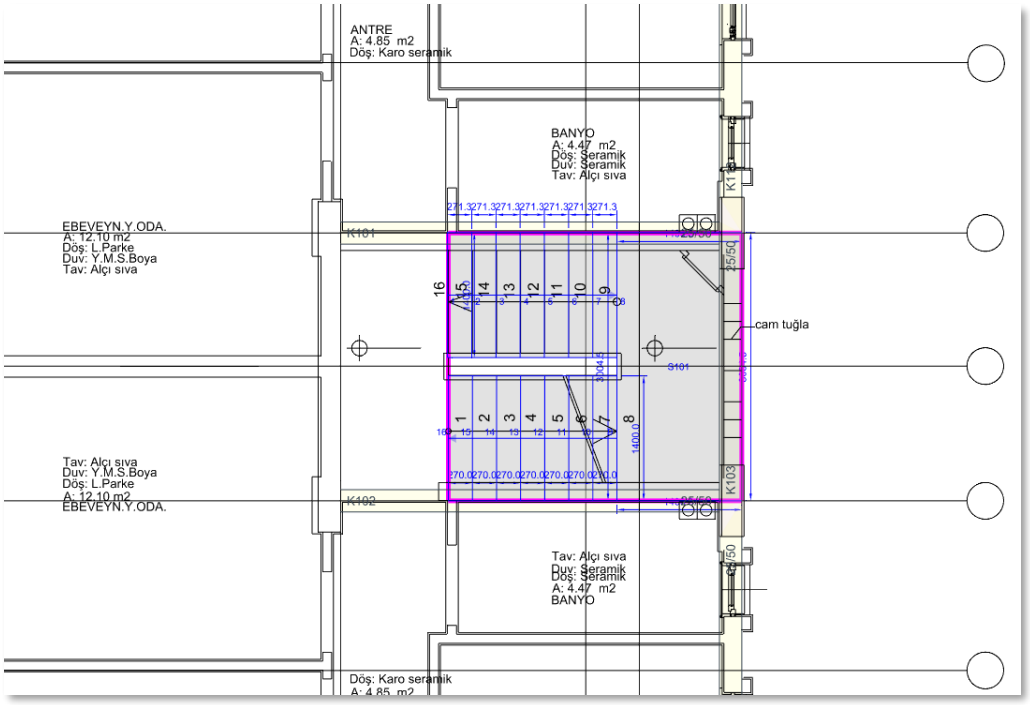
Show Axis

You can use this option to turn on/off the display of axis system defined in ProtaStructure. Displaying the axis system will help you to keep proper orientation and reference to the building model while fine-tuning the staircase parameters.



Show Reference Drawing

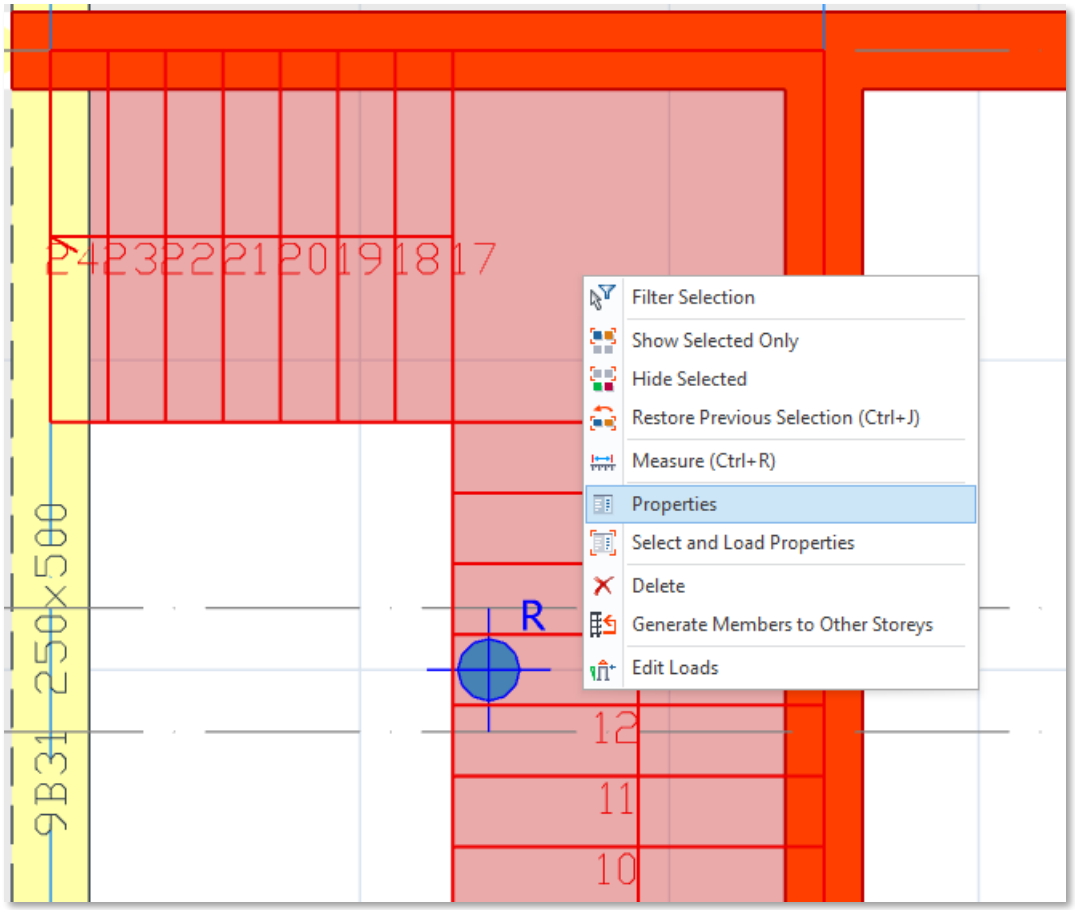
If an architectural reference drawing is active in the current storey, then it can also be displayed on staircase editor. This will help you accurately model the staircase as designated in the architectural drawing. You can snap to the end points and intersections on the architectural drawings.



