



Nuts and Bolts of the Revit® Structure/Robot Millennium® Integration

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SE300-2

This class will teach structural engineers the benefits of using a Revit Structure model for calculations. Along with an in-depth study of the design process combining Revit Structure and Robot Millennium, you will learn how to create a Revit model that is specifically useful for analysis calculation and design validation. We will also discuss the analytical tools available in Revit Structure that help facilitate data exchange during multiple design iterations.

About the Speaker:

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Key Topics Covered:

- Identify the techniques for creating a Revit model that is analytically integrated with Robot Millennium
- Understand how the bidirectional link between both packages functions
- Identify where you can save time and resources to complete a project faster and more efficiently. Best practices for bidirectional links to the analysis software, what to model, and what not to model

Target Audience:

Structural engineers and experienced structural draftsmen



Autodesk
University
2007

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Introduction:

How is the industry at present? Traditional AutoCAD users are in the process of migrating to the new Building Information Modeling system after realizing the possibilities offered by this new way of working. It is important for them to understand the extent of the advantages not only for drafting purposes but also for the management of the projects and the people.

What are we trying to demonstrate with the link between Revit Structure and Robot Millennium?

- 1) Have only one model for structural analysis and drawing production. We will demonstrate that the link can be useful for both resource saving and quality assurance during the whole duration of a project.
- 2) Model generation enhancement: creating a model with Revit is much easier and faster than in an analytical package like Robot.

Using both software packages in combination for the conduction of one project implies a very strong understanding of what every person involved is supposed to do. Drafters and engineers have to know their role in order to avoid time loss caused by mistakes or parallel working.

I. The link: Basics and principles

1) Overview of the link

i. Element export

Description of what Robot is importing:

Structural elements:

- **Columns, beams and braces** are transferred as bars. The following properties are supported: sections, structural usage, family type, material type, rotation angle, top/start and bottom/end release parameters.
- **Slabs and structural walls** are transferred as panels. The following properties are supported: structural usage, geometry (length, width, and thickness), material type.
- **Foundations** are transferred as supports. Isolated ones are imported as nodal supports, wall foundations are transferred as linear supports and panels as slabs.

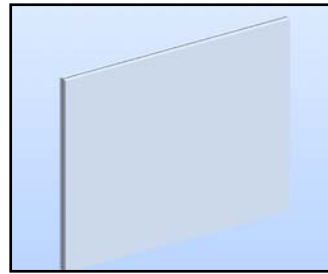
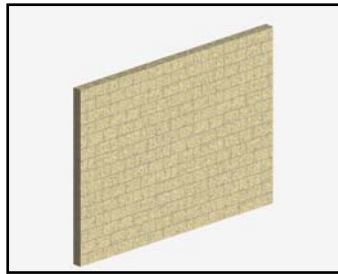
Materials:

We can select the way **materials** are handled:

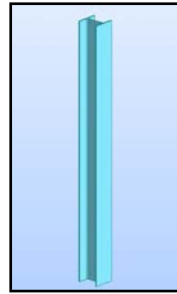
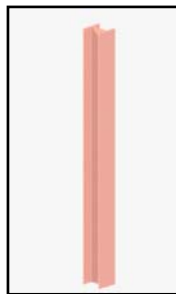
- Either by having ROBOT Millennium default materials. For every element, the material type (steel, concrete and timber) can be assigned by the ROBOT Millennium database with standard properties.
- Or by creating new materials in ROBOT Millennium. This enables us to create new materials with the same physical properties as the ones defined in Revit Structure.
- And finally we can select the best matching materials by assigning material properties from the ROBOT Millennium database. This will try to match the exact or nearest materials defined in Revit Structure.

The link strictly imports structural elements and ignores all the architectural ones.

