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

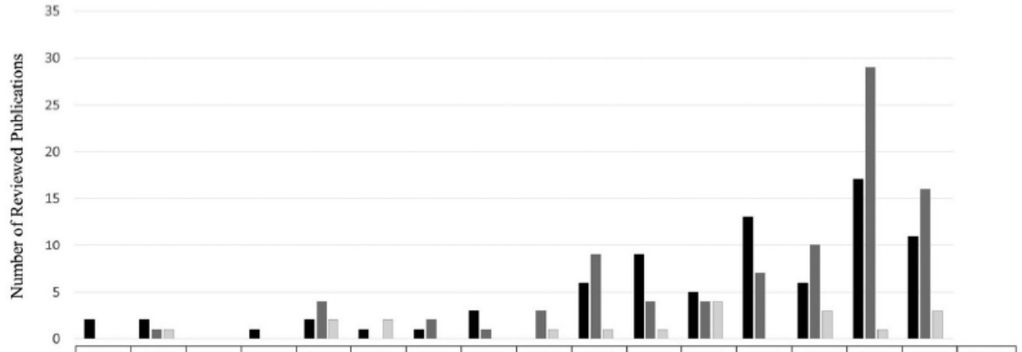
60 COUNTRIES

46 OFFICES

Principal Design Centers

- BEIRUT
- LONDON
- CAIRO
- PUNE
- AMMAN

Introduction



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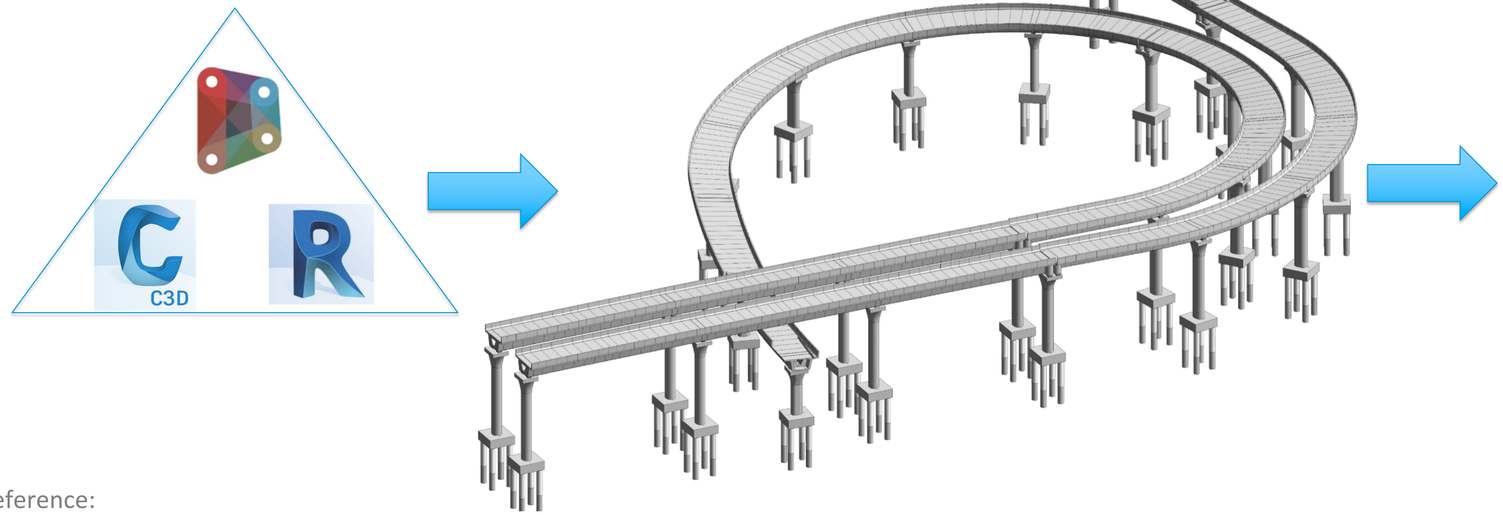
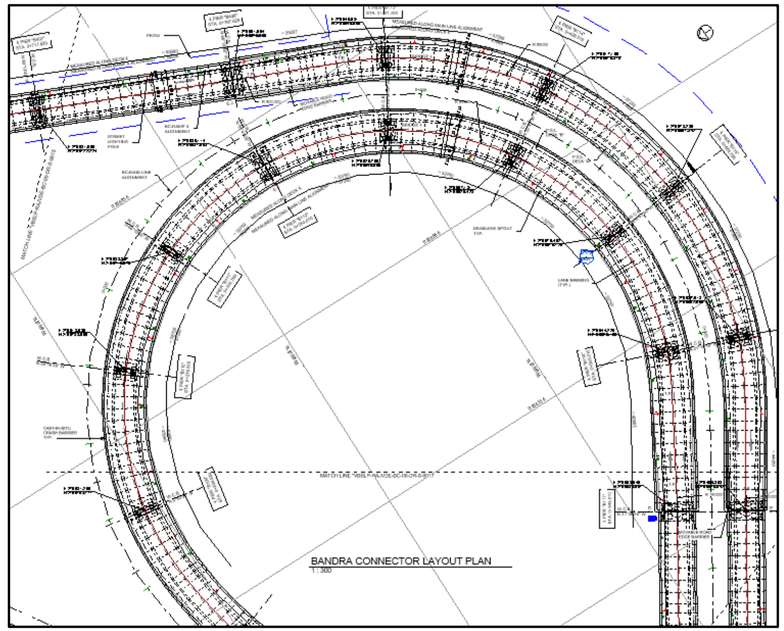
	<2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Total Reviewed Publication	2	4	0	1	8	3	3	4	4	16	14	13	20	19	47	30	189
Journal Article	2	2	0	1	2	1	1	3	0	6	9	5	13	6	17	11	80
Conference Proceeding	0	1	0	0	4	0	2	1	3	9	4	4	7	10	29	16	90
Report	0	1	0	0	2	2	0	0	1	1	1	4	0	3	1	3	19

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





AUTODESK UNIVERSITY

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

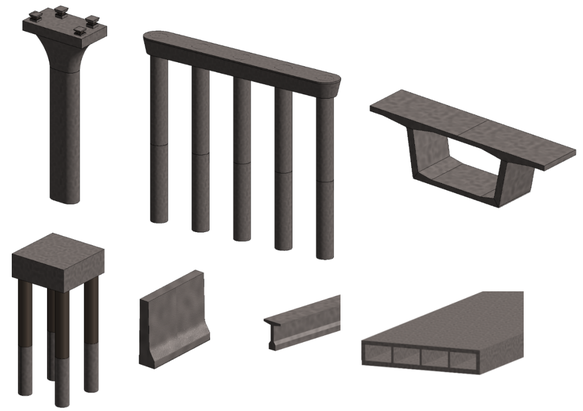
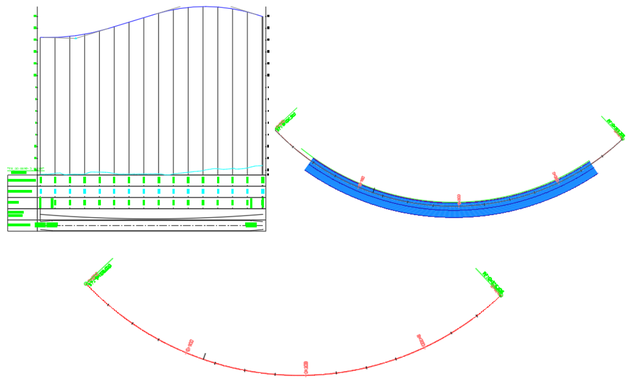
Reference:
1-Aaron Costina,, Alireza Adibfara, Hanjin Hub, Stuart S. Chenc, Building Information Modeling (BIM) for transportation infrastructure – Literature review, applications, challenges, and recommendations, (Automation in Construction 94 (2018) 257–281)

Linear Structure Objects, Challenge and Concept

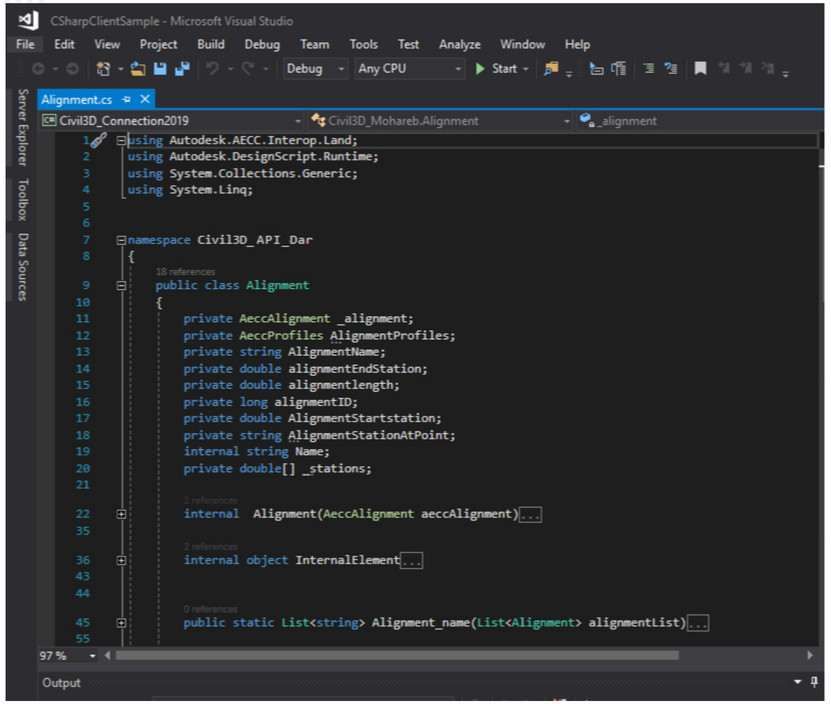
Linear Structure Objects, Challenge and Concept

Dynamo

API
Application Programming Interface

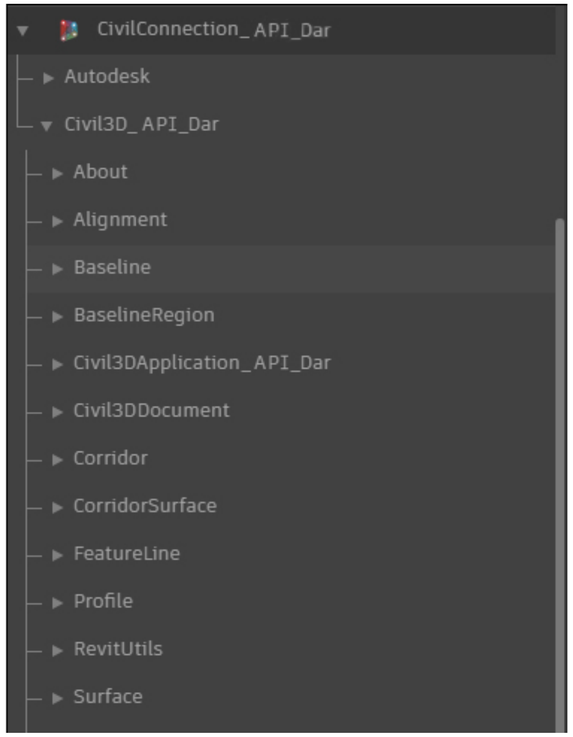
Software	Supported objects	Transportation objects	Structural objects
Revit		✗	✓
C3D		✓	✗

Linear Structure Objects, Challenge and Concept



C# Code for Civil3D API_Dar

Zero touch node



Civil 3D_API_ Dar_ package

Reference:

1- Paolo Serra, “Civil connection” Dynamo package https://github.com/Autodesk/civilconnection

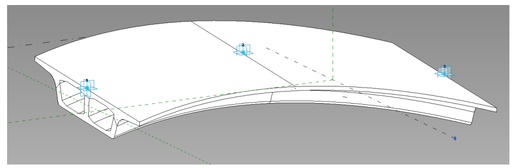
2- Andrew Milford, “Civil 3D Data Mining with Dynamo” AU2018 (CES226095)