Updating the Staircases After Insertion

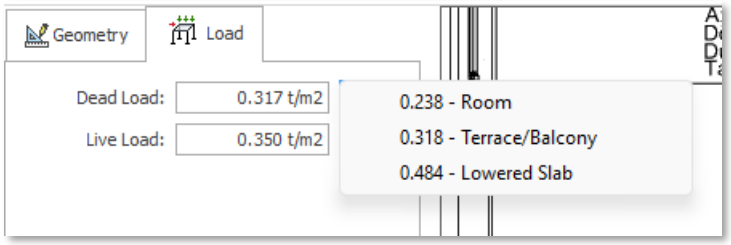
You can update the staircase parameters after you insert them.

1. Select a staircase in the model
2. **Right Click** and pick "**Properties**" command.
3. The staircase editor will be launched.
4. Change the parameters and click **OK**. The selected staircase will be updated according to the new parameters.



Further Editing the Loads on the Staircase

As explained before, the new staircase module automatically calculates the self-weight of the staircase. Additionally, you can also define '**Additional Dead Loads**' and '**Live Loads**' via two designated fields on the staircase editor.

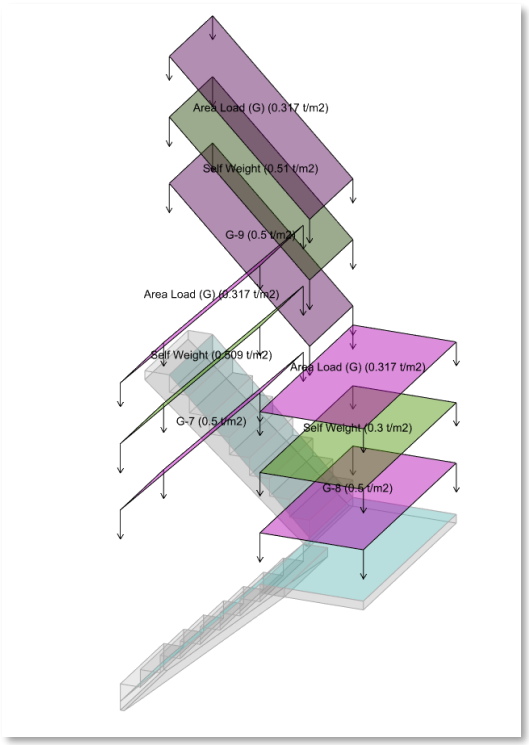


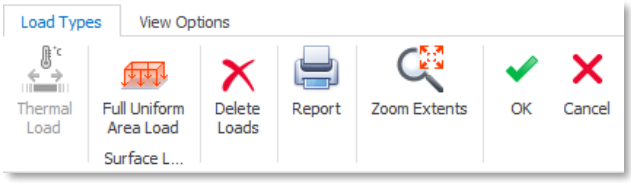
The predefined **Self-Weight** and **Additional Dead Load** is automatically considered in the **'G'** or **'D'** load case, whereas, the **Live Load** will be automatically assigned to **'Q'** or **'L'** load case.

