

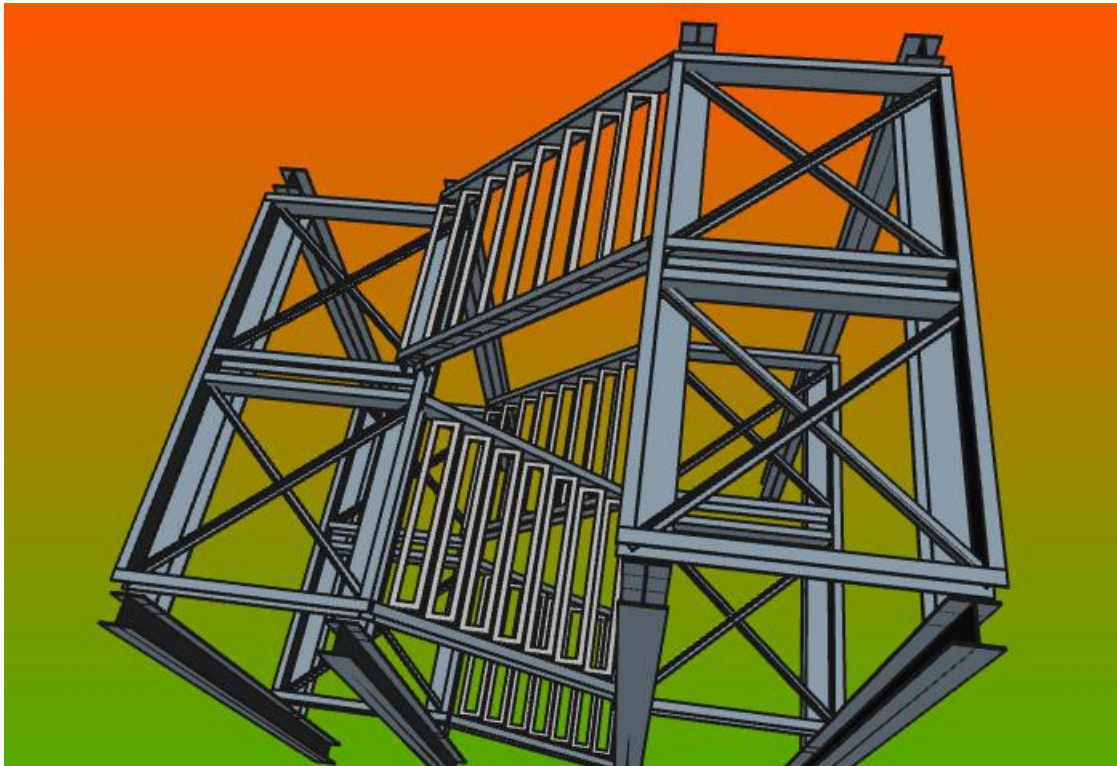
FRAMETOOLS is mainly a set of macros to quickly arrange frames or structures using beams created with the Arch's Structure object. Anyway most of its commands work as well with any other type of FreeCAD's object so that, for example, you can join two edges of extruded "Pads" or lay them to one same plane using the same button of this Workbench as you would do if they were beams.

Using FRAMETOOLS, the workflow to build a steel structure could be as follows.

1. Create with **Sketch** or **Draft** workbenches the skeleton of the structure or with **Part** and **PartDesign** create an auxiliary solid whose edges will be the axis of the structure.
2. Add to the drawing some *Structure* object from the **Arch** workbench; at least one for each type of beam's *Profile* you are going to use in your project.
3. Finally open the **FrameTools** workbench and start to lay down the beams on the edges, make copies of them, adjust their length and position, join them etc. until the structure is finished and good looking.

