TUTORIALS

Connected Structural BIM Workflows for Revit®
About GRAITEC Tutorials

GRAITEC technology evolution is driven by years of practical experience and combined with user feedback to provide the most intelligent and effective structural, BIM and design workflows possible.

GRAITEC Tutorials are provided as a free resource designed to guide users in the best practice methods of applying GRAITEC software, add-ons and industry solutions to speed up, enhance or automate everyday process.

GRAITEC Tutorials are written as illustrated step by step walk-throughs and assume a certain level of industry experience in the given subject matter or know-how with the related Autodesk software.
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GRAITEC Tutorial – Connected Structural BIM Workflows for Revit®

From this tutorial you will discover how FEM results can be transferred and saved in Revit® in order to be able to apply a streamlined and connected structural BIM Workflow and maintain a central BIM model. We will be using Autodesk® Revit®, GRAITEC Advance Design and GRAITEC BIM Connect for Autodesk® Revit® in this tutorial.

The purpose for transferring both geometric data and FEM results data to Revit® is to make it possible to take advantage of industry-driven intelligent automation described in another tutorial.

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 constructible models. By simply transferring (or manually adding) intelligent Finite Element Meshing (FEM) results data from FEM calculation software, such as Advance Design®, to Revit® project models (better: Revit® analytical model), you begin to open up a world of new possibilities.

For instance, being able to utilize intelligent BIM information held in the Revit® software analytical model to automatically:

- Generate 3D reinforcement based on the actual ‘design and loads’
- Automate the production of detailed views and drawing sheets, and more…

At GRAITEC we call this industry-driven intelligent automation.

In this workflow tutorial, we will show how to achieve a connected BIM workflow describing the process step by step in order to be ready to take advantage of industry-driven intelligent automation to automate your reinforcement workflows.

The learning objectives:

- Round trip models between Revit® and FEM calculation software (Advance Design® shown in this tutorial)
- Run FEM calculations and export the results and geometry changes

Synchronize the results and the changes back in Revit®
Part 1: Connected Structural BIM Workflows

The basics

In this tutorial, you will discover how you can connect Autodesk Revit® Structure and your FEM system, such as Advance Design® in order to apply either of the following connected workflows:

As you can see, the objective at the end of this tutorial is to get a Revit® model which contains its typical descriptive model enriched with set of FEM results stored in Revit® analytical model.

In this tutorial we will be applying workflow ‘A’ as this covers both scenarios.

To support this connected workflow, you will need to have the following two add-ons for Revit® on your computer:

1. “Structural analysis toolkit” for Revit® – This will enable analytical results to be displayed in Revit® and is available to download and install from the Autodesk App Store (https://apps.autodesk.com):
2. “GRAITEC BIM Connect” - There are a number of ways to connect your FEM system with Revit®. In this tutorial we’ll be using Advance Design®, a 3D FEM system from GRAITEC, to demonstrate a connected workflow, however the basic steps demonstrated in this tutorial should apply globally with any BIM enabled FEM system. Please contact your FEM software provider to see what is possible with your current system. To be able to use the link between Revit® and Advance Design®, you will need to install GRAITEC BIM Connect for Revit® plug-in (free) which can be accessed via the Autodesk® App Store here or GRAITEC website here. BIM Connect is also installed with the GRAITEC PowerPack for Revit® (recommended as these tools will be featured in further tutorials), if you subscribe any Autodesk® Revit® product with GRAITEC then as a customer you will already have access to this as a loyalty benefit. Alternatively the PowerPack for Revit trial is available from the GRAITEC website here or from the Autodesk Exchange App Store here.

Note: It is assumed the user has a working knowledge of Revit®, and has unrestricted access to model information where the various exercises can be practiced.
Revit® Structure analytical model
To cover the most complex workflow we will start with a Revit® model and make sure that the analytical model is well defined. The Revit® model used in this tutorial is available here to help you achieve the following steps:

1. Open the Revit® model which contains geometrical description of the elements:

As you can see, the analytical model is well defined (all elements are connected together) and, if you are using the sample project, already include some load cases and loads on slabs. This is to show the workflow can support bi-directional load sharing, covered later in this tutorial.
3. If you are using another Revit® model, please make sure that the analytical model is well connected => if it’s not the case, you can use the native Revit® commands available from the Analyze ribbon:

- Check and adjust the analytical model
- Manually manage wall adjustments, openings (to be taken into account or not), the analytical links.
- Adjust boundary conditions
- Define (and change) the automatic analytical alignment settings
- Check the consistency and the supports of the analytical model

4. You can also check the property list of the elements you want to consider as having an analytical role by simply activation or deactivating the Analytical model option in the property list of each Revit® object:

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**Note:** The analytical simplification is subjective and the engineer may want to define the analytical model in a way that suits their individual expectations and requirements. Even if it is possible to manually adjust the analytical model, it can be an important time-saver if the user reviews and adjust the default automatic relation settings!
5. As is the case of the sample project used in this tutorial, it is possible to define the load cases and the loads in the analytical Revit® model, which can be free or hosted by a structural element. The load cases management and the loads creation are available also from the **Analyze** ribbon:

![Image of the Analyze ribbon in Revit®]

**Note:** If load cases and the loads are define in Revit®, they will be completely transferred to Advance Design using the GRAITEC BIM Connect (shown later in this tutorial).

