

Automated Linear Structural BIM Model with Built-in 2D Drawing Extraction Using Civil 3D, Revit and Dynamo

Ramiz Mohareb

Senior Structural Engineer DAR AL-HANDASAH





About the speaker

Ramiz Mohareb

Senior structural engineer in the bridge department at Dar Al-Handasah (Shair and Partners), holding an MSc degree in structural mechanics and having 15 years of experience in structural analysis and design of various structures including bridges and buildings. Currently initiated working on developing BIM and design automation for linear structures (i.e., Bridges & Tunnels) and improving the process automation using C#, Revit API, Civil 3D API, CSI API and Dynamo.

Session Overview

FIRST PART

- Introduction to DAR AL HANDASAH.

SECOND PART

- General Introduction for Linear Structural.

THIRD PART (CONCEPT AND WORKFLOW)

- Linear Structure Objects, Challenge and Concept.
- Overall Workflow.
- Dynamo Script Layout.
- Step 1 Civil 3D connection and read corridors.
- Step 2 - Get Placement Points.
- Step 3 - Adaptive Family.
- Step 4 - Calculate and Set Parameters

FOURTH PART (CASE STUDY)

- Box Girder Precast Bridge.
- Box Girder Cast in-situ Bridge.
- Cable-Stayed Bridge.
- Balanced Cantilever Bridge.
- Cut & Cover Tunnel.

FIFTH PART (2D DRAWING)

- 2D Drawing Concepts.
- Sample of Plans and Sections Drawings.
- Sample Elevation Drawings.

Introduction to DAR AL HANDASAH

**Top 10 ENR
2019**

EST.
1956

9,250
Staff members

Principal Design
Centers

60 COUNTRIES

BEIRUT

LONDON

CAIRO

46 OFFICES

PUNE

AMMAN



Introduction



TR21202

Model Linear Structures: Aligning AutoCAD Civil 3D and Revit with Dynamo for Viaducts and Tunnels

Ghassan Zein
Dar Al-Handasah, Design Application Manager

Ian McGregor
Autodesk, Snr Implementation Consultant - BIM - Co-Speaker

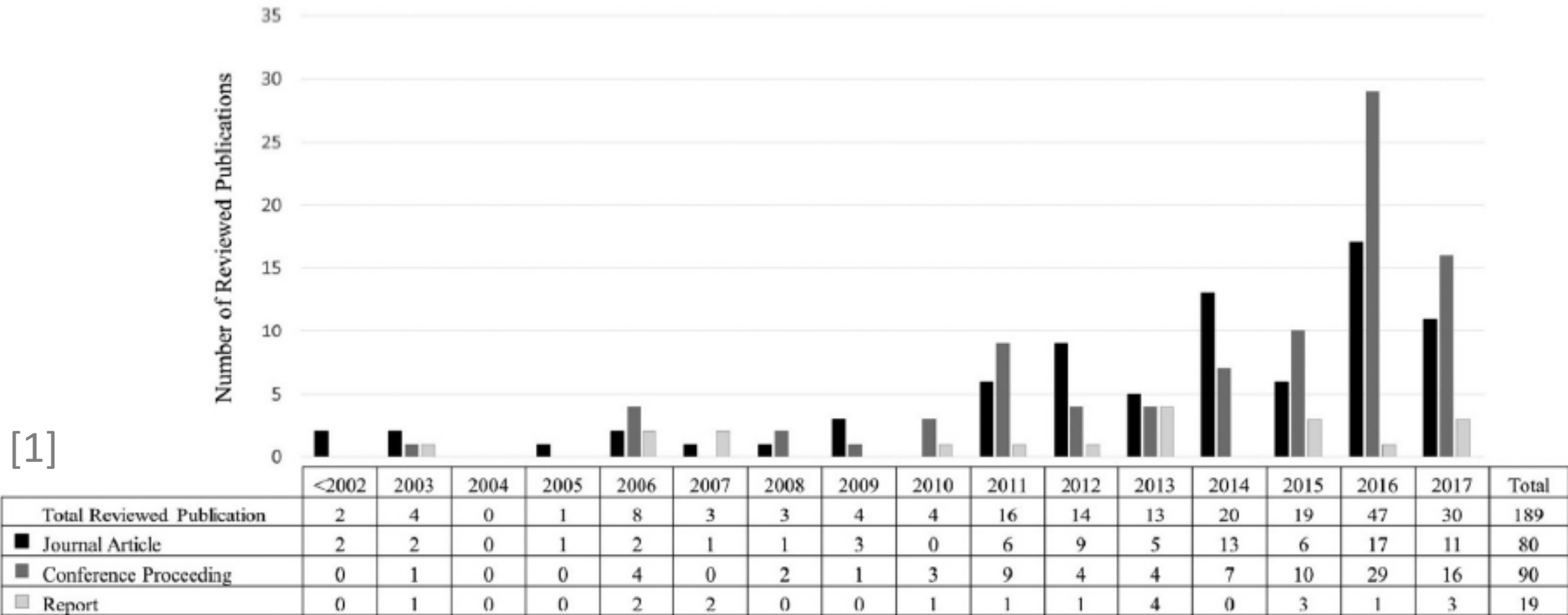
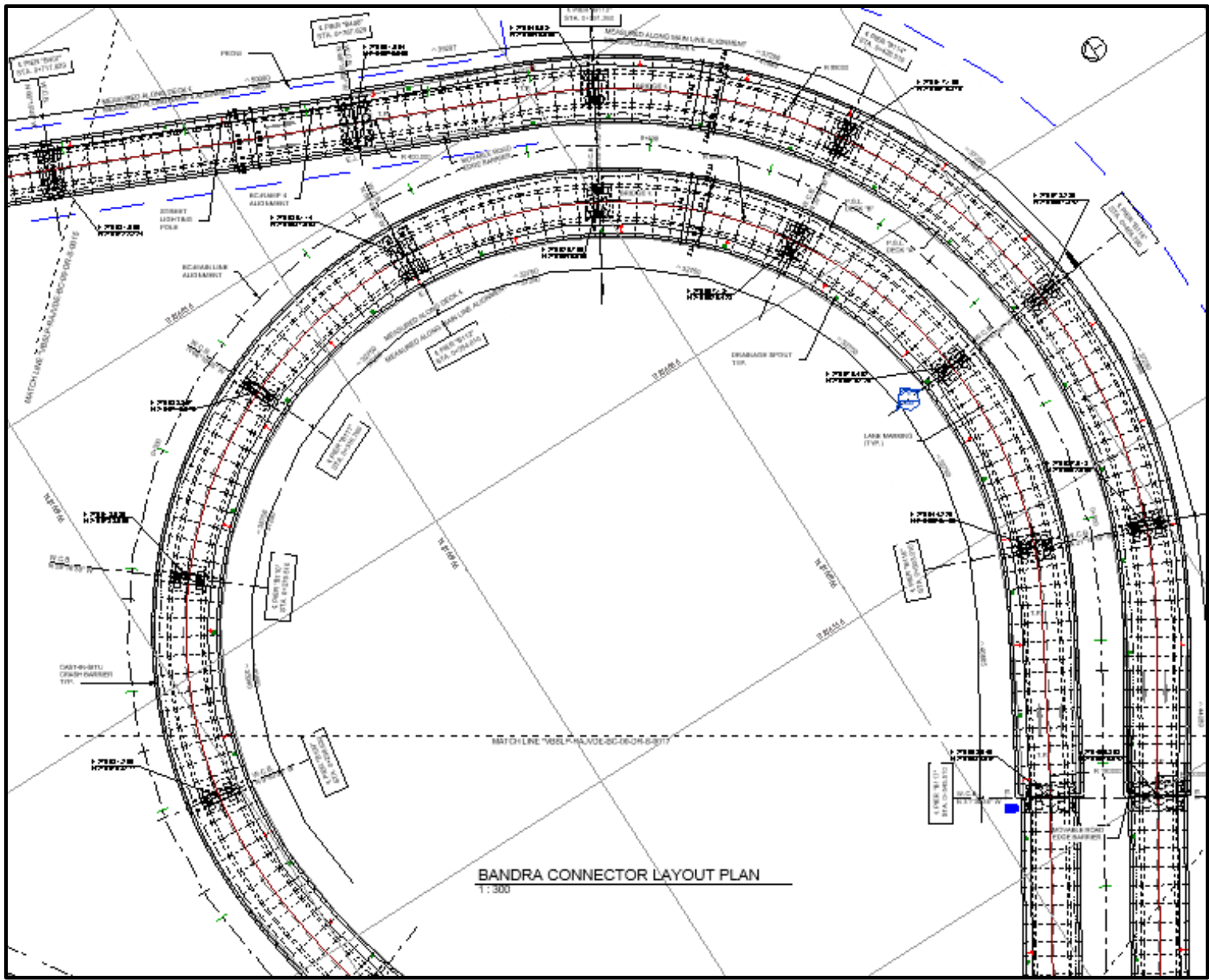
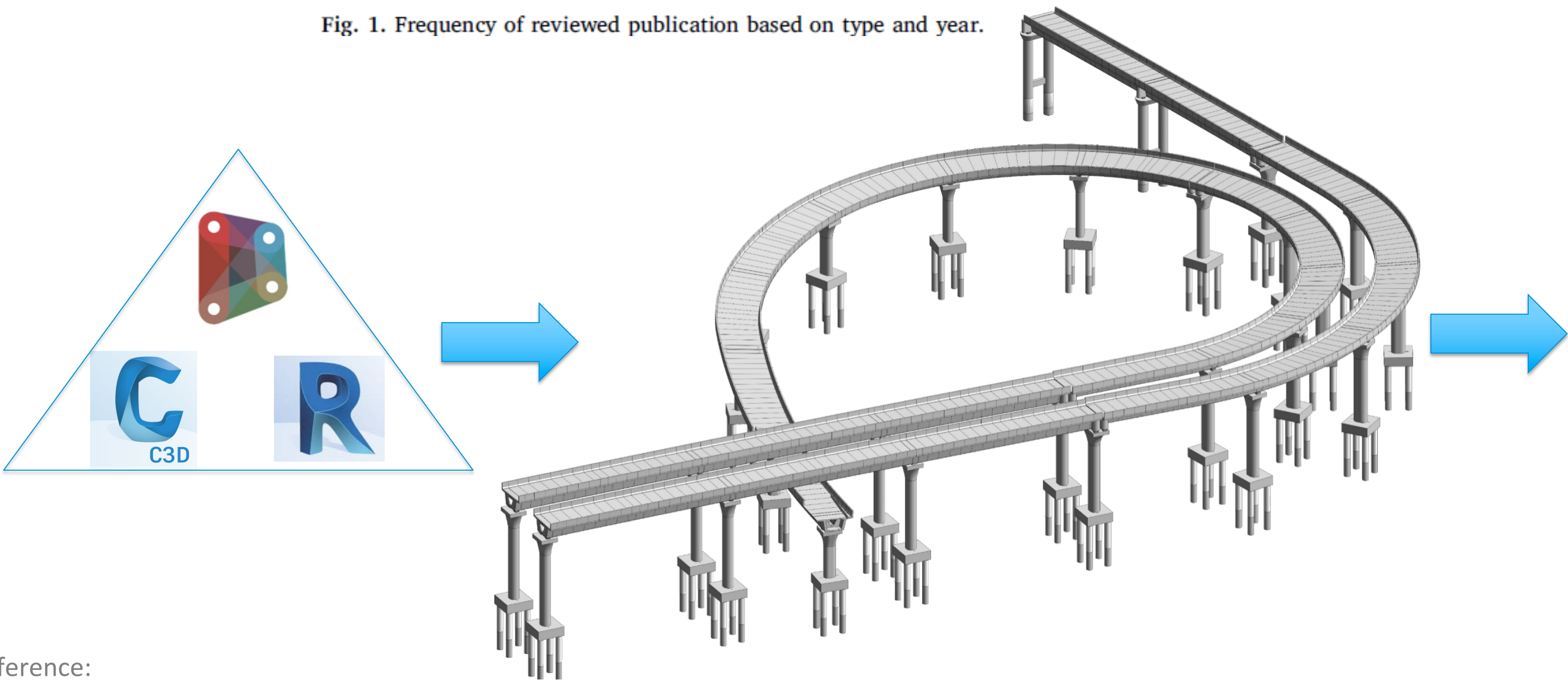


Fig. 1. Frequency of reviewed publication based on type and year.



Reference:


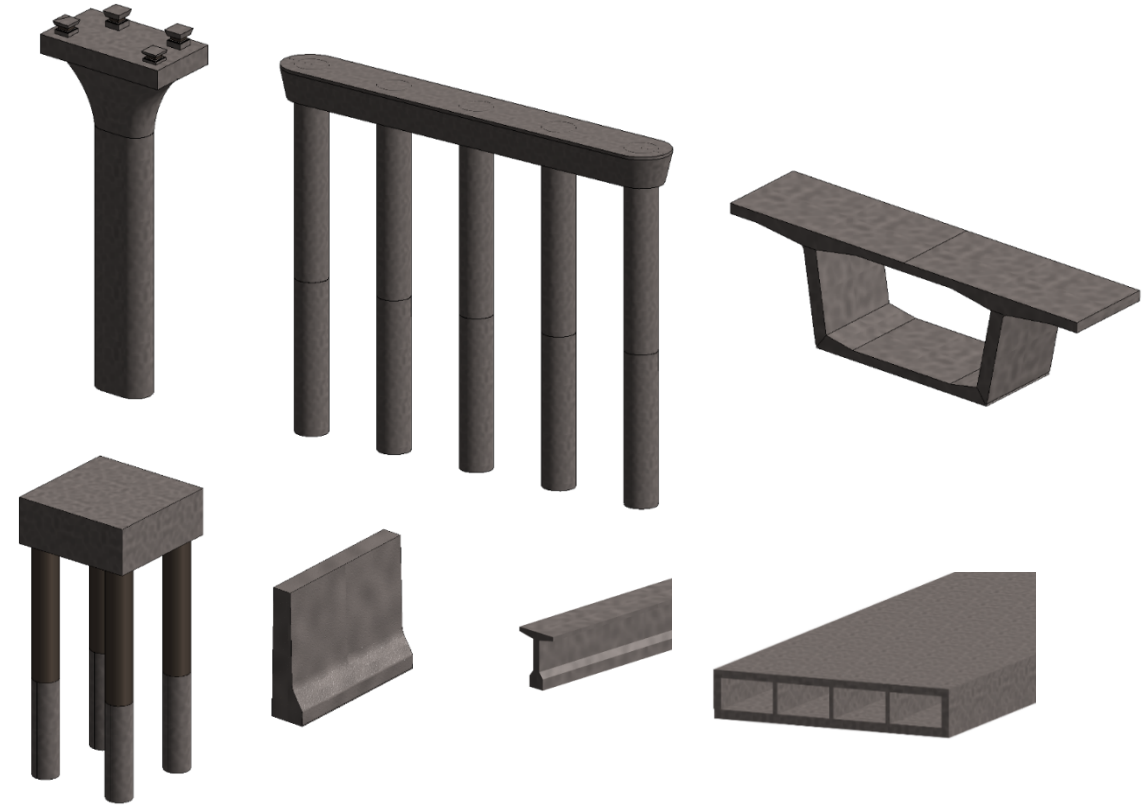



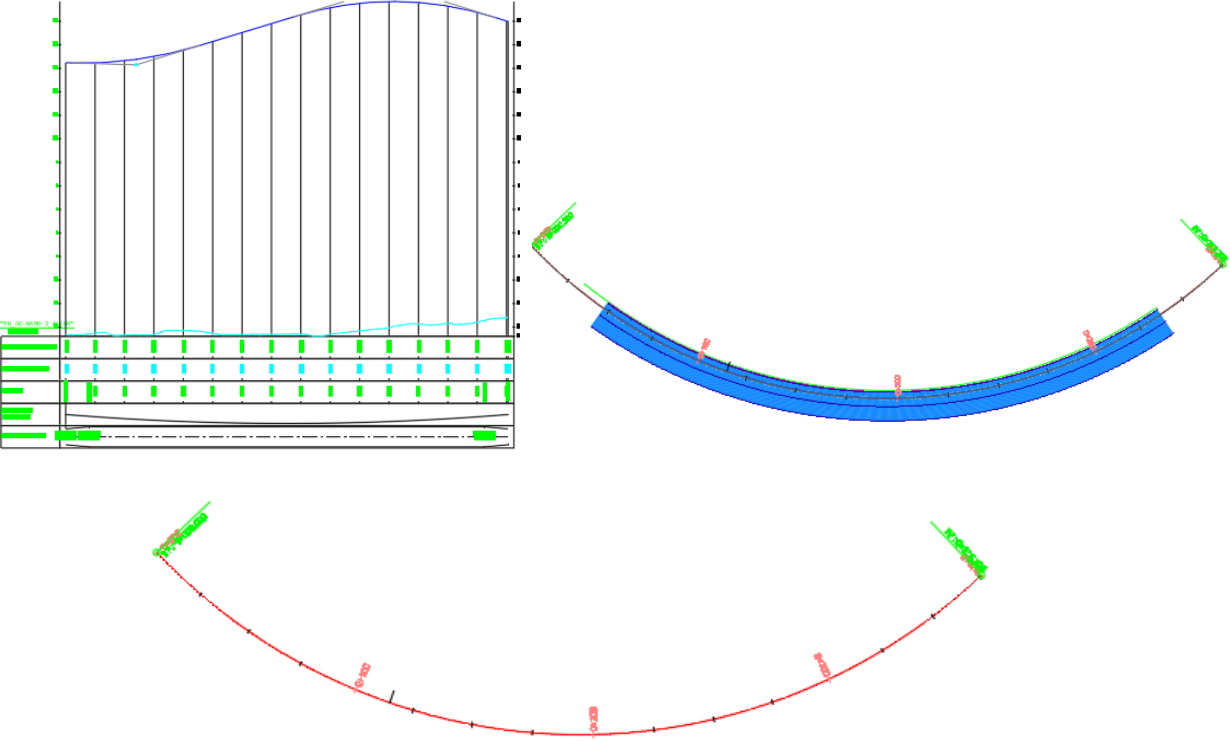


1-Aaron Costina,, Alireza Adibfara, Hanjin Hub, Stuart S. Chenc, Building Information Modeling (BIM) for transportation infrastructure – Literature review, applications, challenges, and recommendations, (Automation in Construction 94 (2018) 257–281)

Linear Structure Objects, Challenge and Concept



Linear Structure Objects, Challenge and Concept



Software	Supported objects	Transportation objects	Structural objects
			
			

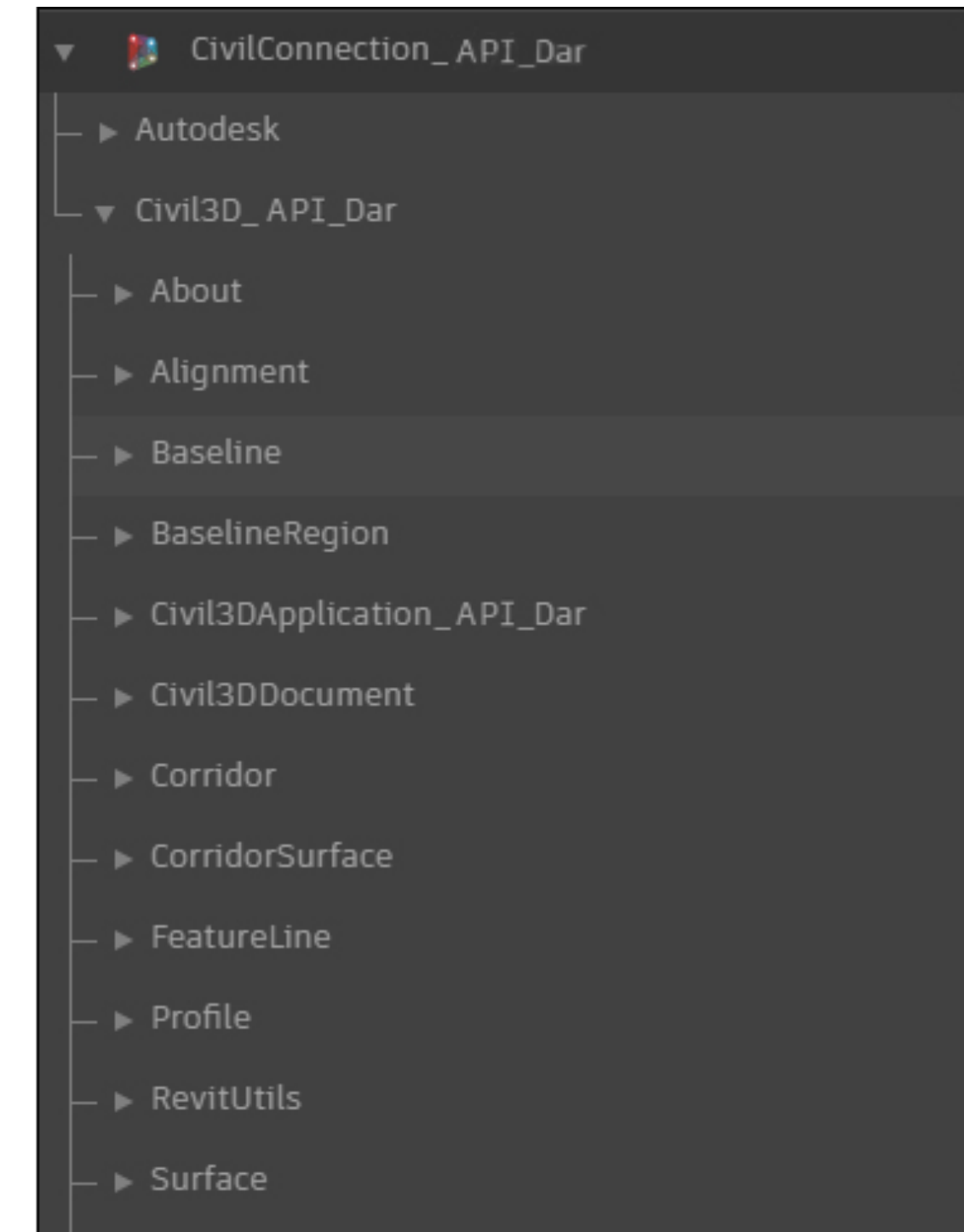
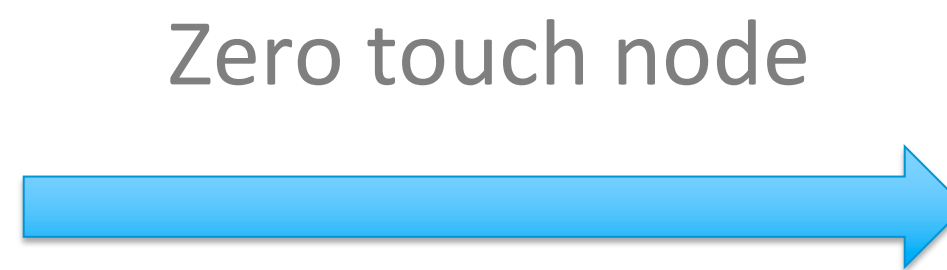
Linear Structure Objects, Challenge and Concept



```
Alignment.cs
Civil3D_Connection2019
Civil3D_Mohareb.Alignment
_alignment

1 using Autodesk.AECC.Interop.Land;
2 using Autodesk.DesignScript.Runtime;
3 using System.Collections.Generic;
4 using System.Linq;
5
6
7 namespace Civil3D_API_Dar
8 {
9     18 references
10     public class Alignment
11     {
12         private AeccAlignment _alignment;
13         private AeccProfiles AlignmentProfiles;
14         private string AlignmentName;
15         private double alignmentEndStation;
16         private double alignmentLength;
17         private long alignmentID;
18         private double AlignmentStartstation;
19         private string AlignmentStationAtPoint;
20         internal string Name;
21         private double[] _stations;
22
23         2 references
24         internal Alignment(AeccAlignment aeccAlignment)...
25
26         2 references
27         internal object InternalElement...
28
29         0 references
30         public static List<string> Alignment_name(List<Alignment> alignmentList)...
```

