

On September 26, 2017 at the Cracow University of Technology there was a defense of the diploma thesis by Marta Tłuścik under the title „APPLICATION OF IAGENTFORM PROGRAM IN THE PRACTICE OF PARAMETRIC DESIGN AND STRUCTURAL OPTIMIZATION USING BIM TECHNOLOGY”.

The promoter of the work was Dr Eng. Jacek Magiera.

One of the elements of this work was the modeling of an existing innovative structure.

One of the towers of Absolute Towers complex has been chosen.

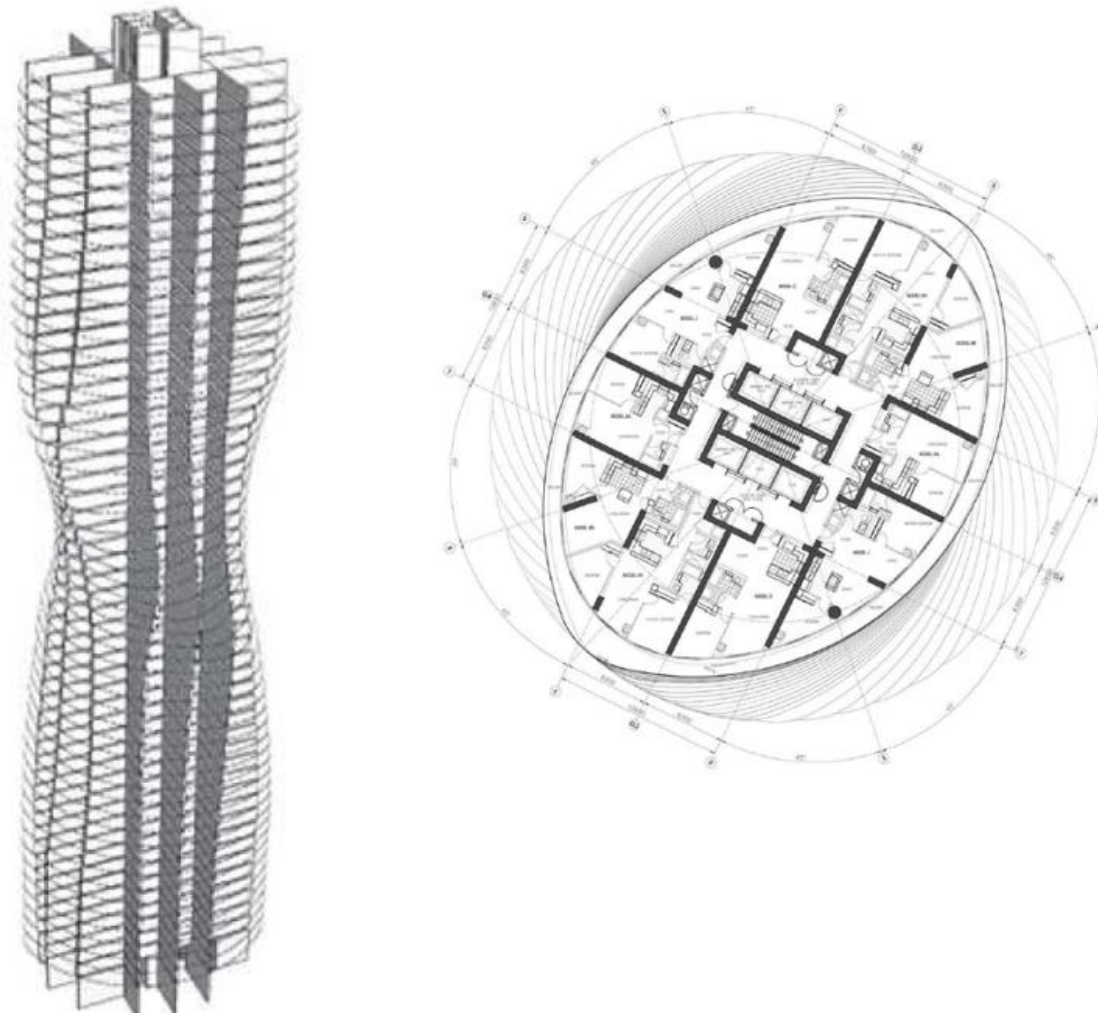
It is a residential complex located in Mississauga, on the suburbs of Toronto, Canada, which is now a showcase for the city. It consists of two towers with winding profiles. Tower A with a height of 170 m, 56 floors and Tower B - lower, 150 m high, which has 50 floors. The buildings were designed by architectural company MAD Architects. The skeleton of the building itself was very difficult and, according to many, unfeasible. Construction of the structure lasted 6 years and was completed in 2012. The following figure shows the towers of the Absolute Towers.



