

[BLD122332]

# Robot Structural Analysis – From design to calculation

Safet Iska



## Learning Objectives

- Gain a better understanding of how Robot Structural Analysis Professional can be used and all its benefits
- Learn how Robot Structural Analysis Professional is integrated to the users primary modeling tool Revit
- Learn how to plan a model and understand what to think of before exporting to Robot Structural Analysis Professional, and what outcomes can be expected with a bad model
- Get an overview of the steel design and reinforcement design tool in Robot Structural Analysis Professional

## Description

Usually our ultimate wish in a project is to eliminate the phase where the user has to remodel the structure in our FEM-software to execute the load take down calculation, this is quite time-consuming. The link between Revit and RSA is getting used more and more with the time but often our first projects doesn't appear to be that time saving because of the lack of knowledge users usually have in the first test. Learn what type of issues might appear, how to eliminate it and which benefits you as a user can have by using these software's correctly.

Robot Structural Analysis Professional (RSA) is a well-used Structural calculation software or even sometimes called FEM-software provided by Autodesk. RSA offers advanced calculation methods for different type of structural material such as concrete, steel and timber. It also allows us to design our structure considering e.g. Eurocode, ASCE etc.



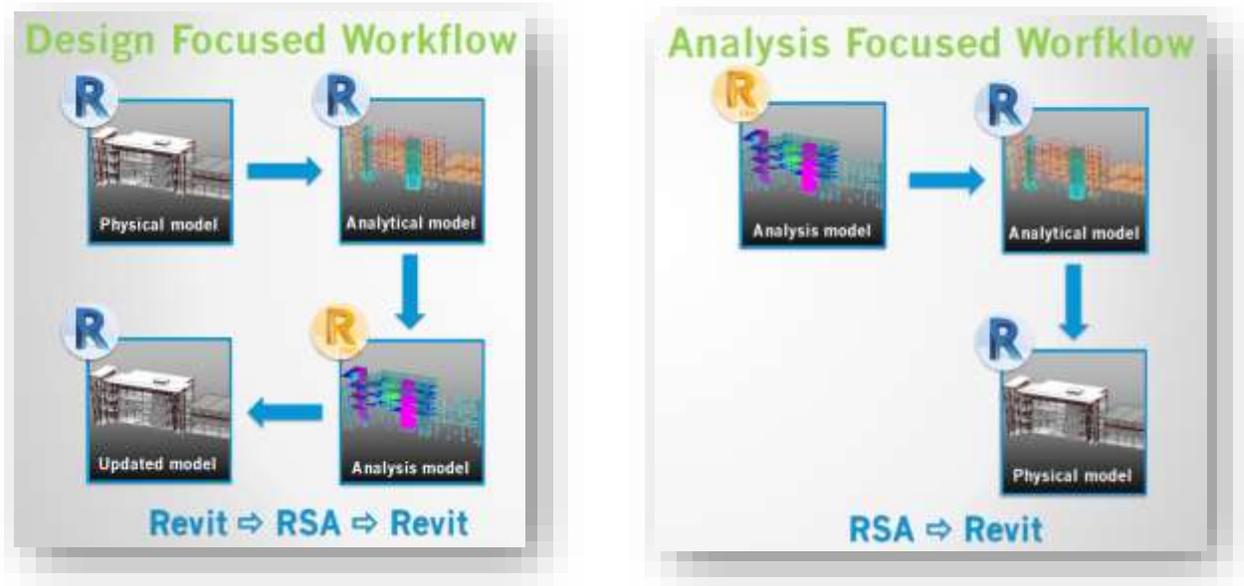
## **Speaker(s)**

Safet Iska, a proud Civil engineer & pioneer who is striving to solve customer questions and help them improve the way of working mainly within Autodesk's BIM-products. A technical sales manager acting within the AEC area in the Nordic market at Symetri AB. Safet Iska is specialized in FEM-software's primary working with Autodesk solution Robot Structural analysis. Influencing the customer to adapt a new perspective of the word FEM and a more connected BIM-workflow with Revit and Advance Steel.

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## Graphical overview of the design process submitted with RSA and Revit

It is critical for a user to understand which process could be used when we are striving to use the integration between Autodesk softwares, in this case particular Revit – Robot.



### Which barriers do we tear down with this integration?

For a Structural engineer, it is of importance to eliminate specific obstacles when working in a project. For instance, to specify information twice, remodel the structure for a certain analyze and submit changes after they are made which is occurs quite often in projects.

Below you can find a work-process which could be implemented after understanding this process and which time-consuming moments can be eliminated by using Autodesk solutions.



## 1. Keywords

**Analytical line** – Each structural object in Revit will provide us with a analytical line. A line placed in the center of the 3D geometry. This is the data that our FEM-software focus on.

**Two-way communication** – Possibility to transfer specific data from one environment to another and later update it back with different data to the same source.

**Load take-down calculation** – Calculation of the forces acting from the top of the structure to the ground.

**Claddings** – A object which acts as a surface and doesn't contain any weight, its purpose is to provide us with more accurate load transfer.