C# Code for Civil3D API_Dar




Civil 3D_API_Dar_package


Reference:

- 1- Paolo Serra, "Civil connection" Dynamo package <https://github.com/Autodesk/civilconnection>
- 2- Andrew Milford, "Civil 3D Data Mining with Dynamo" AU2018 (CES226095)


Overall Workflow



Step 1




Step 2



	A	B	C	D	E
	Index	Start Station	End Station	Family Typical Name	Family Thick Name
1	0	845	905	16m_TYPICAL-3300	16m_THICK-3300
2	1	905	945	16m_TYPICAL-3300	16m_THICK-3300
3	2	945	985	16m_TYPICAL-3300	16m_THICK-3300
4	3	985	1045	16m_TYPICAL-3300	16m_THICK-3300
5	4	1045	1105	16m_TYPICAL-3300	16m_THICK-3300


Input



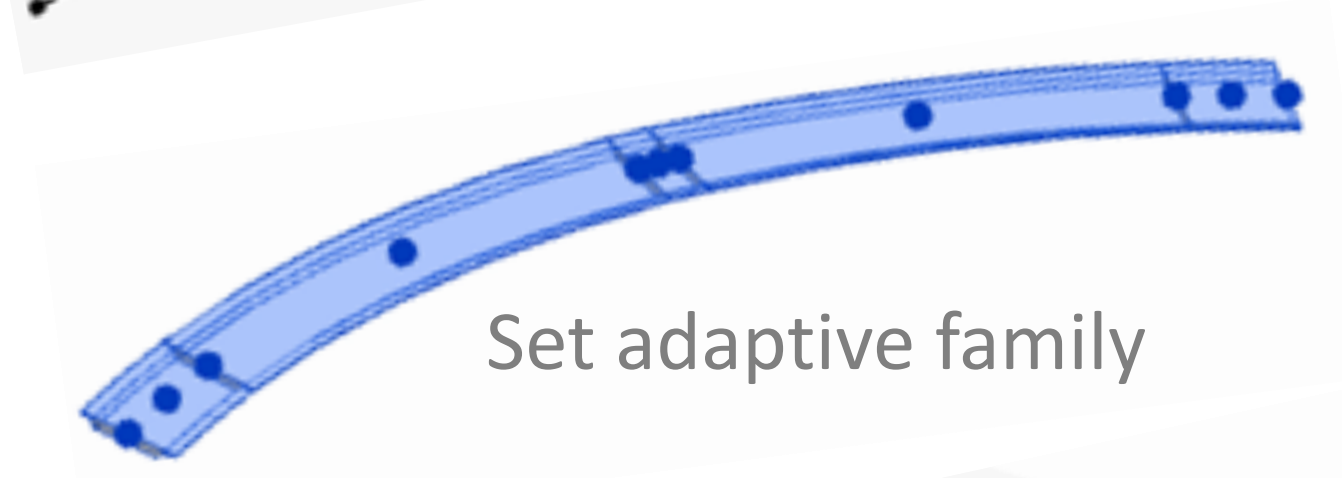


Step 3

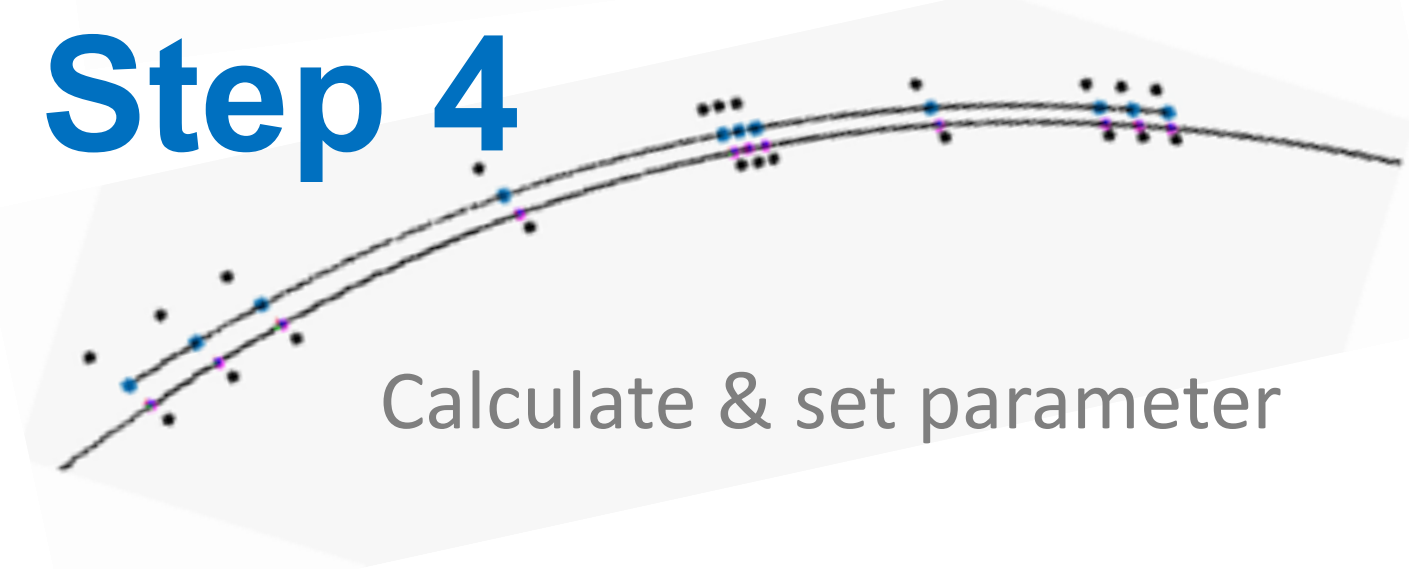
Placement Points



