AEC10342

Design-driven 3D Rebar in Revit® Structure with automated drawings and schedules.

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Learning Objectives

At the end of this class, you will be able to:

- Start from an Autodesk® Revit® structural model, which includes the geometry of reinforced concrete elements, loads and FEM results.
- Complete structural design assumptions according to different design codes and discover how to publish this information in A360®.
- Design reinforced concrete members within Revit Structure®, view the 3D rebar cage, design reports and graphical results.
- Automatically receive the 3D structural rebar with corresponding views and drawing sheets published in A360®

Description

On every type of project, the adoption of a transparent and easy-to-apply Building Information Modeling (BIM) workflow is the key to success. This also helps reduce the risk of errors and it provides huge productivity ratio improvements while making the design and engineering processes more efficient. To reach this objective, the engineer and the technicians, using Revit Structure® software, need tools capable of automating 3D rebar generation (including semi-automated detailed drawings and schedules), but with the ability to make design-driven decisions for the reinforced concrete members in real time.

In this class you will learn how GRAITEC's Revit® software-based 3D rebar design tools deliver real benefits by consolidating design decisions based on local codes to accurately create 3D rebar in Revit® software on the fly with localized families. These tools also produce automatic reinforcement drawings and schedules, published to the cloud, or through Autodesk 360® cloud-computing platform ready for fabrication by the rebar manufacturer.
Design-Driven 3D Rebar in Revit Structure® with Automated Drawings and Schedules

Your AU Experts

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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. Noted for driving down project cost and errors whilst optimizing workflow and processes, BIM promotes early cross-discipline project collaboration and data sharing which ultimately leads to shorter project delivery times, increased accuracy and more effective and efficient designs.

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

If we focus now on the reinforced concrete rebar detailing, we can see there is 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.

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 will it take? How will the data will be shared between the project team members?

We aim to show you that BIM Designers technology from GRAITEC has been designed to bridge this gap and provide a real solution to this problem. We will introduce you to an easy-to-learn, effective and adaptive solution which can fit with almost any workflow and retain the analytical data intelligence within a Revit® environment.
Currently, design and the production of reinforcement drawings is shared between the engineer and the draftsman go through several iterations. The frontier in between is not well defined and can move depending on the companies, 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.

That is why we think it is important to analyse how, through BIM Designers, an adaptive technology can help users switch to a full BIM workflow. There is no doubt that today most engineers still use AutoCAD, eventually enriched with an add-on module, to directly produce 2D reinforcement drawings without handling a 3D model and working directly on the final document. Bearing this in mind, it is important to analyse how to move from 2D detailing to 3D detailing for Reinforcement Detailing.

Gareth Spencer, from GRAITEC UK, will present a class (ES10883) on the theme ‘Should we move from 2D Detailing to 3D Detailing for Reinforcement Detailing?’ This is his class description:

In this class we are going to look at detailing reinforcement in concrete structures and moving from the traditional method of 2D detailing to 3D detailing approach using Autodesk® software. We will take a look at the comprehensive tools in Revit Structure® software, and some third-party tools, to help accelerate the design and detailing of reinforced concrete structures. This class is designed for structural/civil engineers, construction managers, structural engineers/technicians and technical drafters.

Gareth is right to remember the main objective of moving from 2D to 3D for Reinforcement Detailing is to help the user accelerate the design and detailing of reinforced concrete structures.

I strongly recommend you attend or review this class!
Let's get back to the core of our subject - if we look at the definition of ‘BIM’, we arrive at the conclusion that BIM is a workflow based on a complete digital model with the information stored in one place. Is it really true? In the future perhaps, but today? What is the benefit of all this information? For whom?

To start answering these questions, if we assume we are able to give an answer, or at least a partial one, we need to define some possible workflows. Amongst the possibilities, we have identified the most common:

- **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 back the model with updates to Revit® from which the draftsman can create the drawings:

  ![Figure 1: Workflow A](image)

- **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 2: Workflow B](image)
These two workflows are very similar and reach the same conclusion. At the end of the process, we can handle a Revit® model which has all the requested BIM information; the 3D geometrical model, the analytical model and FEM results.