You can define as many user-defined vertical and lateral load cases as possible in ProtaStructure, thanks to the flexible load case and combination system. You can define uniform area loads on staircases and assign them to any load case you want, including lateral load cases. To achieve this:

1. Select the staircase on the screen and pick **Right Click > Edit Loads**. This will launch the load editor for the selected staircase.
2. Alternatively, navigate to **Ribbon > Loading** and click "**Load Editor: Storey X**" button. This will launch the load editor for the active storey.
3. Define loads as usual. Usage of load editor is out of this document's scope.

Note:
Only Temperature Loads and Uniform Area Loads can be assigned to staircases.





Finite Element Model of Staircases

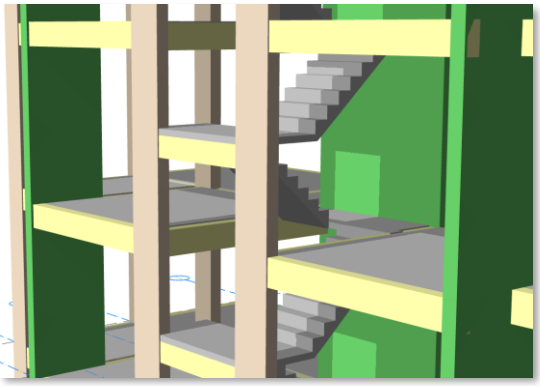
ProtaStructure will always model the staircases with FE Shell elements. And, they will be an integral part of the building analysis model. The staircases will be meshed compatibly with adjacent members such as slabs, sherwalls, beams, columns and other.

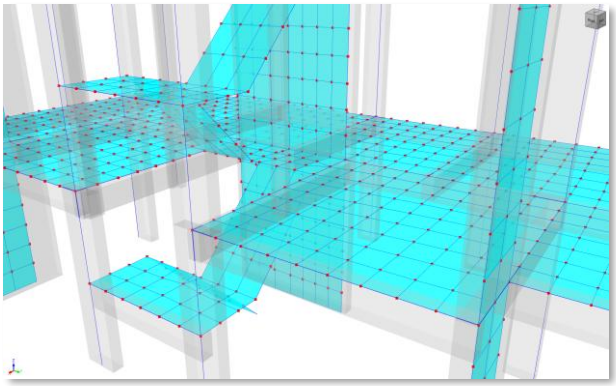
Disclaimer and Warning:

The analysis of staircases together with the building is a controversial topic. Staircases may provide a lateral bracing effect since they connect two storey levels. Because of this, some engineers do not prefer to include them in the building analysis model. In addition to this, staircases tend to crack and collapse during earthquake and may fail to provide stiffness, which is another factor why you may want to design the lateral load resisting system without staircases in order to capture the most critical scenario.

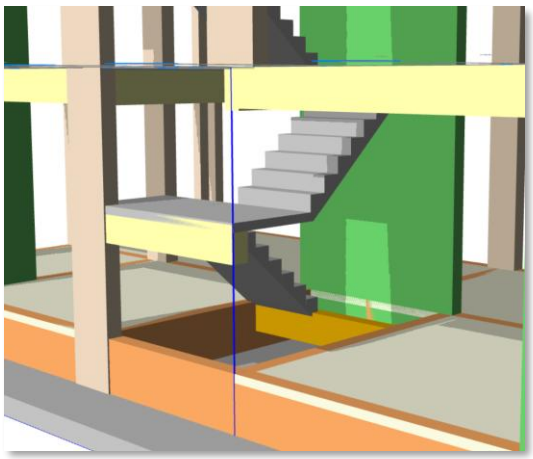
If you do not want to include the staircases in the building analysis model, DO NOT model them. You can still continue using the staircase module in ProtaDetails for individual design and detailing.

