CES322417

Computational modeling linear structure with Civil 3D, Revit & Dynamo CivilConnection Package

Michel Beliën
Royal HaskoningDHV

Rob Zutt
Royal HaskoningDHV

Learning Objectives

- Creating a Civil 3D model with the subassembly composer that is ready for applying with the CivilConnection Package for Dynamo
- Use dynamo to read your Civil 3D model
- Build your Revit Model based on the Civil 3D model and information
- Use the power of Civil 3D and Revit together

Class Description

In an early design phase, a parametric Civil 3D model of a tunnel was setup using the subassembly composer. Where Civil 3D is strong in linear oriented design, Revit is strong in placing object-oriented elements. With the CivilConnection package for Dynamo it is possible to setup and change a Revit model based on the corridor and feature lines from the civil 3D model. Where the Civil 3D Model follows the curved alignment as much as possible, it is necessary to work towards a more implementation-ready model in Revit during designing. We constantly look for optimizations. Without computational modeling, quickly processing new design insights is a time-consuming job and no longer of this time

Speaker(s)

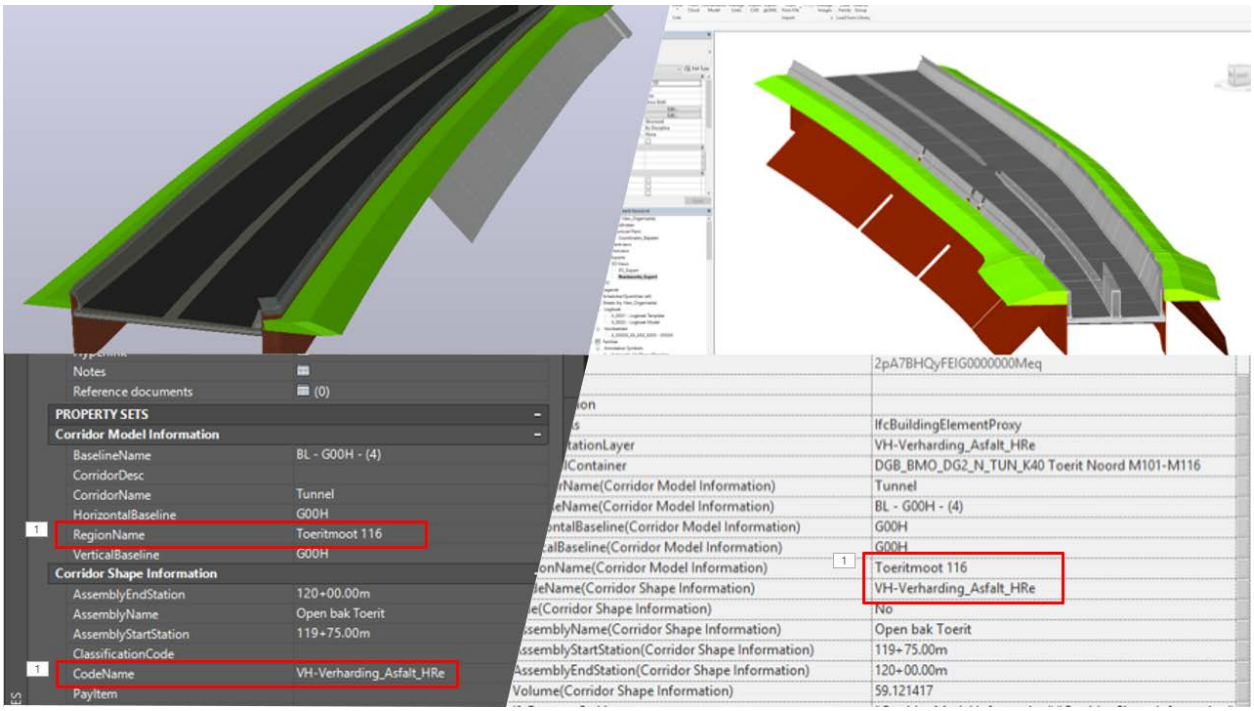
Michel Beliën
Revit & BIM specialist
Royal HaskoningDHV

I am a structural engineer who has been focusing for many years on managing, standardizing and optimizing design software to enable us to be more efficient, effective and profitable in our way working. In recent years I have been made responsible for implementations and developments of applications that need to directly interface with Revit within Royal HaskoningDHV. Therefore we have started in the summer of 2016 looking for opportunities to automate design challenges by either parametric or computational design. I have a keen interest in staying up to date to latest industry trends and I investigate new technologies for their potential usage within the company. I am also actively involved in a Infrastructure User group in the Netherlands with many progressive minds in our field.

Rob Zutt
Design leader - Civil 3D expert
Royal HaskoningDHV

Rob is a design leader and responsible for the design of roads for many different clients; managing of designers, exchange between professional disciplines and assistant project leader. In recent years Rob has been, as one of the pioneers in Royal HaskoningDHV, mainly engaged in 3D road design, visualisations, scripting and the development of innovative methods. These new methods enable us to support our customers efficiently and visually in their development process, so that they can make informed choices. After his study Civil Engineering in 2002 Rob started as a draftsman and from that direction he participated in all facets of civil engineering (draftsman, designer, contract writer, assistant project manager). Rob is constantly looking for ways to simplify working methods, to do things faster and to make them transparent for everyone. This keeps people involved and then we are able to make beautiful things together!

Table of Contents



Introduction

This document is the handout that provides context and more in-depth information for the presentation.

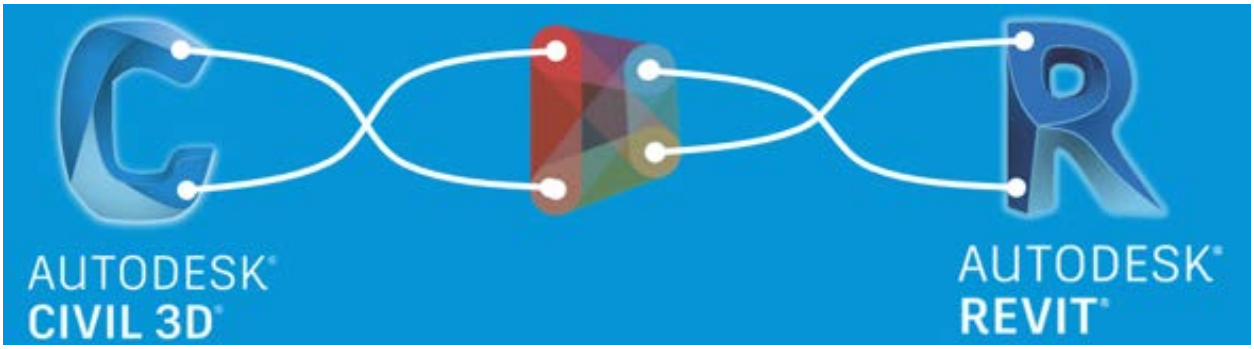


Figure 1: Connection Civil 3D ← Dynamo CivilConnection Package → Revit

Project

Access Ramps Tunnel

Royal HaskoningDHV responsible for the design off the access ramps of the tunnel

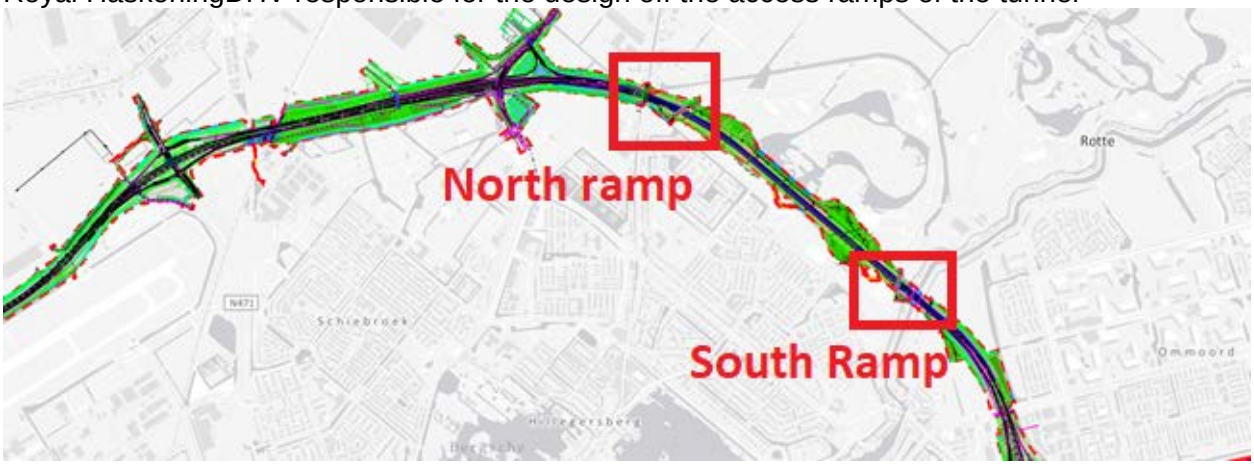


Figure 2: Situation access ramps North & south

Tender Design – Civil 3D

Tender design is done with Civil 3D

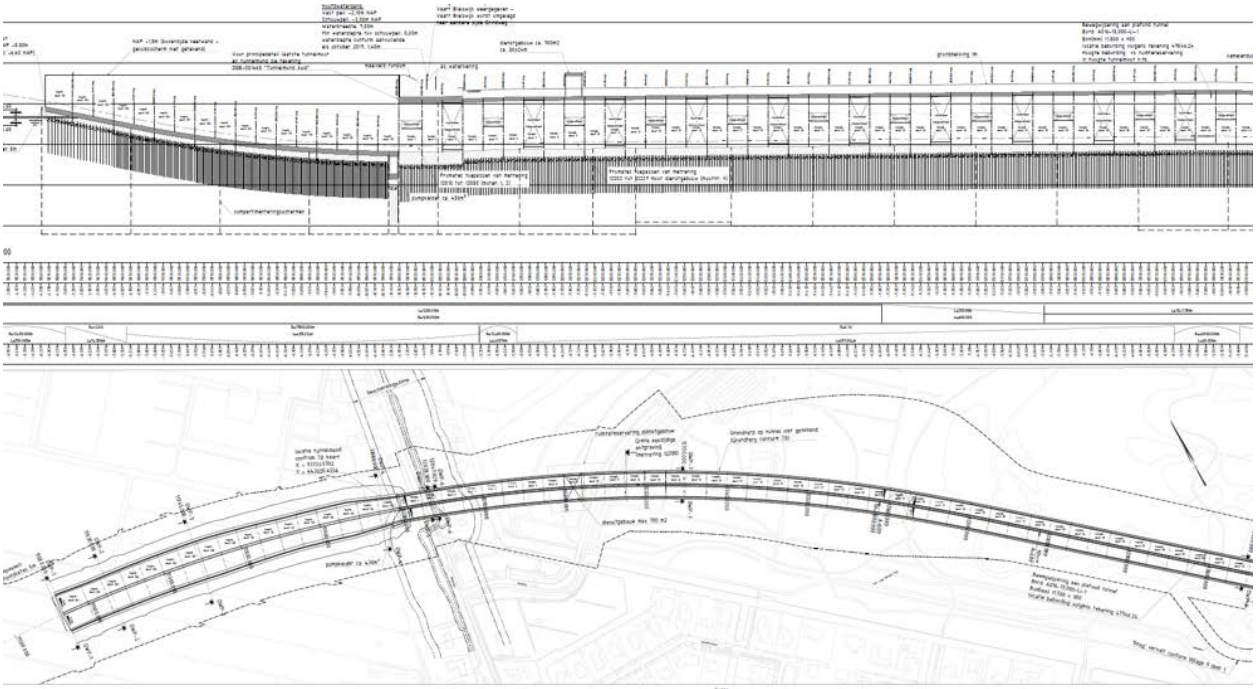


Figure 3: Civil 3D Tender drawing North

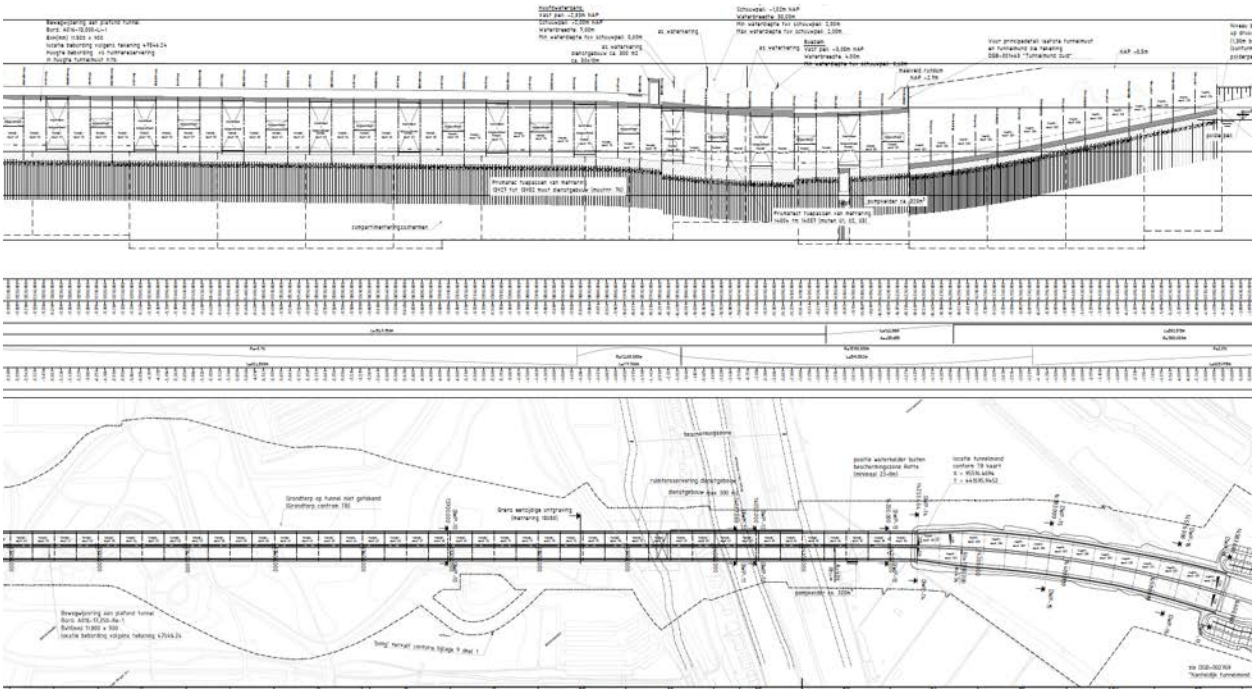


Figure 4: Civil 3D Tender drawing South

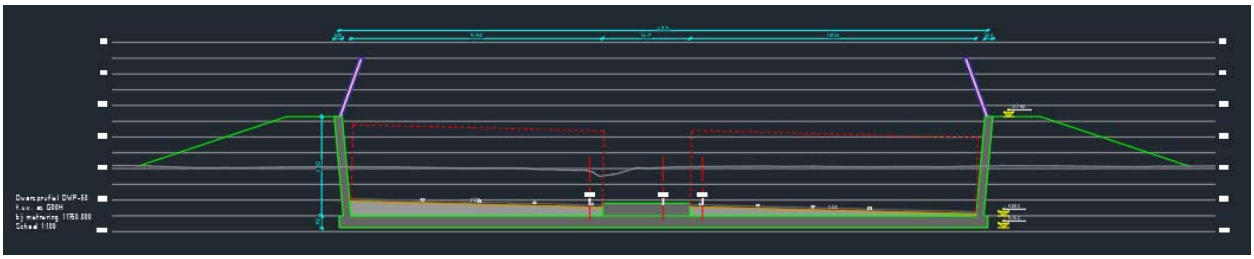
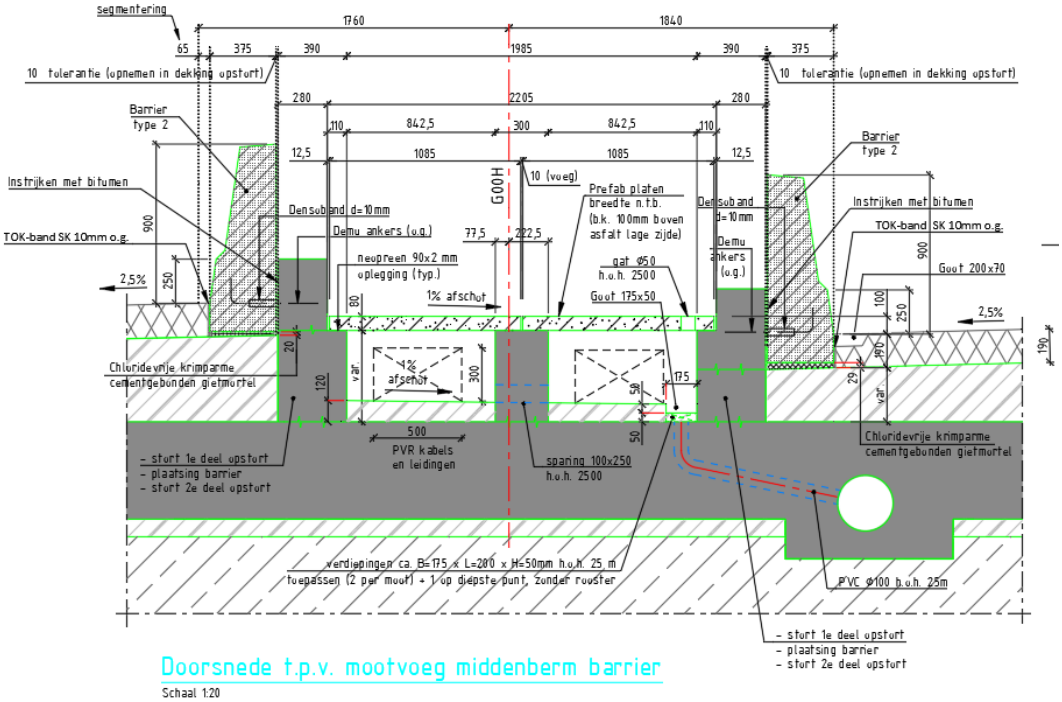


Figure 5: Civil 3D Tender section access ramp

Prelimenary Design

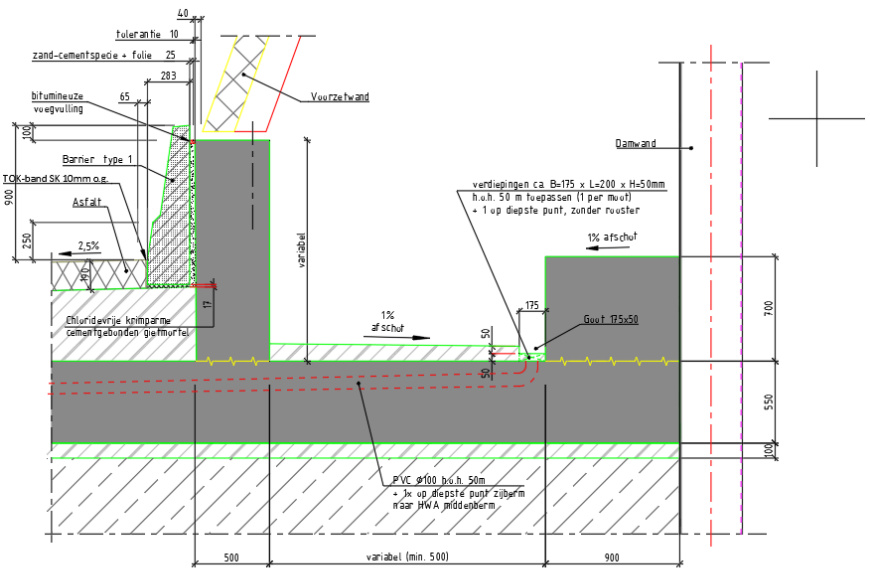
In the preliminary design the Civil 3D model is still the basic model added with 2D details to get a good overview of the design principles and all the needed tolerances.