Overall Workflow

Input

Step 1

Step 2



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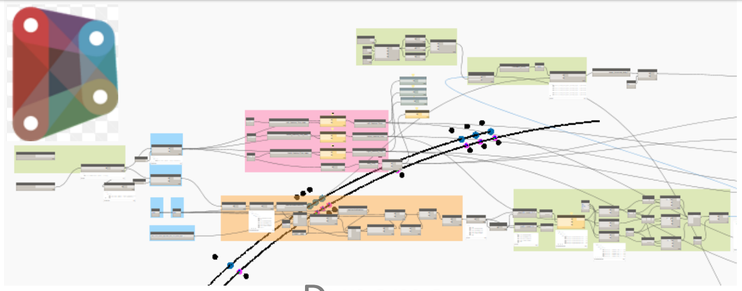
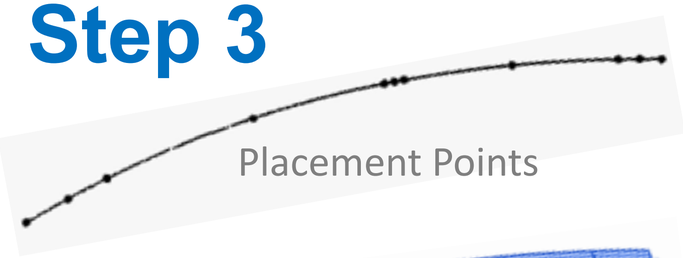
0	845	905	16m_TYPICAL-3300	16m_THICK-3300
1	905	945	16m_TYPICAL-3300	16m_THICK-3300
2	945	985	16m_TYPICAL-3300	16m_THICK-3300
3	985	1045	16m_TYPICAL-3300	16m_THICK-3300
4	1045	1105	16m_TYPICAL-3300	16m_THICK-3300

Solver

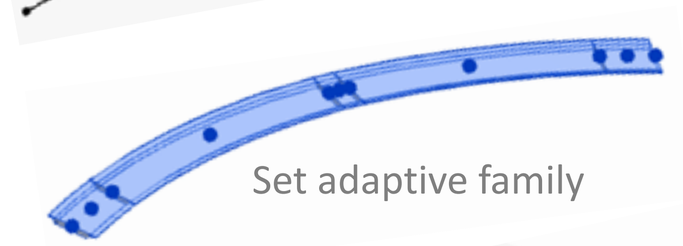


Dynamo

Step 3



Placement Points

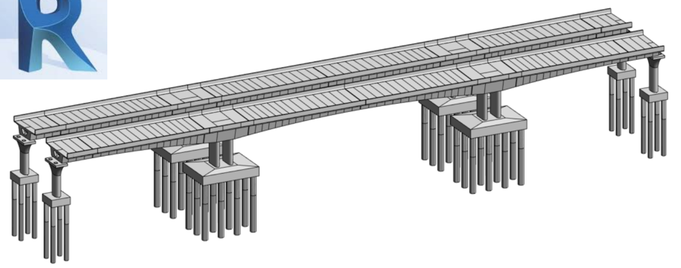


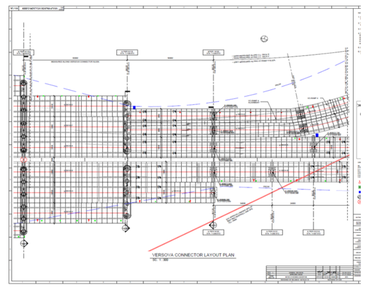
Set adaptive family

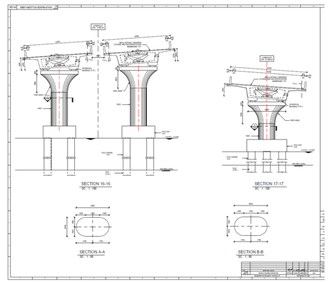
Step 4

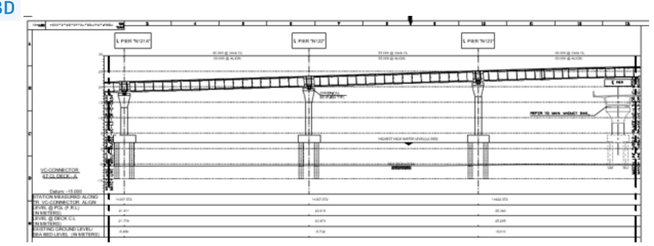
Calculate & set parameter

Output

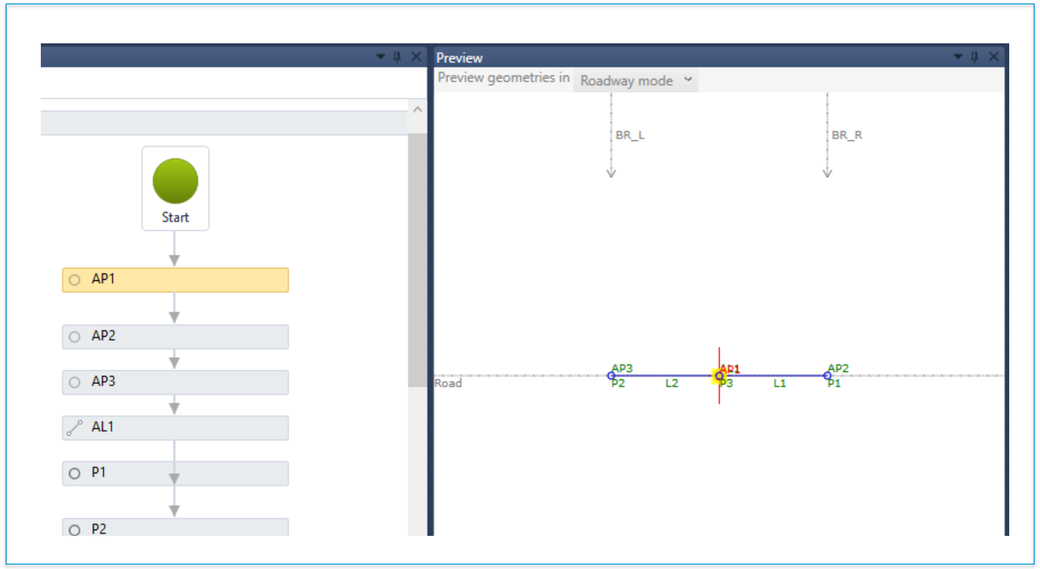




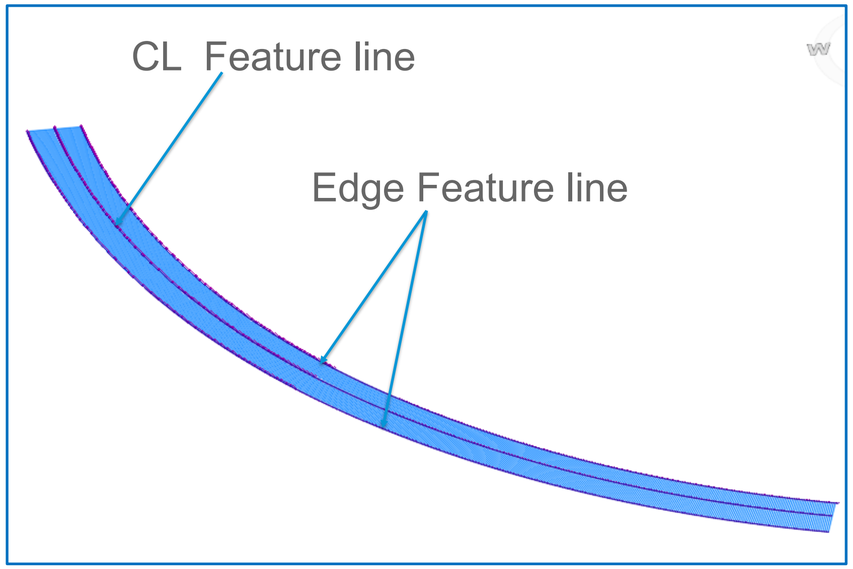




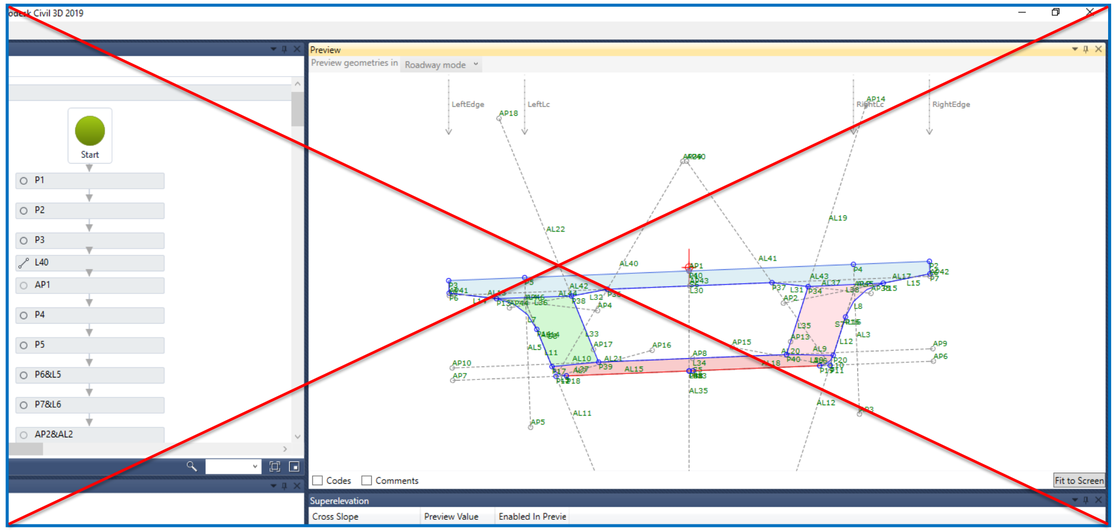
Step (1) Civil 3D Corridor



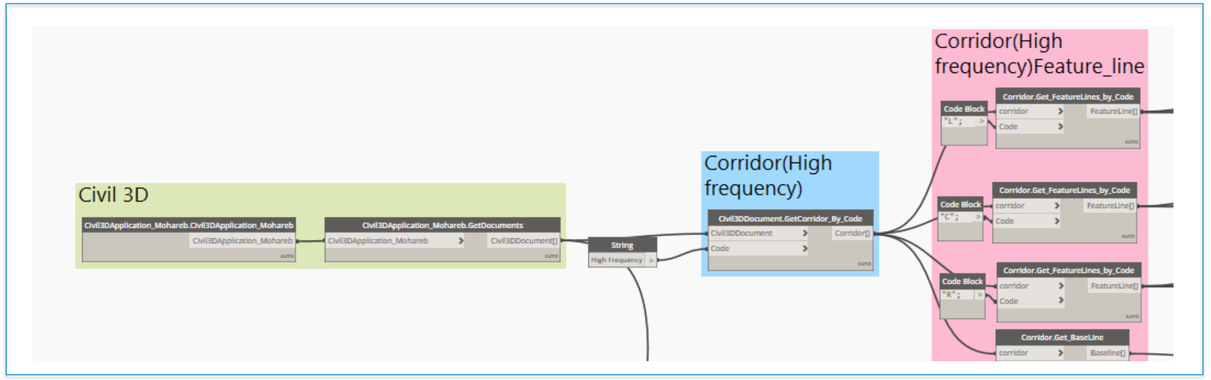
Simple Subassembly composer



High frequency corridor

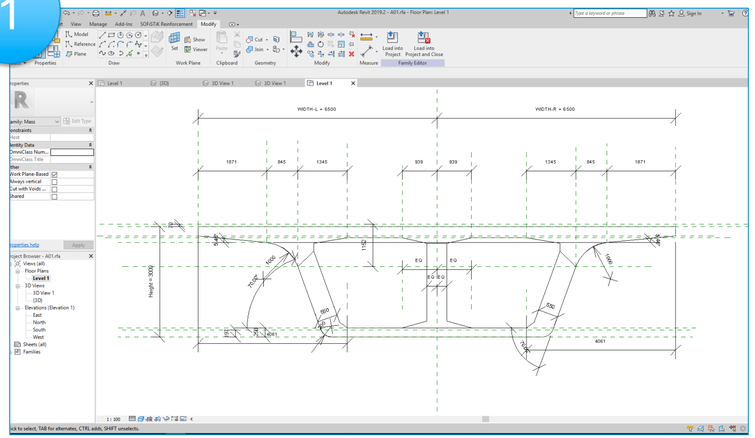


Subassembly composer



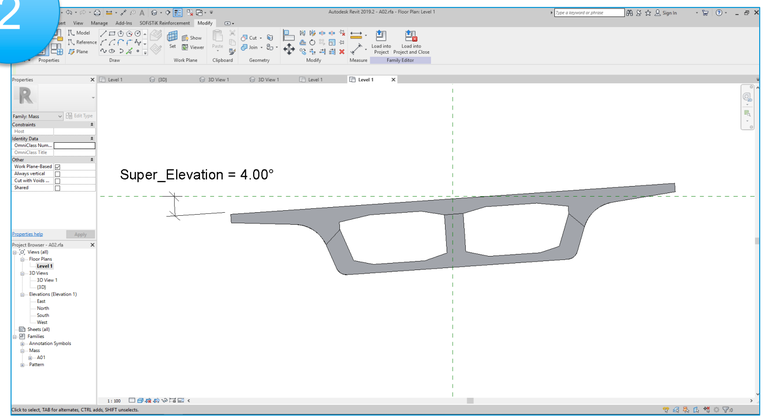
Step (2) Deck Object

1



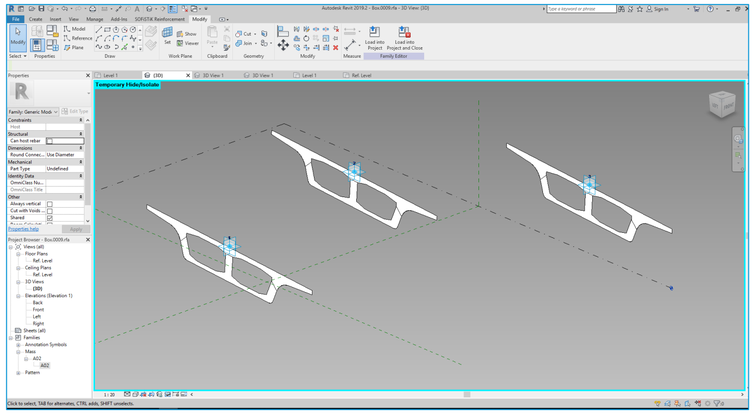
1- Profile Family (Parametric Cross Section)

