AUTODESK UNIVERSITY

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The Future of Making Rebar in Revit

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Learning Objectives

- Understand what a connected structural BIM workflow looks like.
- Learn how to take necessary steps to benefit from intelligent BIM data and take advantage of building performance data to automate downstream processes
- Utilize Revit® as a platform for automating the creation of 3D detailed reinforcement models based on regional design codes.
- Automatically get the 3D structural rebar published in A360®

Description

Connected structural workflows are no longer science fiction but a stark reality that is delivering newfound accuracy and performance. In this class, we will show what a connected structural Building Information Modelling (BIM) workflow in Revit software looks like, which will include exploring augmented reality on site. You will see firsthand how intelligent BIM data in a connected workflow can enable common structural elements (such as footings, columns, and beams) to be quickly designed to local codes, and automatically modeled, detailed, and scheduled all within Revit software. We will explore the essential steps that enable you to utilize default or your own custom structural Revit families to automate the creation of designed 3D reinforcement cages in Revit software, while using standard Revit families to configure automated drawings, views, bar schedules, and comprehensive design reports. You will take a virtual trip to site to visualize the reinforcement of your Revit project model using your mobile device without leaving your seat in the class. This session features Revit, Revit Structure, GRAITEC BIM Designers and GRAITEC Advance Design.

Your AU Expert(s)

Joseph Pais is a structural engineer with more than 15 years' experience in the industry. Joseph is Product Line Manager for structural analysis and design products at GRAITEC INNOVATION SAS and also provides dynamic analysis and reinforced concrete consultancy to highly skilled GRAITEC customers. Joseph has also taught dynamic analysis and reinforced concrete design for more than 10 years at the French university, Conservatoire National des Arts et Métiers (CNAM).

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Carl Spalding started his career as a structural draughtsman for a prominent engineering company in Southern Africa. Carl quickly worked his way up to DO Manager, and then Director of his own design company, developing practical skills born of real-world experience and a refined passion of adopting technology to eliminate repetitive tasks. Since moving to the UK in 2000, Carl has established a successful career within the Autodesk channel, working with, and supporting both SME and major UK firms in the AEC and Infrastructure industry and gaining a wealth of industry knowledge and understanding of Autodesk's extensive portfolio in the process. This knowledge, combined with his strong structural background and his passion for innovation and ambition to succeed, has resulted in quick succession through GRAITEC's ranks and is now GRAITEC Product Strategy Director where he is using his skills to influence the future of construction technology to come.

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Introduction

On every type of project, the adoption of a transparent and easy-to-apply Building Information Modeling (BIM) workflow is the key to success for all companies who wish to be effective and reduce risk of errors on huge projects. BIM is fast becoming the industry de facto. In an age where BIM is driving benefit-proven change across the industry, it is still surprising that the workflow between structural engineers and designers is mostly stop-start, with little or no connected design workflow. At best, it seems there is an initial transfer of model geometry, and in some cases material property data, from one party (or product) to another. Which appears to be used to get the project started and, more often than not, a one-off one-way process, ill repeated thereafter. It seems there is still a tendency to favor the communication of design changes and the sharing project materials using digital 2D or printed documentation – arguably preferred to avert liability or avoid jeopardizing the integrity of the digital model.

Whatever the reason, the rapid advancements in technology, combined with multiple open BIM Formats, should see engineers and designers readily embracing connected workflows. Sharing Project models throughout the engineering design phase should be a regular occurrence, and heavily relied on as would be expected with any BIM workflow. Perhaps this is somewhat of an unreasonable statement given that the evolution in technology and open BIM formats is happening so quickly that it is simply difficult to keep pace.

We all agree that Revit Structure® is an effective and productive answer to this need for BIM data management and communication, but it also raises a lot of questions: what kind of information is useful? For whom? Who is using Revit®?

As we said in the description of this class, design-driven modeling is a common occurrence in the engineering world, but seldom is this process adopted or taken advantage of downstream in Revit® software for producing detailed rebar constructible models—which is surprising considering the age of Building Information Modeling (BIM). If we focus in on the reinforced concrete rebar detailing, we can see a huge gap to be filled between existing 2D processes and the 3D workflow management. The industry is desperately in need of a technical solution which can fit with different workflows for communication and data exchanges, and bridge the gap between the engineer and the draftsman. Who starts working on a project first? Who is doing the member design? It could be the engineer, the draftsman, both, or vary depending on different applications or project types. Regardless of which way you work, there always seems to be a gap resulting in the failure to successfully transfer, retrieve and reuse analytical data throughout the BIM project workflow.

Currently, design and production of reinforcement drawings is shared between the engineer and the draftsman and goes through several iterations. The space in-between is not well defined and can move depending on the companies involved, the project and the country. In the RC field, the creation of these drawings is incredibly time consuming, even using existing tools: The engineer runs a global analysis and designs each element, producing a design intent drawing or sometimes a more detailed one.

The draftsman takes over the information from the engineer and produces the accurate reinforcement drawings including all annotations. In some cases, depending on the project but also dependent on technical knowledge and experience, the draftsman can define all the constructive bars which are also dependent on country codes (Eurocodes, ACI codes, CSA codes, etc.). There may be several iterations between them in order to manage the full engineering cycle of a real project.

At this point, we all agree that most part of the bars are produced and placed considering design requirements, meaning that the main way to automate the generation of a 3D rebar cage is to embed the design codes within the reinforcement production application.

In order to improve in a significant way the production of the 3D rebar cages on a building, we should be able to apply the following pitch: the “80%-20%” rule.

What does mean the “80%-20%” rule!

Let’s try to see how much different ways we can identify to produce 3D rebar cages on a building:

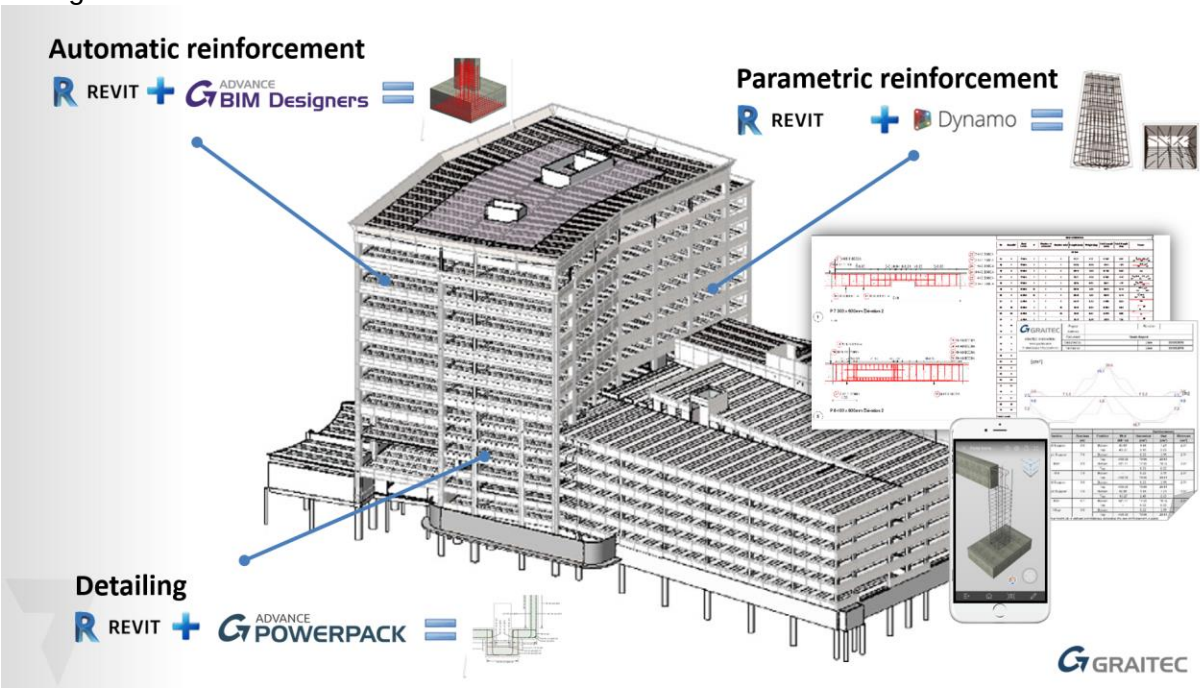


FIGURE 1: 3D REBAR PRODUCTION

1. We can, or let’s say we should, automate the design and rebar on standard elements without investing time too much on this part of the engineering job: This can be done using the native Revit® tools + the GRAITEC BIM Designers tools.
2. We can continue also to annotate the elements, place dimensions, create the drawing using also the out of box Revit® functionalities completed by add-ons as the PowerPack for Revit® from GRAITEC (http://www.graitec.com/en/powerpack-for-revit).
3. The user can also apply advanced technologies provided by Autodesk®, such as Dynamo, in order to reinforce complex 3D geometries.

In this class handout, we will detail the two first points.

Now, if we come back to the definition of the “80%-20%” rule, the production of the 3D rebar cages and the associated documentation can be automated on 80% of the structural elements allowing the engineering team to concentrate on the 20% remaining part:

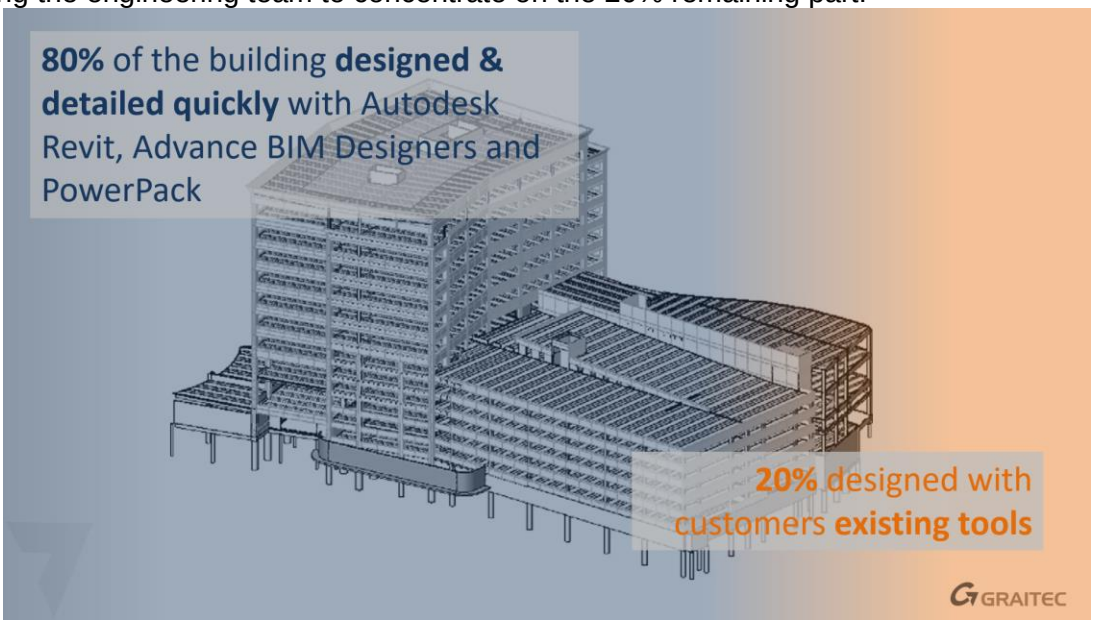
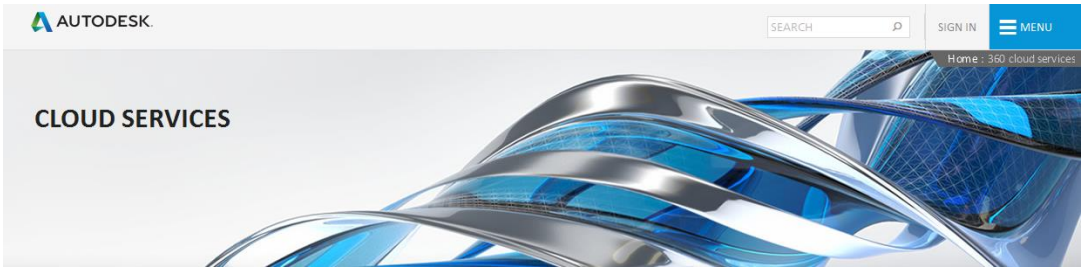


FIGURE 2: “80%-20% RULE”

Another complexity is the conception of such a technology in a time full of uncertainties. Who is able to say how the industry will adopt BIM? How long it will take?

That is why we think it is important to analyze how an adaptive technology can help users switch to a full BIM workflow. There is no doubt that today most engineers and draftsmen still use AutoCAD, eventually enriched with an add-on module, to directly produce 2D reinforcement drawings without handling a 3D model. Bearing this in mind, it is clear that Revit® comes with inventive technology which is changing this way of working. Having a 3D reinforcement model introduce new innovative opportunities to automate the reinforcement drawings starting with this 3D reinforcement model created and handled in Revit Structure®.

In this class, we will focus on the process (step by step) to generate a design-driven 3D reinforcement cage in Revit®, describing what kind of information we need to embed in the Revit® model and discovering that we can, using the BIM Designers modules from GRAITEC, automatically generate the 3D reinforcement cages based on the ’design and loads’ information now held in the Revit® software analytical model. To reach this objective, we will see that we can apply various connected BIM workflows with the same objective at the end: consolidate all this engineering data within Revit® and benefit from the all Autodesk® ecosystem to share and visualize your all project and documentation in the cloud, within the A360 platform!



In the next pages of this class handout, we will discover the all BIM workflow, starting from the Revit® model, integrating there a FEM results package, automating the 3D rebar production and documentation, everything connected to the A360® platform:

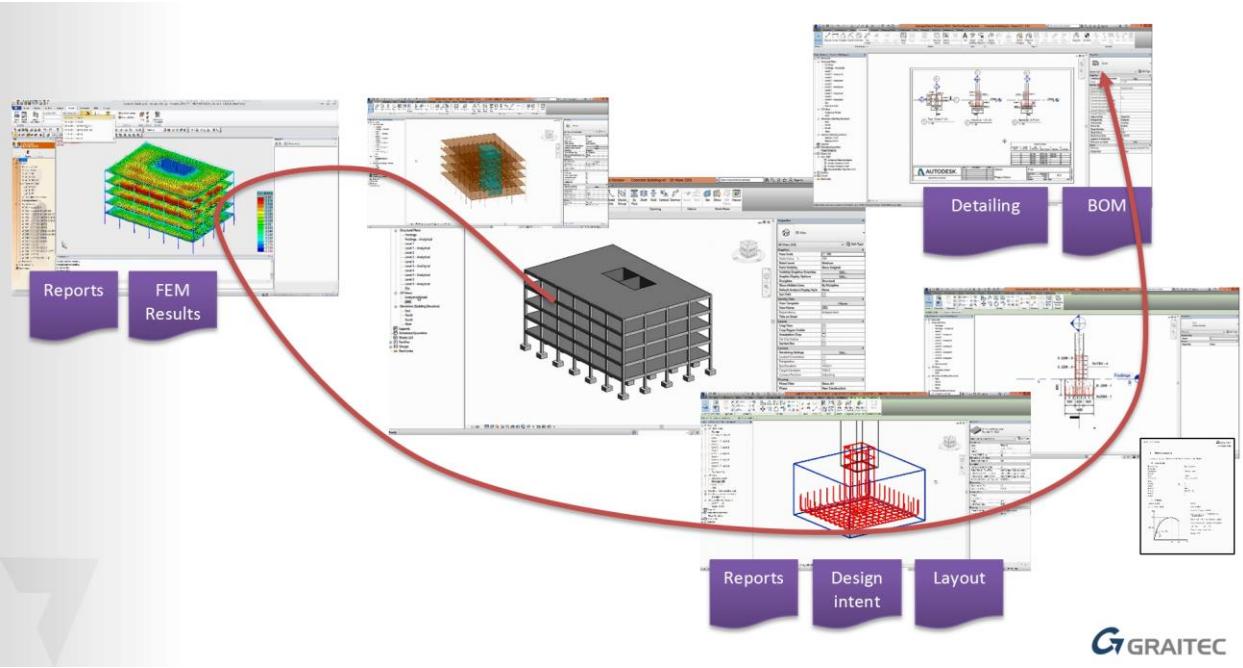


FIGURE 3: GLOBAL WORKFLOW

Connect your FEM software with Revit®

The 1st of the BIM Connected workflow we mentioned here above is to complete the BIM model in Revit® with the analytical information and results: for that, we can identify two different workflows each reaching this same objective.

- ***Workflow A:*** The project starts in Revit® with the draftsman creating both the 3D geometry and the base Revit® analytical model. At this stage, he exports the 3D model to the engineer for optimization and FEM calculation of his input. The engineer then sends the model back with updates to Revit®, from which the draftsman can create the drawings. We can also consider an alternative to this workflow, which is that the engineer starts to fine-tune the analytical model within Revit® before exporting it to his analysis tool. This alternative makes sense because we will see that Revit® propose some dedicated tools to handling the analysis model and define engineering assumptions:

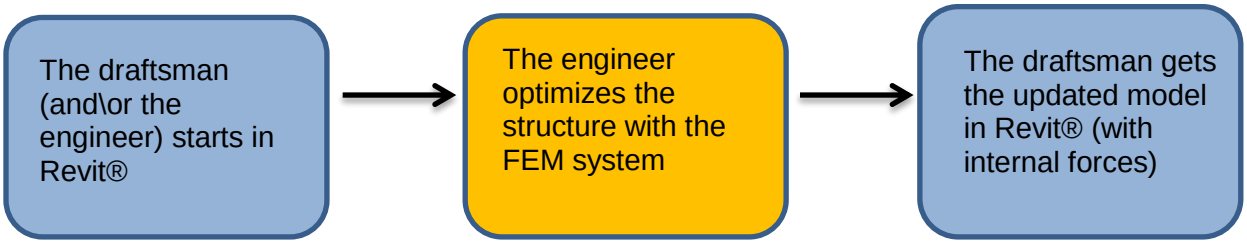


FIGURE 4: WORKFLOW A

- ***Workflow B:*** The project starts with the engineer working in the 3D FEM system where he creates a 3D analytical model, runs FEM analysis and receives results on the efforts of the elements. At this stage, he can export the model to Revit® where the draftsman can continue the modelling in Revit® and can exchange models with the engineer for additional member design.

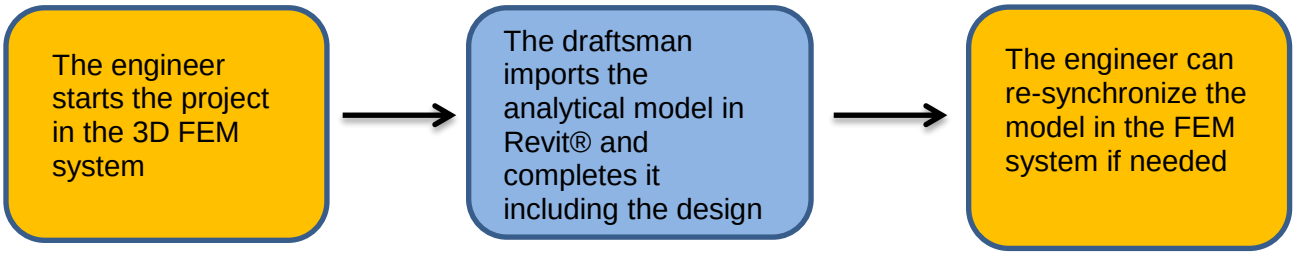


FIGURE 5: WORKFLOW B

These two workflows are very close and reach the same final objective. At the end of the process, we handle a Revit® model which has all the requested BIM information, meaning the 3D geometrical model, the analytical model defined and checked by the engineer and FEM results stored in the Revit® Results Packages:

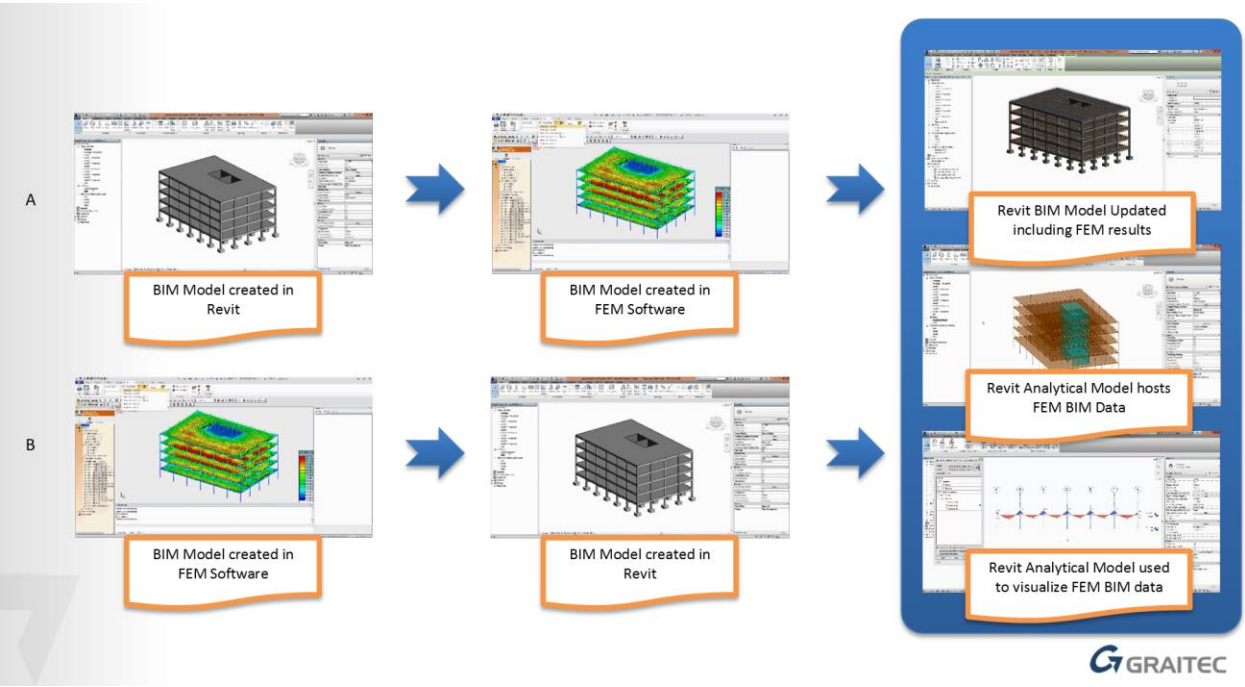


FIGURE 6: GLOBAL WORKFLOW

The Revit® model completed with this information, is the starting point to carrying out the previous workflow up to the reinforcement drawing creation. Independent from the applied workflow, the objective is the same - to automate the 3D rebar creation and corresponding reinforcement drawings, make any changes and update all the documents in one click!

Get real benefits from the power of the BIM with GRAITEC BIM Designers and Autodesk Revit Structure®!

The analytical model in Revit®

The objective of this class handout is not to teach you how to handle the analytical model in Revit® - you can find plenty of information online or technical documentation produced by Autodesk® to help you with this. But let's face the reality: how many Engineers handle the analytical model in Revit®? Do they see any interest on doing so?

I will try to help you answer to those question. For that, let me introduce the main concepts about Revit® analytical models before going into detail on how to connect FEM software to Revit®.

If we start with the analytical model in Revit®, it is clear that we are applying ***workflow A*** we defined earlier, meaning the draftsman and\or the engineer start to work on the 3D BIM model within Revit®, defining-managing together the descriptive model and the analytical one. As you probably know, the analytical model is automatically handled in Revit Structure® and not in Revit Architecture®, even if Autodesk know speaks only Revit® and not anymore about Structure or Architecture! That's a very important statement. We cannot apply such a Design-driven workflow using Revit Architecture®. I think it is important to spend a few minutes to explain why, especially for those who are not entirely convinced by this statement. Autodesk® has implemented in Revit®, dedicated functionalities to link both a Revit Architecture® and a Revit Structure® model, showing that these two models are very different, comparing the geometry, definition of the elements and the objective of the model. Just think - would you let an Architect do the job of an Engineer in your company (and vice-versa)?

In Revit®, tools to convert and link the two models are available with the command '*Copy Monitor'* from the '*Collaborate'* panel:

- You can define the synchronization parameters to link the two different models.
- As we can see in the picture below, we get the complete model in Revit Architecture® and only the structural part in Revit Structure®.
- Then from this synchronized structural model, we can also handle the analytical model.

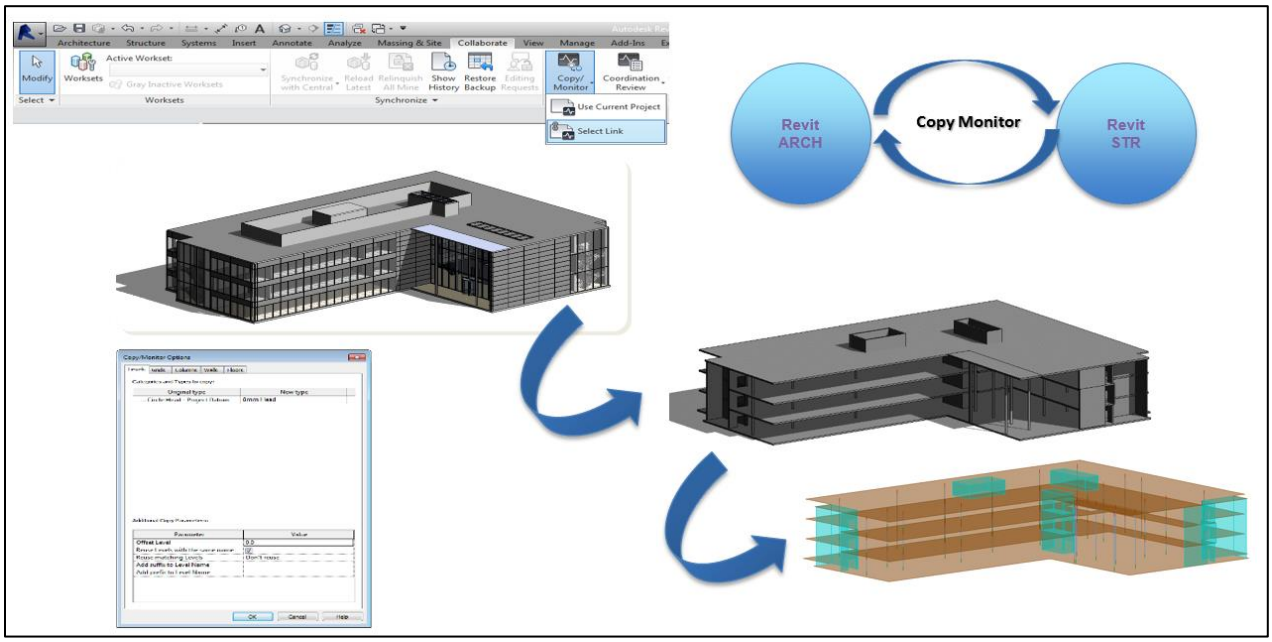


FIGURE 7: SYNCHRONIZATION BETWEEN REVIT ARCHITECTURE® AND REVIT STRUCTURE®

The analytical model is handled in real time in Revit® in parallel with the descriptive model. What I am calling the descriptive model, is the usual 3D BIM model in Revit®. This can be a hugely time-saving for the engineer but it does not mean that this proposed analytical model is perfect. Of course, the engineer has to do his job and take the right decisions to adjust this model. What is new with the BIM workflow is that he can do it within Revit Structure®. Revit Structure® is not only the tool for the draftsman but can also be an effective tool for the engineer.

Each structural element is composed of two entities; the real geometric entity and the analytical one. The geometrical entity is the physical object, defined with families and types and displayed with the real representation. The analytical definition comes with additional properties and a specific representation (axe or surface):

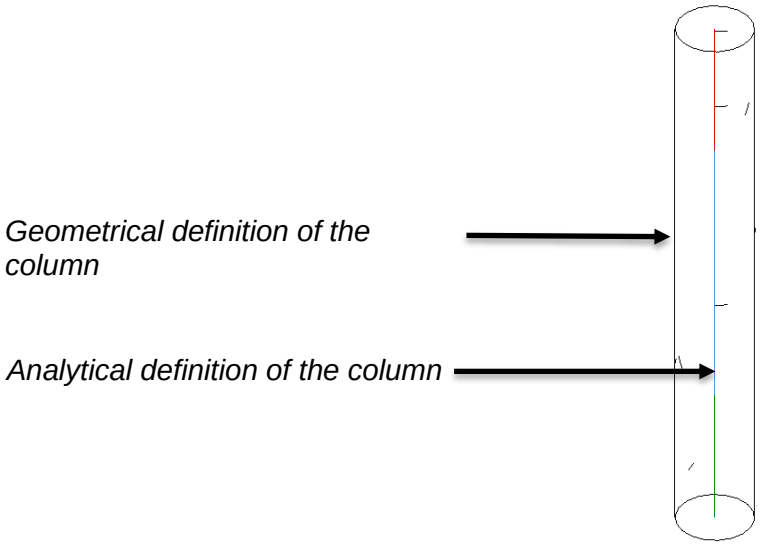
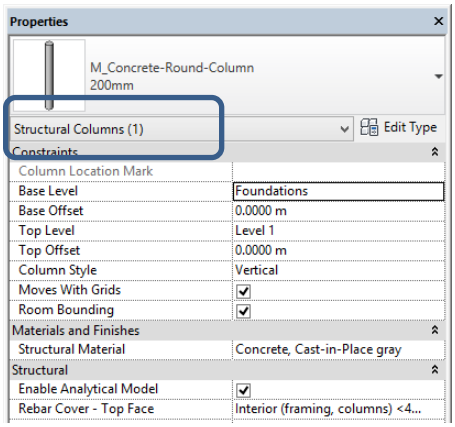
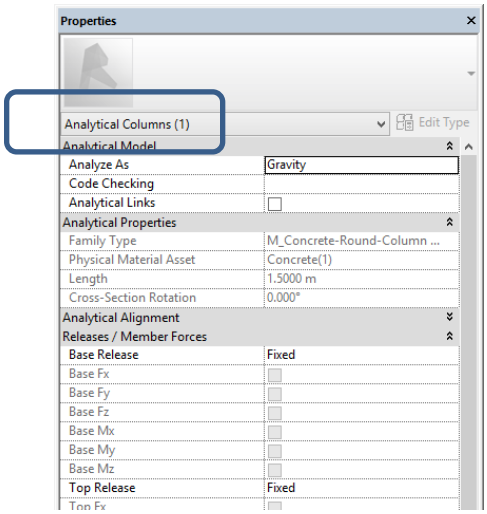


FIGURE 8: GEOMETRICAL AND ANALYTICAL REPRESENTATION OF A COLUMN

You can access the geometrical and the analytical parameters directly from the property list of an element:





Of course, you can display the all analytical model, either superposed with the 3D descriptive model, or on a separated view. These settings can be managed from the visibility dialog in Revit® (vv):

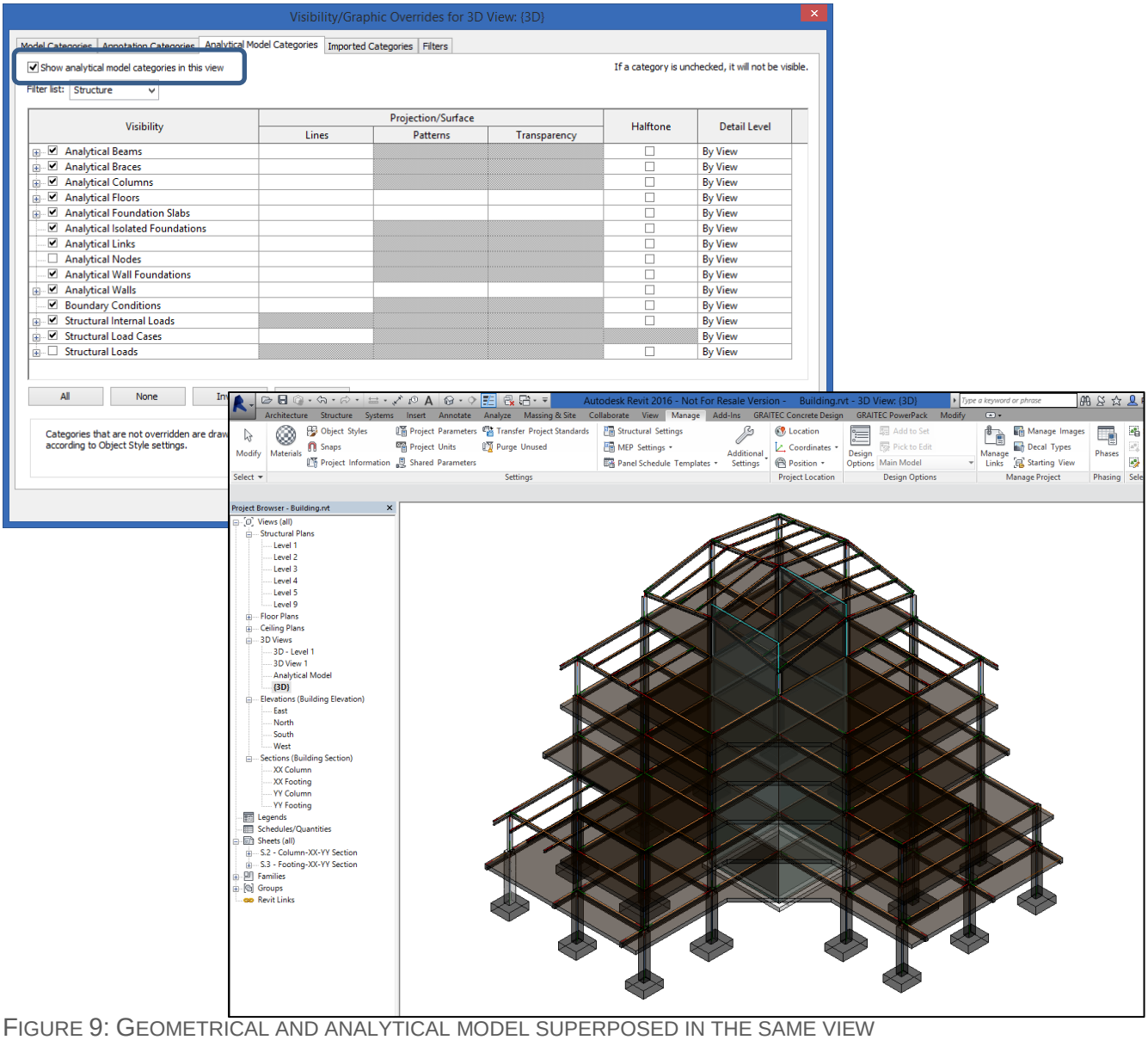


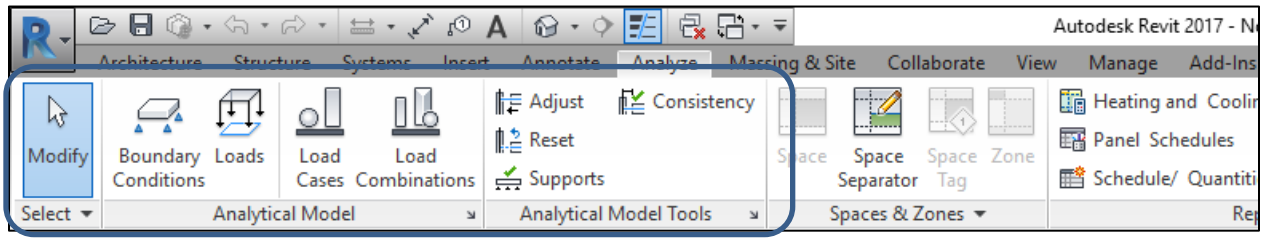
FIGURE 9: GEOMETRICAL AND ANALYTICAL MODEL SUPERPOSED IN THE SAME VIEW

Now, if we deep dive into the analytical model, there are some important assumptions to be aware of:

- Which elements are considered in the analytical model?
- The parameters of the analytical model.
- How to manage the boundary conditions, on linear elements and on supports.
- Structural properties of the materials.
- Load and combination definitions.
- The functionalities to fine-tune the analytical model.
- The analytical model consistency verification.

It is important to define all these parameters in order to link Revit® with an FEM system. Obviously, that's the job of the engineer and that's why I mentioned before that Revit Structure® is also a tool dedicated to both the engineers and the draftsmen.

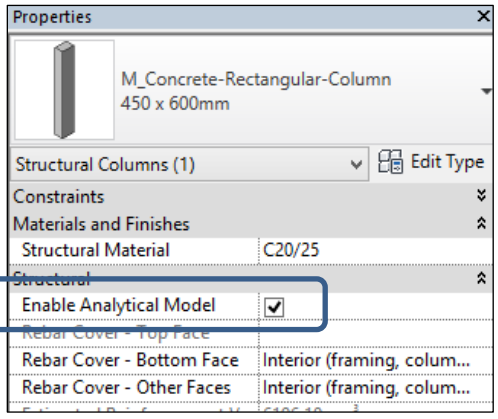
The majority of the functions handling the analytical model are available from the 'Analyze' ribbon:



Enable\Disable analytical behavior

The first decision you have to take when dealing with the analytical model in Revit®, is which elements should be included in the analytical model. Do you want to consider all the openings? Do you want to consider the roof? Which are the structural elements and which are the secondary ones?

These decisions cannot be done automatically and you will need to define them by simply activating or deactivating the 'Analytical Model' option in the property list of each Revit® object:



Analytical model parameters

As we saw before, as the user defines the descriptive model, Revit® automatically creates an analytical model and keep both models consistent. Revit® has some automatic relation settings (between the two models) that should reflect how the user intends to manage the relationship between the geometrical model and its analytical representation. These automatic relation settings are predefined rules that can be changed in the '*Structural Settings'* dialog, under the 'Analytical Model Settings' tab:

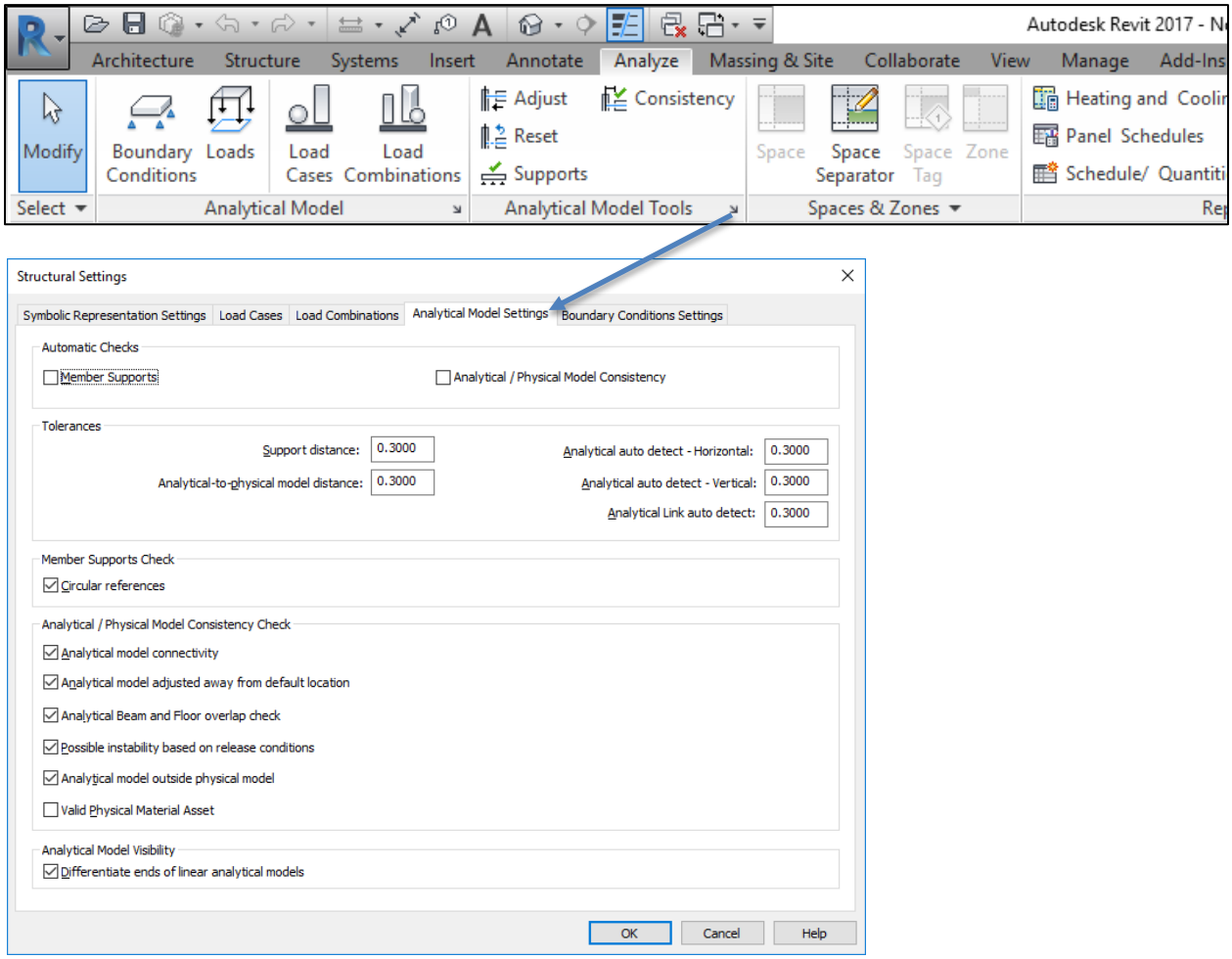


FIGURE 10: ANALYTICAL MODEL PARAMETERS IN REVIT®

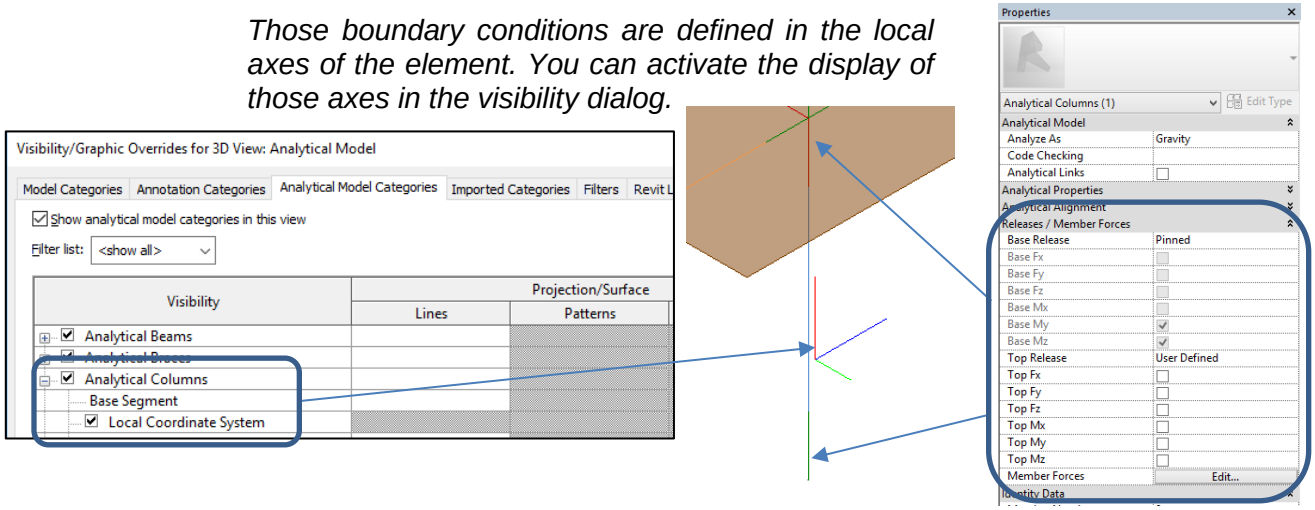
The analytical simplification is subjective and you, as an engineer, may want to define the analytical model in a way that suits your individual expectations and requirements. Even if you can manually adjust the analytical model (see further in this handout), it is important that you review and adjust the default automatic relation settings!

Define the boundary conditions

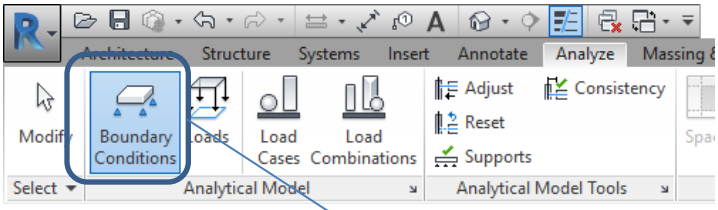
When speaking about boundary conditions, we can make the distinctions between the linear elements and the supports:

- For the linear elements, there are two ways to define the boundary conditions at the extremities of the object:
  - Either directly in the property list, in the analytical set of properties:

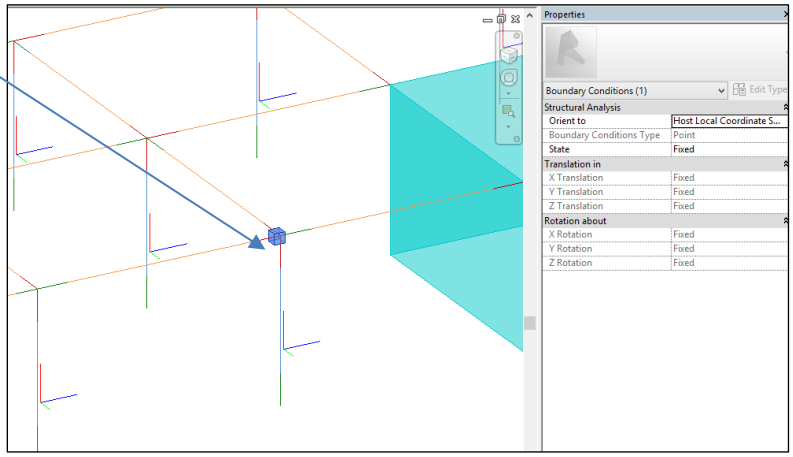
Those boundary conditions are defined in the local axes of the element. You can activate the display of those axes in the visibility dialog.



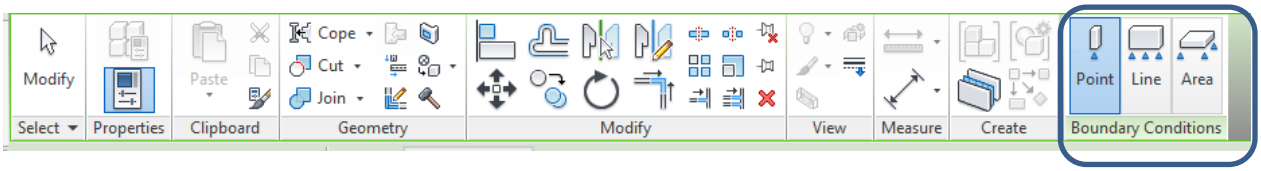
  - Either applying the command ‘Boundary conditions’ from the ‘Analyze’ panel:



Using this functionality, you will be prompted to pick the end of an analytical Beam, Brace or Column and define (in the property list) the boundary conditions in the global axes.



