Enabling
ZERO WASTE

Ice Arena Wales

Noddir gan Lywodraeth Cymru
Sponsored by Welsh Government

ADEILADU ARBENIGRWYDD YNG NGHYMRU
CONSTRUCTING EXCELLENCE IN WALES

Contents

Ice Arena Wales

1 Executive Summary

Enabling Zero Waste (EZW) is a Constructing Excellence in Wales (CEW) initiative which aims to establish if and how, the construction industry can achieve the zero waste targets established in the Welsh Government's waste strategy document Towards Zero Waste.

CEW is working in collaboration with the industry to provide a detailed insight into the achievability of zero waste at present, along with identifying any associated barriers to achieving the targets, and disseminating best practice, solutions and opportunities.

The Ice Arena Wales is a £17.5million development of a two pad ice rink situated in Cardiff Bay on a remediated former municipal landfill site, built by Kier Construction Ltd (Kier) with the design from Scott Brownrigg. Kier were procured in 2013 by Greenbank Partnerships Ltd, developers of the final phases of the International Sports Village and the adjacent Cardiff Pointe housing scheme. The Ice Arena is home to the Cardiff Devils Ice Hockey team with facilities capable of holding European and Olympic standard events.

In total 4185.16m^3, (3945.63 tonnes) of waste was produced during the project. Of this waste, 2869.22m^3 (68.56%) was reused, 1002.15m^3 (23.94%) was recycled, 273.17m^3 (6.53%) was sent for energy recovery at Trident Park (Cardiff), a R1 status facility for energy efficiency and 40.62m^3 (0.97%) was sent to landfill.

The project recorded 100% recycling rates for (wood, metal and inert material) out of the nine waste streams generated. The project achieved a 99% diversion of waste from landfill. Falling slightly short of the zero waste aim, this demonstrates a great achievement and highlights that zero waste to landfill is achievable. The project exceeded the Welsh Government's current target of 70% of all waste, by weight, shall be prepared for reuse, recycled or recovered by 2015/16, and went beyond the future waste target that 90% of all waste be prepared for reuse, recycled or recovered by 2019-20.

The project has highlighted the benefits that Building Information Modelling (BIM) and early discussions with the design team can bring to identifying and realising opportunities for waste prevention and minimisation. The project focused on preventing and minimising waste from construction, whilst examining end of use deconstruction opportunities.

CEW commissioned Arup to investigate the following factors:

Design for Deconstruction (End of Life) - to investigate what materials could currently be reused and recycled at the end of the building's life, providing a method to document the recyclable value of materials through BIM and to define a method that outlines the most opportunistic way to deconstruct the building to maximise savings.

Blockwork standardised dimensions - an investigation utilising BIM on the IAW project post design, to identify possibilities of reducing waste from repetitive items, standardisation and define processes for reuse on future projects.

Reducing pile waste – an investigation utilising BIM post design and construction to assess and compare the structural pile foundation designs to see if there were any possibilities of reducing waste.

Successes experienced during the project include:

- Engagement with the supply chain and the implementation of a take back scheme working with Euroclad.
- Waste prevention measures.
- Four segregated waste streams including inert stones and tiles, non hazardous wood, metal and plasterboard.
- Concrete pile offcuts and inert materials retained and crushed to be recycled on site.
- 93 tonnes of wood waste were sent to Reseiclo, a community wood recycling scheme. Community Wood Recycling shows high records of both wood reuse and recycling.
- Cost savings achieved on the project equate to approximately £40,000 through the segregation of waste; designing out waste and through the use of recycling schemes.

In summary, the report makes the following recommendations:

Client recommendations

- Assess infrastructure currently available for dealing with wastes that will be affected by the upcoming landfill and incineration material bans.
- Consideration needs to be undertaken to assess specific products and disposal options, as some products used on the project were found to be problematic when disposing of.
- Ongoing communication with design consultants and contractors is crucial.
- Pressure applied to complete a project can cause a fall in adherence to site practices, such as waste segregation.

Designer recommendations

- Consideration to the standard sizes of materials during design.
- Engagement with contractors to improve material understanding.
- Awareness of how intricate design affects waste.
- The importance of designing for deconstruction.
- The importance of using Building Information Modelling to identify and prevent clashes from occurring and consequently saving time, resources and money.

Contractor recommendations

- The importance of segregating waste at source. Focussing and discussing waste strategies throughout all stages of the project to all members involved on site.
- Ensure all skips are checked daily and inform site operatives to maintain waste segregation in the correct skips. This can be achieved through clear skip signage, maintaining a clean site and where possible fencing off all segregated skips.
- It should be a priority for contractors to have a member of the site team who takes ownership for waste management. In addition, it is crucial that the person responsible for producing waste forecasts makes regular contact with the site team to ensure that forecasts are achievable, reasonable and based on previous performance.
- The importance of identifying end destinations of all waste types through early discussions with the chosen waste management company, prior to engaging into a contract.

If the forthcoming Environment (Wales) Bill were applied to this project up to 273.17m^3 of material would require an alternative disposal solution. This highlights the need to research alternative disposal options, along with the appropriate infrastructure necessary to enable the changes required by the legislation.

2 About

2.1 Enabling Zero Waste

Enabling Zero Waste (EZW) is a Constructing Excellence in Wales (CEW) initiative providing practical, positive and active intervention to establish if, and how, the construction industry can achieve the overarching strategy target of zero waste to landfill for waste in Wales, together with identifying associated barriers by working with live construction sites.

CEW is working in collaboration with the construction industry to offer practical assistance to construction projects and site teams to explore viable solutions to achieving zero waste. The project provides a detailed insight into the achievability of zero waste to landfill at present.

Project objectives

- To understand and evidence when and how wastes occur during the construction process
- To understand current strategies, methodologies and opportunities for the landfill diversion of on-site wastes
- To analyse the feasibility/viability of achieving zero waste to landfill in the current environment
- To work to develop solutions to prevent and minimise the generation of on-site waste, generating a reduction in waste management, disposal and landfill costs
- To support changes to behaviour and processes that encourage prevention and minimisation of waste
- To achieve site efficiencies from waste management opportunities/solutions – reduction in deliveries, improved site traffic, reduction in supplies and material costs, operational productivity
- To disseminate the solutions and opportunities from the development of effective waste management strategies
- To provide learning and education opportunities regarding alternative waste management techniques which can be disseminated for future projects ensuring continual benefits

This report has been prepared after site completion to present the outcomes, opportunities and achievements of the project

2.2 About Kier

Kier Group has over eighty years of experience in construction. Projects range from property; defence; education; housing; industrial; power; transport and utilities. The Group employs over 24,000 people in its operations in the UK, the Caribbean, the Middle East and Hong Kong.

3 Project Background

The Ice Arena Wales is a high profile £17.5m private investment involving the development of a two pad ice rink on the remediated former municipal landfill site at Cardiff Bay. The development is a focus for ice sports in the UK and offers seating for approximately 3000 spectators along with a café and private event facilities. The building is a commercial template composite metal and backlit polycarbonite cladding on a trapezoidal steel frame.

The project commenced in February 2014 with the design of the Ice Arena finalised prior to the Enabling Zero Waste team engagement. Planning permissions were in place, contractor, tier one sub-contractors, suppliers and waste management contracts had all been appointed.

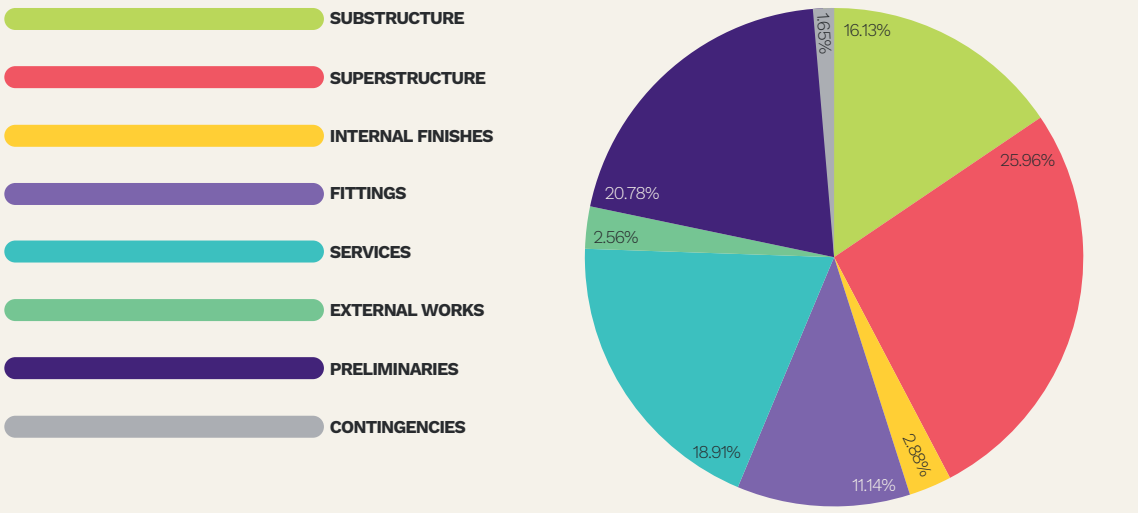
The project experienced a break in construction between October 2014 to April 2015. Cladding and roof works were completed in the initial phase to enable the ice rink to be weathertight. On site Kier reduced their construction staff due to the break in site activities. When construction recommenced in April 2015, there where changes in staff and management. With these staff changes the site waste management was impacted, there was a loss in general management guidance and there was no longer a waste champion in situ at the site. The project was completed in January 2016.

3.1 Cost

Original Value – £17.5 million

Contract Value (circa)	£17,500,000
Element	**Percentage**
Substructure	16.13%
Superstructure	25.96%
Internal Finishes	2.88%
Fittings	11.14%
Services	18.91%
External Works	2.56%
Preliminaries	20.78%
Contingencies	1.65%

PHASING COST



ADEILADU ARBENIGRWYDD YNG NGHYMRU | CONSTRUCTING EXCELLENCE IN WALES

3.2 Contract type

JCT, Design & Build 2011. Originally a 71 week programme, one week extension of time given, completed on a 72 week duration.

4 Methodology

Each EZW project is provided with a tailored work plan/ methodology. The content was developed with the project team and designed to enhance any existing measures being undertaken.

For the duration of the project, the Kier project team were provided with:

1. Technical waste management support and guidance for the duration of the site construction to assist with the pursuit of zero waste to landfill
2. A specific waste management resource allocated to provide hands on support with site waste management and to deliver potential zero waste options/solutions for site waste issues. This assistance included:

- Onsite visits
- Waste management support advising upon increased segregation
- Identification of materials used on site
- Reduction in waste by encouraging good housekeeping to reduce damage and over ordering of materials
- Reduction of waste through re-use or finding alternative solutions to disposal
- Assistance with working with the site supply chain, clients and waste management companies to encourage take back schemes, wider education and increased waste data quality
- Preparation, monitoring and update of a Site Waste Management Plan (SWMP) using a Kier specific version of BRE's SMARTWaste
- Preparation of a Building Information Model (BIM) of the site, prepared from information supplied by Arup and Keller
- Review and optimisation of the design using BIM to minimise waste, analyse and estimate the volume and type of waste arisings, and identify potential on site clashes

In total, thirteen waste management support site visits were undertaken as part of Enabling Zero Waste, which included discussions with the site team regarding current site and waste issues, progress, potential solutions and improvements. Support was also provided to the site team with regard to recording data onto SMARTWaste. After every site visit, recommendations were issued to assist in improving waste management practices.

The principal waste management recommendations were to:

- Improve signage, segregation and storage of materials
- Set up a dedicated waste compound
- Identify possible supply chain take back schemes
- Identify a waste champion to review and ensure that legal compliance and waste management best practices are met
- Undertake toolbox talks to raise awareness of waste prevention and reduction
- Engage with supply chain for packaging minimisation and/or removal service

Associated documentation and guidance regarding the above was also provided

Building Information Modelling (BIM) was undertaken as part of the project to identify blockwork wall setting out and look at possible reductions in waste mainly through hypothetical design or material changes.

Aerial drones were also used to capture progress throughout the project. Communications involved regular updates via twitter, update events, webinars and presentations.

5 Data Analysis

5.1 Analysis by project phase

In total, 4185.16m^3 (3945.63 tonnes) of waste was generated through the construction of the project.

5.1.1 Groundworks

In total, 2797.86 m^3 of waste was produced during the groundworks phase, 66% of overall waste arisings. 2571.14 m^3 of the groundworks waste produced was earthworks, 91.89% of the groundworks total. The soil material was later reused as fill around site.

Groundwork subcontractors E&T L Jones generated the remainder of groundworks waste as follows: 15.42 m^3 was of a mixed waste nature, 4.7 m^3 of timber, 3.79m^3 of plastics, 1.1 m^3 of packaging material, 0.74 m^3 of metals and 0.97 m^3 of canteen waste.

The site is complex being a former municipal landfill site, there are possibilities of movement and gas seepage when settlement of the building occurs. To overcome these problems, Arup the design engineers introduced a series of concrete piles to support the structure and structural buried wall.

In order to distinguish the length of the piles depending upon the local geology of the site, an extensive ground survey was carried out by subcontractors Keller. Following collaboration between Arup and Keller additional piles, ground beams and some pile caps were slightly amended to the project's original design.

Waste, when installing concrete piles is unfortunately unavoidable as the below ground conditions can change dramatically throughout the project, no matter how well the ground is tested. 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. Concrete and inert waste were stockpiled on site with a crusher delivered to recycle into aggregate and reuse on site under the WRAP Quality Protocol.

In total 200m^3 of concrete material was crushed and recycled as hardcore.

5.1.1.1 Structural Steelworks

The steelwork phase accounted for 67.79m^3, 1.61 % of total arisings. Just over 45 % of the waste was of a timber nature 30.57m^3. Of the remaining, the majority was mixed waste 16.7 m^3, comprising 24.63 % of the total for this phase. Other wastes produced included 4.41 m^3 plastics, 3.85 m^3 bricks, 3.12m^3 packaging material, 2.57m^3 concrete, 2.2m^3 soil, 1.28m^3 metals and the remaining comprised canteen waste (3.09m^3).

5.1.1.2 Other Structural works: roofing, elevation treatments and internal structure

For these elements, 560.95 m^3 of waste was produced, 13.4% of the total waste arisings. The majority of waste produced comprised of inert waste 205.7 m^3, timber and mixed wastes. Total figures for mixed waste in this period were 58.74 m^3 with similar quantities of timber, at 54.02 m^3.

The insulated roof panels produced 3.33m^3 of offcuts during this period. A take back scheme was set up for the material as later discussed in section 7.9.

Other waste streams comprised packaging materials, plastics, canteen waste and mixed waste streams, not clearly specified on SMARTWaste.

