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

Michel Beliën — Computational Design & Revit (BIM) Specialist

Rob Zutt — Design leader - Civil 3D expert

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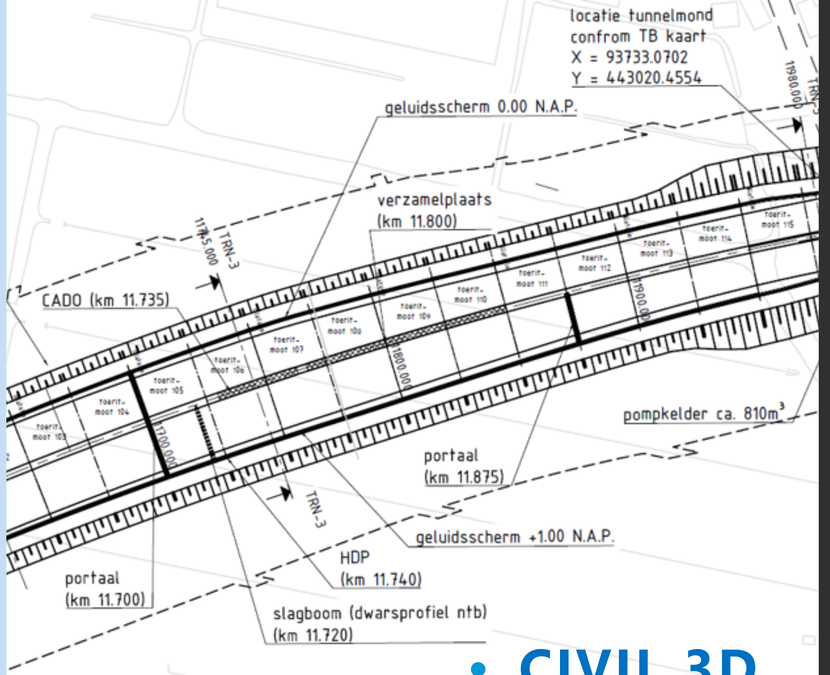
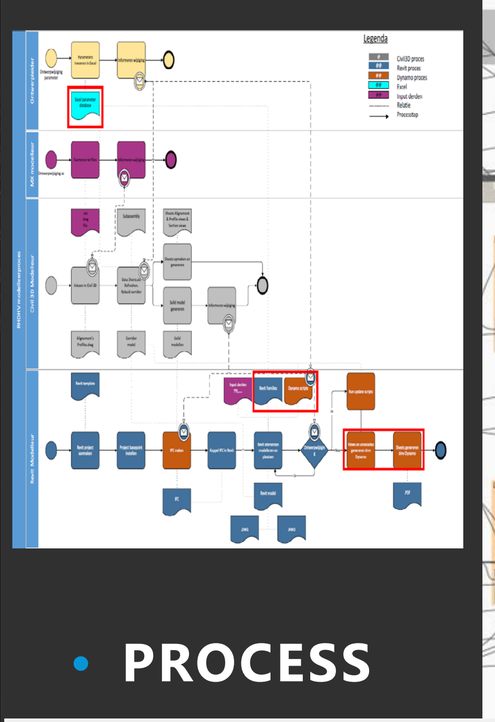
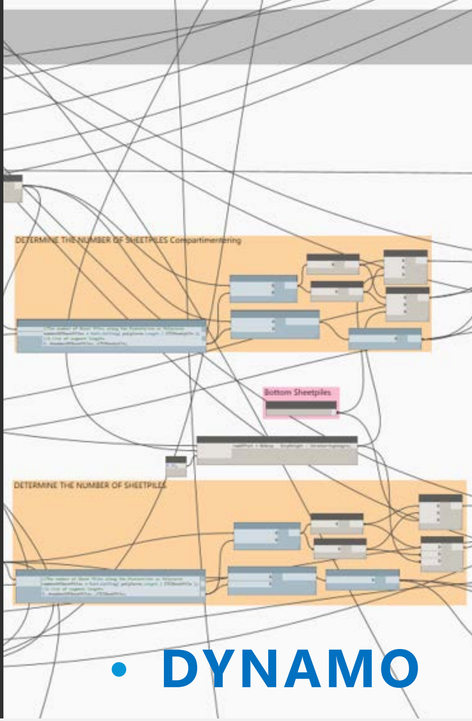
- INTRODUCTION



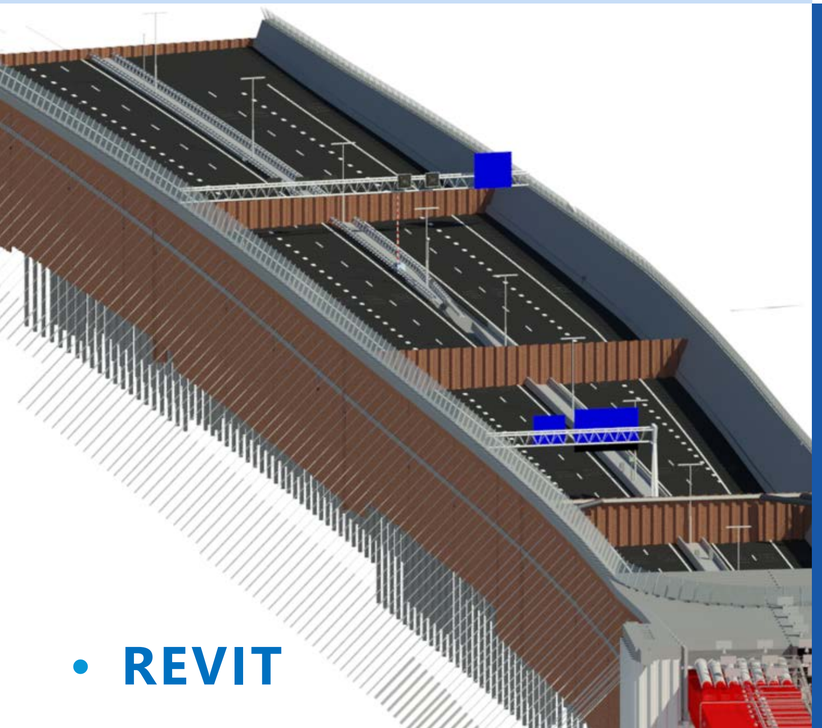
- CIVIL 3D



- PROCESS



- DYNAMO



- REVIT

- “DE GROENE BOOG”

AUTODESK® CIVIL 3D®

AUTODESK® REVIT®

- CIVILCONNECTION

Design Automation by Parametric Design of a Viaduct with Dynamo and Revit in 20 minutes

Michel Beliën
Royal HaskoningDHV
Revit Specialist

Paolo Serra
Autodesk
Implementation Consultant

Join the conversation #AU2017

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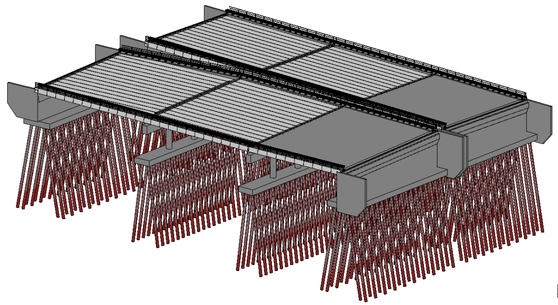
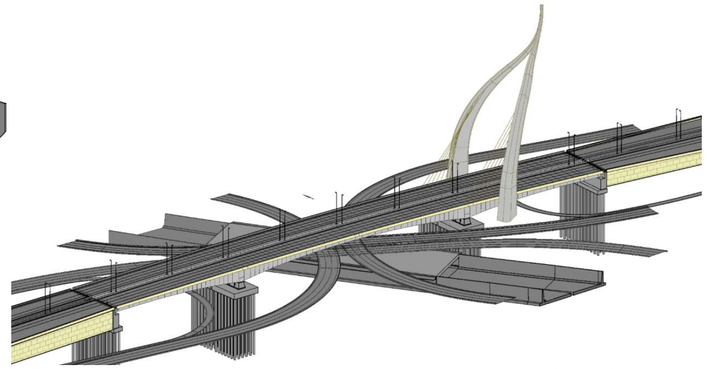
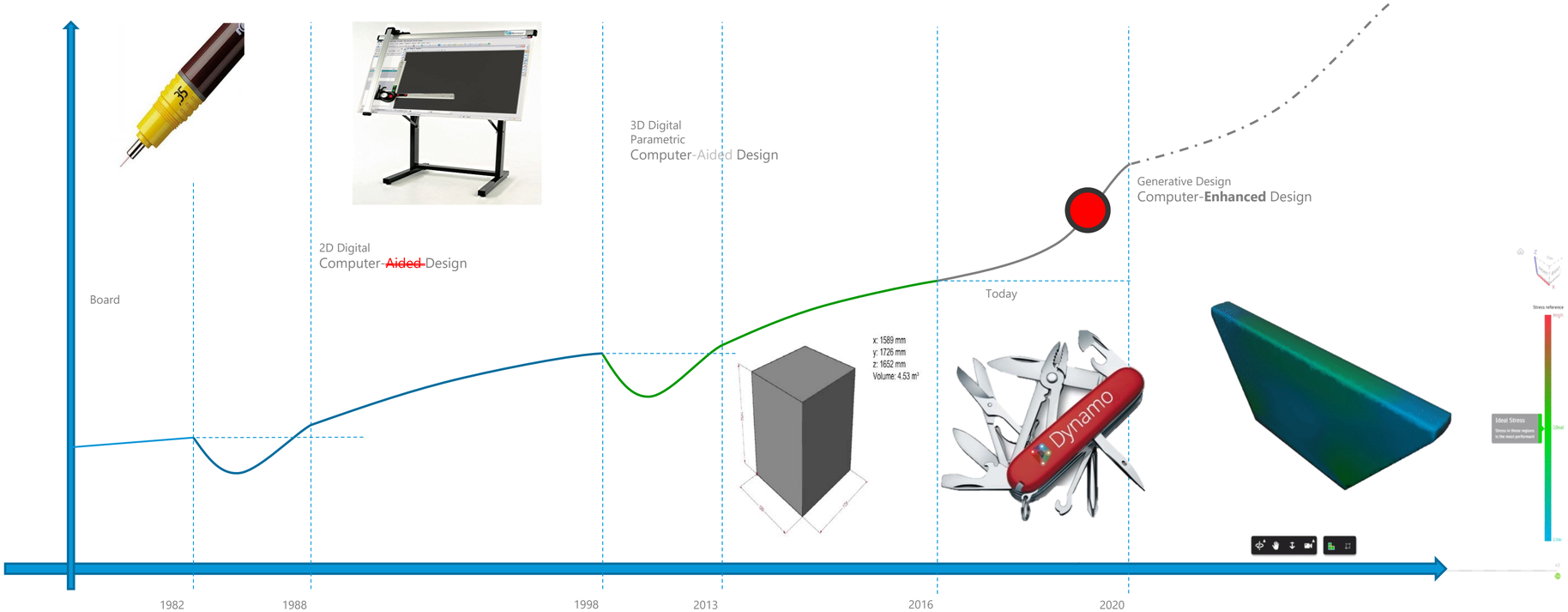




Computational Design
Scripting/Algorithmic
Algorithmic-Aided Design



Michel Beliën

Computational Design

& Revit (BIM) specialist

Royal HaskoningDHV
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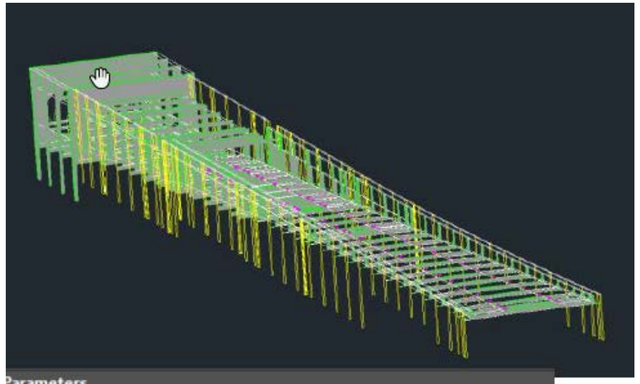
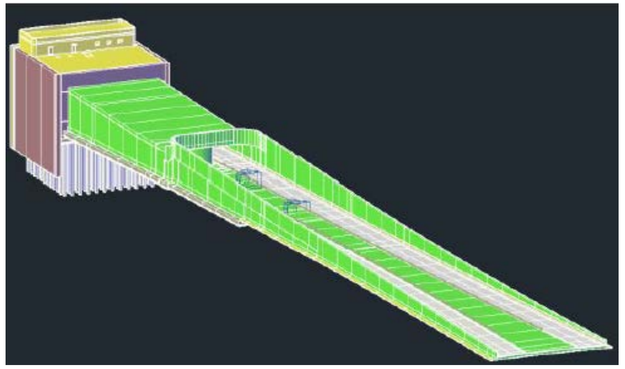
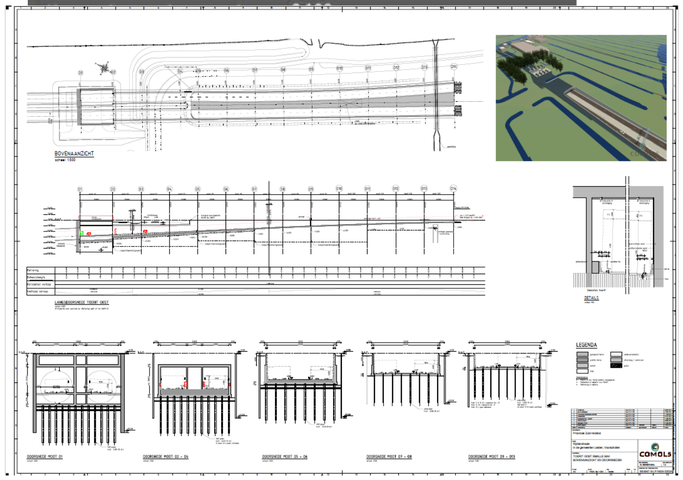
Civil Infra Benelux





Parameters	
Wand dikte	0.800m
Inwendige hoogte	6.000m
Constructie	Constructie_grindlaag
Inwendige wanddikte (rechts)	0.500m
Dakdikte	1.000m



Rob Zutt

Parametric Design

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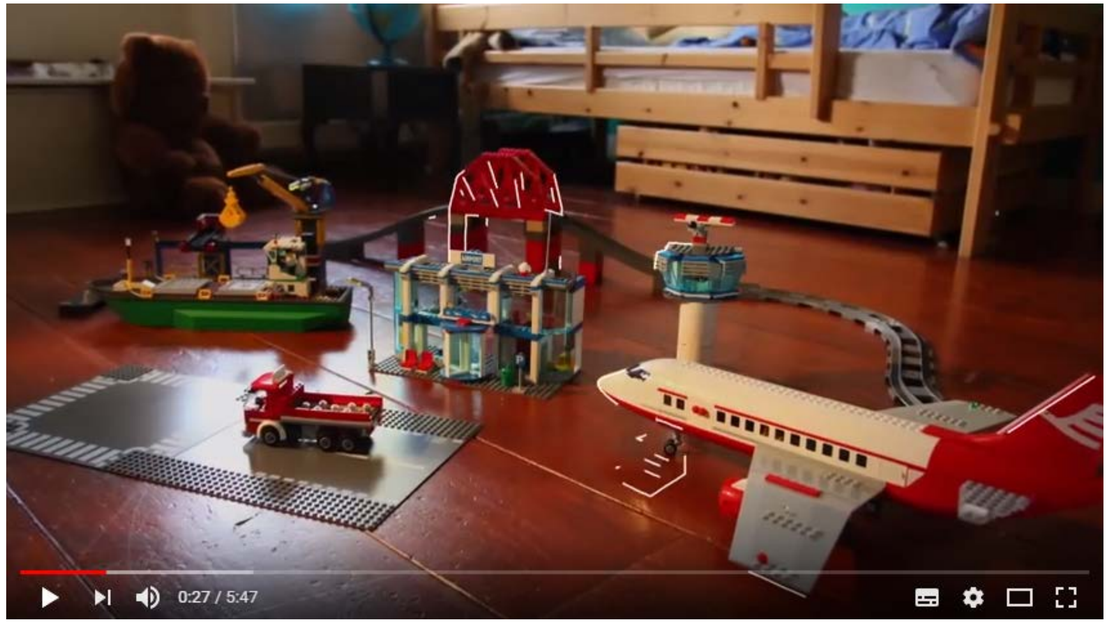
- Maritime & Aviation
- Industry & Buildings
- **Transport & Planning**
- Water



Royal HaskoningDHV Corporate video

www.royalhaskoningdhv.com

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Royal HaskoningDHV in the World

Consultancy, Engineering & Project Management

Workforce of
6,500 in more than
150 countries

One of the top independently owned
engineering companies

Audience?

Engineers

ICT

Management

Applications;Civil 3D, Revit, Dynamo

Attendees

- Australia
- Brazil
- Canada
- China
- Colombia
- Czech Republic
- Ecuador
- Finland
- France
- Germany
- Italy
- Japan
- Malaysia
- Netherlands
- Russian Federation
- Singapore
- Sweden
- United Arab Emirates
- United Kingdom
- United States

FUN FACT

IR. JACOB VAN BRUGGEN (BRIDGES), THE MAASTUNNEL DESIGNER

Ir. J.P. As a civil engineer, van Bruggen was the designer of the Maas tunnel. The engineer from Groningen came to work in 1924 at the age of 28 in the Public Works department where he quickly made a career. In 1927 he was already personally involved in the improvement of the old Willemsbrug.

NEVER USED TECHNIQUES

In 1937 he was appointed chief of the Tunnel Department of the Municipal Technical Service Rotterdam. Thanks to its technical competence, but especially

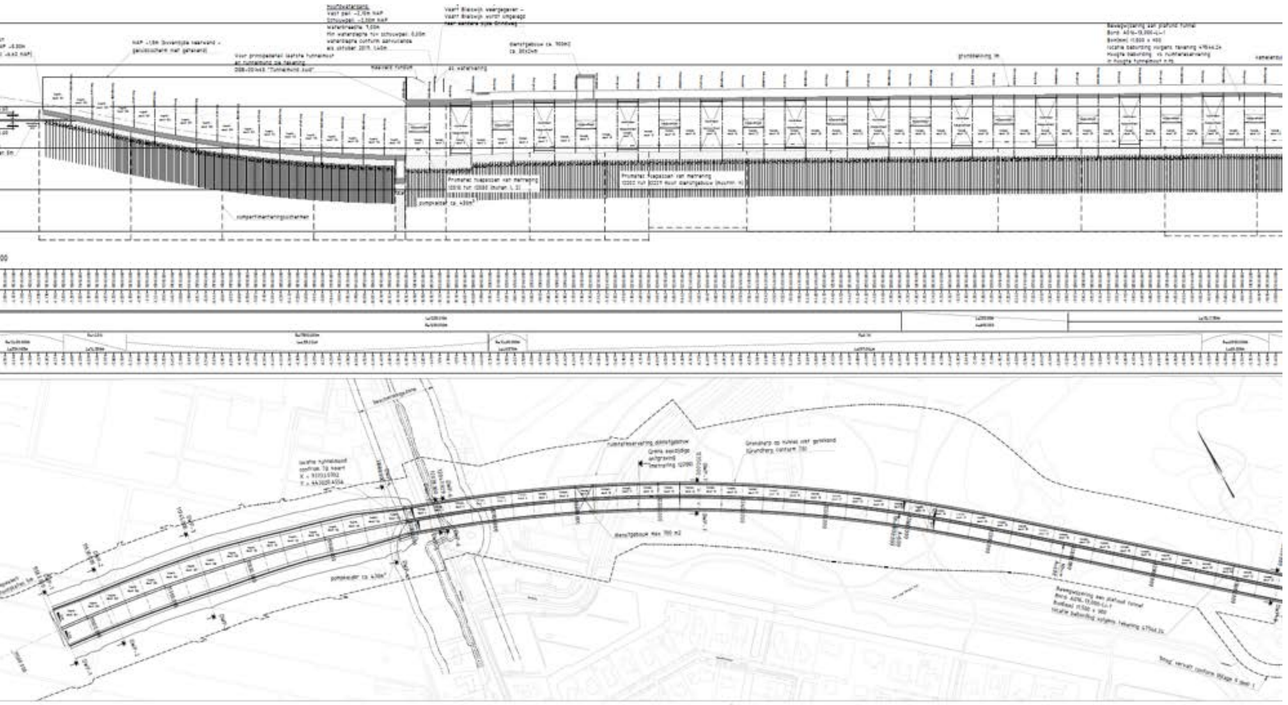
his dare to use techniques never used before,

the tunnel could be made. He thereby resisted the power of the Government, which initially saw nothing in its tunnel design. They preferred a high bridge there.