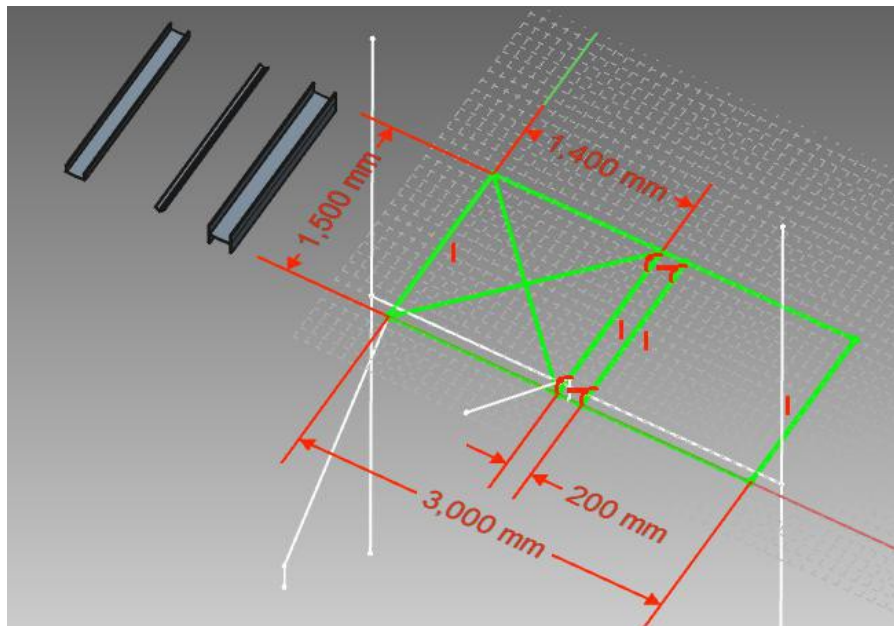
Let's go through the commands with an example.

Say you want to draw an external firefighting stair to use in your bigger project of a New Convention Hall in Gotham City. It should look like this:



As for points 1. and 2. above you may start to create some sketches, for example one for the intermediate floors, two for the ramps and one for the main columns. Also you should add to the drawing the type of beams you will use: an HEA200 for the columns, an UPE

180 for the ramps and intermediate floor and an L50x50 angle for braces. At the end the drawing can be like this:



In the picture above the sketch of the intermediate floor is open just to let you see the constraints and dimensions: these are linked to the dimensions of other sketches with formulas. You may notice also that not "all the lines" are drawn because, after we create, for example, the main columns structure (the "H" shaped sketch) it is possible to copy and translate it simply using one of the FrameTools commands.



At this time, generally, the first thing to do is to move and resize the beams over one edge.

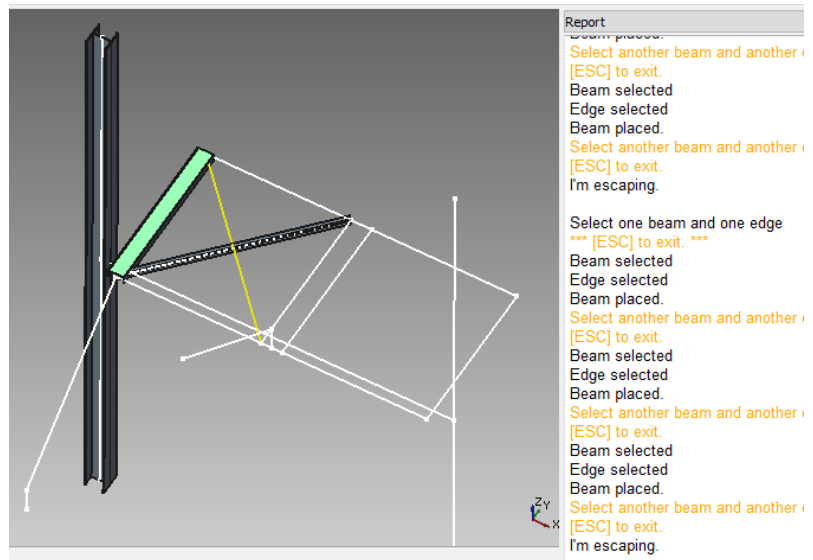
You can accomplish that with the "beam-fit" command.

