AUTODESK UNIVERSITY

CS20727

Stadium Station Revit Infrastructure case Studies

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Learning Objectives

- Using a Cloud base CDE for multiple site collaboration.
- Benefits of Modelling Complex Reinforcement.
- Using Dynamo for construction tasks setting out and modelling
- Integrating OpenBIM file format into Revit

Description

A case study using Autodesk Revit software to establish a multidisciplinary coordinated model using Infrastructure Design Suite software, and the successful workflow of how to best interact between the different software systems. The project is a six-platform Stadium Train Station for easy transfer to the Perth New Stadium. BIM was the key element in ensuring a high level of co-ordination and constructability within the existing conditions and staging for rail shut downs. The presentation will focus on using Revit modelling techniques with the aid of Dynamo for downstream management for construction documentation, formwork area, and setting out, scheduling, pour sequencing and procurement integrating multiple OpenBIM formats. The benefits of modelling complex reinforcement arrangements to ensure critical constraints are met. Workflows for using a Common Data Environment (CDE) cloud base platform to enable design team and construction team to work with the most current data.

Your AU Expert(s)

Dale Harrison, AECOM

Dale has been in the Civil and Structural engineering field for more than 13 years. His Career commenced with AECOM, which has seen him progress from entry levels roles to BIM manger where he has ongoing development of BIM standards, focused on reusable lifecycle data planning for Project Planning & Execution, Co-ordination & 4D planning, onsite technologies and FM deliverables using BIM project datasets. His broad project portfolio has seen him face and overcome numerous challenges along his path to success. In his role as BIM Manger, Dale has faced the challenges of BIM early Adoption and engaging staff, managing internal. Dale has spoken at a number of RTC Australia and BIMDAYOUT events over the past several years.

Contents

Stadium Station Overview

Project Location

Perth *is the capital and largest city of the Australian state of Western Australia. It is the fourth-most populous city in Australia, with an estimated population of 2.04 million (as of 30 June 2015) living in Greater Perth.*[1]

PERTH, AUSTRALIA

OVERVIEW OF PERTH STADIUM AND STATION

Project Overview

The Public Transport Authority commissioned the PRISM Alliance, AECOM in partnership with Laing O'Rourke, to deliver the detailed design of a new six-platform train station at Burswood Peninsula (Stadium Station) with additional stowage capacity at Victoria Park station.
The Stadium Station Project includes the following: -

- A new train station on Burswood Peninsula (Stadium Station) comprising two concourses accessed from passenger assembly areas within the new Stadium Precinct via stairs and lifts –
- Two island platforms of 225m length and one island platform of 150m length, accommodating 6 faces for passenger loading, with an allowance for future extension to 300m of platforms 1, 2, 5 and 6 –
- Track and civil works on Burswood Peninsula to facilitate operation of the new station as a special events station and to accommodate stowage for up to 117 individual railcars –
- Track and civil works at Victoria Park to accommodate stowage for up to 24 individual railcars - All associated Overhead Line Equipment (OLE) works –
- Three new trackside signalling equipment rooms –
- Driver crib facilities on Burswood Peninsula and at Victoria Park –
- Rail systems works comprising electrical works, communications works and infrastructure service interfaces as required (e.g. DAVS, CCTV/PA, passenger information systems, fire systems, earthing and bonding of structures and systems etc.) –
- Utility and railway services work

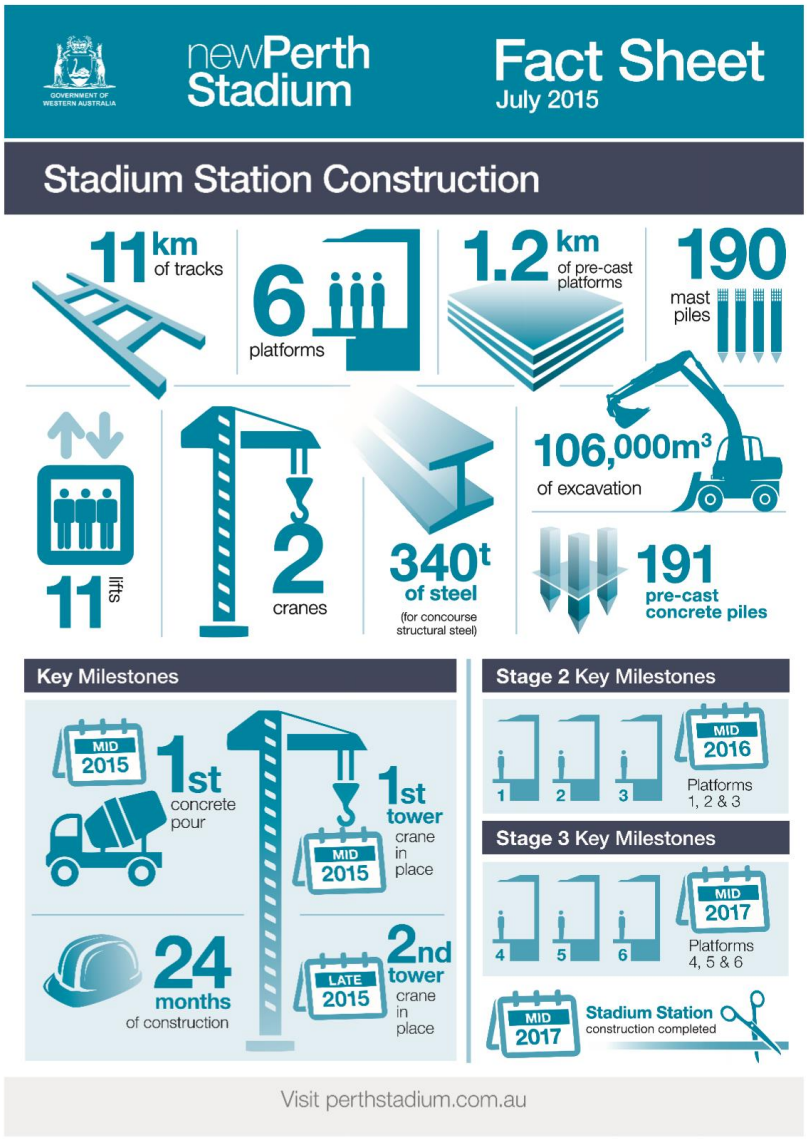
The new station will be a key component of the transport solution for the new stadium, offering spectators multiple options and supporting the cultural shift of reliance on cars. As an essential element of an evolving city, it will support the lifestyle and character of Perth, while offering an exceptional, integrated experience for fans.

Stadium Station Website

http://www.perthstadium.com.au/transport/stadium-station

Stadium Station Construction Process

https://www.youtube.com/watch?v=76dfm5VPzKY



CONSTRUCTION FACT SHEET

Common Data Environment – (CDE)

The project required a Common Data Environment that would host all project data. The solution had to be Cloud-based to enable the following;

- Single Point of Truth.
- Various parties are accessing single/multiple models from a different location (Revit integration).
- Cost Effective System that has Hardware, Software and IT Staff support.
- Met corporate and project security policies.

The Alliance decided to use Bentley ProjectWise because the requirement of a Common Data Environment to meet the project requirements.