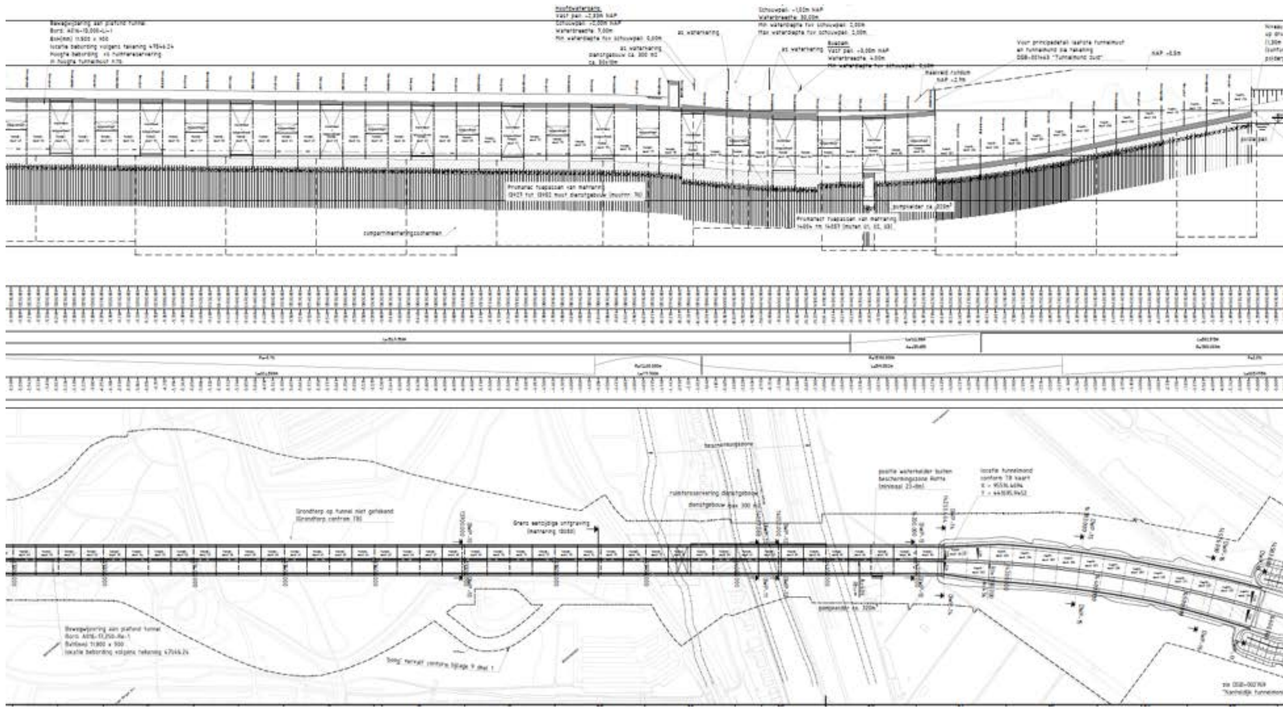
MAASTUNNEL 1ST DUTCH TUNNEL

Project

Tender Design | Civil 3D

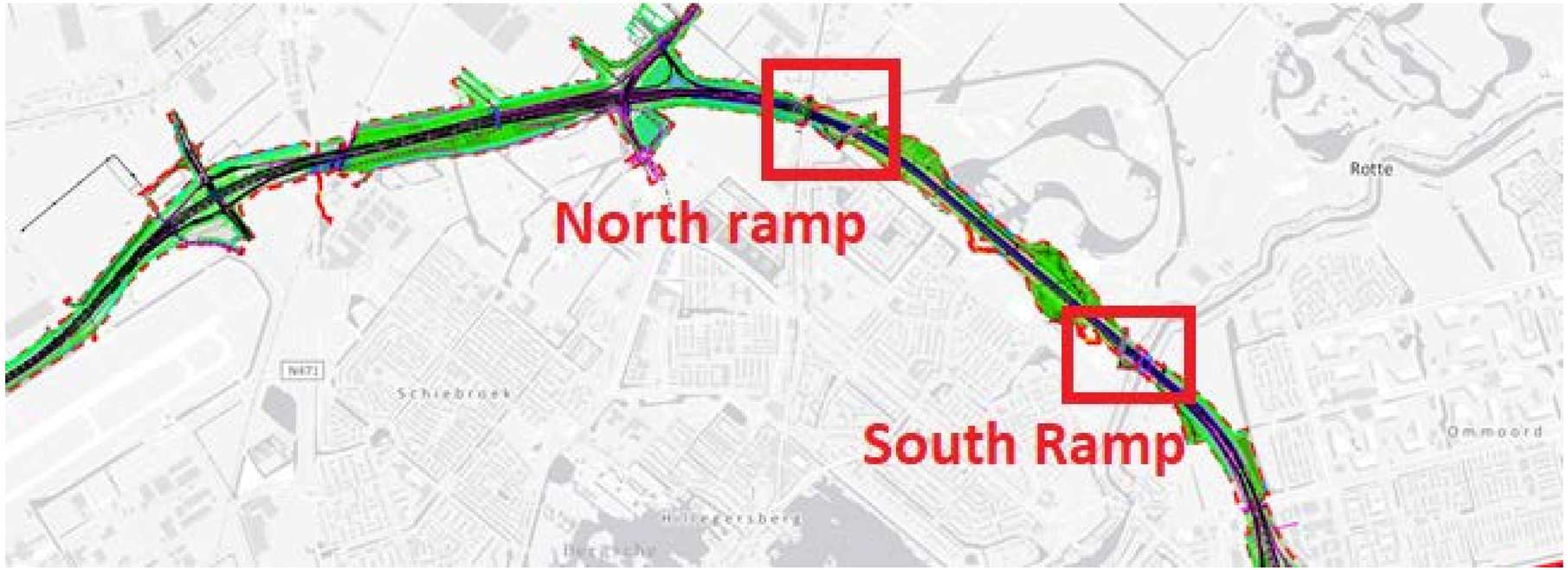


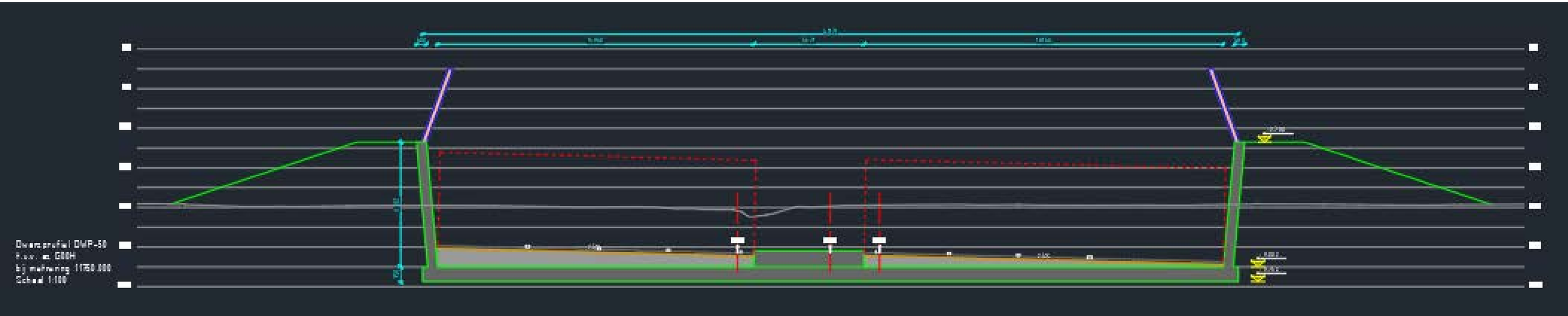
Tender Design North

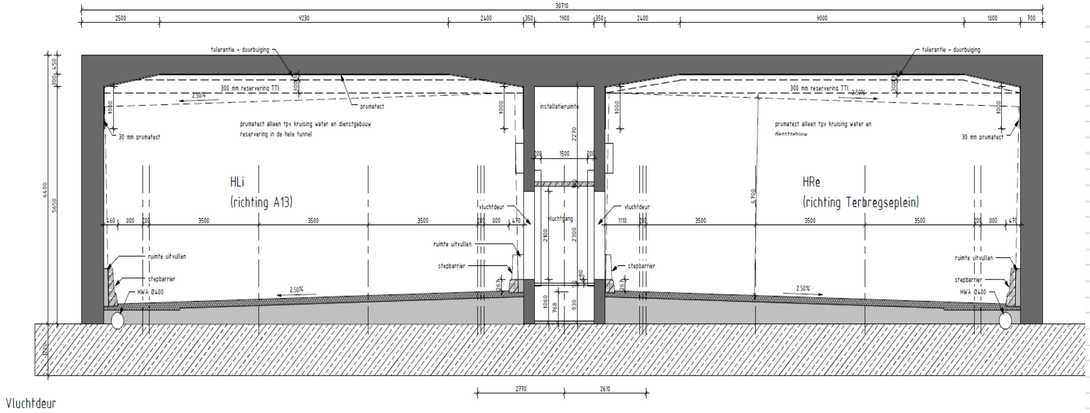


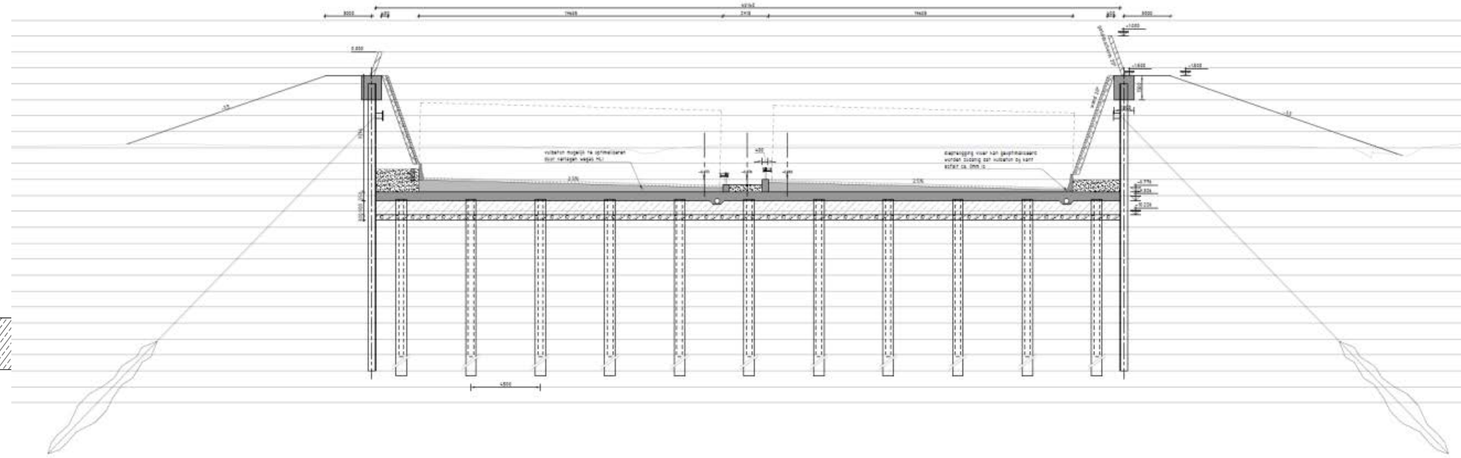
Tender Design South

Tender Design | Civil 3D Access Ramps









Tunnel – half deepened

- **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

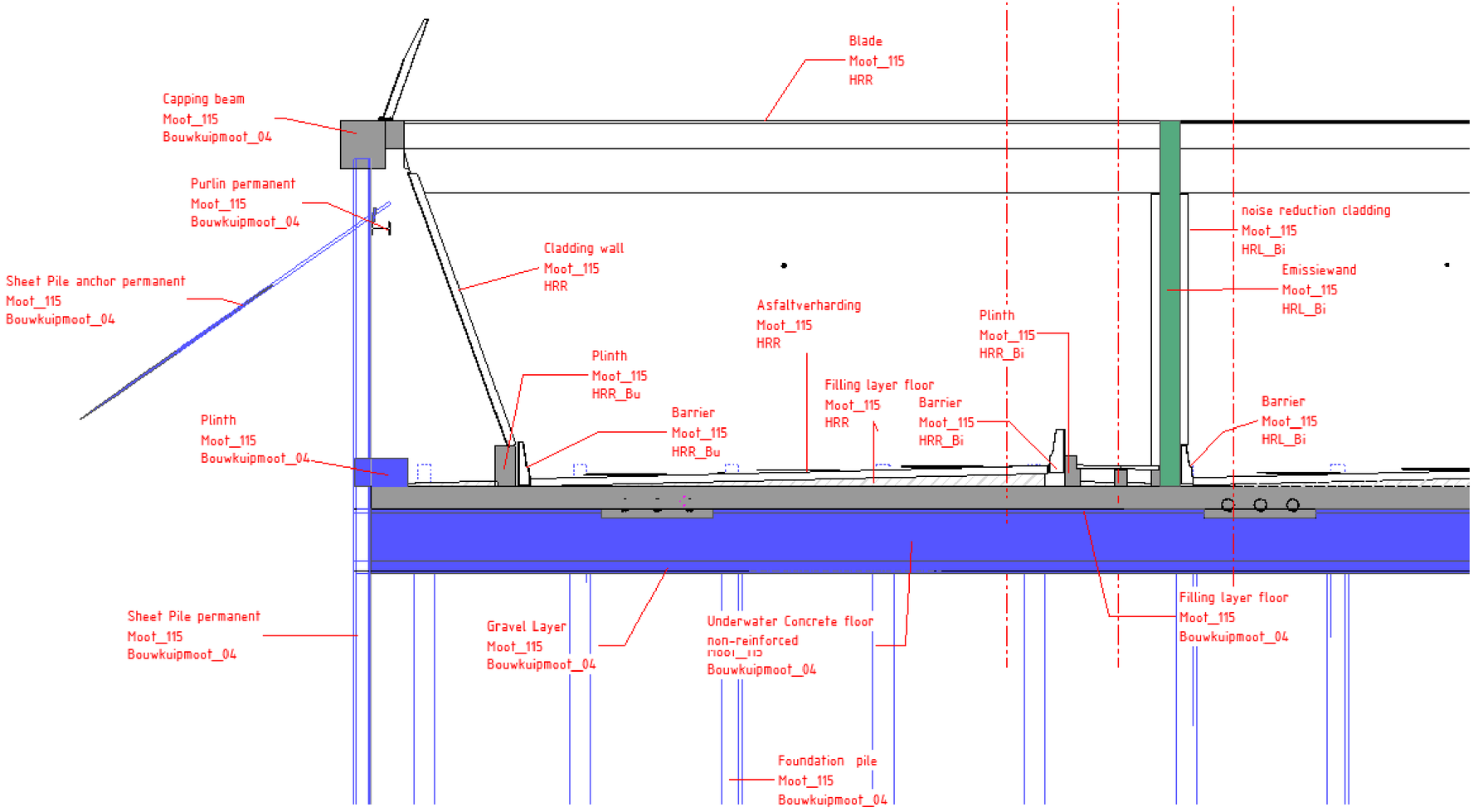
- Underwater concrete with screwed-combi piles
- **Permanent** Sheet piles with anchors
- **Structural Floor**
- Fillings (Variable)
- Central emergency reservation
- **Cladding walls**
- 16 + 13 Segments (North = 400m+ South = 325m)

Project BIM Execution Plan (BEP)

- **Model agreements:**
  - Design should be done in 3D!
  - **All Structures with Revit**
  - Revit Project Manual

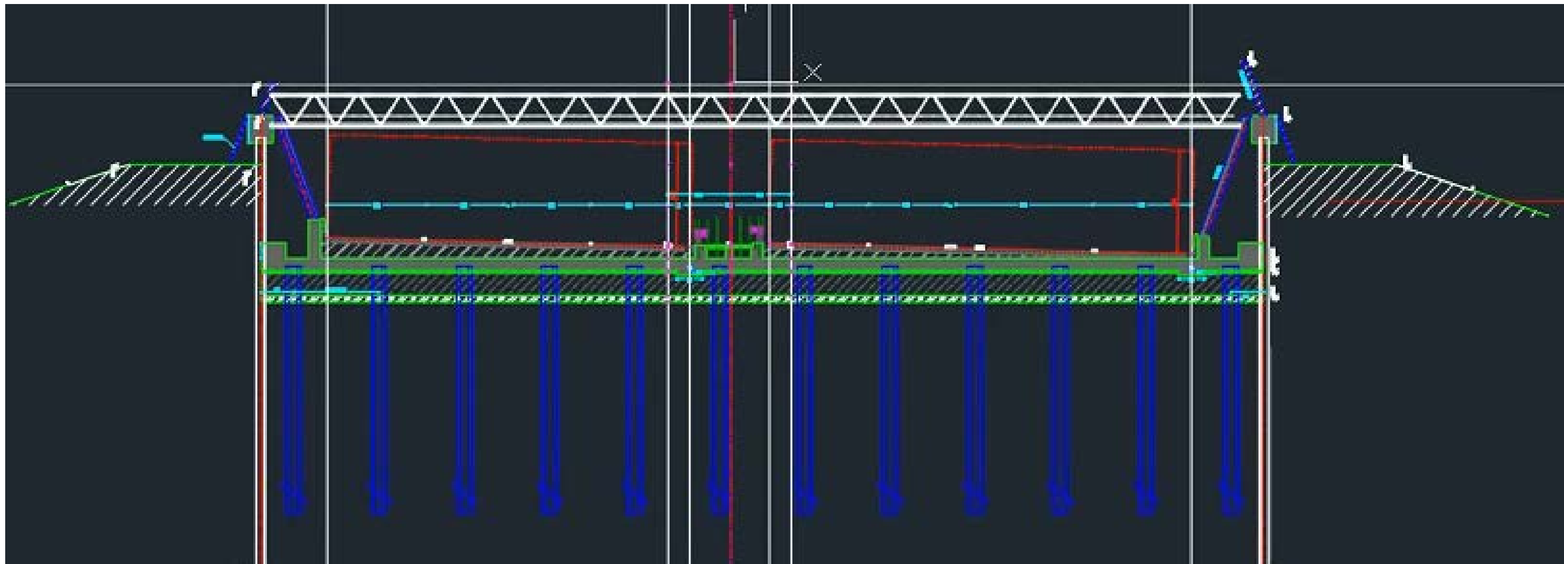
- **Model Division & Components:**
  - North & South
  - Construction pit
  - Access Ramp
  - Specials

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



Access ramps “Complex”?

- Horizontal & vertical Alignment
- Acceleration lanes
- Structural floor, variable sloped fillings (cross fall)
- Non re-inforced underwater concrete with screwed-combi piles
  - Maximum distance; 2 directions
- Facing wall (0-20°)
- Capping Beam + Sound wall
- Barriers, Guiderails
- Central Emergency reservation
- Tunnel Portal (parabola)



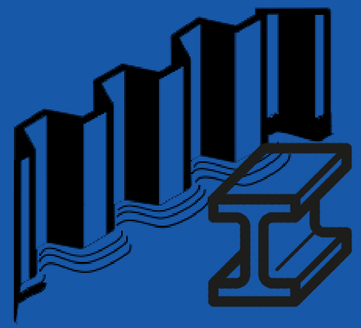
How to create “simple” a 3D Model with “complex geometry” and the available data

Project approach Final Design

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

Brainstorm session

Challenge



Civil 3D start till end

Revit from scratch

Civil 3D – Dynamo - Revit

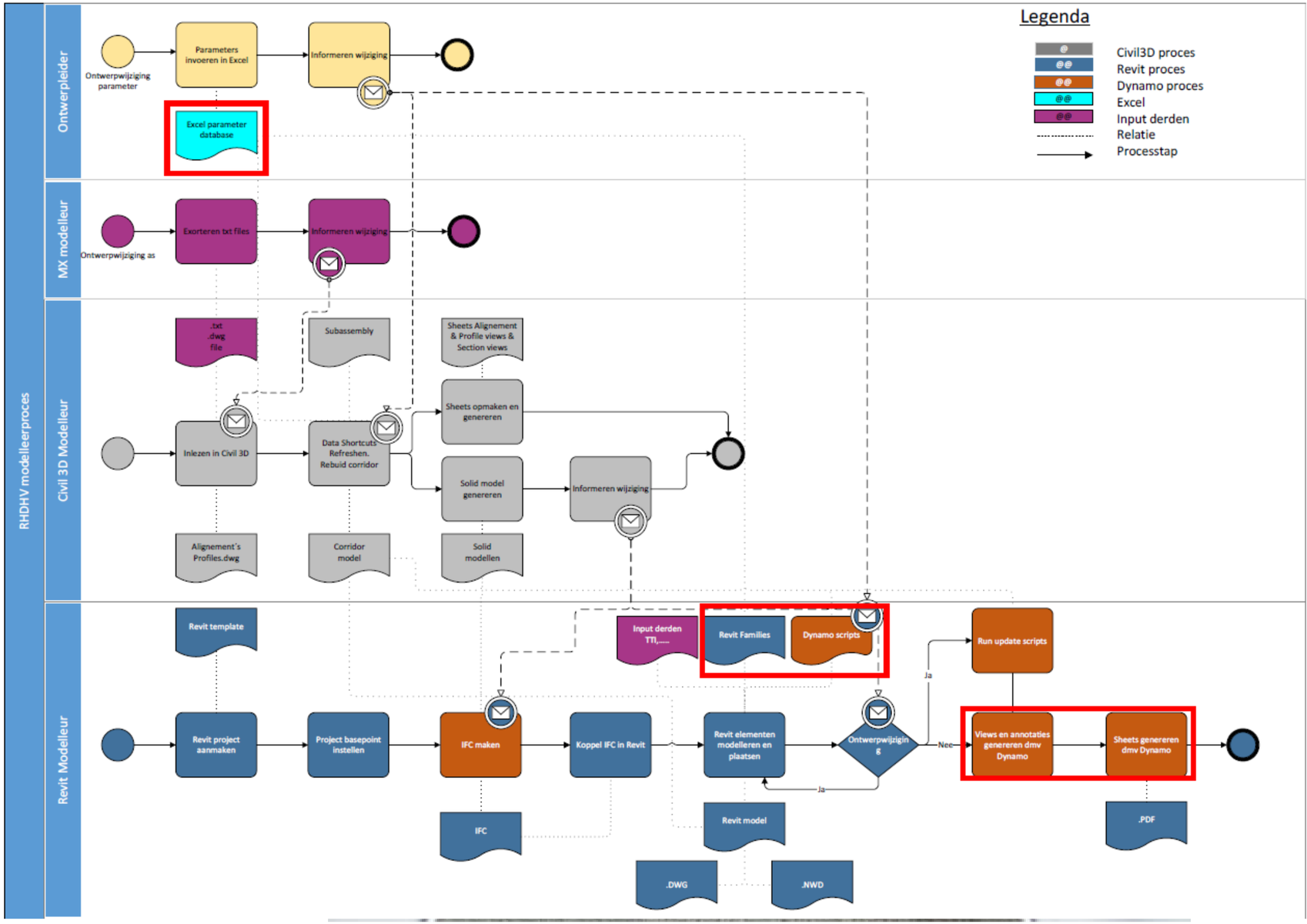
CivilConnection

Workflow

- MX (Road Design)
- Design Parameters
- Design Changes

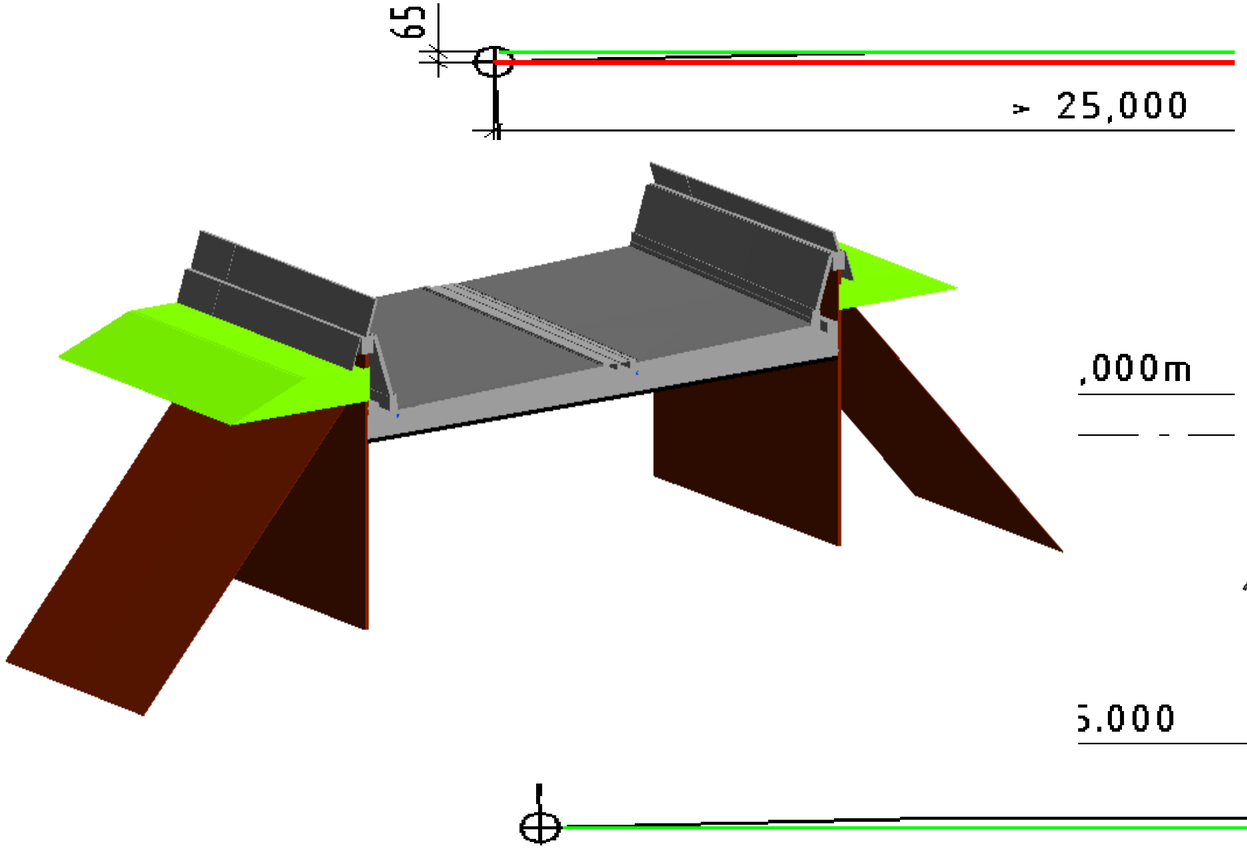
- Civil 3D
- Dynamo (CivilConnection)
- Revit (Structural Design)

- Document management
  - Vault
  - BIM 360

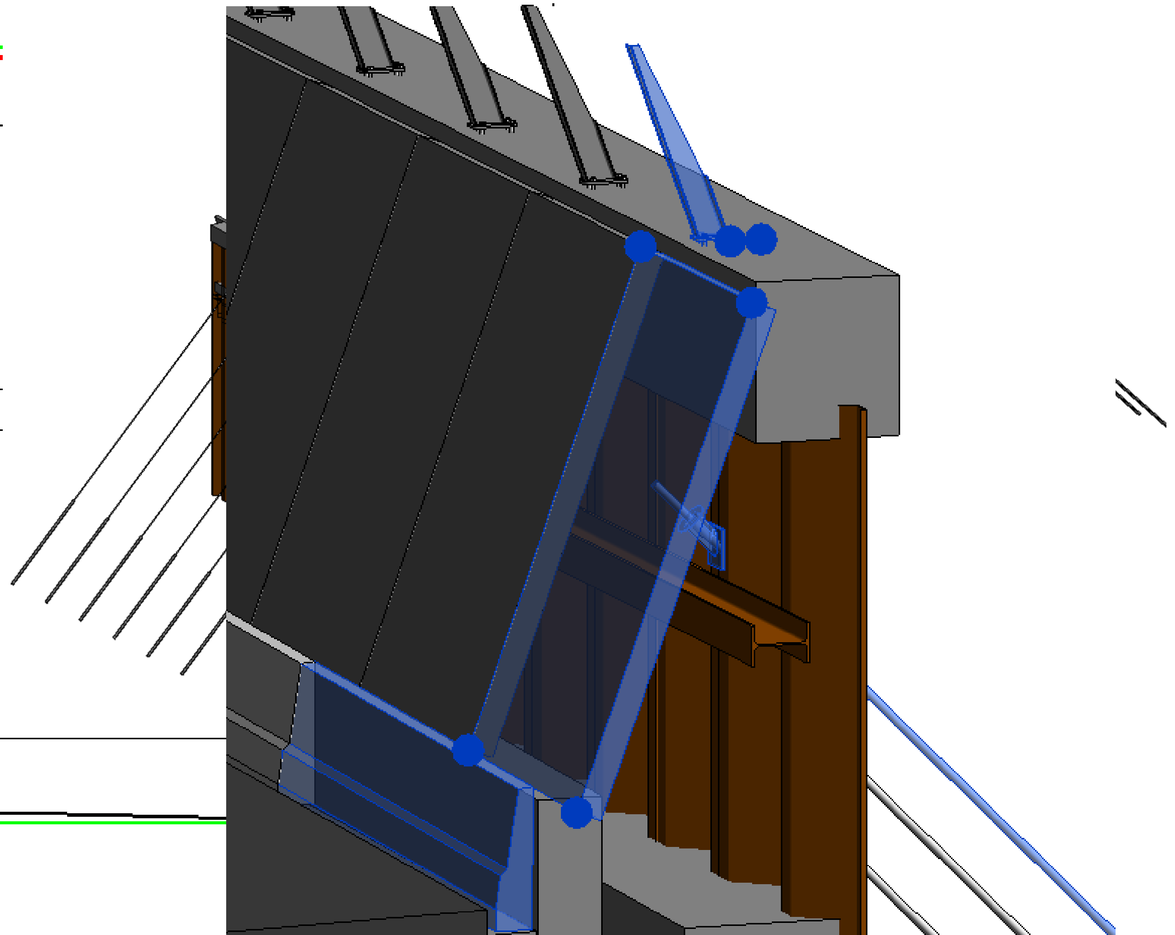


Civil 3D vs. Revit Model

- **Civil 3D:**
  - Linear **curved !**
  - Corridor; Segments per 25m

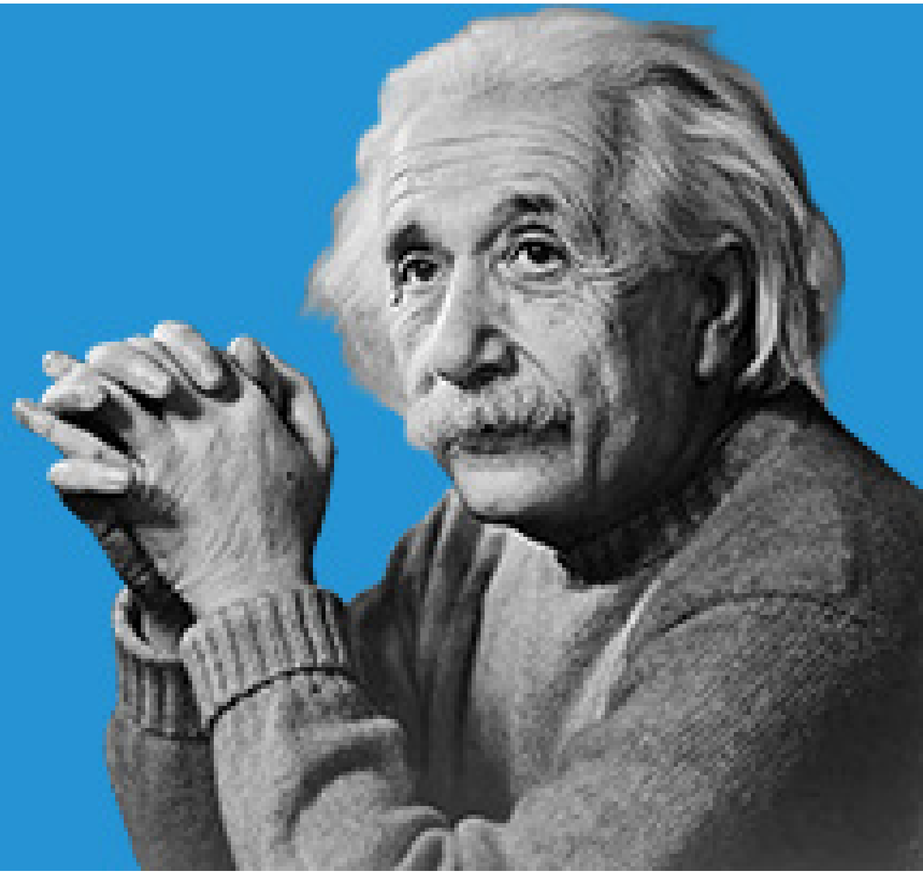


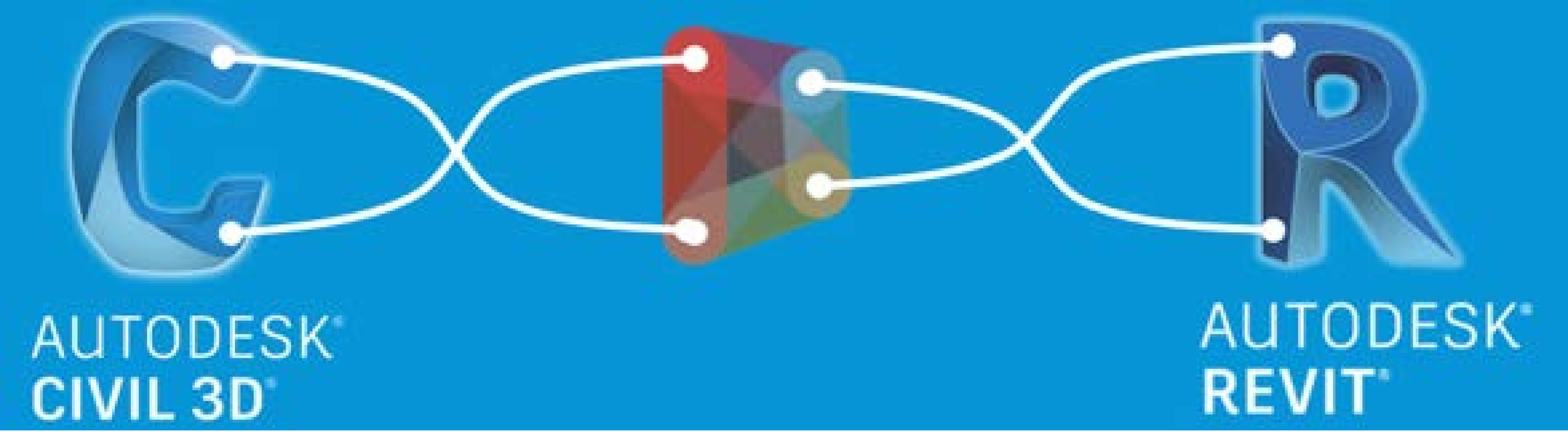
- **Revit:**
  - Straight segments (construction fase)
  - Discrete objects ; Elements 2,5 or 5m



"If you **always** do what you **always** did, you will **always** get what you **always** got"

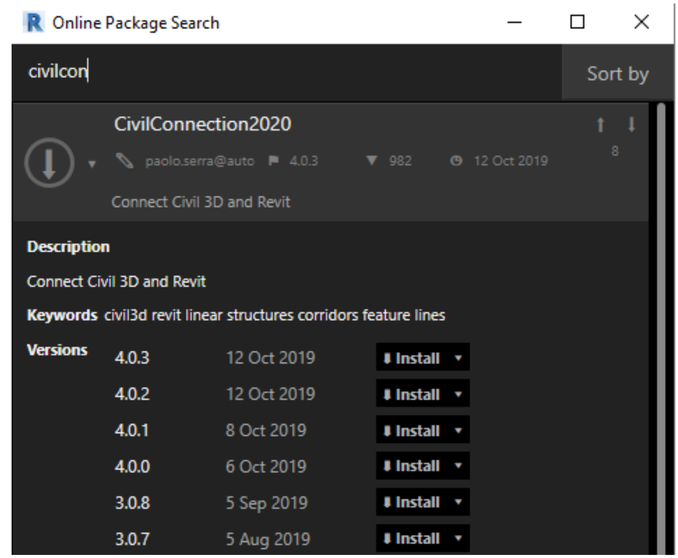
-ALBERT EINSTEIN





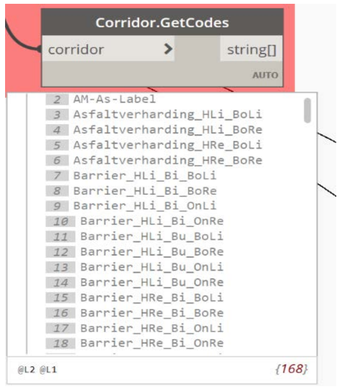
CivilConnection?