Doorsnede t.p.v. mootvoeg middenberm barrier

Schaal 1:20

Figure 6: AutoCad PD Detail



Doorsnede t.p.v. mootvoeg zijberm hoge zijde

Schaal 1:20

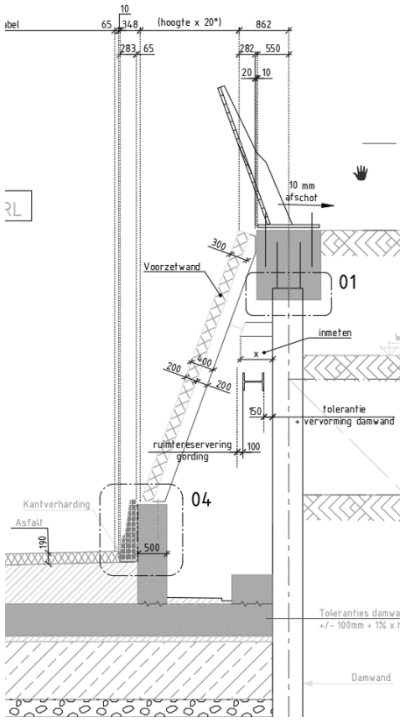
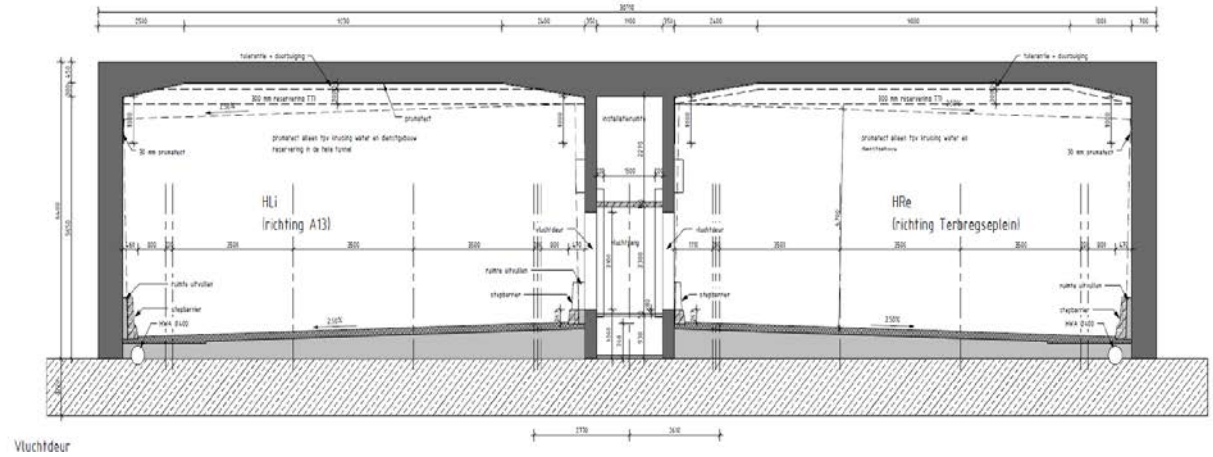
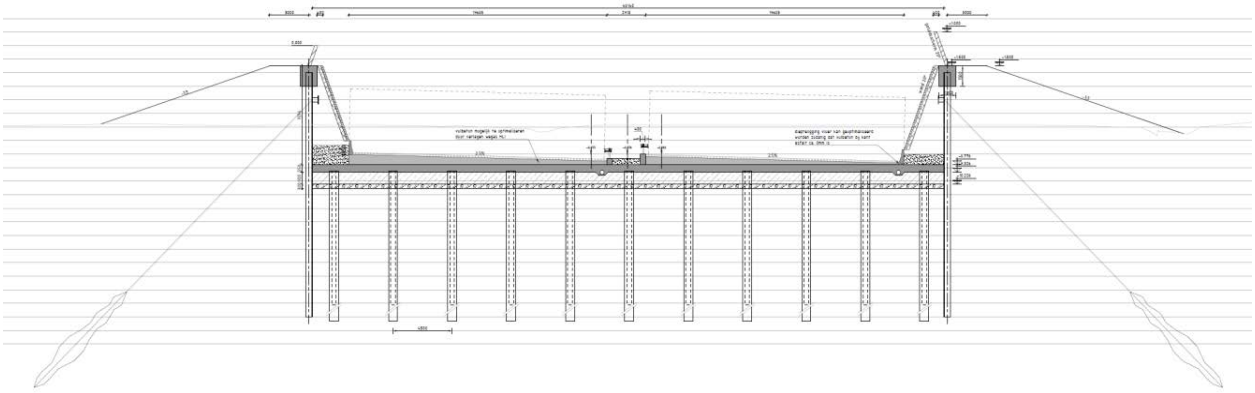


Figure 7: AutoCad PD Details



Tunnel – half deepend (not in the scope)

- **Reinforced** underwater concrete with screwed-combi piles
- **Temporary** sheet piles without anchors
- Without structural floor
- Fillings (Variable)
- Emergency tube
- 89 Segments x 25m (2,225 Km)



Access Ramps

- Underwater concrete with screwed-combi piles
- **Permanent** Sheet piles with anchors
- **Structural Floor**
- Fillings (Variable)
- Central emergency reservation
- **Cladding walls**
- 16 + 13 Segments (North = 400m+ South = 325m)

Final Design

For the final design a Revit model is required (by the BIM managers) for all civil structures.
With the BIM Execution Plan the development for the final design is defined.
Preperation and a good project approach good be defined for creating the Final Design Models

Model agreements

- Design shouled be done in 3D!
- All Structures with Revit
- **Detailed Revit Project manual**
    - Template
    - Project Basepoint / Shared Coordinates
    - File Name convention, include for families
    - View templates
    - Filters
    - Sheets / revision
    - (Shared) Parameters
    - Legends
    - Object styles & Subcategories (NLCS NL CAD Standards infrastructures)
    - Materials
    - Assembly codes
    - Cad Link / ~~Imports~~
    - 

    - Exports settings
        - DWG
        - NWC
        - IFC
    - Project Logbook

Model Division & Components

- Models North
  - Pit Model
  - Access Ramp Model
  - Specials, Pomp Room
- Models South
  - Pit Model
  - Access Ramp Model

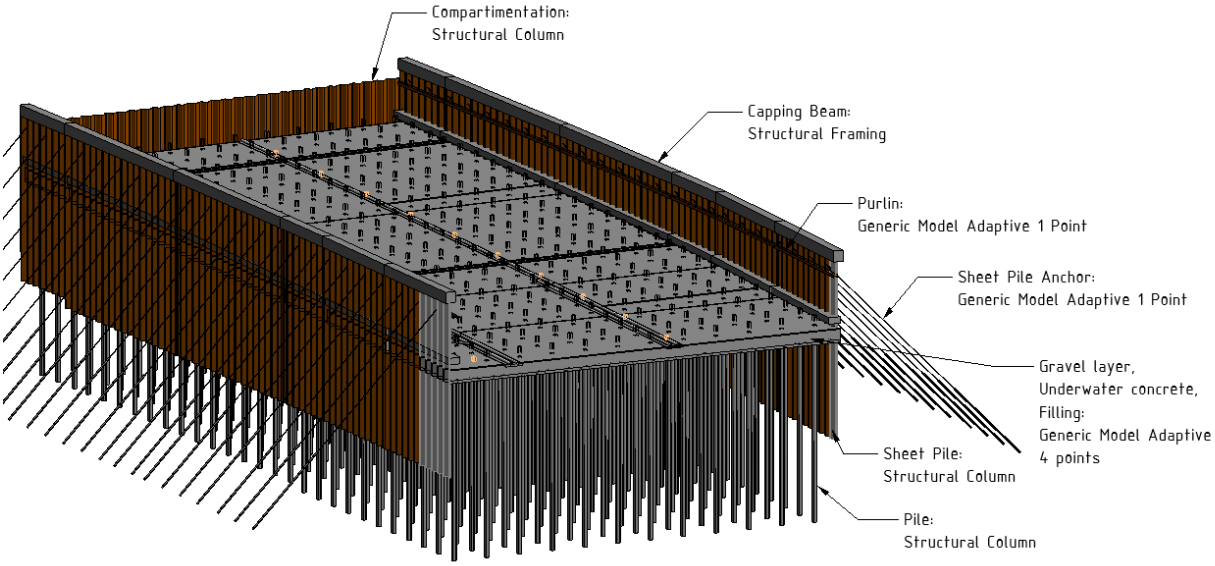


Figure 8: 3D overview construction pit

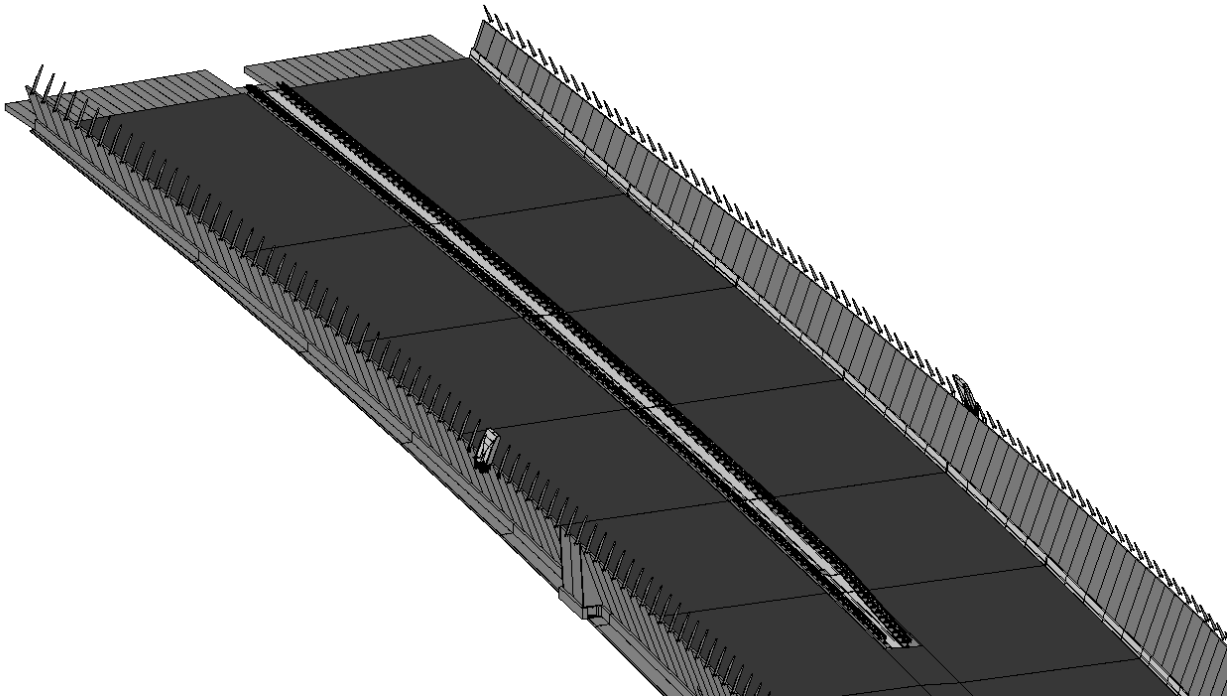


Figure 9: 3D access ramp north

Classification

Every element should be logically coded by:

- Assembly Code
- Location properties
    - Segment Numbers
    - Main Road (Left, Right)
    - Side (In- or ex- terroir)

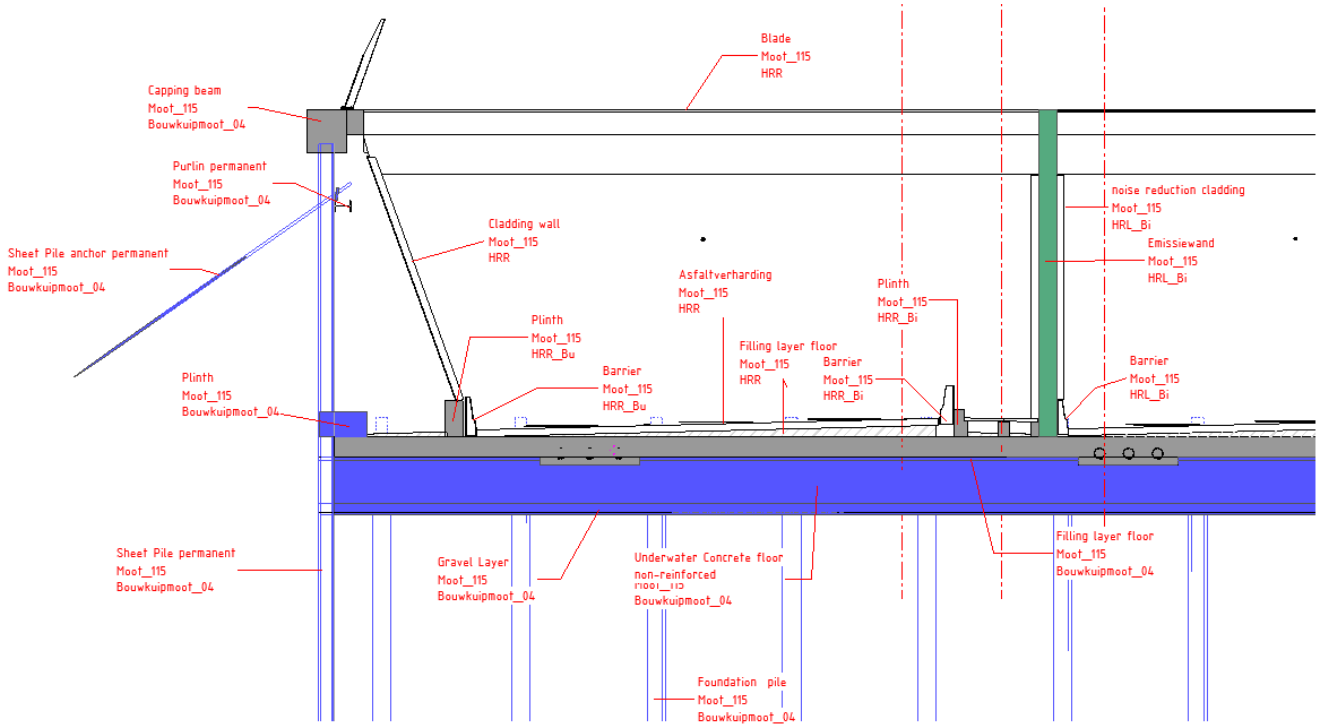


Figure 10: Classification

Preparation Final Design (FD)

Project Approach FD

- Continuity Tender Model
- Digital Engineering
    - Parametric design
    - Scripting
    - Applications
        - **Civil 3D**
        - **Revit**
        - **Dynamo**
            - CivilConnection Package

Figure 11: brainstorm session

Trade off Matrix

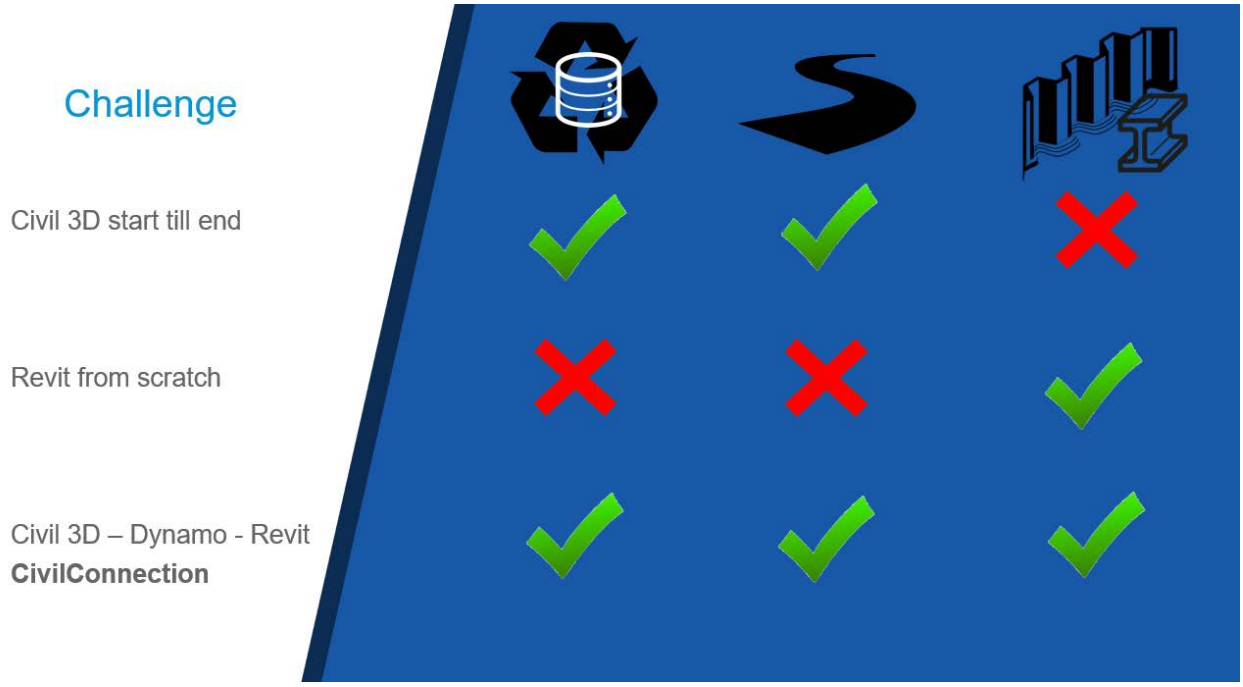
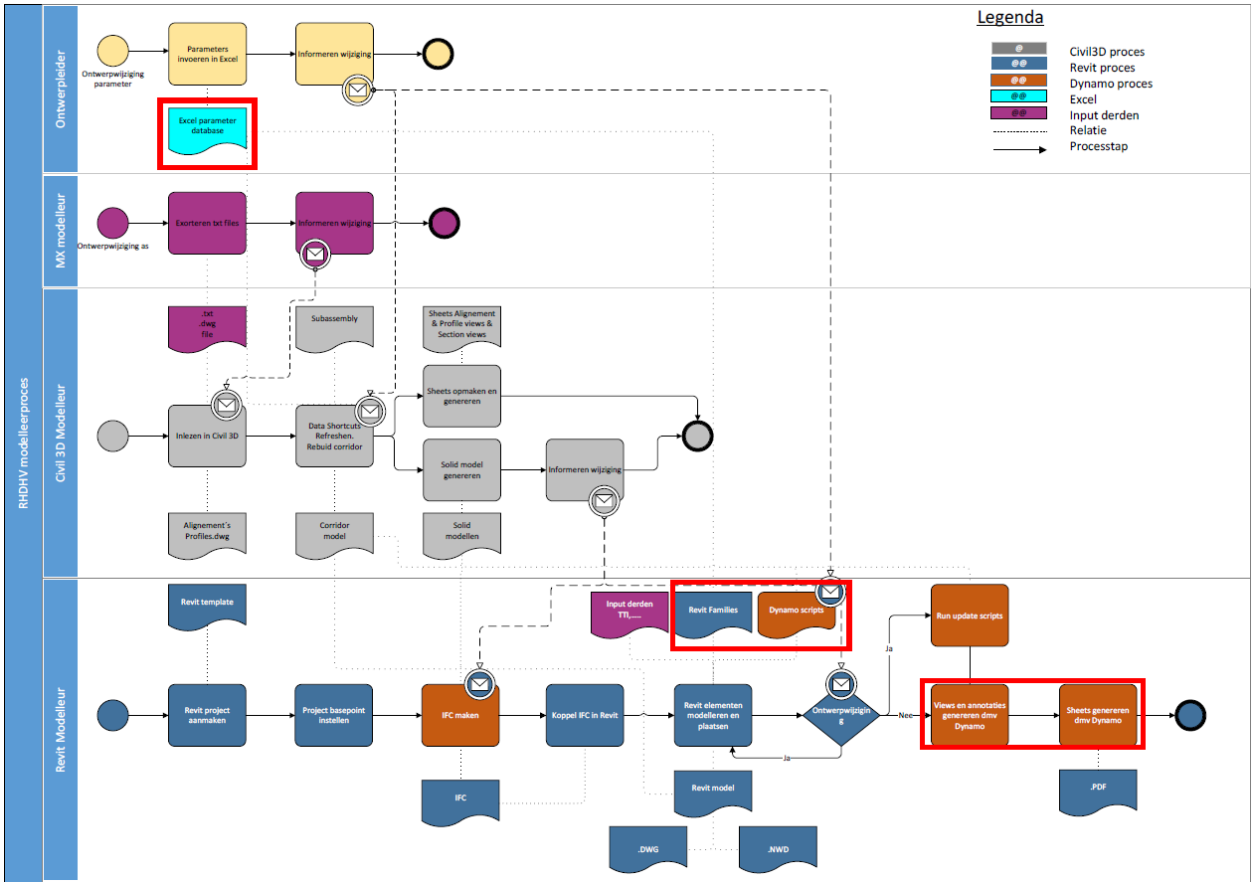