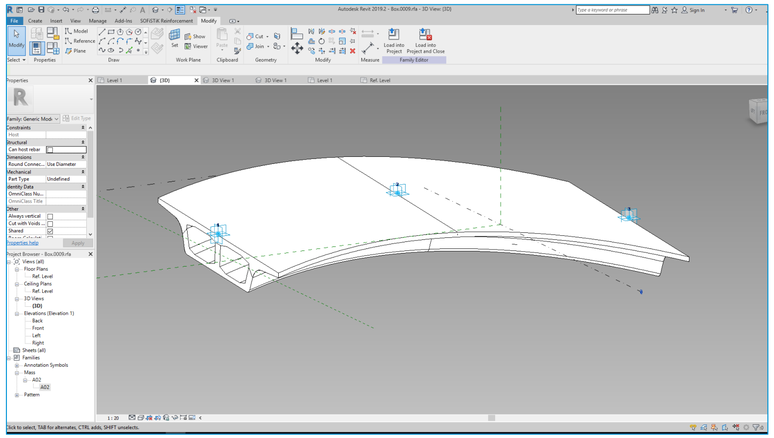
2



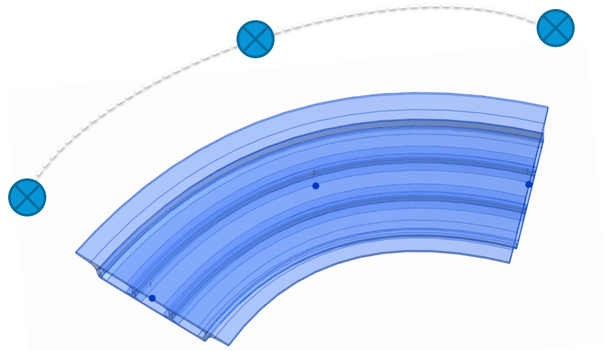
2- Profile Family (Super Elevation parameter)

3

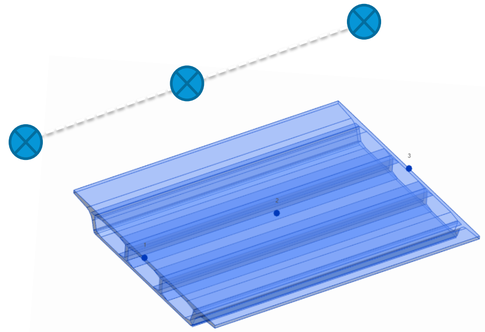




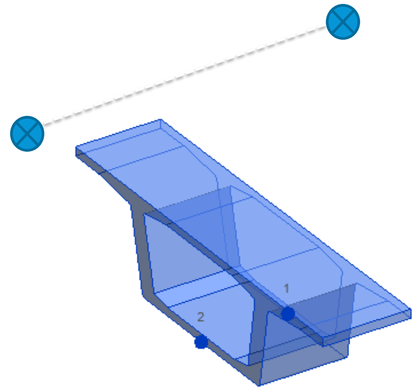
3- Three Points Adaptive Family



3 adaptive Points Along Curve



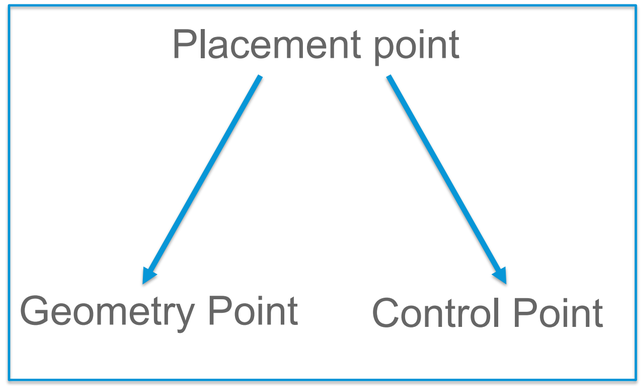
3 Points Along Line

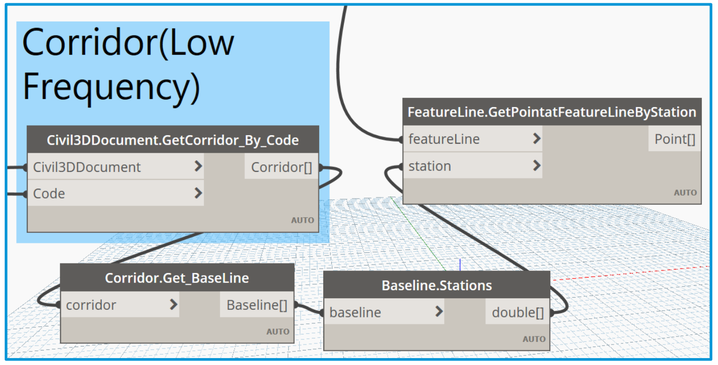


2 Points Along Line

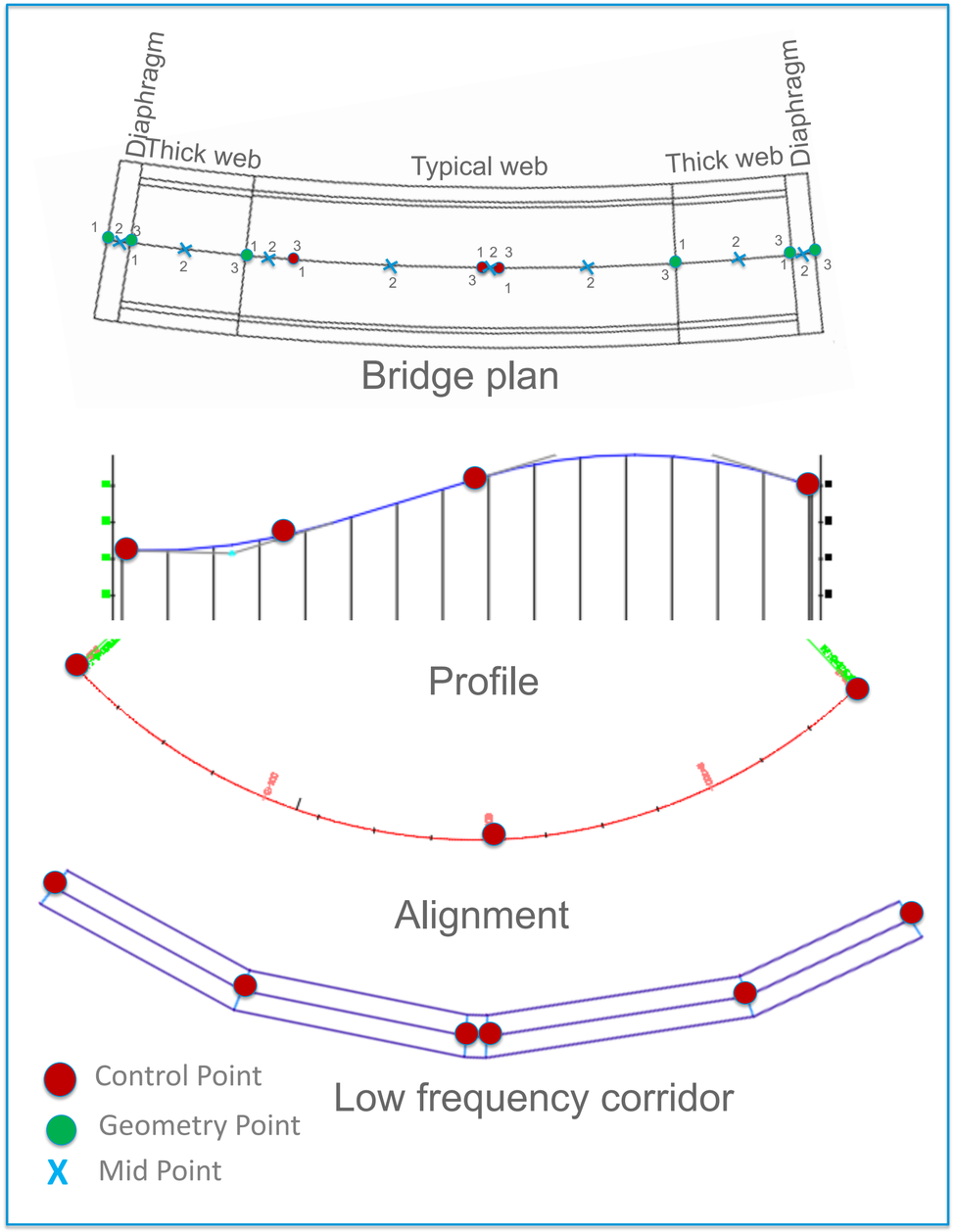
Reference:
1-Andrzej Samsonowicz, “Dynabridge” dynamo package.

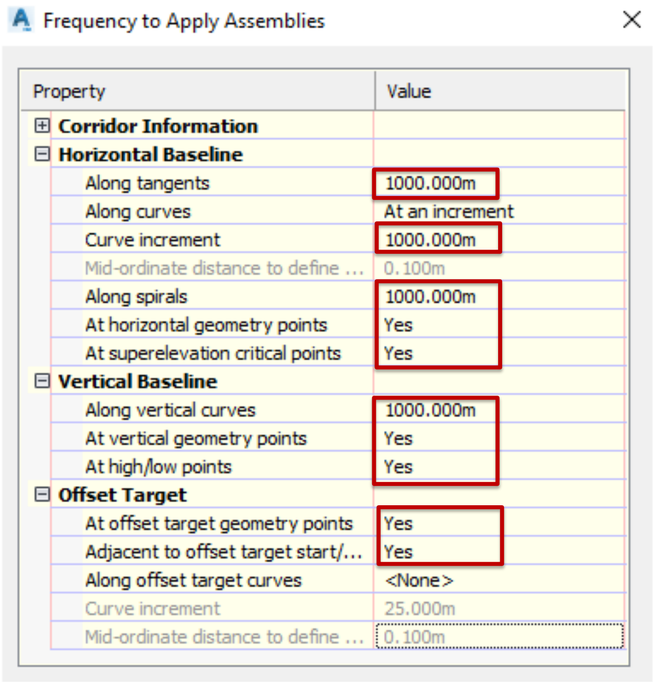
Step (3) Get Placement Point Cast In-situ Element