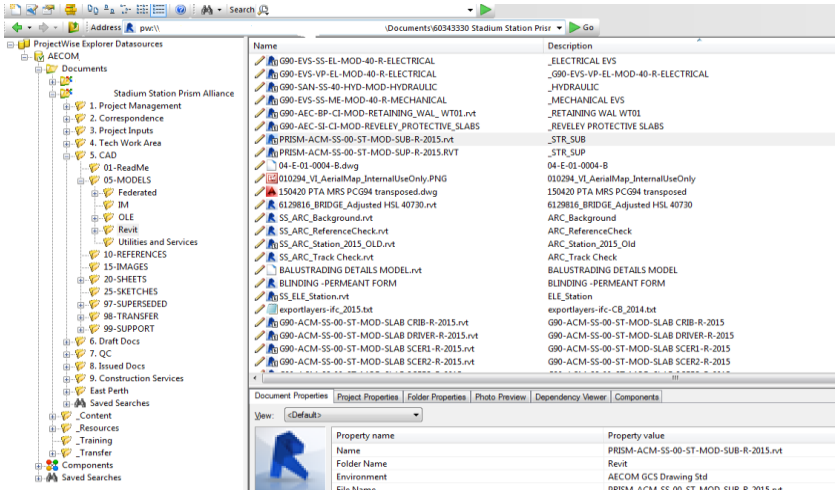
Bentley ProjectWise

https://www.bentley.com/en/products/brands/projectwise

ProjectWise V8i

Why Bentley ProjectWise**;**

- Collaboration for Revit (**CR4**) at the time of the project was not available from outside of North America at the time of the project.
- Revit Server did not meet project requirements. (Superseded by C4R).
- Bentley ProjectWise Integration for Revit is not New, Supported by Companies and met the requirement for **CDE**.
- Tights delivery programs with multiple teams accessing model from serval location constrained by Network Security Policy.



PROJECTWISE EXPLORE

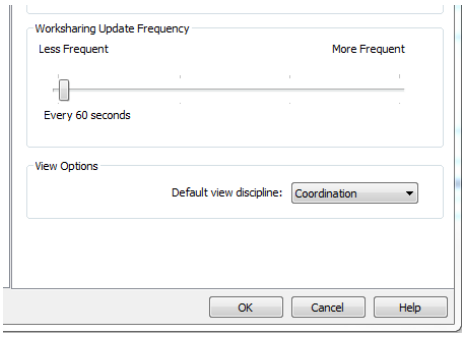
Using Bentley ProjectWise meant a change in workflows. The change was driven from the high network latency caused by multiple parties accessing a single Revit model from a different location. Australian internet ranking according to stateoftheinternet.com Akamai is 48th in the globe, compared to United States of America which ranks 16th. An example of network latency varied between parties ranged from 55ms to 250ms.

The solution to the challenge meant reverting to the early version of Revit workflows; of granulate Worksets, dividing the model to allow multiple users to access.

Multi-user Collaboration with Revit Worksets
http://cad.amsystems.com/products/docs/autodesk-revit-6-worksets.pdf

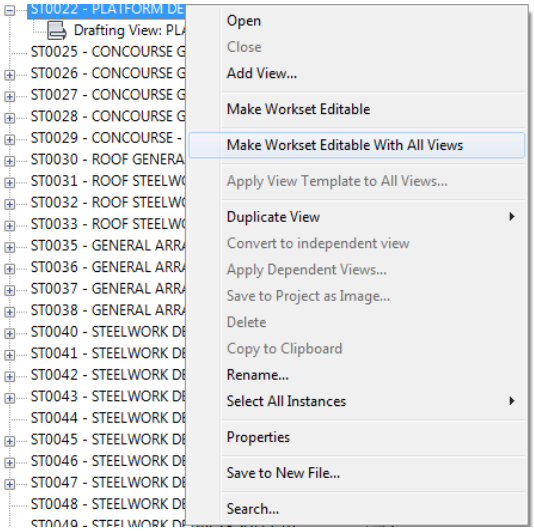
Additionally;

- Models size no great than 200Mb and 8 users with simultaneous access.
- Revit configuration for Workset reporting set to greater than 50 seconds. The less frequency meant limiting the number of central file checks / network traffic.



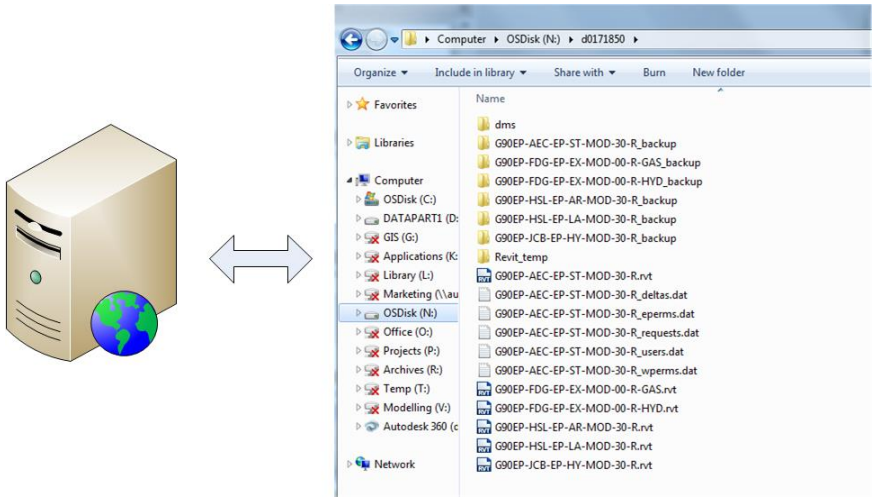
CONFIGURATION FOR WORKSET REPORTING

- Model / Documentation planning which tied into resource program (no ad-hoc approach). It had to be planned and rules, which defined what, when who.
- Example, a user, would have to check out worksets for the area of work including associated sheets / views.



MAKE WORKSET EDITABLE WITH ALL VIEWS

- Caching the Central file to local file each morning. (PW integration works by caching local central file on the user PC). Example, 200Mb file with linked files totaling 1 GB could take a 30min to cache local drive, which would prevent access to the central file for the rest of the team.



CACHE FILE ON LOCAL PC

ProjectWise Application Integration for Revit

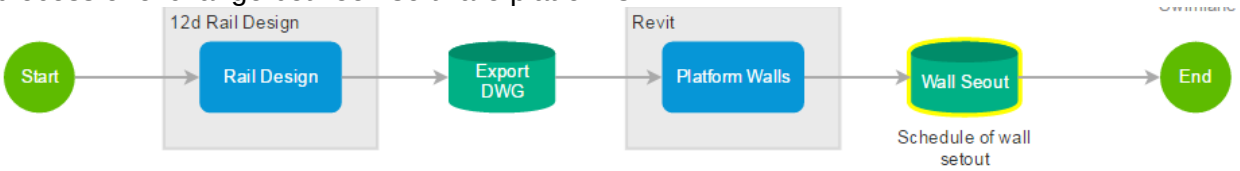
Frequently Asked Questions reference document.

ProjectWise Application Integration for Revit

Shared Coordinates

What AU presentation would be complete without a reference to shared coordinates?