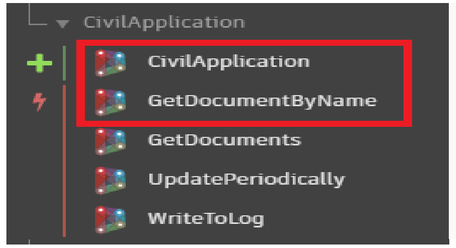
- Dynamo Package (Open source May 2019) https://github.com/Autodesk/civilconnection
- Real time connection Civil 3D ← → Revit
- Uses Civil 3D corridor feature lines as reference
- Improve collaboration, coordination and quality
- Reduce & manage design updates, avoiding manual rework

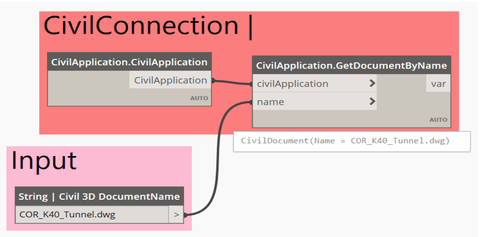


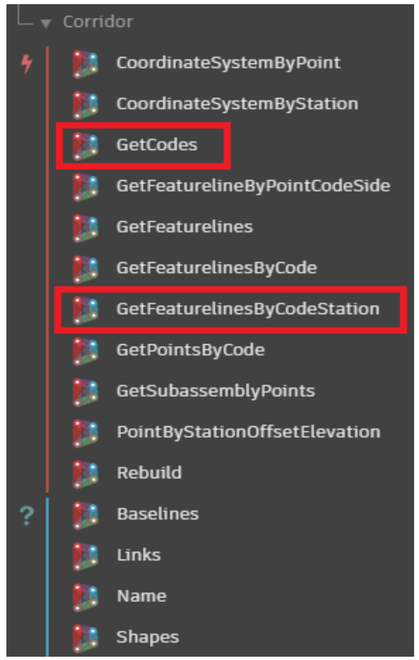
Dynamo nodes Examples

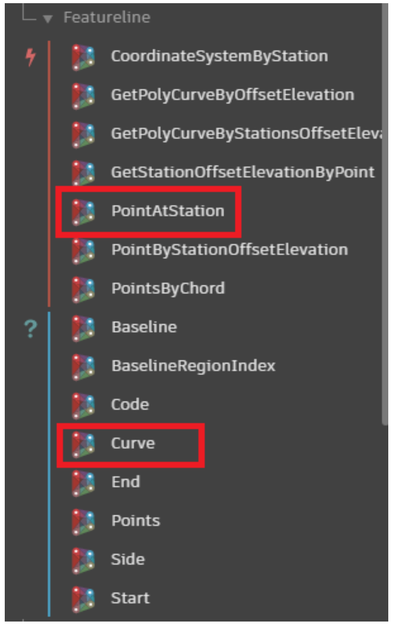
- CivilApplication
- Corridor
- Featureline

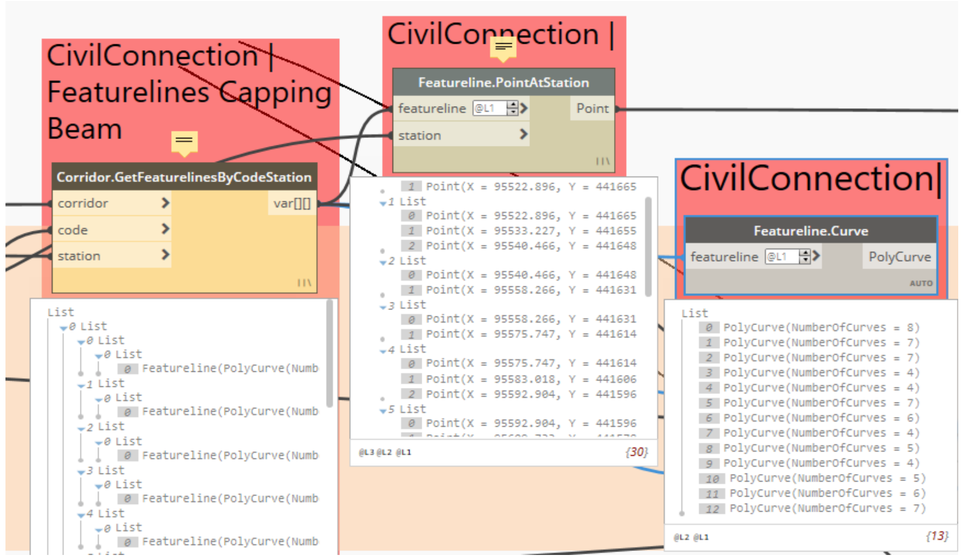






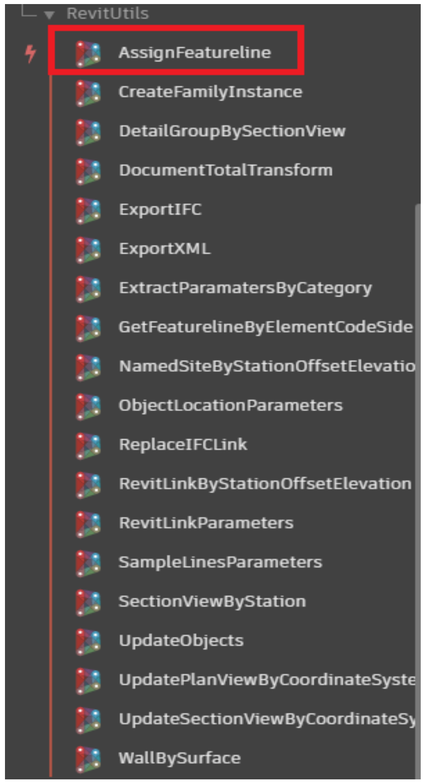


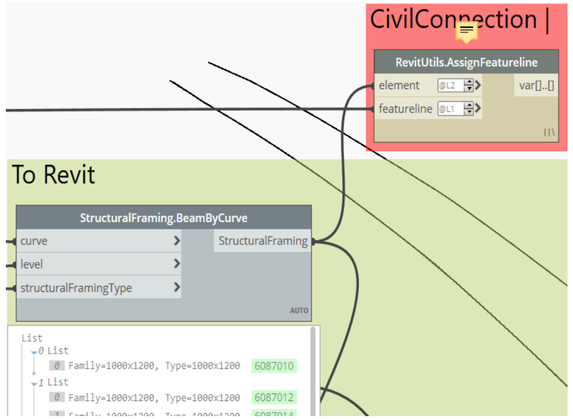




Dynamo nodes Examples

- RevitUtils





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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
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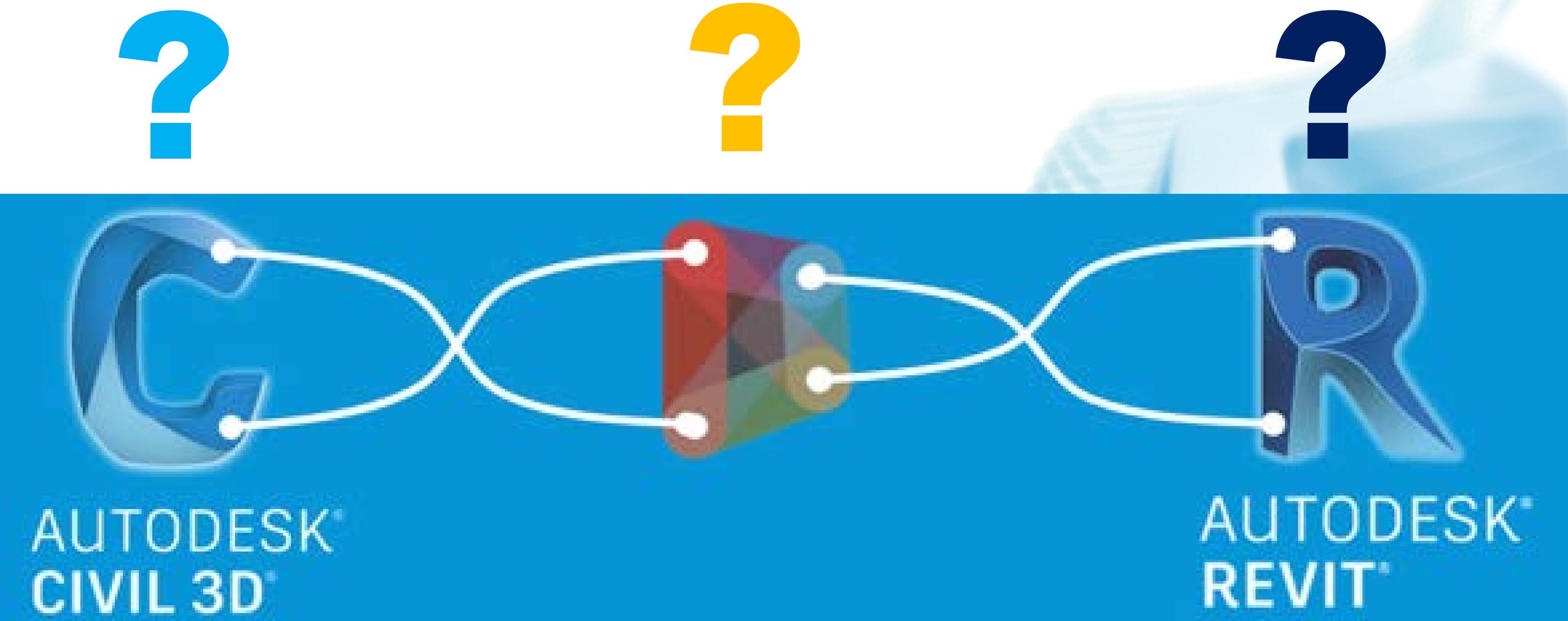
ADSK_EndRegionNormalized	1.000000

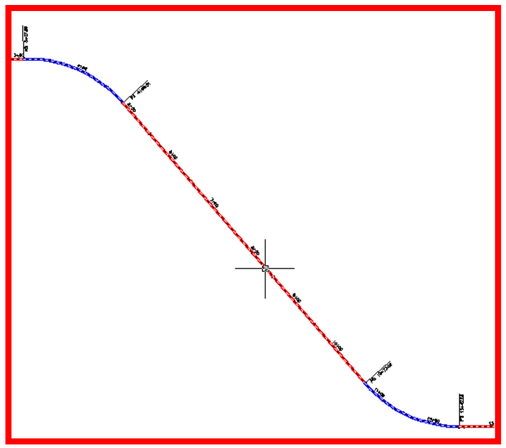
Back to Basics

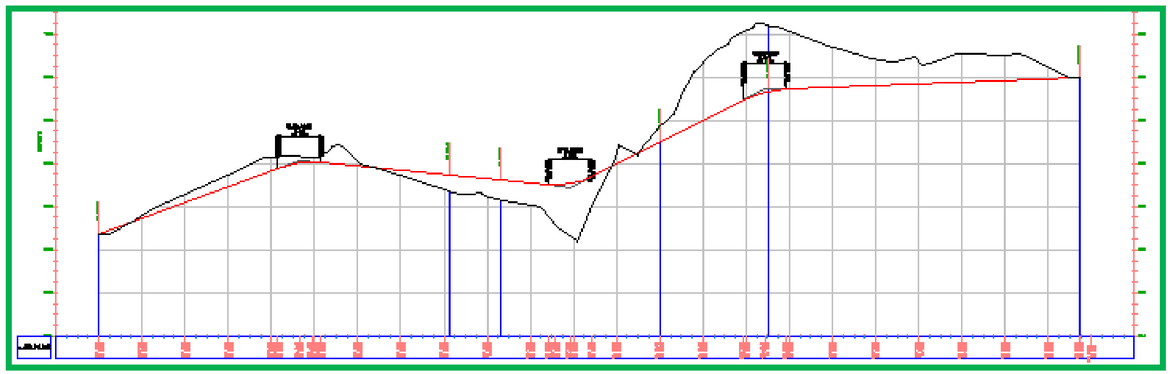


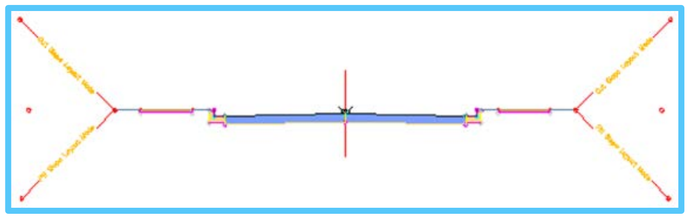
Civil 3D basics

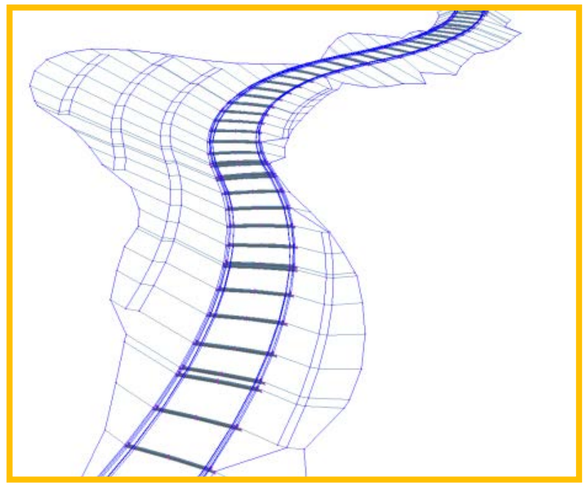
- **Alignment** - Horizontal Alignement
- **Profile** - Vertical Alignement
- Assembly - Basic section profile

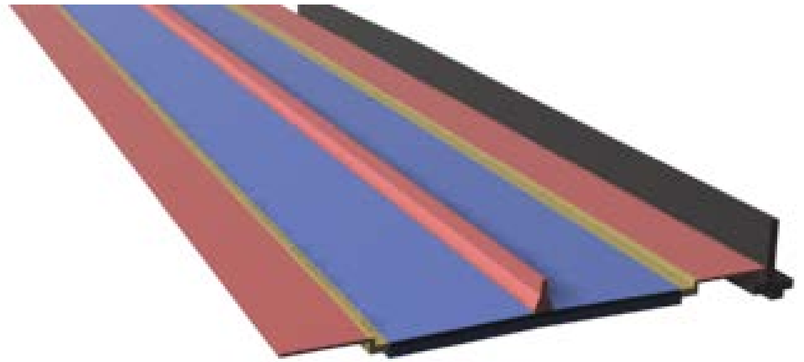
Corridor – 3D model





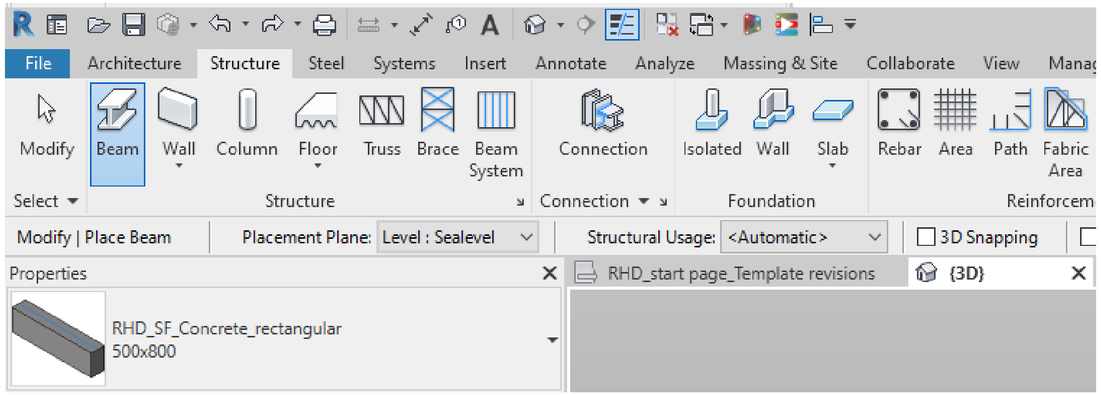


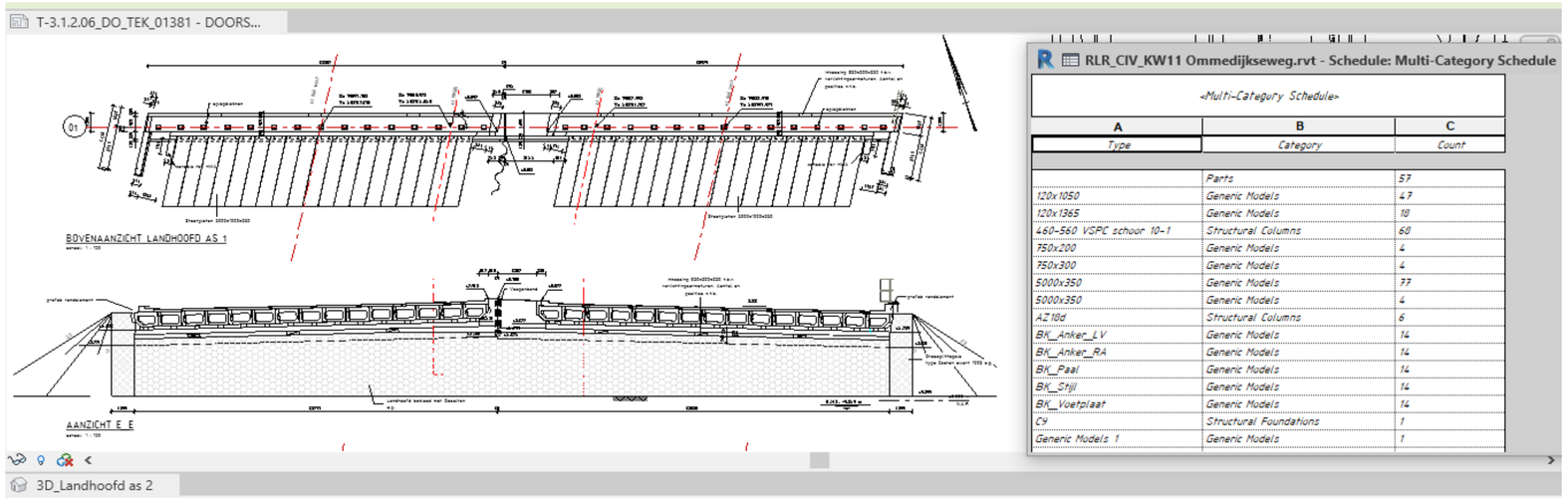


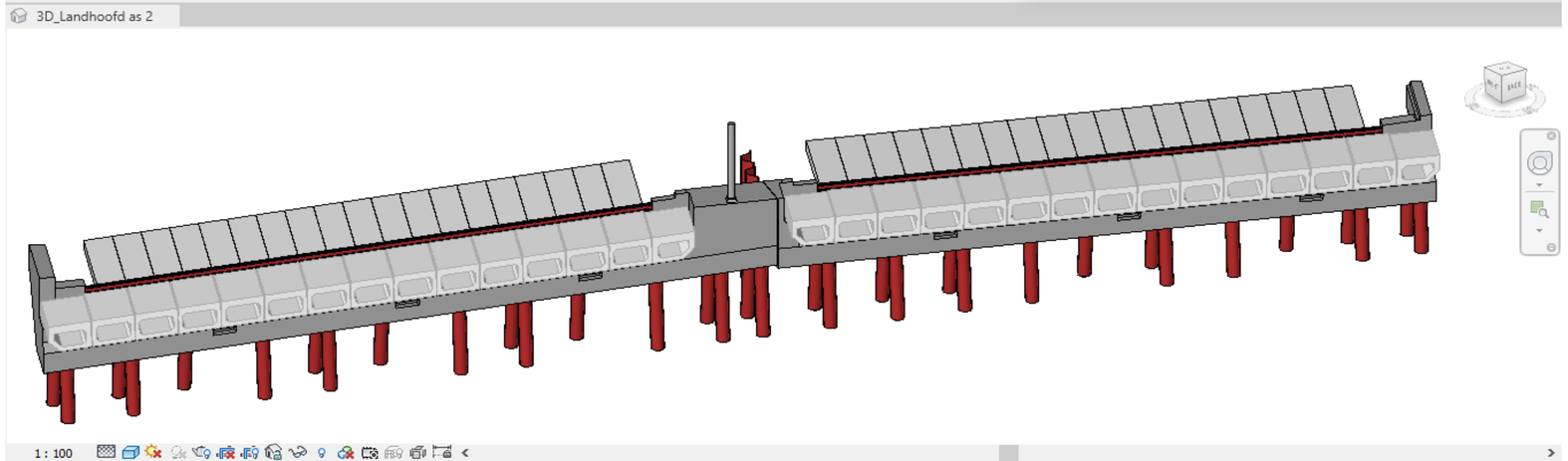


Revit basics

- 3D parametric object-based design
- **Re**vise **i**nst**a**ntly
- Single File Database

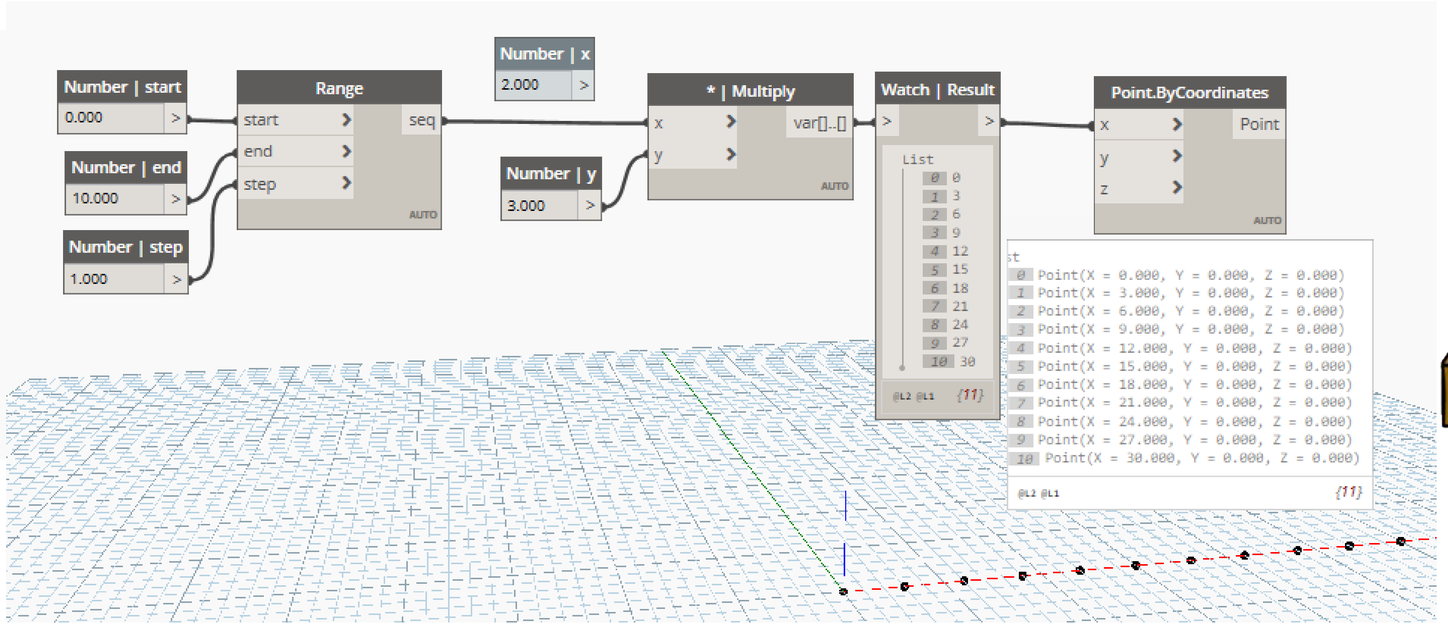






Dynamo basics

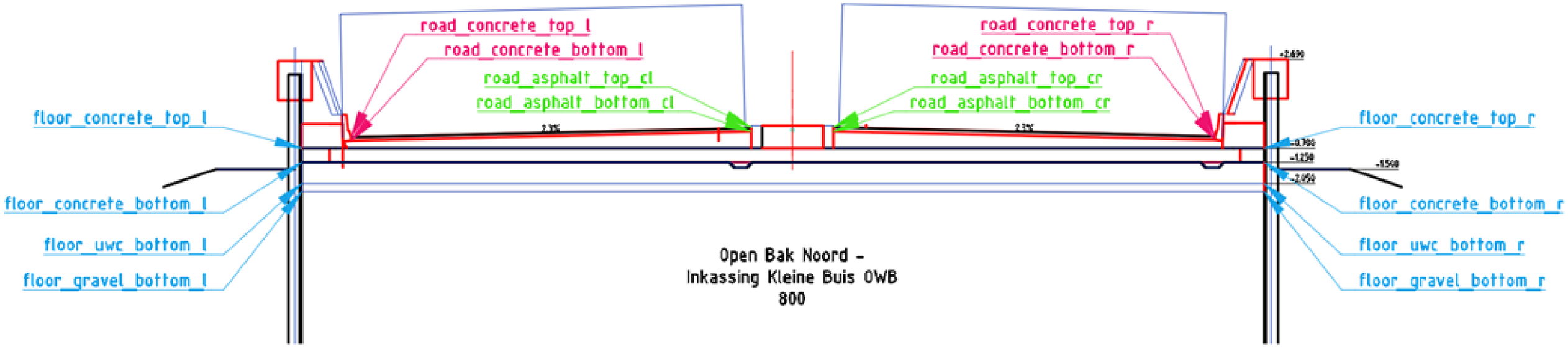
- Visual Programming
- Direct link with the software (Civil 3D, Revit)



No magic skills needed. Can be useful though!