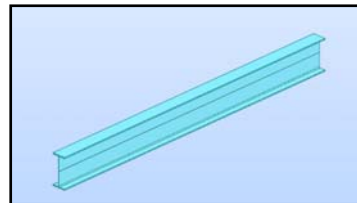
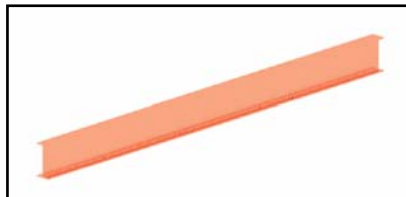
- **Walls**



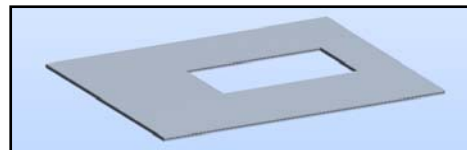
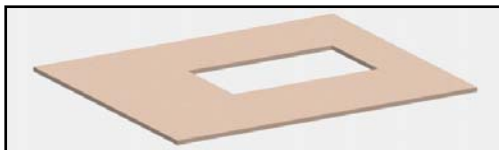
- **Columns**



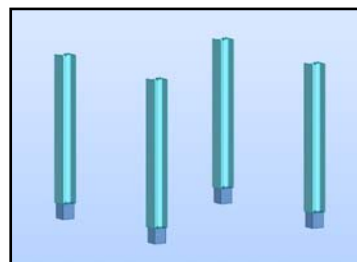
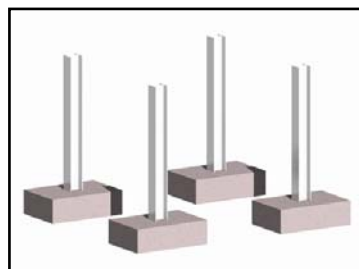
- **Beams**



- **Slabs**



- **Foundations**



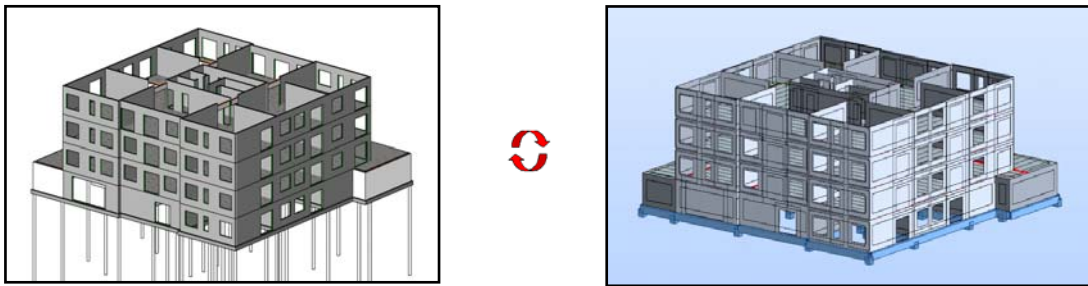
ii. Analytical model adjustments in Revit

Even if the physical model is correct in Revit, it does not necessarily mean that the analytical one is. Many problems can already occur when we build the model in Revit. We have to be careful of **how the elements are connected to each other** during the whole process.

Revit will automatically try to connect all elements according to their tolerance setup and priority order (**Auto-detect** feature). Most of the time this is correct for simple models and the operator will rarely find it useful to know how the elements are analytically connected for the production of simple drawings.

However, when the operator is creating a complex model some inadequacies can rapidly show up and a better understanding of the Revit artificial intelligence is required. Advanced drafters will need a stronger interest in the analytical model.

2) Link from Revit to Robot



i. Revit analytical model

- Default analytical representation of simple elements in Revit:

Element	Columns	Wall	Beams	Slab
Default Position	Center of Column	Center of Wall	Top and Center of Beam unless the creation plane is a Level. If the beam's creation plane is a Level, the default analytical model position is at that Level	Top of Slab
Illustration				