Elevation Treatments – Photograph provided by Scott Brownrigg

5.1.2 Finishing Trades

In total, finishing trades produced 420m^3 (10.03% of total arisings) of waste. The majority of which was of a mixed nature (57.40%). Details by trade or activity are as follows.

5.1.2.1 Plasterboard, partitioning and cladding

Plasterboard waste comprised 70.64 m^3 from activities undertaken by the finishing trades, 16.87 % of the total waste arisings for all finishing trades.

The plastering package was carried out by Richard Kemble contracts (RKC). A pre-let meeting was undertaken between CEW and RKC in order to highlight waste management issues and discuss opportunities to minimise waste from packaging, plasterboard and insulation. A toolbox talk was carried out by CEW on minimising waste on the 5th August 2015, attended by ten RKC operatives and two Kier site labourers.

A number of weeks into the project, waste segregation issues were highlighted. Operatives were found not to be segregating waste within the work areas, leading to contamination of skips with either plasterboard or insulation. Different coloured bins were purchased as part of the EZW initiative which enabled labourers to segregate waste more easily within their own work areas. Waste segregation practices did improve as a result of this, however, cross contamination still did occur.

Plasterboard skips were the responsibility of RKC and stated within their contract. Due to time restraints and contractors working on price per m^2 laid, operatives were reluctant to move far from work stations for usable offcuts. As such, often new sheets of plasterboard were used for cuts.

The plasterboard waste was removed by Atlantic skips who achieve a recycling rate of 98 % for plasterboard material, however, due to some plasterboard waste ending up in a mixed waste skip, this impacted on the rate reducing it to a figure of 97 % overall.

5.1.3 Joinery, decoration, roof insulation, vinyl flooring and carpets

5.1.3.1 Joinery

The site produced 166.25 m^3 of timber waste during this period. The majority of timber waste was sent to Reseiclo Newport, a social enterprise who reclaim the wood for resale and upcycling. A breakdown of the wood waste that was reused and recycled from the scheme is shown in the following table:

Wood collected (cubic yds)	934	
Wood collected (tonnes)	93.4	
Savings £ versus the cost of using a skip	£3,212.96	
High Grade Reuse (DIY, wood products, pallets)	tonnes	%
	26	28
Low Grade Reuse (Firewood, kindling, allotments)	tonnes	%
	2.8	3
Recovery (Chipped for fuel, chipboard)	tonnes	%
	64.6	69

More 'problematic', lower grade timber, a sum of 26m^3 was removed by Oliver's skips which was later sent to Bryn Quarry for recycling.

There were several distinct peaks in timber waste arisings throughout the project. In August 2016 47.17 m^3 of timber waste was produced. The site programme shows a carpentry second fix and fittings during this period which would account for this peak in timber waste.

Another significant increase in timber waste was highlighted in January 2016 (41m^3) which coincided with site completion, clearance and a clear out of store cabins where timber had been stored over the duration of the project.

5.1.3.2 Flooring

A discussion was held with the floor layers on site in regards to the rubber matting offcuts produced. Kier later informed the EZW team that the flooring company was responsible for disposing of any floor waste produced by the company.

Emails were sent to the subcontractor to discuss the EZW scheme and offer assistance in directing the rubber matt flooring for reuse or recycling. No reply was received and no floor covering waste data was present on SMARTWaste.

5.1.4 FFE and Site clearance

In total, 338.04 m^3 of waste was produced from these activities. 240.32 m^3 was of a mixed waste nature, 71% of the total waste produced from the site clearance. The remainder comprised packaging waste 41.39 m^3 (12.24% of the site clearance total), 47.38 timber, 3.67 m^3 bricks, 2.01 m^3 plastic, 0.2 m^3 furniture, 2.34 m^3 of canteen waste and 0.73 m^3 for other waste streams not specified on SMARTWaste.

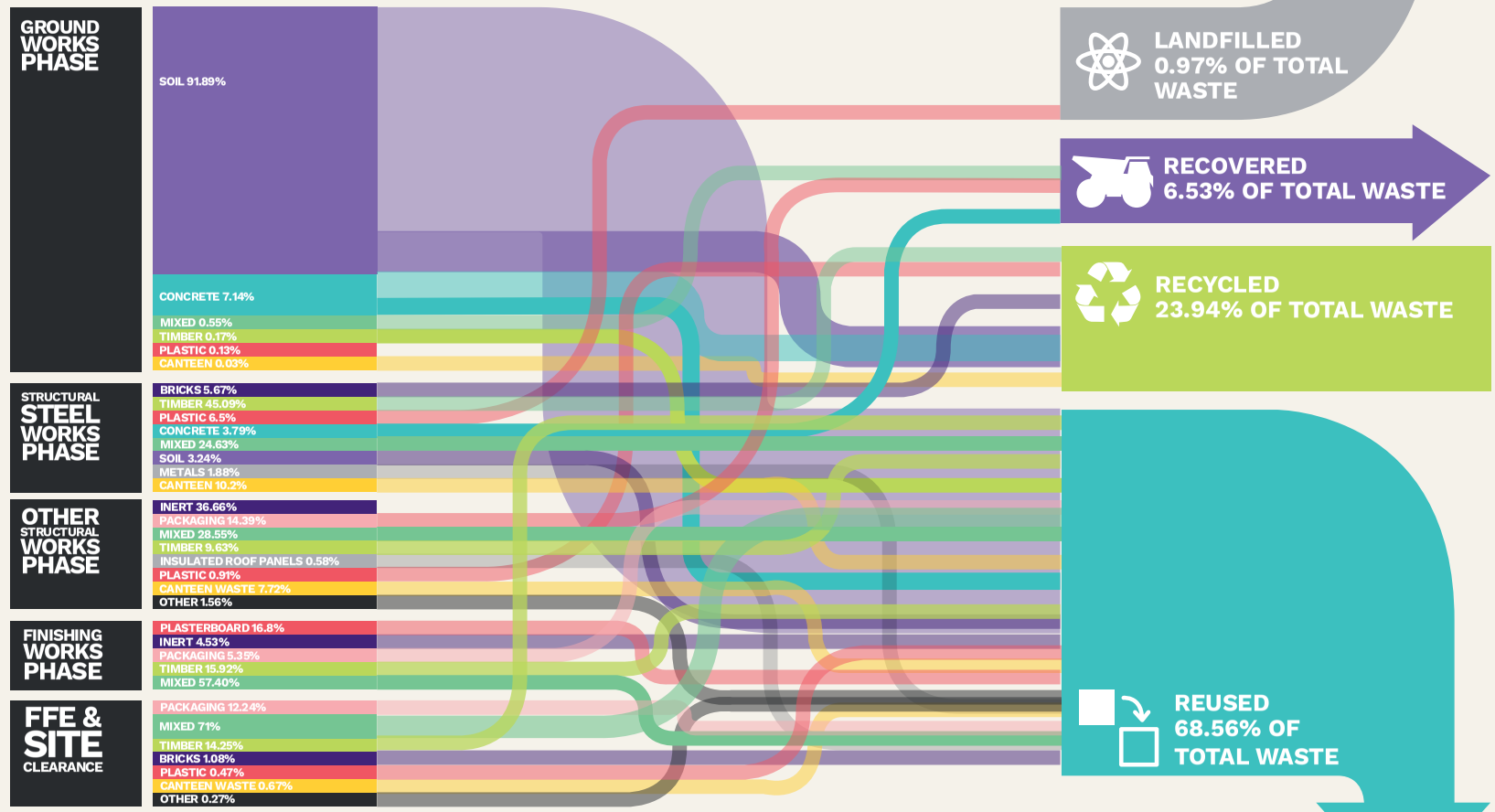
Due to large amounts of floor protection used throughout the project, CEW recommended using a pilot take back scheme provided by Protec. The service offers a removal of used protective sheeting with a 100% recycling rate back into new product. The cost of this initiative consists of approximately £343.00 per tonne of protection waste.

Kier took the decision to utilise the Protec sheets on other projects, avoiding the material from being classified as waste and avoiding landfill. In total Kier purchased 750 sheets, 7.5m^3 of protective sheeting from Protec.

The significant amount of mixed waste recorded during this time period, is considered likely to result from time pressures with regard to the handover deadline.

ICE ARENA WALES

END DESTINATION OF WASTE REMOVED FROM SITE



5.2 Analysis by programme

Between October 2014 to April 2015 a decision was made by the developers to suspend the construction of the building due to financial constraints. During this period site activity was minimal with a small amount of waste produced due to the site closure.

During the programme, there were distinct peaks in waste generation. The possible reasons behind these peaks are outlined below:

5.2.1 March 2014 Peak

In March the majority of waste consisted of soils, 2570m^3 in total due to a movement of earth through groundworks activities. All soil waste was stored on site and later used for fill. 7.71m^3, of waste arisings in March were of a mixed nature. The remaining waste arisings produced included 0.37m^3 of packaging, 1.29m^3 of timber and 0.37m^3 of scrap metal.

5.2.2 August 2014 Peak

In August, just under 28m^3 of waste was produced. 13.89m^3 of the waste was of a timber nature, 5.32m^3 consisted of mixed waste, 2.2m^3 of soil, 1.1m^3 of scrap metal, 3.49m^3 of plastic waste with the remaining 1.5m^3 comprising inert and packaging waste.

During this period, groundworks were coming to an end which may be the reason for an increase of timber waste as shuttering works were dismantled and disposed of.

Groundworkers also produce plastics and scrap metal arisings due to rebar and pipework offcuts and also material packaging for bricks and fittings. Damp proof membrane (DPM) packaging waste streams will also be produced during these activities.

A small volume of sub soil, 2.2m^3 was added to the original soil stockpile later to be reused for fill.

5.2.3 July 2015 Peak

In July, a total of 60.95m^3 of waste was produced. Almost half of the waste was of a mixed waste nature (29.37m^3). 9.14m^3 consisted of brick waste, packaging produced 6.9m^3, timber 6.42m^3, and plastic waste totalled 4.56m^3. 4.56m^3 of canteen waste was also produced, the highest amount shown throughout the project, which indicates that site operatives reached their peak attendance during this month.

5.2.4 November 2015

In total 157.14m^3 of waste was produced during this month. The programme indicates that this was a peak time for finishing trades completion. 104.57m^3 of the total for the month of November consisted of mixed waste. The remaining waste streams comprised 22.47m^3 packaging waste, 16.97m^3 timber, 5.51m^3 bricks,3.67m^3 concrete, 0.79 plastics, 2.14m^3 canteen waste and 1.02m^3 of remaining other unspecified waste streams.

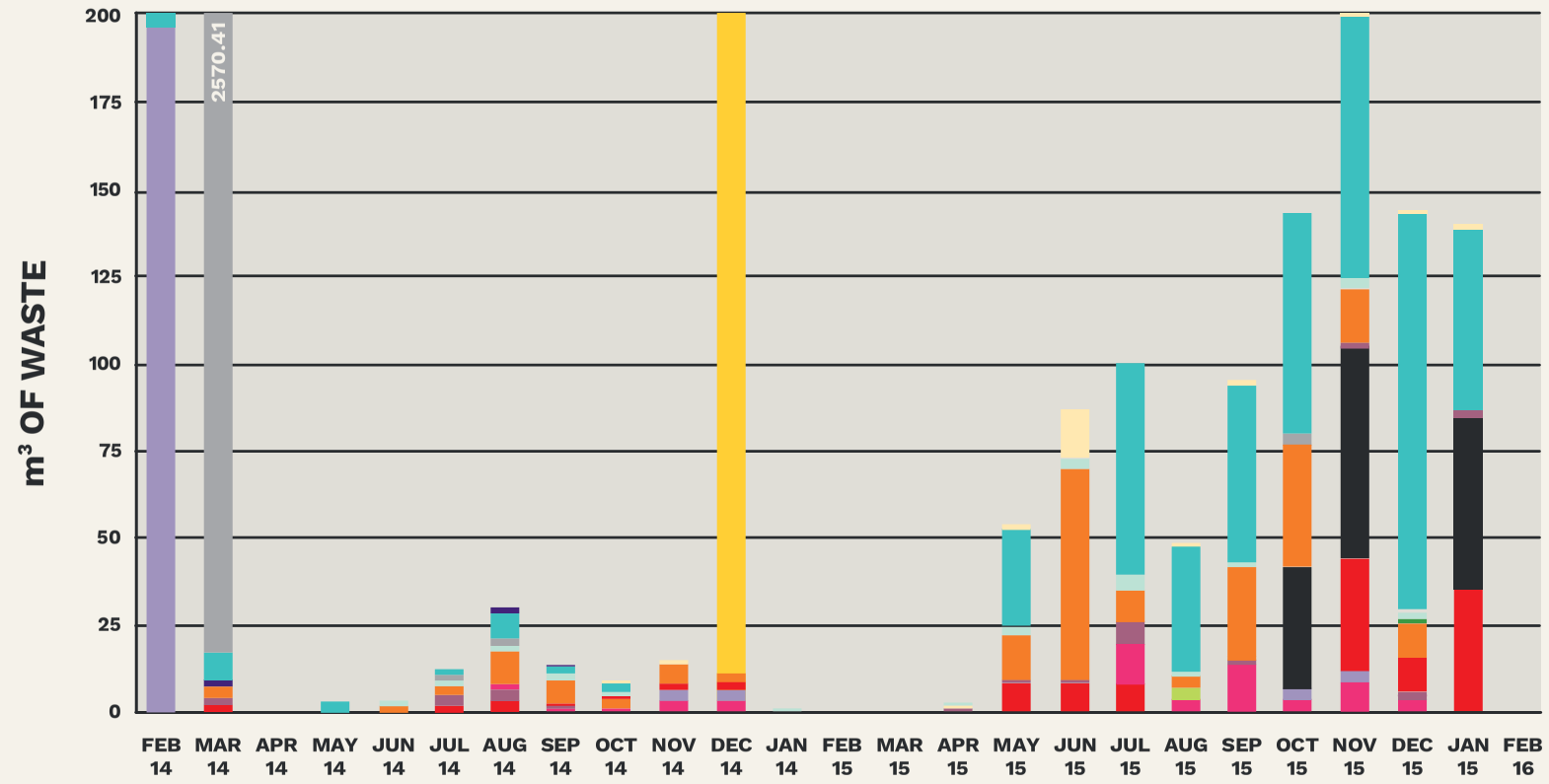
The significant quantities of waste produced, over two thirds being of a mixed waste nature highlights the impact that time constraints for the site to complete the project can have on waste management and performance.

5.2.5 January 2016 (Site Clearance) Peak

In total, 189.27 m^3 of waste was produced during the site clearance. 111 m^3 of the waste produced was of a mixed nature. In order to avoid large quantities of mixed waste being produced on site, emphasis on waste segregation is required from the site team to avoid mixed waste skips leaving site.

The reason behind the high quantities of mixed waste is understood to have resulted from handover pressures.