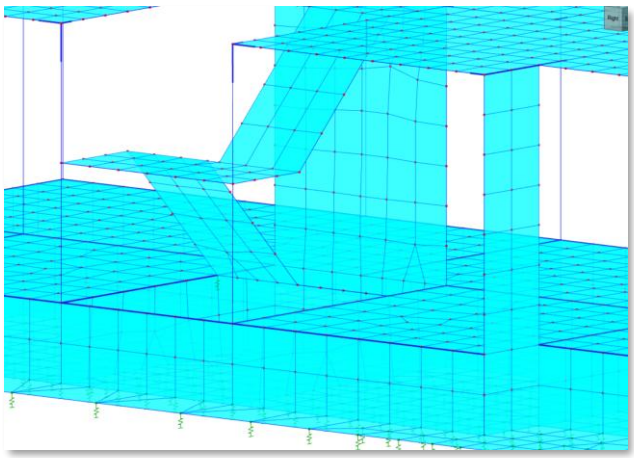
Physical and FE Model of U-shaped Staircase is shown above. Note that the staircase is connected to landing beam and the slab in front of the shearwall.



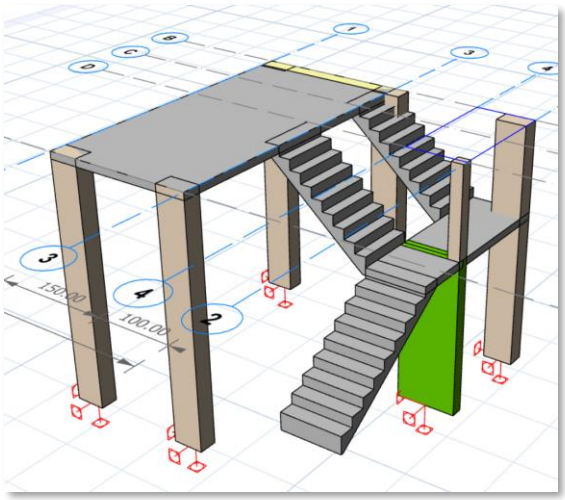


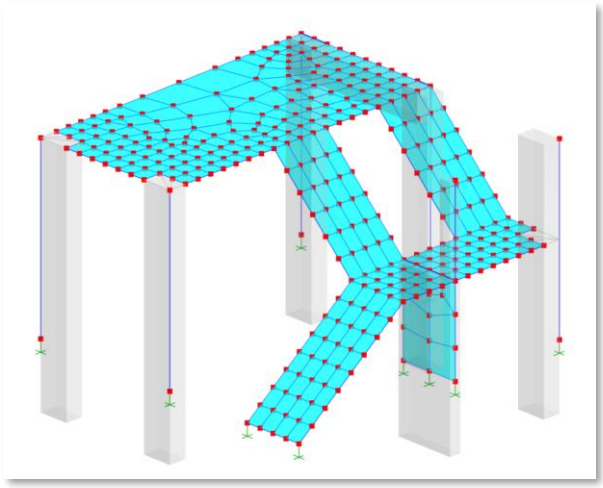
You can see the same staircase automatically connected to the subbasement beam at the foundation level.



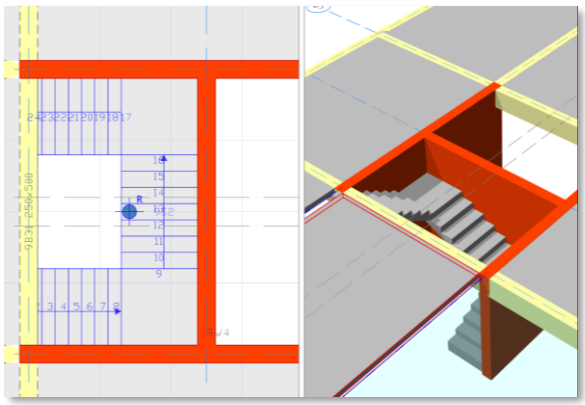


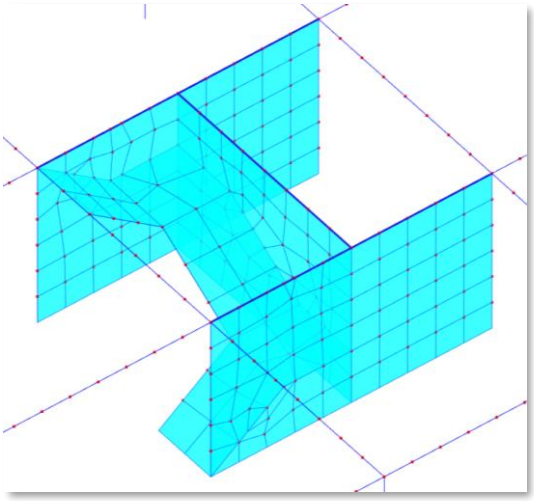
Physical and FE Model of an L-Shaped and Straight staircase is shown below. Supporting slabs, shearwalls, stair landings and stair flights are meshed compatibly. ProtaStructure will assign supports to the ends of the staircase at foundation level if they are not connected to a subbasement beam, subbasement slab or subbasement wall.