Draw. 1 Absolute Towers
Source: <http://www.i-mad.com/>

Floors are elliptical and rotated in relation to each other with different angles. The first, higher tower begins to turn from the bottom at 1° , increasing in turn angle of rotation. The maximum rotation of the floor relative to the previous one is 8° . Final rotation angle of plates is 209° . The most interesting element of the Absolute Towers are the continuous balconies that surround the floors and twist together with them, forming an integral part of the entire structure.

The IgentForm model was based on a one-story plan, as a part of the available documentation of the project.



Draw 2. Structural scheme of Tower A and plan of one of the stories

Source: <http://www.i-mad.com/>

Modeling of such an object using traditional software would be a very tedious task requiring many weeks of work, and any later modifications of the model could force the model to be created from the beginning.

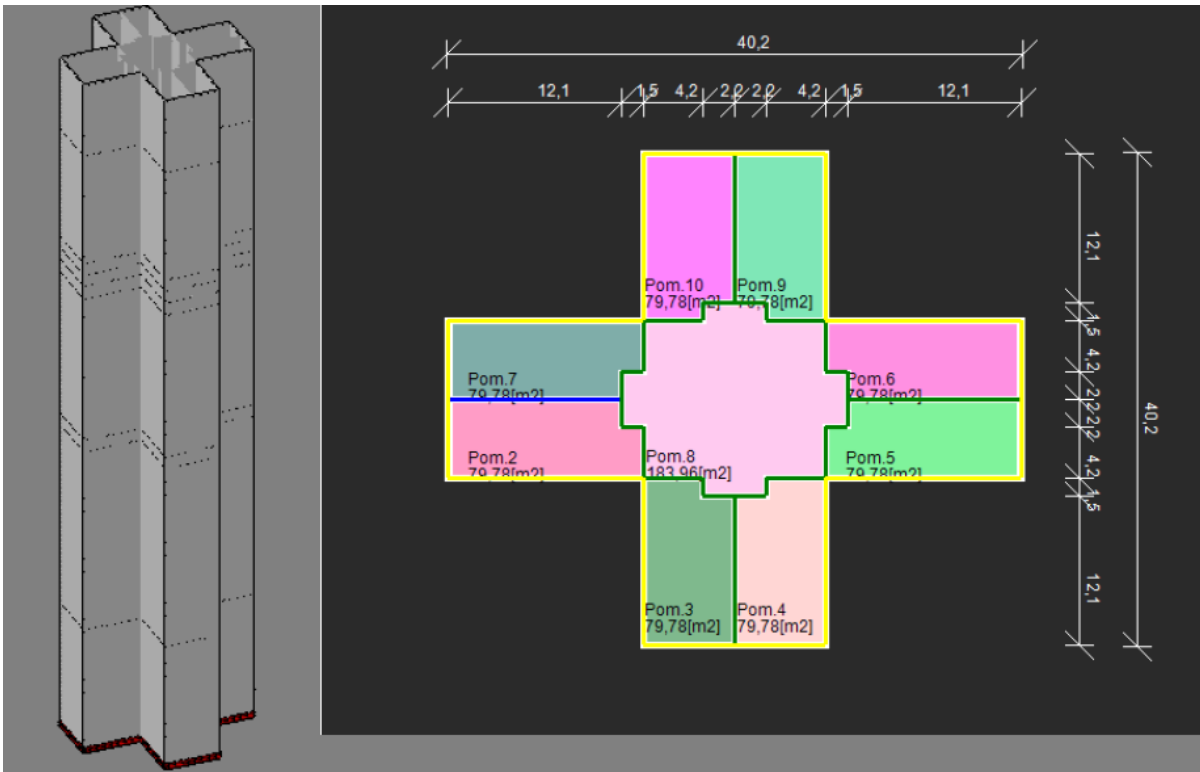
The parametric approach minimizes both the creation time of the model as well as the risk of subsequent modifications.