Set adaptive family



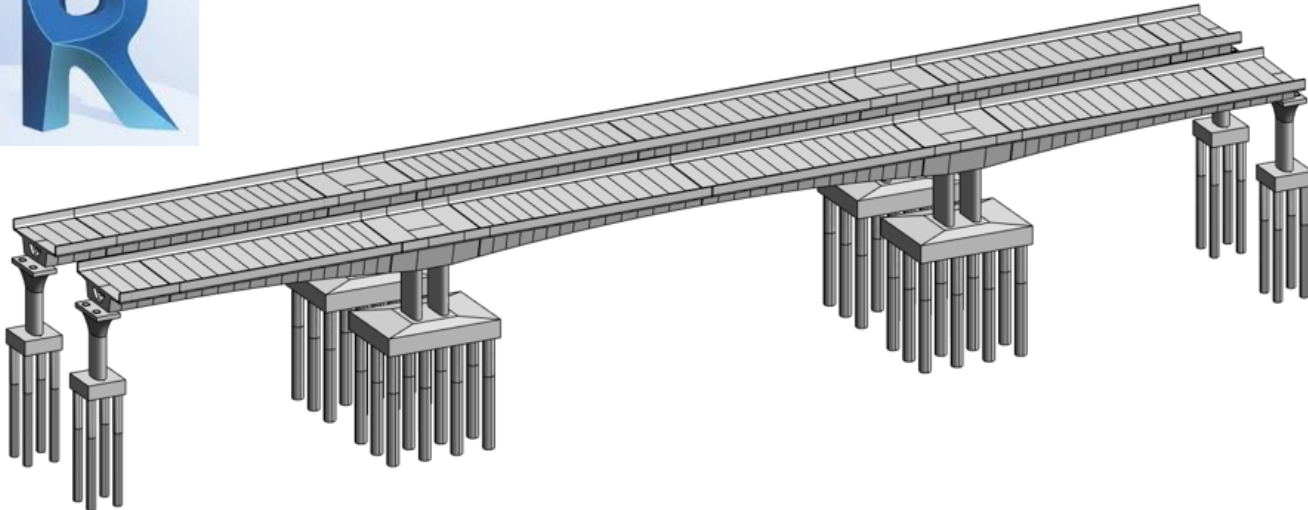

Step 4

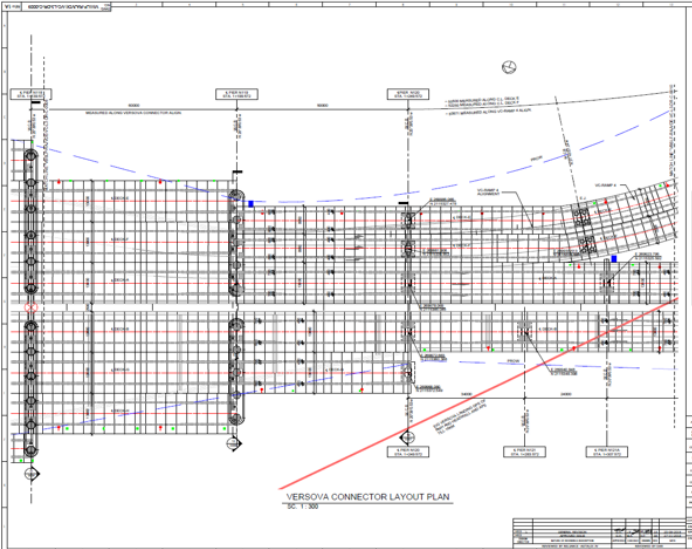



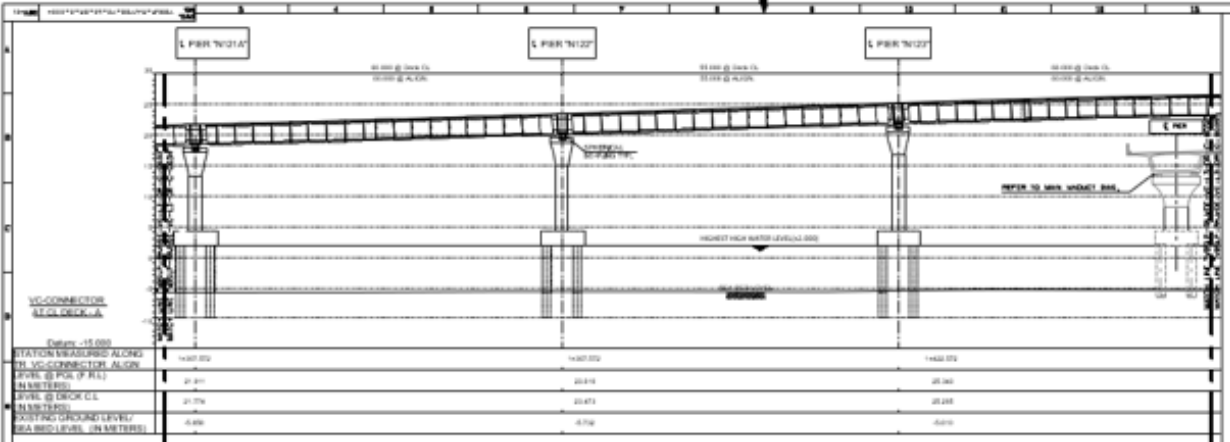

Calculate & set parameter

Solver



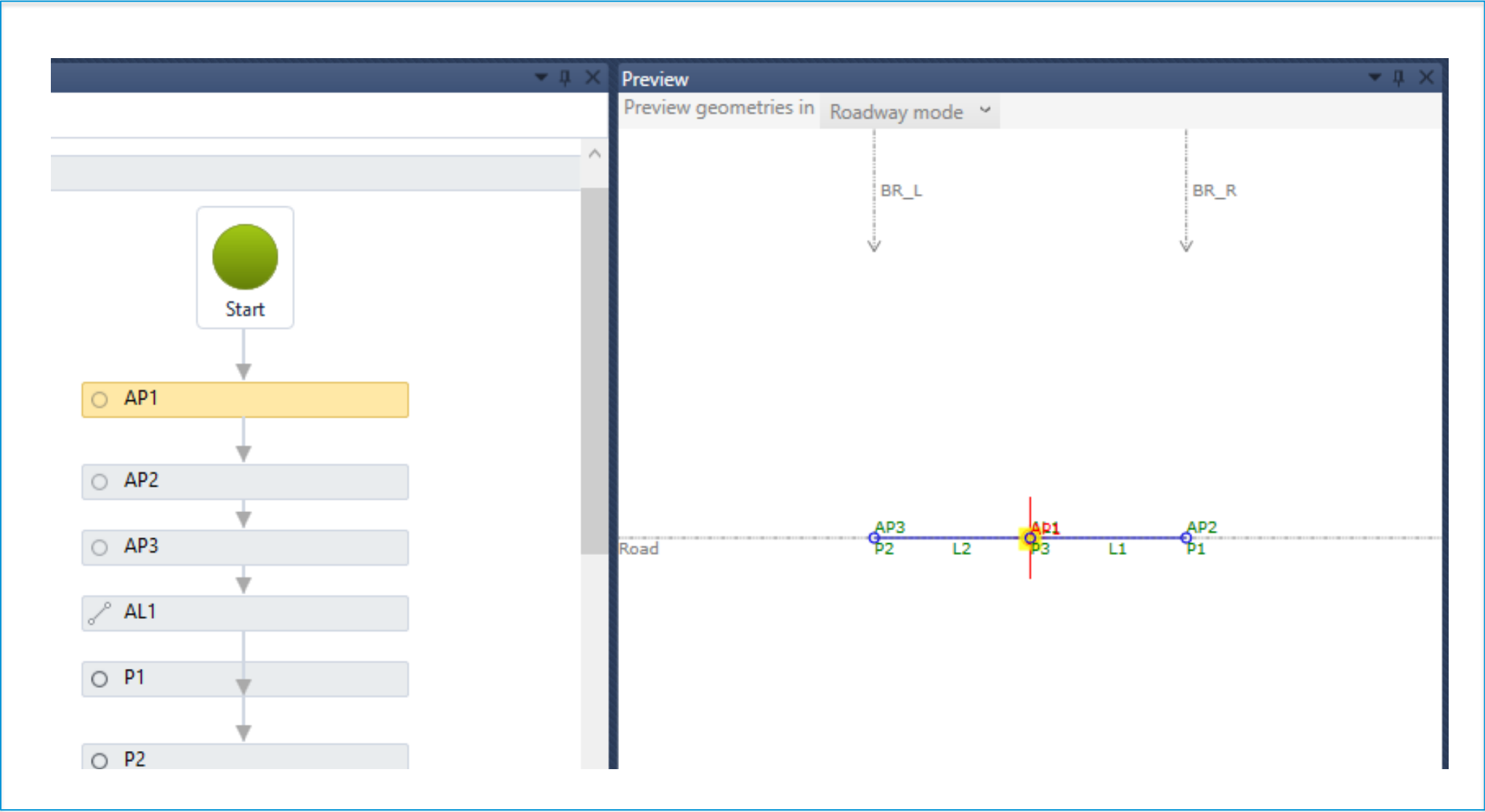




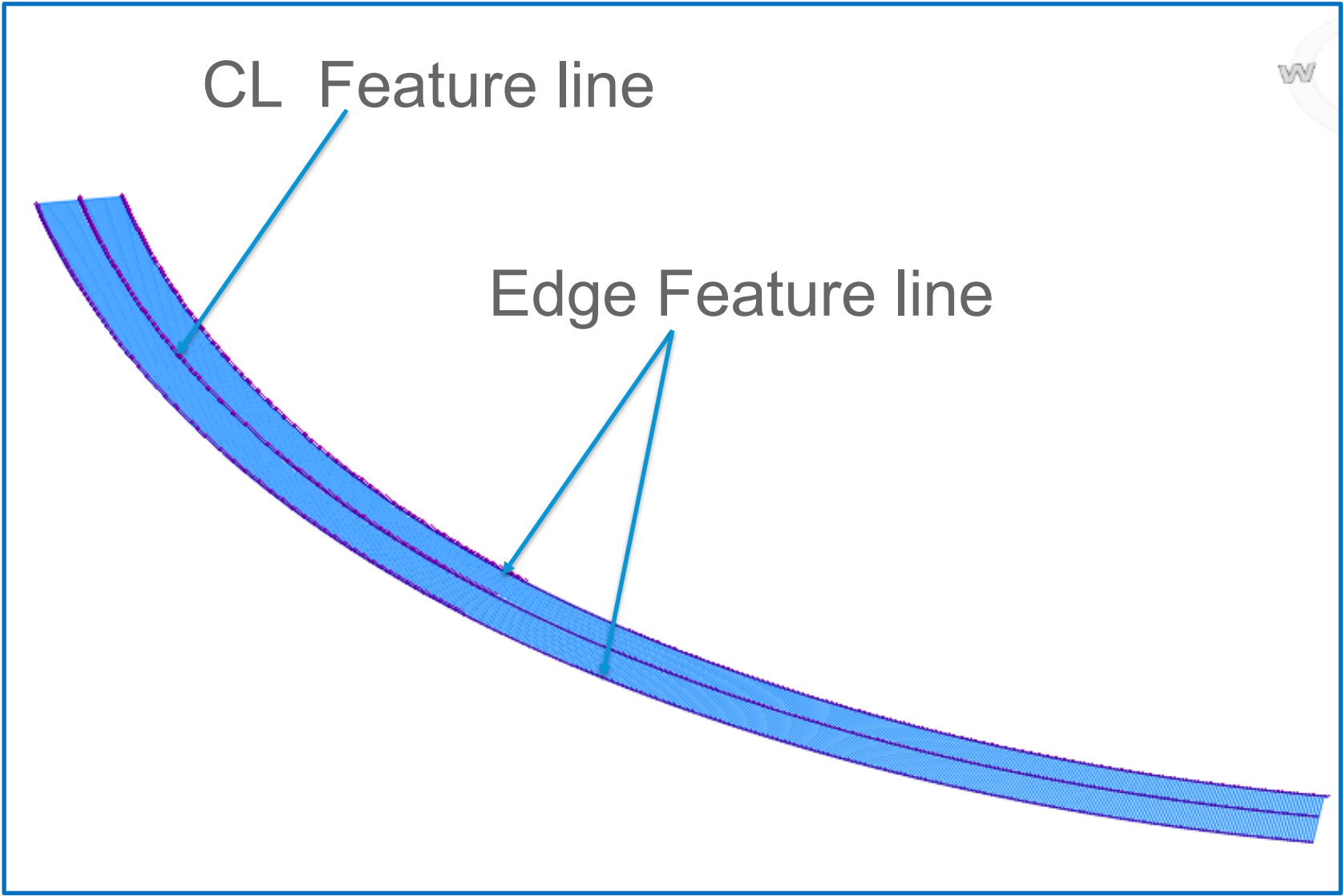


Output

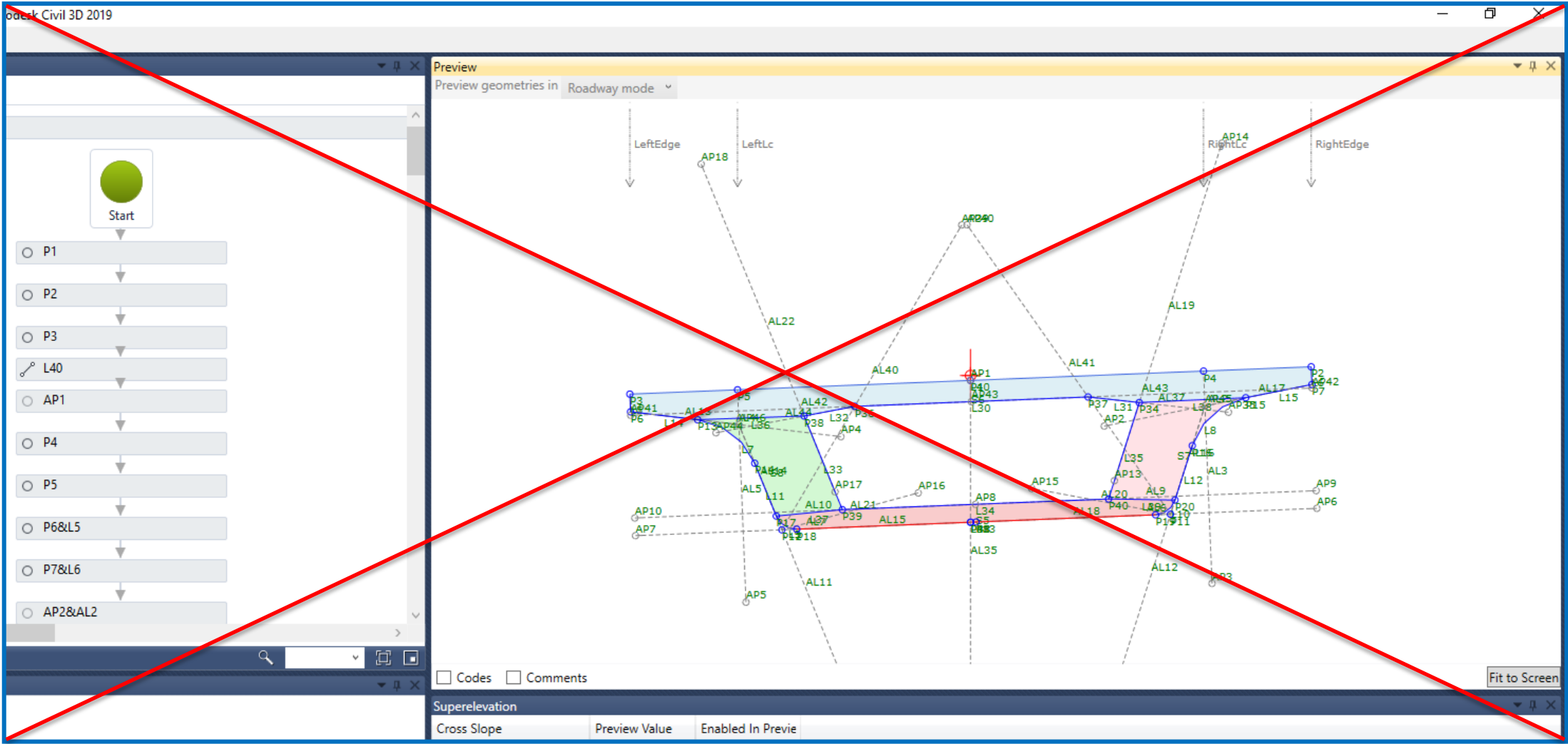
Step (1) Civil 3D Corridor



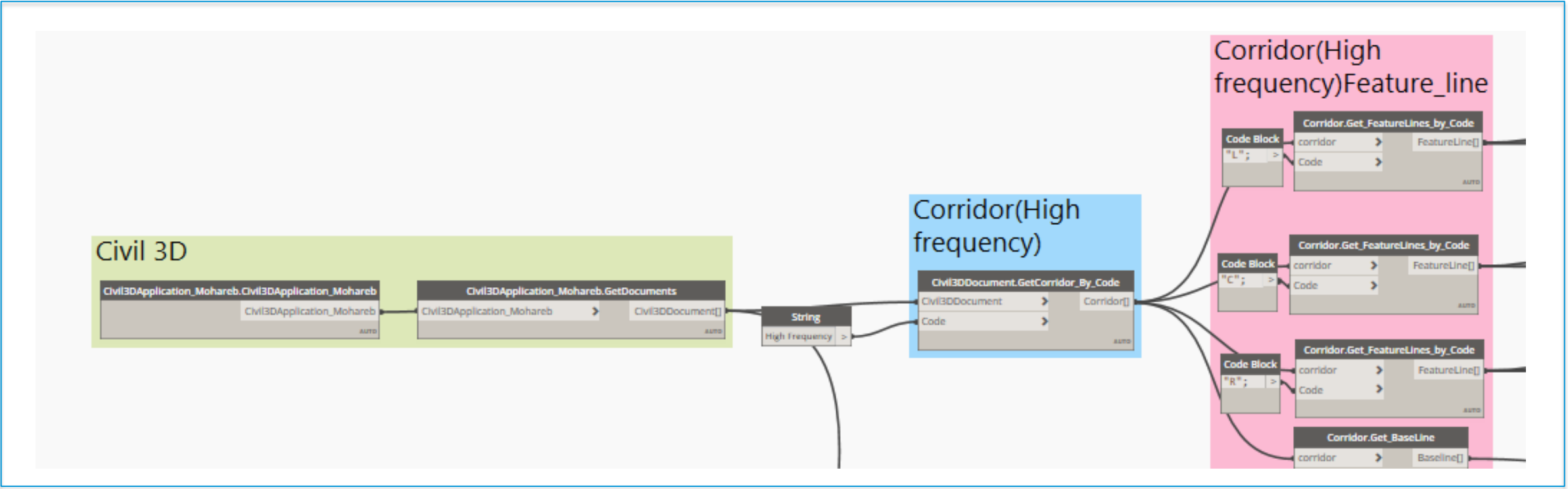
Simple Subassembly composer



High frequency corridor

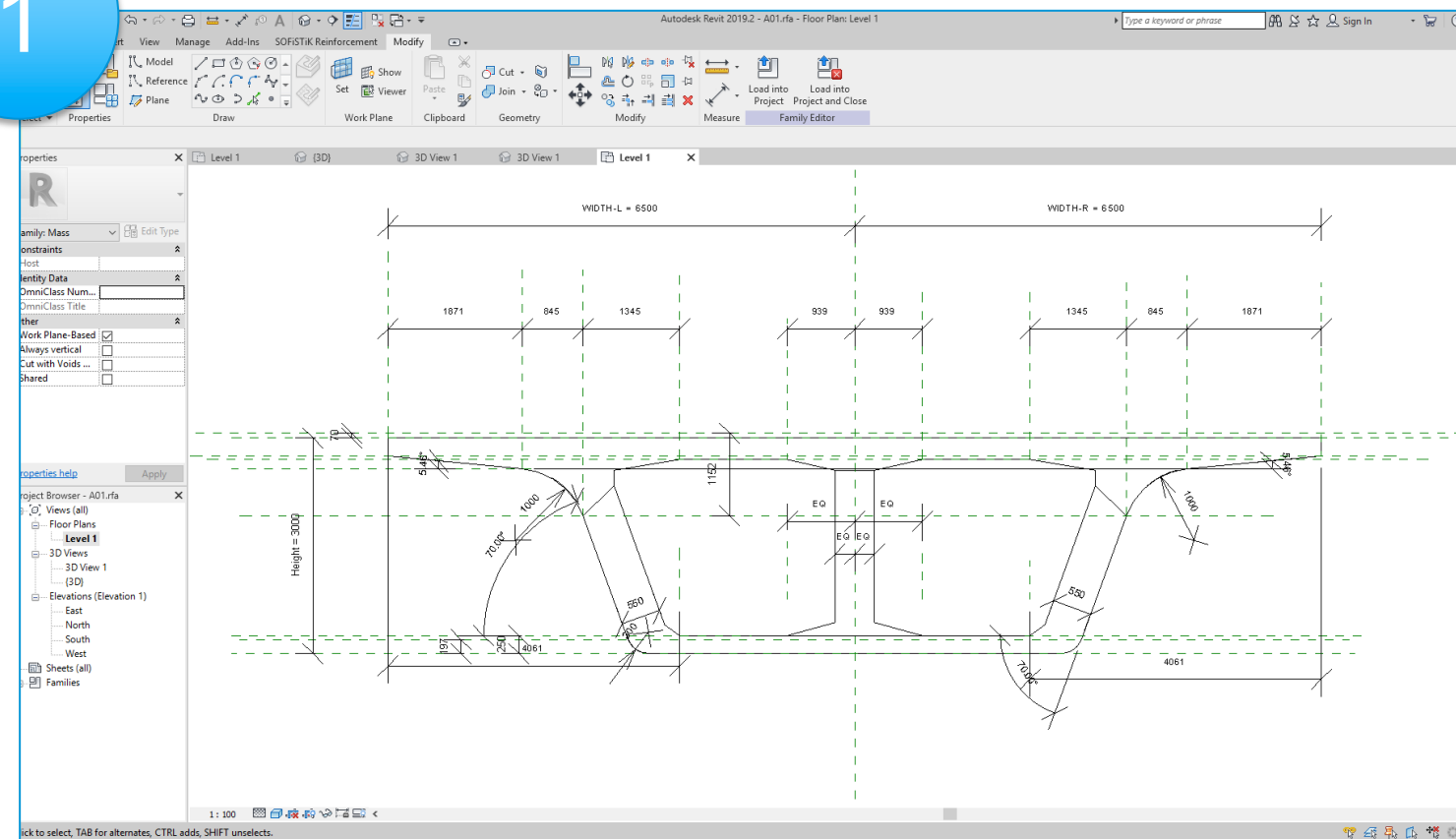


Subassembly composer



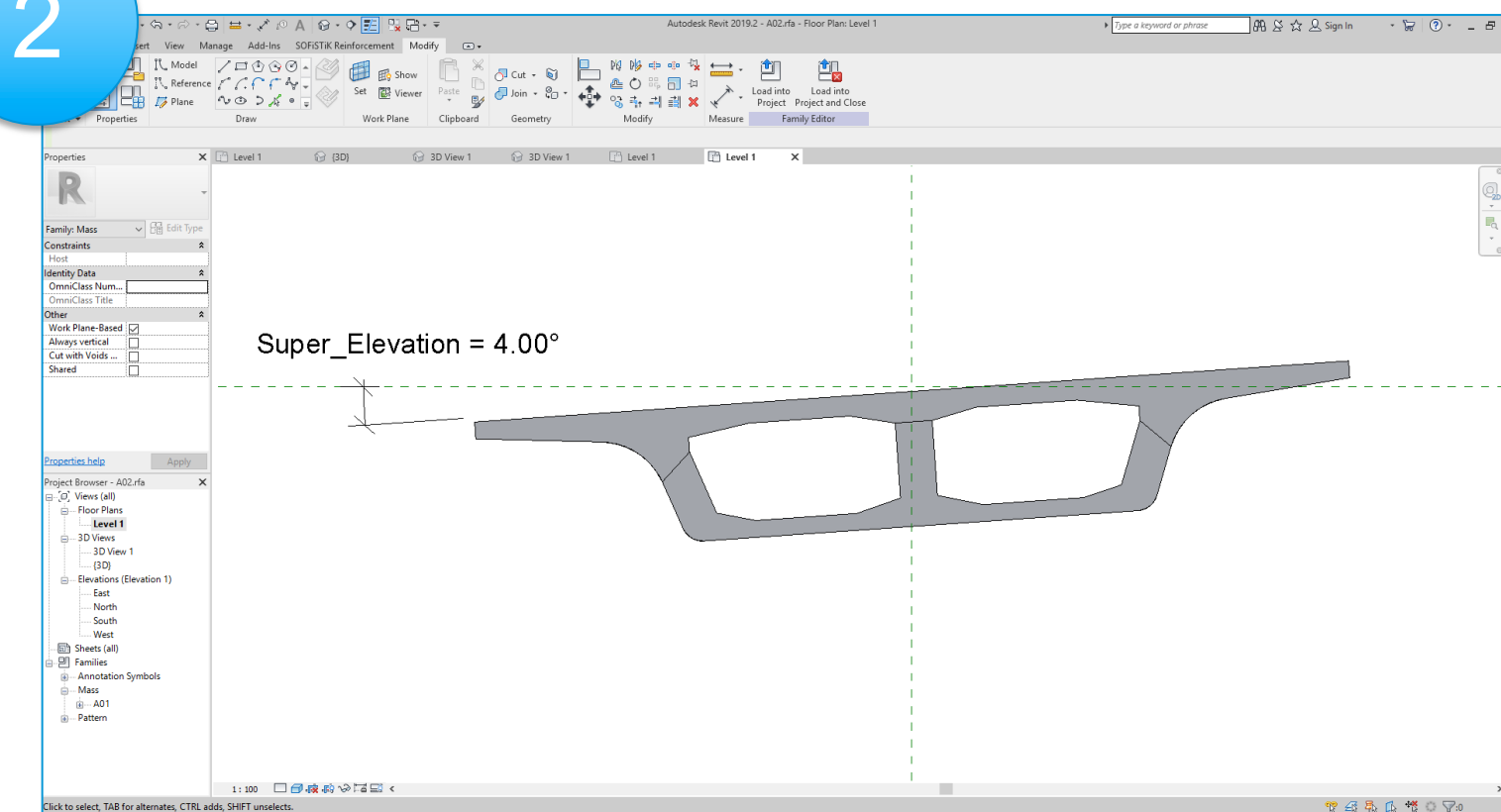
Step (2) Deck Object

1



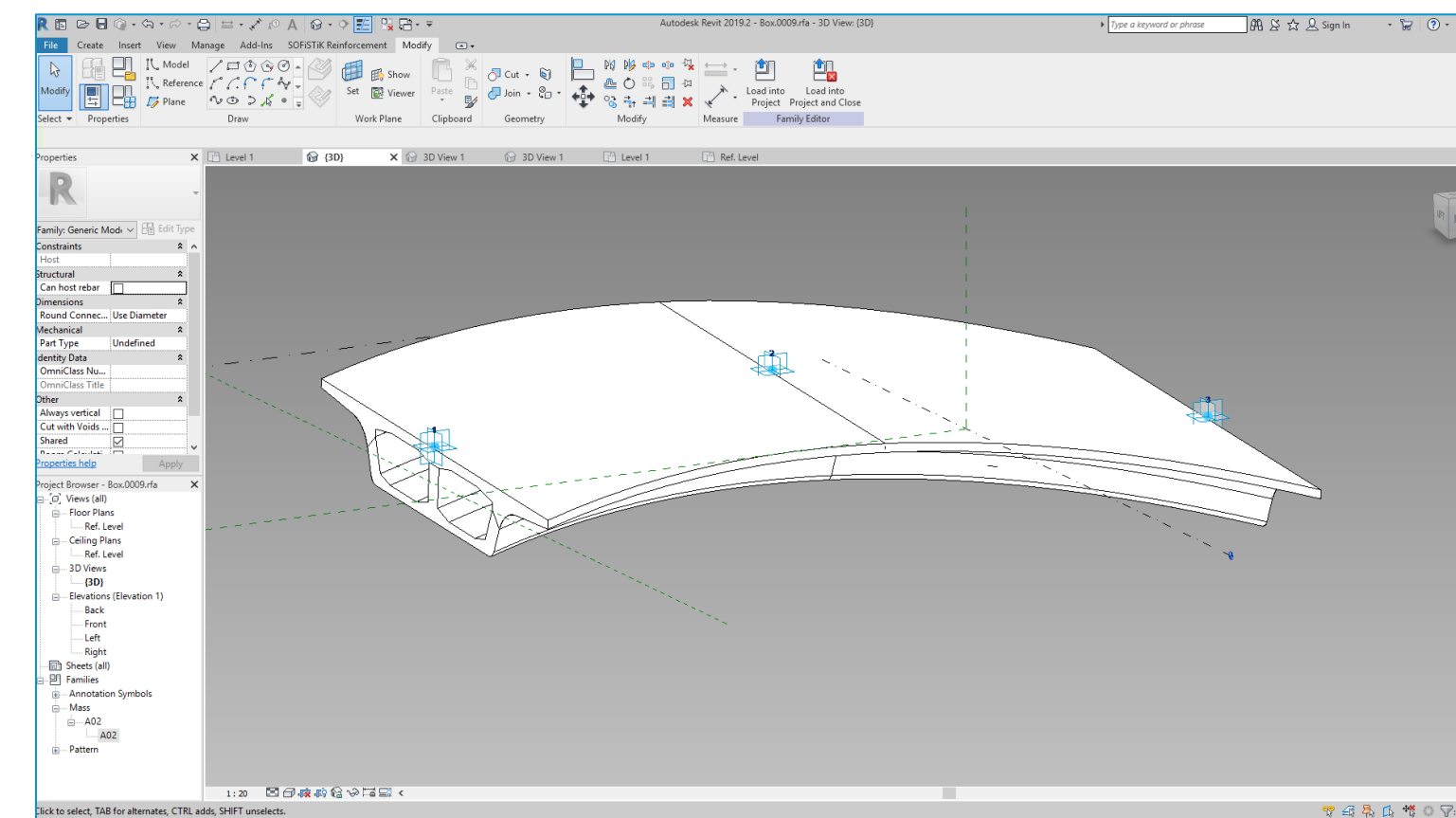
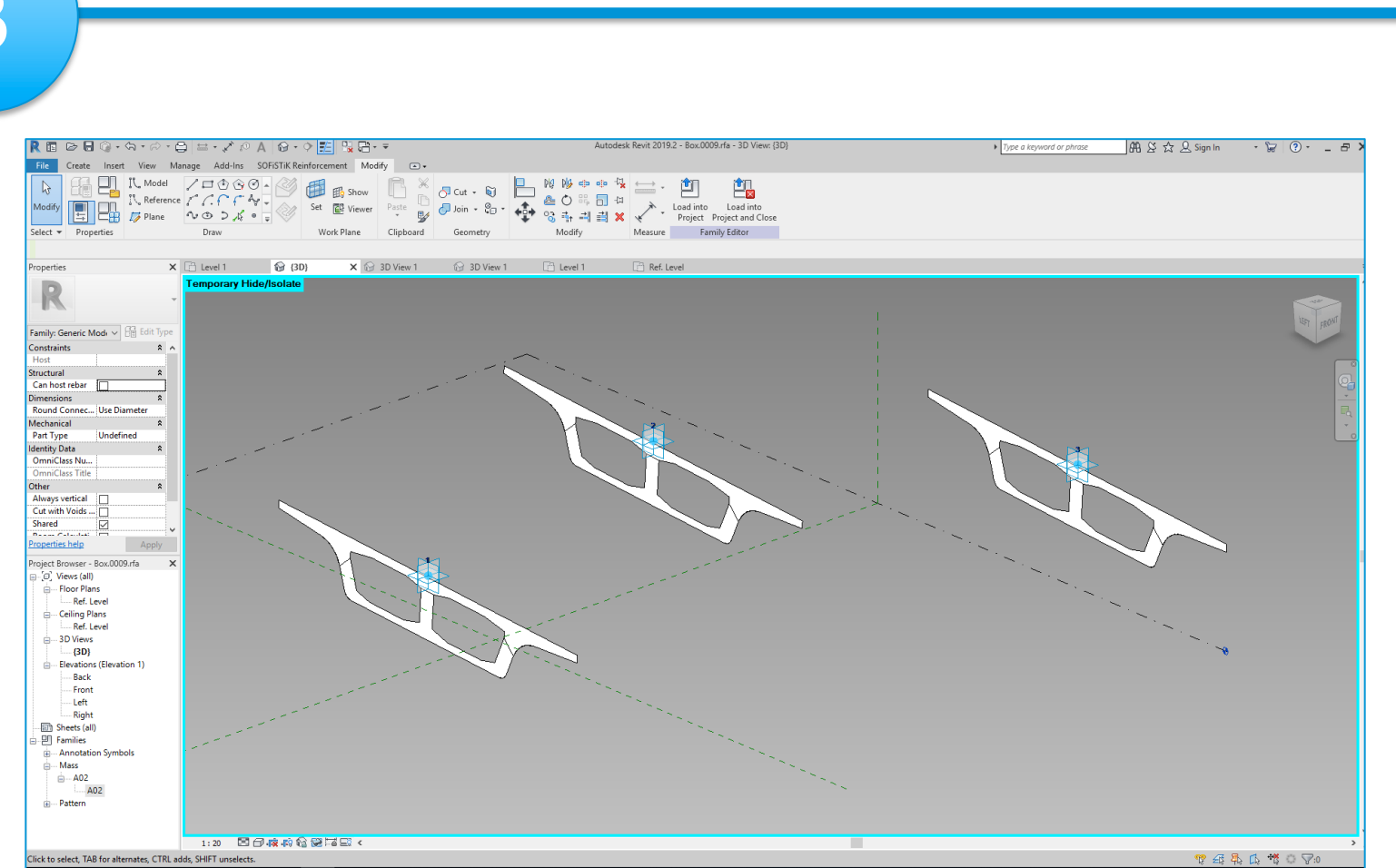
1- Profile Family (Parametric Cross Section)