Due to the nature of the project being linear infrastructure, coordinates are the basic requirement of successful multi-discipline spatial coordination.
The coordinated system gives a mathematical method of measuring the relationship with earth. Establishing a workflow, ensures that exchanging data between software platforms is seamless and without issues. The project had a robust workflow for coordinates which enabled the process of exchange between software platforms.



EXAMPLE OF A WORK FLOW ON THE PROJECT FOR THE SETTING OUT OF THE PRECAST WALL.

BIMFix Framework for Shared Model Establishment_v1-0

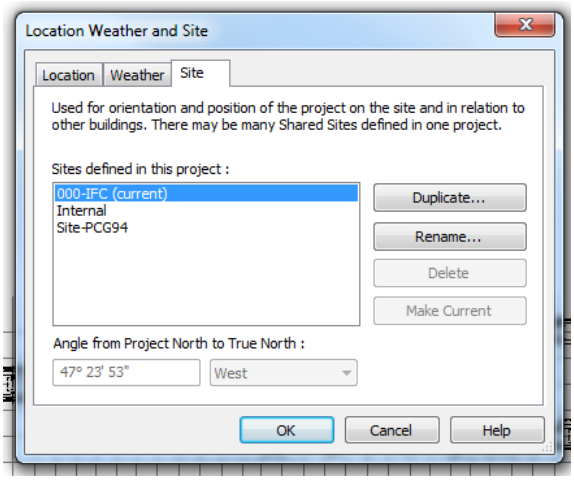
BIMFix has produced an excellent workflow for establishing shared coordinates in Revit and exchanging data between software platforms. The project used this workflow of for establishing coordinates and exchanging of dwg's. (Except IFC)

Link to BIMFix Framework for Shared Model Establishment_v1-0
http://bimfix.blogspot.com.au/p/framework.html

OpenBIM

IFC Workflow

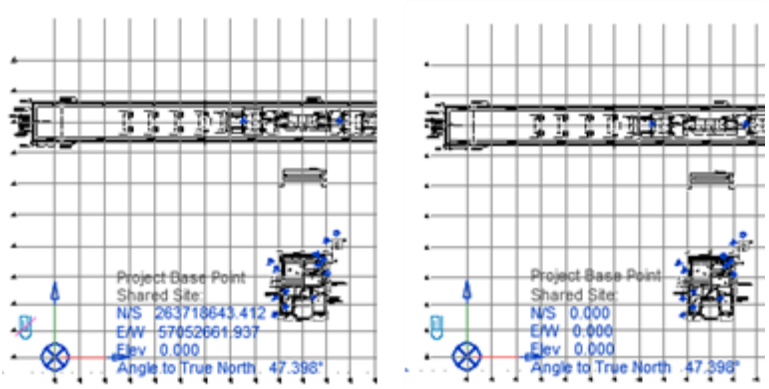
Prior to the July 2016, Revit IFC workflow for Trimble Tekla and Graphisoft Archicad had to be done using multiple site location. Simply put, you would have a Site location which had World Coordinates and 0,0,0 location. ***Trimble Tekla and Graphisoft Archicad both now have the ability to use IFCLocalplacement attribute of PlacementRelTo, which makes this project workflow become redundant.***



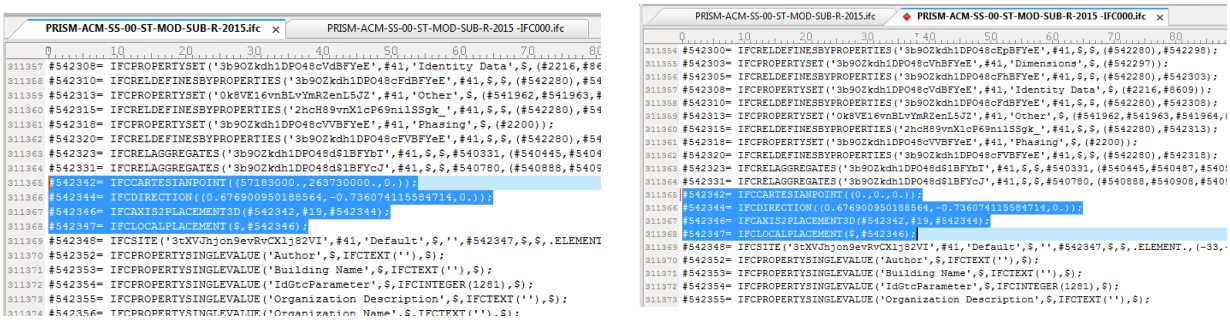
MULTIPLE SITE LOCATION 000-IFC USED FOR EXPORTING IFC

Export IFC

Creating an IFC file from Revit would consist of changing the site location to 000-IFC and exporting the IFC file with no coordinates. This workflow would allow Trimble Tekla and Graphisoft Archicad to be able to import the IFC file, which would not have world coordinates. Note: Graphisoft Archicad IFC exporter Addin 2016 now has the function to export IFC with no coordinates.



WORLD COORDINATES VS 000-IFC



WORLD COORDINATES VS 000-IFC VIEWED IN A NOTEPAD

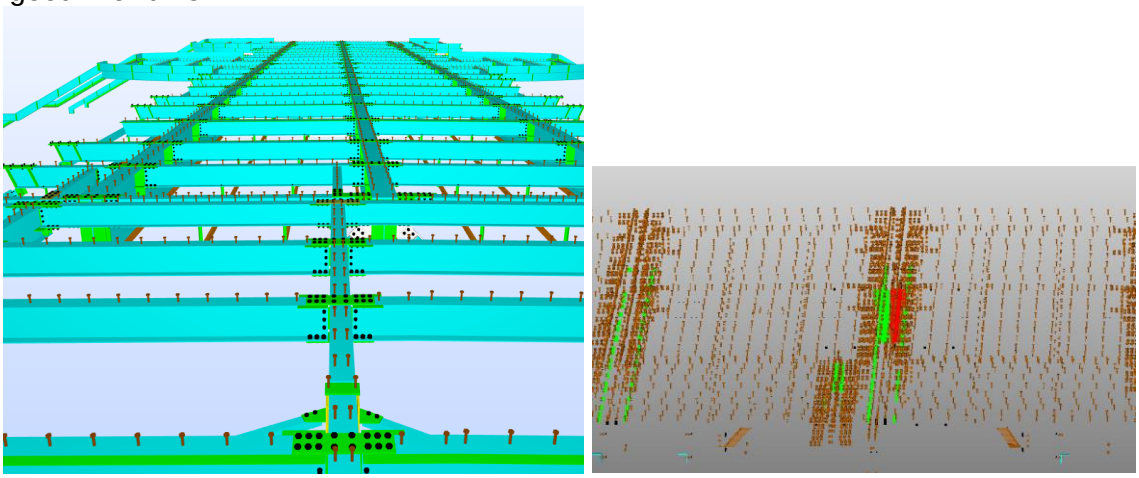
Importing IFC

Opening an IFC file within Revit requires having no coordinates, which would ensure that imported elements are within the 20miles radius to project base point. Revit's project base point is the mathematical set-out point of the graphical database. The project base point removes large numbers from the database and makes the math simple. If the IFC has world coordinates, elements created will be deformed, and create geometry errors. ***Trimble Tekla and Graphisoft Archicad both now have the ability to use IFCLocalplacement attribute of PlacementRelTo, which makes this project workflow become redundant.***

OpenBIMStepping LOD

The project workflow required the Fabricator model to be brought back into Revit for work pack documentation and coordination with other service templates. The challenge of bringing the Fabrication model into Revit is the amount of detail contained in the model (the amount of Polygons). An example of this being the steel fabrication model, containing detail for fabrication, which includes all bolts and studs. Opening a 125Mb IFC file in Revit would result in an 800Mb file which takes 8 hours to process and almost unusable. The workflow to step the geometry level of detail down, suitable for coordination, was to use an IFC edit to remove non-requirement elements. The project used SimpleBIM to edit the fabrication models and remove the non-

requirement elements which simplifies the IFC file for coordination within Revit. The result was a 'good' Revit file.