Its operation is very simple: just select in the active view one edge and one beam one after the other. When you've done press [ESC] to finish (i.e. remove the *selection observer*, for those who like scripting): don't forget to escape, otherwise the command will remain active.

Now you see that the UPE section is not rotated as desired since the longest side of the profile should be vertical.



To rotate the section you can select it and click on the "spinTheBeam" button, that rotates the beam around its axis by steps of 45 degrees. It's possible also to select multiple beams before invoking the command, so that each will rotate of the same amount at each click.

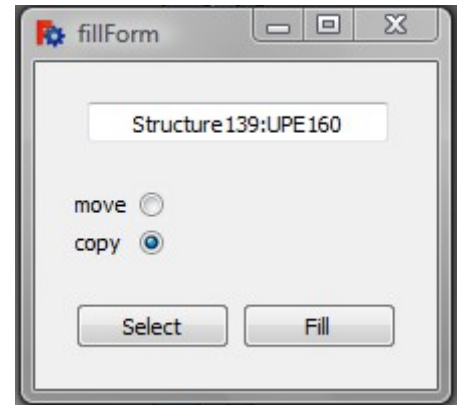




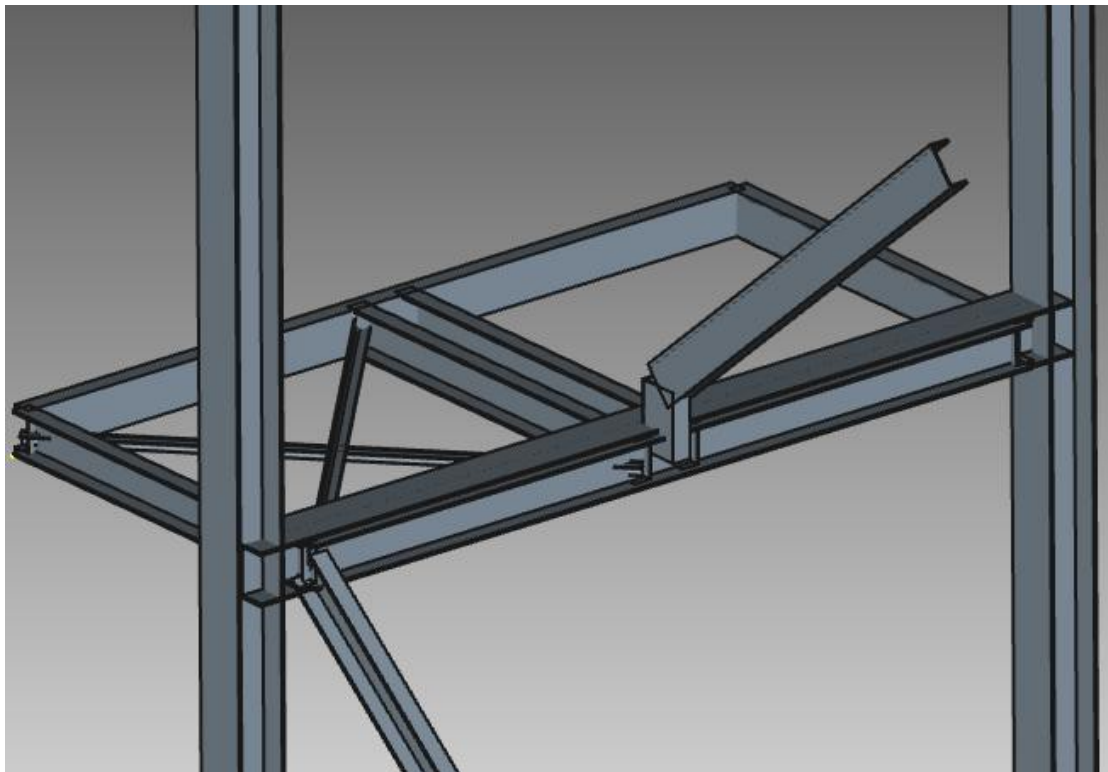
As an alternative you can choose the more fancy command "alignFlanges" which actually rotate one or more beams to make the selected faces parallel to the first selected one. This command can work at "one-shot" if you select all the desired faces (one for each beam) that you want to make parallel: the first of selection will be the master. Otherwise, if your selection is null or not congruent, the program request to select the target face and then the consecutive faces to make parallel to it, until you press [ESC].