**Maps** – Solution to present static results by color, forces such as moment, shear and normal forces.

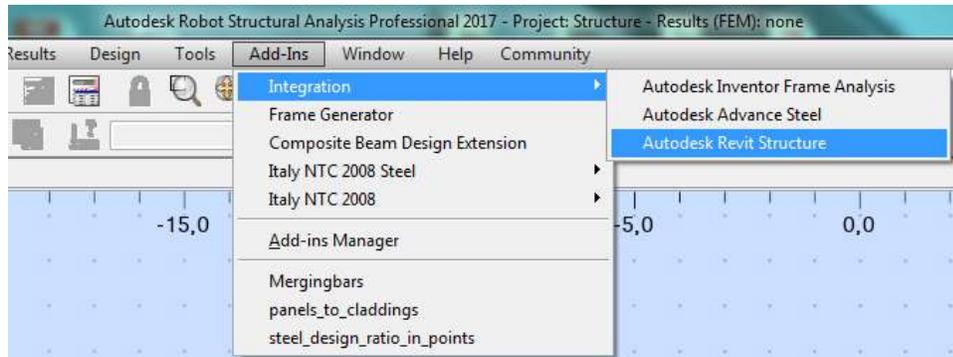
**Optimization** – Enhance the objects performance so the loads applied on it is not causing too great strain and overcome the bearing capacity of the object.

## 2. The link between Robot Structural analysis and Revit

We will start by visualizing the export/update button for starter in both Revit and RSA.

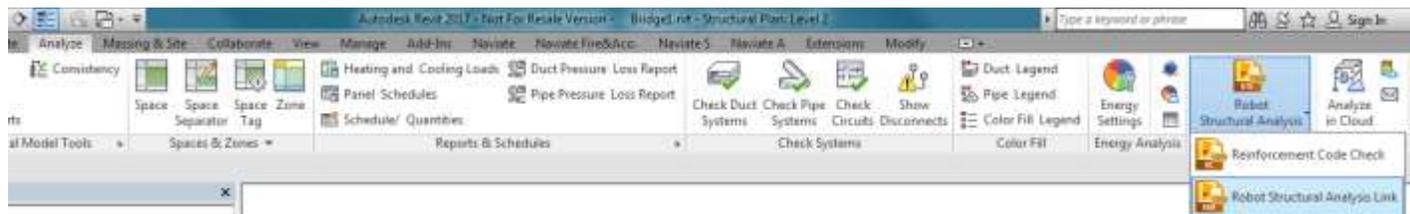
### RSA

Take these following steps: Add-Ins > Integration > Autodesk Revit Structure



### Revit

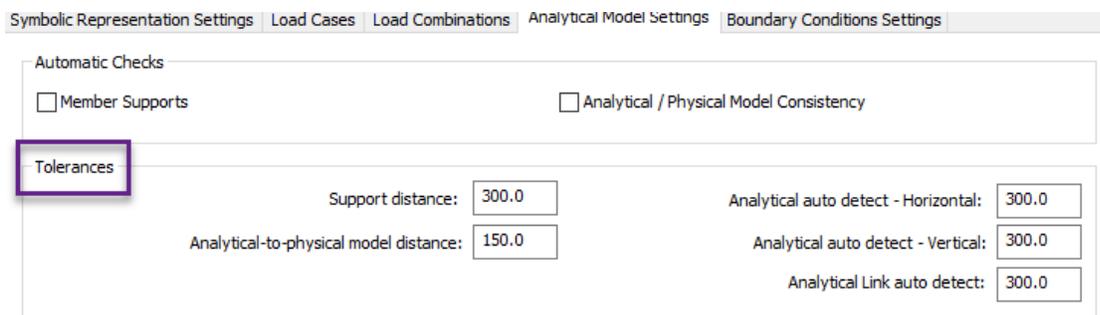
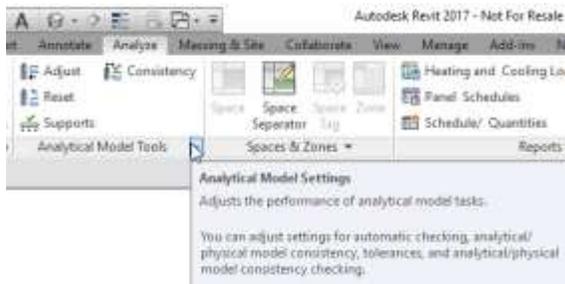
Similar steps will be needed in Revit as well: Analyze > Robot Structural Analysis link >



Once we have done the transfer from Revit to Robot the model will be completely dependent on how well we have prepared the analytical model. It is very important to have the lines connected so we can get an accurate load transfer from one object to another, that's how we can finalize the total behavior of the structures deformation, critical points etc.

