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## From Revit Model to Production: A Detailed Look into the Workflow at Voorbij Prefab

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### Learning Objectives

- Learn how to collaborate with partners and clients to get an efficient workflow
- Learn how standardized modeling can be used to benefit the prefab production process
- Learn how to integrate Dynamo for Revit in a production setting

### Description

Voorbij Prefab is a highly automated concrete factory in the Netherlands that produces wall elements for housing. At Voorbij Prefab, the clients' Revit models are directly used to generate data for the robots. This class will show the complete workflow. It starts with managing the clients to get uniform models, then combining the Revit models, and using Dynamo to add all the concrete detailing. Using IDAT software, based on AutoCAD software, reinforcement is added and files are created to feed the robots. Finally, BIM 360 Field software is used in combination with QR codes to scan and view the precast elements on the building site. Not only will we explain this workflow, we'll do it from start to finish during this one-hour class—and an element by choice will be produced live in the factory in Amsterdam! At the end of this class, we'll take a look into the future regarding how the Structural Precast Extension in combination with IDAT tools can be used to produce even more efficiently with Revit software.

## About the speakers



After his bachelor in Building Engineering Ruben van Dijk started his career as a BIM modeller just to earn some quick cash. While not really keen on modelling he started to automate some of the workload. Now he is a BIM consultant at HFB, specialised in the concrete prefab industry, and loving his job. Started consulting at Voorbij Prefab, a highly automated concrete factory in the Netherlands, and stayed there ever since. At the moment Ruben van Dijk is helping factories to optimize their modelling workflow. Always trying to find improvement in the process from model to production.



Jonathan started working at HFB in 2009, creating BIM in Revit. Since then he was part of a wide range of projects, from simple housing project, to apartment buildings, to more diverse and complex BIM projects like a research center, hotel and an existing Palace with point clouds. Using the experience of these projects he is advising other company's about creating and using BIM. He loves to keep track of the latest innovations to make work easier and faster. Which results in working more with Dynamo then using basic Revit, creating scripts for all kinds of tasks.

## Contents

Introduction .....	4
Voorbij Prefab .....	4
Revit .....	4
HFB .....	6
Workflow .....	7
Workflow .....	7
Engineering process .....	8
Part 1: Input .....	9
Family template.....	9
Example: Electrical fixtures .....	10
BIM protocol.....	11
Example: reducing the requirements; window hosting.....	13
Part 2: Model enrichment .....	14
Combining models .....	14
Automating with Dynamo .....	15
Example: Adding anchors for roof connection .....	15
CCAD .....	16
Example: Rebar .....	17
Part 3: Output .....	18
Production.....	18
As-built model .....	18
QR-code .....	19

## Introduction

### Voorbij Prefab

In 1935 Cor Voorbij founded the family business Voorbij's Beton. The company was based in Wilnis in the Netherlands and engaged in rebar tying activities. A few years later Voorbij's Beton started to focus on piling work instead of rebar tying activities. From 1958 the piling work was expanded with the production of reinforced concrete piles. In more than 50 years, the company had grown to such an extent that it was decided to make Voorbij's Beton the Voorbij Group. This group consisted of specialized departments including Voorbij Prefab Beton.

Voorbij Prefab Beton started with the production of prestressed piles and prefab walls but in the following years the company grew into an all-round factory. Producing girders for bridges, solid floor slabs with integrated installation components, you name it. Starting with the financial crisis in 2008 the company began to lose money every year and in 2014 the company was on the brink of closing its doors.

Instead of closing, in 2015, the company decided to give the factory a complete metamorphosis. The all-round factory has been converted into a high-tech robotized and automated factory specialized in the building industry only. Since then, the focus in the factory has been purely on walls for single-family housing with a standardized nature. The walls that are produced include the electrical installation, plumbing components and the windows are mounted in the factory. At the moment [Voorbij Prefab](#) produces approximately 20.000 wall elements a year which results in 1250 houses a year.



*SHUTTERING ROBOT AT VOORBIJ PREFAB*



## Revit

Robotizing the factory led to a big reduction in labour and also improved the quality a lot. On the other hand the engineering process was still old fashioned. Creating production sheets took a lot of effort with a lot of back and forth with the different clients. The goal at Voorbij Prefab is to act as the 3D-printer in the building industry. In 2015 the majority of the contractors were working in Revit or where just converting to work with Revit. Voorbij Prefab decided to use Revit for its production process as well. In this manner Voorbij could directly use the 3D models from the clients to produce their elements. Working this way has a lot of benefits which will be explained more elaborately later on.

To connect the Revit models from different clients to the production in the factory HFB was consulted.