FABRICATION MODEL WITH ALL THE BOLTS AND STUD, THE IMAGE OF FILTERING OUT THE BOLTS STUDS.

The current workflow for OpenBIM

Further reading on the OpenBIM workflow

Revit / Tekla workflow

http://teklastructures.support.tekla.com/en/support-articles/tekla-revit-bim-workflow-example

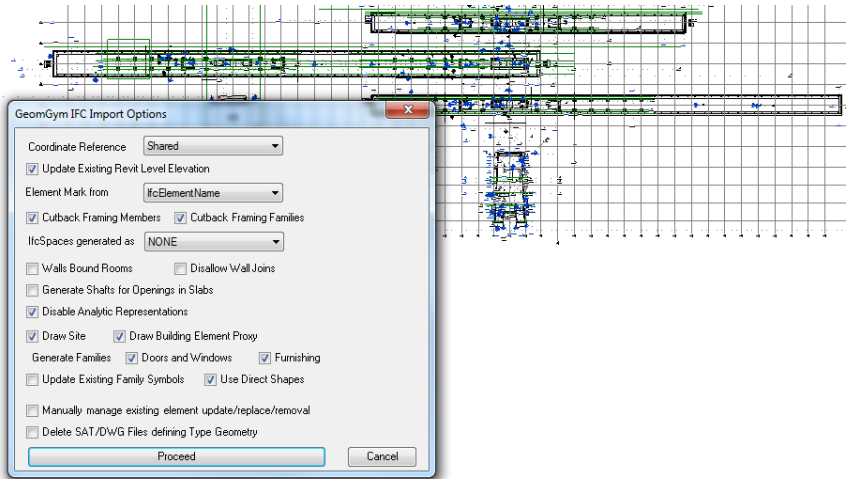
Revit / Archicad workflow

http://www.graphisoft.com.sg/downloads/interoperability.html

Geometry Gym IFC

The Geometry Gym Addin has a function to import an IFC file into Revit and uses the coordinate system to allow world coordinates. Additionally, the Addin creates a Revit Object instead of unique individual elements.

http://www.geometrygym.com/



EXTENDED IMPORT FUNCTION OF IFC INTO REVIT

Construction Set out

A linear infrastructure does not rely on Grids for set out as in a building project. The project required elements to have world coordinate locations for set out. Revit does not a have a built-in function to schedule the location of elements without the use of API. Without an automated solution, each element would have to be tagged with a spot coordinate for set out.

<PILE SETOUT SCHEDULE>

A	B	C	D	E	F	G
MARK	PILE SIZE	EASTING	NORTHING	TOP OF PILE	PILE LENGTH	Rotation to North
P1-01	0.45	55688.527 m	264257.809 m	12.310 m	1.8	73.35°
P1-02	0.45	55741.236 m	264398.589 m	12.916 m	1.8	73.35°
P1-03	0.45	55731.152 m	264401.610 m	12.916 m	1.8	73.35°
P1-04	0.45	55739.514 m	264392.841 m	12.896 m	1.8	73.35°
P1-05	0.45	55737.792 m	264387.094 m	12.876 m	1.8	73.35°

EXAMPLE OF THE PILE SETOUT SCHEDULE

The solution to being able to schedule the setting out of each element was to use Dynamo.

Coordinates and Dynamo

Revit Project Base Point

Revit's project base point is the mathematical set-out point of the graphical database. The project base point removes large numbers from the database and makes the math simple.

Matrix transformation

For bringing in and exporting out points within Revit, the data is required to go through a matrix transformation rotation. I don't know how to write it in words but to put it simple if you had the option of x =235982030, y=230923092, Z=14000 vs. x=1, y =1, z = 1 for every point as a reference point which one would you chose? Well, Revit makes it simple by using 1,1,1 and tells the base point that large number which is multiplied by linear algebra. To get the reverse into Revit from Dynamo you need to take the points that you have, and Matrix transforms them from the Project base point and rotation to true north.

Refer to the Wikipedia for Matrix transform https://en.wikipedia.org/wiki/Transformation_matrix

Rotation

For rotation by an angle θ **clockwise** about the origin, the functional form is $x' = x\cos\theta + y\sin\theta$ and $y' = -x\sin\theta + y\cos\theta$. Written in matrix form, this becomes:[4]

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

SIMPLE MATH BUT COMPLEX TO GET AT THE START.

A brief explanation of Dynamo custom nodes.

The project created serval nodes which performed the matrix transformation rotation;

Transform_**in**

Custom node when bringing world coordinates point's data into Revit with Dynamo.
The node gets the project define base point, and true north angle and 2d matrix transforms data and subtracts against the input values. The result being the values are now relative to project base point.

Transform out.

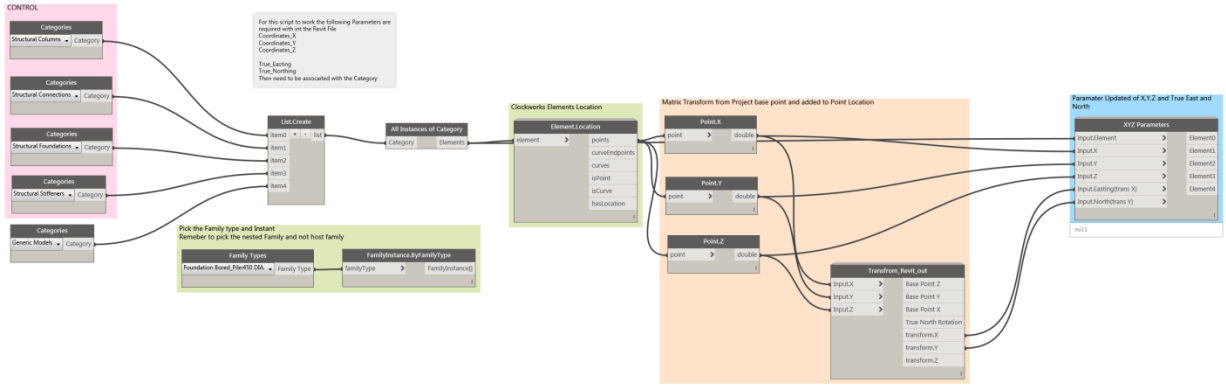
Custom node when getting world coordinates values out of Revit with Dynamo. The node takes the project define base point and true north angle and 2d matrix transform and adds to the element's local coordinate values, resulting in world coordinates.