### 3. Preparing the model in Revit

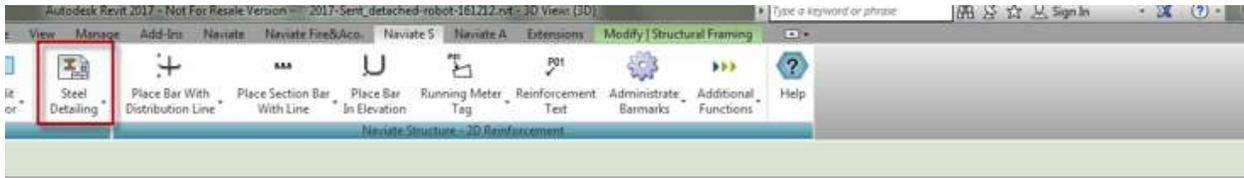
Revit will also assist us in the analytical part by defining constraints for the analytical lines. If we for instance have applied an offset in the analytical model settings, Revit will automatically connect 2 nodes if they are located within the defined distance.



Additional function which have great impact on this workflow is Steel design from a third-party product called Naviate Structure. Previous experience has revealed that when we have several engineers working towards a central file in the same project there might appear accidental change. Should we move one object and others will follow, the exact height on similar objects is also something which benefits us in the calculation phase.

This solution helped us secure that there weren't any accidental changes on the steel frames. By analyzing our current status of steel frames/objects we could easily follow if that model still was identical later on in the modelling phase.

A project sample of Steel design function is described below.



**Steel Detailing**

All Steel elements  
 From Filter Settings:

Keep existing numbers  
 Do not reuse used numbers

Element(s) is added, removed or changed

Filter Setting	Prefix	Start Number	Analyzed	Numbered	#Elements(Groups)
CFRS 100x100x6	C	101	2017-10-02 11:07	2017-10-02 11:07	4 (2)
CFRS 150x150x8	C	201	2017-09-29 09:53		17 (2)
<b>HEA Balk</b>	<b>B</b>	<b>401</b>	<b>2017-10-02 11:09</b>		<b>876 (78)</b>
Pelare CFRS 180x180	C	301	2017-10-02 11:08		108 (4)
Stanger CFRS 80x80x6	T	501	2017-09-29 09:54		732 (32)

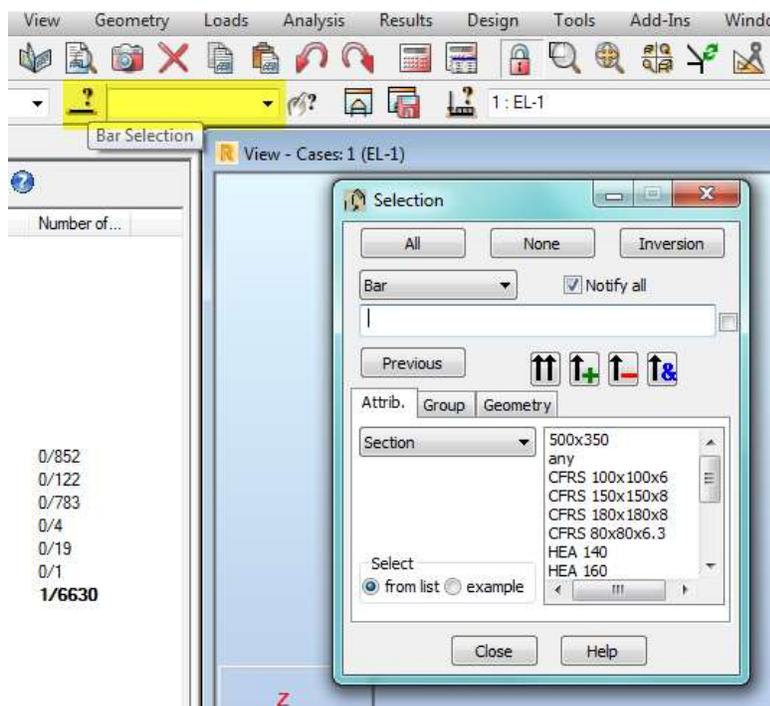
#	Type Name	Material	New Mark	Existing Mark	Drawing Created	Revision	
4	HE 140 A	Stal - S355			<not created>		
<b>111</b>	HE 140 A	Stal - S355			<not created>		
30	HE 140 A	Stal - S355			<not created>		
16	HE 140 A	Stal - S355			<not created>		
4	HE 140 A	Stal - S355			<not created>		
8	HE 140 A	Stal - S355			<not created>		
1	HE 140 A	Stal - S355			<not created>		
<b>1</b>	The graphic for element(s) has changed					<not created>	
32	HE 140 A	Stal - S355			<not created>		

Rounding: 0.5 mm

#### 4. Design-phase in Robot Structural Analysis

When we finally have completed our Revit model and done a quick check that no surprising changes appear then we can export our model to Robot. Take to account that when the export is finalized it might be a good step to check so all our profiles do have the right physical data. Such as profile geometry, steel quality and releases so we can adjust missing part and receive a good calculation performance.