*SINGLE-FAMILY HOUSING*

## HFB

[HFB](#) started in 2008 as BIM company, basically creating 3D models, mainly for contractors and investors. The companies' origins are in modelling single-family housing but the company grew out to modelling difficult building projects even winning an AEC excellence award in 2016. HFB's core business is to create 3D technical models from an architectural design, used for drawings, clashing and quantities.

After years of experience in all kind of models the role HFB is taking as a company is slowly expanding. From a company that makes technical models based on architectural design, HFB is now involved earlier in the design process. HFB is asked by investors to create a raw model using the program of requirements, the location and all available data with it to set borders for the architectural design. In this manner avoiding a lot of problems and extra time in an early stage. Apart from being involved earlier in the process, HFB is also trying to make a connection from the technical model to the fabrication process. Voorbij Prefab is a prime example of where this process is working.

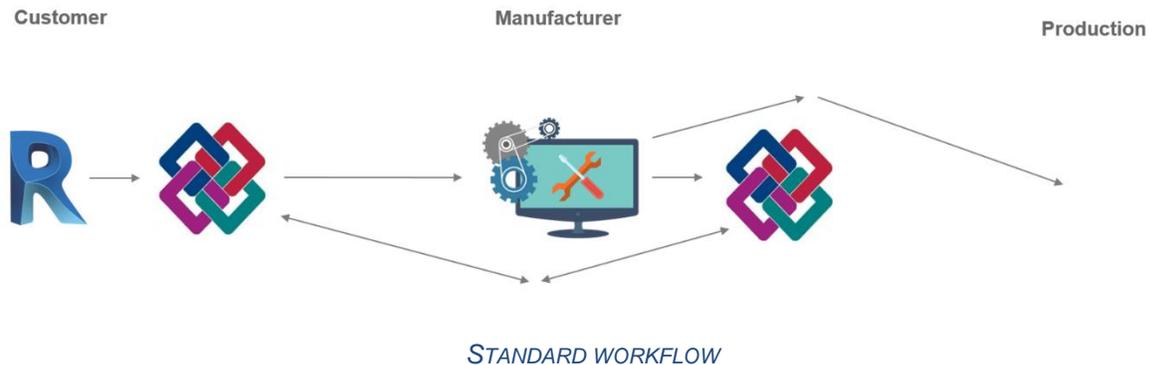
While Voorbij Prefab has a lot of clients all around The Netherlands the expertise of HFB was used to connect the Revit models of different clients to the production process at Voorbij Prefab.

The logo for HFB, consisting of the lowercase letters 'hfb' in a bold, black, sans-serif font.

## Workflow

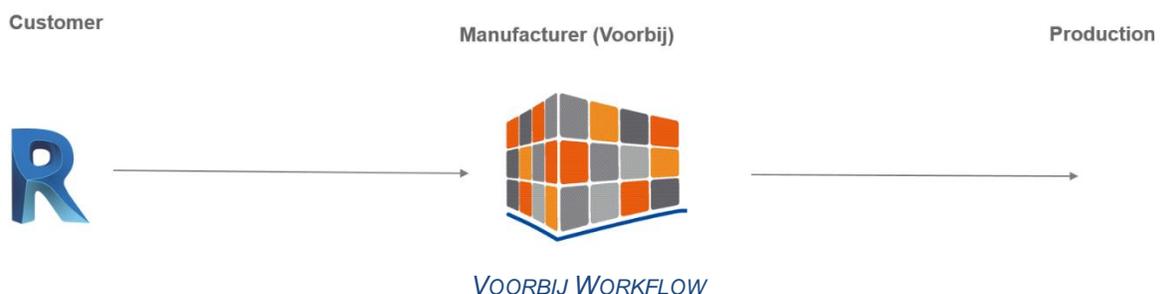
### Workflow

In the process from model to production, normally a lot of time is wasted on remodeling. The reason for this is that the production software that controls the factory does not match the models that are supplied from the customer. A typical fabrication workflow will look something like the picture below.



1. Customers will make their technical model (or models) in their own software (mostly Revit).
2. Customers share their models with the manufacturer in an IFC-format.
3. Manufacturer will use this IFC model as an underlying model to create its own production model.
4. The production model generated in the production software of the manufacturer is then exported to IFC and sent back to the customer.
5. After checking for clashes and differences by the customer the project can be produced.

At Voorbij Prefab this is not the case. The models from the customer are directly used and combined. Therefore they are not remodeled, but rather enriched with production data. Because the models are used directly there isn't a need for checking. To be able to do this, it is important to get models that can be produced.