CivilConnection |
Prepare Civil 3D

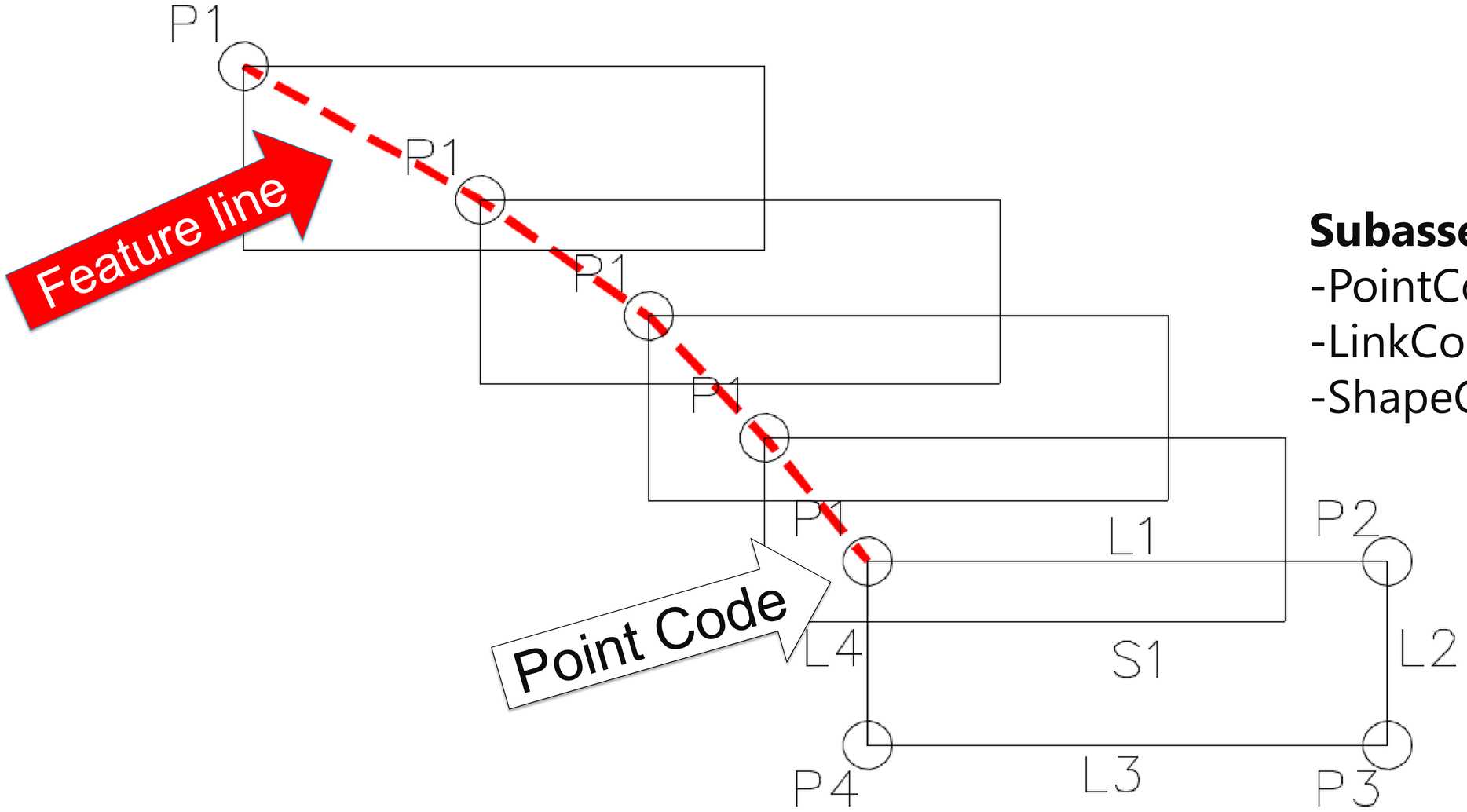
Naming convention – subassembly points



OBJECT_MATERIAL_TOP/BOTTOM_L/CL/CR/R

onderdeel	part	materiaal	material	boven- / onderkant	positie h	l/r
vloer	floor	asfalt	asphalt	top / bottom	links	l
rijbaan	road	beton	concrete		links bij center	cl
wand	wall	onderwaterbeton (OWB)	underwaterconcrete (UWC)		rechts	r
		grind	gravel		rechts bij center	cr

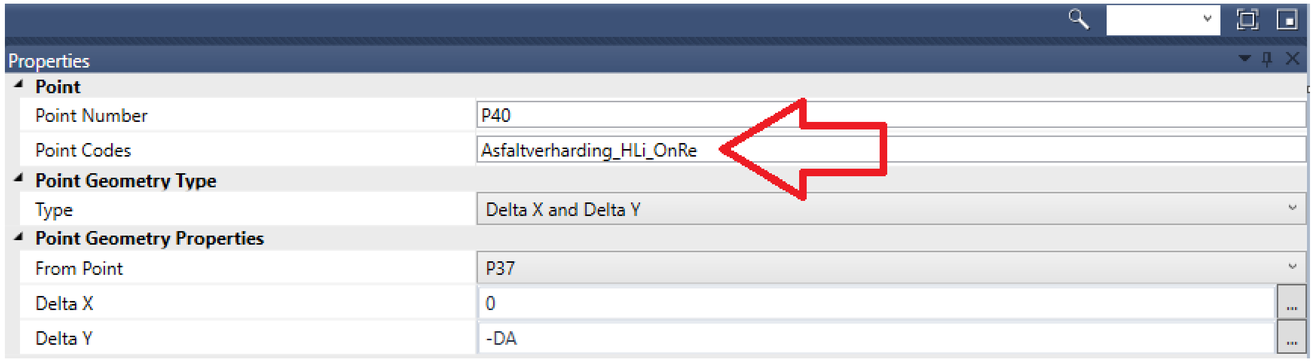
Feature Lines created from Pointcodes



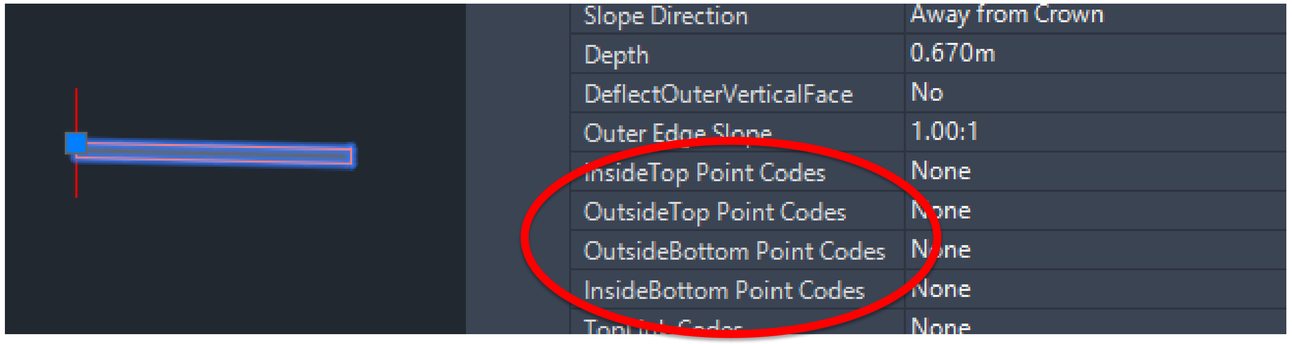
Subassembly basics
-PointCodes
-LinkCodes
-ShapeCodes

Adding point to the Subassembly

- Via Subassembly Composer

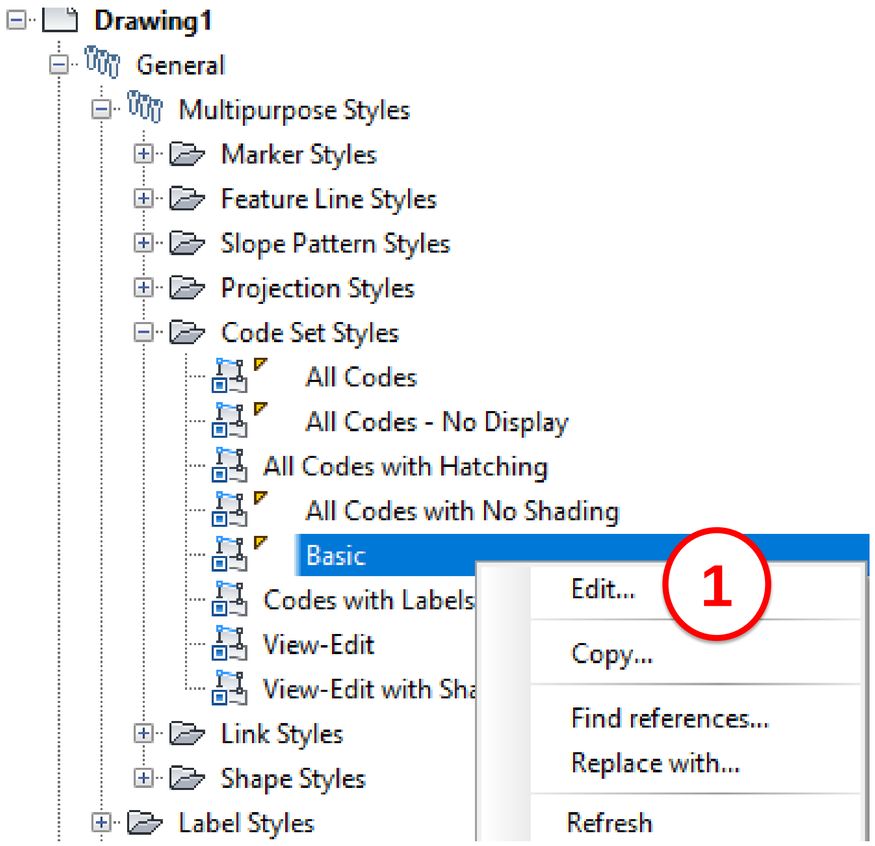


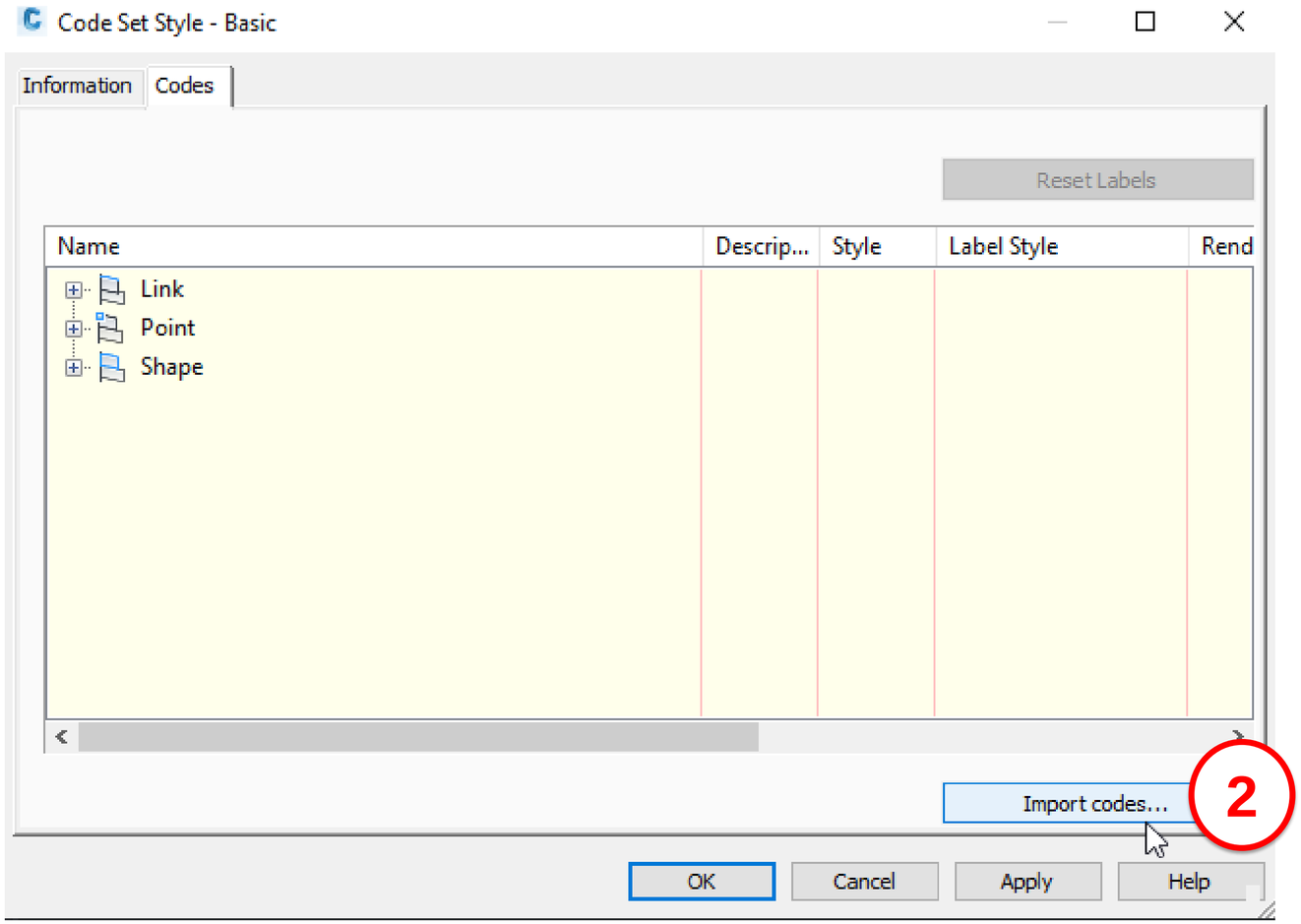
- Via Stock Subassemblies



Adding points to the Corridor

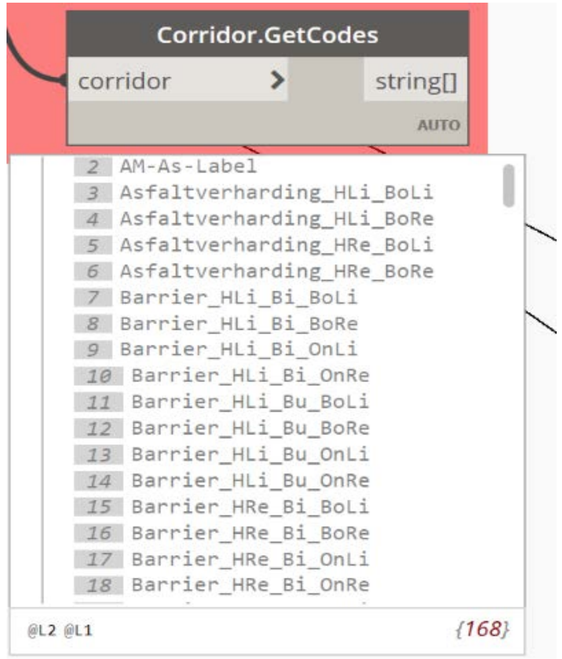
1. Edit… Code Set Style used for the Corridor
2. Import the Codes from your Subassembly

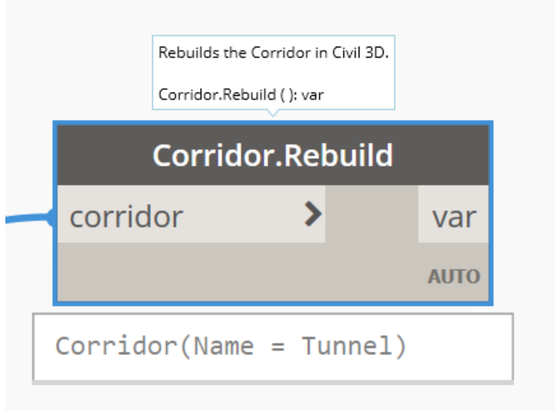


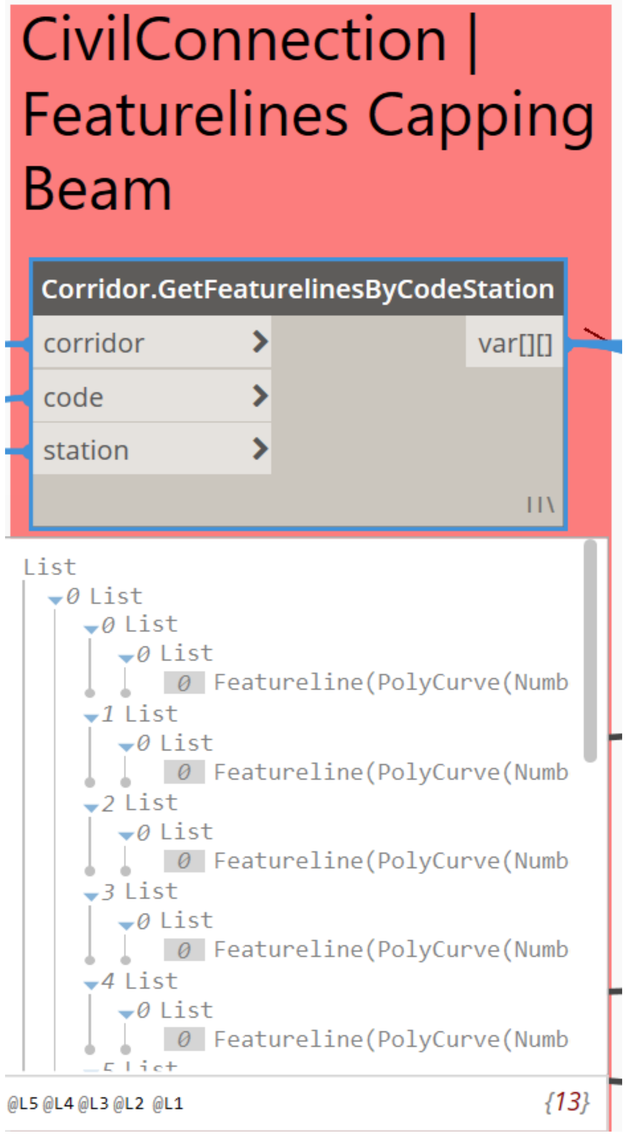


Corridor ready for Dynamo

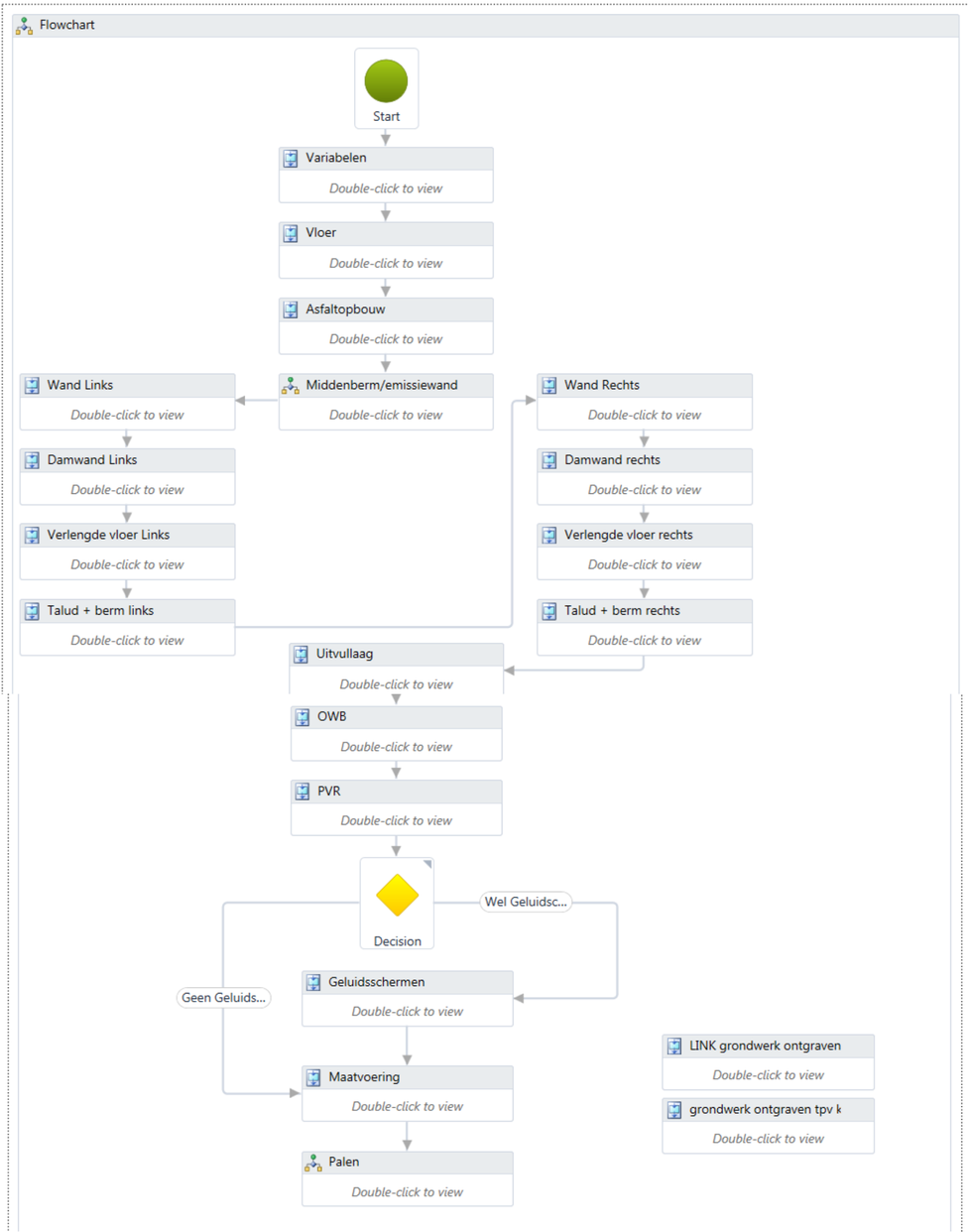
- Corridor:
  - o Get Codes
  - o Get Featurelines
  - o Rebuild

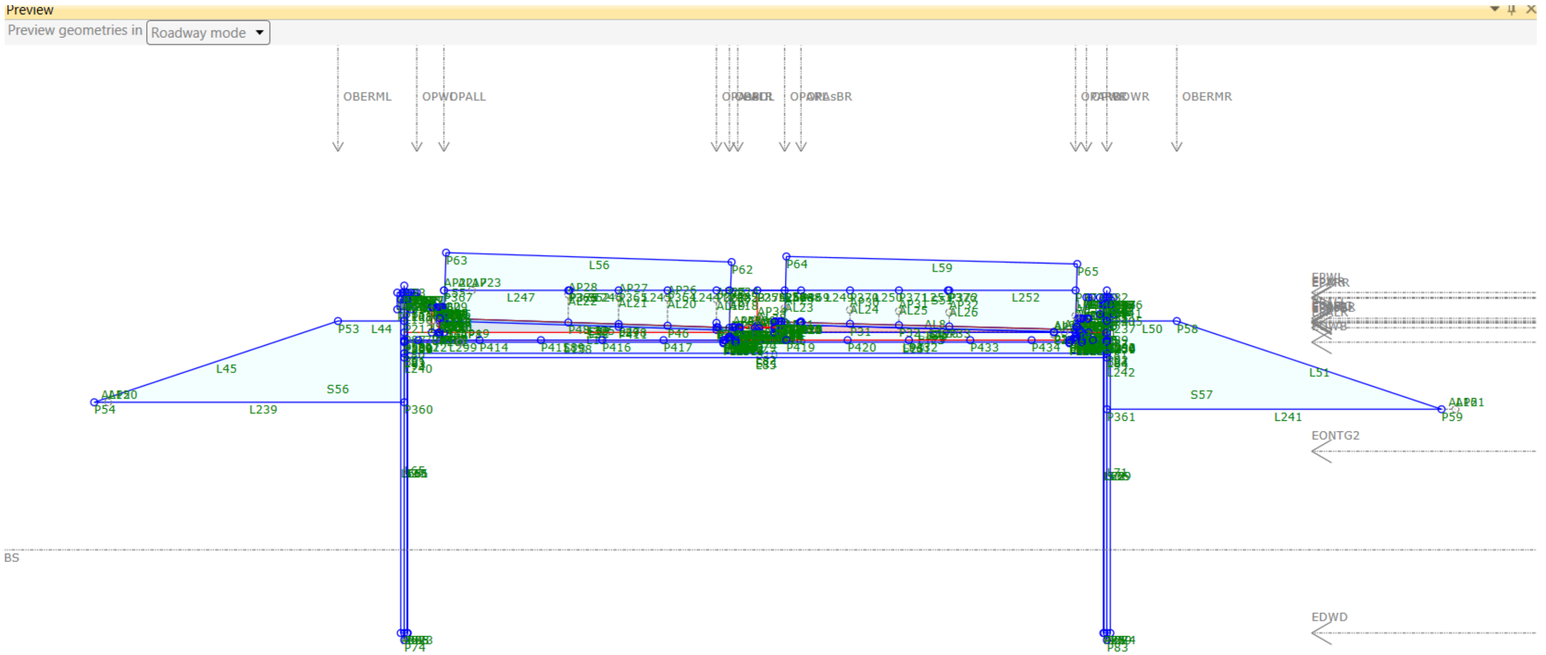






Subassembly Composer

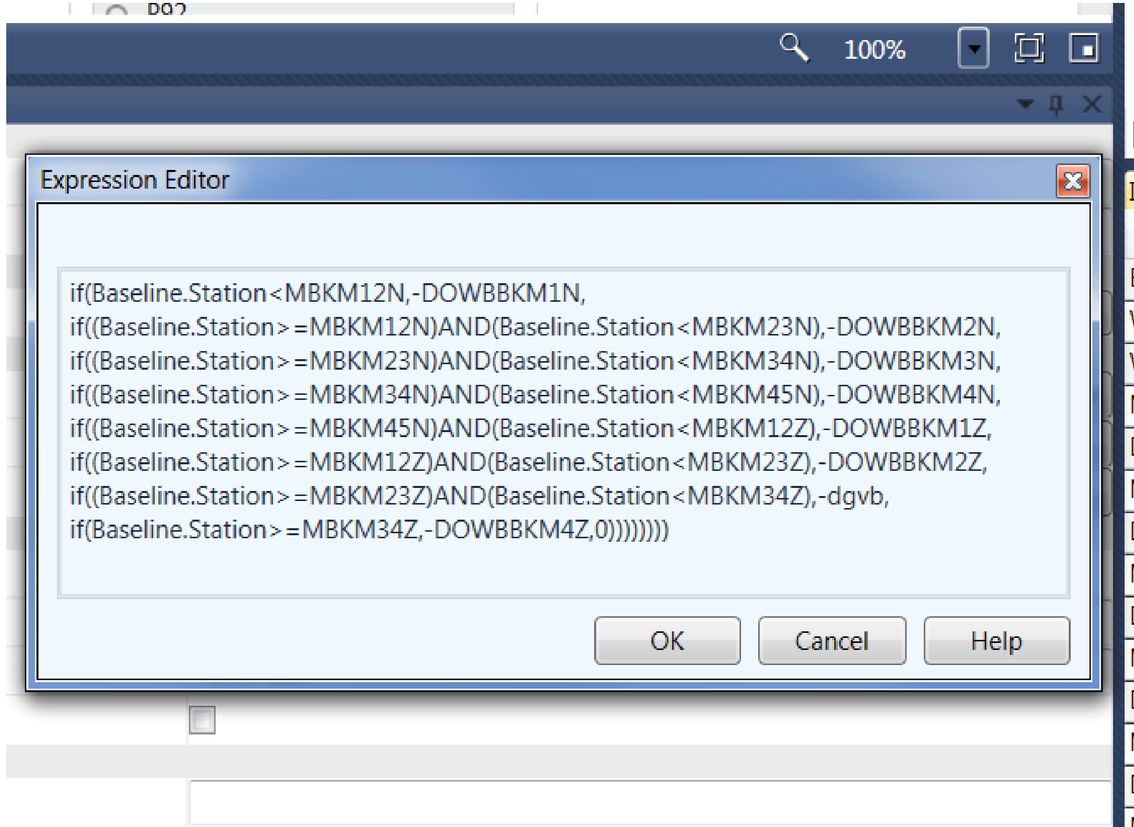




- One Subassembly for the Ramp
- Input based on stations
- Formulas for several thickness / purposes

Subassembly Composer

Formulas + input different thickness Underwater Concrete

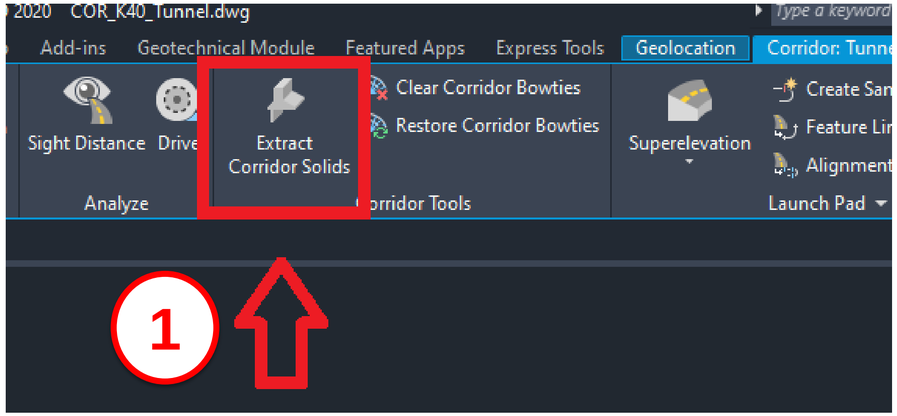


Input/Output Parameters

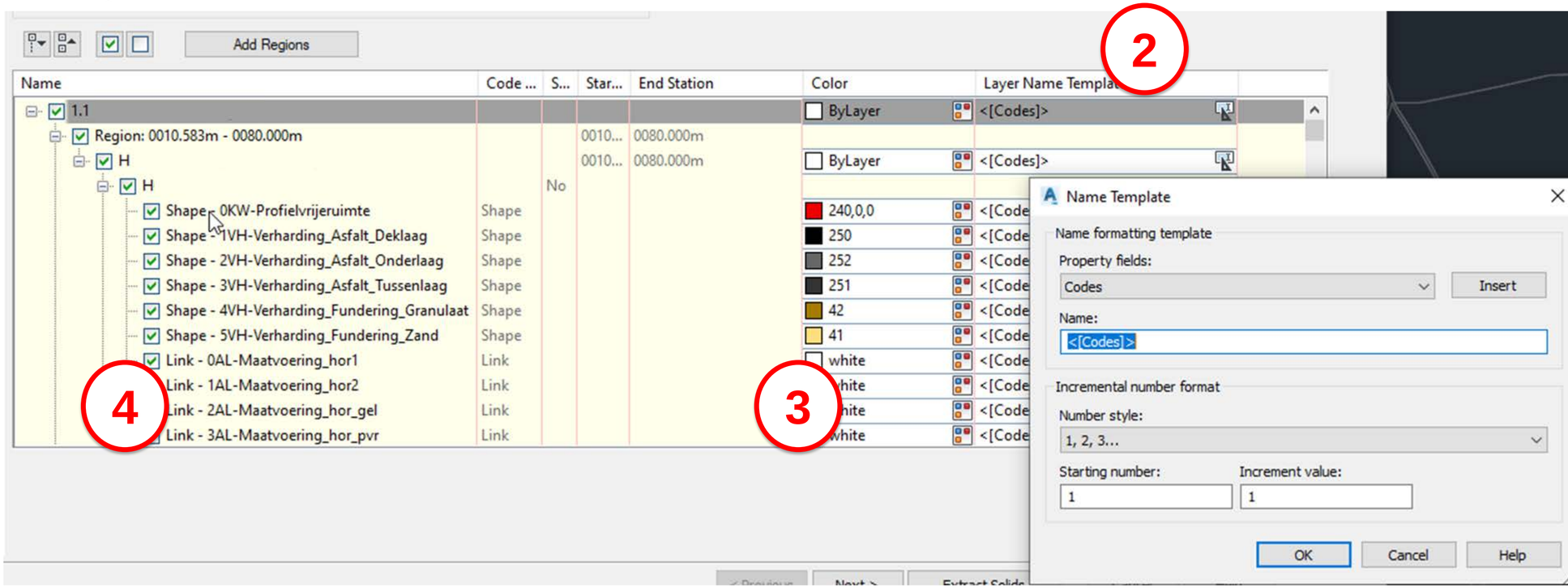
Name	Type	Direction	Default Value	DisplayName
EBAR	Double	Input	14384	Eind metrering barriers
WTOLRBu	Double	Input	0,1	Wandtolerantie buitenkant Rechts
WTOLLBu	Double	Input	0,1	Wandtolerantie buitenkant Links
MBKM12N	Double	Input	11700	Metrering overgang bouwkuipmoot 1-2 noord
DOWBBKM2N	Double	Input	1,05	Dikte OWB bouwkuipmoot 2 noord
MBKM23N	Double	Input	11800	Metrering overgang bouwkuipmoot 2-3 noord
DOWBBKM3N	Double	Input	1,05	Dikte OWB bouwkuipmoot 3 noord
MBKM34N	Double	Input	11900	Metrering overgang bouwkuipmoot 3-4 noord
DOWBBKM4N	Double	Input	1,05	Dikte OWB bouwkuipmoot 4 noord
MBKM45N	Double	Input	12000	Metrering overgang bouwkuipmoot 4-5 noord
DOWBBKM1Z	Double	Input	1	Dikte OWB bouwkuipmoot 1 zuid
MBKM12Z	Double	Input	14344,477	Metrering overgang bouwkuipmoot 1-2 zuid
DOWBBKM2Z	Double	Input	1	Dikte OWB bouwkuipmoot 2 zuid
MBKM23Z	Double	Input	14509,477	Metrering overgang bouwkuipmoot 2-3 zuid
DOWBBKM3Z	Double	Input	0,8	Dikte OWB bouwkuipmoot 3 zuid
MBKM34Z	Double	Input	14700	Metrering overgang bouwkuipmoot 3-4 zuid

