

Autodesk® Revit® as a Tool for Modeling Concrete Reinforcement

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SE4240

Autodesk Revit software provides tools for modeling 3D concrete reinforcement in an advanced Building Information Modeling (BIM) environment. This class will provide insight into how to use these tools in the best way for creating complete, detailed, and accurate reinforcement design. Learn how to use the modeling, drawing, and scheduling tools for standard rebars and wire fabric mesh. Discover all the possibilities in custom rebar shapes. Get new ideas on how you can communicate your reinforcement designs to contractors and fabricators with innovative methods. For a structural engineer, there are few things in this world that exceed visualized digital 3D reinforcement layouts in beauty, and when you can work with these aesthetics in the world's greatest building database modeling software, life turns into a celebration. Let's make that happen!

Learning Objectives

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

- Use Revit as an efficient modeling tool for all concrete reinforcement
- Customize Revit rebar schedules for variable use
- Work with Revit rebar shapes for various concrete designs
- Visualize 3D rebar layouts for communication purposes

About the Speaker

Håvard Vasshaug is a structural engineer and Revit power user at Ramboll, one of the world's leading multi-disciplinary engineering, design and consultancy companies, with close to 10 000 dedicated specialists. He has vast experience providing Revit training, solutions and seminars for architects and fellow engineers at Autodesk Authorized Training Centers the past 8 years and now uses this background to distribute knowledge of Revit solutions at Ramboll. He is a part of the Autodesk BIM open source steering committee, and a member of the program committee of, and presenter at "Den Klokke Tegning" – an annual Norwegian conference for smart technologies in the building and civil businesses. Håvard arranged the three first Revit user group meetings at Cad Quality, is a Revit blogger at revitnorge.blogspot.com and a very proud Revit Gunslinger.

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1 Introduction

When I first started working as a structural engineer back in 2003, I was introduced to the concepts of reinforcement drawings and bending schedules for the first time. This was of course something we never saw at the university, where static, dynamic and finite element analysis covered the curriculum. Little was I to know that these drawings and schedules were to be my main occupation the first years. And now, looking back, not always did I feel like Michelangelo drawing away.

Today, most of my fellow engineers and I are modeling almost all reinforcement in our projects in 3D. Some structures are harder to master, but most are quite easy. We are planning for our skills and knowledge to append a future where all fabrication detailing is done in a 3D database, and what better 3D database than Revit?

Our two biggest challenges in doing this are efficiently modeling reinforcement in non-rectangular, curved and double-curved concrete forms, and the shouting valley of a gap between new BIM and old CAD. The first problem is something I will discuss shortly.

The last problem is one we share with our software vendors. They are given an impossible task by us; “Please make the most sophisticated modeling software in the history of humankind, and make it how I want it in 5 years. At the same time, make it compatible with 50 year old symbolic drawing standards.” How do you solve a problem like that? As I said, and in particular this is true for reinforcement, we are faced with the same challenge when we need to model all reinforcement in a 3D building information model, and simultaneously represent and communicate it in the same way as we did 20 years ago. It is the ever present gap between future and past. In the end we are dealing with humans. And many humans love the past.

The future, however, is way more exciting. The future is a place where everything that is to be built is represented in an intuitive 3D model, just the way it is going to be built. The future is a place where the materials ordered and delivered on site, is done so from the same high-detail 3D model. The future is a world where engineers and contractors communicate design using the most intuitive way possible yet; the visual 3-dimensional representation of future.

Then, perhaps, we can feel more like Michelangelo.

Note

All information in this class handout is based on Revit 2013 Update Release 2, Build 20121003_2115(x64). If any of my examples deviate from your experience, please run a check on the version you are using.

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3 Modeling challenges; what is difficult?

As I described in the introduction, two things are perceived as challenging when working with 3D reinforcement in Revit; Complex concrete forms and the gap between BIM and CAD.

3.1 Complex concrete forms

The way the different reinforcement tools appear today, we must acknowledge that some forms are inefficient to do 3D in Revit, and some seem straight out impossible.

This is mostly due to the confession that a single distribution of Structural Rebars cannot have varying dimensions, and cannot be distributed in another direction and form than linear and perpendicular to the rebar shape plane. These limitations turn the workflow *inefficient* and *boring*, but not *impossible*.

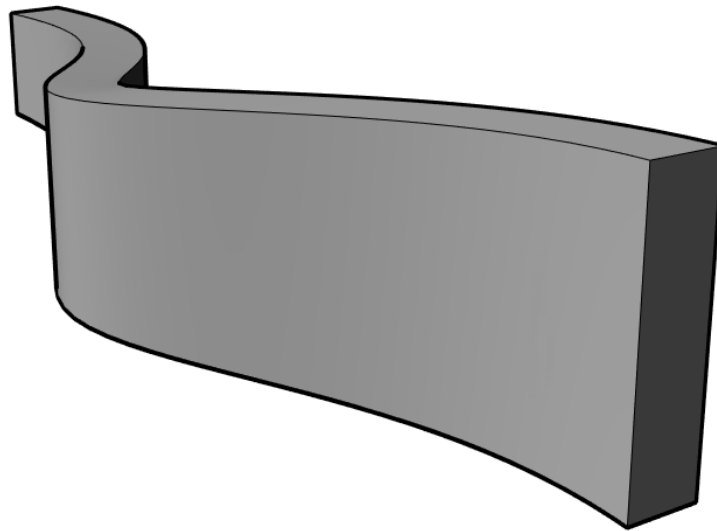


Figure 1: Curved, tapered concrete beam

When concrete walls and slabs end up curved or double-curved, the available reinforcement tools simply do not pull through. In some cases the tools does not even recognize the concrete element. These limitations turn the workflow *impossible*.

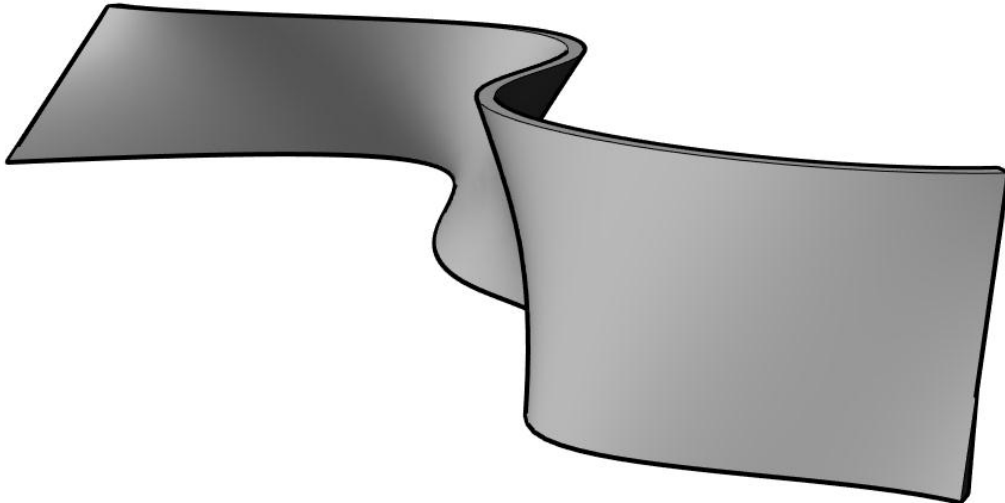


Figure 2: Double-curved concrete wall by face

That said, there is *a/ways* a way to cheat. In the example above (yes Revit, it *is* a wall) you could do the Detail Item, Annotation Symbol and Note Block tricks, and land reinforcement drawings and schedules without modeling a single 3D element. You could also look into Adaptive Components for an alternative way of modeling 3D reinforcement. These workarounds will not be covered in this class.

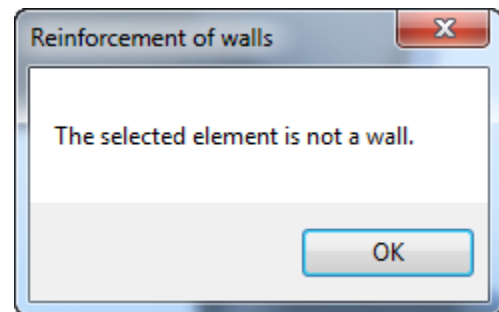


Figure 3: Are you sure?

3.2 The gap between BIM and CAD

I tried to explain the problem of the gap between BIM and CAD to a friend the other day, and for a structural engineer there are few things that illustrate this better than reinforcement drawings. Think about the symbols on reinforcement drawings as hieroglyphs from ancient Egypt. At one time in history, they were needed. How better document something when all you have is rock and hammer?

Some years back in time from today all we had were lines and text on a computer. Some years before that we (well, really more 'they' to be honest) had paper and pencil. Should they draw

every single reinforcing bar in all projects? Of course not. That would be the mother of all boredom, and suicide rates would shoot through the roofs throughout the engineering businesses. They needed symbolic representation. Enter hieroglyphs.

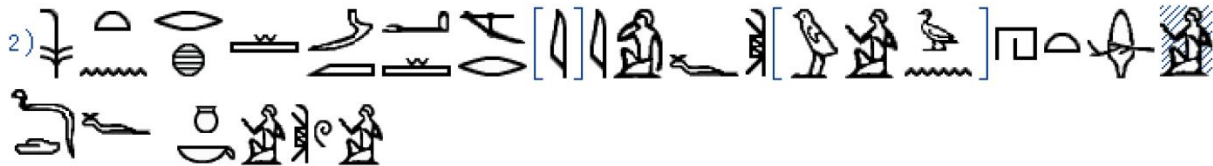


Figure 4: Ancient Egypt hieroglyphs, stolen from The Internet

Now, the contractor who reads these drawings today has maybe 30 years' experience studying hieroglyphs. He knows them like he knows his back of his hand, and you can be sure he knows when you've missed a line. All his younger colleagues, on the other hand, and especially all our younger engineers who are now modeling all that 3D reinforcement in the first place, does not get a word ancient Egyptian. These guys wonder why they have to learn the ancient language when everyone except the contractor with 30 years in the business is speaking plain 3D.

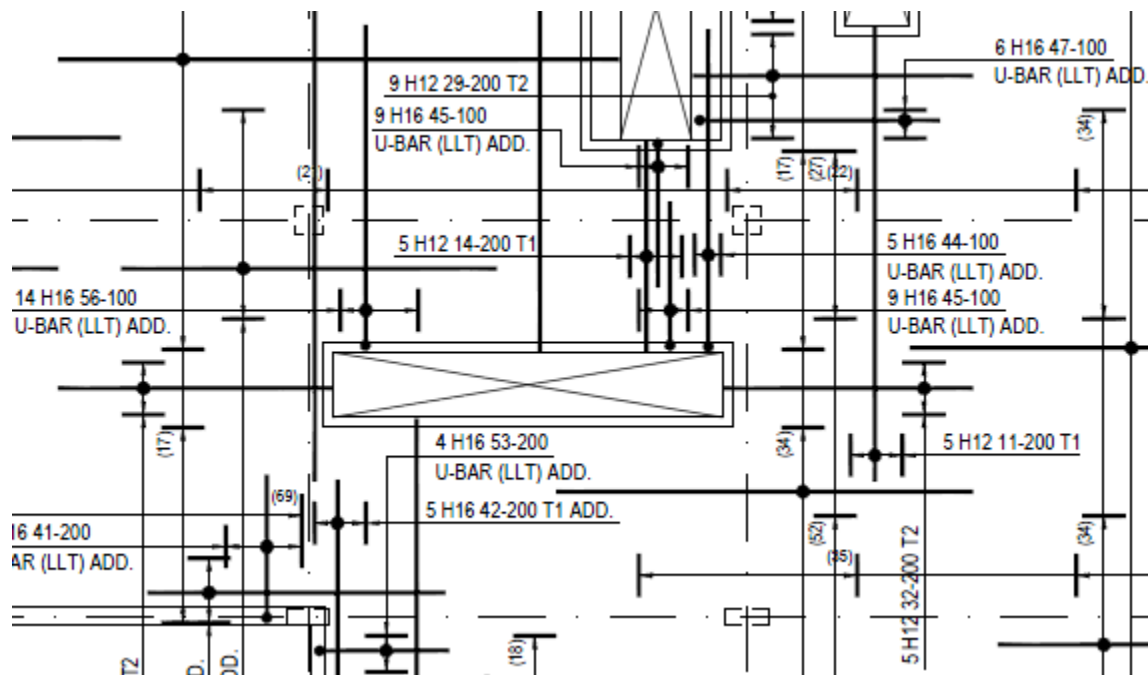


Figure 5: Top modern reinforcement drawing

Everybody on the planet understands 3D. Even the contractor with 30 years on site understands 3D. He just does not master the tools.

Hence, we're challenged with not only modeling 3-dimensional reinforcement in complex forms, but also representing it in ancient ways for people to understand. It does not help either that these hieroglyphs vary between countries. So, we basically have one variation of hieroglyphs for each country. We've got Norwegian hieroglyphs and Swedish hieroglyphs. It's a mess.

And in all this, we ask of Autodesk to enhance 3D modeling functionality and 2D representation tools at the same time. And as of now, the available 2D tools do not support efficient drawing production. I'll get into the details later.

These two challenges need to be considered by each company and individual, with each different project in mind before a plan for using 3D reinforcement tools in Revit is introduced.

3.3 Why use Revit in the first place?

It is possible to track down building information modeling software that does 3D reinforcement better than Revit. Tekla Structures is possibly one of them. The cross-disciplinary environment in Revit however, often results in the fact that we have native concrete elements available from early on. And unless you have a very sophisticated modeling transfer application available between the programs, and you're stuck with maintaining two building information models – one for cross-disciplinary coordination and one for structural detailing, you're in a world of pain. Multiply that with the open BIM exchange format IFC, and your original world of pain now seems like The Bahamas.

So, when you have decided to go all in and put your life in the hands of the Revit Reinforcement Tools, you probably want to get a view at what you've got to deal with.

4 Reinforcement categories and parameters

In Revit you can model regular reinforcement and wire fabric reinforcement. There are a number of various categories assigned for these reinforcement types, and they all behave and interconnect differently;

- Structural Rebar
- Structural Area Reinforcement
- Structural Path Reinforcement
- Structural Fabric Areas
- Structural Fabric Reinforcement

In addition, Structural Rebars are defined from two system families and one regular family, and Structural Fabric Reinforcement of two system families;

- Structural Rebar
 - Rebar Bar (System)
 - Rebar Hook (System)
 - Rebar Shape (Regular)
- Structural Area Reinforcement
- Structural Path Reinforcement
- Structural Fabric Areas
- Structural Fabric Reinforcement
 - Fabric Sheet (System)
 - Fabric Wire (System)

When detailing reinforcement you are expected to schedule and document every single bar that is to be built within your contract. To do so there are a couple of things you need to know about the different categories and their limitations.

First, to let the cat out of the bag, Area and Path Reinforcement cannot be scheduled. They cannot be displayed in 3D either, and are really only made for 2D representation (the hieroglyphs again). A year or so back that meant they could not be used by detailers for other purposes than symbolic representation. In the fantastic 2013 release of Revit, however, Autodesk provided the possibility to host Structural Rebars (which *can* be scheduled) in Area and Path Reinforcement. That really saved the day for a lot of reinforcement detailers around, as you couldn't really say the tools available pre 2013 were very effective for whole structures. Walls and slabs in particular.

The same is sort of true when it comes to Fabric Areas, as it's only the Fabric Reinforcement category that can be scheduled. This is a bit awkward for European engineers as we often quantify the total fabric areas, and leave the detailing of sheets to the contractor. It feels a bit weird though, to complain that the information is “too accurate”, and besides; we can work around this by calculating the total sheet areas in a Fabric Reinforcement Schedule.

Let's get back to these details later. Before we hit the actual rebar tools we should have a short look at an important setting for all our reinforcement; The Rebar Cover Settings.

4.1 Rebar Cover

The first thing you need to do before you place a single rebar in your project (given that you have some families at hand) is add and assign some Rebar Covers. This is done from the Structure Tab and Reinforcement menu. Expand the fly-out and click on Rebar Cover Settings. This is due to the fact that the different Rebar Cover properties on every concrete element are not Length Parameters, but rather drop-down menus.

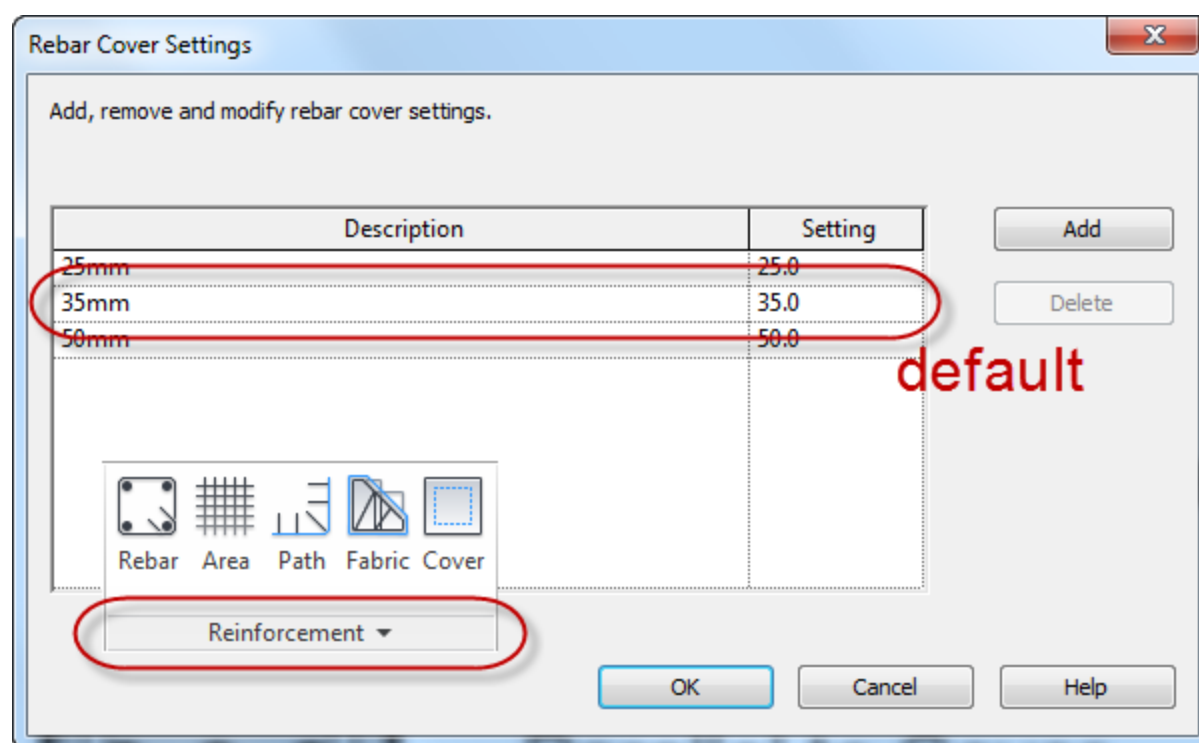


Figure 6: Rebar Cover Settings

The Rebar Cover Settings is a simple dialogue where you can add all the different covers you need in the project.

Tip: There is always one default cover setting. If there is one cover value you intend to use more than others in your project, overwrite the default cover with this value, and add the other afterwards. This way your most used cover setting will be the default value on all elements you model.

It's obviously important to get the cover setting right because all (well, almost all) modeled reinforcement will be slaves to the cover. The Cover Settings can of course be changed in your model over time, but experience shows that this can disrupt your model and schedules.

4.2 Structural Rebar

The Structural Rebar category is the original and main tool for detailing reinforcement in Revit. It can be accessed from the Structure Tab in Revit or from the Modify Tab after selecting a valid object.



Figure 7: Structural Rebar in a straight, rectangular concrete beam

You can add a Rebar to an element in many different ways, but the approach I like most is to draw a Reinforcement Section perpendicular to the object in question, click on the element and choose “Rebar” from the Modify Tab. Then I go ahead and choose my Rebar Bar (diameter), Rebar Shape and Placement Orientation.

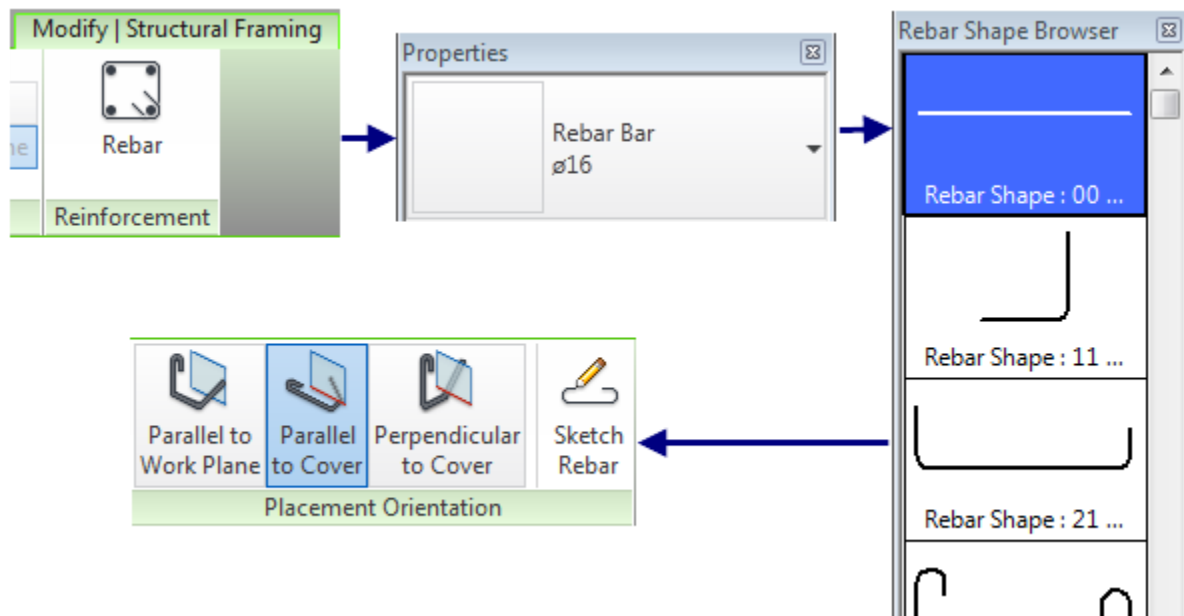


Figure 8: Structural Rebar modeling workflow

If you are looking at a section that is perpendicular to the element, choosing **Parallel to Cover** will draw a bar perpendicular to your view, and choosing **Parallel to Work Plane** will draw a bar that is parallel to the section view (even though the view has no valid Work Plane).

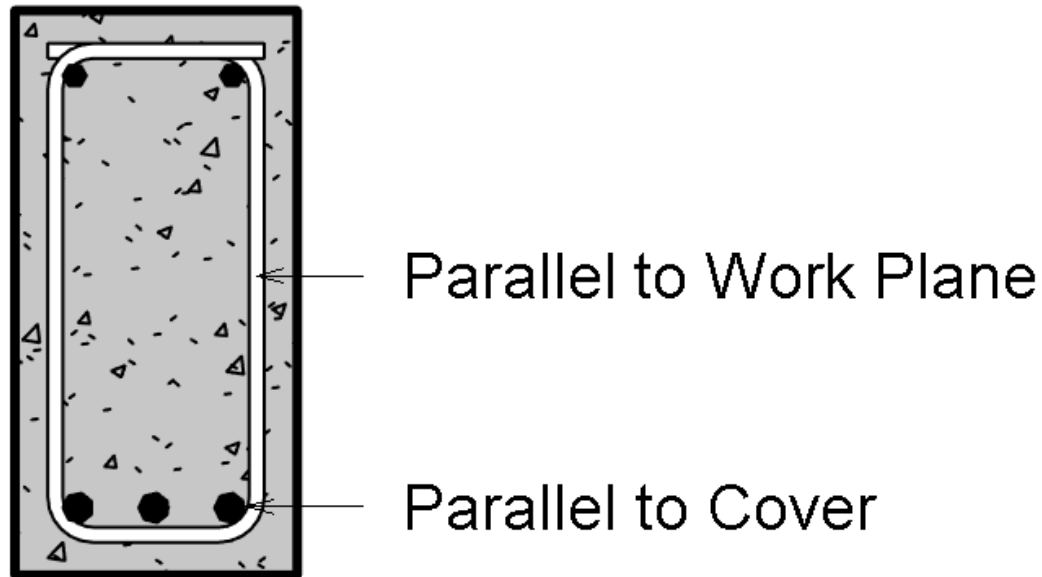


Figure 9: Structural Rebar Placement Orientation

You can also choose to lay out the Rebar Set before you actually place the rebar(s):

Layout:	Maximum Spacing
Quantity:	11
Spacing:	250.0
Rebar Set	

Figure 10: Rebar Set

These parameters will distribute the Rebar Set perpendicular to the rebar shape plane.

One common problem that vertical sections does not solve, is horizontal reinforcement distributed vertically in elements that does not intersect the Work Plane in which you are working on. The classical example is stirrups in vertical columns. You can solve this pretty straight forward by adding a Reference Plane that intersects the column, give it a name and assign it as the current work plane in the plan view in which you see the column cross-section.

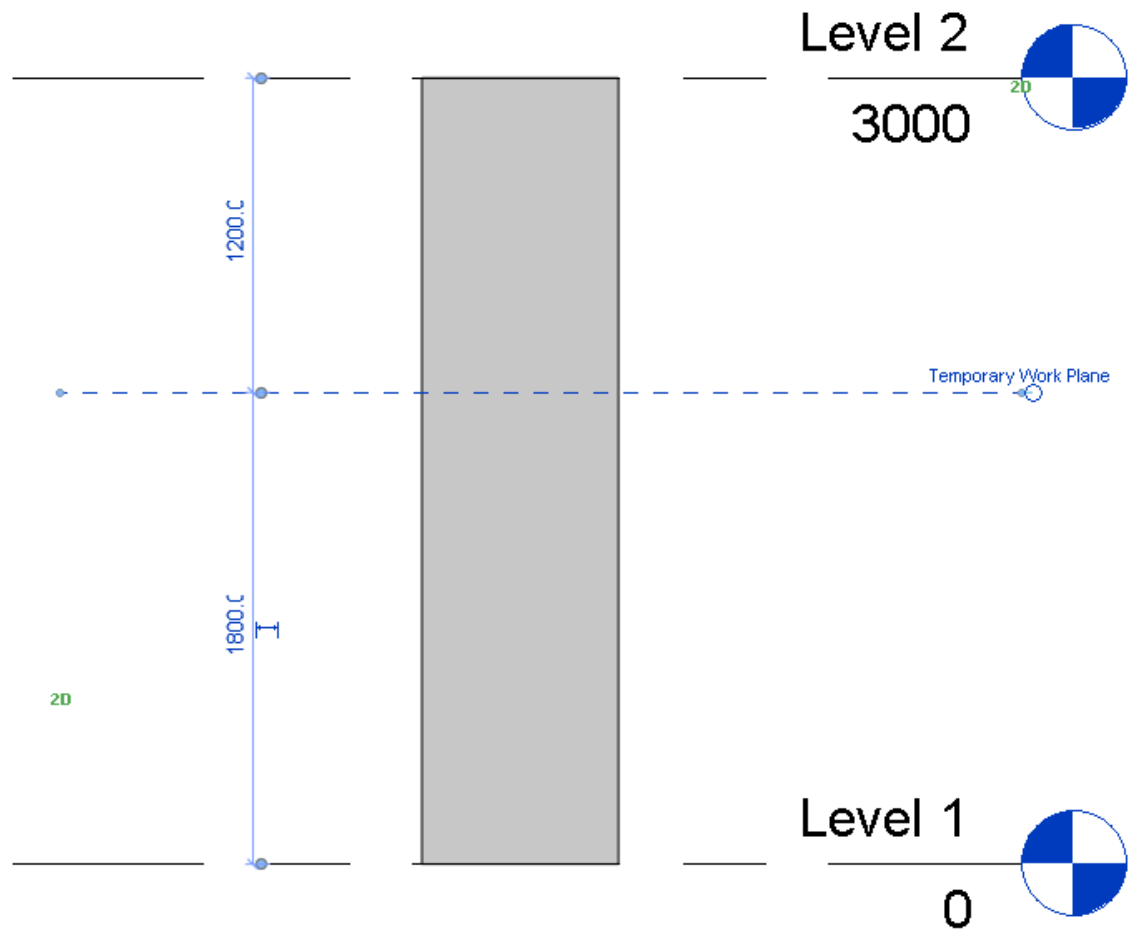


Figure 11: Temporary Work Plane

Another way is to use the Sketch Rebar command under Placement Orientation.

