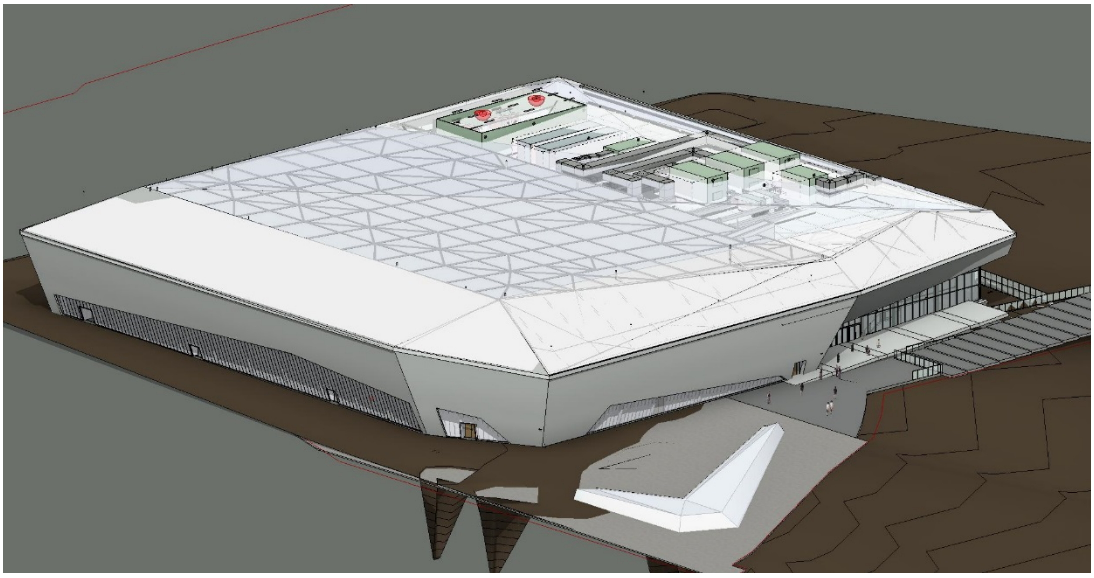
Constructing Excellence in Wales Building Information Modelling Enabling Zero Waste, Ice Arena Wales reducing waste, blockwork case study



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 who manage the 'Enabling Zero Waste' project have worked in collaboration with four live construction sites (and continue to work with) 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.

This case study will look at the functionality of utilising Building Information Modelling (BIM) on the IAW project, post-design to identify possibilities of reducing waste generated from repetitive items and define processes for reuse on future projects.

Study Objectives

- To identify and assess repetitive construction materials used on the scheme
- Use BIM methodologies to quantify waste generated through the design and construction process using these materials
- Develop practical solutions to help designers prevent and minimise waste on future projects.

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Utilising BIM for automation

BIM is broadly accepted across the construction industry as a process enhanced by the use of digital technology. The combination of the BIM process and technology allows designers to access, retrieve and implement vast amounts of data relevant to construction materials and components used within the construction process. Through efficient access to this data, designers can improve the design and eventual completed project. The design team on the IAW project implemented BIM technologies to create the two storey large open spanned building.

Construction items such as brickwork, blockwork, plasterboard and timber can be ordered in bulk, in predefined sizes and erected on site as needed. These items however, are identified as those that provide a high percentage of skip waste due to localised cutting. Blockwork in particular, is the main construction material for the internal walls of the IAW and has been identified as an item for testing waste reduction within the design process.

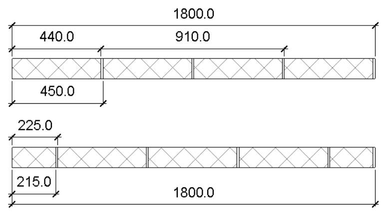
Waste Calculations

In general, the internal partitions are mainly constructed through the installation of concrete blockwork walls in a variety of shapes and lengths. The base element of these walls are concrete blocks that come in a variety of widths, but in general are 440mm long x 215mm high which intergrate nicely with standard construction dimensions for doors and windows.

On completed project plans, it is very rare for wall lengths to be designed to match blockwork lengths since concrete blocks are relatively cheap to purchase and build with. On the IAW project, the ground floor contains 220 concrete blockwork walls which are in general 4890mm in height, equalling 4840 blocks to be cut at that level. This equates to a lot of time for cutting blocks and possible waste generation.