FIGURE 3: GLOBAL WORKFLOW

The Revit® model completed with this information is the starting point to completing 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 BIM with GRAITEC BIM Designers.
Start from an Autodesk® Revit® structural model

Which kind of model? Revit Architecture® or Revit Structure®?
At the introduction, we explained that the starting point of an easy-to-apply BIM workflow to handle the 3D rebar in Revit, is an Autodesk® Revit® structural model, which includes the geometry of the reinforced concrete elements, loads and FEM results:

![Revit Structure® Model Including FEM Results](image)

**Figure 4: Revit Structure® Model Including FEM Results**

It is important to keep in mind that we are speaking here about a structural BIM workflow. So we need to start with a Revit Structure® model and not a Revit Architecture® model, which will not embed all the information we need to handle such a structural workflow.

Of course, it is possible to synchronize a Revit Architecture® and a Revit Structure® model using the “Copy/Monitor” functionality but it is not the subject of this class. So we assume that we have a Revit Structure® model with analytical model defined.
How to get the FEM results in Revit Structure®?

We are sure that many of you reading this question will think about another question: “I do not want to know how to get the FEM results in Revit Structure® but I am wondering why should I store FEM results in Revit Structure®?” and it’s natural to have this question in mind.

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 the benefit 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, let’s challenge this opportunity from the other side. Revit Structure® is not currently able to handle FEM analysis but has several interesting capabilities:

- Revit Structure® creates an analytical model with some intelligence that can be expanded.
- Revit® can host analytical data and FEM results in a dedicated database.
- Revit® has a ‘Results Explorer’ to display the results from FEM data saved in its analytical model/database which originates from an external source.
- And Revit Structure® is the central application of a real structural BIM workflow.

Having these capabilities in mind, we can go one step further applying some design tools within Revit® in order to bring intelligence to this specific data stored in Revit Structure® and automate the generation of the 3D rebar cage and the corresponding reinforcement drawings.

Imagine a process which allows you to get a 3D rebar cage and the drawings instantly within Revit Structure® just relying on the FEM results database! It really does start to make sense. That’s what we propose with our BIM Designers tools which we will describe later on in the document.

Now that we are curious to learn more, let’s answer the initial question: “How do I get the FEM results in Revit Structure®?”

Most of you already know the answer to this question and there is nothing new; several tools/plug-ins are available to link Revit® and the 3D FEM system, including the FEM calculation in the cloud with Robot. In our example, we chose to use 3D FEM software external to Revit® to make this workflow relevant to all companies.: If you’re not using Advance Design, just replace with your own FEM system (providing it links to Revit®), or apply the forces manually and still get BIM benefits from the structural workflow.
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Let’s come back to our illustration. To export the model from Revit® to Advance Design, the draftsman uses 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®:

When installed, the Revit® user will get a specific ribbon in Revit® with options to share the 3D model:

- Export the geometrical and the analytical model from Revit®
- Import a 3D model in Revit®
- Synchronize changes between models.
- Define the export/import settings
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Powerful filtering options are available:

- 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:
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- 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 to our example:

- As we saw before, we start with a Revit Structure® model which also embeds the analytical model:
Using the GRAITEC BIM Connect module, we export the model from Revit Structure®:

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’.

You will then receive 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, the engineer has a 3D model in Advance Design corresponding to the analytical model sent from Revit Structure®. He is in his environment with all the functionalities required to tune the FEM model:

- He can access all the properties of each member, either to check what was defined in the Revit® analytical model, or to stipulate his own assumptions. This is an important step for the engineer who must be able to trust the FEM model.
- He can define what kind of finite element he 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.
- He 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 5:** 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 6: DEFORMATIONS ON THE ENTIRE 3D MODEL**

**FIGURE 7: 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® if you have installed the Autodesk® Structural Analysis Toolkit for Autodesk Revit® 2016 available from the Autodesk App store:

After installing this kit, you will get specific options in the 'Analyze' ribbon to access to the 'Results Manager' and the 'Results Explorer':
• 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 synchronisation 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 8: SYNCHRONIZING THE CHANGES**
This synchronisation 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”!