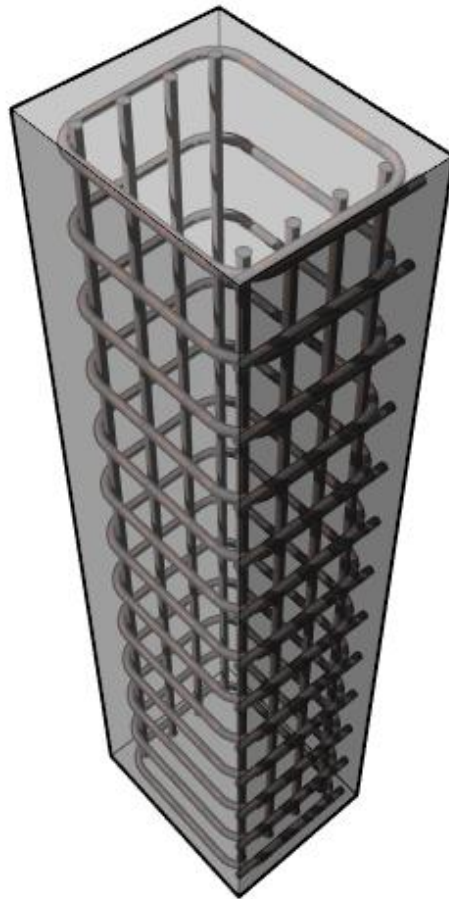


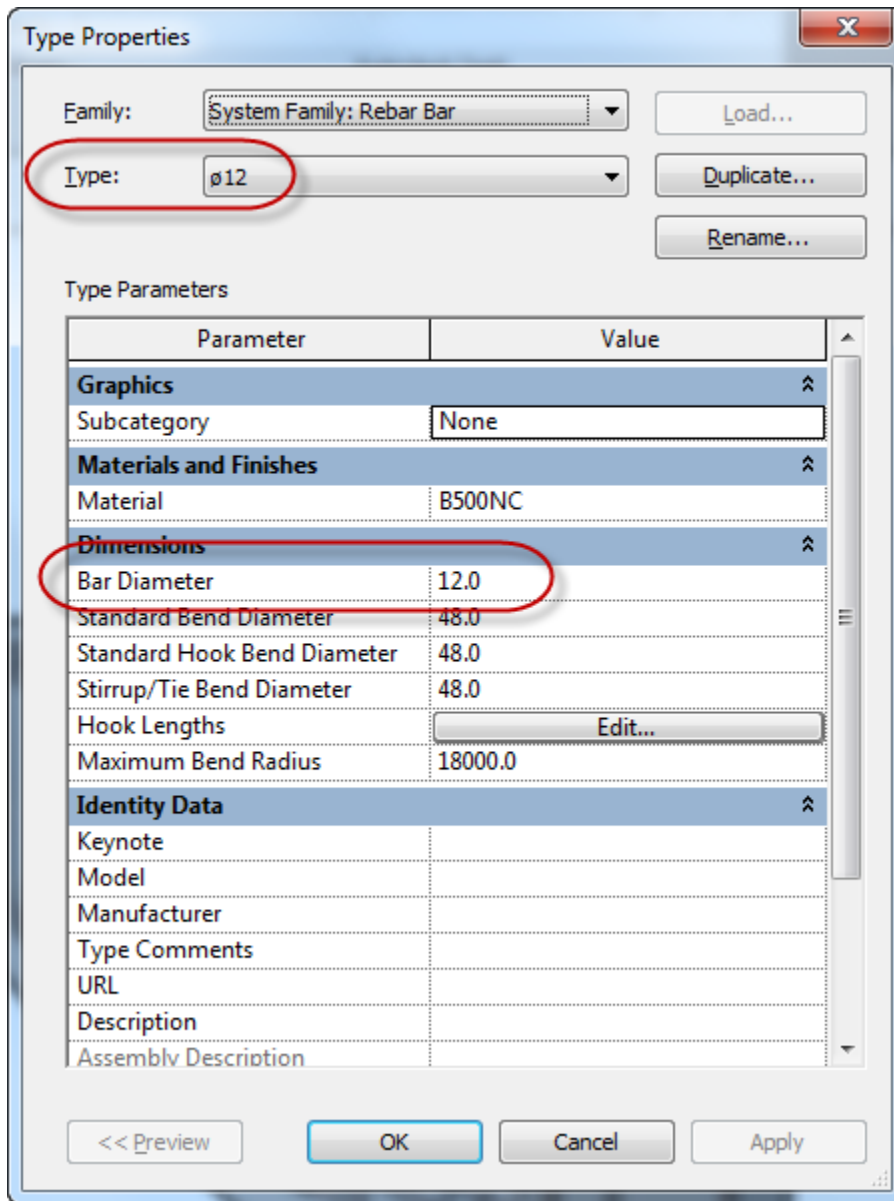
Figure 12: Reinforced concrete column

The Structural Rebar, as mentioned above, is defined by 3 families; the Rebar Bar, Rebar Hook and Rebar Shape.

4.2.1 Rebar Bar

Being a system family, the Rebar Bar can only exist inside your project or template files. That is only partly true, as they also enjoy a presence inside Rebar Shape families. This can cause some hassle, as when you load a Rebar Shape that contains a Rebar Bar that is not present in your project, you can lose control over your Rebar Bar system families. Therefore I suggest that you spend an hour of your life and make sure your template Rebar Bar families are the same in your Rebar Shape families. It's sort of like Materials in that way.

Looking at the Rebar Bar Type Properties, there is one parameter that stands out as more important than the others.



The 'Type Properties' dialog box for a Rebar Bar is shown. The 'Family' is 'System Family: Rebar Bar' and the 'Type' is 'ø12'. The 'Type Parameters' table lists various properties, with 'Bar Diameter' set to 12.0. The 'Dimensions' section is highlighted with a red circle.

Parameter	Value
Graphics	
Subcategory	None
Materials and Finishes	
Material	B500NC
Dimensions	
Bar Diameter	12.0
Standard Bend Diameter	48.0
Standard Hook Bend Diameter	48.0
Stirrup/Tie Bend Diameter	48.0
Hook Lengths	Edit...
Maximum Bend Radius	18000.0
Identity Data	
Keynote	
Model	
Manufacturer	
Type Comments	
URL	
Description	
Assembly Description	

Figure 13: Rebar Bar Type Properties

Like with a wall thickness, it's equally important to let the Bar Diameter parameter of a Rebar Bar family reflect the Type Name. In my example, I *only* use the Bar Diameter parameter for naming, but that's simply because all regular reinforcement in my geographical region is produced from the same material (B500NC). I see no reason for using more parameters in naming, as the only thing we're looking for here is the diameter.

Comment: I've been asked if it's possible to add the small additional diameter produced by the reinforcement grooves, as the bar diameter description 12 mm really reflects the inner diameter of the rebar core. Reasons for doing something like this may be to eliminate any potential reinforcement clashes. There is really no other way of doing this than modeling the bar with the total diameter.

4.2.2 Rebar Hook

If the Rebar Bar system family is simple and straight forward, the Rebar Hook family is nothing less. With its 3 parameters it seems to disrupt no night sleep. There are, however, some tricky parts you should be aware of.

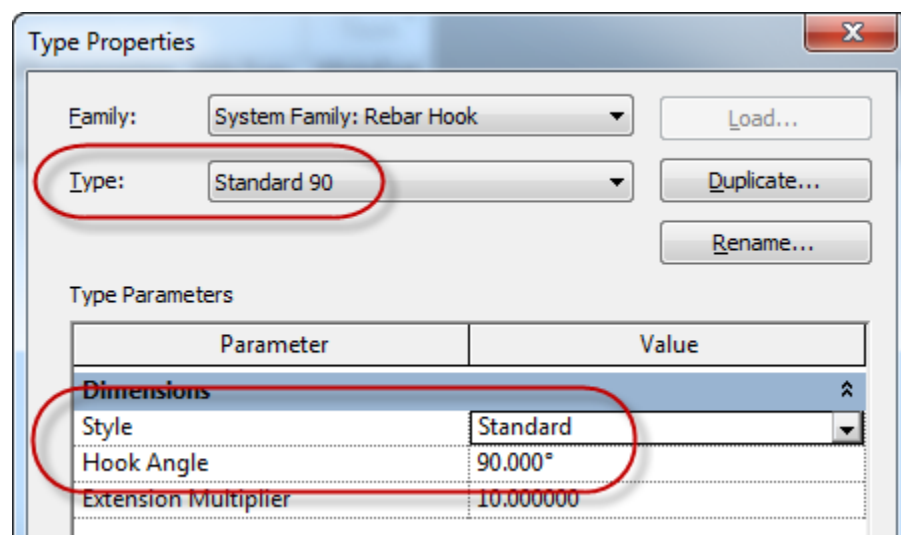


Figure 14: Rebar Hook Type Properties

First, the Hooks are actually, unlike what seems to be the case when studying the Structural Rebar Properties, Rebar Shape dependent.

Construction	
Schedule Mark	1
Rebar Number	
Style	Stirrup / Tie
Stirrup/Tie Att...	Interior Face...
Shape	41 0 0
Hook At Start	None
Hook At End	None
Hook 1	0
Hook 2	0
Shapecode	41

Figure 15: Hook parameters in Structural Rebar Properties

They are defined in the Rebar Shape families. Troubles arise when you try to change the hook definition inside the project environment, without having the proper shape families at hand. If you do so, the shape you had previously selected will be automatically be redefined and renamed to something like “Rebar Shape 1”. Naturally, if your project is “contaminated” with several Rebar Shape 1’es, 2’es and 3’es you soon lose track of your design. Solve this potential problem by predefining and loading the shape families with all the hook definitions you need.

Second, the Rebar Hook Lengths can be assigned manually per Rebar Bar family (bar diameter) or automatically. Either way by combining the Hook Lengths list available in the Rebar Bar Type Properties and the Extension Multiplier parameter in the Rebar Hook Type Properties.

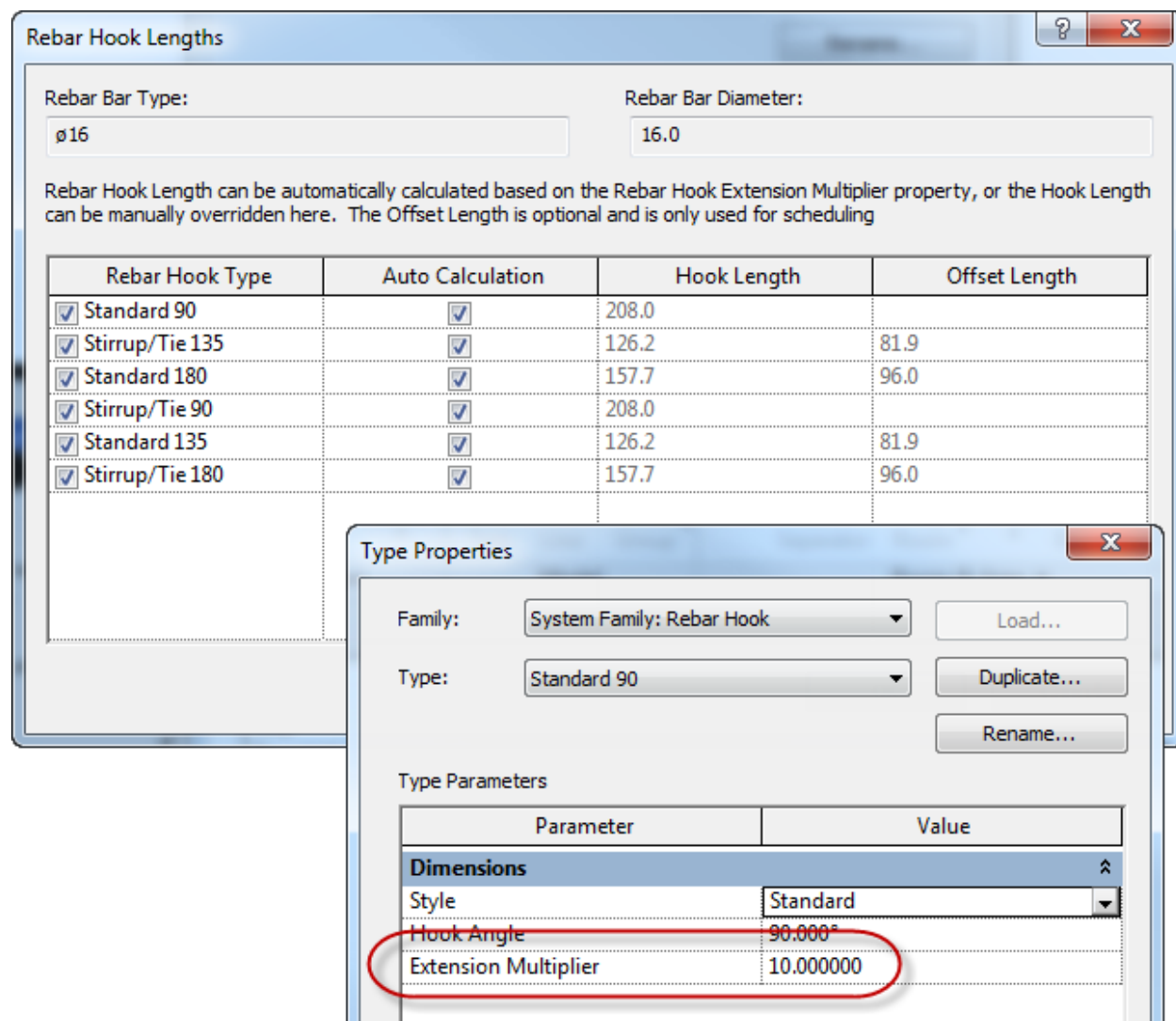


Figure 16: Rebar Hook Lengths

This can be kind of hard to pull together. I use Auto Calculation all the way with a set of Extension Multipliers, as that correlates well with the standard hook lengths used in my region. If you want to override these values, the following image (and the like), stolen from the online Revit WikiHelp, can be of assistance.

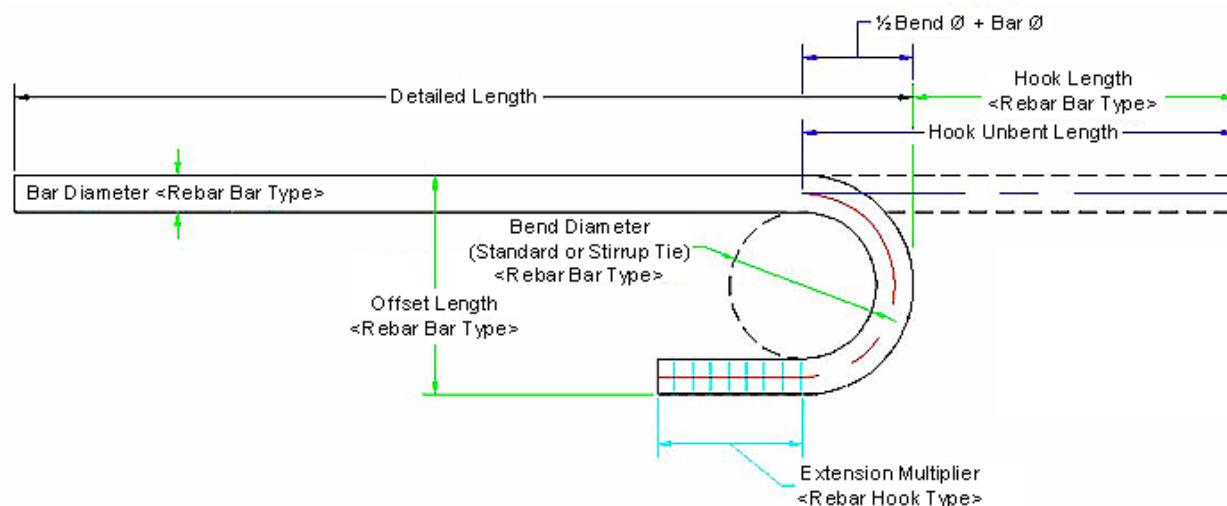


Figure 17: Rebar Hook length parameters, from Revit WikiHelp

4.2.3 Rebar Shape

The Rebar Shape families are the only reinforcement families defined in the Family Editor environment. They are also vitally important to have available and correctly modeled in order to obtain smiling faces on the engineers doing the reinforcement modeling.

Much can be said about the Rebar Shape families, and much is possible, but I will contain myself to the basics and some complex examples.

Rebar Shape families are mostly 2D families, not entirely unlike Profile families. *Mostly*, because it is possible to make multi-planar shapes. Most of the shapes you will define will be 2D.

The shape families are modeled with lines and parameterized only with Shared Parameters. This means that you have to set up a Shared Parameter file in order to add any custom parameters to a shape family.

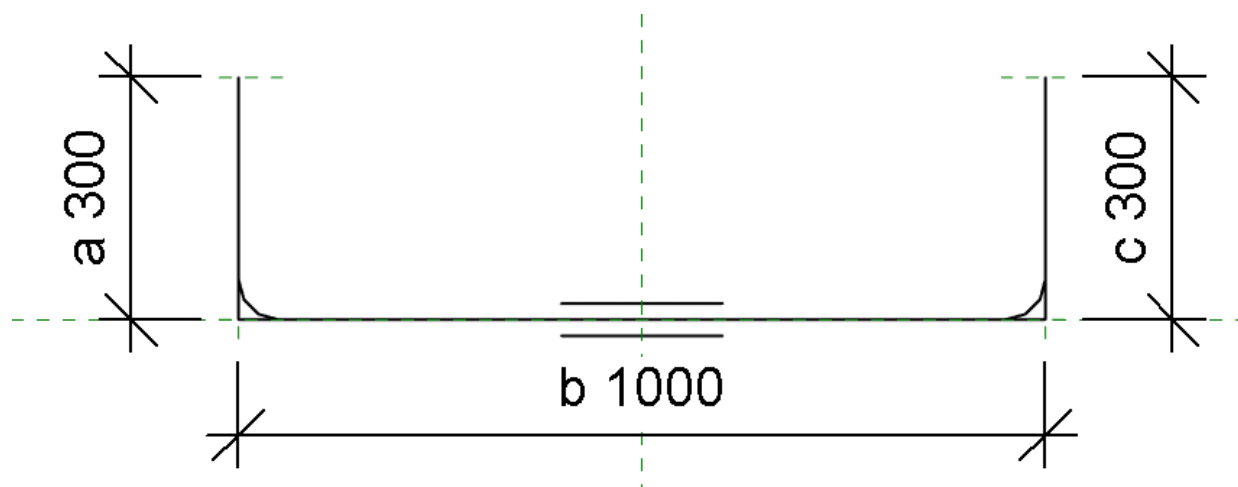


Figure 18: Rebar Shape family with three bar segments

In a Rebar Shape family, each Rebar Line has two References that the labels (length parameters) that control the size of the bar segments, drive. One of the Rebar Lines also has to be defined as Major Segment. This will typically be the segment that you use while placing the bar.

Please remember, as mentioned in the Rebar Hook section, to provide correct hook definitions in the shape family, and reflect that definition in the naming of the shape family. This is maybe only a European problem, as in Europe there is typically no standardized difference in shape definitions between the following examples:

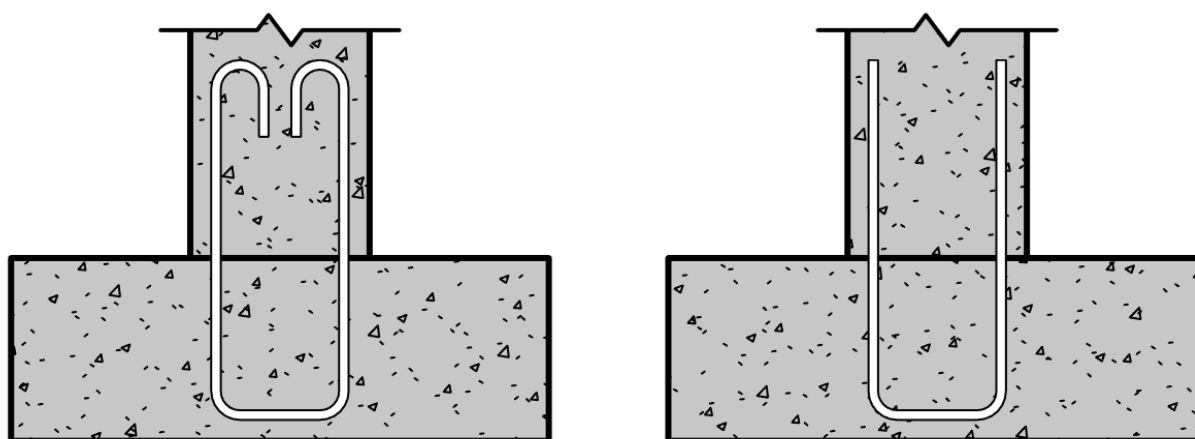


Figure 19: The same Rebar Shape, with and without hooks

These are just 21-shapes with and without hooks. Hence, in Revit you should make two different shape families, and name these something like “21 0 0” and “21 3 3”. (“0 0” and “3 3” is used in Norway to identify no hooks and two 180° hooks, respectively.)

Some shapes can be trickier to set up than others, especially when scheduling considerations have to be made. I’ll provide some examples in the following section.

First, as always in Revit, it can be difficult to define overlapping sketch lines. This can be a challenge in shape families when defining shapes like this:

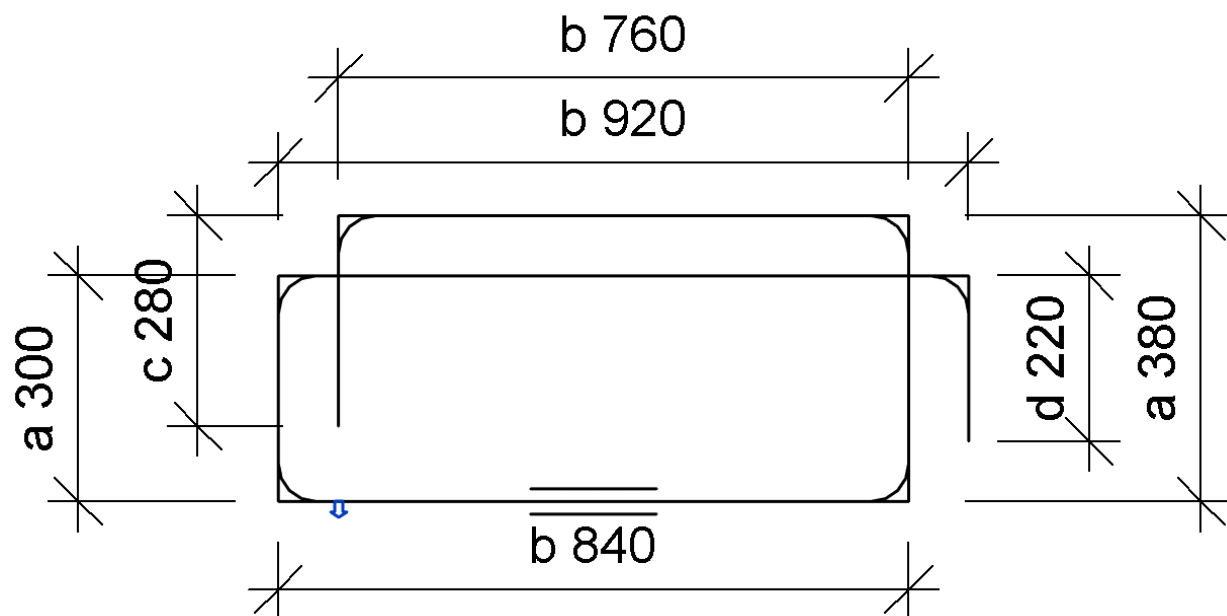


Figure 20: Rebar Shape with multiple identical bar segments

In this example two sets of bar segments have the same dimensions (labels a and b). There are even three bar segments constrained by label b. This sort of situation normally produces an error related to overlapping sketch lines in Revit. The problem in the illustrated example can be solved by dragging the bar segments so that no one label has the same value (as you can see; label a equals both 300 mm and 380 mm). This seems odd, as one is used to the correlation between constraints and parameters in the Revit Family Editor, but for some reason this is not a problem when working with Rebar Shapes. The default value of a parameter in a Rebar Shape family can vary between dimension instances. Or, more precisely; there is really no link between

labeled dimension instances and the default value seen in the Rebar Shape Parameters in the Rebar Shape family environment.

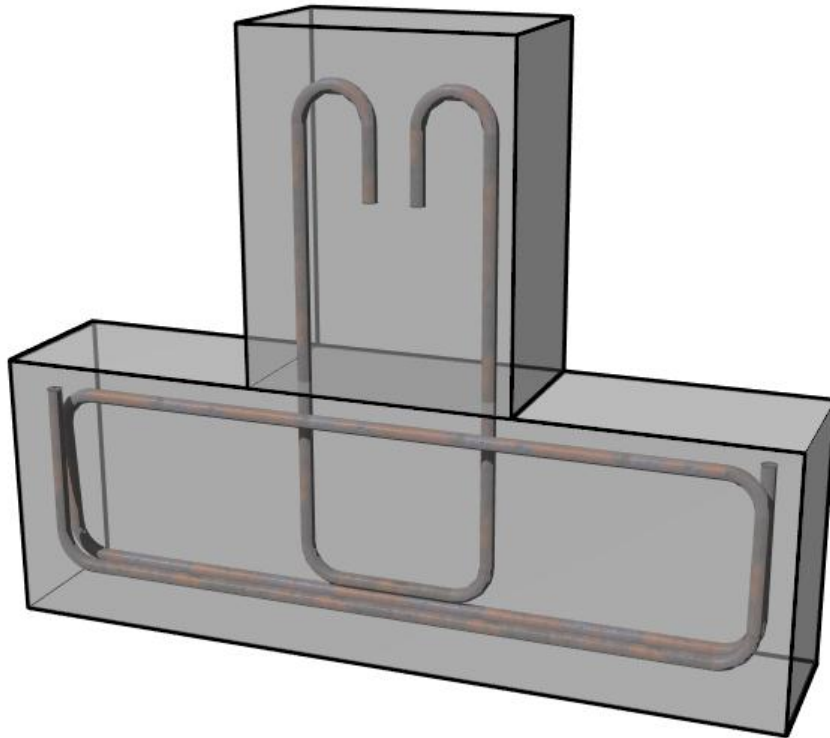


Figure 21: Rebar Shape with overlapping bar segments

Another similar example, that cannot be solved the same way, is circular rebar shapes with a parameter for overlap:



Figure 22: Circular Rebar Shape with closed loop and overlapping lines

Revit will give you pain the instant you try to draw a single Rebar Line that defines a closed loop, and even more so if the closed loop is flanked by overlapping lines. This problem cannot be solved by varying dimensions, as there is only a single diameter label that controls the entire form.

You can work around this by drawing two lines, and let the second line partly define the overlap, which in turn you parameterize. You will get a warning on one of the lines, but nothing serious.

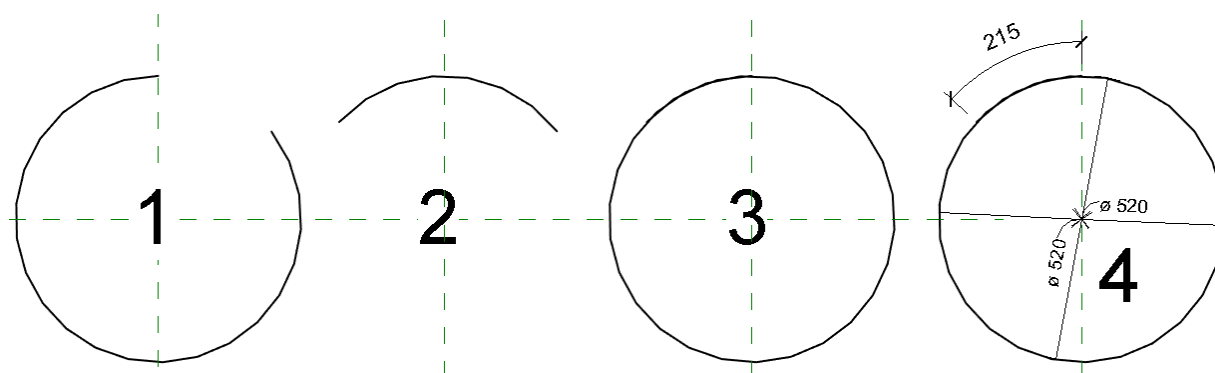


Figure 23: Procedure for making a closed loop, circular Rebar Shape with overlap

You probably need to feel around the snapping a bit, in particular when adding dimensions, but once you get there it works surprisingly well.

In some cases our regional reinforcement standards for reporting bar segment lengths does not comply well with the way Revit works (I guess you can really say the same for a lot of CAD standards). One example of this is a Rebar Shape with angles defining bar segment lengths, and you need to report a straight dimension length.