Figure 12: trade off matrix

Workflow

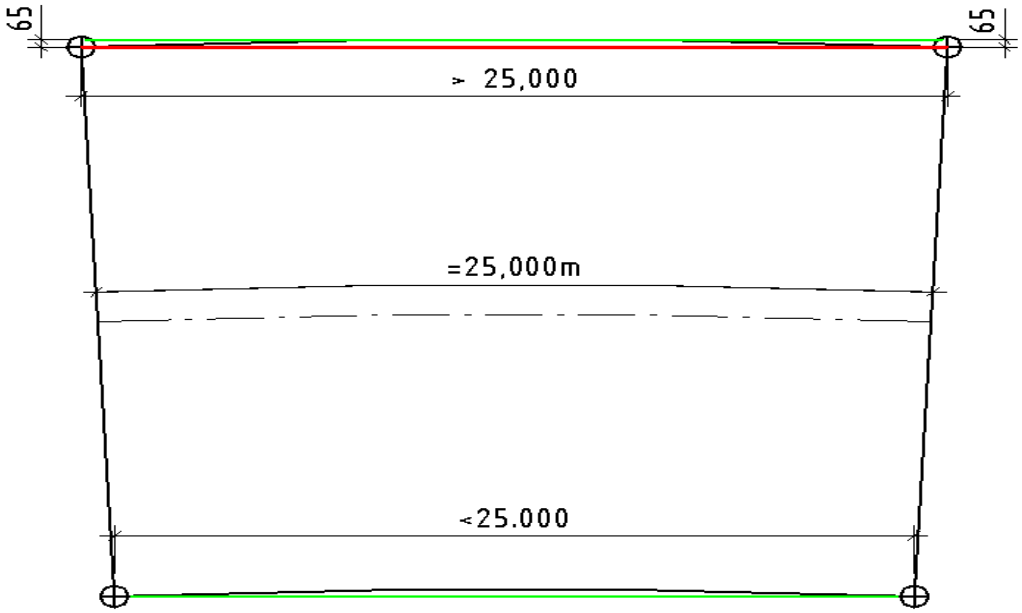
- MX (Road Design0
- Design Parameters
- Design Changes
- Aplications
    - Civil 3D
    - Dynamo (CivilConnection)
    - Revit (Civil Structures)
- Document management Engineering Data (WIP)
    - Vault
    - BIM 360

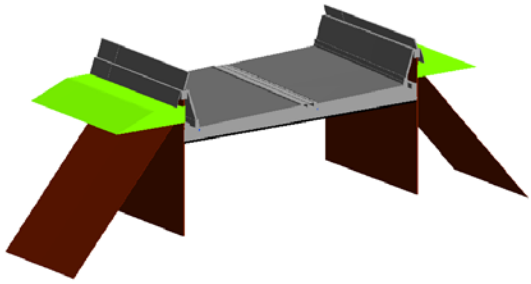


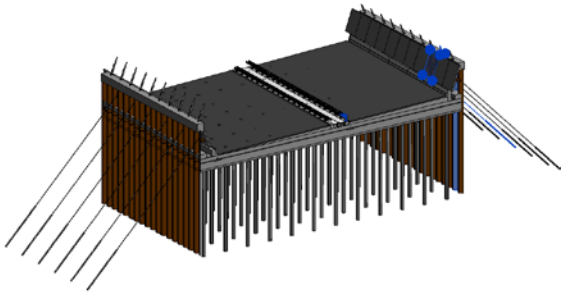
- *Figure 13: workflow scheme*

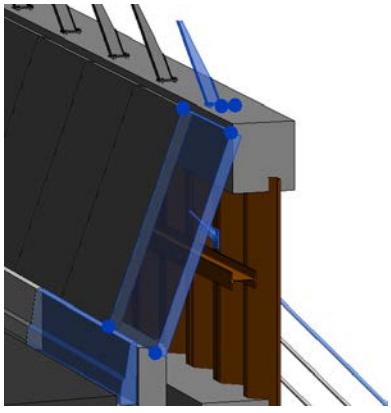
Civil 3D Vs Revit

Linear Curved	vs	Straight Segments
Corridor segment 25 m	vs	Discrete objects, Elements 2,5m/ 5m









Setting up the Civil 3D model

Civil 3D is the common Application for linear orientated infrastructure projects. Civil 3D has multiple options for 3d modeling. For this class we mainly will look at the Corridor modeling part of Autodesk Civil 3D.

When wanting to use the Dynamo CivilConnection package, the Civil 3D model needs to be set up correctly. This chapter will explain how to code your model so it can be read in Dynamo.
It will also give a short introduction to the Civil 3D basics that are needed to setup the Civil 3D model.

Corridor modeling basics

When building a Corridor 3 elements are important:

- **Alignement** - Horizontal Alignement
- **Profile** - Vertical Alignement
- **Assembly** - Basic section profile

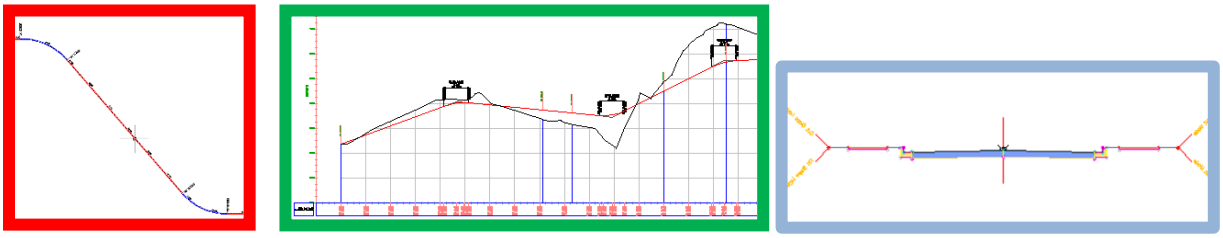


Figure 14: Civil 3D Alignment, Profile and Assembly

These 3 are required when building a Corridor. When buiding a Corridor the Assembly will be placed on a defined frequency and part of the alignment and the Corridor is formed.

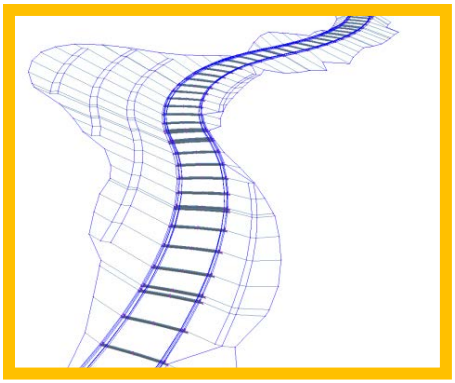


Figure 15: Civil 3D Corridor

The Subassembly

An important part of the assembly is the subassembly. The subassembly defines which parts of the Corridor are generated, by using **P**oint-, **L**ink- and **S**hapecodes.

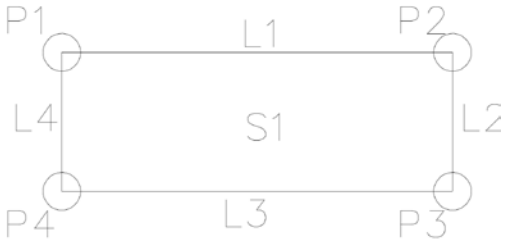


Figure 16: Civil 3D Subassembly codes

The Points from the subassembly define the Corridor featurelines. In the Corridor, the Points with the same code are connected. This is the Corridor FeatureLine.

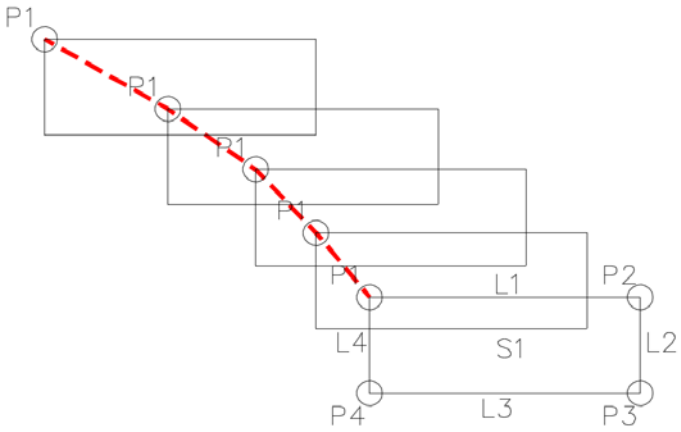


Figure 17: Civil 3D Corridor featureline connection

The Autodesk out-of-the-box subassemblies can be used and edited to add codes to subassemblies. And there is also a possibility to create custom subassemblies in the Subassembly Composer.

The Autodesk® Subassembly Composer provides an interface for composing and modifying complex subassemblies, without a need for programming.

For this case a custom subassembly was created in the subassembly composer.

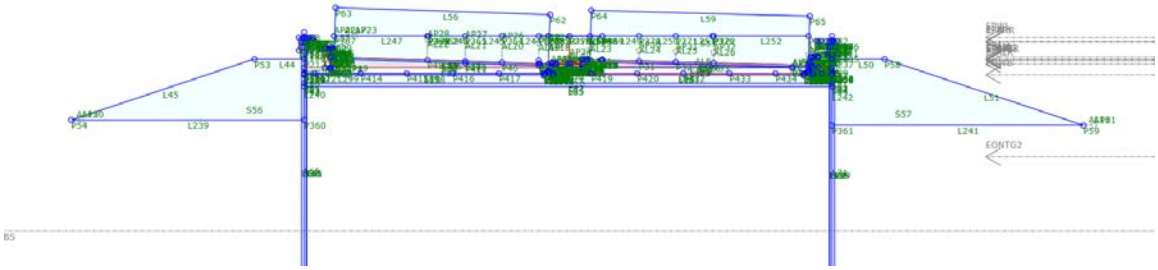


Figure 18: Subassembly composer

Adding points to the Subassembly

The point codes are added to a subassembly in the subassembly composer or you can add it to the pre-defined fields in the properties window in Civil 3D.

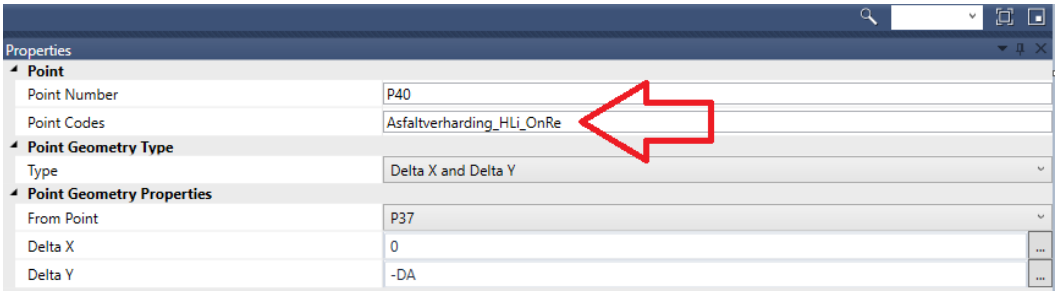


Figure 19: Adding Point Codes to the Subassembly composer

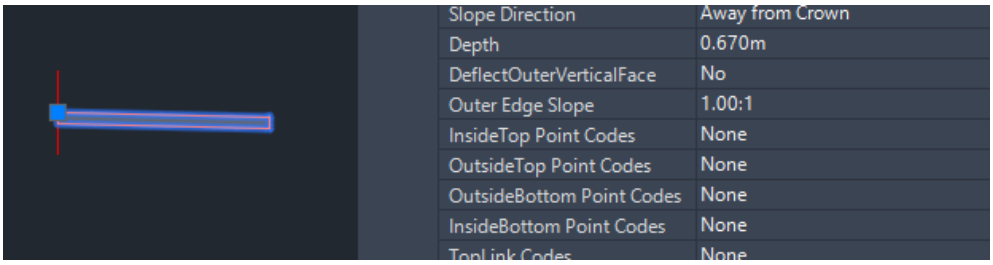


Figure 20: Adding Point Codes to the Subassembly in Civil 3D

Adding points to the corridor

When the point codes are filled in you need to check if they are also added to the corridor. The Code Set Style the Corridor uses, must contain the codes you added to the subassembly.

Go to the Settings tab, General \ Multipurpose Styles \ Codes Set Styles and right-click to edit the Code Set Style you want to change.

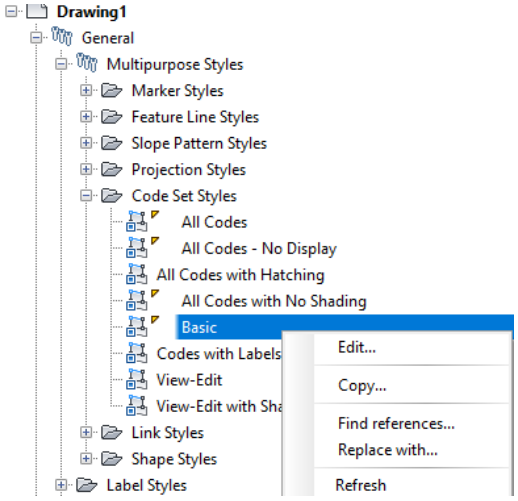


Figure 21: Adding Point Codes to the Subassembly in Civil 3D

With import codes, you can select your subassembly to add the codes to the Code Style Set used for the Corridor.

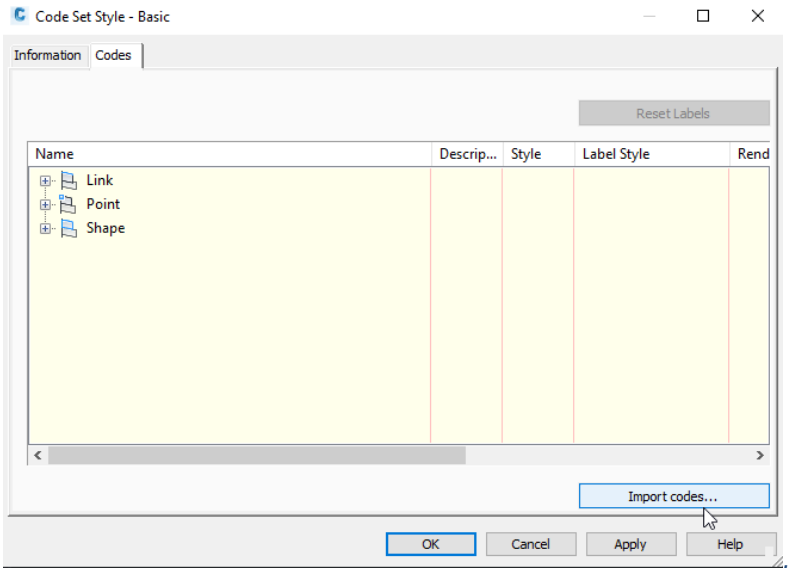


Figure 22: Import Codes to the Code Set Style

Now the codes are added to the Corridor and recognized when reading it into Dynamo via the Civil Connection Package.

The Corridor.GetFeaturelinesByCode can be used to read the Corridor Feature lines.

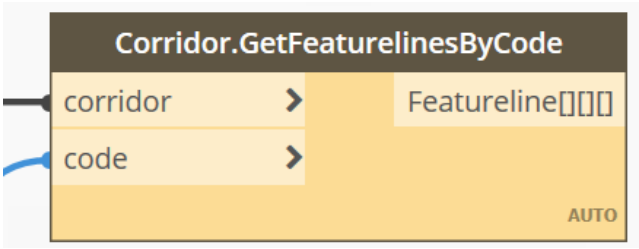


Figure 23: Dynamo Node Corridor.GetFeaturelineByCode

The node will look at the PointCodes of the specific featureline and will then use it.

Dynamo for Revit

To make the dynamo scripts readable for other users we made some agreements

Dynamo legend

Group nodes by topics
Give general information about the script
Needed instructions
Known issues
Used packages

Figure 24: Dynamo Legend

Group colors

In the legend we use a different color for used nodes from a Dynamo packages.
This red color isn't available in the standard group colors of Dynamo

Figure 25: standard Dynamo group colors

To change the group color we are using a Dynamo add-in named *Beyond Dynamo*

Beyond Dynamo

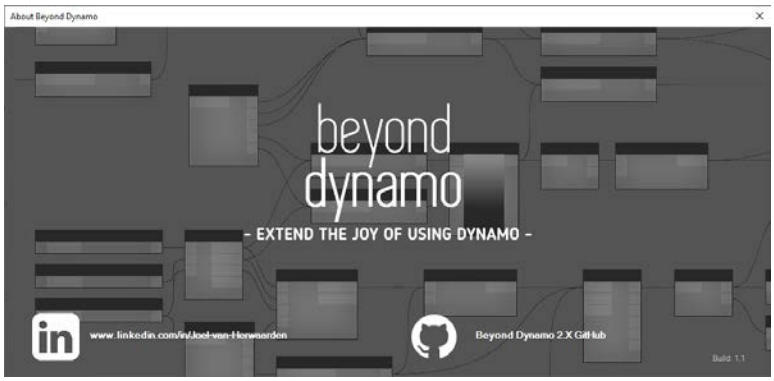


Figure 26: about Beyond Dynamo

https://github.com/JoelvanHerwaarden/BeyondDynamo2.X

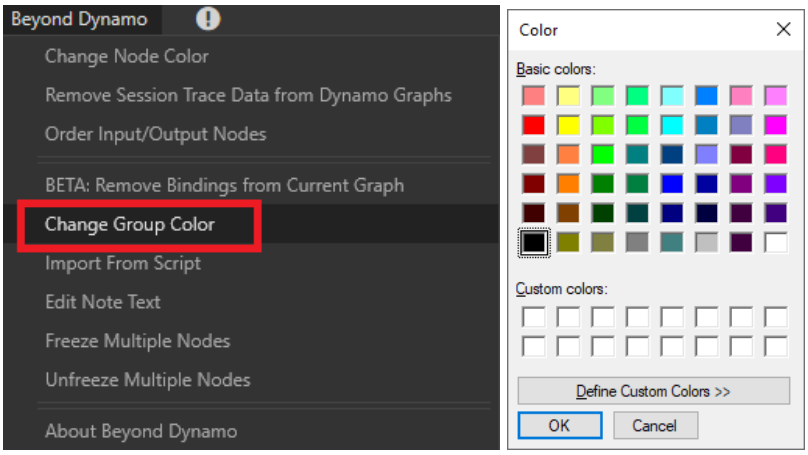


Figure 27: Change group color Beyond Dynamo

Parts By Component

Creating a group with 2 note nodes and a big (Font Size 96) clear title name above the relevant nodes for the components will help to order your script

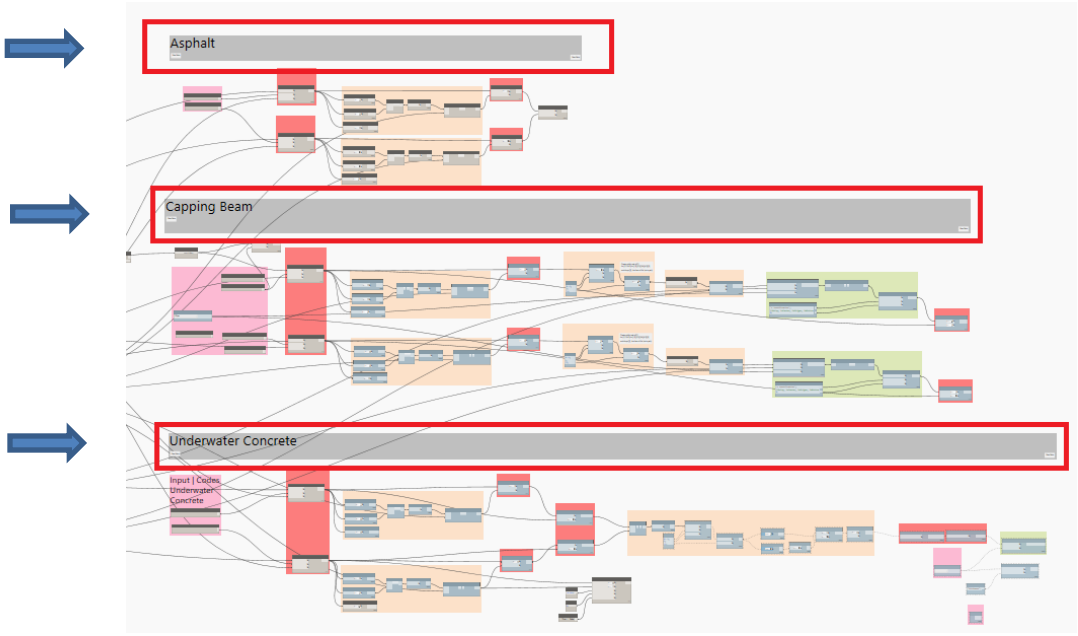


Figure 28: parts by component

Rename Groups and Nodes

Renaming the group name and also the node name with a clear description will help to make the script readable for others

Rename the node <OriginalName><Space><Vertical line><Space><Clear Description>

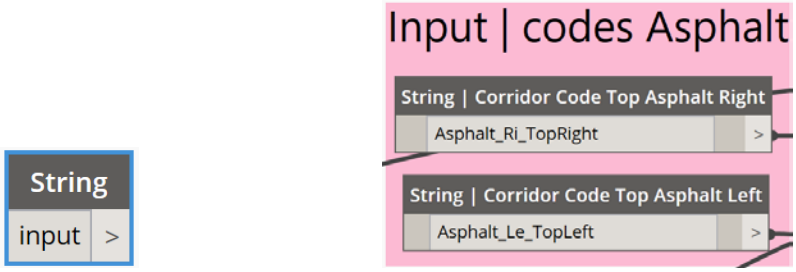


Figure 29: rename string

CivilConnection Package

CivilConnection is a package for Dynamo for Revit that connects Revit and Civil 3D. The package enables prototyping and interoperability between the two modeling environments.

