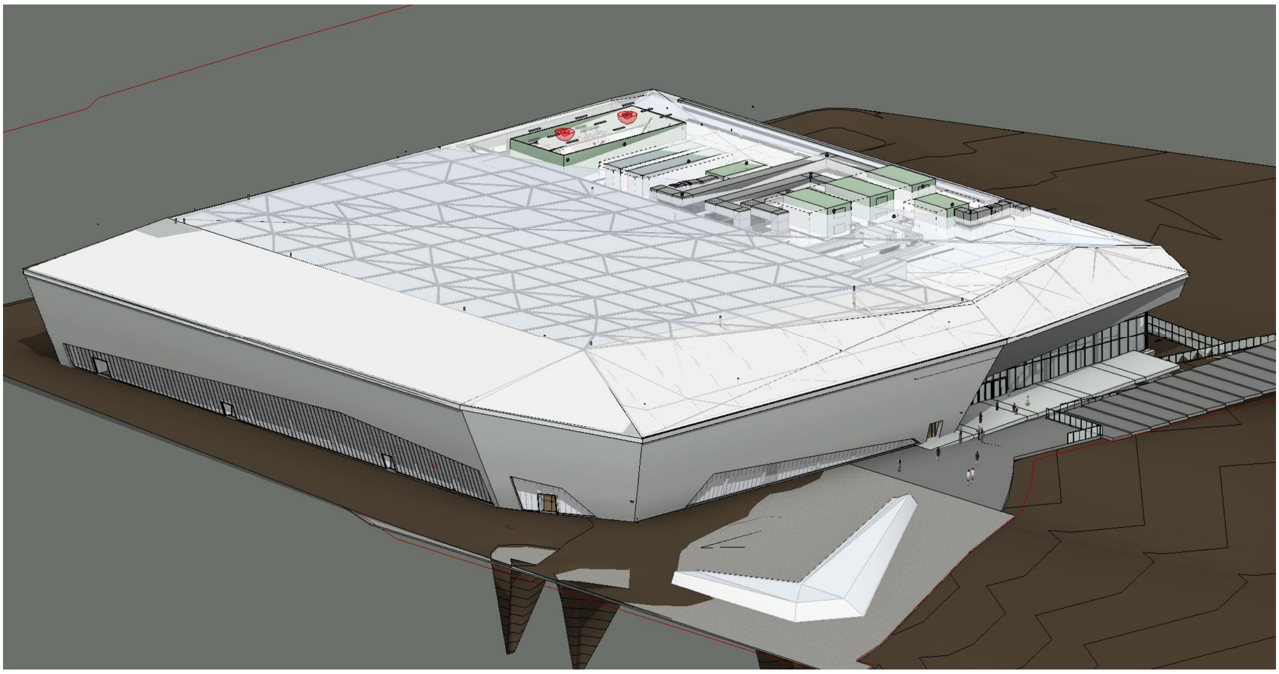
CEW BIM Waste, Ice Arena Wales
Reducing waste, pile case study



Client
Constructing Excellence in Wales

Key services provided
BIM Consultancy
Waste Expertise

Project overview

Waste is one of the most important issues facing the Welsh construction industry. Using more recycled materials and minimising waste in the construction and demolition process is crucial to creating a more sustainable environment.

The Constructing Excellence in Wales (CEW) team managing the 'Enabling Zero Waste' project are working in collaboration with four live construction sites in partnership to offer practical intervention to the construction project and site teams exploring viable solutions for achieving zero waste. One of the collaboration projects 'Ice Arena Wales' (IAW) in Cardiff Bay is to provide a 3,000 seat Ice rink, separate training rink and support rooms and become home of the Devils Ice Hockey Team.

The project utilised concrete piles for its foundations which through the design and construction phases altered to reflect design changes and suggestions following sub-contractor engagement. This case study will look at the functionality of utilising Building Information Modelling (BIM) post design and construction to assess and compare the structural pile foundation designs to see if there were any possibilites of reducing waste.