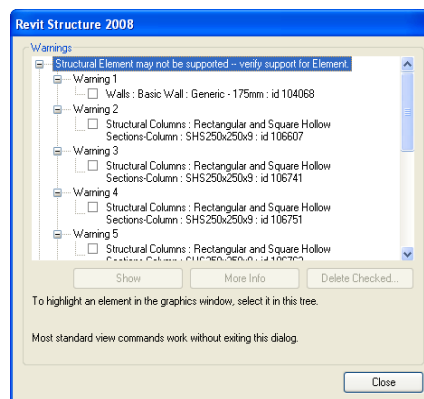
- **Default analytical representation of connections in Revit:**

Connection	Beam to Column	Beam to Beam	Wall to Column	Beam to Wall	Slab to Wall
Default relationship	Top of beam to center of column	Top of beam to top of beam	Analytical models of each are not joined (manual override necessary)	The concrete beam and wall are shown in plan	Analytical models of each are not joined (manual override necessary). You may also change the level of the analytical projection plane of the slab analytical model in order to place it at the level of top of wall. This would make the analytical model of the slab coplanar with the top horizontal line of the wall analytical model
Illustration					

ii. Revit model issues

- **Member support check**

In Revit we can obtain many warnings and errors if we run a member support check. It will indeed check every model element and make sure that it is connected to and supported by another one. It does not mean that the element needs to look connected, but it will check the analytical model itself and report all the errors found.



What the user needs to understand is that not all elements will be exported to Robot, but only the ones that matter for the structural analysis. Consequently, the member support check available by Revit **should not be important for the exportation to Robot** and could be misleading the user.

- **Analytical/Physical model consistency check**

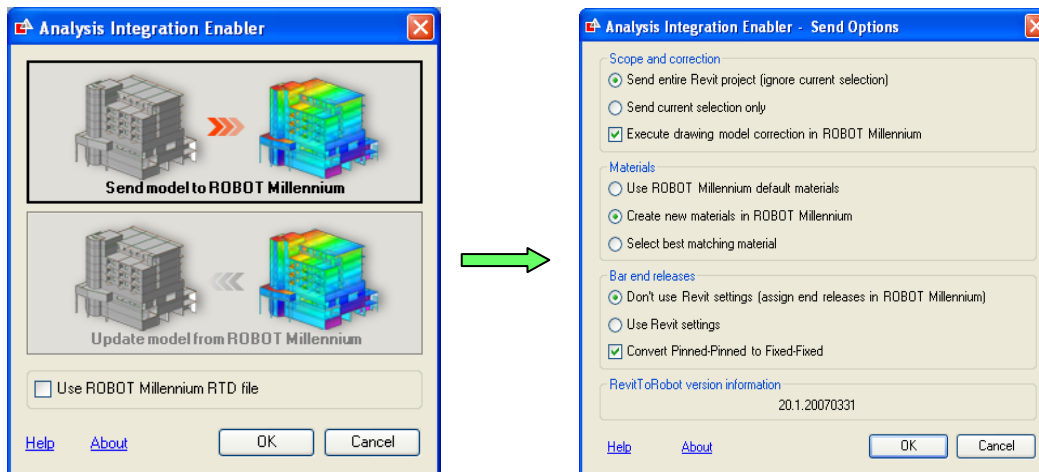
It is possible to check if the representations of the analytical and physical models are matching and if all the elements are connected to each other. If the automatic adjustment of each element is ticked in the Revit model (horizontal or/and vertical projection), the physical model might look right but the analytical one might be inaccurate simply because Revit is guessing the position of each element instead of having the user specify how the elements are connected to each other.

Analytical Model	
Enable Analytical Model	<input checked="" type="checkbox"/>
Horizontal Projection	Auto-detect
Top Vertical Projection	Auto-detect
Bottom Vertical Projection	Auto-detect

Some problems might then occur during the transfer to Robot and it would be better **if the user was checking how every component is analytically connected**. The best way to work is to make sure that the analytical projection of each element is manually set during the creation process. Then the analytical/physical model consistency check is unnecessary.