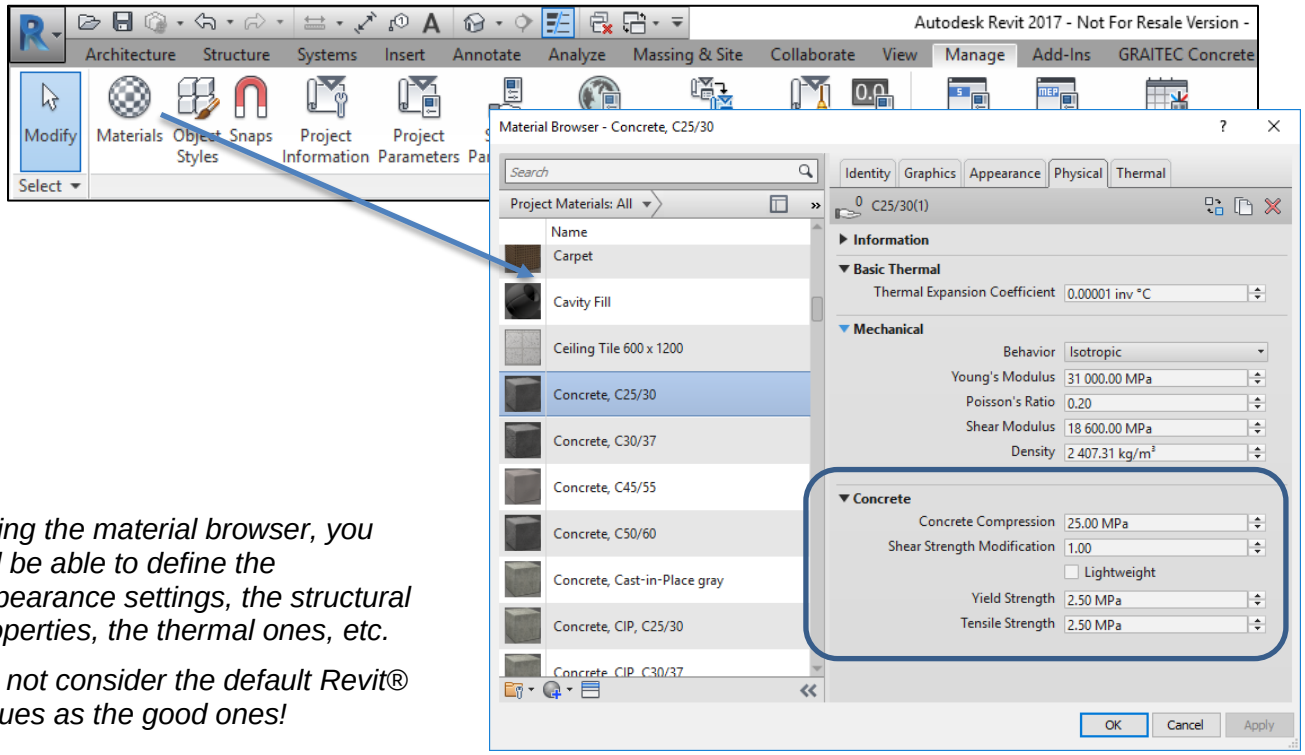
- For the footings, you also have two ways to define the support boundary conditions:
  - If you have defined structural foundations in the descriptive Revit® model, these elements will be transferred (either to RSA or Advance Design) as fully fixed supports. In this case, you may need to change the support releases directly in your FEM analysis software and eventually synchronize back the changes in Revit® (that's possible using the GRAITEC Advance Design FEM software).
  - To be more accurate within the analytical model in Revit®, you can create an analytical support using the same 'Boundary conditions' command we saw just before. Please notice that when activating this command, you can choose between a punctual, linear or planar boundary condition:



Structural properties of the materials

When creating the Revit® model, bearing in mind that you will link to an FEM system, it is important to review the mechanical properties of the materials. As an advanced user, do not consider the default material database in Revit®, ready to be used. Do not forget that you are building within Revit Structure®, a real 3D BIM model! So you cannot define the materials just to have the right graphical representation, you must also define all the mechanical properties that will be used and applied by the different project stakeholders.

You can access the material browser from the "Manage" ribbon:

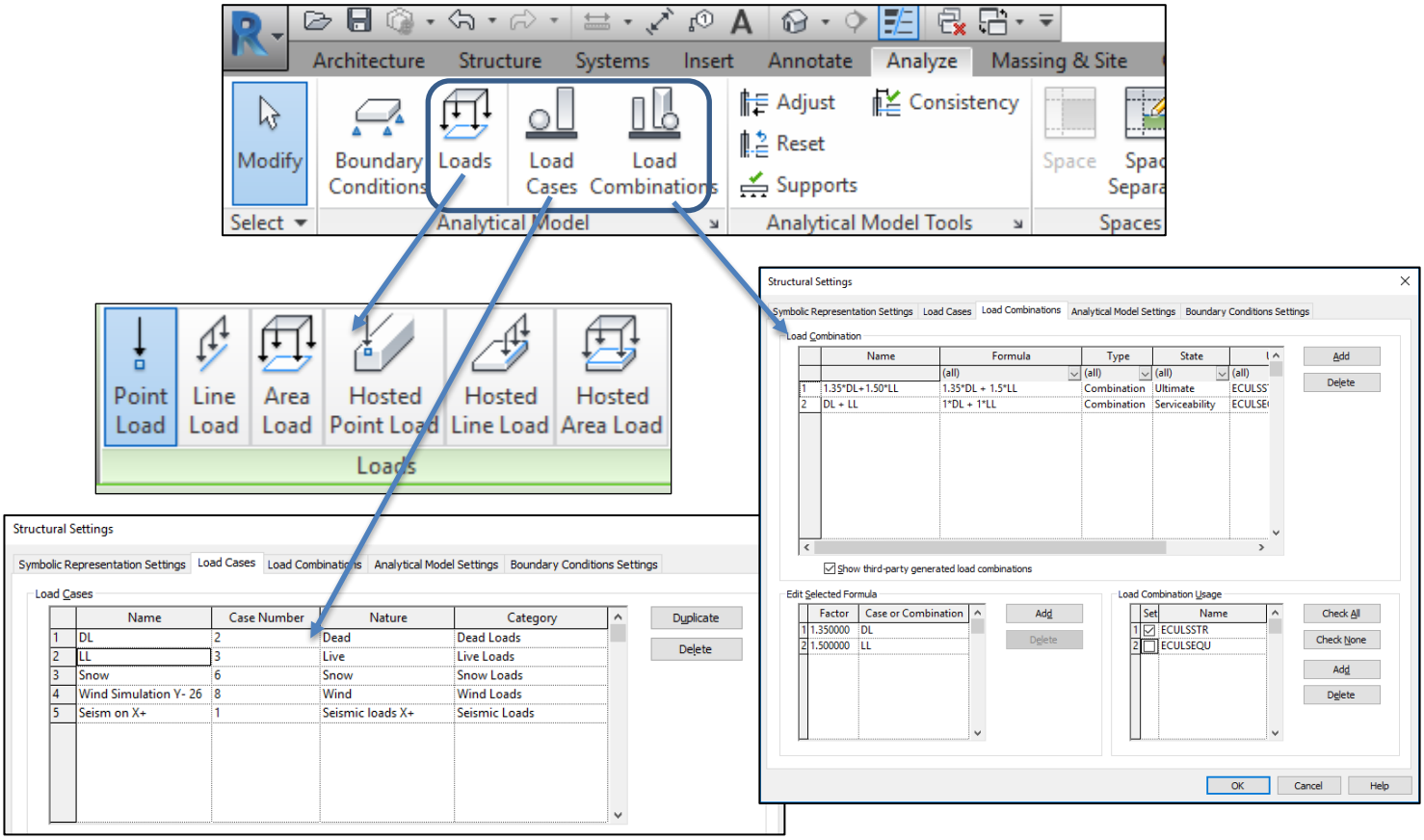


Using the material browser, you will be able to define the appearance settings, the structural properties, the thermal ones, etc.

Do not consider the default Revit® values as the good ones!

Loads and combinations definition

It is possible within Revit Structure® to define the loads cases, the loads and the combinations. These three functionalities are available on the '*Analyze'* ribbon:

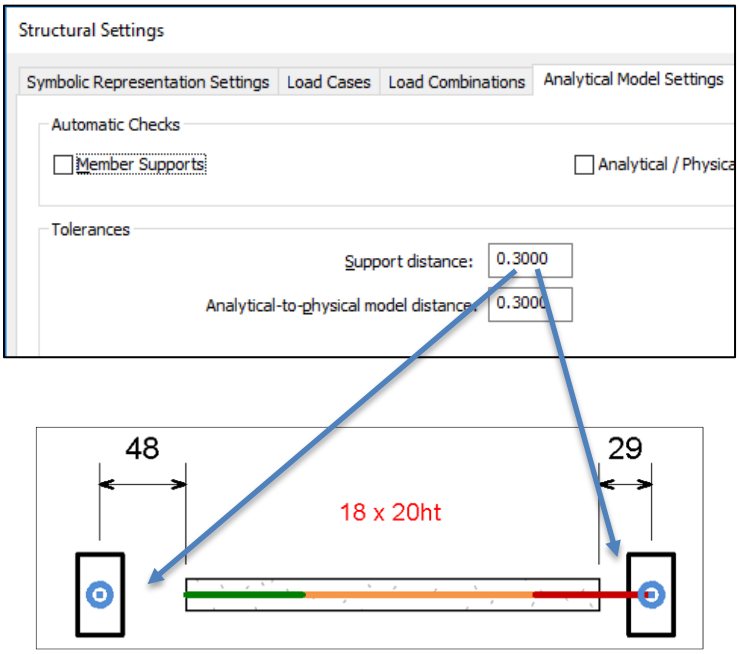


You can create different types of load cases (dead loads, live loads, wind loads, etc.) but not define the factoring coefficient for the combinations. This set of properties have to be defined in the FEM system. Regarding the loads, you can create 'free' loads (punctual, linear or planar loads) anywhere on the model or create loads hosted by structural elements.

Whilst it makes sense to create the loads cases and the loads in Revit® with a view to linking the model to an FEM system, I strongly advise you not to spend time creating the combinations within Revit®. Effectively, there is no possibility to automatically generate a set of combinations in Revit® according to a specified design code. Having this limitation in mind, it will take you a long time to create them manually (you have to define one for each combination, the name, the type, the state, etc.) with a high risk of errors due to the manual input. It will be much more effective to generate them automatically in the FEM system and update afterwards the Revit® model.

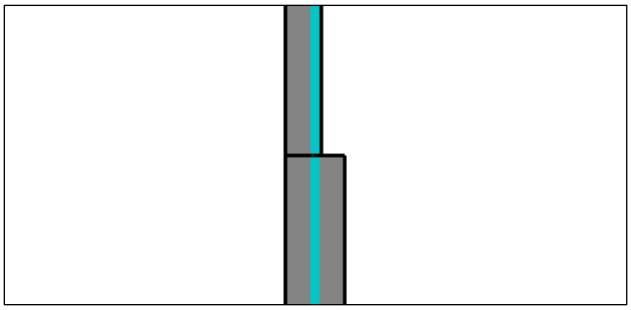
Analytical model adjustment tools

Playing with the tolerances defined in the analytical model preferences, Revit® is able to automatically adjust the analytical in some situations. For example, on the following beam, the right extremity of the analytical definition of the beam will be automatically extended to the column because the distance (29 cm) is smaller than the support distance tolerance value (30cm):

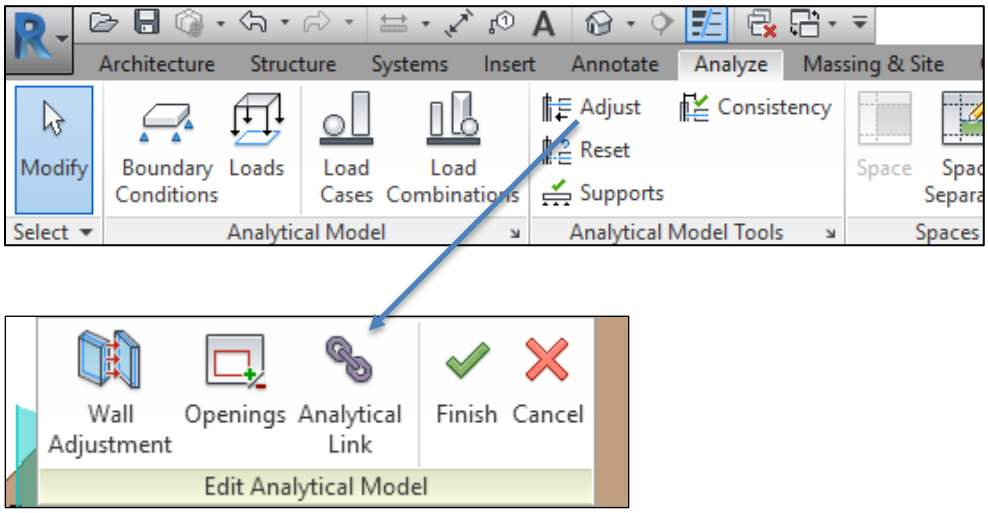


You can notice that the left extremity of the analytical beam is not extended because bigger than the defined tolerance!

This tolerance mechanism works also for walls as shown in the top view here below:



Revit Structure® also includes the possibility to enable direct manipulation on the analytical model. The corresponding tools are available from the 'Analyze' ribbon under the command 'Adjust' which displays a dedicated toolbar:

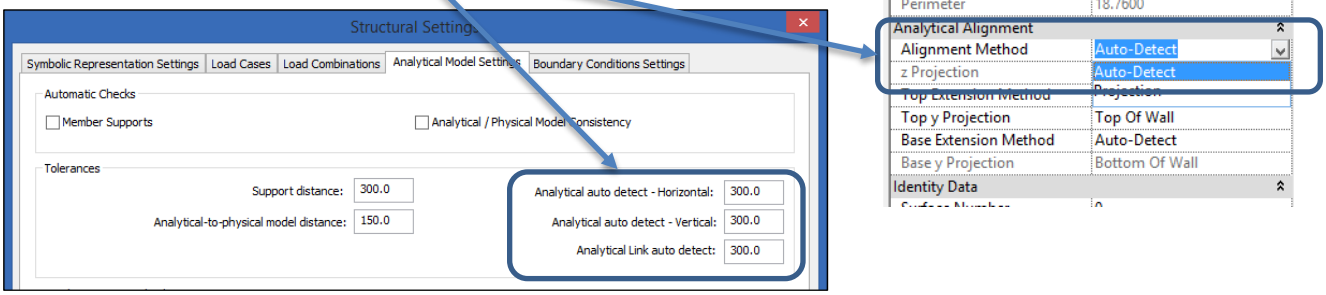


Among the different possibilities, we can mention the following ones:

- Define the analytical alignment: there are different options in Revit® to manage the alignment of the axes (for linear elements) or the reference planes (for planar elements). Those different possibilities are available from the property list of each structural element:

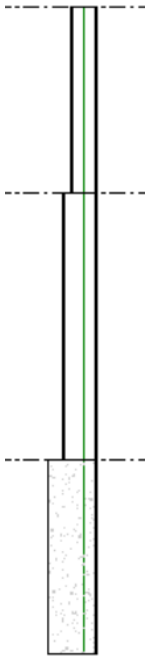
If you select "Auto-Detec", Revit will automatically connect the analytical axes and planes, depending on the tolerance define in the structural settings dialog.

If you select "Projection", you have the possibility to define the analytical axe or the analytical plane projected on the center of the element, the exterior face, the bottom face…

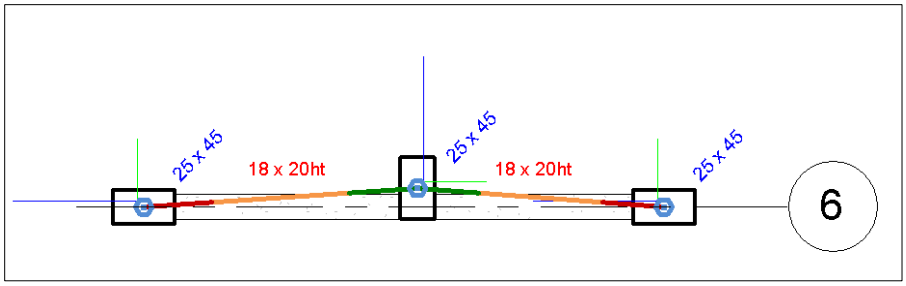


Having practiced for hundreds of hours with the Revit® analytical model, I must admit that the automatic alignment works quite well. When doing a project, I always keep the default *'Auto-detect'* setting and just later adjust the few specific cases as needed.

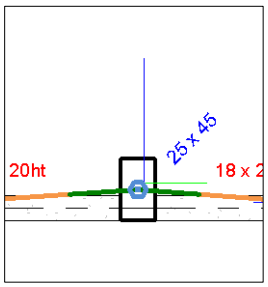
For example, if you create two walls with different thicknesses, in different levels, you get the following analytical planes alignment which is quite good:



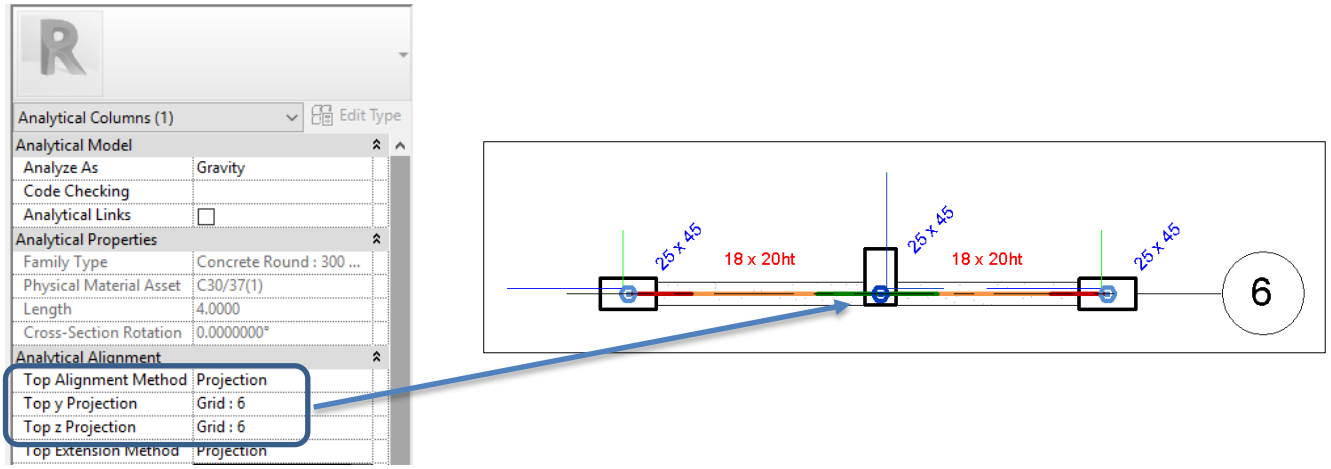
Another real example I encountered is the following (top view with 3 columns and 2 beams):



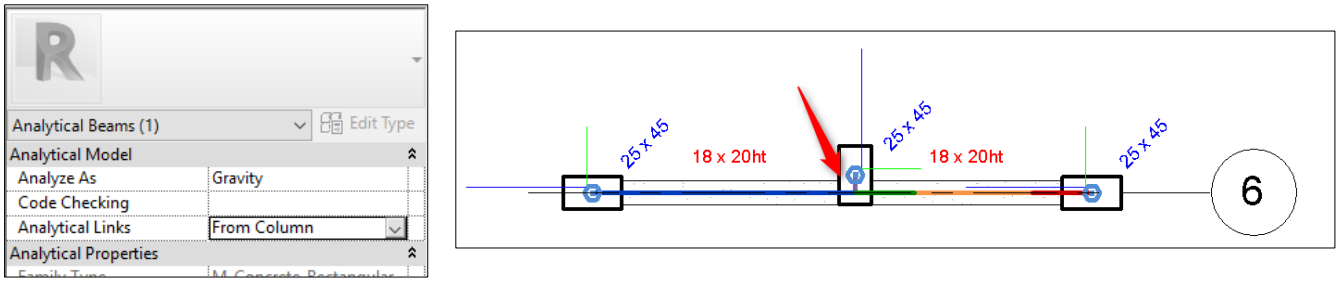
Because of the different orientation of the columns, we can see that the analytical definition of the beams is not aligned with the descriptive model. Revit® is keeping the connection between the two beams and the central column and then stretch the analytical beam.



To manage this situation, I decided to impose a manual projection of a predefined axe (the axe 6 from the picture here after):

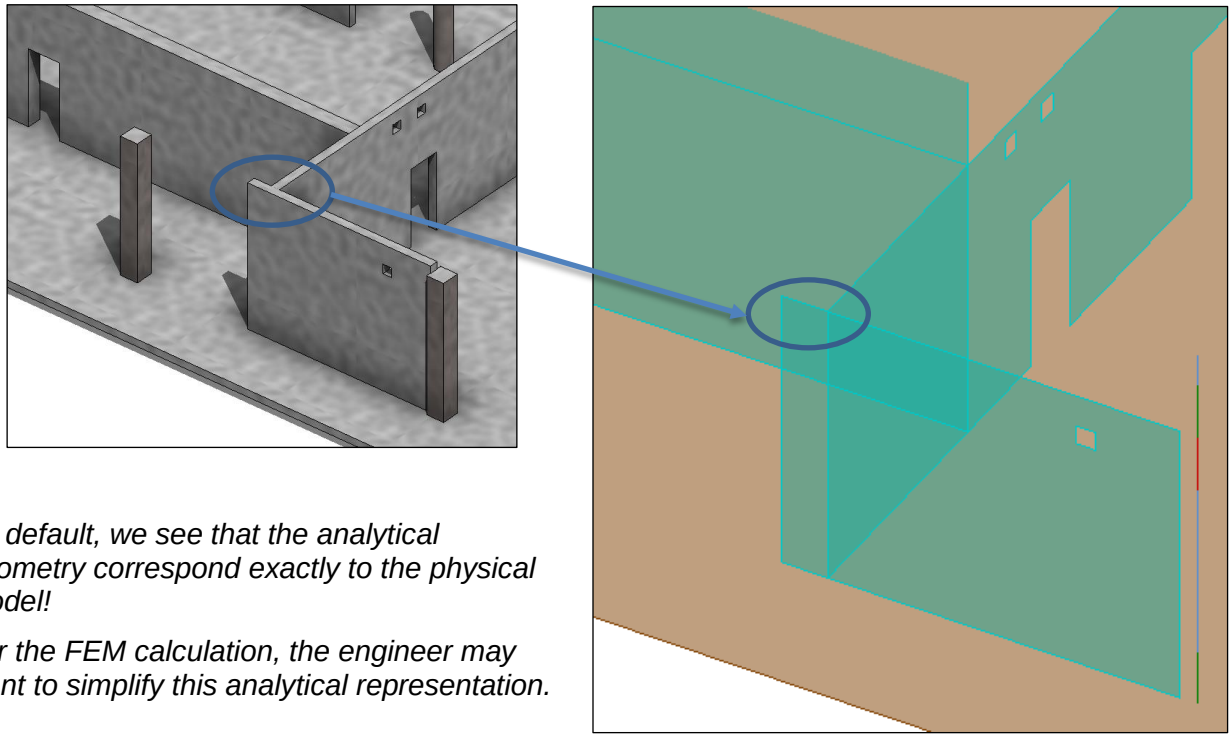


I could have also decided to apply an analytical link (see here after) to get the following analytical model:



- Manually modify the analytical definition of a linear element - when activating the command 'Adjust', you will notice that the nodes appear on screen. Just pick one and move it with the mouse!

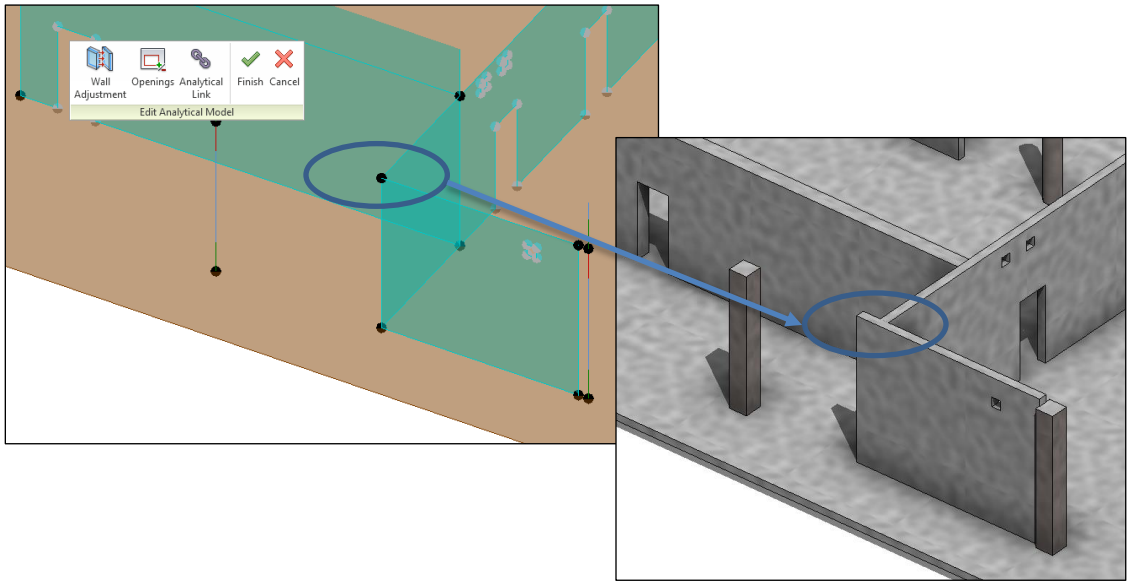
- Adjust the analytical walls:
  - Let's take the following case regarding the intersection of two walls:



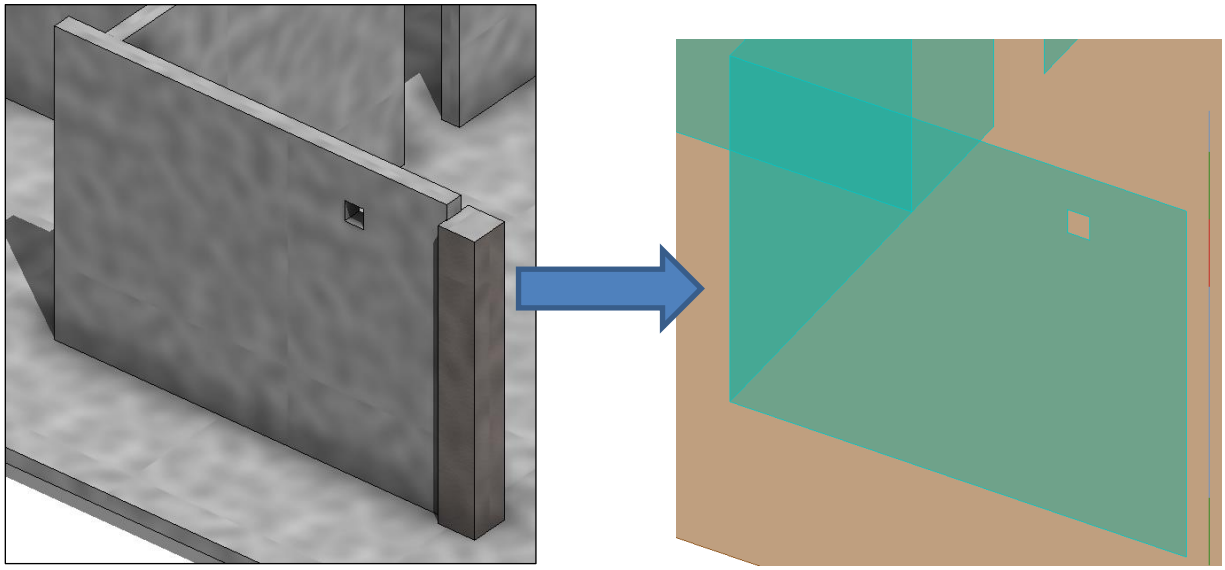
By default, we see that the analytical geometry correspond exactly to the physical model!

For the FEM calculation, the engineer may want to simplify this analytical representation.

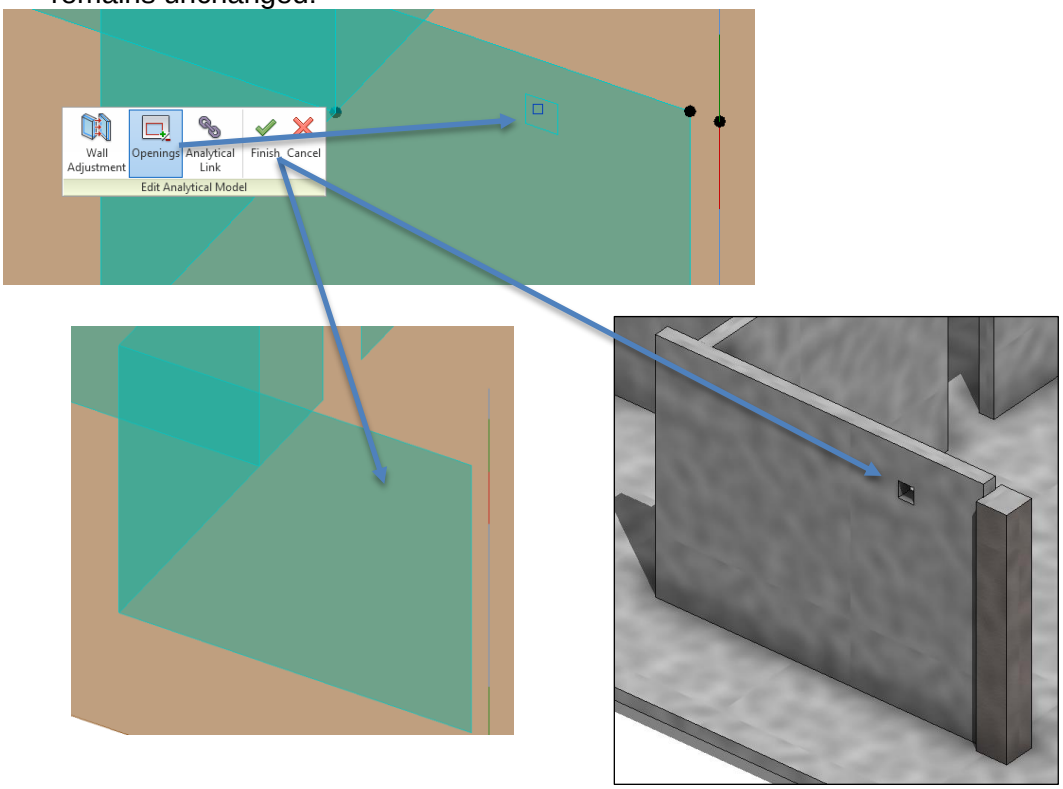
  - To simplify analytical geometry, we can use the "Wall Adjustment" command, select first the wall to be adjusted and then the reference wall. The analytical model is adjusted while the geometrical model remains unchanged:



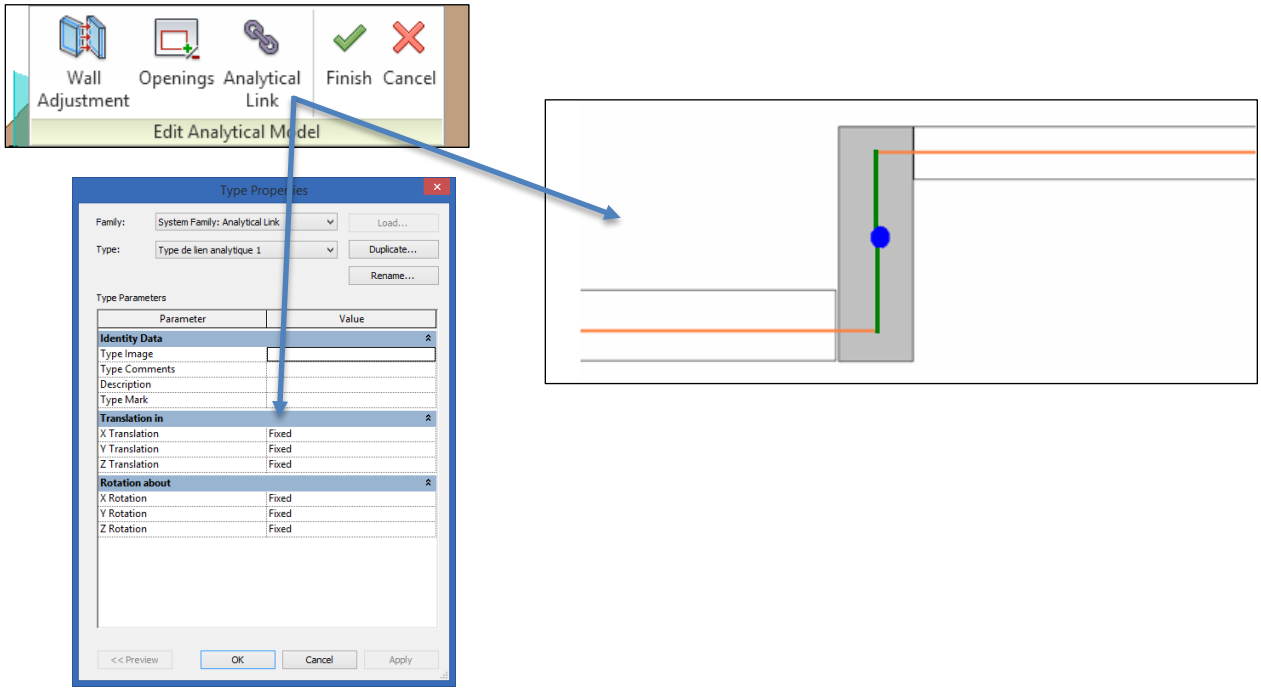
- Manage the openings in the analytical model - taking into account all the openings for the analytical model can bring to an unnecessary complexity. With the command 'Openings', you have the possibility to define which openings can be ignored in the analytical model.
    - Let's take back the same wall which has a small opening. By default, the opening is considered in the analytical model:



- Activate the command '*Openings'*, disable the analytical opening and click on '*Finish'*: the opening is no longer considered in the analytical model while the physical model remains unchanged:

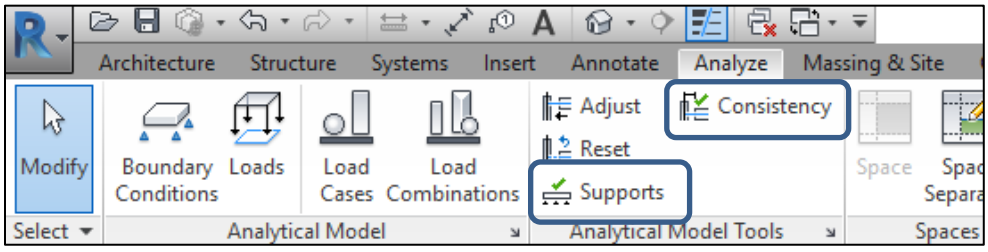


- Define analytical links - in some cases, you may want to keep the original position of the elements and just use an “analytical link” to link two separated nodes, defining:

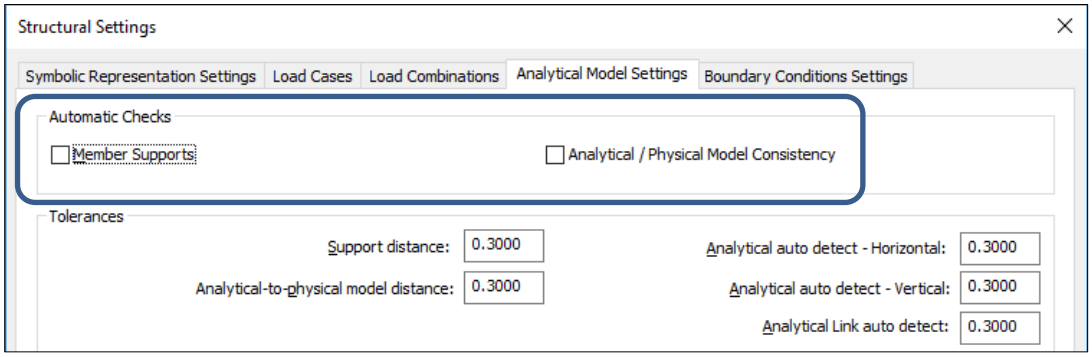


Analytical model consistency verification

Revit Structure® also includes tools dedicated to the analytical model check. These tools are available from the same ’*Analyze’* ribbon:

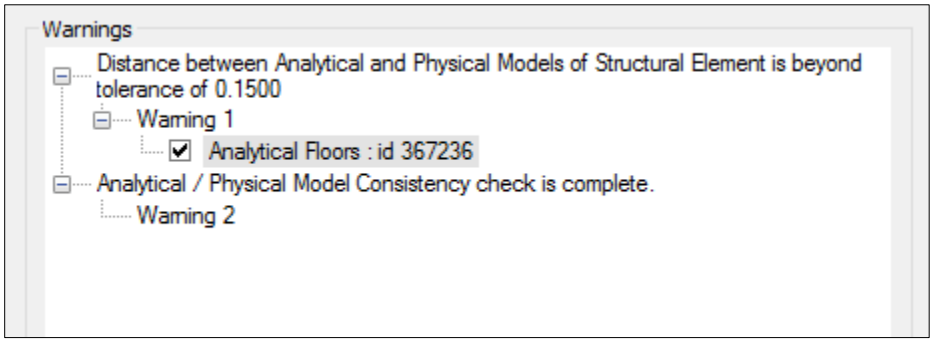


You can also activate these functions in the structural settings - in this case, the consistency of the model will be done in real time:



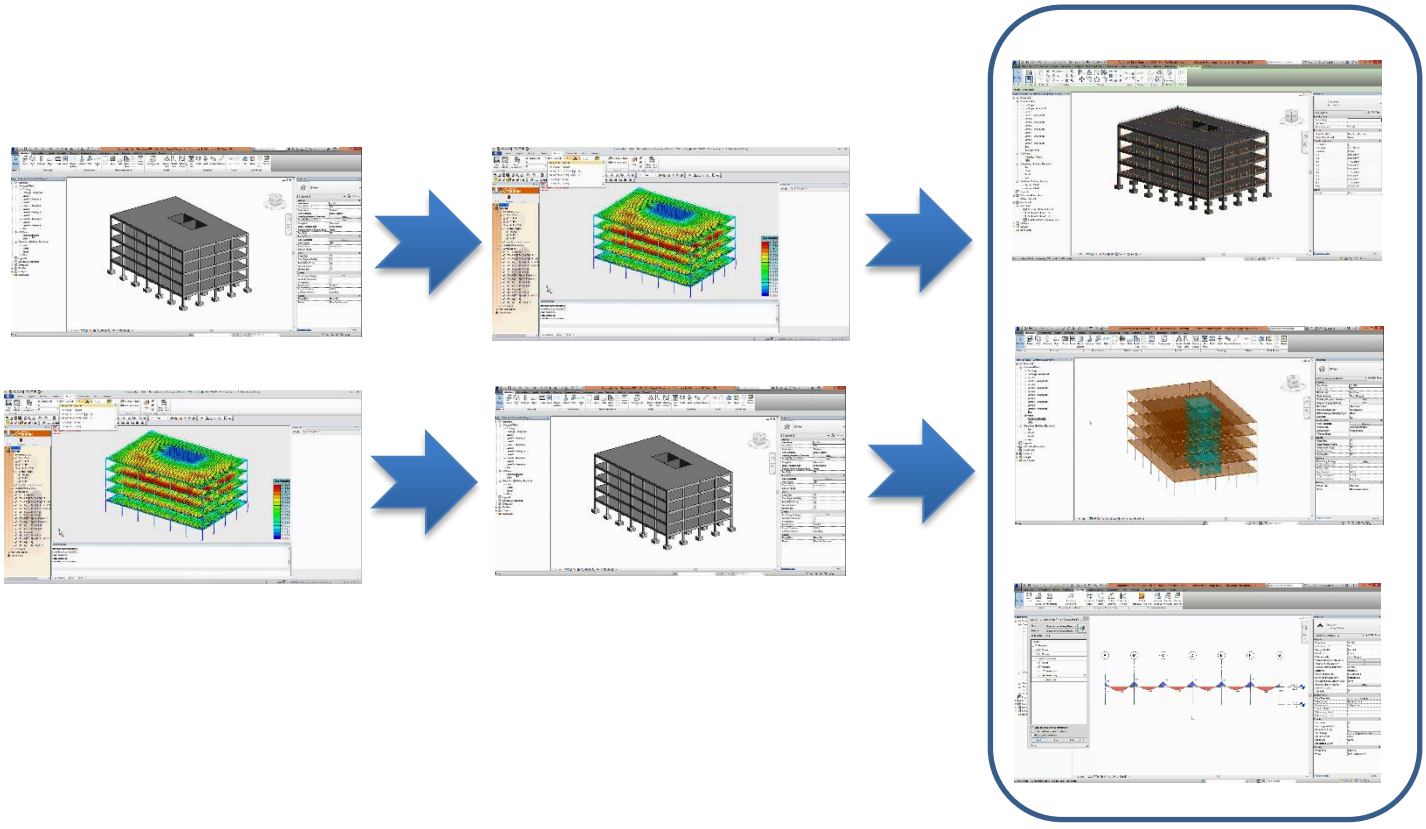
The automatic verification will be done considering the tolerances we already talked about in this document. This is an important step before sending the analytical model to the FEM system. Checking and fixing the eventual warning messages within Revit® will avoid meshing or calculation problems in the FEM analysis software.

The warning message will be displayed in a dedicated dialog from where you can identify and easily localize the concerned elements:



Revit Structure® - FEM system integration workflow

In the introduction of this class handout, we introduced two possible workflows to connect Revit® with a FEM system in order to get the FEM results package updated:

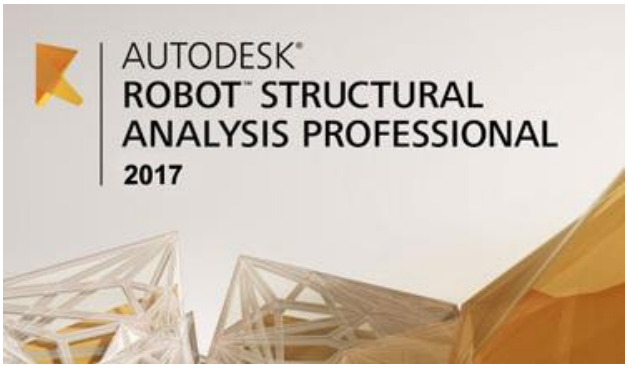


Looking to this scheme, I'm pretty sure that many of you have the following question in mind: "*Why should I store FEM results in Revit Structure®?*"

Today it is extremely unlikely that anyone is transferring results to Revit Structure® in a real workflow. We will try to explain why you would and what interest there is of having FEM results in the Revit® model. Right now, for users transferring this data to Revit®, it is a dead end with nowhere else to go and nothing else to do with the data. Now, imagine a process that allows you to get a 3D rebar cage in a minute, within Revit Structure® relying of the FEM results database! It really starts to make sense. That's what we propose with our BIM Designers tools that we will describe later on in the document.

For the moment, let's focus on how we can connect Revit Structure® with a compliant FEM software. Currently, on the market, there are several FEM software which can exchange geometry with Revit Structure®, and only few of them are able to store FEM results in the Revit® Results package database. Among those ones, we can mention the two following ones that I know:

- Autodesk Robot Structural Analysis®



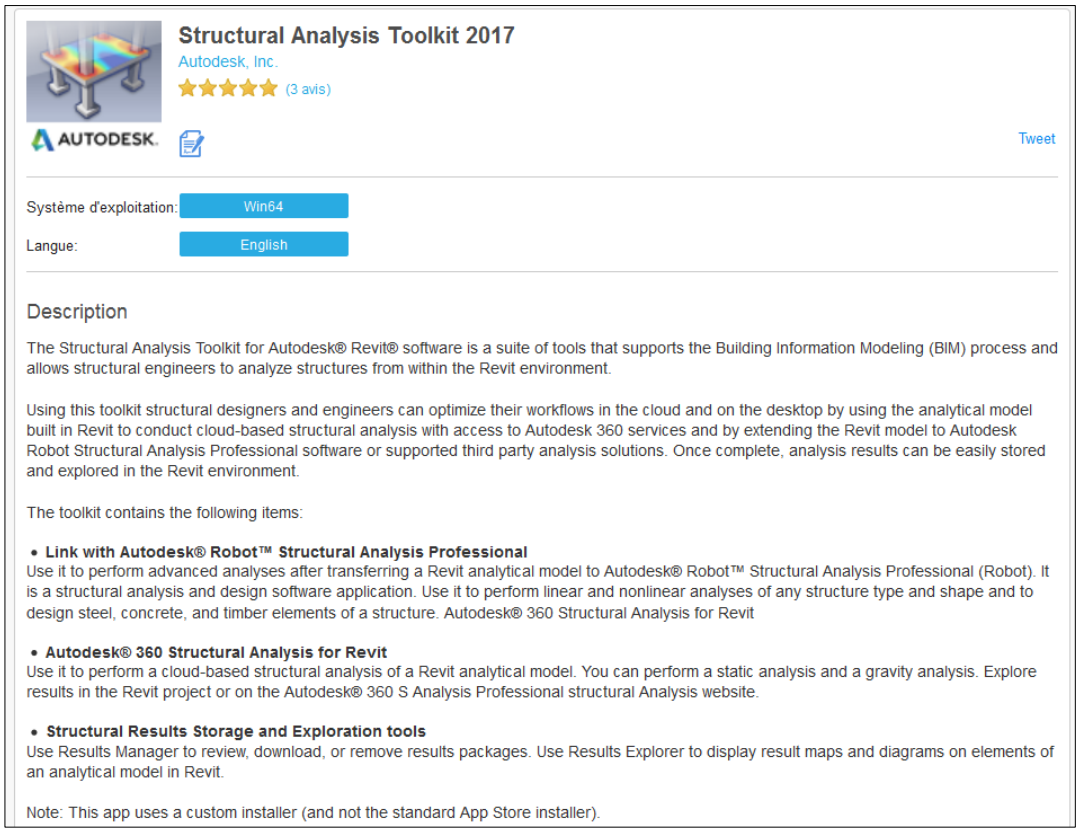
- GRAITEC Advance Design

In this class handout, we will detail the workflow using Advance Design®.

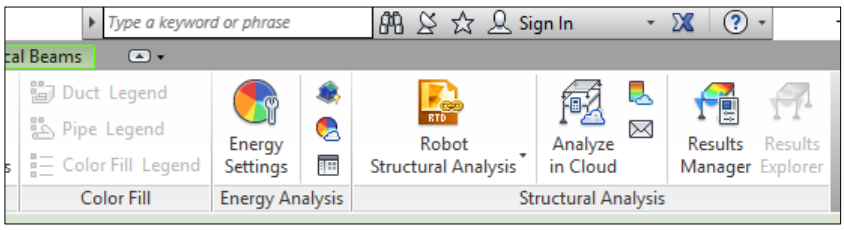
Connection with Autodesk Robot Structural Analysis® for FEM results

As I said here above, I will detail the workflow using Advance Design because I 'am definitively not a good user of Autodesk Robot Structural Analysis® and I really apology for the ones who are using this system. But, anyway, I will try to give you the main steps to setup this workflow with RSA.