The IgentForm program began with the creation of an elliptical contour that corresponds to the shape of the building's floors.

The next stage of modeling was the creation of a skyscraper form. Due to the varying angle of rotation of each floor, the model was made up of a combination of nine masses of different heights and angles of rotation, placed on top of each other.

Absolute Tower exterior walls are offset from the edge of the floor to the width of the balconies surrounding the tower. Modeling them in IgentForm required the formation of nine more masses with parameters similar to those generated in the previous step. The only difference was their contour, which had to be smaller than the previous one due to the retraction of the walls deep into the structure.

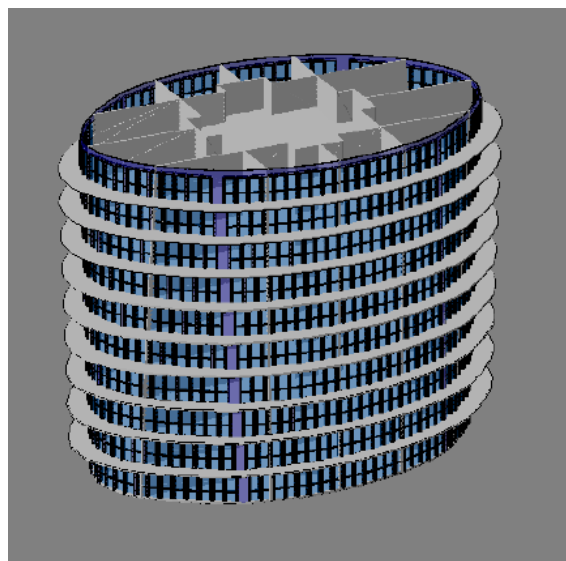
The next stage of the Absolute Tower modeling was the creation of a shaft walls that constitute a very important structural element. Because of the rotating floors, the shaft geometry is very specific because it changes along with each floor. In order to create the shaft wall, a mass was to be built, which despite the rotation of the entire structure by a total of 209° could be used at full height, thanks to the option of masses cutting.



Draw. 3. Shaft contour with dimensions
Source: Marta Thušcik, Diploma thesis

The last mass created for the needs of the model was a lift shaft with rectangular cross-section. For this purpose, a rectangular contour was modeled with two internal walls, securing a staircase. Slabs of floor slabs were cut by a lift shaft mass. Thanks to that, the holes in all slabs were created in a very easy and fast way.

Modeling of window and door openings in IgentForm program is done by assigning an appropriate Elevation to the selected contour lines. In order to define the Elevation, the user can control parameters such as hole type, upper edge of hole, number of holes, coordinates, dimensions, as well as the material of the hole and the frame.



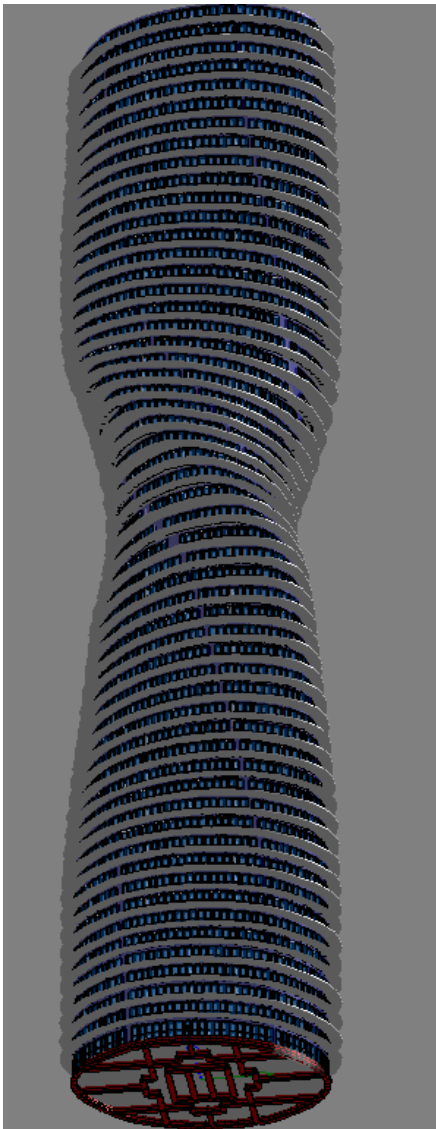
Draw.4. View of lower part of Absolute Tower model with openings
Source: Marta Thušcik, Diploma thesis