## Engineering process

In a typical project produced by Voorbij Prefab there are four models, from four disciplines, that are necessary for producing the wall elements:

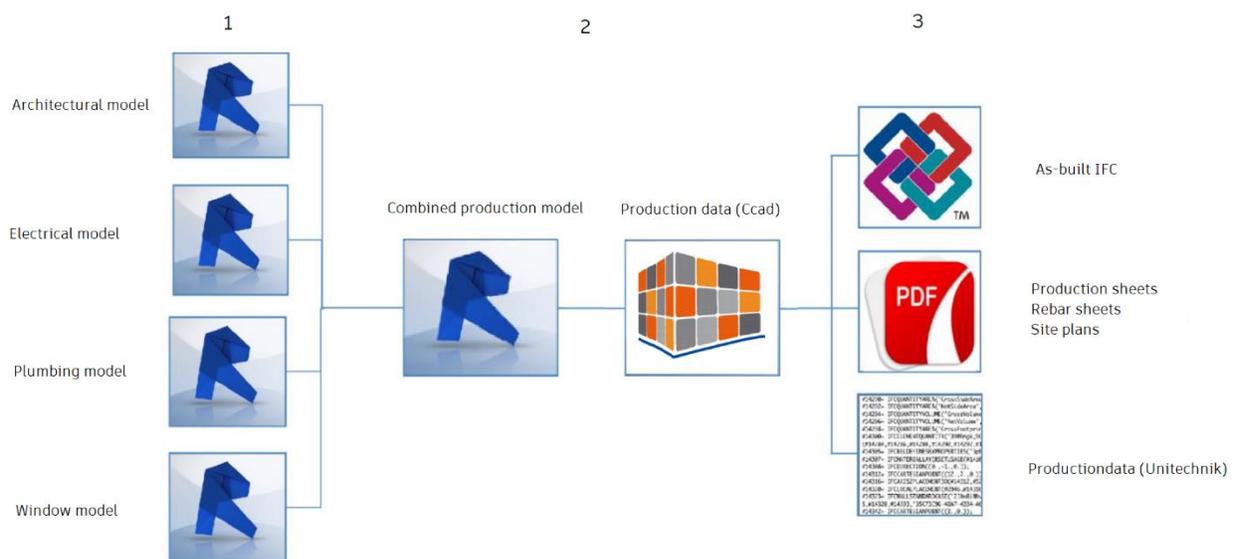
1. Technical model from architect/contractor
2. Model from electrical engineer including electrical fixtures and conduits
3. Model from plumber with openings and wall slots
4. Model from window factory

In some cases models from other disciplines are used, for example anchors for scaffolding or connections with steel structures. In general, every component that is desired to be produced in the wall elements should be part of the model input.

The models of the different disciplines are the direct input for the engineering process. They are filtered and combined by Voorbij Prefab without modification. The combined model is then enriched with all the necessary components for production, e.g. wall connections, lifters, bracing inserts, rebar, etc. In general, all components that are part of the concrete engineering process and components that will have an influence on the structural integrity of the building will be modelled by Voorbij.

Lastly, the output for the factory is created, containing production sheets, siteplans, As-built models and data for controlling robots and the ERP-software.

All three parts of the engineering process will be explained more in-depth in the next three paragraphs.



ENGINEERING PROCESS

## Part 1: Input

The engineering process cannot start without final models. Voorbij Prefab uses the models directly which means draft models are of no need, this will only result in unnecessary work.

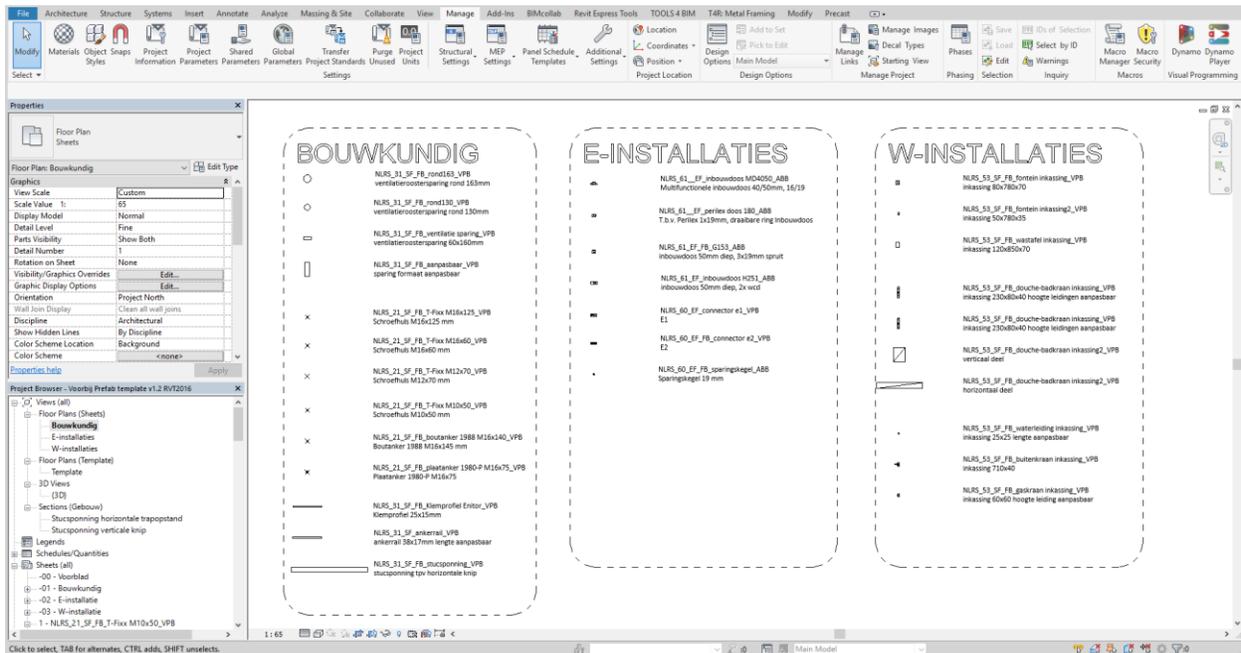
Working this way results in every discipline becoming accountable for their own model. Any mistakes or clashes should be handled before the engineering process starts. The slogan at Voorbij Prefab is therefore: "What you BIM is what you get!"