MONTHLY WASTE BY TYPE m³



ADEILADU ARBENIGRWYDD YNG NGHYMRU

CONSTRUCTING EXCELLENCE IN WALES

6 Analysis by waste management option

6.1 Prevention

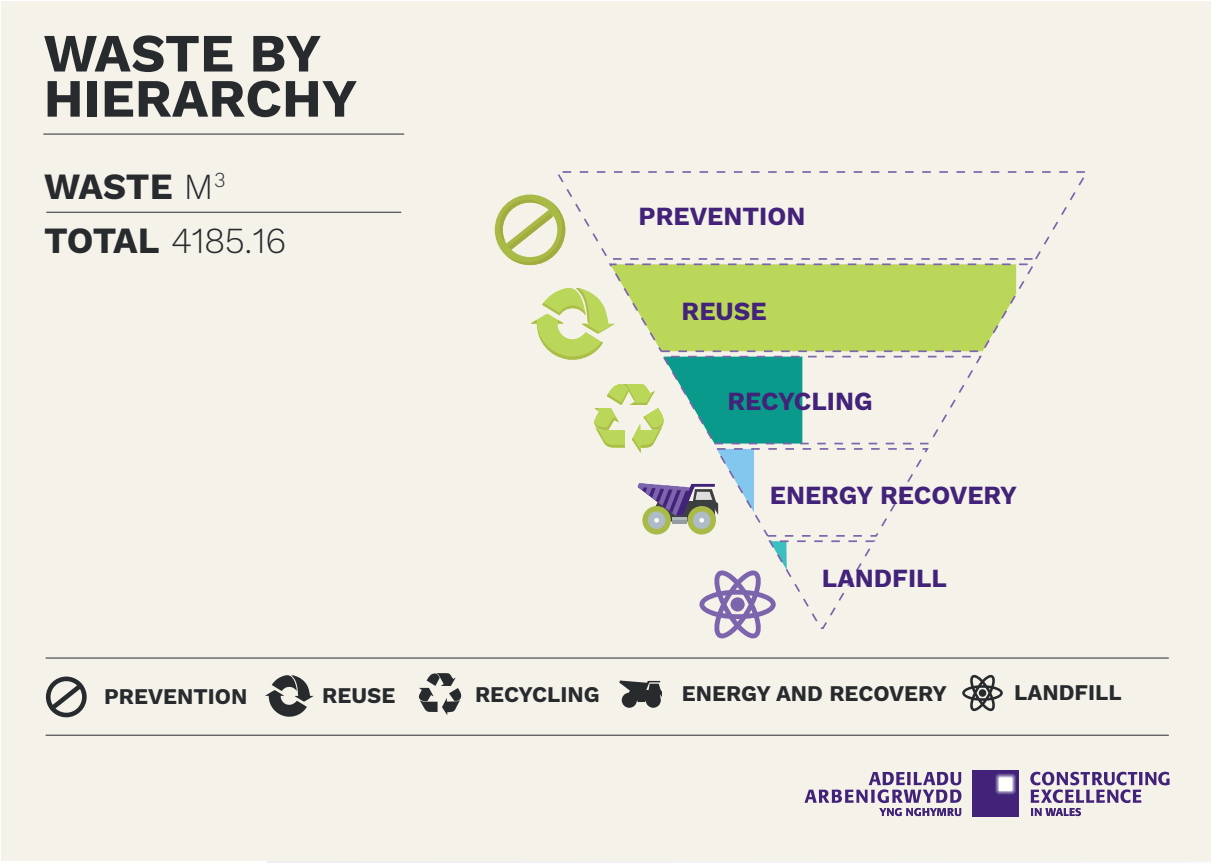
6.1.1 Packaging

With encouragement from the EZW team Richard Kemble Ltd (plastering contractors), made contact with their plasterboard supply chain to request that plasterboard packaging was reduced to a minimal quantity when boards were delivered to site. All plasterboard was stored within the building to protect from the rain. Approximate volumes resulting from the above are estimated to equate to 1.5 m^3 of waste savings.

Millstream contractors produced 100 cardboard boxes totalling 17kg and 6000 shrink wrap bags reaching a total of 15kg. All packaging waste material was sent back to Millstream premises for bulking and recycling.

6.1.2 Clash detection exercise (concrete staircase)

A BIM exercise crosschecking the 2d information with the model identified that the concrete staircase design did not fit with the steel frame terraced seating – some stairs were cutting through the seating areas which is not allowed as it creates a trip hazard. This was amended in the design stage with the staircase redesigned prior to being precast. Savings have been calculated for time and material costs for rework had the incorrect staircase arrived on site, these are in the region of £30,000 - £40,000, half the original cost of the staircase. No volume/weight savings have been provided by Kier.



6.1.3 Other

Other measures of prevention used are as follows:

- Prefabrication of external cladding panels
- BIM exercise to identify clash detection with the arena's seating
- The use of BIM enables improved coordination of drawings and schedules, reducing construction information inconsistency which can lead to site waste, with the need to re-work construction errors
- The setting out of the ice rink's extension, designed to a standard brick and blockwork dimensions
- Building elements have been standardised as far as possible from blockwork walls and internal partitions
- Exposed concrete to structural frame to remain, reducing requirements for further finishes
- Connection of new drainage into existing estate facilities, minimising new drainage run
- The specification of high performance insulation, therefore, reducing wall thicknesses, minimising the building's footprint
- Specifying suppliers who will accept unused returns (undamaged) products
- Metal studs to external and internal walls cut to length off site
- Cementitious board packs sourced to correct size
- Careful loading out of materials into the building area

6.2 Reuse

6.2.1 Soils

In total, 2573.35m^3 of excavated soil material was retained on site and later used as fill. As the site was built on a remediated landfill, excavation material was checked for contamination. During excavation of the drainage system the soils were returned to infill those excavations.

6.2.2 Reseiclo, Community Wood Recycling

Just over 273m^3 (93.4 tonnes) of timber waste was collected by Reseiclo, a community wood recycling scheme based in Newport. The not-for-profit organisation's aggregated reuse rate is 28% for timber products removed from sites around Wales. Based on the weights removed from the ice rink, 26 tonnes of timber were likely to have been reused. The percentages for reuse, recycling and recovery are reported as follows:

Table made from IAW timber waste

- 28%, high-grade reuse (DIY wood products and pallets)
- 3%, low grade reuse (firewood, kindling, allotments)
- Remaining 69%, chipped and recovered for fuel

In total 76.47m^3, 26.04 tonnes of timber were reused through the Reseiclo scheme, with savings of £3,213 in comparison to disposing of the material in skips.

6.2.3 Pallets

Millstream Ltd, the chosen contractor who supplied and fitted the stadium seating provided the material in large ply crates with additional cardboard and plastic protection and plastic pallet bases. Millstream stated that the twenty-four plastic pallets 7m^3 (1.05 tonnes in weight) were taken back for re-use. The ply crates were also reused saving a total of 6.4m^3 (2.2 tonnes).

Massey cladding reused twenty pallets throughout the contract, saving a total of 6m^3 from filling a skip. 8kg bearings were also reused throughout the project.

In total, 19.4m^3 of pallets and packaging products were reused throughout the project.

Other elements reused by Kier include concrete piles used as traffic management barriers prior to being crushed and recycled for onsite, totalling 200m^3.

Overall figures show that 2869.22m^3 of construction waste was reused throughout the project.

6.3 Recycling

The recycling rates reported by Olivers skip hire for construction waste include:

- 95% recycling rates for brick (34.81m^3), inert (1.98 m^3), tiles and ceramics (2.65m^3) and concrete (9.99m^3). In total 49.43m^3 of inert waste was recycled and sent to Bryn Quarry for further processing as reported by Olivers skip hire.
- 100% of wood (26 m^3) sent to Bryn Quarry (Hengoed).
- 85% of mixed waste (486.48m^3) sent to Bryn Quarry.
- 100% of metals (2.01m^3) sent to SR Recycling (Penalta).
- 80% of plastics (13.28m^3) sent to Bryn Quarry.
- 90% of packaging (80.55m^3). Packaging waste was then sent to Bryn Quarry (Green Compass company for further processing).

All inert, wood, plastic and cardboard waste was sent from Olivers skip hire Hengoed to Bryn Quarry for further processing.

In total, 657.75m^3 of waste was recycled by Olivers skips and Bryn Quarry.

A separate waste management contract was set up for the canteen and office waste. The chosen company was MJ Church of Bristol. A breakdown of the waste removed from the Ice Rink is as follows.

- (6.57 m^3) for plastics - 90% recycling rate reported, sent to Plastic Experts (Hampshire)
- (0.35 m^3) for aluminium cans - 100% recycling rate reported and sent to Thamesdown Recycling (Swindon).

A total of 6.92m^3 of waste was recycled by MJ Church.

Plasterboard waste was removed by RKC, as part of the plastering works package. 128.58 m^3 of plasterboard waste was recycled with a 100% closed loop back into product, reported by Atlantic Recycling. 3.09 m^3 of the plasterboard total was Siniat board waste produced by Massey cladding.

The remaining precast pile offcuts were later crushed on site to produce aggregate for recycling. The crushed material was used as infill on site to level the ground external to the building. In total, just over 200m^3 of crushed concrete was used.

As part of the Enabling Zero Waste initiative the project looked at whether a metal composite cladding panel could be separated in order to increase recycling rates. Biffa provided a service to separate insulation from a metal composite cladding panel. 1.96 m^3 (100%) of Rockwool insulation was recycled back into product. The remaining 3.84 m^3 of metal sheeting was sent to John Ford & sons for recycling. The initiative ensured that all of the waste produced 5.8m^3 was recycled. Whilst this initiative was successful it may not be deemed to be economically viable.

As a result of Massy Cladding and the EZW collaboration, 3.84m^3 of metal and 1.96m^3 of Rockwool insulation was recycled, closed loop back into Rockwool product. 0.017m^3 of packaging waste was also recycled as part of these activities.

Overall figures show that 1002.15m^3 of construction waste was recycled throughout the project.

6.4 Energy Recovery

In total, 273.17m^3 of waste was sent for energy recovery from the project.

Reseiclo sent 197.05m^3 of timber waste received from the site to South Wales Wood Recycling (SWWR) in Bridgend. SWWR then chip the wood and sell it for energy recovery or particle board manufacture, dependant on type.

MJ Church reported 2.81m^3 of canteen waste was sent for energy recovery.

The remaining quantity of waste was sent to Trident Park in Cardiff from Olivers skip hire. Trident Park holds a R1 classified status therefore meets energy recovery rather than disposal, as set out in the Waste Framework Directive.

6.5 Landfill

Olivers Skip Hire reported that 9% of residual waste 40.62m^3 produced from the project was sent to landfill at Bryn Pica, Aberdare.

Olivers skip hire were unable to provide a breakdown of the landfill waste streams.

7 Analysis by individual waste streams

A breakdown of individual waste streams and forecast % recorded on SMARTWaste is shown below:

Waste material produced IAW	Actuals m^3	SMARTWaste forecast
Mixed construction waste	572.28	259.5
Timber	299	188.1
Plasterboard	131.67	40.2
Packaging material	91.8	108.5
Bricks	38.68	9
Concrete	200	52.1
Insulation material (non-hazardous)	19.26	22.9
Metal	5.87	27.7
Inert	209.79	65.2
Canteen Waste	18.49	34
Soils	2573.35	1363
Metal	2.02	27.7
Other waste	3.48	46.3
Plastic (excluding packaging)	16.33	No Forecast
Tiles	2.94	No Forecast
Furniture	0.2	No Forecast

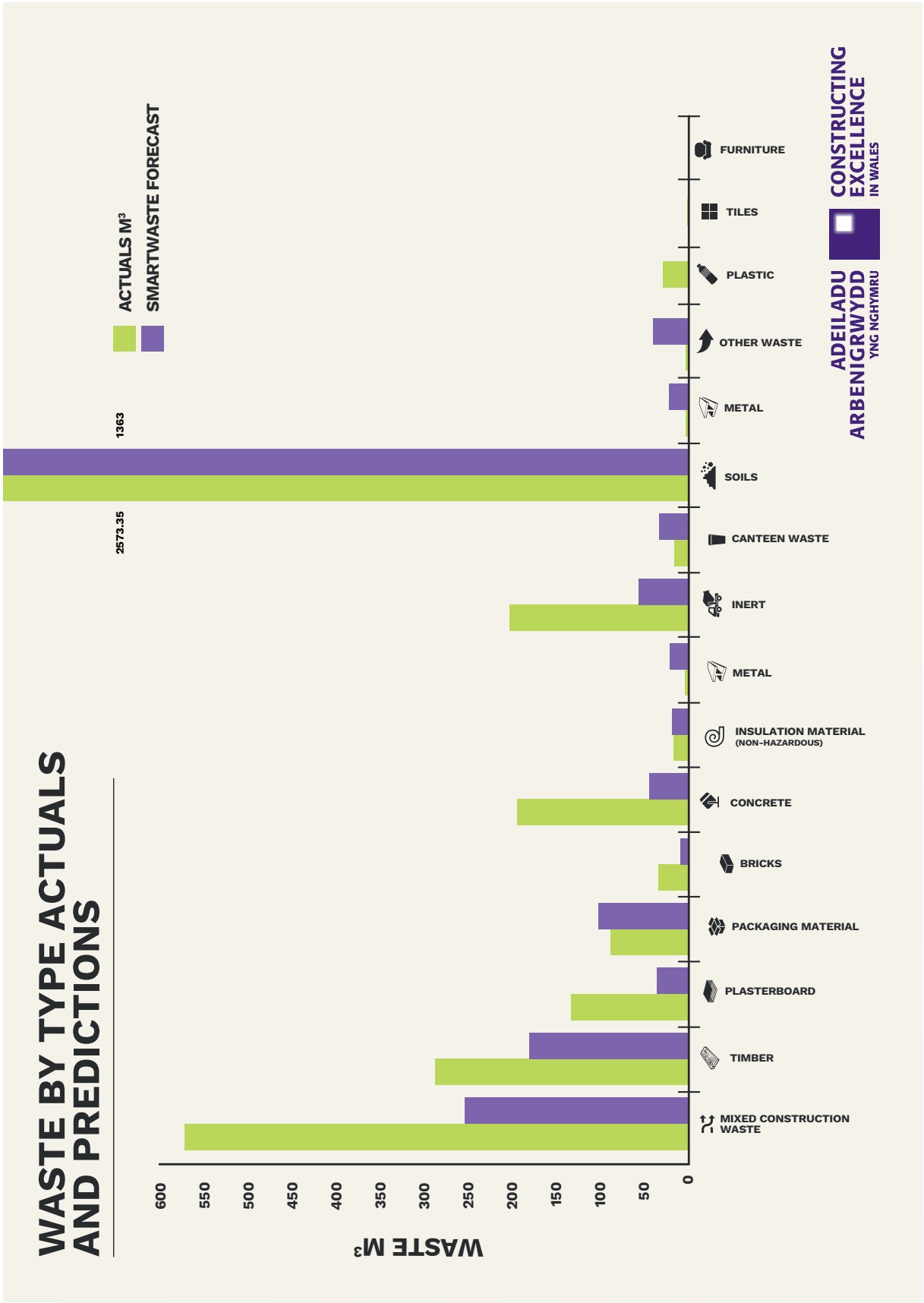
7.1 Mixed waste

Large quantities of waste disposed of from site were not segregated and were sent as mixed waste for further processing. Mixed waste was processed by Olivers skip hire, who reported a 85% recycling rate during the construction of the Ice Rink. Mixed waste impacts on the quality of the recyclate that can be produced through recycling. Source segregated waste streams can be recovered at a higher rate, generating a better quality and higher priced recyclate.