Autodesk Consulting has developed this package to support the linear Structure Model Authoring workflow.
Linear structure Workflow Guide.pdf
Or …\AppData\Roaming\Dynamo\Dynamo Revit\2.2\packages\CivilConnection2020\extra

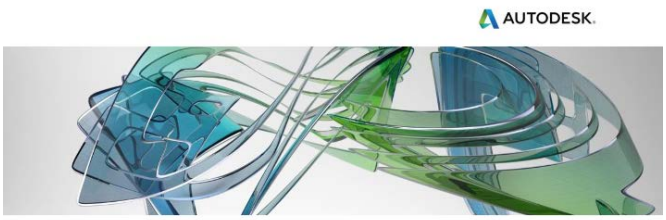


Figure 30: Linear Structure Workflow guide

The Dynamo CivilConnection package can be installed through ***Packages > Search for a package..*** in Dynamo for Revit.

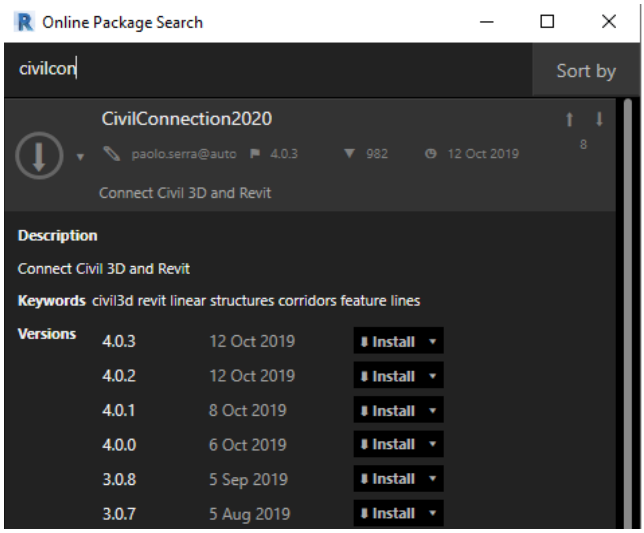


Figure 31: CivilConnection Package install

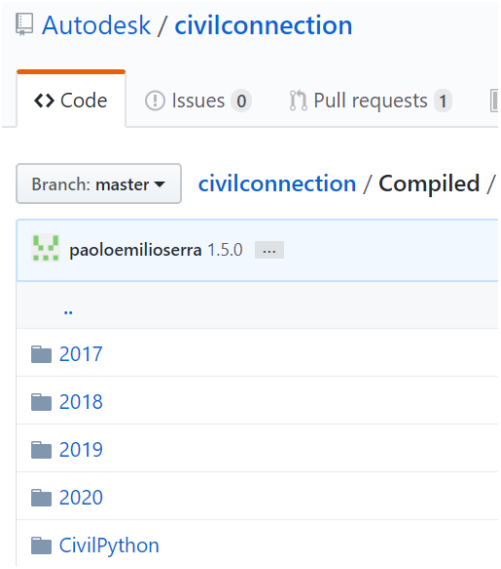


Figure 32: CivilConnection github

https://github.com/Autodesk/civilconnection

CivilPython Installation

CivilPython is also needed to let CivilConnection work properly.
Make sure the CivilPython.bundle folder is copied to.
C:\ProgramData\Autodesk\ApplicationPlugins

CivilConnection Example Nodes

CivilApplication

Get the DocumentName from the Civil 3D Application

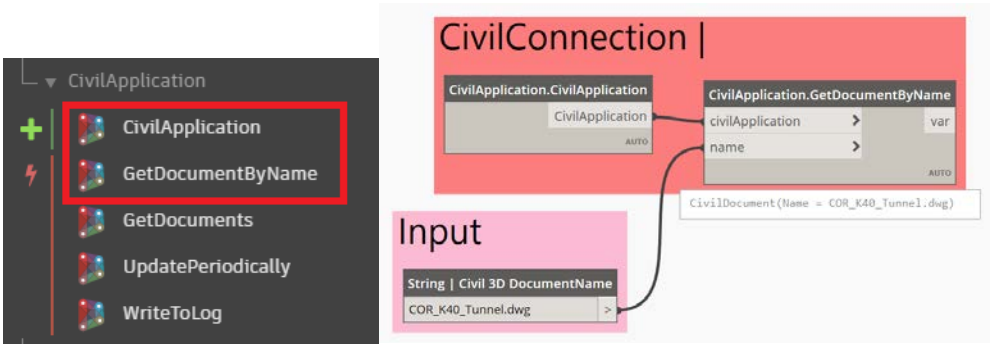


Figure 33: CivilConnection nodes; CivilApplication and GetDocumentByName

CivilDocument

From the Civil DocumentName read the alignements and Corridors

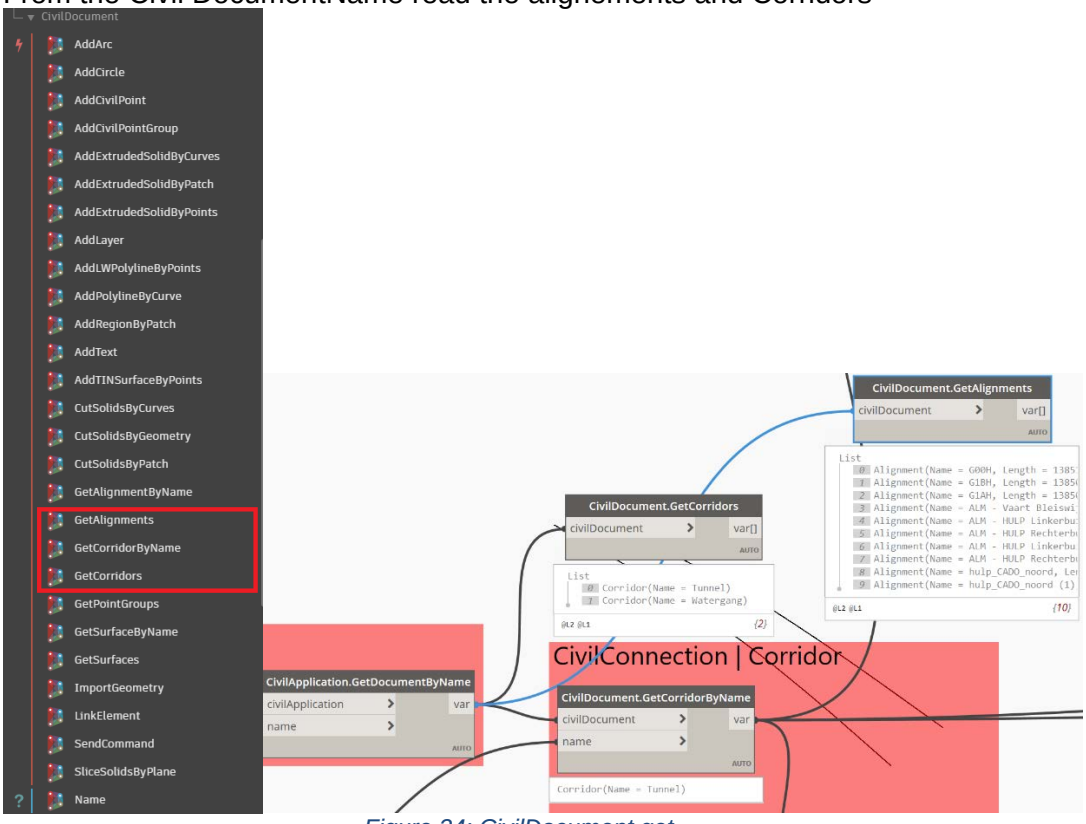


Figure 34: CivilDocument get…

Corridor

From the corridors get the Codes and Featurelines (By Station)

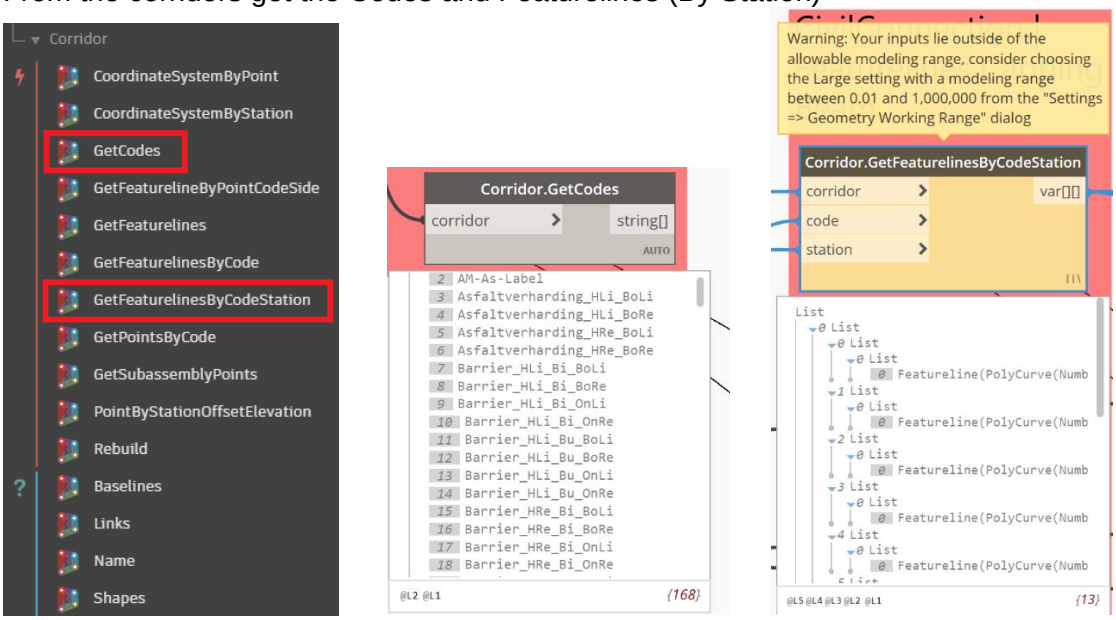


Figure 35: CivilConnection, corridor.Get..

Warning: about Geometry Working Range see Linear Structures Workflow Guide

…\AppData\Roaming\Dynamo\Dynamo Revit\2.2\packages\CivilConnection2020\extra

Featureline

From the Featurelines get the curves or points on the featureline by station.

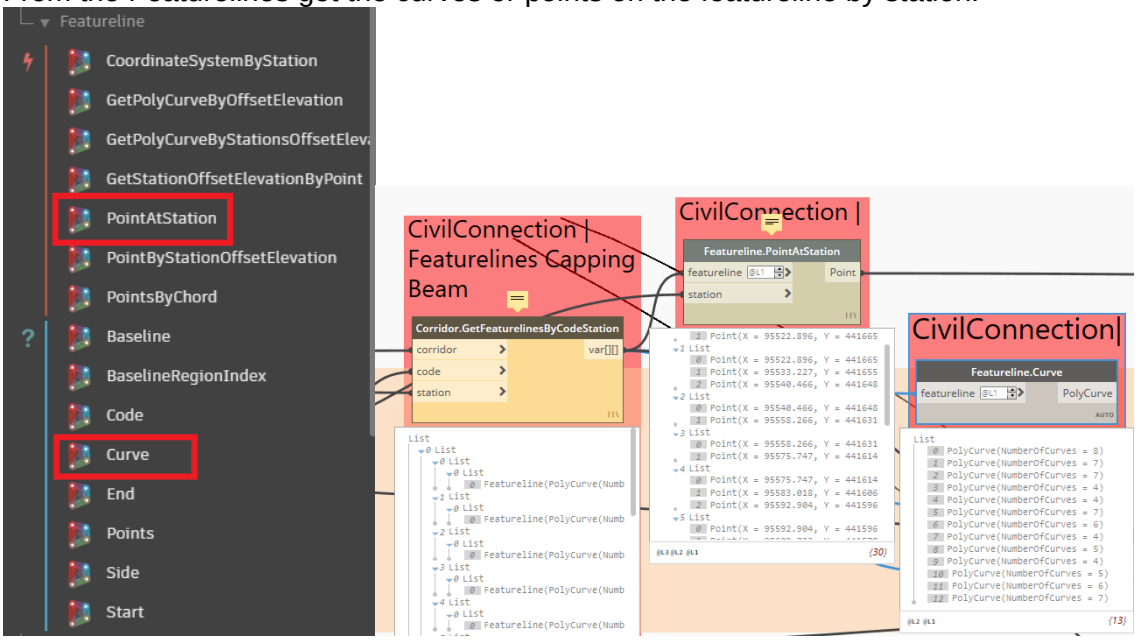


Figure 36: CivilConnection, Featureline

RevitUtils

with the curves and points create Revit Elements and assign them to featurelines

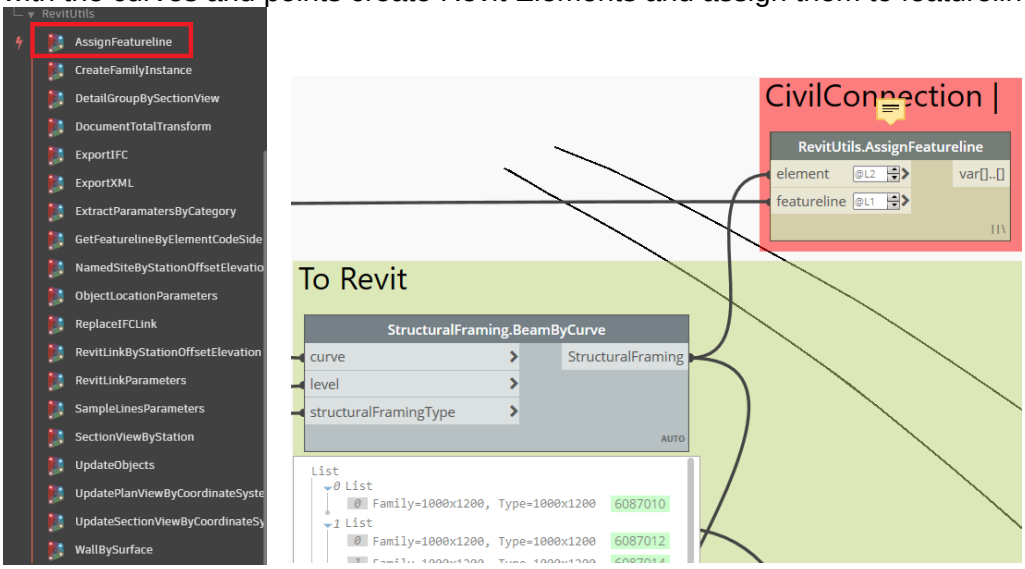


Figure 37: RevitUtils, assign featureline

In Revit there are ADSK Parameters created by CivilConnection with Civil 3D data

Data	
ADSK_Corridor	Tunnel
ADSK_BaselineIndex	0
ADSK_RegionIndex	32
ADSK_RegionRelative	0.0004
ADSK_RegionNormalized	0.000011
ADSK_Code	Deksloof_HLi_BoMi
ADSK_Side	Left
ADSK_X	95733.7670
ADSK_Y	441485.8080
ADSK_Z	-0.5000
ADSK_Station	14534.4770
ADSK_Offset	0.0000
ADSK_Elevation	0.0000
ADSK_AngleZ	
ADSK_Update	☑
ADSK_Delete	☐
ADSK_MultiPoint	
ADSK_EndStation	14571.1300
ADSK_EndOffset	0.0000
ADSK_EndElevation	0.0000
ADSK_EndRegionRelative	36.6530
ADSK_EndRegionNormalized	1.000000

Figure 38: ADSK parameters

Work process

C3D | Extract Corridor Solid

From the Corridor model we need a 3D Solid Model.