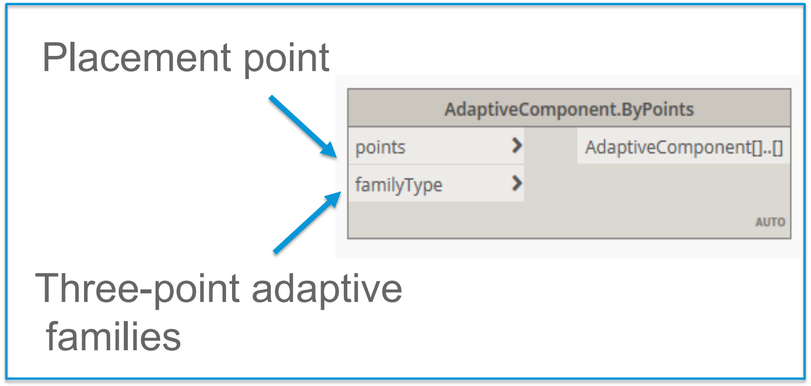




Dynamo-Get control Points



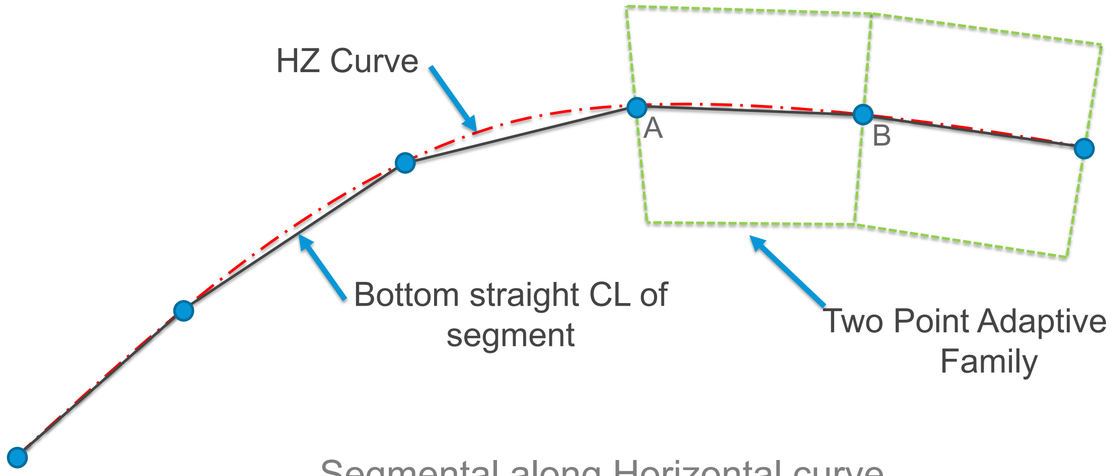




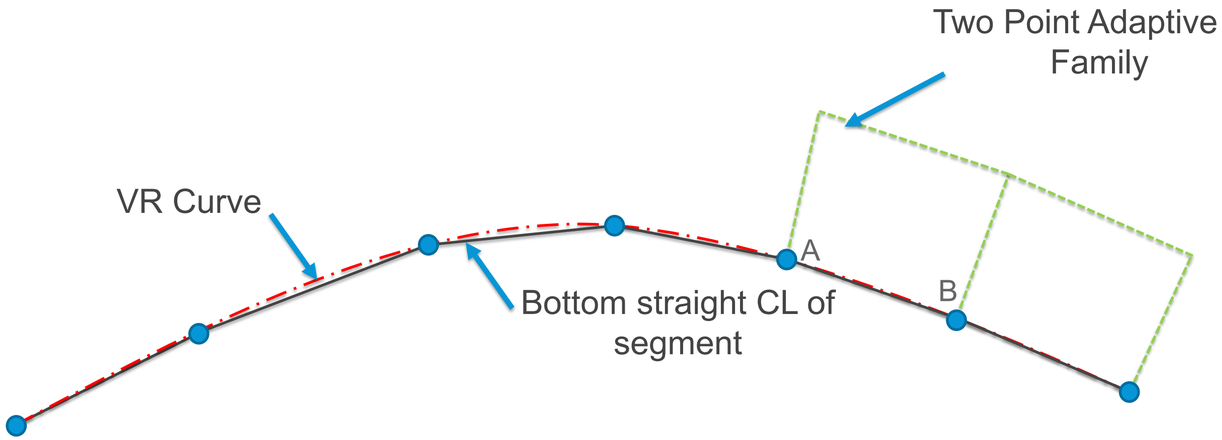
Step (3) Get Placement Point Precast Element

Match casting

Pre-cast segment

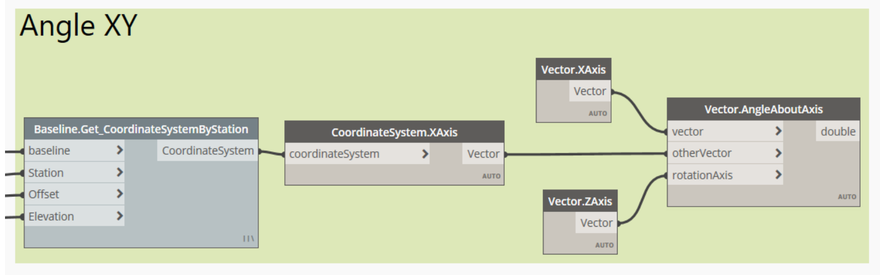


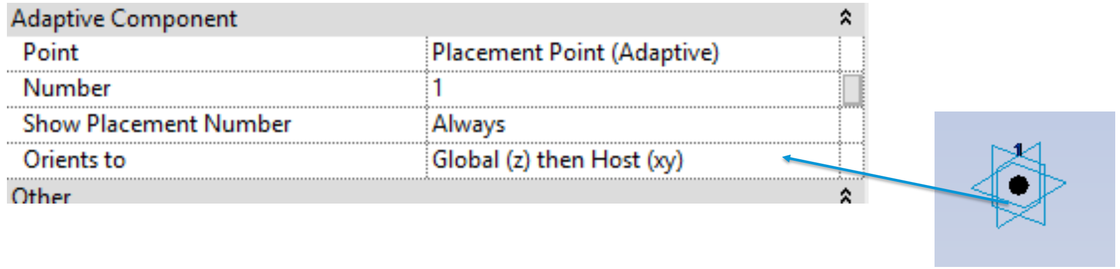
Segmental along Horizontal curve

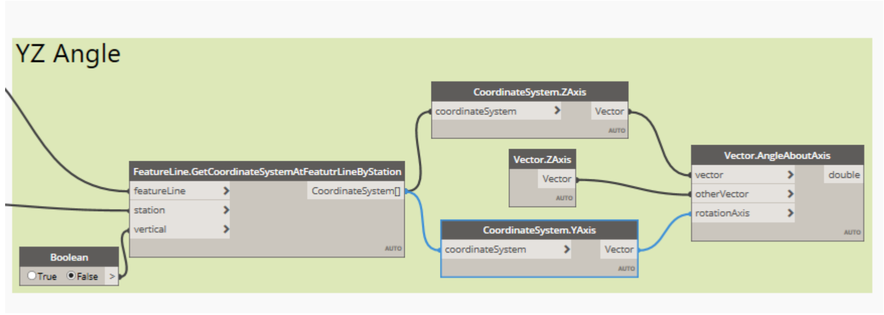


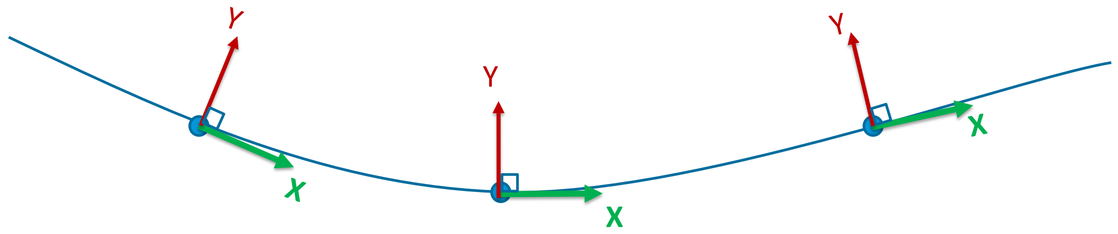
Segmental along Vertical curve

Step (4) Calculate & Set Parameter

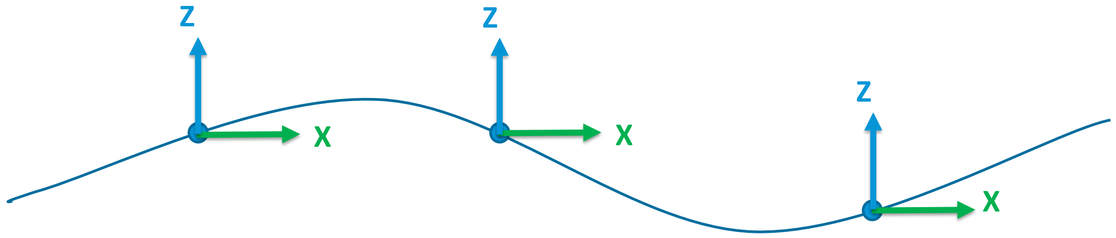




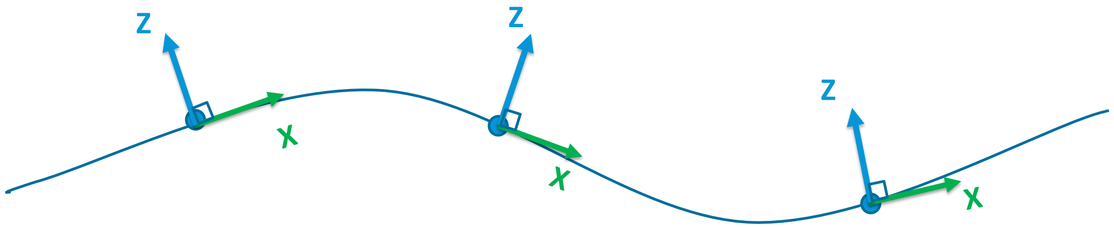




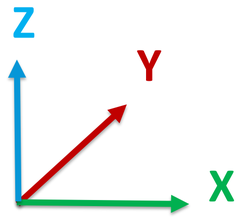
Plan



Elevation (Cast In-situ)

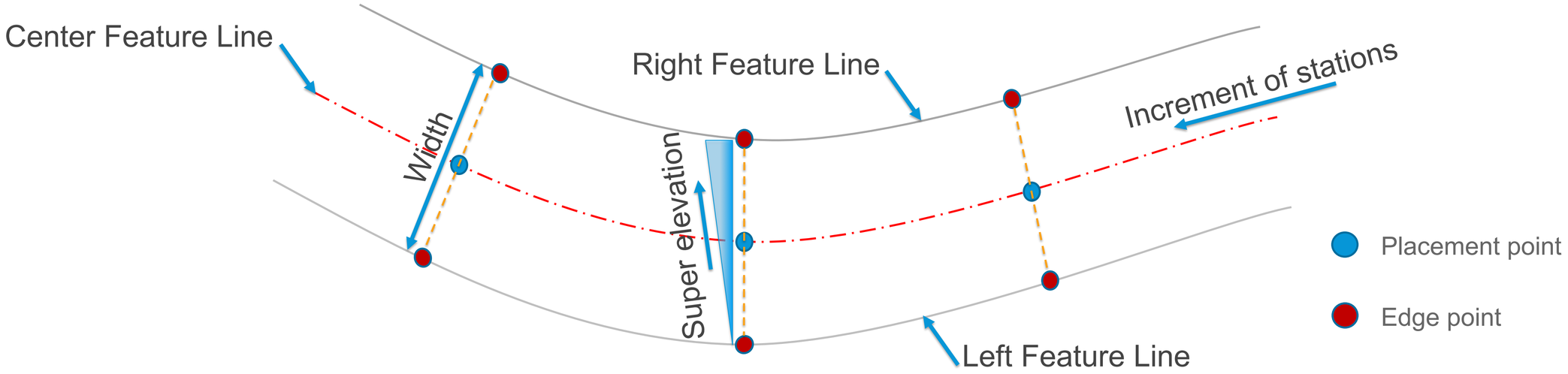


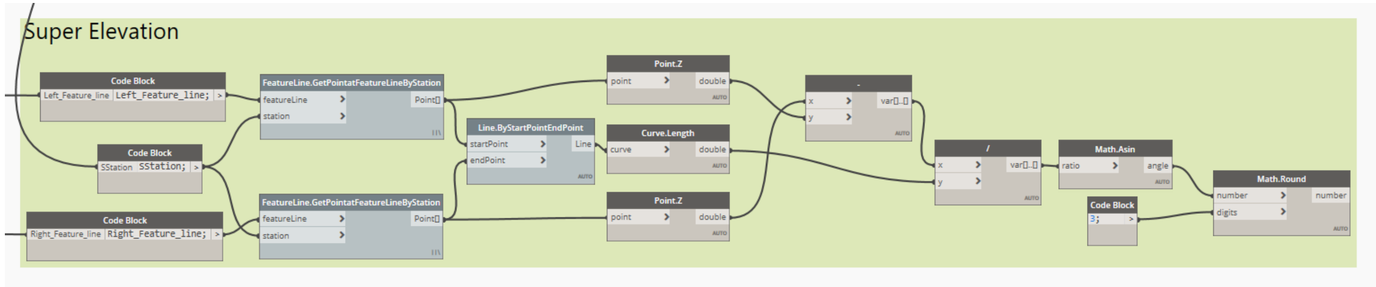
Elevation Precast



Placement point

Step (4) Calculate & Set Parameter





Linear Structure Objects, Challenge and Concept

Linear Structure Type	Step 1 Civil 3D Corridor	Step 2 Deck Object	Step 3 Placement Point	Step 4 Calculate & Set Parameters
Cast In-situ Element	High & Low Frequency Corridor	Three-point adaptive family	• Geometry Points • Control Points	• XY Plan Rotation • Super Elevation • Variable Width • Variable Depth
Precast Element	High Frequency Corridor	Two-point adaptive family	• Segment Discretization	• XY Plan Rotation • YZ Profile Rotation • Super Elevation • Variable Width • Variable Depth