Let's fill the other edges! Obviously you will use the "fillTheFrame" function which pop-ups a simple dialog that prompts you to select the reference beam (select the beam and press "Select" button) that will be copied over the edges (select one or multiple edges and press "Fill" button). The dialog is provided also with two radio buttons that let you choose to create new beams (default) or just move them (as an alternative to the beamFit command).




You may need to rotate and align your beams with the commands seen above; at the end the drawing looks like this:



As it looks now, the model needs some "make-up": the angle of the frame are not well terminated, there are lots of gaps and overlaps, the UPE180 beam of the intermediate floor is completely "swallowed" by the HEA200 orizontal beam of the columns structure... so let's make some order.

First let's group the beams object in the model tree so that it will be easier to hide/show them as necessary. This is not mandatory but only a good practice.

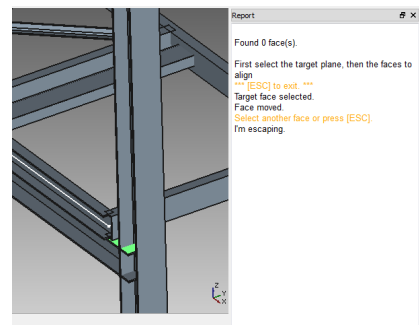
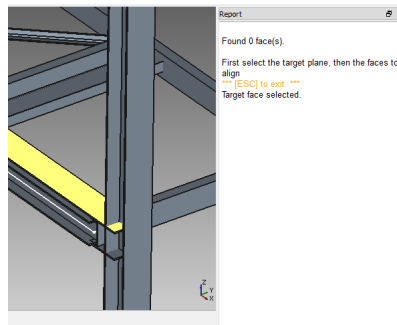
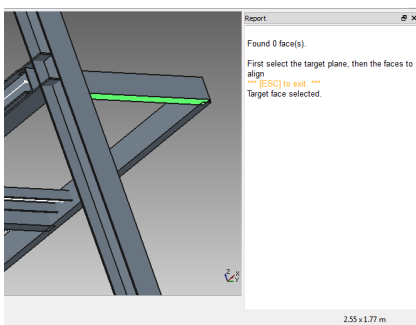
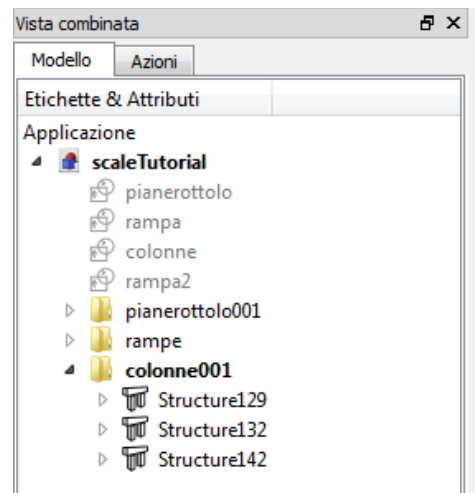
Then focus on the intersection between the horizontal beam, of the "H" structure and the intermediate floor: it's necessary to shift the HEA200 beam below the lower face of the UPE 180 beam so that it supports the intermediate floor.


 This can be accomplished by using the "levelTheBeam" command, that moves one object so that the CenterOfMass of one of its face lay in the same plane of another face.

Notice that I say "object" and not "beam" because this command works with any FreeCAD solid. Also, despite the icon of the button, this action works also if the faces selected are not parallel.

The behaviour of this command is similar to "alignFlanges" (read above) because if you select all faces before invoking the command, the program brings all CoM to the plane of the first face selected; otherwise it lets you choose the target and, afterwards, the faces to be moved.