2

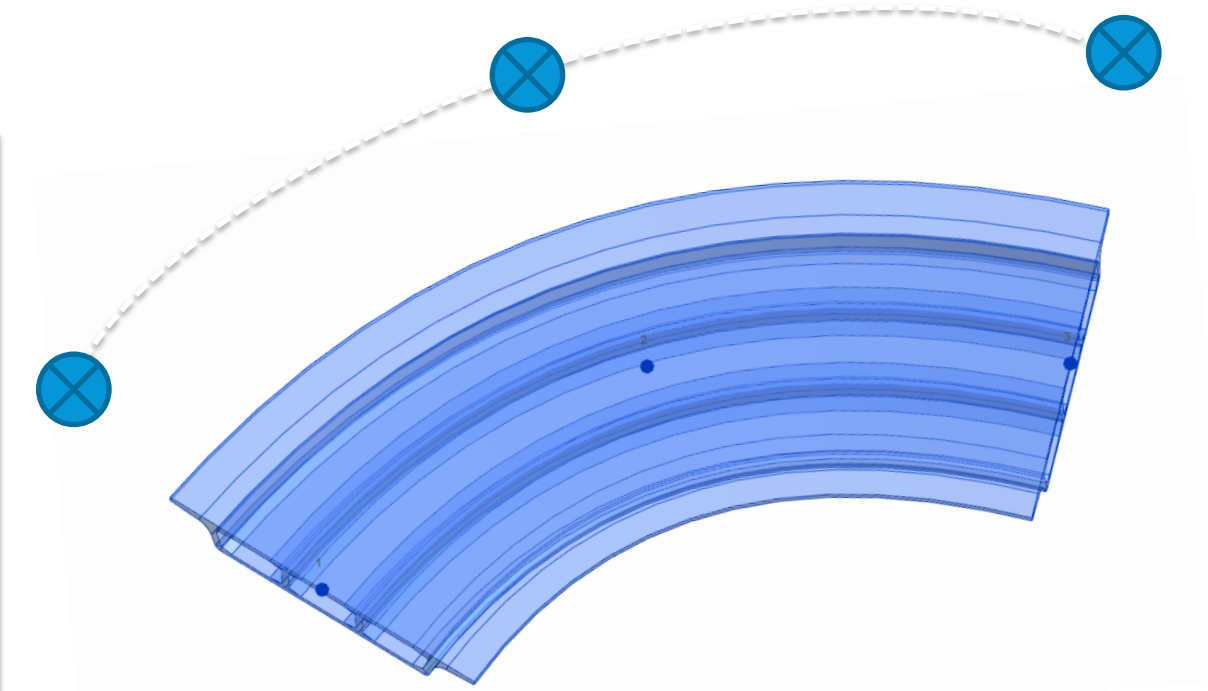


2- Profile Family (Super Elevation parameter)

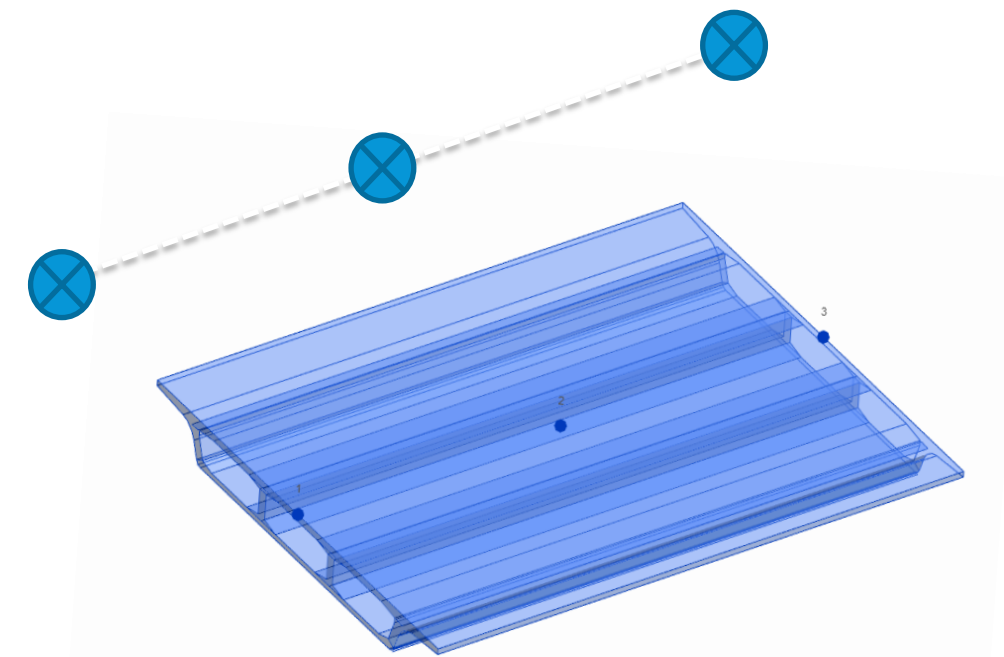
3



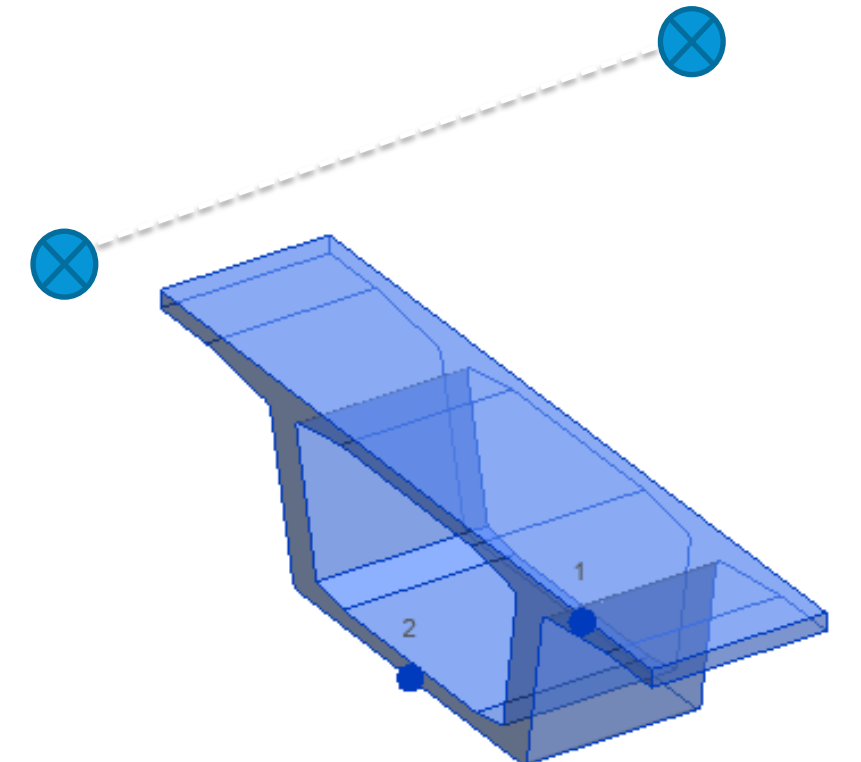
3- Three Points Adaptive Family



3 adaptive Points Along Curve



3 Points Along Line

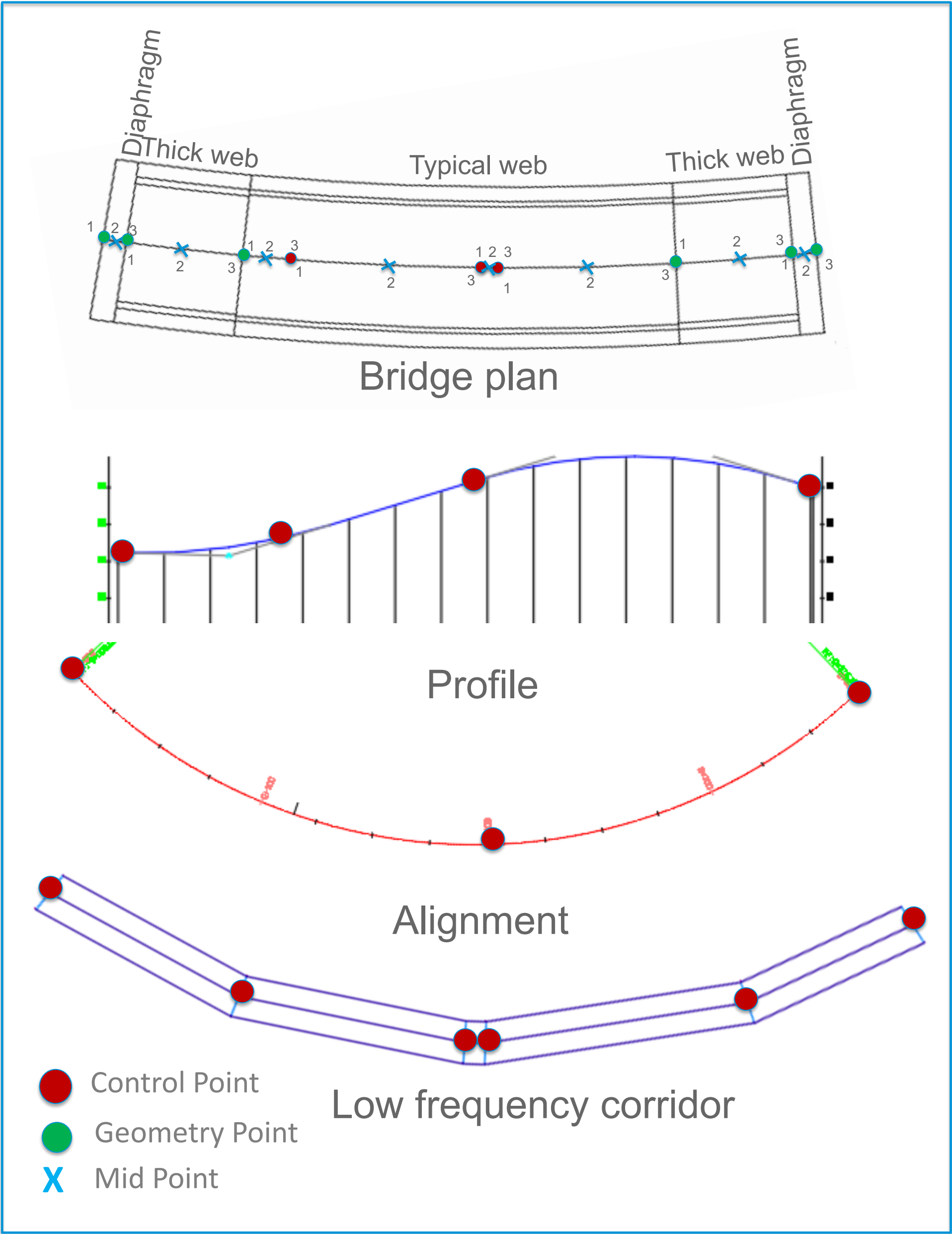
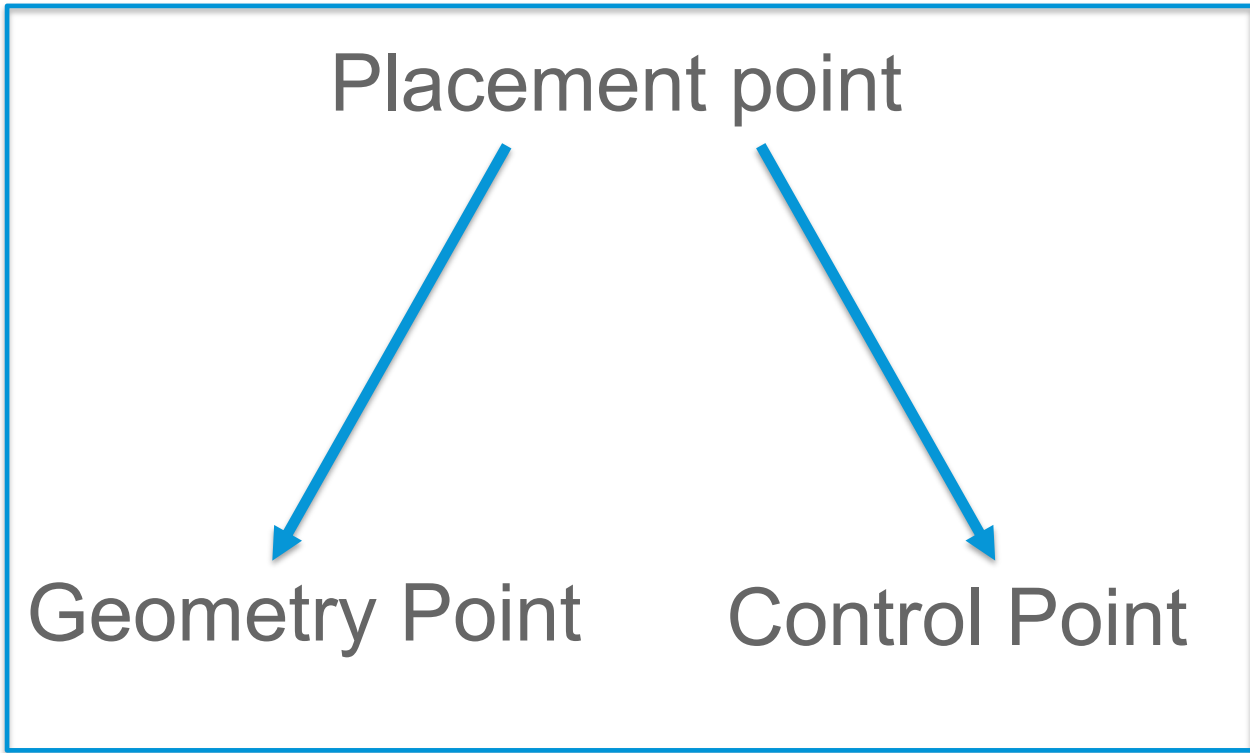


2 Points Along Line

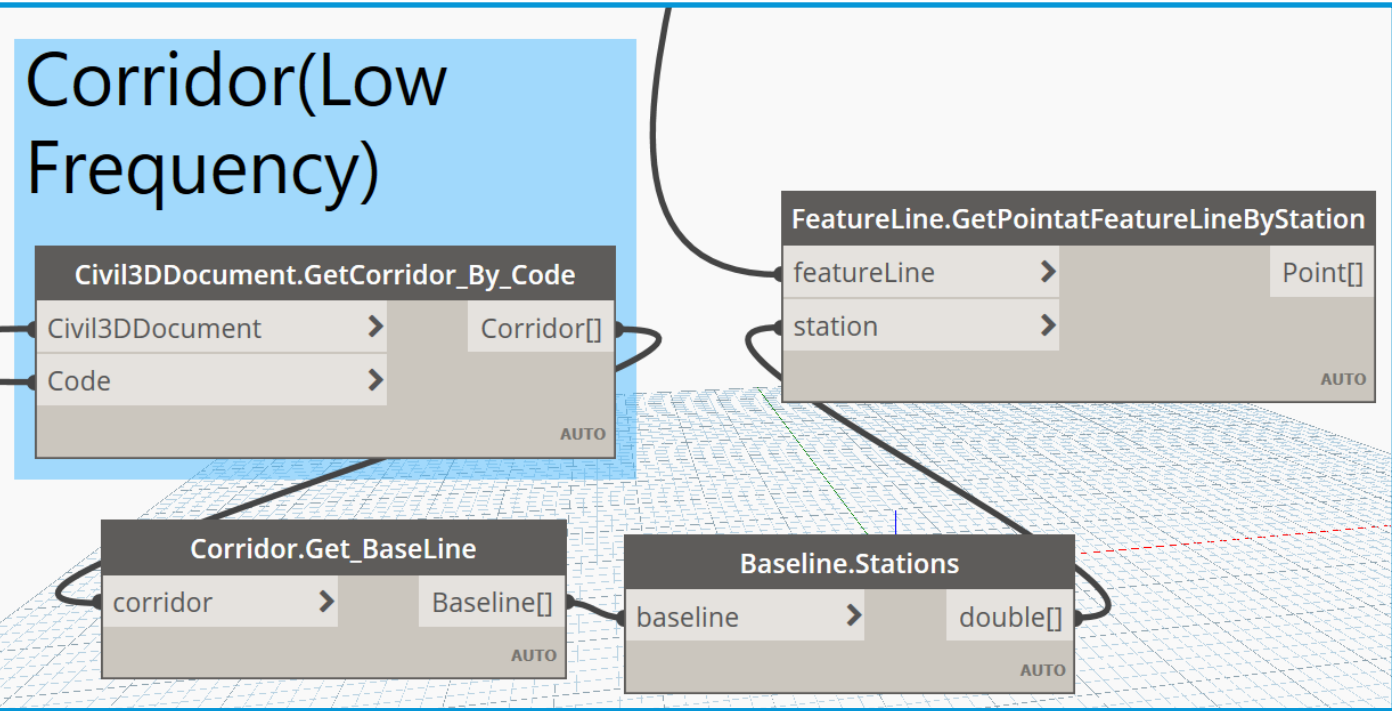
Reference:

1-Andrzej Samsonowicz, “Dynabridge” dynamo package.

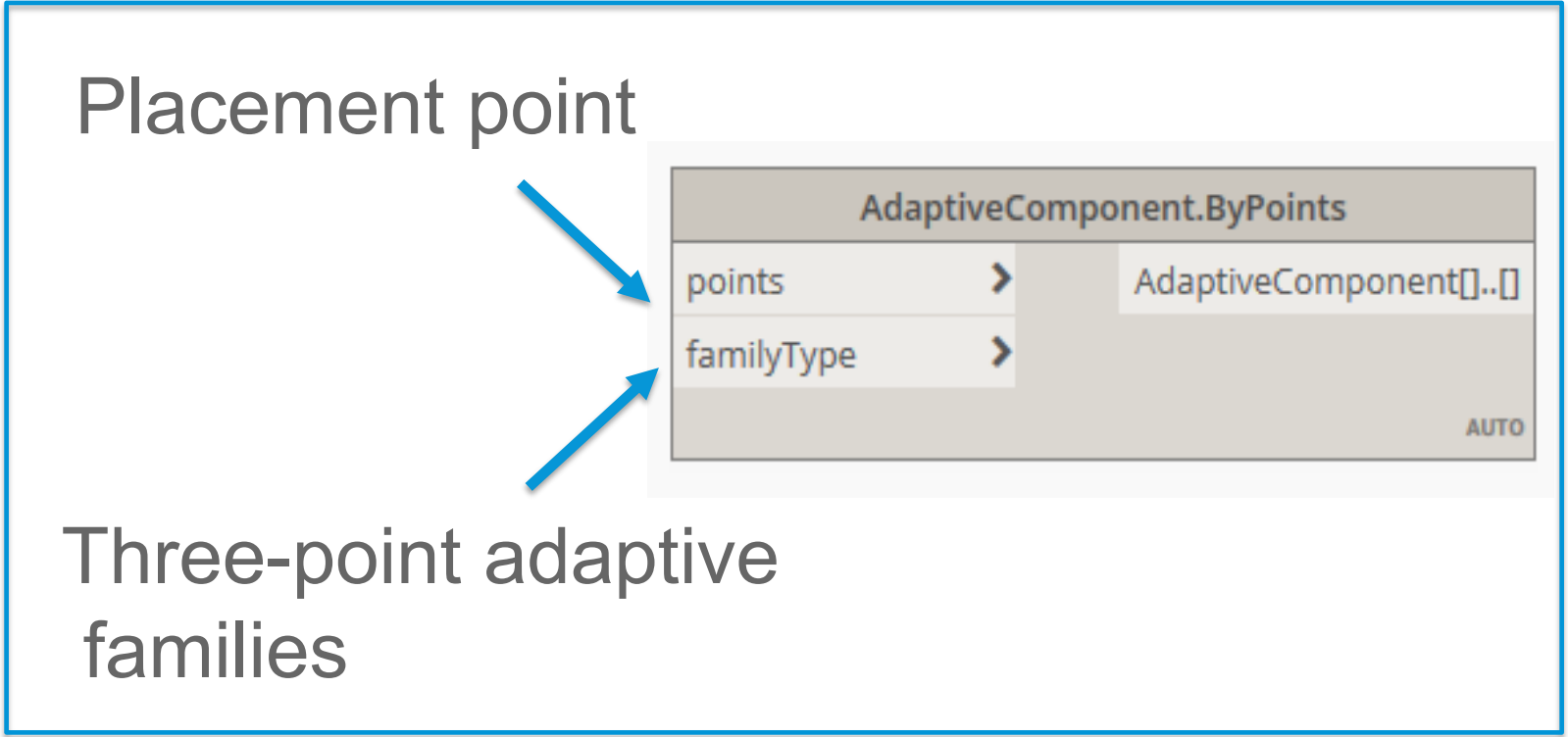
Step (3) Get Placement Point Cast In-situ Element



Property	Value
Corridor Information	
Horizontal Baseline	
Along tangents	1000.000m
Along curves	At an increment
Curve increment	1000.000m
Mid-ordinate distance to define ...	0.100m
Along spirals	1000.000m
At horizontal geometry points	Yes
At superelevation critical points	Yes
Vertical Baseline	
Along vertical curves	1000.000m
At vertical geometry points	Yes
At high/low points	Yes
Offset Target	
At offset target geometry points	Yes
Adjacent to offset target start/...	Yes
Along offset target curves	<None>
Curve increment	25.000m
Mid-ordinate distance to define ...	0.100m