Study objectives

- To quantify pile volume differences between design & construction
- To quantify the waste volume of concrete piles created in installation

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Volume comparisons

The IAW project is located on reclaimed land which was previously a municipal landfill site. Due to the nature of the reclaimed land with possible movement and gas seepage whilst settling, a dividing wall (see image right) was introduced below ground as a preventitive message. To allow for this wall and the type of soil structure in this reclaimed area the foundations were designed using concrete piles to ensure that settling wouldn't affect the structure and to cross the buried wall.

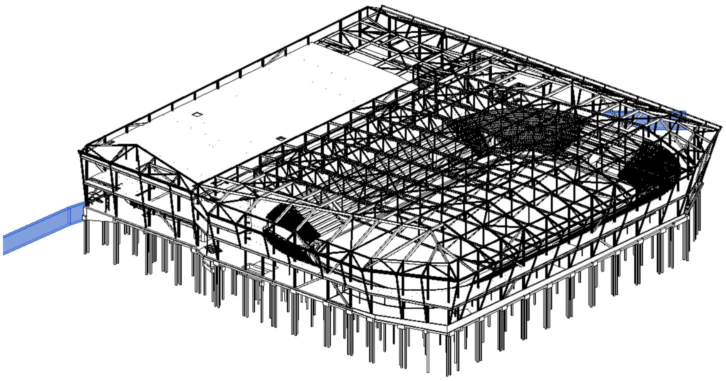
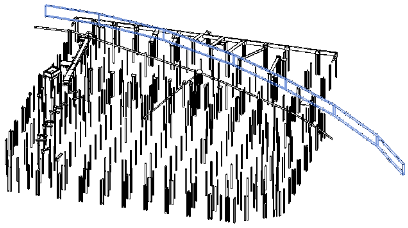


Figure 1 – Structural design supported on pile foundations



Below ground obstruction
The IAW design team modelled the buried below ground wall to improve the co-ordination of the finished design

When designing pile foundations there are two key elements that determine the design of the piles, firstly where the piles are required to take the weight of the building and secondly the length of the piles which depends on the local geology of the site. On this project Arup were engaged to design the positions of the piles in relation to the structure and not to confirm pile lengths. The sub contractor Keller were responsible for the final design length of the piles following ground survey tests.

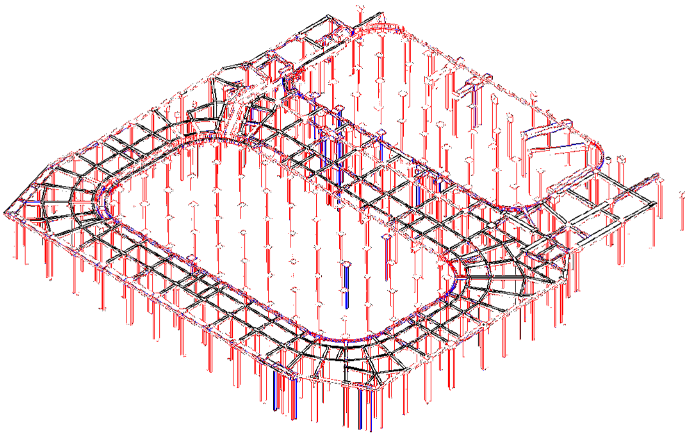
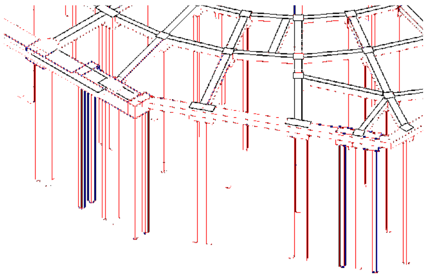


Figure 2 – Changes to Arup Design following subcontractor engagement (red original, blue amended)



Pile Design
Following the engagement of the sub contractors changes were proposed to the Arup design. The blue elements in the image above show where the pile design was amended. In general only a few extra piles were introduced with some slight modifications to the pile caps.