Solids export

1. Select Corridor → Extract Corridor Solids (ribbon)

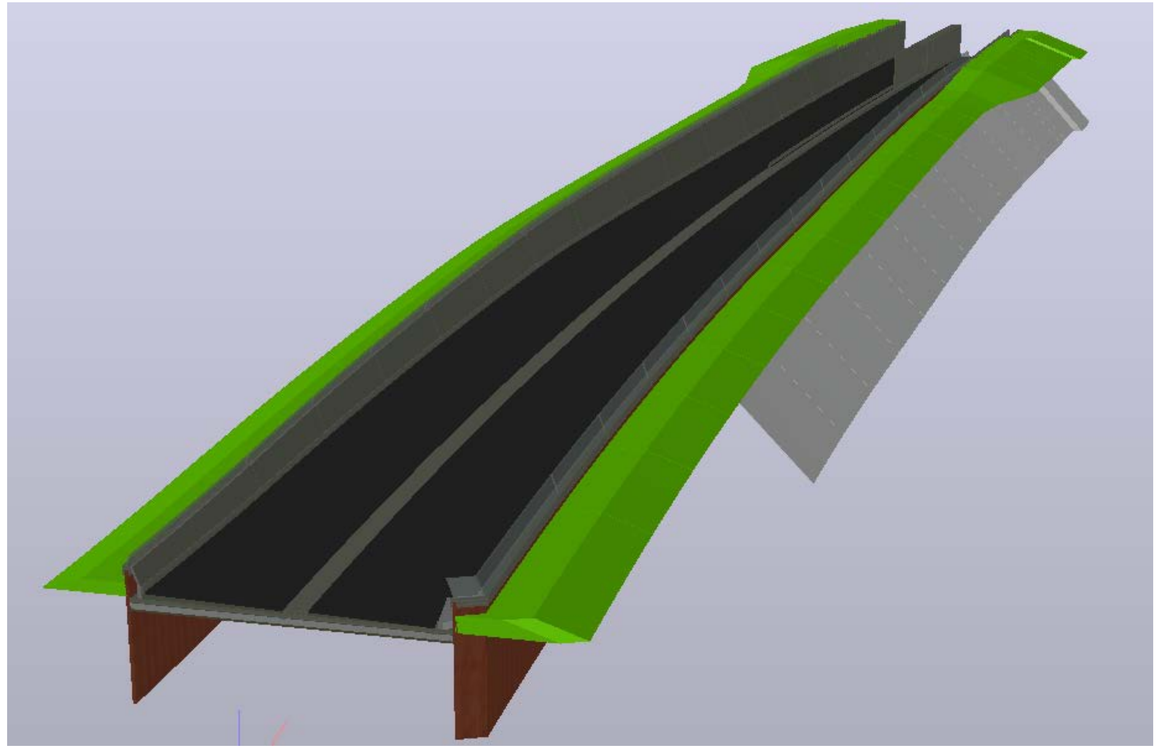


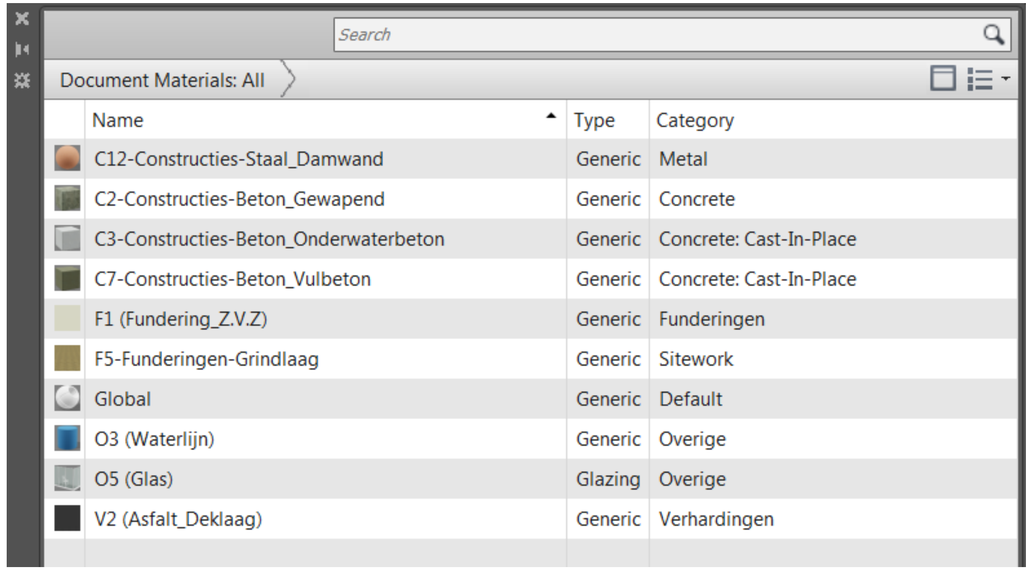
2. Use <[Codes]> for your Layer Name Template
3. Make sure the shape you need has a color
4. Only select the solids you need

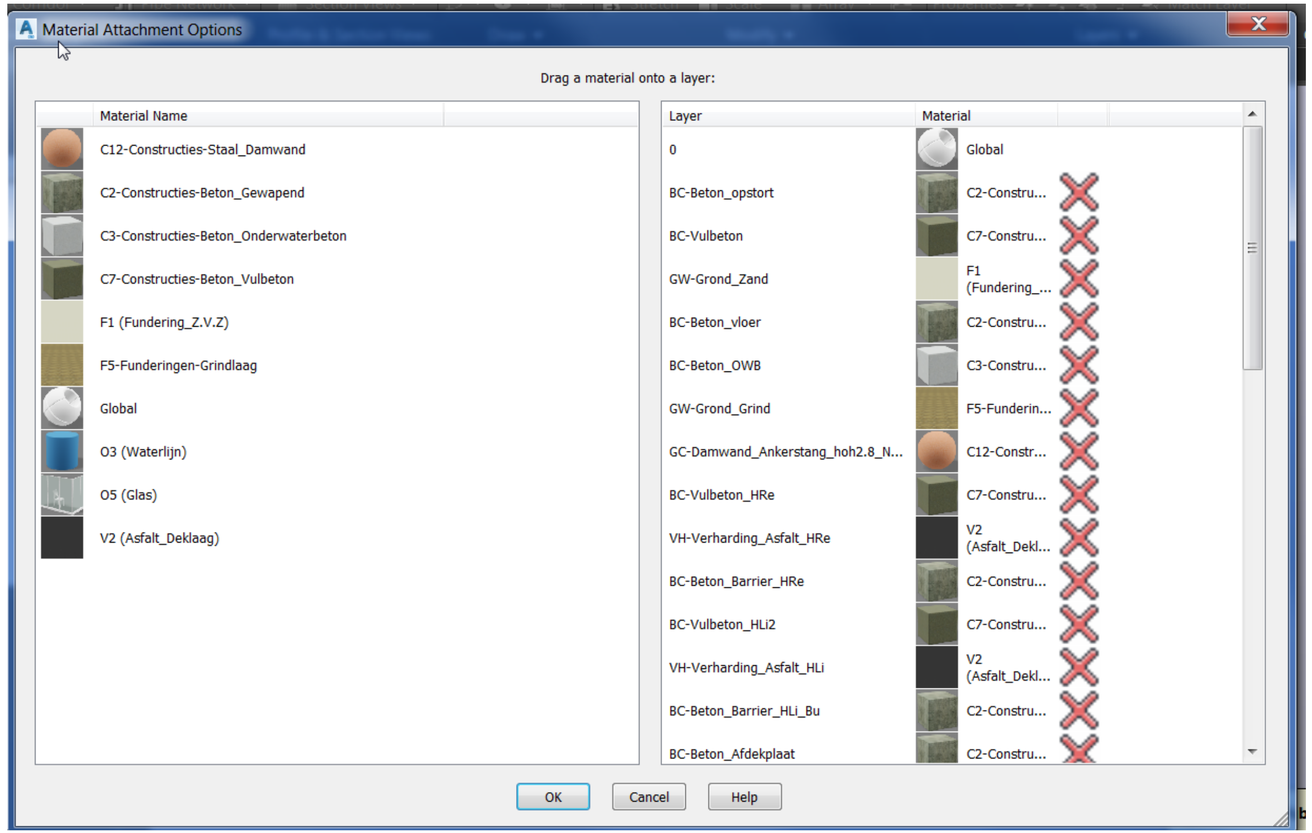


Solids export

- Use a template that contains your materials
- Materials are added to layers via *Material Attachment Options* (“MATERIALATTACH”)

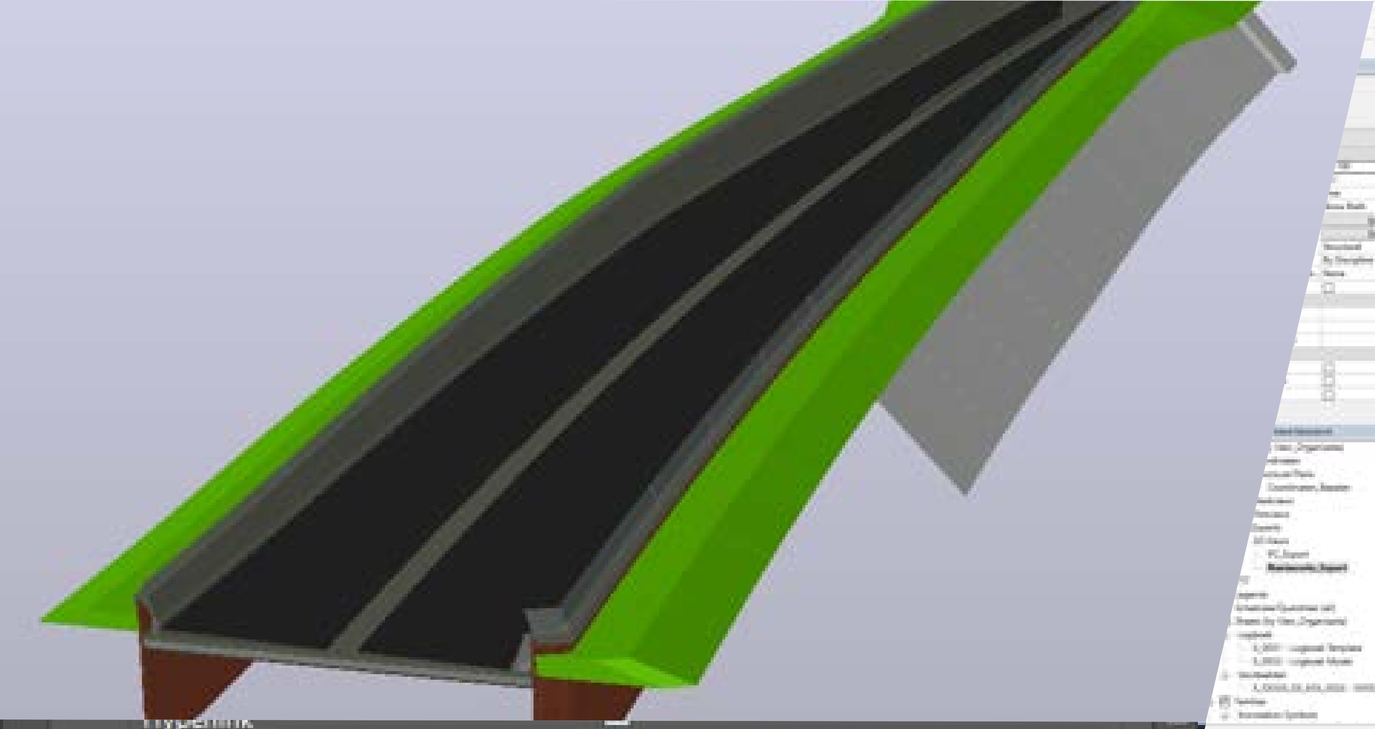


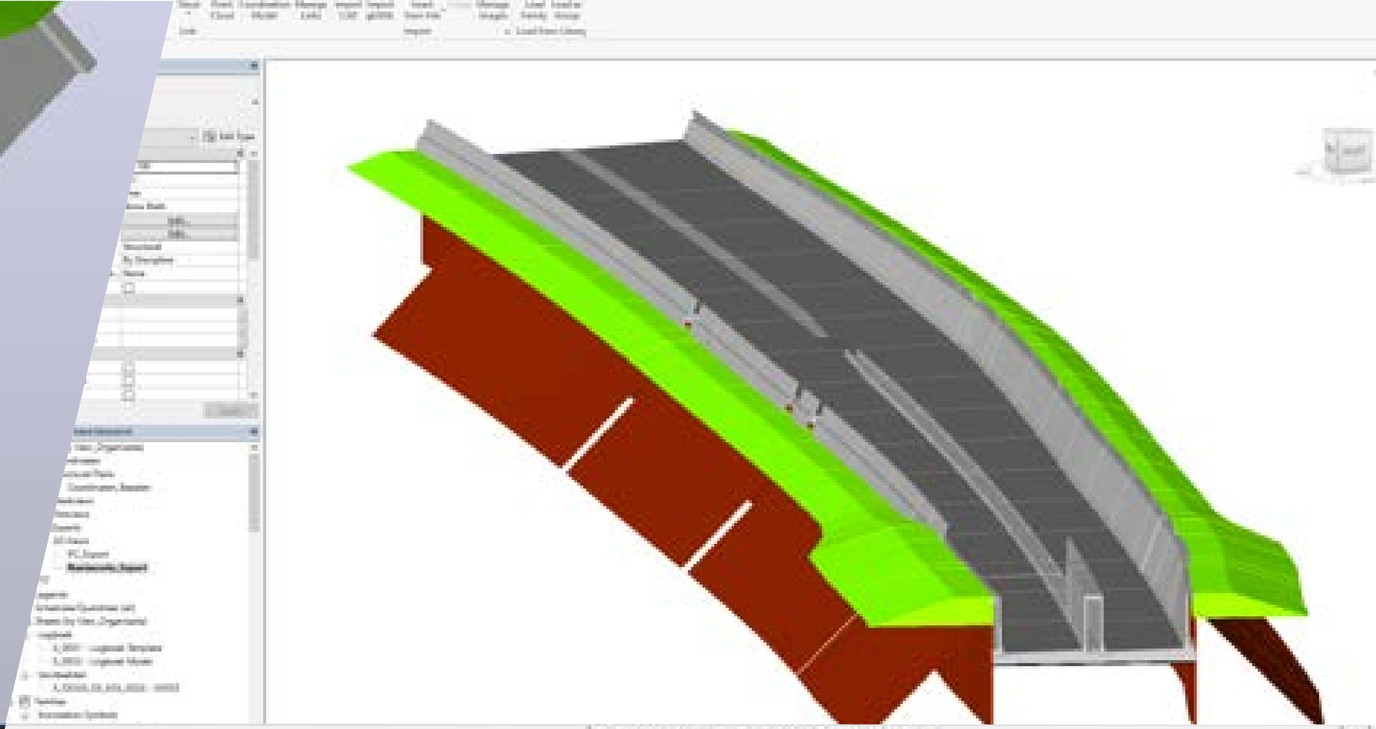




CivilConnection |

Civil 3D → Revit



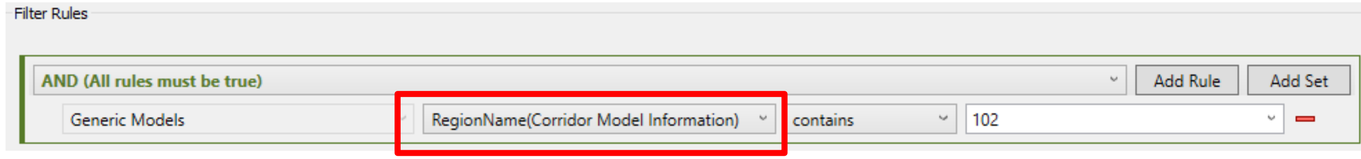


Notes	
Reference documents	(0)
PROPERTY SETS	
Corridor Model Information	
BaselineName	BL - G00H - (4)
CorridorDesc	
CorridorName	Tunnel
HorizontalBaseline	G00H
RegionName	Toeritmoot 116
VerticalBaseline	G00H
Corridor Shape Information	
AssemblyEndStation	120+00.00m
AssemblyName	Open bak Toerit
AssemblyStartStation	119+75.00m
ClassificationCode	
CodeName	VH-Verharding_Asfalt_HRe
PayItem	

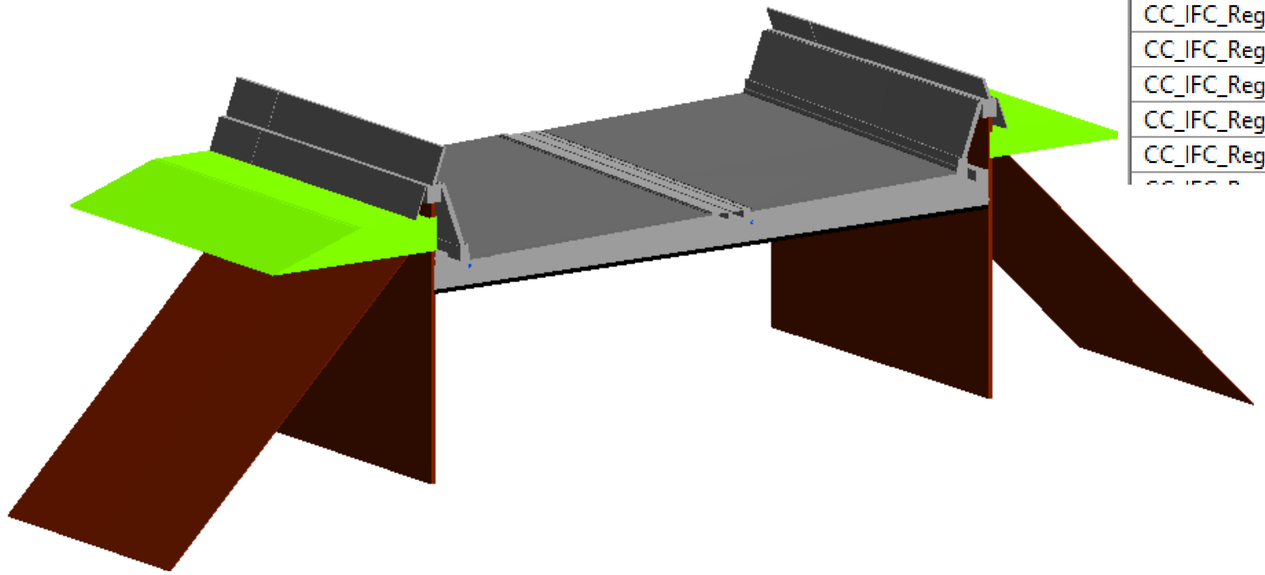
	2pA7BHQyFEIG0000000Meq
	IfcBuildingElementProxy
tationLayer	VH-Verharding_Asfalt_HRe
lContainer	DGB_BMO_DG2_N_TUN_K40 Toerit Noord M101-M116
rName(Corridor Model Information)	Tunnel
eName(Corridor Model Information)	BL - G00H - (4)
ontalBaseline(Corridor Model Information)	G00H
calBaseline(Corridor Model Information)	G00H
onName(Corridor Model Information)	Toeritmoot 116
deName(Corridor Shape Information)	VH-Verharding_Asfalt_HRe
e(Corridor Shape Information)	No
ssemblyName(Corridor Shape Information)	Open bak Toerit
AssemblyStartStation(Corridor Shape Information)	119+75.00m
AssemblyEndStation(Corridor Shape Information)	120+00.00m
Volume(Corridor Shape Information)	59.121417

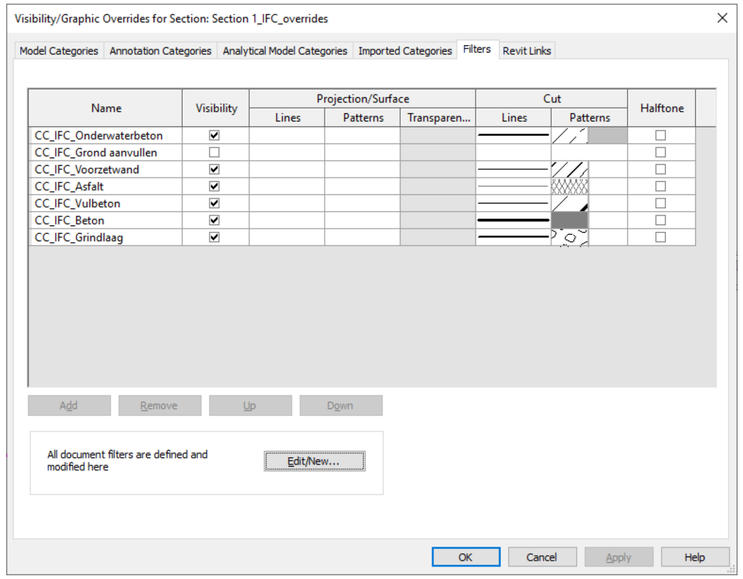
Revit “IFC” Visibility (PD)

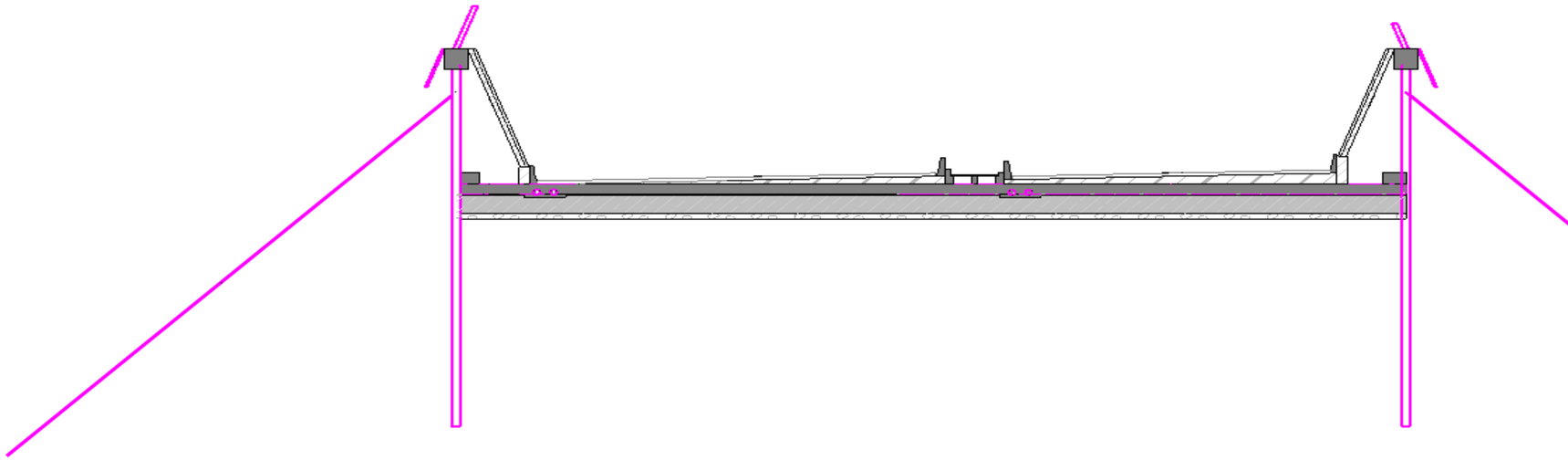
- Shared Parameters created CivilConnection
  - CodeName
  - RegionName
- Filters
  - Overrides



Name	Visibility
CC_IFC_Region_107	☐
CC_IFC_Region_106	☐
CC_IFC_Region_101	☐
CC_IFC_Region_102	☑
CC_IFC_Region_103	☐
CC_IFC_Region_104	☐







Revit “IFC” Preliminary Design

Dynamo script

- Export IFC from C3D
- Link IFC
- Update IFC

Note!