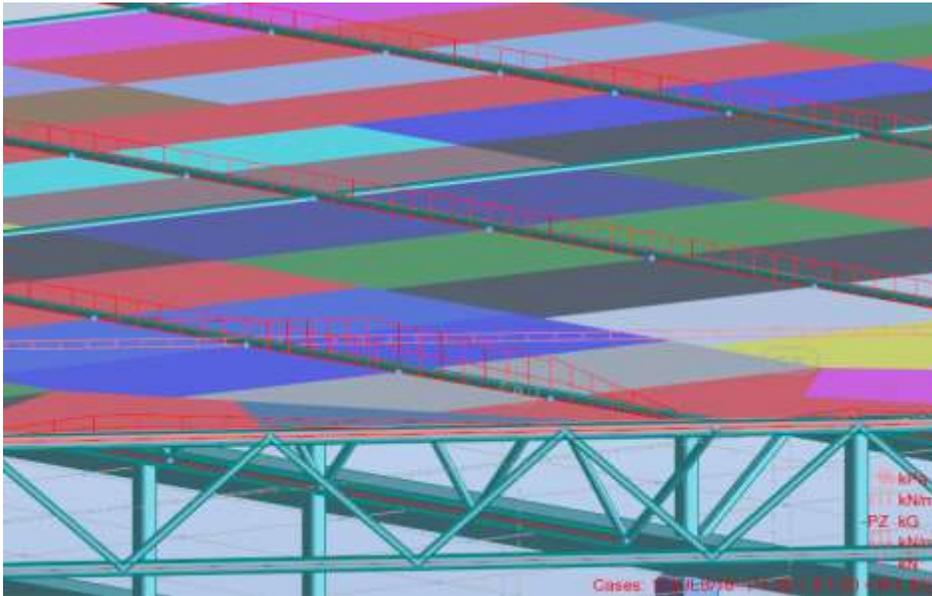
Easy step to filter this data can be done with bar selection tool as in the following picture below.



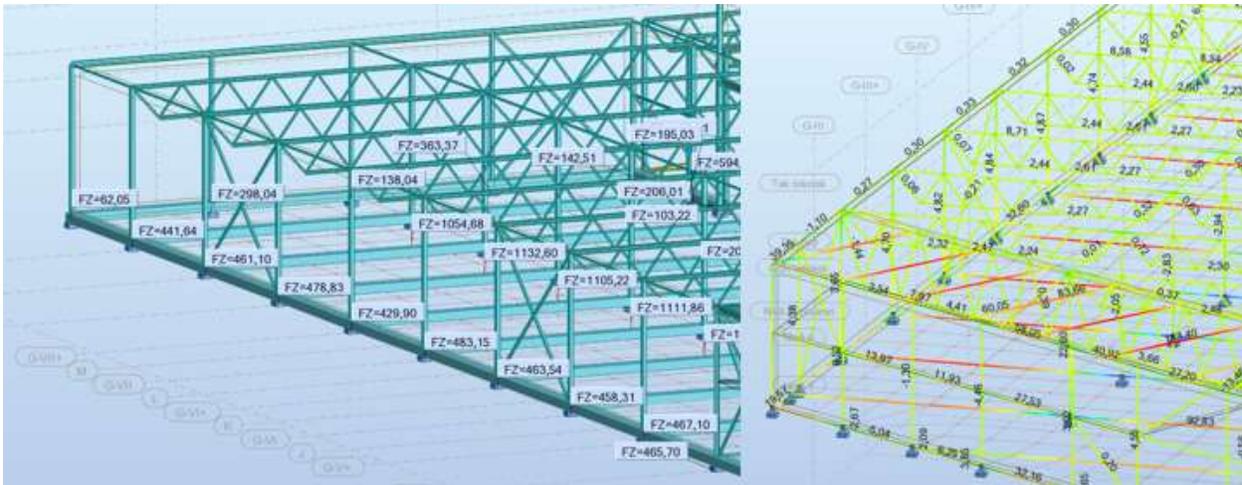
When we later have completed the model check we can start the calculation part of the static forces. I will highly recommend that we start by doing a quick calculation with just a dead load to assure that we do not get warnings that will be critical for the results. If that step is ok then we can proceed with the correct load-cases and combination.

To include combinations and a lot of load-cases in the calculation will lead to a longer calculation time which will be very time consuming if we bump into some problems we must correct.

In this particular case, we used claddings on rooftops instead of doing a manual calculation of the linear loads on each beam. With claddings, we can easily apply surface loads on it and robot will automatically calculate the linear load for us in each beam. We can also define how the load-transfer should behave, which objects should take up load and which shouldn't.