Following issue of the Arup Design the subcontractors for both the Pile foundations and the Façade design added suggested amendements that were carried out to the original design before construction was carried out. The changes required a handful of

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extra piles and some ground beams & pile caps were slightly amended.

Following the subcontractor Keller carrying out test bore holes across the site they issued a generic design length of between 13 & 23m for all the piles on the site with an expected maximum design length of 22.250m. The purchased concrete piles would be delivered to site in nominal lengths of 13m to achieve the design lengths required.

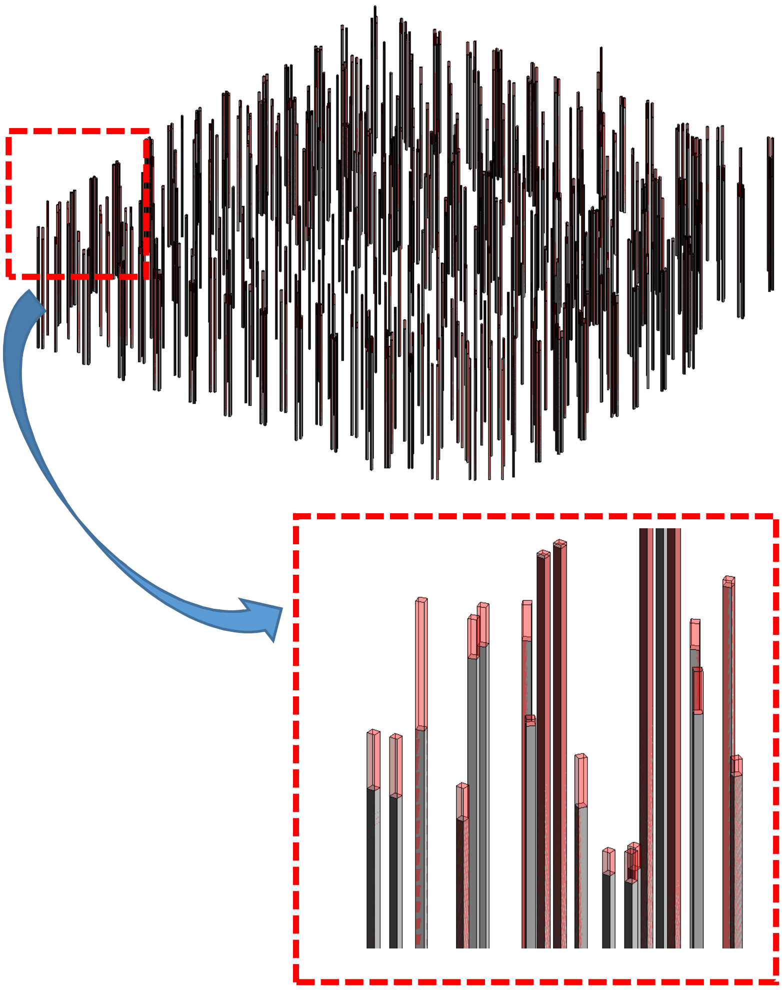
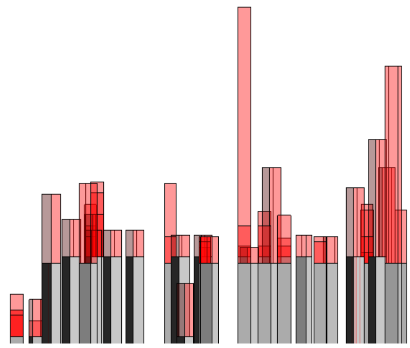


Figure 3 & 4 – Combined installed pile section lengths (red) versus actual driven lengths (grey)



Concrete pile waste
Waste when installing concrete piles is unfortunate necessity as the below ground conditions no matter how well tested can change dramatically across a site. The red sections in the image above emphasise the amount of waste generated in one area of the IAW project.