The following images show a U-shaped staircase with two landings placed inside a corewall. ProtaStructure will identify the supports and mesh the staircase compatibly with the shearwalls.





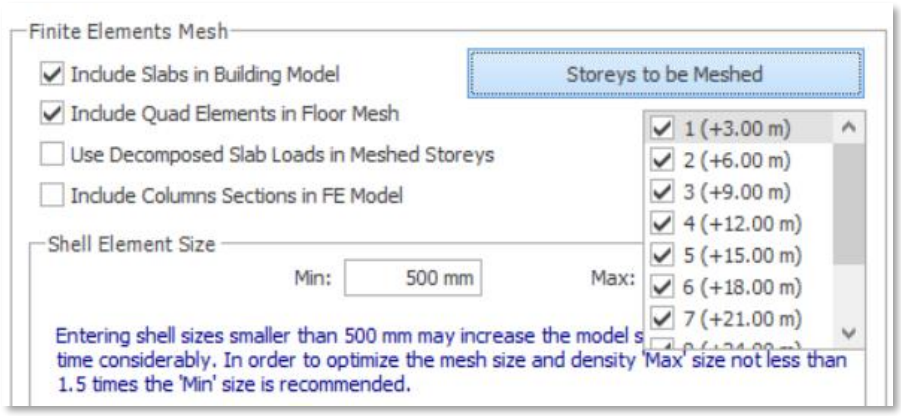
Warning:

Even though the staircase is connected to a shearwall at the sides, the real life as-built rebar anchorages may not satisfy a fixed/continuous support conditions because of insufficient anchorage length. You may expect the staircase flights to behave pin supported or not supported at all at the shearwall face. In those cases, you can model the staircase so that it does not touch the wall. You can leave a small gap between the staircase and the shearwall. ProtaStructure will assume a monolithic continuous connection if the staircase and shearwall is in contact with each other.

Don’t forget that this is a modeling tool that is developed for your convenience. It is up to you to decide or reflect the real-life behaviour on your model.

Including the Slabs in Building Model

ProtaStructure has an option to **mesh the storeys** in the building analysis. This feature is useful especially when you want to decompose the loads directly during the building analysis or when you want to use a flexible diaphragm. This option is accessible through **Building Analysis > Model Options > Slab Model**.



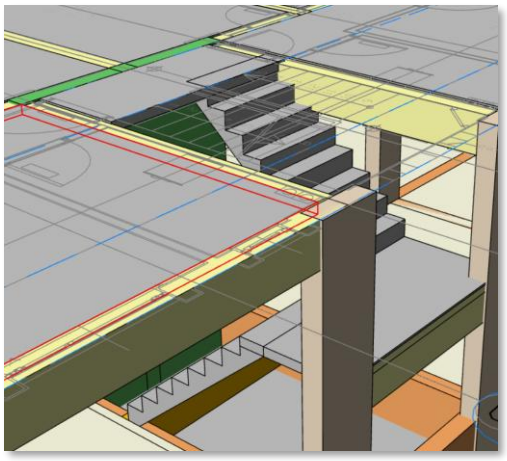
Warning:

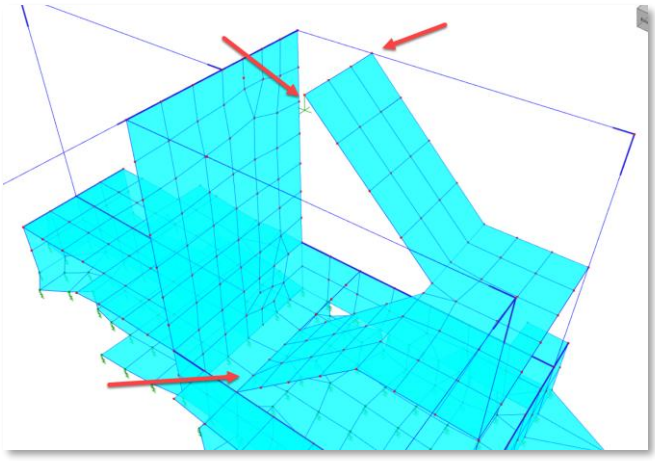
Regardless of the option, ProtaStructure **will always mesh the staircases** in the building analysis model. So, you may find yourself in a situation where the slabs are not meshed and staircases are meshed if you do not include the slabs in the building analysis.