At the start of the EZW team involvement, it was found that the majority of waste consisted of mixed construction waste with the exception of timber waste. Within skips placed near to the site boundary, waste was found that did not originate from the site (bathroom tiles, carpets and a mattress). As such, the skip compound was moved closer to the construction site and fenced off. The relocation of the skips avoided this issue from occurring again. Segregation of waste was still found to be an issue once the compound had moved. Significant quantities of timber waste were being placed in the mixed waste skip. After speaking to site operatives, it was made apparent that the segregated timber waste was being placed in the mixed waste skip as this was the nearest option to them. As such, the site team moved the mixed waste skip furthest away within the compound and moved the segregated skips closer. Waste segregation practices improved significantly as a result of this.

Kier nominated a waste champion on site who would promote segregation on a daily basis which helped to improve and drive segregation practices. Following the construction suspension period, a new temporary site manager was appointed on site, who unfortunately was not made aware of the EZW initiative.

During the pause in site works, no waste streams were removed by Kier, however, in order to make the building watertight, Massey cladding were still allocated to work on site. The contractors were depositing waste into two 1,100ltr recycling and two 1,100ltr mixed waste bins


WASTE BY TYPE ACTUALS AND PREDICTIONS
ACTUALS M3
SMARTWASTE FORECAST
WASTE M3
600
550
500
450
400
350
300
250
200
150
100
50
0
1363
2573.35
FURNITURE
TILES
PLASTIC
OTHER WASTE
METAL
SOILS
CANTEEN WASTE
INERT
METAL
INSULATION MATERIAL (NON-HAZARDOUS)
CONCRETE
BRICKS
PACKAGING MATERIAL
PLASTERBOARD
TIMBER
MIXED CONSTRUCTION WASTE
CONSTRUCTING EXCELLENCE IN WALES
ADEILADU ARBENIGRWYDD YNG NGHYMRU

which were collected by BIFFA. A breakdown of the waste created by Massey is shown below. The data has been provided by BIFFA, however, it is unclear as to how many collections took place. A request to BIFFA for a detailed breakdown was requested, however they were unable to provide this information.

Within the Ice Arena there were smaller waste bins provided, however, these were not colour coded nor signed to indicate a segregated waste stream. As a result, this did not help to encourage segregation practices to take place.

7.2 Timber

The site produced a total of 299 m^3 of timber waste.

The majority of timber waste was sent to the Reseiclo community wood scheme with the remaining 26m^3 removed by Olivers skip hire.

Sixty-eight skips of timber waste were removed from site by Reseiclo, compared to a target of forty seven forecast on SMARTWaste at the start of the project. Timber waste increased on site coinciding with activities of shuttering and carpentry.

Scott Pallets collected 120 pallets in March 2015. Scott Pallets repair the pallets and sell them on for reuse. In total 17m^3 of pallets were reused as a result of the scheme.

A delivery of block pavers resulted in 51 pallets being used for transportation ease. The EZW team contacted Kilsaran, the pavers manufacturer to discuss if pallets could be removed and reused on other deliveries. Kilsaran's response was that the takeback scheme was not financially viable as the delivery wagons and material came from Ireland. As a result the pallets were removed by Scott Pallets as part of the total of pallets removed as previously mentioned.

Timber produced from shuttering activities was reused by the groundworkers where possible. This was eventually disposed of via Reseiclo.

The concrete seating area and stairs were manufactured off site which prevented the use of timber for shuttering on site. Door frames were manufactured off site to reduce off cuts. No prevention quantities have been provided by Kier for these activities.

7.3 Inert Waste (concrete, bricks, blocks, tiles and ceramics)

Waste within inert skips were recorded by Olivers Skip hire drivers and the estimated breakdown was then written onto Waste Transfer Notes. Material within the inert skip contained of the following waste types:

- Bricks 17 01 02
- Tiles and ceramics 17 01 03
- Concrete 17 01 01
- Inert 17 01 07

The site also retained inert materials such as blocks and concrete piles which were crushed on site to be used as infill to raise ground levels external to the building. 200 m^3 of crushed aggregate including the materials mentioned above was later recycled and used on site.

7.4 Bricks and Blocks

In total 38.68m^3 (46.44 tonnes) of brick waste was produced from the Ice Rink, which was recorded in two phases between August – December 2014 (6.03m^3) and July – December 2015 (32.63m^3).

A target of 9m^3 was forecast for brick waste prior to construction. An issue was highlighted whereby the quality of blocks were not of a good enough standard to be used in the areas where blockwork was visible, as some blocks were chipped and damaged in places. Recommendations were provided that damaged blocks could be used in the areas which were to be plastered, however, blocks were still found in the skip. After a discussion with the bricklaying company to see why this was occurring, it was reported that this was a time constraint issue. Inspecting the blocks and moving them to other areas lost time as bricklayers were paid per metre laid.

7.5 Tiles

In total, 2.94m^3 of tile waste was produced from the Ice Arena. The tile waste was produced from the tiled areas of toilets, washrooms and player's changing rooms.

7.6 Plasterboard

In total 131.67 m^3 of plasterboard waste was produced. Richard Kemble Ltd the chosen contractor supplied their own skips provided by Atlantic waste. The project exceeded the originally estimated target by 87m^3 (68%).

7.7 Metal

In total 5.87m^3 of metal waste was recorded from the project, 2.02m^3 of the total figure was recorded on SMARTWaste, the remaining 3.85m^3 was recycled as part of the cladding sheeting removal. All metal waste was produced during the structural phase and cladding of the building.

7.8 Packaging Materials

In total 91.8m^3, 18 tonnes of packaging waste were produced throughout the project. 34.97m^3 (39%) arisings occurred during the site clearance.

7.9 Eurobond Panels/Insulated wall panels

Eurobond panels were used for cladding the lower sections of the building. The product consists of composite Rockwool insulation with attached metal weathering skin (as shown below). In order to separate the insulated board from metal, the product required further processing. The product was unable to go back to the manufacturer to be separated as the company did not have a permit to accept waste material produced off site.

Therefore, the option was to find a waste management company that would be willing to separate the materials and are licenced to treat the waste. Materials were taken to BIFFA waste transfer station where they were separated into metal and Rockwool. The metal was recycled 100% with the Rockwool insulation taken back to Rockwool where it was processed back into the product.

Weight of waste panels removed off site	Cost	VAT
3.33 tonnes	£1,443.20	£287.58

Table: *Costings for Cladding waste*

As shown in the table above, whilst this exercise ensured that 100% of the waste was recycled back into a closed loop system, the economic viability of the scheme might be questioned.

7.9.1.1 Euroclad take back scheme

With the support of Massey Cladding, CEW engaged with Euroclad Ltd who provide metal roof and cladding systems for the Ice Rink. Euroclad also supplied the solid insulation panels and weatherproof plasterboard (Siniat) to the site. Euroclad provided a service to minimise the packaging and takeback scheme for all packaging used on its products. Flexible tonne bags were provided to Massey Cladding to achieve segregation into plastics, cardboard, timber bearers and timber pallets. The company were very willing to provide this service and which they did free of charge given that they were committed to the Enabling Zero Waste initiative.

Euroclad also provided a take back service for the rockfibre insulation, the waste product was sent back into the manufacturing process ensuring a closed loop process.

7.9.1.2 Siniat Plasterboard

Siniat weatherproof boards were used as part of the external cladding detail. The waste produced consisted of offcuts and damaged boards. As the building was of a design with overhanging and angled sections, offcut reuse was unable to occur.

Euroclad arranged for separate plasterboard skips for the Siniat waste through Reconomy, a waste broker. Siniat recommended Reconomy who would ensure a 100% closed loop recycling process by taking the waste back to Siniat for reprocessing. Waste reports provided by Reconomy showed that the Siniat waste went to Atlantic Recycling.

After investigation, it was found that this material was not sent back to Siniat for reprocessing. This was very disappointing as Euroclad had committed to the EZW initiative and had tried to ensure that their waste was 100% recycled within a closed loop process but was let down by the waste broker.

Type of material	Type of container and size	No of pick ups	Average weights	Total estimated weights (kg)	Destination	
Timber pallets	1.8 x 1.2 m	20	n/a		Euroclad	Reuse
Plasterboard (siniat)	12 yard skip	3	3.093 tonne		Atlantic	Transfer station
Insulation (rockfibre)	1m^3 bags	14	55 kg	770	Knauf Queensferry	Recovery Process
Timber bearers	1m^3 bags	41	8 kg	328	Euroclad	Reuse
Cardboard	1m^3 bags	11	11 kg	121	Atlantic	Recycling
Plastic wrap	1m^3 bags	12	6 kg	72	Graig Environmental Recycling	Recycling

8 Canteen and Office waste

From past EZW projects it has been highlighted that canteen food waste can stray into the site skips causing contamination and reducing recycling rates. The EZW team recommended that a separate canteen service was established.

The waste was collected by MJ Church in 1,100ltr bins and a segregation system was set up outside the site's canteen. In total 18.49m^3 of canteen waste was produced. All canteen waste produced was sent to Warmley Transfer Station in Bristol. A percentage breakdown and end destination summary is provided below.

Amber supplied wheelie bins for the office waste to the project, no waste data has yet been provided by Amber.

Wastestreams	Waste %	End Destinations
Paper and cardboard	11.53	Mark Lyndon (Nottingham)
Plastic	2.01	Plastic Experts (Gosport)
Cans	0.008	Thamesdown Recycling (Swindon)
General waste	86.44	EFR Waste plant in Spremburg, Germany

9 Analysis by cost

9.1 Actual Waste Management Cost

The project used a total of 273 skips and 126 1100ltr bins at a total cost of £71,371. These figures include 8 plasterboard skips sent to Atlantic at £3,362.40 removed by the plastering sub-contractor as part of their package.

Savings from the Reseiclo removal service totalled £3,212.96.

Waste management and broker companies	Costings	No. of Skips and bins
Olivers Skip Hire	£44,776	185
Atlantic	£3,362	8
Reseiclo (Wood recycling)	£14,944	68
Biffa	£1,443	3
Scott Pallets	£675	8
Reconomy	£600	1
MJ Church	£3,824	125 x 1100ltr bin
Amber	£1,747	1 x 1100litr bin
Total	£71,371	273 skips 126 1100ltr skips

Wooden pallets were removed from site by Scott Pallets. In total 120 pallets were reused and £675 was spent on the scheme. Disposal of pallets in timber skips would have cost approximately £1280, based on 15 pallets per skip, totalling 8 skips. A total saving of £605.

The percentages of skip type and the associated percentage of cost for the other segregated waste streams are as follows.

Skip Type	% of Total No of skips	% of Total Cost
Mixed Waste	60 %	634 %
Timber	30 %	250 %
Bricks, Tiles & Inerts	6 %	7 %
Plasterboard	4 %	5% %

Mixed waste was the most used skip type at 60%, and naturally incurred the greatest percentage of cost.

9.2 Potential Waste Management Costs

Based on cost figures from Olivers skip hire, without waste segregation the cost of disposing of 185 mixed waste skips would have been £50,440. This is £5,664 more than the actual cost, which means a saving of 11% was achieved through waste segregation.

If all 185 skips removed by Olivers skip hire waste was segregated £37,810.60 could have been spent on waste, saving £6965.40.

Savings	
Clash detection exercise	£30,000
Segregation	£5,664
Wooden Pallets	£605
Reseilco/Wood saving	£3,212.96
Total savings	£39,481.96

WASTE MANAGEMENT COSTS

TOTAL	£71,371	273 SKIPS	126 1100ltr BINS

ADEILADU ARBENIGRWYDD YNG NGHYMRU
CONSTRUCTING EXCELLENCE IN WALES

10 Analysis against benchmarks

Waste data is available in the SMARTWaste system for projects completed in Wales. Projects can report in waste volumes or waste tonnages for a wide variety of project types. The data has been analysed to produce performance indicators for waste arisings per £100k and per 100m^2 for volume and/or tonnage of waste produced.

BREEAM (BRE Environmental Assessment Method) is a widely used environmental assessment method for buildings and communities. It addresses environmental and sustainability issues and credits are used as part of the assessment criteria.

Leisure projects on SMARTWaste average 23.4m^3/100m^2 and 15.9m^3/£100k. The project achieved figures of 49.23m^3/100m^2 and 41.81m^3/£100k, suggesting that the project was less waste efficient than the construction of the average leisure building. This, however, is likely to result from the intricate and unique nature of the Ice Arena.

Ice Arena Wales	Volume of waste per 100 m^2	Average m3/£100k
SMARTWaste Leisure project average*	23.4m^3	15.9m^3
Ice Arena Wales	49.23m^3	41.81m^3
Difference	25.83m^3	25.91m^3

**(based on 9 projects)*

11 Modelling

11.1 Building Information Modelling (BIM)

It is widely recognised in the built environment sector that the translation of drawings into the actual structures frequently gives rise to unforeseen clashes, particularly in respect of complex junctions and mechanical and electrical services. It is common practice that clashes encountered are resolved reactively on site, often wasting materials and time. Through the use of software BIM's goal is to eliminate this waste.

BIM is, however, as much about people and process as it is about software, offering the opportunity to achieve greater efficiencies, as well as better working methods. The collaborative approach required to produce an effective design through BIM ensures a constant flow of information between disciplines. BIM then allows operatives to visualise each other's inputs, encouraging mutual understanding and good working relationships.

As part of EZW, CEW commissioned Arup to undertake additional work utilising the BIM model. The aim was to focus on some key elements such as Design for Deconstruction (D4D), reducing waste with an emphasis on blockwork setting out and reducing concrete pile waste.

11.1.1 Design for deconstruction

In order to meet Welsh government's targets of becoming a high recycling nation by 2025 and reaching a zero-waste nation by 2050, material selection and waste management will play a key role in reaching these objectives. In order to benefit the sustainability of any construction project all stages of the project must show a key emphasis on waste management including planning, design, manufacture, construction, deconstruction and reconstruction.