XYZ parameter.

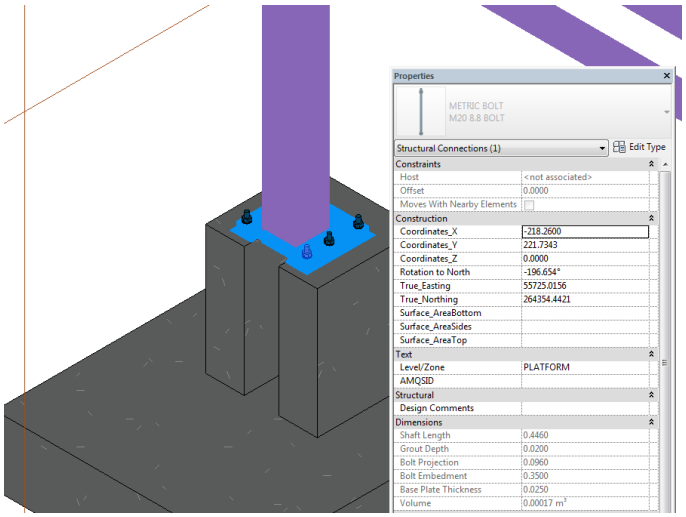
Custom node but more of a time saver. We have reparations. Uses of this node when inputting, or modifying elements with XYZ parameter and world coordinates parameters

Construction set out

The node collects the entire defined category within Revit and finds their location using custom Node by Clockwork element location of the point family. The point location is then placed through transform_out node to get the defined points relative to world coordinate. Then the elements share parameters of Coordinate_X, Coordinate _Y, Coordinate _Z, True_Northing Location and True_Eastisng Location are updated with the location. Including nested elements within hosted family.



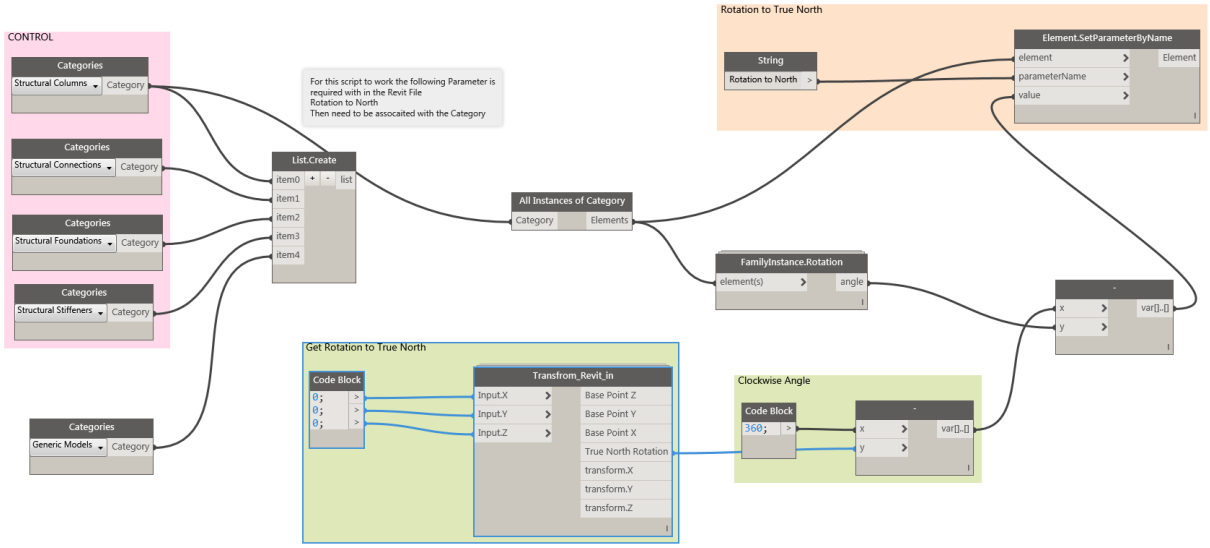
COORDINATE SETOUT



EXAMPLE OF COORDINATE OF A H.D BOLT

Rotation to True North

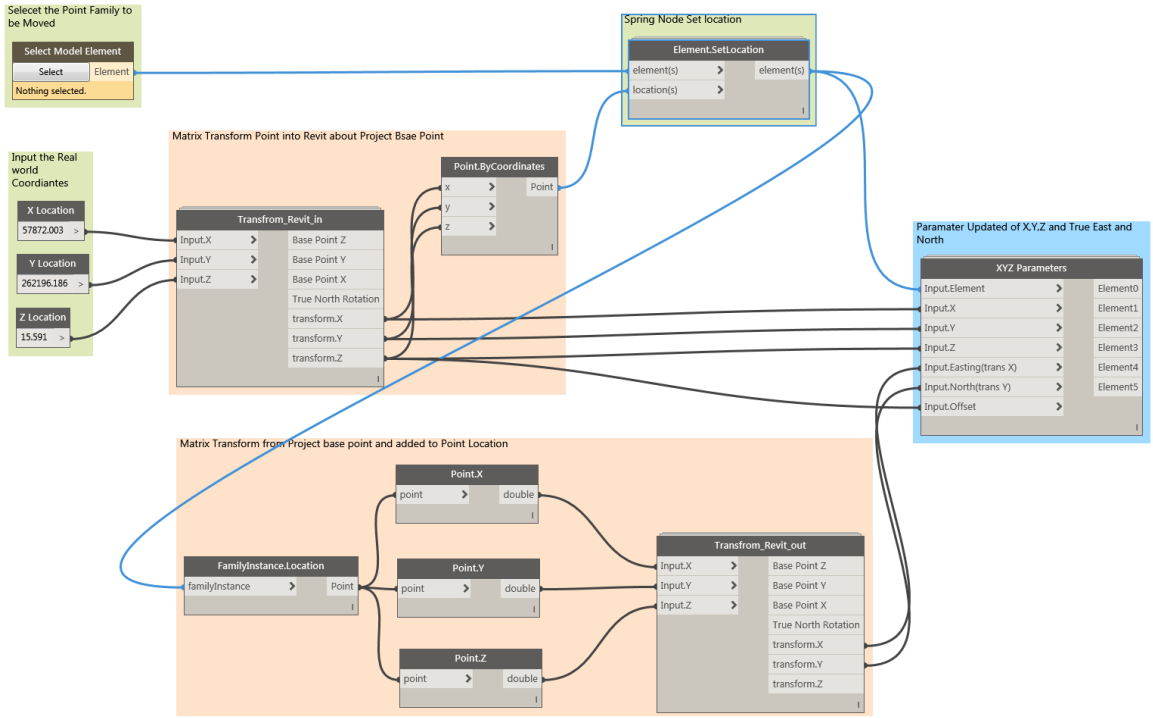
The node collects the entire defined category within Revit and finds their rotation using custom Node by Spring family instance location of the point family. The Shared Parameter of Rotation to North is updated with the rotation.



ROTATION *SETOUT*

Move Element

Selecting the elements to be moved and inputting the new location as world coordinates. The new location is processed though Transform _Revit_in relative to project base point and moved using Custom Spring node set element location. The shared parameter for the location of the element is updated using the node XYZ.