BIM technology however, provides a method to list information of elements in a variety of ways including the data of individual objects (such as the wall example shown right) or in schedules (such as the example shown in Figure 1). The schedule lists basic construction data of the concrete walls contained within the modelling environment. The data shown in the schedule includes the level it's based from, the type of wall and its length; all of which can be used by the contractor and quantity surveyors to calculate quantities and costs for the project.

These schedules however, can be adapted to carry out a series of predefined calculations. For use on this waste case-study, the length of the wall was assessed against the number of blocks (full 450mm or half 225mm) required at each course and used to work out what length any resultant offcut would be.



Blockwork dimensions
Based on the dimensions of the block work shown above we proposed to base our calculations on a standard unit that equalled a half block (225x225mm including mortar).

Constraints	
Location Line	Core Centerline
Base Constraint	Level 01
Base Offset	0.0
Base is Attached	☐
Base Extension Distance	0.0
Top Constraint	Up to level: Level 01 Soffit
Unconnected Height	3233.0
Top Offset	333.0
Top is Attached	☐
Top Extension Distance	0.0
Room Bounding	☑
Related to Mass	☐
Text	
Structural	
Structural	☐
Enable Analytical Model	☐
Structural Usage	Non-bearing
Dimensions	
Length	4000.0
Area	12.932 m^2
Volume	1.371 m^3

Wall 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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Wall Schedule			
Base Constraint	Family and Type	Length	Material Type
Level 00	Curtain Wall: Exterior Glazing 1	5476	
Level 00	Curtain Wall: Exterior Glazing 1	2304	
Level 00	Curtain Wall: Exterior Glazing 1	5476	
Level 00	Basic Wall: RW 45 db 2	4767	Concrete Block
Level 02	Basic Wall: External Wall Euroclad Vieo Prisma Standing Seam	25629	
Level 00	Basic Wall: Wall type 1 - 100mm Blockwork	2711	Concrete Block
Level 00	Basic Wall: RW 45 db 2	5279	Concrete Block
Level 00	Basic Wall: RW 45 db 2	3281	Concrete Block
Level 00	Curtain Wall: Exterior Glazing 1	22966	
Level 00	Basic Wall: Wall type 2 - 140mm Blockwork	2541	Concrete Block
Plaza level	Basic Wall: External Wall Temp Cladding	74384	

Figure 1 – Wall schedule listing types and lengths

For example, the 4767mm long wall selected in Figure 1 above we have carried out the following calculations:

No. of full blocks = 4767 / 450 = 10.59 (10 full blocks required with 267mm surplus)

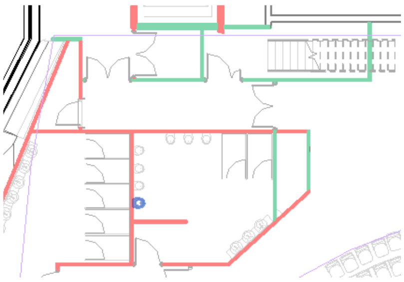
No. of half blocks = 4767 / 225 = 21.18 (21 half blocks required with 42mm surplus)

Waste Wall Schedule				
Length	Number of full Blocks	Number of Half Blocks	Waste Check	Length Left Over
3563	7	15	WASTE	188
1563	3	6	OK	213
6305	14	28	OK	5
1000	2	4	WASTE	100
2800	6	12	WASTE	100
2800	6	12	WASTE	100
1740	3	7	WASTE	165
2380	5	10	WASTE	130
6305	14	28	OK	5
2377	5	10	WASTE	127

Figure 2 – Wall schedule listing lengths and waste calculation results

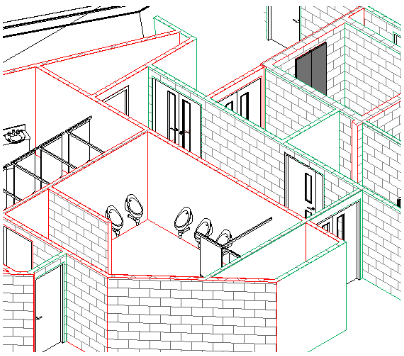
The schedule (in Figure 2 above), shows these simple calculations in action, providing automated design information that can improve decision making. The schedule has also been formatted so that colour and text are used to identify where lengths indicate waste and need to be reduced, or increased in length to remove the possible waste. The length left over is based on half block lengths with a tolerance of +/- 30mm. The schedule in Figure 3 (on page 4), shows where certain walls have been decreased in length to remove the possible waste.

This process can be quickly adapted to other data sources such as 3D views, elevations and plans. The examples to the right show visually through colour, where walls can be identified as producing left over waste and where changes may need to be made. BIM technology provides the ability to save these view types to be used on future projects from the outset and to encourage waste reduction.