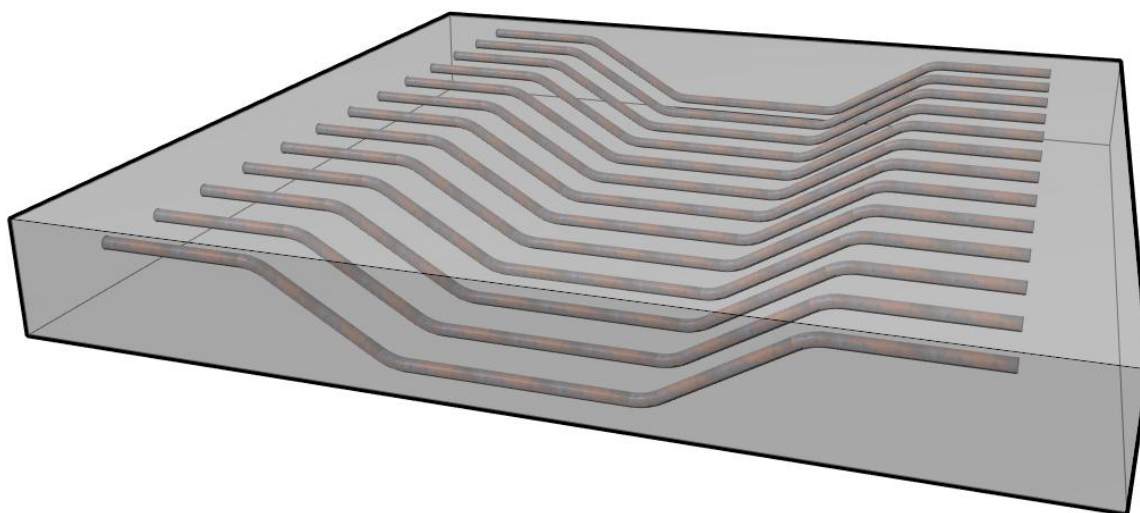


Figure 24: Angle-driven Rebar Shape

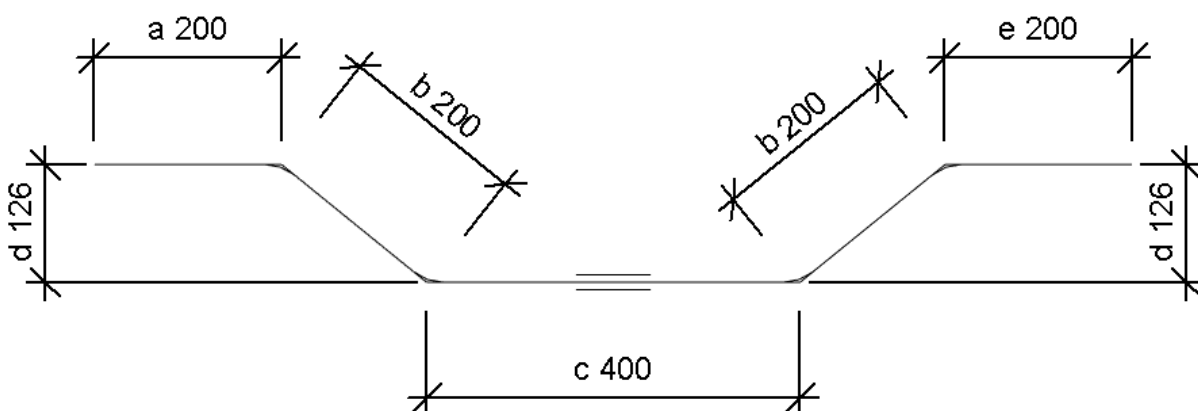


Figure 25: Required reporting parameters of an angle-driven Rebar Shape

In order to make the angle 'live' (meaning you can actively change it by dragging), it needs to be assigned a label with a corresponding angle parameter. This does not combine well with the need for a straight length label (d in the image above example). You can solve this by using formulas in the parameters that reports the straight lengths.

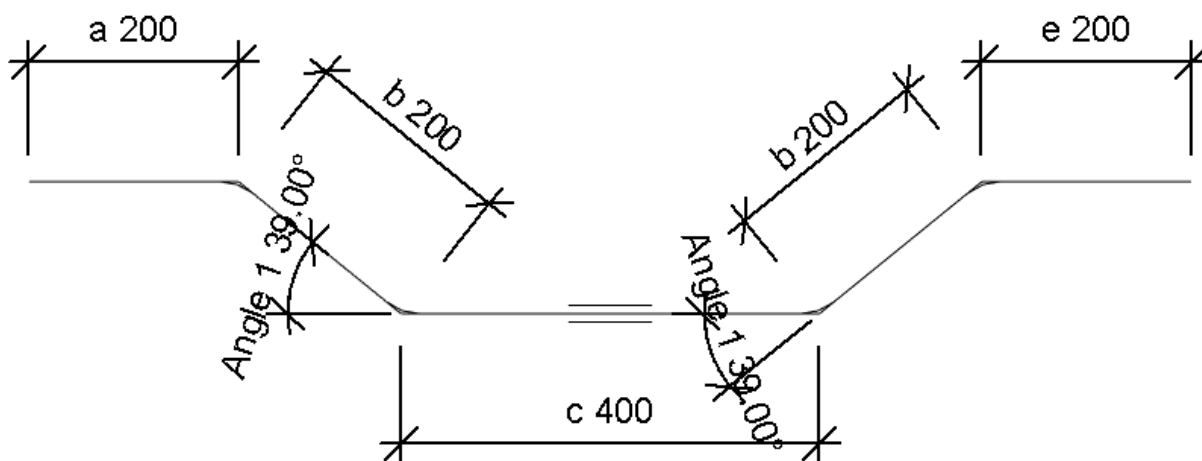


Figure 26: Angle-driven Rebar Shape with real angle parameters

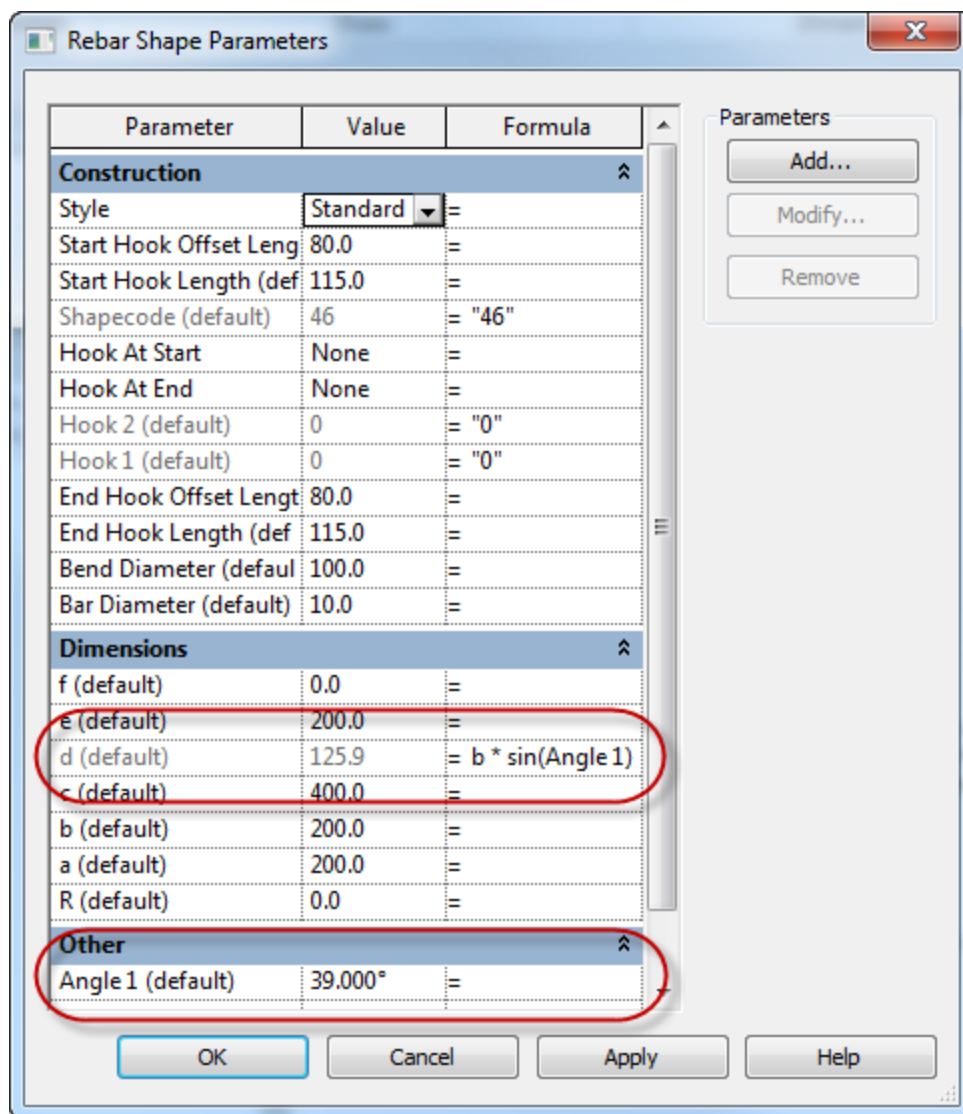


Figure 27: Formula used to derive straight lengths from angle

In the illustration above you can also see one more modification that I constantly use in order to make my Rebar Shapes report the exact information that my Rebar Schedules need; Shape Code and Hook information. The values you see above are national standards, so please don't pay too much attention to those. The main point is that I use these locked text parameters to report something that the out-of-the-box parameters cannot.

Using a custom text parameter to report the Shape Code, I don't have to rely on the Rebar Shape Family Name. And using the same for Hook information, I do not have to rely on Rebar Hook Type Names. Lastly, using formulas and quotation marks I lock these parameters so they cannot be accidentally manipulated in the project environment. Fool proof! (Well, at least as long as I don't mess up.)

I will get back to the use of these parameters in the section on Rebar Schedules.

These are all workarounds of which I'm immensely proud. Hopefully though, Autodesk will provide more intuitive solutions in the future. This is something that I will discuss in the last section in this document.

4.3 Structural Area Reinforcement

As mentioned in the introduction to this chapter, about a year ago Area and Path Reinforcement would probably not even be mentioned in this *Grand Tour de Reinforcement Detailing*. Now, however, because of a small tick box, they play an immensely important part for us.

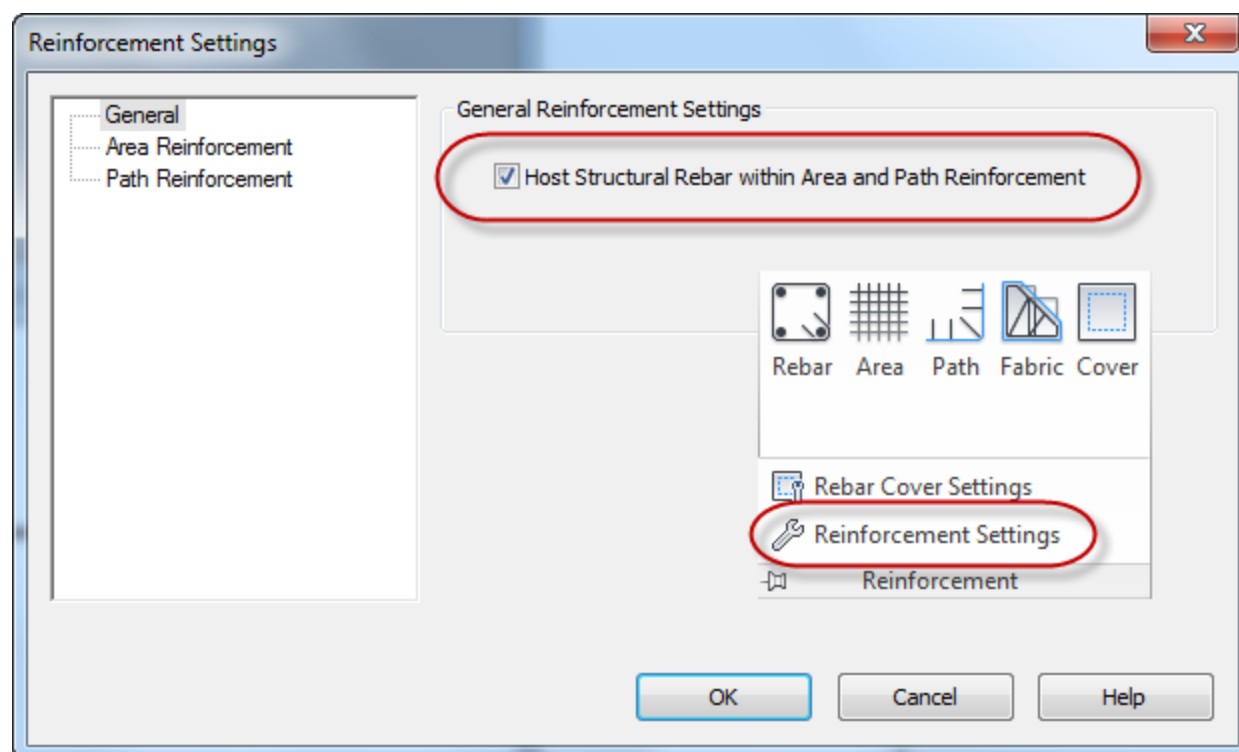


Figure 28: Option to host Structural Rebar within Area and Path Reinforcement

This basically means that we can use all the good things that Area (and Path) Reinforcement bring to the table; hieroglyphs (or symbolic representation if you will), modeling tools and updating functionality. And then of course we can use the now hosted Structural Rebars for detailing in 3D and Schedules. Could life be any sweeter? (Yes actually, but let's get back to that later.)

Note that while modeling Area Reinforcement you can limit yourself to only draw the Major Direction line. That way Revit will distribute all needed Structural Rebar Sets to the covers of the concrete element.

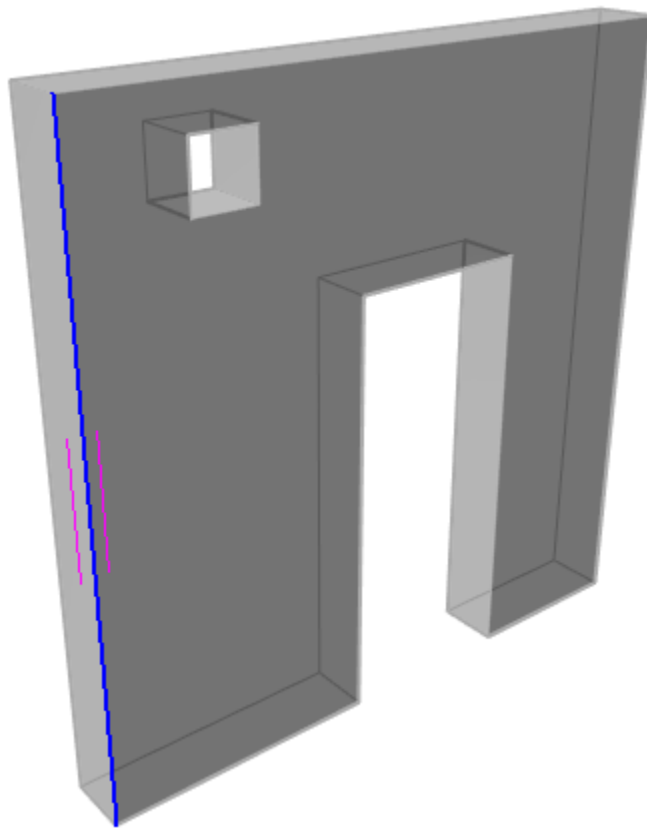


Figure 29: Wall reinforced by Major Direction line

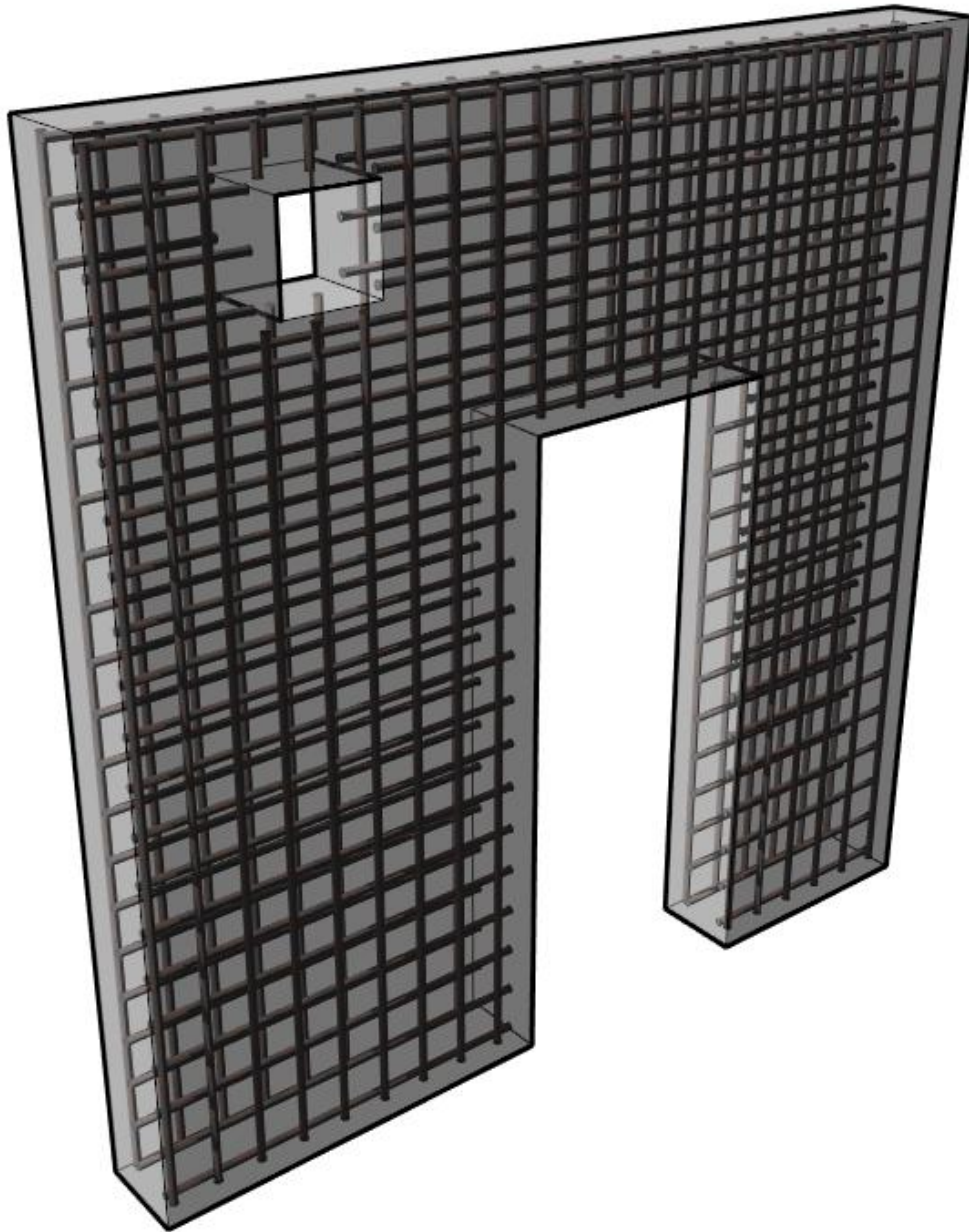


Figure 30: Reinforced wall with openings

Updating your reinforcement design through Area and Path Reinforcement is extremely effective, as you only change the sketch or properties, and watch all Structural Rebars update instantly. The Area Reinforcement will submit to all openings, also when they are modified. This may all seem like something you'd take for granted, and right you are. Still, the joy we feel when reinforcing a wall like the one above in 3 seconds rather than 1 hour, and still get the hieroglyphs for free, is immense.

There are some aspects with this workflow that should be discussed before we move on.

First, both the Area and Path Reinforcement will use the first straight Rebar Shape available in the project. And by *first* I actually mean alphabetically first. This is irrelevant if you only have one straight Rebar Shape loaded in your project. If you have several, like me, you might want to keep track of the alphabetical sorting of Rebar Shapes in the Families-section of the Project Browser. Obviously, again, if you do not use the Rebar Shape Family Name for scheduling purposes but rather custom parameters, it does not matter if you change the family name of Rebar Shapes. And this I do, with the use of the hash tag (#), to move Rebar Shapes up and down in the alphabetical order.

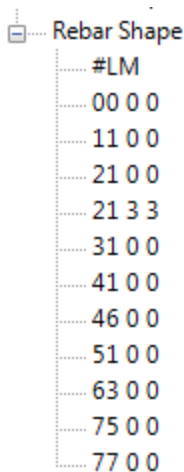


Figure 31: Rebar Shapes ordered alphabetically

Second, there are no tools or options available as of today to automatically control lap splices. This is a general challenge when working with all reinforcement except Wire Fabric Mesh in Revit. When modeling Structural Rebars we have to model the laps manually as two (or more) different Rebar Sets. This can also be done with Area and Path Reinforcement by modeling separate areas (or paths), but you soon get the feeling that your level of effectiveness and the general awesomeness of your project took a few hits.

An alternative solution to this issue, and one that we constantly use in our region of the world, can be to just model the reinforcement to the extents of the concrete elements and let the Rebar Schedule take care of lap splices. This won't automatically "make new rebar sets" for each lap splice, but it can make the total bar length of the area in question correct without having to actually model the lap splices. This is sort of a "cheat" and I'm on a general level critical to manipulating schedules so that they no longer reflect the exact precise 3D model, but it *can* help you obtain a higher level of project awesomeness, and who doesn't want that?

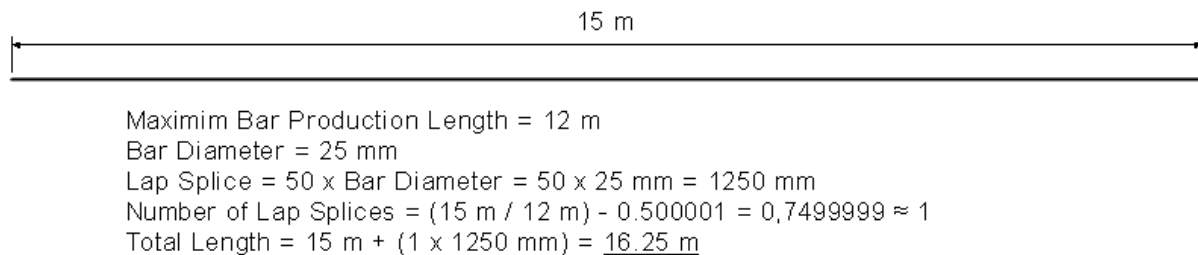


Figure 32: Formula for calculating lap splices

A comment on the constant 0.500001: This is provided to make sure the exact tipping point of the addition of one lap splice coincides with the way number rounding works. It basically makes everything round down to a precision of 6 decimals.

Note: the constant 50 used to derive the Lap Splice is Norwegian Standards, and may be different in other places on earth.

In our projects (and in the Rebar Shape list above) this solution is defined as separate Rebar Shape family called "LM" (translated from Norwegian "Running Meter").

This formula is used in your Rebar Schedule, not the Rebar Shapes because Total Bar Length is not available outside the Revit project environment. This will be covered in greater detail in the section about Schedules.

4.4 Structural Path Reinforcement

Area and Path Reinforcement is similar in many ways, and much of what is said for Area goes for Path. The main difference is how Path Reinforcement is modeled as opposed to Area. There are in addition some use cases where other differences occur.

Firstly, when using Path Reinforcement I soon get the urge to change the Rebar Shape used for hosting. For instance when I'm modeling rebar bends on multiple slab edges and top of walls.

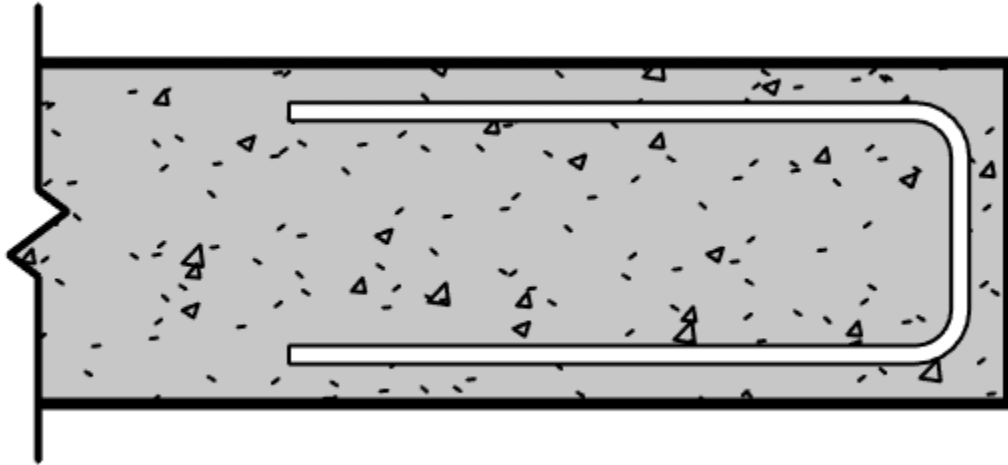


Figure 33: Rebar bend along slab edge

You can use Path Reinforcement quite effectively for this, but in order to change the Rebar Shape you need to disassociate the hosted Structural Rebars from the Path System. There simply is no way for us to use other than straight Rebar Shapes in Area or Path Reinforcement without using the Remove System tool.

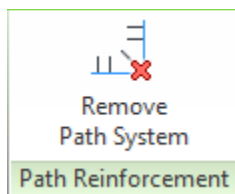


Figure 34: Remove Path System

Still, it can be a lot faster than modeling the Structural Rebars manually, especially along curved slab edges.

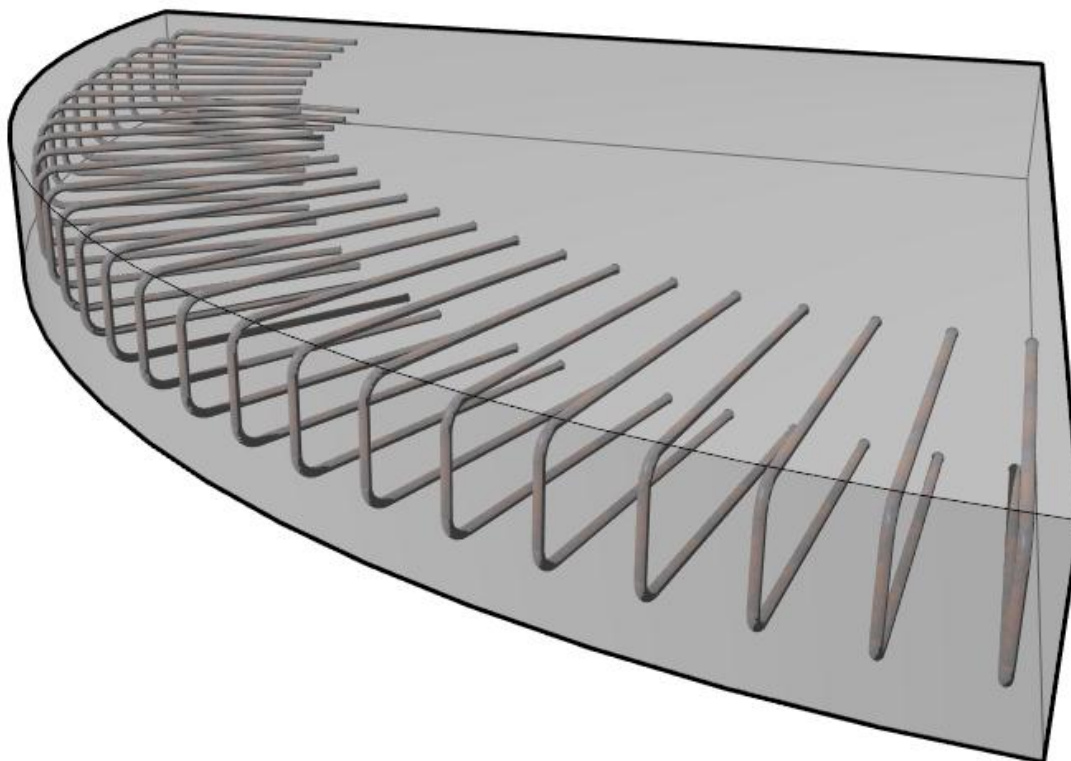


Figure 35: Rebar bend distributed along curved slab edge using Path Reinforcement

Note: Please be aware that removing an area or path system, depending on the distribution of Structural Rebars, often will make tagging Spacing and Quantity parameters more complex. In the example above, every bar now has a Single Layout Rebar Set, Quantity = 1 and no value for Spacing. This can be worked around with custom parameters for Quantity and Spacing, but you will lose the automatic database connection between modeled geometry and reported parameters.

That's all on standard reinforcement for now. Let's move on to Wire Fabric Mesh.

4.5 Structural Fabric Areas

The Category Structural Fabric Areas include one system family (Structural Fabric Area) and as many Types as you like, the default type being Structural Fabric Area 1. Instances of Structural

Fabric Areas contain Fabric Sheets, which in turn contain Fabric Wire. It's really a set up of hard-wired (pun intended) family nesting operations.

Structural Fabric Areas are much like Structural Area Reinforcement now, working as sketch-based hosts for instance-driven model elements.

While in the Structural Fabric Area sketch you can add Boundary Lines and a Major Direction line. Once a closed loop is completed four tick boxes will appear. These tick boxes are used for determining from which corner the first Fabric Sheet is aligned.

Along with selecting the proper Fabric Sheet and Location (Top/Bottom), you can modify the Lap Splices used for laying out the separate Sheets.

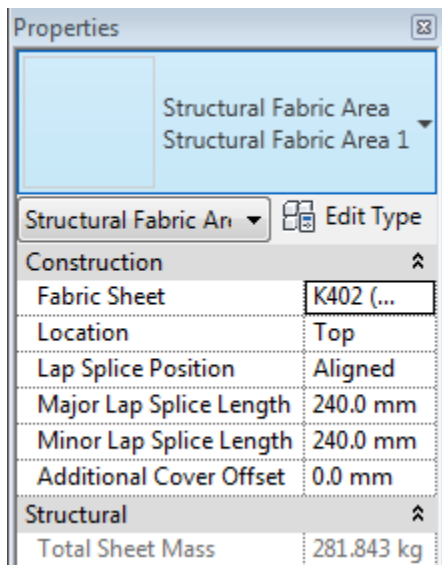


Figure 36: Structural Fabric Areas Properties

Also note that, again as with Structural Area Reinforcement, you can very simply add Structural Fabric Reinforcement to an entire concrete element by just drawing a Major Direction line while in the Structural Fabric Area sketch.