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.

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). The exercise was to look at 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.

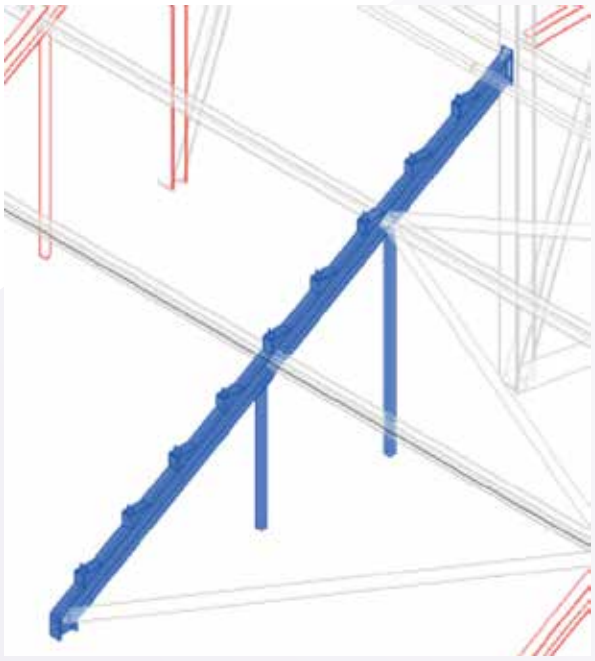
Initially, the IAW had no deconstructive elements designed in. However, the steel frame structure of the building holds a high possibility of reuse rather than recycling.

11.1.2 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.

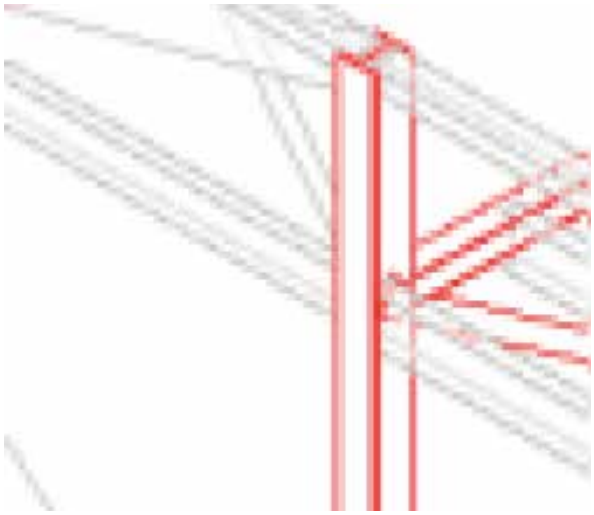
The reusability factor of the steel was graded to give an indication of possible reuse. For example, to have a low, medium or high rating as outlined below;

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.



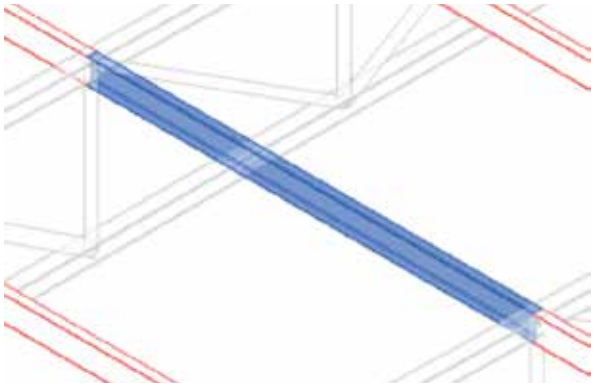
Low Reuse

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.



Medium Reuse

High rating – Simple straight elements with simple end connections e.g. straight beams between the trusses.



High Reuse

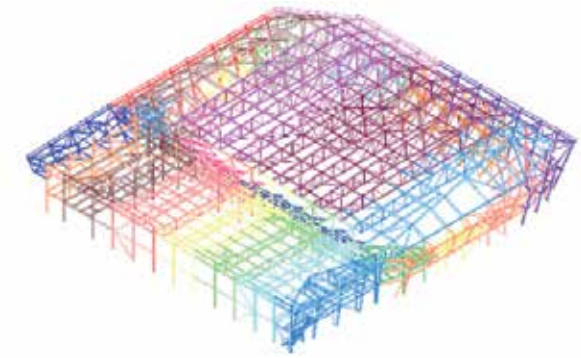
By introducing the reuse factor into the BIM data, future users of the building can quickly generate an idea of what elements could be reused well in advance of the deconstruction period.

11.1.3 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 buildings 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 manner 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. 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.

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



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

11.1.4 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.

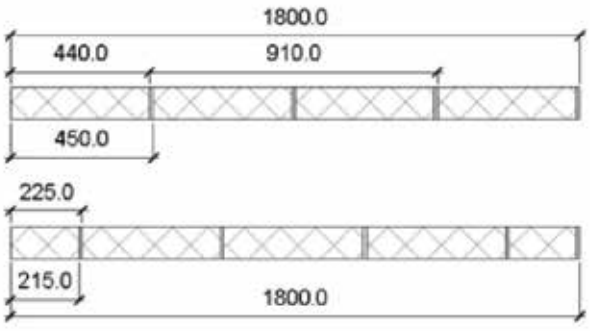
11.2 BIM, Ice Arena Wales reducing waste, blockwork study

This exercised looked 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.

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, was 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.



Blockwork dimensions

Based on the dimensions of the block work shown above Arup proposed to base their calculations on a standard unit that equalled a half block (225x225m including mortar).

11.3 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 integrate 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 schedule 1 shown below. 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.

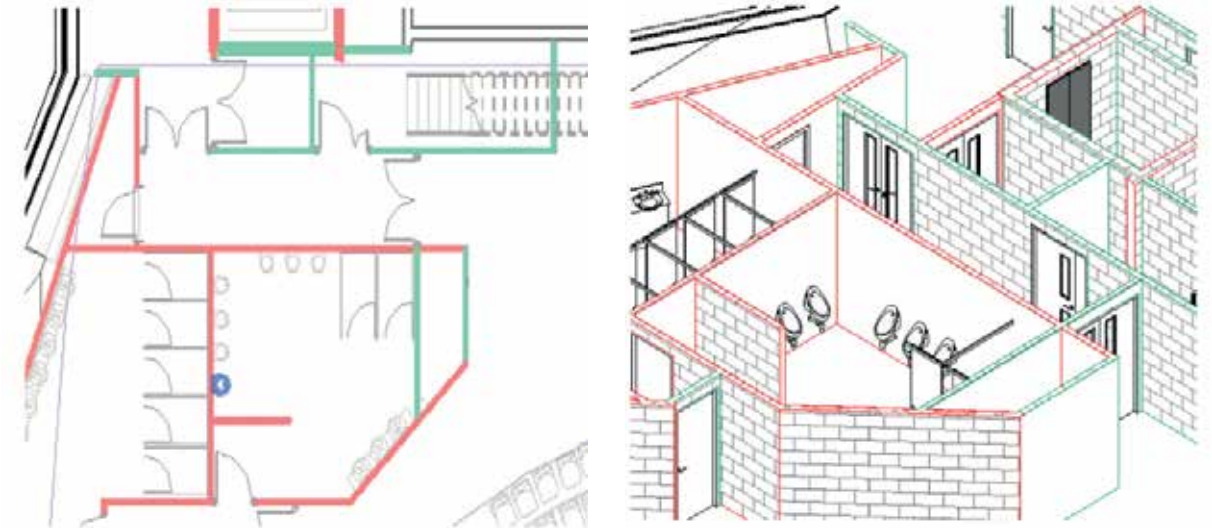
Constraints	
Location Line	Core Centerline
Base Constraint	Level 01
Base Offset	0.0
Base is Attached	☐
Base Extension Distance	0.0
Top Constraint	Up to level: Level 01 Soffit
Unconnected Height	3233.0
Top Offset	333.0
Top is Attached	☐
Top Extension Distance	0.0
Room Bounding	☑
Related to Mass	☐
Text	
Structural	
Structural	☐
Enable Analytical Model	☐
Structural Usage	Non-bearing
Dimensions	
Length	4000.0
Area	12.932 m²
Volume	1.371 m³

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.

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.

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	

***Schedule 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 267 m surplus) No. of half blocks = 4767 / 225 = 21.18 (21 half blocks required with 42mm surplus)*



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

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	155
2380	5	10	WASTE	130
6305	14	28	OK	5
2377	5	10	WASTE	127

***Schedule 2**: Wall schedule listing lengths and waste calculation results.*

The schedule 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 3, 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.

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
2730	6	12	OK	30
2730	6	12	OK	30
1740	3	7	WASTE	155
2380	5	10	WASTE	130
6305	14	28	OK	5
2377	5	10	WASTE	127

***Schedule 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.

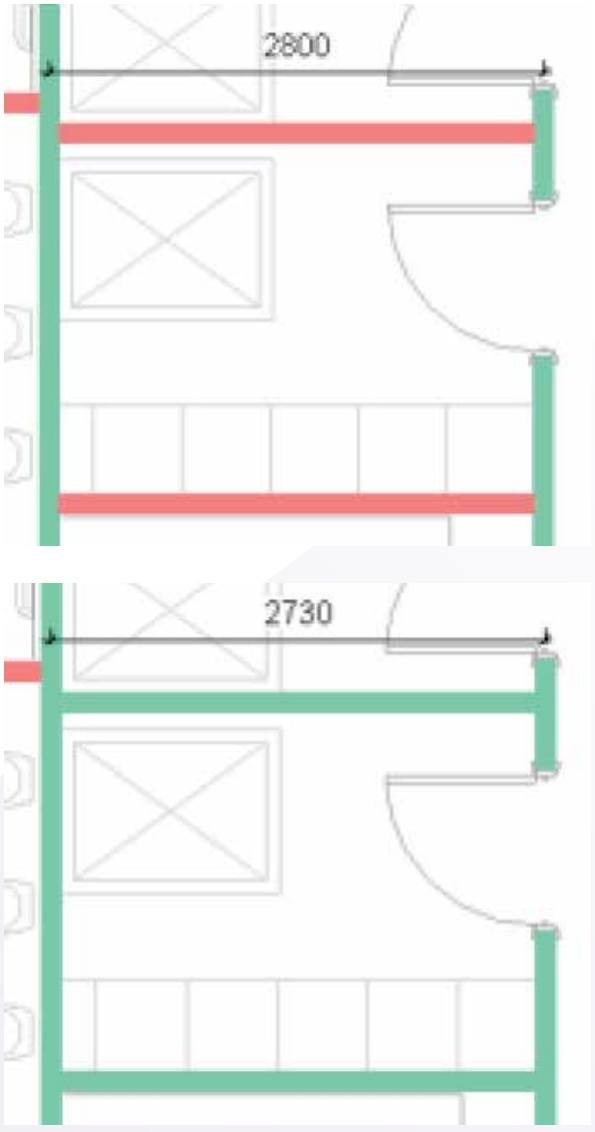
The total waste on the project from the concrete walls can also be calculated. Schedule 4 shows the total waste length for the project. This is for only one course and needs to be multiplied by the number of courses.

For this example, the floor to floor height is 4890 equalling 22 courses. This gives a total waste length of blockwork of 773m.

***Schedule 4**: Total concrete blockwork wall waste.*

11.3.1 Implementing the tools

It is essential that these tools are understood before implementing on future projects. The examples below 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.

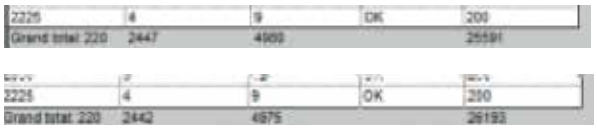


'Before' and 'After' images showing wall length reduction.

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 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 1 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.



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

11.3.2 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.

11.4 Reducing Pile Waste

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 possibilities of reducing waste.

Study objectives:

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

11.4.1 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 Figure 2) was introduced below ground as a preventative 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.

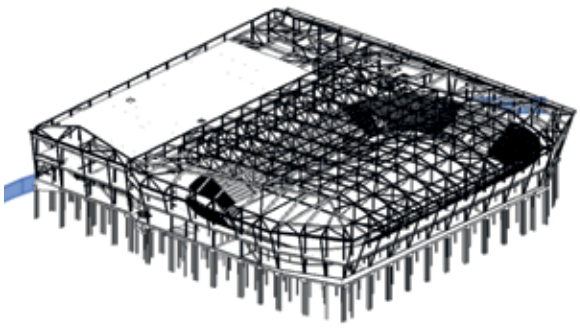


***Figure 1**: Structural design supported on pile foundations*

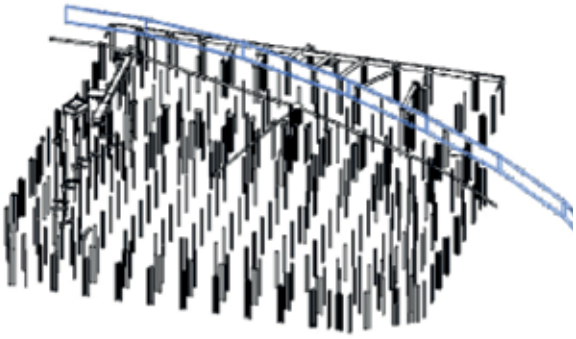


Figure 2: Below ground obstruction. The IAW design team modelled the buried below ground wall to improve the coordination of the finished design

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.

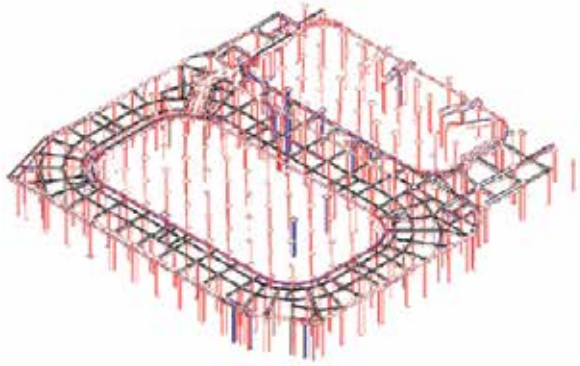
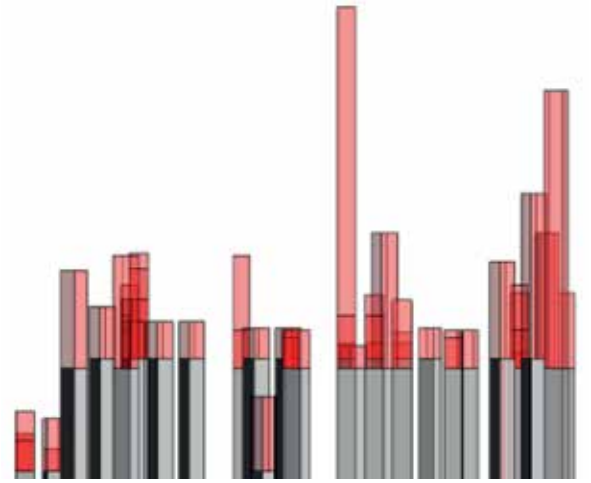


Figure 3: Changes to Arup Design following subcontractor engagement (red original, blue amended)

Following issue of the Arup Design the subcontractors for both the pile foundations and the façade design added suggested amendments that were carried out to the original design before construction was carried out. The changes required a handful of 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 13m & 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.