In this case, ProtaStructure will do its best to support the staircases, but it is recommended to include the slabs in the building analysis for a more realistic model.

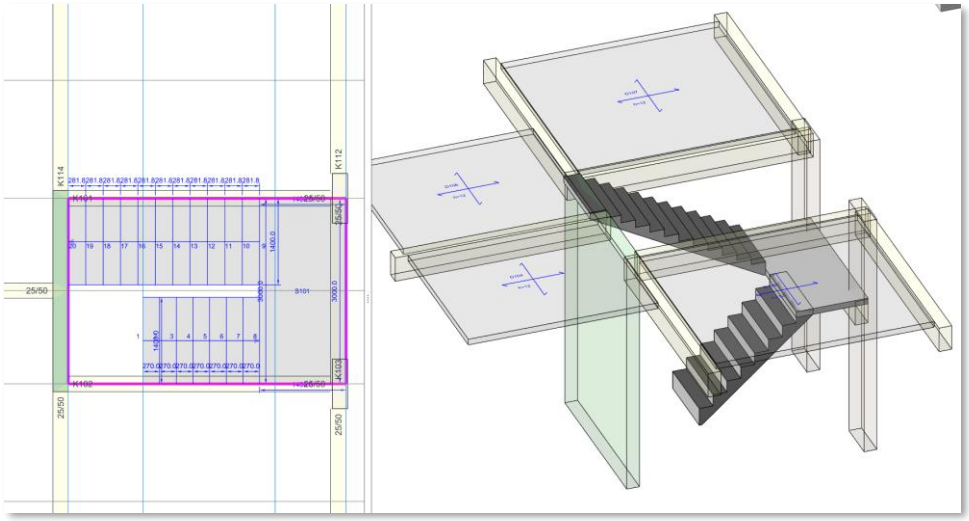
However, there may be cases where staircases are supported by beams and shearwalls. In this case, you don't need to mesh the slabs. You should be careful and examine the automatically created analytical model to see if anyting is disconnected or unsupported.

To illustrate this, the slabs are not included in the building analysis, in the following images The staircases are meshed and since ProtaStructure can not find any slab meshes to connect the stair flight, a support is assigned to the staircase to prevent loss of loads. However, this is not a desired model and it is better to mesh the slabs in the building analysis. There is a subbasement beam at the foundation level so, there is no problem connecting the stair flight.