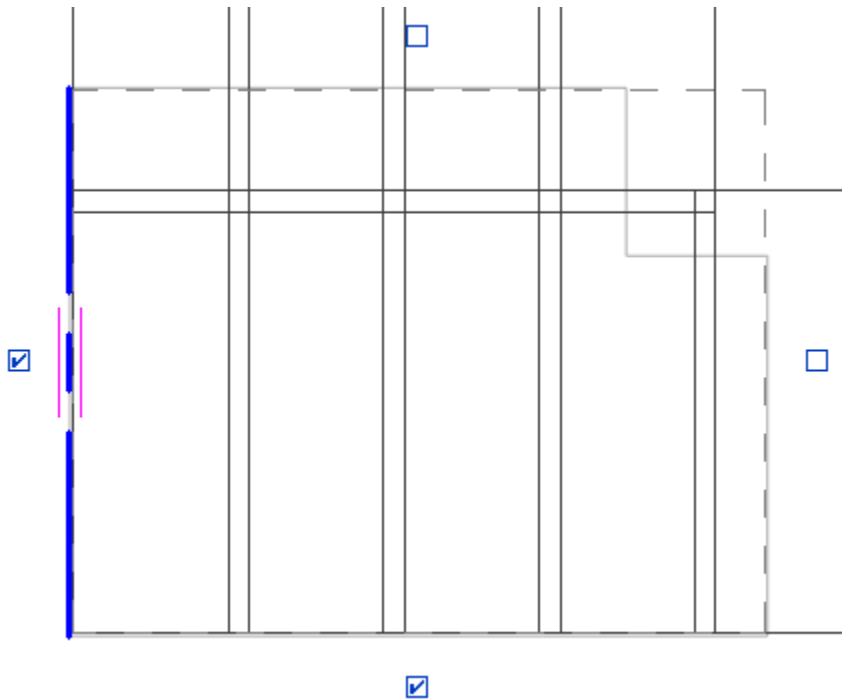


Figure 37: Structural Fabric Areas defining Fabric Sheet layout

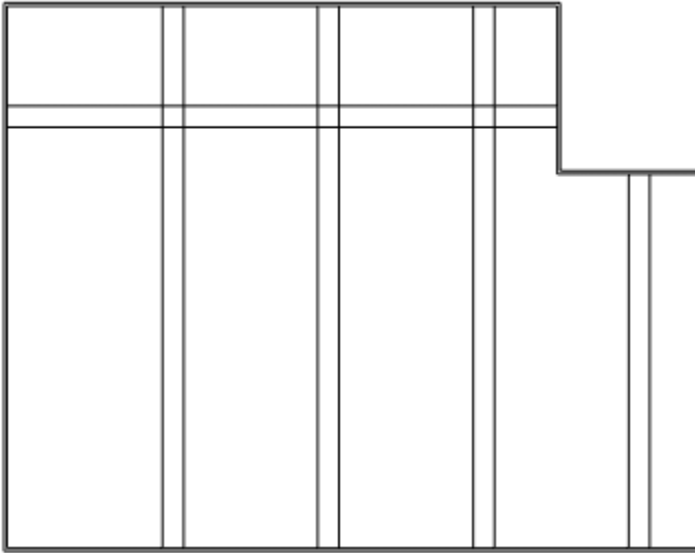


Figure 38: Finished Fabric Sheet layout

4.6 Structural Fabric Reinforcement

Structural Fabric Reinforcement is the main category for fabric reinforcement, like Structural Rebars for regular reinforcement. And like Structural Rebars, it is built up by nested system families; Fabric Sheet and Fabric Wire.

Being the main category it is also the category we use for scheduling purposes.

4.6.1 Fabric Sheet

As mentioned, Structural Fabric Areas host Fabric Sheets. This means that the placement of the Fabric Sheets is determined in the Area, but the parameters that make up the size, layout and material of each sheet are in the sheet families themselves.

Type Properties

Family: System Family: Fabric Sheet Load...

Type: K402 (2x5m) Duplicate... Rename...

Type Parameters

Parameter	Value
Construction	
Major Direction Wire Type	8
Minor Direction Wire Type	8
Default Major Lap Splice Length	240.0 mm
Default Minor Lap Splice Length	240.0 mm
Materials and Finishes	
Material	B500NA
Physical Material Asset	B500NA
Structural	
Sheet Mass	63.222 kg
Sheet Mass per Unit Area	6.32 kg/m ²
Major Reinforcement Area	4.021 cm ² /m
Minor Reinforcement Area	4.021 cm ² /m
Layers	
Overall Length	5000.0 mm
Length	4875.0 mm
Major Start Overhang	62.5 mm
Major End Overhang	62.5 mm
Major Layout Pattern	Actual Spacing
Major Number of Wires	16
Major Spacing	125.0 mm
Overall Width	2000.0 mm
Width	1875.0 mm
Minor Start Overhang	25.0 mm
Minor End Overhang	100.0 mm
Minor Layout Pattern	Actual Spacing
Minor Number of Wires	40
Minor Spacing	125.0 mm

Figure 39: Fabric Sheet Type Properties

Using the Fabric Sheet Type Parameters you can standardize sheet sizes, bar diameters, spacing, mass and overhang, among other properties. Even though the Structural Fabric Reinforcement category is the one we use for scheduling, these are the parameters that are combined in the schedules.

You may have noticed that the Fabric Sheet bar diameter (Major and Minor Direction Wire Type) is not a regular length parameter, but rather a nested parameter of the last group of fabric components; the Fabric Wire.

4.6.2 Fabric Wire

A simpler family is hard to find. The Fabric Wire has but one parameter; Nominal Diameter. One can ask why go to such measures just to add a bar diameter, but once you get the connection between the families, types and sub-components, it runs very smooth. It also obviously makes it harder for people to accidentally deviate from the standardized sizes that we always operate with.

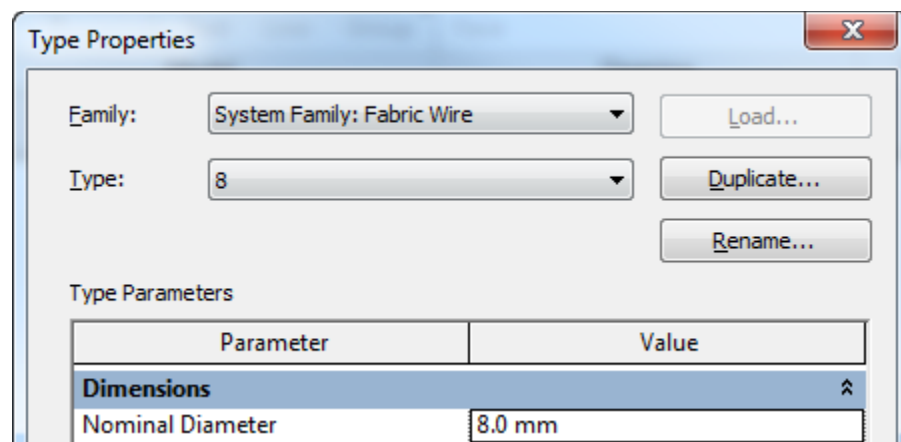


Figure 40: The juggle of Fabric Wire Type Properties

That pretty much sums up the different modeling tools that are provided for us. I sometimes use Generic Models to do special solutions (for instance for reinforcement hosting in families) and Adaptive Components for really special structures (like walls by faces), but will not cover these here. Perhaps we'll look into those situations in the next edition!

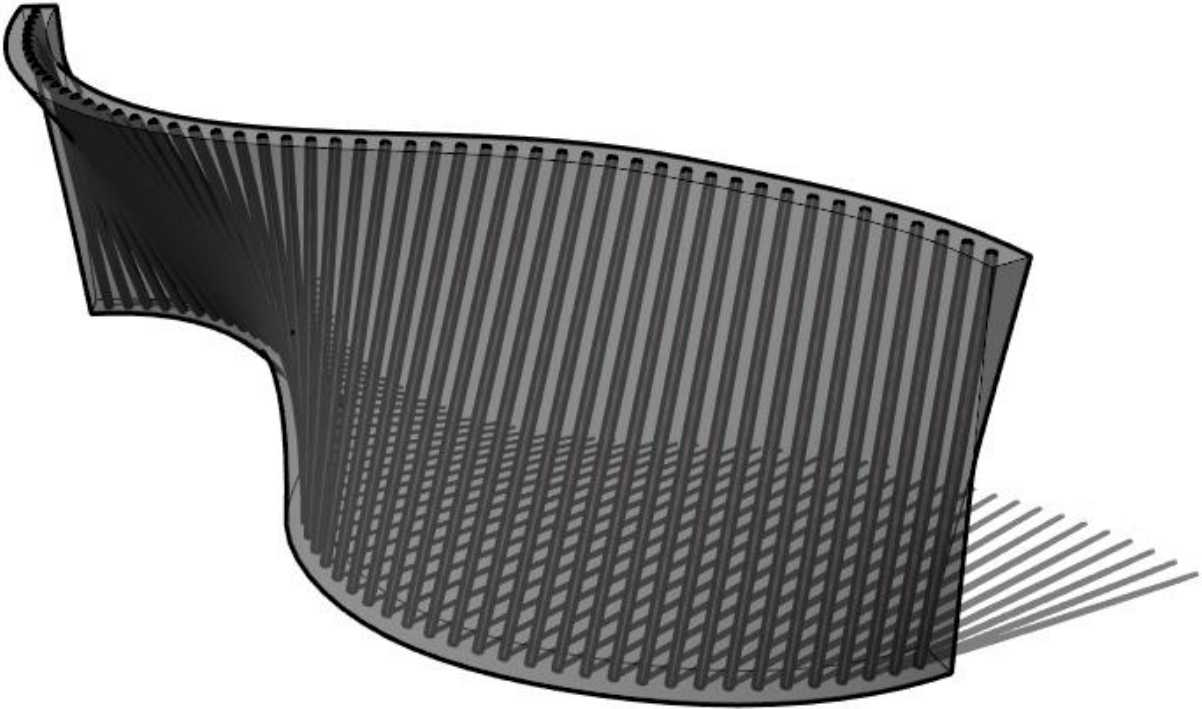


Figure 41: Concrete wall by face, vertically reinforced using Adaptive Components

It's time to direct our attention to the documentation part of reinforcement detailing, and first out of the hat are schedules.

5 Schedules

An important part of reinforcement detailing is documenting the quantities of reinforcing bars and sets of bars in a structure. This work has been done for centuries by so-called Bending Schedules or Rebar Schedules. I'm not entirely sure how much longer we will use these CAD tools in documentation. Building complex 3D models should (and will) provide us with the opportunity to use the models directly in fabrication and construction. I will touch this subject in the Model Export section later in this document. The future is now, Carl Bass says. Still, today we are required to produce these schedules, and this section is dedicated to that.

The way Rebar Schedules have been created and developed previously, be it in Word, Excel, AutoCAD or some other system, vary between countries and continents. Therefore, this section will inevitably be more relevant for some than others, and for that I apologize. I hope, however, that some ideas can be valuable for all.


 tel 01223 369220 fax 01223 356215 cambridge@ramboll.co.uk www.ramboll.co.uk				Client: U.O.C.				Prep By: BDS			Dwg No.: 239			
				Site Ref: Materials Science & Metallurgy				Prep. Date: 25/11/2011			Sheet No.: 1 of 3			
				ROOF SLAB TOP [SHEET 2 OF 4]				Chk'd By: IM			Rev.:			
				Job No.: 6433				Rev. Date:						
Member	Bar Mark	Type & Size	No. of mbrs	No. of bars in each	Total no.	Length of each bar (mm)+	Shape code	A *	B *	C *	D *	E/R *	Weight (kg)	Rev letter
SLAB	01	H12	1	56	56	11125	00						553.22	
	02	H12	1	20	20	6675	00						118.55	
	03	H12	1	17	17	7050	00						106.43	
	04	H12	1	14	14	12000	00						149.18	

Figure 42: Classical bending schedule according to Ramboll UK

Let's start by looking at what parameters we need to make a working Rebar Schedule in Revit.

5.1 Parameters

Revit provide us with a lot of out-of-the-box parameters that we can use in our Rebar Schedules, but in most cases we still need more. Examples of provided parameters that we use are Bar Diameter, Bar Length, Total Bar Length, Quantity, Comments and the different bar

segment lengths (a, b, c, etc.). Many of these we manipulate, hide and use in Calculated Values instead, but we'll get back to that in the section about Lap Splices and Total Lengths.

Parameters that we need to provide ourselves are Rebar Number, Rebar Comments, Rebar Revisions, Shape code and Hook parameters (as mentioned in the section about Rebar Shape). How we define these parameters depend on our need for use.

As you know, Shared Parameters can appear in both Schedules and Tags, whereas Project Parameters are only for Schedules. Also, some parameters are needed in the Rebar Shape families, and some are not. The following list will try to provide an overview of how I set this up.

- Shared Parameters in Rebar Shape families
 - Shape code
 - Hook 1
 - Hook 2
- Shared Project Parameters
 - Rebar Number
 - Rebar Comments
- Project Parameter
 - Rebar Revision

Many of these parameters are actual substitutes for out-of-the-box parameters that are already present in Revit. The Shape code and Hook parameters have already been discussed in the Rebar Shape section. I use a custom Rebar Number as the main reinforcement identifier, because the provided Mark and Schedule Mark parameters have hard-coded functionality in them that does not work to our advantage. The Schedule Mark parameter will use a confusing host ID and change whenever you rehost a Rebar, and the Mark parameter will produce a persistent Warning for each duplicate Mark value.

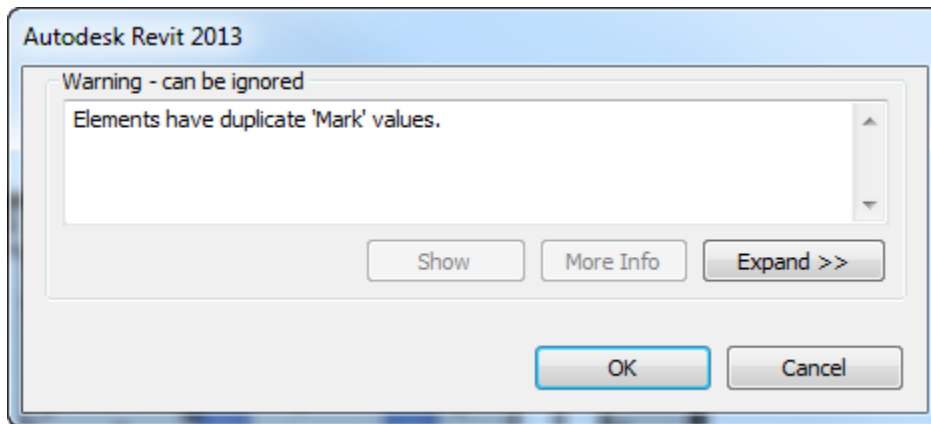


Figure 43: The Fall of the Mark Parameter

The Rebar Comments parameter is an addition to the default Comments parameter, as we often need different comments for Schedules and Tags. Hence we use the parameters Rebar Comments in Schedules and Comments in Tags.

When your parameters are in place you have an entire Rebar Schedule in Revit that lists all Structural Rebars in your project.

Rebar Number	Bar Diameter	Cut Length	Rebar Quantity	Total Length	Shape code	Hooks		a	b	c	d	e	f	R	Rebar Comments	Rebar Revision
100	16	1351	27	36	21	0	0	600	217	600	0	0	0	0		
101	16	1364	10	14	21	0	0	600	230	600	0	0	0	0		
102	16	1617	9	15	21	3	3	569	230	569	0	0	0	0		
103	16	1617	11	18	41	0	0	230	530	230	530	230	0	0		
104	16	3170	11	35	63	0	0	220	830	220	220	0	0	0		
105	25	12000	0	191	LM	0	0	0	0	0	0	0	0	0		
106	25	2330	2	5	00	0	0	2330	0	0	0	0	0	0		
107	25	2678	13	35	41	0	0	530	680	530	680	530	0	0		
108	32	1130	16	18	00	0	0	1130	0	0	0	0	0	0		
109	32	2154	13	28	46	0	0	400	399	600	203	400	0	0		
110	32	2330	3	7	00	0	0	2330	0	0	0	0	0	0		
111	32	2930	8	23	00	0	0	2930	0	0	0	0	0	0		
112	32	3221	9	29	75	0	0	465	400	0	0	0	0	0		

Figure 44: Revit Rebar Schedule

To make this work with printing (we use A3 sheet sizes for Rebar Schedules), construction phases (Plan 1, Plan 2, etc.) and controlling information issue dates, we apply filters to focus the information in these Rebar Schedules.

5.2 Filters

A Rebar Schedule can get very long. There are a few ways to go if you need to print it on several sheets of paper, one being multiple title blocks inside a Title Block family and different Print Setups. We prefer to duplicate Schedules for each construction phase and use filters.

You can use mostly all included parameters for filtering purposes. Exceptions are normally for some bizarre reason Family and Type Names. You can also add new parameters (Construction Phase for instance), use them for filtering and hide them in the printed version.

We normally use the custom Rebar Number parameter for filtering, and work with numbering sequences. For instance Plan 1 reinforcement is identified between the numbers 100 and 199, Plan 2 from 200 to 299, etc.

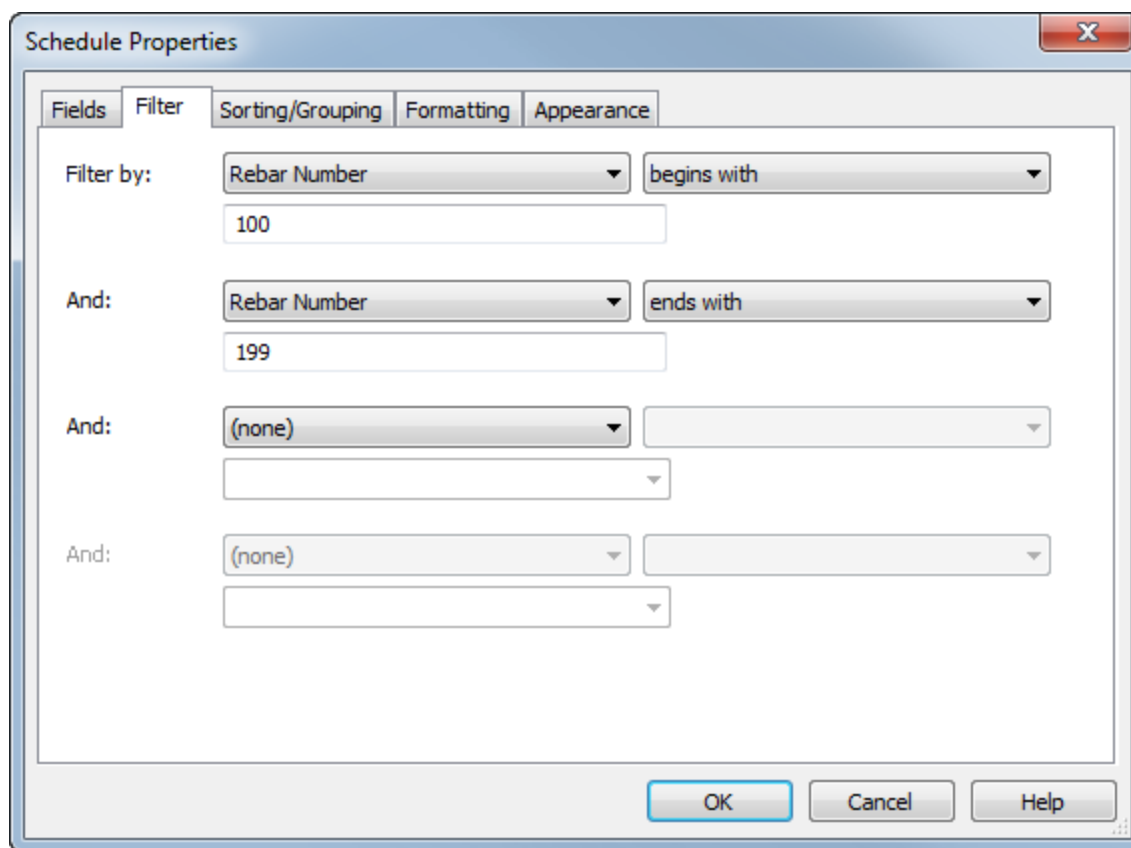


Figure 45: Filter settings using Rebar Number

5.3 Lap Splices and Total Lengths

You may have noticed the “LM” Shape code in the line of Rebar Number 105 in the Rebar Schedule above. In the section on Structural Area Reinforcement I touched the issue with Lap Splices gently. In this section we will dig into the details of how I manipulate Rebar Schedules to automatically calculate these additions for very particular Rebar Shapes.

To start with the desired end product, we want all Rebar Shapes to be part of the same Rebar Schedule. We also want the LM-bars to add one lap splice for each maximum production length, and add the summary of these to the total length. And we want the regular Rebar Shapes to report all regular parameters.

In obtaining this, we have to start by creating some new parameters. First we make a parameter for Production Length. This is a Rebar Shape dependent parameter, and we set the default value to the maximum lengths of produced reinforcing bars in our region. We add another length parameter used for controlling the length of the bars (the equivalent of ‘a’ in regular bars). I call this parameter LM. Finally I parameterize the Extension Multiplier with a number parameter. This is for changing the constant that lap splices are derived from by multiplying it with Bar Diameter.

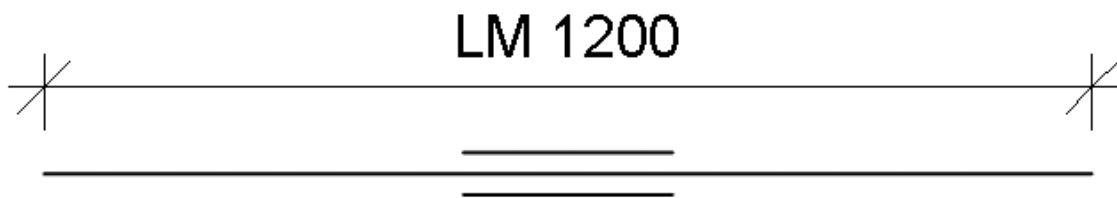
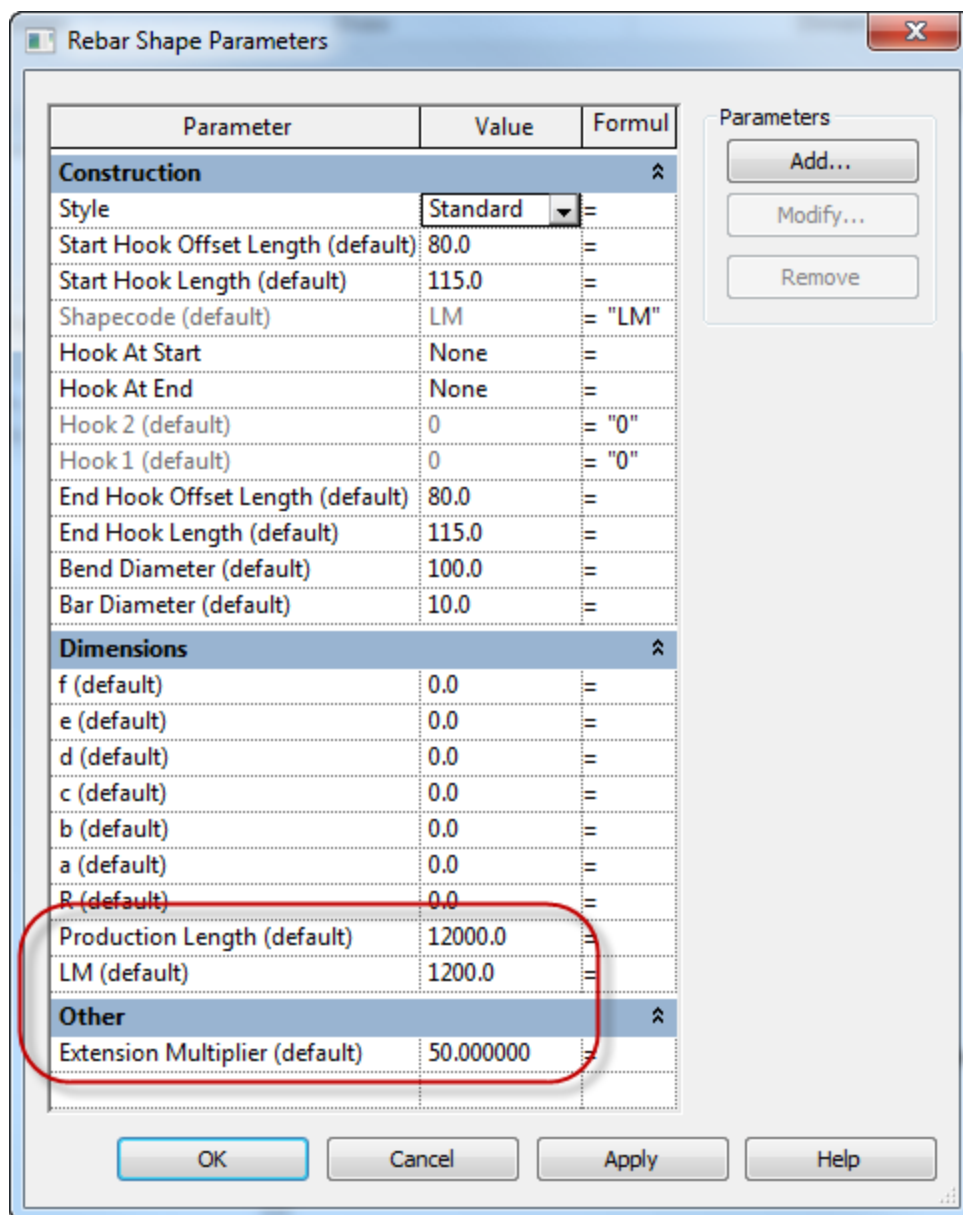


Figure 46: The straight LM-bar is constrained by the label LM



Rebar Shape Parameters

Parameter	Value	Formul
Construction		
Style	Standard	=
Start Hook Offset Length (default)	80.0	=
Start Hook Length (default)	115.0	=
Shapecode (default)	LM	= "LM"
Hook At Start	None	=
Hook At End	None	=
Hook 2 (default)	0	= "0"
Hook 1 (default)	0	= "0"
End Hook Offset Length (default)	80.0	=
End Hook Length (default)	115.0	=
Bend Diameter (default)	100.0	=
Bar Diameter (default)	10.0	=
Dimensions		
f (default)	0.0	=
e (default)	0.0	=
d (default)	0.0	=
c (default)	0.0	=
b (default)	0.0	=
a (default)	0.0	=
R (default)	0.0	=
Production Length (default)	12000.0	=
LM (default)	1200.0	=
Other		
Extension Multiplier (default)	50.000000	=

Parameters: Add..., Modify..., Remove

OK Cancel Apply Help

Figure 47: LM (lap splice) bar rebar shape parameters

Moving back to the schedules, we hide the default parameters Bar Length, Quantity and Total Bar Length. We add the parameters Production Length, LM and Extension Multiplier, but hide these as well.

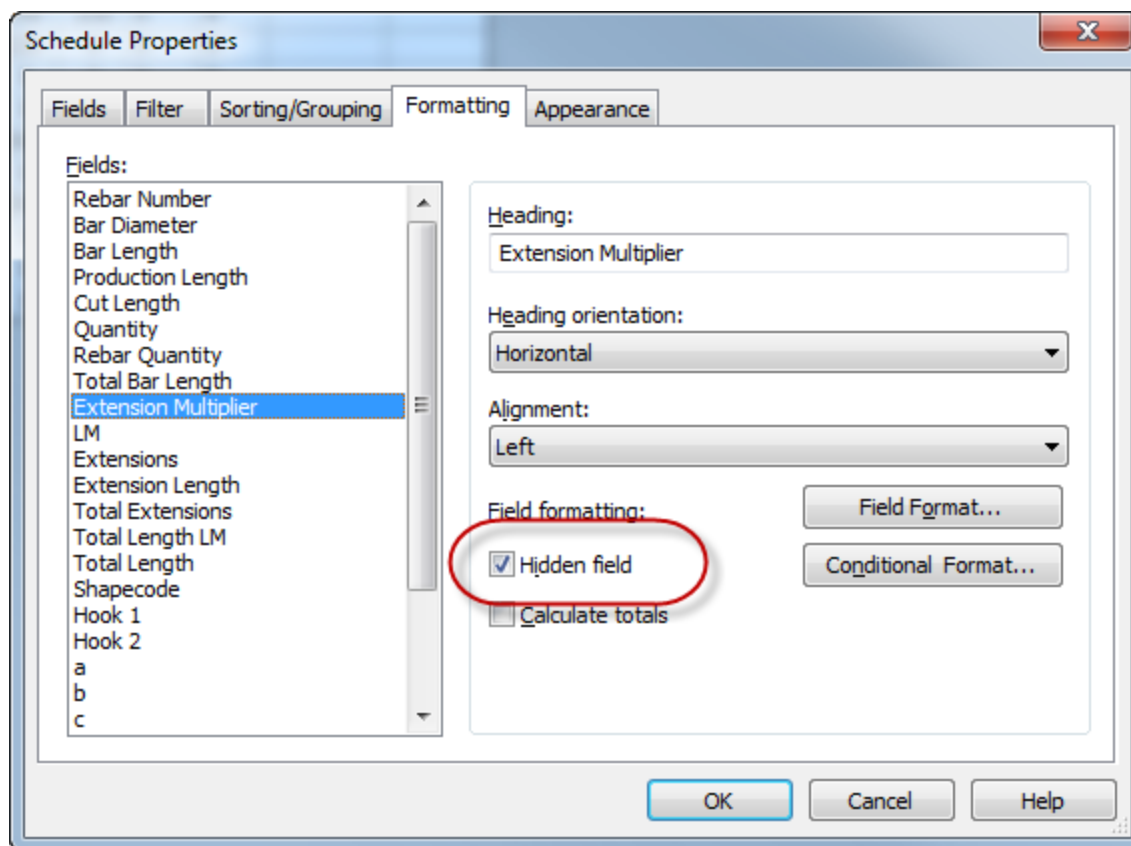


Figure 48: Hide the fields used for calculation and not presentation

Then we start adding some Calculated Values to display the information we want. The key here is to differentiate between the regular bars and the LM (lap splice) bars. This we can do by introducing a couple of formula expressions:

- Cut Length = if(and(a = 0 mm, R = 0 mm), Production Length, Bar Length)

Here, if 'a' and 'R' both equals 0 mm, the rebar in question is a LM bar. And if that is the case, use Production Length. If not, use Bar Length. Let's add some more:

- Rebar Quantity = if(and(a = 0 mm, R = 0 mm), 0, Quantity)

This will zero out the quantity column for LM bars. Remember, using these bars we only document the total length, not quantity and bar length.