Concrete pile waste
Waste when installing concrete piles is an 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.

Figure 4 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 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.

The majority of the leftover lengths (noted as pile waste in the table) were in the region of 100mm 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.

<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				8696.600 m	9296.000 m	597.400 m

Figure 4: The top and bottom sections of the Driven Pile Schedule showing the totals

11.4.2 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 learnt 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.

12 Future proofing - Application of Environment Bill

The project has highlighted future potential issues for the industry. Specifically, with regard to the upcoming incineration and landfill bans for wood, paper, cardboard, glass, plastic, metal and food waste as part of the Environment (Wales) Bill.

If the Bill were applied to this project up to 273.17m^3 of material would require an alternative disposal solution. As such, research will need to be carried out to understand what alternative disposal options, along with the appropriate infrastructure, are necessary to enable the necessary changes required by legislation.

13 Key challenges

13.1 Waste

The main challenges around site waste were:

- Lack of commitment to segregation
- Changes in key site personnel
- Large numbers of waste management companies used throughout the project
- Material specification – difficulties when disposing of composite material
- Infrastructure/ Technology
- Inconsistencies from waste management services

13.2 Behavioural/cultural Challenges

Changes in staff can lead to a reduced focus on waste. In addition, as a result of the staff changes it was difficult to keep the Enabling Zero Waste message embedded within site practices.

An understanding that all waste material that leaves site, whether it is carried out by the supply chain should be recorded onto SMARTWaste.

Site specific recycling/recovery rates from individual waste management companies should be reported rather than relying on generic rates.

13.3 Time

As is common in the rest of the construction sector, there was a client expectation to complete the project within the agreed timescale. This inevitably results in commercial pressures on principal contractors, and their supply chain and as a resultcan then impact on environmental and waste performance.

13.4 Design

The BIM exercise crosschecking the 2d information with the model identified that the concrete staircase design did not fit with the steel frame terraced seating – some stairs were cutting through the seating areas which is not allowed as it creates a trip hazard. This was amended in the design stage and the staircase redesigned prior to being cast. Savings have been calculated for time and material costs for rework had the incorrect staircase arrived on site, these are in the region of £30,000 - £40,000, half the original cost of the staircase. This was a partial BIM exercise, not all elements were identified through a BIM model.

14 How has EZW influenced waste management for the project team?

Derwyn Pugh, Contracts Manager, Kier

From a personal point of view and from the team I worked with initially at the Ice Arena it was a privilege and a valuable learning experience to be involved with CEW looking at EZW. We went into the process with open minds and were more than happy to take advice from the experienced waste advisors and implemented most if not all the suggestions that were made. A whole life strategy is required to maximise the benefits of a coordinated approach to enable the minimisation of waste generated on site. Early involvement and continuous education starting with the client, the design team through procurement up to and including the operatives at the coalface is necessary if we are to meet the ambition of Enabling Zero Waste.

15 Successes

There were a number of waste management successes on the project.

15.1 Achieving Welsh Government's Waste Targets

Towards Zero Waste (TZW), the Welsh Government's overarching strategy document for dealing with waste in Wales, aims to produce benefits for the environment, economy and for society. TZW sets a target for the construction and demolition industry in Wales to prepare for reuse, recycling or other material recovery at least 70% of waste, by weight, by 2015-16. The target for 2019-20 is 90%.

By achieving 99% reuse, recycling or other material recovery, the construction phase of this project has met the 2015-16 and 2019-20 targets. This helps to provide evidence that TZW presents achievable reuse, recycling or other material recovery targets for the industry.

The Welsh Government aims for 100% diversion of construction and demolition waste from landfill by 2050. Overall the project achieved a 99% diversion of waste from landfill as Olivers Skip Hire reported that 9% of residual waste 40.62m^3 produced from the project was sent to landfill at Bryn Pica, Aberdare.

Further focus is considered to be required on waste prevention and reuse rather than relying on the efficiencies of waste management infrastructure. A 1.4% reduction of waste still needs to be achieved year upon year in order for the Towards Zero Waste targets for the sector to be achieved.

Other success for the project include:

- Engagement with supply chain and the effectiveness of a takeback scheme working with Euroclad
- Waste prevention measures
- Concrete pile offcuts and inert materials retained and crushed on site in preparation for reuse
- Storage of excavated soils for reuse
- Designated site waste champion
- Effective reuse timber schemes from Reseiclo and Scott Pallets
- Cost savings achieved on the project equate to approximately £40,000 through the segregation of waste; designing out waste and through the use of recycling schemes.

16 Conclusion and recommendations

The project achieved a 99% diversion of waste from landfill. Falling slightly short of the zero waste aim, this demonstrates a great achievement and highlights that zero waste to landfill is achievable. The project exceeded the Welsh Government's current target of 70% of all waste, by weight, shall be prepared for reuse, recycled or recovered by 2015/16, and went beyond the future waste target that 90% of all waste be prepared for reuse, recycled or recovered by 2019-20. Whilst targets for 2015-16 and 2019/20 have been met, further focus is required on waste prevention and reuse, rather than relying on the effectiveness of waste management infrastructure. Opportunities exist for greater efficiency and effectiveness on site, offering potential for waste and cost savings.

Cost savings are available for companies willing to consider the waste hierarchy at all stages of a project. Prevention is the key level in the hierarchy when it comes to unlocking substantial savings, as highlighted by this project. BIM offers an opportunity for designs to be tested and altered with a view to prevention of, for example, clashes or avoidable cut and fill, both of which can be expensive and wasteful.

16.1 Contractor recommendations

The importance of segregation of waste at source has been made clear, along with focussing on and discussing waste at all stages of a project, with all involved on site. Engagement with all members of the site team is important when attempting to maintain best practice and segregation during periods of pressure on site, especially during the final stages before handover.

It is important to identify the end destinations of all waste types through early discussions with the chosen waste management company, prior to engaging into a contract. After investigation into a Siniat plasterboard take back scheme, it was found that this material was not sent back to Siniat for reprocessing. This was very disappointing as Euroclad had committed to the EZW initiative and had tried to ensure that their waste was 100% recycled within a closed loop process but was let down by the waste management contractor.

The set-up of the waste compound is a key part of the waste management strategy and should be a major concern of the site waste champion during planning for work on site. Waste compounds should contain segregated skips from day one on site and their purpose explained to everyone on site. Ideally a mixed waste skip should not be available, but if it is necessary it should be located furthest away from the site works, to discourage its use.

Waste should be a consideration in the selection of subcontractors. Main/lead contractors should give consideration to their duty of care and how it extends to the waste disposal options taken by subcontractors. Focus should be given to ensuring contractual obligations, specifying that all stages of the waste hierarchy are observed before disposal to landfill. This will reduce the potential impact of sub-contractor decisions on project reuse, recycling or other material recovery targets.

Packaging waste was a significant challenge on this project, as it often is. Suppliers can play a key role in reducing packaging as long as contractors communicate the problems they face with disposal with their suppliers. Often packaging takeback schemes can be organised with manufacturers or suppliers, but this requires foresight and planning so agreements are in place before the waste becomes an issue.

The importance of documenting up to date waste data and waste transfer notes through SMARTWaste not only protects the company legally but can monitor waste streams and eventually avoid and prevent waste. Through conversations with sub-contractors and toolbox talks, with an emphasis on housekeeping and waste segregation, commitment to the EZW scheme can be achieved. Communicating zero waste aims to all site operatives is important to ensure full investment in the scheme. To this end, waste, and its segregation, should be discussed during site induction at all phases of construction and demolition.

In addition, it is crucial that the person responsible for producing waste forecasts makes regular contact with the site team to ensure that forecasts are achievable, reasonable and based on previous performance. When a change in staff has occurred in the site management team, it is important that the sites new members are briefed to the procedures and exercises of the site in preparation for take over.

Waste data recording onto SMARTWaste will assist the company to review the actual volumes of waste that has left the site. Kier has implemented a new work practice in which at the start of the project all data is inserted by

a dedicated SMARTWaste trained member of the site team which sets up the site waste management plan and information relating to the waste management company. At present Kier record a generic waste recycling rate of 85% rather than using company specific recycling rates.

The upcoming Environment (Wales) Bill will ban disposal by incineration or landfill for wood, paper, cardboard, glass, plastic, metal and food waste. Contractors will need to consider how they will deal with these wastes as the cost for disposal will likely increase to pay for research into alternate disposal options. As highlighted in this report, prevention offers the most cost effective solution so removing waste through greater use of prefabrication should be considered.

16.2 Client recommendations

Design and product selection can have a significant impact on waste arisings. Early client participation in driving waste prevention will have a significant impact on waste arising throughout a project. This can be managed when paying attention to housekeeping and waste segregation when visiting a site.

Time decisions and programming can have a significant influence on a project. Pressure to complete can cause a fall in adherence to site practices, such as waste segregation. This then impacts on the project's reuse, recycling or other material recovery rates at a cost which may exceed those that the client is attempting to avoid, by accelerating the build.

16.3 Designer recommendations

Designers should give greater consideration to the standard sizes of materials during design. Standard dimensions or design in multiples of units of a material would reduce the volume of off-cuts produced. This can be applied to dimensions of rooms or lengths of piping. Engagement with contractors to improve material understanding should be encouraged. Awareness of how intricate design affects waste should also be improved, specifically consideration of complex joints.

BIM offers a viable option for the elimination of design waste. Uptake of BIM will mean more design decisions are made earlier making the process more proactive than reactive. Easy visualisation of each discipline's inputs allows for easy identification of errors or clashes between the designs of different disciplines. Effective working in BIM ensures a constant flow of information, encouraging mutual understanding and good working relationships.

17 Process improvement

Throughout the course of the contract it was noted that eight separate waste management companies were used. The complexity of these arrangements can result in difficulties to control when ensuring duty of care is met, recording waste data and recording end destinations.

Euroclad supplied the Siniat board to Massey Cladding and made a commitment to provide a collection service for the Siniat board waste. As the Siniat board contains a silicone compound, the material can only be processed back into Siniat and not a standard Gypsum product. Euroclad contacted Siniat about the best way to set up this collection and they were given the contact details for Reconomy. Euroclad were given verbal confirmation by Reconomy that the Siniat board would go back into a Siniat product. Through further investigation it was found that board had gone back to Atlantic Waste through the report issued by Reconomy. Euroclad had then contacted Reconomy who said that the waste would have gone from Atlantic to Siniat. Through contact with Atlantic it was found that they do not send any waste to Siniat and all Siniat product is disposed of through gypsum manufacturing.

The process improvement identified throughout the EZW initiative would be to adere to waste contracts agreed with sub-contractors during pre-let meetings. Although waste procurement, agreements and legalisation is part of the Kier pre-let meetings, Kier's site management should follow up on the subcontractors and check that the operatives are following the agreed contract, risk assessments and method statements, including endearing to housekeeping rules and waste segregation.

The reason behind this improvement was highlighted during the Massey Cladding's site works. Massey agreed to all information discussed in the pre-let meeting. Once on site it was found that their waste was going into the Kier skips. The EZW team approached Massey Cladding's site manager who was not aware of the waste contract agreements. Kier and the EZW team reviewed the method statement Massey Cladding submitted to Kier, which stated that Massey Cladding would not be creating any waste. Massey then supplied their own skips for the waste arisings the company produced from the project.It is important that these factors are not over looked, as it may have an impact on final accounts and waste end destinations for all involved.

It is important that staff overseeing the waste management are trained and aware of SMARTWaste and the site waste management system. The appointed person can then understand the waste management options, recycling figures and monitor waste production against targets.

Galluogi

DYFODOL DIWASTRAFF

Canolfan Iâ Cymru

Noddir gan Lywodraeth Cymru
Sponsored by Welsh Government

ADEILADU ARBENIGRWYDD YNG NGHYMRU
CONSTRUCTING EXCELLENCE IN WALES

Contents

Canolfan Iâ Cymru

1 Crynodeb Gweithredol

Mae Galluogi Dyfodol Diwastraff (EZW) yn gynllun gan Adeiladu Arbenigrwydd yng Nghymru (CEW) sy'n ceisio sefydlu os, a sut, y gall y diwydiant adeiladu gyrraedd y targedau diwastraff a osodir yn strategaeth wastraff Llywodraeth Cymru, Tuag at Ddyfodol Diwastraff.

Mae CEW yn gweithio mewn cydweithrediad â'r diwydiant i geisio dirnad yn well sut y gall y diwydiant anelu at fod yn ddiwastraff ar hyn o bryd ynghyd ag adnabod unrhyw rwystrau cysylltiedig i gyflawni'r targedau, ac i ledaenu arferion gorau, atebion a chyfleoedd.

Mae Canolfan Iâ Cymru (IAW) yn ddatblygiad gwerth £17.5 miliwn i greu dau rinc iâ ym Mae Caerdydd ar hen safle tirlenwi gwastraff trefol, i'w godi gan Kier Construction Ltd (Kier) a'r dyluniad gan Scott Brownlee. Cafodd Kier eu caffael yn 2013 gan Greenbank Partnerships Ltd, datblygwyr camau olaf y Pentref Chwaraeon Rhyngwladol a chynllun tai cyfagos Cardiff Pointe. Mae'r Ganolfan yn gartref i dîm Hoci Iâ Devils Caerdydd gyda'r cyfleusterau'n addas i gynnal cystadlaethau i safon Gemau Ewropeaidd ac Olympaidd.

Cafodd cyfanswm o 4185.16m^3, (3945.63 tunnell) o wastraff ei gynhyrchu yn ystod y prosiect. O'r gwastraff hwn ailddefnyddiwyd 2869.22m^3 (68.56%), ailgylchwyd 1002.15m^3 (23.94%), anfonwyd 273.17m^3 (6.53%) i Barc Trident (Caerdydd), sef canolfan statws R1 ar gyfer arbed ynni, i adfer ynni ohono, ac anfonwyd 40.62m^3 (0.97%) i gael ei dirlenwi. synchr

Cofnododd y prosiect gyfraddau ailgylchu 100% ar gyfer (deunyddiau pren, metel ac anadweithiol) allan o'r naw ffrwd wastraff a gynhyrchwyd. Llwyddodd y prosiect i osgoi anfon 99% o wastraff i gael ei dirlenwi. Gan syrthio fymryn yn brin o'r nod dim gwastraff o gwbl, mae er hynny'n dangos llwyddiant ysgubol ac yn dangos ei bod yn bosib anfon dim gwastraff i'w dirlenwi. Llwyddodd y prosiect i ragori ar darged presennol Llywodraeth Cymru o sicrhau y caiff 70% o bob gwastraff, yn ôl pwysau, ei ailddefnyddio, ailgylchu neu ei adfer erbyn 2015/16 ac yn llawer gwell na'r targed gwastraff ar gyfer y dyfodol i ailddefnyddio, ailgylchu neu adfer 90% erbyn 2019-20.