Making sure the final models are actually suitable for further engineering and production is the quest we've been on the past few years.

### Family template

To establish a uniform connection between model and production, a Revit template is shared with all clients and their participating companies. The Voorbij Family template is nothing more than the storage of the factory translated into Revit families. Every family is mapped and recognized by the software.

However, in most cases clients are not obliged to make use of the families. They can, for example, use every wall type or window family to their liking.



VOORBIJ FAMILY TEMPLATE

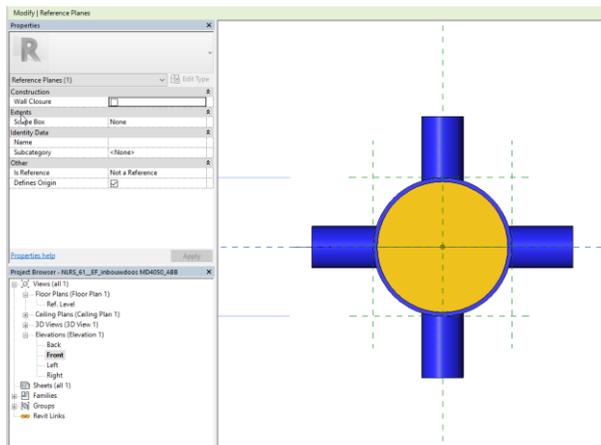
## Example: Electrical fixtures

The electrical installation is a crucial part because remodeling the electrical model is time consuming. Electrical engineering companies can use the families delivered in the template but in practice all companies already have there own workflow and families. Therefore they can just use there own families when they are following three simple requirements:

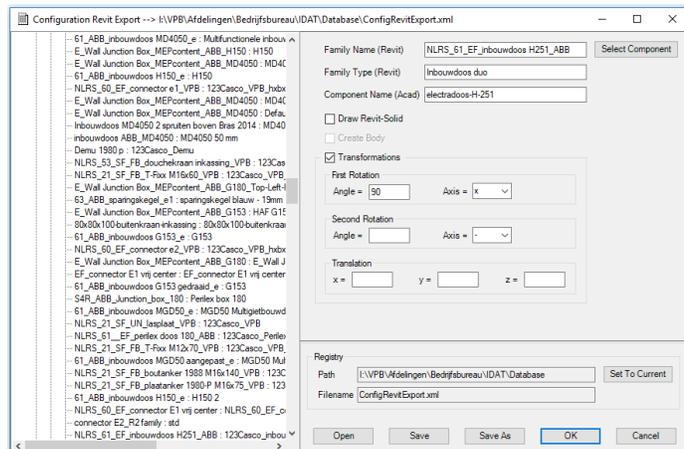
- Location: The origin of the family is used to place the electrical fixture by the robot. The origin should be in the center of the fixture and on the wall face.

(While this sounds very logical it did happen, in an actual project, that electrical fixtures where offsetted because of a faulty origin. Accountability can be a real problem in cases like this.)

- Uniform naming: The Family and Type name are used to map the family to the electrical fixture
- When the electrical fixture family is nested in to another family the electrical family should be “shared”. Only when shared, it’s possible to find it’s specific location.



ORIGIN FAMILY SHOULD BE CENTERED



ONLY A SMALL PART OF MAPPING ELECTRICAL FIXTURES IN THE PAST 3 YEARS  
UNIFORM NAMING IS “HARD”

## BIM protocol

The family template is only a part of connecting the models to production. The BIM protocol is where the real action starts. A typical BIM protocol will be an agreement, almost like a binding contract. The Voorbij BIM protocol is only partly that. It contains a list of hard requirements but also a list of optional requirements. The client can make their own choices on how to model.