II. Analysis in Robot

1) The interface options



i. Selection possibilities

The possibility to export either the whole project or only some pre-selected elements is available. This is useful when we want to study a particular part of a project without having to recreate another smaller project adapted to that case. It is also useful for quality assurance purposes. We can indeed check that the model is exported correctly and if not where the issues are located. An export by levels can show which ones are hosting inadequacies, for example.

ii. Materials in both packages

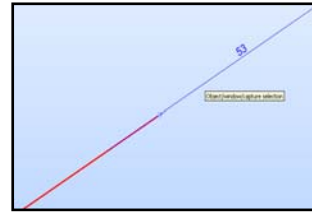
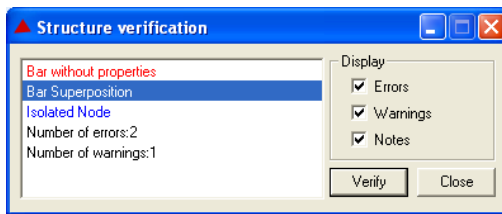
In case some materials do not match both software packages, the link gives us the option to either create new materials in Robot after the export, to use Robot default materials or even to select the best matching one. In general, we have to create the new material to ensure that the physical qualities are adequately set.

iii. Bar end releases choice

By default the link allows us to choose if the bar end releases must be the ones used in Revit or if we should specify those after the exportation process. The advantage of using the Revit end releases is that we can make sure they are adequately represented in Robot after the export. Thus, the operator has to understand how to modify those manually to make sure they are correct.

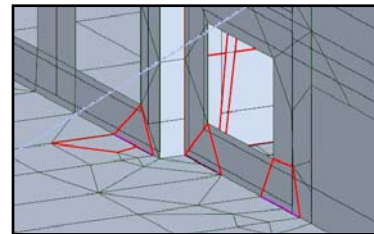
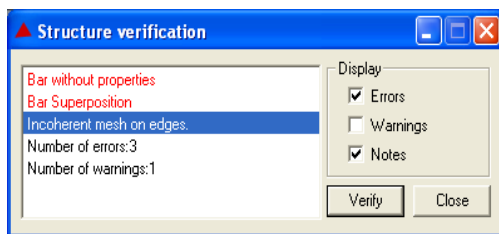
2) Robot model issues

i. Bar superposition



If the “Execute drawing correction in Robot” option is ticked, Robot can sometimes modify the model and **create some errors in the beam connections**. It then advises us of those inadequacies when the structure verification is performed.

ii. Meshing errors

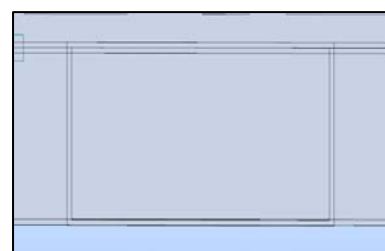
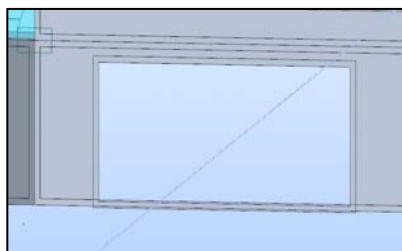


After transferring the model and running its analytical check, we need to generate the meshing of all the panels in order to be able to run a finite element analysis. During this process some errors can appear due to the choice of the **meshing generation type** or between **panels adjacent** to each other.

3) How to complete the Robot model successfully

i. Structural/Architectural levels

Some walls are sometimes not perfectly exported to Robot because of their vertical analytical projection. From experience it has been proved that creating **architectural levels** and some others for **structural purposes** has worked better than with only one set of levels. In this way we create the model with all the walls being attached to structural levels and we attach the doors to the analytical ones. Consequently, the export to Robot is much better.





ii. Rigid links

When the seismic analysis is performed, the slabs have been exported from Revit they will be represented as panels in Robot. This means that they will be studied by the software package as being the same kind of element as a wall.

But before the calculations take place, Robot will create meshes on all panels and this will result in the slab being decomposed into many elements as well. Eventually, the finite elements analysis would give us a building composed of very small elements from the walls and the slabs.