Mae'r prosiect wedi dangos y manteision y gall Modelu Gwybodaeth Adeiladu (BIM) a thrafodaethau cynnar â'r tîm dylunio eu cyfrannu i adnabod a gwireddu cyfleoedd i atal a lleihau gwastraff. Roedd y prosiect yn canolbwyntio ar atal a lleihau gwastraff o adeiladu gan edrych ar gyfleoedd i ddadadeiladu pan ddaw defnydd adeilad i ben.

Comisiynodd CEW gwmni Arup i ymchwilio i'r ffactorau canlynol:

Dylunio ar gyfer Dadadeiladu (Diwedd Bywyd) - ymchwilio i ba ddeunyddiau y gellir eu hailddefnyddio a'u hailgylchu pan ddaw bywyd adeilad i ben, gan gynnig dull o gofnodi gwerth ailgylchol deunyddiau drwy BIM a diffinio dull sy'n disgrifio'r ffordd fwyaf manteisgar o ddadadeiladu'r adeilad i wneud yr arbedion gorau.

Mesuriadau blocs safonol - ymchwiliad yn defnyddio BIM ar brosiect y Ganolfan Iâ, yn y cam ôl-ddylunio, i ganfod lle'r oedd yn bosibl lleihau gwastraff a gynhyrchir gan eitemau ailadroddus, safoni a diffinio prosesau i'w hailddefnyddio ar brosiectau yn y dyfodol.

Lleihau gwastraff pyst sylfeini – ymchwiliad yn defnyddio BIM yn y cam ôl-ddylunio ac adeiladu i asesu a chymharu dyluniadau gwahanol byst sylfaen i weld a oedd yn bosib lleihau gwastraff.

Mae'r llwyddiannau a gafwyd yn ystod y prosiect yn cynnwys:

- Trafod â'r gadwyn gyflenwi a sefydlu cynllun derbyn yn ôl drwy weithio gydag Euroclad.
- Mesurau atal gwastraff.
- Gwahanu pedair ffrwd wastraff gan gynnwys cerrig a theils anadweithiol, metel, plasterbord a phren diberygl.
- Torion y pyst sylfaen concrid a'r deunyddiau anadweithiol wedi eu cadw a'u malu ar y safle'n barod i'w hailgylchu
- 93 tunnell o wastraff pren wedi'i anfon i Reseiclo, cwmni ailgylchu pren cymunedol. Dengys cofnodion y cwmni Ailgylchu Pren Cymunedol lefel uchel o ailddefnyddio ac ailgylchu pren.
- Mae'r arbedion cost ar y prosiect yn dod i tua £40,000 drwy wahanu gwastraff; dylunio i ddileu gwastraff a defnyddio cynlluniau ailgylchu.

Yn gryno mae'r adroddiad yn gwneud yr argymhellion canlynol:

Argymhellion i'r cleient

- Asesu pa seilwaith sydd ar gael i ddelio gyda gwastraff fydd yn cael ei effeithio gan y gwaharddiad sydd i ddod ar dirlenwi a llosgi deunyddiau.
- Mae angen ystyried er mwyn asesu cynhyrchion ac opsiynau gwaredu penodol oherwydd cafwyd fod rhai cynhyrchion a ddefnyddiwyd ar y prosiect yn broblematig wrth eu gwaredu.
- Mae cyfathrebu'n barhaus ag ymgynghorwyr dylunio a chontractwyr yn hollbwysig.
- Gall pwysau i gwblhau prosiect arwain at lai o ymdrech i lynu wrth arferion safle fel gwahanu gwastraff.

Argymhellion i'r dylunydd

- Ystyried beth yw meintiau safonol y deunyddiau yn y cam dylunio.
- Ymgysylltu â chontractwyr i wella dealltwriaeth o ddeunyddiau.
- Ymwybyddiaeth o sut y mae dyluniadau cymhleth yn effeithio ar wastraff.
- Pwysigrwydd dylunio ar gyfer dadadeiladu.
- Pwysigrwydd defnyddio Modelu Gwybodaeth Adeiladu i ganfod ac atal gwrthdaro sydd yn ei dro'n arbed amser, adnoddau ac arian.

Argymhellion i'r contractwr

- Pwysigrwydd gwahanu gwastraff ar y dechrau. Canolbwyntio a thrafod strategaethau gwastraff drwy holl gamau'r prosiect i bawb ar y safle.
- Sicrhau bod sgipiau'n cael eu harchwilio bob dydd a hysbysu gweithwyr ar y safle bod angen parhau i wahanu gwastraff i'r sgipiau cywir. Gellir cyflawni hyn drwy arwyddion clir ar sgipiau, cadw'r safle'n lân a lle bo hynny'n bosib drwy ffensio'r holl sgipiau a wahanwyd.
- Dylai fod yn flaenoriaeth bod gan gontractwyr aelod o'r tîm ar y safle sy'n cymryd meddiant o reoli gwastraff. Mae hefyd yn hanfodol bwysig bod y person sy'n gyfrifol am gynhyrchu rhagolygon gwastraff mewn cysylltiad rheolaidd â thîm y safle i sicrhau bod y rhagolygon yn gyraeddadwy, rhesymol a seiliedig ar berfformiad blaenorol.
- Pwysigrwydd adnabod cyrchfannau pen draw'r gwahanol fathau o wastraff drwy drafod hyn gyda'r cwmni rheoli gwastraff sydd mewn golwg ar y dechrau un, cyn gosod y contract.

Pe bai Bil yr Amgylchedd (Cymru), sydd ar ddod, yn cael ei gymhwyso i'r prosiect hwn byddai angen ateb gwaredu arall ar gyfer hyd at 273.17m^3 o'r deunydd. Mae'n dangos felly bod angen mwy o ymchwil i opsiynau gwaredu eraill a sicrhau'r seilwaith priodol fel bod modd cyflwyno'r newidiadau a ddaw'n ofynnol o dan y ddeddfwriaeth.

2 Amdan

2.1 Galluogi Dyfodol Diwastraff

Cynllun gan Adeiladu Arbenigrwydd yng Nghymru (CEW) yw Galluogi Dyfodol Diwastraff (EZW) i gynnig ymyriad ymarferol, cadarnhaol a gweithredol i sefydlu os, a sut, y gall y diwydiant adeiladu gyrraedd y targed strategol ar gyfer Cymru o beidio ag anfon unrhyw wastraff i gael ei dirlenwi ynghyd ag adnabod unrhyw rwystrau cysylltiedig drwy weithio gyda safleoedd adeiladu 'byw'.

Mae CEW yn gweithio mewn cydweithrediad â'r diwydiant adeiladu i gynnig cymorth ymarferol i brosiectau adeiladu a thimau safle i drafod atebion hyfyw i sicrhau dim gwastraff. Mae'r prosiect hwn yn taflu mwy o oleuni ar ba mor debygol yw tirlenwi dim gwastraff ar hyn o bryd.

Amcanion y prosiect

- Deall a dangos pryd a sut y mae gwastraff yn digwydd yn ystod y broses adeiladu
- Deall y strategaethau, y methodolegau a'r cyfleoedd presennol i osgoi tirlenwi gwastraff ar safleoedd
- Dadansoddi pa mor ymarferol / ddichonadwy yw anfon dim gwastraff i'w dirlenwi yn yr amgylchedd sydd ohono
- Gweithio i ddatblygu atebion i atal a chynhyrchu llai o wastraff ar safleoedd adeiladu gan arwain o ganlyniad at orfod rheoli llai o wastraff a chostau gwaredu a thirlenwi is
- Cefnogi newid ymddygiad a phrosesau sy'n annog atal a lleihau gwastraff
- Sicrhau safle mwy effeithlon o weithredu cyfleoedd / atebion rheoli gwastraff – llai o ddosbarthiadau nwyddau, gwelliannau i'r traffig ar y safle, costau cyflenwi a deunyddiau is a chynhyrchedd gweithredol gwell
- Lledaenu atebion a chyfleoedd drwy ddatblygu strategaethau rheoli gwastraff effeithiol
- Cynnig cyfleoedd addysgol ac i ddysgu am dechnegau rheoli gwastraff eraill y gellir eu lledaenu ar gyfer prosiectau eraill yn y dyfodol gan sicrhau manteision parhaus

Paratowyd yr adroddiad hwn ar ôl cwblhau'r gwaith ar y safle i gyflwyno canlyniadau, cyfleoedd a llwyddiannau'r prosiect.

2.2 Amdan Kier

Mae gan y Kier Group dros 80 mlynedd o brofiad adeiladu. Mae eu prosiectau'n amrywio o eiddo; amddiffyn; addysg; tai; diwydiannol; pŵer; trafnidiaeth a chyfleustodau. Mae'r Grŵp yn cyflogi dros 24,000 o bobl ar ei raglenni yn y DU, y Caribî, yn y Dwyrain Canol ac yn Hong Kong.

3 Cefndir y Prosiect

Buddsoddiad preifat proffil uchel gwerth £17.5m yw Canolfan Iâ Cymru (IAW) i greu dau rinc iâ ar yr hen safle tirlenwi trefol ym Mae Caerdydd. Mae'r datblygiad yn ffocws i chwaraeon iâ yn y DU ac yn cynnig seddi i tua 3000 o wylwyr ynghyd â chaffi a chyfleusterau i gynnal digwyddiadau preifat. Mae'r adeilad yn seiliedig ar dempled masnachol o fetel cyfansawdd a chladin polycarbonad ar ffrâm ddur trapesoid.

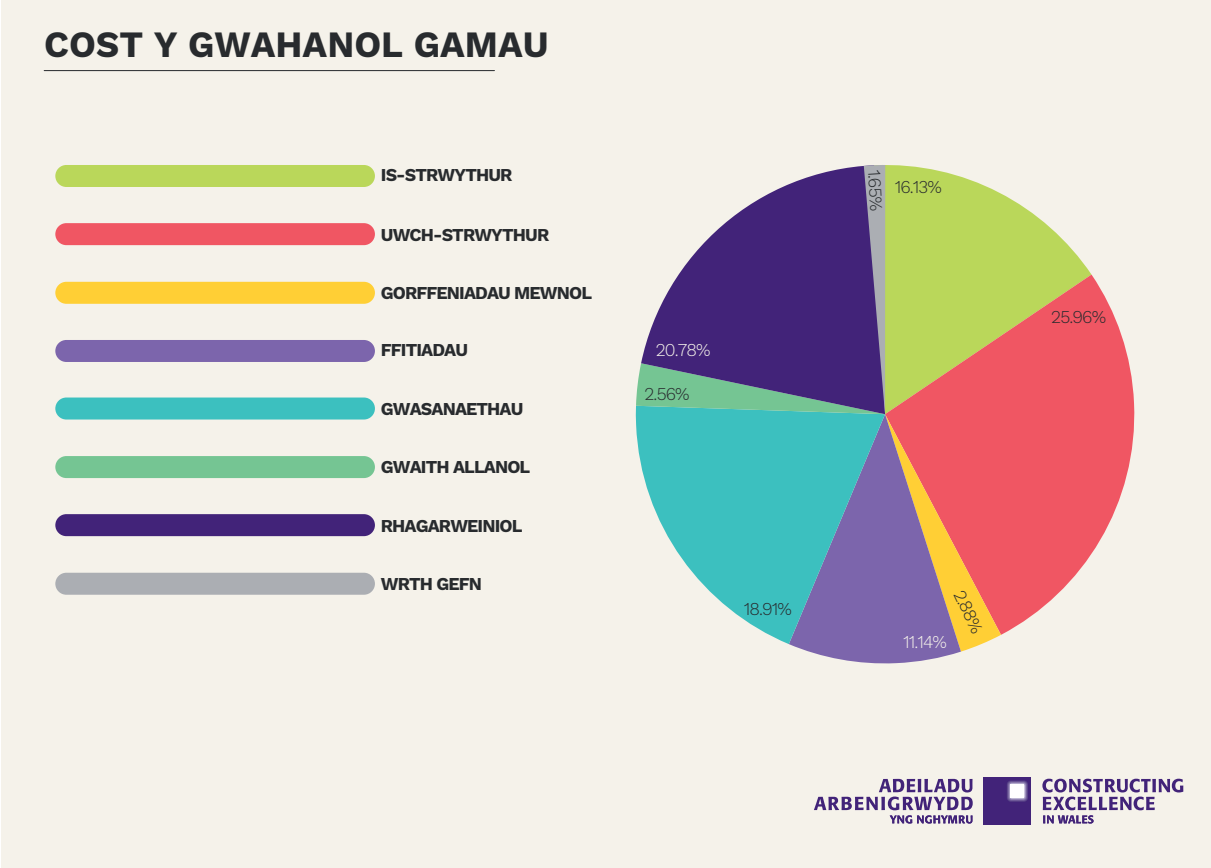
Dechreuodd y prosiect ym mis Chwefror 2014 gyda dyluniad y Ganolfan Iâ'n cael ei gwblhau'n derfynol cyn cyflogi'r tîm Galluogi Dyfodol Diwastraff. Roedd y caniatadau cynllunio yn eu lle a'r contractwr, yr isgontractwyr haen un, y cyflenwyr a'r contractwyr rheoli gwastraff wedi eu penodi.

Gwelodd y prosiect doriad mewn adeiladu rhwng Hydref 2014 ac Ebrill 2015. Cafodd y gwaith cladin a thoi ei gwblhau yn y cam cychwynnol fel bo'r rinc iâ'n ddiddos rhag y tywydd. Penderfynodd Kier dorri'n ôl ar eu staff adeiladu ar y safle oherwydd y toriad yn y gwaith. Pan ailddechreuodd y gwaith adeiladu yn Ebrill 2015 roedd newidiadau i'r staff a'r ochr reoli. Gyda'r newidiadau staff hyn effeithiwyd hefyd ar reoli gwastraff ar y safle, collwyd cyfarwyddyd cyffredinol yr ochr reoli ac nid oedd pencampwr gwastraff ar y safle mwyach. Cwblhawyd y prosiect yn Ionawr 2016.

