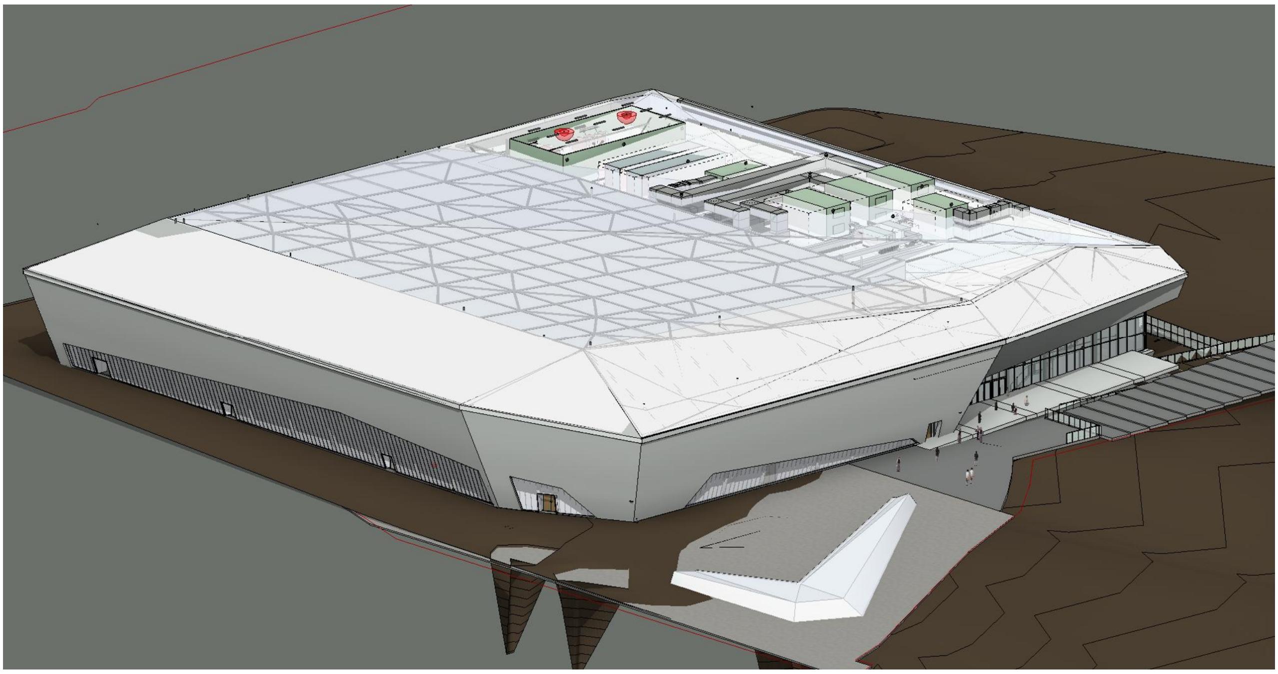
Constructing Excellence in Wales Design for Deconstruction, Ice Arena Wales Project



Client
Constructing Excellence in Wales

Key services provided
BIM Consultancy
Waste Expertise

Project overview

Design for Deconstruction (D4D) is an overarching action of the Welsh Government Construction and Demolition Sector Plan (November 2012). The aim is to encourage the construction industry to design for the end of the life of projects and ensure that materials used in construction contain a high percentage of recycled content.

The Constructing Excellence in Wales (CEW) team work with the construction industry to promote the consideration of the deconstruction and demolition of buildings at both the design and construction stages. The Ice Arena Wales (IAW) project in Cardiff Bay, which is to provide a 3,000 seat Ice rink, separate training rink and support rooms was identified as a possible example project for D4D.

CEW in partnership with the IAW design and construction team wanted to investigate the possibility of designing in D4D retrospectively through Building Information Modelling (BIM). This case study will focus on providing a method to document the recyclable value of materials through BIM and to define a method that outlines the safest way to deconstruct the project.

Study Objectives

- To quantify materials and resources that can be recycled through the use of BIM
- To use BIM to categorise and grade materials to be reused
- To identify methods to record the process for deconstructing buildings in the future to enable reuse.

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Benefits to Adopting BIM for D4D

BIM technologies used correctly allow the construction industry to document, track and store all materials used within a building in a central database. The data can include a variety of information such as; length, grade, weight, basic construction techniques required for installation, costs, and many more. This valuable data can be used by future building owners to assess the recyclability of construction elements when decommissioning a project.

The table below in Figure 1, was created using the completed IAW model and its associated data. The table lists information for all the structural steel elements within the IAW model. These include the possible reuse grade factor (as detailed later) of the steel, its grade, how many elements it relates to, total weights volumes and lengths of the steel material. Any one of these individual pieces of data can be used in the future to assess the recyclability of steel. For example, the total weight of the steel is 686 tonnes.