MOVE ELEMENT

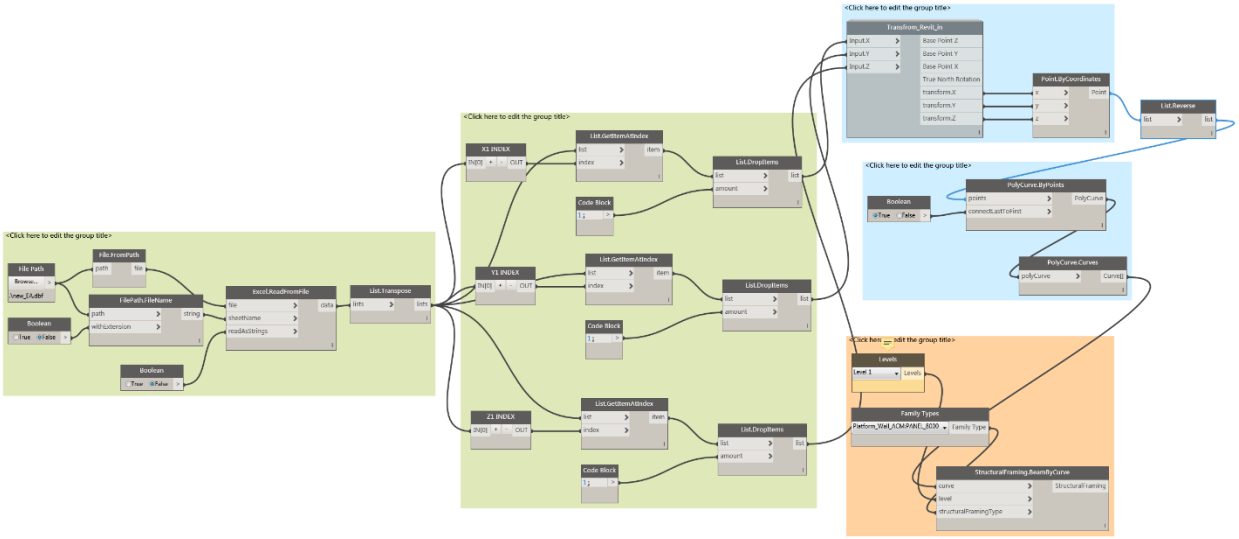
Platform Wall Set out

The project had 1.2km of platform wall which had a vertical and horizontal curve that followed the rail alignment. The process to model the precast platform wall by traditional methods would be time-consuming and complex. Using Dynamo simplified the process to model the precast platform wall which was able to follow the track alignment.

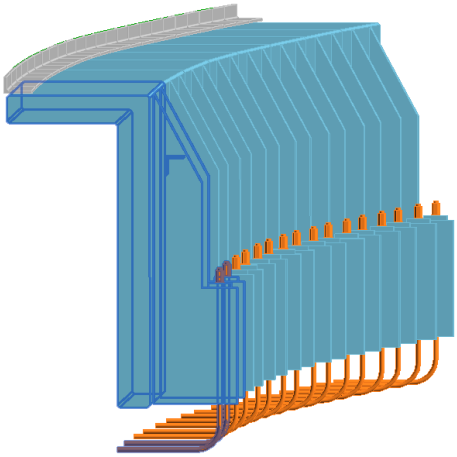
The process for laying out the 1.2km of precast platform walls was to use the Centre line of the track alignment and offset the center line of the meet the platform wall.

The design string would be split into intervals to suit the precast wall length. The points will have x,y,z and exported from AutoCAD with the attribute of XYZ. The precast platform walls family created as structural framing having a start and end point.

Dynamo for setting out the platform walls read the set-out point from excel and turned into a list of X, Y, Z. Using again Transform Nodes which transforms the points about base points which draw a Curve. The curve then is inputted into the structural framing to create the precast platform wall.