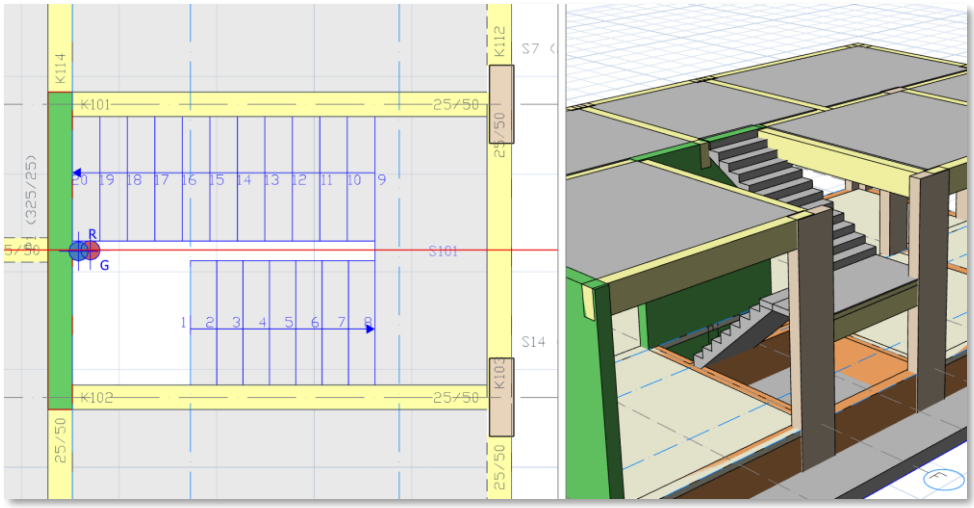




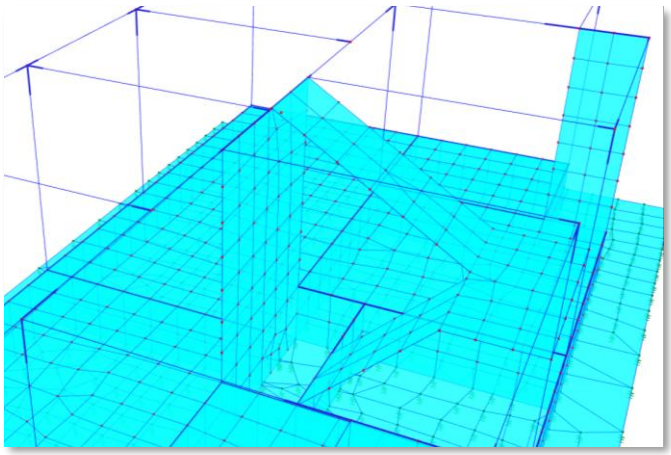
An alternative model is created with a U-shaped staircase with unequal flight lengths.The lower flight is connected to a subbasement slab and upper flight is connected to the shearwall. We will not include the slabs in the building analysis.



The view from the staircase editor. See how the staircase has unequal flights



Plan and 3D view of the model

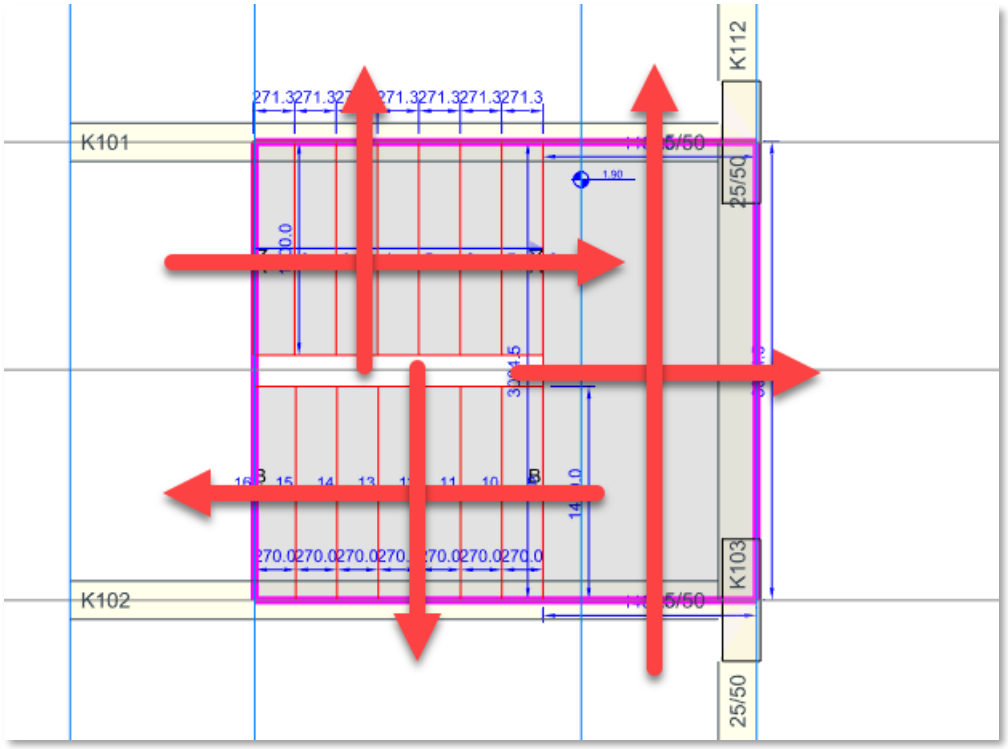


Analytical model of the building. Slabs are not meshed with the building. Staircase is connected to the shearwall at the top and subbasement wall at the bottom.

Design of Staircases

As mentioned in the previous chapters, the staircases are modelled with FE shell elements as a part of the building during building analysis.

ProtaStructure will automatically create slab strips inside the staircase and collect the most critical results for each stair component to be used in the design. The image below show the schematic representation of the automated slab strips for the staircases.



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