<Steel Reusability Schedule>

A	B	C	D	E	F
Reuse grade factor	Grade	No. of elements	Gross volume (m3)	Gross weight (Kg)	Length (mm)
High	S275	11	0.119	934	62000
High	S355	416	10.927	85777	2175671
High	S275	22	0.279	2186	147963
High	S355	421	15.029	117976	2652572
Medium	S275	41	0.099	779	35561
Medium	S355	738	43.336	340191	5051722
Low	S275	22	0.030	234	15937
Low	S355	473	17.243	135358	2548566
Low	Steel_Undefine	43	0.073	576	10750
	S355	97	0.257	2020	55738
Grand total: 2284			87.393	686033	12756480

Figure 1 – Table of steel elements

In the same way other materials have data stored in the model to be assessed in the future. The table below (as shown in Figure 2) lists wall data from the model. This table however, is slightly more complicated due to data in the table containing multiple material categories assessed at the same time. For example, this project has a variety of wall types including wood stud partition walls, concrete blockwork walls and a variety of cladding type walls, each having totally different material and structural qualities.

<Wall Schedule Quantities>

A	B	C	D	E
Family and Type	Count	Length	Volume	Width
Basic Wall: Bar Height Mass	6	13893	9.45 m³	750
Basic Wall: External Wall Euroclad Vieo Pri	18	209587	1322.43 m³	531
Basic Wall: External Wall Temp Cladding	1	74384	338.95 m³	478
Basic Wall: Generic Cladding - 2	3	12067	4.13 m³	338
Basic Wall: Wall type 3 - Stud Wall 100mm	2	5284	1.15 m³	100
Basic Wall: Wall type 5 - 60min Compartme	2	10181	1.95 m³	100
Basic Wall: Wall type 6 - 30min FR - 100m	7	46357	17.19 m³	100
Curtain Wall: Curtain Wall	2	11795	0.00 m³	
Curtain Wall: Curtain Wall interior	2	6883	0.00 m³	
Curtain Wall: Exterior Glazing 1	77	317898	0.00 m³	
Curtain Wall: RW 39 db	2	15463	0.00 m³	
Grand total: 506		2944073	2547.89 m³	

Figure 2 – Table of wall elements

UC203*203*52 9777

Structural Framing (Other) (1) — Edit Typ

Constraints	
Level	Default
Host	Level : Default
Offset	23727.3 mm
Moves With Nearby Elements	☐
Reference Level	
Construction	
Construction Phase	Week 20
Reusability	100
Materials and Finishes	
Structural	
Dimensions	
Volume	0.041 m³
Identity Data	
Phasing	
IFC Parameters	
IfcGUID	1L$2T9000Lc34qD38rE3an
Description (Attribute)	UC203*203*52
GlobalId (Attribute)	1L$2T9000Lc34qD38rE3an
Name (Attribute)	BEAM

Steel parametric data

Every element within the BIM environment contains many pieces of information and data that can be used in a variety of ways

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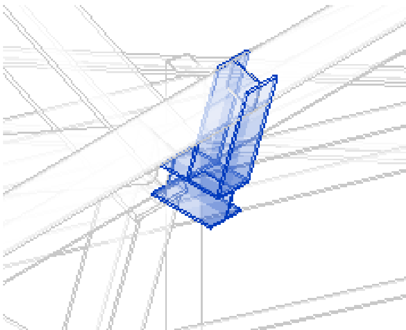
Through intelligently adding further appropriate data to all objects within the BIM environment provides for better grouping and decision making. The table in Figure 3 below has been generated by focusing on data assigned to the all the walls that contain concrete blocks. This allows future users to assess the viability of reusing all the blockwork by looking at the total volume of the blockwork and including allowance for possible breakage when deconstruction takes places.

<Concrete Block Wall Quantities>		
A	B	C
Family and Type	Length	Volume
Basic Wall: Generic Cladding - 2	12067	4.13 m³
Basic Wall: Int Partn 140mm Blockwork	18971	11.06 m³
Basic Wall: RW 40 db	1220391	418.89 m³
Basic Wall: RW 40 db plaster finish	12828	6.09 m³
Basic Wall: RW 45 db 2	50460	21.87 m³
Basic Wall: RW 50 db	60077	69.37 m³
Basic Wall: test	11196	3.33 m³
Basic Wall: Wall type 1 - 100mm Blockwork	36128	8.26 m³
Basic Wall: Wall type 2 - 140mm Blockwork	41071	26.27 m³
Basic Wall: Wall type 5 - 60min Compartment 100mm Blockwor	10181	1.95 m³
Basic Wall: Wall type 6 - 30min FR - 100mm Blockwork	46357	17.19 m³
Grand total: 301	1519726	588.41 m³