1. Select the corridor

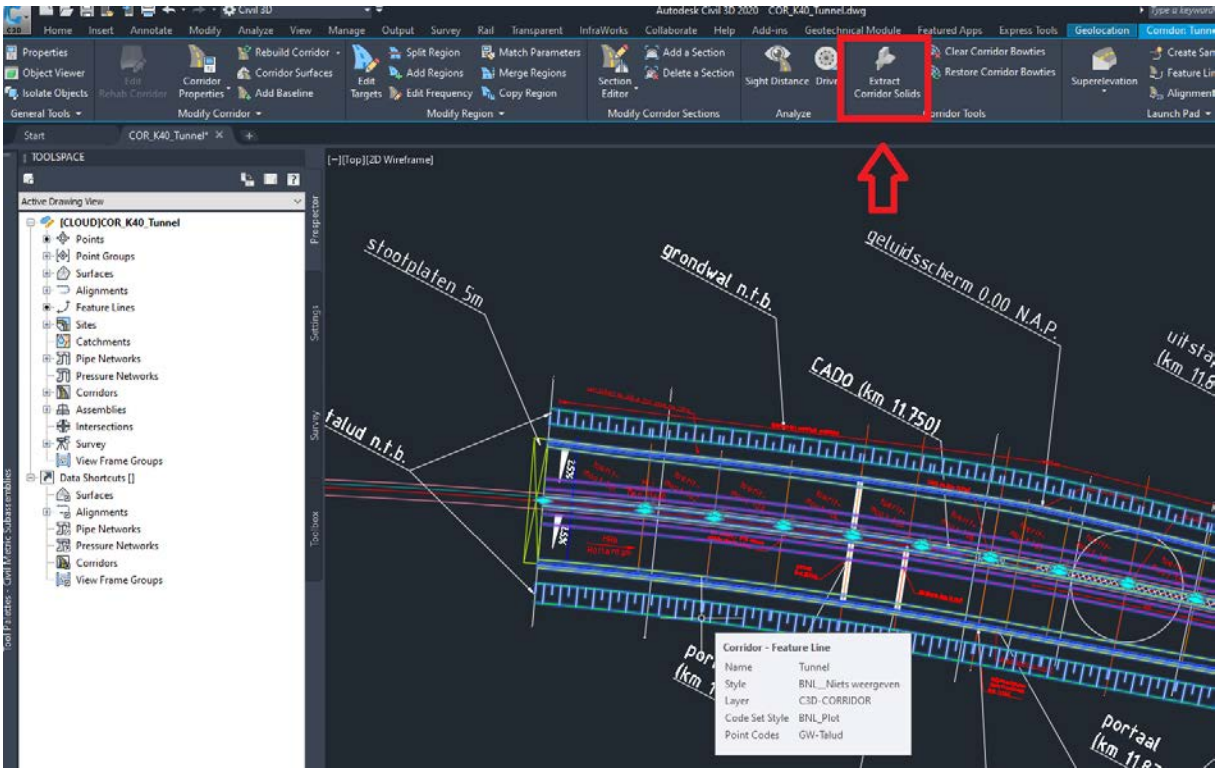


Figure 39: Civil 3D Extract Corridor Solid

2. From the ribbon choose the extract Corridor Solid Button
3. Select All regions [A]

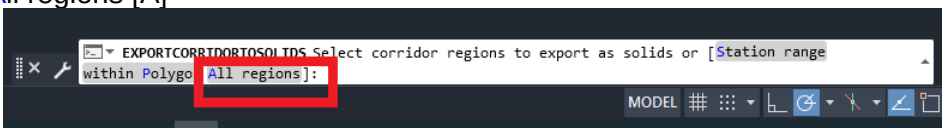


Figure 40: Civil 3D All Regions

4. The extract Corridor Solids Dialog box is shown

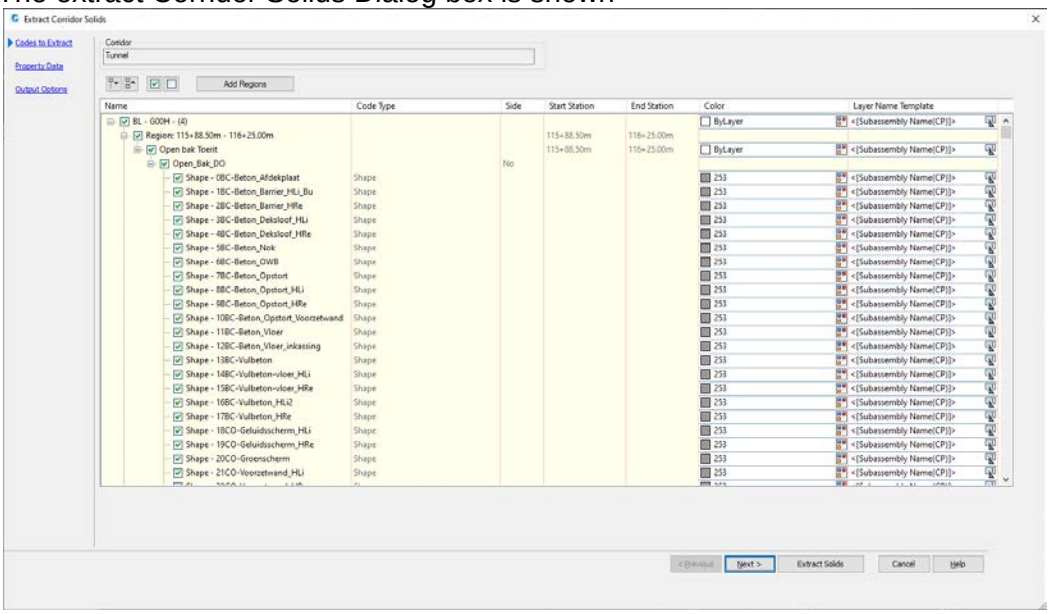


Figure 41: Civil 3D Corridor Solid Dialog box

5. Codes to extract | Make your selection

a. Regions

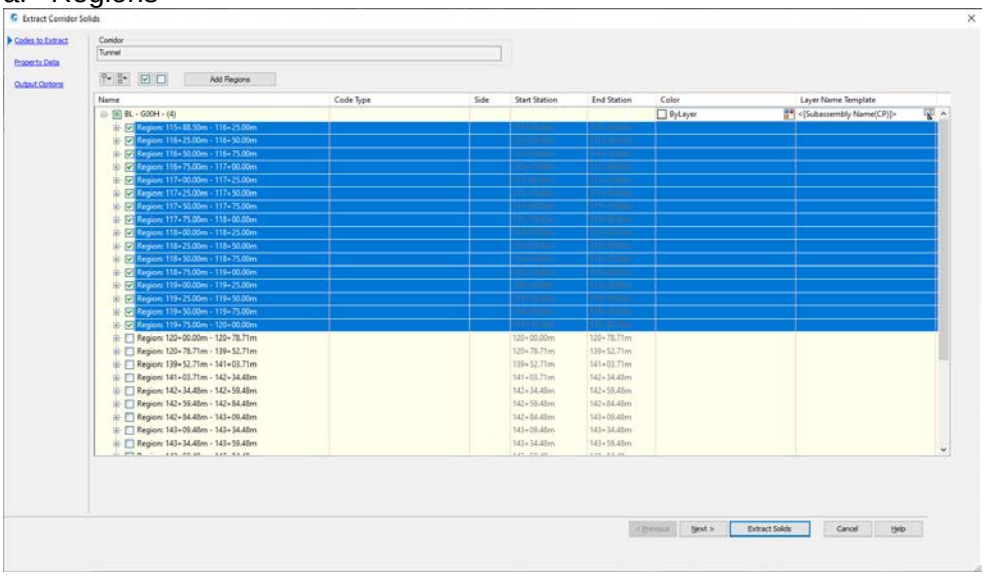


Figure 42: Civil 3D Codes to extract

b. No Link (turn them off)

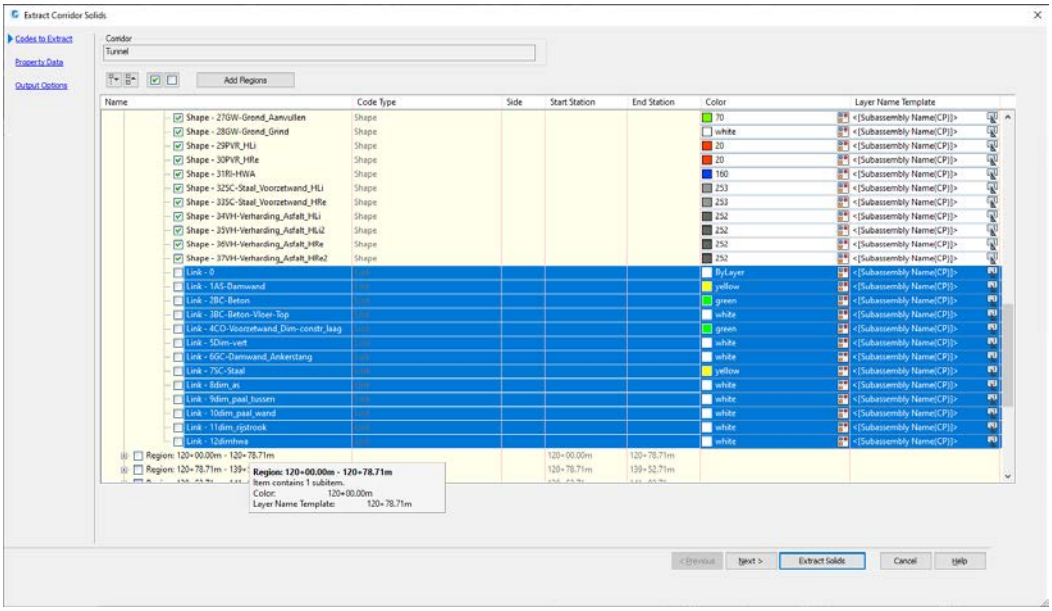


Figure 43: Civil 3D Corridor Solid Dialog box unselect Link

c. Avoid White Colors, Change them in Color 254

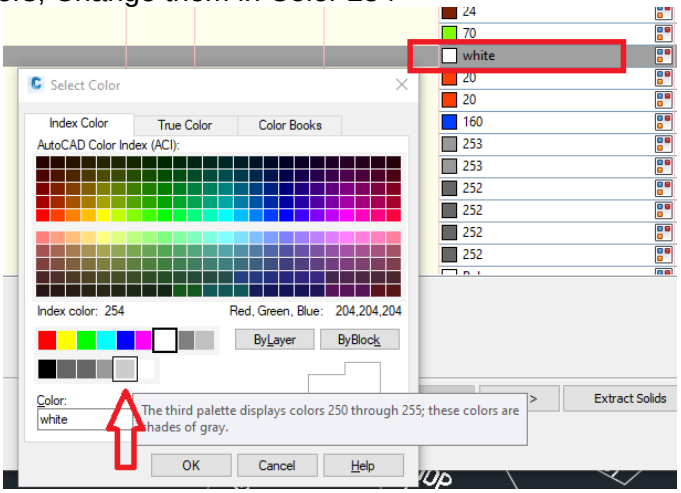


Figure 44: Civil 3D avoid white colors

d. Turn off unnecessary Shape

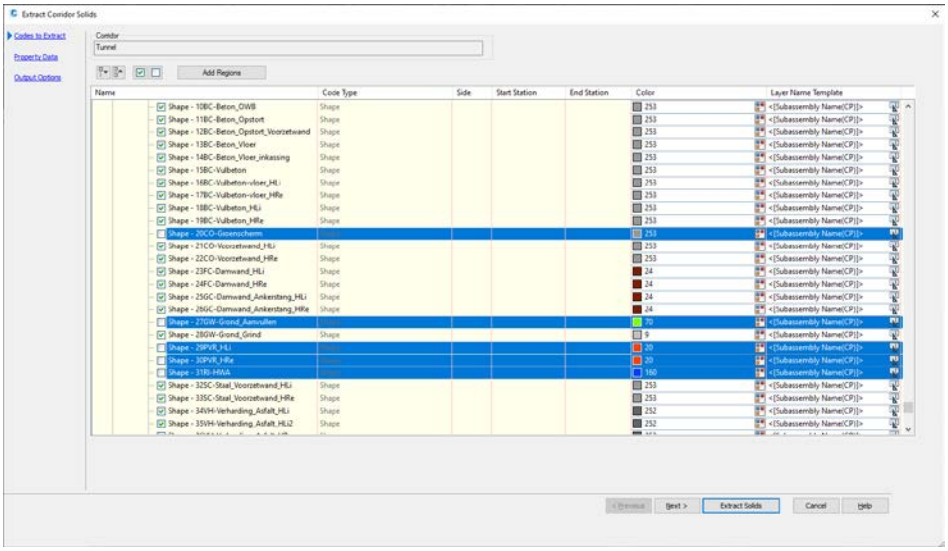


Figure 45: Civil 3D Corridor Solid Dialog box turn off unnecessary shapes

e. After finishing your selection Click next

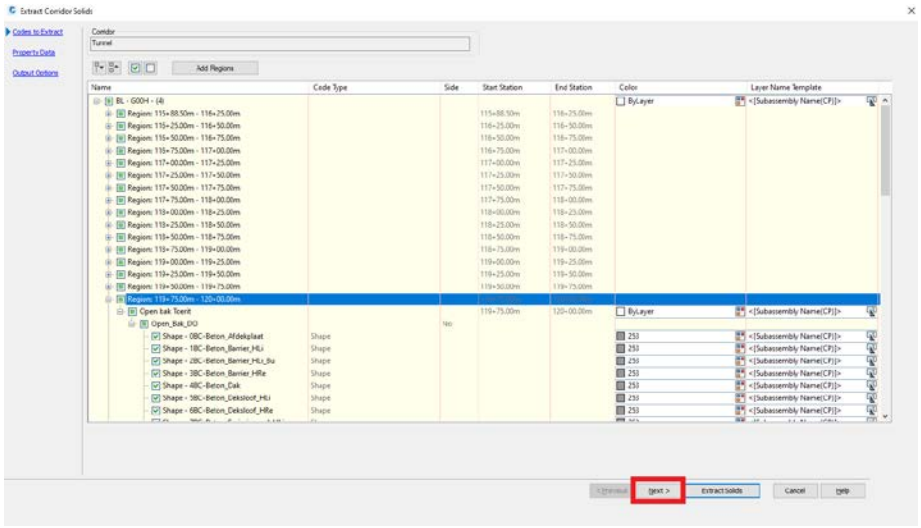


Figure 46: Civil 3D Corridor Solid Dialog box next

f. Property Data | as they are and click Next

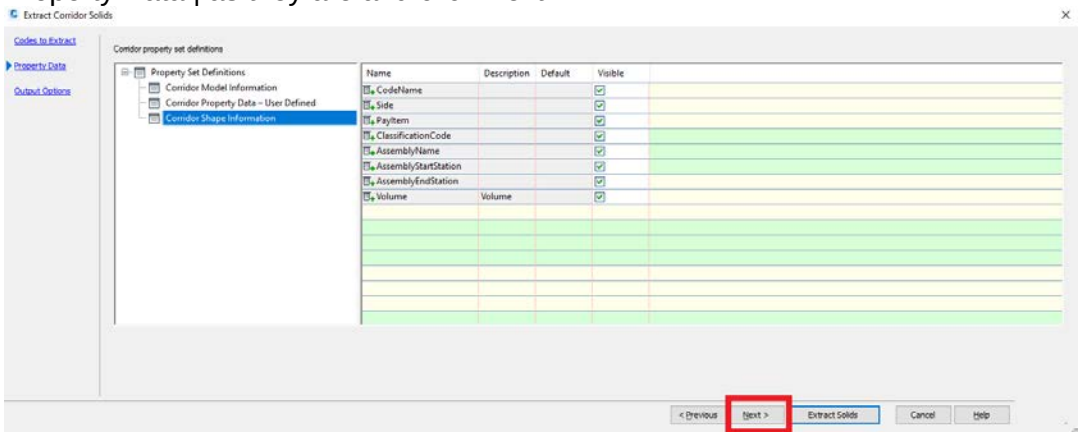


Figure 47: Civil 3D Solid Property data

g. Output Option | 1. add to a new drawing; 2.select output file

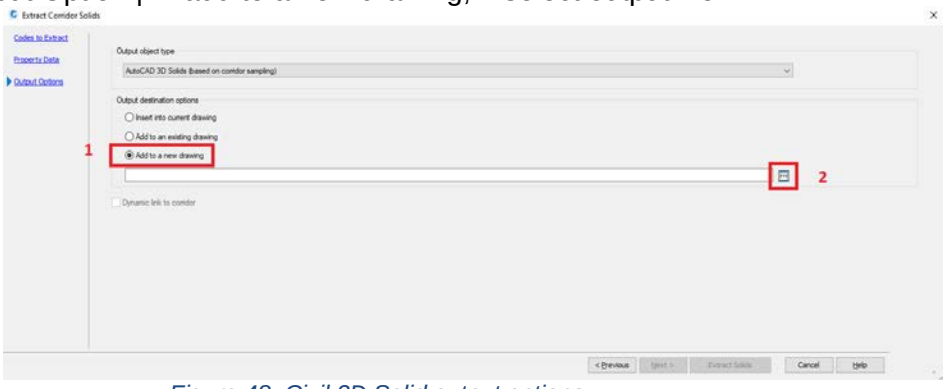


Figure 48: Civil 3D Solid output options

h. 1.Correct folder; 2.file name (Sol = Solid); 3.save

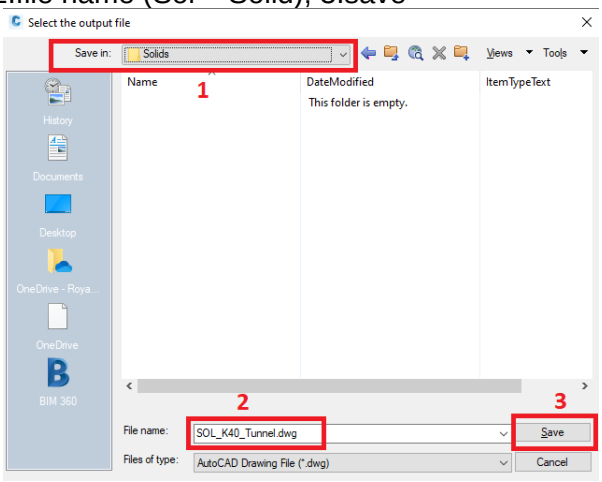


Figure 49: Civil 3D Solid file name

i. Extract Solids

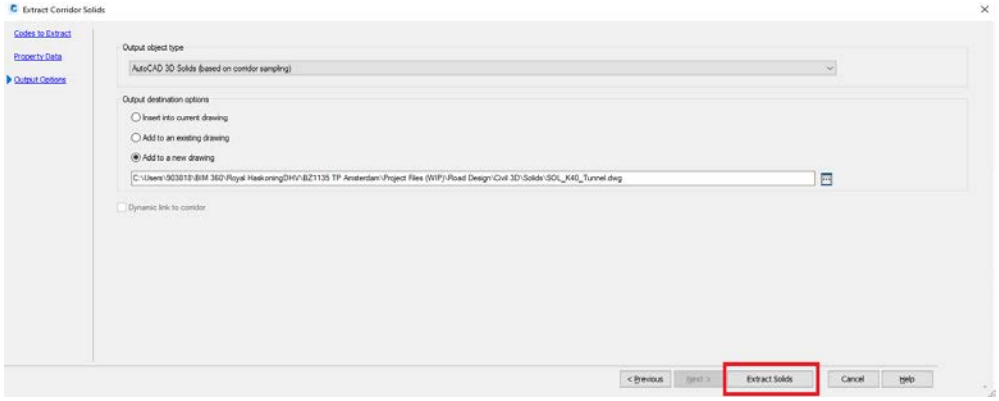


Figure 50: Civil 3D extract Solids

6. Open the Solid model file in C3D

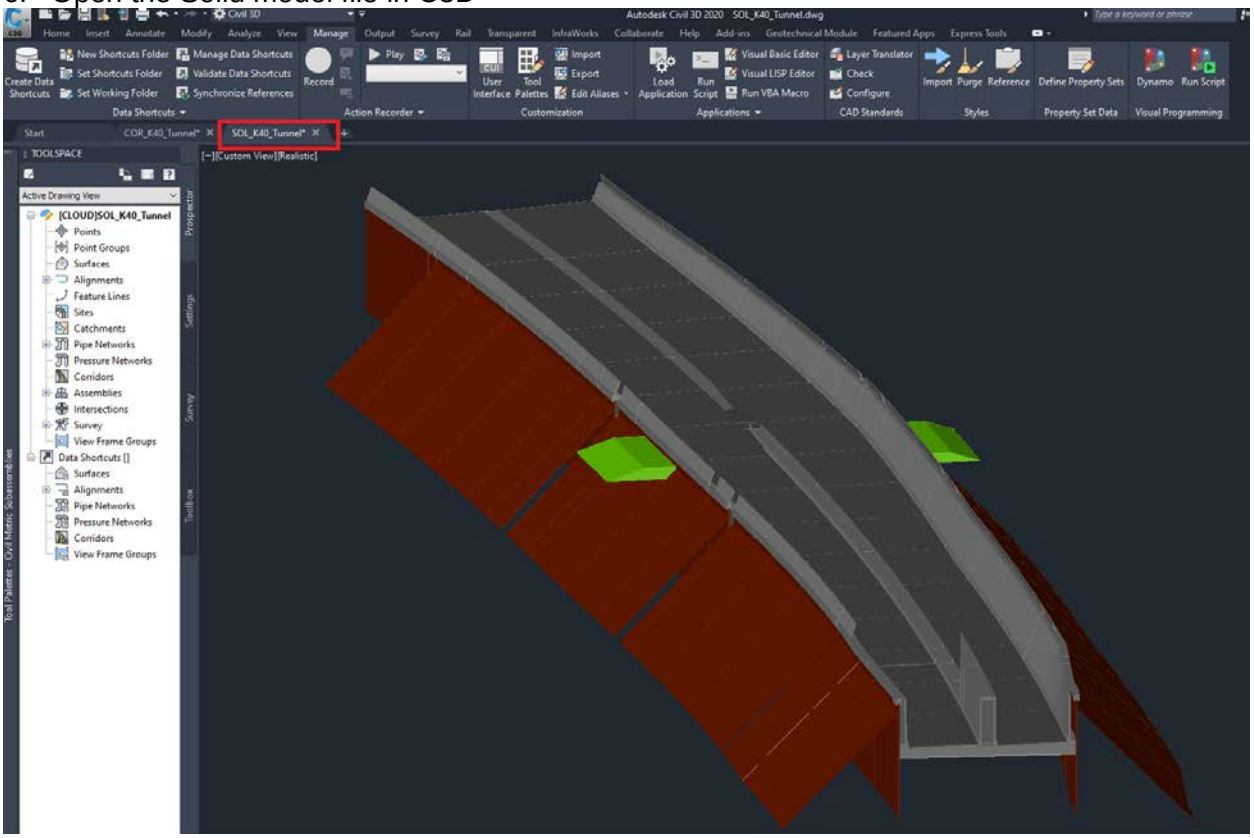
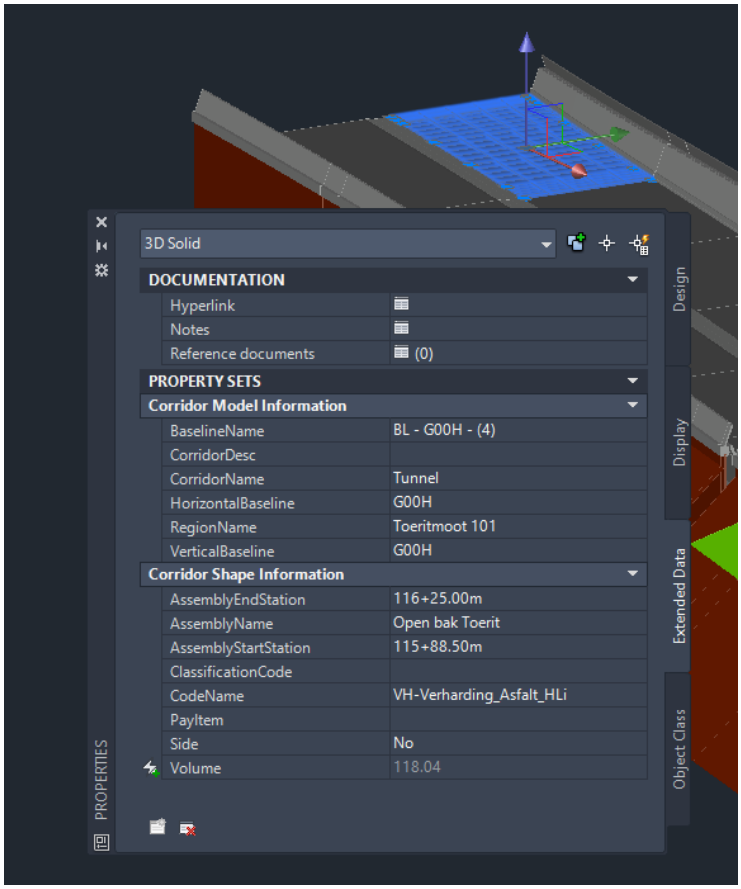


Figure 51: Civil 3D Solid model

C3D | Property Sets

Every solid in C3D has a property sets, with Corridor Model Information & Corridor Shape Information.