Unfortunately, during the seismic analysis these pieces of slab will be studied as being able to move independently from each other and the outcome will result in incorrect calculations. To avoid this issue we need to **replace the model slabs by rigid links** behaving like diaphragms and make the walls hold together horizontally during the seismic analysis.

iii. Meshing

Avoiding meshing errors is almost impossible and is inherent to the meshing method used. Robot lets us use different ones and the choice only depends on the project and the user's preferences or experience. The only way we can correct those errors is by using the local mesh generation tool.

4) Updates from Robot to Revit

i. Updates in the Revit Models

After the model has been exported, we can perform different analysis in Robot - like static, modal or spectrum analysis. The results obtained are then used to design every element and to get a model that satisfies the structural codes.

One advantage of the link is that it enables us to import this updated model back to Revit without having to manually change all the modified elements. This saves a lot of time and ensures better quality assurance during the duration of the project.

ii. Hidden updates

The link will automatically update the **loads applied** on the model from Revit to Robot and vice versa. It is possible to import our loads from Revit but it can be done directly in Robot after the exportation. This has no influence on the results and depends entirely on the preference of the user.

iii. Re-export to Robot

Unfortunately, the link is not as perfect as we would like it to be yet. During the life of a project the architect and the engineer often have to make modifications that need some design updated. That has a direct impact on the way we manage the project.

Every time we need to update the model we will indeed have to go through the same process again. Once the exportation to Robot is completed we always need to **set up the grid axis** since there is no tool that imports them from Revit. We also need to **generate the meshing** and **correct the occurring errors**. Once this is done we can start to design and update the model and eventually export it back to Revit.

A proper management of the project to limit the number of exportations is therefore what guarantees a successful use of the link.

III. Managing the project: Engineer/Drafter collaboration

1) Workflow process

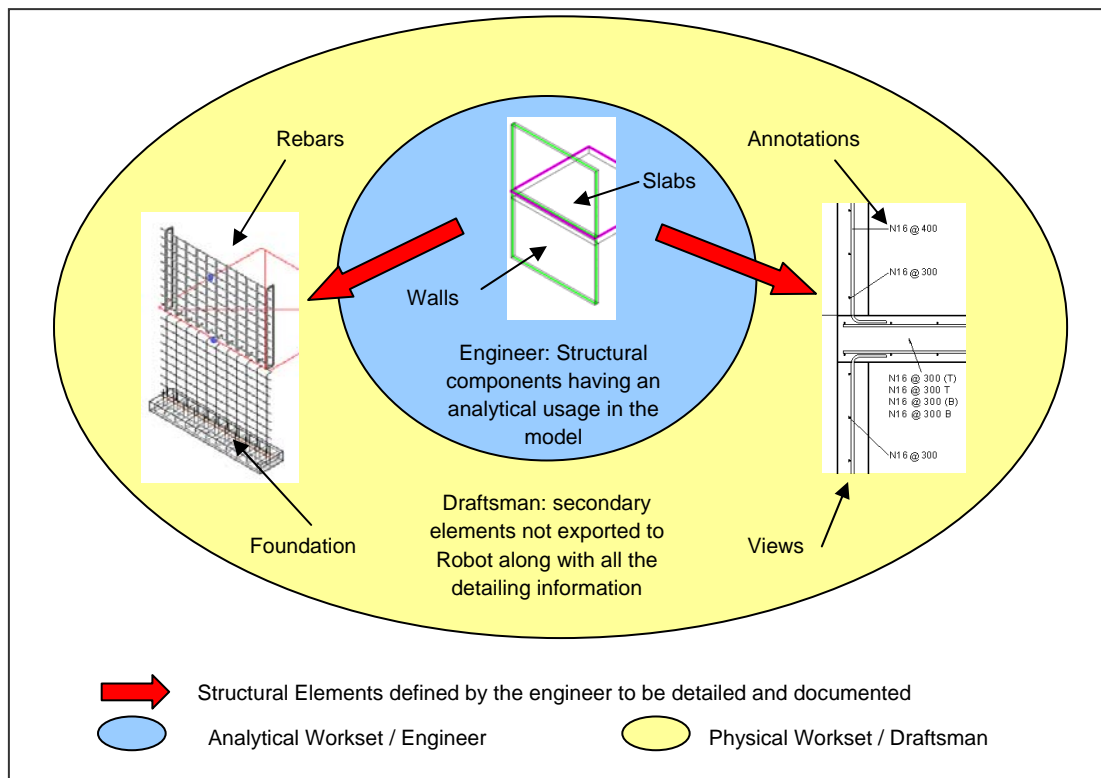
Having a better understanding of the functionality of the link between Revit Structure and Robot Millennium, the next challenge is to implement an **efficient workflow process** that allows both the engineer and the draftsman to work on the Revit model.