1. The 1st step is to install over Revit® the "Autodesk Structural analysis Toolkit" which is available from the Autodesk App Store (https://apps.autodesk.com/RVT)



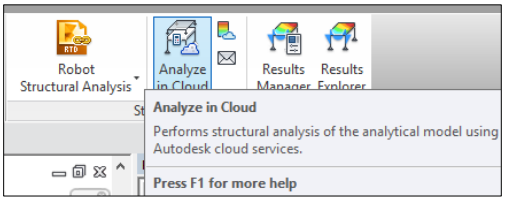
2. After the installation, you get new entries in the 'Analyze' Revit® ribbon:



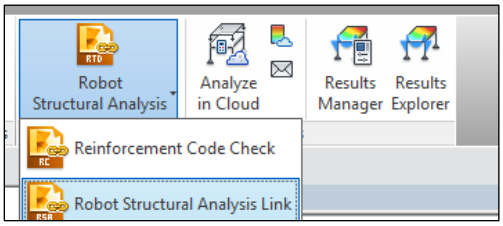
Tip: *As you can see, this Structural Analysis toolkit also includes the 'Results Manager' and the 'Results Explorer' request to see and post-process the FEM results packages stored in Revit®. We will use later on this class handout those results management tools.*

Using RSA, you have two possibilities to run a FEM calculation from your Revit® model:

- Either using the command ‘Analyze in Cloud’:

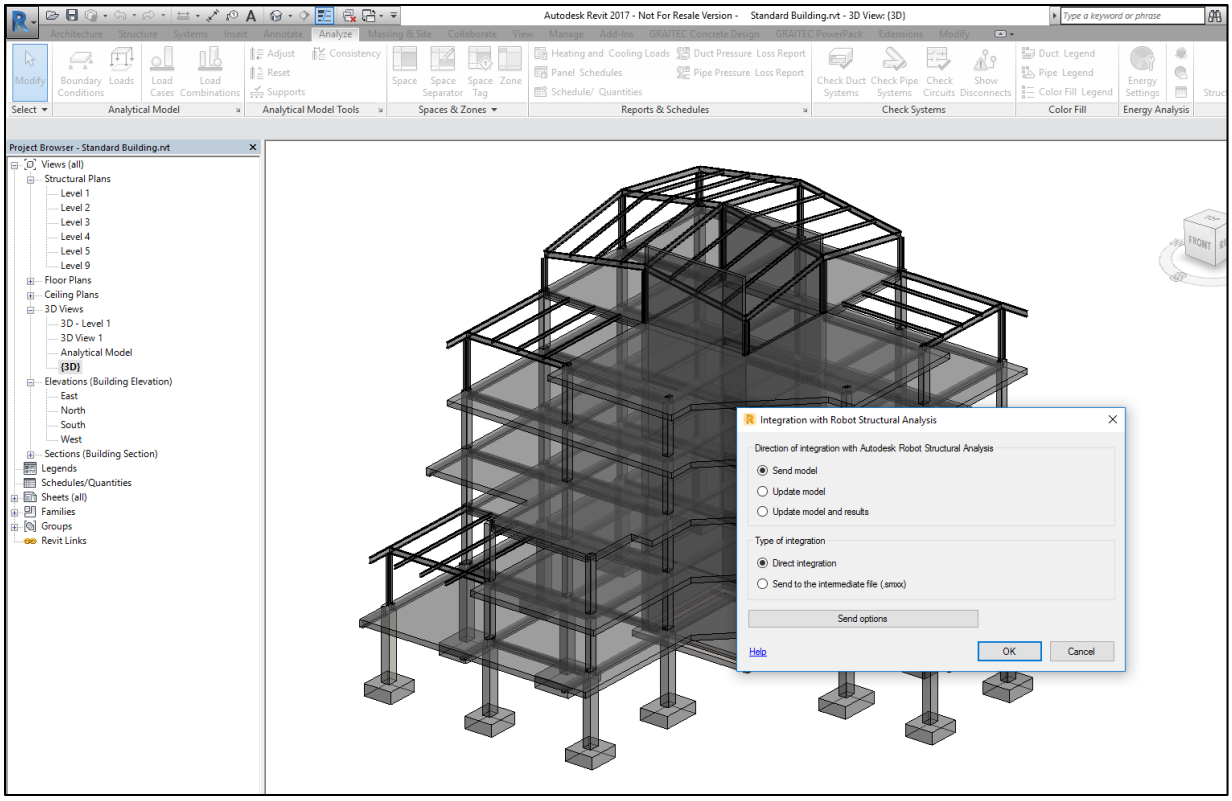


- Either using the link with RSA, exporting and importing integration files:

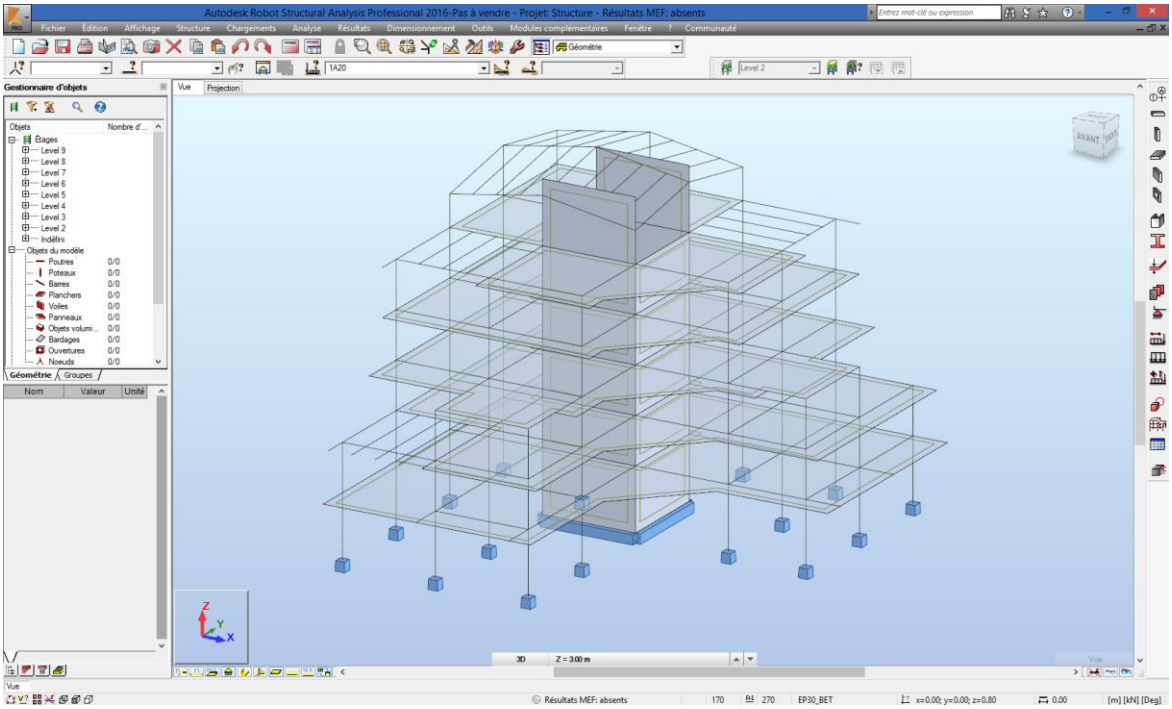


I am personally not convinced that engineers are ready to run a FEM analysis in Cloud without having the possibility to fine-tune their FEM model in their dedicated FEM software. That’s why I will focus on my class handout about the second option.

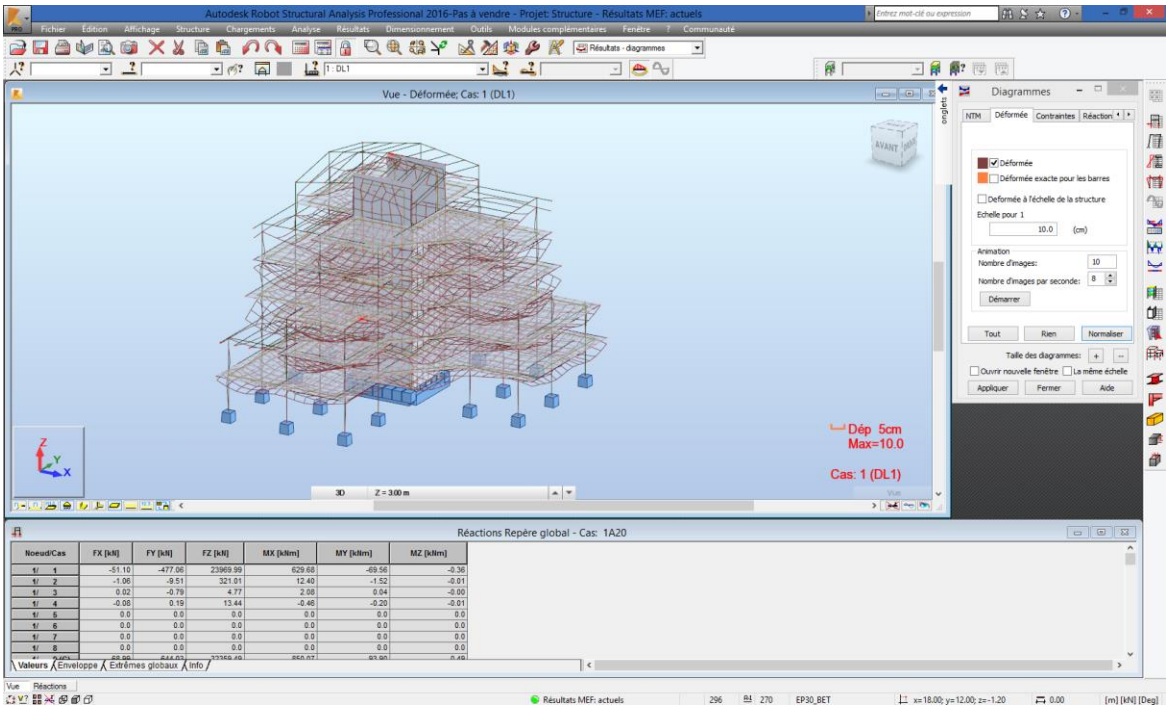
When you activate the command ‘*Robot Structural Analysis Link*’, you get a dialog where you have to select the option ‘Send model’ to export the Revit® analytical model to RSA:



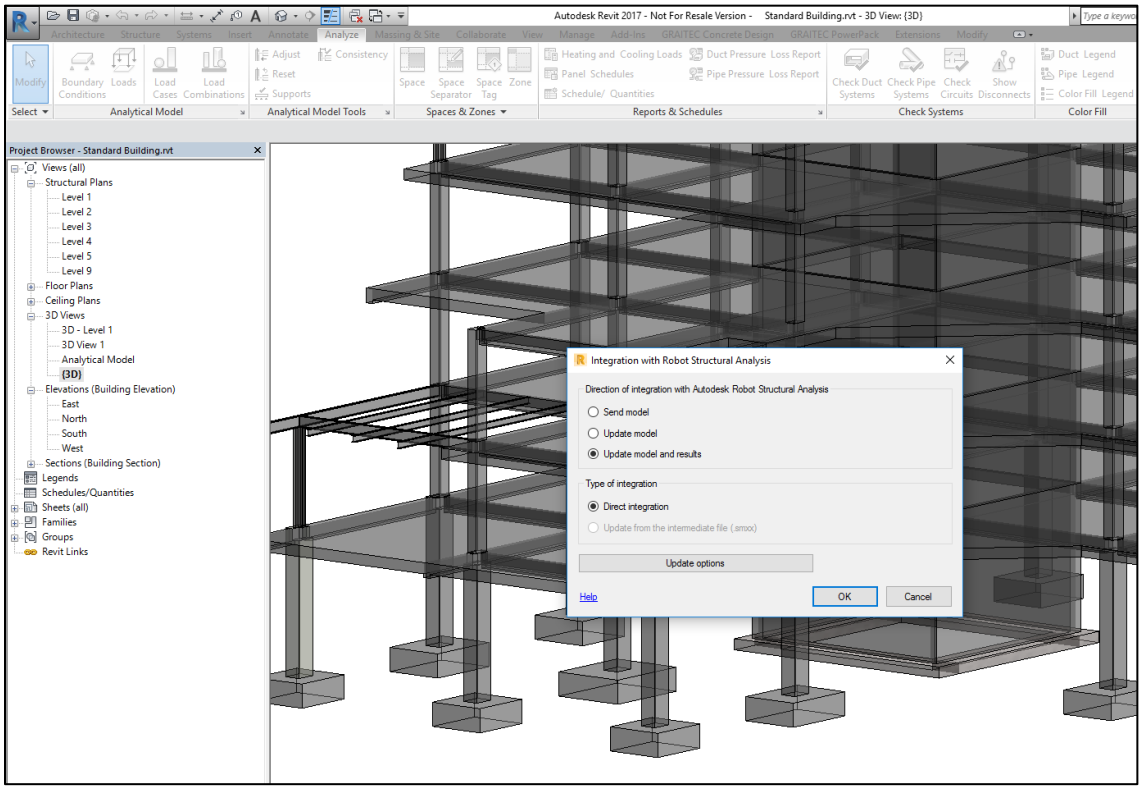
Just wait few seconds and you get the model in RSA:



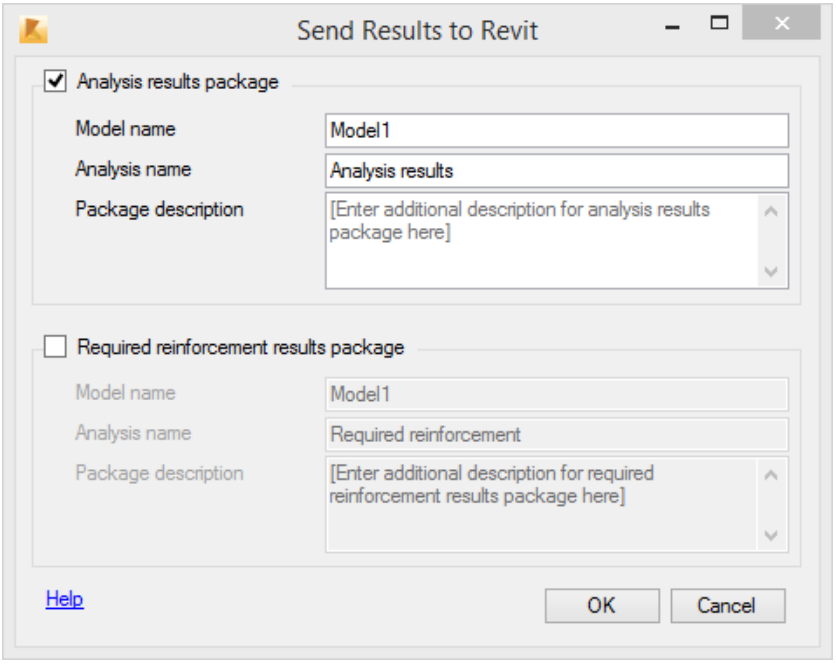
You can then run the calculation (the objective of this class handout is not to teach you how to use RSA) and get FEM results:



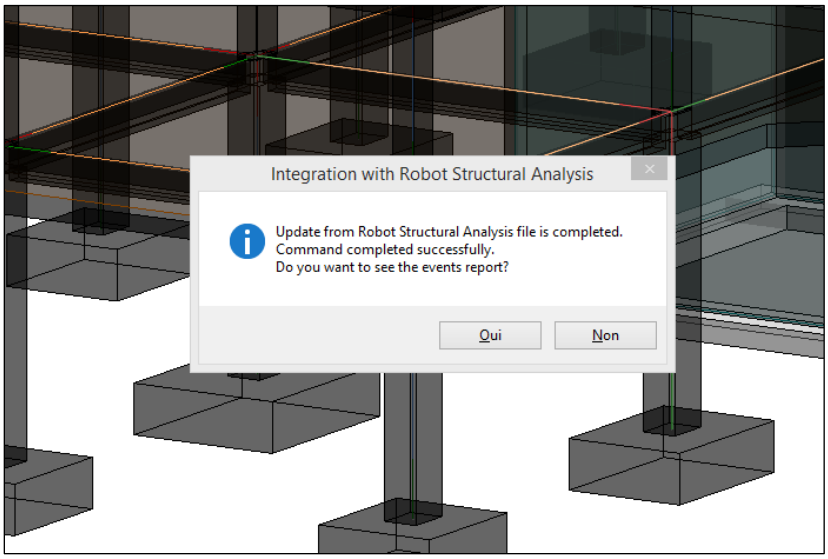
Save the calculated model in RSA, get back to the '*Robot Structural Analysis Link*' dialog in Revit® and choose the option 'Update model and results':



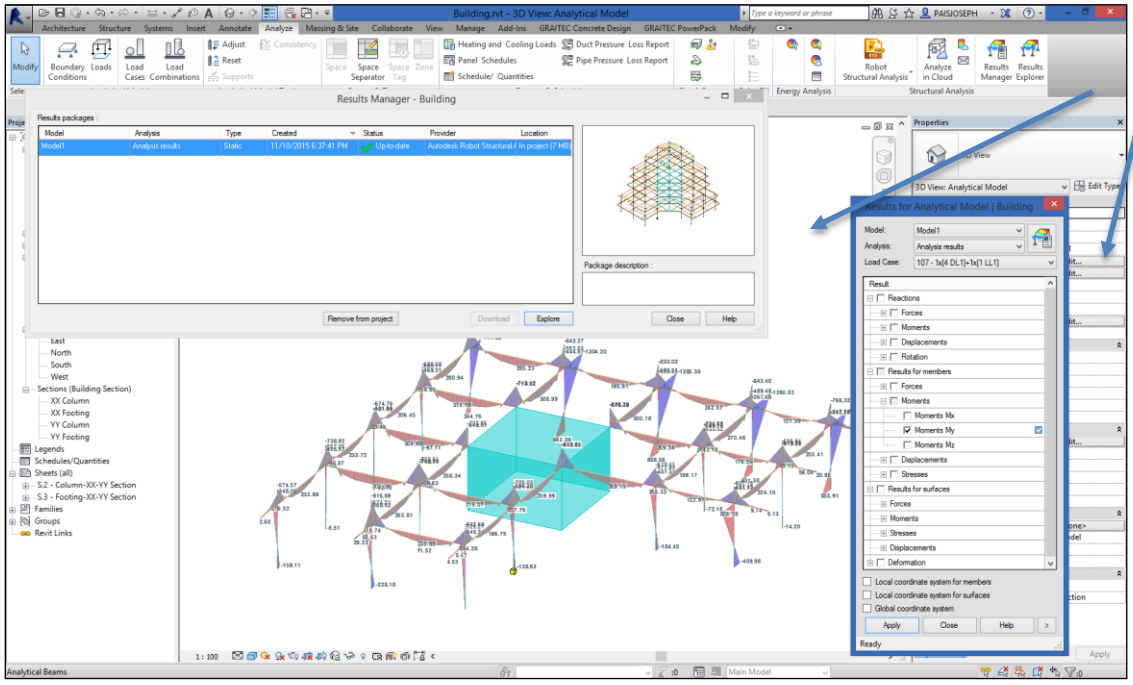
You can give a name to the results package that will be stored within Revit®:



The update process can take few minutes and you will get confirmation of the update:



At this point, you can start to browse the FEM results within Revit® using the '*Results Manager*' and the '*Results Explorer*':



Connection with GRAITEC Advance Design® for FEM results

Another alternative is to use GRAITEC Advance Design software to handle FEM analysis and synchronize the FEM results in Revit®. As we saw here before, the objective is to handle the following workflows:

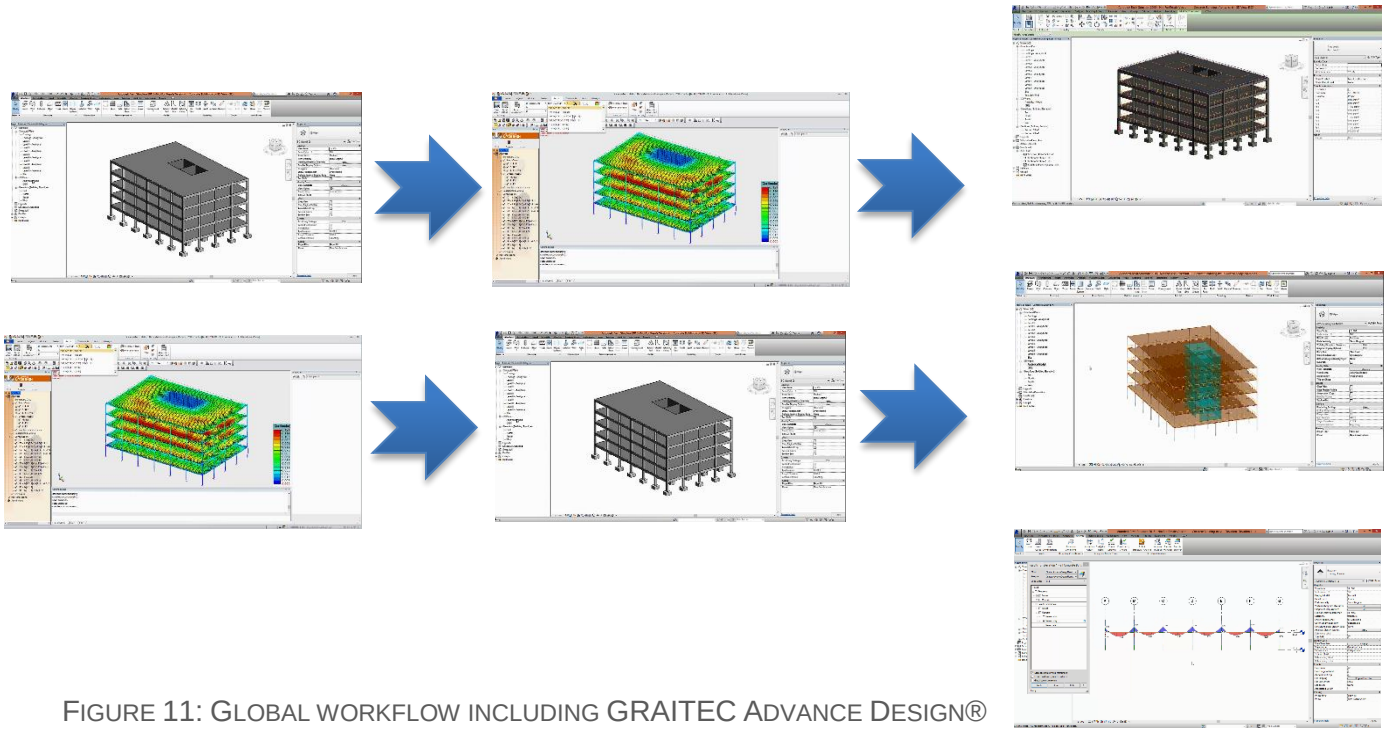


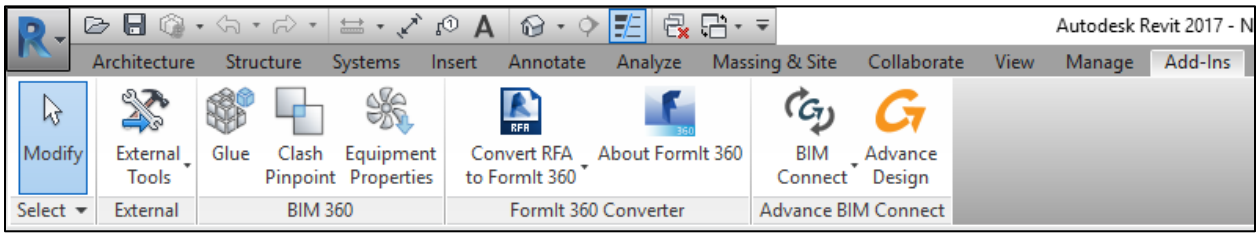
FIGURE 11: GLOBAL WORKFLOW INCLUDING GRAITEC ADVANCE DESIGN®

Advance Design is a 3D FEM software developed by GRAITEC which allows the user to handle static, dynamic, nonlinear analysis and includes the design of steel, concrete and timber members. It is compliant with different design codes, including the Eurocodes (with several national appendixes), the American codes and the Canadian codes.

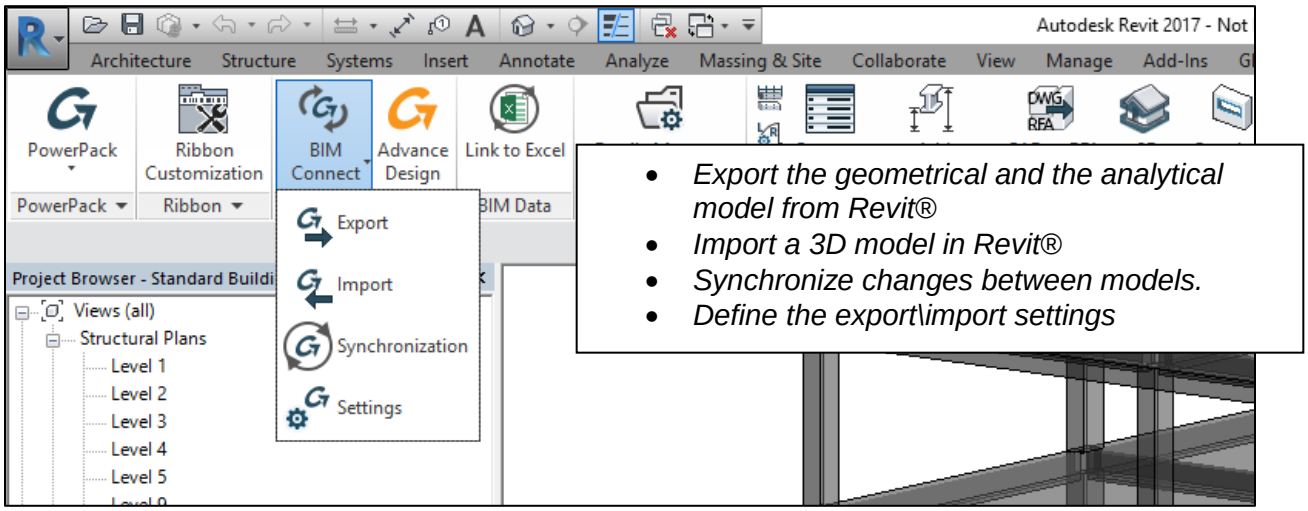
You can find much more information about this software on the following web page:
http://www.graitec.com/en/advance-design

To be able to use the link between Revit® and Advance Design, you also have to install the GRAITEC BIM Connect Revit® plug-in, which is available free of charge from the GRAITEC website (http://www.graitec.com/en/bim_connect.asp) or from the Autodesk Exchange App Store (https://apps.autodesk.com) and included in the GRAITEC PowerPack for Revit® (http://www.graitec.com/en/powerpack-for-revit) also available on the Autodesk Exchange App Store.

If you have installed only the GRAITEC BIM Connect tool, two new icons will appear on the "Add-ins" ribbon of Revit®:

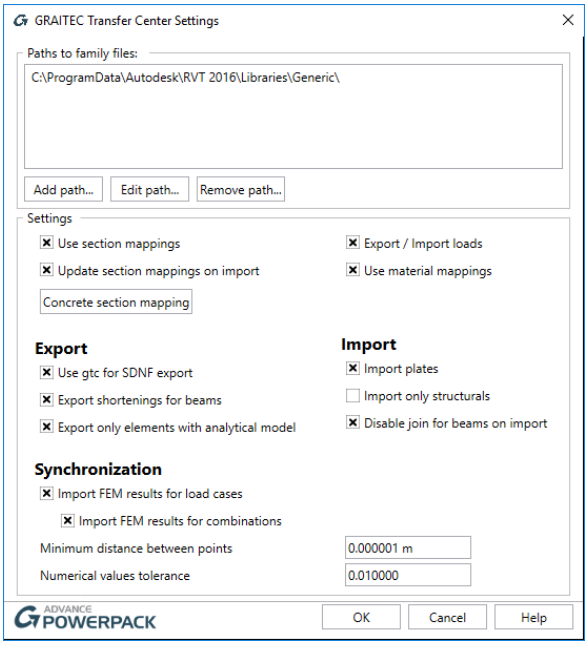


If you have installed the GRAITEC PowerPack for Revit®, the Advance BIM Connect will be part of the “GRAITEC PowerPack” ribbon which include also a set of tools to improve the Revit® daily use:

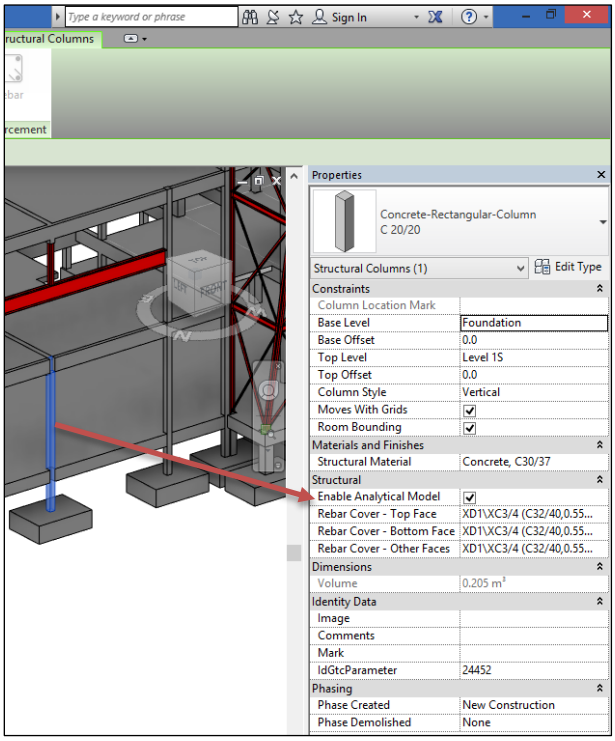


Powerful filtering options are available to manage the export, the import and the synchronization of models between Revit® and Advance Design:

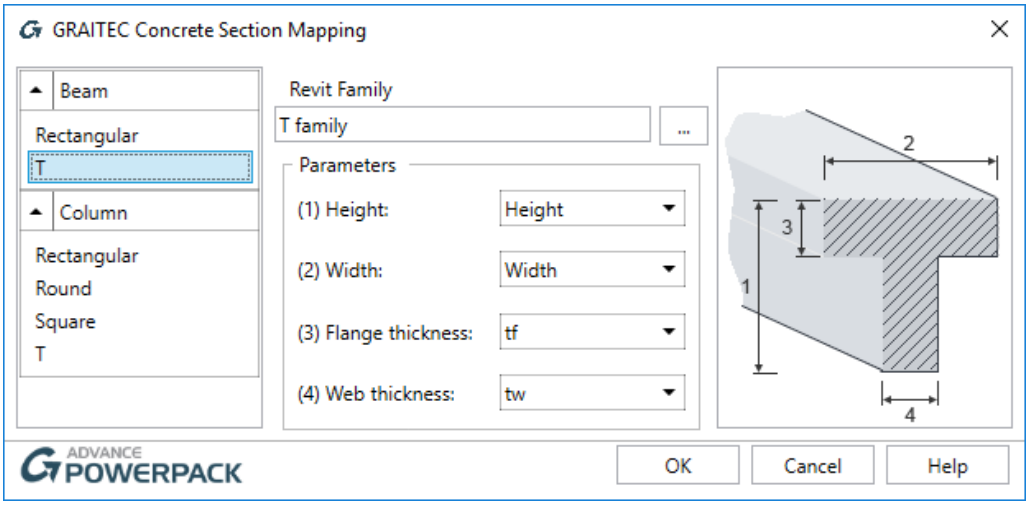
- Options to export\import the loads, in addition to the geometry. This option is really useful when the user wants to run FEM calculations starting with a Revit Structure® model on which the loads have been defined. Just import this model in Advance Design, load the automatic combinations (if not defined in Revit®) and press the button to run FEM analysis:



- It is possible to export only the Revit® objects which have an analytical definition:

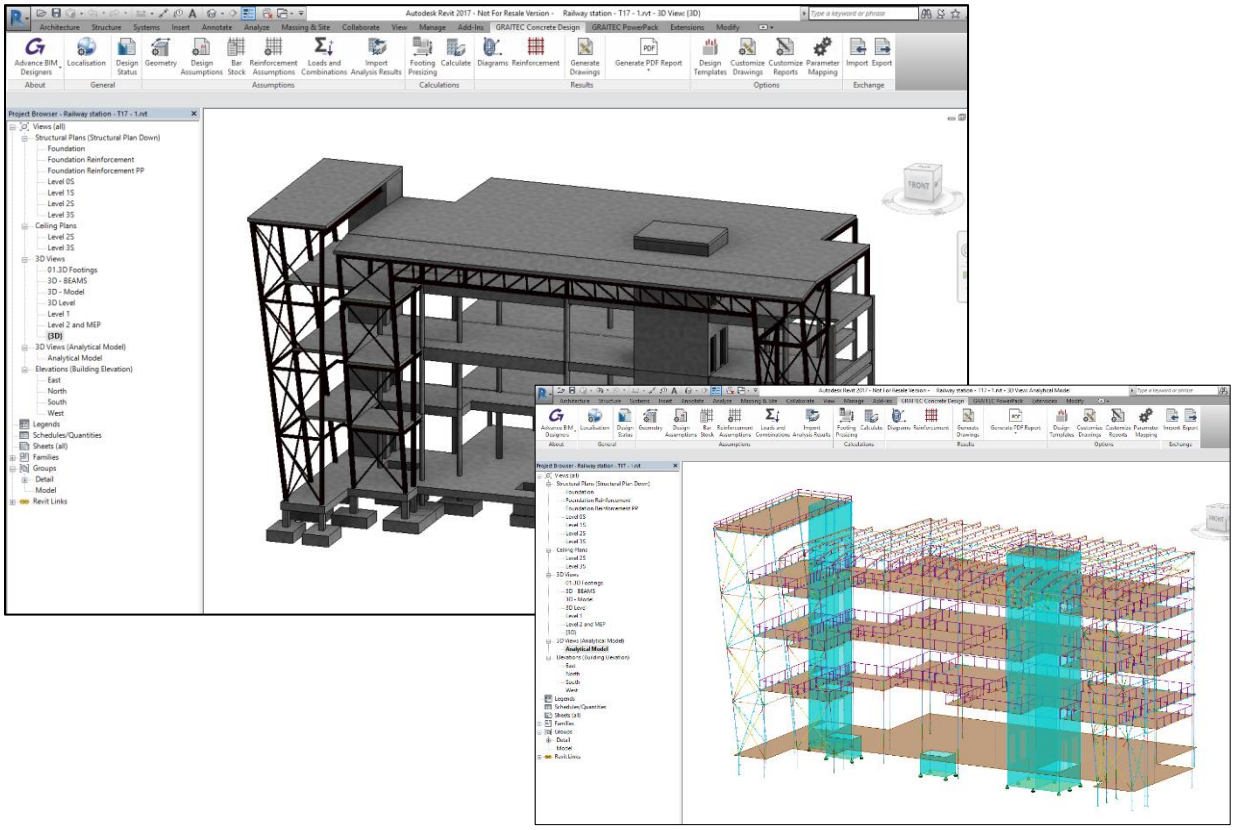


- The option of using a mapping database for sections and materials when linking Revit® and Advance Design. Thanks to this mapping database, the Revit® user has the possibility to apply his own Revit® families and define the correspondence with the parameters in Advance Design. This database is enriched real-time when the module is used, keeping track of the user's mapping settings.

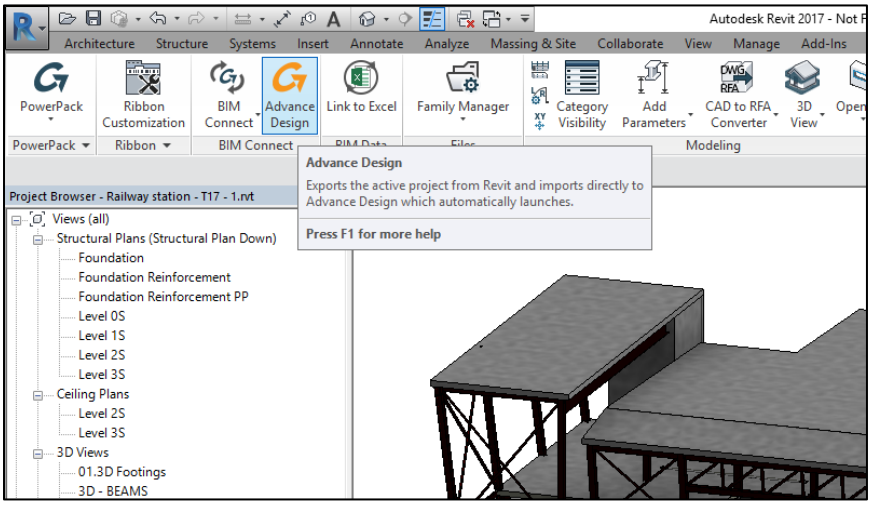


So let's apply this GRAITEC BIM Connect module on an example:

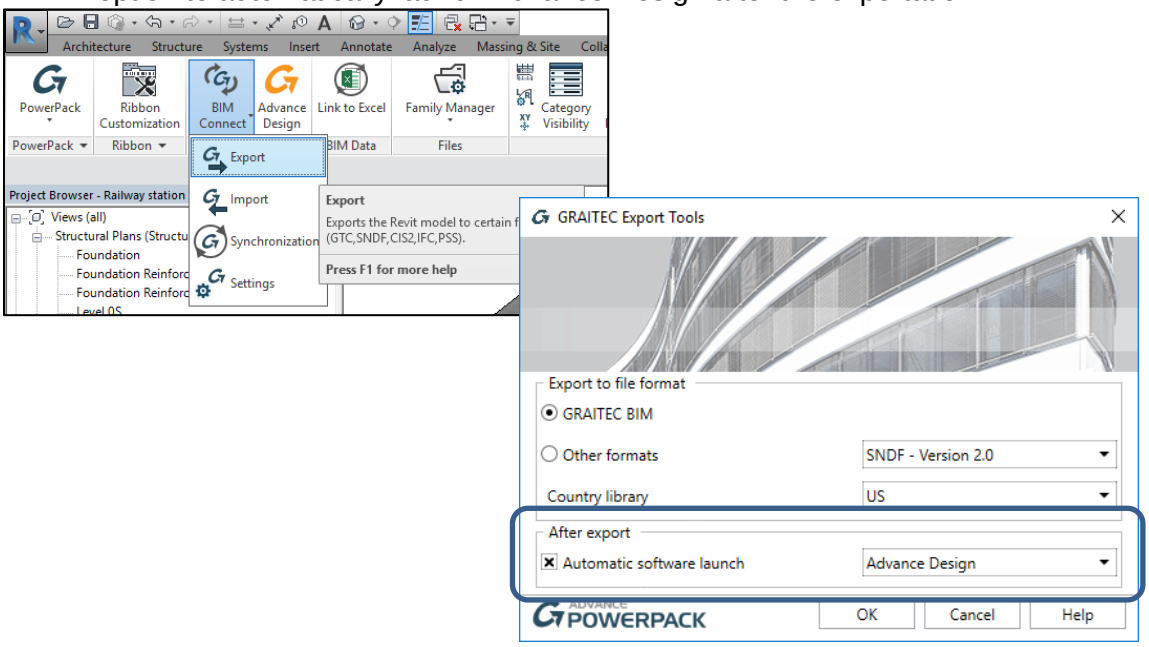
- As we saw before, we start with a Revit Structure® model which also embeds the analytical model (with loads and load cases:



- Using the GRAITEC BIM Connect module, either with the "export" command, either using the flash connection icon, you can export the model from Revit Structure® to Advance Design:
  - Using the flash export icon:

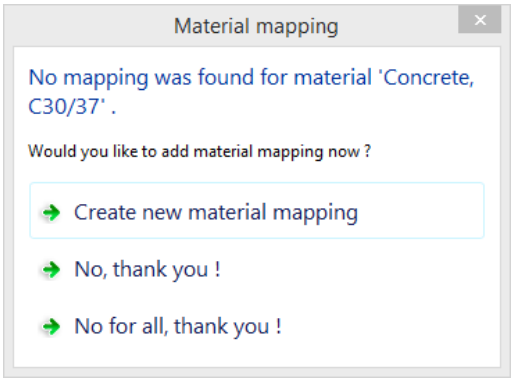


- Using the drop down list and selecting “Export” => in this case, you will have an option to automatically launch Advance Design after the exportation:

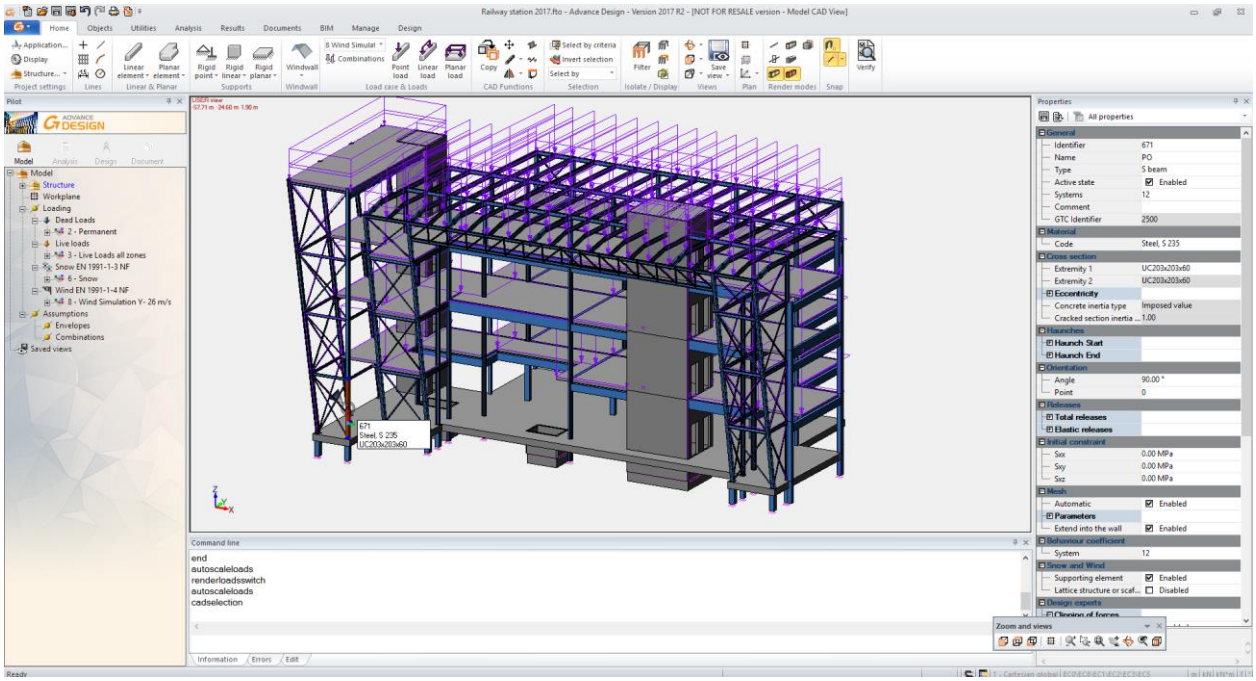


***Tip**: The link is based on “GTCx” files with is a native transfer file format developed by GRAITEC. GTC means Graitec Transfer Center!*

- When the component finds new material, you will receive a message asking if you would like to update the mapping database in real time. Just select ‘Create new mapping material’.



- At the end of the exportation process, you get the 3D analytical model in Advance Design, including the geometry and all the analytical properties; loads, materials, mechanical properties, analytical supports and boundary conditions on the elements. The model is ready to be calculated.



At this stage of the workflow, we have the 3D model in Advance Design corresponding to the analytical model sent from Revit Structure®. We are in a FEM system with all the functionalities required to tune the FEM model:

- We can access all the properties of each member, either to check what was defined in the Revit® analytical model, or to stipulate our own assumptions. This is an important step for the engineer who must be able to manage and rely on the FEM model.
- We can define what kind of finite element we would like to apply, e.g.; a beam with 6 degrees of freedom, a truss with only 3 degrees of freedom working in tension or compression, a tie, a cable, etc.
- We can check and change the boundary conditions on the elements; rigid or semi-rigid links, elastic supports, articulations between slabs and walls, etc.
- Set the meshing parameters.
- Define the loads, either manually or using the automatic generator for climatic and seismic loads:

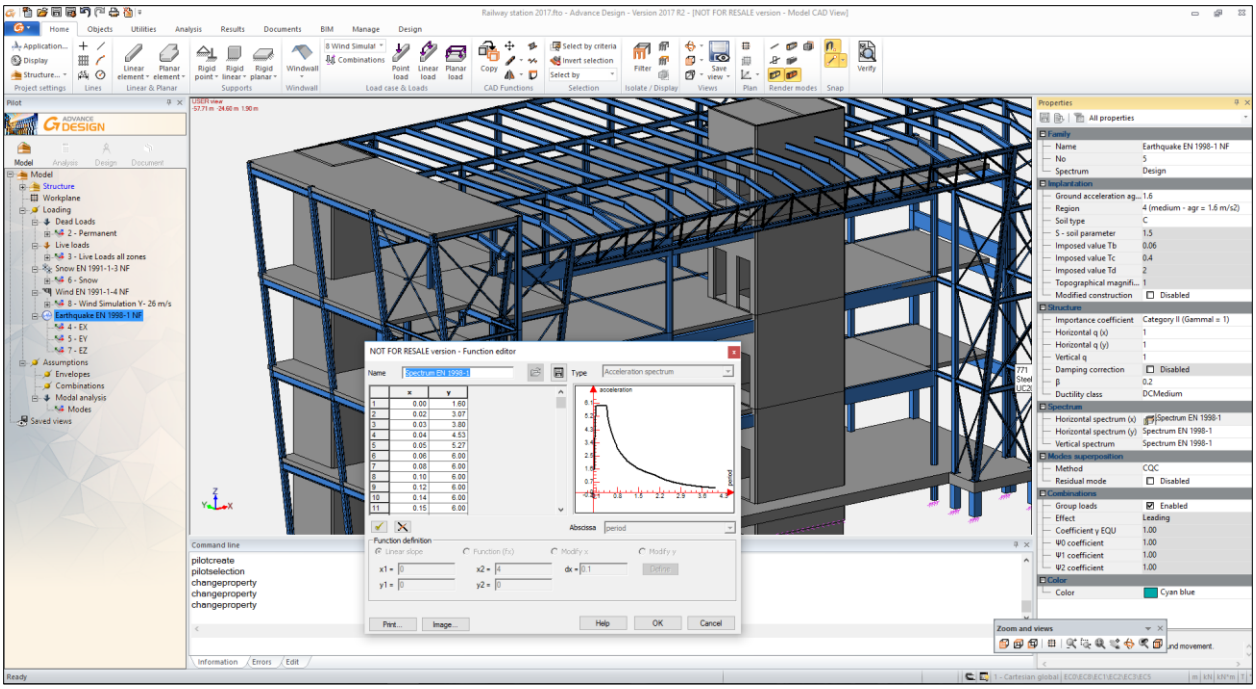


FIGURE 12: IN A FEW SECONDS, THE ENGINEER CAN DEFINE A SEISMIC ANALYSIS IN ADVANCE DESIGN

With Advance Design, the user can run an FEM analysis and get all the requested results (including the internal forces on all elements):

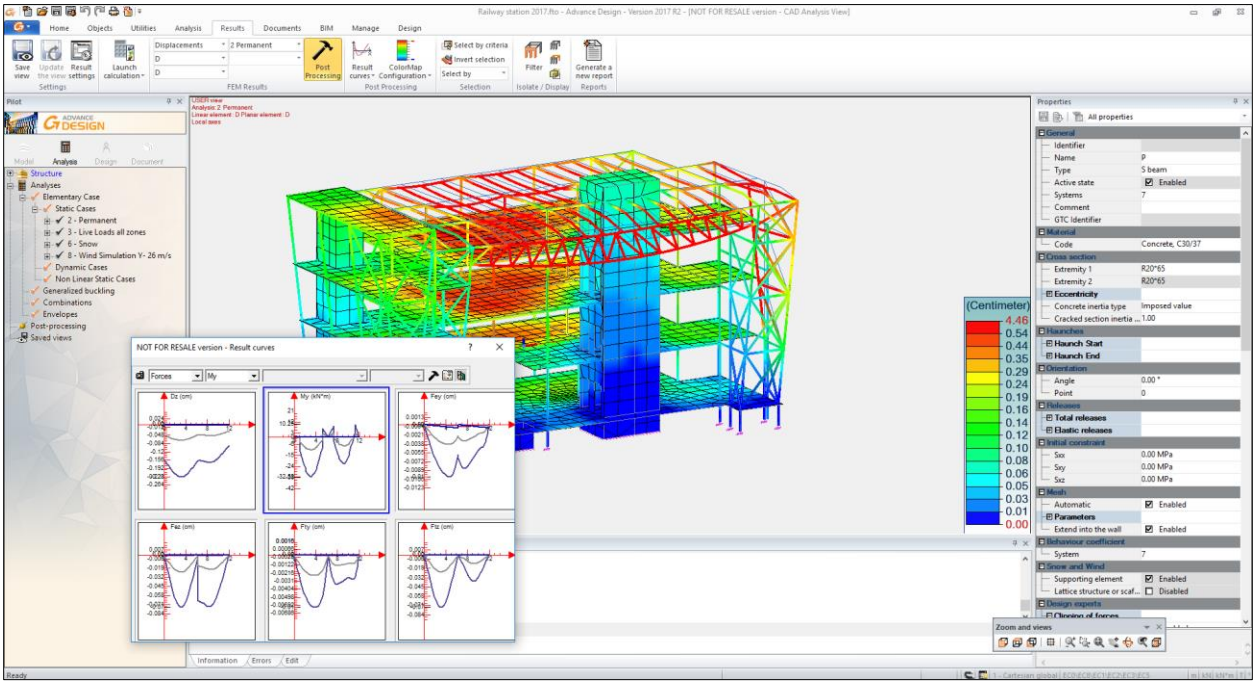


FIGURE 13: DEFLECTIONS ON THE ENTIRE 3D MODEL

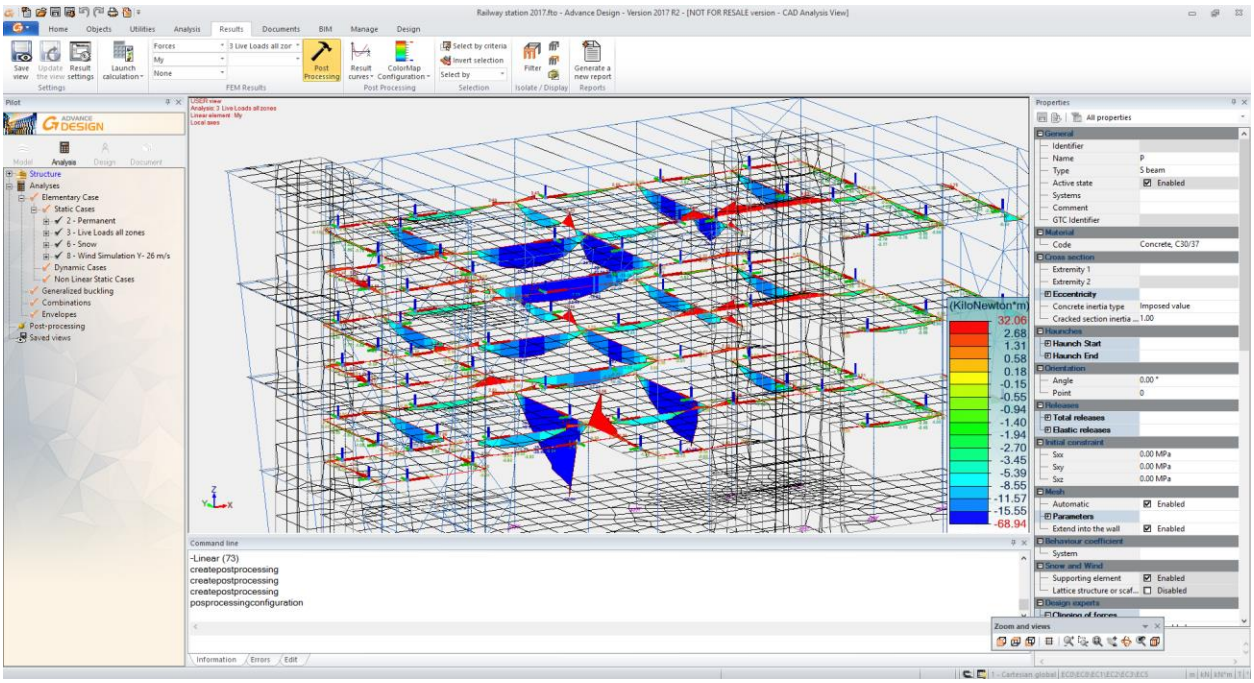
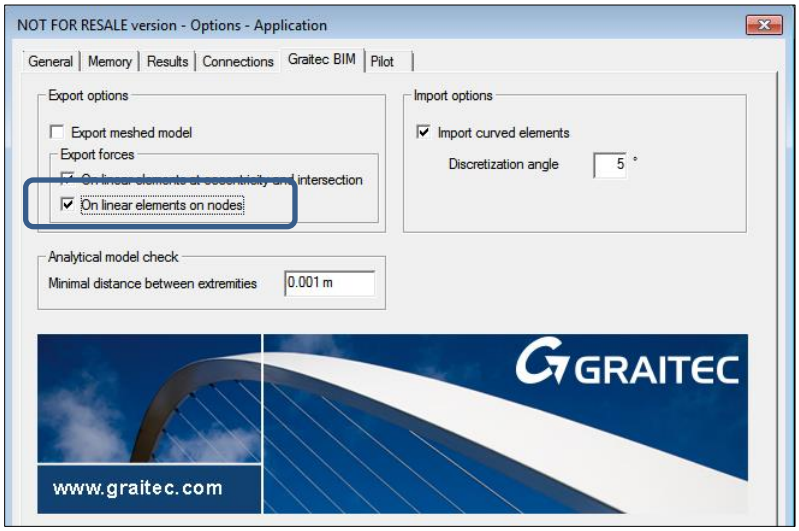


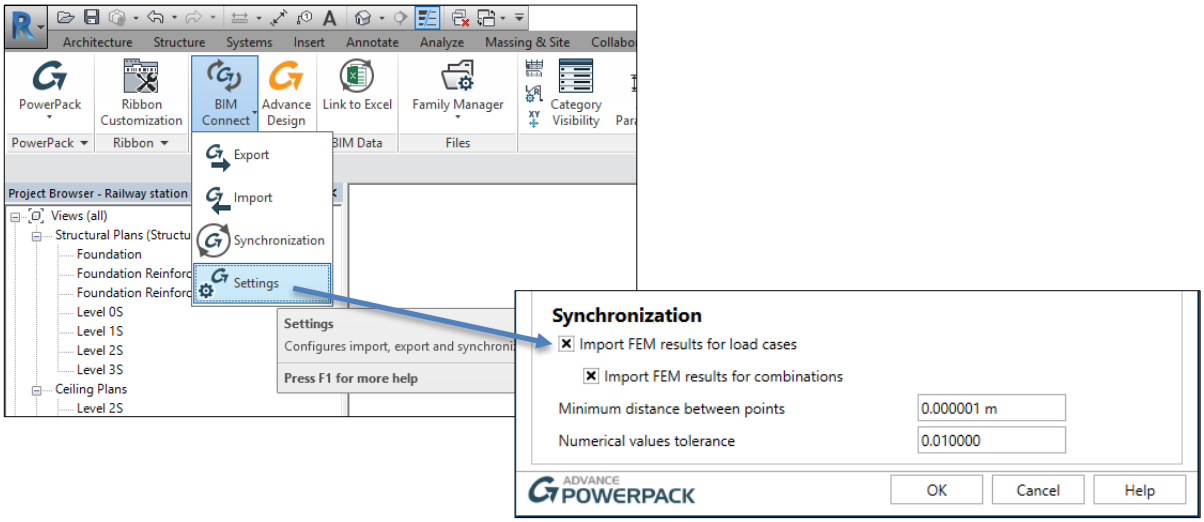
FIGURE 14: BENDING MOMENT ON REINFORCED CONCRETE BEAMS

After the calculation, the Advance Design user can send back the calculated model to Revit Structure® in order to synchronize the FEM results in Revit® and automatically fill the results database.