Because the input models will be used directly, checking is not needed anymore. In the BIM protocol accountability is also taken care of.

### *Hard requirements*

To be able to use input models directly it is inevitable to have hard requirements.

Two examples of hard requirements:

- Window openings should be the exact production size and modelled in the “window” or “door” category.

#### *Explanation:*

*Voorbij will not modify the input models. This means that window/door openings should always be the exact production size. Possible clearance dimensions should already be taken in to account in the input model. The window/door family category is needed for two things:*

- 1. The shuttering robot will have different settings for window openings then normal openings. Drawing the window/door opening as a wall opening or even with the edit profile function will result in the wrong production method.*
- 2. Voorbij will assemble the window/door in the factory, therefore a window/door should have a brand name as a parameter in Revit, which is not possible with drawing the window/door as a wall opening or edit profile.*

- Conduits should be modelled in the “conduit” category.

#### *Explanation:*

*The underlying line geometry of the conduit is used to control the plotter that will draw a reference line in the factory. When drawing conduits in other categories, for example generic model families, this underlying line geometry will not be there.*

### *Optional requirements*

The optional requirements are part of ranking system with a total of 100 points. When all optional requirements are met, the models are 100% perfect for production.

Two examples of optional requirements:

- Modelling the walls with the location line at the correct side.

#### *Explanation:*

*The location line in Revit will be used to determine the clean and rough side of the*

wall element. When the location line is already correct in the input model this will save checking and modelling in the engineering process for Voorbij.

- Adding the building number as a parameter inside the wall.

**Explanation:**

For production and delivery the building number is needed as a parameter in every wall element. When the building number is already in the input model this will save checking and modelling in the engineering process for Voorbij.

The optional requirements are like a deal. To give the client an incentive to get a high score, the points in the ranking system are linked to a real discount. The higher the score the more discount the client gets for every single-family house. It is a fair option for dividing the modeling work.

### Reducing the number of requirements

Voorbij Prefab aspires to make the number of requirements in the BIM protocol as small as possible. In theory the ultimate goal should be to have no BIM-protocol at all; “Just send us your input models and the walls will be delivered at the building site whenever you need them”. Of course this is utopia, never the less Voorbij will attempt to reduce the requirements by making changes in their own engineering process.

Code	Titel	Beschrijving	Volgens	Actie	Afpraak	Waarde
B	Structural wall	De bouwmuren zijn als "structural wall" gemodelleerd.	Niet	Alle wanden overbreken / Remodeleren als "structural wall".	OG L	0
B	Window family	Koosjesparingen / sparringsmakers zijn als "window family" op het binnenblad of unhosted gemodelleerd.	Niet	Alle sparringen moeten overname worden gemodelleerd.	VP	-20
EW	Voorbij Prefab families	Die in te starten bouwkundige voorzieningen/ sparringen, en werkstukbouwkundige sleuven zijn middels de meegeleverde "Voorbij Prefab families" gemodelleerd.	Niet	De "Voorbij Prefab families" moeten handmatig over de in te starten bouwkundige voorzieningen/sparringen, en werkstukbouwkundige sleuven worden gestuurd.	OG L	0
B	Location Line	De stortijpeenlijnie van de wand zijn in het model correct aangegeven door de "location line" correct te hebben gemodelleerd.	Niet	OG: Remodeleren van alle wanden. VP: Stortijpeen goed zetten in Revit.	OG L	0
B	Koosjemark	De koosjeverleverancier levert een model aan waar het koosjemark is opgenomen in de desbetreffende koosje object. Een andere mogelijkheid is dat in het bouwkundig model het koosjemark van de koosjeverleverancier is opgenomen in een parameter naar keuze van de "window family".	Niet	Handmatig per sparring het koosjemark toevoegen aan "window family".	OG L	0
B	Verticale scheidingswanden	Verticale scheidingswanden bij aansluiting (gevel-bouwmuur) zijn niet gemodelleerd (Dinn tussen de elementen).	Niet	Alle wanden moeten worden aangepast (verfrijd) zodanig dat de scheidingswanden op 0mm worden gezet.	OG L	-15
B	Manufacturer parameter	In alle koosjesparingen en de door Voorbij Prefab te produceren wanden is in de "manufacturer parameter" de tekst "123assop" opgenomen.	Niet	OG: Toevoegen van de tekst "123assop" in de "manufacturer parameter". VP: Verfragslijst aan risicovolle overname.	OG L	0
E	Familytype name	Oefenamen van een gelijk type zijn met een consequente "family name" en "type name" gemodelleerd. Dit geldt niet alleen per project maar ook over de projecten heen.	Niet	OG: Van alle gelijksoortige gevelbouwdozen de "family name" en "type name" gelijk maken. VP: Koppelen van de gevelbouwdozen met de productiesoftware van VP.	OG L	0
B	Bouwnummers	Bouwnummers zijn in de wanden in de parameter "NLRs_C_bouwwerk_nummer" toegevoegd.	Niet	Toevoegen bouwnummers in "NLRs_C_bouwwerk_nummer".	OG L	0