IFC model ≠ Revit model

Reference model

Phased Revit model elements

- Piles
- Sheet piles + anchors
- Floor, etc…/

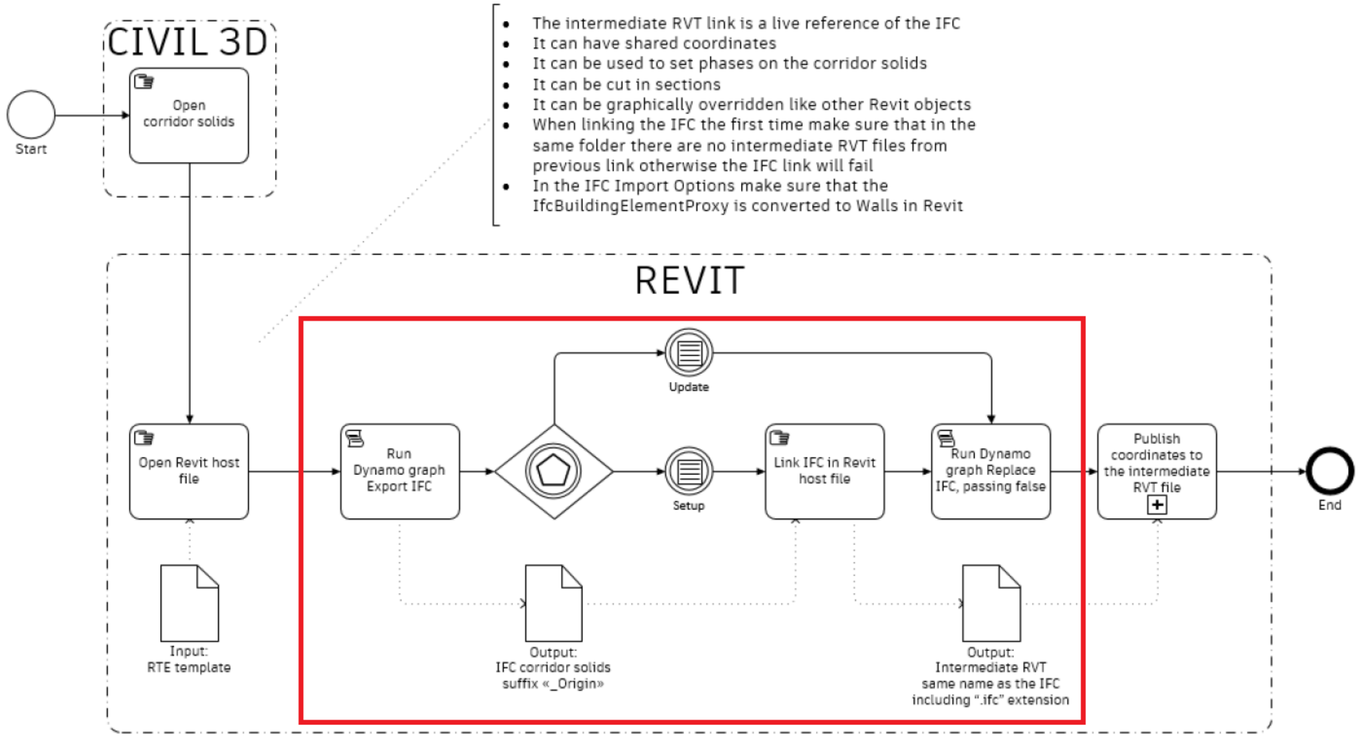
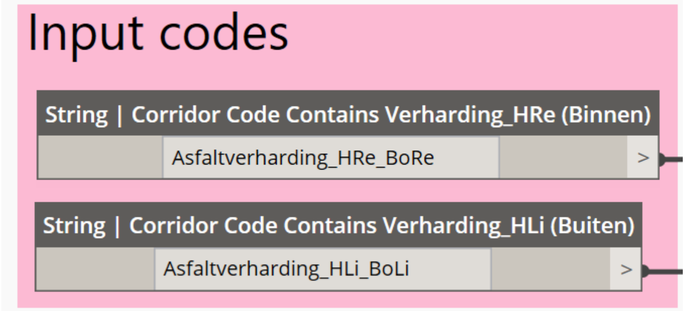
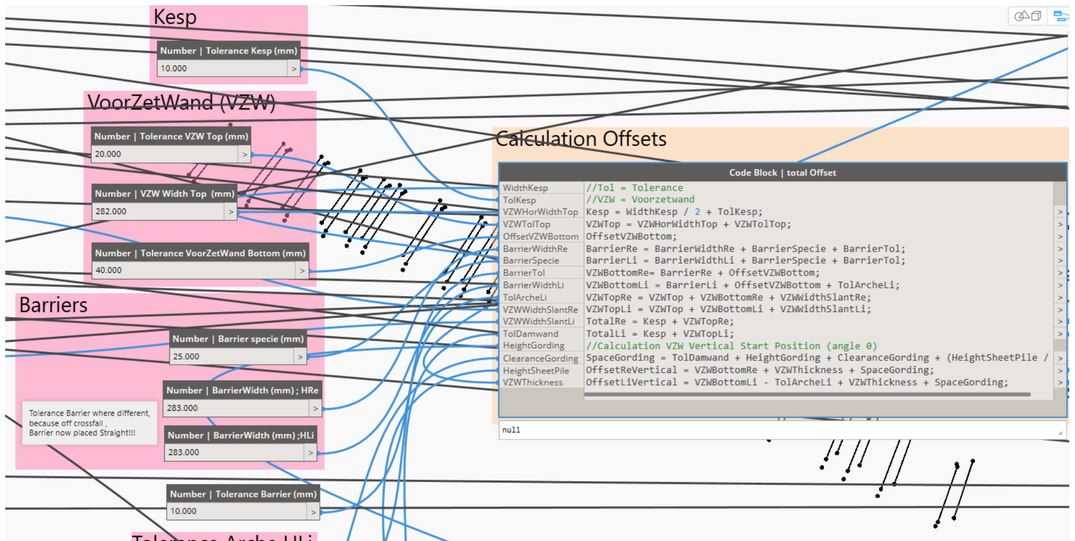


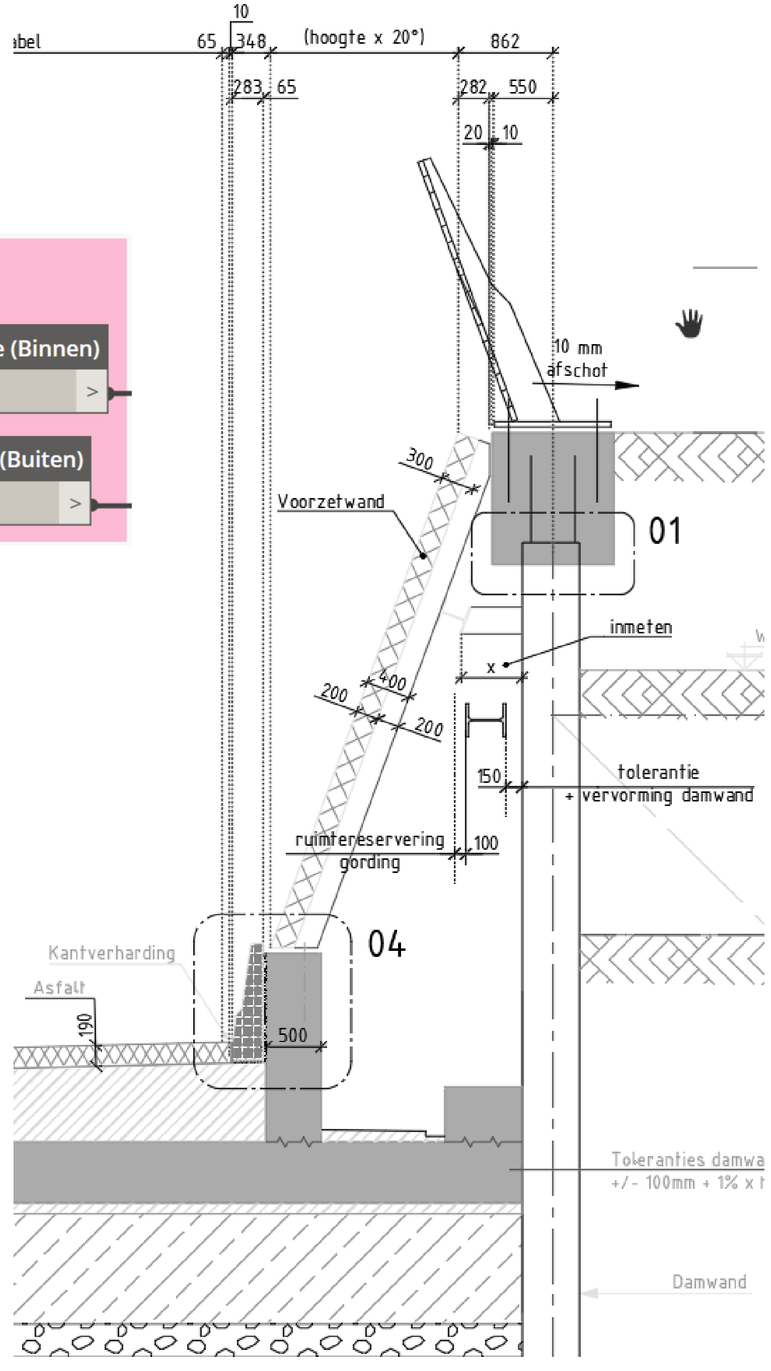
Figure 6: Setup and Update an IFC link

Capping Beam (start point Pit!)

- 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

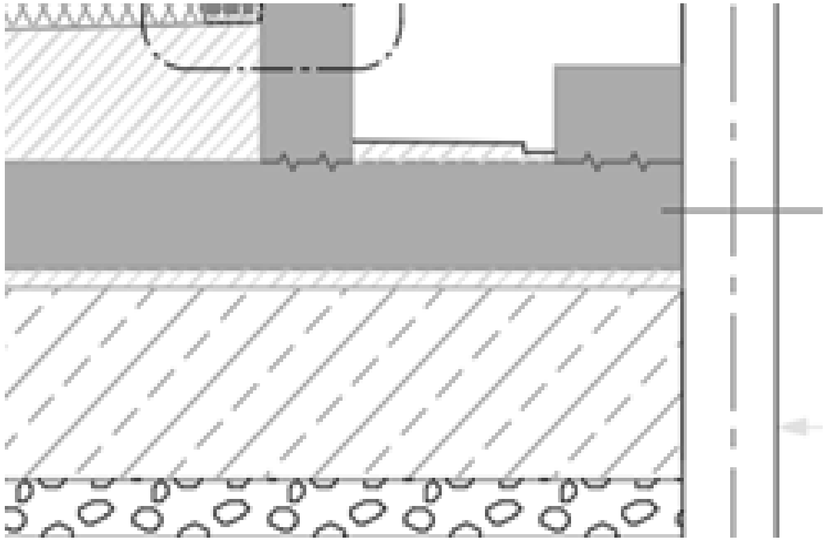


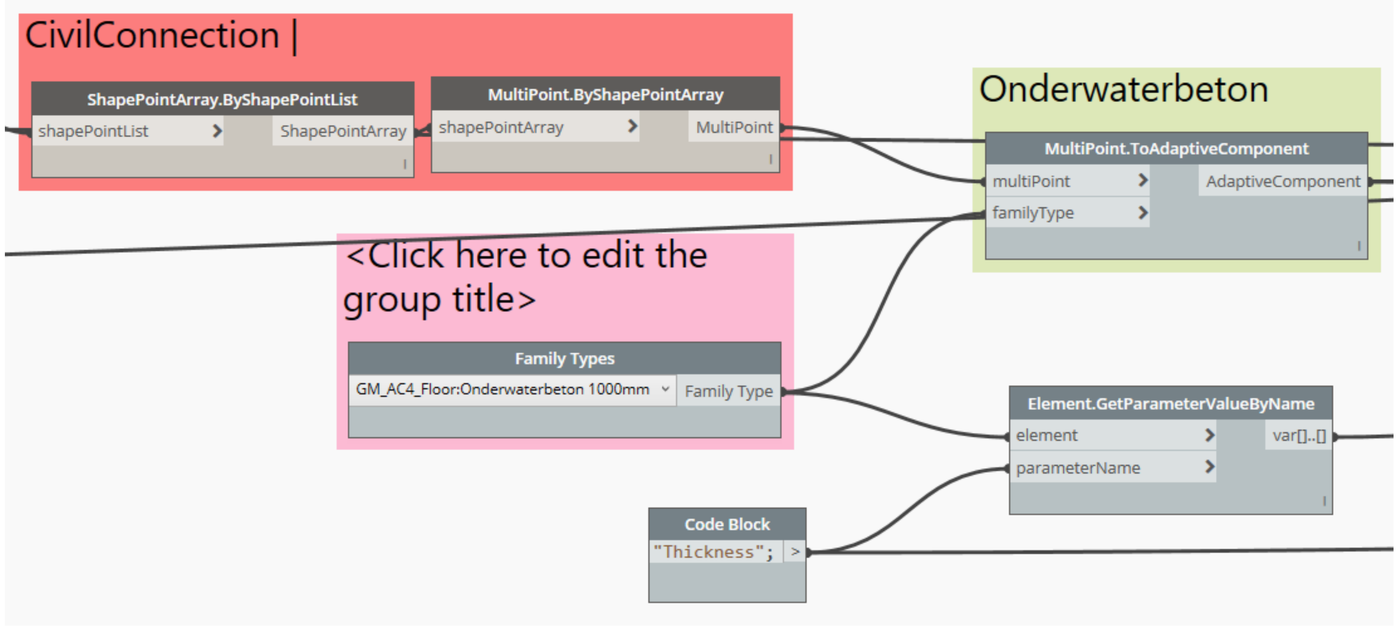


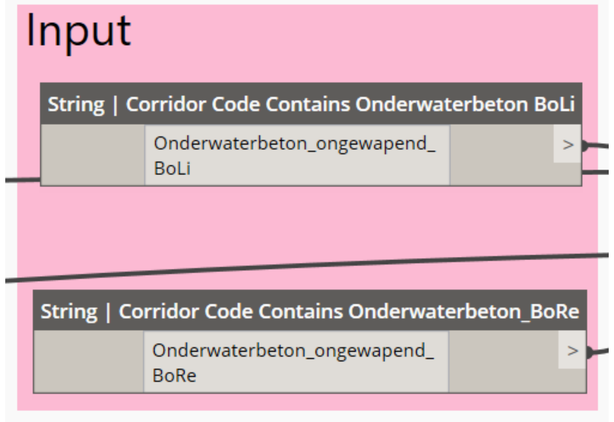


Floors (MultiShapePoints; Multiple Featurelines)

- **Generic Model Adaptive (4points)**
  - Concrete structural floor
  - Plinth along sheet piles
  - Filling
  - Gravel
  - Underwater concrete (Basic)





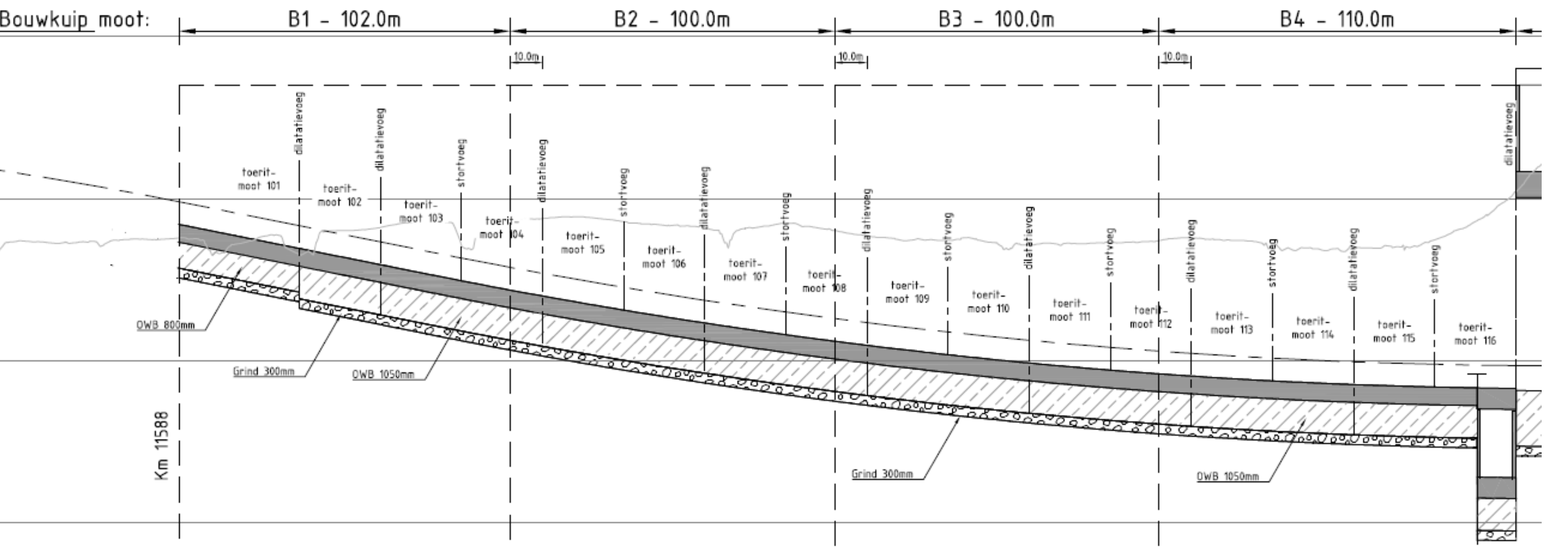


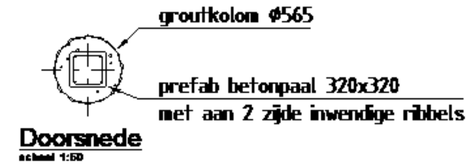
Piles

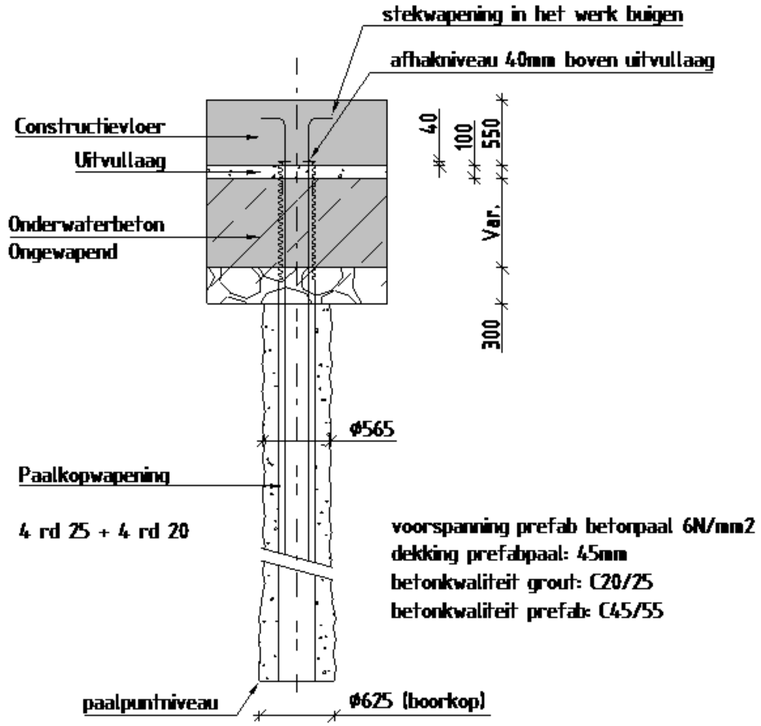
- Structural Columns
- Lateral and longitudinal Center to Center distance?
  - Excel Structural engineer (6 parameters)
  - Calculated segment length 50m (2 segments 25m)
- Top off Pile, bottom underwater concrete (sloped)

Code Block

```
lst //Input From Excel
    aantal_voegrijen = List.GetItemAtIndex(lst@@-2<1>, 0);
    Maximale_afstand_voegrijen = List.GetItemAtIndex(lst@@-2<1>, 1);
    Maximale_afstand_dwarsrichting = List.GetItemAtIndex(lst@@-2<1>, 2);
    Maximale_afstand_lengterichting = List.GetItemAtIndex(lst@@-2<1>, 3);
    Afstand_tot_voeg = List.GetItemAtIndex(lst@@-2<1>, 4);
    Afstand_tot_damwand = List.GetItemAtIndex(lst@@-2<1>, 5);
    //output van variabelen;
```

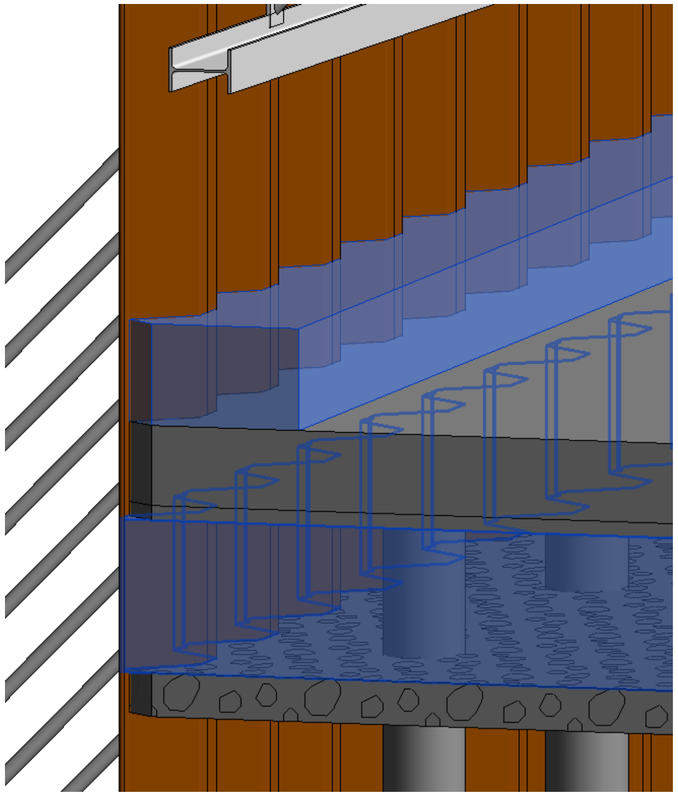


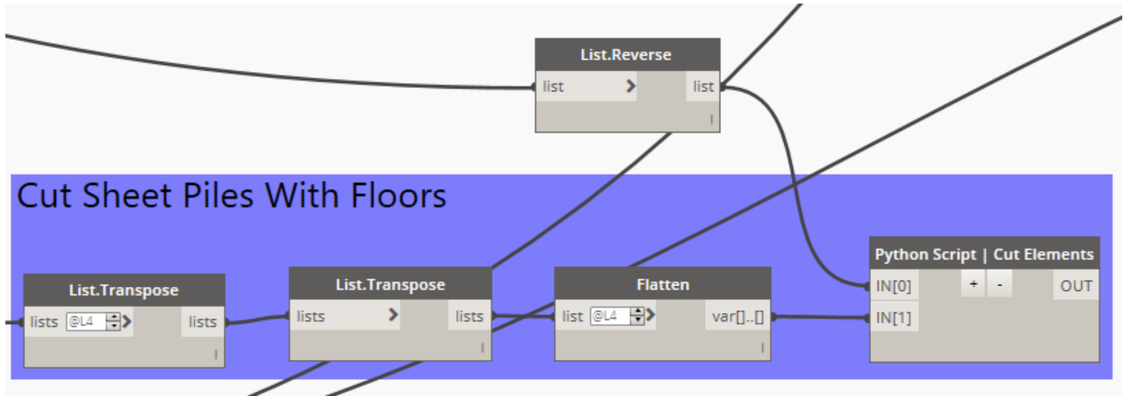




Dynamo & Python

- Floors cut with sheet piles



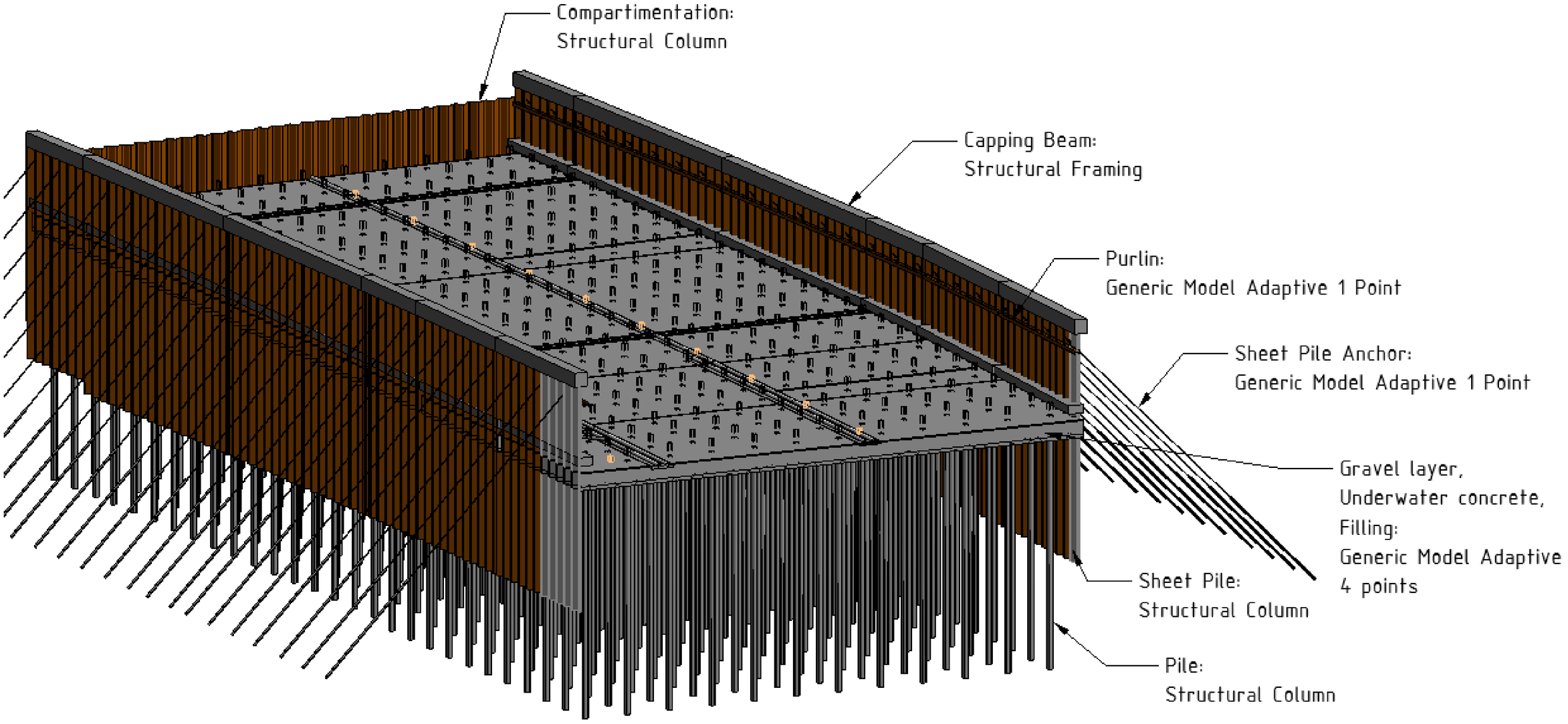


Edit Python Script...