- Activate the results export in Advance Design:

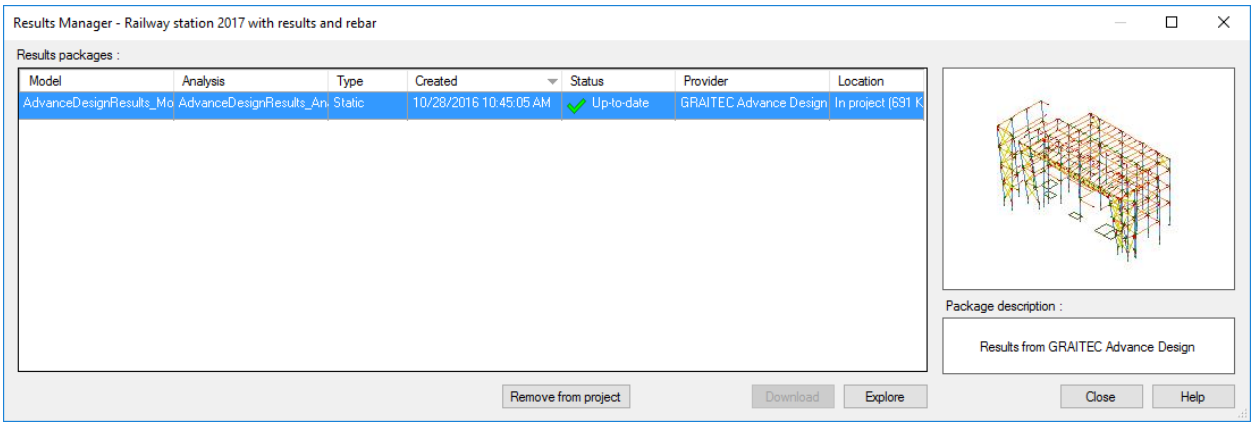


- Activate in the PowerPack for Revit®, the synchronization of the FEM results including the results per load cases and\or the results per combination:

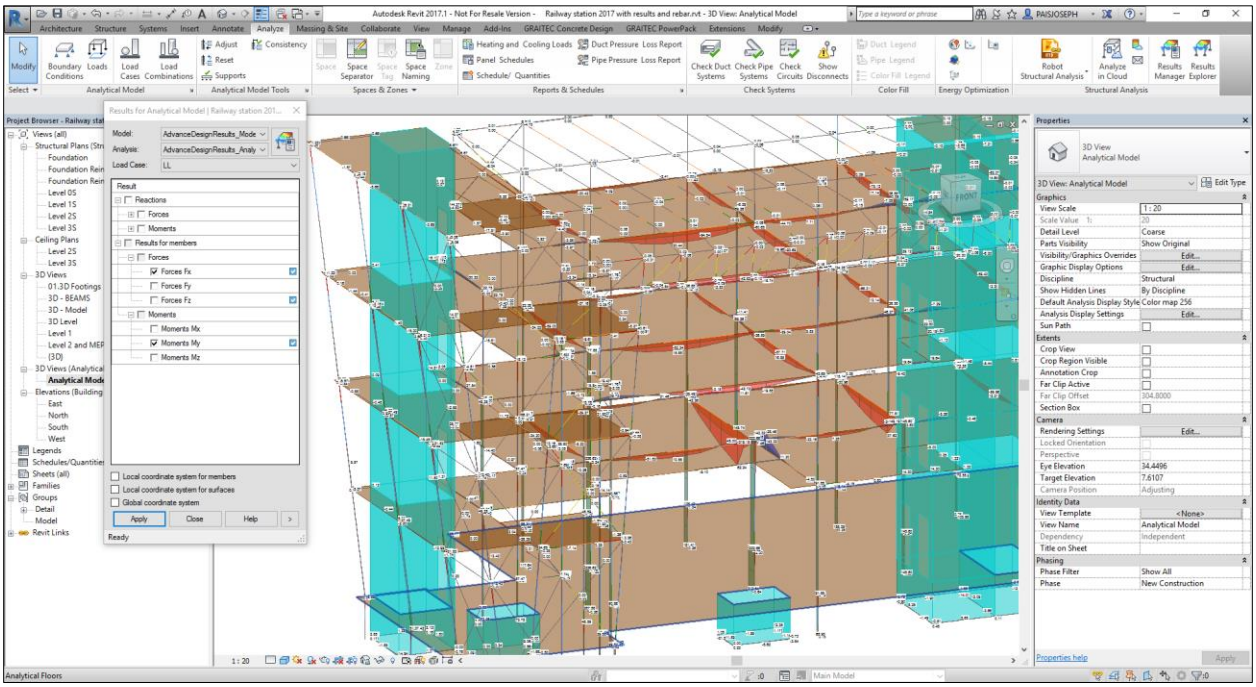


At this stage of the workflow, it is possible to post process the results in Revit Structure® as we previously saw in this class handout:

- With the 'Results Manager', you will be able to see all the results package available in the current Revit® model (with its corresponding status) and select the one you want to access:

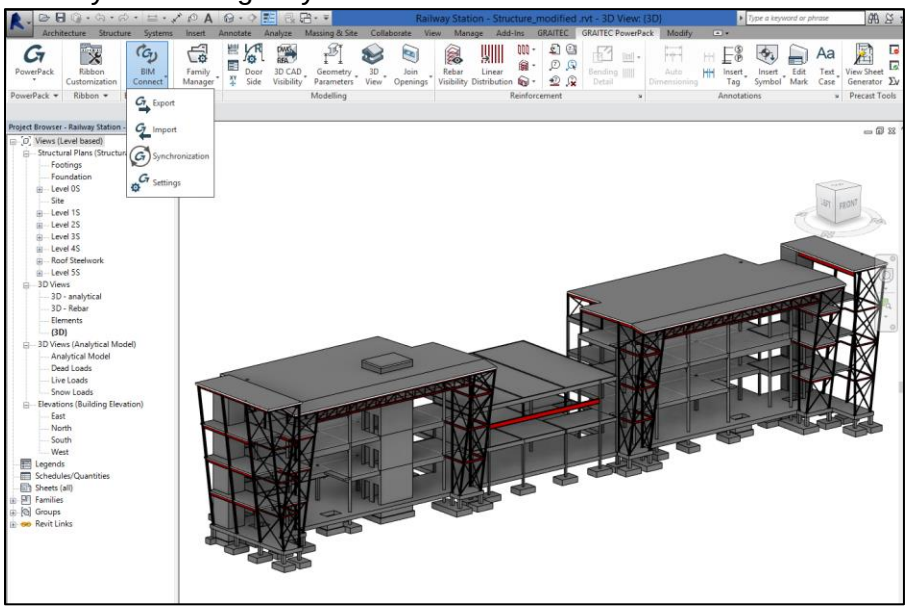


- Then with the ’Results Explorer’, you can view the main results on the members and supports, selecting the load case or the combination you wish to see:

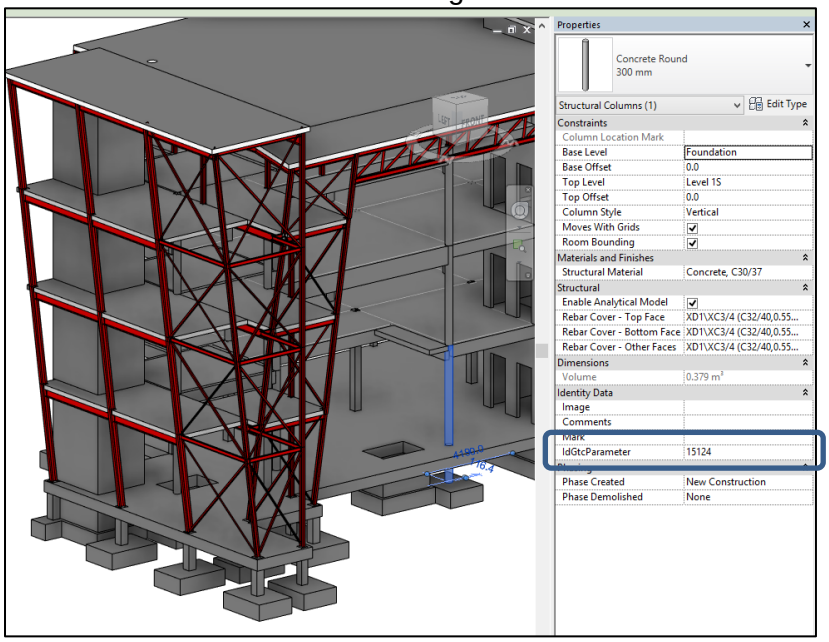


How does the synchronization mechanism from the GRAITEC BIM Connect work?

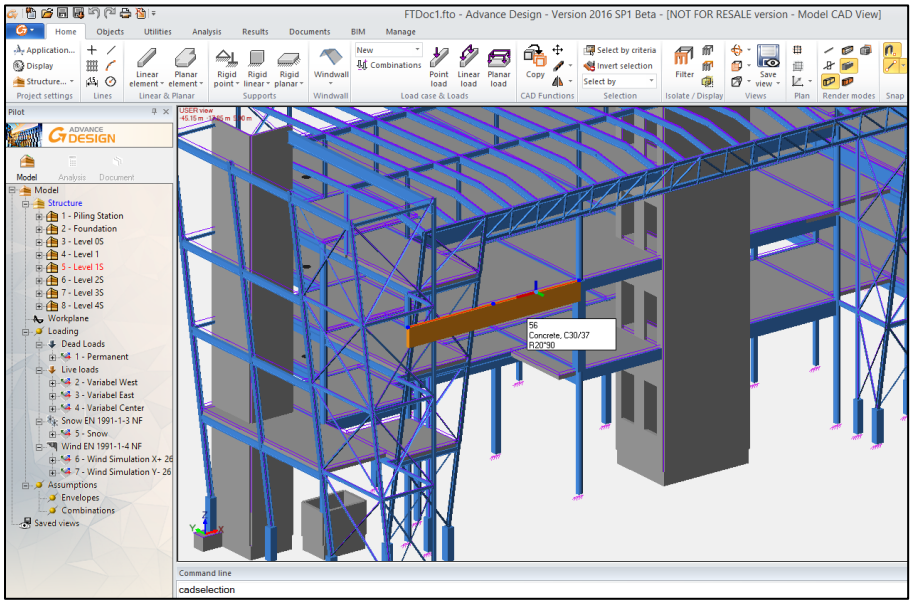
When the draftsman in Revit® and the engineer in the FEM system have already made one roundtrip, they continue to work in parallel on their own models. At this stage of the project, the synchronization mechanism is important to ensure a good communication to manage the change synchronization in both models. The GRAITEC BIM Connect 'Synchronization' option ensures the Revit® user is in full control of any changes to the 3D model and is able to manage modifications visually and intelligently.



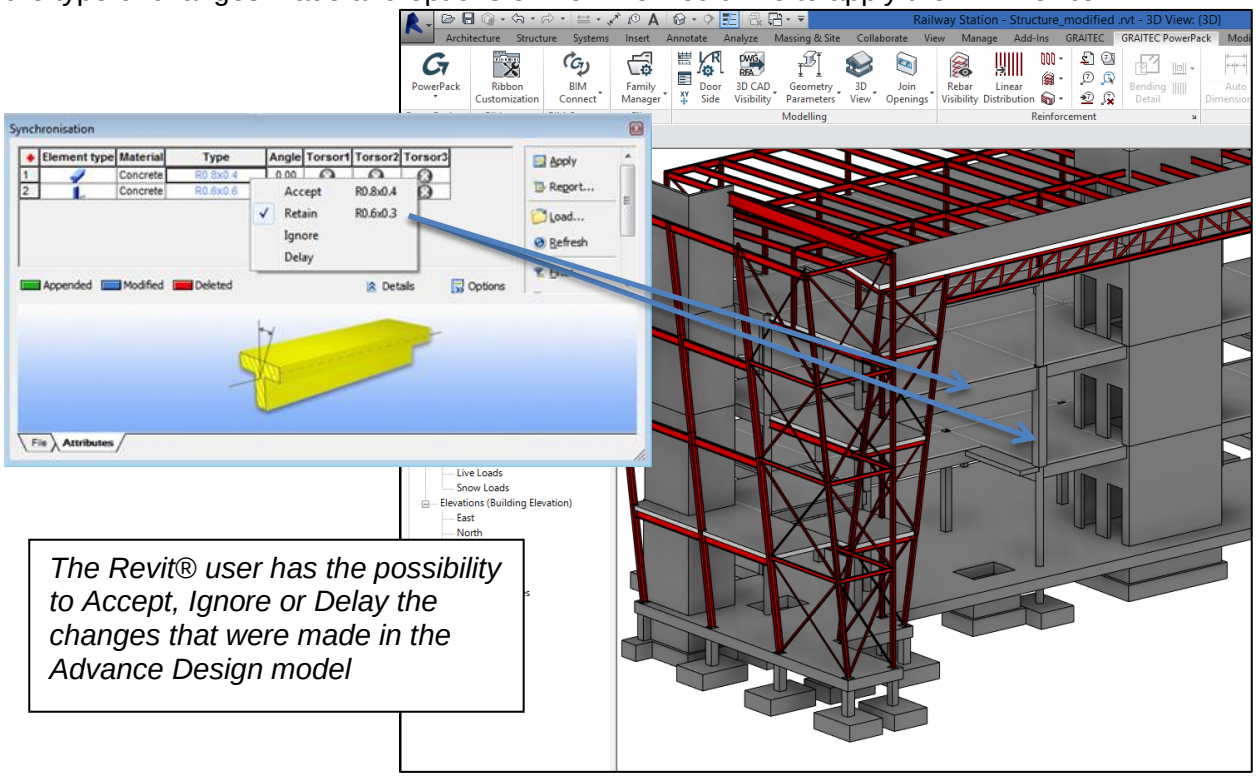
When exporting the model from Revit® to Advance Design, using the 'Export' function of the BIM Connect module, it creates a specific ID called 'IdGtcparameter' which will be used to synchronize both the Revit® and the Advance Design models:



To illustrate the workflow in Advance Design, we changed the section of a concrete beam and a concrete column:



When synchronizing the model in Revit®, we receive the following messages informing us about the type of changes made and options on how we would like to apply them in Revit®



The Revit® user has the possibility to Accept, Ignore or Delay the changes that were made in the Advance Design model

FIGURE 12: SYNCHRONIZING THE CHANGES

This synchronization mechanism is important to the integrity of the BIM workflow, giving the possibility to quickly and safely handle changes to the models during the different project phases.

At this stage of the workflow, we have all the results in our Revit® model. Those internal forces will be the input data for our BIM Designers tools that will handle the reinforced concrete design within Revit Structure®. Now we will explain to you in a few lines about the ''BIM Designers''!

Automatic creation of 3D reinforcement models

GRAITEC BIM Designers concept

GRAITEC BIM Designers are the next-generation software for automation, optimization and interoperability. Combining analysis, intuitive modelling, automatic drawing and report creation, GRAITEC BIM Designers are crafted to deliver exceptional performance and design accuracy across multiple BIM and analytical software applications.

Working across multiple software platforms, including GRAITEC Advance Design, Autodesk® Advance Steel and Autodesk® Revit®, GRAITEC BIM Designers enable users to utilize the same model and analytical data simultaneously across all supported applications.

FIGURE 13: THE BIM DESIGNERS ARE MULTIPLATFORM.

We will see that this multiplatform approach opens broad possibilities for multiple BIM workflows, especially if we include multi-users projects.

For the moment, let's come back on the BIM Designers concept. With easy-to-use intuitive modelling tools, comprehensive built-in analytical assumptions covering a wide spectrum of uses and customizable outputs, GRAITEC BIM Designers not only add analytical capabilities to Revit® but also automate the creation and design of the 3D rebar models, producing fully detailed documents and simplifying and supporting a complex multi-discipline model-sharing BIM exchange workflow.

We can summarize the BIM Designers workflow as following:

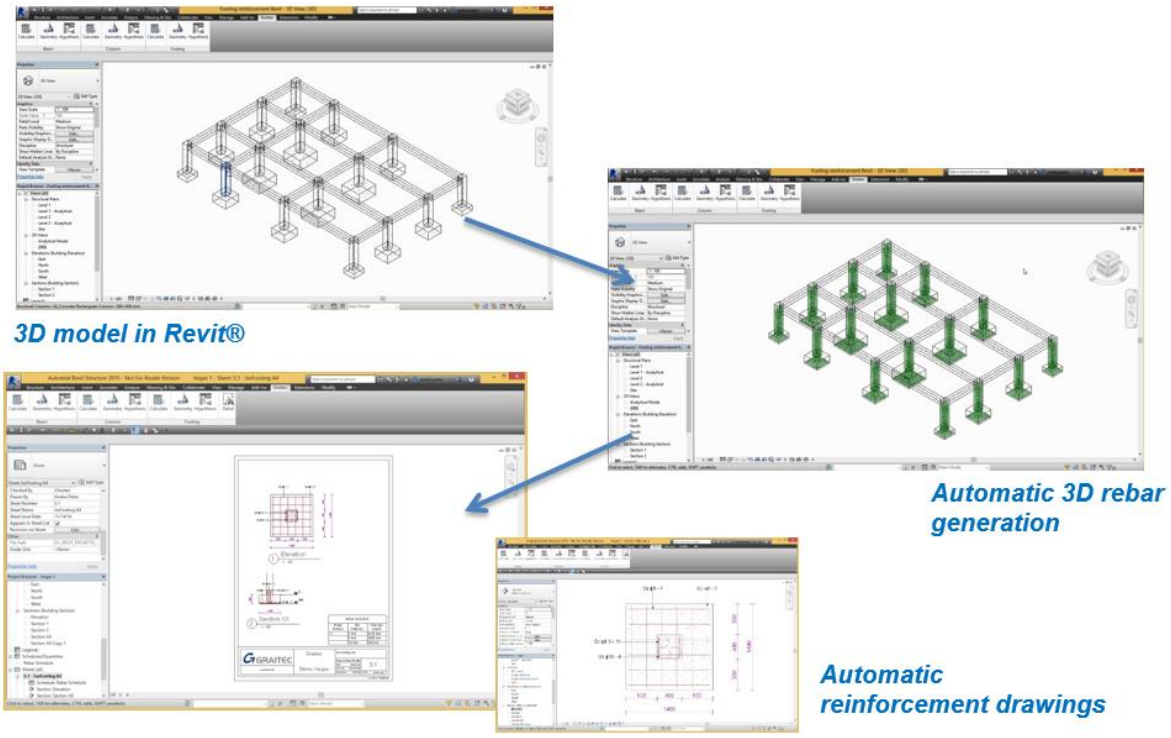
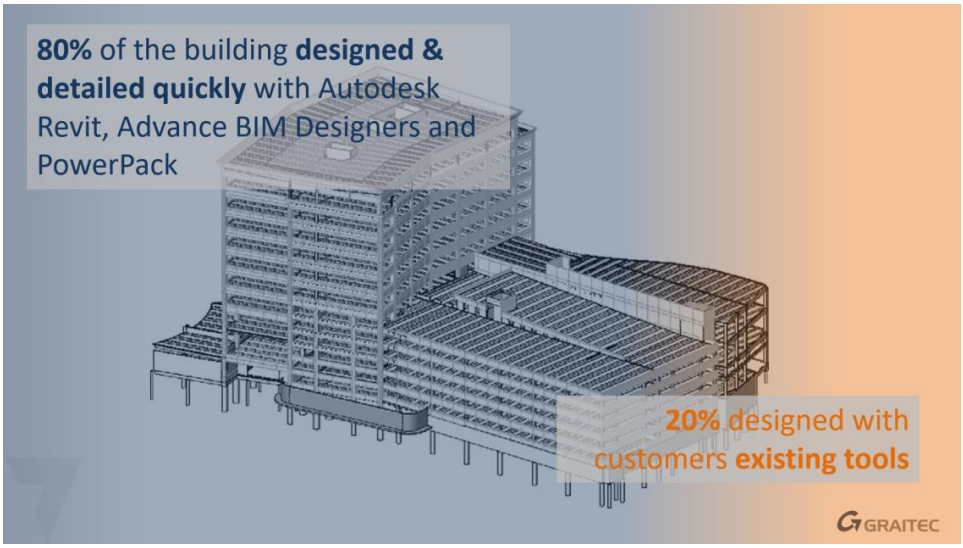


FIGURE 14: BIM DESIGNERS IN REVIT®

Even if this definition is limitative comparing to the all BIM Designers capabilities…

If you remember well the beginning of this class handout, we said that on a standard building, we can automate the production of 3D rebar cages on 80% of the building:



That's the purpose of the BIM Designers!

What are the benefits of applying a BIM Designers module within Revit®?

Using the BIM Designers in Revit® does not change or make your workflow in Revit® more complex. On the contrary, they provide the Revit® user with increased productivity for 3D rebar cage creation and 3D reinforcement drawings, taking care of:

- The design of the elements and automatic generation of the corresponding 3D rebar cage. The tools generate native Revit objects!
- The automatic creation of technical documentation: design reports, details Revit® views, drawing sheets, annotations and bar tags…
- The enrichment of the BIM model in Revit Structure® with the consolidation of the entire engineering data.

These modules are integrated in Revit Structure® and all the corresponding functions are available from a specific ribbon called “GRAITEC Concrete design”

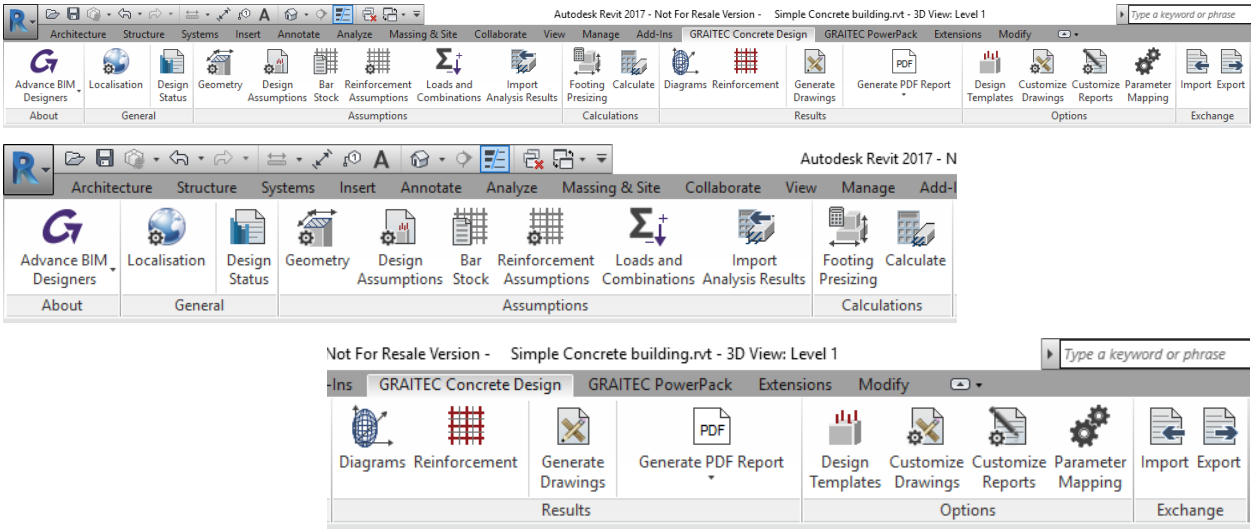


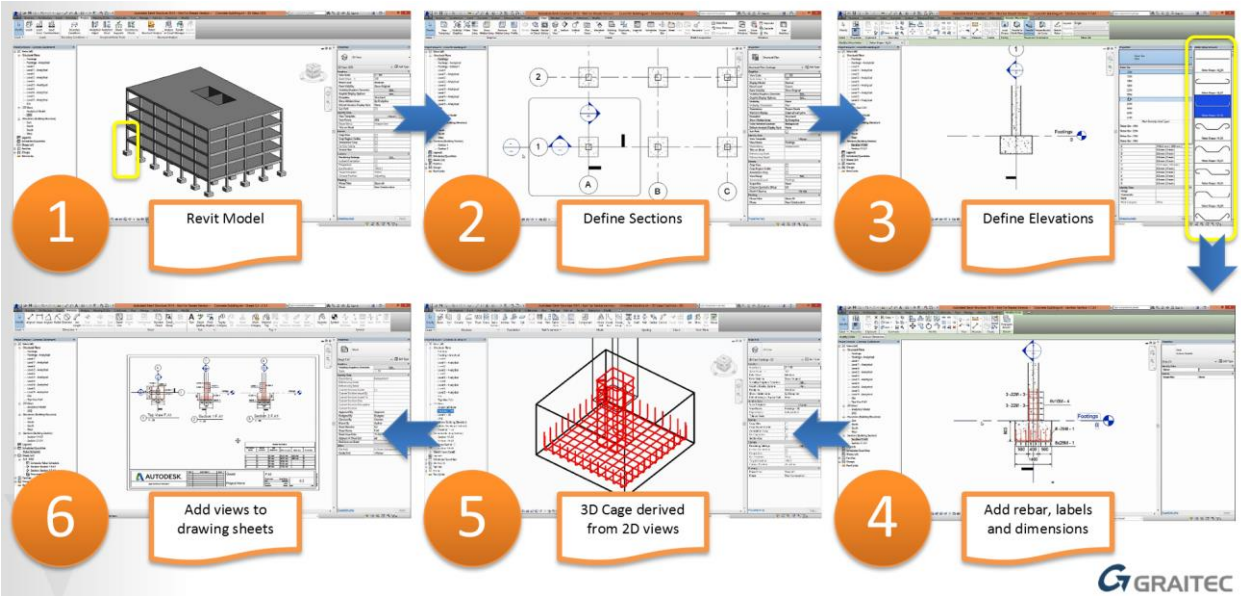
FIGURE 14: SPECIFIC BIM DESIGNERS RIBBON IN REVIT STRUCTURE®

Nothing is magic and coming from the hat! To automate the production of the 3D rebar cages in Revit®, the BIM Designers are embedding the reinforced concrete design within Revit®. Going through the BIM Designers ribbon, you will be able to:

- Define the concrete design assumptions (code dependent) within Revit®!
- Define the reinforcement assumptions, which are also partially design code dependent.
- Run the calculation of the concrete members and access to the design results: detailed reports, diagrams, working ratios, warning and error messages…
- Produce the Revit® detail views and drawing sheets applying your Revit® drawing templates.

I ‘am sure that you start to see the productivity increase you can get using the BIM Designers within Revit®!

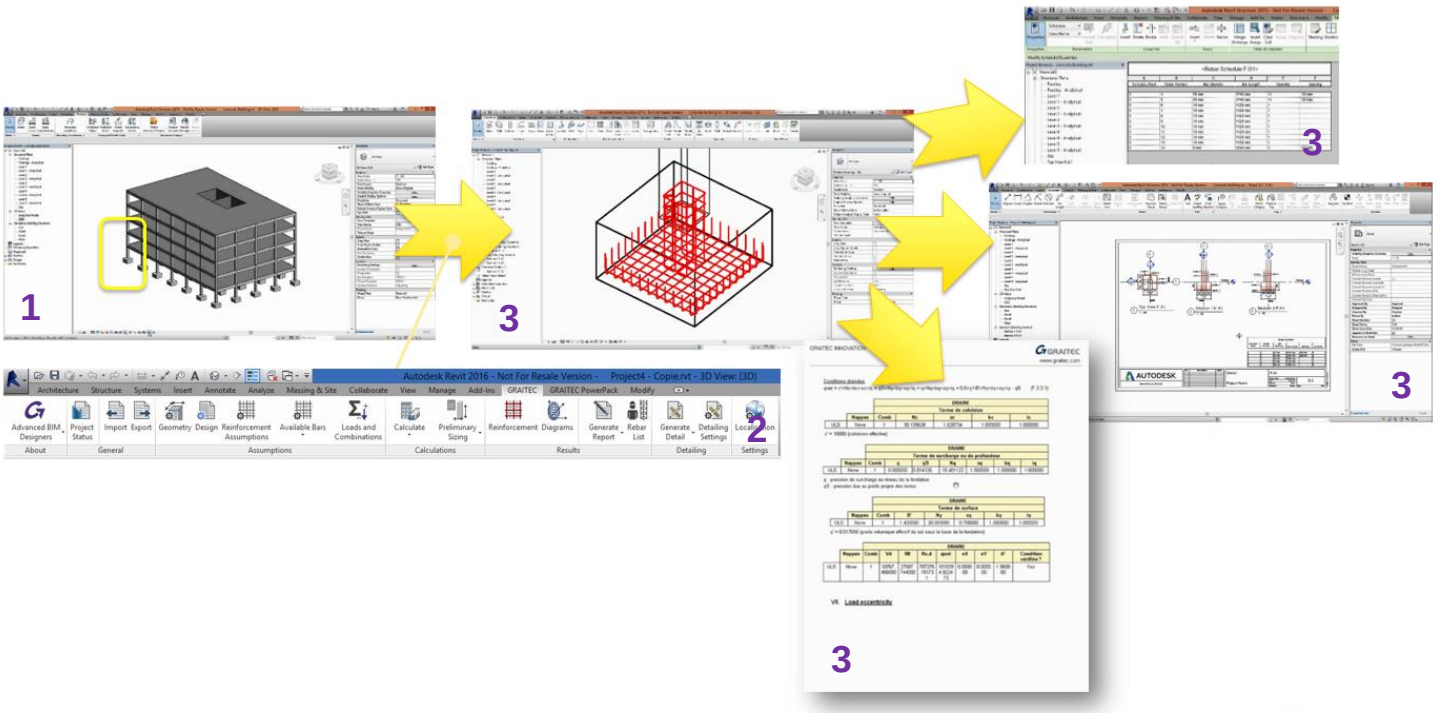
Let's remind ourselves of the 'standard' workflow to create 3D rebar cages and reinforcement drawings using the existing tools in Revit Structure®:



1. Let's take the example of an isolated footing from a 3D model in Revit®. The objective is to create the 3D rebar cage and the corresponding drawing inside this structural element.
2. First, we have to create several 2D views (sections, elevations, callouts, etc.) around the element.
3. Then working on those different 2D views, we can start to place reinforcement bars using the Rebar Shape Browser in Revit®. Of course, as you know, to create all the bars, we need to switch several times between the different 2D generated views.
4. We also have to place in the different 2D views, all the tags, annotations, dimension lines, etc.
5. At the end of this process, we have the final 3D rebar cage completed for the corresponding structural element.
6. The final step is to create a drawing sheet, include in it the different 2D views, defining the right position and the right scale.

The complete process can take quite a few minutes depending on the complexity of the elements to be reinforced. Of course, we have to repeat this work for every element to be reinforced. This is incredibly time consuming and not the most interesting part of the job for a draftsman!

Our proposal with BIM Designers is not to change this workflow with a 'standard' Revit® workflow, but to automate it:

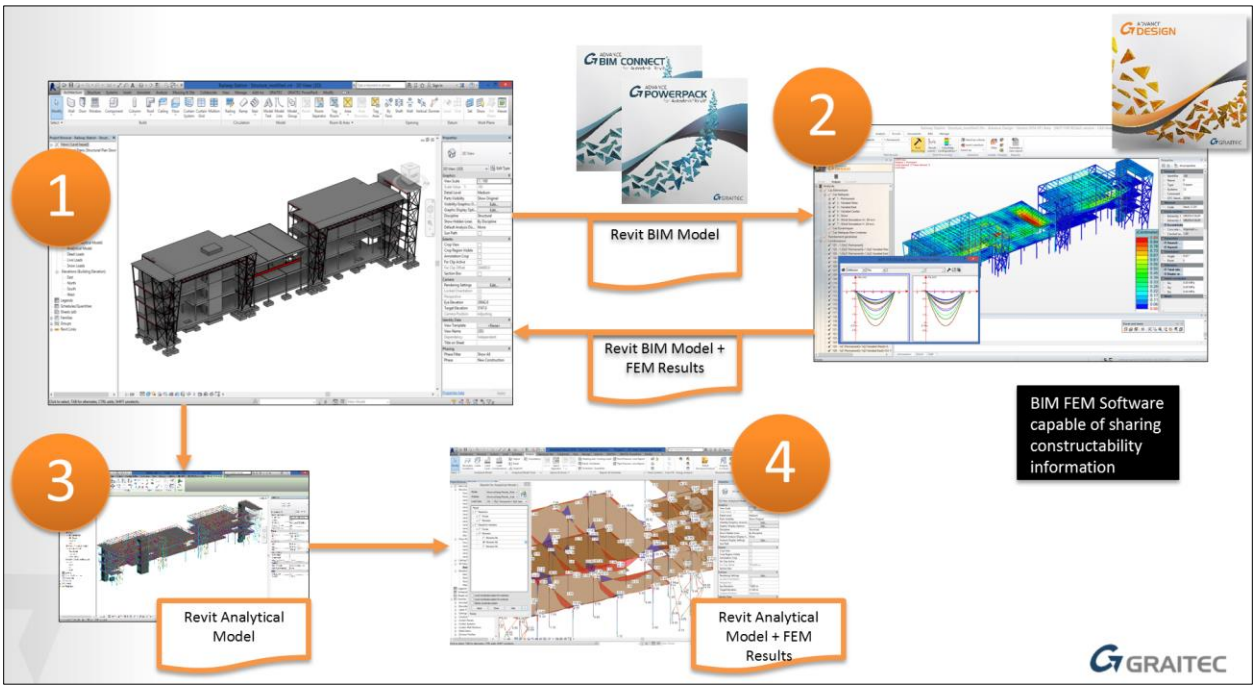


1. We can take the same example as before - we want to create the 3D rebar cage on an isolated footing and produce the reinforcement drawings.
2. To do this, we just need to access the specific 'BIM Designers' ribbon and run the calculation of the element.
3. Then you automatically get the design-driven 3D rebar cage, the corresponding detailed calculation report, the automatic creation of the requested 2D views, the bar schedule and the final drawing sheet of the element.

With BIM Designers, you can do this with just one click - and a job that takes several minutes to do with standard Revit Structure® tools will take just a few seconds! Just imagine the huge increase in productivity you will get. That's what we call; 'innovative technologies for the service of users!'

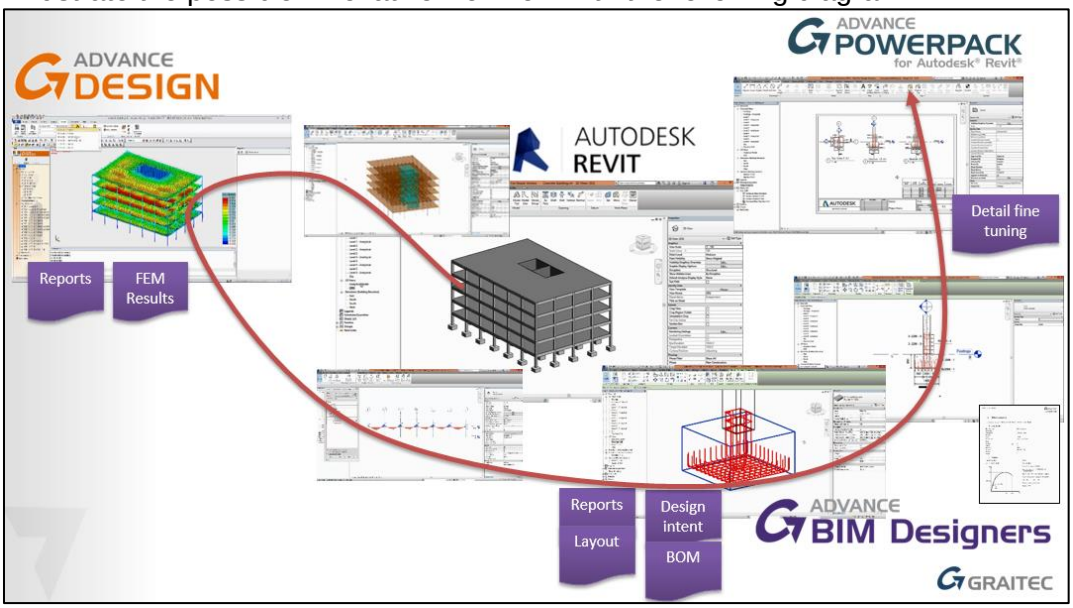
The global process including FEM results.

Just remember that we previously that the possibility to store the FEM results within Revit® using the Autodesk Structural Analysis Toolkit.



To be honest, when I discovered this possibility for the first time, I did wonder why. What is the benefit of storing the FEM results in the Revit® model? For what use?
Now if we put BIM Designers in the picture, you suddenly realize that it really make sense and brings to life an effective and easy-to-apply workflow for my reinforcement generation in Revit®. That's completely part of the ***Future of making rebar!***

We can illustrate the possible innovative workflow with the following diagram:



- We start the workflow in Revit Structure® where we can manage\define the analytical model in real time according to the descriptive model.
- We export the Revit® model to a 3D FEM system which can be RSA (Robot Structural Analysis) or Advance Design. In the FEM system, we can run the calculation, post process the FEM results, generate reports and send the FEM results back to Revit Structure®.
- From the FEM results stored within Revit®, we can start to design the structural elements with the BIM Designers modules and automatically get the 3D rebar cage, the design reports, the 2D views with tags-annotation-dimensions and the final drawing sheet.
- Of course, all the automated processes have limits and this is why we can also use the GRAITEC PowerPack for Revit® to fine-tune the 3D rebar cage. Later on in this document, we will say a few additional words about this PowerPack.

The multiplatform approach

In order to fully appreciate how the BIM Designers can improve the workflow of the design of reinforced concrete structures, it is important to keep in mind what I mentioned there before:
The GRAITEC BIM Designers modules are multi-platform compliant!

This means that different people in an engineering company can use the same design modules and share the corresponding model and data, even if they are working in different applications: Revit®, Autodesk® Advance Steel, Advance Design, or even as a standalone solution.

This is a unique adaptive technology dedicated to the AEC market!

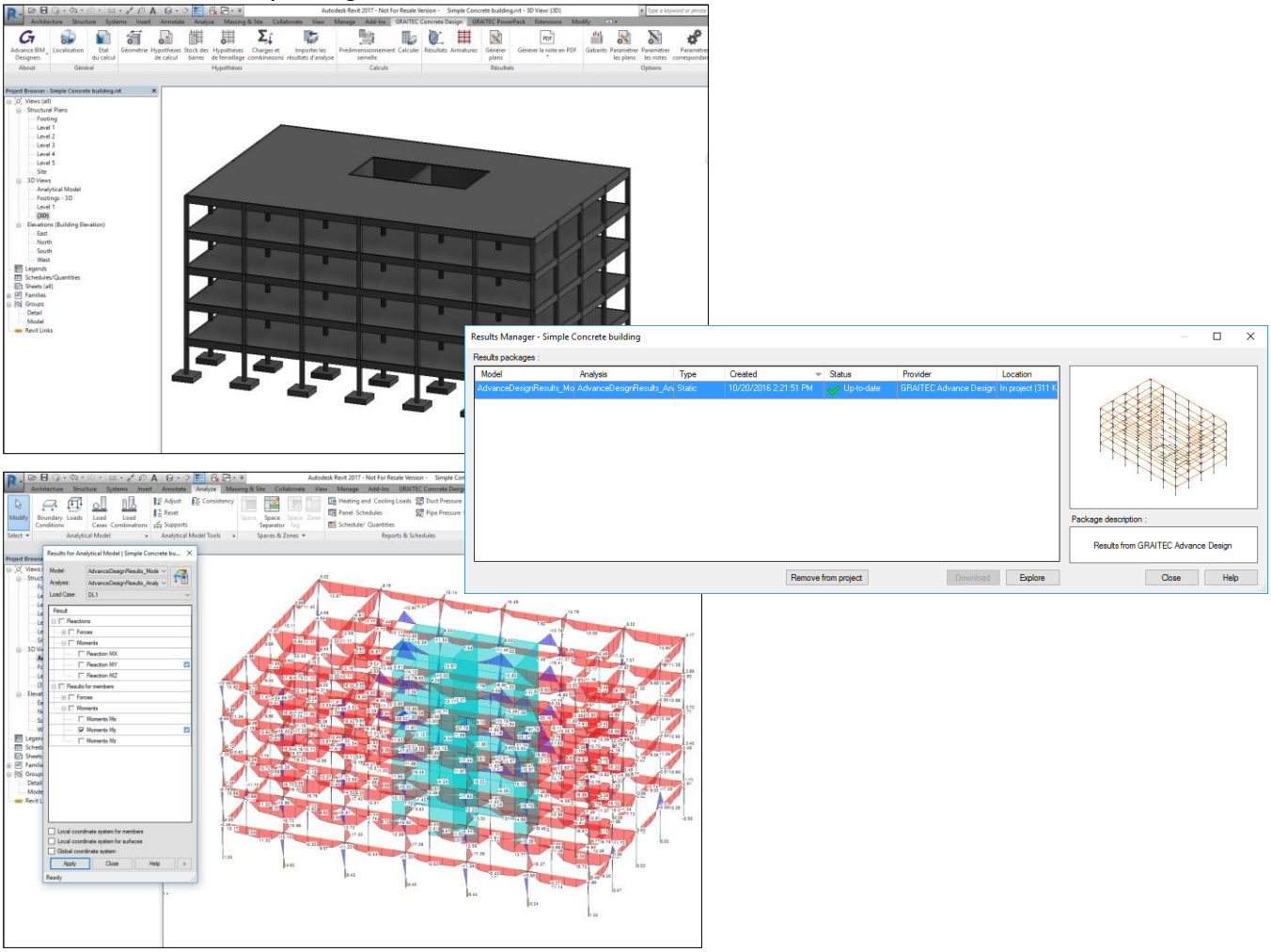
This flexibility makes the system adaptable to different workflows depending on your company's preference, process and workflow or project type, for example:

- The engineer (or the draftsman) wants to create and manage the concrete design directly in Revit® (this is the workflow we previously described in this technical note). In this case, we can see that the Revit® user has the possibility to enter the loads manually or re-use the internal forces calculated by the FEM application (again as described in a previous chapter).
- Alternatively, the engineer could import the Revit® model into Advance Design (as described above) and use the native tools or the same BIM Designers in the FEM application to take design decisions and validate the design. Then transfer the project to the draftsman who, re-using the same data in Revit®, produces the final drawings (as the bars are already generated by the BIM Designers in Advance Design).