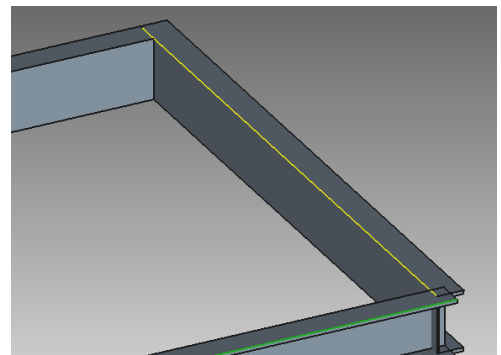
Using the latter option: press the button, select one of the bottom faces of the intermediate floor and finally select the top face of the HEA beam. The beam is moved below the intermediate floor. Press [ESC] to stop this action.



 What we want now is to adjust the funny overlap of beams at the angles of intermediate floor. Let's focus on it: for clarity sake we'll hide the other groups in the model tree.

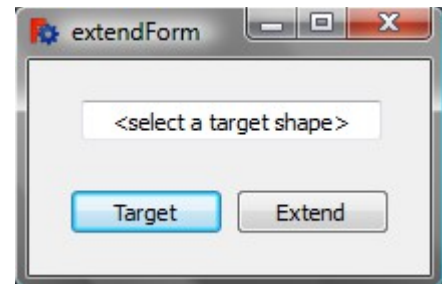
Select the "adjustFrameAngle" tool and select consecutive square-angled edges belonging to the beams to join: the program will extend or retract one beam to the edge of the other, so that the beams ends will fit right.

Repeat that for all 4 angles and then escape with [ESC].



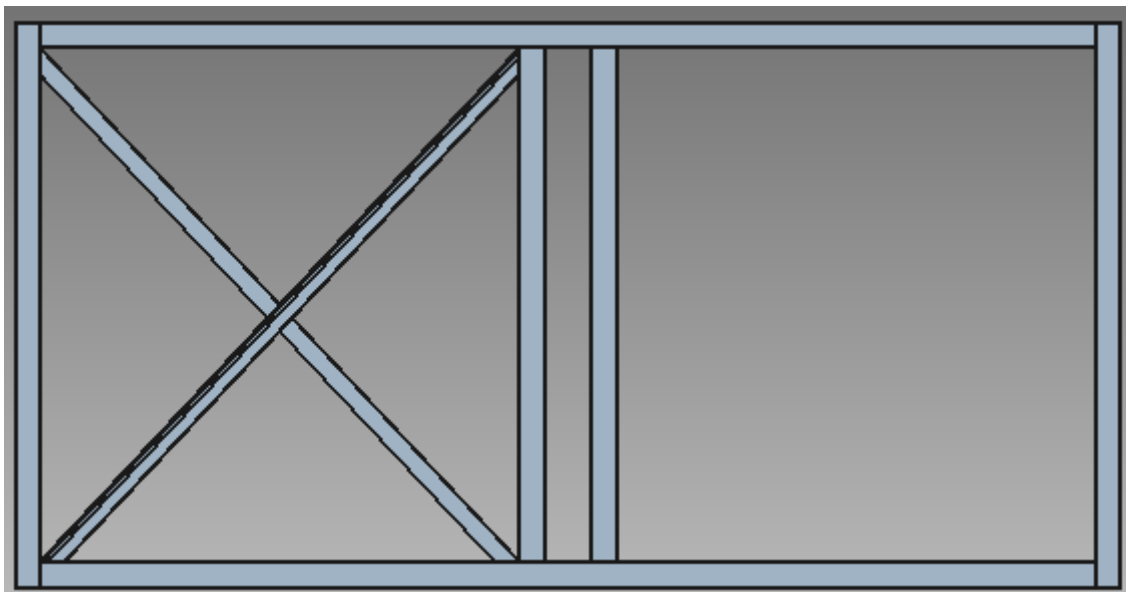


To eliminate also the overlaps at the center of the beams, that are not angles but T joints, and those with the diagonal braces use the "extendBeam" command. This will bring up another simple dialog which first asks to select one target *Shape* to which the beams will be extended.