Workflow Pros & Cons

Pros:

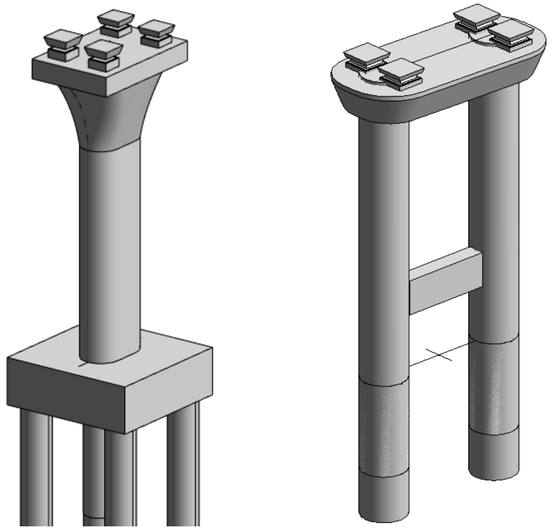
1. Model all types of linear structures.
2. Model both horizontal and vertical elements in the same package.
3. Easily integrate different structural attachments
4. Easily modify model according to any update in the structural geometry by just editing parameter values.
5. Possibility to upgrade the model 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:

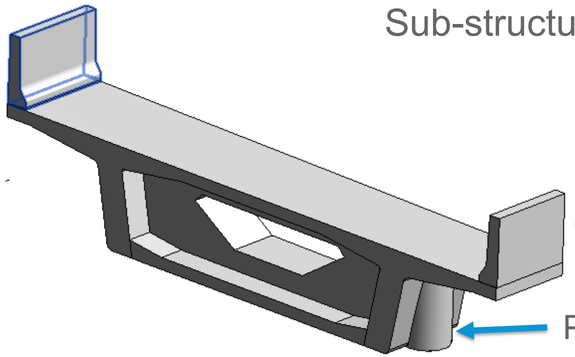
1. Each type of linear structural need a specific Dynamo script.
2. Each project need specific linear structure object to be created as an adaptive family.