Dynamo | Extract Corridor Solid

1. Open Dynamo file CC_Export CivilSolids to IFC
2. Fill in CivilDocument and browse to path where your Revit file is saved

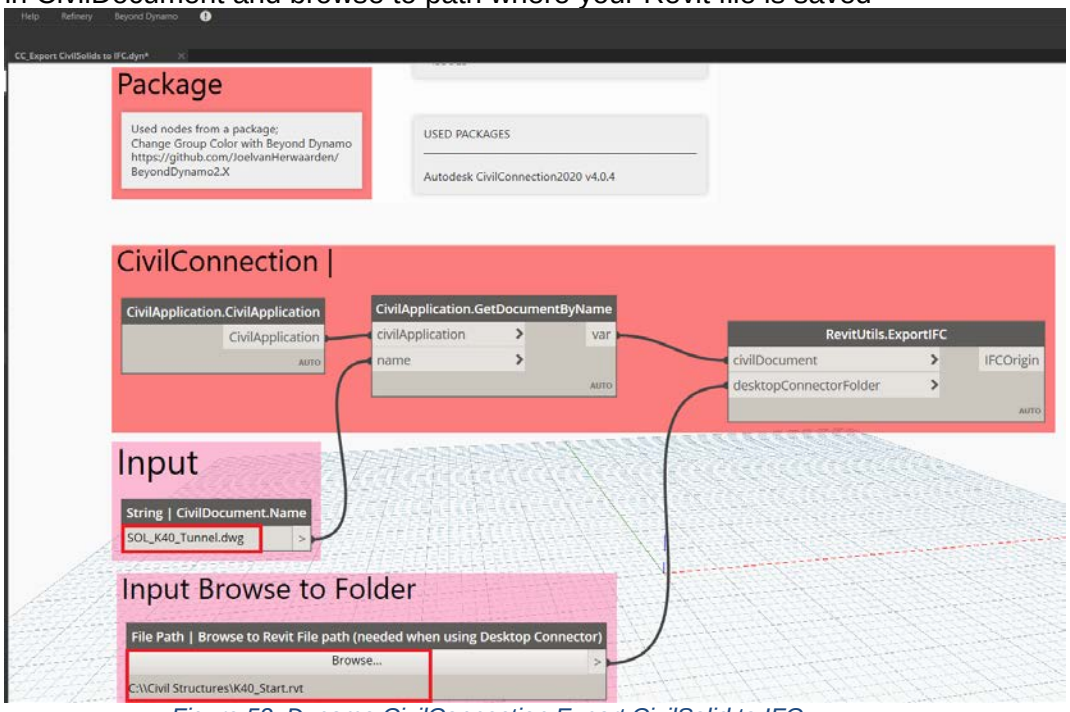


Figure 52: Dynamo CivilConnection Export CivilSolid to IFC

3. Run Dynamo script

4. Dynamo export a IFC from Civil 3D

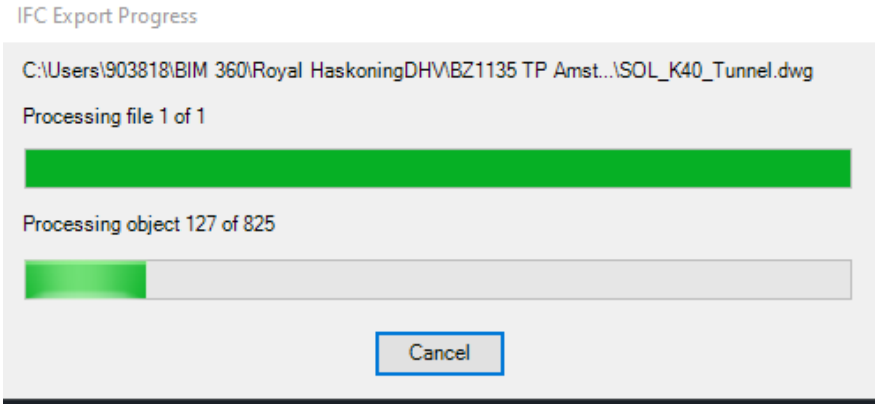


Figure 53: IFC Export Progress (In C3D)

Figure 54: IFCEXPORT

5. The IFC is named as your Civil 3D file with the suffix _Origin
6. Also a log file is created

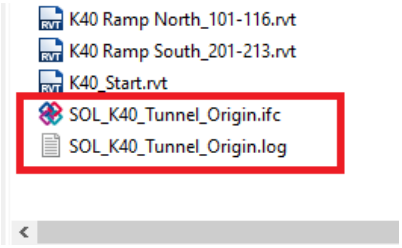


Figure 55: IFC solid file

Revit | Link the IFC

1. In Revit Link the IFC

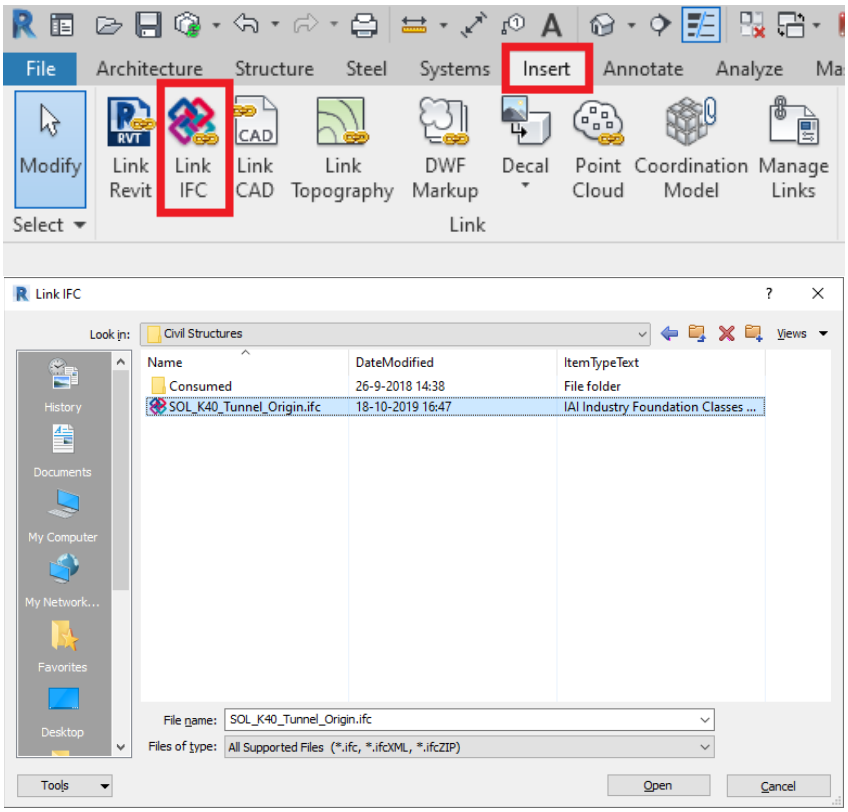
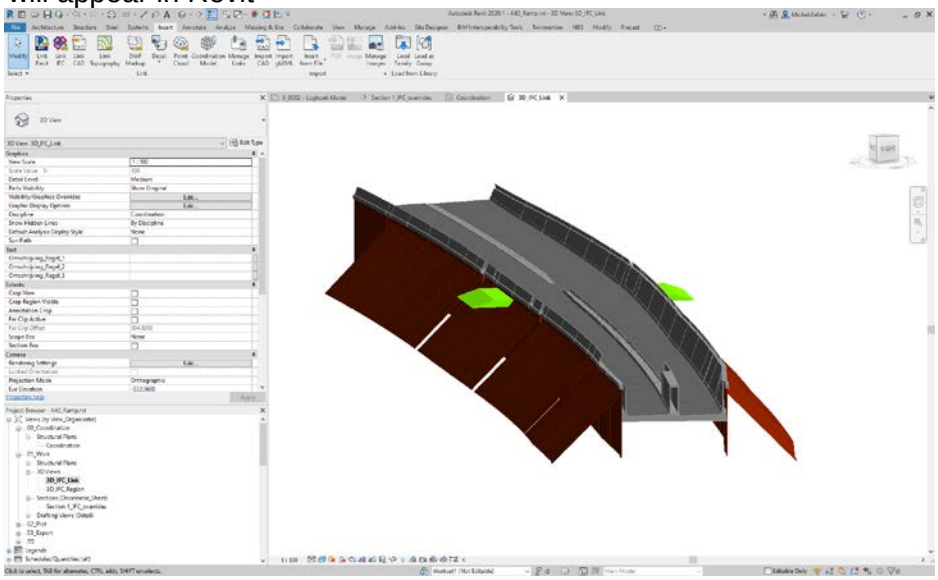


Figure 56: Revit Link IFC

2. The IFC will appear in Revit



3.

Figure 57: IFC in Revit

4. There are also new files created

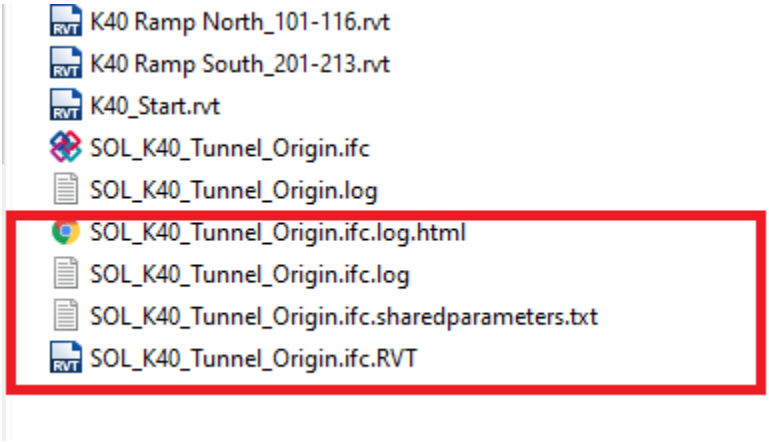


Figure 58: Origin.ifc files

Revit | C3D Shared Parameters

With linking the IFC in Revit the properties from C3D are visible.

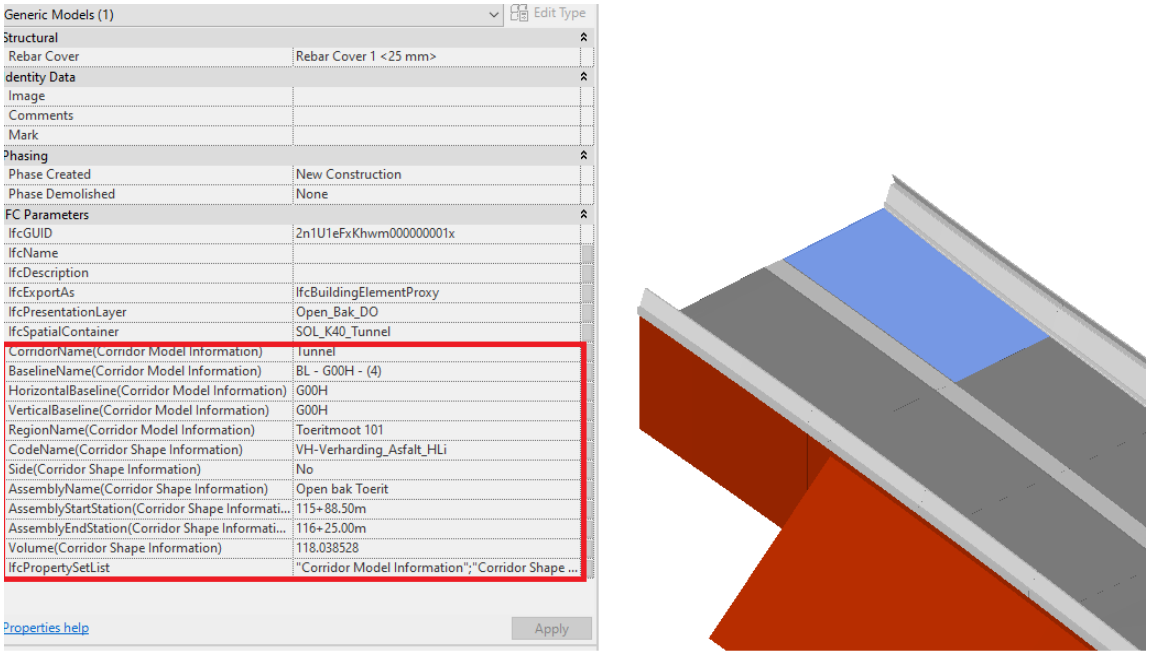


Figure 59: C3D properties in Revit

These are stored in a shared parameter file and can be add in Revit as a Project Parameter to use them for filtering your object.

add the project parameter from the shared parameter ***RegionName(Corridor Model Information)*** to create filters by RegionNames and play with the Region visibilities.

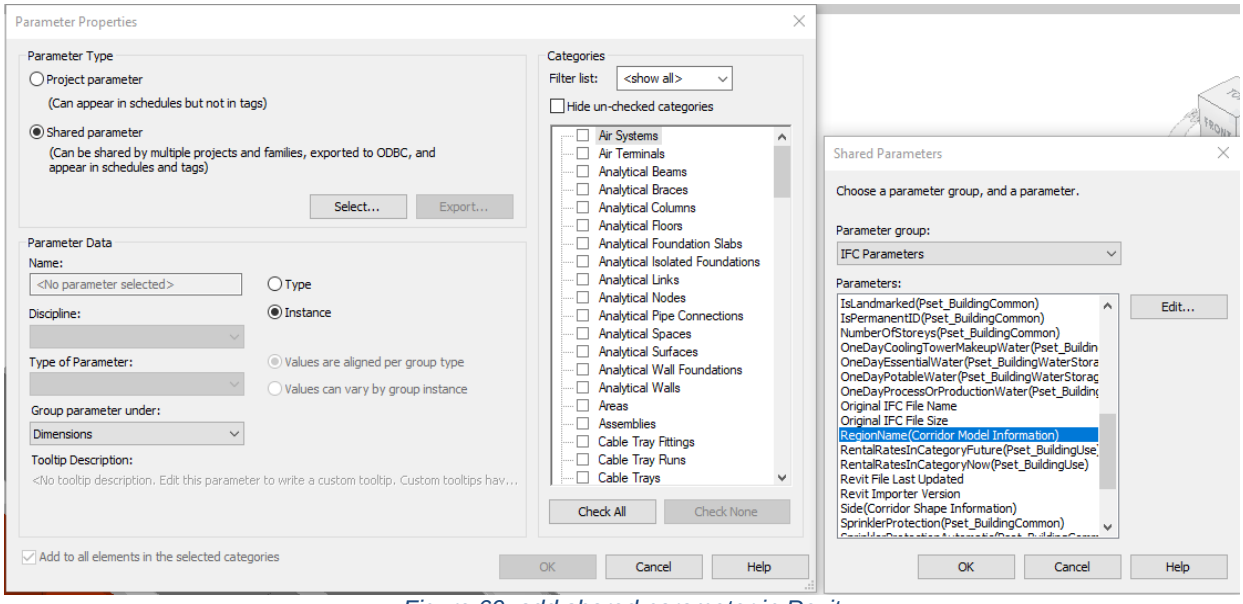


Figure 60: add shared parameter in Revit

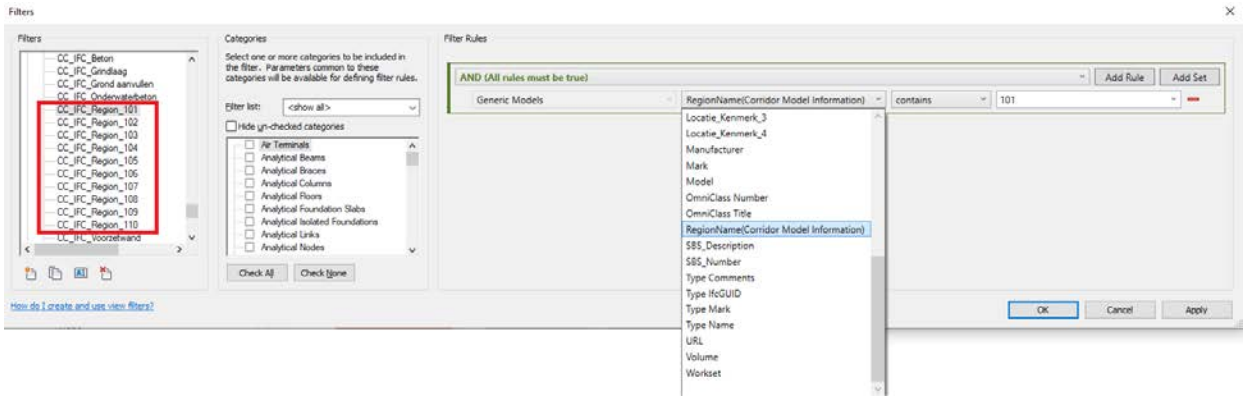


Figure 61: create region filters in Revit

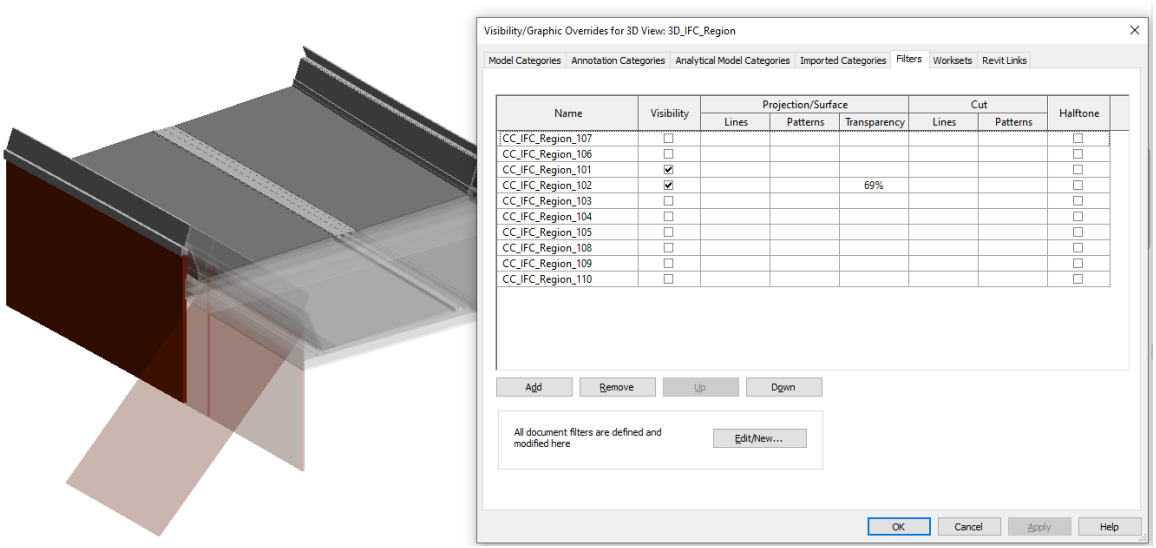


Figure 62: region visibility in Revit

Revit | Parameter CodeName

When creating sections, the linked ifc model doesn't have the correct pattern yet.

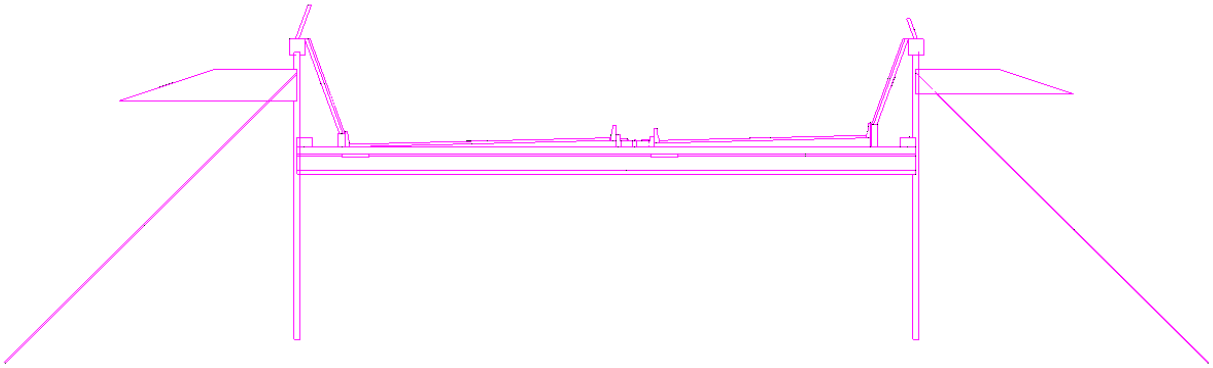


Figure 63: Revit section without patterns

To make the section useable we can use the property Codename from the C3D model by creating a Project Parameter of ***CodeName(Corridor Shape Information)*** Shared Parameter.