- Extensions = if(LM > Production Length, ((LM / Production Length) - 0.500001), 0)

This will give us the numbers of lap splices for a single rebar distribution.

- $\text{Extension Length} = \text{Bar Diameter} * \text{Extension Multiplier}$

This Formula will provide the lap splice length of a single rebar distribution (one bar).

- $\text{Total Extensions} = \text{Quantity} * \text{Extensions}$

This calculates the total amount of extensions in a rebar distribution (all bars).

- $\text{Total Length LM} = \text{LM} * \text{Quantity} + (\text{Extension Length} * \text{Total Extensions})$

Here we derive the total length, including all lap splices, of all LM bars.

- $\text{Total Length} = \text{if}(\text{and}(a = 0 \text{ mm}, R = 0 \text{ mm}), \text{Total Length LM}, \text{Total Bar Length})$

And last, if we have an LM bar, please use the Total Length LM Calculated Value. If not, then go for the out-of-the-box Total Bar Length.

I've included this nerd festival to show that there are some manipulations you can do with schedules and the values that they display. If you should decide to venture into this, please make sure that you get *everything* right, because it kind of sucks if you forget one operator and that leads to a building lacking reinforcement. In the first version of our Rebar Schedules in Revit I forgot to use the $\text{Total Extensions} = \text{Quantity} * \text{Extensions}$ formula. That led to the contractor ordering less reinforcement than they really needed, and I having to explain that there "is something wrong with our software". Sorry Autodesk.

One essential aspect of working in a database like Revit is that there is a bi-directional link between different presentations of the same data. This can be very helpful when working with reinforcement, especially when you can play around with schedules. Let's have a quick look at working schedules.

5.4 Working Schedules

This is what I call a schedule in Revit that will not be used for documentation. I always name these Working <something>, for instance Working Rebar Schedule, and I use them actively all the time for model quality assurance.

Create these by duplicating your printed Rebar Schedule. This way you get all the nasty formulas for free.

Tweak around with Sorting/Grouping and Itemize every instance to display model information in the most appropriate way for the task you want to perform.

This can be helpful when correcting small bar segment length differences, numbering purposes, temporary deactivating filters, and so on. One example that I use all the time is to Sort by Cut Length. That is a pretty good way of determining if your Rebar Numbers are okay.

Rebar Number	Bar Diameter	Cut Length	Rebar Quantity	Total Length	Shape code	Hooks		a	b	c	d	e	f	R	Rebar Comments	Rebar Revision
108	32	1130	16	18	00	0	0	1130	0	0	0	0	0	0		
100	16	1351	27	36	21	0	0	600	217	600	0	0	0	0		
101	16	1364	10	14	21	0	0	600	230	600	0	0	0	0		
102	16	1617	9	15	21	3	3	569	230	569	0	0	0	0		
103	16	1617	11	18	41	0	0	230	530	230	530	230	0	0		
109	32	2454	13	28	46	0	0	400	399	600	203	400	0	0		
		2330	5	12	00	0	0	2330	0	0	0	0	0	0		
107	25	2678	13	35	41	0	0	530	680	530	680	530	0	0		
111	32	2930	8	23	00	0	0	2930	0	0	0	0	0	0		
104	16	3170	11	35	63	0	0	220	830	220	220	0	0	0		
112	32	3221	9	29	75	0	0	465	400	0	0	0	0	0		
105	25	12000	0	191	LM	0	0	0	0	0	0	0	0	0		

Figure 49: Working Rebar Schedule sorted by Cut Length

5.5 Totals

You may want to schedule a summary of reinforcement, and provide some indication of the total tonnage required. This can be done quite simple if you already have a Rebar Schedule at hand. Plainly duplicate, hide a bunch of parameters, Sort by Bar Diameter and introduce another Calculated Value that computes the steel weight.

Bar Diameter	Total Length	Weight (kg)
16	210	336
20	131	328
25	231	899
32	106	665
678		2229

Figure 50: Rebar Schedule Totals

In case you use the LM (lap splice) bars, please remember to not delete the parameters and Calculated Values that you have duplicated, as that will mess up your total lengths.

The Calculated Value I use for weight uses constants for steel unit weight. I currently see no other way of doing this, as Structural Rebars aren't available from Material Takeoffs and Material parameters aren't available in Rebar Schedules. The formula looks like this:

- Weight (kg) = (Total Length / 1000 mm) * if(Bar Diameter = 5 mm, 0.2 mm, if(Bar Diameter = 6 mm, 0.2 mm, if(Bar Diameter = 7 mm, 0.3 mm, if(Bar Diameter = 8 mm, 0.4

mm, if(Bar Diameter = 10 mm, 0.6 mm, if(Bar Diameter = 12 mm, 0.9 mm, if(Bar Diameter = 14 mm, 1.2 mm, if(Bar Diameter = 16 mm, 1.6 mm, if(Bar Diameter = 20 mm, 2.5 mm, if(Bar Diameter = 25 mm, 3.9 mm, if(Bar Diameter = 32 mm, 6.3 mm, if(Bar Diameter = 40 mm, 9.9 mm, 0 mm)))))))))))))

The people who are still awake will notice that there is something strange here. The weight unit type is Length and Millimeters. Therefore I include (kg) in the Calculated Value name and make sure no Unit Symbol is used.

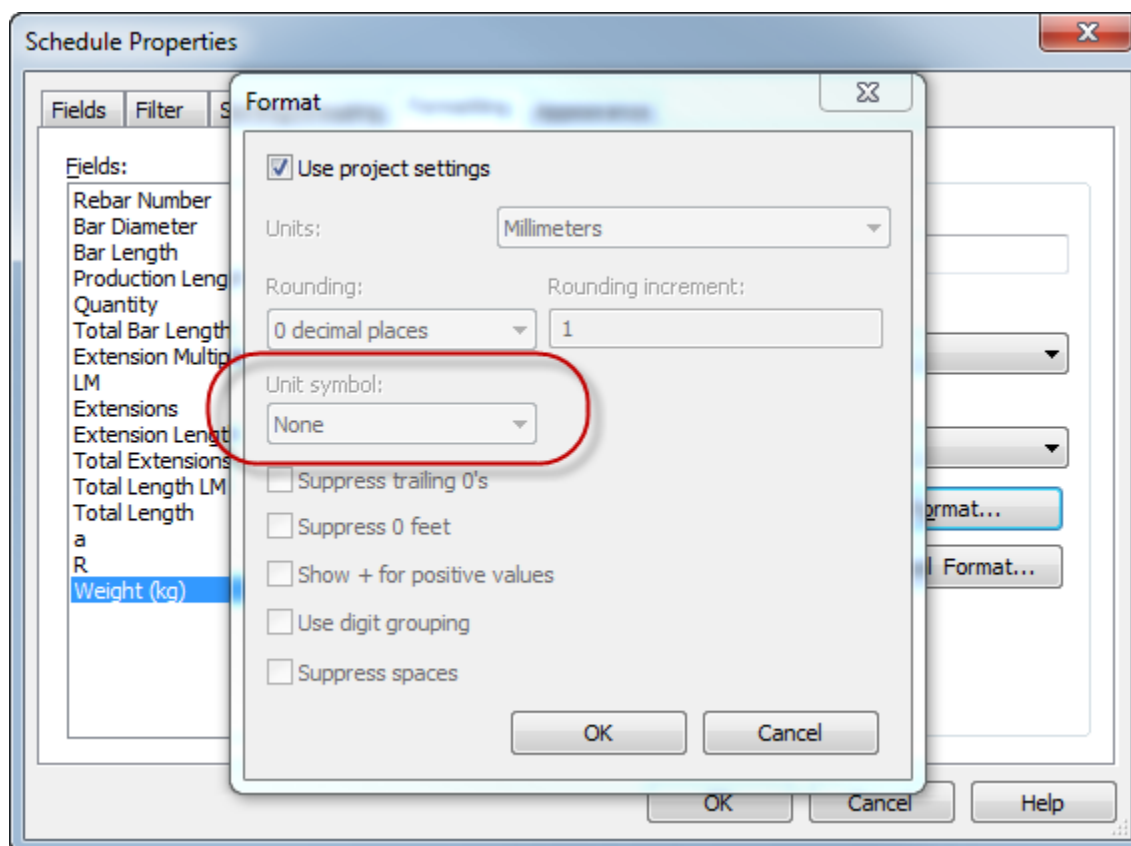


Figure 51: No automatic Unit symbol for tonnage please

5.6 Wire Fabric Reinforcement Schedules

Wire Fabric Reinforcement Schedules are *much* simpler than Structural Rebar Schedules. The only small challenge really is calculating the Total Cut Area, but after what we've done in the previous section this should be a walk in the park.

Instead of making new parameters for numbering, comments and revisions use the ones you've made for Structural Rebars by adding the Structural Fabric Reinforcement category to the parameters.

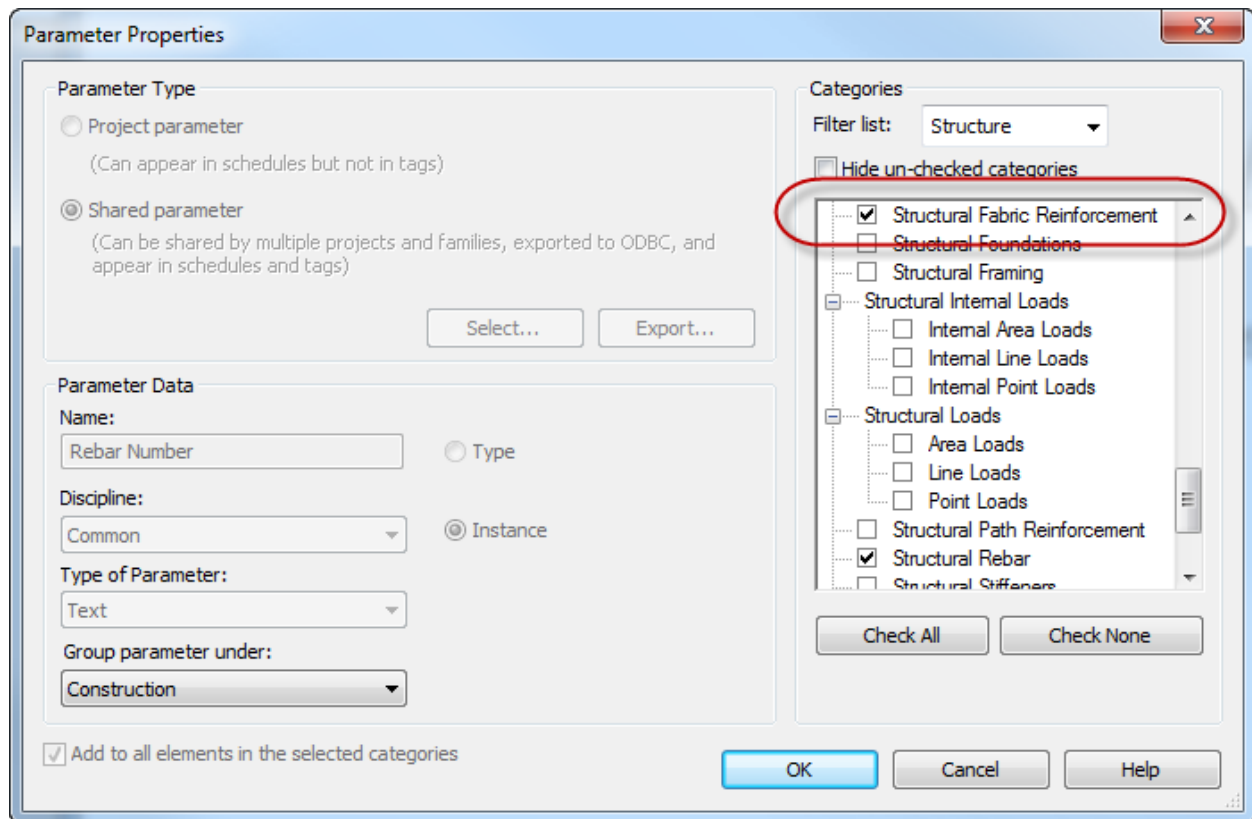


Figure 52: Rebar Number Parameter Properties

After that we'll go ahead and add all the proper parameters and the Calculated Value for Total Cut Area:

- Total Cut Area = Cut Sheet Mass / Sheet Mass per Unit Area

Hide Sheet Mass per Unit Area and Cut Sheet Mass, and change the Unit symbol to m^2 and you are all set.

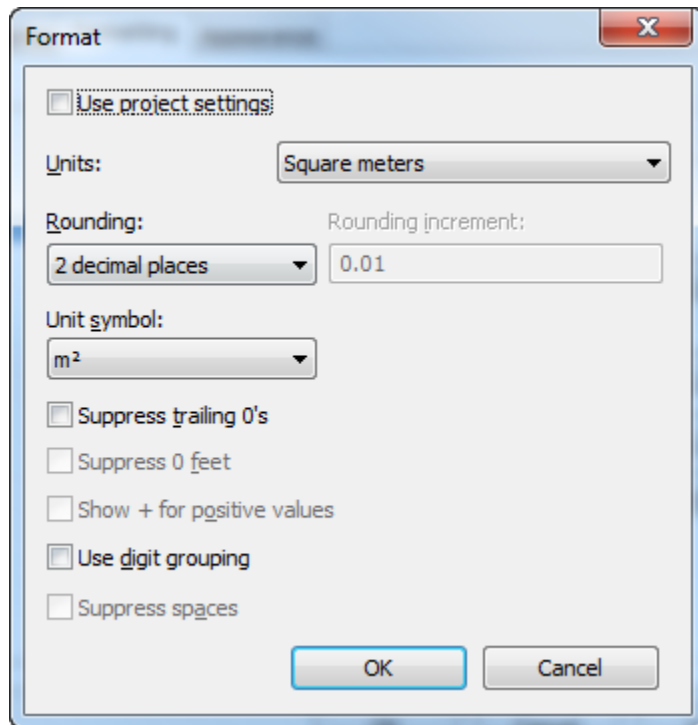


Figure 53: Total Cut Area Unit symbol

Rebar Number	Type	Total Cut Area	Rebar Comments	Rebar Revision
1	K402 (2x5m)	52.86 m²		
		52.86 m²		

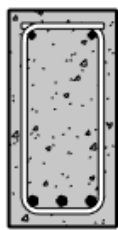
Figure 54: Finished Structural Fabric Reinforcement Schedule

This, of course, is adequate if you are not responsible for the wire fabric details. If the contracts require that you detail every Fabric Sheet, just change the numbering policy and Sorting/Grouping.

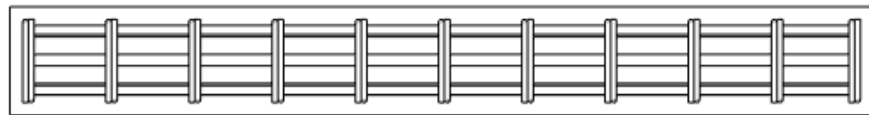
That concludes the section on Schedules. It's time we move on within the realm of documentation to the fabled drawings.

6 Drawings

As with schedules, drawings are nearing the end of their existence as the *main* communication and documentation tool. Right now the contractors on the biggest BIM project in Norway are trying to construct all reinforced concrete from IFC models exported from Tekla Structures. No reinforcement drawings. No hieroglyphs. And it seems to work. Some of us, however, still need to produce drawings for a living and in doing so we often have to handle one good and one bad item.



Section



Plan

Figure 55: The good and the bad drawing item

In 2D there are mainly two ways of viewing reinforcement; section and plan. Or, more precisely; cut through the reinforcement and viewed from above.

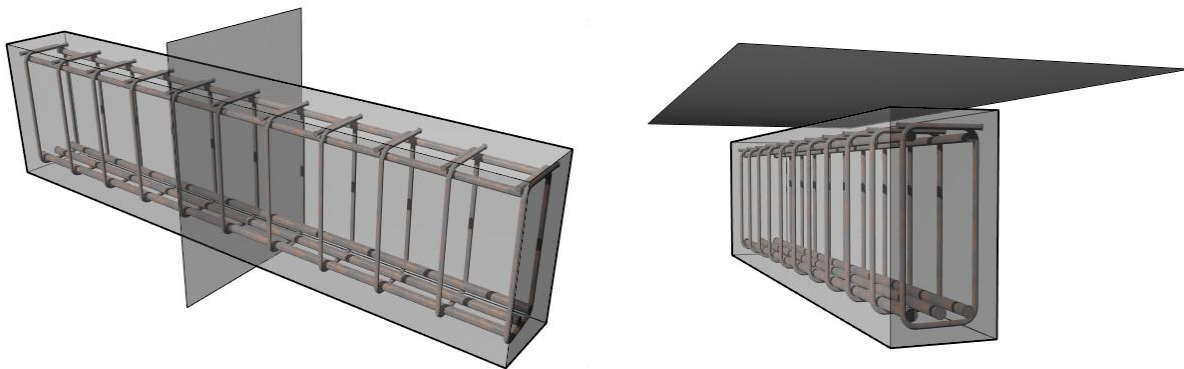


Figure 56: View plane section and plan

The reason for this is simple. In sections the amount of information is very limited compared to plans, and we can show the geometry as it is. In plan views (and elevations) the amount is overwhelming, and we have to rely on symbolic representation (hieroglyphs) for anyone to understand. (The irony.) This is particularly true for walls and slabs, not so much for columns, beams, foundations, etc.

Right now Revit does not have very efficient tools for representing distributed rebar sets symbolically viewed from above. We have the symbolic families of Area and Path Reinforcement, but they come short in many situations, especially in Europe.

This may very well change in the future, but then again; how much CAD do we really want to force into our BIM tools? Let's get back to that in the section on Going Forward.

Until CAD become irrelevant enters the museums, we need some tools for making drawings as efficiently as possible. Let's have a look at the good guys first.

6.1 Sections

Plain and simple, vertical sections with Fine Detail Level will represent your reinforcement design perfectly as it is going to look in reality. We often make 1:20 or 1:50 detail sections along interesting lines on a level and as many as possible because these are the good guys.

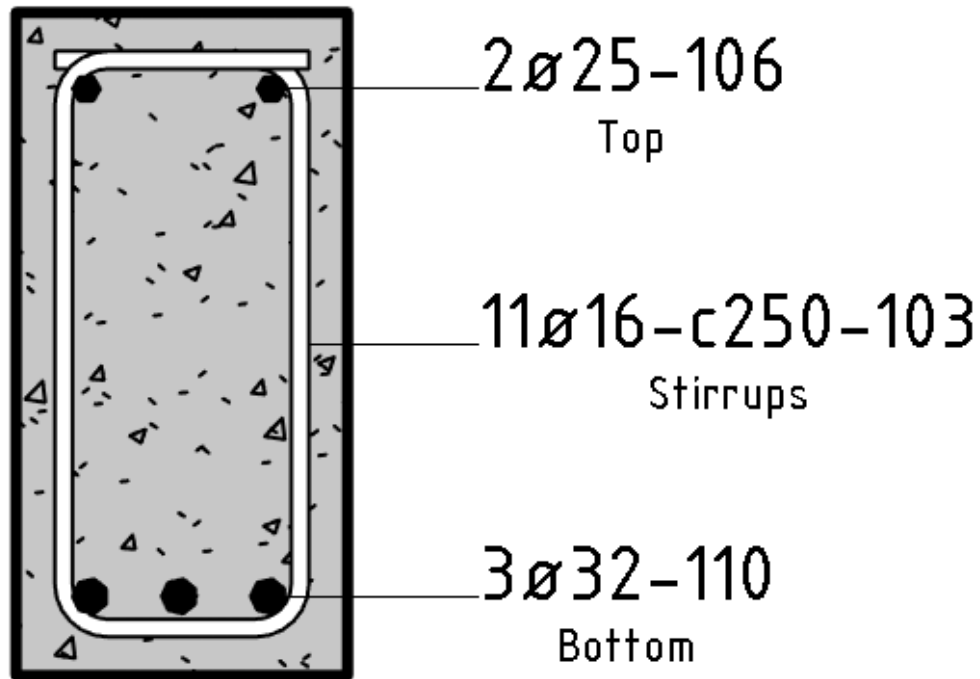


Figure 57: Reinforcement section

We need to make a few Rebar Tags for different purposes. This is pretty straight forward; just make sure you add the same Shared Parameters that you used in the Rebar Shape families and Project Parameters.

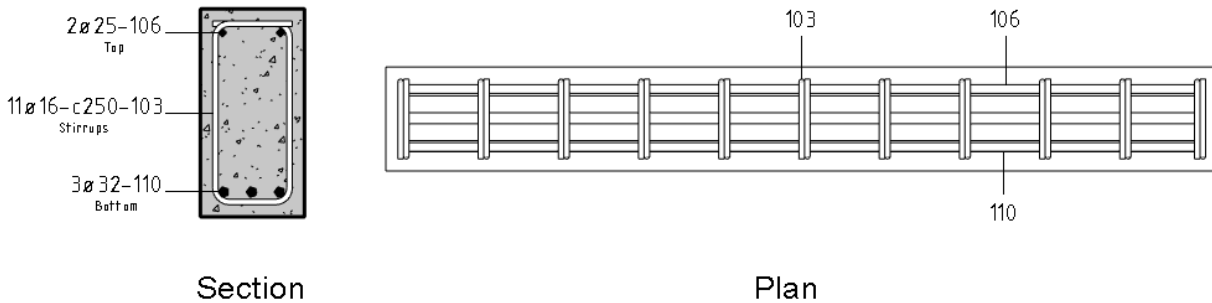


Figure 58: Different tags for different views

There are a couple of potential situations where it can be difficult to exactly see the ends of each bar, because they lie behind each other. Some people add Annotation Symbols manually to these bar ends, but I think you shouldn't bother. As long as you place the Rebar Tag in the most natural position and the shape code and bar segment lengths is well represented in the rebar schedule, it all should be fairly clear.

Now, inevitably, we need to move on to the bad guys.

6.2 Plans and Elevations

As Revit cannot annotate Structural Rebar sets with Symbols, as Area, Path and Fabric Reinforcement can, we need to draw the symbols manually.

First, we need some Detail Items with hosted Annotation Symbols to represent the actual bars. This because we want the end symbols to change size with View Scale, but not the length of the rebar lines. Depending on your national drawings standards this can be done quite simple with one family and parameters for start and end symbols.

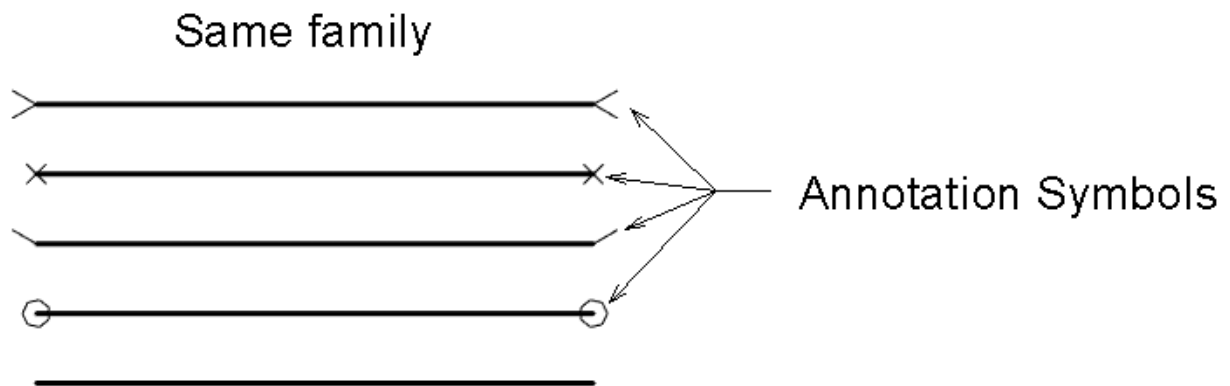


Figure 59: Rebar line detail item examples

We try to tag all rebar sets, but that requires that the rebars are visible in view but obscured by the concrete form. It's time we have a look at Structural Rebar View Visibility States.

View Visibility States is a hard-coded property (instance parameter) of all Structural Rebars. It controls the visibility of rebars per view, and looks like this:

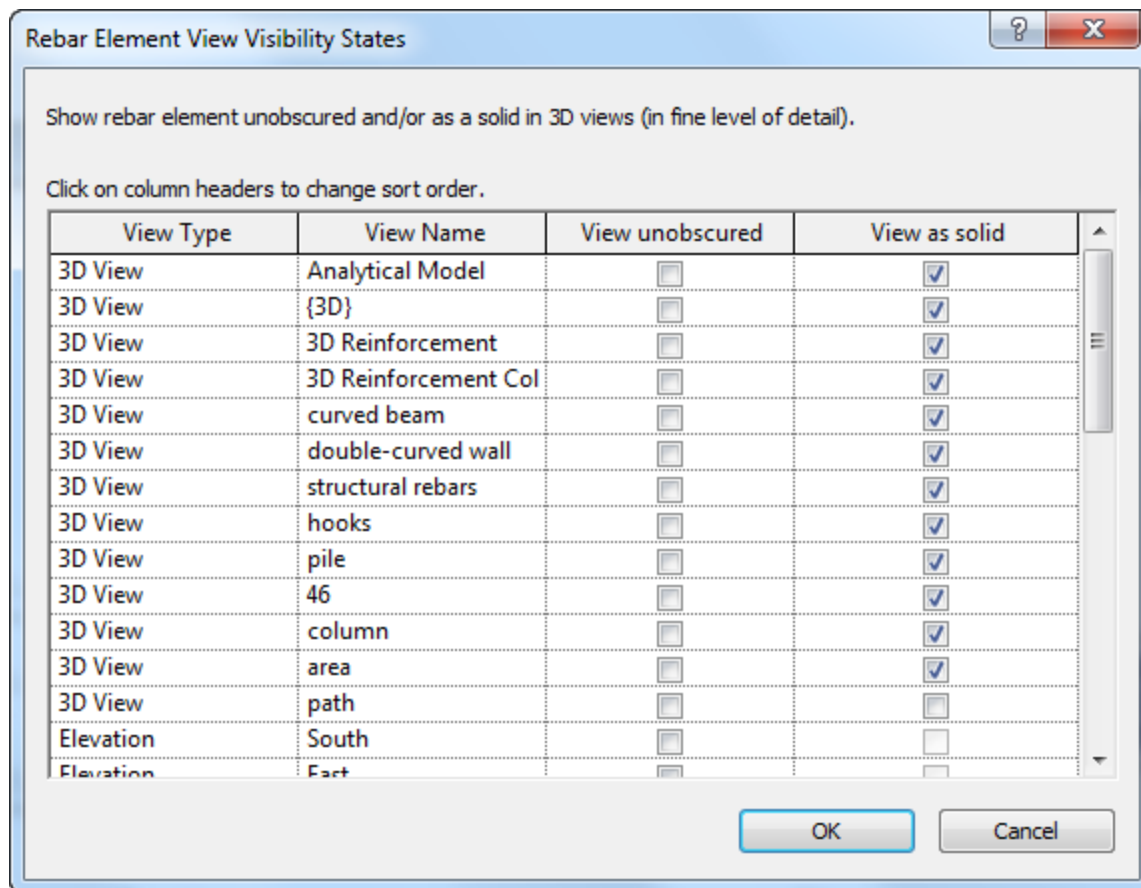


Figure 60: Structural Rebar View Visibility States

This is a kind of annoying property, as changes you make here has to be made again for new rebars. Also, this does not work very well across linked Revit files. It does, however, provide us with the opportunity to control if a bar is shown through formwork or not. Using this for plan and elevations drawings, make sure View unobscured is *not* checked in the appropriate views and you'll be able to tag the rebars without hiding them.