Dynamo-Get control Points



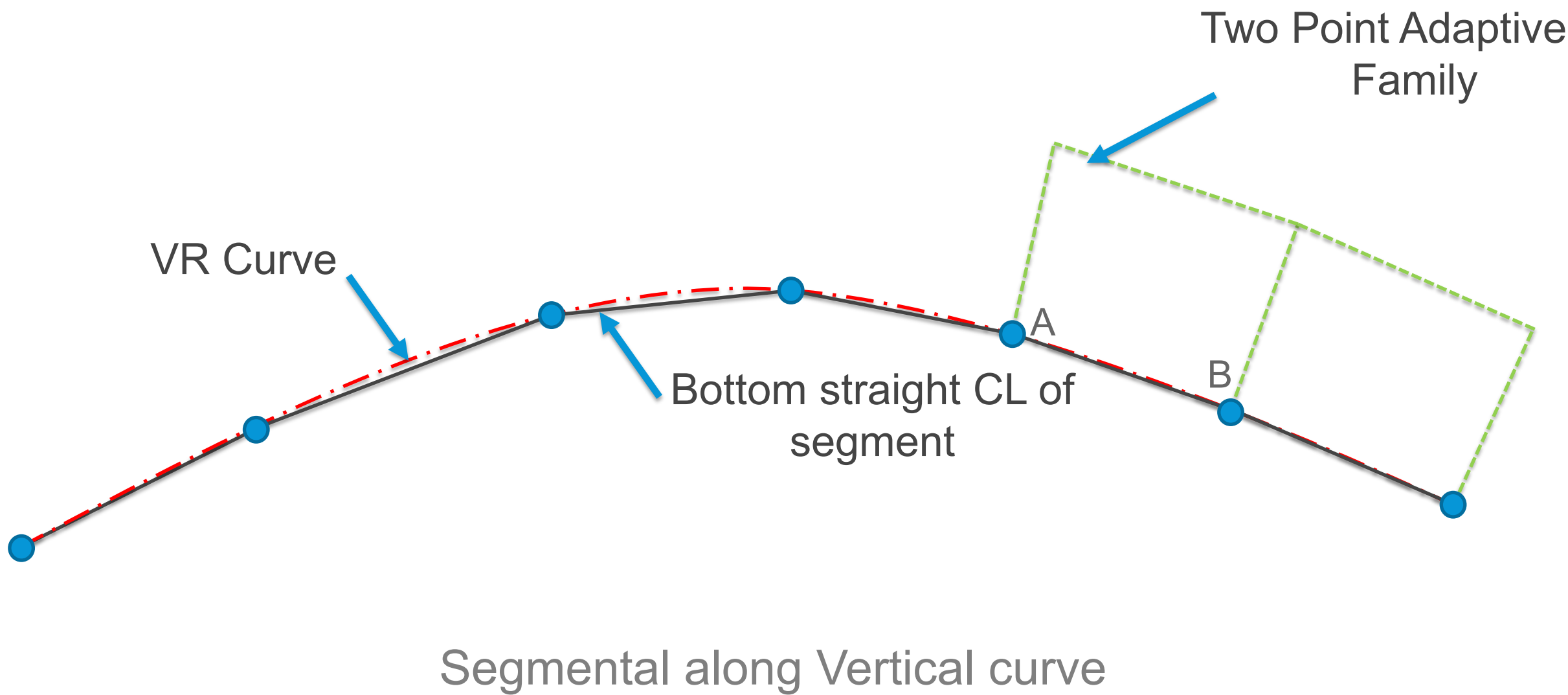
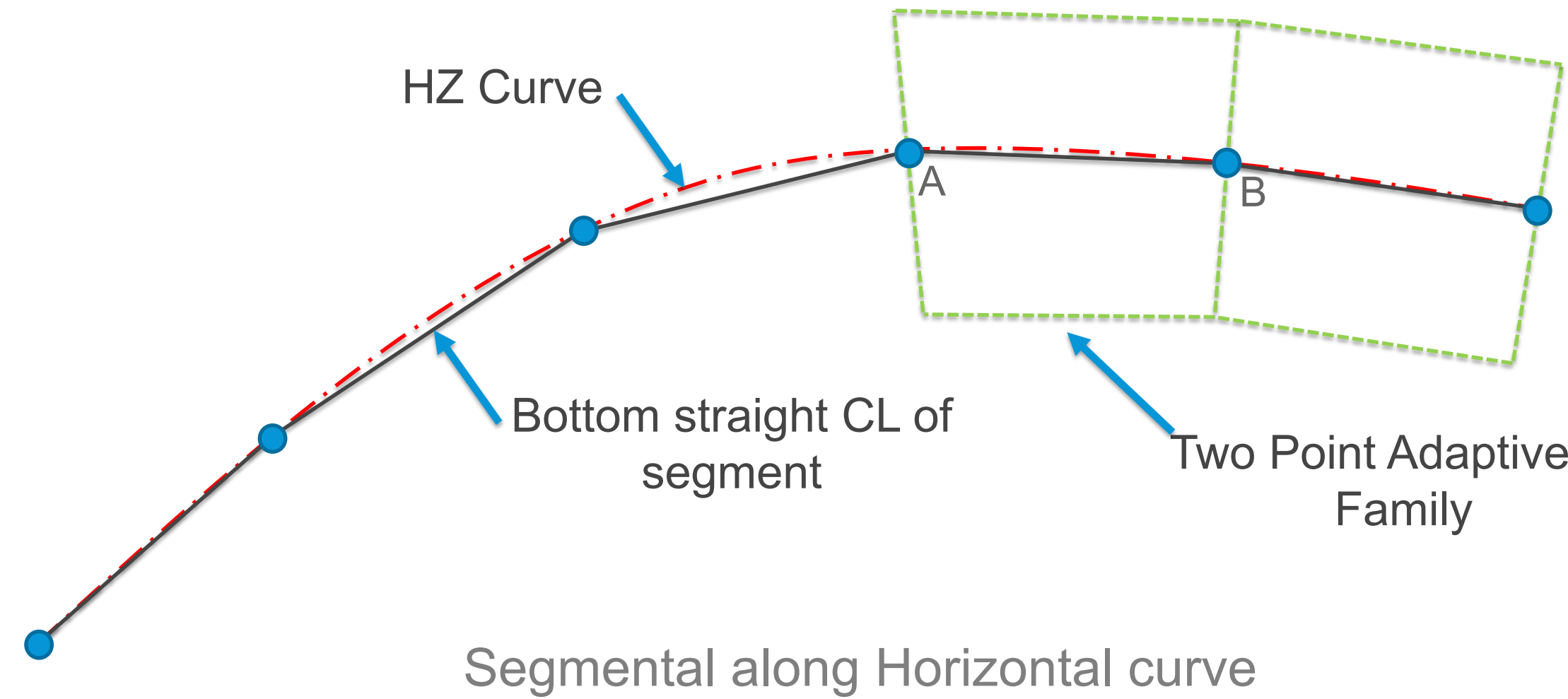
Step (3) Get Placement Point Precast Element



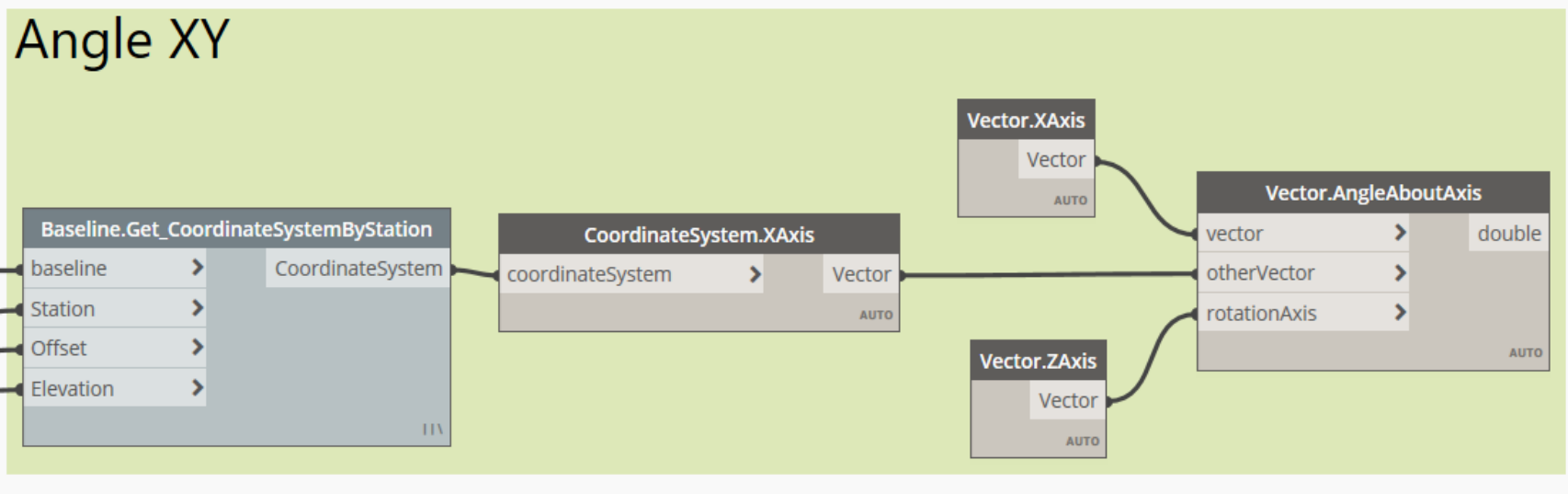
Match casting



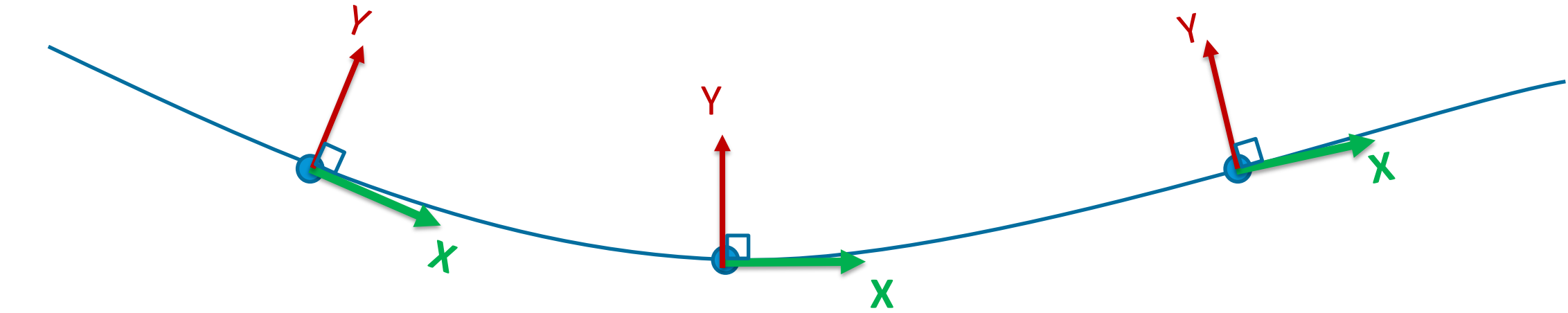
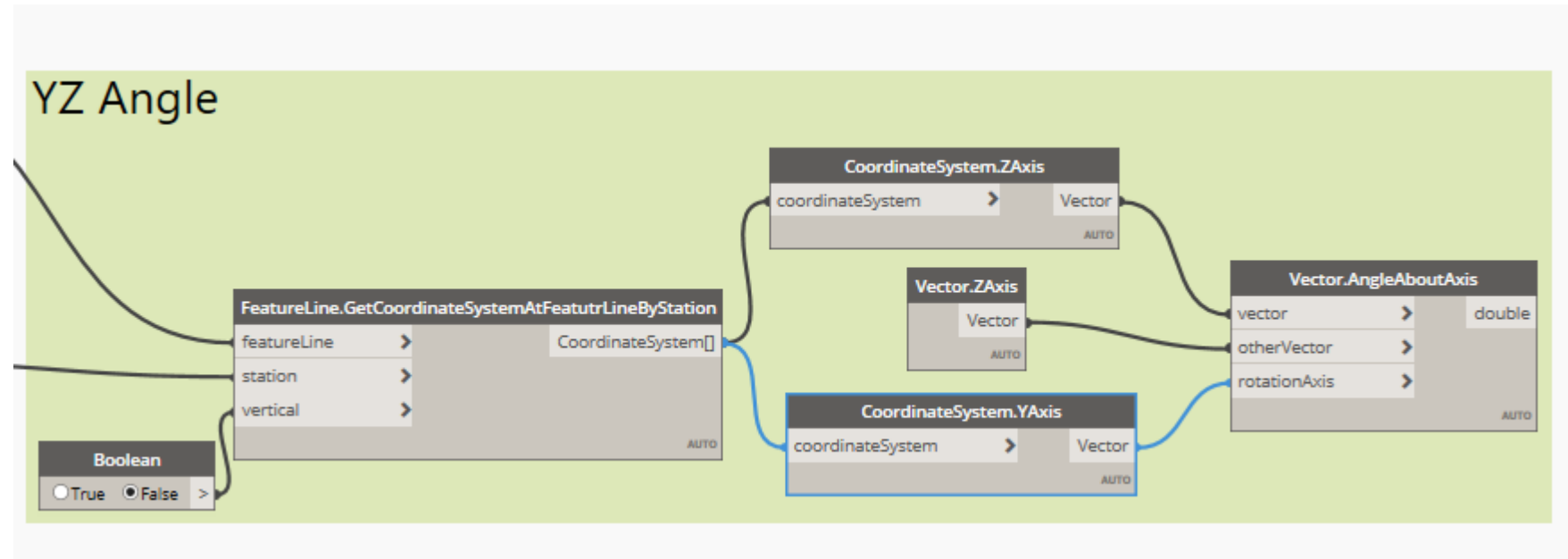
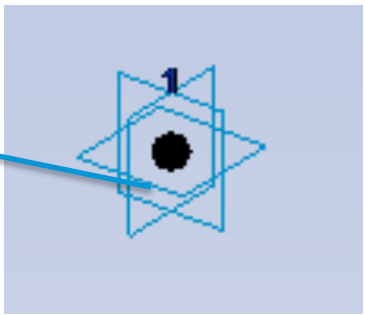
Pre-cast segment



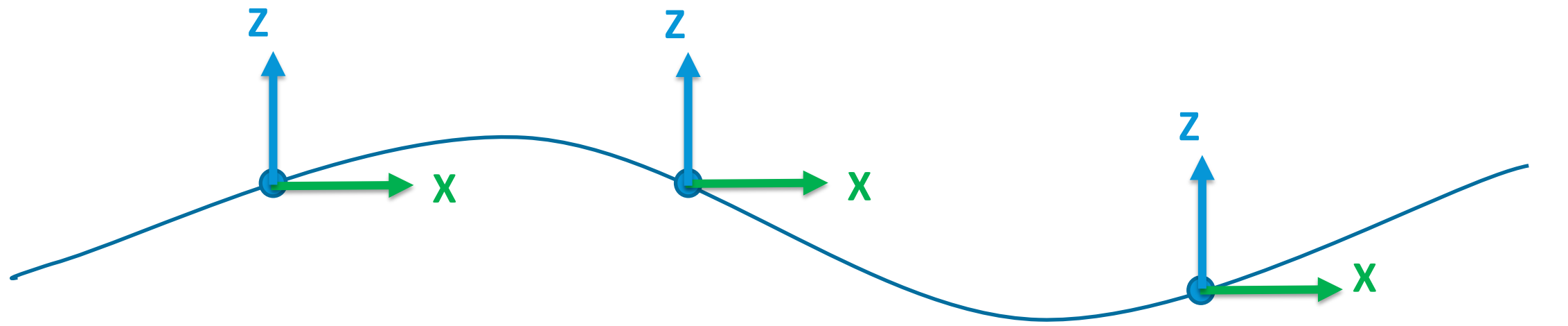
Step (4) Calculate & Set Parameter



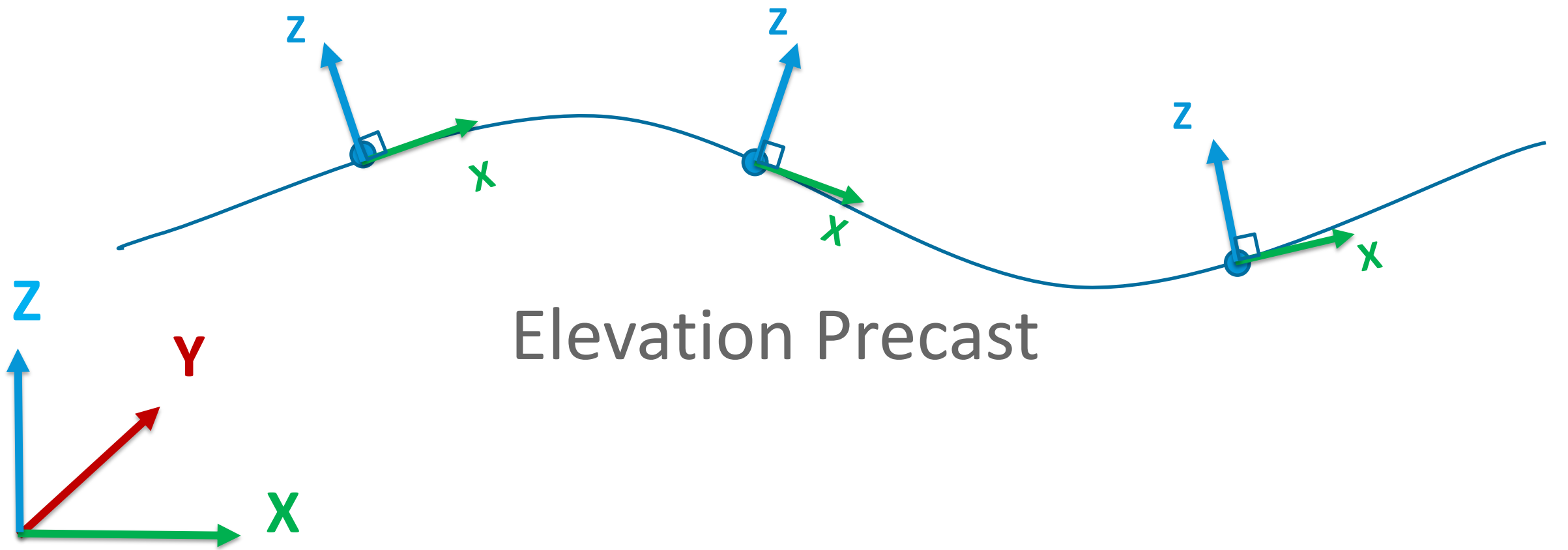
Adaptive Component	
Point	Placement Point (Adaptive)
Number	1
Show Placement Number	Always
Orients to	Global (z) then Host (xy)
Other	



Plan



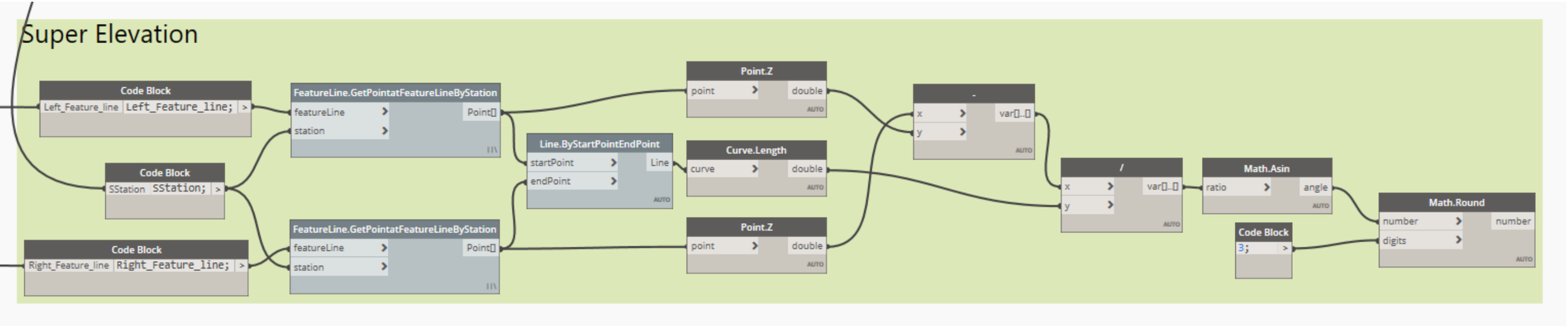
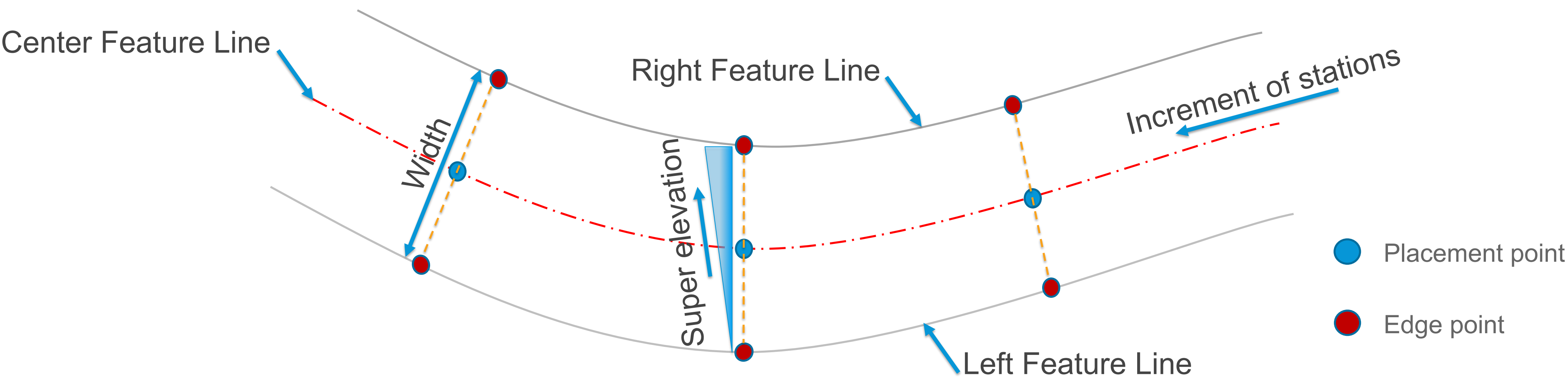
Elevation (Cast In-situ)



Elevation Precast

● Placement point

Step (4) Calculate & Set Parameter



Linear Structure Objects, Challenge and Concept

Linear Structure Type	<u>Step 1</u> Civil 3D Corridor	<u>Step 2</u> Deck Object	<u>Step 3</u> Placement Point	<u>Step 4</u> Calculate & Set Parameters
Cast In-situ Element	High & Low Frequency Corridor	Three-point adaptive family	<ul style="list-style-type: none">Geometry PointsControl Points	<ul style="list-style-type: none">XY Plan RotationSuper ElevationVariable WidthVariable Depth
Precast Element	High Frequency Corridor	Two-point adaptive family	<ul style="list-style-type: none">Segment Discretization	<ul style="list-style-type: none">XY Plan RotationYZ Profile RotationSuper ElevationVariable WidthVariable Depth

Workflow Pros & Cons

Pros:

1. Model all types of linear structures.
2. Model both horizontal and vertical elements in the same package.
3. Easily integrate different structural attachments
4. Easily modify model according to any update in the structural geometry by just editing parameter values.
5. Possibility to upgrade the model by adding additional object into the model using Revit.
6. Ability to integrate reinforcement and prestress cable into the same information system.
7. Easy to upgrade the model to 4D BIM model.
8. Automated 2D drawings extraction.
9. Easily link the BIM model with the other BIM software.