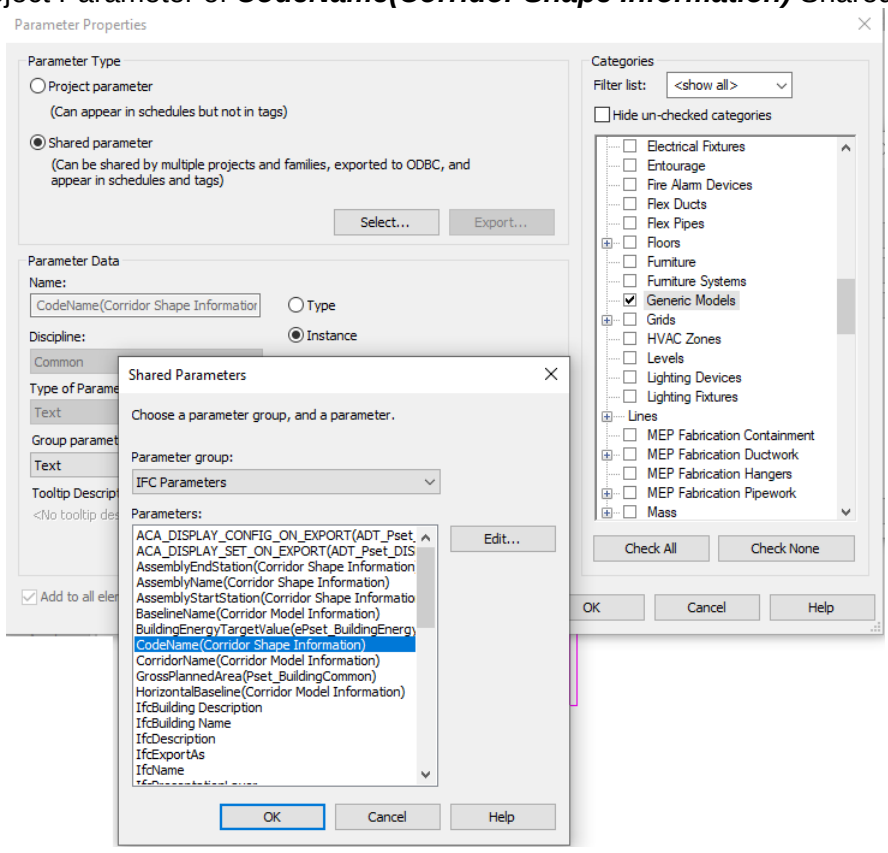


Figure 64: Add CodeName Parameter

Creating filters with overrides will give a better section

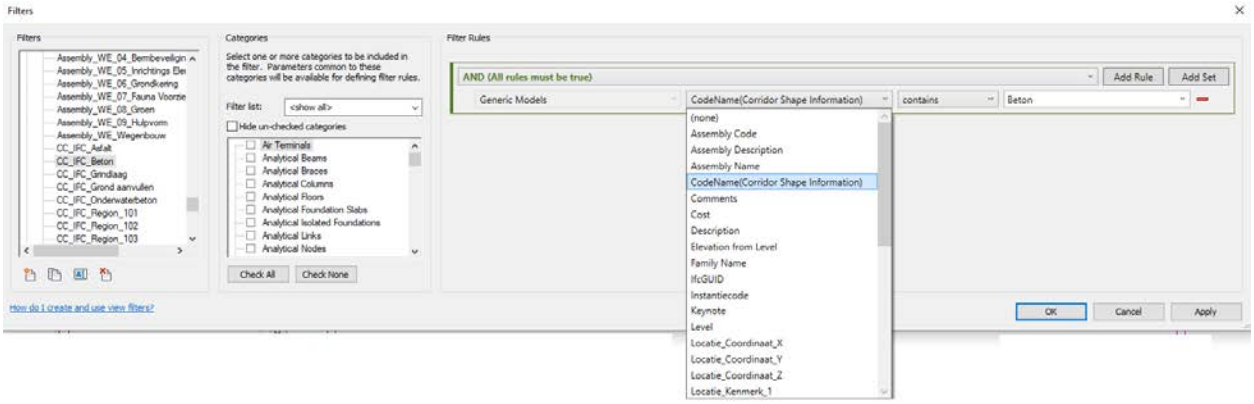


Figure 65: filter CodeName parameter

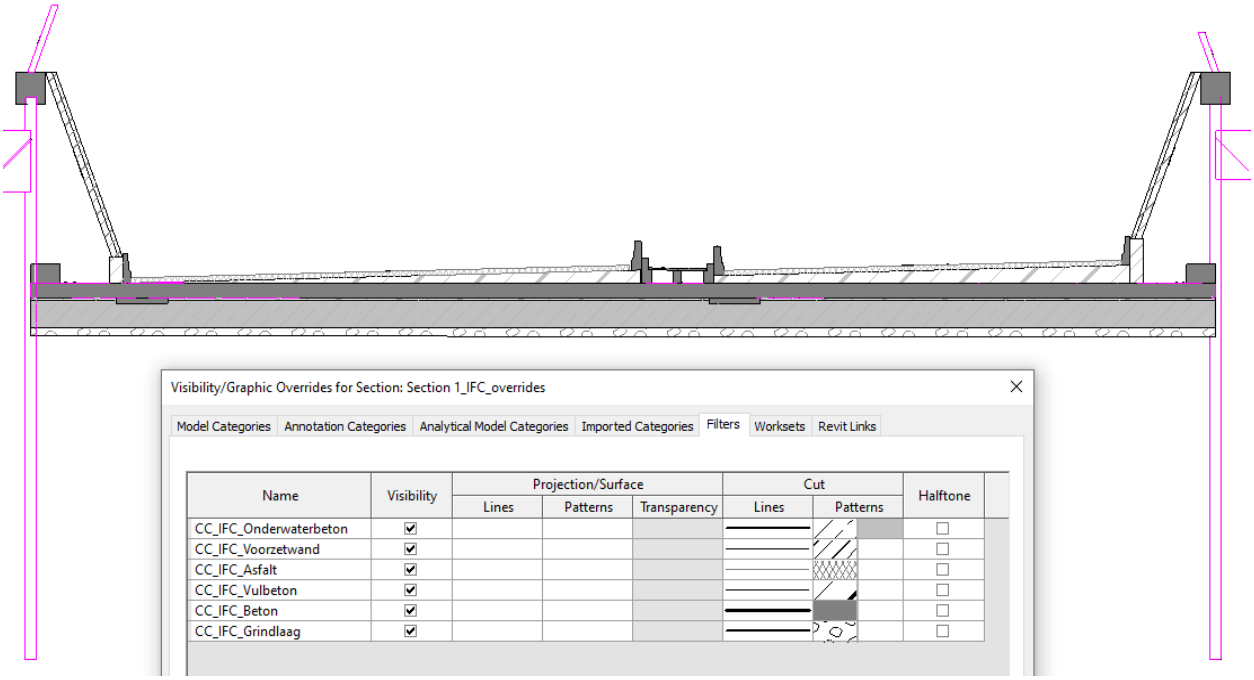
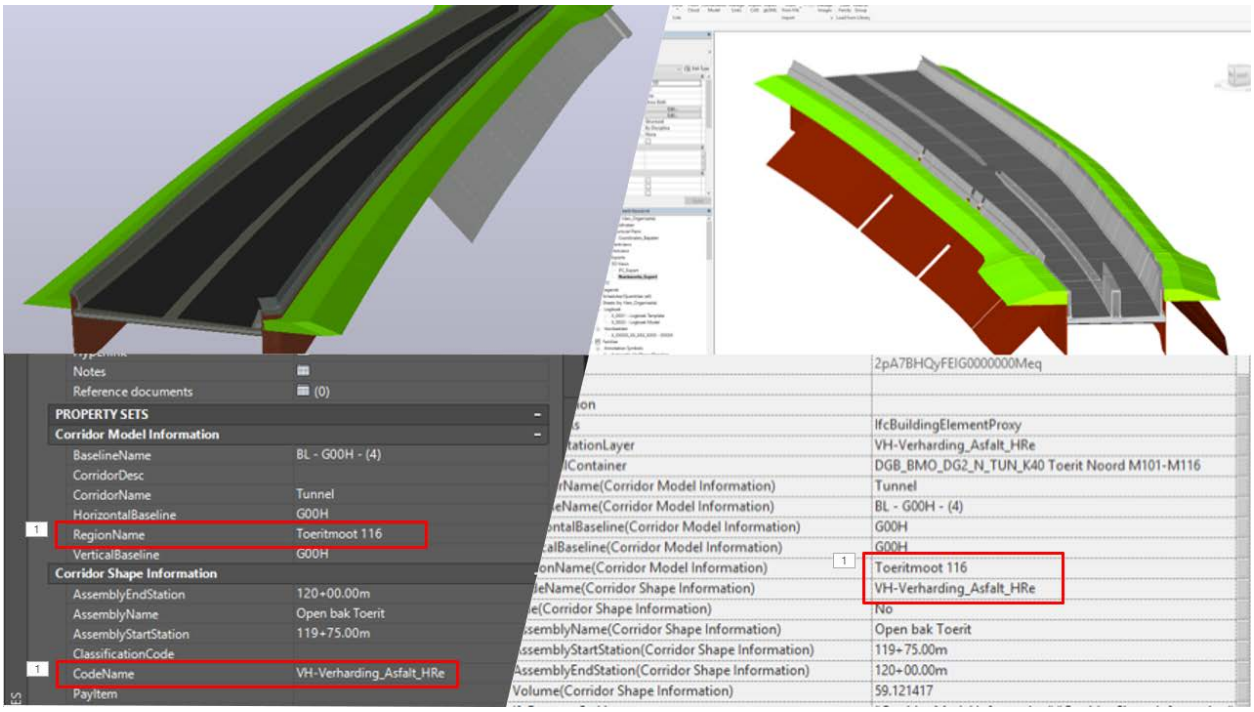


Figure 66: Filter overrides

Civil 3D “IFC” into Revit

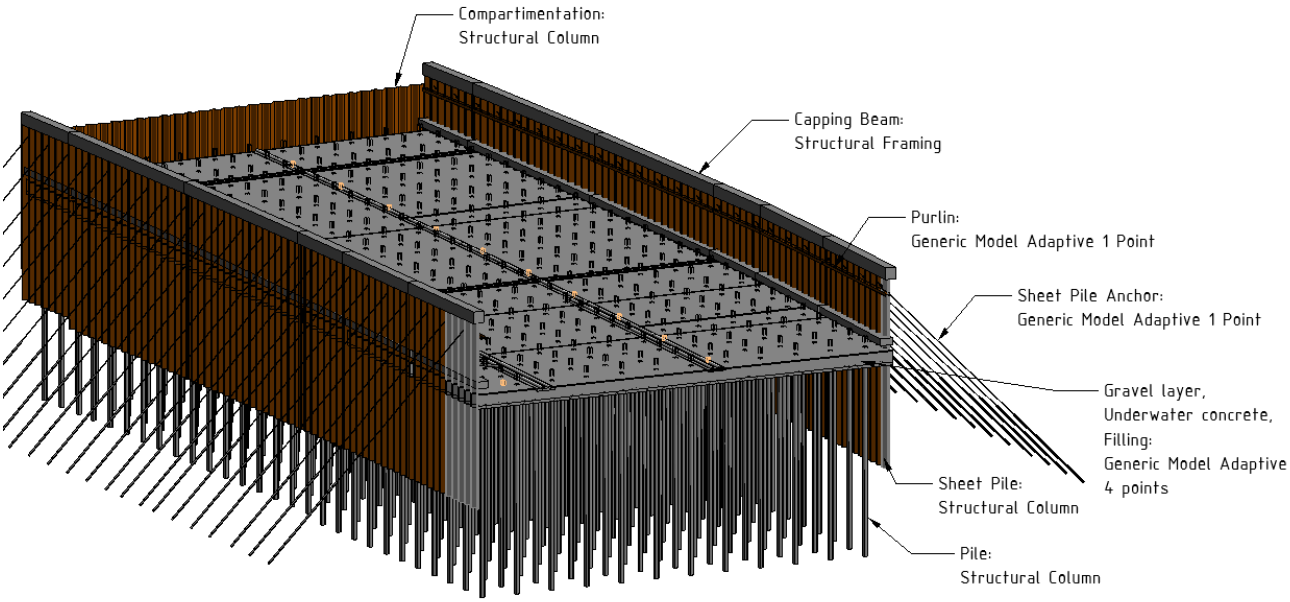


With the IFC linked into Revit we do not have a Specific Revit model

We use the IFC as a reference for modelling the revit object

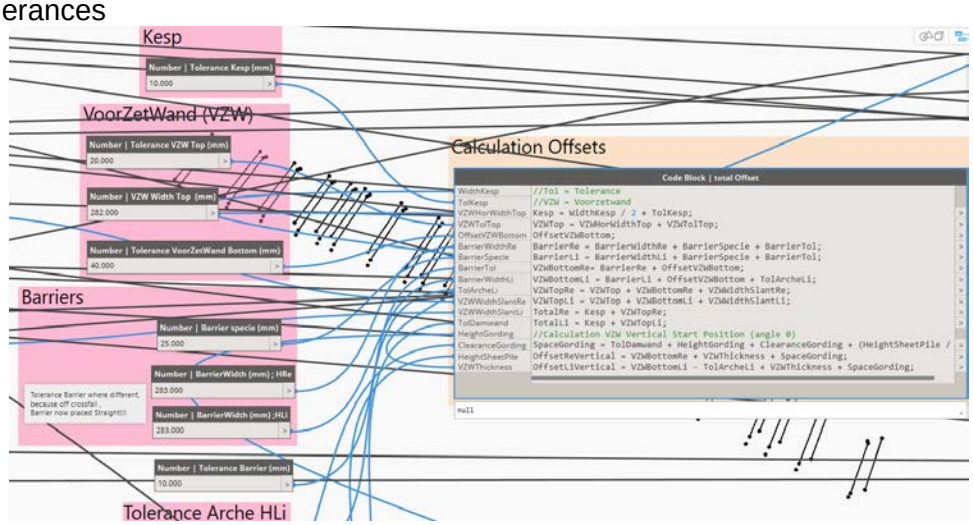
Revit Project Model

Model Elements Construction Pit



Capping Beam

- **Structural Framing**
- Featureline code
- Variabele distance edge asphalt
- Slope ramp (determine horizontal distance cladding wall)
- Dimensions elements
    - Capping beam (1000x1200) → 1100x1200
    - Barriers
    - Cladding wall (angle 0-20° 40m)
- Tolerances

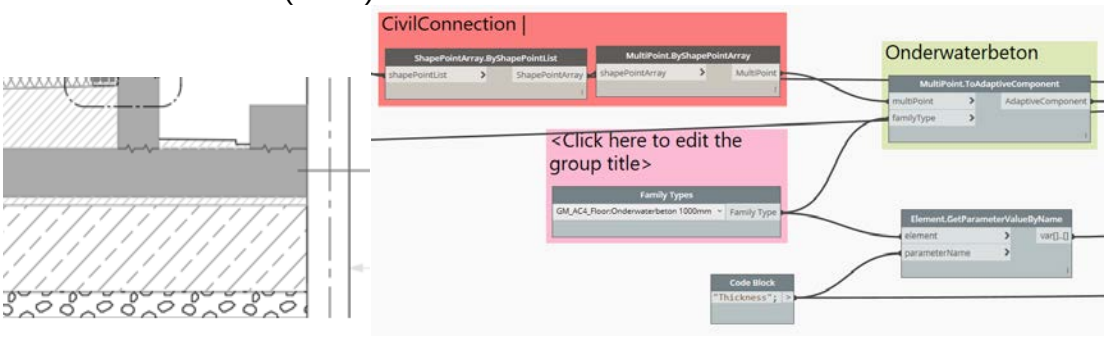


Sheet Piles
Structural Columns with voids.

Piles
Structural Columns

Floors

Generic Model Adaptive (4points)

- Concrete structural floor
- Plinth along sheet piles
- Filling
- Gravel
- Underwater concrete (Basic)
- 

Cutting Sheet piles with Floors

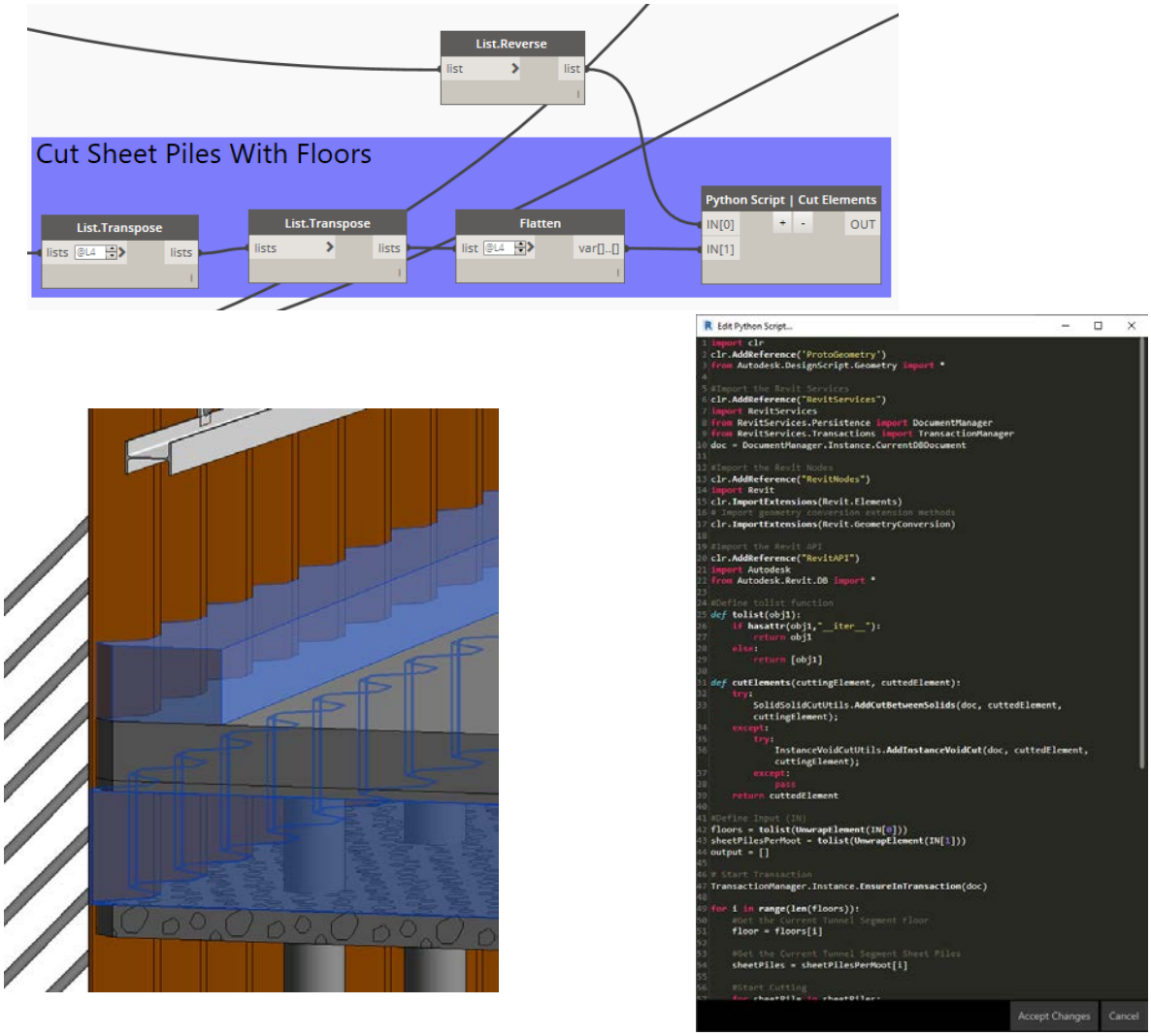
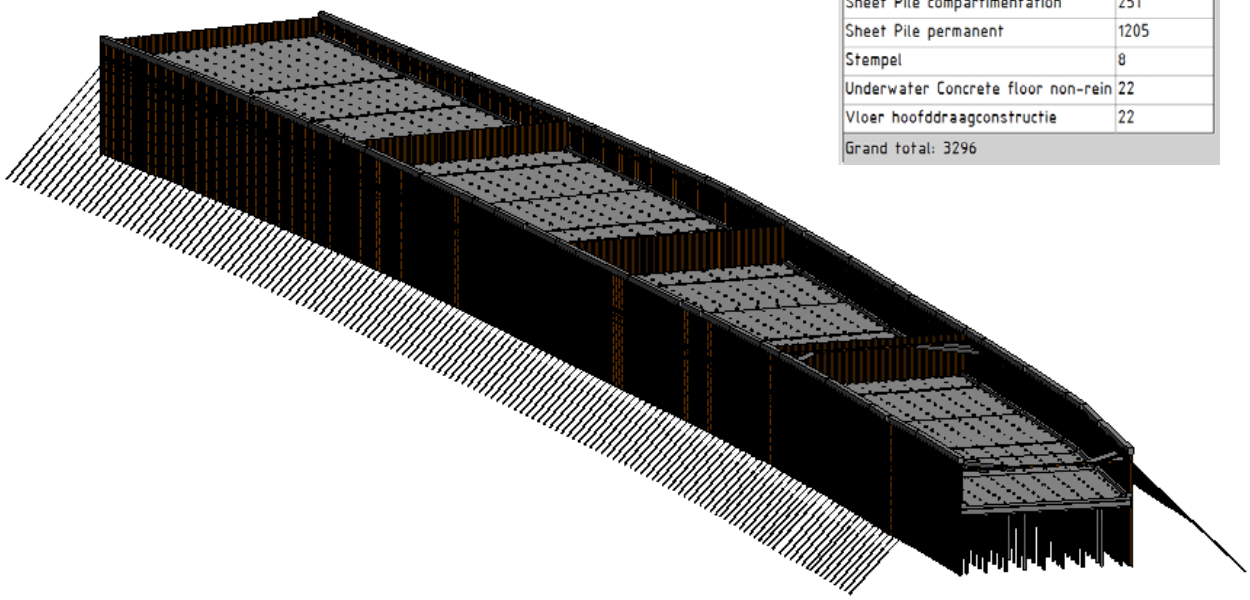