i. Worksets: separating the roles

We will consider the situation where the engineer would look at the **analytical** side of the model and the draftsman would handle the **physical** part of the model. Due to the technicality of the operation of the link, it is necessary to control **who is in charge of which information**. **Worksets** in Revit seem to be the best tools to separate and manage both physical and analytical information. In our case we would create two worksets:

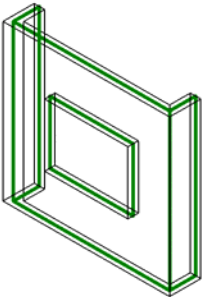
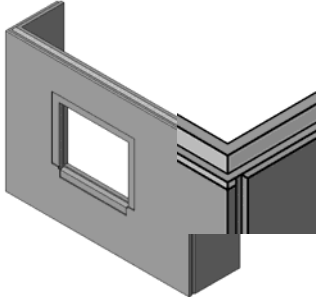
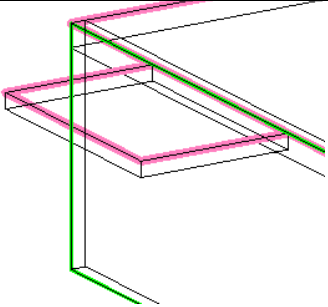
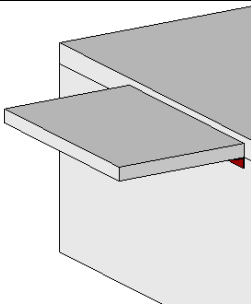
Workset Name	Description	Ownership
Analytical	Primary Structural Components (all transferred elements) such as walls, floors, columns and framing Structural Loads and boundary Conditions if used	Engineer
Physical	Secondary Structural Components (non transferred elements) Detail Information Rebars	Draftsman

In Revit terminology the engineer will keep his rights on the analytical workset all along the design stage. In this situation the engineer is in control of the core of the structure and the draftsman inherits this information to complete the documentation tasks but **cannot in any case modify the information transferred to Robot**.



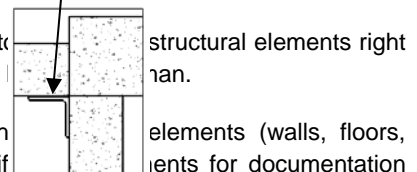
ii. Model interoperability: Copy/monitor feature

From a practical point of view, the principle described above is not flexible enough. In other words **the model created by the engineer for calculation purposes is too simple and not descriptive enough to produce documentation** without the draftsman being able to change the physical aspect of some of the primary structural components.

	Engineer's vision	Draftsman's vision
Example of a Precast Panel	 <p>Location of the analytical model / Position of the openings / Material</p>	 <p>True physical dimensions / Chamfers / Rebate / Reinforcement</p>
Example of cantilevered balcony supported by an Equal Angle	 <p>Analytical model of the connection / Boundary conditions / Volume / Material</p>	 <p>Physical description of the connection / Detail of the reinforcement</p>
Roles	The engineer will prioritize criteria such as material, analytical dimensions and structural usage	The draftsman needs to focus on physical dimensions, assembly situations, detailing and annotations

There are also some Revit related issues that add to the fact it is not possible to control the model only to the engineer only. **Hosted elements** and **Groups** will therefore be controlled

When starting the **physical model**, the draftsman will **copy/monitor** all the elements (walls, floors, columns) and take ownership of these copies. He will then be able to modify them for documentation purposes. He will also add the rest of the information with a physical approach in order to create documentation. The **monitor** tool will ensure that **modifications coming from the engineer** such as change of size and add or removal of elements will be **automatically taken in consideration**.