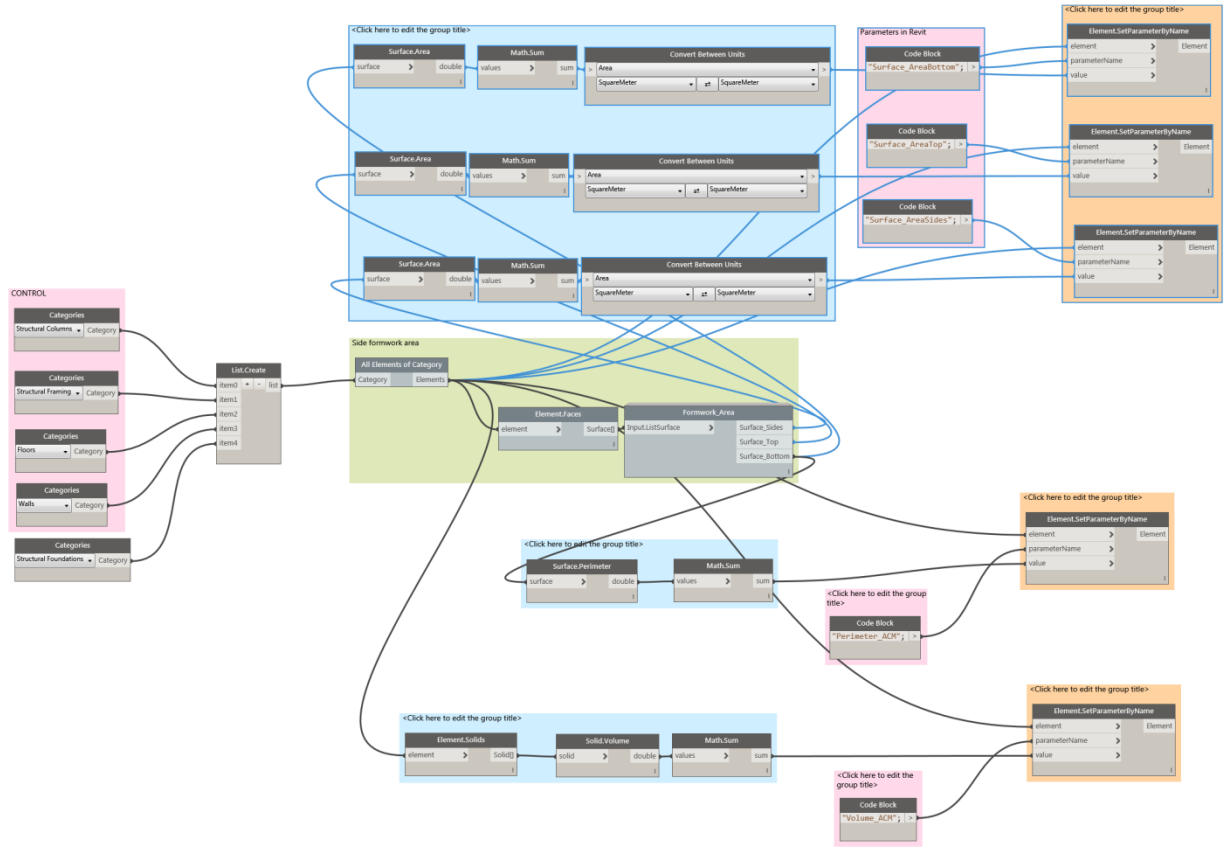
SETTING OUT PLATFORM WALL



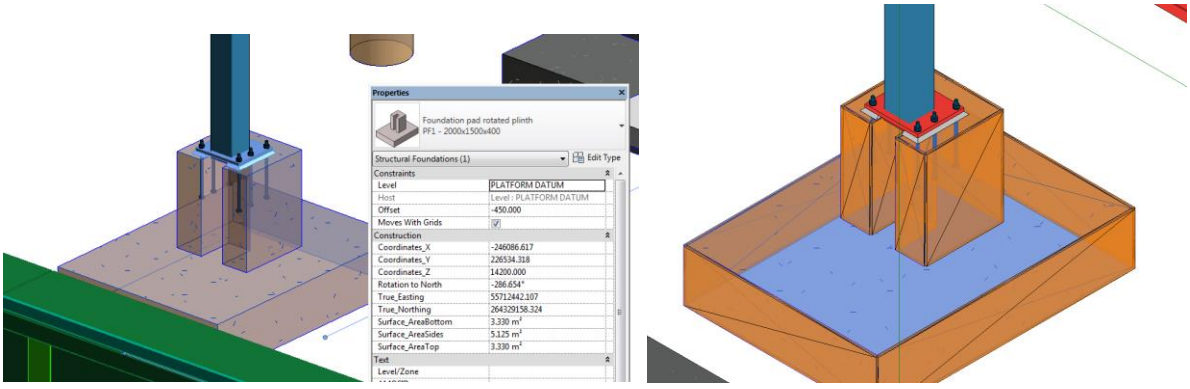
PRECAST PLATFORM WALL MODELED WITH A HORIZONTAL AND VERTICAL ALIGNMENT

Formwork Areas

The project requirement specified all INSITU concrete elements to have formwork surface areas calculated. Revit does not have a simple solution to calculate formwork Areas. The solution to schedule the formwork areas of each INSITU elements was to use Dynamo. The node does not take into account joint faces, only elements as a whole. The shared parameter for the top, bottom and side formwork area updated.



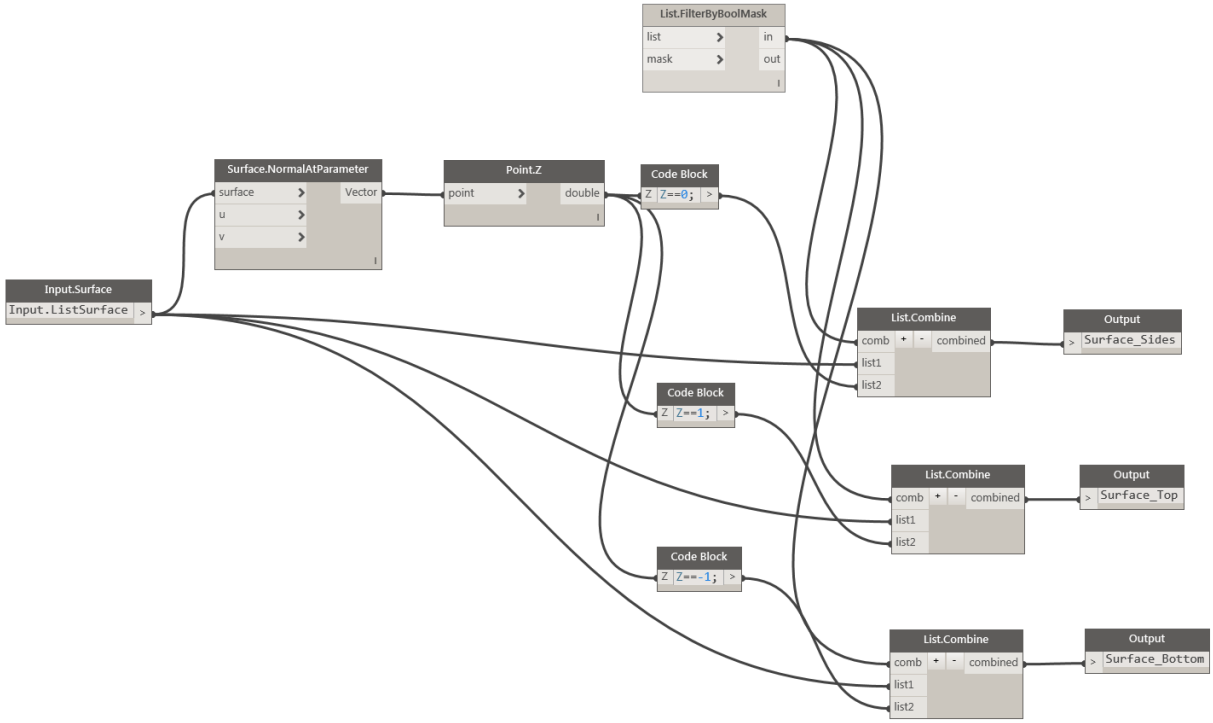
FORMWORK AREA



EXAMPLE OF THE FORMWORK AREAS

Formwork Area

A custom node that split the surface based on the vector direction Z value relative to the surface. The result, the top, bottom and side area values are filtered to each.