- If the target shape is a *Face* the beam's nearest end will extend to the plane that includes that face.
- If the target shape is a *Vertex* the beam's nearest end will extend to the plane, orthogonal to the beam's axis, that includes that point.
- In any other case, if the target object has a *CenterOfMass* attribute, the beam will extend to the plane, orthogonal to its axis, that include the center of mass of the target (that's the case of "adjustFrameAngle" command: read above)

So, for the purpose of this tutorial, you can set the target to the inner face of the long side's beam (press button "Target" after you selected it) and then extend/trim the two middle beams to that ([Ctrl]+select for multiple selection, then press "Extend" button). Repeat the operation with other beams and targets until the frame looks like in the picture below.



Well, it's almost like we want it, except that braces must be copied also to the right part of the frame.



To do this you can use the "translateTheBeam" command. This is quite articulate so it's worth to look at all of its parts and what they do.

When you invoke the command the dialog to the right pop-ups. As you may desume the x/y/z text boxes are the coordinates of a vector that may be used to define the direction and amount of translation.

If you want to input directly these three values, the next two text boxes can remain to "1" as default.

Instead, if you wish to translate the objects on the basis of existing geometry in your drawing, you have two other options:

- Select two *Shapes* (2 *Vertexes*, 1 *Vertex* and 1 *Face* or 2 *Edges*) and press "Displacement"
- Select one *Edge* and press "Vector"

"Displacement" button: fills the form with

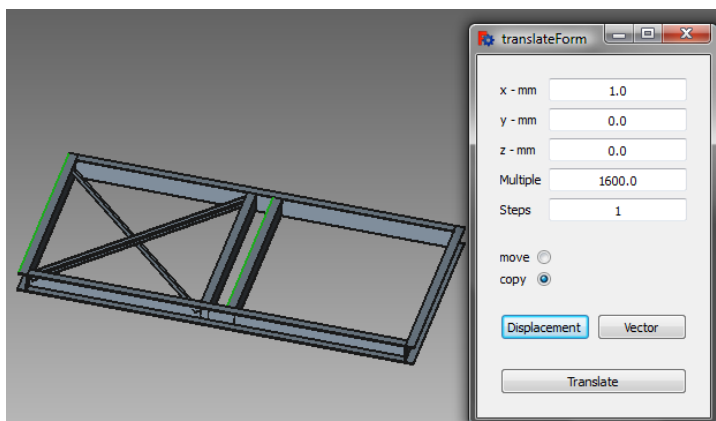
- a) the distance vector between the two *Vertexes*,
- b) the projection vector from the *Vertex* to the plane that include the *Face* or viceversa,
- c) the distance vector between the *CenterOfMass* of the *Edges*.

"Vector" button fills the form with the direction of the selected *Edge*.

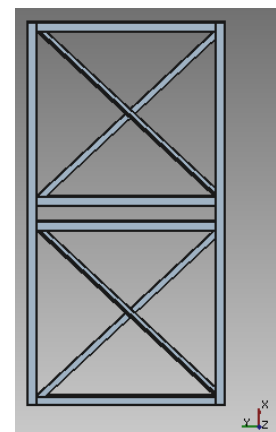
In both cases the x/y/z values will be the coordinate of the direction *normalized* (i.e. with unit length) and the actual distance will be written in the "Multiple" text-box. That is to allow to scale the length of translation before performing actually this action.

For the same reason in the text-box "Steps" it is possible to insert the denominator for which "Multiple" will be divided, in case you want to repeat the action a certain number of times along the length of translation (that is how the steps of the stairs are actually drawn in this example).

So, coming back to the tutorial, all you need to do is select the two edges of beams like in the picture below and press "Displacement" button. Then tag the "copy" radio-button, select the two braces and press "Translate".