Figure 67: Python scripting for cutting sheet piles with floors

Result scripting construction Pit North

<Construction Pit>	
A	B
Assembly Description	Count
Capping beam	44
Expansion profile	16
Filling layer floor	22
Foundation pile	1301
Gravel Layer	22
Plinth	44
Purlin permanent	46
Sheet Pile anchor permanent	293
Sheet Pile compartimentation	251
Sheet Pile permanent	1205
Stempel	8
Underwater Concrete floor non-rein	22
Vloer hoofddraagconstructie	22
Grand total: 3296	



Model Elements Access ramps

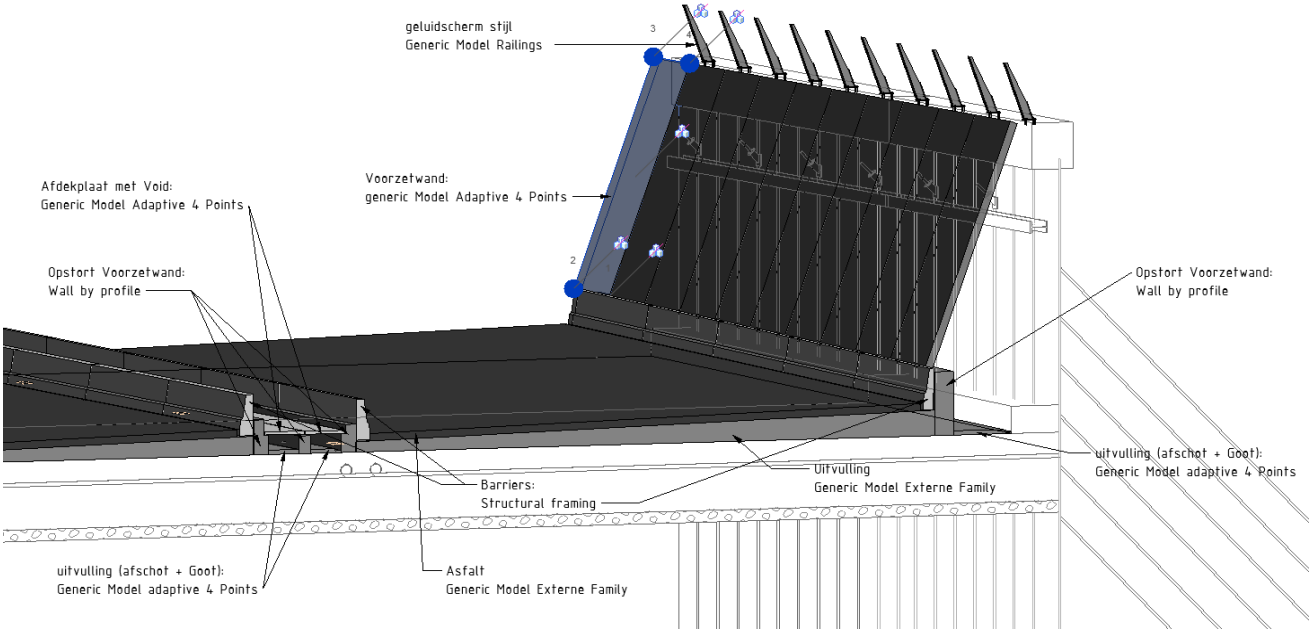
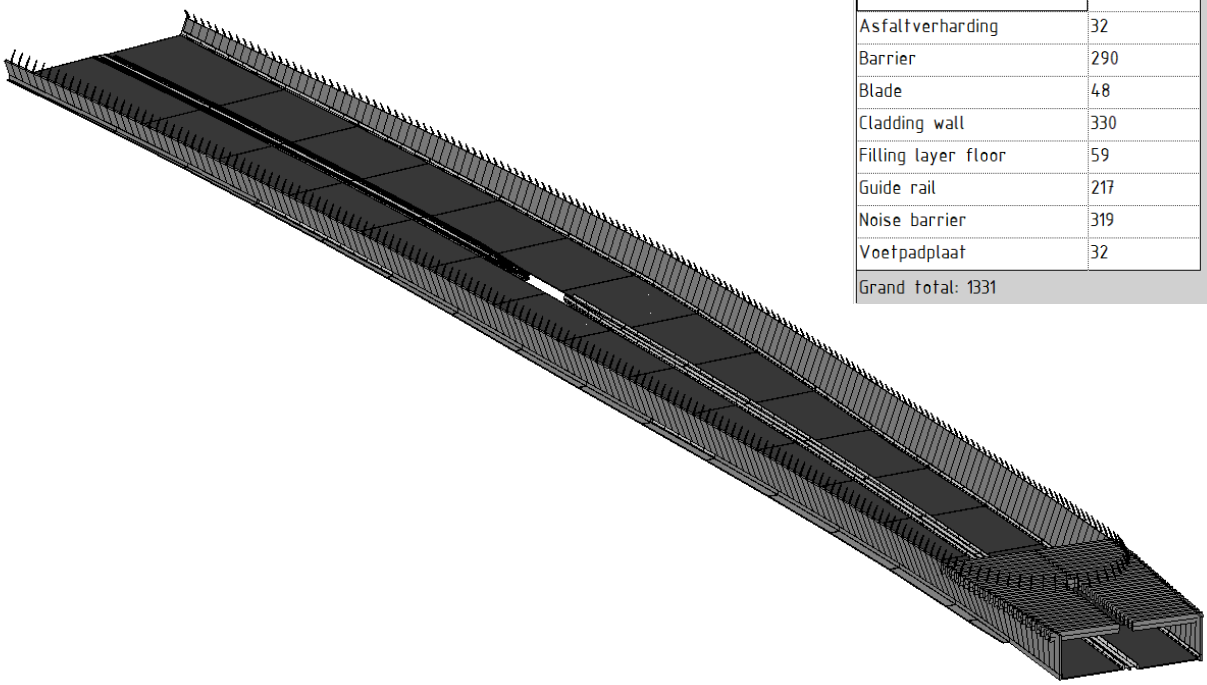


Figure 68: overview model elements access ramp

Cladding walls	4 Point Adaptive Component
Fillings	Generic Model (external Family)
Asphalt	Generic Model (external Family)
Barriers	Structural Framing
Guide rails	2 Point Adaptive Component
Concrete Plinth	Wall by Profile

Result Scripting Access ramp North



<access ramp>

A	B
Assembly Description	Count
	4
Asfaltverharding	32
Barrier	290
Blade	48
Cladding wall	330
Filling layer floor	59
Guide rail	217
Noise barrier	319
Voetpadplaat	32
Grand total: 1331	

Specials

Tunnel Portal

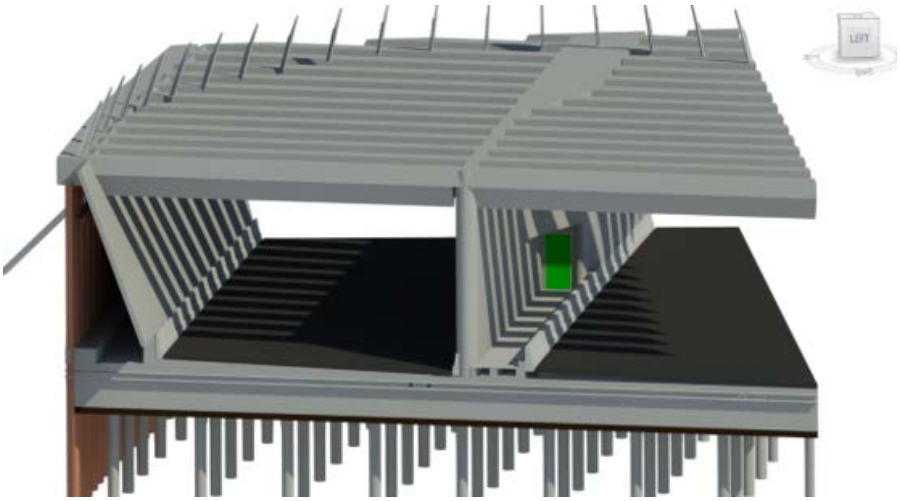


Figure 69: 3D section view Tunnel portal

Pomp Room

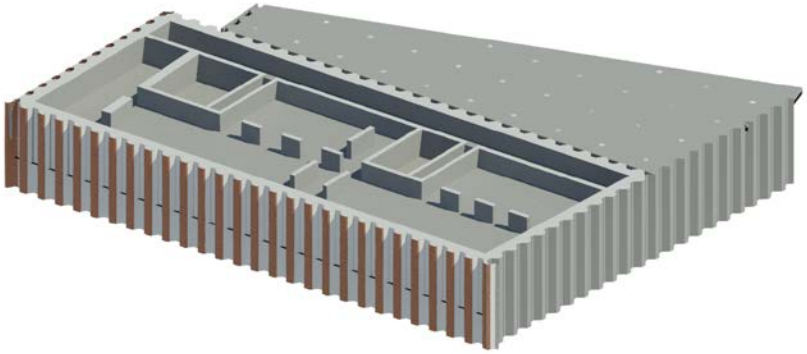


Figure 70: 3D Pomp Room

Traffic barrier area

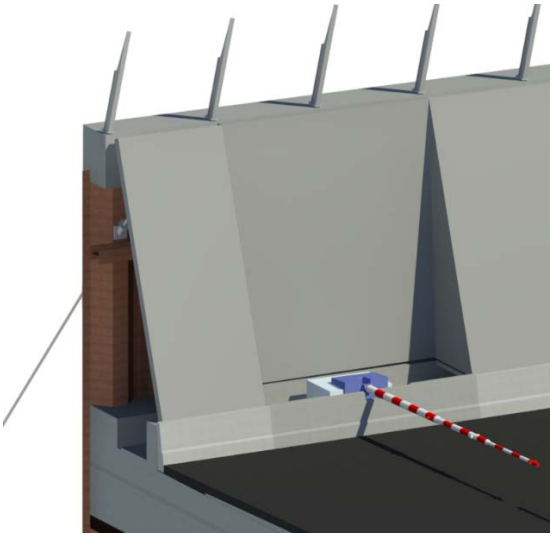
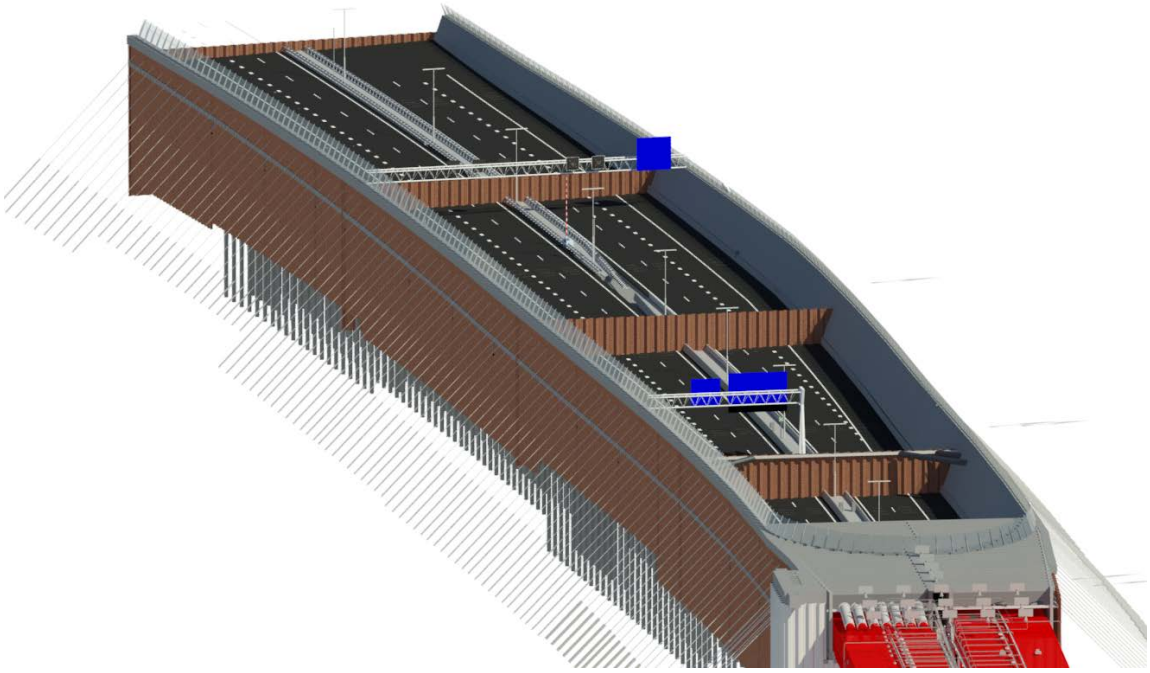


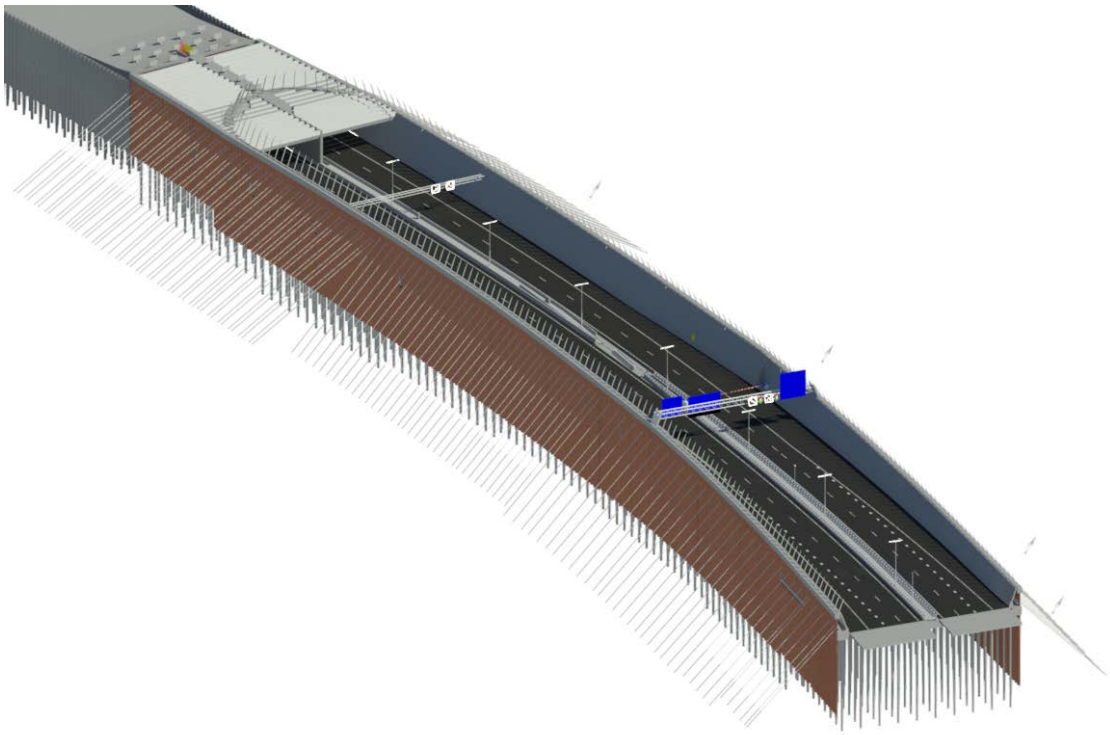
Figure 71: 3D section traffic barrier area

Current Situation

North



South



Advantages CivilConnection

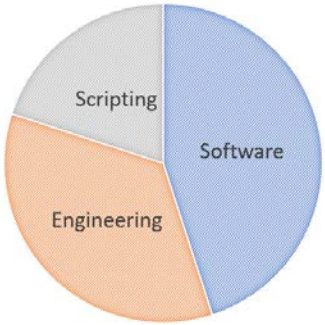
- Best of 2 worlds C3D (Linear) & Revit (discrete objects)
- Civil 3D model long useable during design
    - Alignment changes
    - Featurelines
    - Codenames (subassembly)
- Lineare C3D object bi-directional with revit model
- Revit objects zijn coordinated and dynamic connected with Civil 3D
- Changing Alignement as long as Possible.
- Placed objects can be convert to C3D.

Focus Areas CivilConnection

- Dynamo knowledge
- Clean Civil 3D model (Dynamo is consequent, roundups !)
- Reading Corridor Featurelines Codes names, **“slow”** {188 x (16+89+13)= 22,184 }
- Not yet many project experience.
- C3D, IFC and Revit in same directorystructuur!
    - Vault, not with Revit Collaboration
    - BIM 360, not yet for C3D! (2020 Beta 2)
    - IFC possible with Desktop connector

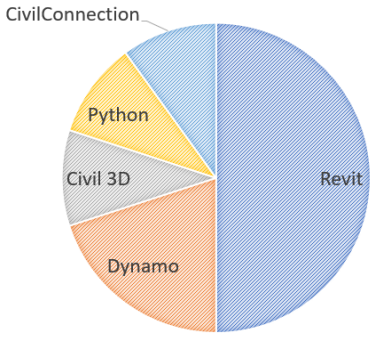
Skills

Main skills

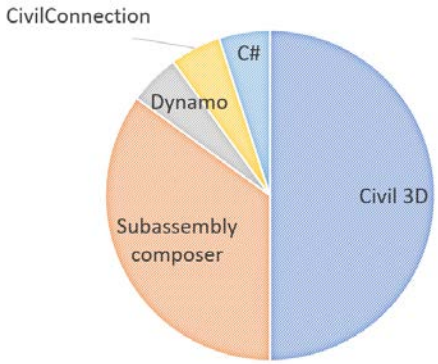


Software skills

Revit Engineer



Civil 3D Engineer



About Royal HaskoningDHV

Royal HaskoningDHV is an independent international engineering and project management consultancy leading the way in sustainable development and innovation.
An organization with 6000 employees, 100 permanent offices in more than 30 countries committed to enhance society together.
Royal HaskoningDHV professionals deliver services in the fields of aviation, buildings, energy, industry, infrastructure, maritime, mining, transport, urban and rural development and water.
The organization focuses on delivering added value for the clients while at the same time addressing the challenges that societies are facing. These include the growing world population and the consequences for towns and cities; the demand for clean drinking water, water security and water safety; pressures on traffic and transport; resource availability and demand for energy and waste issues facing industry.
By showing leadership in sustainable development and innovation, together with the clients, Royal HaskoningDHV is becoming part of the solution to a more sustainable society now and into the future.
The organization is driving positive change through innovation and technology, helping clients use resources more efficiently and creating solutions which connect with people to make their lives easier, happier and safer.
Connecting lives is our history and our future. We are connected through a passion to work on projects that matter and to engineer solutions for our clients that go beyond the original brief. We are connected through work that is enhancing society, contributing to a more sustainable future for our children and our children's children.

Royal HaskoningDHV Corporate video
www.royalhaskoningdhv.com
Enhancing Society Together