Following Keller driving all the piles they issued records of each pile noting the section lengths, driven length, pile size and working load. The lengths from the records were added to the model to show a finished driven version and section length version so that the volume of waste generated could be documented and visualised. Figures 3 & 4 show views from the model recording the finished driven pile lengths shown in grey and the combined length of the multiple pile section lengths used to form the piles in red.

The table below (see figure 5) shows a record of this same data from the model. The table allows us to subtract the completed driven length from the section length and leave the leftover length

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of the pile that can be considered as waste. The total length of pile sections brought to site was 9296m. The total pile waste recorded as a length was 597.4m. This equates to 6.5% of the total sections brought to site.

<Driven Pile Schedule (As-Installed)>

A	B	C	D	E	F	G
		Constraints			Pile Section	
Mark	Structural Material	Base Offset	Top Offset	Driven Pile Length	Lengths	Pile Waste
1a	C30	-10925	7575	18.500 m	19.000 m	0.500 m
1b	C30	-10425	7575	18.000 m	19.000 m	1.000 m
2a	C30	-9425	7575	17.000 m	19.000 m	2.000 m
2b	C30	-9725	7575	17.300 m	19.000 m	1.700 m
2c	C30	-9725	7575	17.300 m	19.000 m	1.700 m
3a	C30	-9925	7575	17.500 m	19.000 m	1.500 m
3b	C30	-9425	7575	17.000 m	19.000 m	2.000 m
3c	C30	-8925	7575	16.500 m	19.000 m	2.500 m
4a	C30	-10025	7575	17.600 m	18.000 m	0.400 m
4b	C30	-10025	7575	17.600 m	20.000 m	2.400 m
4c	C30	-9925	7575	17.500 m	18.000 m	0.500 m
5a	C30	-8595	8405	17.000 m	20.000 m	3.000 m
5b	C30	-8595	8405	17.000 m	20.000 m	3.000 m
1003d	C30	-8200	9100	17.300 m	18.000 m	0.700 m
1004a	C30	-9165	8535	17.700 m	18.000 m	0.300 m
1004b	C30	-9165	8535	17.700 m	18.000 m	0.300 m
1005a	C30	-8400	9100	17.500 m	19.000 m	1.500 m
1005b	C30	-8100	9100	17.200 m	19.000 m	1.800 m
1005c	C30	-7200	9100	16.300 m	18.000 m	1.700 m
1005d	C30	-6900	9100	16.000 m	18.000 m	2.000 m
1006a	C30	-8200	9100	17.300 m	19.000 m	1.700 m
1006b	C30	-8100	9100	17.200 m	19.000 m	1.800 m
1007a	C30	-8400	9100	17.500 m	19.000 m	1.500 m
1007b	C30	-8400	9100	17.500 m	19.000 m	1.500 m
Grand total: 493				8698.600 m	9296.000 m	597.400 m

Figure 5 – The top and bottom sections of the Driven Pile Schedule showing the totals

The majority of the left over lengths (noted as pile waste in the table) were in the region of 100 to 500mm with 35 being over 3m in length and the longest being 6.9m in length. The process of installing piles means waste will be generated due to the nature of the geology below the surface and to the pile section lengths chosen to drive the pile. In some instances this waste length will be made excessive due to the sections delivered to site or what section lengths were left at the time of installation.

Summary

The main intention of this study was to compare the pile designs and waste generation across the design and construction stages to see if there could be any lessons learned to reduce waste. Two obstacles arose from the outset of this study to prevent any clear conclusions relating to improving waste reduction.

Firstly the original Arup design did not include any lengths due to the engagement on the project. This removed any possible volume or length comparisons across stages. Secondly due to the nature of the reclaimed site and geological tests, wide tolerances were put in place to allow for the expected variations in completed pile lengths. This meant that no design lengths were put in place to check, only a record of the section lengths used.

The study did succeed in using BIM technology to calculate and visualise the comparisons between the delivered section lengths and the finished driven piles to generate simple visuals and metrics to document the waste generated for the project.

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