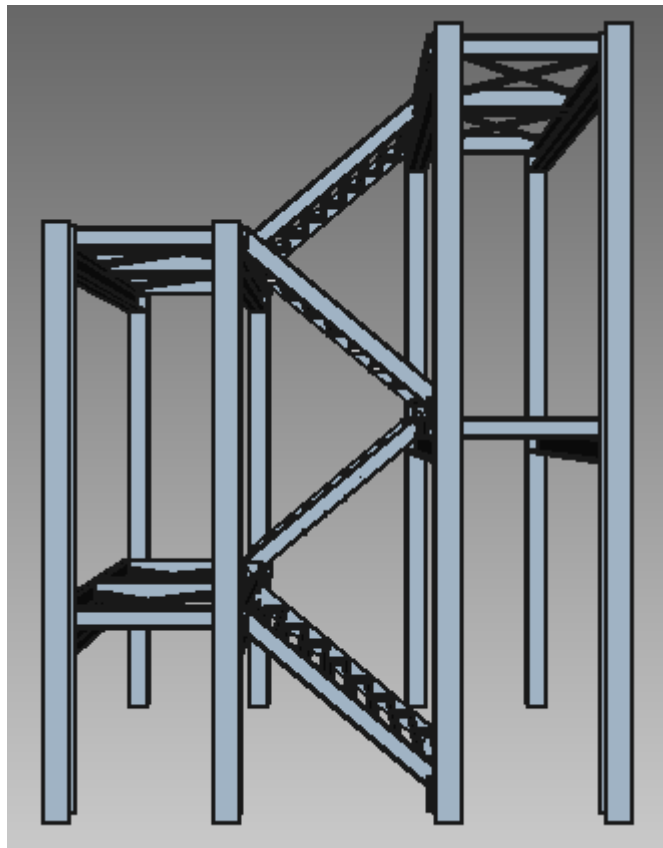
In this way
the braces
are copied:



Now it's easy to understand how to complete the rest of the drawing:

- copy and translate the other floors, ramps and columns using existing geometry to measure the necessary displacement;
- trim or extend the beams to the right length;
- import one part for the steps and complete the ramps using "translateTheBeam" with "Displacement" + "Steps" options.

You can also find the file of this exercise in the \examples subfolder.

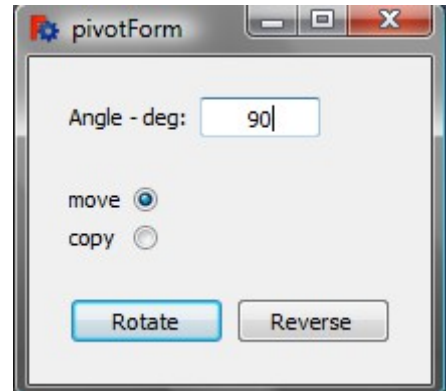


For completeness sake, in the next page there is a short presentation of remaining commands not used in this tutorial.

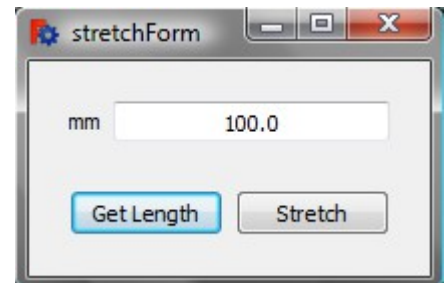
Other commands:



"pivotTheBeam": rotates a beam around one of its edges. It works with a dialog where you can specify the angle of rotation and if you want to move or copy the beam. There is also a "Reverse" button to change the direction of rotation if it's not the desired one.



"stretchTheBeam": change the *Height* of the *Structure* object. The dialog has also one button to get the length from existing geometry in the drawing, either distance between objects or length of a single edge.



"alignEdge": translate one object along the min. distance vector of one of its edges to another edge. Edges don't need to be parallel.



"rotJoinEdge": same as above but also rotate the object in order to make the edges parallel