The walls of the shaft had to be cut by external walls. For this purpose, new cutting masses have been created, which are copies of external walls bypassing openings and assigned a material of full transparency. The final tower model is shown in the figure below. When exporting to Autodesk Revit and Autodesk Robot Structural Analysis software, a framework without windows is used.

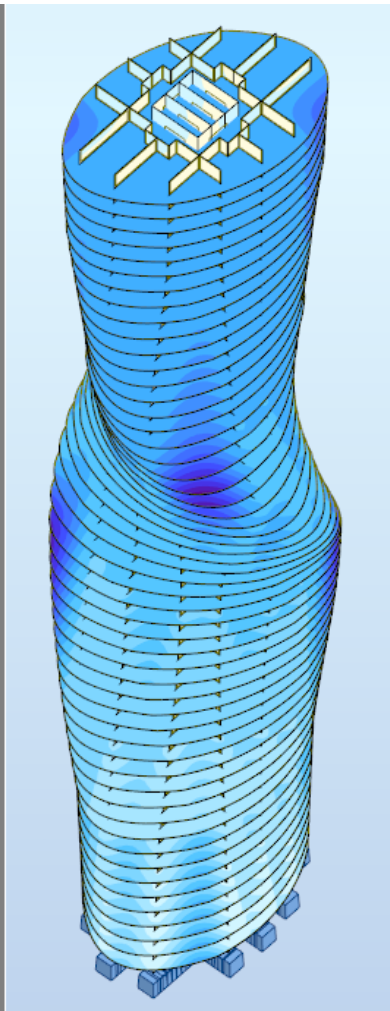
To Autodesk Revit a model in IFC format has been exported.

To Autodesk Robot Structural Analysis program a model in RTD format has been exported.

The model has been calculated with default mesh settings and below the results of displacement under self-weight has been presented. The model export time is less than 10min, and the calculation time is about 13min on the machine with i7-4790 processor.

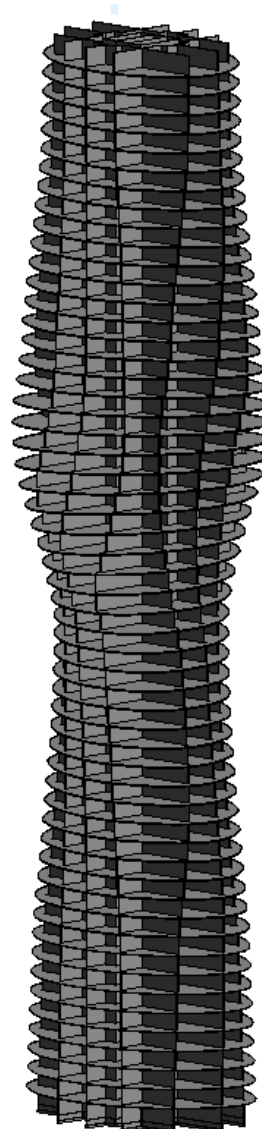


Draw. 5a



Draw. 5b

Source: Marta Thućik, Diploma thesis



Draw.5c

Draw. 5a – Full model in IgentForm program

Draw.5b – Structural framework in Autodesk Robot Structural Analysis

Draw.5c – Structural framework in Autodesk Revit

In Diploma thesis conclusions the strengths of the IgentForm program have been emphasized, namely:

- The ability to create advanced forms without programming knowledge, as it is the case of other solutions like Dynamo or Grasshopper.
- Simple and very intuitive interface
- Smooth creation of large models without time delay
- Rapid modification of the model
- Collaboration with other BIM programs through the implementation of widely supported formats