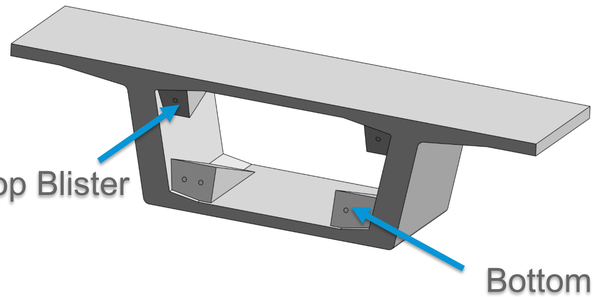
Case study

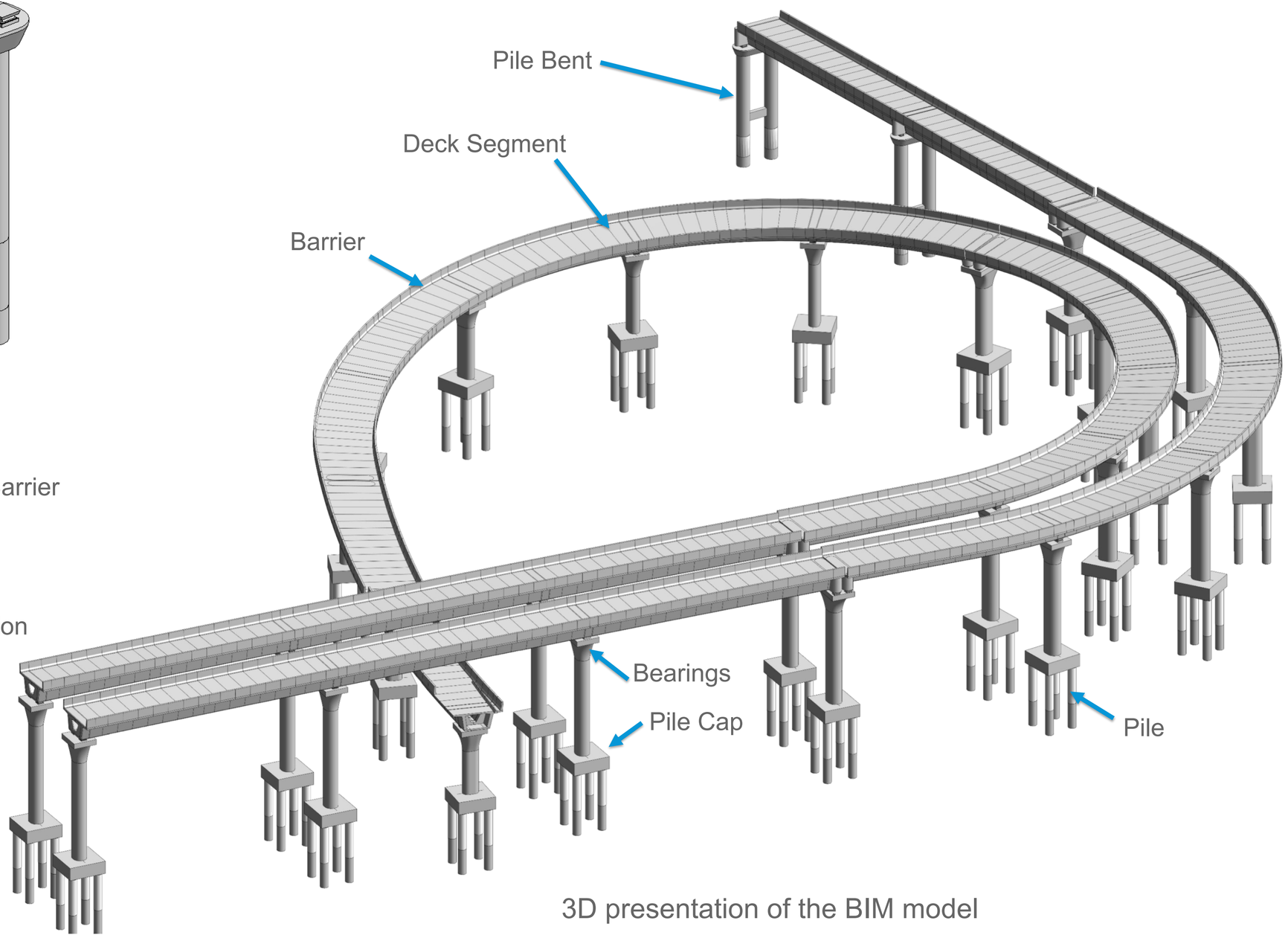
BIM Model for Segmental Bridge



Sub-structure

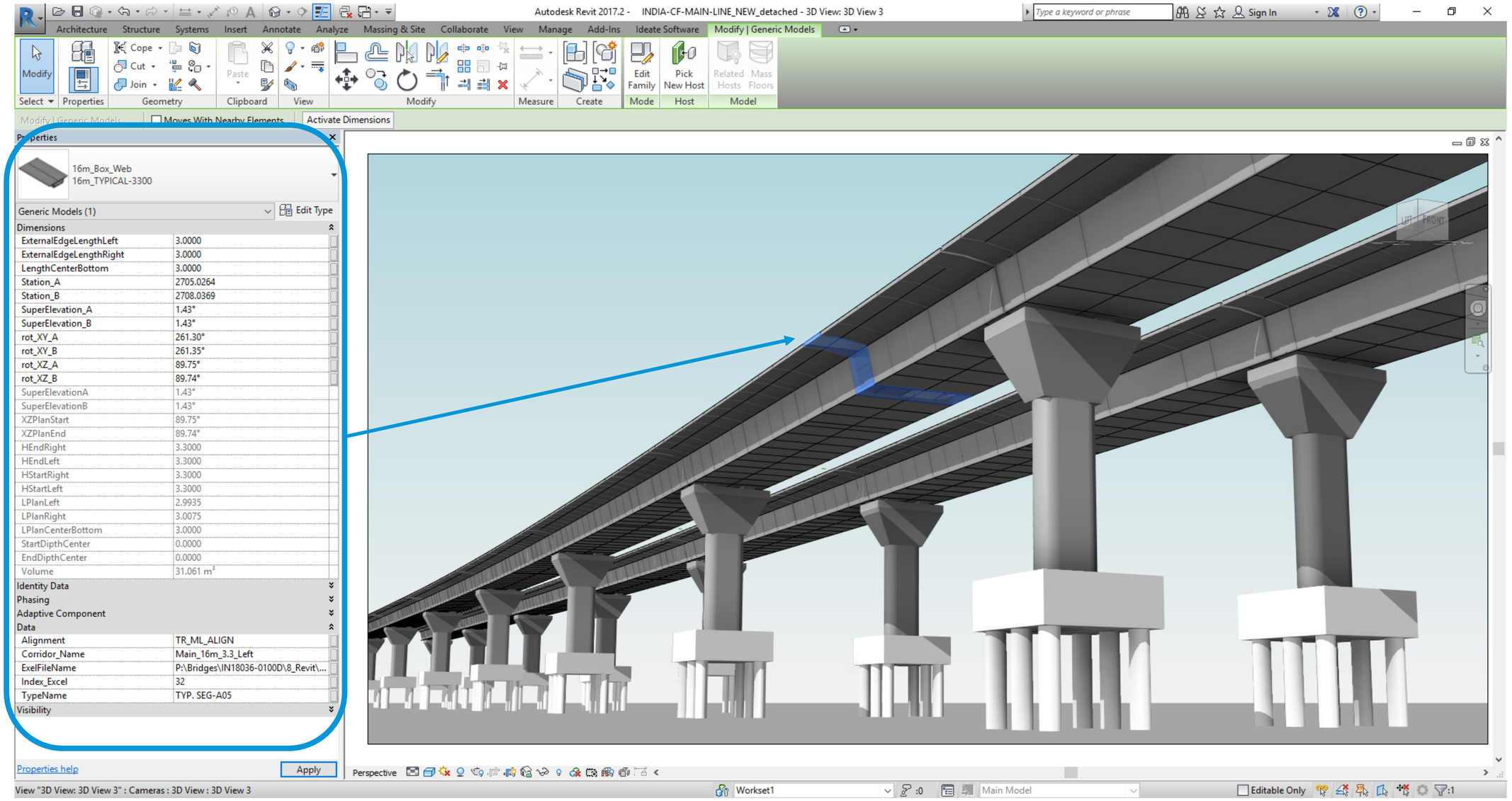




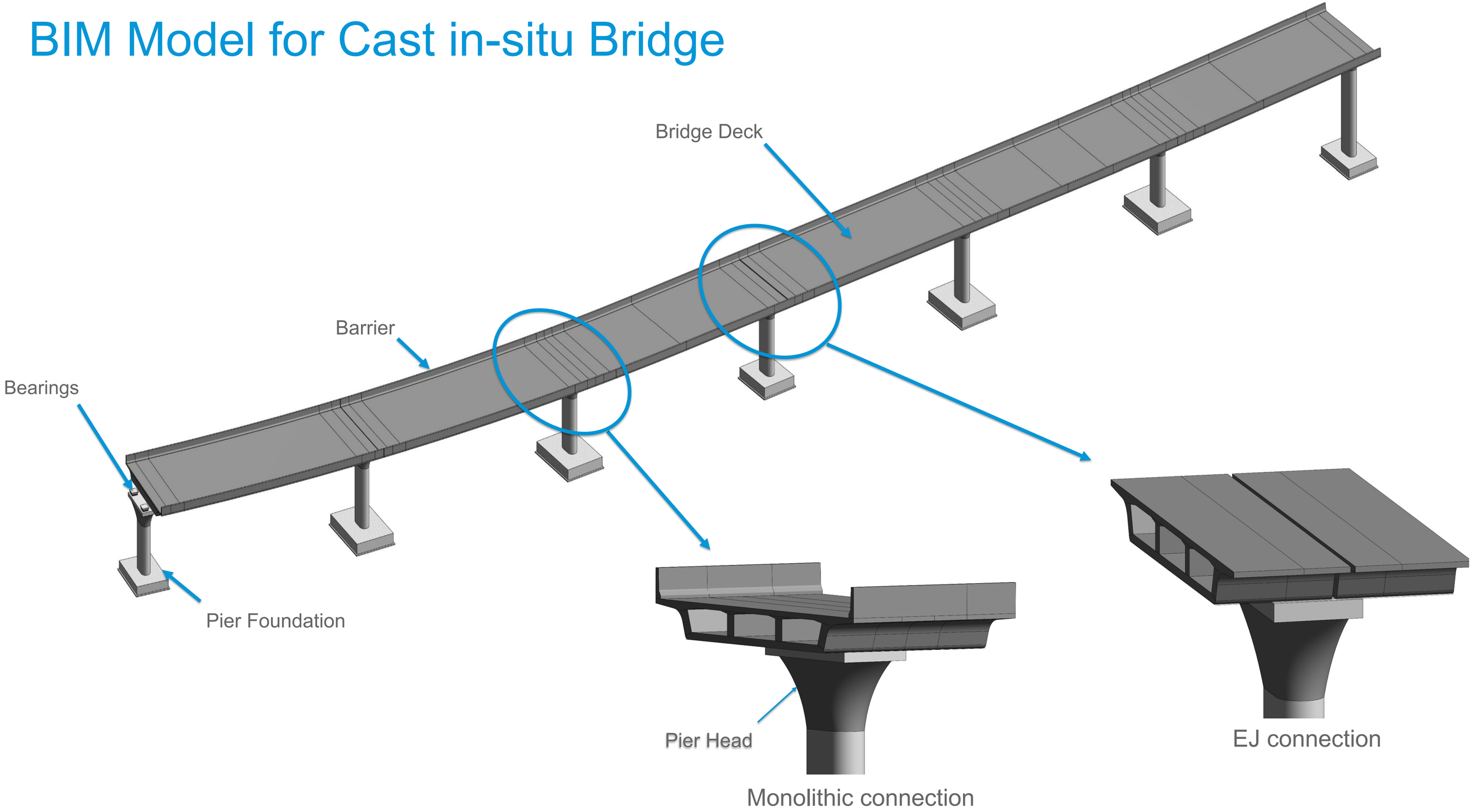


3D presentation of the BIM model

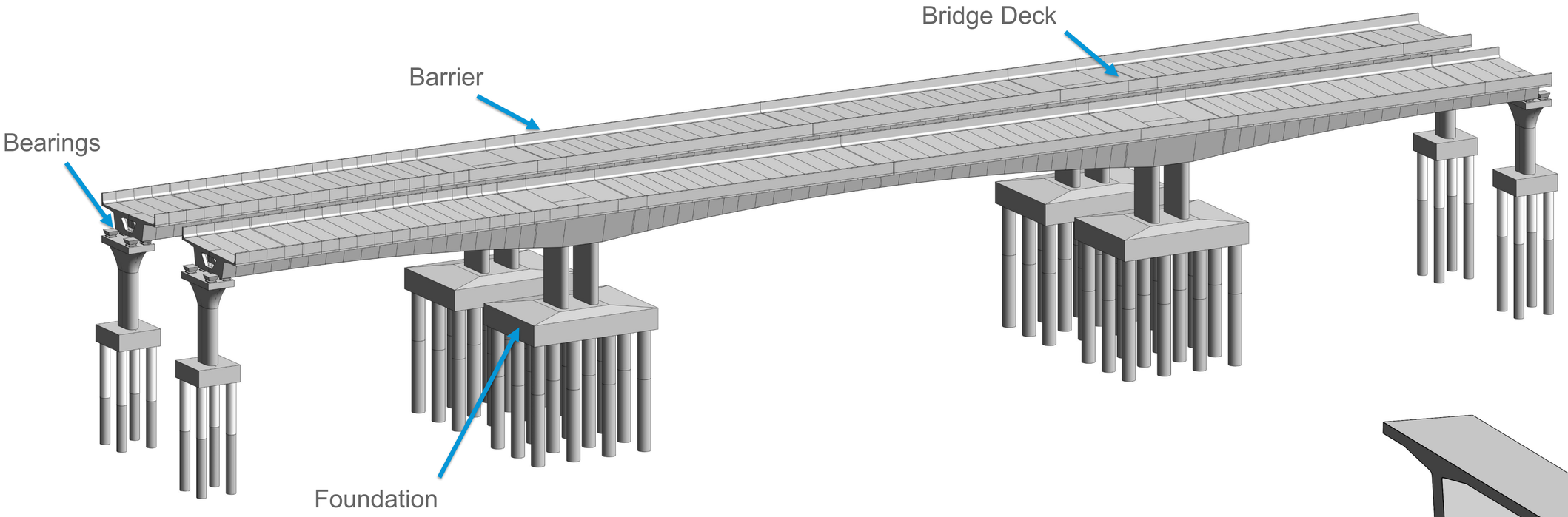
BIM Model Data for Segmental Bridge

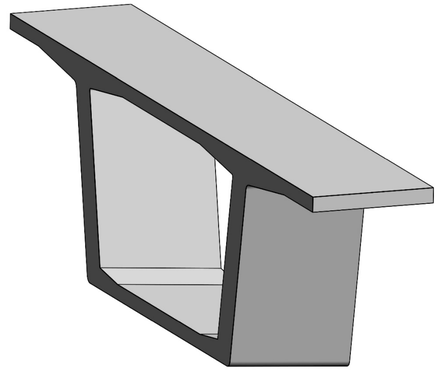


BIM Model for Cast in-situ Bridge



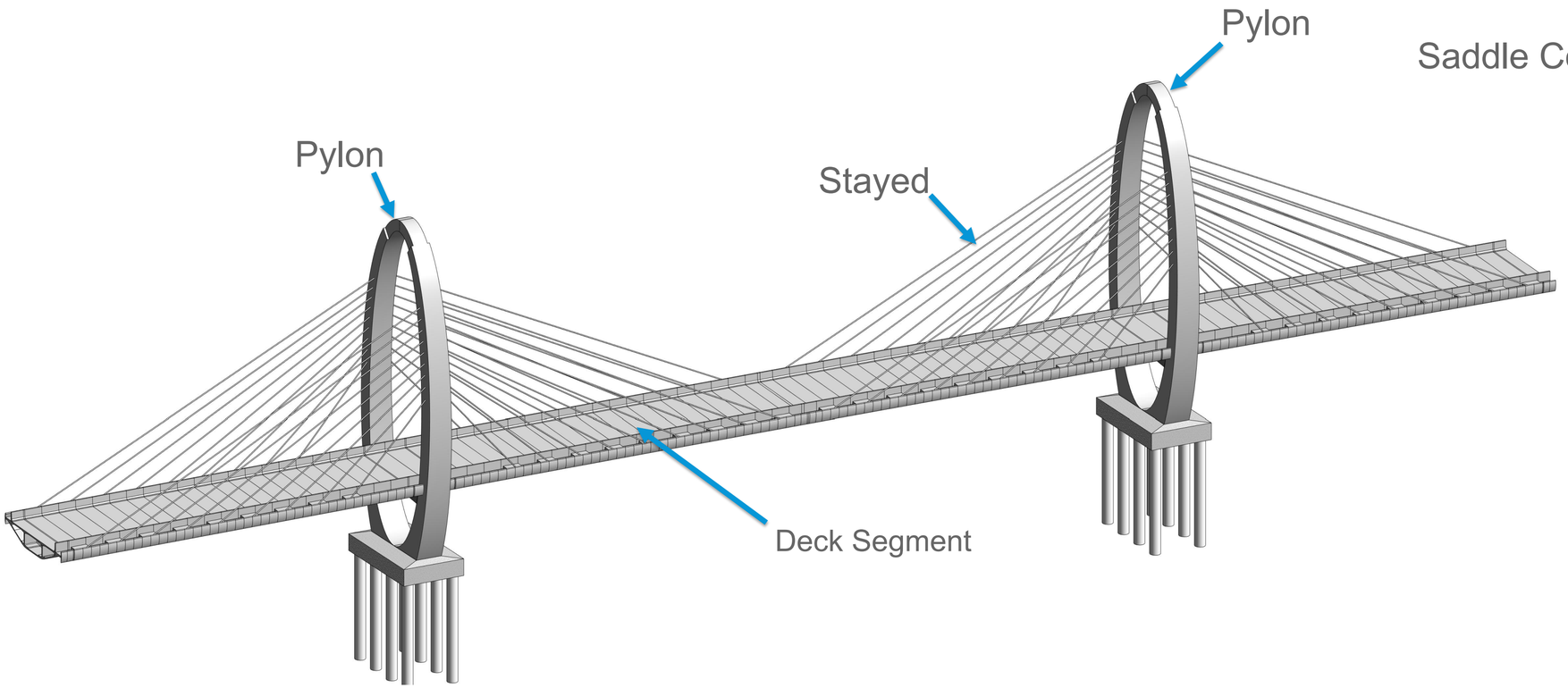
BIM Model for Balanced Cantilever Bridge