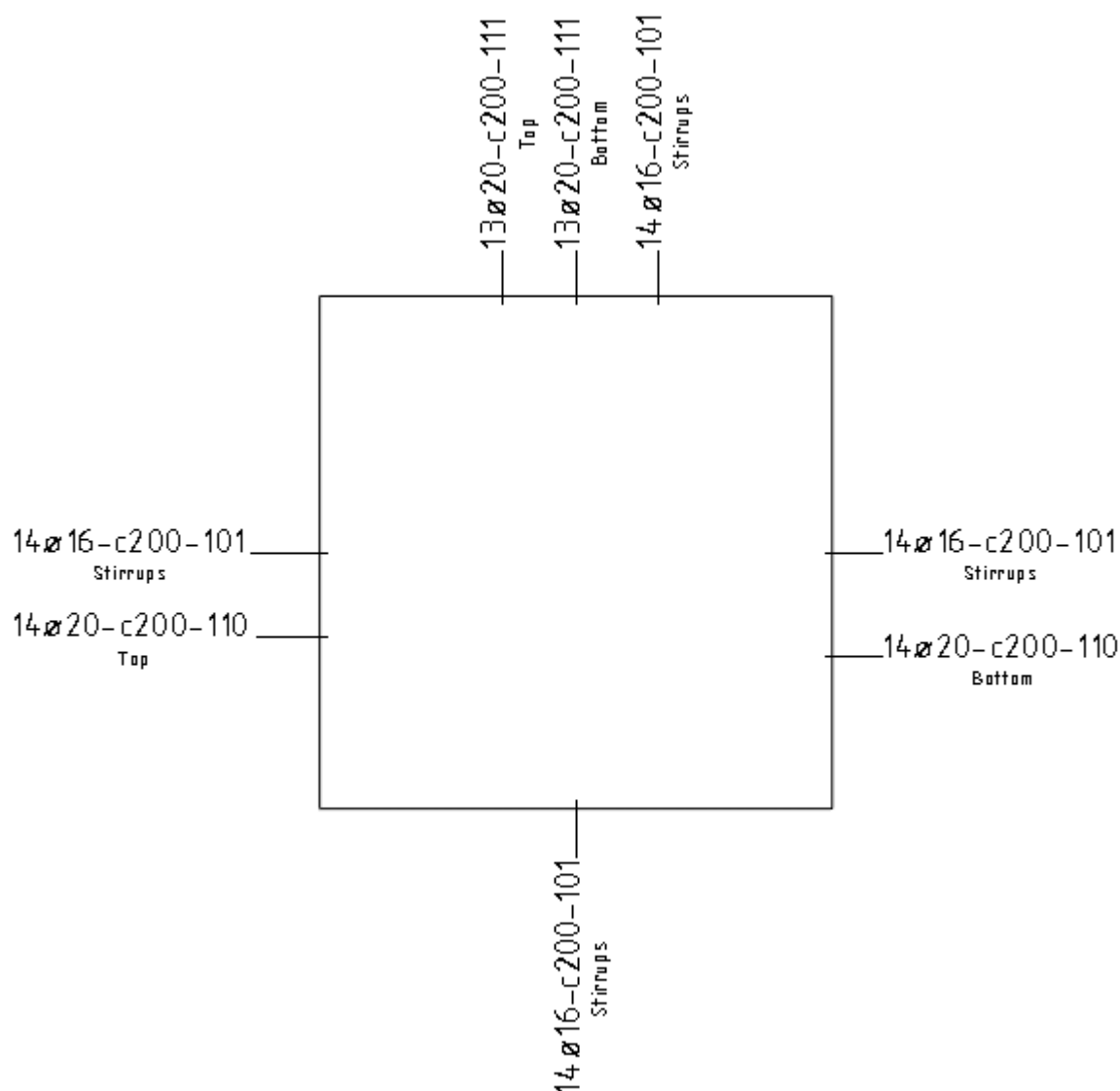


Figure 61: Tagged Structural Rebars in plan view

Tip: I regularly select all Structural Rebars in the entire project and check the View as solid checkboxes for all 3D views. For some reason that setting is not defaulted, resulting in rebars showing as lines rather than solids even though I use Fine Detail Level in 3D views. If you rather want the rebars to show as lines, simply change to Medium Detail Level.

Adding the some Detail Items for distribution lines, in addition to the rebar lines, the end product can look like this:

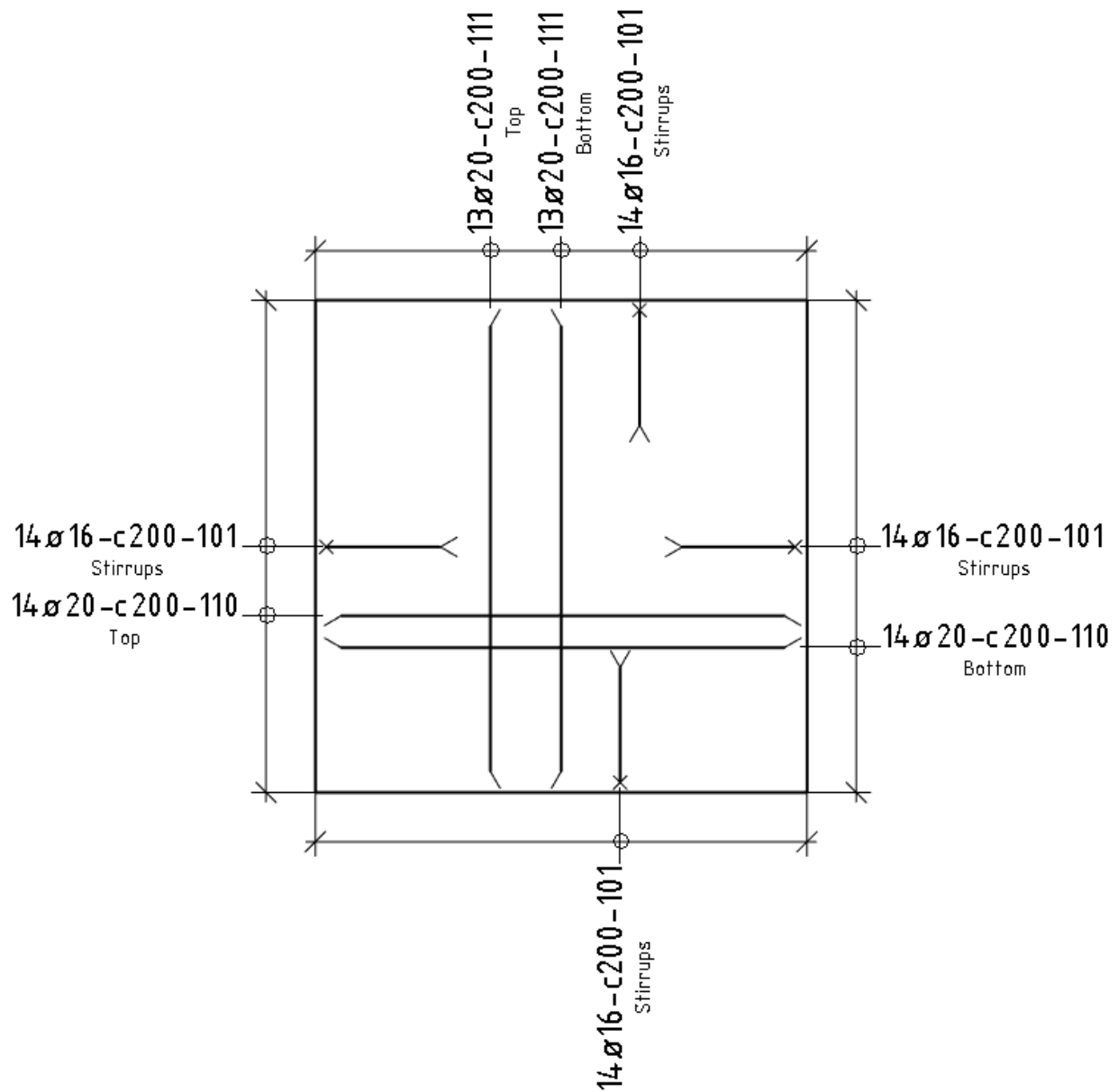


Figure 62: Reinforcement plan drawing according to Northern European standards

This corresponds pretty well with the CAD that our clients and contractors expect in Northern Europe.

Let's get into some further tips that can make our drawing production run smoother.

6.3 View Templates

After Revit 2013 was introduced the use of View Templates in our projects has taken an even more significant role than before. We can now control almost every aspect of View Properties retroactively, meaning automatically *after* the views have been created. This allows for some pretty good control and quality assurance, and also lets us differentiate reinforcement drawings quite effectively from other drawings.

We basically set up three or four different View Types; Reinforcement Plan, Reinforcement Callout, Reinforcement Elevation and Reinforcement Section, and equip these with corresponding View Templates and a Sub-Category parameter that distinguishes them from other drawing types.

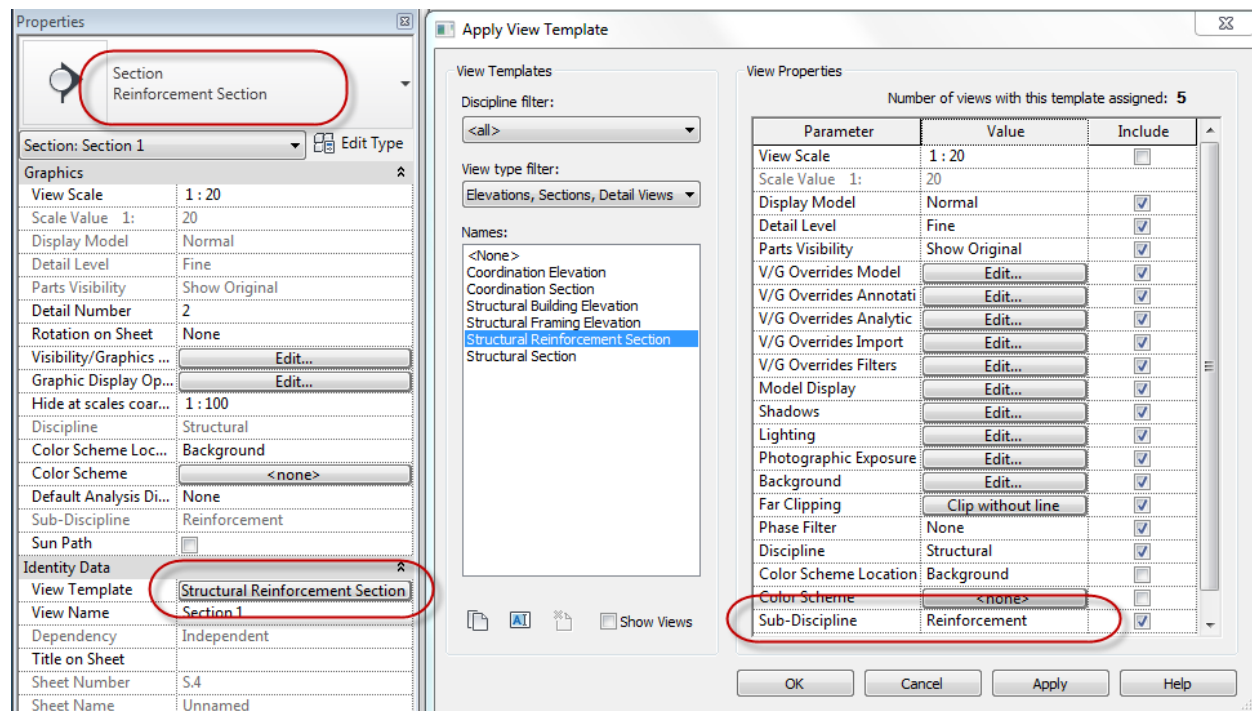


Figure 63: The connection between View Types, View Templates and Sub-Disciplines

A typical scenario where this distinguishing is needed is when we only show Reinforcement Callouts, Elevations and Sections on Reinforcement Plans, and vice versa (as opposed to showing all sections on all plans). For this we use the before mentioned View Templates and a View Filter.

6.4 Filters

In the Reinforcement View Templates we add a Filter that hides all view references (Callouts, Elevations and Sections) that does not have Sub-Category parameter value 'Reinforcement'. This is done easiest by creating one Filter that reacts to everything that is *not* reinforcement views, and uncheck this in the View Template settings.

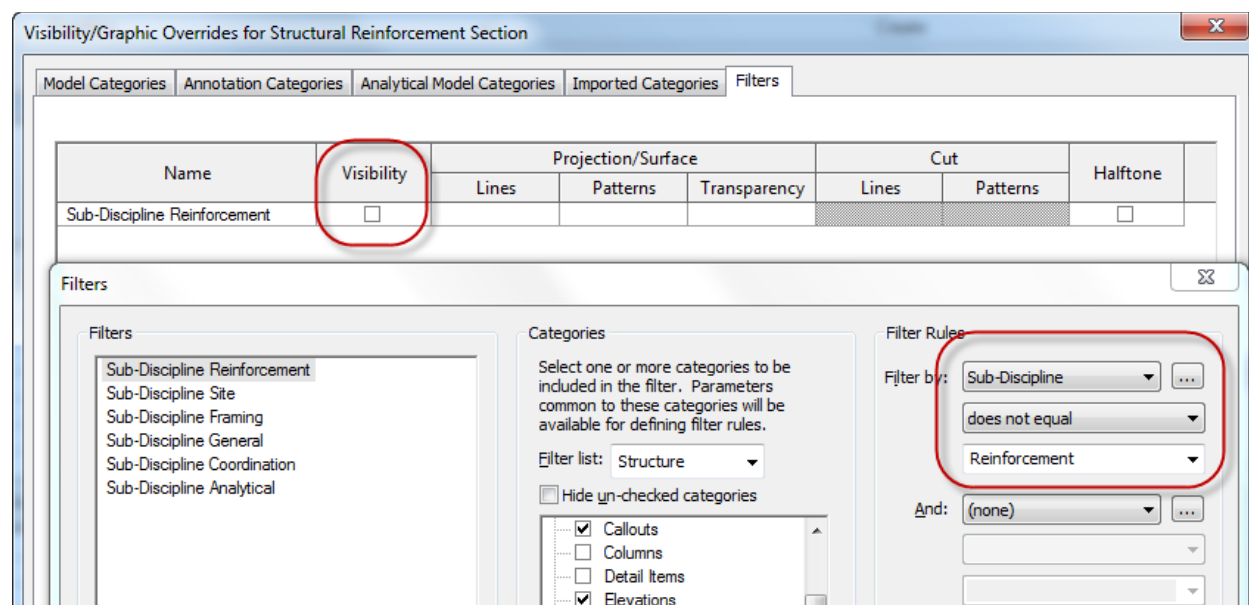


Figure 64: Filter settings for Reinforcement View Templates

Filters can be used to enhance 3D views as well.

6.5 3D Views

All of the perspectives you have seen in this document are screen shots from Revit. I find them illustrative, helpful and beautiful, and they are really easy to create.

As we know, there are two different 3D views in Revit; orthographic views and perspective views. In Autodesk Vasari this can be changes on-the-fly, but in good old Revit this is a one-

time choice you make when creating the view. I always prefer perspectives for presentation. You create these from View – 3D View – Camera.

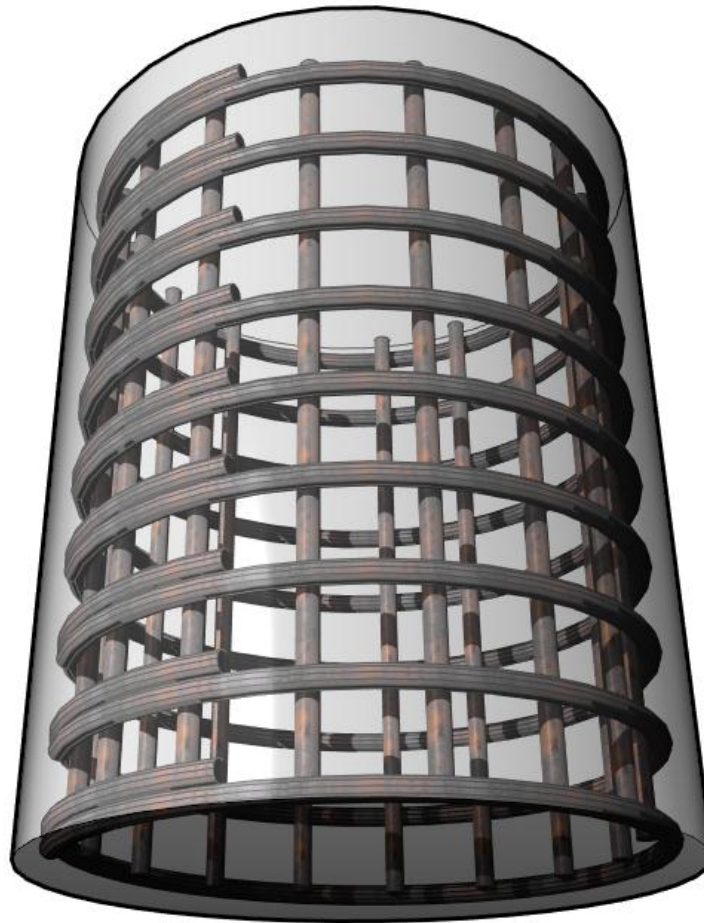


Figure 65: Beautiful perspective of beautiful reinforcement in a beautiful concrete pile

Maneuvering around in a perspective view is slightly different from orthographic 3D views, as you are more or less dependent on using the Full Navigation Wheel (F8). It can also take a short while getting used to the way the actual camera works and moves around.

Now, one thing distinguishes reinforcement from most all other object categories, and that is it is *a/ways* inside something else, preferably concrete. This means we either have to hide concrete elements or make them transparent. This can be done in two different ways, depending on the

way you produce these images. If you want to render the perspectives you need to select a transparent Material Appearance Asset.

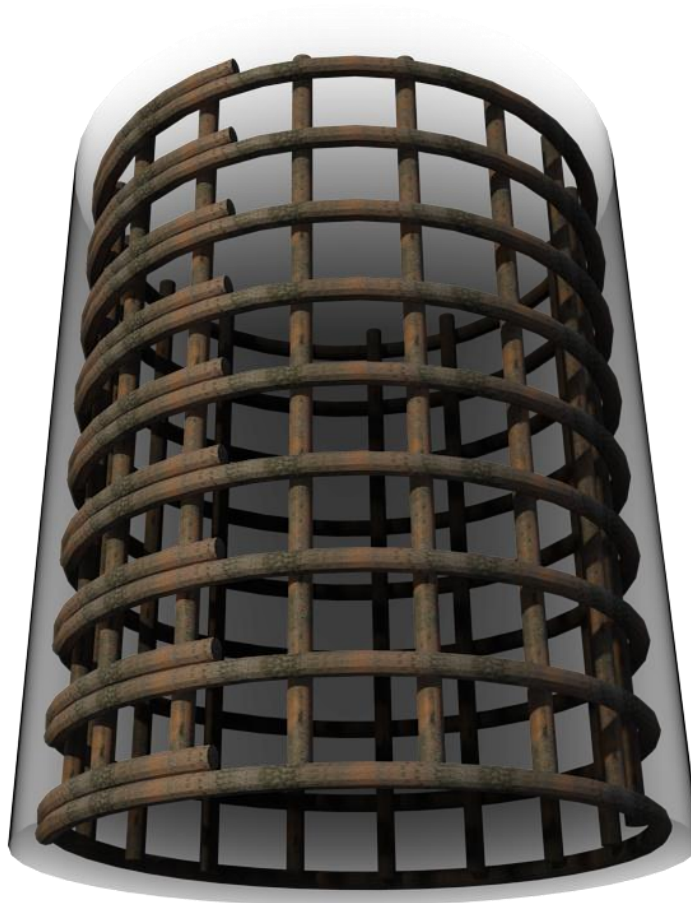


Figure 66: Concrete pile with glass material appearance, Realistic Visual Style

If you want to export an image directly from Revit (or take a screen shot like I do) you can either override transparency in View/Visibility Graphic Overrides or change the transparency of the materials Graphics Asset. Note that this last method only works with Shaded Visual Style.

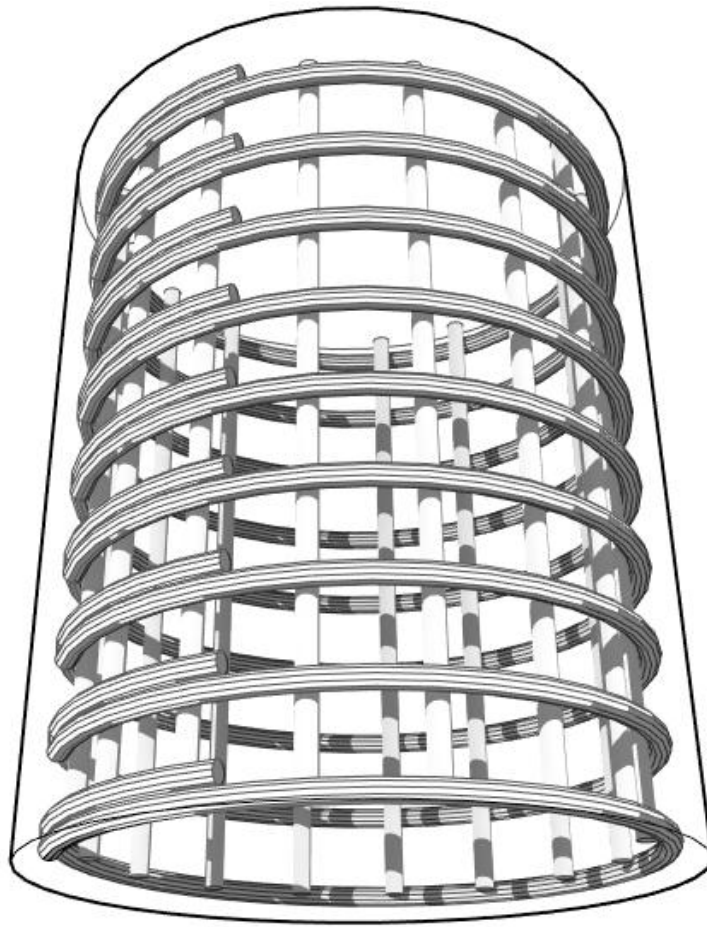


Figure 67: Structural Foundations category transparent, Hidden Line Visual Style

Remember to turn on Cast Shadows and Show Ambient Shadows from the Graphic Display Options.

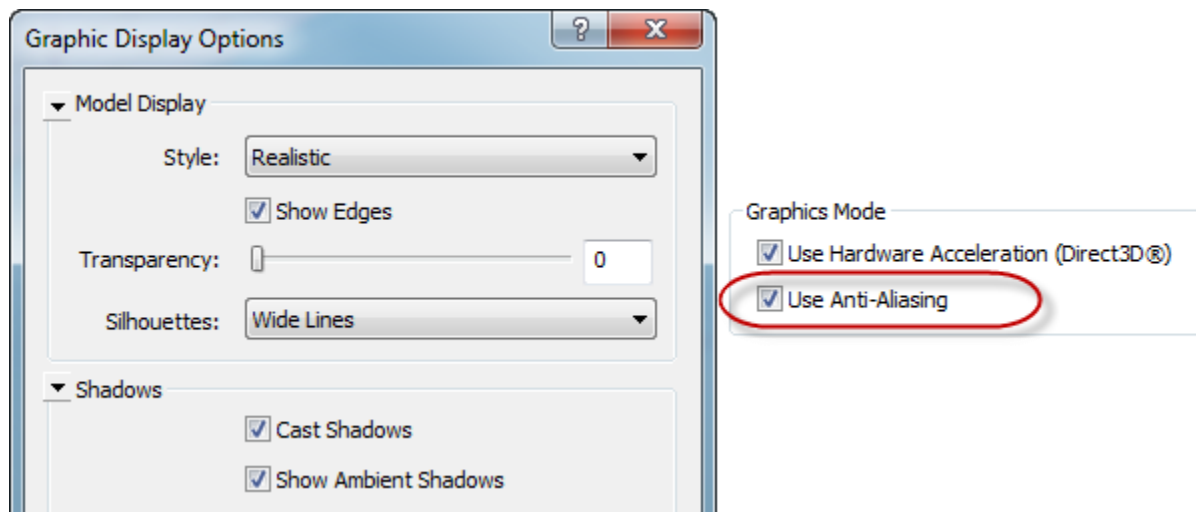


Figure 68: Shadows, Silhouettes and Anti-Aliasing

A hot tip if you are taking screen shots from Revit is to turn on Anti-Aliasing in Options. This will make all slanted lines look smoother. You will also notice that I use Silhouettes with Wide Lines to get a more sketch-like appearance.

In orthographic 3D views it is possible to save the view orientation and tag elements. This can be of great help in complex connection areas.

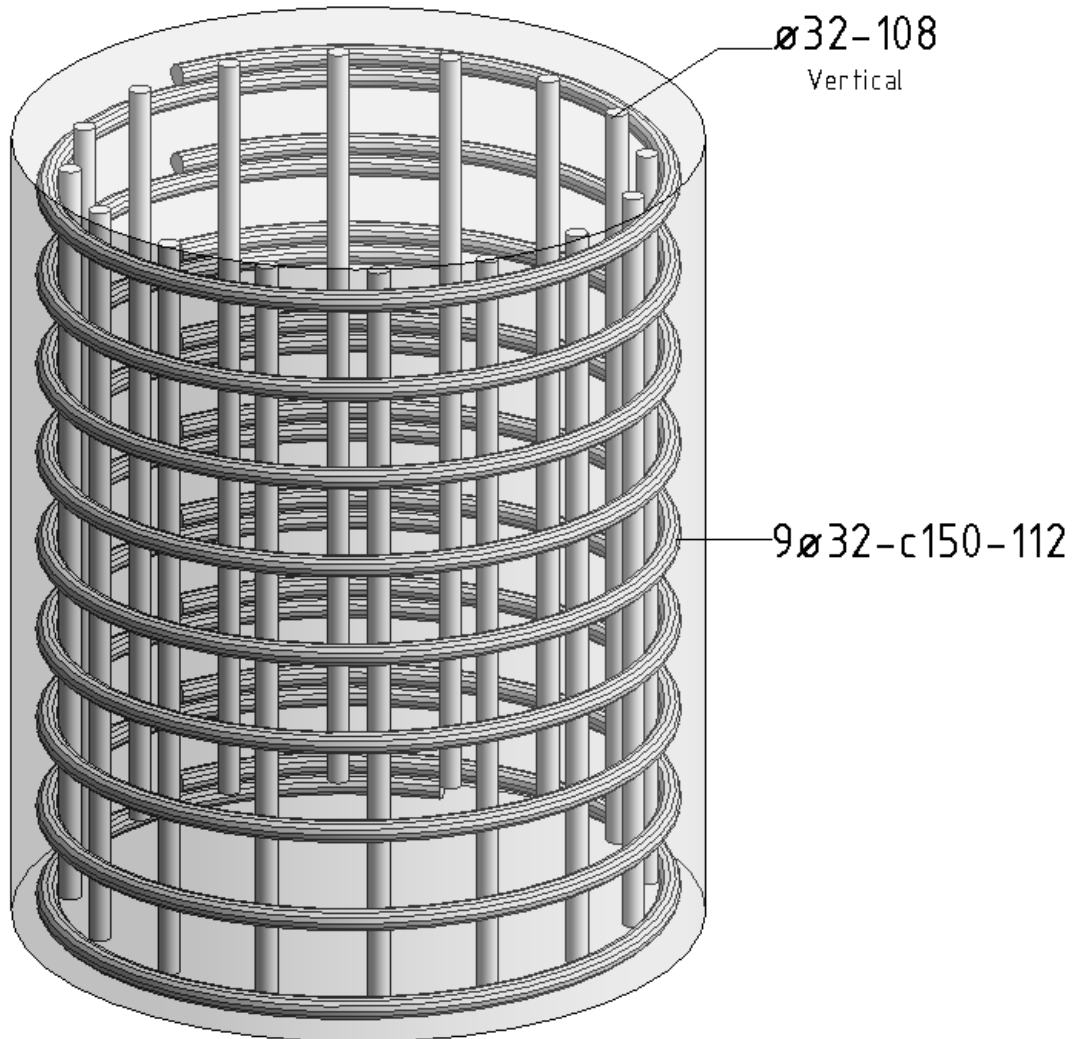


Figure 69: Locked and tagged 3D View

We can also work with Filters in 3D views to differentiate between various Bar Diameters.