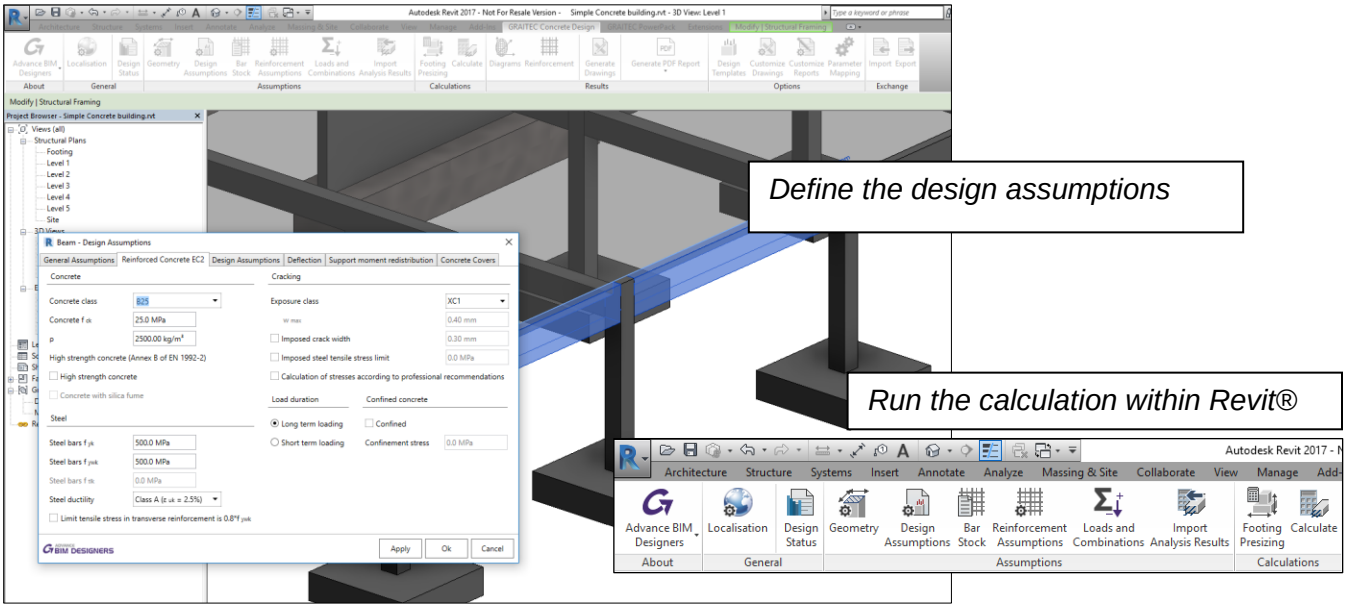
As you can see, the adaptive BIM Designers technology will help you on the transition from your current workflow to a full connected BIM workflow.

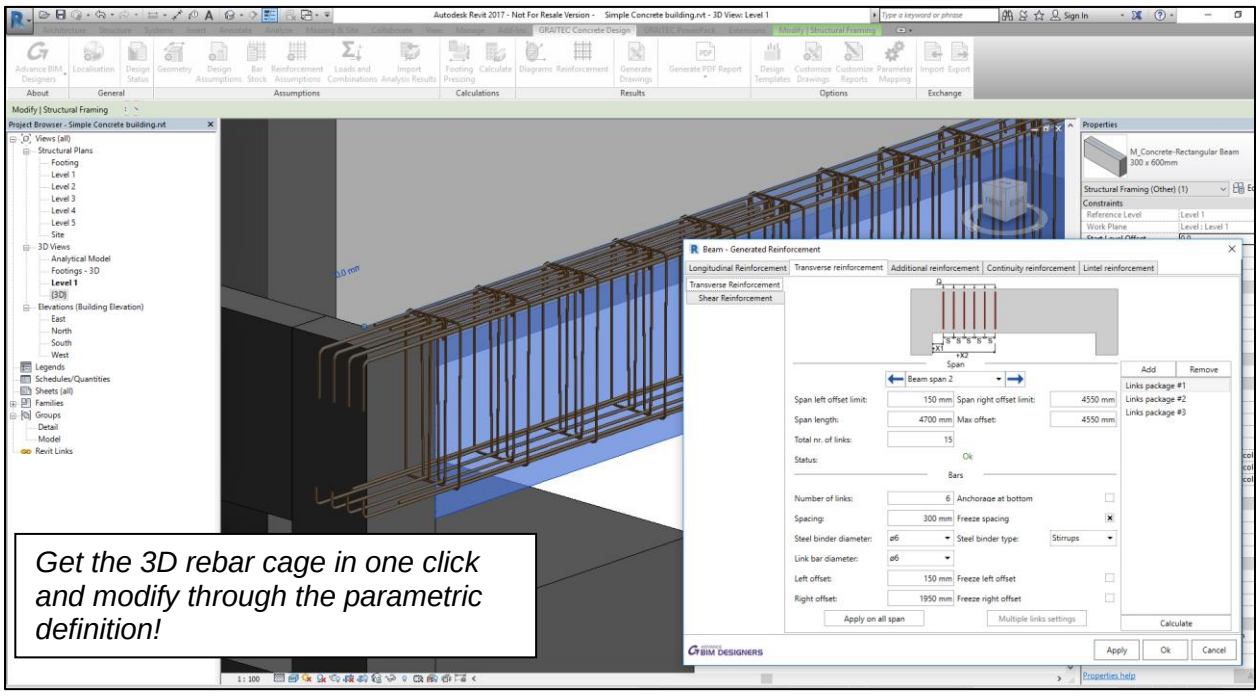
Let's illustrate this multiplatform concept with a simple example, on which we want to reinforce a beam:

- We start from a Revit® model having already a set FEM results. As we saw here before, those FEM results can be produced by any FEM software able to save the results in a Revit® results package:

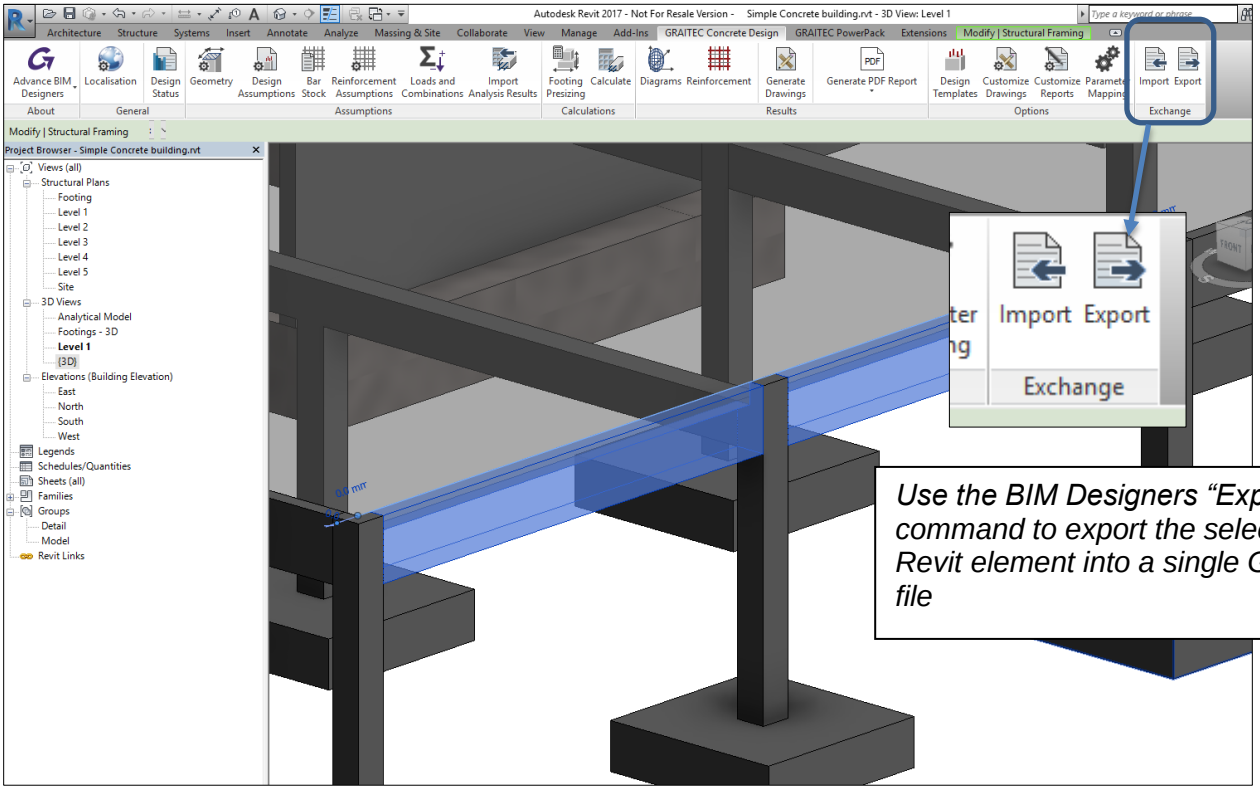


- The 1st possibility you have is to design the element within Revit®. Just select the element, push the calculation icon (after having defined the design and reinforcement assumptions) and you will get the 3D rebar cage:



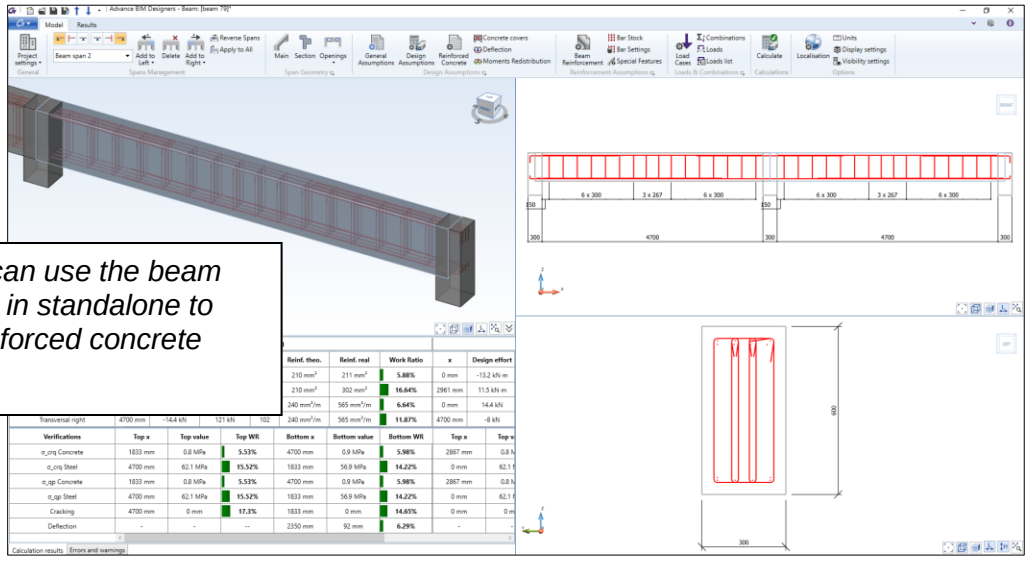


- The 2nd possibility is to design this element outside Revit, either using the BIM designer module as a standalone tool, either using the module within the FEM system, Advance Design => this possibility is really important in case of a multi-user workflow:
    - The draftsman export from Revit® the beam with its geometry and internal forces (coming from the Revit® results package):



Use the BIM Designers "Export" command to export the selected Revit element into a single GTCx file

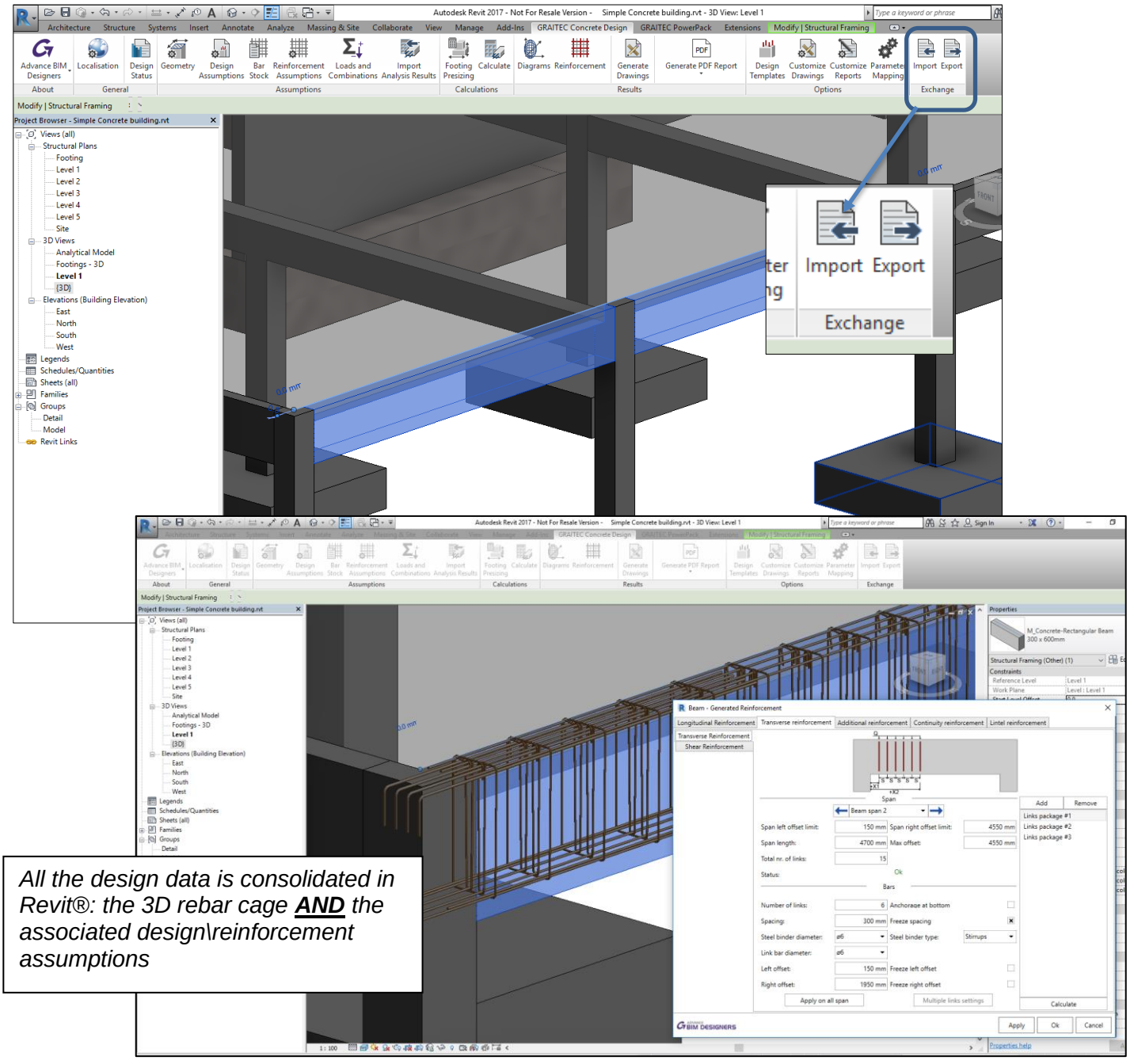
    - The engineer can open this file in the standalone design tool, change the design parameters, the reinforcement parameters, the geometry of the beam based on design-driven decisions:



The engineer can use the beam design module in standalone to design the reinforced concrete member.

- Back in Revit®, the draftsman wants to import the job done by the engineer. Not only the 3D rebar cage and the all set of information coming from the engineer who did his job on his side: the design assumptions, the reinforcement assumptions, the geometry, the 3D rebar cage…

  The Revit® user can achieve this, using the [Import] command from the BIM Designers ribbon:



*All the design data is consolidated in Revit®: the 3D rebar cage **AND** the associated design\reinforcement assumptions*

Tip: *We are reaching here a very important point of the structural BIM connected workflow: we cannot speak about BIM just ignoring that the different stakeholders of a project are using different tools, handling different type of data and there is clearly a need to consolidate all this information into a single BIM model handled by Revit®.*

That's the purpose of the GRAITEC BIM Designers technology!

Revit® embed all the 3D rebar cages AND all the associated design and reinforcement assumptions. Later in the project conception cycle, the Revit® will have all the requested information in order to update the 3D reinforcement model in case of any change on the project.

In the next pages of this class handout, we will go more in details on how the BIM Designers work.

Revit® parameters mapping

As we can see, the only way to automate the 3D rebar cage creation is to embed the design capability directly in the BIM application. This is the differentiating principle GRAITEC is introducing with the BIM Designers modules working on top of Revit®. Considering the previous steps, the Revit® model includes the forces on each element originating from the FEM calculation. The BIM Designers will start from the Revit® geometry and the stored FEM results, give you the possibility to define the additional requested parameters and handle the reinforced concrete design.

The difficulty of the integration of such modules in Revit® is the parameter's mapping: the BIM designers module must be able to read the Revit® parameters already define and complete them with the missing ones. The complexity is the 'Family' concept in Revit® where the user can create his own families with specific parameters and names, while on the other hand, the BIM Designers have their own set of parameters to be define.

By default, GRAITEC is providing a parameters mapping database which is compliant with the 'standard' Revit® families, depending on the country installation settings: Europe, US, Generic ones:

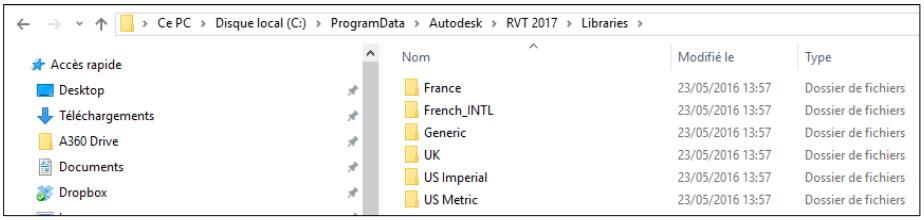


FIGURE 15: DEFAULT REVIT® INSTALLED FAMILIES COUNTRY DEPENDENT

Then, from the '*Project Status*' dialog, the user can access to a detailed mapping dialog just clicking on the '*Mapping*' icon:

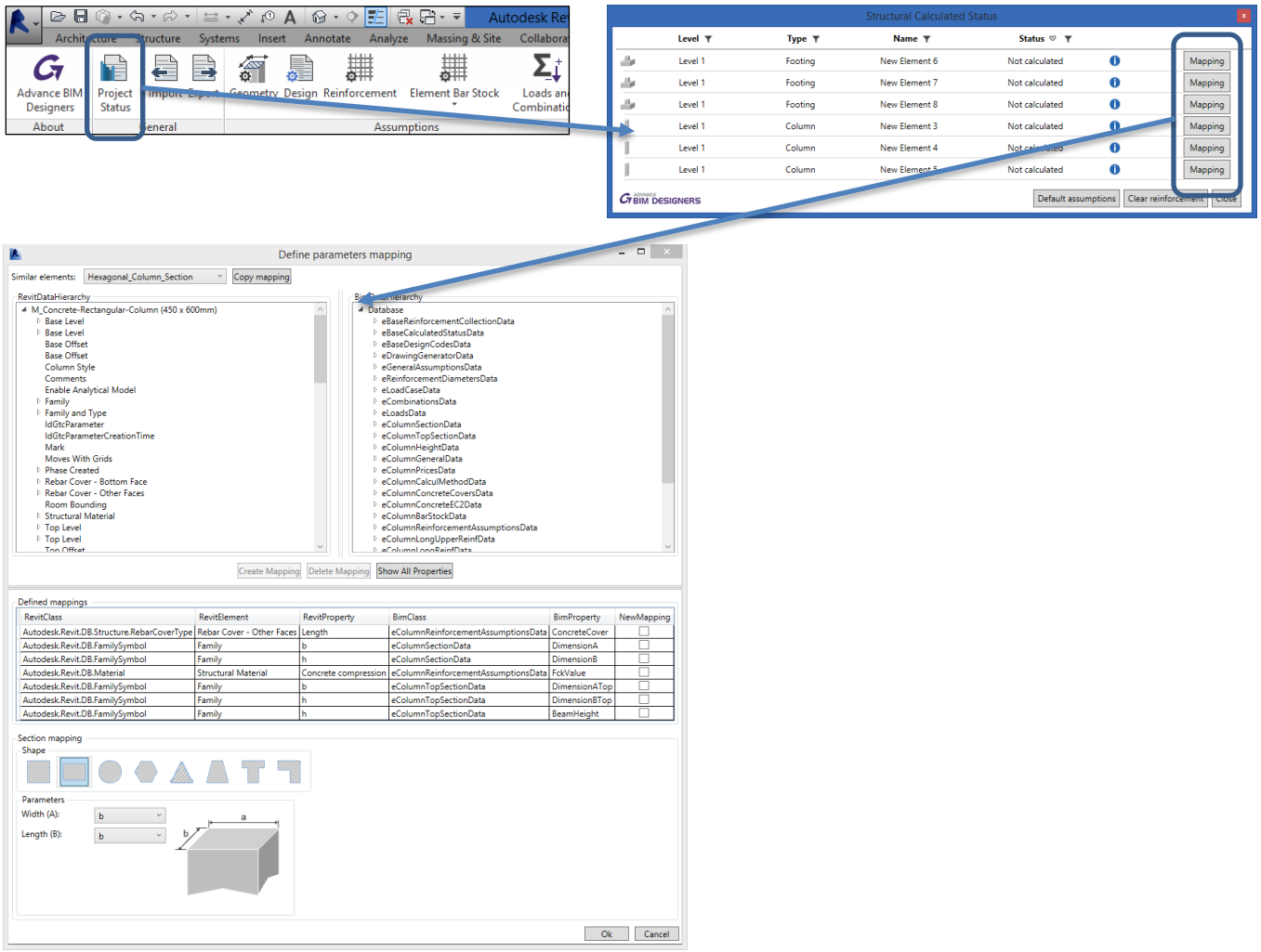
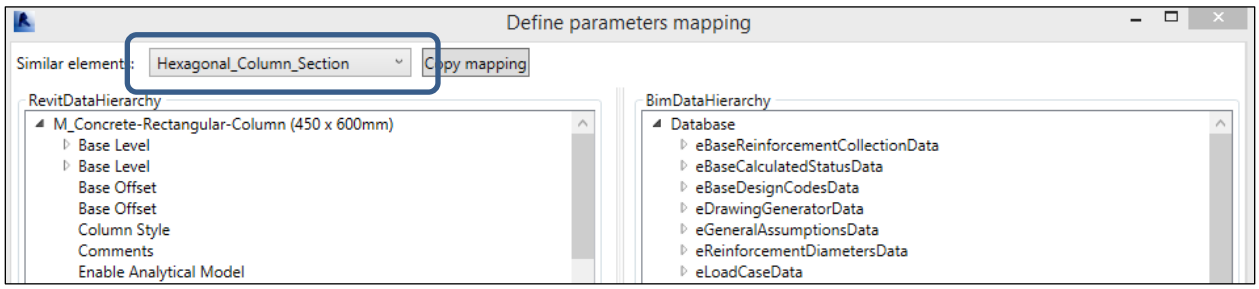


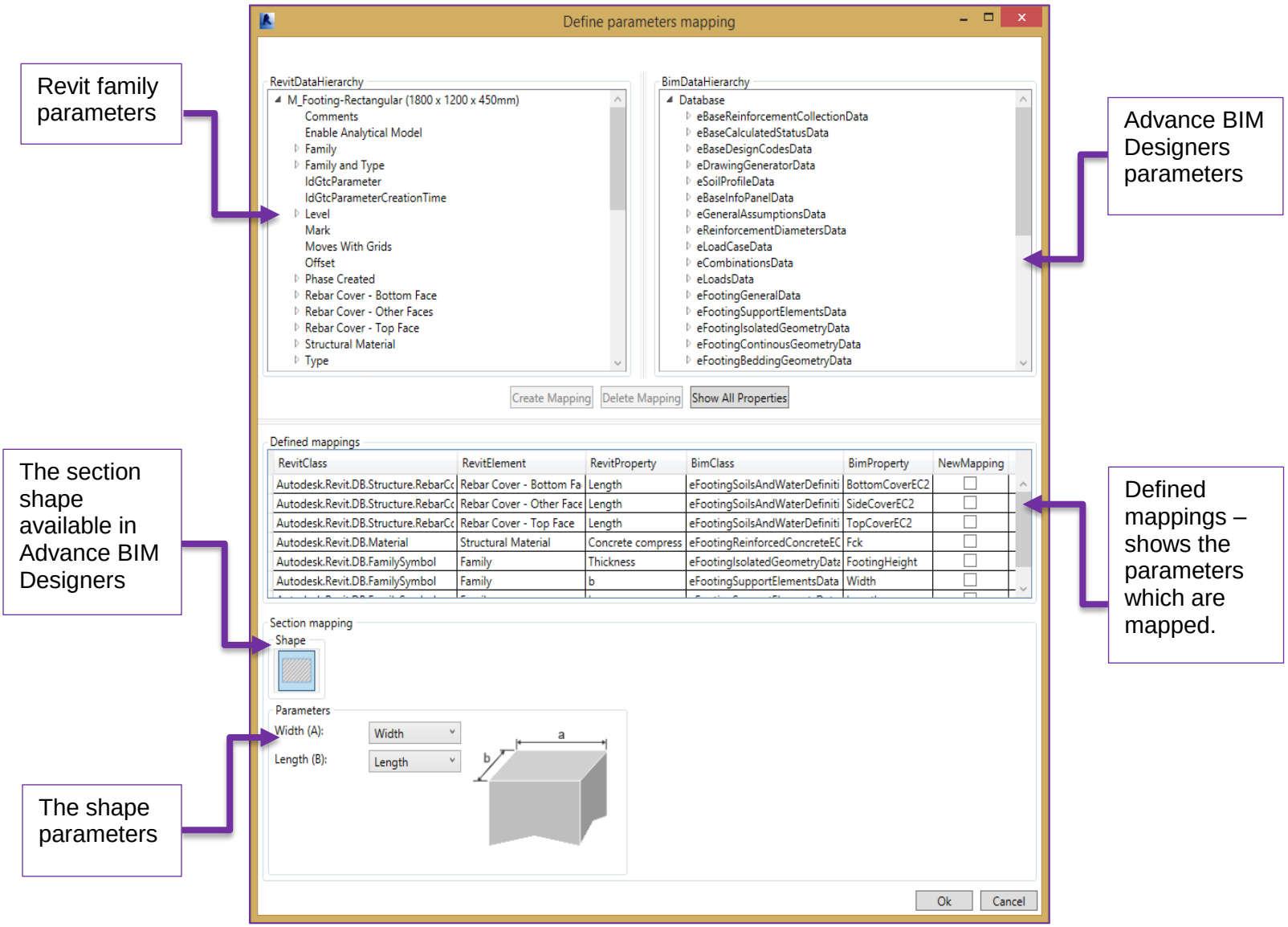
FIGURE 16: PARAMETERS MAPPING DIALOG

This dialog is initialized with the Revit® family corresponding to the element you choose in the '*Project status*' dialog but allows you to map the parameters of different Revit® families, just selecting on the top the family you want to work on:



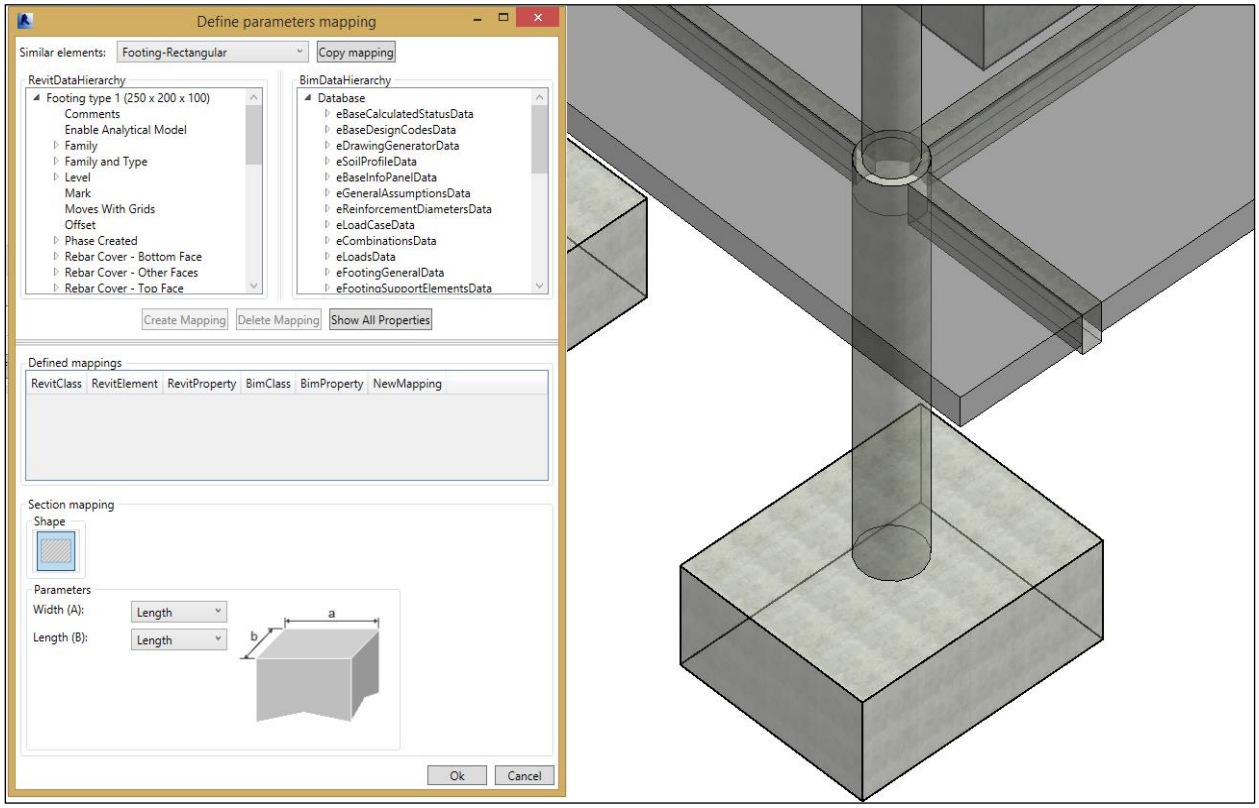
I must admit that this dialog is not so easy to use but is really powerful. It makes the BIM Designers modules working on any user Revit® family. Let's discover these options in more detail.

Advance BIM Designers will come with the default mapping for standard Revit® families. The organization of the mapping dialog is the following:

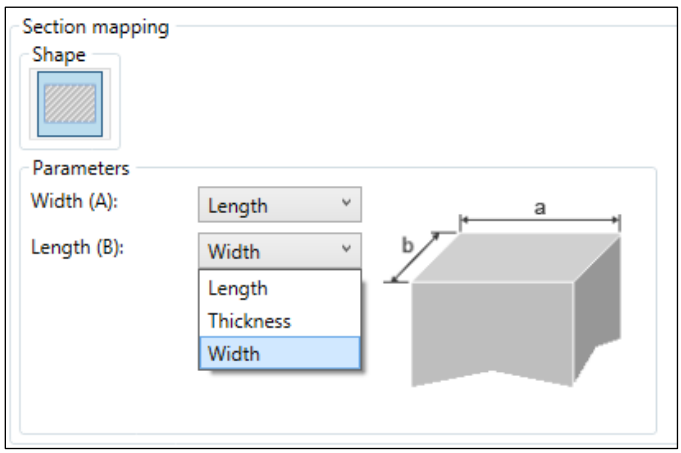


For the Revit® user families, Advance BIM Designers will automatically display the mapping dialog, as those families will not have a default mapping. The dialog will pop-up at the first BD command used on an element without mapping.

As an example we will map some Revit® user families for a footing and a circular shape column.

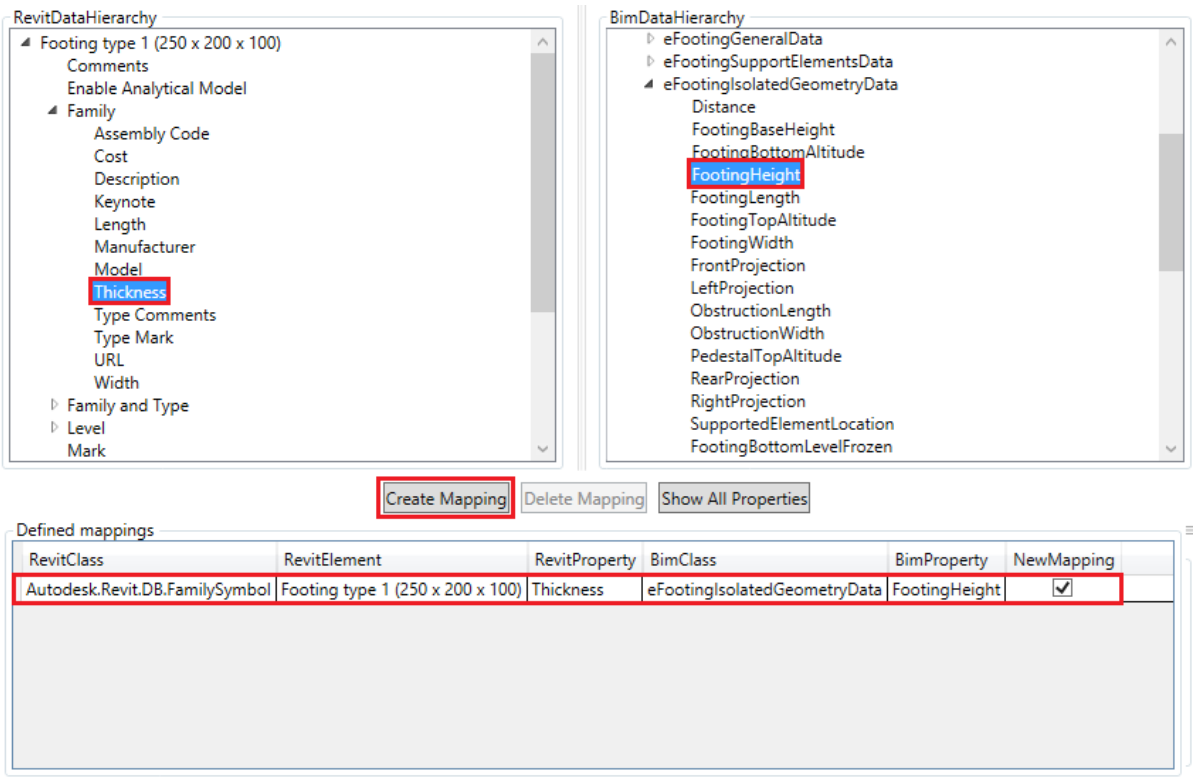


The first step is to select the shape of the footing section and to map the parameters that define the section dimensions.



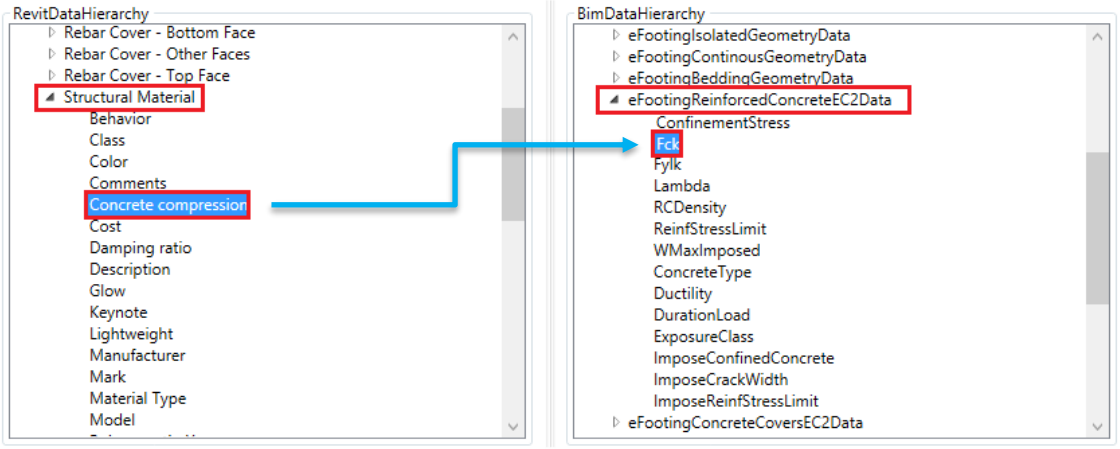
> ***Note*** *The thickness of the footing is not mapped here as this parameter is not a native Revit® parameter for the Structural Footing category. This will be mapped as a user parameter.*

In the '*RevitDataHierarchy*', search the parameter that needs mapping. Then search the corresponding parameter from Advance BIM Designers in the 'BimDataHierarchy'. Once the match is found, click '*Create Mapping*' and the new line will be added in the Defined mappings dialog:

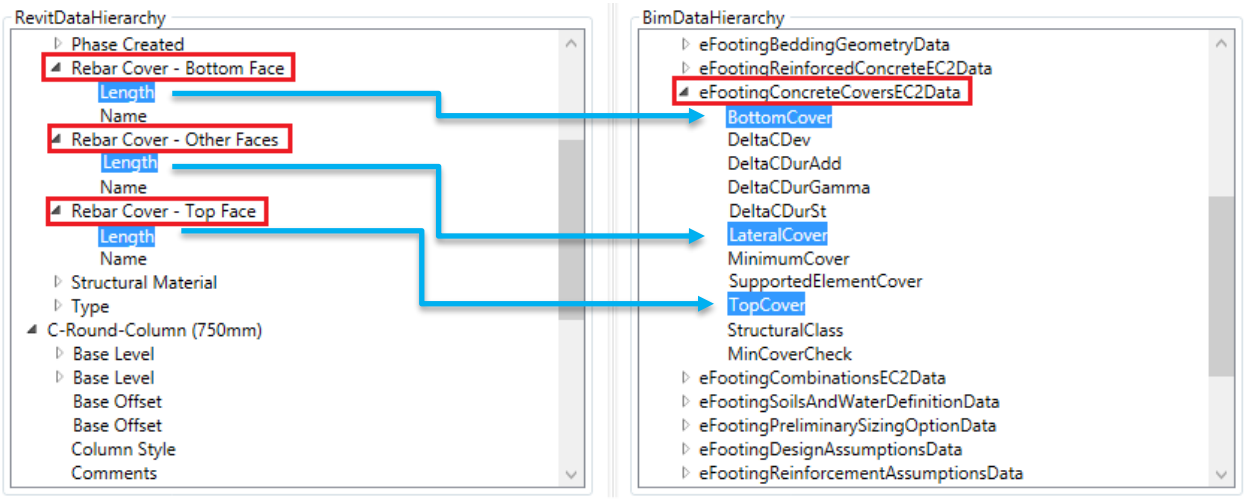


Beside the parameters that define the section dimensions, a mapping must be defined also for the material, the rebar cover and the adjacent elements geometry, which in the case of the footing is the column above (the supported element).

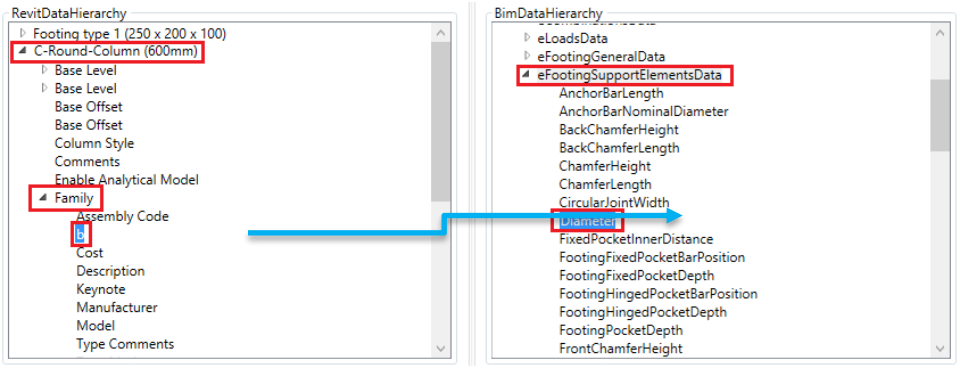
Material properties



Rebar covers



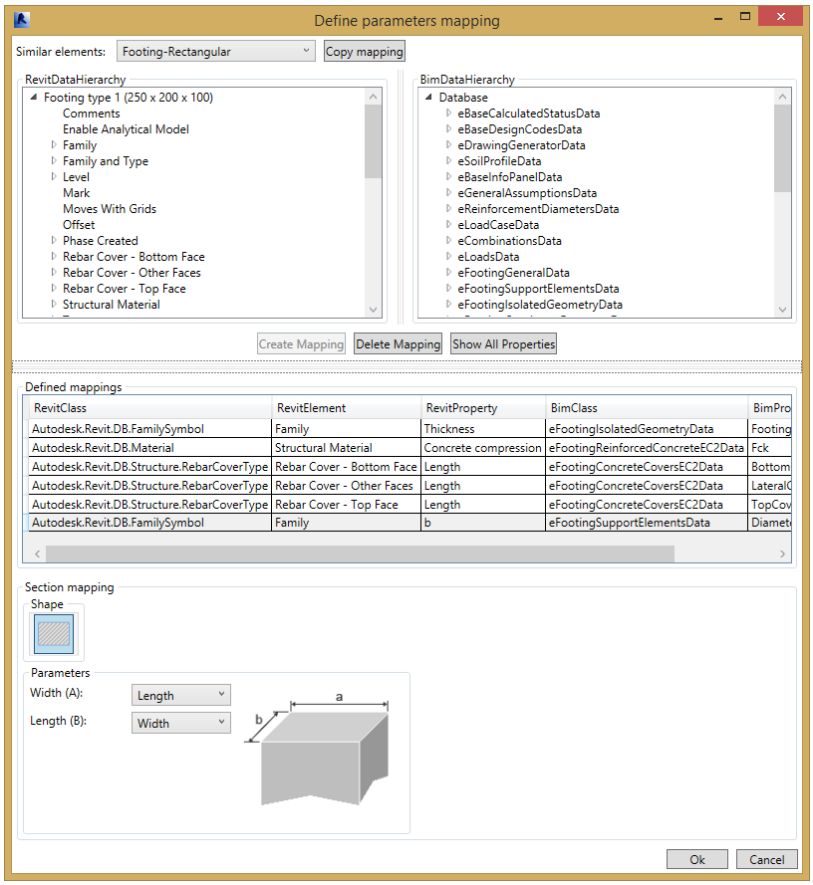
Supported element – circular column



Once you close the dialog with '*OK*', the mapping is saved automatically in 3 XML files which are stored here: 'C:\Users\XXX\AppData\Local\GRAITEC\Advance BIM Designers\2016.2':

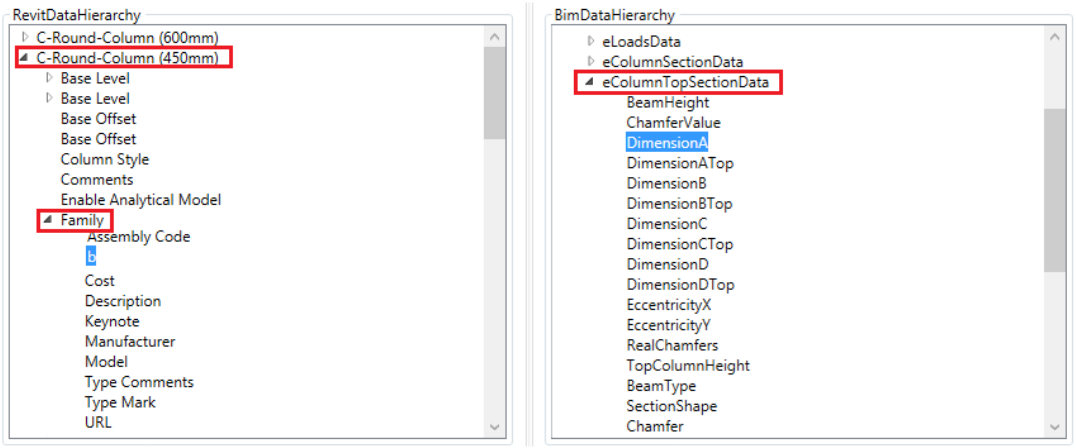
- 'FamilySymbolToShapeDataManager.xml'
- 'RevitParametersDatabase.xml'
- 'ShapeDataToBimObjectManager.xml '

Therefore the mapping will be used for all the Revit® models created with the same families.