Complete Structural design assumptions

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.

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

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 automatic creation of technical documentation.
- The enrichment of the BIM model in Revit Structure®

These modules are integrated in Revit Structure® and all the corresponding functions are available from a specific ribbon:
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 that, 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.
We saw before that it is possible to save a set of FEM results within the Revit® model. 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, I suddenly realize that it really make sense and brings to life an effective and easy-to-apply workflow for my reinforcement generation in Revit®.

We can illustrate the possible 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 drawing. Later on in this document, we will say a few additional words about this PowerPack.
Tip: 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 that GRAITEC BIM Designers are multiprofessional. 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 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 described previously 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).

Design assumptions

The only way to automate the reinforcement 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 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 will be 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 ribbon from where he can manage all the design assumptions for the selected object:

![BIM Designers ribbon in Revit®](image)

**Figure 11: BIM Designers ribbon in Revit®**
We cannot include the exhaustive list of all design parameters here, it would be too long and dare I say boring! But 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.

Of course, both assumptions families are country code dependent (Eurocodes with different national appendixes, US codes and Canadian codes) and that raises the question of country compliancy. It is a hard task for a software editor, especially when speaking about design and automatic drawings, to localize any application for different countries. That is why the BIM Designers are built on a parametric technology. We will see this in detail later in the document.

The system is really intuitive to use. 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:
• 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 12: DIALOG TO SET THE DESIGN CODES IN BIM DESIGNERS
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.
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.
Loads and combinations in BIM Designers
As you can imagine, the loads and combinations definition is a must, to be able to design the concrete members. So let’s go.

As we explained before in this class handout, we can store several packages of FEM results in the Revit® model. Although, 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, if we return to the workflow we proposed a few pages before, we can see the start of an answer:

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

Tip: By the way, I have worked at GRAITEC for more than 17 years, so I am constantly thinking GRAITEC and living GRAITEC.

At this point I will explain that the FEM results package in Revit®, to be used by the BIM Designers to design the elements, can fit fully with another FEM system compatible with Revit Structure® structural analysis toolkit - Robot Structural Analysis (RSA). This is the only alternative for the moment, the other software just synchronizes the geometry with Revit® and not the results.

But let’s get back to the workflow which includes Advance Design.
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 if you select an element and call up the ‘Loads and Combinations’ dialog from the BIM Designers ribbon, you will get the following dialog where you can see the FEM results inside the ‘Loads Definition’ tab:
These values are the input for the reinforced concrete design handled with the BIM Designers within Revit®:

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 envelopes.
  - Each load case comes with the design code properties according to Eurocodes or American codes; category of the live loads, factoring coefficients, actions effects, etc.
- BIM Designers can automatically generate combinations (this is not possible with the standard Revit® functionality) depending on the selected design code:

- The loads entered manually in the BIM Designers dialog are saved with the Revit® model and can be accessed from the same dialog at any time.
Design-driven 3D Rebar in Revit Structure® with Automated Drawings and Schedules

Design reinforced concrete members within Revit Structure®

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 the icon “Generate Report”, select a report template, define the level of details and run the generation. You will complete the report in seconds!
Design-Driven 3D Rebar in Revit Structure® with Automated Drawings and Schedules

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 with the views and drawings

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

**And the automatic drawings creation**

The reinforcement drawings creation is also automated with the BIM Designers. Starting from the 3D reinforcement rebar, the application is able to create the section views required, place annotations and dimensions, produce bar schedules, bill of quantities and consolidate all those views in a drawing sheet.