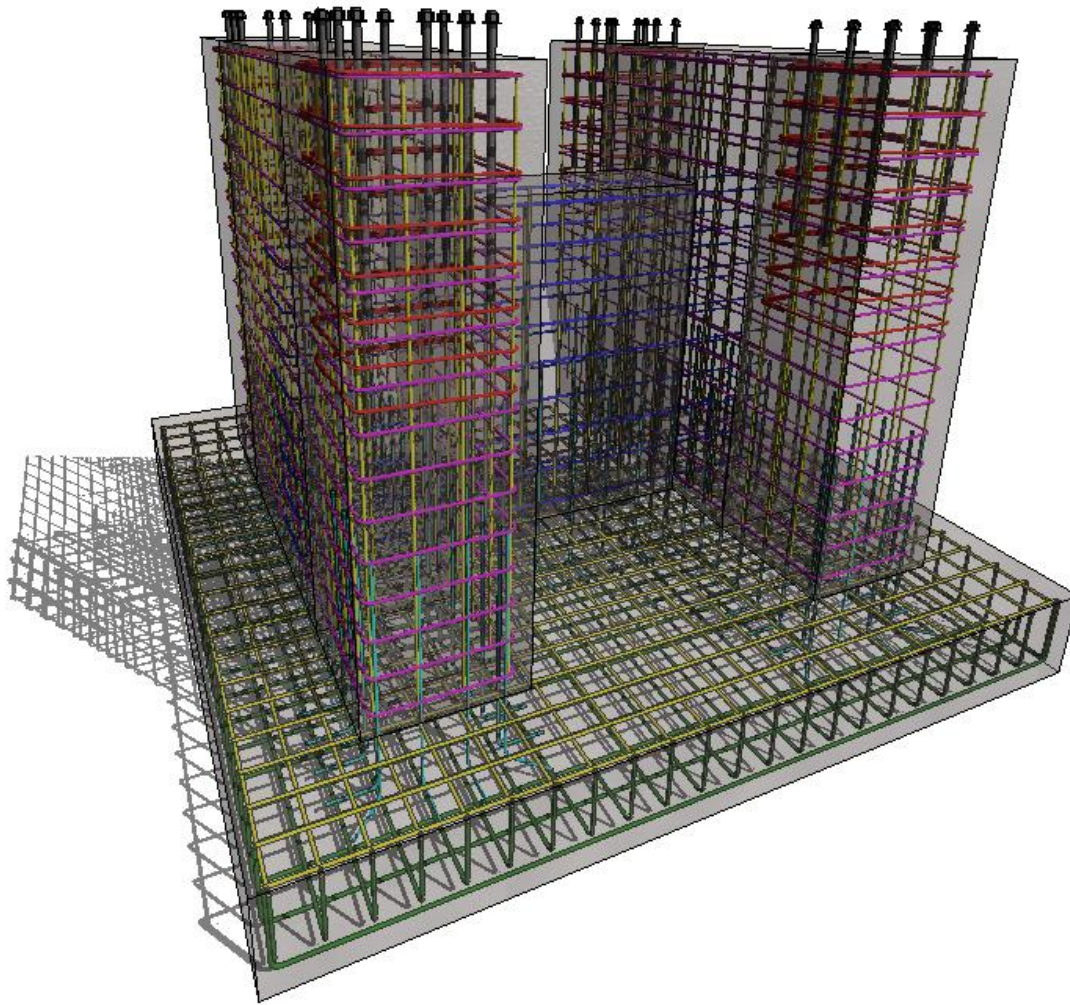


Figure 70: Project example: View Filters as a tool for displaying bar diameter in 3D Views

Last, I use orthographic 3D views constantly, together with schedules, to work with selections and parameters. If something is wrong in the schedule, click in the cell, open a 3D view and use Isolate Elements.

Extending the reach of our 3D reinforcement, it is now time to study what can be done from model export.

7 Model Export

When we are modeling complex 3D models of all reinforcement in our projects, with all relevant information connected to the bars, it only seems natural that these models are the basis for building the structures. In this section we will look at different ways of exporting reinforced concrete models from Revit. Let's head off with one of the most obvious file formats; DWF.

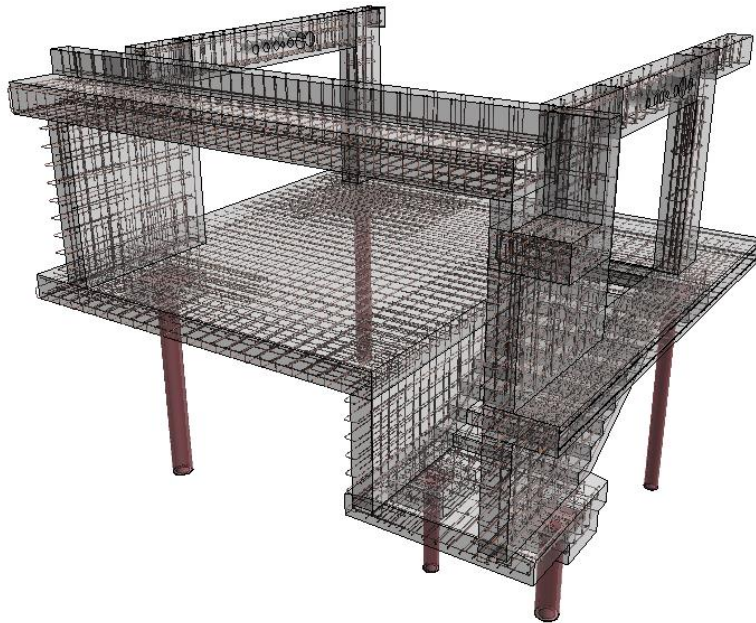


Figure 71: Project example: sectioned part of a basement in reinforced concrete

7.1 Autodesk Design Review and DWF

The free Autodesk Design Review can open any 2D or 3D (or combined) DWF file exported from Revit. All 3D views, with their visibility settings (Filters, Transparency, Visual Style, etc.) can be exported and viewed almost like in Revit. You can use the Section Box tool to minimize the models before exporting.

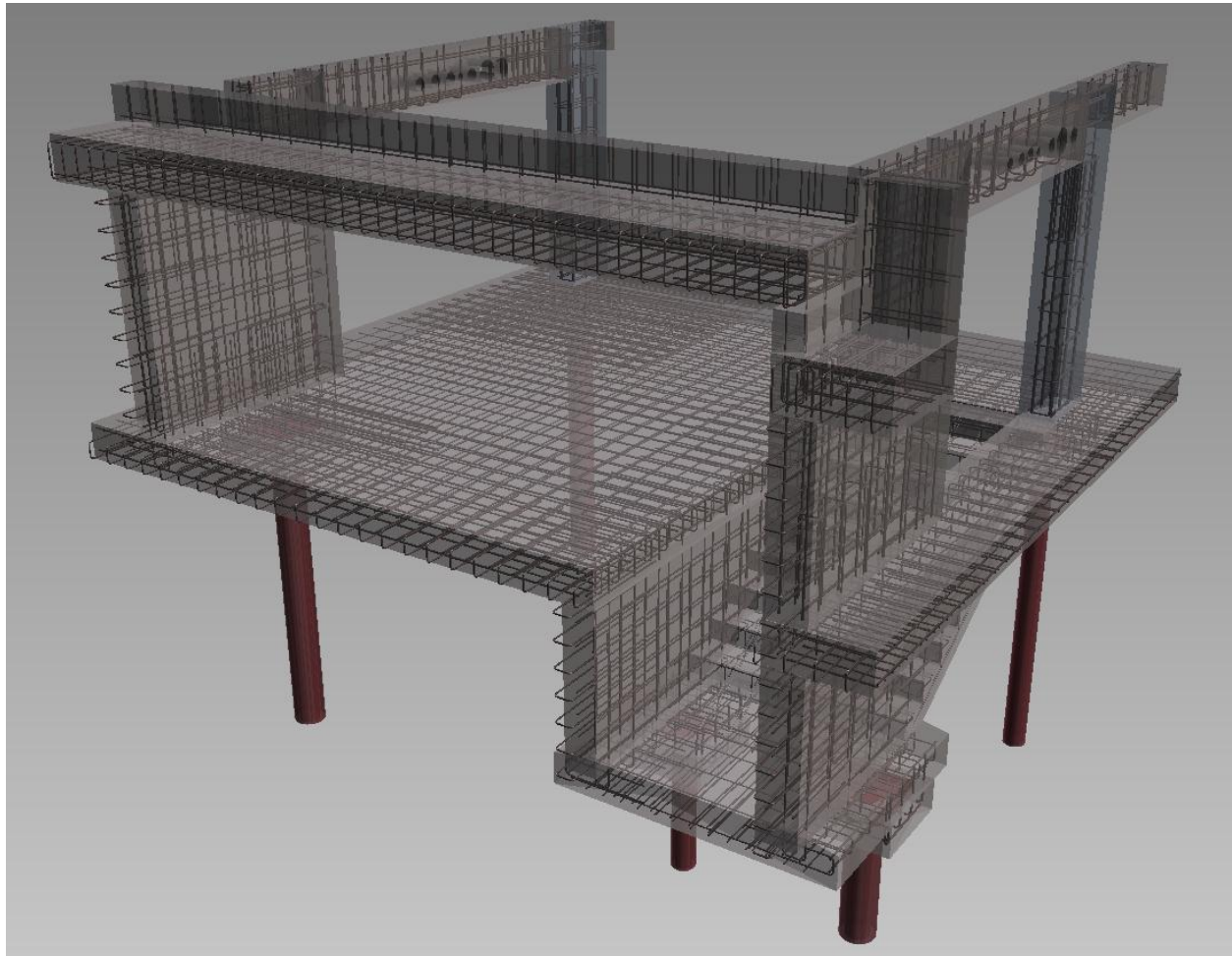


Figure 72: Sectioned and transparent concrete structures exported from Revit, viewed in Autodesk Design Review 2013

A DWF will also contain all object properties. That means people using these files for reinforcement communication can click on each rebar set and review parameters like Rebar Number, Shape code, bar diameter, bar segment lengths, etc.

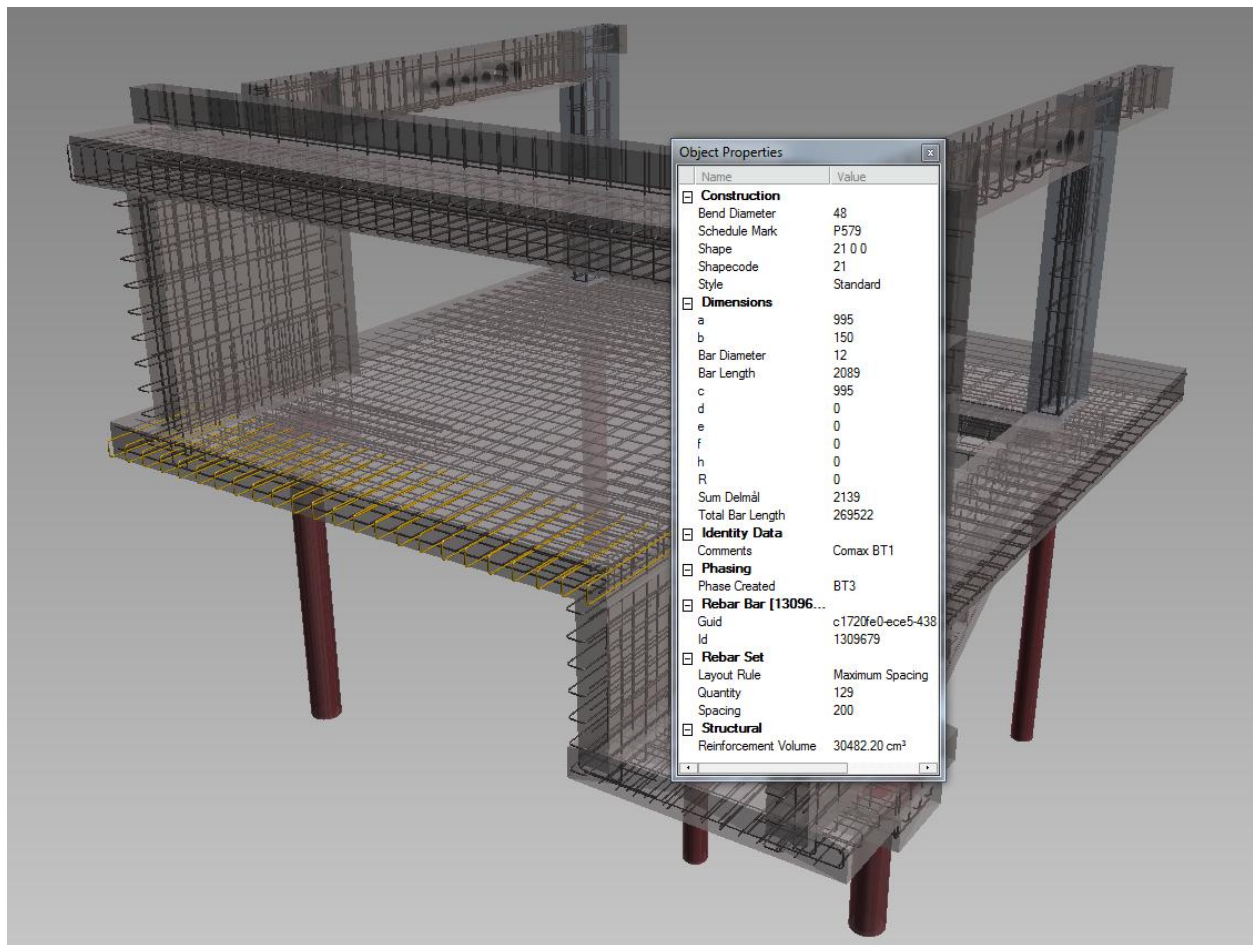


Figure 73: Rebar Set properties in Autodesk Design Review

With the introduction of Autodesk 360 we can upload these DWF's to the cloud and view, review and comment models and drawings using web browsers.

Autodesk® Revit® as a Tool for Modeling Concrete Reinforcement

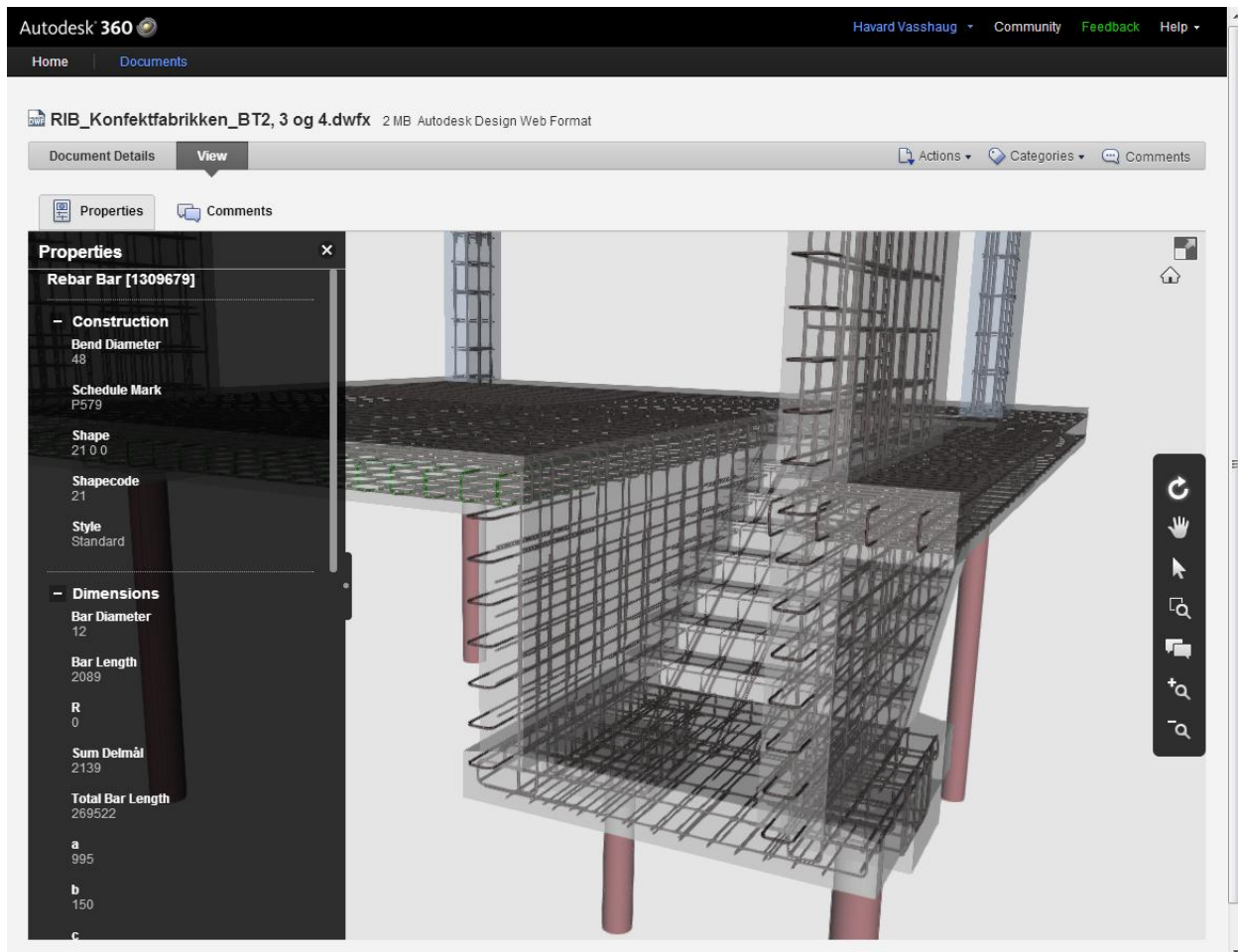


Figure 74: 3D DWF viewed on Autodesk 360 using the Google Chrome web browser

When a model has been uploaded to Autodesk 360 it also can be viewed on mobile tablets and smartphones, like the iPad or iPhone.

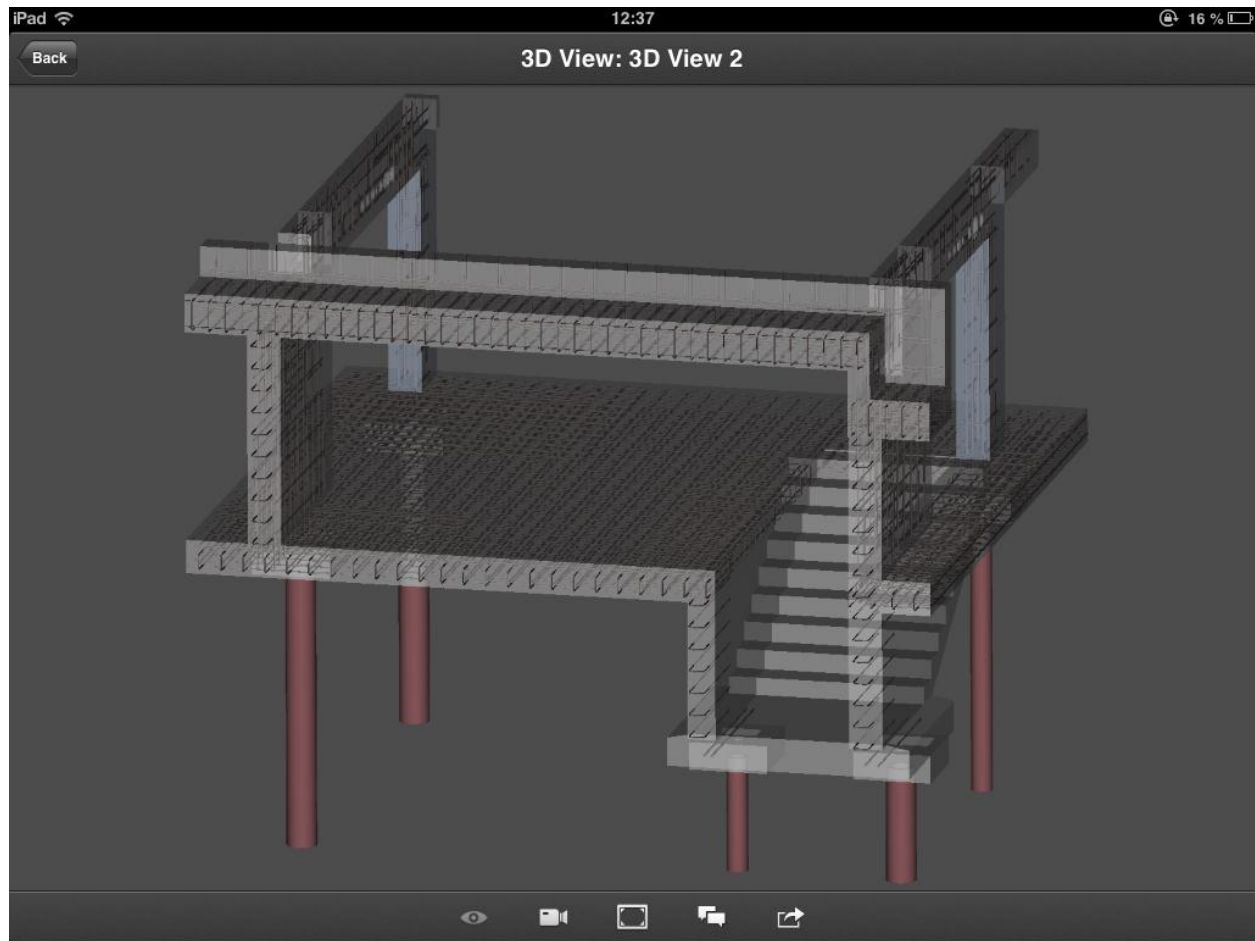


Figure 75: 3D DWF viewed with Autodesk 360 on Apple iPad

This can really reshape the way we exchange and access models on a regular basis. We are just scratching on the surface of what is possible here. Imagine this with GPS and Augmented Reality. Not very far away.

On several projects that we work on now contractors are asking for 3D DWF's of reinforcement layouts. This is because they are self-explanatory and intuitive, and clear up misunderstandings that hieroglyphs cannot. And once the humans begin to master the software (that is really the biggest challenge), this will become more and more common.

The problem with DWF is that it is not an open format. We cannot expect contractors to request these files from *all* companies they work with, especially those who do not use Autodesk products.

It cannot be an *official* workflow.

And thus we move on to the open format IFC.

7.2 Industry Foundation Classes (IFC)

This is fresh out of the lab, but just recently the Revit IFC team managed to provide IFC Export of Structural Rebars. This also opens up an entire new world of possibilities for us as communicating engineers. IFC is an open BIM format, and is widely accepted as a model delivery.

Contractors across Northern Europe have already started using IFC-files in construction, and now they are looking at solutions for doing so with reinforcement designs.

In order to export reinforcement from Revit to IFC, you need to make sure you use the following settings:

- Set up a 3D view with Fine Detail Level and make sure all Structural Rebars are viewed as solid (View Visibility States)
- Make sure the IFC class mapping (IFC Options) for Structural Rebar is set to IfcReinforcingMesh (or something else except Not Exported)
- When exporting, use the options Include Internal Revit property sets and Visible elements in current view.

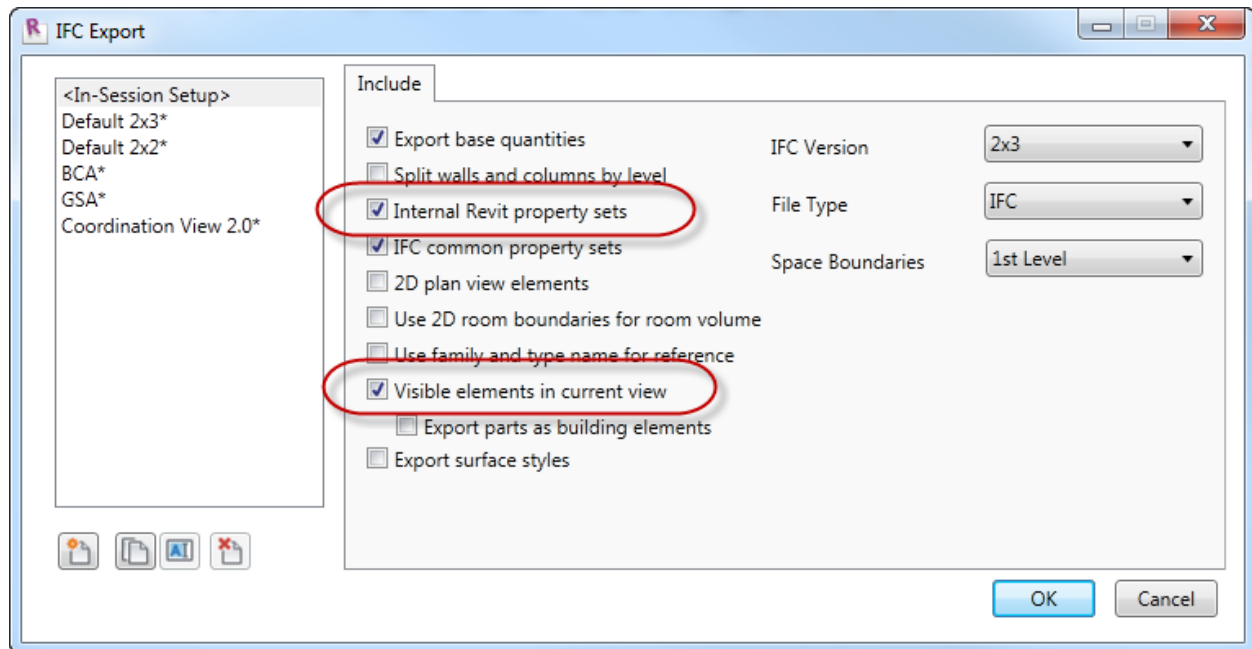


Figure 76: Revit IFC Export settings for Reinforcement

There are several tools available for reading, viewing and structuring IFC data, one of the most acknowledged being Solibri Model Checker.

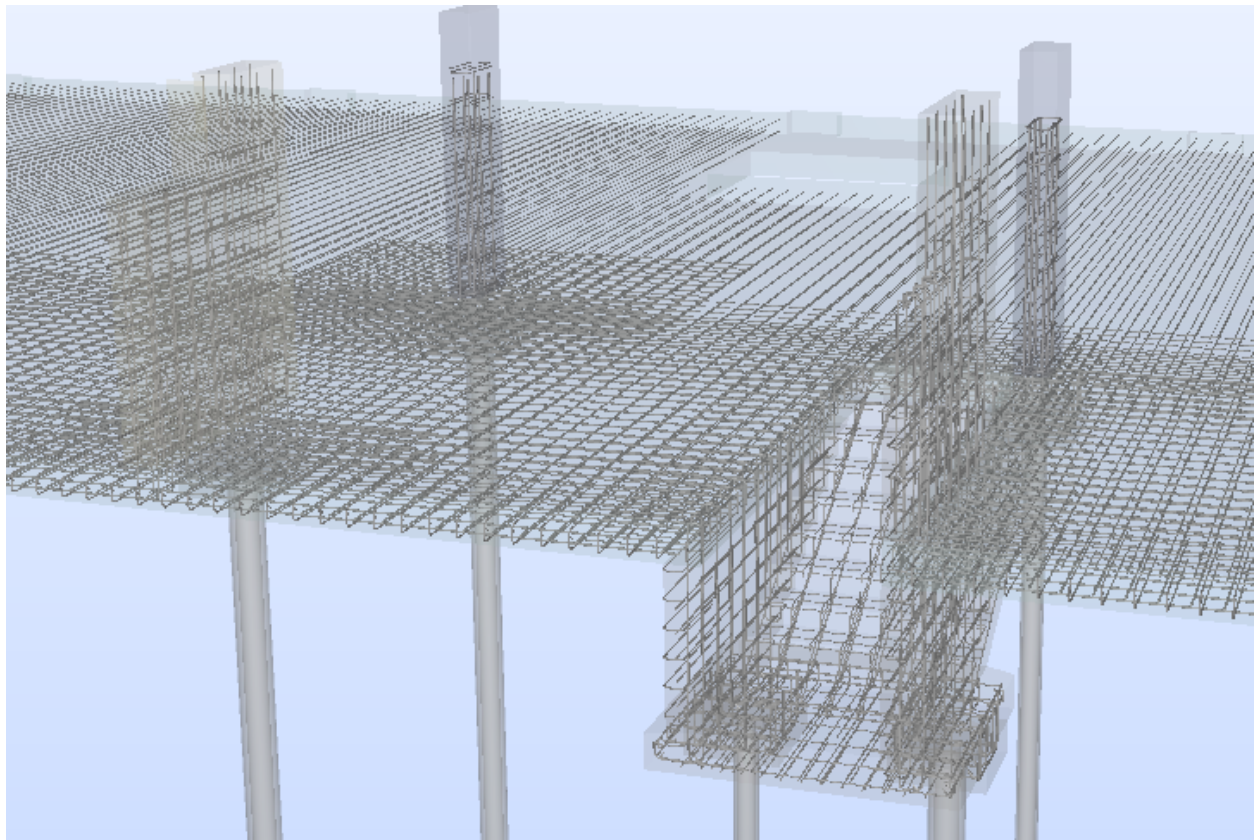


Figure 77: Exported IFC model with reinforcement, viewed in Solibri Model Checker

Using a section box (as I've used in the illustrated example above) will exclude all Structural Rebars that are outside the section box. At the same time it will not cut a rebar set, and rather include all sets that are partly or wholly inside the box. Sort of like a crossing selection rectangle in Revit and AutoCAD – everything that touches it is exported.

Solibri has a module called Information Takeoff that allows us to structure and view IFC models quite intuitively from exported properties. The takeoffs can use all IFC data exported with the elements, and this in turn enables us to isolate model reinforcement using something that looks suspiciously like a Rebar Schedule.