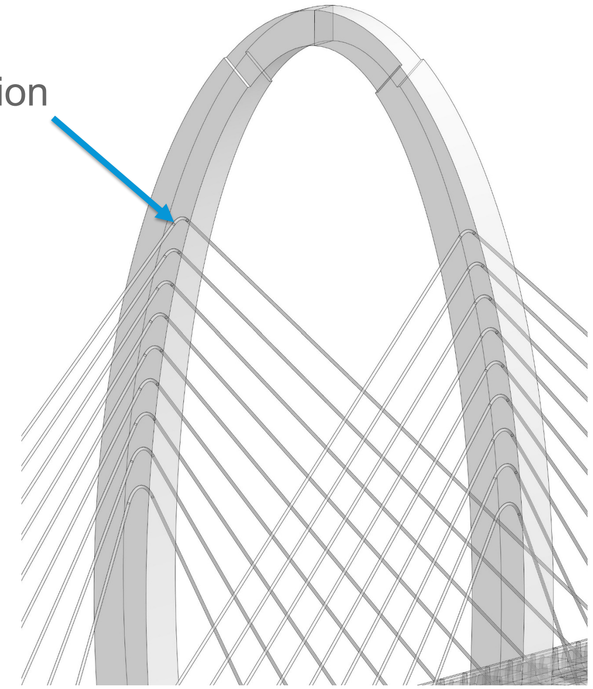




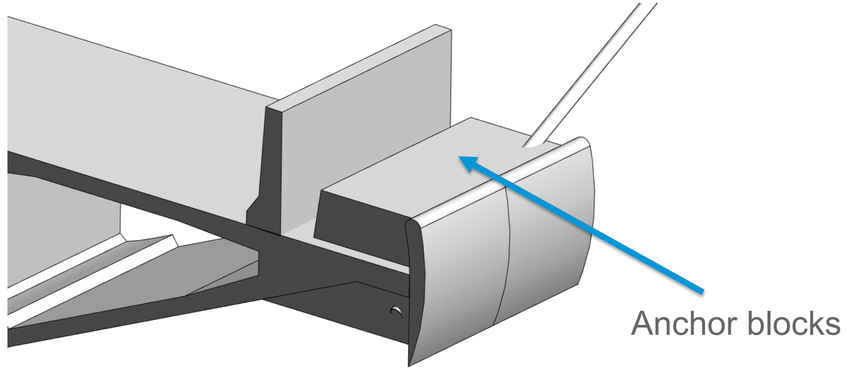
Cross section

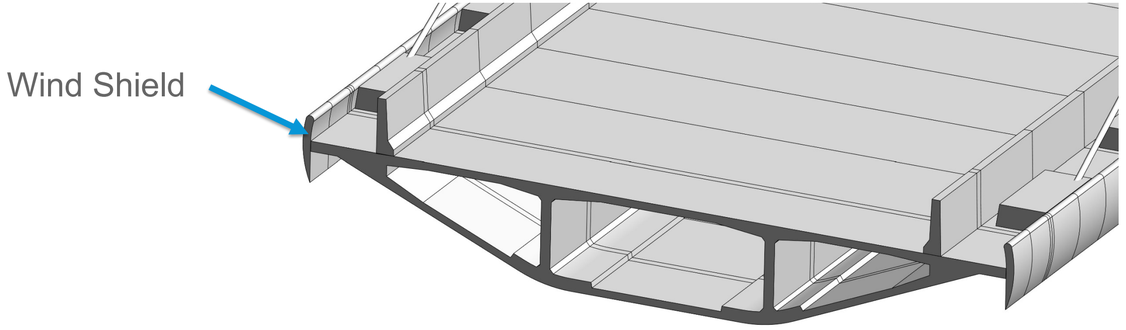
BIM Model for Cable-stayed Bridge





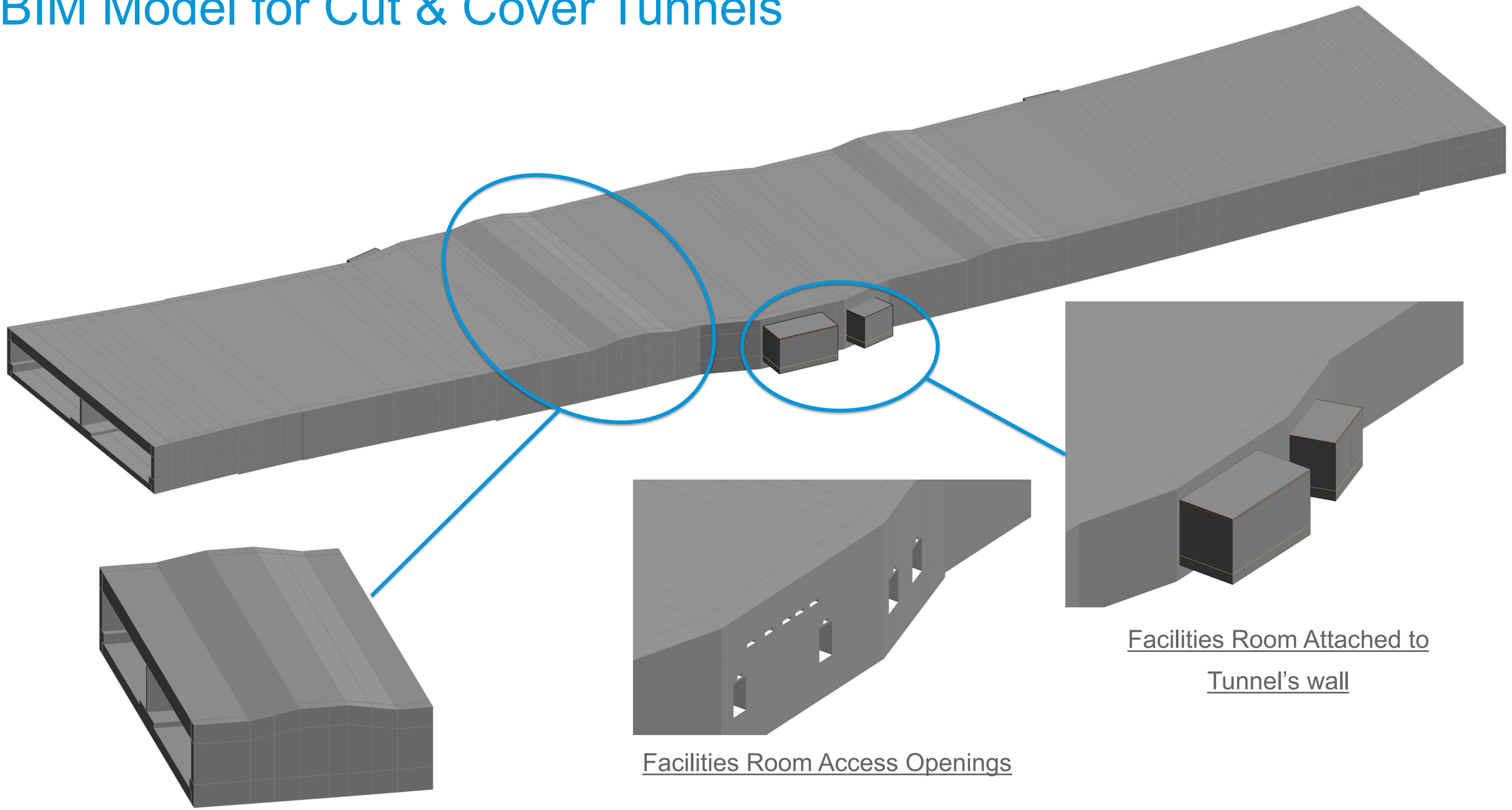
Pylon





Cross section

BIM Model for Cut & Cover Tunnels



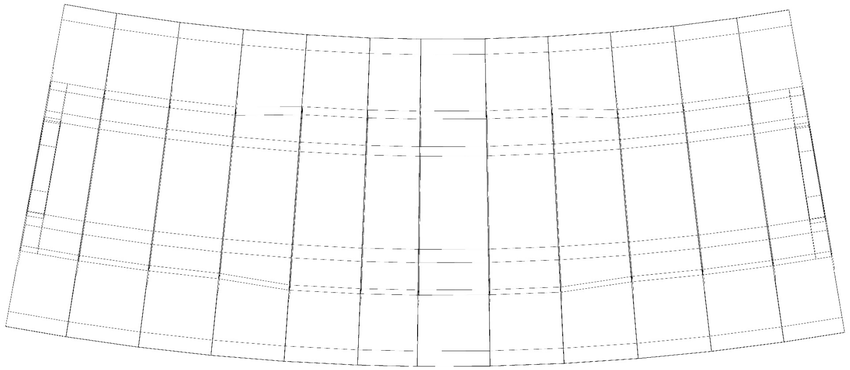
Facilities Room Attached to Tunnel's wall

Facilities Room Access Openings

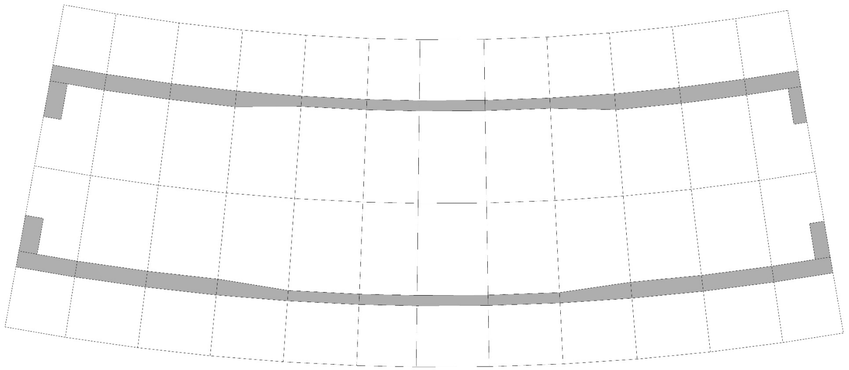
2D Drawings

2D Drawings Concept

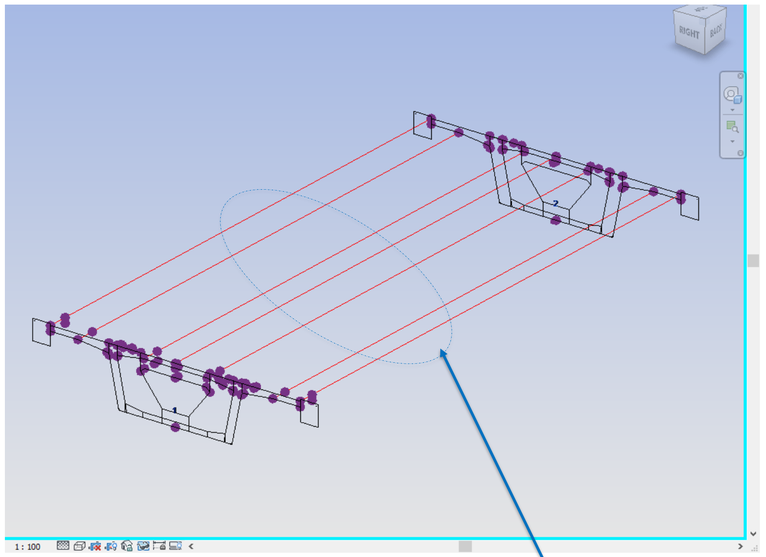
- Why 2D drawings for linear structures are considered a challenge?