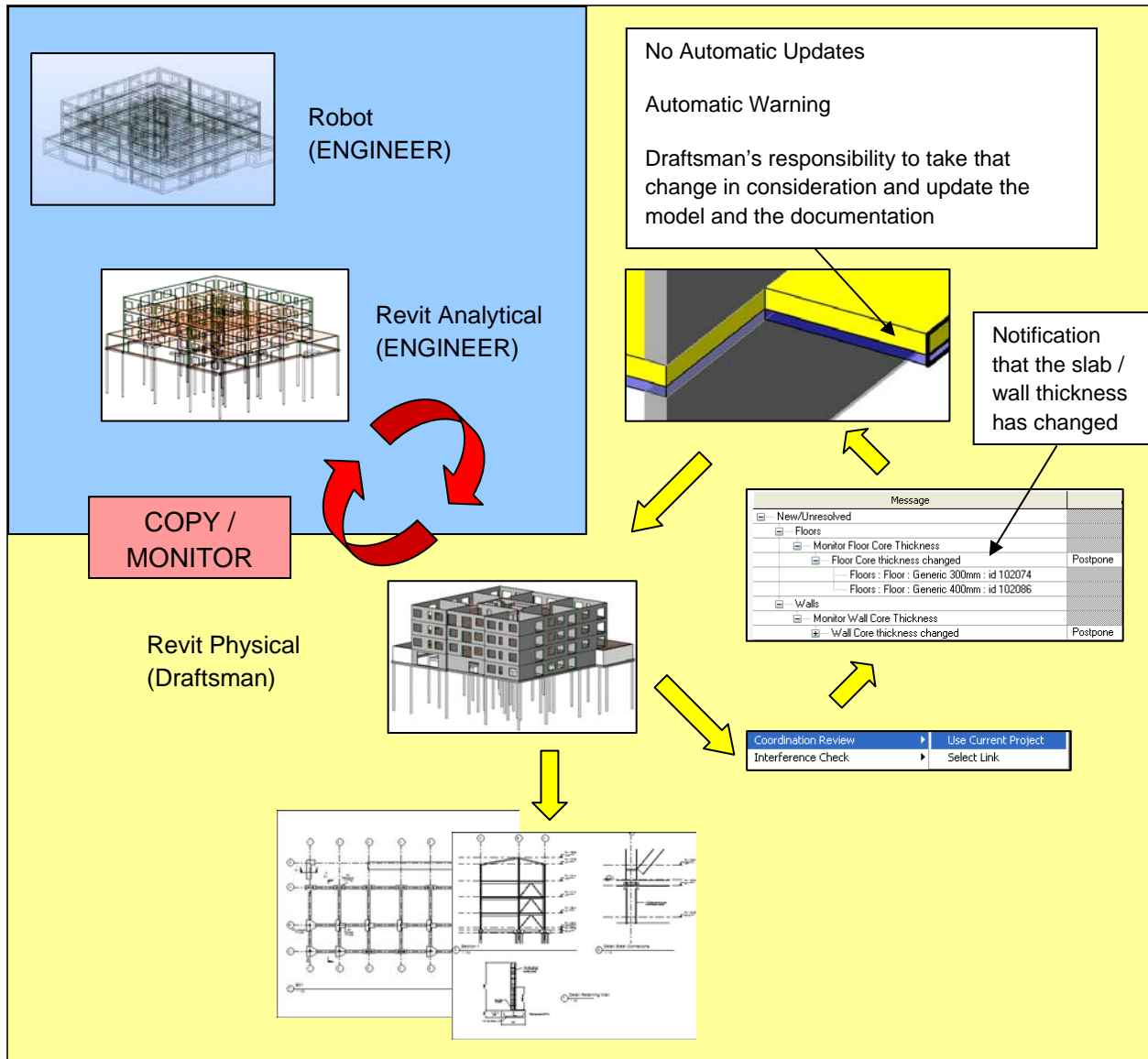



2) Management of the project


i. Advantages of copy/monitor option after structural analysis of an element

In this section we will see with an example how the **workflow process** is working. We will take the following case:

“After analysis and design, the engineer decides to change the thickness of some precast panels and the thickness of some floor slabs throughout the model”



 Process of flagging a modification and updating the model and documentation

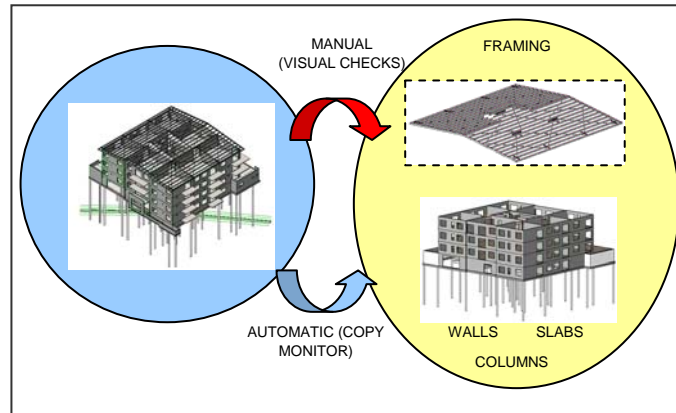
 Analytical Workset / Engineer

 Physical Workset / Draftsman

ii. Limitations and other options

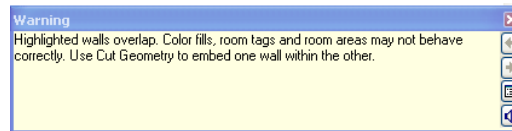
- **Beams**

However, there are some elements that cannot be monitored in Revit. The main limitation today concerns **structural framing**. In this case, the draftsman will have to maintain **the physical model up to date by means of visual checks he can run on the analytical model**. But he will rely mainly on the communication that he has with the engineer to keep him up to date with the structural design changes that occur all along the project.



- **Double counting in schedules**

Another negative consequence of the copy/monitor is the **double counting in schedules**. Once again we can fix this problem by implementing filtering systems to extract the right quantities.



- **Alternative method: Linked Files**

It is possible to implement a similar workflow process based on the Revit Link files technology. The separation of analytical and physical information will be assured due to the fact that we are working with two Revit files, one for the engineer and one for the draftsman. The copy monitor tool will work on a very similar basis as described above and some of the issues, like double counting in schedule, would be resolved very easily.

The main disadvantage of this approach is the creation and management of two Revit models in two separate files. This reason has motivated us to not use linked files as we are losing a great deal of coordination and of access of the common information.

iii. Quality assurance:

Having the engineer and the draftsman working so closely together and **sharing common information** via the Revit platform will ensure a much better quality insurance plan inside the organisation. Where we used to communicate with hand sketches, mark-ups and so on, **we now can send information about project changes directly to the right person with a minimum of delay and a maximum of accuracy**.

More than automating these methods of communication, we actually open the door to a true collaborative design where both engineers and draftsmen have an instant access to the model and all its information.



Conclusion:

The workflow enables direct time and cost savings along with better quality assurance for the duration of the project.

However, the engineer has to make sure the model is transferable at all times to avoid mistakes that could force him to redo a model at a later stage. Exportation of the model to run a simple check should be carefully conducted for quality assurance. Consequently the creator of the model has to understand how the exported model would work and be studied in Robot. More importantly, he also has to appreciate the different physical and analytical aspects of the model in Revit.

What do we wait for in the future? Total integration of both software packages would be preferred: at the moment exportation is working well but re-exportation involves correcting the errors reappearing in Robot.