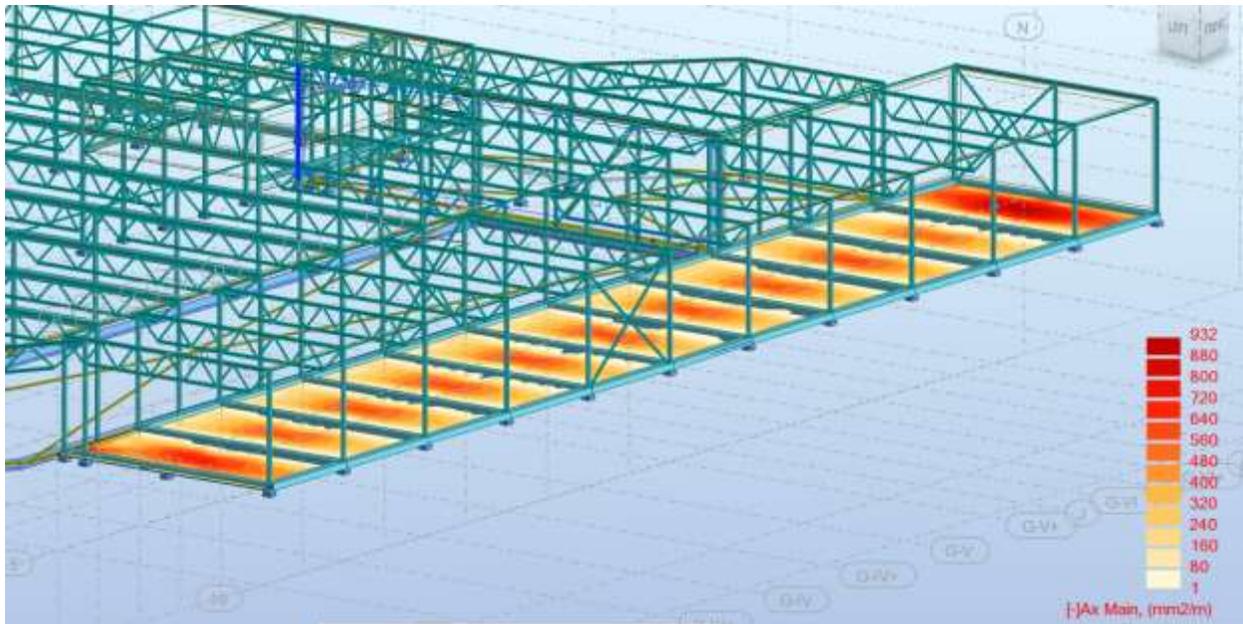
The next step will allow us to examine the results such as moments, normal-/shearforces and reaction forces which will define the loads the piles will carry.



## 5. Concrete design – Reinforcement

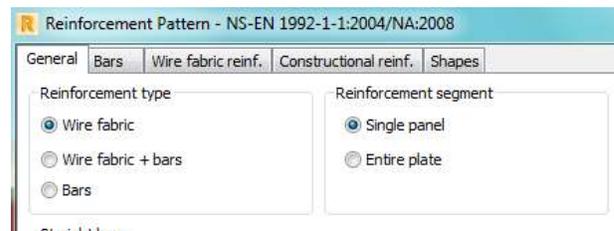
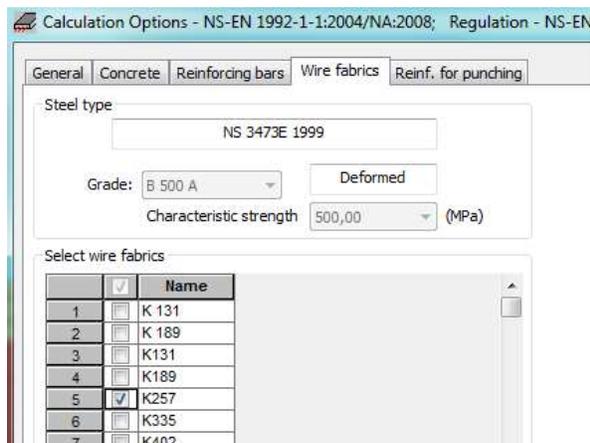
Concrete objects were further detailed in Robot, as our customer wished for fabric area reinforcement on the slabs we took that into consideration when we executed the calculation for reinforcement.

With Slab required reinforcement we could see which requirements was needed to fulfill the demands, this is presented by maps.