These load systems, as well as others, can also be created in Advance Design: in this case, and using BIM Connect, you will be able to synchronize new and existing loads with Revit®.
Export the Revit® model to the FEM system

Once you have the descriptive and the analytical models properly defined in Revit®, you are ready to export your project to Advance Design (or your 3D FEM system).

As previously mentioned, you need to have BIM Connect installed on your machine, either the single tool or as part of the GRAITEC PowerPack:

1. If you have installed BIM Connect, you will get two new icons in the Add-ins ribbon in Revit®:

   ![BIM Connect icon](image1)

2. If you have installed the GRAITEC PowerPack for Revit®, you have a dedicated ribbon with numerous tools and functions, including BIM Connect:

   ![GRAITEC PowerPack ribbon](image2)

Clicking the BIM Connect icon will access several options to manage the workflow:

![BIM Connect options](image3)

- Export the geometrical and the analytical model from Revit®
- Import a 3D model into Revit®
- Synchronize changes between models
- Define the export/import settings

3. The 1st step is to set check the options and set your preferences when exporting project models => Click [1] Settings:
4. The **Settings** dialogue has four sections:
   - **Paths to family files** – you can add your own here if necessary.
   - **Settings**: Check both **Use section mappings** and **Update section mapping on import**.
   - The ‘Concrete section mapping’ button enables users to use their own Revit® families by defining the corresponding parameters used in Advance Design. This database is enriched in real-time when BIM Connect is used, keeping track of custom family mapping preferences:

   ![Concrete section mapping](image)

   - **EXPORT** and **IMPORT** options to define what is included / excluded on export / import. Make sure the option **Export only elements with analytical model** is checked.
   - **SYNCHRONIZATION**: Ensure both ‘Import FEM results for’ options are checked to receive FEM results

5. Next, activate the [2]“Export” command. The following dialog and options appear before applying the export

   ![Export options](image)

   - **GRAITEC BIM** - Exports a GTCx file which is an advanced BIM format developed by GRAITEC
   - **Other formats** - Select export format from drop list
   - **Country library** – Select country section to set the library used in the GRAITEC Software (useful for the mapping process)
   - **After export**:
     - Automatic software launch (if Advance Design® is not installed/detected nothing will happen)

   **Note**: You can also transfer the Revit® model directly to Advance Design by clicking the corresponding orange ‘G’ icon on the ribbon. In this case, your project will arrive directly in Advance Design®

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When a new material is detected, BIM Connect will prompt asking if you want to update the mapping database in real time. Just select **Create new material mapping**: 

This operation will add new materials to the file using the same name as the Revit® model => you will be prompted to define the location to save the file.

**Note:** If you have selected the option “Automatic software launch”, you will arrive directly in Advance Design with the analytical model from Revit® and the Revit® project tree (see next chapter).

You will also get a message asking if you want to generate a report file with all the information about the export: name of the exported file, date, location, elements exported… This is for reference only.
Part 2: Internal FEM forces calculation

Import the Revit® model in Advance Design

Depending on the option you choose when exporting the model in Revit®:

- If you have selected the option “Automatic software launch” or clicked the orange ‘G’ icon from the PowerPack ribbon, you arrive directly in Advance Design® with a 3D model corresponding to the analytical model transferred from Revit® and the project tree structure intact.

- If you have NOT selected the previous option, it means that the BIM Connect prompted to created an exchange file on disk which you have to import manually in Advance Design®:

1. Run Advance Design® and create a new empty project:

2. From the Advance Design BIM ribbon, select the command Import GRAITEC BIM:
3. If an unknown material or section is detected, you will get a dialog prompting either to map with an existing material/section from the Advance Design® library or to create a new entry using the Revit® properties:

Please select the option [Create a new material from the existing data] and also the option [For all unknown materials] in order to not define it several times.

At this stage of the workflow, you have a 3D model in Advance Design which corresponds exactly to the analytical model sent from Revit®, including the geometry, the loads, the analytical supports and the systems description in Advance Design corresponding to the levels description in Revit®.
4. IMPORTANT REMARK: The self-weight of the elements was not defined and therefore not transferred from Revit® to Advance Design. Please ensure you select the dead loads case in Advance Design and activate the self-weight in the right axis:

The purpose of this tutorial is not to teach Advance Design, but at this stage of the process, it is expected that you have access to all the equivalent functionalities required manage the FEM calculations possible in Advance Design, including:

- You can access all the properties of each member, either to check what was defined in the Revit® analytical model, or to stipulate your own assumptions. This is an important step for you to be able to trust the FEM model.
- You can define what kind of finite element you 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.
- You 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 any missing loads, either manually or using the automatic generator for climatic and seismic loads:
With Advance Design®, you can run a FEM analysis and get all the requested results (including internal forces on all elements for all the load cases) that you can post process graphically or with tables in reports:

Export FEM results to Revit®

Once the calculation is complete, we need to ensure we export the FEM results to Revit® in order to automatically fill the analysis results database (called “results package” in Revit®).