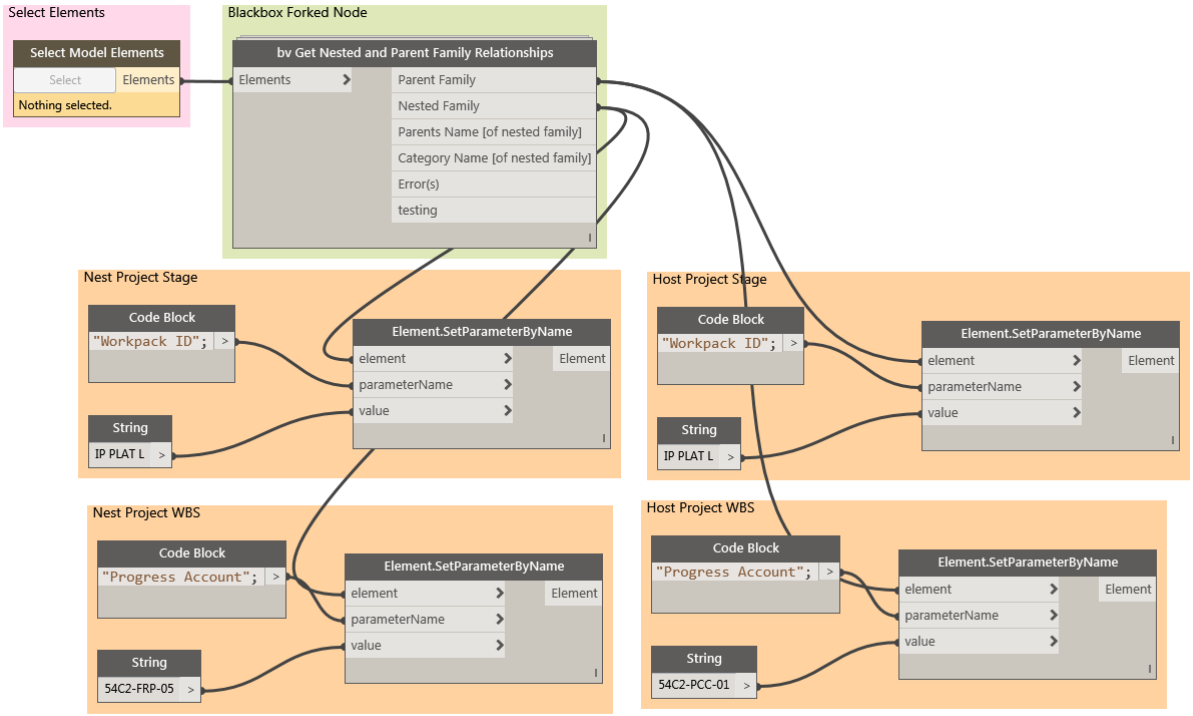
FORMWORK AREA CUSTOM NODE

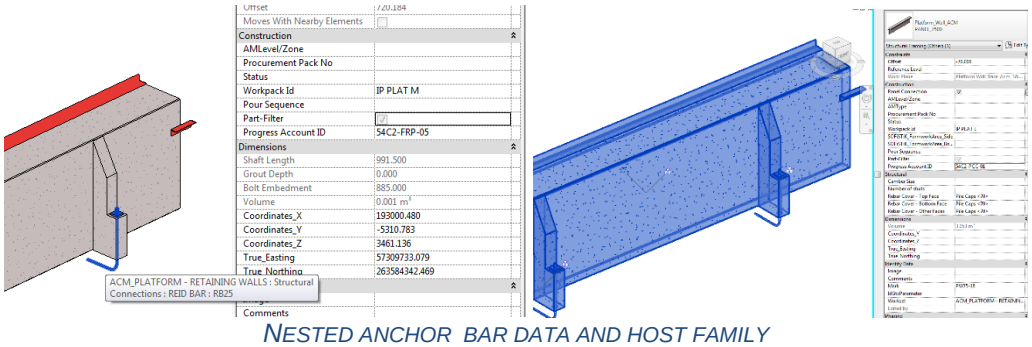
Data input for Work pack and Timeline scheduling

The project requirement specified that the model elements with have sufficient granularity to enable the model to be broken break up into construction sequences to that suit logistics and construction methodology. The method of modelling used families within nested families. This meant that imputing the data to nested family was a challenge.
Using Dynamo allowed inputting data to nest with a simple process.

Nest family data input

The solution to select the host family with Dynamo which would split host and nested family to list and allow project parameters for each element to be updated.



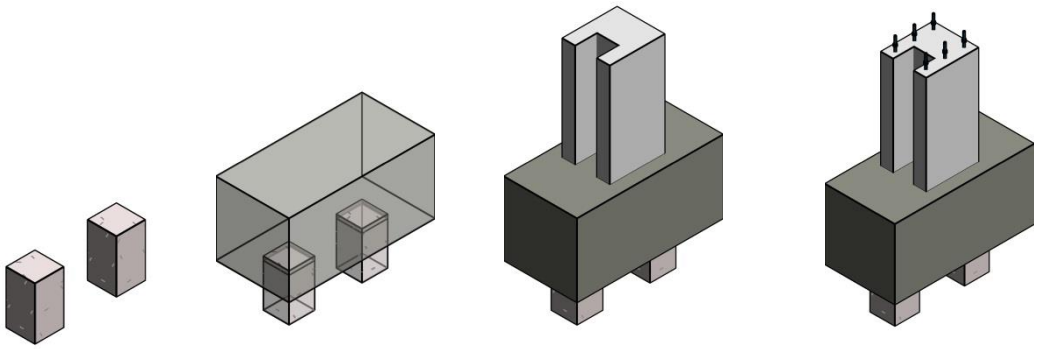


NESTED ANCHOR BAR DATA AND HOST FAMILY

Example, anchor down bolts nested into the Pre-Cast wall. This would remove users tabbing and cycling through each element of inputting data.

Modelling For Construction

The project requirement specified that the model elements have sufficient granularity to enable the model to be broken up into construction sequences to that suit logistics and construction methodology. Modelling using of families nested within families for was the best approach due to the repetitive elements of a linear infrastructure project. Example, a pile cap with pile and plinth nested within it. Additionally, each element would be created with sub-categories with appropriate material to achieve the method of construction methodology. The result allows for scheduling, sequencing / pours sequencing and Work pack documentation.



EXAMPLE OF A PILE CAP MODELLED AS PER CONSTRUCTION METHODOLOGY

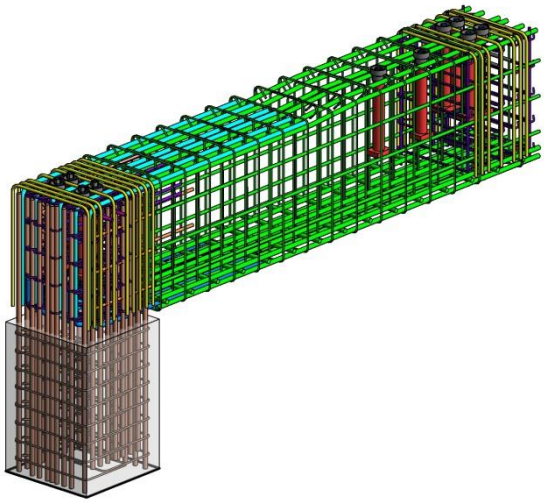
The approach to creating a family to support the construction methodology was derived from the following handout. By Paul Aubin
http://aucache.autodesk.com/au2015/sessionsFiles/10641/7489/handout_10641_AU%202015_AS10641-L_Aubin_Families_Intro.pdf

Additionally, Reference Details for modelling for Base Plates. By Tina Bos

http://au.autodesk.com/au-online/classes-on-demand/class-catalog/2013/revit-for-structural-engineers/se3048-l

Complex Reinforcement

Traditionally in Australia we do not detail reinforcement at the design stage. This is the responsibility of the contractor and sub-trades to detail. The project had a similar approach, except for the area where it was critical to ensure coordination between reinforcement and other trades. The concrete bridge had piers with complex arranged reinforcement. The challenge to with the arrangement of pier reinforcement was the addition of holding down bolts for the bridge girder over. The Girder has spans of over 26m with the tolerances for the placement of the holding bolts being only 2mm. The arrangement of the reinforcement had to be perfectly coordinated and placed. Additionally ensuring the correct placement of reinforcement meant reducing time that trades were required to work at heights in proximity to Overhead Live Power. The project team modelled the arrangement of the reinforcement and holding down bolts to ensure that interface between multiple trades are seamlessly integrated.



EXAMPLE OF HOLDING DOWN BOLTS AND REINFORCEMENT ARRANGEMENT IN PIERS

Using Revit the Project team was able to model the holding down bolts and reinforcement to demonstrate that the design and construction method requirements were met. The modelling of the reinforcement was then available for downstream use by the construction team to perform sequencing to find the optimize installation solution to minimize crews working at heights

The approach to reinforcement modelling was drived from the following handout
Refer document by HÅVARD VASSHAUG
http://au.autodesk.com/au-online/classes-on-demand/class-casetalog/2013/revit-for-structural-engineers/se2925

Summary

- Revit can be used for Infrastructure documentation using Dynamo.
- Revit modelling techniques can support downstream construction management workflows.
- OpenBIM file formats can be used effectively into Revit for coordination.