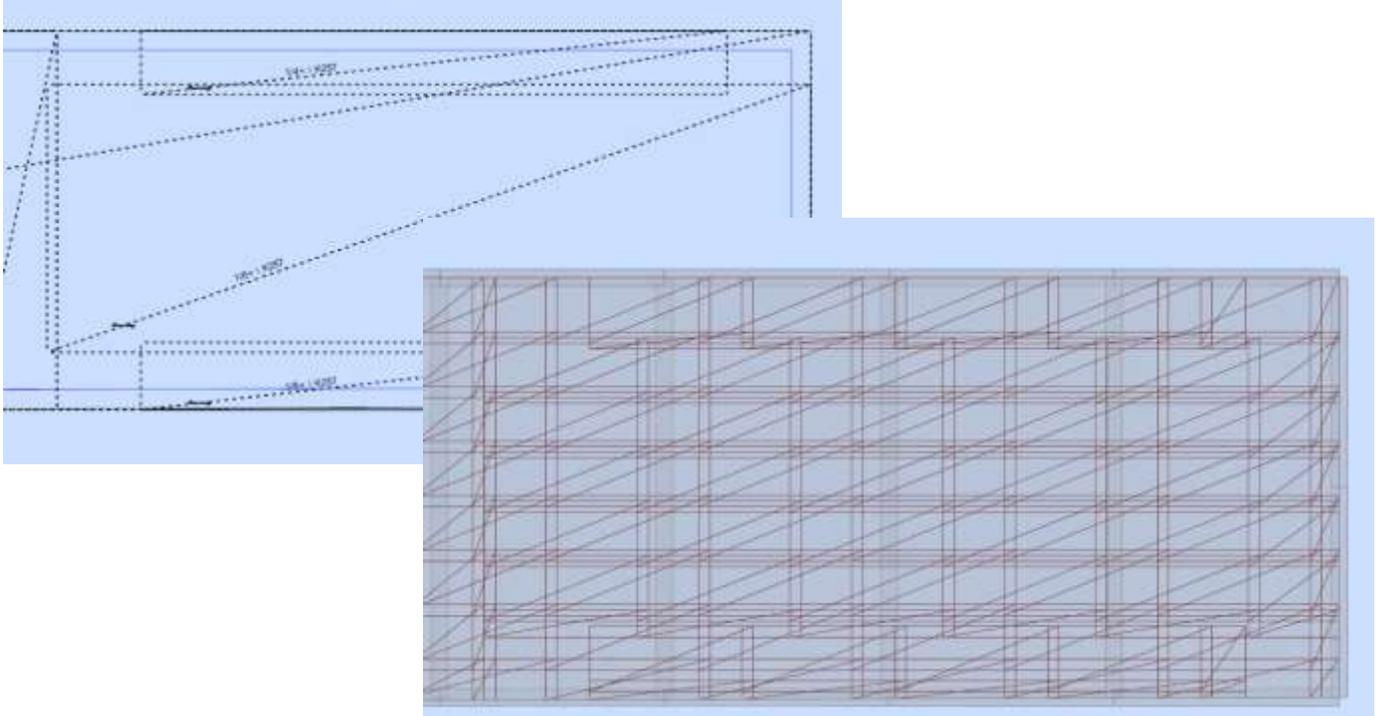


After we received the required reinforcement we could easily go further to Provided Reinforcement and define which fabric area we wished for and apply it to the plate.

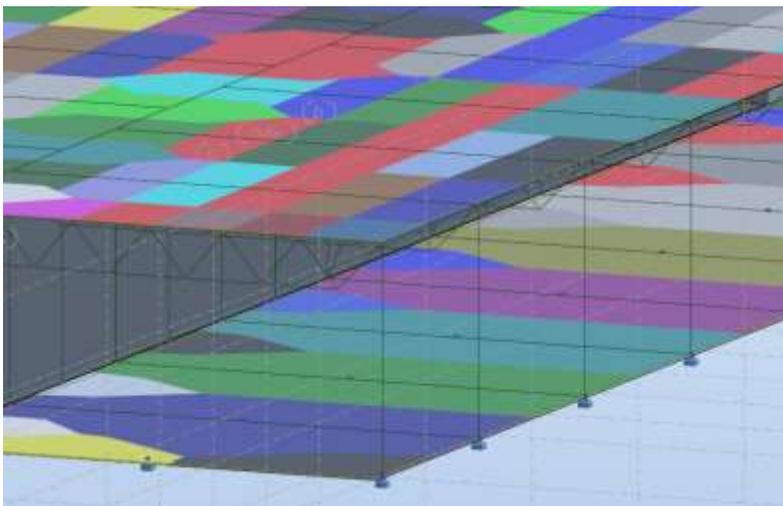
The configurations for the slab will be defined in **Calculation options** and **Reinforcement pattern**.



After performing these steps, we now could get an estimated value of how many Fabric reinforcement net (K257) we needed to get an accepted solution. The reinforcement was manually placed in the Revit.