1. First, make sure that the option **Exports forces > On linear elements on nodes** is activated in the Application option dialog from the Manage ribbon:
2. Then, from the analysis model in Advance Design, go to the BIM ribbon and activate the Export option from GRAITEC BIM panel:

![Image of BIM ribbon with Export option](image)

This action will save a GRAITEC BIM (GTCx) file this on disk which describes both the complete geometry of the 3D Advance Design model and also includes the complete FEM results. Make a note of where you saved the file as you will need it for the next step.

**Note:** It is IMPORTANT to export your project from the FEM software after the analysis is complete in order to include both the geometrical model and calculated model – as described in the example above when exporting the project from Advance Design® using GRAITEC BIM file GTCx. Otherwise the exported file will contain only the geometry and no FEM results.
Part 3: FEM results in Revit®

Importing the FEM results in Revit®

This is the final step of the workflow, synchronizing the calculated project model and FEM results with the original Revit® project.

1. When using GRAITEC Advance Design® and BIM Connect, before importing the GTCx file in Revit®, ensure both options 'Import FEM results for *' are checked under SYNCHRONIZATION:

2. Next, select ‘Synchronization’ from the BIM Connect drop down menu to launch the control center:
[1]: First you’ll need to load the GTCx file you created from Advance Design®, click **Load** and select the file you saved in the previous chapter.

- The contents of the GTCx file will be displayed in the window in a tabular format
- Whilst the GTCx file contains the entire project, only the elements which have been added, modified or deleted will be displayed in the list (taking into account any applied filters)

[2]: Next, click on **Apply** to accept all changes displayed and the contents of the GTCx file (the FEM results) will be sync’d with the Revit® model. Alternatively you can determine what action is taken for each item by ‘right clicking on each entry and then clicking **Apply**. This process may take a few seconds or several minutes depending on the size of the project. You can close the dialog at the end of this step or dive a little deeper.

[3] **Filter** and [4] **Attributes** options allow more control over what elements are shown in the synchronization dialog and which parameters are synchronized

The possibility to ‘Filter’ what you want to synchronize is very important as you are able to predefine the content that is synchronized enabling BIM workflows to be fine-tuned for each project or situation. For example you can decide to synchronize only specific sections or materials changes, or even ignore the specific modifications done by the engineer in Advance Design.

![Select the attribute columns you want to see in the synchronization list](image)

**Note:**

1. The results package does not appear in this synchronisation list, but you will just see the name of the GTCx synchronized file under **Filename**;

2. Bear in mind that in cases where no changes are made to the geometric model by the engineer, the file may still contain a results package. You will need to click “apply” to append the results package to the Revit® project model. This applies even if you have not validated or excluded changes appearing in the synchronisation dialog.

3. It is important to understand that clicking **Apply** without taking any other action will only import the FEM results package ignoring all items other changes listed in the table
At this stage, the FEM results coming from Advance Design® are now saved in Revit® project and you can post process them (display them) directly in Revit®:

3. At the end of the Analyze tab on the Revit® ribbon, you have two functions called Results Manager and Results Explorer:

The Results Explorer can display the main results on the members and supports in the analytical model, select the load case or the combination you wish to see:
Part 4: Behind the scenes: How synchronisation with GRAITEC BIM Connect works

The objective of the tutorial was to explain how to apply a connected BIM workflow which allows you to store within Revit® a set of FEM results coming from your FEM software package (Advance Design in this tutorial).

Let’s take few minutes more in this additional chapter to explain you a bit more how the GRAITEC BIM Connect module works and how you can also synchronize geometrical changes (and loads) between Revit® and Advance Design®.

Let’s continue with the same Revit® model:

1. When exporting the model from Revit® to Advance Design, using the Export function of the BIM Connect plugin, it creates a specific unique ID for each element called ‘IdGtcParameter’, which will be used to synchronize both the Revit® and the Advance Design models:
2. To illustrate the workflow, we will change the section size of a concrete beam and a concrete column from Advance Design and send the project back to Revit® using the process described above:

When synchronizing the GTcx file with Revit®, we are able to clearly see the type of changes made and have several options on how 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.

This synchronisation mechanism is important to the integrity of the BIM workflow, giving the possibility to quickly and safely handle any changes whilst working with a single model during the different project phases, and ensures the project model is always current.

**Note:** The synchronization mechanism and the corresponding dialog can be used to synchronize any kind of changes between Revit® and Advance Design: geometry changes, load cases and loads, FEM results… Of course this works in both directions and can be applied any number times!
Useful links and information

We hoped you enjoyed this tutorial. We welcome all feedback and new/improvement suggestions.

To contact your nearest GRAITEC office or Partner, click here.

To download a free trial, read more information or purchase any product mentioned in this tutorial please visit Graitec Store.

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