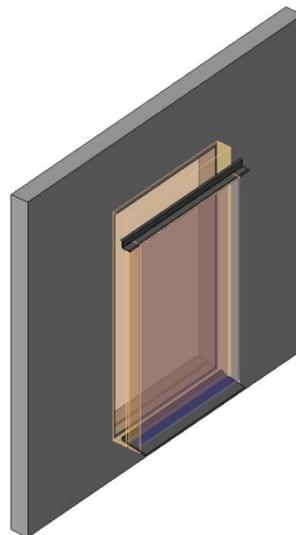
### BIM-PROTOCOL RANKING SYSTEM

## Example: reducing the requirements; window hosting

The window openings are exported from Revit to the production software. Architects/contractors often model with an opening family that cuts multiple walls at once (brick wall, insulation, concrete wall). In the past, to directly use the window family for production, it would be necessary to have the window family hosted on the concrete wall. Doing it this way the software could recognize the connection between wall and window.

For an architect it makes a lot more sense to host the window opening on the brick wall. The position of the window opening is depending on the distribution of the bricks. With this information Voorbij has put in effort to change their own engineering process.

By programming differently in the export software, hosting is not needed anymore. The export software will find the corresponding wall not by searching for a host but it will search wall elements that are cut by the window. By making this change in the exporter, the list of the requirements in the BIM-protocol gets smaller. Therefore, the client is more free to model however they like.

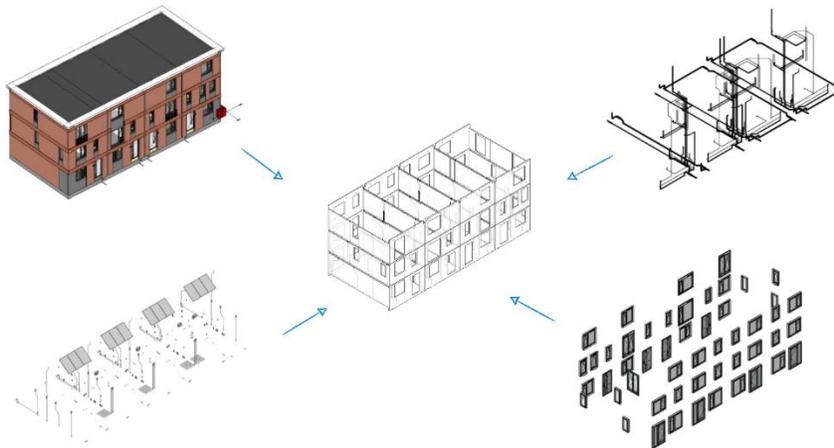


*MULTIWALL WINDOWOPENING HOSTED ON CONCRETE WALL*

## Part 2: Model enrichment

### Combining models

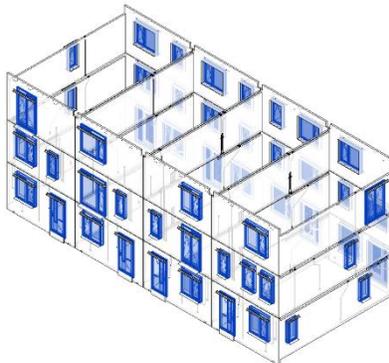
Voorbij will first of all filter and combine the final input models.



*FILTERING & COMBINING INPUT MODELS*

While the architect/contractor will model the window openings. The final window model with the window brands is made by the window factory.

A simple Dynamo script was made where the location of the window, in the linked file, is matched with the closest window opening. The window brand from the linked model will be taken and put in to a parameter in the matching window opening. This script was the start of doing much more repetitive tasks in Dynamo.