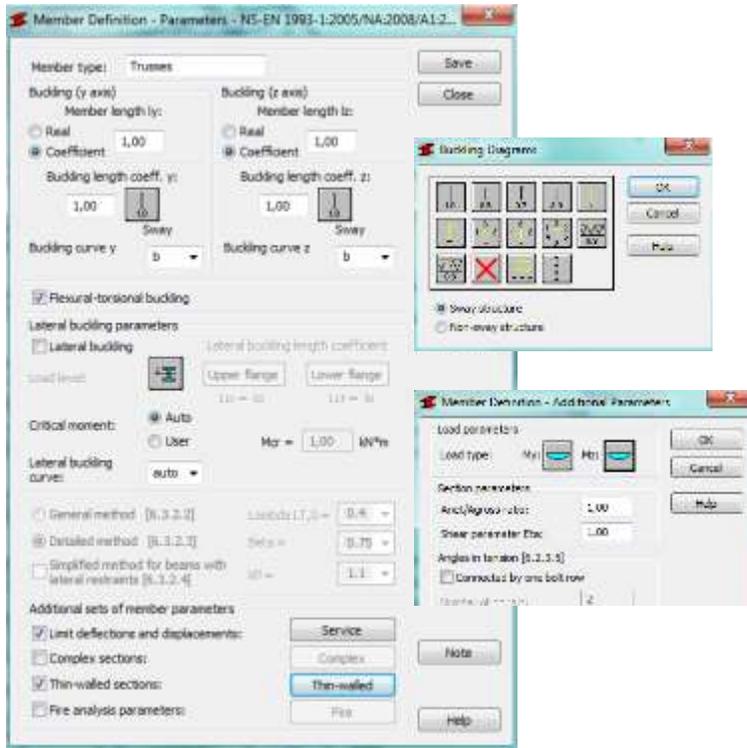


For the foundation beams we used similar method as with the frames where we change the slabs to claddings and could receive the linear loads which is distributed to the beams. In that way, we could perform a reinforcement calculation, unfortunately this part was done manually after we received the right linear loads.

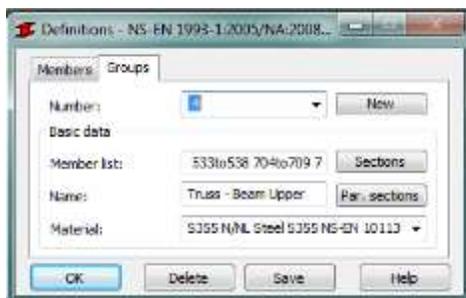


## 6. Steel design - Optimization

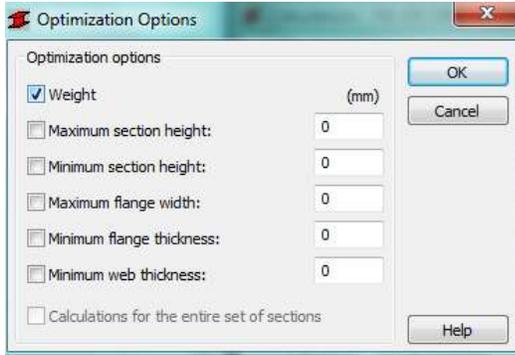
The optimization phase of the steel objects was managed under steel design. First step is to apply right parametric behavior of each system, such as columns, beams and trusses. If the calculation shall be accurate we must apply defined member type on the objects.



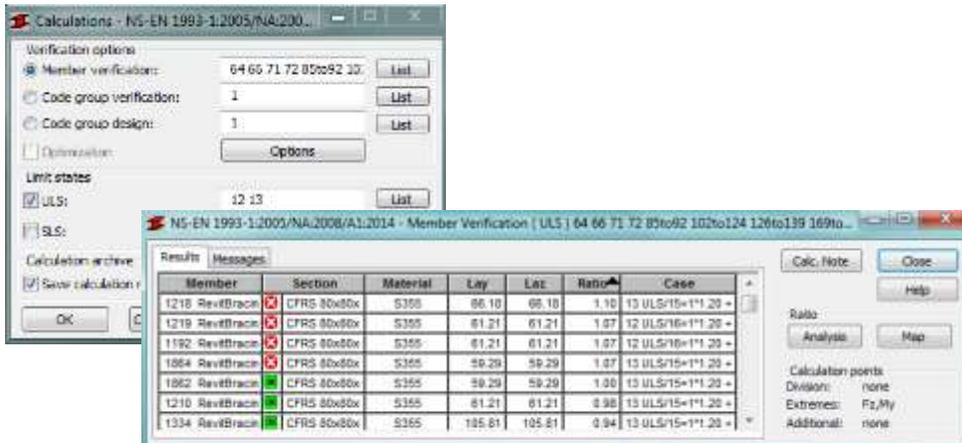
To be able to have more control of the objects we decided to divide the objects into groups for the optimization. We had specific groups for columns, one for trusses and another one for the beams. The optimization is a process which is performed in several iterations to finalize a complete utilization of the objects.



After creating our groups, we could then define how Robot should optimize the objects, by a type of section, weight etc.



At last we could finally press calculations button to get an overview of the verification. All the objects that had an utilization of more than 100 % were increased in section and those with low utilization was decreased, because of esthetic part was a thing we wanted to maintain we instead used the same type section for the certain frame, we didn't want to have different size of the section on the same frame.