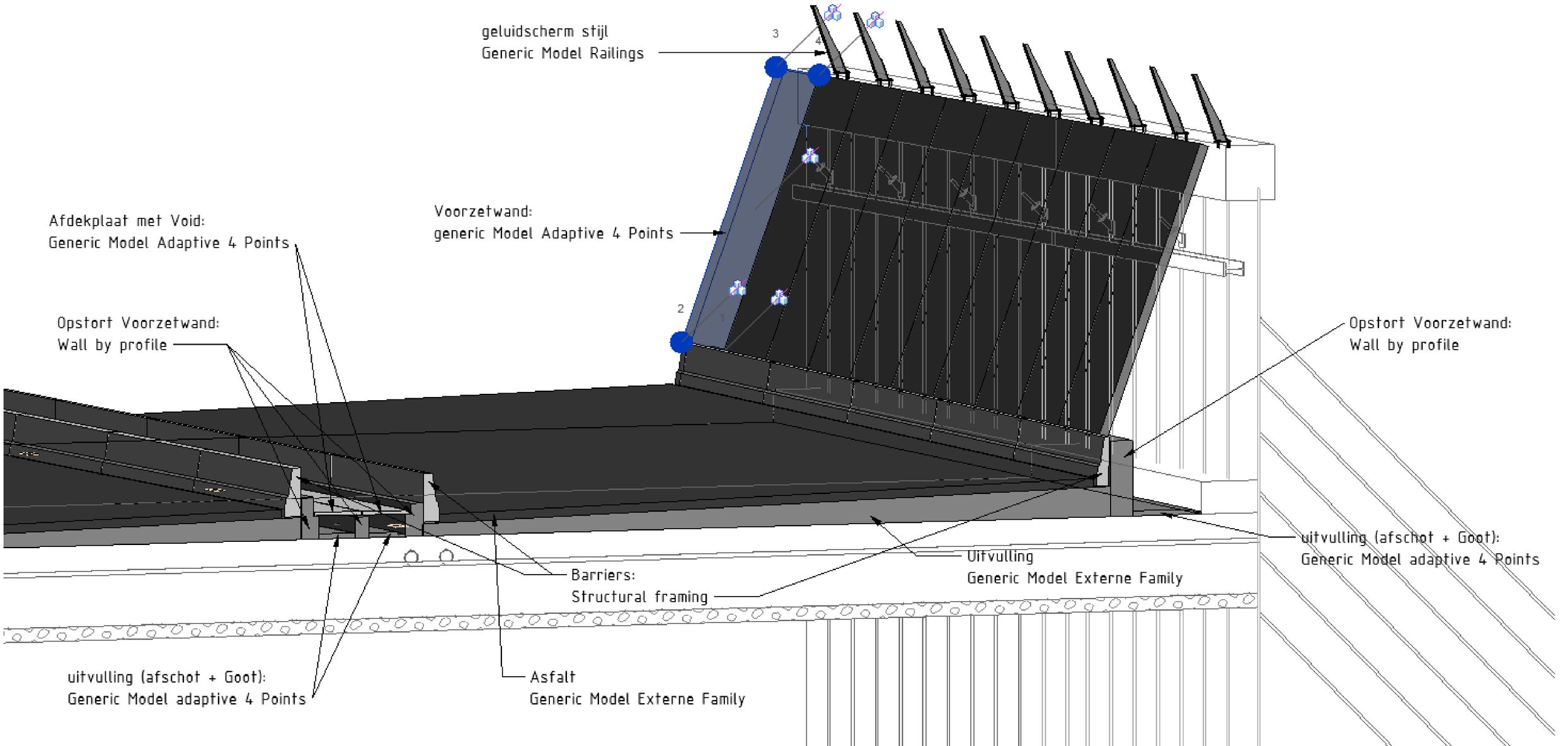
```python
import clr
clr.AddReference('ProtoGeometry')
from Autodesk.DesignScript.Geometry import *

#Import the Revit Services
clr.AddReference("RevitServices")
import RevitServices
from RevitServices.Persistence import DocumentManager
from RevitServices.Transactions import TransactionManager
doc = DocumentManager.Instance.CurrentDBDocument

#Import the Revit Nodes
clr.AddReference("RevitNodes")
import Revit
clr.ImportExtensions(Revit.Elements)
# Import geometry conversion extension methods
clr.ImportExtensions(Revit.GeometryConversion)

#Import the Revit API
clr.AddReference("RevitAPI")
import Autodesk
from Autodesk.Revit.DB import *

#Define tolist function
def tolist(obj1):
    if hasattr(obj1,"__iter__"):
        return obj1
    else:
        return [obj1]

def cutElements(cuttingElement, cuttedElement):
    try:
        SolidSolidCutUtils.AddCutBetweenSolids(doc, cuttedElement,
        cuttingElement);
    except:
        try:
            InstanceVoidCutUtils.AddInstanceVoidCut(doc, cuttedElement,
            cuttingElement);
        except:
            pass
    return cuttedElement

#Define Input (IN)
floors = tolist(UnwrapElement(IN[0]))
sheetPilesPerMoot = tolist(UnwrapElement(IN[1]))
output = []

# Start Transaction
TransactionManager.Instance.EnsureInTransaction(doc)

for i in range(len(floors)):
    #Get the Current Tunnel Segment Floor
    floor = floors[i]

    #Get the Current Tunnel Segment Sheet Piles
    sheetPiles = sheetPilesPerMoot[i]

    #Start Cutting
    for sheetPile in sheetPiles:
```

Accept Changes | Cancel

Construction pit (4 per side)

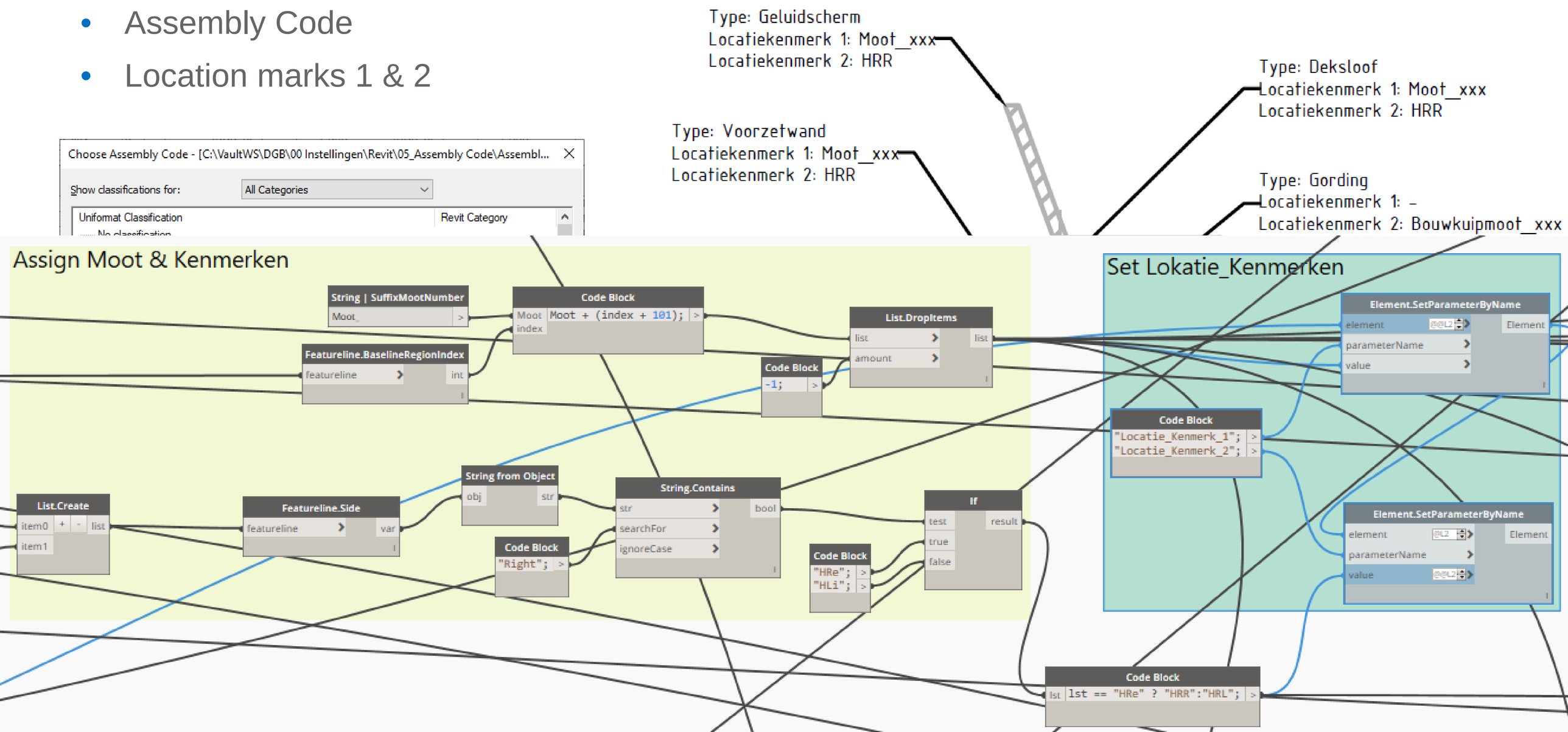


Access ramp


geluidscherm stijl
Generic Model Railings
Voorzetwand:
generic Model Adaptive 4 Points
Afdekplaat met Void:
Generic Model Adaptive 4 Points
Opstort Voorzetwand:
Wall by profile
Opstort Voorzetwand:
Wall by profile
Barriers:
Structural framing
Uitvulling
Generic Model Externe Family
uitvulling (afschot + Goot):
Generic Model adaptive 4 Points
uitvulling (afschot + Goot):
Generic Model adaptive 4 Points
Asfalt
Generic Model Externe Family

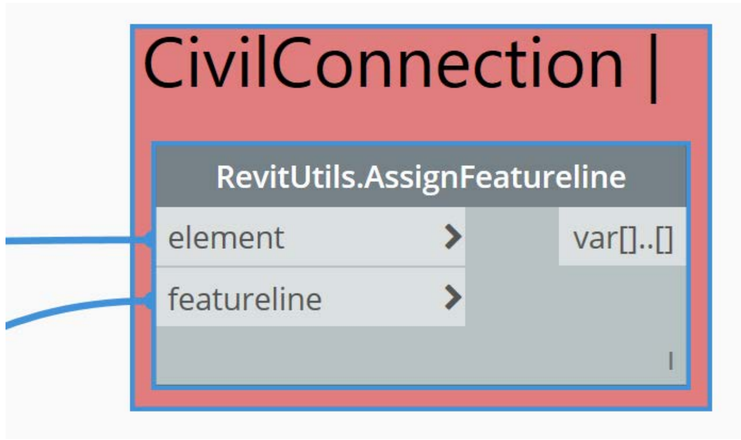
Coding Revit elements (per segments)

- Assembly Code
- Location marks 1 & 2

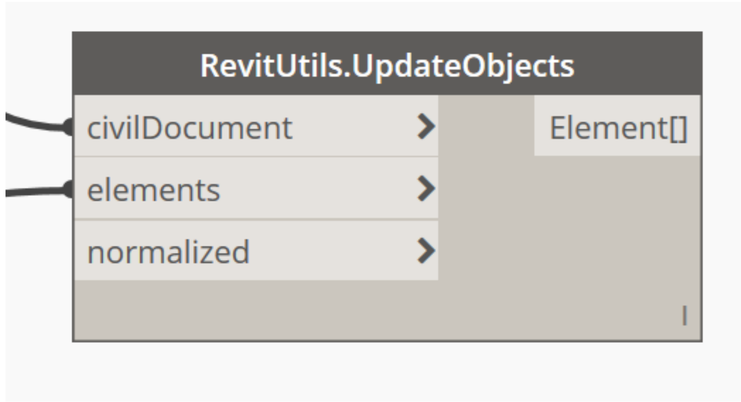


Assign Featurelines

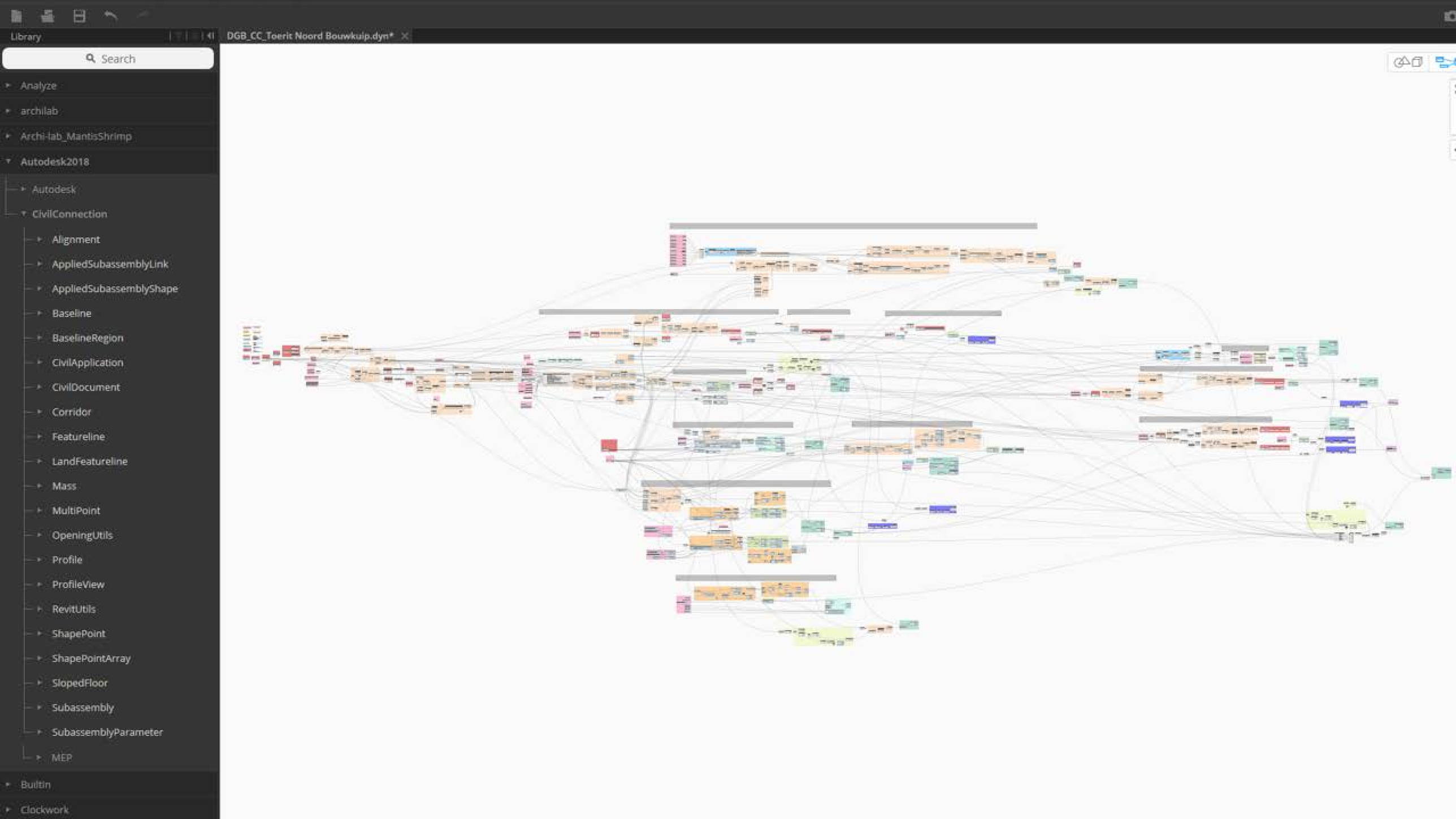
- Assign Revit elements to C3D feature lines



- Update!



Data	
ADSK_Corridor	Tunnel
ADSK_BaselineIndex	0
ADSK_RegionIndex	0
ADSK_RegionRelative	7.2
ADSK_RegionNormalized	0.000198
ADSK_Code	Deksloof_HLi_BoMi
ADSK_Side	Left
ADSK_X	93332436.0
ADSK_Y	443123413.0
ADSK_Z	-1500.0
ADSK_Station	11588507.0
ADSK_Offset	130.0
ADSK_Elevation	0.0
ADSK_AngleZ	
ADSK_Update	☑
ADSK_Delete	☐
ADSK_MultiPoint	
ADSK_EndStation	11625000.0
ADSK_EndOffset	130.0
ADSK_EndElevation	0.0
ADSK_EndRegionRelative	36499.6
ADSK_EndRegionNormalized	0.999990


Library
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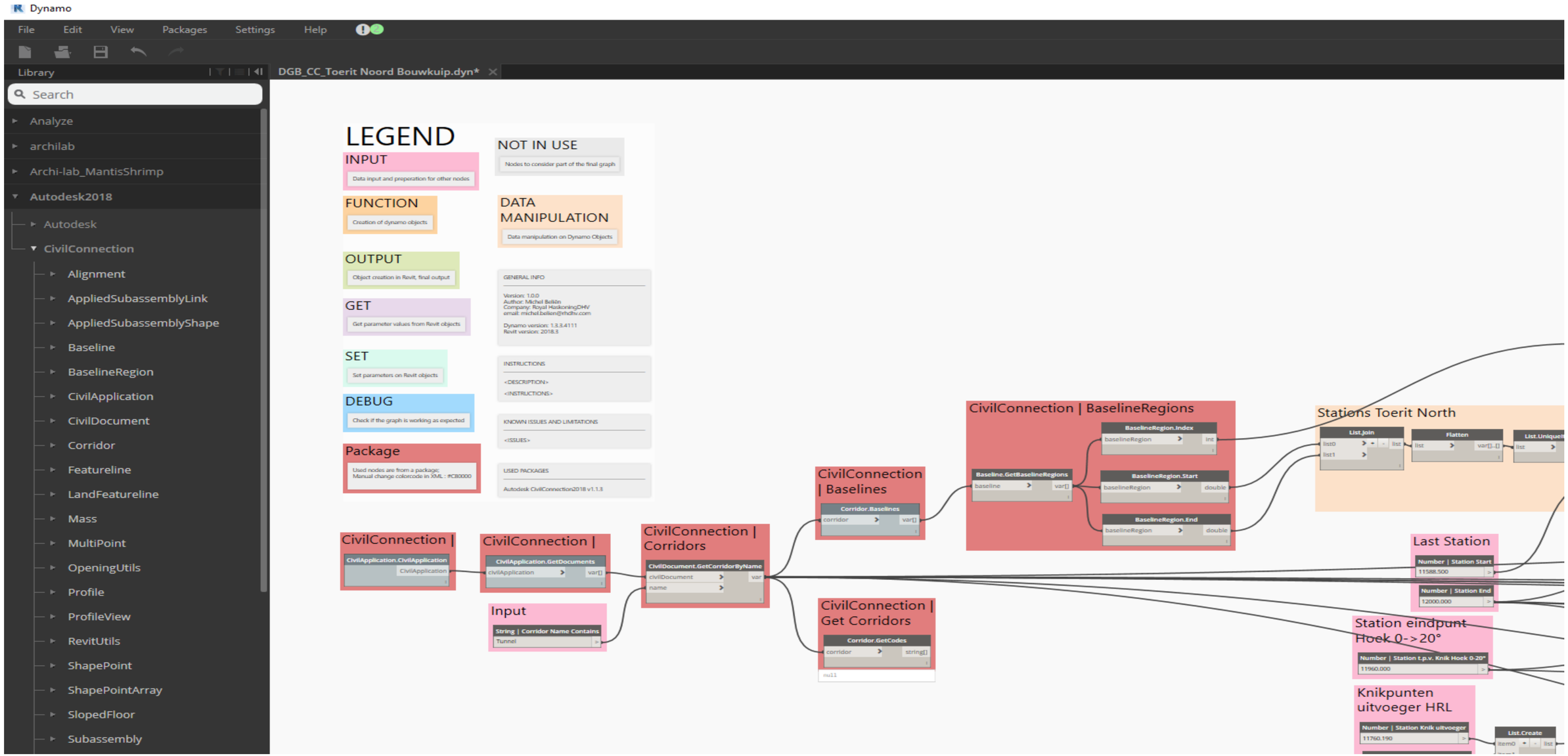
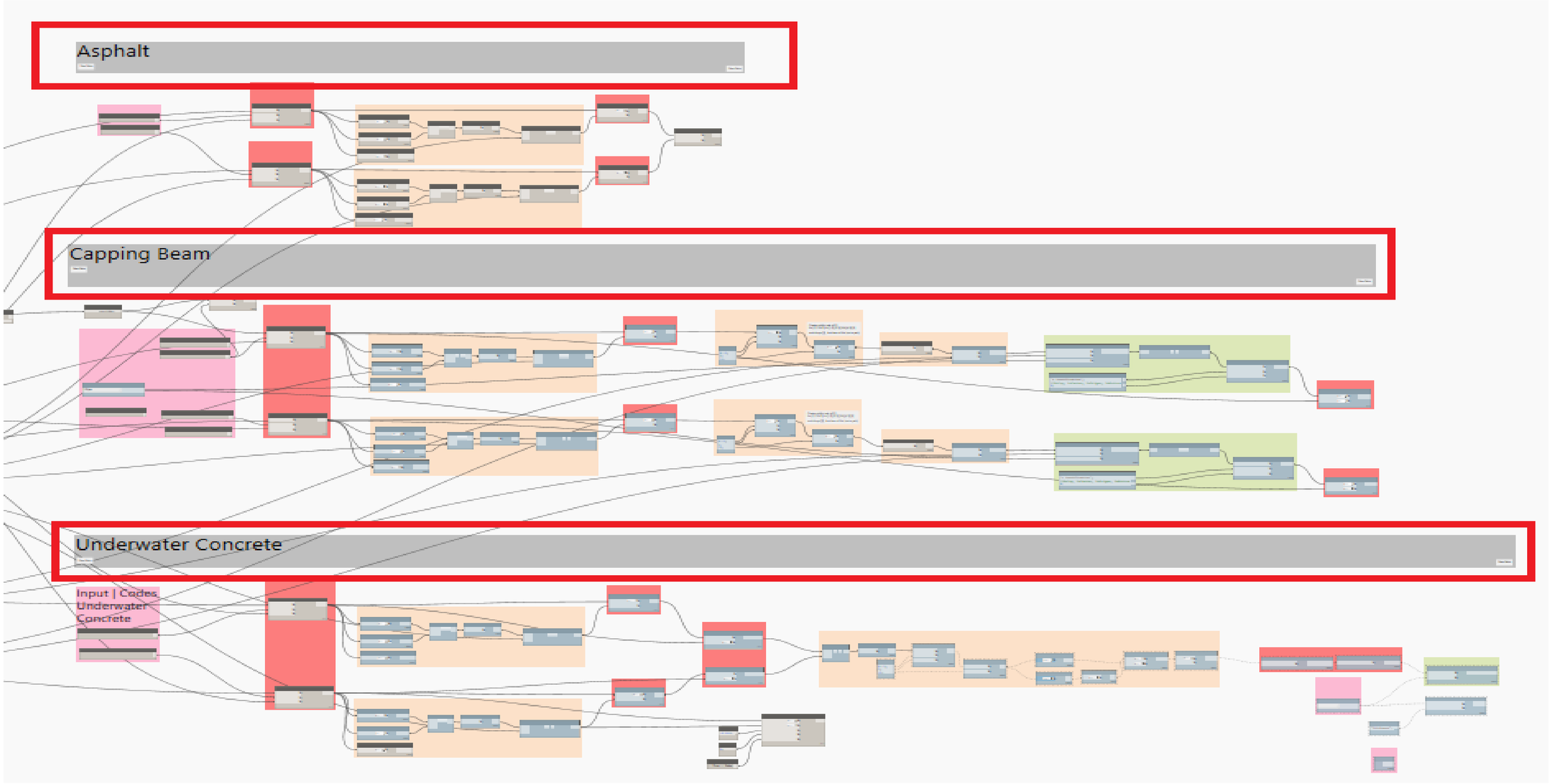
Search
Analyze
archilab
Archi-lab_MantisShrimp
Autodesk2018
Autodesk
CivilConnection
Alignment
AppliedSubassemblyLink
AppliedSubassemblyShape
Baseline
BaselineRegion
CivilApplication
CivilDocument
Corridor
Featureline
LandFeatureline
Mass
MultiPoint
OpeningUtils
Profile
ProfileView
RevitUtils
ShapePoint
ShapePointArray
SlopedFloor
Subassembly
SubassemblyParameter
MEP
Builtin
Clockwork