*WINDOW MODEL LINKED IN COMBINED PRODUCTION MODEL*

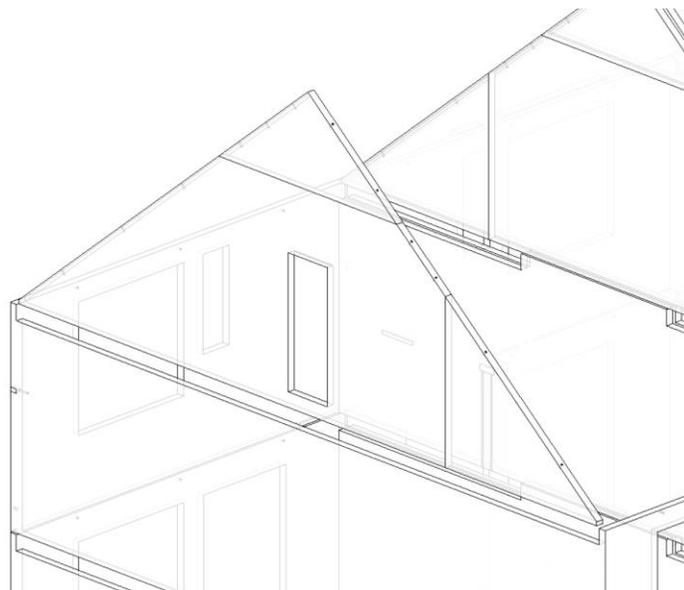
## Automating with Dynamo

The combined production model will be enriched with all necessary components. In general, Voorbij will model two kind of components. First of all, the components that will be needed for production, think about rebar, lifters, bracing inserts, etc. Secondly, all components necessary for the structural integrity will be modelled, think about wall connections, floor connections, etc.

In the past 3 years almost all adding of the components are automated with Dynamo in a certain way.

### Example: Adding anchors for roof connection

To make a connection with the roof there are anchors needed, this connection also acts as a structural connection. A Dynamo script will place the anchors according to the standard Voorbij method. This method has been calculated and the method is shared with all clients. If for some reason the client wants to have another anchor distribution, the client will be asked to add the anchors in the model themselves. In general, all deviations from the Voorbij standard have to be modelled by the client.



*ANCHORS FOR ROOF CONNECTION*

## CCAD

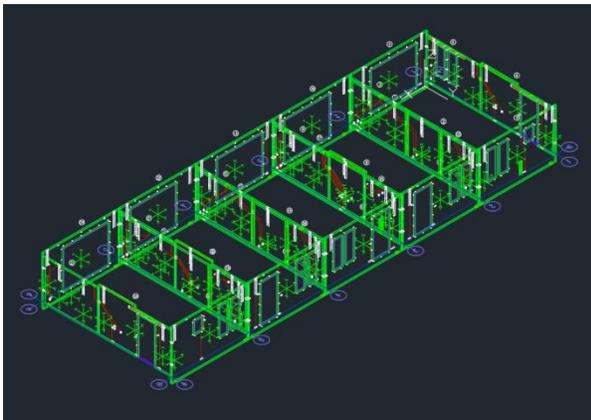
Not the whole engineering process is done inside Revit. The production files are made inside [CCAD](#) which is a plugin made by IDAT on AutoCAD Architecture. IDAT is strongly focused on delivering programming flexibility. In the past 3 years the CCAD software has been specifically programmed to the requirements of Voorbij Prefab. This highly automated and personalized software makes it no match for the options there are for producing wall elements in Revit at the moment.

While CCAD is normally used for modelling purposes, at Voorbij, CCAD is only used as a production tool. With the use of a custom XML exporter the model is exported from Revit to CCAD. Every family in Revit is mapped with an object in the CCAD software.

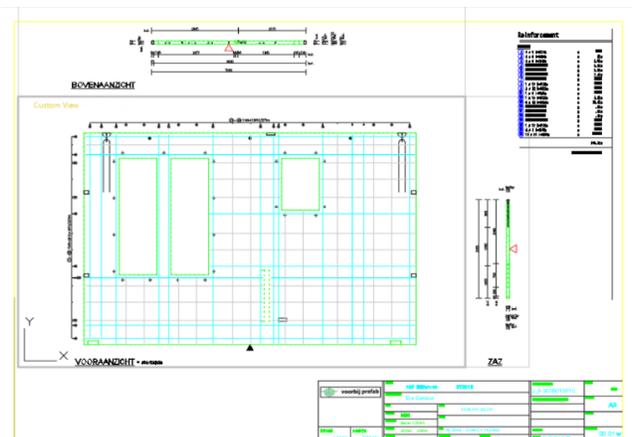
Based on customizable settings CCAD will automatically add:

- Lifters
- Bracing inserts
- Rebar meshes
- Wall connections

Production sheets are produced including dimensions and a Unitechnik file is created for controlling the robots and ERP-system.