This process relies on the Revit® templates similar to the ones used in Revit® to manually produce section views. When assigning another template to an existing drawing, you will automatically receive another updated drawing:
Depending on the country uses and the projects, there is an option to automatically produce one drawing sheet per element (see the option in the dialog box above). If the option is enabled, you will get these kind of reinforcement drawings:

![Example of a drawing sheet produced automatically by BIM designers](image)

**Figure 17: Example of a drawing sheet produced automatically by BIM designers**

This technology is also able to easily manage the drawing updates when a design change is introduced. They do not need to be recreated or updated manually - no errors and more productivity!
Fine-tune the drawings with the GRAITEC PowerPack for Revit®
Let me remind you of the workflow we talked about at the beginning of this document:

We can see on the top right that GRAITEC propose a ‘PowerPack for Revit®’ to ease your Revit® user experience and make it more effective. Obviously, the automation of reinforcement drawings have limits, and as the Revit® user, you will feel the need to fine-tune the automatic drawing. That’s a job where the PowerPack can give you increased productivity.

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.
Design-Driven 3D Rebar in Revit Structure® with Automated Drawings and Schedules

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

Just to give you an overview, here are some of the available functionalities:

**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/those 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 at any time change the status to whichever combination best suits.
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.

Additional possibilities to arrange views

The PowerPack for Revit® includes a small tool with commands to arrange views in other methods than those available in Revit® by default. Revit® has two methods to arrange windows: Cascade and Tile. In addition, we can now offer the possibility to display one of the windows as main with the others tiled next to it. The dimensions of the main window are adjustable and the ‘Center’ command performs a zoom simultaneously on all views opened in the project resulting in a centered representation of the project in all views.
Possibility to update multiple files at once

This tool is a time-saver if the user needs to update files from an older version to the current one. Instead of opening each project/family/template and waiting for the update process to be fulfilled, you can now run the command for a folder and the procedure is completed in your spare time (for example, at night). The behavior splits into two parts - overwrite the existing files or copy them to a different location in order to have both versions and avoids irreversible removal.
Automatic calculation of gravity center for irregular shapes

The ‘Center of Gravity’ command automatically calculates and displays a tag for the geometrical center of gravity of an element or a set of elements at a time. With this automatically calculated, users can further move to apply loads, for example at the specified location.

Possibility to administrate families; Family Manager, Export Families, Add Copyright Watermark
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Users now have the option of administrating families in an easier and more productive way. The ‘Family Manager’ command allows you to choose which families and types are to be loaded into the project. They appear in the Project Browser and can be used within the project. This innovative command occurs as a tool able to filter and search families by name (missing in Revit®) and a view with graphical previews of families in selected groups (missing in Revit®).

In a similar way, users can now export the families from the current project to a specified destination via a tool which is intuitive and easy-to-use.

Adding watermarks to families is also one of the innovations of the ‘Family Manager’ panel, meaning that users can add copyright watermarks to families. This information is protected by a password chosen by the user and cannot be overwritten.

The 3D rebar cage and all the technical documents in A360

Autodesk A360®

I’m sure you are familiar with data management in the cloud, using such technologies as ‘Google Drive’. But did you know that it exists as an Autodesk® solution, dedicated to the AEC industry - Autodesk A360® (http://www.autodesk.com/products/a360/overview). A360® is a cloud-based collaboration tool which allows you to collaborate with all the project stakeholders, sharing all kinds of data (documents, 3D models, 2D drawings, etc.)

Figure 18: Autodesk A360® Web site to get access to the A360.
Design-Driven 3D Rebar in Revit Structure® with Automated Drawings and Schedules

With A360®, you will be able to store and share data via email or chat but you will also be able to access a 2D and 3D file viewer in your web browser without installing any plug-ins. This viewer can also be used on other devices such as your smartphone or tablet in order to access your projects and documents wherever you are.

There are three possible ways to get connected:

- 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!

**Tip:** At the beginning of my experience with the A360® cloud-based collaboration tool, I was quite confused by the A360® drive and the A360® team. In fact, it is quite easy to understand (after someone more experienced explained it to me😊). After installing A360® on your computer, you automatically get a shared folder which syncs with the A360® drive:
Then, when you select a file from a shared folder, you have the option to copy the file to an A360® project. Just click on ‘Copy to A360® Project’, select the A360® project and that’s it!