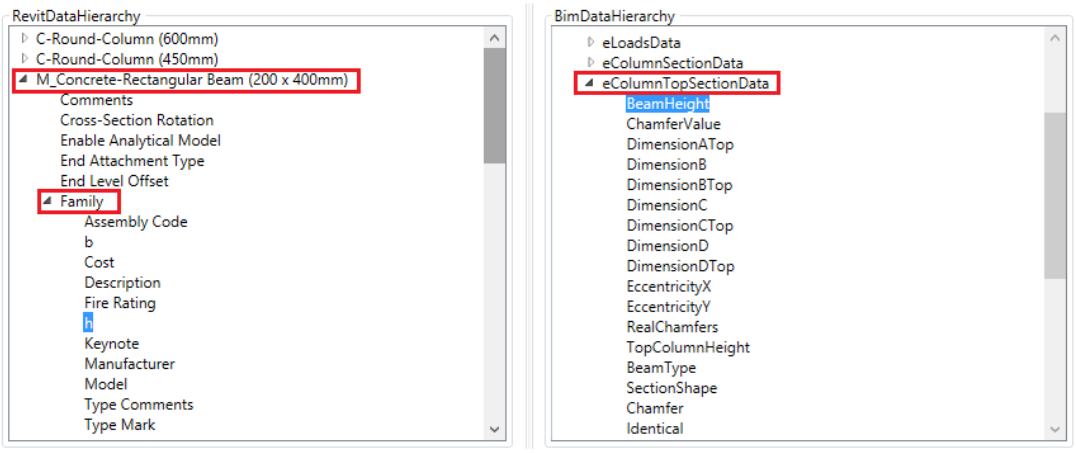


The steps applied to map the footing can be applied also for the column:

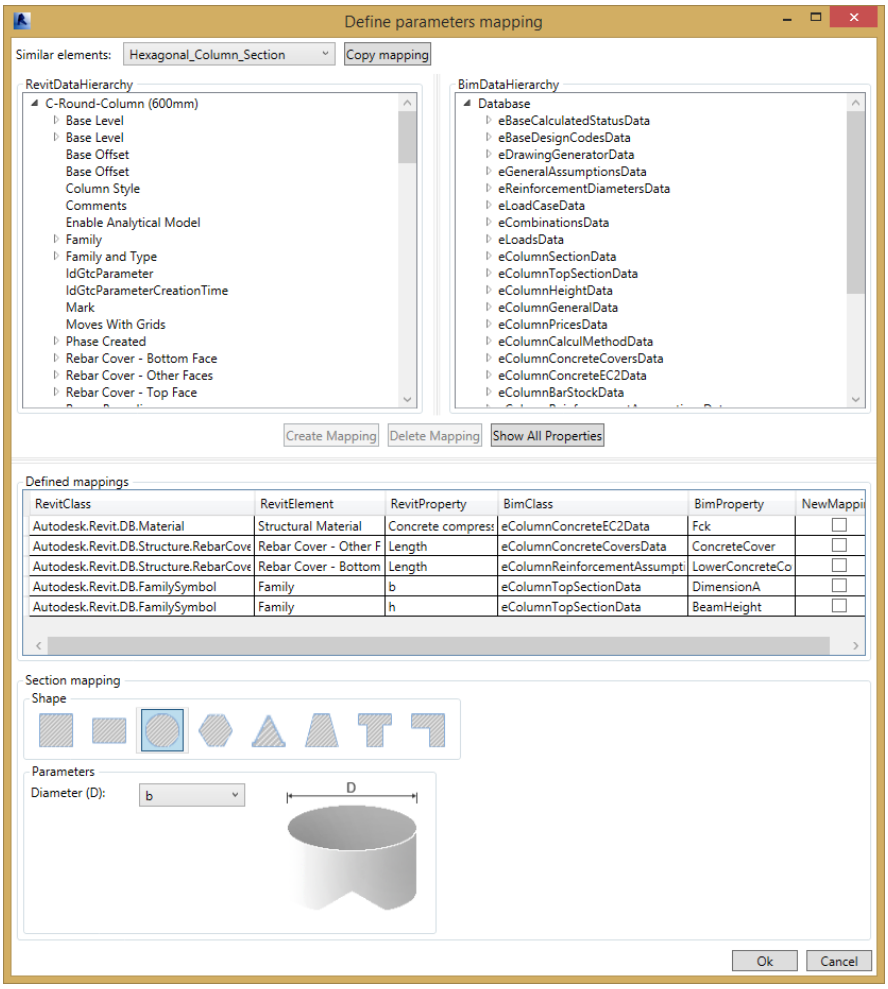
- Section shape
- Material
- Rebar cover
- Adjacent elements geometry, which in the column case can be the column above if exist and one or 2 beams, depending on the model.
- Supported element – circular column (from the level above)



Beams

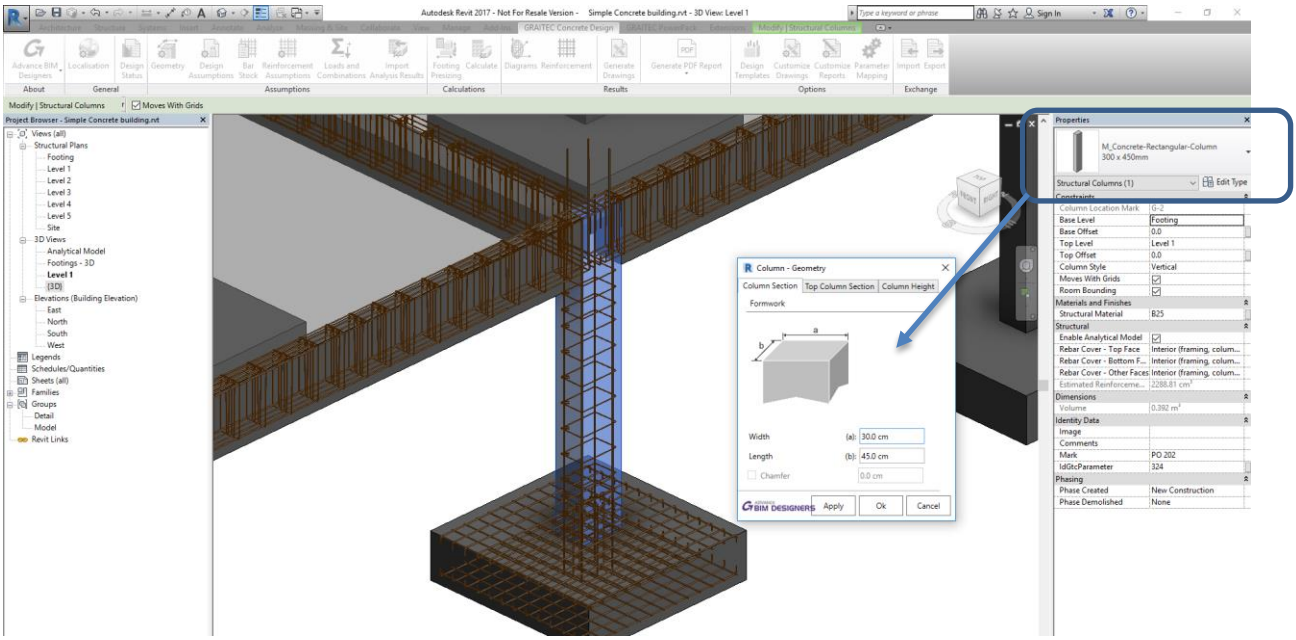


The final mapping dialog for the circular column

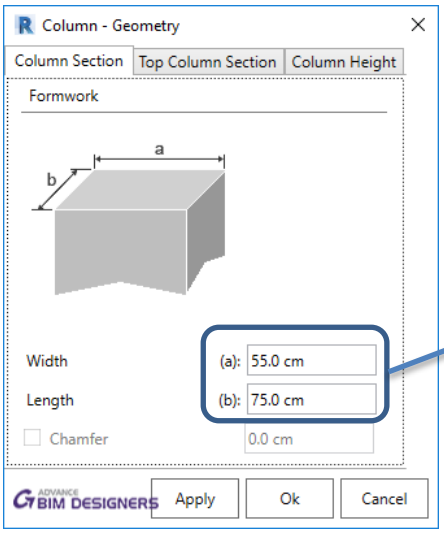


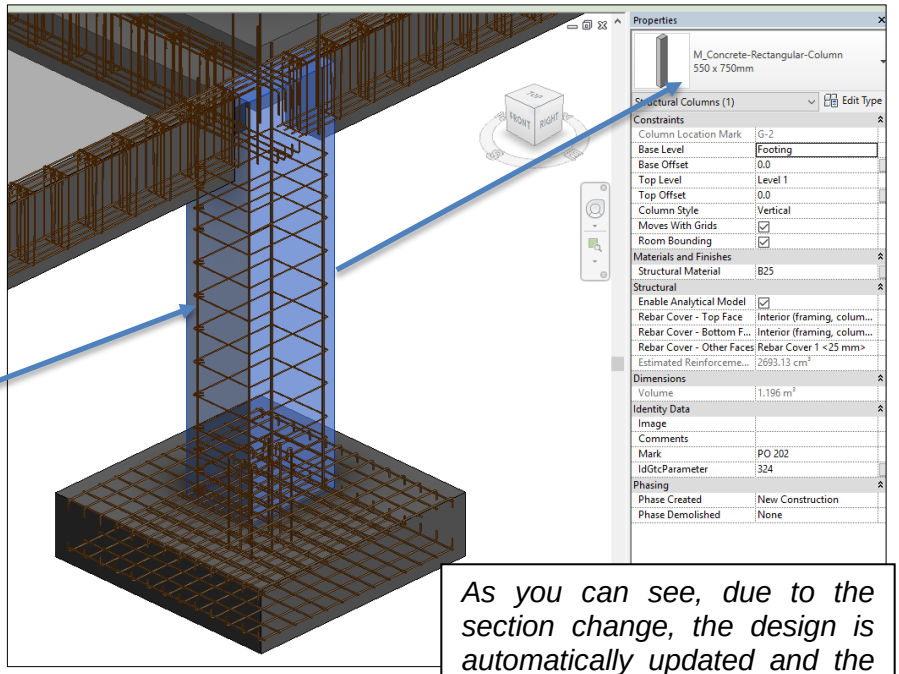
Revit® families integrated in BIM Designers

When the mapping is done, you can access the BIM Designers geometry dialogs by clicking on the corresponding icon in the 'GRAITEC Concrete Design' ribbon. For example, let's take a column:



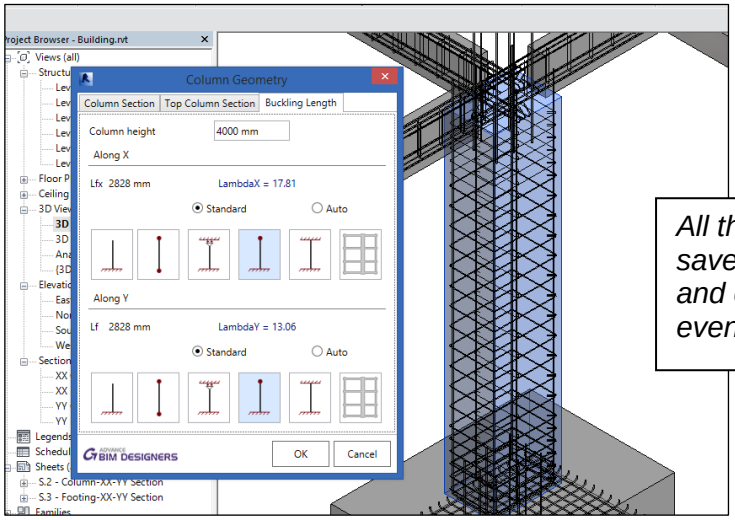
- In the displayed dialog, you can notice that the geometry of the selected column is automatically detected. If you change it here, it will create a new type in the Revit® corresponding family:





As you can see, due to the section change, the design is automatically updated and the 3D rebar cage automatically adjusted!

- In the 'Column geometry' dialog, you can also define additional parameters, not existing in the Revit® model but requested for the reinforced concrete design. That's the case of the buckling length:



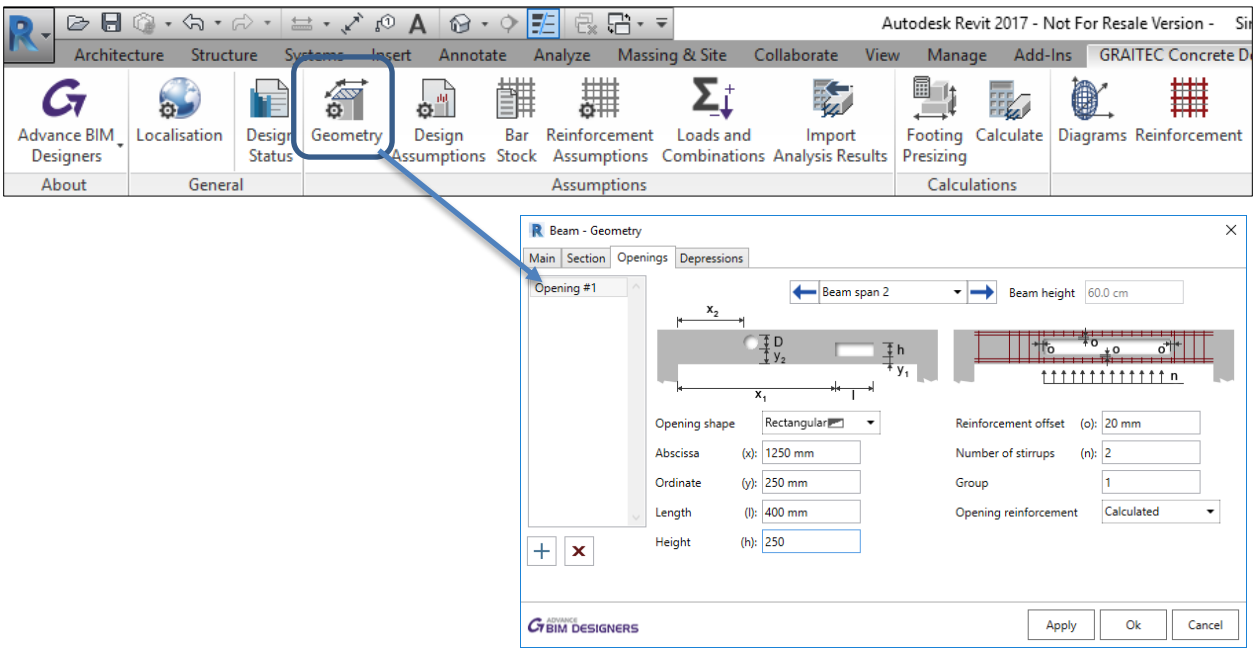
All those additional parameters are saved within the Revit® project and can be accessed any time, even by another user!

This behavior is the same for the reinforced concrete footings and beams.

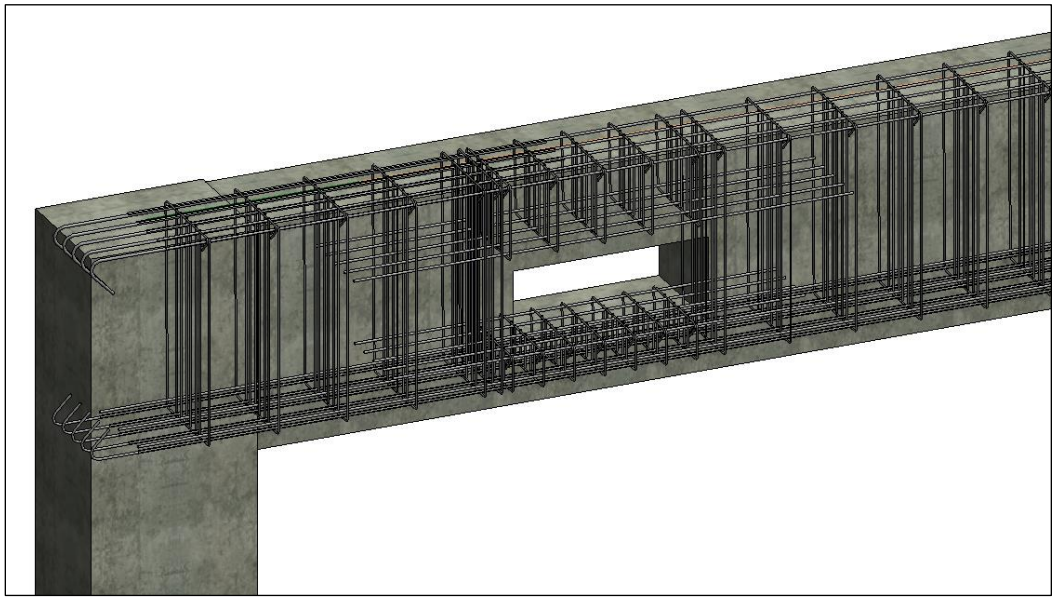
***Tip**: We can also see the BIM Designers as tools that can speed up the element's features modelling in Revit®.*

Let's take the example of a reinforced concrete beam:

- With the BIM Designers modules, when going to the geometry dialog, you can easily define openings along the same: just add one to the list, define the position and the dimensions and it is done!



You can automatically get the opening created in the Revit® geometry and the corresponding 3D rebar cage:



Design assumptions

The initial Revit® model does not, however, include any structural design assumptions. This is what is introduced with the BIM Designers. In this technical section, we are focusing on reinforced concrete footings, columns and beams, but in the portfolio of BIM applications, GRAITEC is also able to provide BIM Designers modules for generating steel structures, stairs and railings, steel connections, etc.

When the user selects an appropriate element in the Revit® 3D model, he can access the corresponding icon on the 'GRAITEC Concrete Design' ribbon from where he can manage all the design assumptions for the selected object:

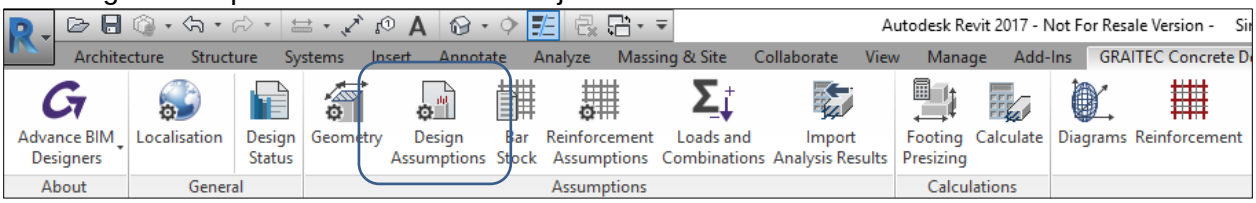


FIGURE 17: BIM DESIGNERS RIBBON IN REVIT®

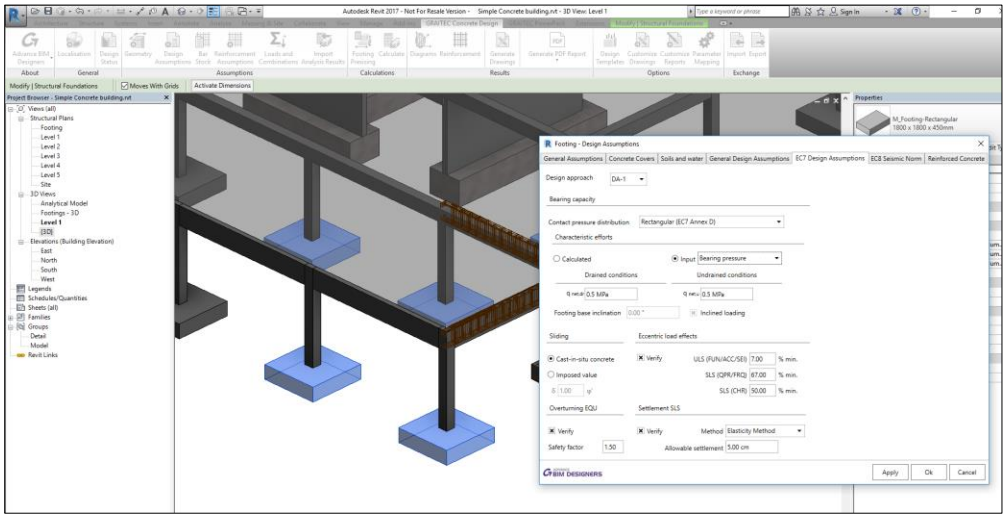
In the first version 2017 of BIM Designers, you have access to the Beams, Columns and Footings reinforced concrete design.

Let's try to list the different design parameters without being too long and dare I say boring! We can split these assumptions into two different families:

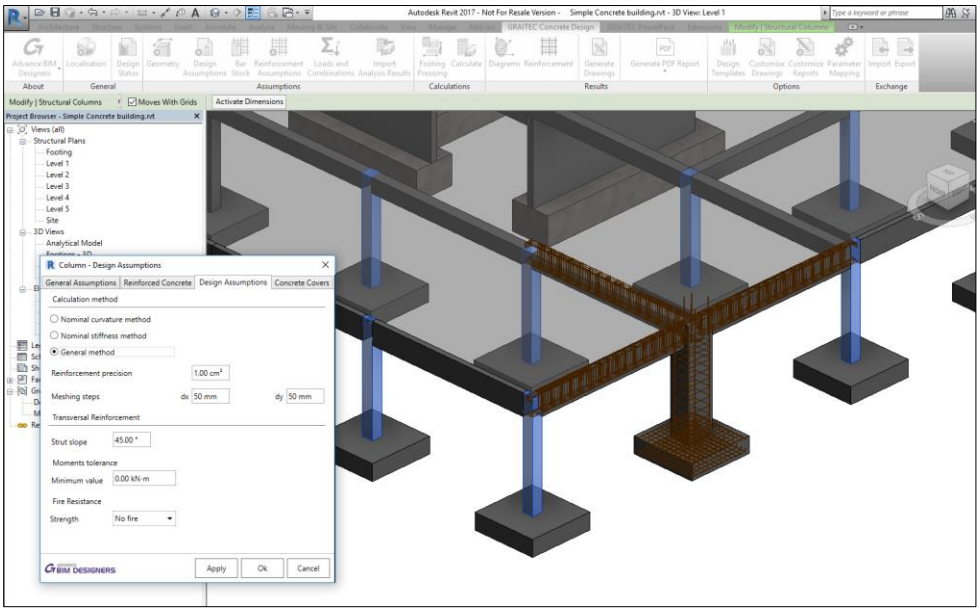
- The design codes assumptions
- The constructive dispositions for the automatic placement of bars inside the concrete members - this part will be detailed in the next chapter.

The BIM Designers are perfectly embedded in a Revit® working workflow, you create the Revit® objects as usual and as soon as you want to define the design assumptions, you select the concerned elements - depending on the type of selected elements, the BIM Designers will display the corresponding design assumptions:

- If you select one or several footings, you will get the corresponding design assumptions dialog with several tabs for the concrete design assumptions, the water table, the geotechnical assumptions…



- If you select one or several columns, you will get another dedicated dialog, using the same icon.



Of all those design assumptions, dialogs are code dependent and the user can choose between several possibilities:

- Eurocodes 1, 2 and 7 for concrete members
- National appendix for UK, GE, CZ, FR, PL, IT
- American codes
- Canadian codes

It is important to keep in mind that the BIM Designers are part of the Revit® Workflow. All this additional data which enriches the BIM model is stored within the Revit® model. You can save the project, reopen it and access it again with previous saved parameters. You can also save design assumptions templates and do not need to define those tens of options for each member, on each project.

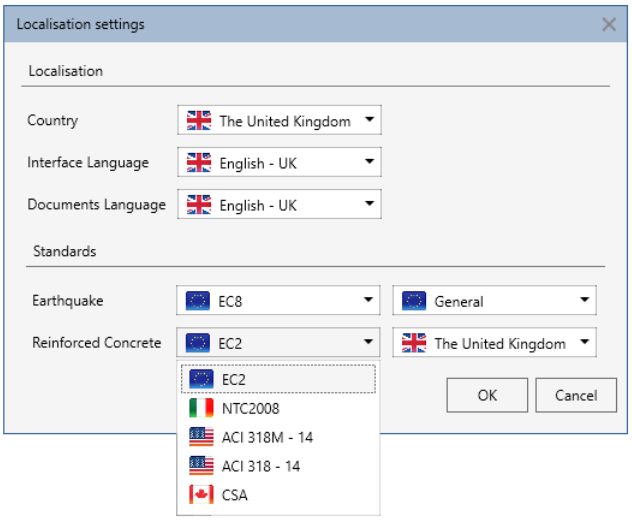
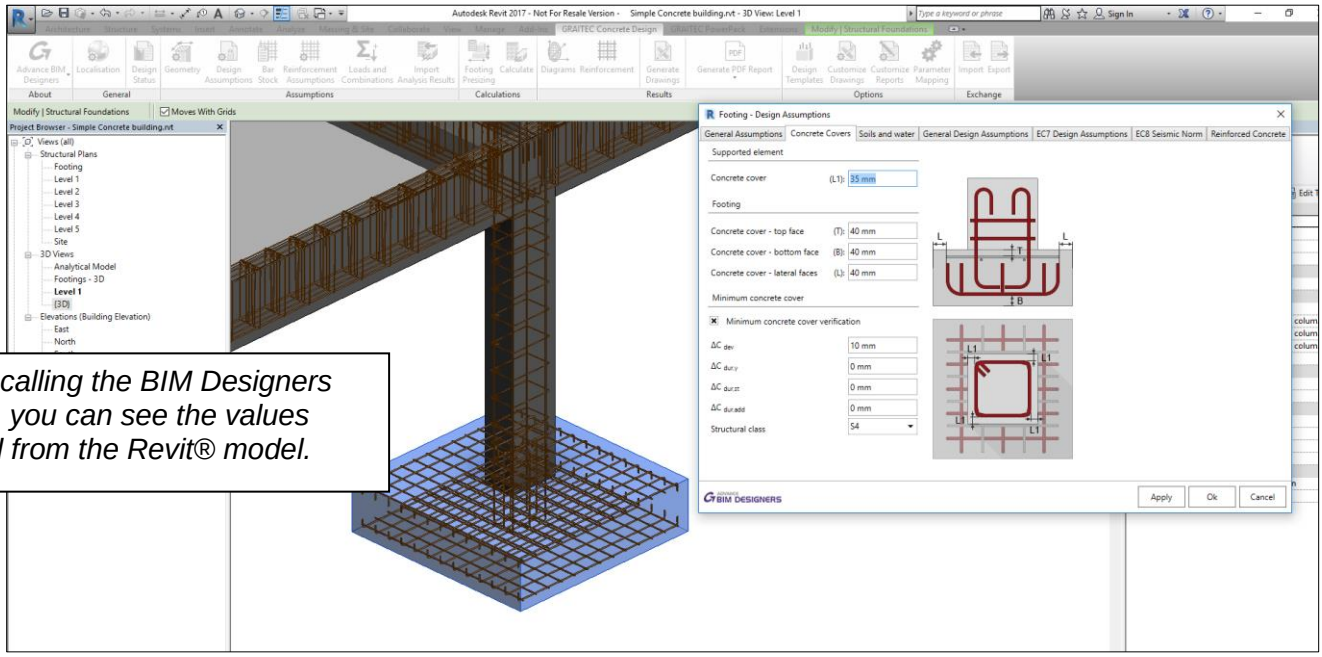


FIGURE 18: DIALOG TO SET THE DESIGN CODES IN BIM DESIGNERS

As we saw in the previous chapter, when you load a BIM Designers design assumption dialog, the module is loading the Revit® known parameters that can then be changed in the BIM Designers dialog. Let's take the example of the concrete cover values on an isolated footing:



When calling the BIM Designers dialog, you can see the values loaded from the Revit® model.

FIGURE 19: CONCRETE COVER MANAGEMENT IN BIM DESIGNERS

In this case, the added value of the BIM Designers module is that you can define the tolerance on concrete cover values according to the applied design code and ask the module to check the defined values and change them if they are not verifying the minimal design codes requirements. In this case, the Revit® model will be consequently updated.

It is easy to define or change the partial safety factors, the concrete covers, the steel ductility, etc. on various structural elements with just one click!

For safety reasons, the design assumptions are only available on selection. If you want to apply a common design assumption to the entire model, just select all elements and call the BIM Designers design assumption dialog.

Loads and combinations

As you can imagine, the loads and combinations definition is a must, to be able to design the concrete members. That's why we started this class handout explaining how to store several packages of FEM results in the Revit® model. But, being realistic, it is extremely unlikely that anyone is currently transferring results to Revit® in a real workflow. What do you think? Why would you do it? What interest would you have in it?

Now, returning to the workflow we proposed a few pages before:

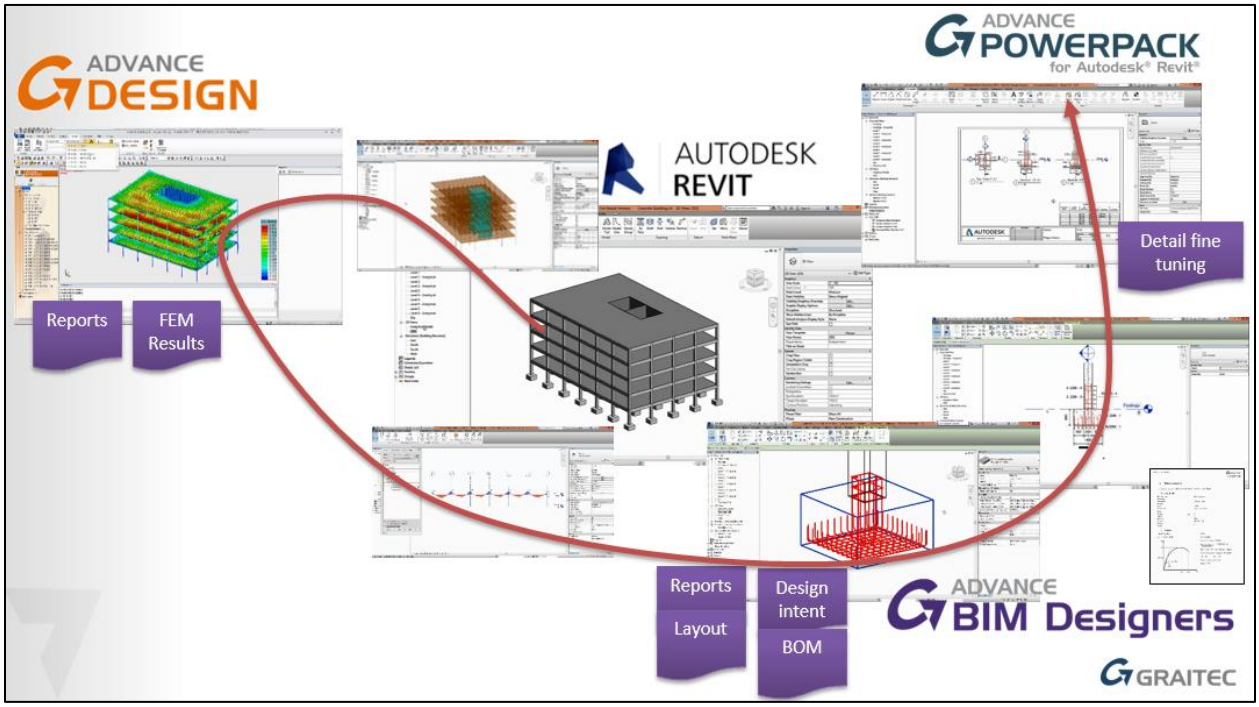
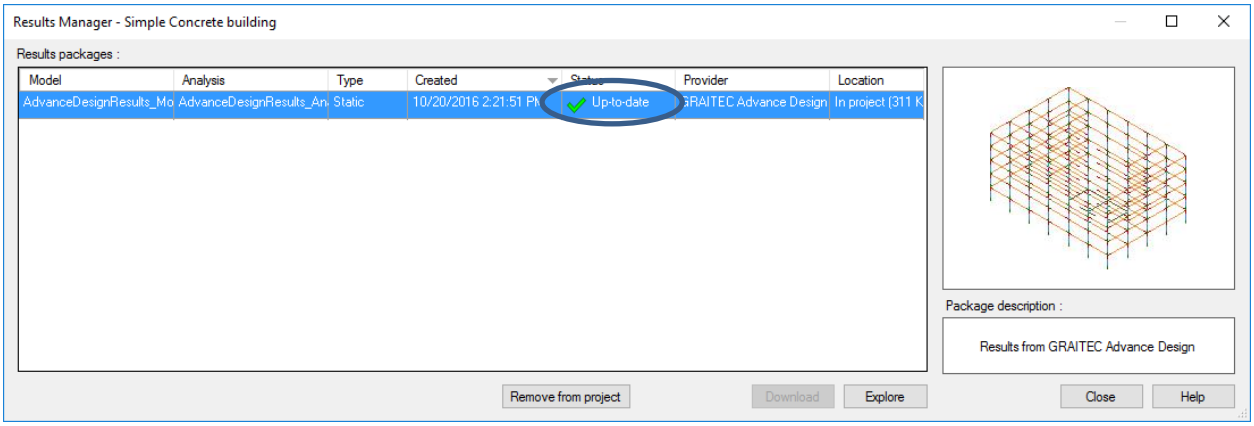


FIGURE 20: BIM CONNECTED WORKFLOW

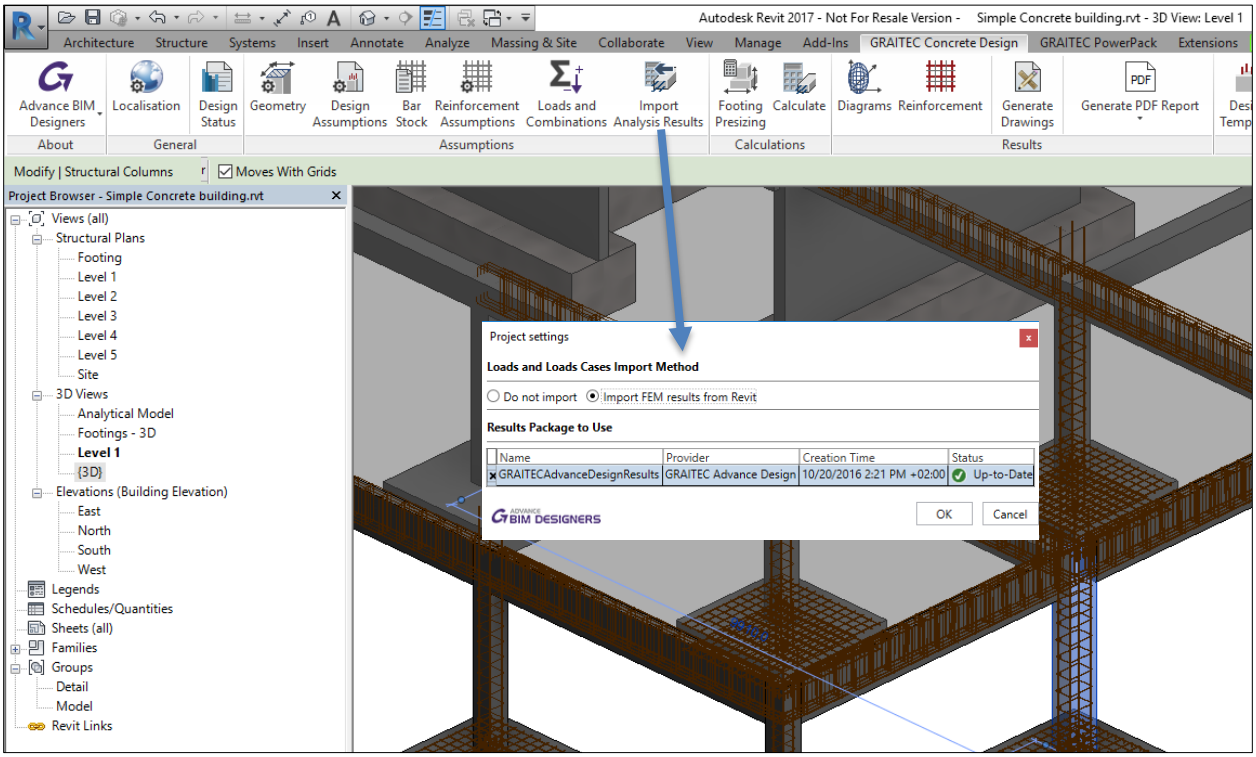
It is clear that having the FEM results stored in the Revit® model makes this workflow possible.

In case you have a Revit® model which contains a FEM results package, you can directly run a calculation with BIM Designers starting from those results:

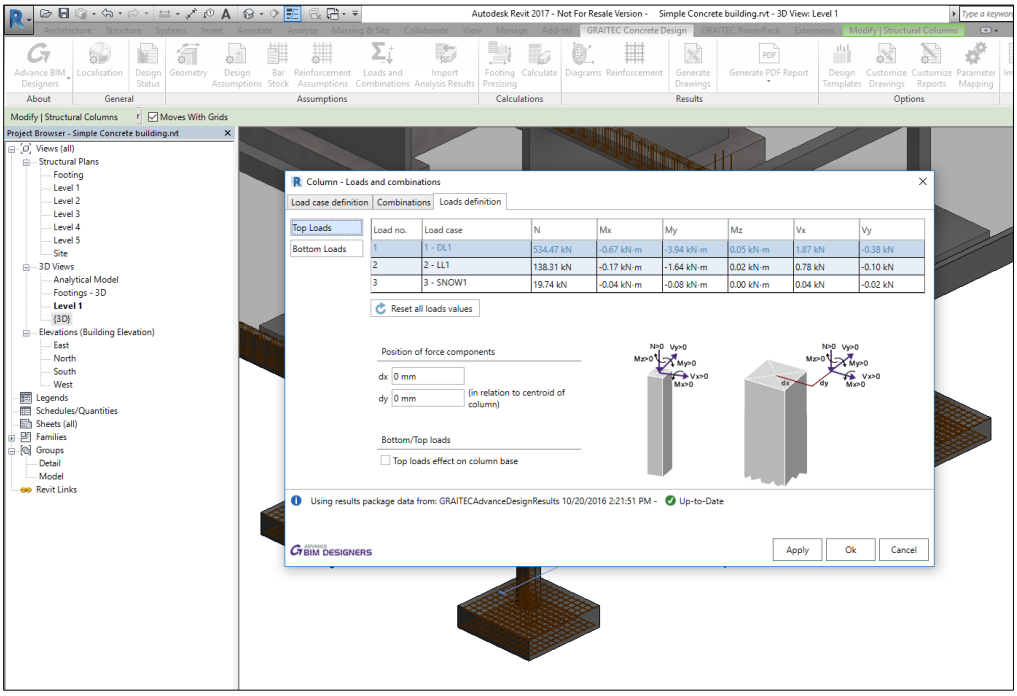
- Just check with the 'Results Explorer' in Revit® that you have an updated package of FEM results:



- Then, in the BIM Designers ribbon, you can select [Import analysis results] and select the Revit® results package you want to apply to design the elements:



- These values are the input for the reinforced concrete design handled with the BIM Designers within Revit®:



- And you can design the members directly in Revit®!

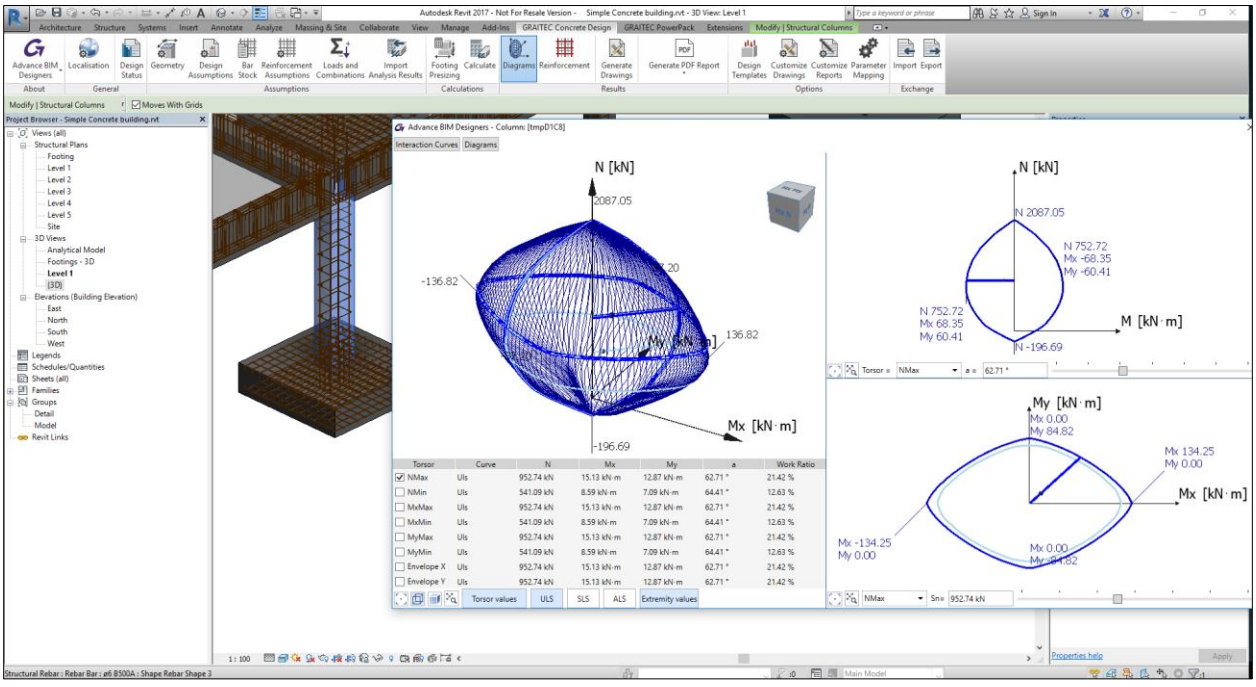
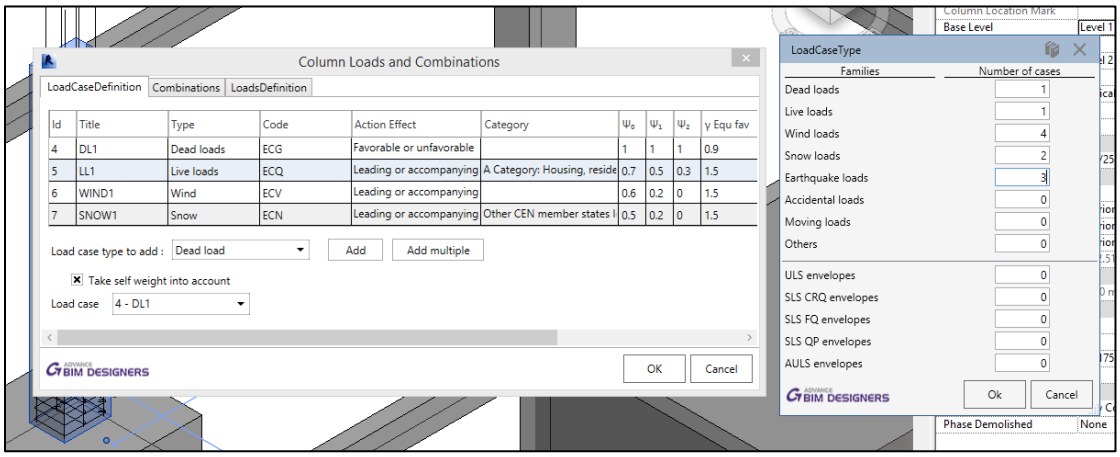


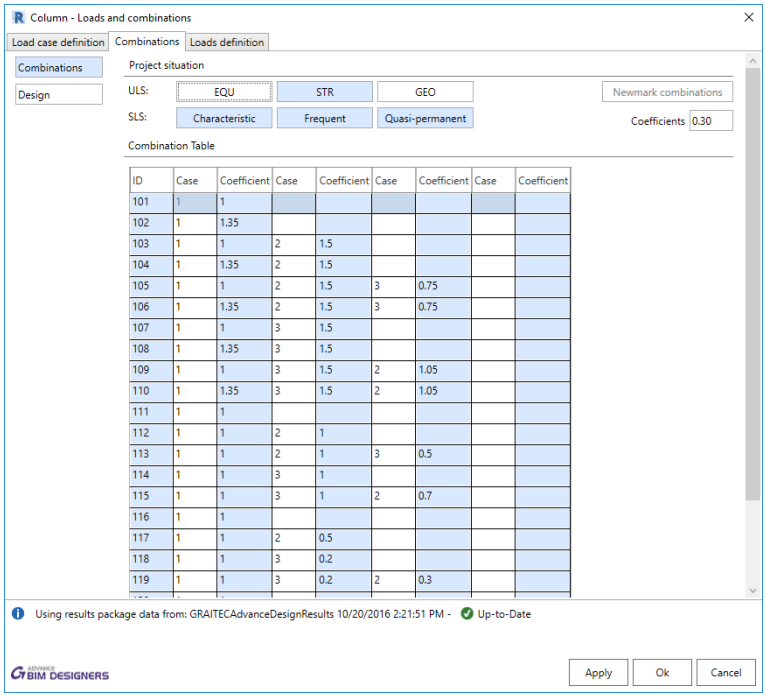
FIGURE 21: REINFORCED COLUMN DESIGN POST PROCESSING

With BIM Designers, you can also apply another workflow which will probably be the first one you will instinctively apply - you can just use the BIM Designers as a 2D tool (embedded in Revit®) to design the members without applying a full BIM workflow. In this case, just open the loads dialog, manually enter your estimated loads on the element and run the calculation. The BIM Designers module will automatically generate the combinations, run the calculation and generate the corresponding 3D rebar cage:

- Locally, you can create as many load cases as you need in the BIM Designers module. You will have more options compared to what you can do in Revit®:
    - You can create several different types of load cases; dead loads, live loads, wind and snow loads, seismic loads, moving loads but also ULS and SLS envelops.
    - Each load case comes with the design code properties according to Eurocodes or American codes; category of the live loads, factoring coefficients, and action effects, etc.

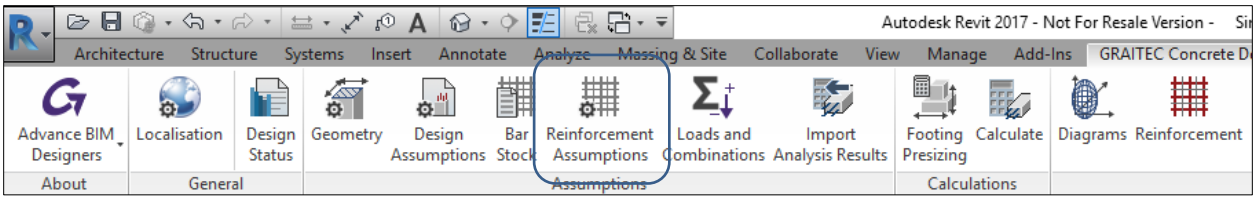


- BIM Designers can automatically generate combinations (this is not possible with the standard Revit® functionality) depending on the selected design code:



Reinforcement assumptions

From the BIM Designers ribbon, the user can access the reinforcement assumptions to define the constructive dispositions in order to get a 3D reinforcement proposal fitting within the constraints of the project:



The BIM Designers user can define his preferences for the rebar placement. Here are some of the reinforcement assumptions for a column - longitudinal and transversal bars, stirrup shapes, starting bars, number of bars and maximal diameters depending on the column size, etc.

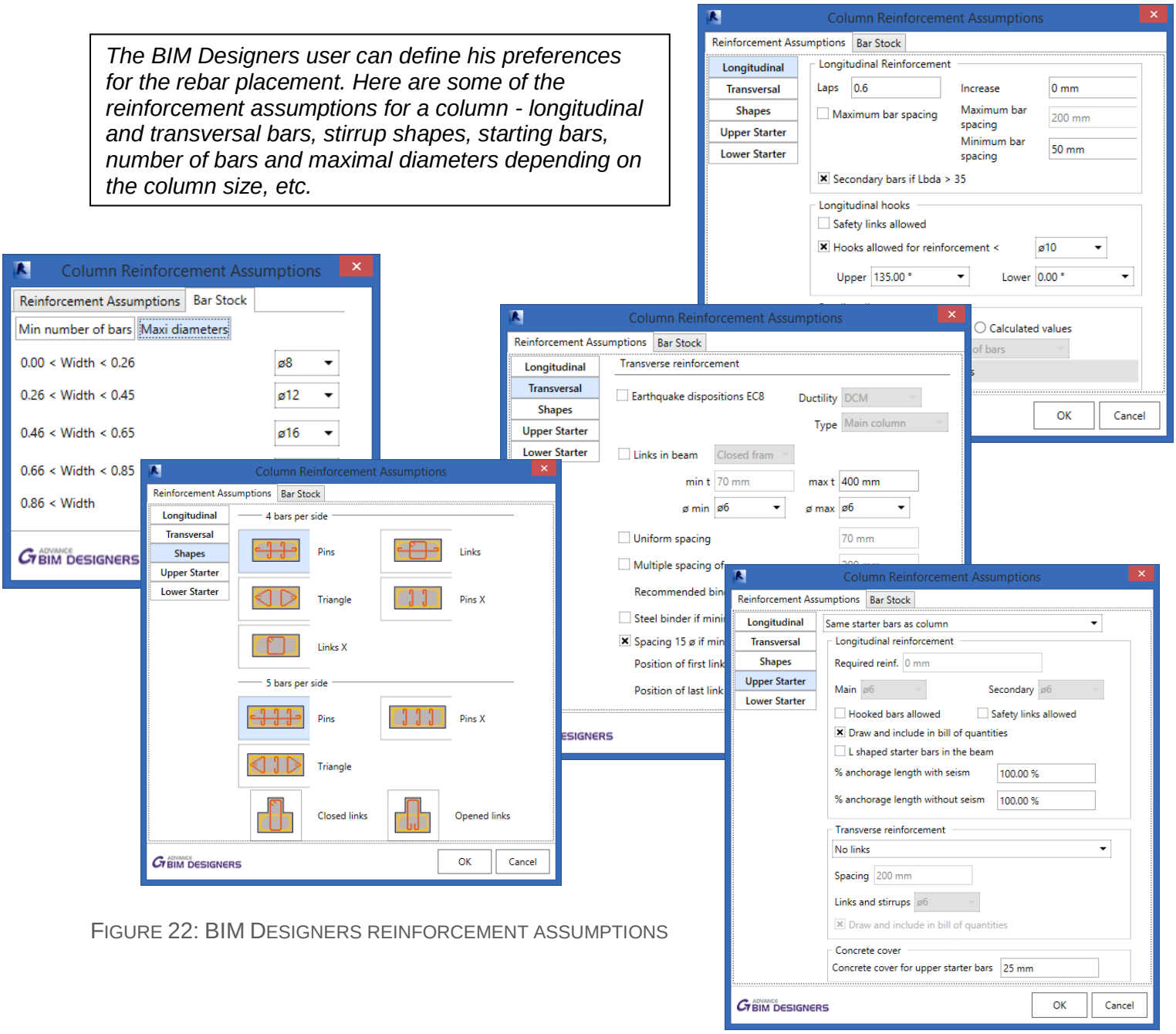
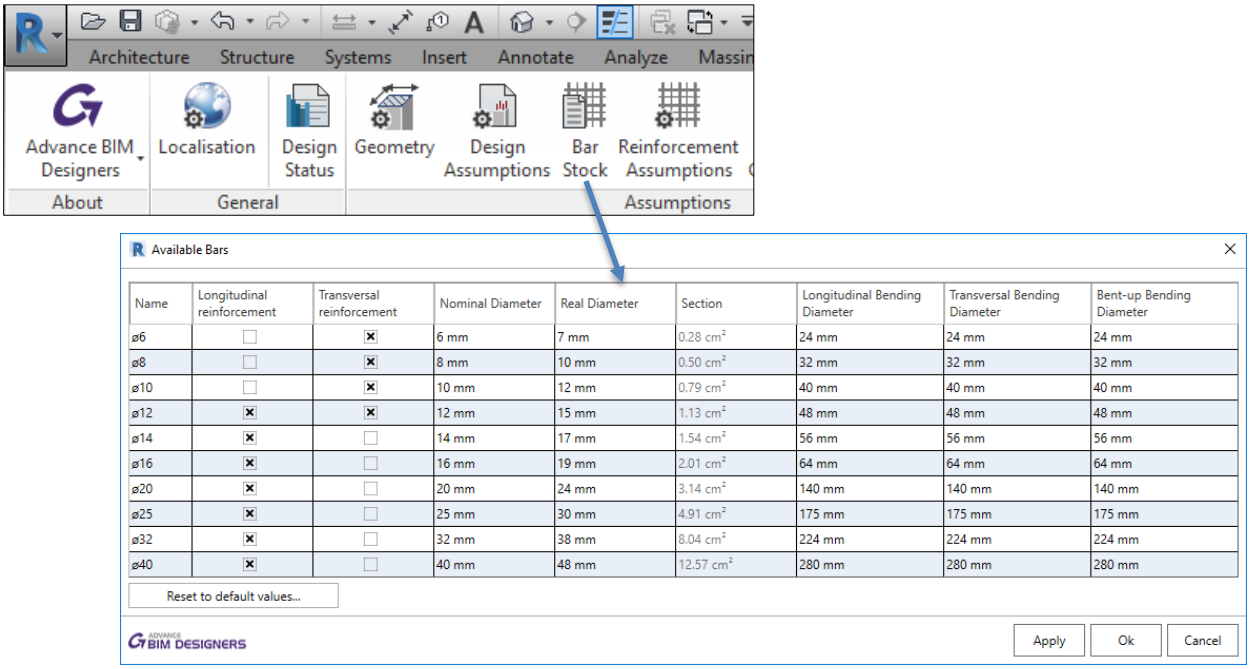


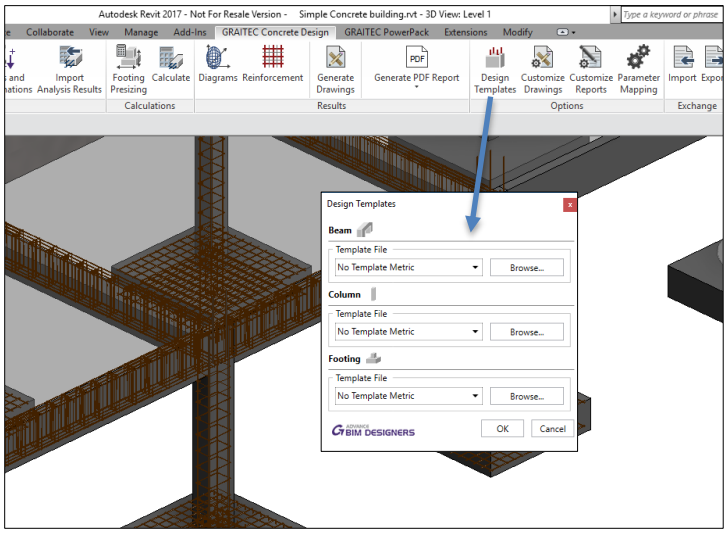
FIGURE 22: BIM DESIGNERS REINFORCEMENT ASSUMPTIONS

The user has also the possibility to filter the diameters to be used to reinforce the selected elements. This definition can be done at the level of the selected elements or for the entire project.