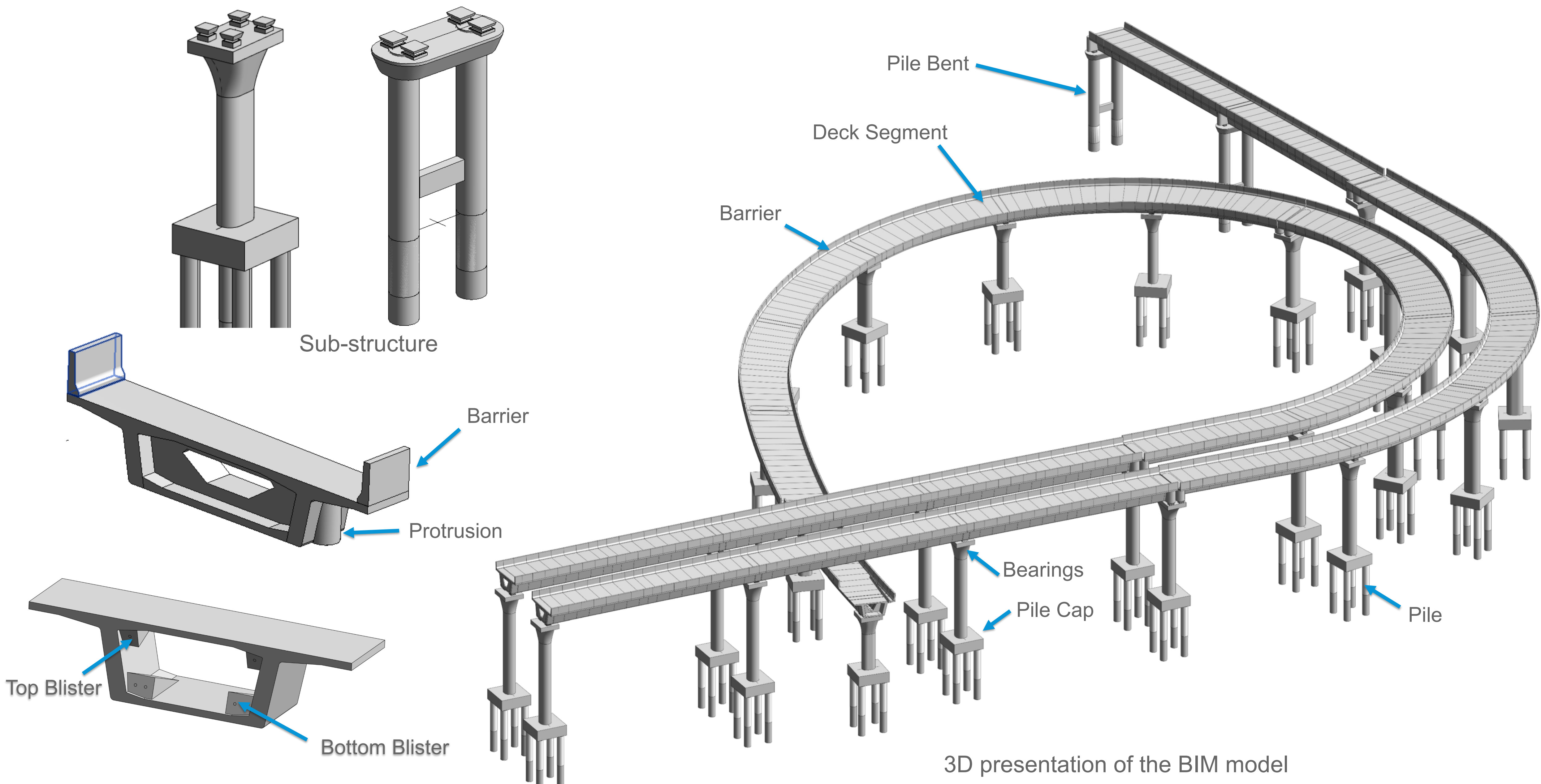
Cons:

1. Each type of linear structural need a specific Dynamo script.
2. Each project need specific linear structure object to be created as an adaptive family.

Case study



BIM Model for Segmental Bridge



BIM Model Data for Segmental Bridge

16m_Box_Web

16m_TYPICAL-3300

Generic Models (1)

Edit Type

Dimensions

ExternalEdgeLengthLeft	3.0000
ExternalEdgeLengthRight	3.0000
LengthCenterBottom	3.0000
Station_A	2705.0264
Station_B	2708.0369
SuperElevation_A	1.43°
SuperElevation_B	1.43°
rot_XY_A	261.30°
rot_XY_B	261.35°
rot_XZ_A	89.75°
rot_XZ_B	89.74°
SuperElevationA	1.43°
SuperElevationB	1.43°
XZPlanStart	89.75°
XZPlanEnd	89.74°
HEndRight	3.3000
HEndLeft	3.3000
HStartRight	3.3000
HStartLeft	3.3000
LPlanLeft	2.9935
LPlanRight	3.0075
LPlanCenterBottom	3.0000
StartDipthCenter	0.0000
EndDipthCenter	0.0000
Volume	31.061 m³

Identity Data

Phasing

Adaptive Component

Data

Alignment	TR_ML_ALIGN
Corridor_Name	Main_16m_3.3_Left
ExelFileName	P:\Bridges\IN18036-0100D\8_Revit\...
Index_Excel	32
TypeName	TYP. SEG-A05

Visibility

Properties help

Apply

Autodesk Revit 2017.2 - INDIA-CF-MAIN-LINE_NEW_detached - 3D View: 3D View 3

Type a keyword or phrase

Sign In

Architecture

Structure

Systems

Insert

Annotate

Analyze

Massing & Site

Collaborate

View

Manage

Add-Ins

Ideate Software

Modify | Generic Models

Modify

Select

Properties

Geometry

Clipboard

View

Modify

Measure

Create

Mode

Host

Model

Moves With Nearby Elements

Activate Dimensions

16m_Box_Web

16m_TYPICAL-3300

Generic Models (1)

Edit Type

Dimensions

ExternalEdgeLengthLeft	3.0000
ExternalEdgeLengthRight	3.0000
LengthCenterBottom	3.0000
Station_A	2705.0264
Station_B	2708.0369
SuperElevation_A	1.43°
SuperElevation_B	1.43°
rot_XY_A	261.30°
rot_XY_B	261.35°
rot_XZ_A	89.75°
rot_XZ_B	89.74°
SuperElevationA	1.43°
SuperElevationB	1.43°
XZPlanStart	89.75°
XZPlanEnd	89.74°
HEndRight	3.3000
HEndLeft	3.3000
HStartRight	3.3000
HStartLeft	3.3000
LPlanLeft	2.9935
LPlanRight	3.0075
LPlanCenterBottom	3.0000
StartDipthCenter	0.0000
EndDipthCenter	0.0000
Volume	31.061 m³

Identity Data

Phasing

Adaptive Component

Data

Alignment	TR_ML_ALIGN
Corridor_Name	Main_16m_3.3_Left
ExelFileName	P:\Bridges\IN18036-0100D\8_Revit\...
Index_Excel	32
TypeName	TYP. SEG-A05

Visibility

Properties help

Apply

3D View: 3D View 3

Cameras: 3D View: 3D View 3

Perspective

Workset1

Main Model

Editable Only

16m_Box_Web

16m_TYPICAL-3300

Generic Models (1)

Edit Type

Dimensions

ExternalEdgeLengthLeft	3.0000
ExternalEdgeLengthRight	3.0000
LengthCenterBottom	3.0000
Station_A	2705.0264
Station_B	2708.0369
SuperElevation_A	1.43°
SuperElevation_B	1.43°
rot_XY_A	261.30°
rot_XY_B	261.35°
rot_XZ_A	89.75°
rot_XZ_B	89.74°
SuperElevationA	1.43°
SuperElevationB	1.43°
XZPlanStart	89.75°
XZPlanEnd	89.74°
HEndRight	3.3000
HEndLeft	3.3000
HStartRight	3.3000
HStartLeft	3.3000
LPlanLeft	2.9935
LPlanRight	3.0075
LPlanCenterBottom	3.0000
StartDipthCenter	0.0000
EndDipthCenter	0.0000
Volume	31.061 m³

Identity Data

Phasing

Adaptive Component

Data

Alignment	TR_ML_ALIGN
Corridor_Name	Main_16m_3.3_Left
ExelFileName	P:\Bridges\IN18036-0100D\8_Revit\...
Index_Excel	32
TypeName	TYP. SEG-A05