You can then use the A360® team to share the data you want with the people you want, access the model viewer and insert the comments you want!
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 Structure® 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 a column.

- I have saved the 2D section view into a DWF file:

- And saved the design report as a PDF:
Design-Driven 3D Rebar in Revit Structure® with Automated Drawings and Schedules

To publish these documents on A360®, just create a shared folder on your disk and place whatever you wish to share. I did so with my Revit® model, the DWFx views and the PDF report:

Wait for the folder to be synchronized, then you can access the content directly from your A360® drive:
Copy the documents you want from your drive to the A360® corresponding project and you are ready to collaborate through A360®.

**Figure 19: Revit® views and 3D rebar cage displayed in A360® Team**
When loading the Revit® model in A360®, you also have direct access to the drawing sheets produced automatically with BIM Designers:

**FIGURE 20:** DRAWING SHEET IN A360® WITH THE TOOL TO MEASURE THE DISTANCES.
Design-Driven 3D Rebar in Revit Structure® with Automated Drawings and Schedules

As you can see, this A360® collaboration tool is really useful because it allows you (and any people you have shared the project with) access to the project documentation, access to the model itself with the option of navigating through the 3D model, to select an element and view its properties, add comments online directly from your tablet or smartphone, or from any other device connected to the web.

This will undoubtedly change the way people manage their job and their projects.

Tip: When publishing a model on A360®, the default 3D view and all 2D drawing sheets are published by default (as mentioned above). If you want to change the views to be used in A360®, you can proceed as following:

- Go to the ‘Collaborate’ ribbon and activate the command ‘Views for A360®’ in the ‘Manage Models’ panel:

- You can create different “sets”, each one defining the list of views to be used:
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- Publish the Revit® model to A360® to see the predefined views:
**Autodesk A360® Collaboration for Revit®**

Autodesk® is also working on a new tool called ‘Autodesk® A360® Collaboration for Revit®’ which is a Cloud Subscription service that works with Revit® to connect building project teams with centralized access to BIM project data in the cloud. Teams stay connected in real time using the Communicator chat tool within models. Integrated with Autodesk A360®, Collaboration for Revit® enables the entire project team to work on shared building information models.

![Diagram of collaborative process with A360®](image)

**Figure 21: Collaborative process with A360®.**

This tool is complimentary to Autodesk® A360® as described before and will give you access to the cloud directly from Revit®.

To use the new Autodesk® A360® Collaboration for Revit®, you have to install the tool from the following web site [http://www.autodesk.com/products/collaboration-for-revit/overview](http://www.autodesk.com/products/collaboration-for-revit/overview). Then setup an A360® team project (as shown above) and invite the required people.
Once an A360® project is set up and people have been invited, you can run Revit® and sign in to A360® with your account:

Then activate the command ‘Collaborate’ inside the ‘Collaborate’ ribbon (you will only have this option if you have installed the ‘A360® Collaboration tool for Revit®’ tool and not in standard Revit®):
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You will then get a dialog where you can choose to collaborate using A360®:

Select ‘Collaborate using A360®’ then select the project on A360® team you wish to use:
When the A360® team project is defined, you can start the collaboration by clicking ‘Initiate’ and see the file automatically uploaded by Revit®:
Conclusion

We hope that by reading this document, you have found out how to take advantage of BIM to design your reinforced concrete structures and get a design-driven 3D Rebar in Revit Structure® with automated drawings and schedules.

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.
- Engineers and detailers communicate via a 3D model (using the BIM Designers 3D rebar) and not only via drawings.
- Drawings do not need to be recreated when a design is changed.
- All the information can be easily shared using the Autodesk A360® capabilities.

GRAITEC BIM Designers technology is flexible enough to fit with different possible workflows. The objective is to provide tools with complementary added value, smoothing the transition from manual workflow to an entire BIM workflow.

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.

For further information, please contact:

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