Tip: *As you can see, there are hundreds of assumptions to automatically reinforce a concrete member (beam, column or footing). Obviously, the user can set\change all those parameters for each single member but that's definitely not the most effective and efficient workflow. You can group the identical elements and apply those assumptions together. This will ensure the same rebar on all elements and the whole project will be much easier to manage.*

You can also define a set of assumptions as a template to be re-used on another project. Additionally, we can allocate administration rights management functionalities, giving an administrator the option to define the templates (per company, per projects) to be used (and not modified) by 'standard' users. But that's for the future and not yet implemented in the BIM Designers.



Integrated reinforced concrete design within Revit®

As mentioned previously, the objective of the BIM Designers module is to embed the design into Revit® which is the primary BIM application. This new way of working raises an important question that you may already have in mind: "*How can the user trust the automatic reinforcement provided by the BIM Designers?"*

Of course, the final result is the 3D rebar cage and there is a graphical control when visualizing the 3D reinforcement rebar but it is not enough. The design codes (Eurocodes, US codes, Canadian codes) impose a set of verifications which must be completed and this is an important responsibility for engineering companies.

Thanks to GRAITEC BIM Designers, you can create a detailed design report directly in Revit®. You will get all the design detail in a technical document, including all the formulas and corresponding articles from the standard, the numerical applications and the corresponding graphics. To generate this report, just click on [Customize reports] to choose your report template and on [Generate Report] to get the document. You will complete the report in seconds!

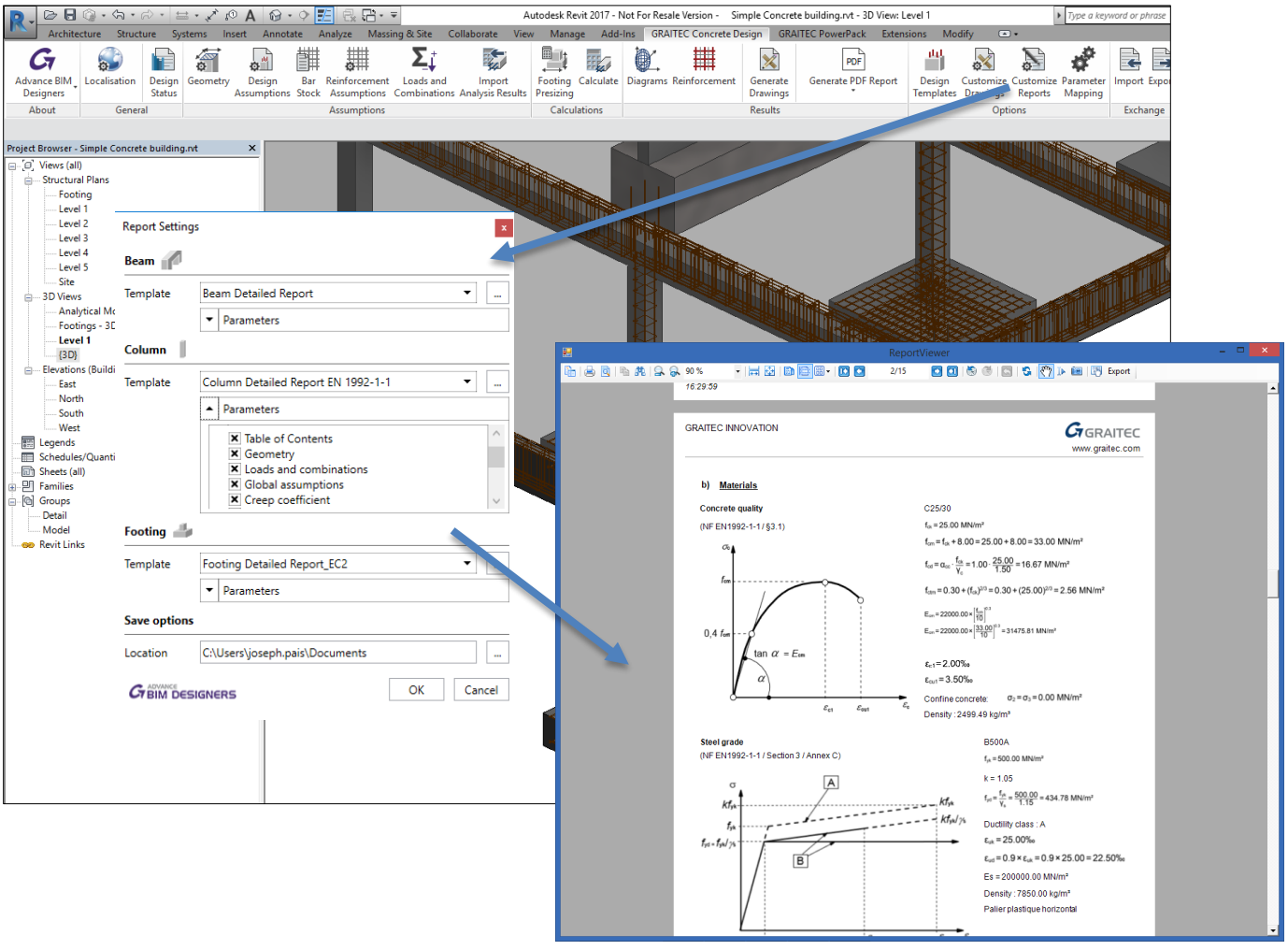
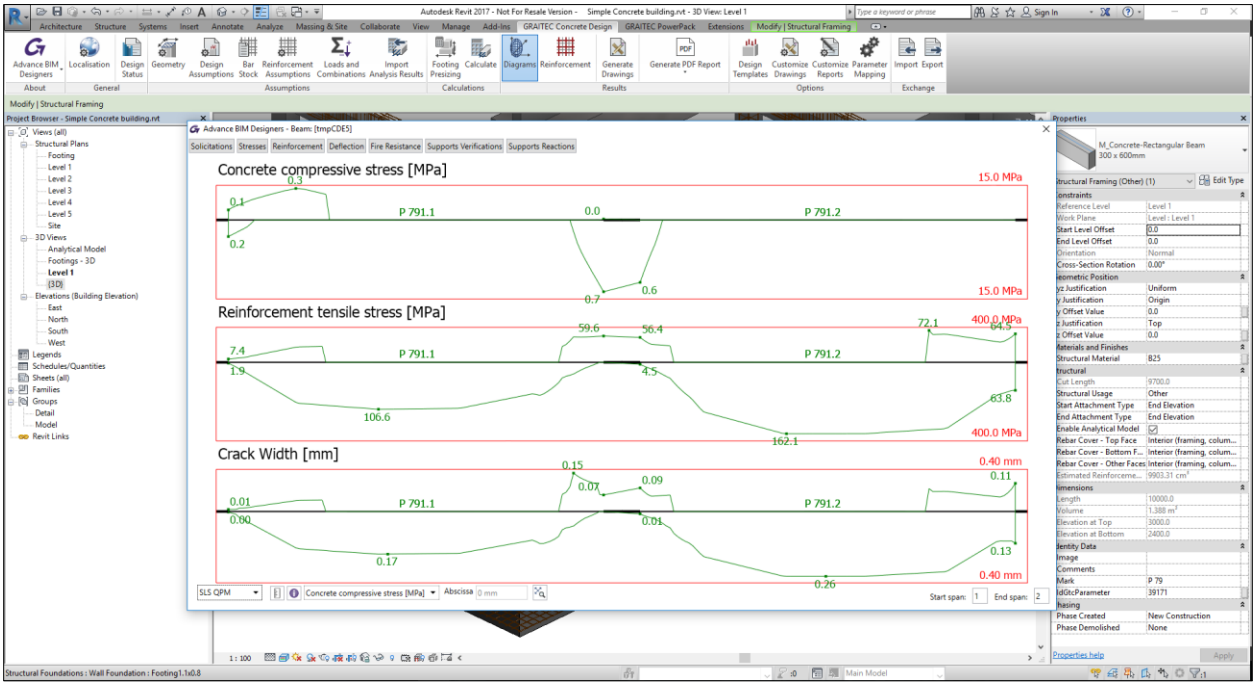
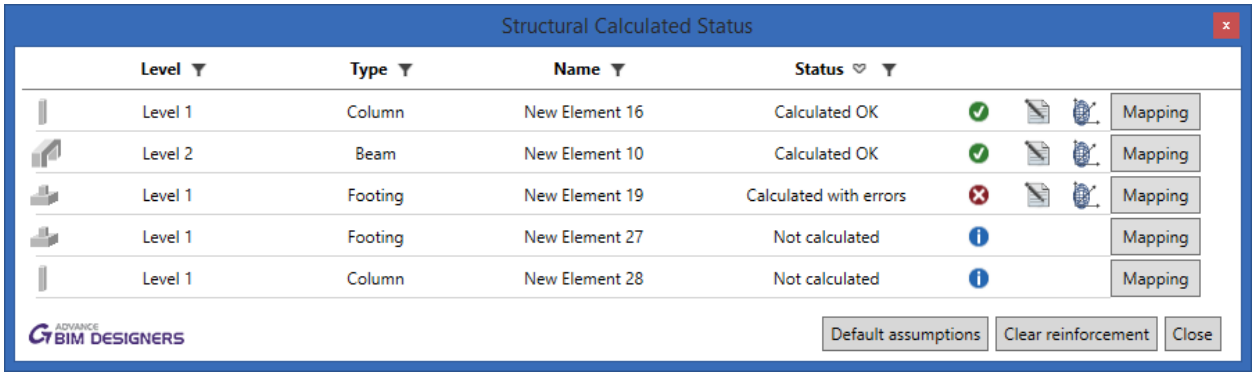


FIGURE 23: DETAILED REPORT WITH BIM DESIGNERS

In addition to the detailed design reports, you can also access the integrated graphical post-processing engine in order to visualize in Revit® the design results as interaction curves on columns, stability verification on footing, crack width check and stress diagrams on beams. For this, just select an element and activate the function ’Diagrams’:



Nothing is magic and this all requires preparation. The 3D reinforcement rebar is not produced out of thin air! Every bar, every result can be justified. Of course, you will not check all the calculated elements one by one, that would waste too much time. At any moment, you can call up the ’Project Status’ dialog and see directly which element is calculated, which have errors or warnings and which ones remain to still be designed. That is the main board of your RC project:



The BIM workflow also makes the communication between the draftsman and the engineer easier and more efficient. If the draftsman is using BIM Designer modules in Revit®, to automate the 3D rebar creation, he will be able to send (or publish in A360®) a detailed calculation report to the engineer for a proof check.

We saw that this workflow can be applied to a single element or an entire building. The design is done on the fly when selecting the 3D rebar creation. Of course, if a change occurs in the model, (geometry or design assumption change) the design is updated on the fly and the user can produce an updated design report. Importantly, all the results, including the design results for each member, are saved in the Revit® model. The Revit® objects include additional properties linked to the design and the user can return to previous design results when he wants. This is an important advantage of BIM for reinforced concrete structures, making the general workflow more flexible and efficient. Everything is saved in the same place.

In the case of large projects (with multiple-users), it is also possible to export from the 3D Revit® model, different members to be designed using the same BIM Designers modules but in standalone mode. In such a workflow, the BIM Manager using Revit® can dispatch the design job among several people using the BIM Designers modules outside Revit® and re-import the data after work.

Automatically get the 3D rebar

The automatic design-driven 3D rebar generation

At the end of the design process handled by the BIM Designers, you will automatically receive the 3D reinforcement cage, considering all the design assumptions and the constructive dispositions defined above:

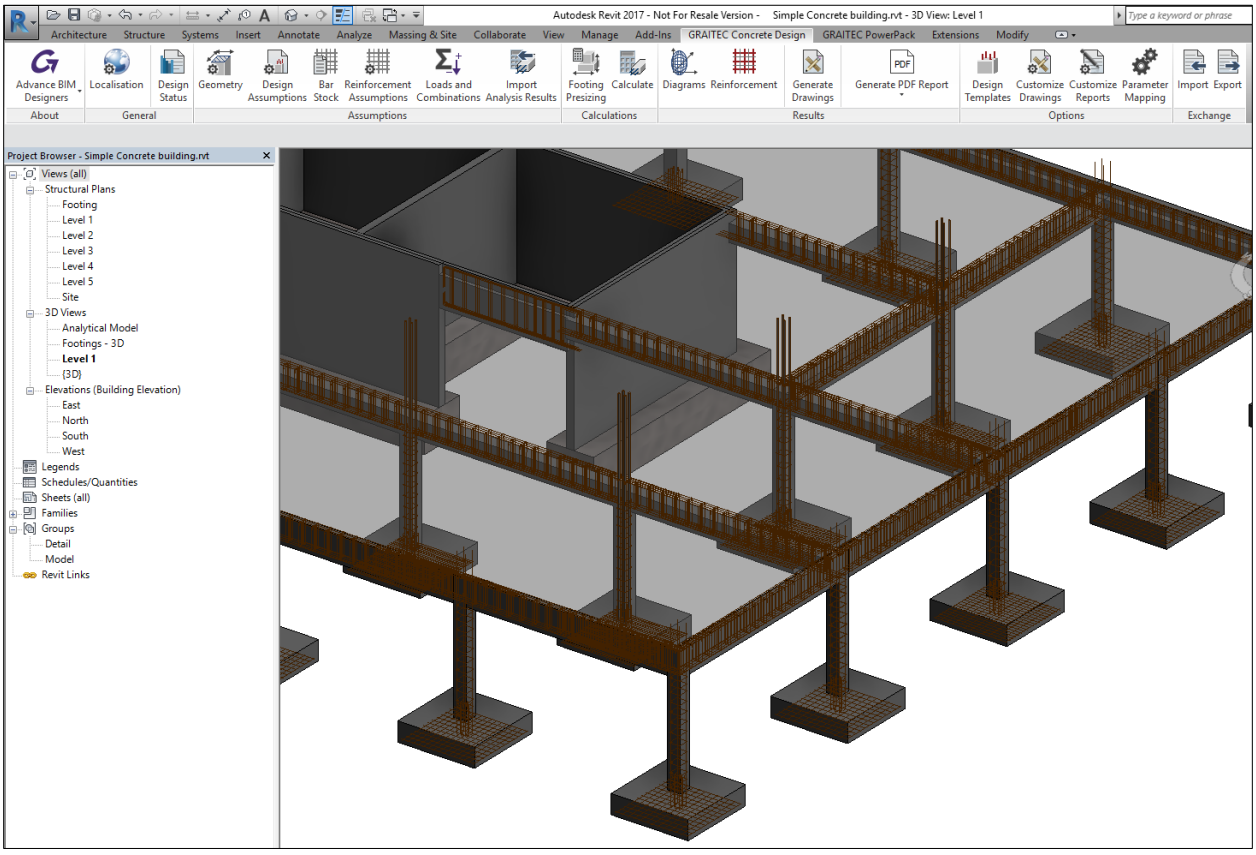


FIGURE 24: EXAMPLE OF AUTOMATIC 3D REBAR CREATED WITH BIM DESIGNERS

The created bars are native Revit® objects which can be changed through the default Revit® properties and functionalities:

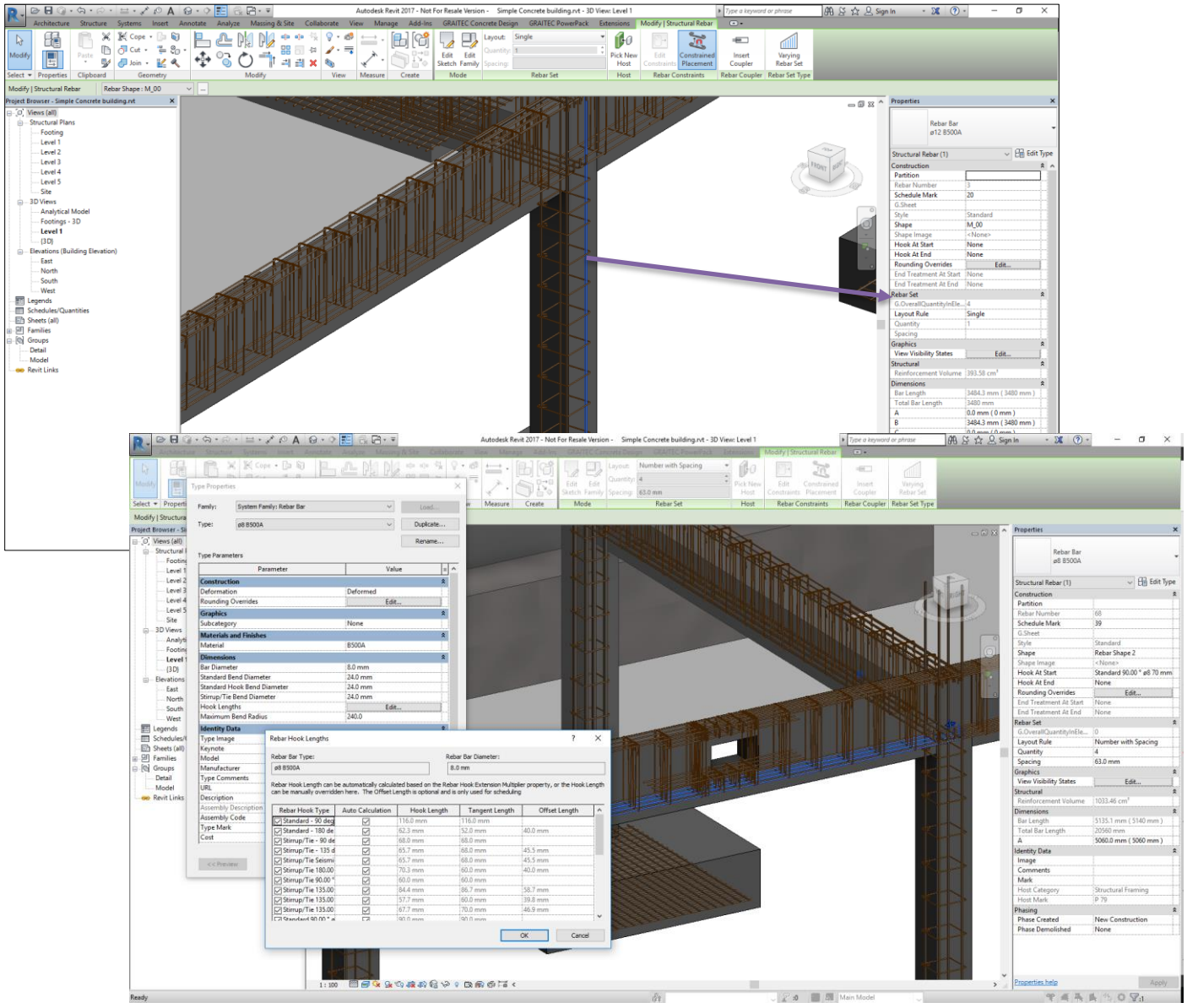


FIGURE 25: THE CREATED BARS ARE REVIT® OBJECTS.

With the BIM Designers, you can either design and instantly get the 3D rebar cage with single or limited elements, or design the full model and get the complete 3D rebar cages within a few minutes, instead of hours - if working with standard Revit® tools!

Just to give you an idea of the productivity increase you can get with the BIM Designers in Revit® - to reinforce the following model which has around 150 columns, more than 200 beams spans and around 35 isolated footings, it took five minutes! Bearing in mind that each generated bar is design-driven.

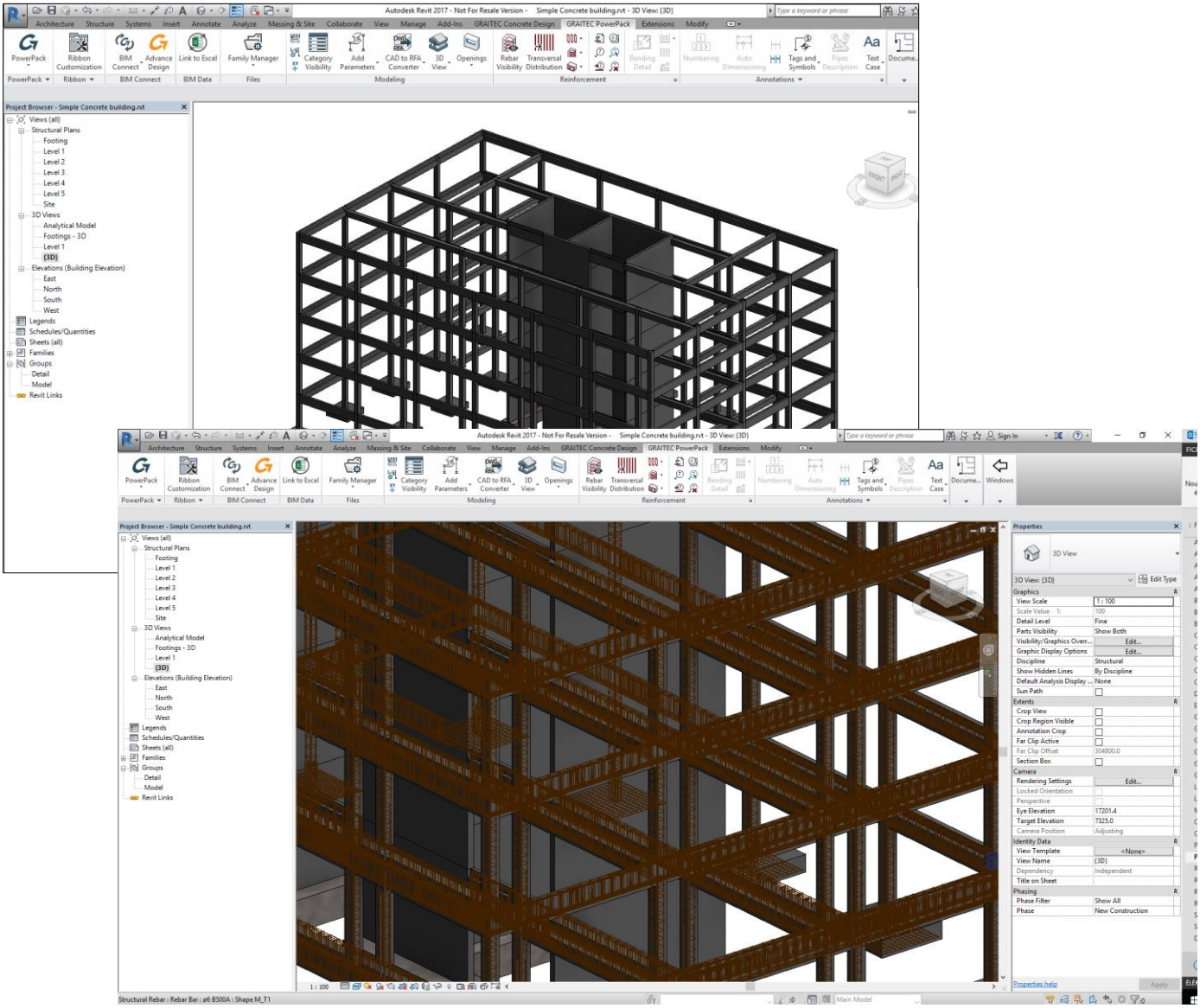


FIGURE 26: 3D REBAR GENERATED WITH BIM DESIGNERS.

Of course, I would not lie (and you would not believe me) by saying that you get perfect 3D rebar cages with no changes, but just imagine the time saved even if you still have some fine tuning to get the final reinforcement of the entire building.

Also, an important point is the fact that the BIM Designers are dedicated to 3D rebar production. All the produced 3D rebar cages are parametric. At any time, you can select a footing, a column, a beam - just click on the icon ‘xxx’ and change the 3D rebar cage in the parametric reinforcement dialog:

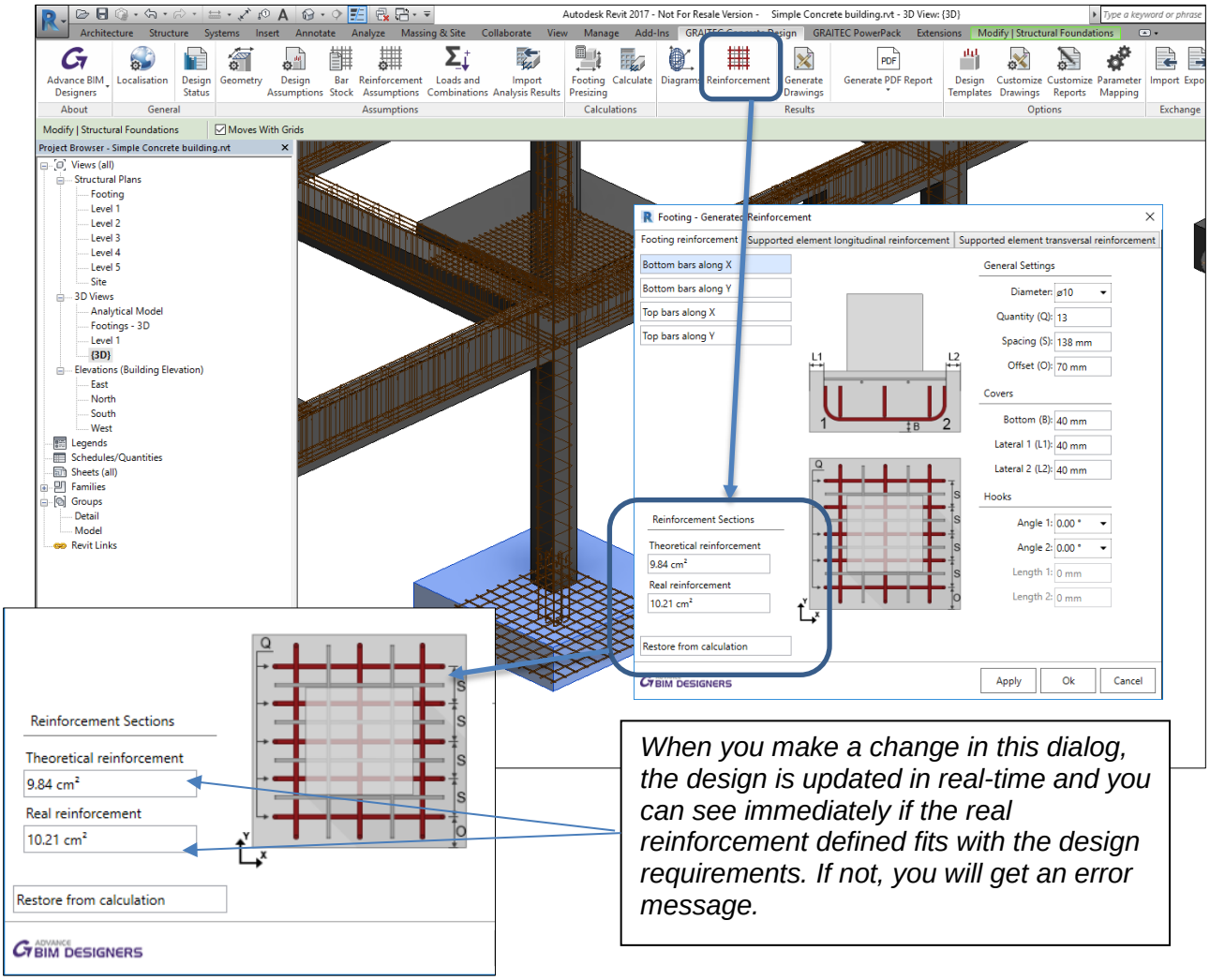
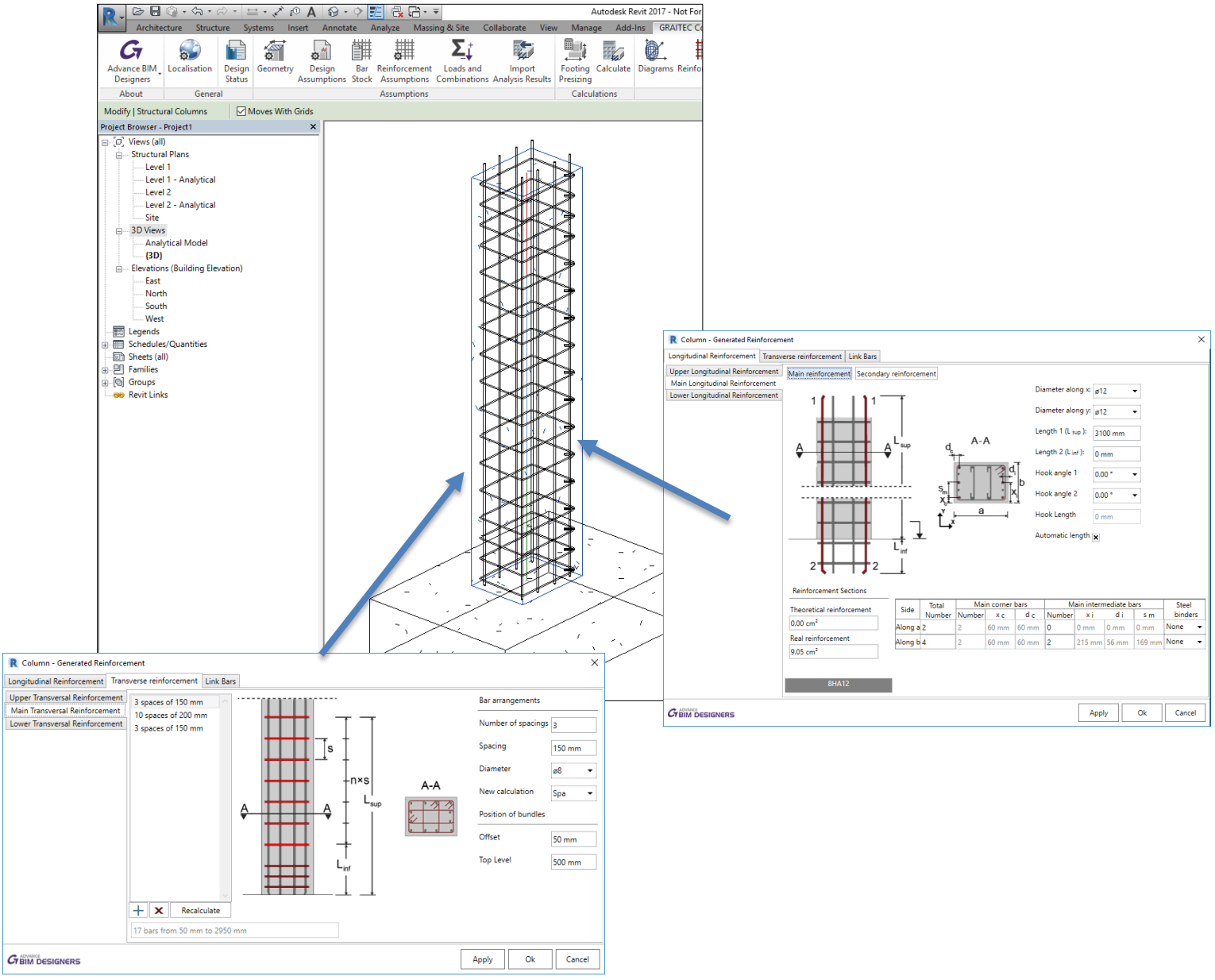


FIGURE 27: PARAMETRIC 3D REBAR DEFINITION WITH BIM DESIGNERS.

Manual rebar generator

You can also use the BIM Designer as “simple” parametric reinforcement templates. Just select a concrete member, call the BIM Designers reinforcement dialog, set the numbers of bars, diameters, distances between bars, stirrups… and get the corresponding 3D rebar cage in one click! Without design!



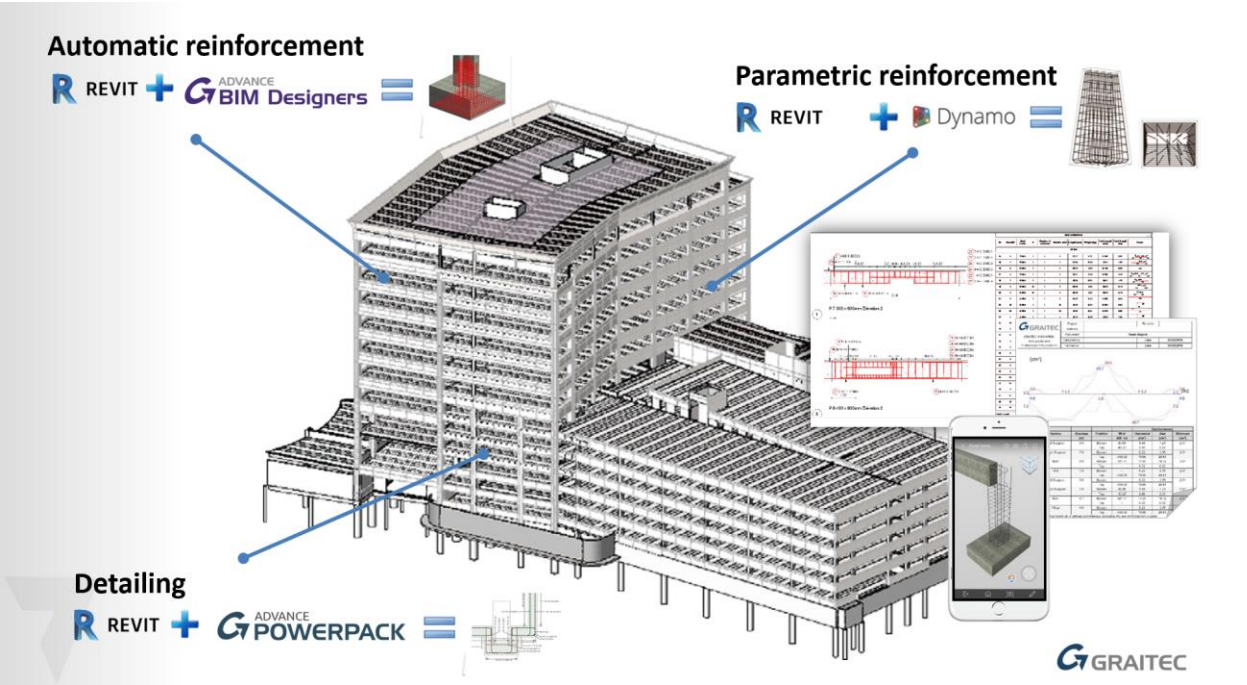
Then, continue to apply your usual Revit® workflow!

GRAITEC PowerPack for Revit®

Revit® is an extremely versatile BIM platform able to produce really impressive multi-discipline project models but as every experienced user will tell you, tools which speed up processes or make it easier to achieve certain tasks, are always welcome. Autodesk is committed to providing a robust BIM platform in Revit®, and whilst they focus on workflows and performance, Autodesk look to their experienced partners, like GRAITEC, to provide essential localized tools dedicated to improving their users' everyday experience.

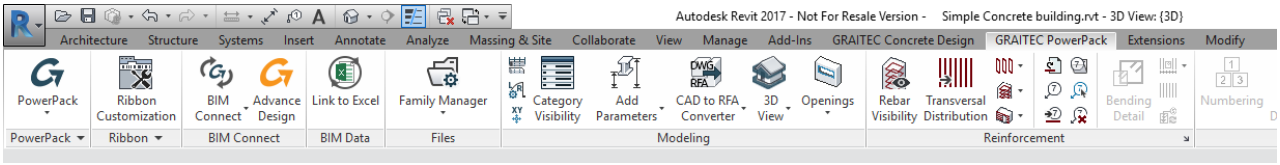
GRAITEC PowerPack for Autodesk Revit® is packed with tools for Architects, Engineers, M&E Consultants and specialist detailers providing a wealth productivity tools across all disciplines. GRAITEC PowerPack for Autodesk Revit® comes in multiple languages and delivers a wide range of purpose-built tools and utilities which have been expertly localized to help Revit® users across the globe deliver their projects more efficiently. GRAITEC PowerPack for Autodesk Revit® is readily available from the Autodesk Exchange App Store or directly from GRAITEC. GRAITEC Revit® subscription customers are able to access the PowerPack as a loyalty benefit at no extra cost.

This PowerPack comes also with very interesting tools for rebar placement which are additional to the BIM Designers capabilities in order to fine tune the drawings. Just remember a picture I shown at the beginning of this document explaining the "80%-20%" rule and the fact that there are several solutions to reinforce concrete elements in Revit®:

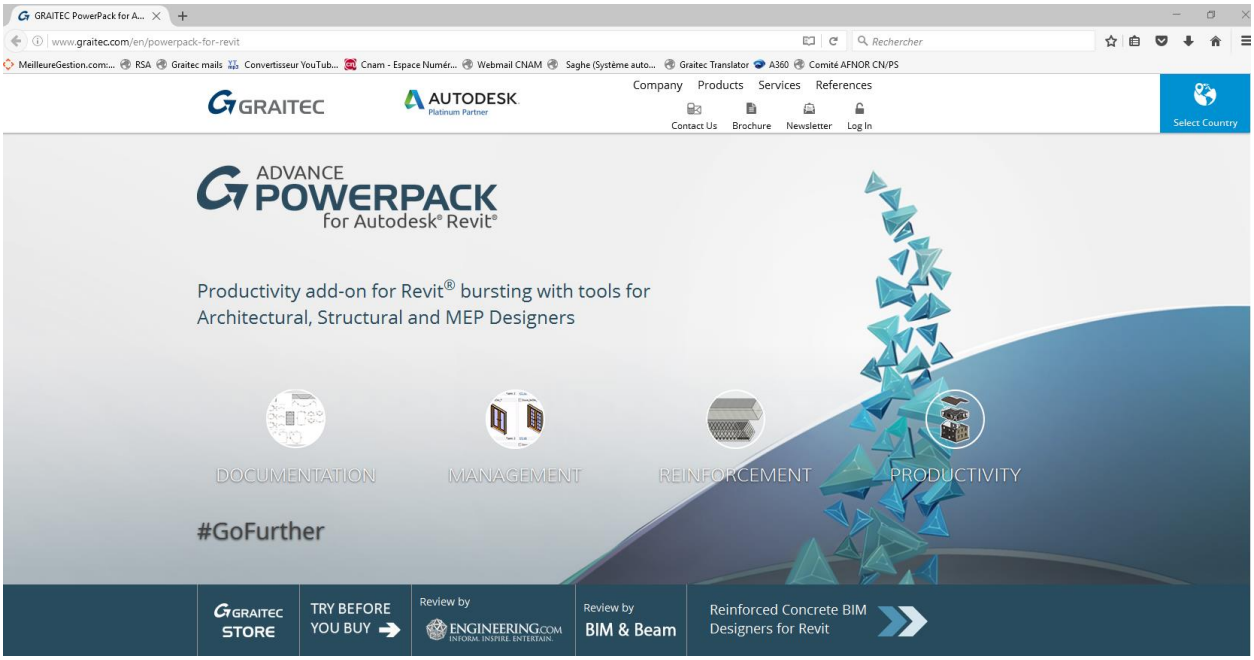


The reinforcement tools of the PowerPack are clearly dedicated to the "detailing" step here above in this picture.

When installed, you can access to the PowerPack for Revit® functionalities through a dedicated ribbon:

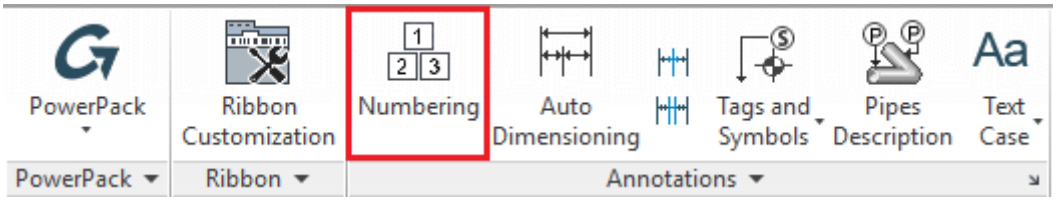


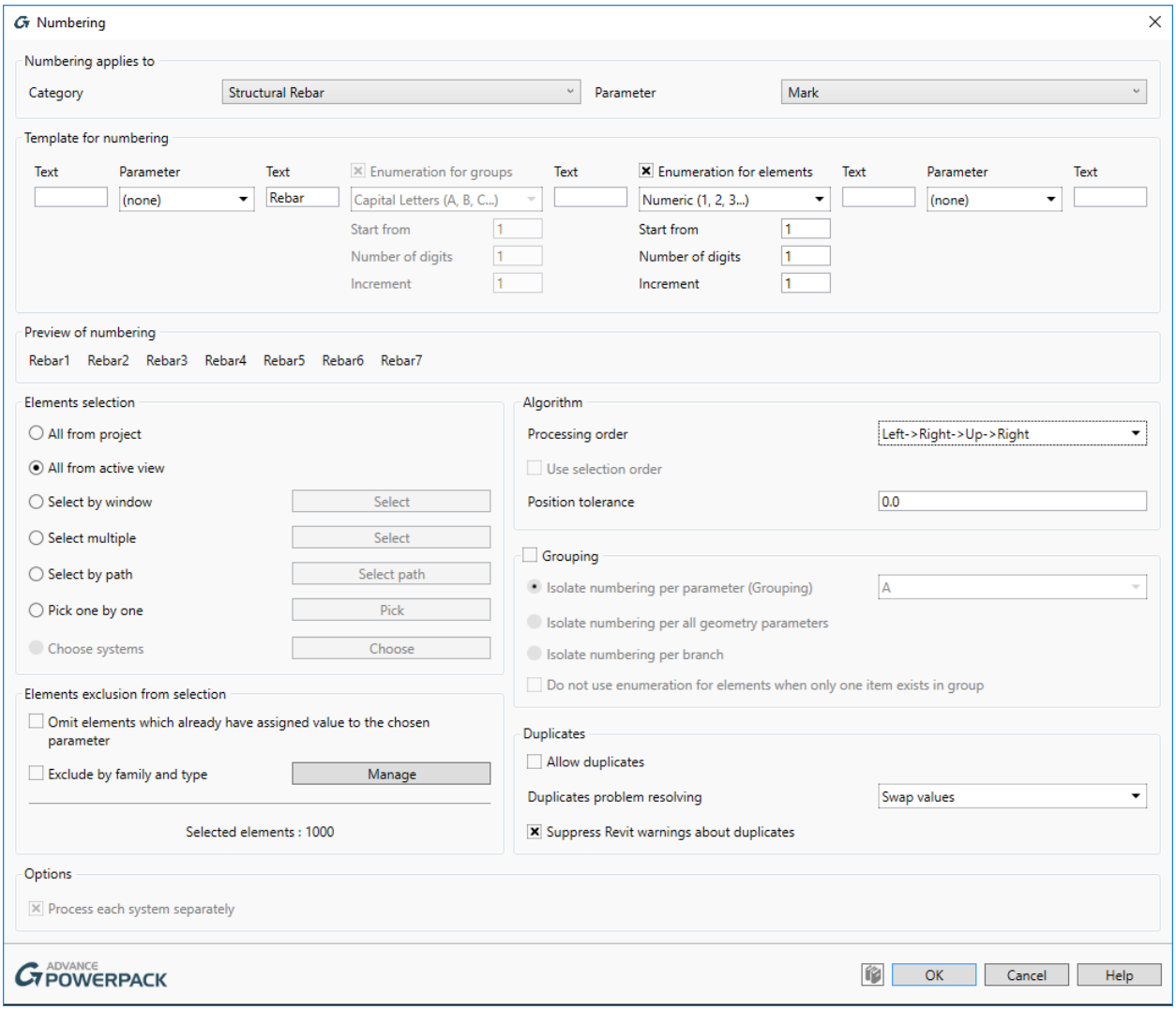
In this class handout, I will just give you some details about the tools dedicated to reinforcement production in Revit®. You can have more details about the GRAITEC PowerPack for Revit® on our web site (http://www.graitec.com/en/pp_revit.asp).



Numbering tool

One of the most requested and expected functionalities of the 2017 version is the generic "Numbering" command. Its major advantage is that with only one tool users can apply, re-organize or remove a numbering sequence for ANY loaded category from the project. The complexity of the command resulting from its vast applicability area is balanced by the intuitive and user friendly manner in which it was designed.

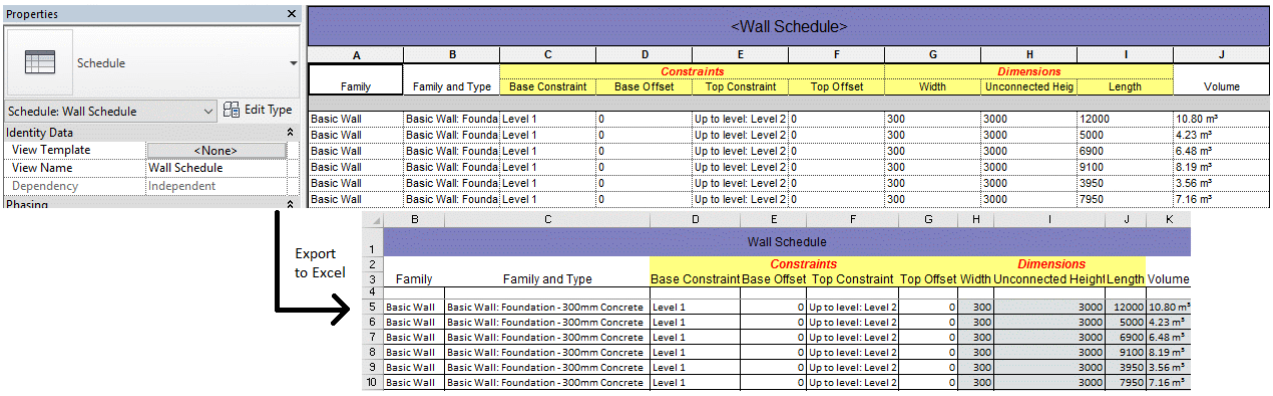




Link to Excel

Another major novelty brought by GRAITEC PowerPack for Revit® 2017 is the possibility to synchronize data using a bi-directional link between Autodesk Revit® and Microsoft Excel, through the new, powerful “Link to Excel” tool.