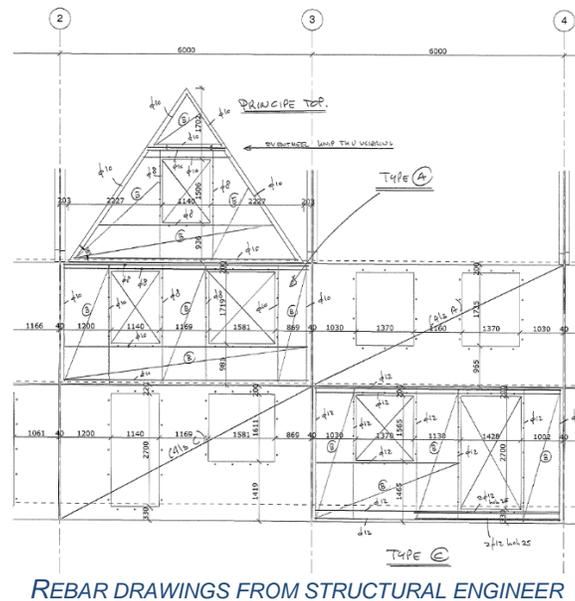
STOREY EXPORTED FROM REVIT TO CCAD



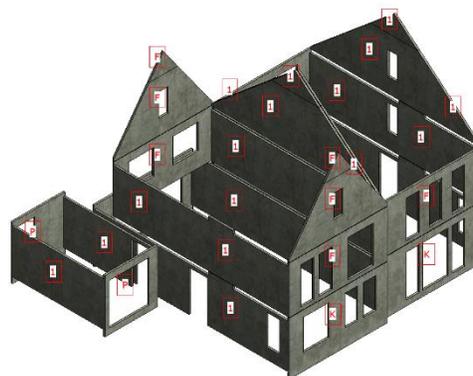
REINFORCEMENT SHEET

## Example: Rebar

All wall elements contain a unique rebar mesh that is produced by a mesh welding machine. The structural engineer calculates the rebar that is necessary in the wall element. In the past this was done with sending the structural engineer 2D prints of the project. Using the prints they made calculations for just this one project and its walls. The drawings were used to manually model the rebar meshes in CCAD to be able to be produced by the mesh welding machine. This was very time consuming.



This process has been reversed. Based on the requirements of the mesh welding machine a set of 30 rebar recipes were created inside the CCAD software. By choosing a specific recipe CCAD will automatically create the rebar mesh based on predefined rules. Right now, these rules are shared with the structural engineer and they can only choose between those standard recipes. These standard recipes are linked to wall types in Revit. The structural engineer will change the wall types accordingly to his calculations. The different wall types are then exported from Revit to CCAD and the correct rebar is generated.



*REBAR RECIPES IN REVIT*

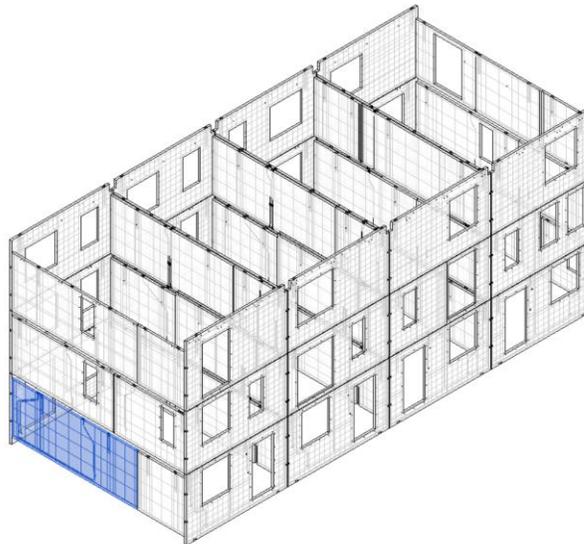
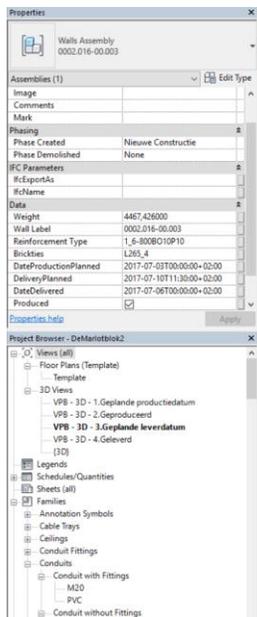
## Part 3: Output

### Production

When the model is finalized in CCAD, for every wall a unique Unitechnik files is produced. The Unitechnik file is a worldwide standard for controlling machines and is widely used in the concrete industry. At Voorbij the Unitechnik file is also used for controlling the ERP-system. Every component in the Unitechnik file that should be produced is automatically booked in the system. Production planning is also done with the Unitechnik files.

### As-built model

The finalized project in CCAD can be exported back to Revit. The As-built model can be used on the building site and for management and maintenance.



AS-BUILT MODEL

## QR-code

All elements are produced with a sticker containing a QR-code. This code is nothing more than the unique element number. This QR-code is used for multiple cases. First of all it is used for intern communication. The code is used to scan elements on loading the elements for transportation and for internal quality control.

Secondly, the QR-code is used on the building site. The QR-code is also present in the As-built model. Therefore by scanning the element on the building site information can be requested such as the position of the element in the model. In addition, any comments about the element can easily be communicated with Voorbij.



*ELEMENT STICKER CONTAINING QR-CODE*



*SCANNING ON THE BUILDING SITE*