Visibility

Properties help

Apply

3D View: 3D View 3

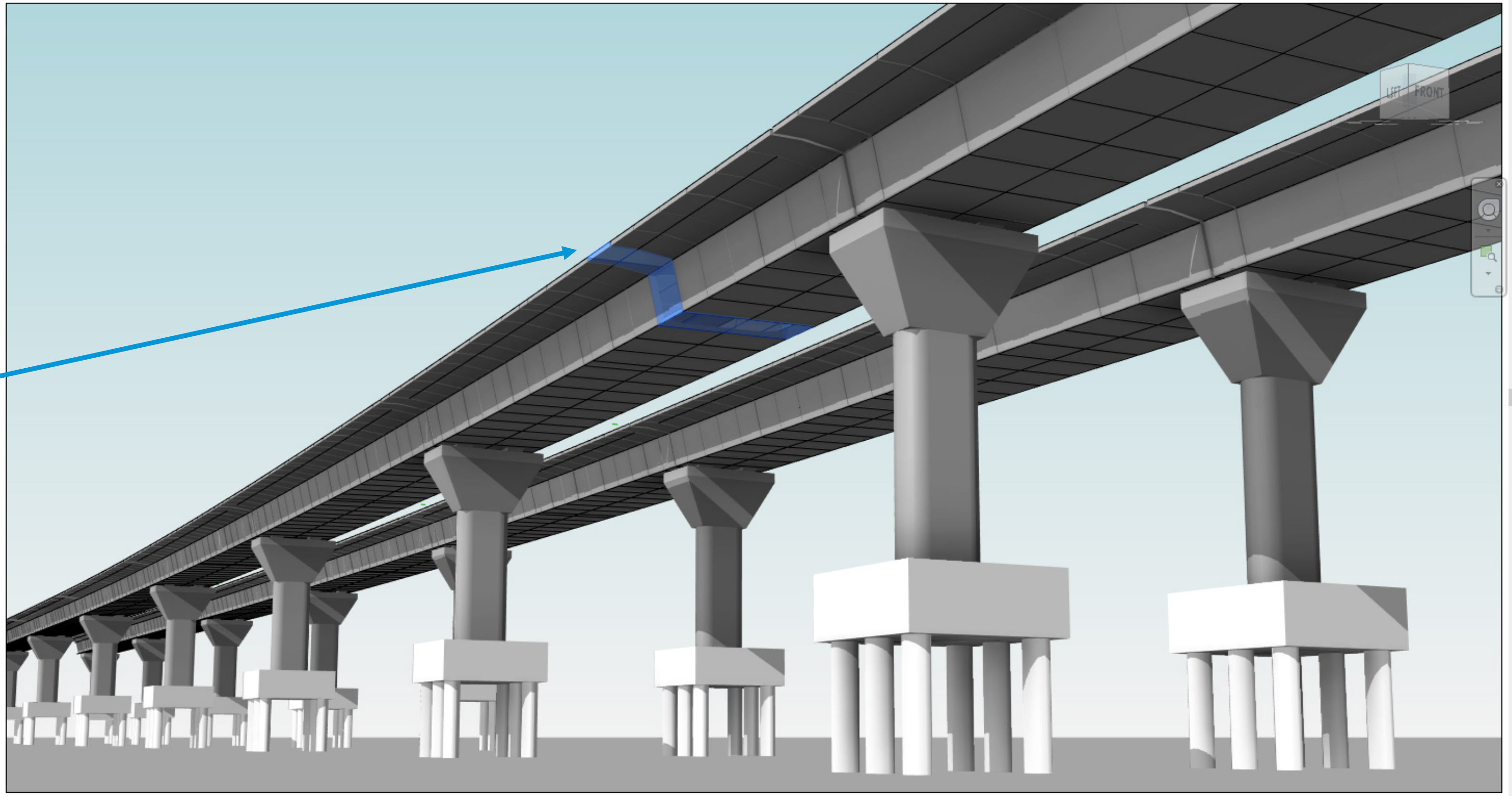
Cameras: 3D View: 3D View 3

Perspective

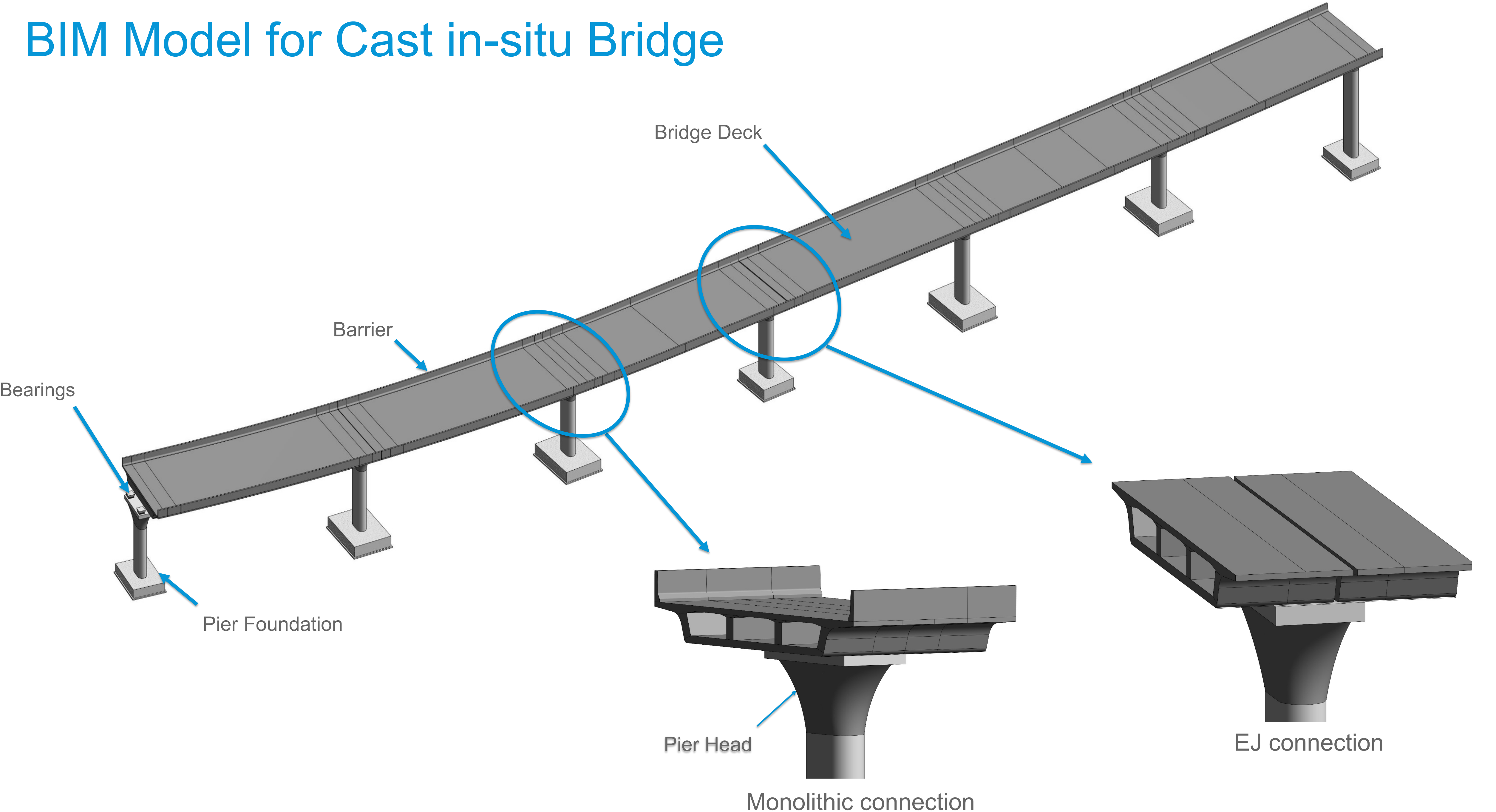
Workset1

Main Model

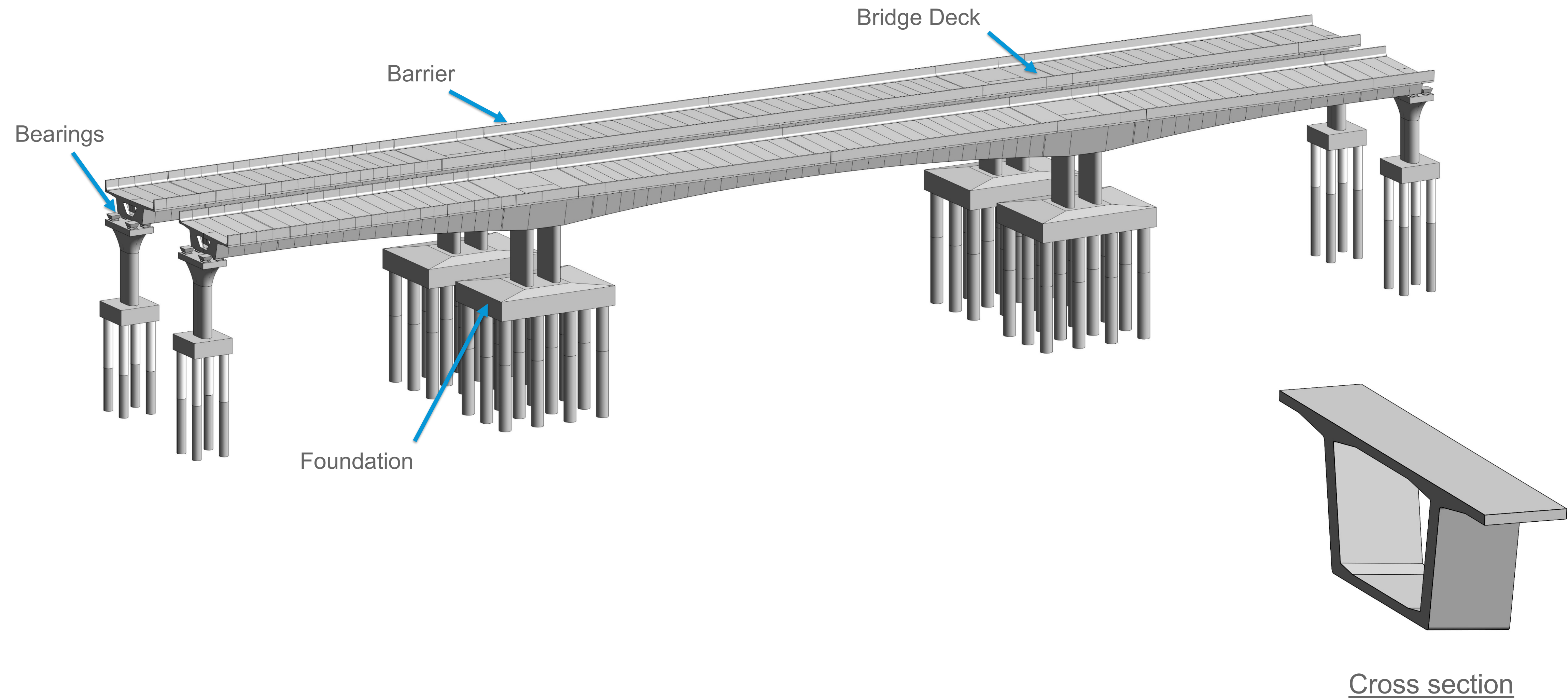
Editable Only



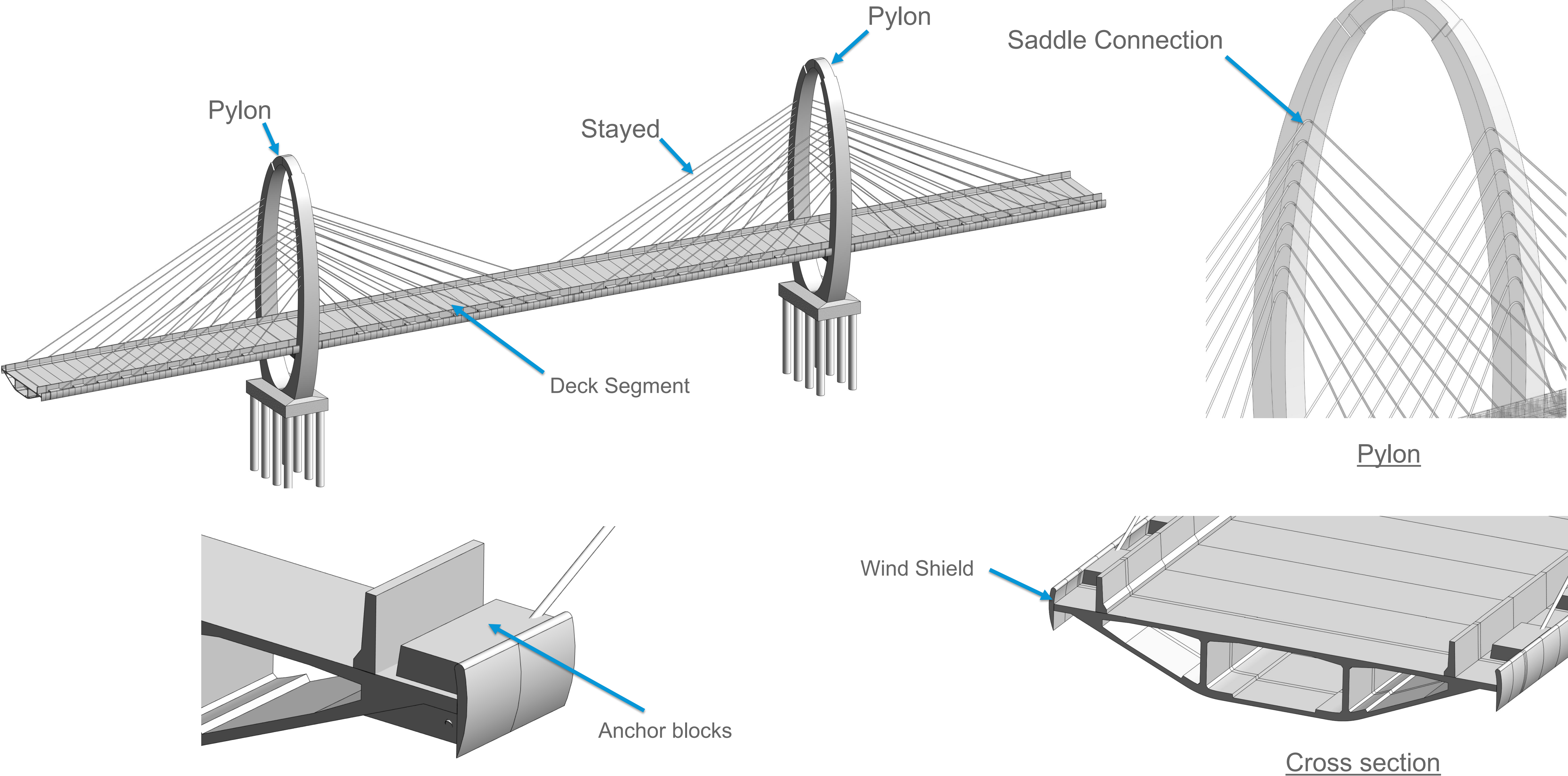
BIM Model for Cast in-situ Bridge



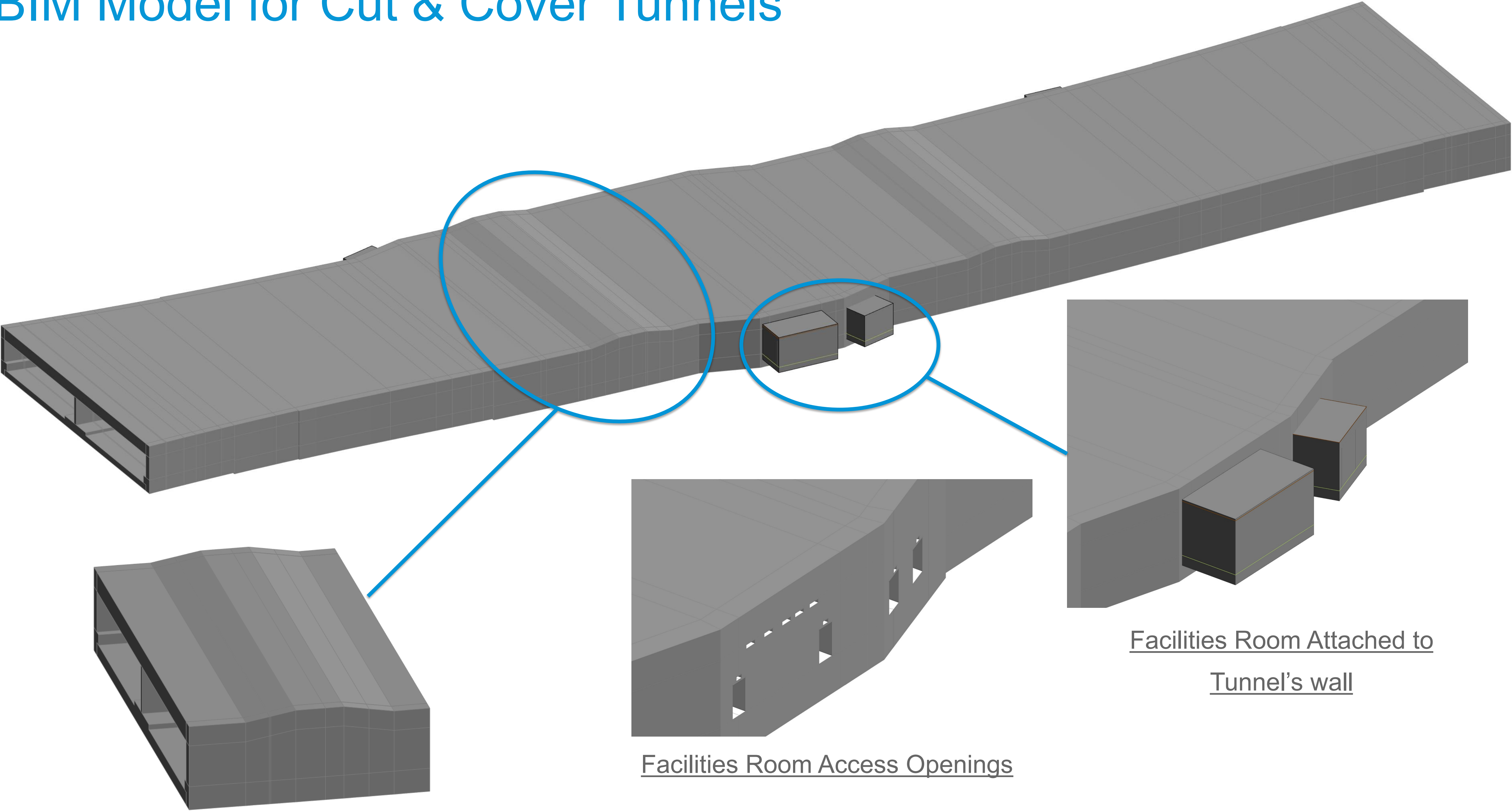
BIM Model for Balanced Cantilever Bridge



BIM Model for Cable-stayed Bridge



BIM Model for Cut & Cover Tunnels



Facilities Room Attached to
Tunnel's wall

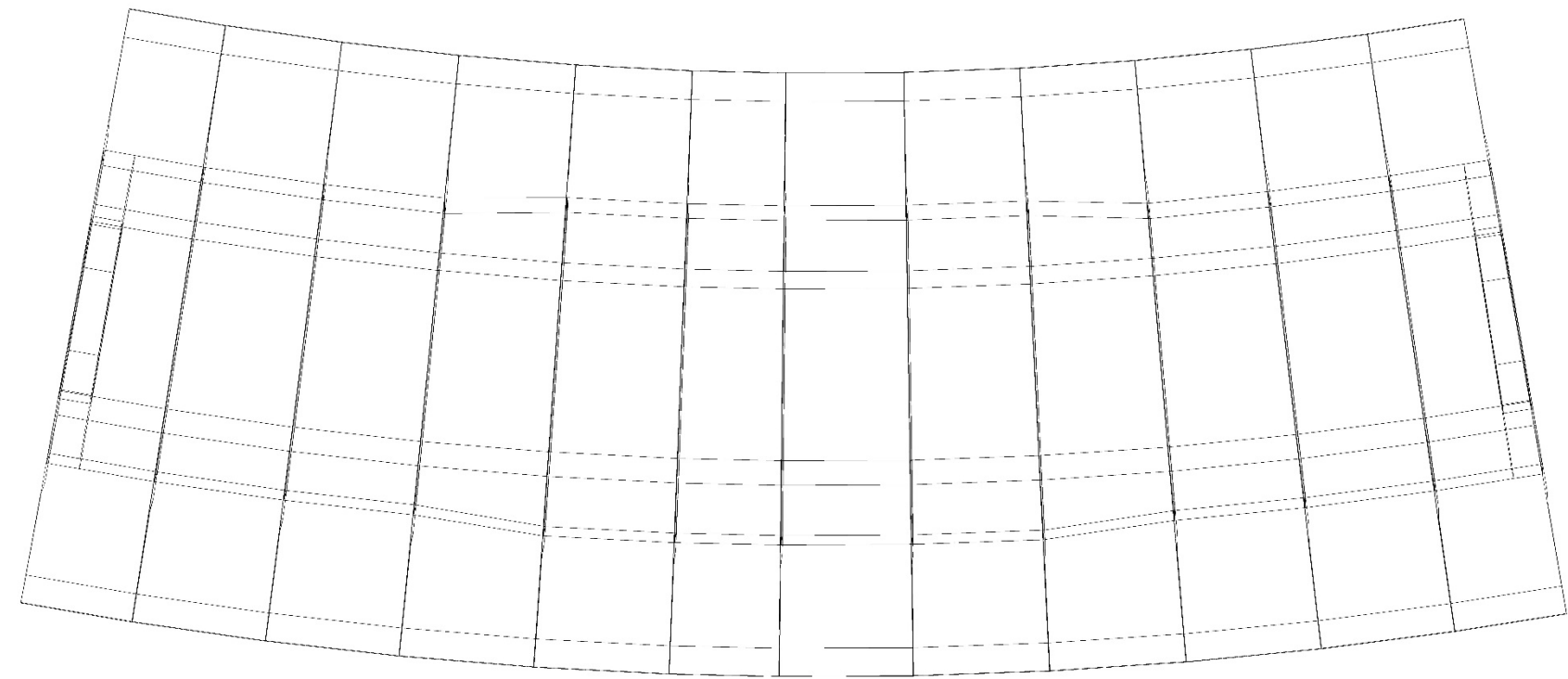
Facilities Room Access Openings

2D Drawings

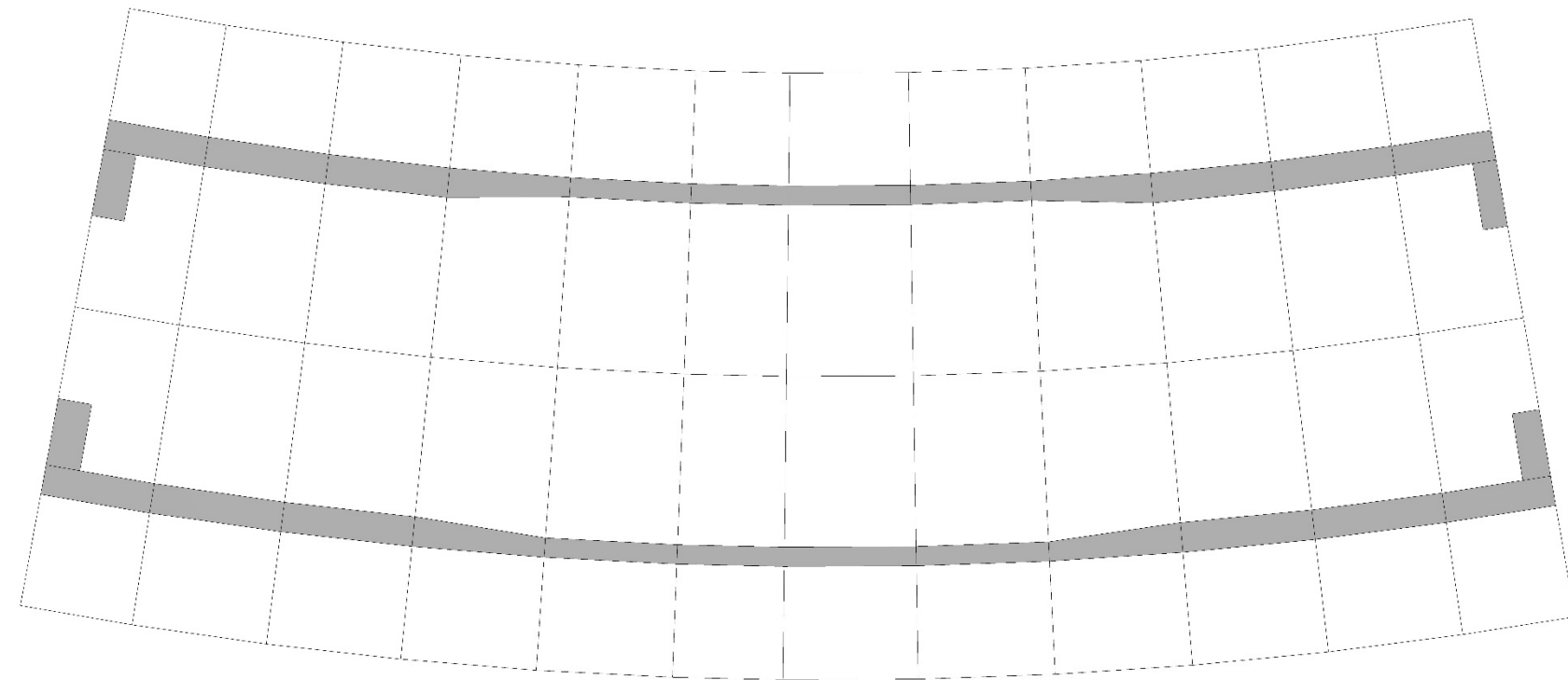


2D Drawings Concept

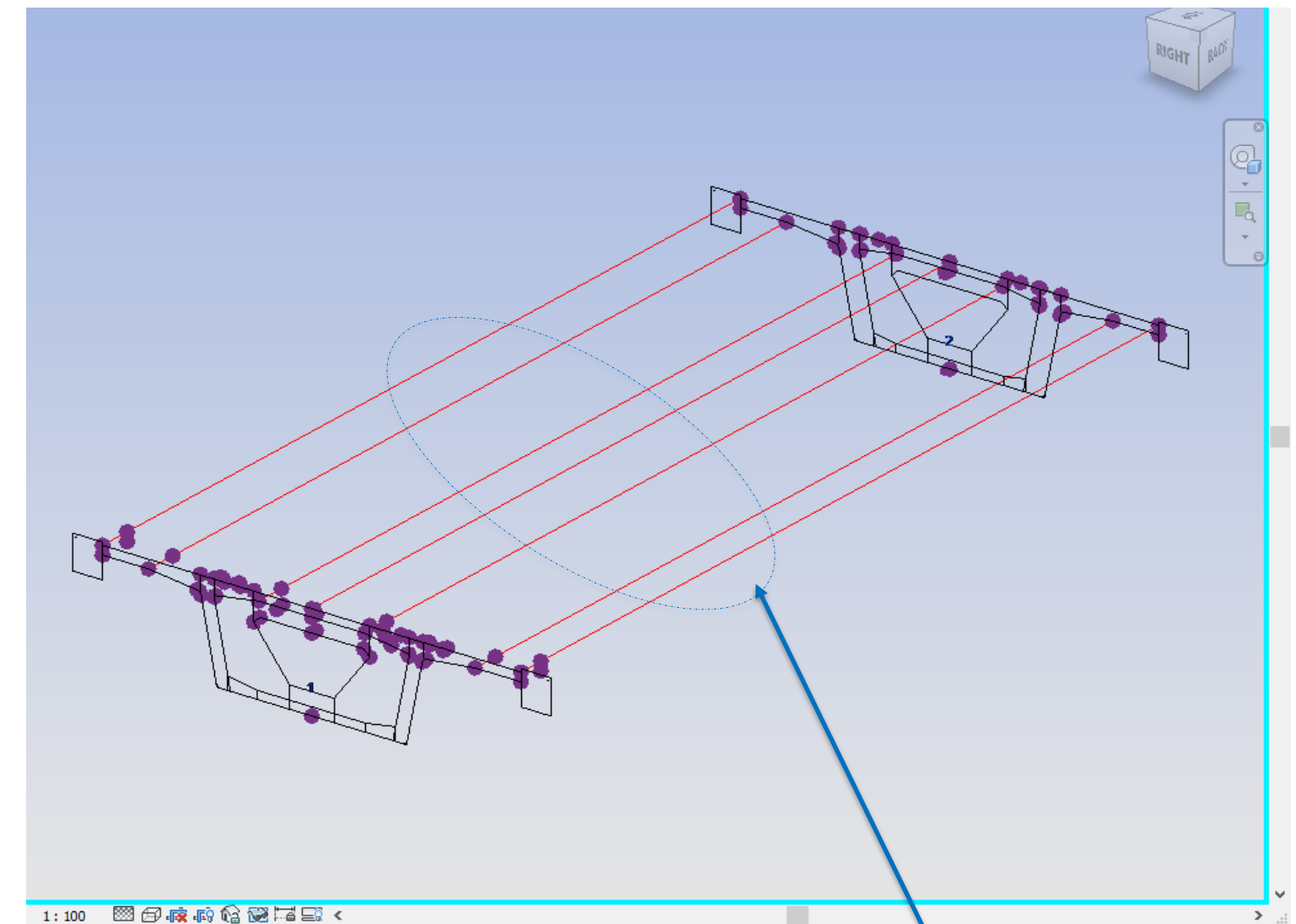
- Why 2D drawings for linear structures are considered a challenge?