Users can export Revit schedules or compose a list of parameters to be treated as a table, in order to manage them in Excel. Once modified, the tool can import the data back into Revit and the schedules or parameter values will be updated according to the changes.

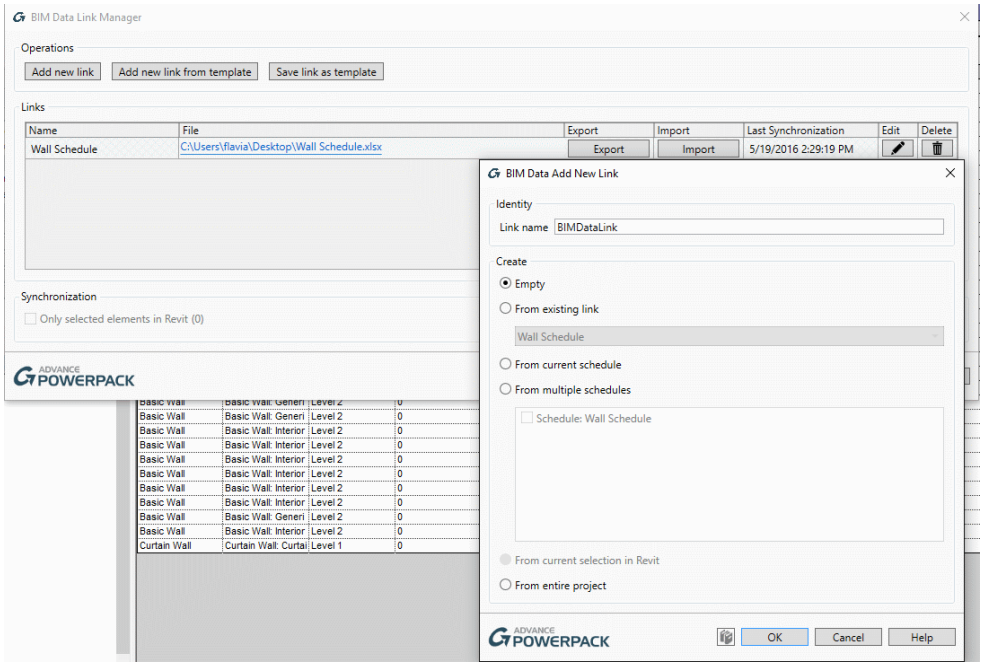


Family	Family and Type	Constraints: Base Constraint	Base Offset	Top Constraint	Top Offset	Dimensions: Width	Unconnected Height	Length	Volume
Basic Wall	Basic Wall: Foundation - 300mm Concrete	Level 1	0	Up to level: Level 2	0	300	3000	12000	10.80 m³
Basic Wall	Basic Wall: Foundation - 300mm Concrete	Level 1	0	Up to level: Level 2	0	300	3000	5000	4.23 m³
Basic Wall	Basic Wall: Foundation - 300mm Concrete	Level 1	0	Up to level: Level 2	0	300	3000	6900	6.48 m³
Basic Wall	Basic Wall: Foundation - 300mm Concrete	Level 1	0	Up to level: Level 2	0	300	3000	9100	8.19 m³
Basic Wall	Basic Wall: Foundation - 300mm Concrete	Level 1	0	Up to level: Level 2	0	300	3000	3950	3.56 m³
Basic Wall	Basic Wall: Foundation - 300mm Concrete	Level 1	0	Up to level: Level 2	0	300	3000	7950	7.16 m³

Tip: If the schedule in Revit is customized in matters of appearance and merging, then the resulted Excel table will preserve the desired format from Revit.

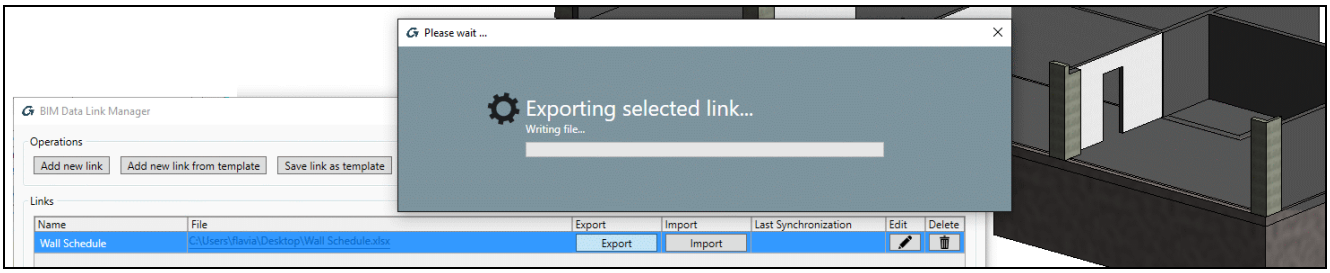
The most impressive aspect of this new tool is that it offers a powerful and strong link between the Revit project and the managing of data in Microsoft Excel. Also, the time consumed to handle modifications and updates in either of the two platforms is reduced to minimum, since the process of project organizing and documenting in Revit is accurately performed.

There are several methods through which users can create such a link between a Revit project and an Excel spreadsheet:

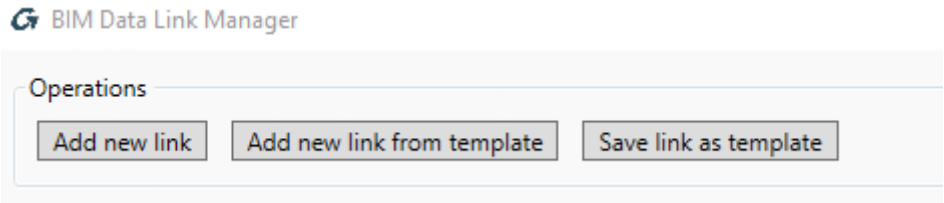


- *Empty*: A new link can be created from scratch, meaning that the user will select one or more categories, pick from the available parameters, and generate an Excel file with several spreadsheets, one for each selected category.
- *From existing link*: A new link can be obtained starting from an already existing one, by creating a duplicate which can be edited. The advantage is that there is no need to start the whole process for two similar links all the way from the beginning.
- *From current schedule*: If the command is applied in an active schedule, then the resulted Excel table will contain the rows and columns as they were created in the Revit Schedule. Modifying the data in the Excel file and importing it back into Revit will affect both the information in the schedule and the elements from the model.
- *From multiple schedules*: The tool can be used to create an Excel file with multiple sheets, containing the information from several schedules included in the current project.
- *From current selection in Revit*: The category/categories for which Excel tables will be created may be limited to result from a selection of elements in Revit.
- *From entire project*: For each category loaded in the project, a spreadsheet will be created in Excel, with the possibility to exclude some categories or to customize the list of loaded parameters.

After the structure of the link is decided, the “Export” operation generates the Excel file, which can be opened directly from the “Synchronization” dialog:



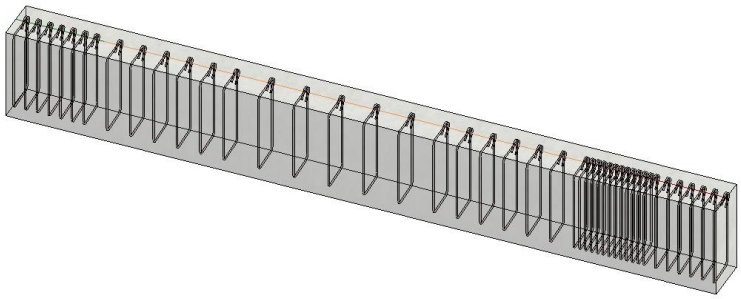
Users also have the possibility to save links as templates to be further used in other projects. The template is saved as an *.xls file containing the fields that form the header of the table, and it can be used to create a new link out of it.



Tip: *If the source schedule from Revit has one of the following applied: filters, sorting, grouping, the resulted appearance will be preserved*

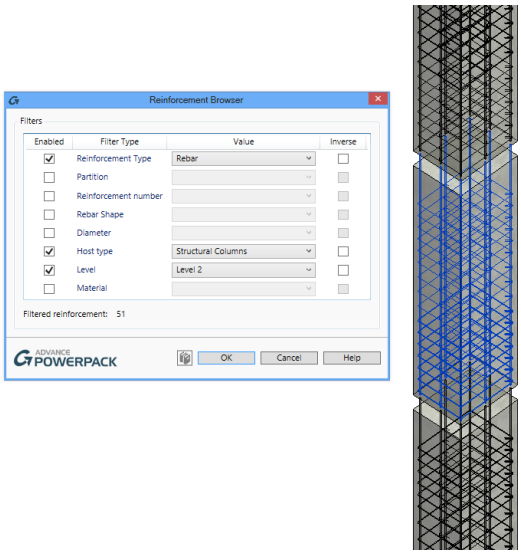
Linear distribution

This new feature increases productivity whilst working in Revit®, due to the automatic generation of transversal rebar sets with multiple spacing for linear elements. Users have the option to quickly create the different configurations of the transversal reinforcement in a cage with only one command.

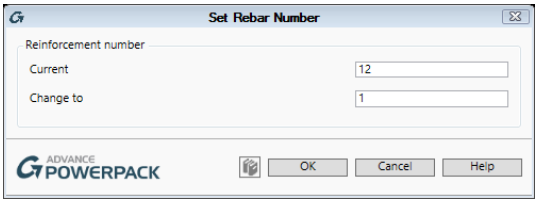


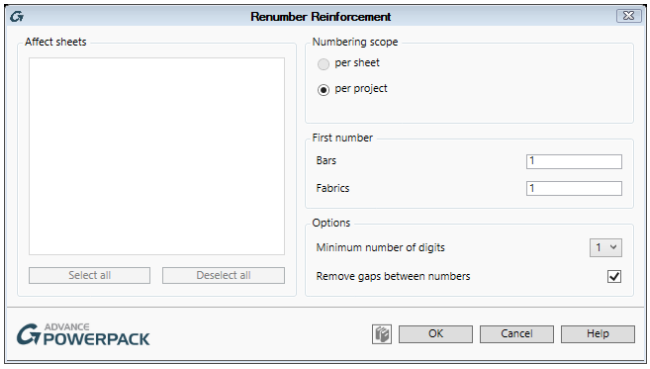
Multi-criteria selection of reinforcement

This command allows users to browse and select reinforcement, based on multiple criteria; reinforcement type, rebar number and shape, diameter, host type, level and material. Any combination of the above filters is allowed and the corresponding rebars are highlighted in the drawing. This method can be applied in two ways; as a single dialog, or included in the selection options from other commands.



Set Rebar Number/Renumber Reinforcement



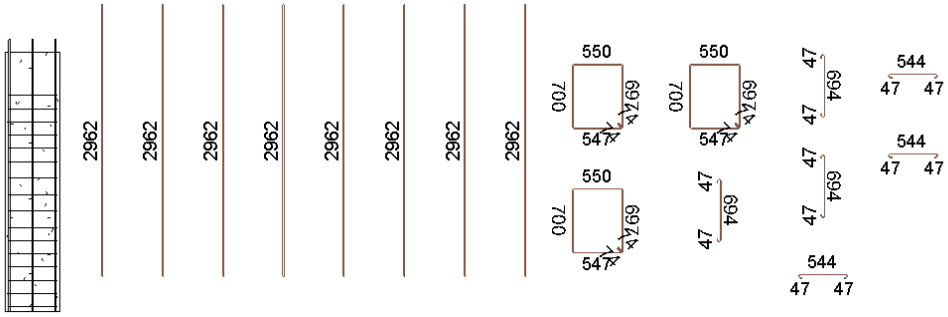


With the first tool (Set Rebar Number), users can manually change the rebar number of a bar. If the chosen number is already assigned to a rebar, a warning message is displayed to inform the user of this situation and the corresponding rebar will receive a different number.

The renumbering tool automatically changes the numbers for all reinforcement, in order to eliminate the gaps that may appear in numbering or to create uniform counting starting from a specific number.

The numbers assigned to the rebars may also be used to filter rebars using this criterion.

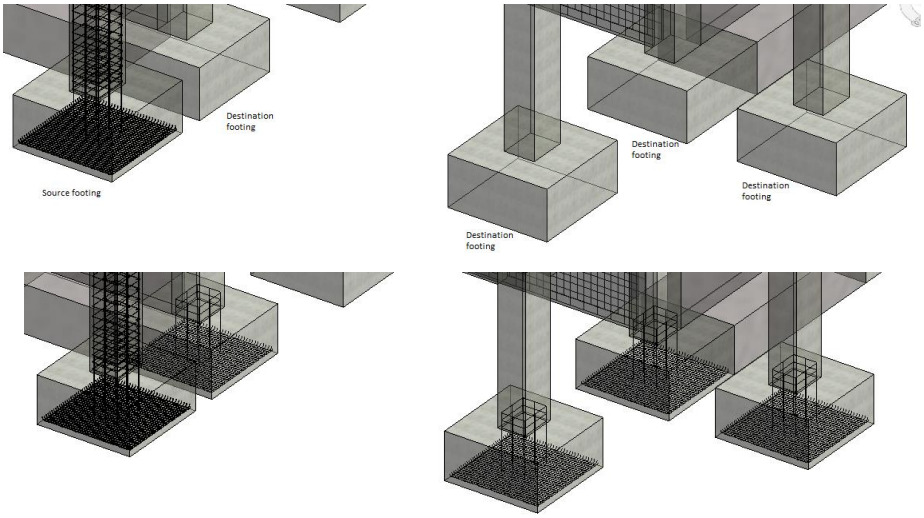
Bending detail



A very useful tool that allows users to automatically generate all bending details for rebars at once. The details are created as groups with specific line types and annotations which can be easily modified to obtain the desired display of the reinforcement detail.

Each rebar included in the selection has a corresponding rebar shape and all groups are arranged by default in the proximity of the source reinforcement.

Copy rebar cage/Delete rebar cage

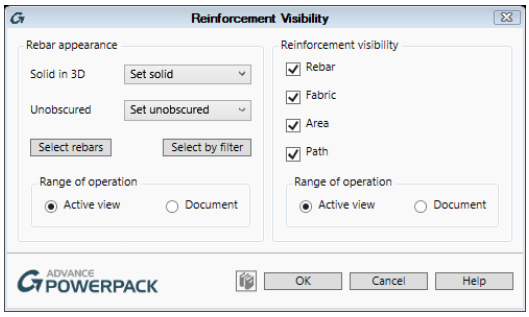


These two options were added in order to increase productivity whilst working with identical host elements that need to be reinforced/that already have reinforcement assigned to them.

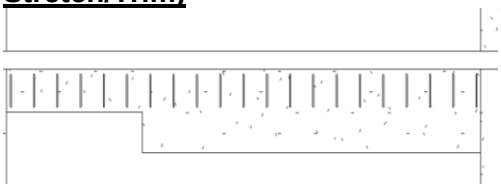
The ’Copy Rebar’ tool allows users to copy the entire reinforcement of an element to an identical or similar element that has no reinforcement assigned to it. The entire reinforcement cage can now be copied to one or more elements at a time. The reverse of the command is the ‘‘Delete Reinforcement’ tool, which offers the ability to delete the entire reinforcement of the selected host element, or certain parts of it.

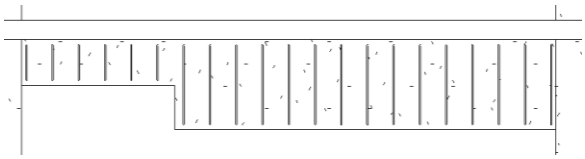
Rebar Visibility

The **'Rebar Visibility'** tool allows users to change the view visibility states in order to show rebars unobscured and/or as solid in 3D views, or to hide certain bars. These settings are applicable for the fine level of detail and can be used in a very practical way for the active view or for the whole project. Once the visibility state is defined, users can change the status at any time to whichever combination suits best.



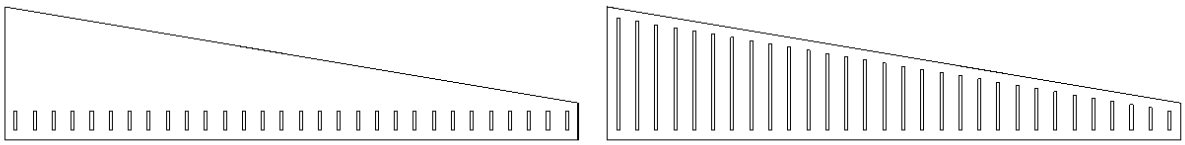
Intelligent edit tools for reinforcement (Split/Explode/Isolate/Unite Rebar Sets, Stretch/Trim)



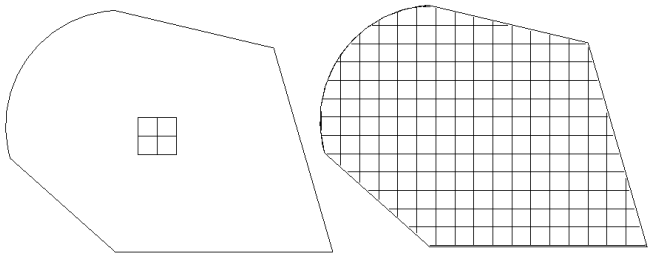


The PowerPack for Revit® offers several tools in order to adjust reinforcement to the desired parameters. A rebar set can be exploded to independent bars, which can be individually edited further. An alternative is to divide the set into two identical sets and modify them separately (the set in the above image was split into two parts in order to adjust them to the shape of the formwork). The particular case of this situation is to isolate a bar between two sets.
Users can also link two or more sets in order to create a single set, which can then be more easily manipulated.

Another editing tool such as 'Rebar to Face' refers to the option to stretch/trim the reinforcement sets to a chosen edge of the concrete element. The closest part of the rebar shape to this face becomes stretched or trimmed. The face to which the rebars are stretched/trim can belong to the same concrete element or to a different one (users can stretch the bars from a column to the exterior face of a beam supported by the column). The stretch tool can also be applied if the face of the host element is slanted.



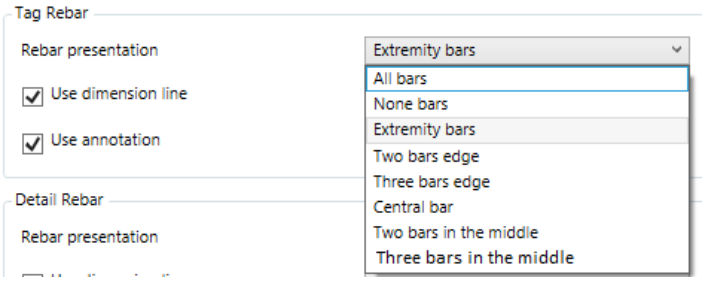
The **'Area to Element'** tool allows users to stretch already created area reinforcement to the dimensions of the host concrete element.



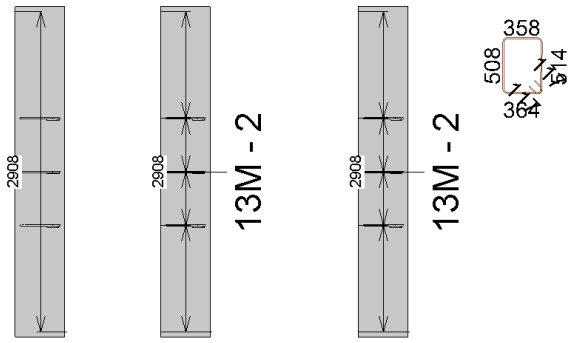
The cut reinforcement tools offer the option of adjusting the reinforcement cage as in the following situation; the cage is already modelled and the user needs to create openings in the concrete element without deleting reinforcement. The rebar set can now be modified in order to cut the actual reinforcement to the edges of the openings, keeping the concrete cover.

Symbols and Dimensions

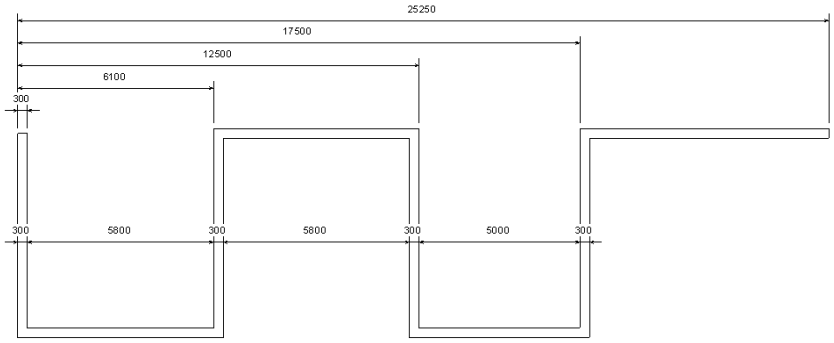
This set of tools offers representation styles for rebar sets in addition to the ones that are native to Revit®.



Users can choose to display only the dimension line, include an annotation or add a bending detail to each one of the above representation styles.



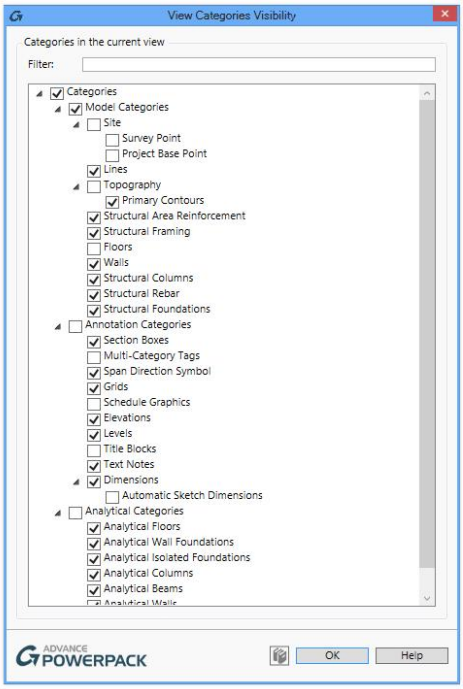
Tools for quick dimensioning

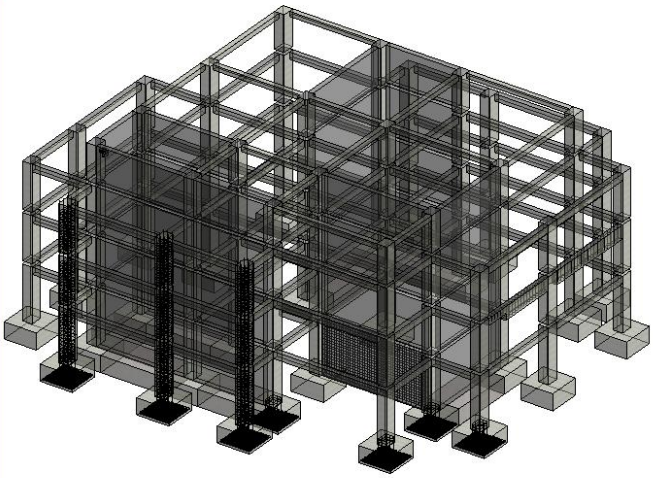


The user can now save time in detailing the project using these annotation tools. This way, dimensions can be easily added to the drawings. Instead of manually selecting each element, users can now automatically create a chain of dimensions along a direction or based on a line that intersects model elements. Individual dimensions can also be joined to create a single chain which can be moved or copied in an easier way.

Categories Visibility

This tool offers the user the possibility to quickly switch the visibility of selected categories of objects (floors, walls, windows, etc.) in the current view. It behaves as an interactive switching of elements' visibility and can be applied separately for each view. Its major advantage is that it is easy-to–use, with results that can be seen in real-time.





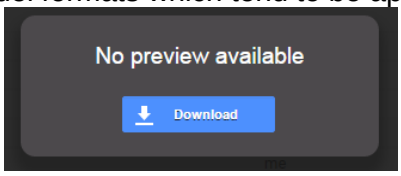
3D structural rebar published in A360®

Cloud Services

The cloud is the easiest way to share data that is replicated in multiple sources simultaneously. There are multiple cloud based services available from a wide variety of sources from Google to Microsoft to Dropbox, all vying for business in a very competitive space.

The cloud (simply explained as data saved on a secure server accessed online or synced to your computer and mobile devices) enables data to be easily shared with others. A folder can be shared with others and as a file is added or amended it is immediately synchronized updating all other instances (when connected to the internet). This ensures everyone has access to the very latest data. In reality the cloud has been around since the beginning of the World Wide Web under different names but recently reinvented, and seriously simplified.

All cloud services offer free storage space and the ability to securely share data, however the biggest challenge with storing multiple file types is the ability to view them. This is particularly true of CAD and related BIM model formats which tend to be application specific.



Cloud services that enable viewing of 3D CAD and BIM models opens up new possibilities to share digital BIM data in real-time from and with multiple sources. This level of interaction with project partners starts to introduce new ways to visualize and represent digital information together with the working BIM model. But let's not get ahead of ourselves. First we must adopt a cloud services from which we can capitalize on the viewing of BIM project models … in this case Autodesk A360.

AUTODESK A360

Autodesk A360®

From the web page http://www.autodesk.com/products/a360/overview, you can have an overview of the A360® system capabilities:

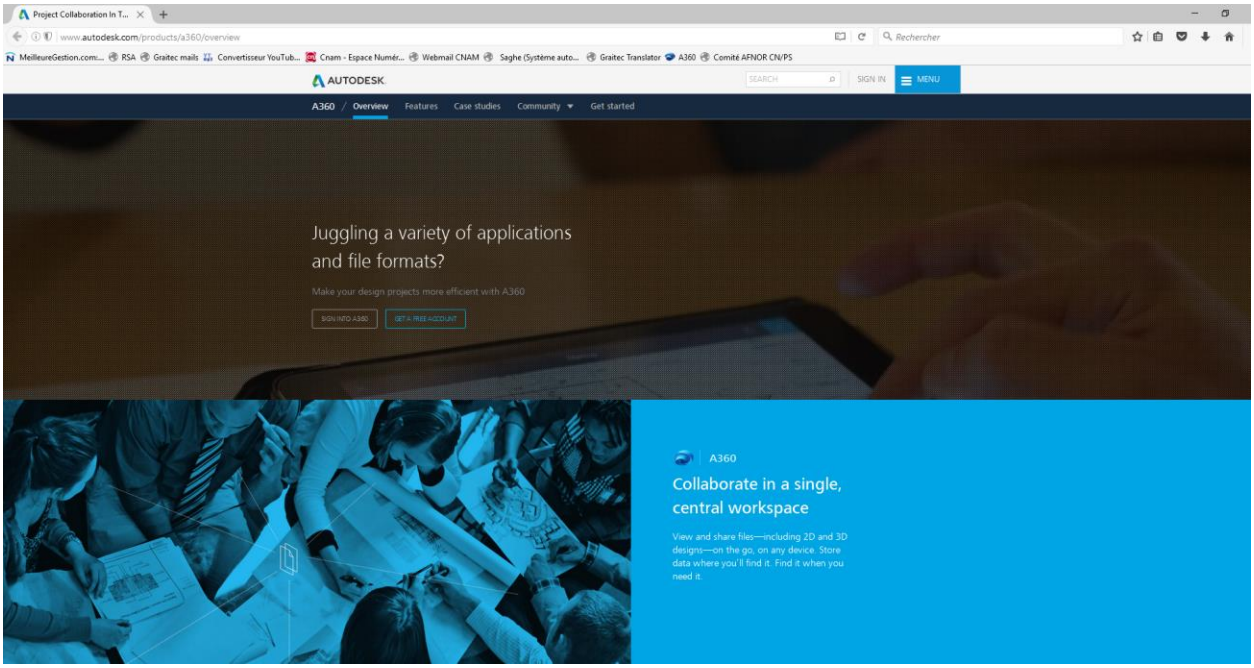


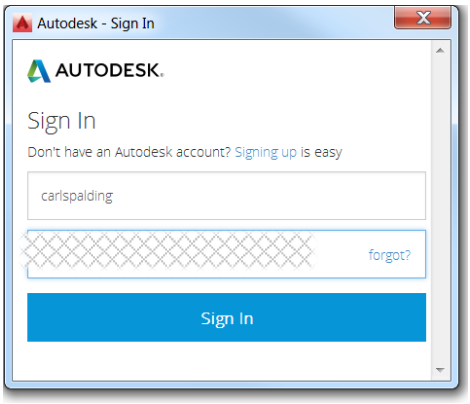
FIGURE 27: AUTODESK A360® WEB SITE TO GET ACCESS TO THE A360®.

There are multiple cloud based services available from Autodesk with many more services planned. The base of which is A360 included with all Autodesk product subscription contracts and accessed using your Autodesk Account. https://a360.autodesk.com/

Autodesk Account / ID

Your Autodesk Account (also known as Autodesk ID) is a single sign in account that enables you to use the same user ID and password to access multiple Autodesk websites. This simplified sign in process makes remembering and managing your account information easier.
Sites Accessible with Autodesk ID:

Alias Design Community
AutoCAD Exchange
Autodesk 360
Autodesk Discussion Groups
Autodesk Green Building Studio(*)
Autodesk Labs
Autodesk Learning Central
Education Community
International Communities
Manufacturing Community
Registration & Activation
…



(*) Access to this website requires a current Autodesk® Subscription contract.

Your Autodesk Account also provides access to your profile and all the products and services you have purchased or for which you have a subscription contract - however the levels of services available will depend on the types of products you have on subscription.

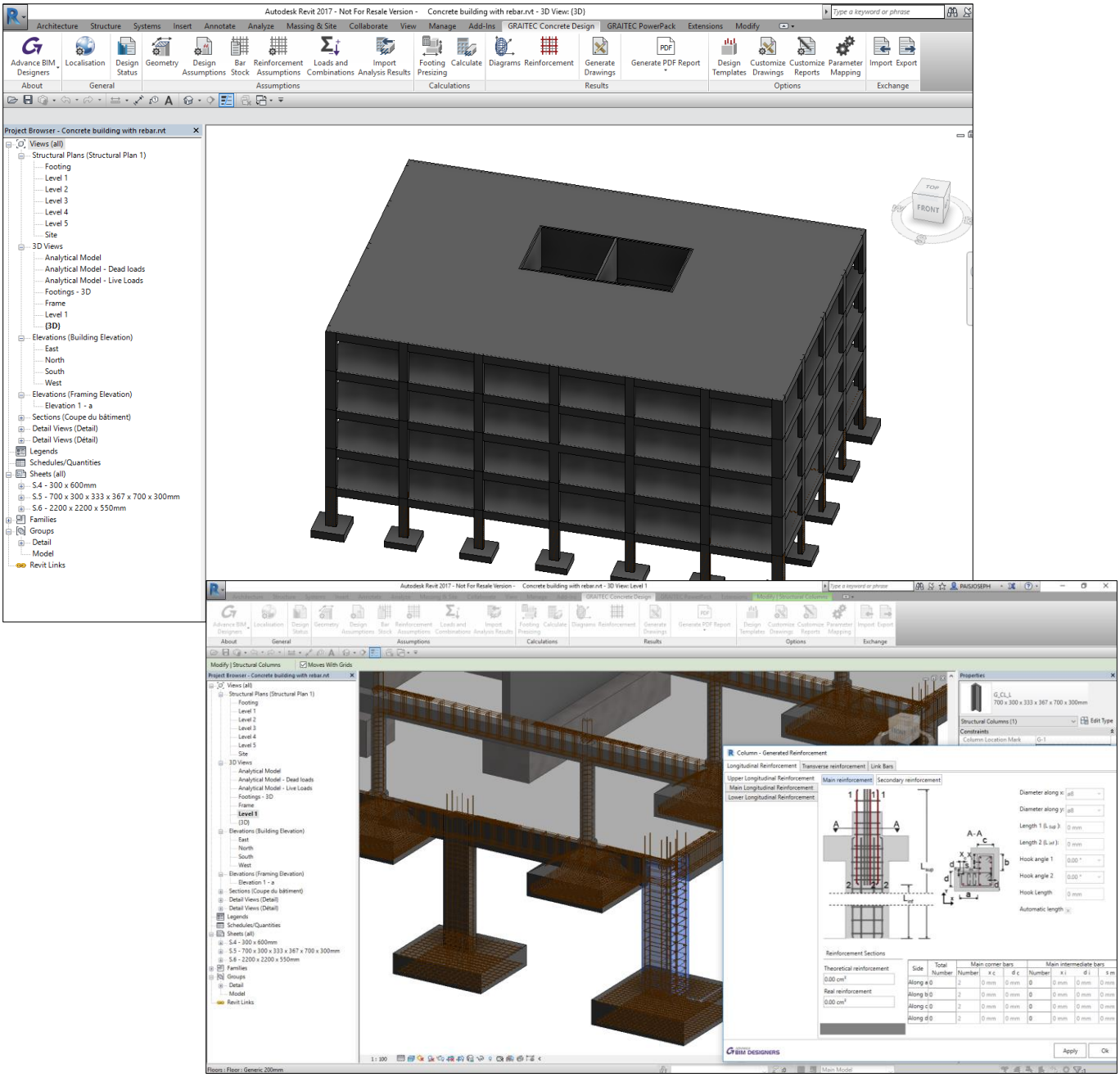
Then, there are three possible ways to get connected to A360®:

- Create an A360® free account using the web address above. For this option, you will be able to access all functionalities but just for one project.
- Download a 30 day trial version for an unlimited number of projects and access to all functionalities.
- Purchase the full kit, available with monthly and annual subscriptions (please see terms and conditions on the Autodesk website).

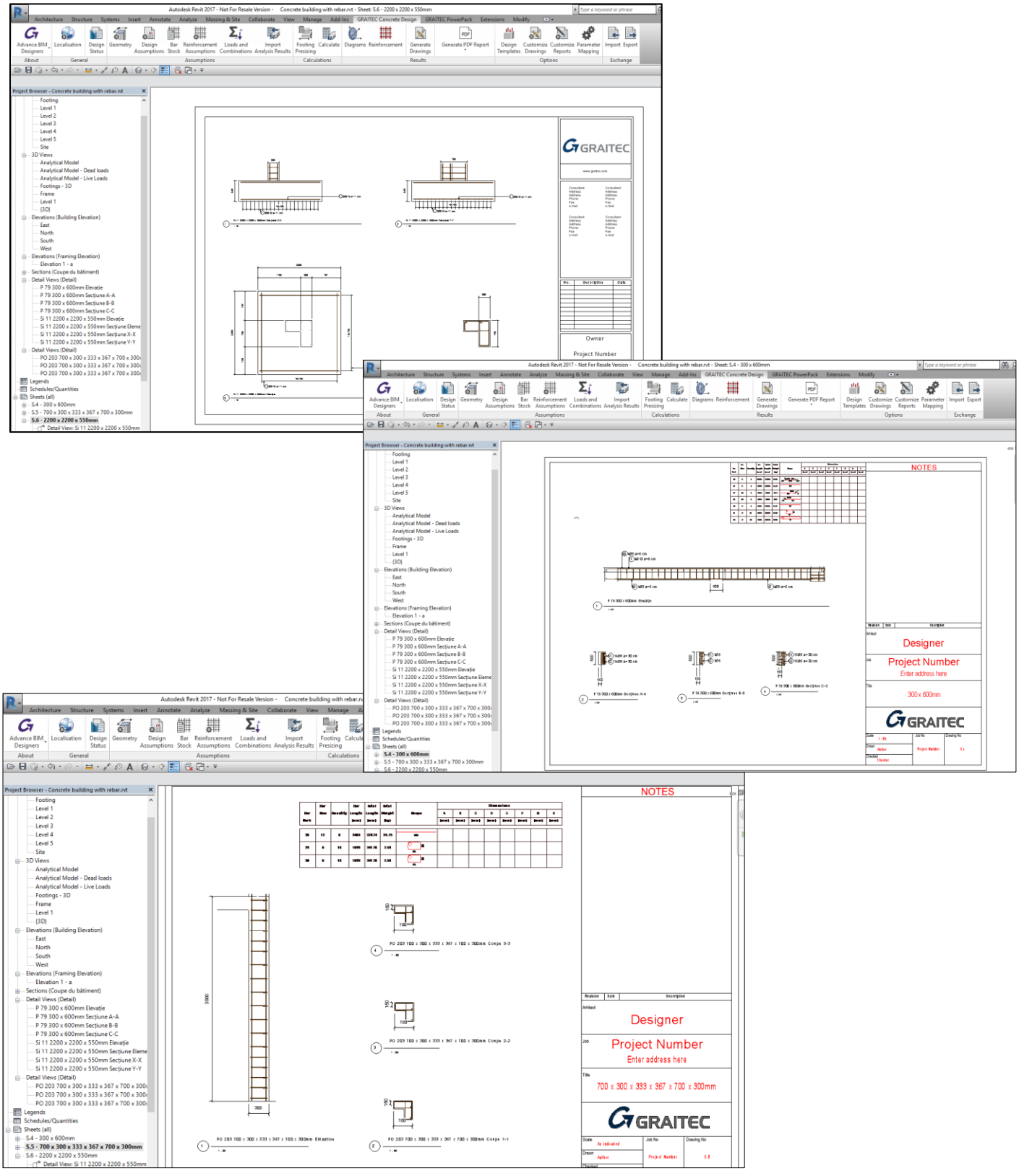
If you are a student, you can download a three year license for free!

Having set an A360 project, you will be able to share a project, publish a 3D rebar model, collaborate with the other stakeholders at any stage of the project, view the models, the documents, insert and answer comments… Collaborate!

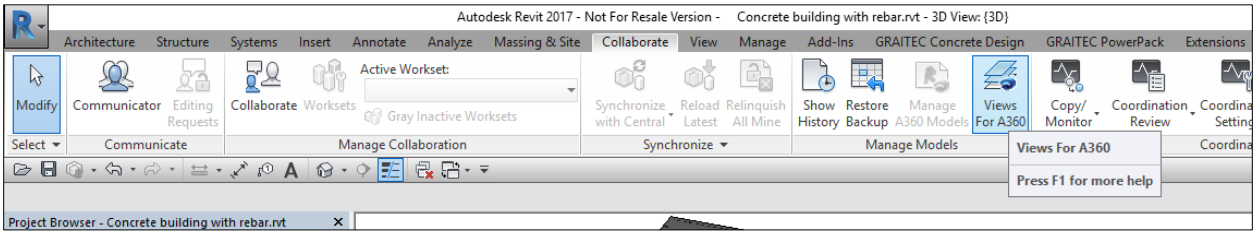
To illustrate the workflow you can apply to your projects using Autodesk A360® and GRAITEC BIM Designers inside Revit®. Let's use the following example. It is a Revit® model on which we have generated the reinforcement on the beams, columns and footings of the first level:



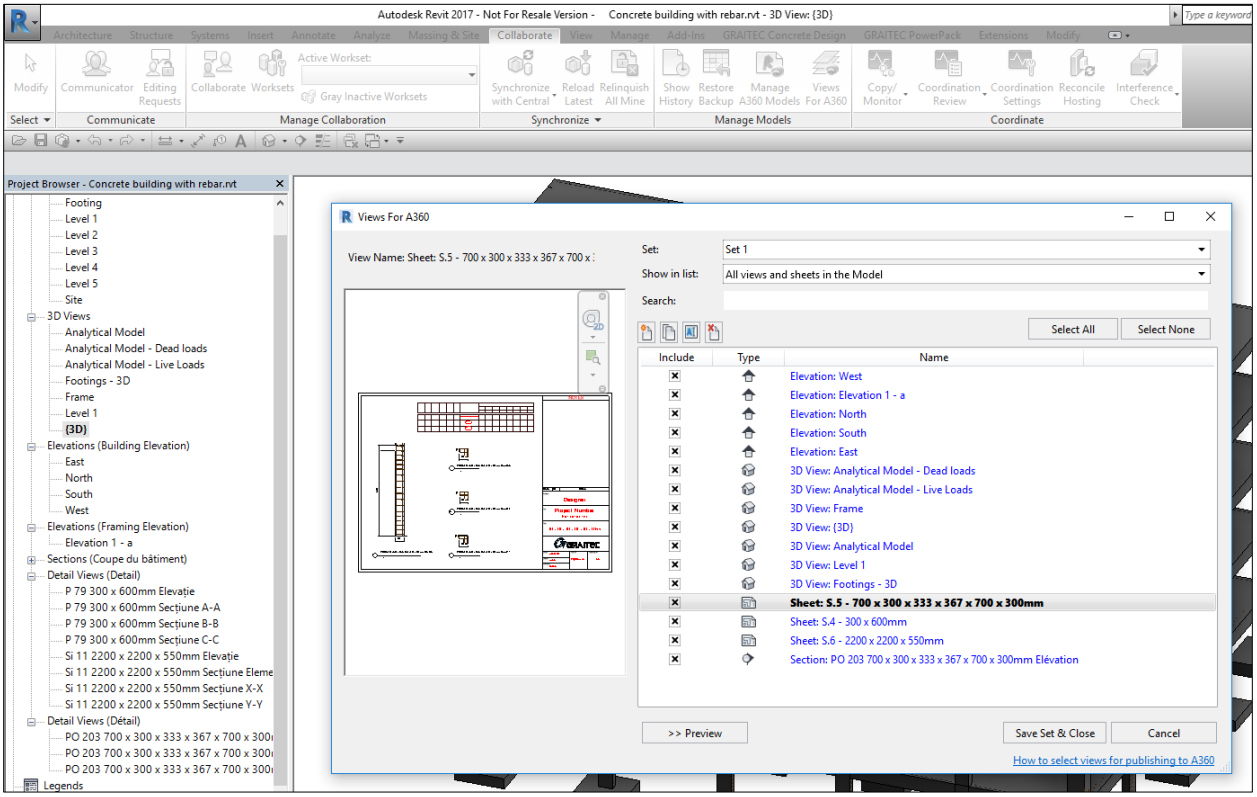
Using the BIM Designers modules, I have also automatically created 2D section views with annotations and generated a 2D design report for columns, beams and isolated footings:



Before publishing this Revit® model to the A360® cloud, you can select directly from Revit® which views and sheets will be published in the cloud, selecting the command [Views for A360@] from the “collaborate” ribbon:



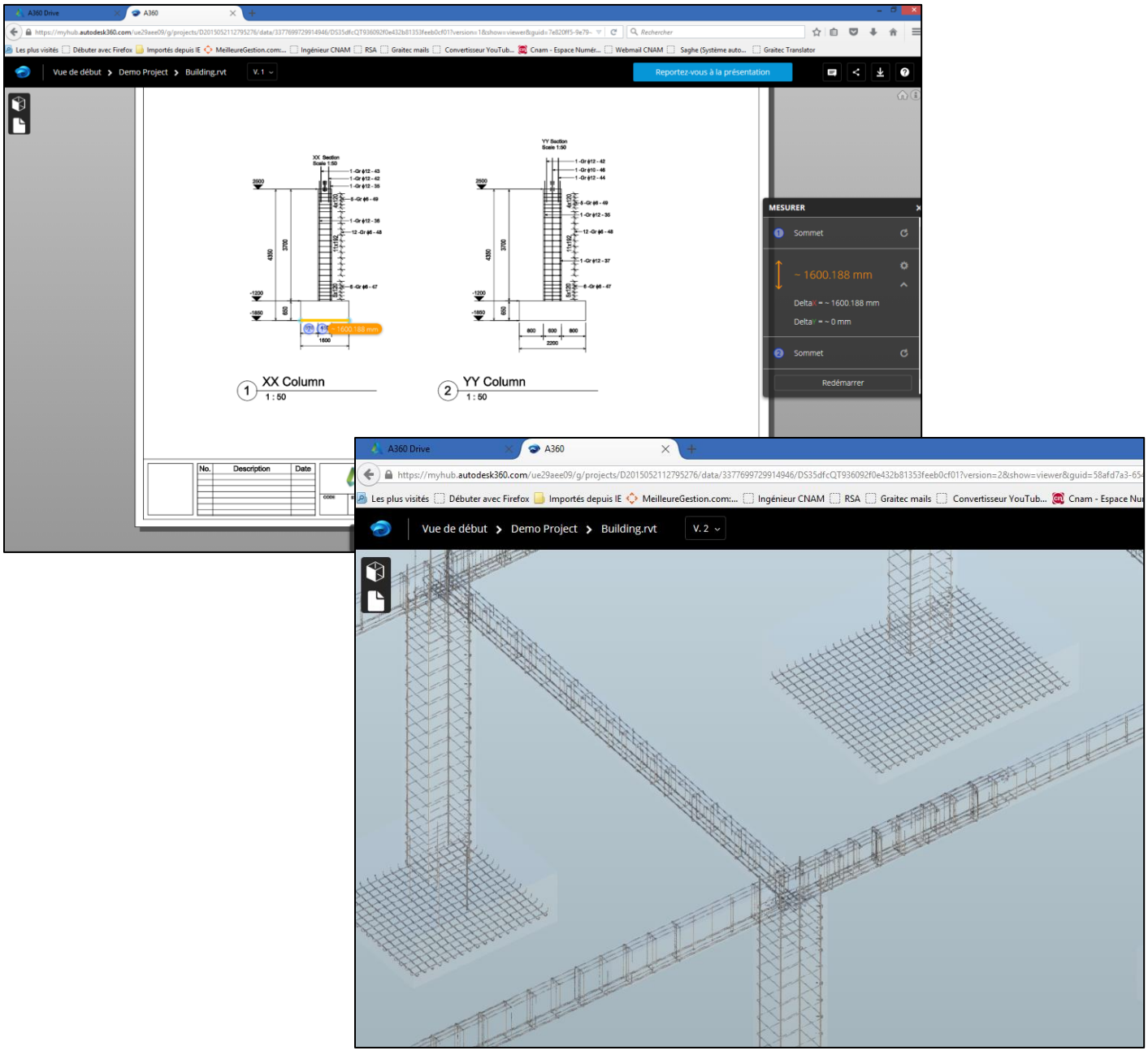
Just select the views you want to publish:



Connect to your A360 project and just drag and drop the Revit® file and wait a few time for the upload!

You are ready to collaborate in the cloud!

All people connected to the A360® project can access the 3D model, check the properties of the different components, add any comment, visualize the views, the drawing sheet, pick up a dimension…



If you want to understand more about A360®, learn how to prepare for the future of BIM 360, I advise you to attend the class from Grant Dott: CS20320 - BIM 360 Docs: Indistinguishable Evidence of the Situation.

Conclusion

We hope that by reading this document, you have found out how to take advantage of using our new technology (BIM Designers and PowerPack) to produce 3D rebar cages and the corresponding documentation within Revit®.

With BIM Designers technology, it is clear we are trying to bring some innovative changes that benefit the BIM workflow and the whole construction industry:

- Analysis results are part of the BIM model, relying on a real 3D BIM application which is Revit®
- Engineers take design driven decisions in the BIM Design application (Revit®) using BIM Designers tools. Thanks to this, Revit® is now able to understand and post process the engineering data.
- The GRAITEC technology is really adaptive and applies to different possible workflow depending on your company, your team, your project…
- Engineers and detailers communicate via a 3D model (using the BIM Designers 3D rebar) and not only via drawings.
- All the information can be easily shared using the Autodesk A360® capabilities.

With the power to automate and control complex manual processes, as well as bridge the 'analytical and detailed model data-sharing' gap between engineers and draftsman, GRAITEC BIM Designers help you take advantage of BIM for reinforced concrete structures. Then, it's up to you to decide how you want to apply this technology! It's your decision how to use the analytical model in order to transform it as a benefit and not a waste of time!

The workflow being proposed in this class handout may look disruptive at first but it is not. It goes far beyond the current argument of '*having all the data in a single model*' but actually represents a new intelligent workflow with real benefits offered by the rebar BIM Designers for automating downstream processes and bridging a 'defined' stop/start gap between engineers and detailers.

We are convinced that the entire rebar industry is moving into this direction and it's our job to work to providing you with effective tools to accompany you in this transition! It's time to take advantage of **industry-driven-intelligent-automation** and connect your structural BIM workflows. It's time to change the game.

For further information, please contact:

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