Colour coded plans & 3D Views

By utilising parametric data to respond to values associated to colour we can quickly identify all walls that currently will produce block waste through offcuts as shown in red



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Waste Wall Schedule				
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1563	3	6	OK	213
6305	14	28	OK	5
1000	2	4	WASTE	100
2730	6	12	OK	30
2730	6	12	OK	30
1740	3	7	WASTE	165
2380	5	10	WASTE	130
6305	14	28	OK	5
2377	5	10	WASTE	127

Figure 3 - Wall schedule demonstrating waste calculation results

The predefined formulas within the schedules can be adapted further to calculate the number of blocks required, the amount of waste in block totals and the possible cost value of that waste. If taken further, this could be combined with the amount of man hours required to carry out all the extra cut blocks

The total waste on the project from the concrete walls can also be calculated. The table in Figure 4 (below), shows the total waste length for the project. This is for only one course and needs to be multiplied by the number of courses. For this example the floor to floor height is 4890 equalling 22 courses. This gives a total waste length of blockwork of 773m.

4000	8	17	WASTE	175
2399	5	10	WASTE	149
Grand total: 301	3230	6598		35176

Figure 4 – Total concrete blockwork wall waste.

Implementing the tools

It is essential that these tools are understood before implementing on future projects. The examples below in Figure 5 show the result of walls being reduced in length to remove waste. What the images don't show, is that the room area and dimensions may not comply with the standards used to create them. Care must be taken when implementing retrospectively.

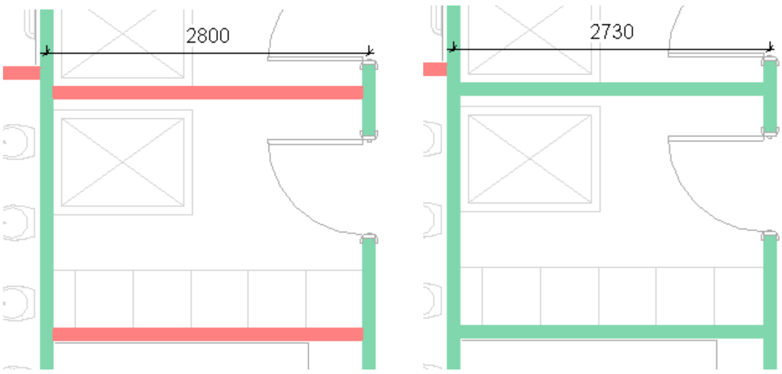

Figure 5 – 'Before' and 'After' images showing wall length reduction

There will also be instances – especially on this IAW project – where the angled walls, not only in plan and elevation, will have cut lengths regardless, so reducing the length may not be of any benefit. The curved structure of the ice arena will also cause problems as the

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associated walls will be constrained due to the precise requirements of the ice rink.

When designing a building, the primary function of the architect is to provide all the rooms and transitional spaces that allow the building to function efficiently and provide a positive experience for the end user. It is with this in mind that it is not always possible to utilise the lengths of blockwork walls to match block lengths. Situations will, and do, occur where the room functions, adjacencies and floor areas will be more important and quite rightly the focus of the design team.

The tools are also not there to reduce materials, but to reduce waste. In some cases the walls may need to be increased to efficiently remove the waste without drastically changing the areas of the rooms affected. The two images below in Figure 6 show the totals for the ground floor 'Before' (top image) and 'After' (bottom image) for a area containing 20 walls which were amended. The figure on the right of each table shows the waste length has decreased from 26.193m to 25.591m however, the total number of blocks required has increased.

2225	4	9	OK	200
Grand total: 220	2442	4975		26193

2225	4	9	OK	200
Grand total: 220	2447	4980		25591

Figure 6 – Before and after schedule totals for an area where 20 walls were amended to reduce waste

Summary

This study has shown that through the introduction of BIM and its technology on a project, design and construction teams can decide, define and implement from the outset processes to help reduce waste. The implementation of BIM can dramatically assist in the assessment of repetitive elements used.

The study has shown that combining new processes with the automation of BIM will help designers and contractors quickly identify waste, provide the opportunity to create savings and grow the value of the scheme. Through the introduction of the predefined schedules and view templates, the design and decision making process can be improved and the visual representations saved and reused on future projects.

On its own, the blockwork example will not make a dramatic impact on waste reduction. But through amending the processes and templates above to suit different construction materials such as plasterboard, timber and ceiling tiles, the whole construction process can start to make a bigger impact on waste reduction.