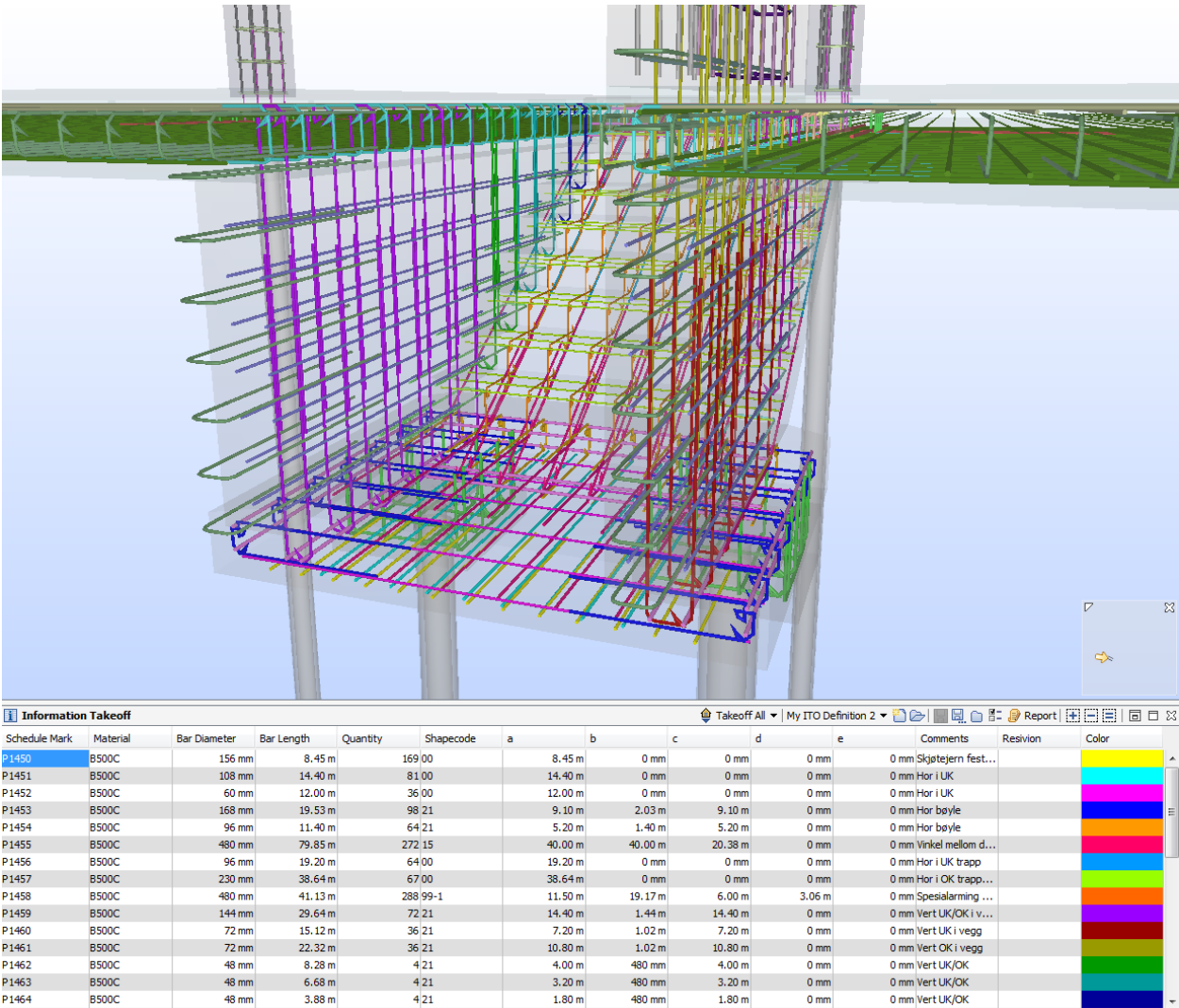


Figure 78: Information Takeoff as a tool for structuring reinforcement designs in IFC models

Selecting the different Rebar Numbers (Schedule Mark is used here) will isolate the rebars in the 3D environment. This in turn makes it even more visually intuitive to use the exported models.

Tekla BIMsight is another IFC viewer that can structure and filter building information. Contrary to Solibri Model Checker it's free and has note viewing functionality for smartphones and tablets.

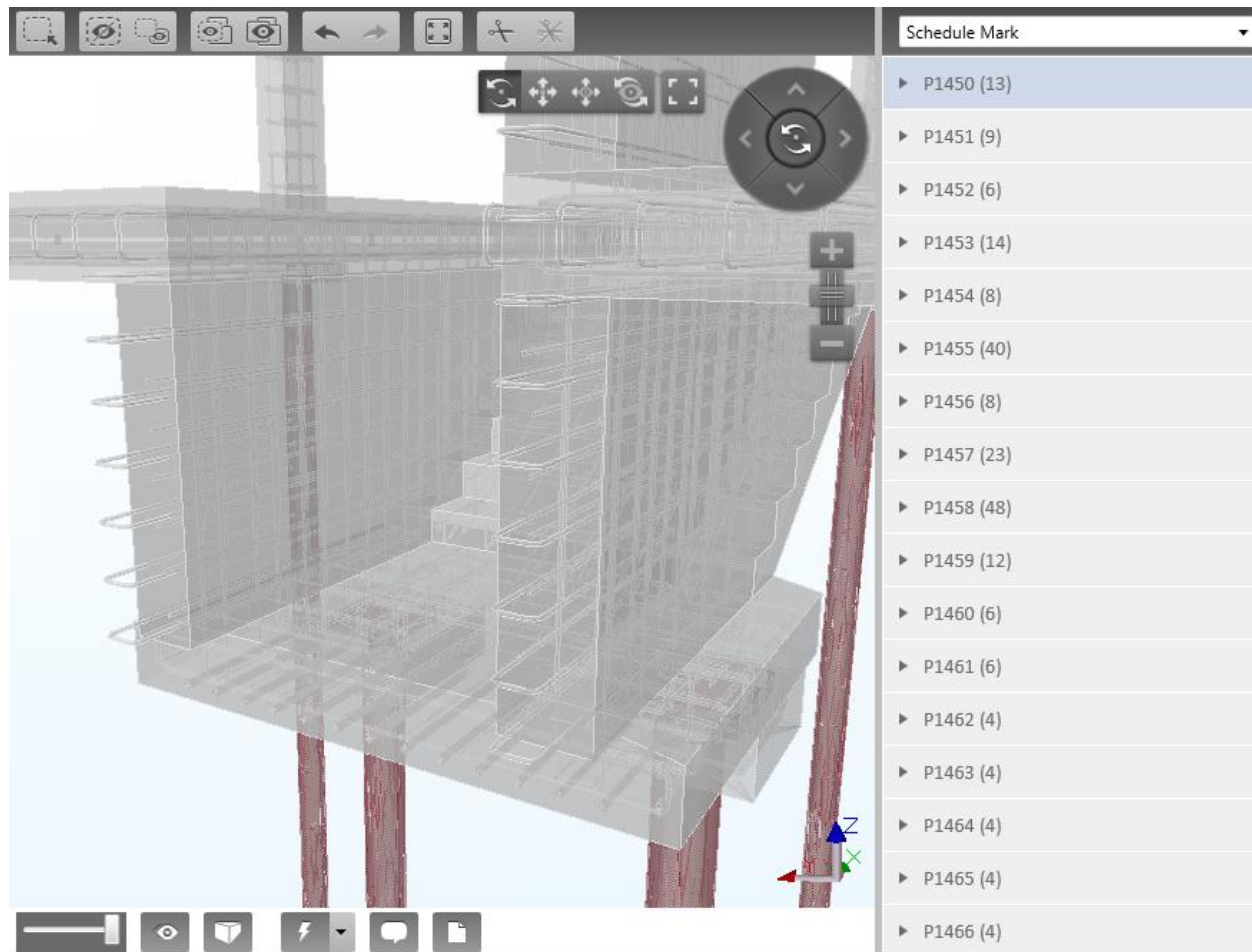


Figure 79: IFC model viewed in Tekla BIMsight, reinforcement sorted by Schedule Mark

You'll notice that Tekla BIMsight also can filter and sort from all available IFC properties, Schedule Mark in this case. But unlike Solibri Model Checker's Information Takeoff we cannot combine and display several properties simultaneously, which is useful when working with reinforcement.

Right now there are a couple of reinforcement objects that will not export correctly or at all to IFC. I am confident that these issues will be handled soon enough, and that we'll be able to say we can export all reinforcement to IFC. Bye-bye reinforcement drawings and bending schedules. See you never.

7.3 Navisworks

While it's perfectly possible to open IFC-files in Navisworks, the exporter in Revit seems a more natural option. With the 2013 launch it is possible to open Revit files directly in Navisworks, but this operation seems to exclude all reinforcement. So the best way to review reinforcement model information in Navisworks is to use the exporter in Revit.

Note: This exporter is installed in Revit when you install Navisworks, and eventually located in the Add-Ins tab under External Tools.

It is the Current view option in export settings that enable the reinforcement to be exported.

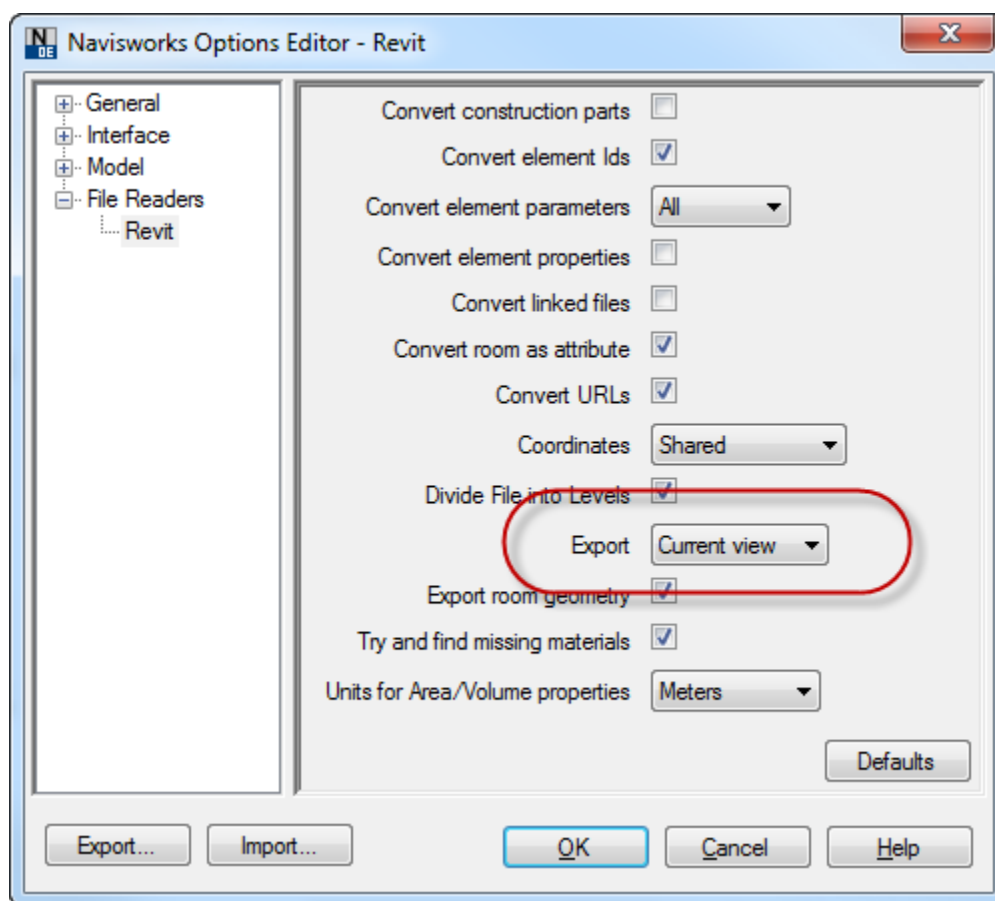


Figure 80: Current view export setting in Revit's Navisworks Options Editor

Reinforcement properties are also available in Navisworks, both passively through the Properties panel and actively through the Selection Tree.

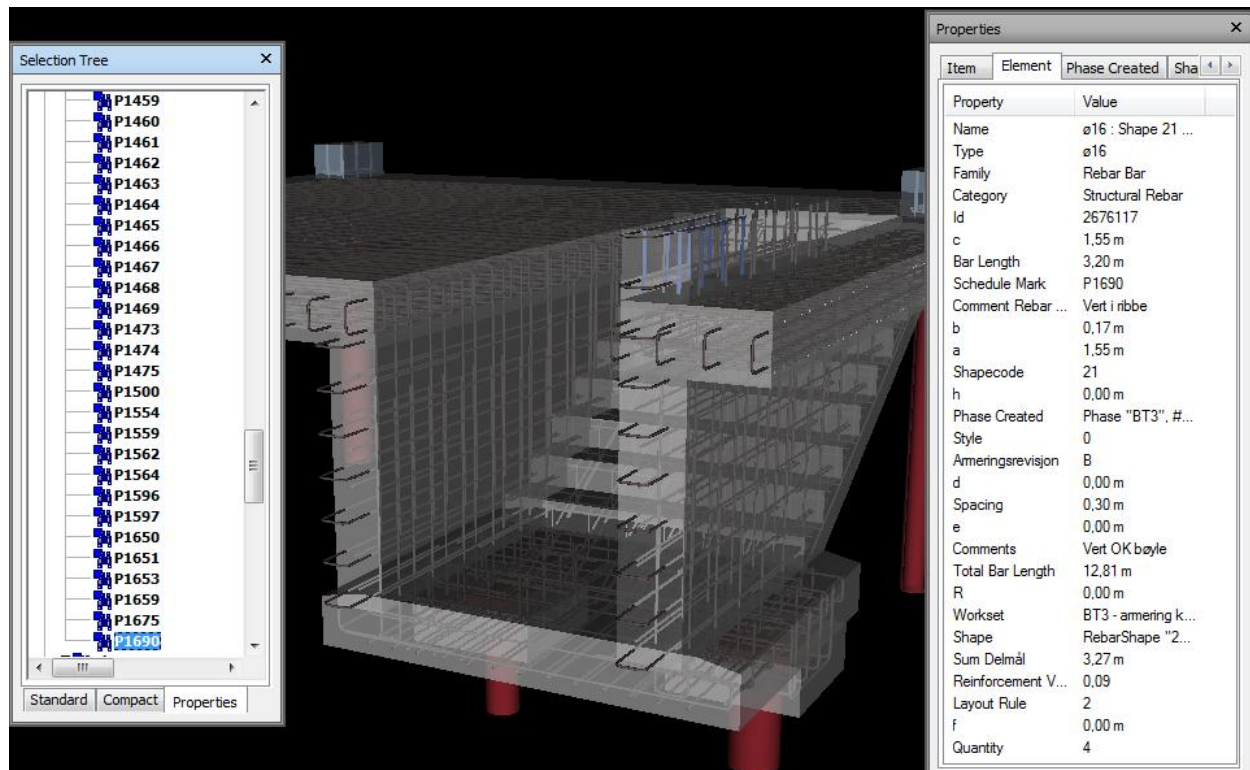


Figure 81: Reinforced concrete structure viewed and sorted in Navisworks

One very interesting thing with Navisworks is the timeliner functionality, which can divide structures into construction sequences and connect these to 4D (construction progress and phases).

All of a sudden available 3D software far exceeds what we are doing with reinforcement drawings and bending schedules today.

It doesn't stop there, however. Let's venture into the mechanical industries and look at what's possible with assembly tools and mobile platforms.

7.4 Inventor Publisher

The last section on model export of reinforced concrete structures combines exported DWF geometry, object information, time, animation, and mobile platforms. It really combines everything that is mentioned in this chapter, except open BIM. And after seeing what we can do with this, I don't really care about open BIM anymore.

What we will do is use our Revit model in an assembly animation that can be viewed on tablets and smartphones.

To start off, we insert the exported 3D DWF into Autodesk Inventor Publisher. Select the different sections of the structure and either hide them and turn them on again sequentially, or move them in place between snapshots. All elements can be tagged with the callout tool, and exported object information shown in the tag.

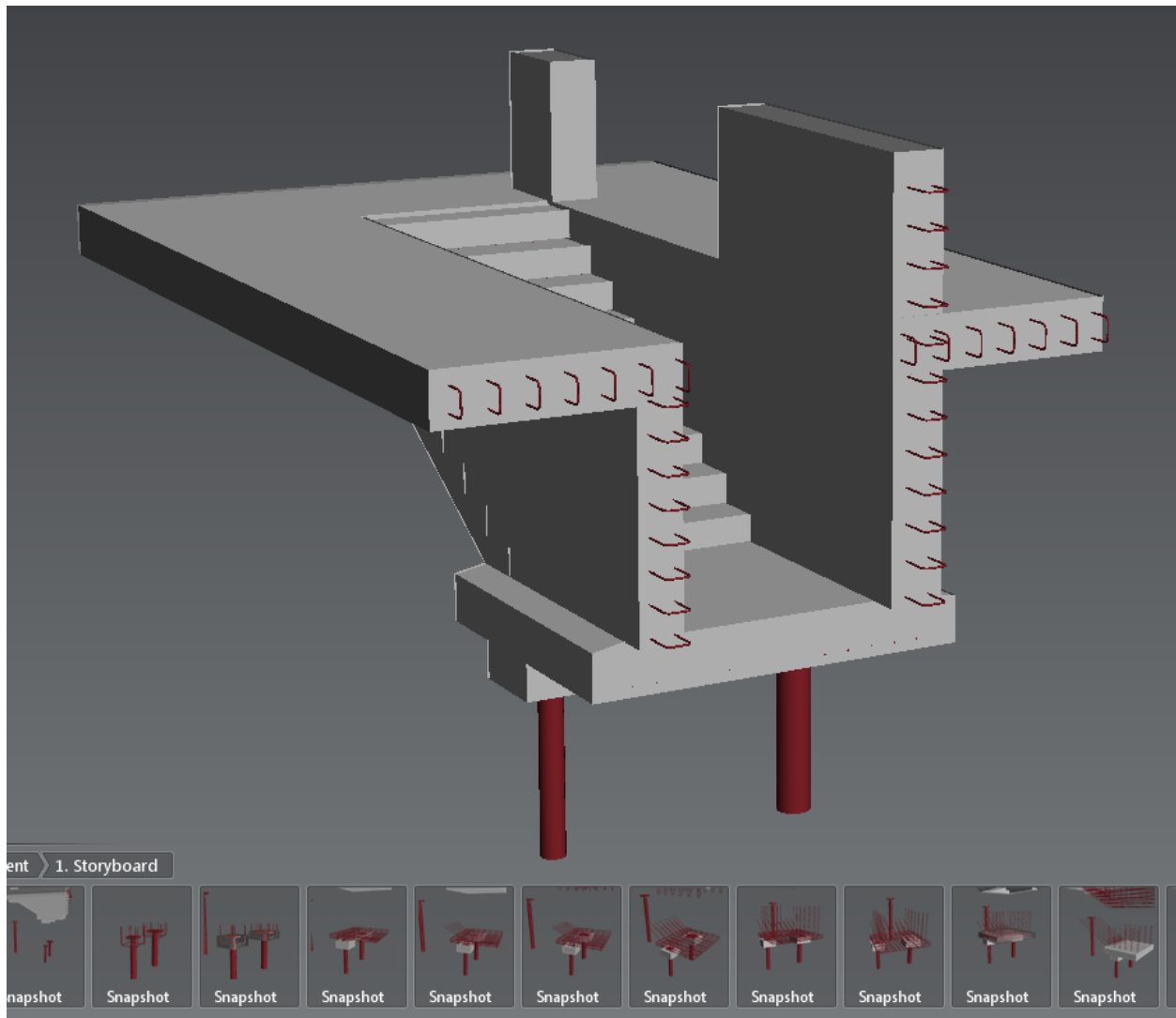


Figure 82: 3D DWF in Inventor Publisher, with multiple snapshots

After the assembly animation is complete we sign in with our Autodesk accounts and Publish to Mobile. This will generate an Inventor Publisher Mobile file that actually cannot be seen using the Autodesk 360 site, only through the program's mobile interface (Manage Online Documents). Signing into Inventor Publisher Mobile on our tablet and smartphones, we can open the model and play the assembly animation.

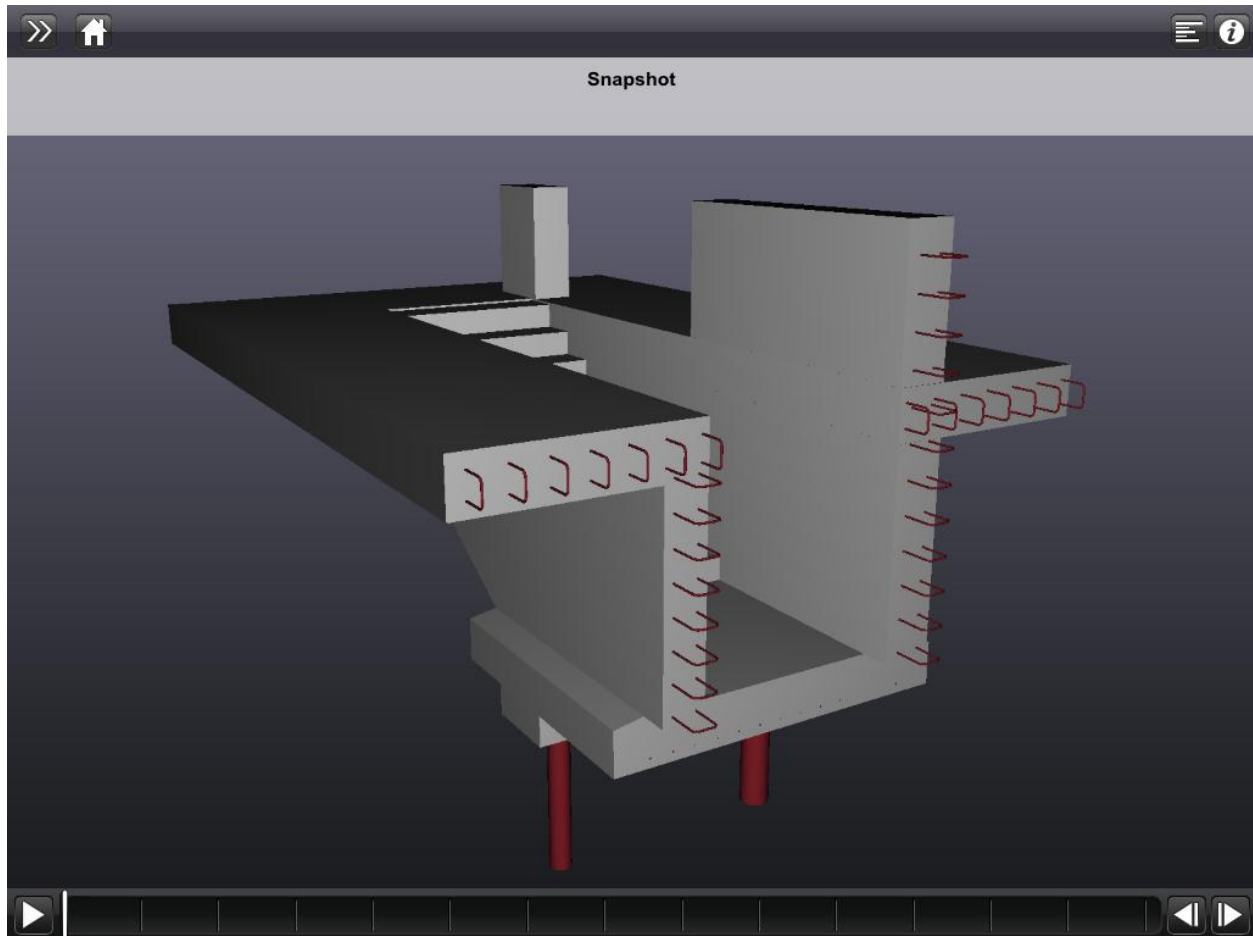


Figure 83: Published assembly animation viewed on Apple iPad

Also note that you can pause the animation at any time, zoom and spin, and even select every object instance and review its properties.

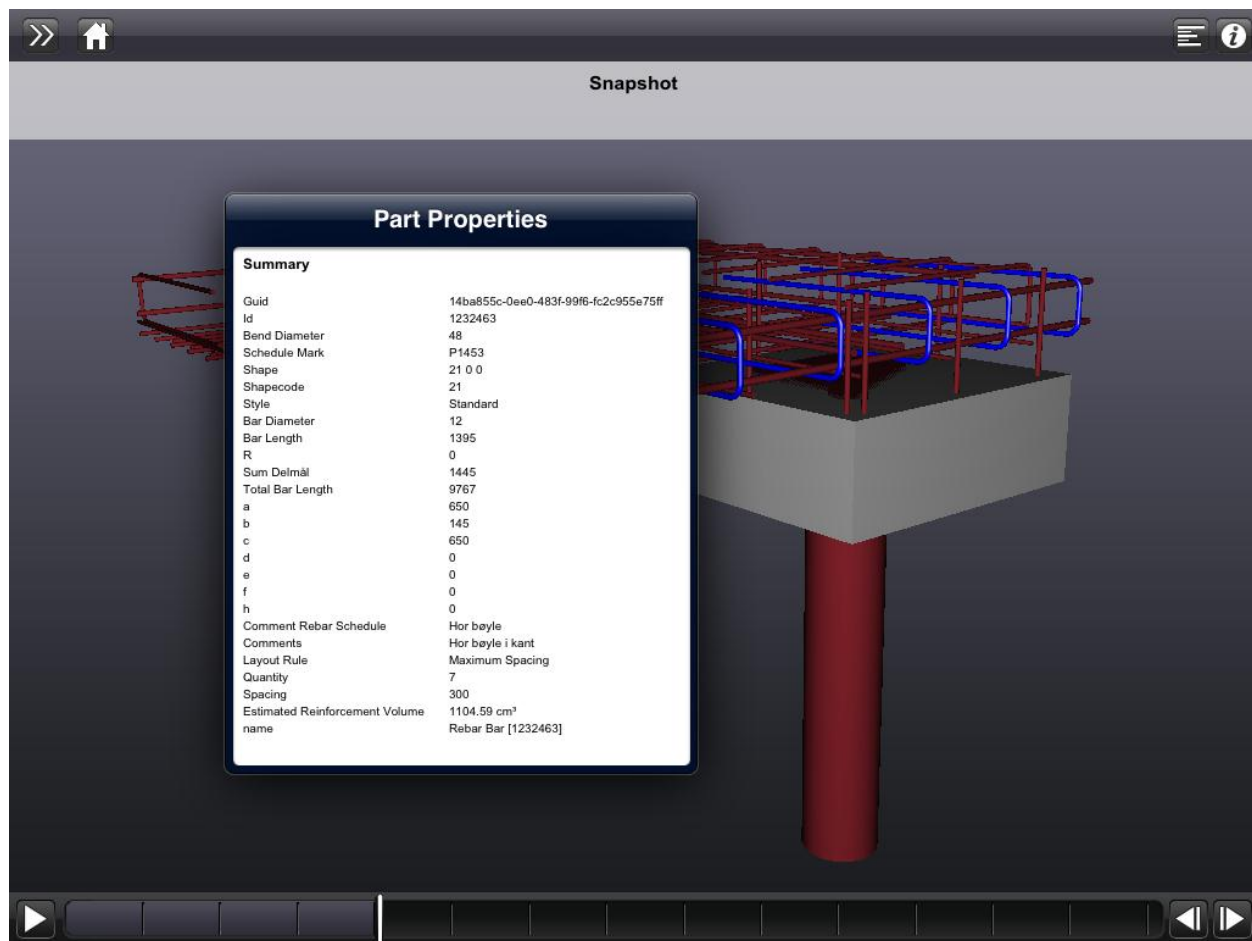


Figure 84: Assembly animation paused and exported properties reviewed

There is so much that can be done with 3D building information models, especially when they are highly detailed and complete. The gap between what is possible technologically and what is actually used on the majority of construction projects around seem to expand. I therefore think one of the most important things we can do as engineers and architects who are interested in technology, is to communicate these possibilities to everyone we meet and collaborate with. Help people see these opportunities and share your knowledge with them. Only that way can the gap between old and new, CAD and BIM be narrowed. Only that way can hieroglyphs find its rightful place in history; a beautiful thing of the past.

8 Going Forward

There is a whole bunch of things that can be asked for regarding future development of Revit Reinforcement tools. All of these suggestions have been communicated by a united community of Revit power users to Autodesk, and we are eagerly awaiting the next couple of releases to see how we can work in better, more efficient and intuitive ways with structural detailing.

Here is my list of main potential enhancements;

- Better modeling tools for Structural Rebar Sets
 - Add Structural Rebar to Revit families
 - Varying rebar lengths
 - Control physical lap splices
 - Free form Rebar distribution
 - Selection of Rebar Shapes in Area and Path Reinforcement
 - Increment snapping of rebars
 - Avoid undesired cover snapping
 - Select and lock Rebar Number for modeling
 - Modify single rebar instances in a distribution
 - Add rebars to Parts
 - Group several Structural Rebar sets to a single set
 - Automatically generating reinforcement from national codes
- Better documentation tools for Structural Rebars
 - Report-like schedules printed in A4
 - Tag Structural Rebar sets with Symbol
 - Hard-coded and automatically numbered Rebar Number parameter
 - Fully functional IFC export of *all* reinforcement
- Visual representation
 - The View Visibility States need an overhaul, and preferably a removal
 - A better workflow for transparent concrete in reinforcement sections
 - Structural Fabric Reinforcement visible in 3D

As said, this list could and should be longer. It is a short summary of the most important features I'd like to see in future releases of Revit. Please let me know if you have other suggestions or think my list is ridiculous. I'm looking forward to a good discussion!

That concludes this handout on reinforcement detailing in Revit. Please do not hesitate to contact me if you have questions or ideas to do thing in other ways. I'm always happy to learn!