Solid Element Plan



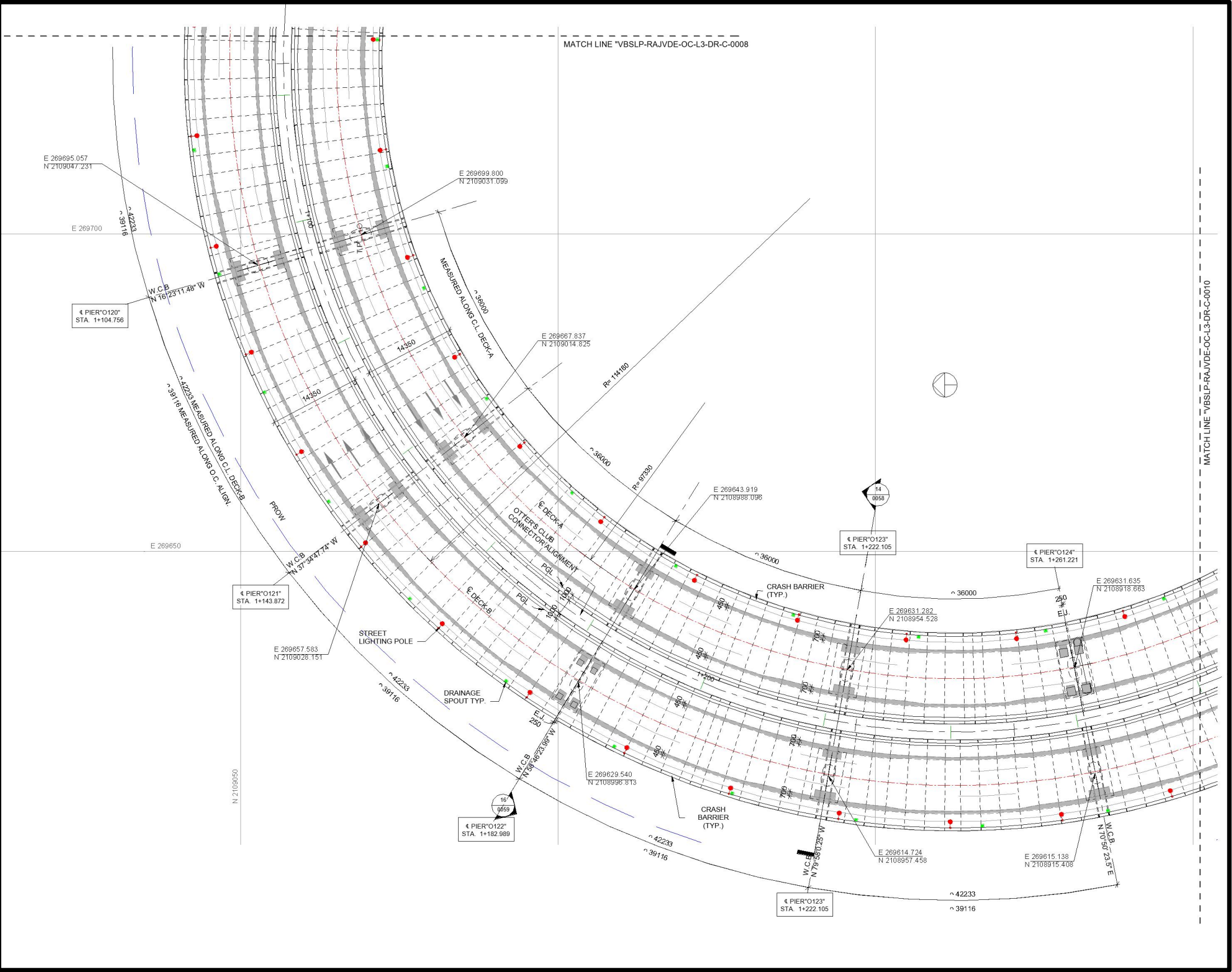
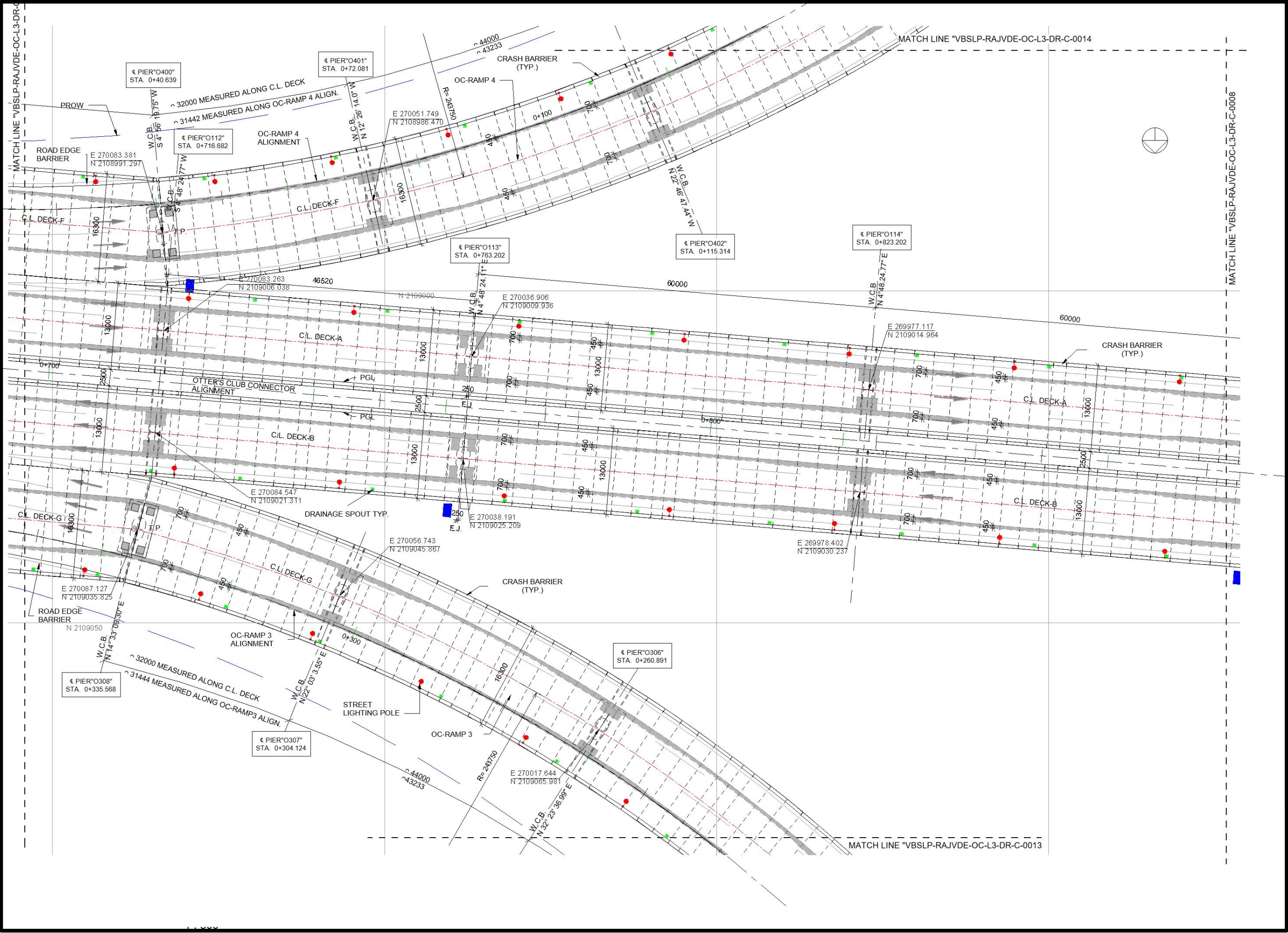
Model Line Top Plan



Top plan Model lines

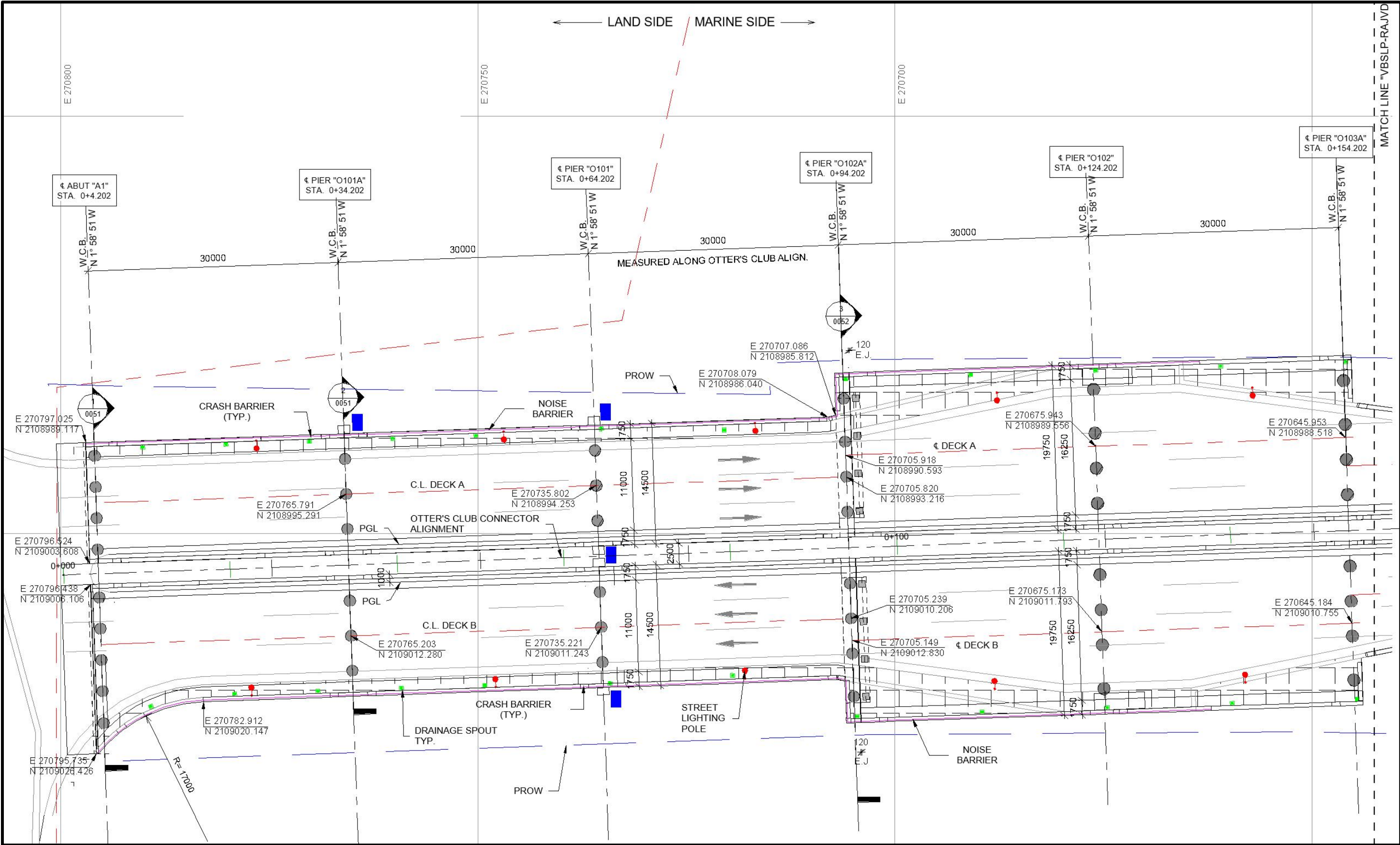
Model lines representing Top plan

2D Drawings Concept



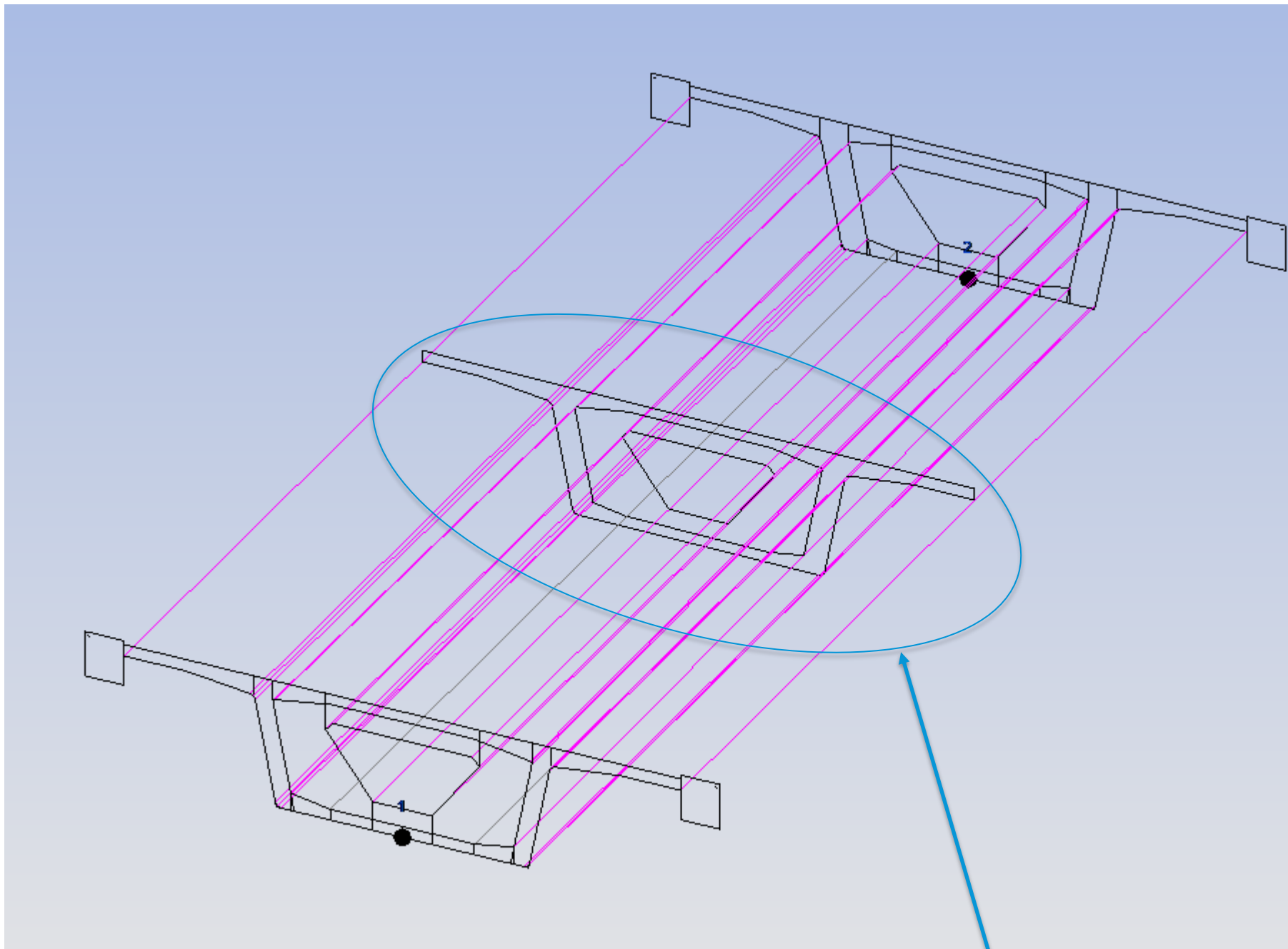
Segmental Bridge Top Plan
Sample

2D Drawings Concept

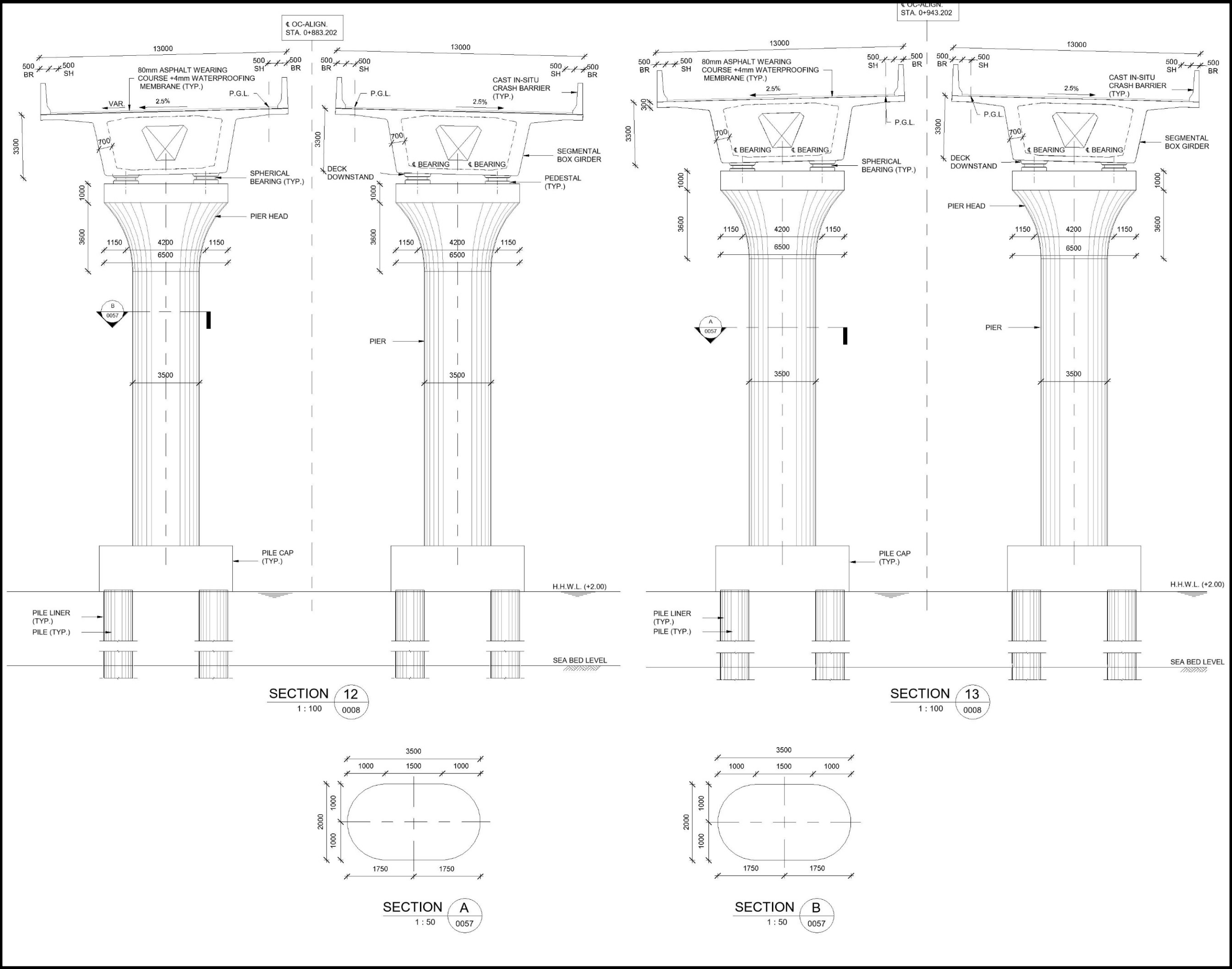


Slab-Type Bridge Top Plan
Sample

2D Drawings Concept

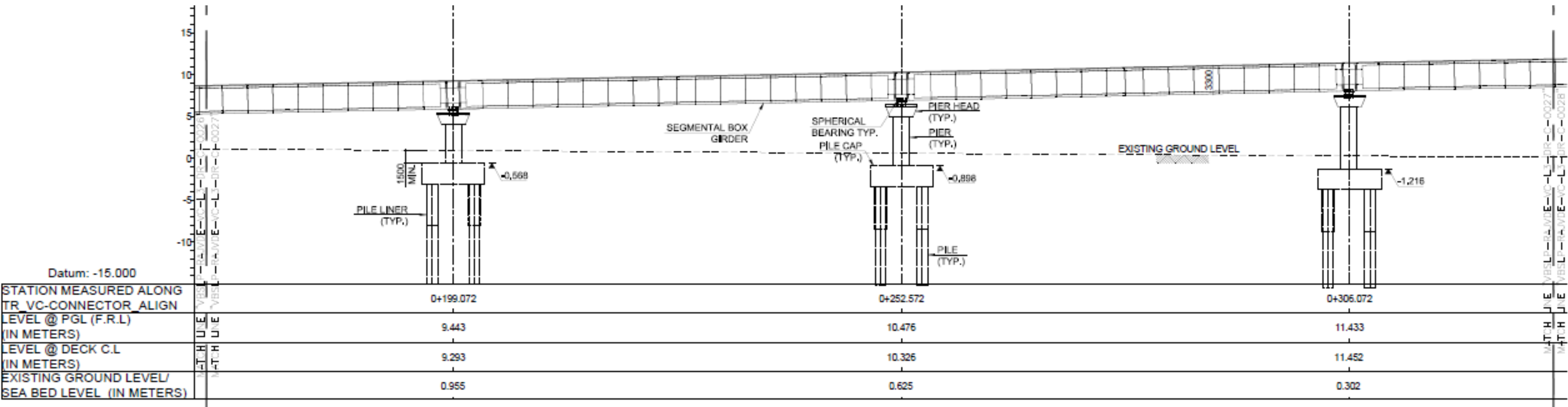


Cross section
model line

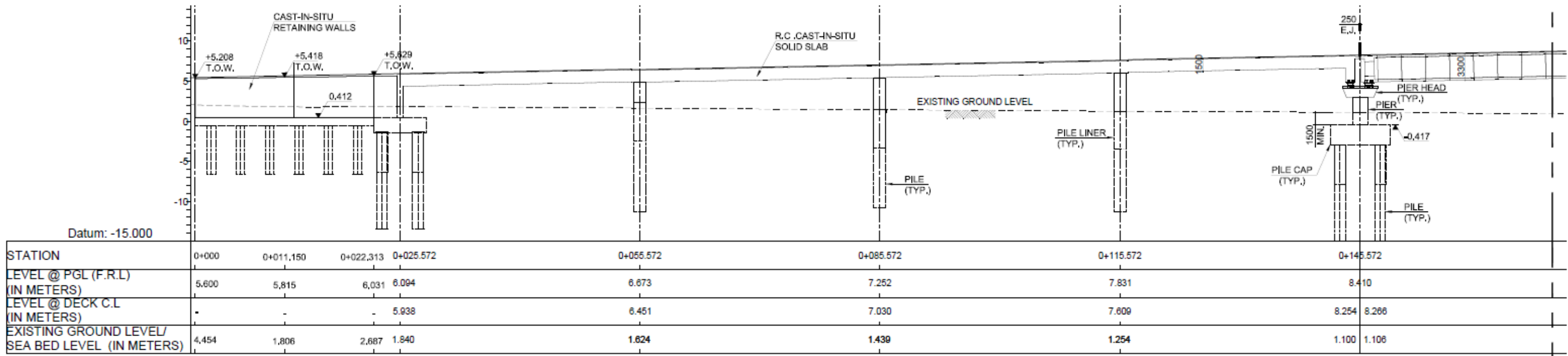


Cross Section Sample

2D Drawings Concept



Segmental Bridge Elevation



cast In-situ Bridge Elevation

Thank You

Questions

Ramiz Mohareb

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dar

making progress together



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