Solid Element Plan

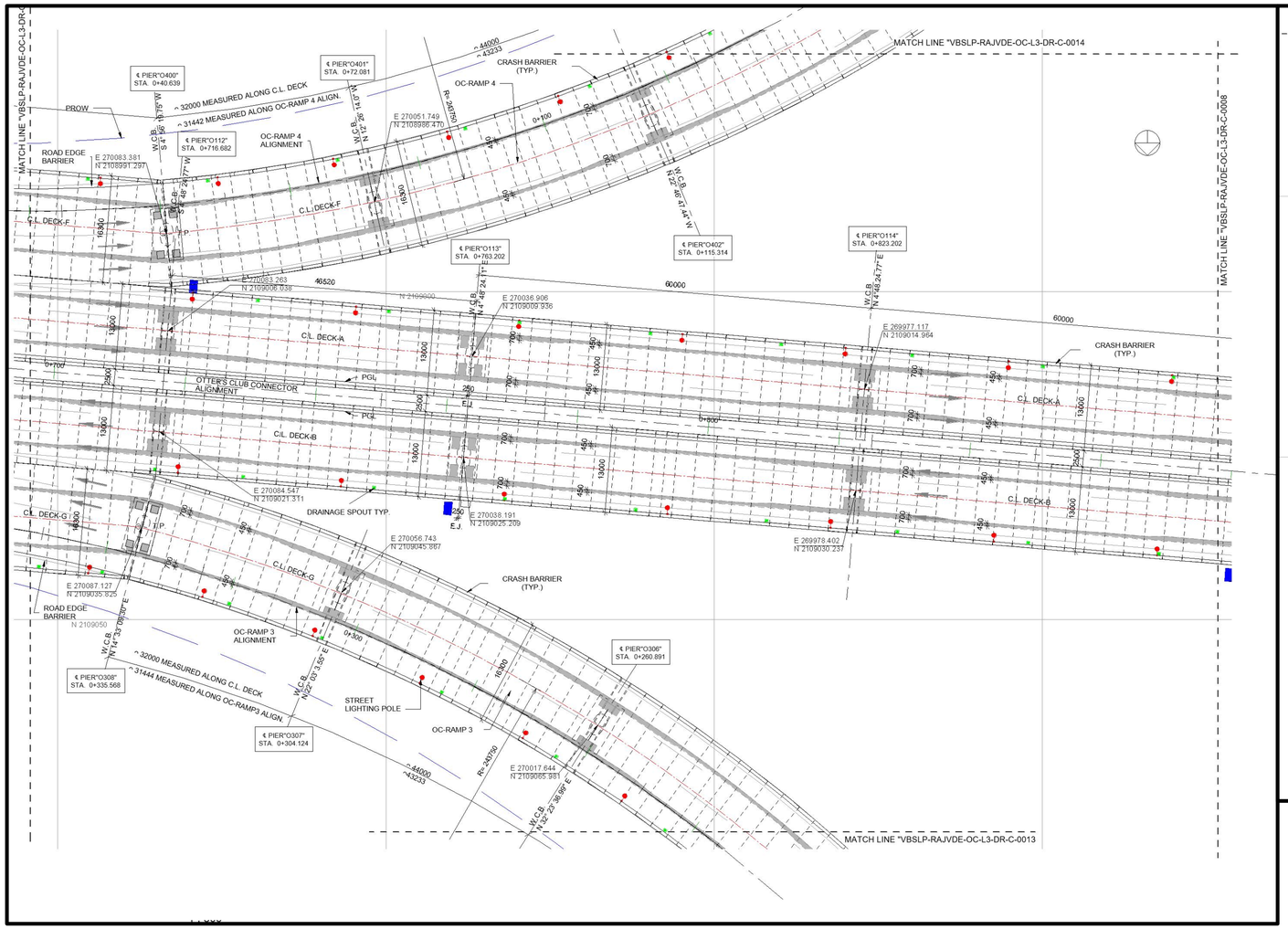


Model Line Top Plan



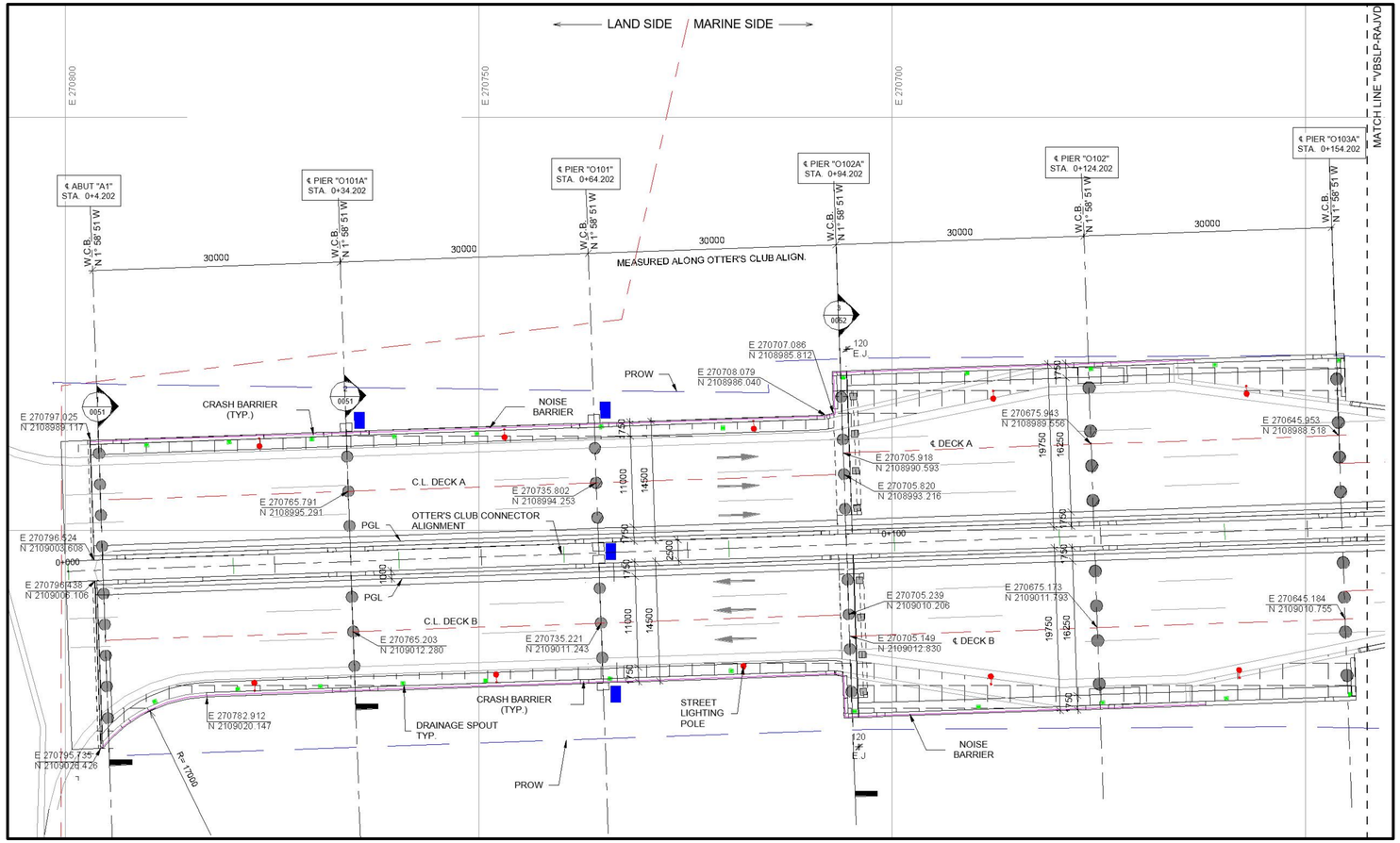
Model lines representing Top plan

2D Drawings Concept



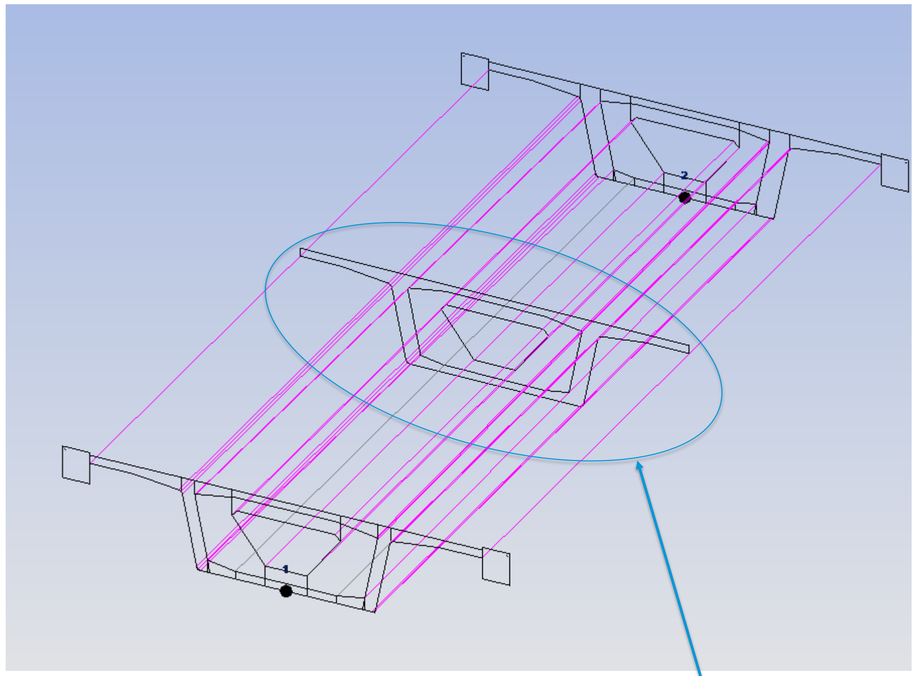
Segmental Bridge Top Plan Sample

2D Drawings Concept

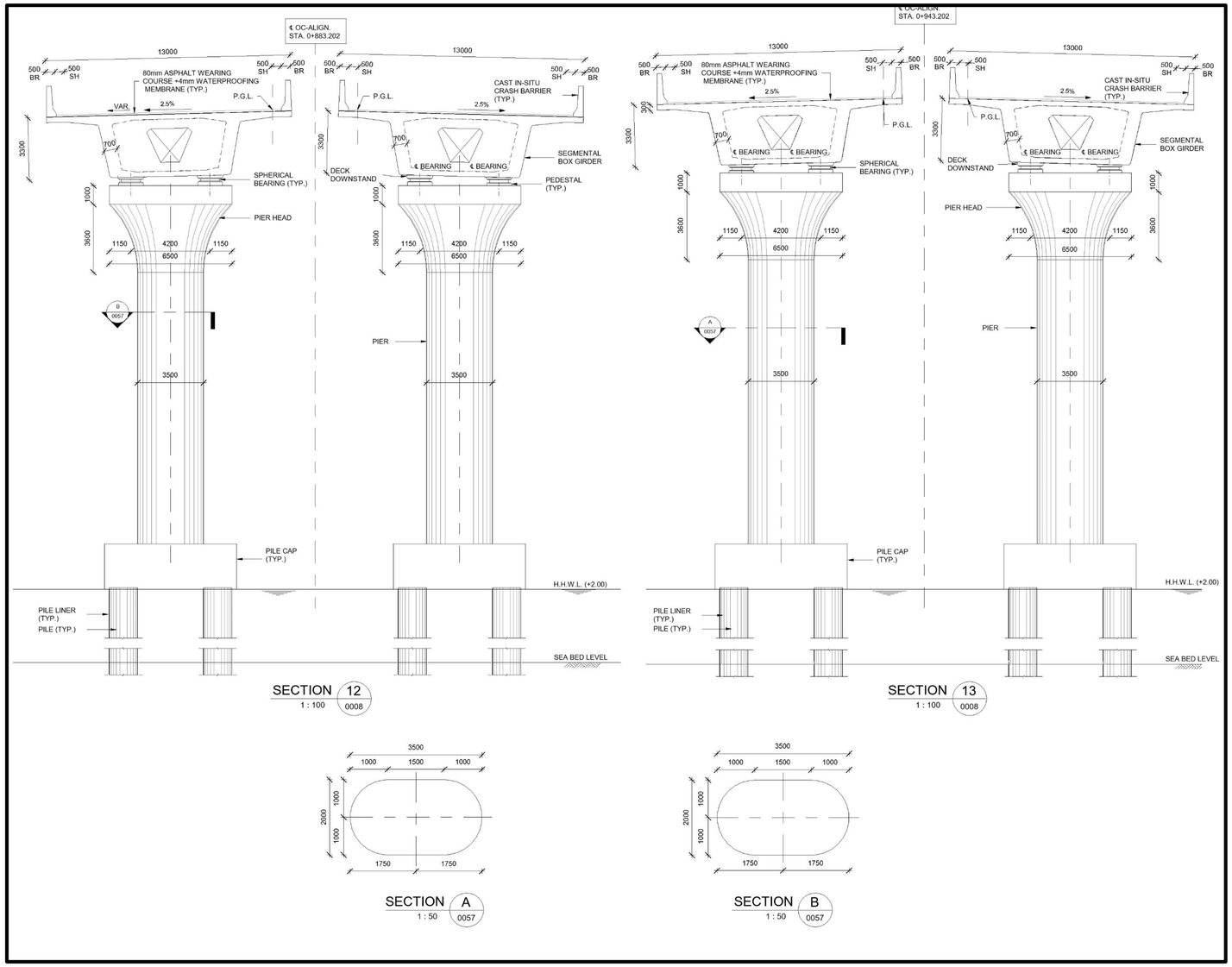


Slab-Type Bridge Top Plan Sample

2D Drawings Concept

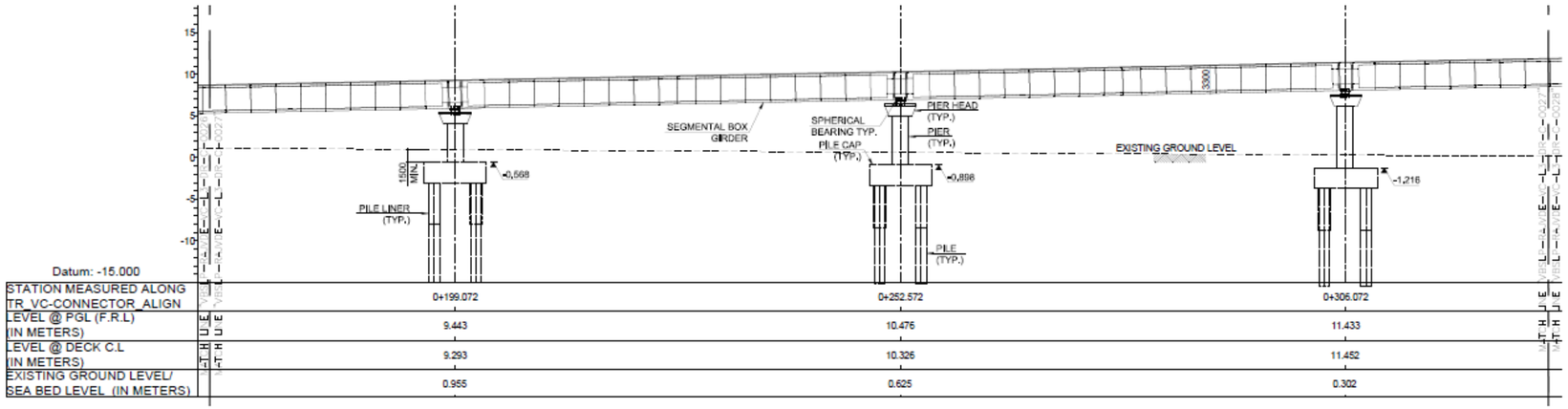


Cross section model line

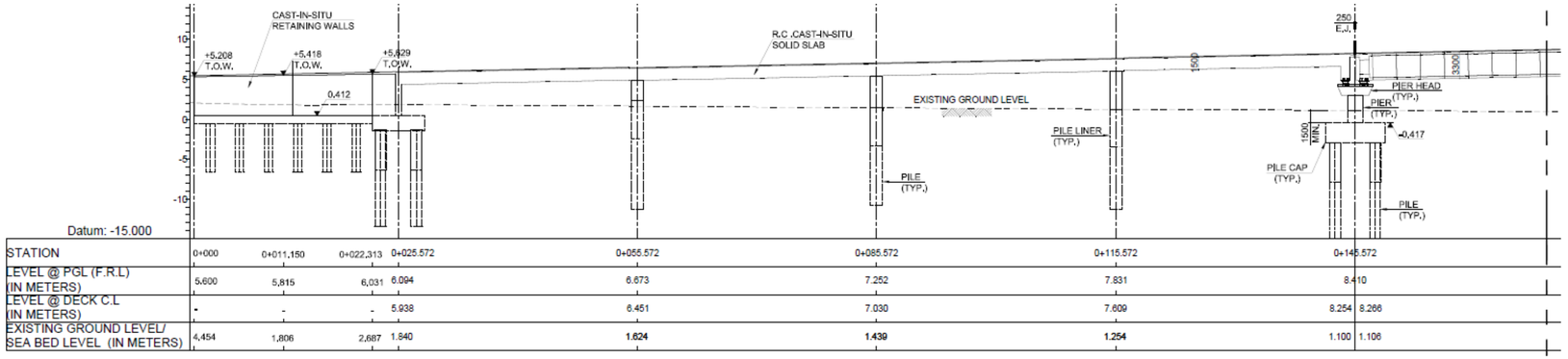


Cross Section Sample

2D Drawings Concept



Segmental Bridge Elevation



cast In-situ Bridge Elevation

Thank You

Questions

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