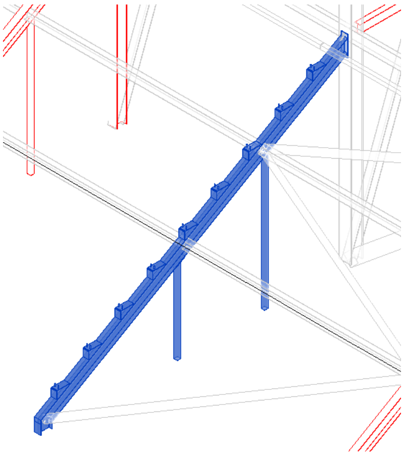
Figure 3 – Table of concrete block wall elements



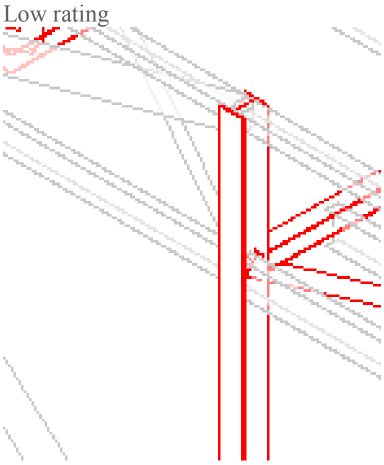
No reuse

Steel reusability grading

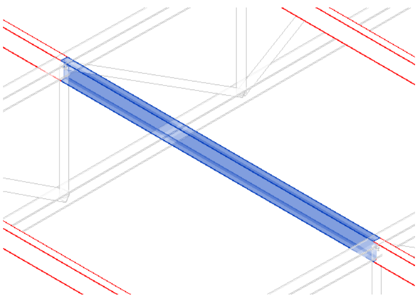
Every steel element was graded as either not reusable or to have a low, medium or high possibility of resuse..



Low rating



Medium rating



High rating

Assessing Reusability

Steel as a construction material is very versatile, in general has a long life if well treated and has a great opportunity of being 100% recyclable at the end of the project's lifecycle. It can also be reused as it was originally constructed on other projects without being melted down and recast, giving it a reusability factor. The IAW project hasn't been designed with deconstruction in mind, but the steel elements that have been used to construct it have varying possibilities for possible future reuse.

The grading of the steel for reuse can be measured in a variety of ways by weight, length, grade, profile etc., but which property of the steel is the most important? As in most cases, when choices have to be made there can be multiple options. These choices can be subjective and also dependant on the future unknown needs of the industry. The profile of the steel may be more important than the overall weight if we choose to reuse the steel as it is rather than melt it down.

It is with this in mind that a simple grading system was created based on the steel elements from the IAW model for use directly after its deconstruction. The reusability factor of the steel was graded to give an indication of possible reuse. For example, to have a low, medium or high rating as outlined below;

- Low rating – Bespoke steel elements created specifically for this project with limited options for reuse on other projects e.g. banked seating support structure and large span trusses

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- Medium rating – Steel elements that could be transferred to other projects but may need minor work carried out to adapt e.g. steel columns have multiple connections that may not be required on other projects
- High rating – Simple straight elements with simple end connections e.g. straight beams between the trusses.

By introducing this reuseability factor to the BIM data, future users of the building can quickly generate an idea of what elements could be reused well in advance of the deconstruction period. Figure 4 below, shows the simple straight sections with simple connections that have a high grade of reuse.

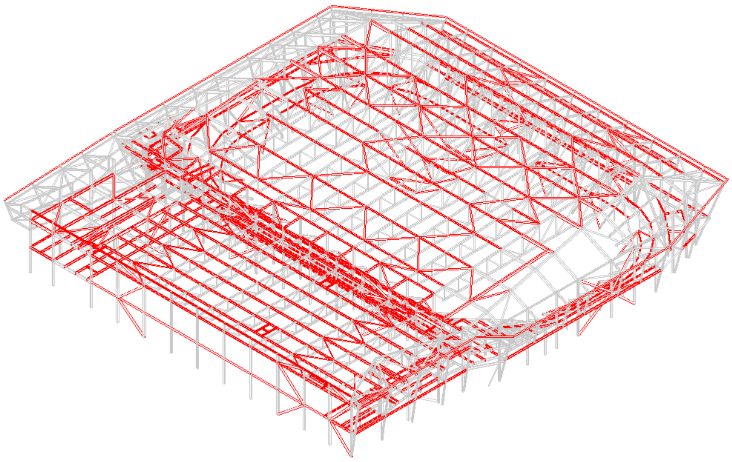


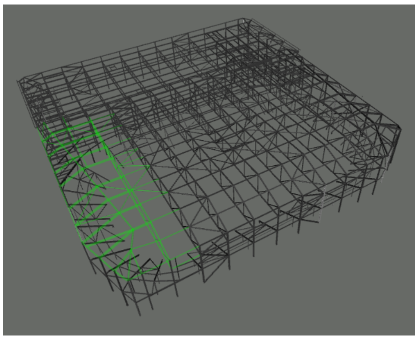
Figure 4 – Structural steel elements coloured red where there is a high grade of possible reuse.