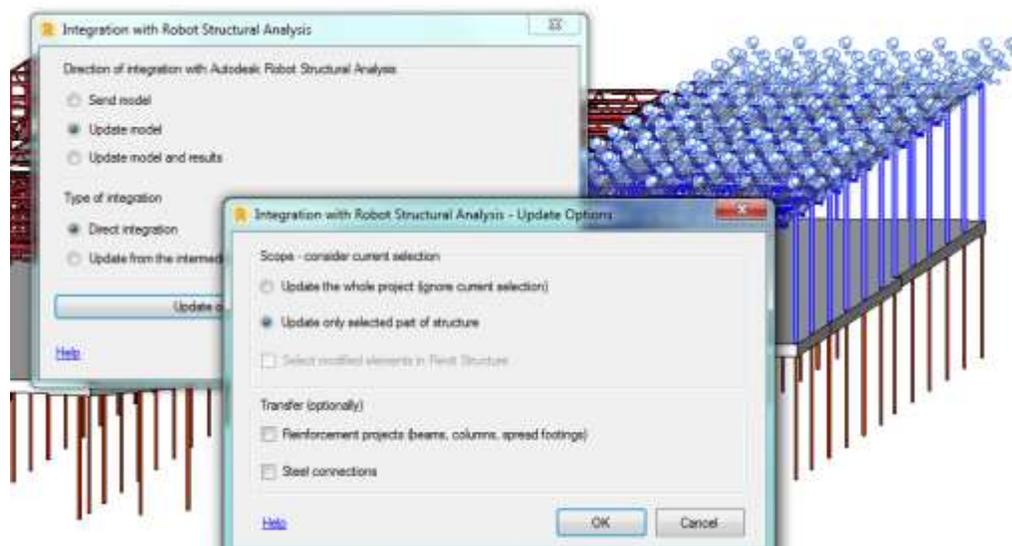


## 7. Back to Revit from Robot

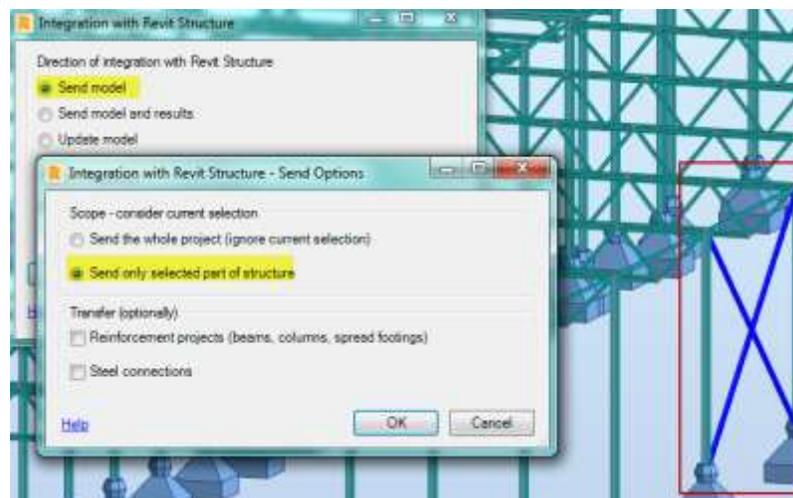
In this case because of the large number of objects and changes with sections and movements we decided to perform this step in several updates so we don't get too big changes on the model which will be too hard to control.

Observe when we update back the objects which has been exported to Robot from the start it is very important that we do it by opening Revit and select which objects should be updated and then update.

If we press send model from Robot to Revit then we will force the new Robot model into the opened Revit file and there will appear two models. This step is something we only use when we have added new objects in Robot which doesn't include in the Revit model.



Export steps when we have added objects in Robot that needs to be transferred to Revit.



## 8. Conclusion

By implementing this integrated workflow between Revit and Robot Structural analysis Autodesk's solution offers the engineers a complete and unique opportunity. The workflow allows us to eliminate several time-consuming and unnecessary phases between the modelling and calculation span. Steps we can eliminate which can be confirmed after this project scenario is following (see below).

- ✓ Remodel the structure.
- ✓ To manually calculate distribution of loads to each frame.
- ✓ Generate a lot of manual combinations and find out which one is the right combination for the specific case.
- ✓ After optimization submit changes back to the modelling tool.

It happens that the engineers often must manually calculate the load take down for the structure. This happens to be done by using simple 2D drawings as reference where we must measure distances between the bearing objects. If the project is a multi-story building then this must be done for each floor and it takes more time than we really need to put down. A great benefit with 3D FEM-software's is that the engineers get a full overview of the structures behavior and in early steps finds out the weaknesses of the structure. Now that the 3D model can be exported to a FEM environment, that gives us a great leap forward and leaves the engineer to dump the 2D drawings and plan views from the designer and can directly focus on the loads calculation process.

## 9. References

### Document

<http://bimandbeam.typepad.com/files/linking-autodesk-revit-and-robot-structural-analysis-professional.pdf>

### Get going with Robot Structural analysis – Symetri AB

### Video

<https://www.youtube.com/watch?v=bhEaucg3EBs>

[https://www.youtube.com/watch?v=ksLjZd62DoY&index=10&list=PLY-ggSrSwbZqow\\_60fiqJwS69mg1nQMzk](https://www.youtube.com/watch?v=ksLjZd62DoY&index=10&list=PLY-ggSrSwbZqow_60fiqJwS69mg1nQMzk)