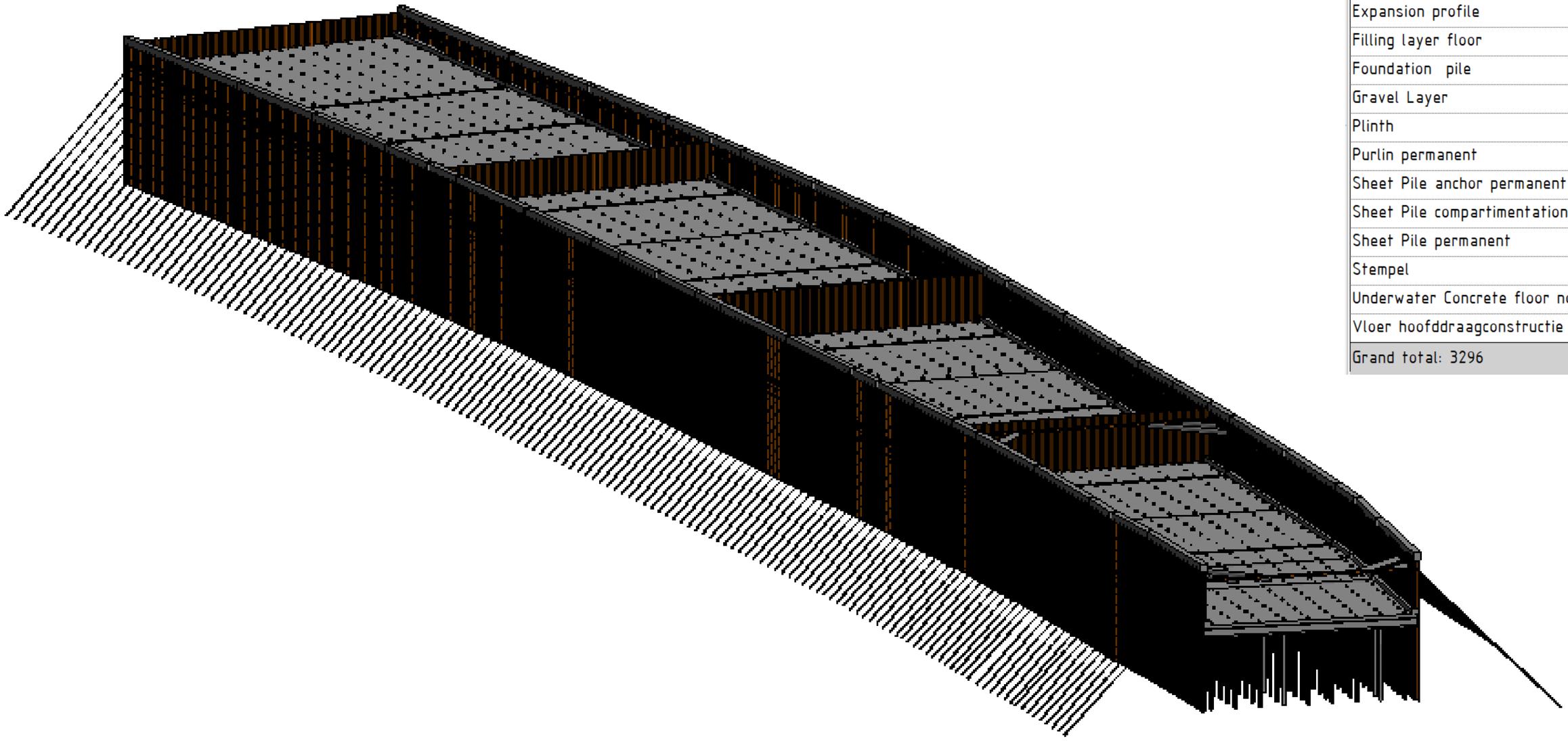
Dynamo Legend , Packages



Parts By Component



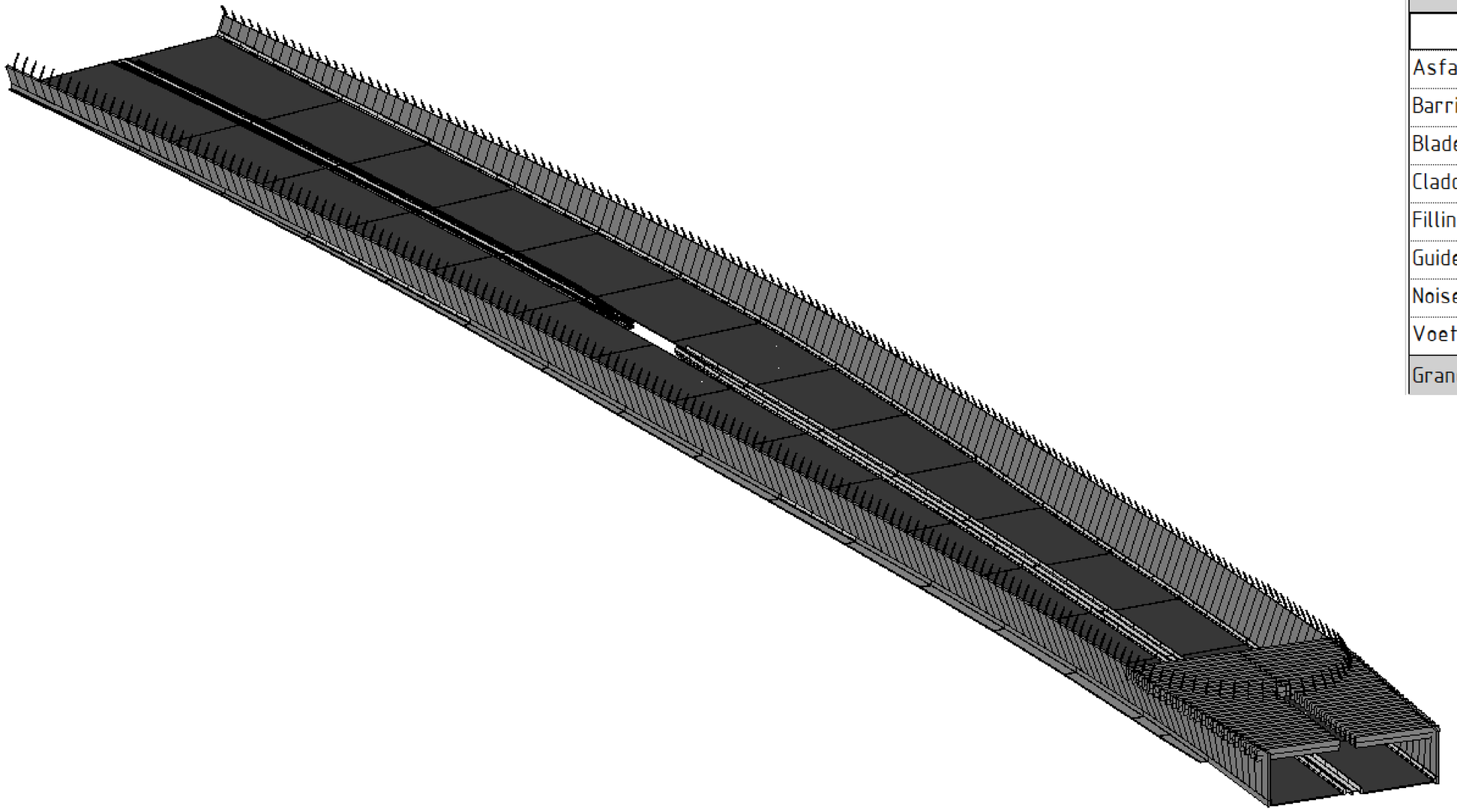
Scripted elements Pit North



<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	

Scripted elements access ramp North

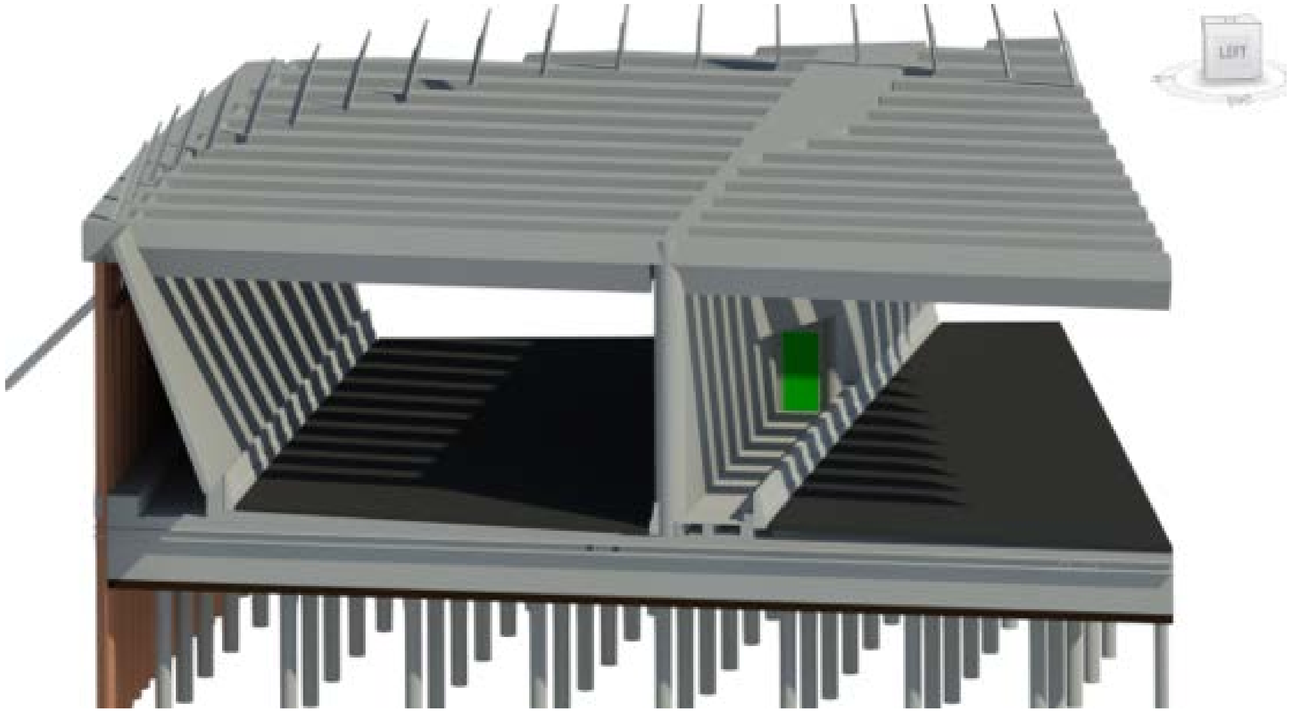


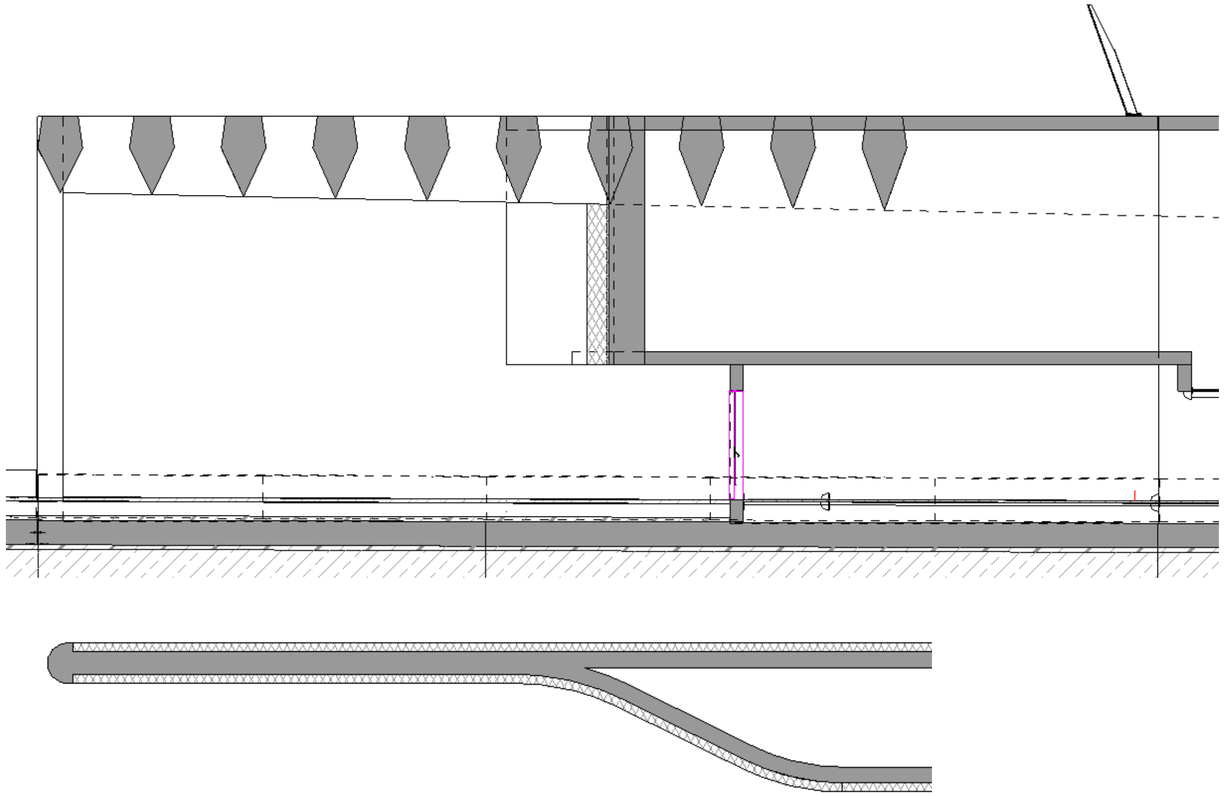
<access ramp>

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

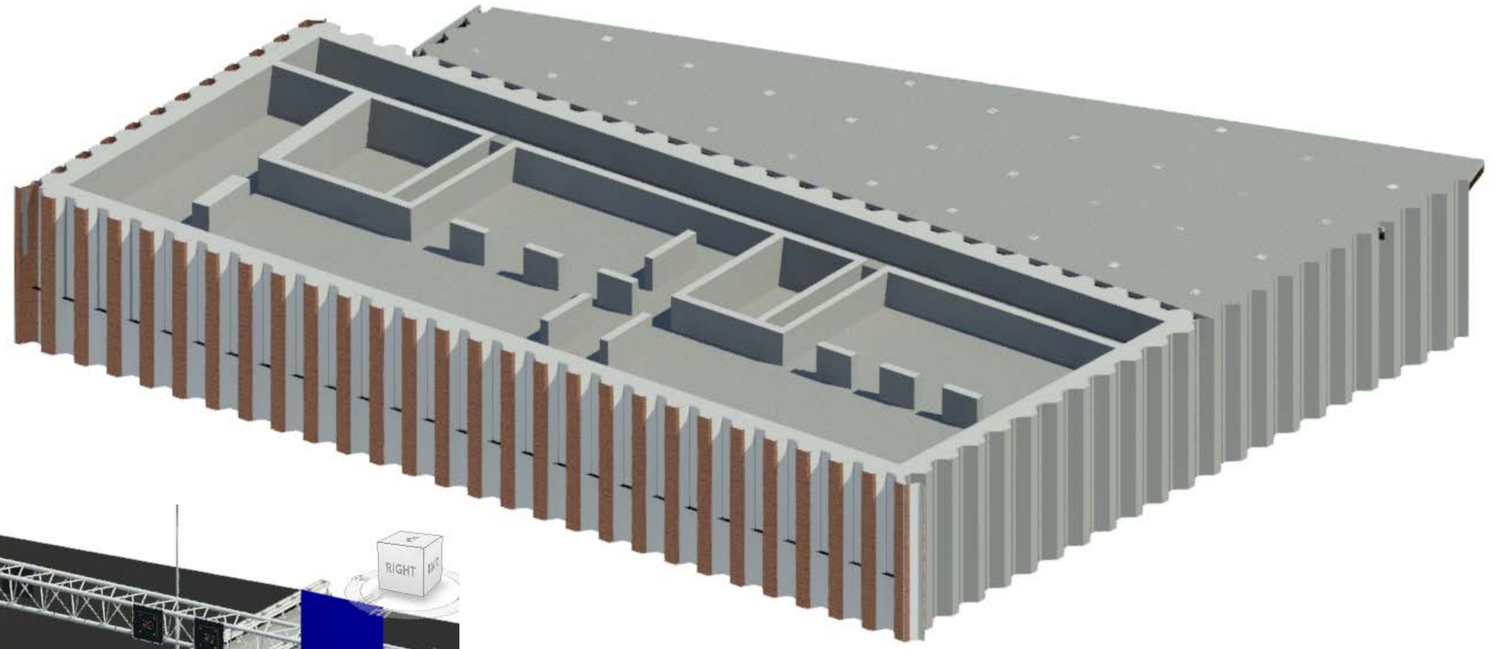
- Blades variable height + joint detail
- Sound wall (parabola)
- Ending
  - Emergency exit door
  - Fire resistant cladding
  - Rounded walls

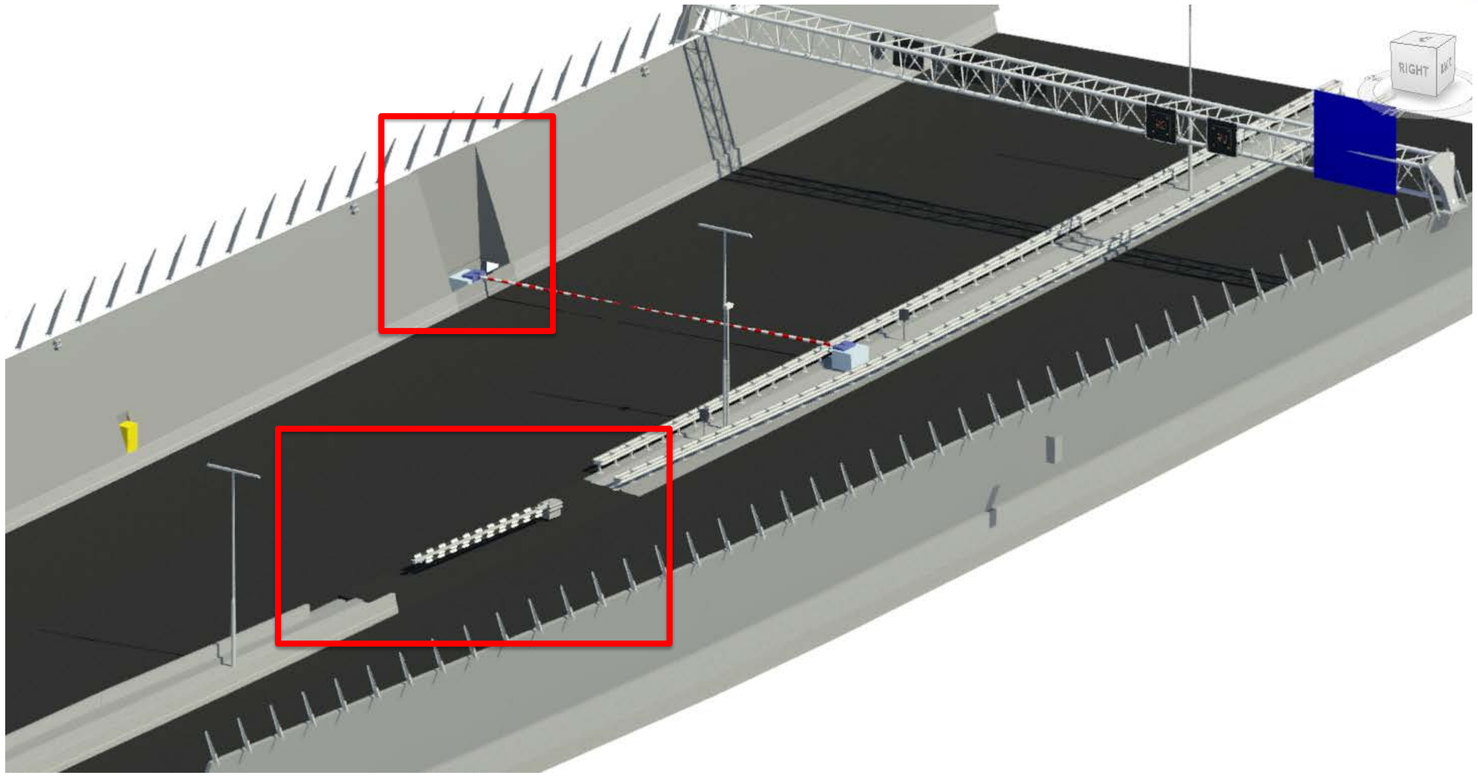




Miscellaneous Specials

- Pump room
- Emergency barrier area
- Emergency Transit (CADO)





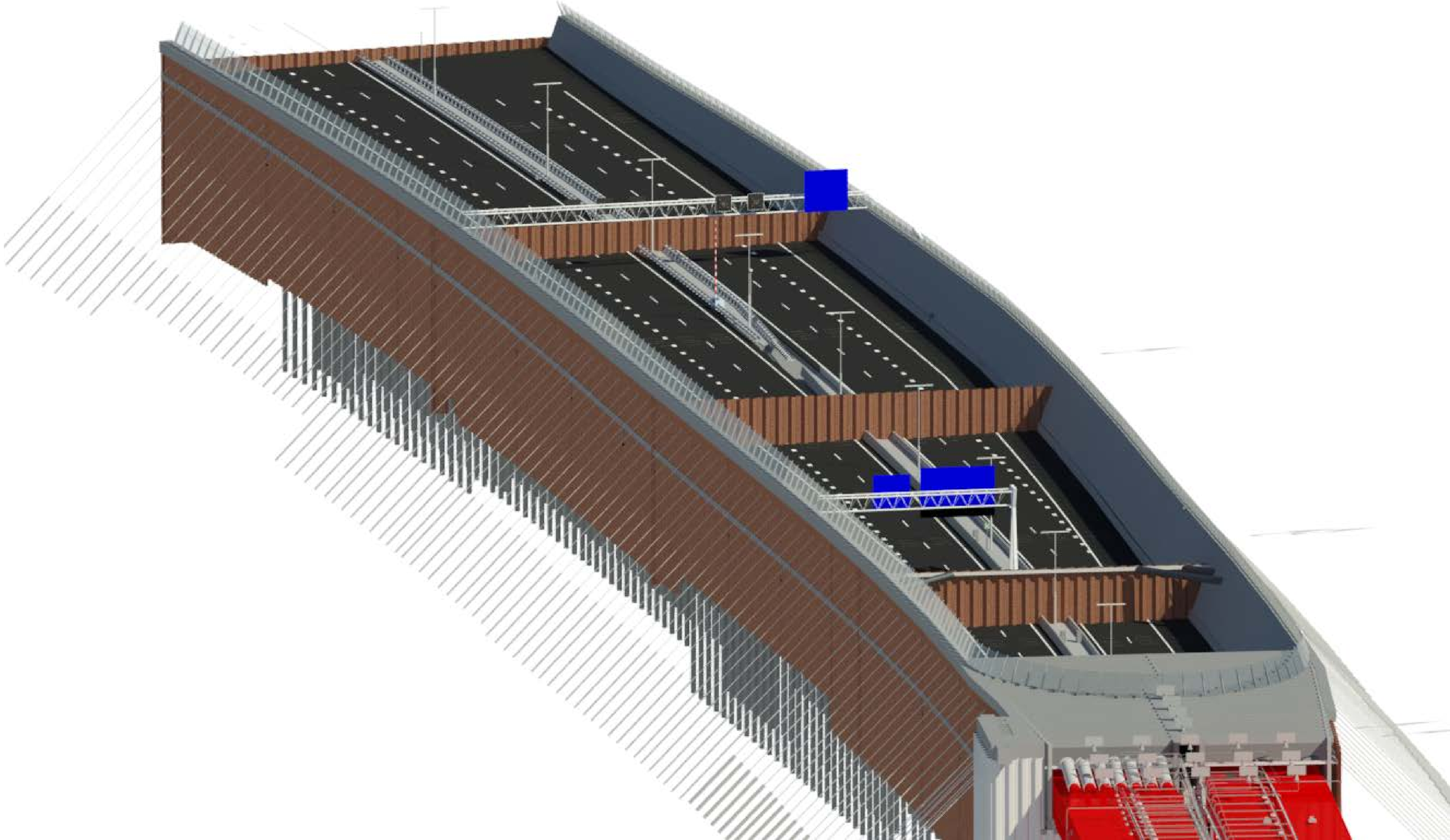
Advantages CivilConnection

- Best of 2 worlds C3D (Linear) & Revit (discrete objects)
- Civil 3D corridor model long useable during design
  - Alignement changes
  - Feature lines
  - Codenames (subassembly)
- Linear C3D object bi-directional connected with Revit model
- Revit objects are coordinated and dynamic connected with Civil 3D
- Revit objects (solids) can be convert to C3D

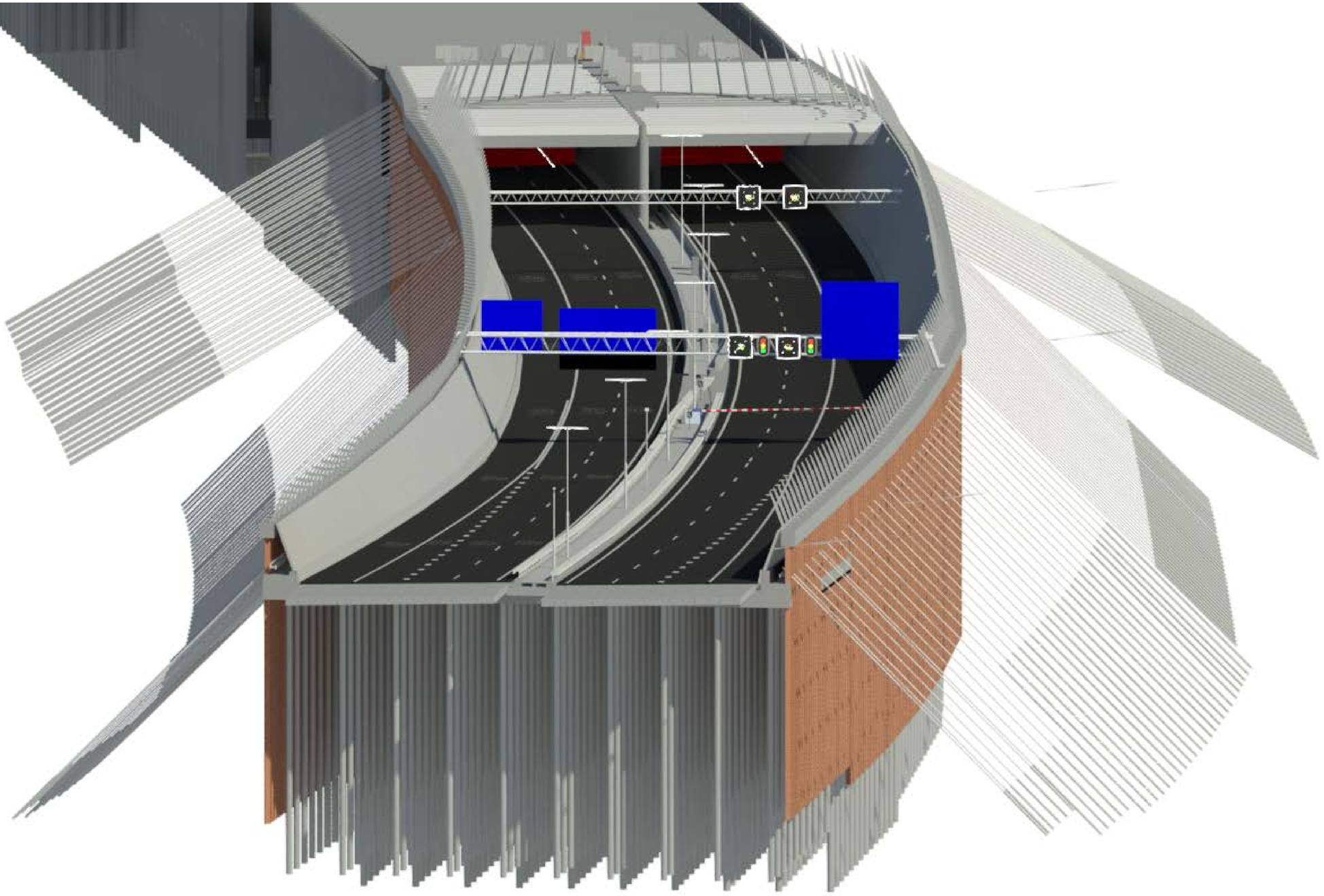
Focus areas CivilConnection

- Dynamo knowledge
- Clean Civil 3D model (Dynamo is consequent, roundups !)
- Reading Corridor 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, (also for Civil 3D 2020)
  - IFC possible with Desktop connector

Current situation North



Current situation South

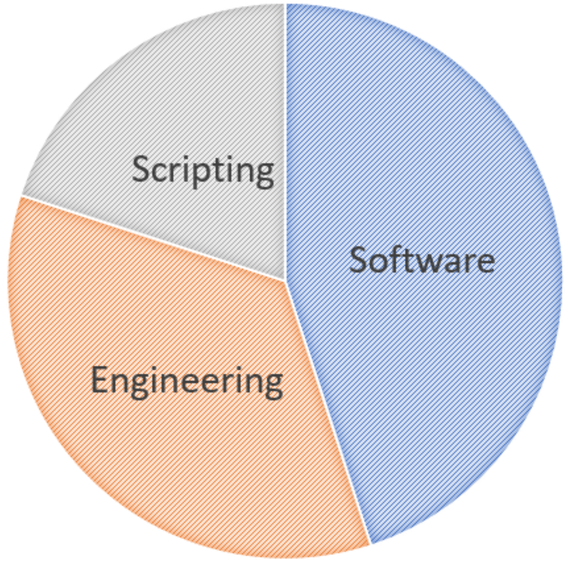


Learning Objectives

- 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

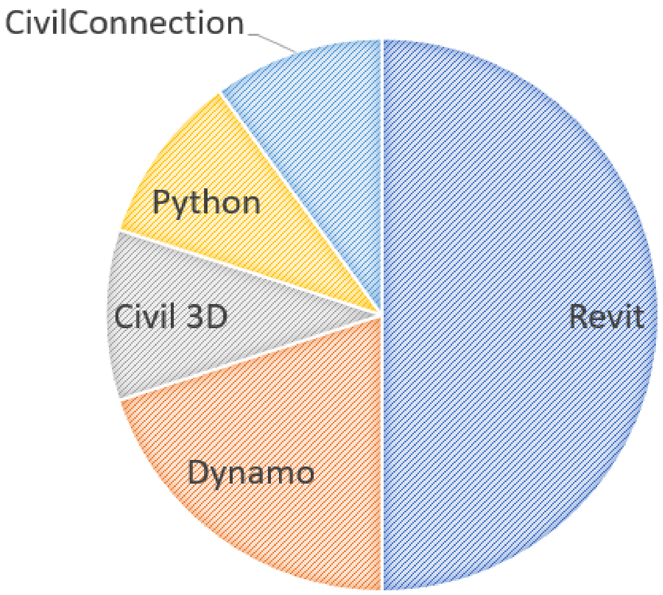
Skills Needed

Main skills

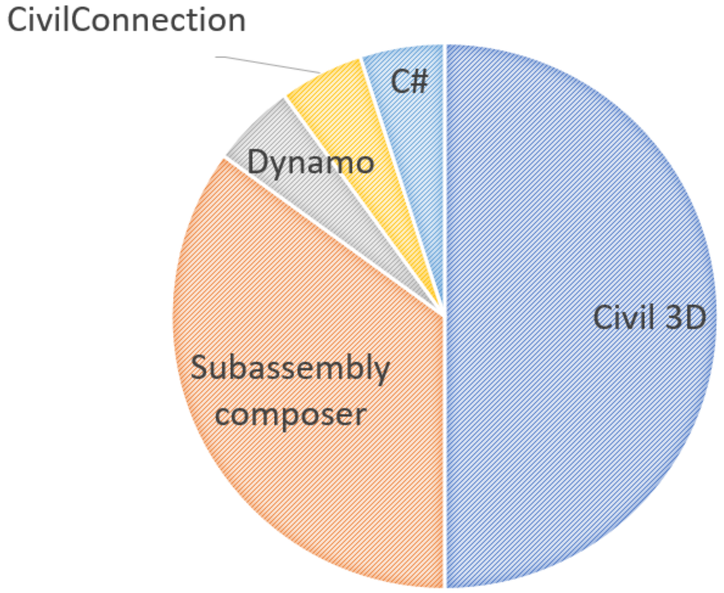


Software skills

Revit Engineer



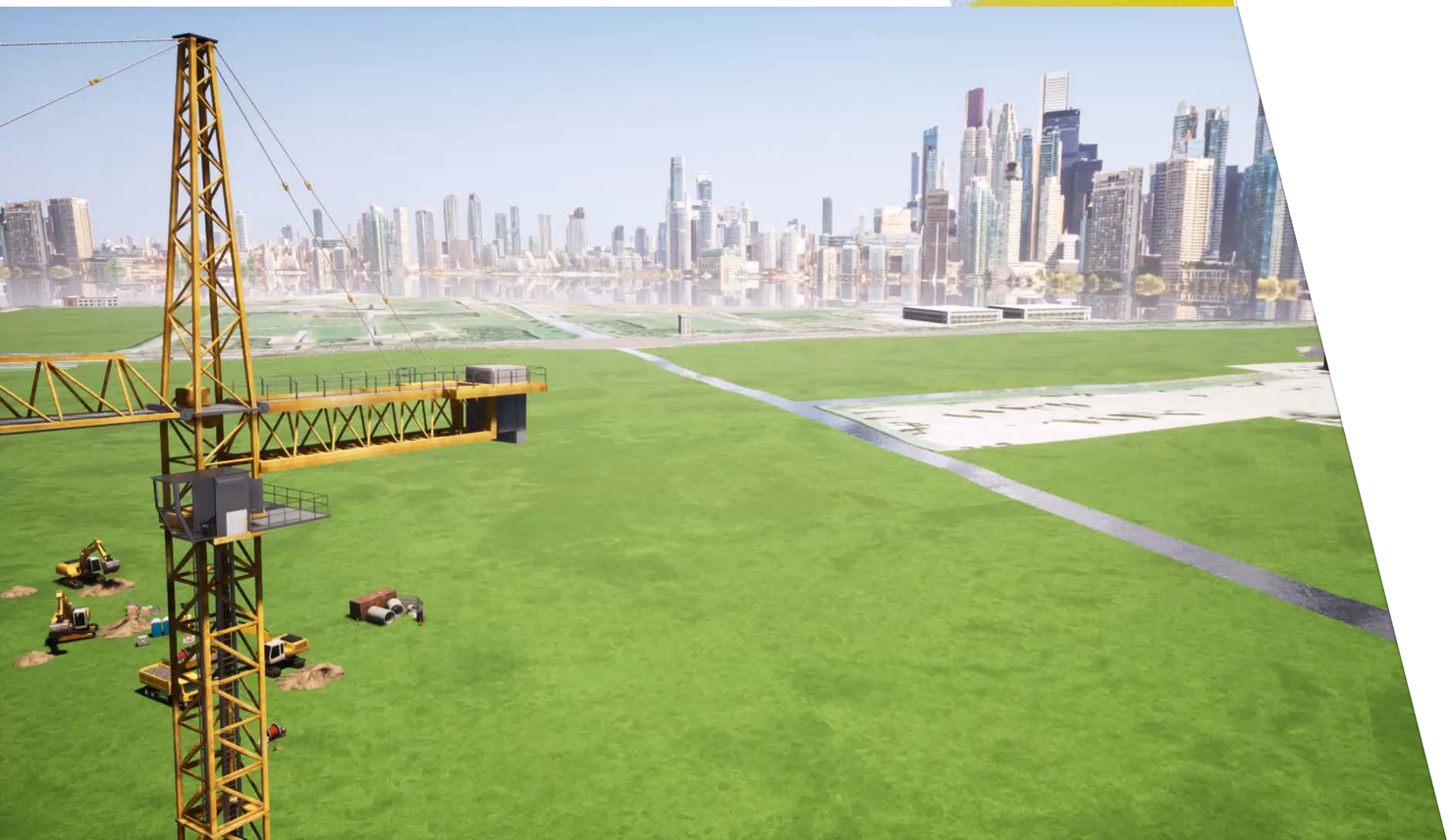
Civil 3D Engineer



If you want to go fast
Go alone!
If you want to go far
Go together!

Royal HaskoningDHV
Enhancing Society Together

Infrastructure
It's all about connections



Thank you

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