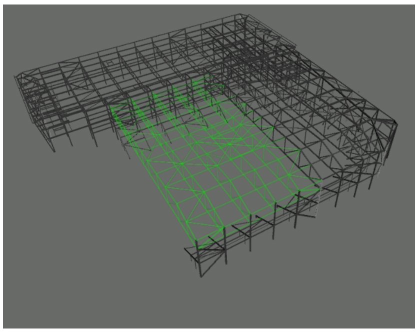
Deconstruction process

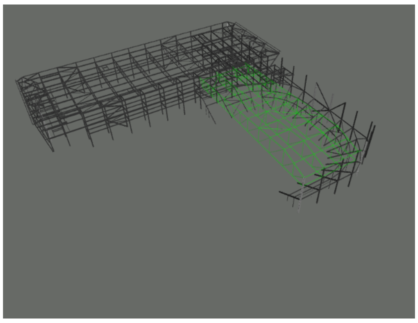
When buildings are constructed, they are planned and built in a specific way so that the right supports are provided, the correct machinery is used and health & safety procedures are followed. For the construction industry to fully access and utilise reusable materials from building in the future, such as the steelwork discussed above, it is essential that current practice provides a means to document the construction procedures required in order to disassemble buildings in a safe and efficient manor and maximise the recyclable materials

BIM technologies are a perfect platform to provide the functionality to add data to help this process. The elements within the IAW project were grouped in relation to when they were installed (as seen in Figure 5). Start and finish dates were added to the steel elements to show the construction timeline of the building process. These values were then reversed to utilise visualisation software to show the deconstruction process shown in the deconstruction images on the right.

Objects within the BIM environment can also hold data that can inform future users of any specific requirements needed when







Deconstruction timeline
BIM technology provides a means to record and document the construction process in a visual manor which can provide relevant information such as the building being deconstructed in a safe and secure way

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deconstructing the structure. This could be if supports are required, what machinery is needed to carry out the task and the correct order to carry out the dismantling process. Currently out of the box software used to generate timeline imagery is unable to elevate this data into the imagery in a meaningful form to provide warnings before deconstruction. That said, bespoke online web solutions can be generated that can catogorise all the recyclable data associated with all the elements of a building. These bespoke options come at a cost but could be a huge benefit for the Facilities management team.

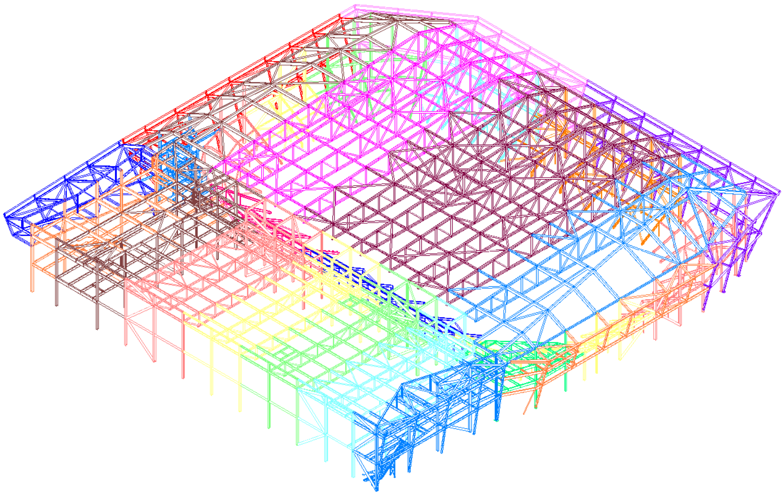

Figure 5 – Structural steel elements coloured based on the installation dates used for the deconstruction timeline

Summary

This study has shown that Design for Deconstruction (D4D) can be applied retrospectively to design and construction models through using BIM and a clear documentation process.

The utilisation of BIM on this project provided the team an efficient means to measure materials within the built environment that can be assessed at any time to quantify recycling. Even though reuse of building elements is a subjective process, BIM provides the means to validate it as a possibility.

Even though off the shelf technologies don't fully provide the requirements to show in a meaningful manner the deconstruction process, BIM allows for it to be fully documented for use in the future.

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