3.1 Cost

Gwerth Gwreiddiol - £17.5 miliwn

Gwerth y Contract (tua)	£17,500,000
Elfen	**Canran**
Is-strwythur	16.13%
Uwch-strwythur	25.96%
Gorffeniadau Mewnol	2.88%
Ffitiadau	11.14%
Gwasanaethau	18.91%
Gwaith Allanol	2.56%
Gwaith Rhagarweiniol	20.78%
Wrth Gefn	1.65%



3.2 Math o gontract

JCT, Dylunio ac Adeiladu 2011. Rhaglen 71 wythnos yn wreiddiol gydag wythnos o estyniad amser wedi'i roi ac wedi'i gwblhau mewn 72 wythnos.

4 Methodoleg

Mae pob prosiect EZW yn derbyn cynllun gwaith / methodoleg wedi'i deilwrio. Cafodd y cynnwys ei ddatblygu gyda thîm y prosiect a'i ddylunio i wella unrhyw fesurau presennol oedd yn cael eu cymryd.

Drwy gydol y prosiect, darparodd tîm prosiect Kier y pethau canlynol:

1. Cymorth ac arweiniad ar reoli gwastraff technegol drwy gydol y prosiect i helpu i osgoi anfon unrhyw wastraff i gael ei dirlenwi
2. Adnodd rheoli gwastraff penodol i ddarparu cymorth ymarferol gyda rheoli gwastraff ar y safle ac i ddarparu opsiynau / atebion diwastraff posib ar gyfer materion gwastraff yn codi ar y safle. Roedd y cymorth hwn yn cynnwys:

- Ymweliadau safle
- Cymorth rheoli gwastraff yn cynnwys cyngor ar wahanu fwy o wastraff
- Adnabod deunyddiau a ddefnyddiwyd ar y safle
- Llai o wastraff drwy annog arferion "cadw tŷ" da i leihau difrod a gorarchebu deunyddiau
- Llai o wastraff drwy ailddefnyddio neu ddod o hyd i atebion eraill yn lle gwaredu
- Cymorth i weithio gyda'r gadwyn gyflenwi ar gyfer y safle, cleientiaid a chwmnïau rheoli gwastraff i annog cynlluniau derbyn yn ôl, addysg ehangach a data gwastraff gwell
- Paratoi, monitro a diweddaru'r Cynllun Rheoli Gwastraff Safle (SWMP) yn defnyddio fersiwn benodol Kier o system SMARTWaste y BRE.
- Paratoi Model Gwybodaeth Adeiladu (BIM) o'r safle, wedi'i baratoi o wybodaeth wedi'i chyflenwi gan Arup a Keller.
- Adolygu ac optimeiddio'r dyluniad yn defnyddio BIM i leihau gwastraff, dadansoddi a rhoi amcan o faint a'r math o wastraff oedd yn cael ei greu, ac i adnabod unrhyw wrthdaro posib ar y safle

Cafodd 13 o ymweliadau safle i gynorthwyo rheoli gwastraff eu cyflawni fel rhan o EZW, gan gynnwys trafodaethau â thîm y safle i siarad am broblemau safle a gwastraff, y cynnydd, atebion a gwelliannau posib. Rhoddwyd cymorth hefyd i dîm y safle ar gofnodi data ar y system SMARTWaste. Ar ôl pob ymweliad safle gwnaed argymhellion er mwyn helpu i wella'r arferion rheoli gwastraff.

Y prif argymhellion a wnaed ar gyfer rheoli gwastraff oedd:

- Gwella arwyddion, gwahanu a storio deunyddiau
- Creu compownd gwastraff dynodedig
- Adnabod unrhyw gynlluniau lle byddai'r cyflenwyr yn derbyn deunyddiau'n ôl
- Adnabod pencampwr gwastraff i adolygu a sicrhau cydymffurfio â deddfwriaeth a bod arferion gorau o ran rheoli gwastraff yn cael eu dilyn
- Cynnal sgyrsiau i godi ymwybyddiaeth o atal a lleihau gwastraff
- Trafod â'r gadwyn gyflenwi i leihau pecynnu a / neu gaffael gwasanaeth i'w symud o'r safle

Cafodd dogfennau a chanllawiau cysylltiedig ar yr uchod hefyd eu darparu.

Cafodd Modelu Gwybodaeth Adeiladu (BIM) ei wneud fel rhan o'r prosiect er mwyn cael cynllun gwaith blocs a gweld sut y gellid lleihau gwastraff, yn bennaf drwy ddylunio damcaniaethol neu newid deunyddiau. Defnyddiwyd drôns awyr hefyd i ffilmio'r cynnydd drwy gydol y prosiect. Roedd y gwaith cyfathrebu'n cynnwys diweddaru'n gyson drwy twitter, digwyddiadau diweddaru, gweminarau a chyflwyniadau.

5 Dadansoddiad o'r Data

5.1 Dadansoddiad yn ôl camau'r prosiect

Cynhyrchwyd cyfanswm o 4185.16m^3 (3945.63 tunnell) o wastraff drwy waith adeiladu'r prosiect.

5.1.1 Gwaith daear/tyllu

Cynhyrchwyd cyfanswm o 2797.86 m^3 o wastraff yn ystod y cam gwaith tyllu, 66% o'r holl wastraff a gynhyrchwyd. Roedd 2571.14 m^3 o wastraff y gwaith tyllu'n waith pridd, 91.89% o holl wastraff y gwaith tyllu. Ailddefnyddiwyd y pridd i lenwi'r ddaear o gwmpas y safle.

Cynhyrchwyd gweddill y gwastraff gwaith tyllu gan yr isgontractwr tyllu E&T L Jones, fel a ganlyn: Roedd 15.42 m^3 yn wastraff cymysg, 4.7 m^3 yn bren, 3.79m^3 yn blastig, 1.1 m^3 yn ddeunydd pecynnu, 0.74 m^3 yn fetelau a 0.97 m^3 yn wastraff ffreutur.

Mae'r safle'n gymhleth oherwydd ei fod yn hen safle tirlenwi trefol ac mae'n bosib i'r adeilad symud ac y gallai nwy hefyd ollwng unwaith y bydd yr adeilad yn setlo. I oresgyn y problemau hyn cyflwynodd Arup, y peirianwyr dylunio, gyfres o byst sylfaen concrid i gynnal y strwythur ynghyd â wal strwythurol gladdedig.

Er mwyn gwahaniaethu rhwng hyd y pyst sylfaen gan ddibynnu ar ddaeareg leol y safle, cafodd arolwg daear helaeth ei gyflawni gan gwmni isgontractio Keller. Yn dilyn cydweithrediad rhwng Arup a Keller, newidiwyd fymryn ar ddyluniad gwreiddiol y pyst ychwanegol, y trawstiau daear a rhai o gapiau'r pyst sylfaen.

Yn anffodus nid oes modd osgoi gwastraff wrth osod pyst concrid oherwydd gall yr amodau tanddaearol newid yn ddramatig drwy gydol y prosiect, pa mor dda bynnag y profir y ddaear. Daethpwyd â chyfanswm o 9296m o byst sylfaen i'r safle. Cynhyrchwyd cyfanswm o 597.4m o wastraff pyst sylfaen. Mae hyn yn cyfateb i 6.5% o'r holl ddarnau pyst a ddaethpwyd i'r safle. Pentyrrwyd concrid a gwastraff anadweithiol ar y safle a defnyddiwyd malwr i'w ailgylchu'n gerrig agreg ar y safle o dan y Protocol Ansawdd WRAP.

Cafodd cyfanswm o 200m^3 o ddeunydd concrid ei falu a'i ailgylchu'n gerrig rwbel.

5.1.1.1 Gwaith dur strwythurol

Cynhyrchwyd 67.79m^3 o wastraff o'r cam gwaith dur, 1.61 % o'r holl wastraff. Roedd ychydig dros 45% o'r gwastraff, 30.57m^3, yn bren. O'r gweddill roedd y rhan fwyaf yn wastraff cymysg 16.7 m^3, sef 24.63% o'r holl wastraff a gynhyrchwyd yn y cam hwn. Roedd gwastraff arall a gynhyrchwyd yn cynnwys 4.41 m^3 o blastig, 3.85 m^3 o frics, 3.12m^3 o ddeunydd pecynnu, 2.57m^3 o goncrid, 2.2m^3 o bridd, 1.28m^3 o fetelau, a'r gweddill yn wastraff ffreutur (3.09m^3).

5.1.1.2 Gwaith strwythurol arall: toi, trin y drychiadau a'r strwythur mewnol

Ar gyfer yr elfennau hyn cynhyrchwyd 560.95m^3 o wastraff, 13.4% o'r holl wastraff a gynhyrchwyd. Roedd y rhan fwyaf o'r gwastraff yn anadweithiol sef 205.7m^3, gwastraff pren a chymysg. Cyfanswm y ffigur gwastraff cymysg ar gyfer y cyfnod hwn oedd 58.74m^3 a tua'r un faint o bren sef 54.02m^3.

Cynhyrchodd y paneli ar gyfer inswleiddio'r to 3.33m^3 o dorion yn ystod y cyfnod hwn. Sefydlwyd cynllun i dderbyn y deunydd hwn yn ôl, fel y trafodwn nes ymlaen yn adran 7.9.

Roedd y ffrydiau gwastraff eraill yn cynnwys ffrydiau deunydd pecynnu, plastig, gwastraff ffreutur a chymysg, a heb eu nodi'n glir ar SMARTWaste.

Trin y Drychiadau – llun gan Scott Brownrigg

5.1.2 Crefftau Gorffen

Cynhyrchodd y crefftau gorffen gyfanswm o 420m^3 o wastraff, 10.03% o'r holl wastraff. Roedd y rhan fwyaf yn wastraff cymysg (57.40%). Rhoddir y manylion isod yn ôl crefft neu weithgaredd:

5.1.2.1 Plasterbord, parwydydd a gwaith cladin

Roedd y gwastraff plasterbord o weithgareddau'r crefftau gorffen yn 70.64 m^3, 16.87% o'r holl wastraff a gynhyrchwyd gan y crefftau gorffen.

Cafodd y gwaith plastro ei wneud gan Richard Kemble Contracts (RKC). Cynhaliwyd cyfarfod cyn gosod y contract rhwng CEW a RKC i dynnu sylw at faterion rheoli gwastraff ac i drafod cyfleoedd i leihau gwastraff pecynnu, plasterbord ac inswleiddio. Rhoddwyd sgwrs gan CEW ar leihau gwastraff ar 5 Awst 2015, gyda deg o staff RKC a dau o weithwyr safle Kier yn mynychu.

Rai wythnosau i mewn i'r prosiect, cododd broblemau gyda gwahanu gwastraff. Cafwyd nad oedd y gweithwyr yn gwahanu gwastraff yn yr ardaloedd gwaith gan halogi'r sgipiau naill ai gyda phlasterbord neu ddeunydd inswleiddio. Prynwyd biniau o wahanol liw fel rhan o'r cynllun EZW fel y gallai'r gweithwyr wahanu gwastraff yn haws yn eu hardaloedd gwaith. Cafwyd gwelliant yn yr arferion gwahanu gwastraff o ganlyniad i hyn er bod croes-halogi'n dal i ddigwydd o hyd.

Cyfrifoldeb RKC oedd y sgipiau plasterbord yn unol â'u contract. Oherwydd cyfyngiadau amser a bod contractwyr yn gweithio ar sail pris am osod pob m^3, roedd y gweithwyr yn gyndyn o symud yn bell o'u mannau gwaith i nôl torion addas. O'r herwydd torrwyd shitiau newydd o blasterbord yn aml.

Symudwyd y gwastraff plasterbord o'r safle gan sgipiau Atlantic a lwyddodd i ailgylchu 98% ohono, fodd bynnag oherwydd bod peth o'r plasterbord wedi'i daflu i sgip gwastraff cymysg roedd hyn wedi effeithio ar y gyfradd derfynol a'i gostwng i 97%.

5.1.3 Gwaith saer, addurno, inswleiddio'r to, lloriau finyl a charpedi

5.1.3.1 Gwaith saer

Cynhyrchodd y safle 166.25 m^3 o wastraff pren dros y cyfnod hwn. Anfonwyd y rhan fwyaf o'r gwastraff pren i Reseiclo yng Nghasnewydd, menter gymdeithasol sy'n adfer y pren i'w ailwerthu a'i uwchgylchu. Rhoddir dadansoddiad yn y tabl isod o'r gwastraff pren a ailddefnyddiwyd ac a ailgylchwyd o'r cynllun:

Pren a gasglwyd (llathenni ciwbig)	934	
Pren a gasglwyd (tunelli)	93.4	
Arbedion £ yn erbyn y gost o ddefnyddio sgip	£3,212.96	
Ailddefnydd Gradd Uchel (DIY, cynhyrchion pren, paledi)	tunelli	%
	26	28
Ailddefnydd Gradd Isel (coed tân, priciau tân, rhandiroedd)	tunelli	%
	2.8	3
Adfer (torri'r pren yn sglodion tanwydd, bordiau sglodion)	tunelli	%
	64.6	69

Symudwyd y pren gradd is mwy 'problematig', 26m^3 i gyd, o'r safle gan sgipiau Olivers a'i anfon wedyn i Chwarel y Bryn i'w ailgylchu.

Roedd cyfnodau penllanw penodol drwy gydol y prosiect o ran cynhyrchu gwastraff pren. Yn Awst 2016 cynhyrchwyd 47.17m^3 o wastraff pren. Dengys rhaglen y safle fod y gwaith saer gorffenedig a'r ffitiadau wedi'i wneud yn ystod y cyfnod hwn a fyddai'n cyfrif am y penllanw hwn mewn gwastraff pren.

Cafwyd cynnydd sylweddol arall mewn gwastraff pren yn Ionawr 2016 (41m^3) a gyd-ddigwyddodd â chwblhau'r safle a chlirio cabanau'r safle lle'r oedd pren wedi cael ei storio drwy gydol y prosiect.

5.1.3.2 Lloriau

Cafwyd trafodaeth â'r gweithwyr gosod llawr ar y safle am y gwastraff o'r torion matiau rwber. Rhoddodd Kier wybod nes ymlaen i'r tîm EZW mai'r cwmni lloriau oedd yn gyfrifol am waredu unrhyw wastraff llawr oedd yn cael ei gynhyrchu gan y cwmni.

Anfonwyd e-byst at yr isgontractwr i drafod y cynllun EZW ac i gynnig cymorth gydag anfon y torion matiau rwber i'w hailddefnyddio neu ailgylchu. Ni chafwyd ateb ac nid oedd unrhyw ddata ar wastraff llawr wedi'i gofnodi ar SMARTWaste.

5.1.4 FFE a chlirio'r safle

Cynhyrchwyd cyfanswm o 338.04 m^3 o wastraff o'r gweithgareddau hyn. Roedd 240.32 m^3 yn wastraff cymysg, 71% o'r holl wastraff a gynhyrchwyd o glirio'r safle. Roedd y gweddill yn wastraff pecynnu 41.39m^3 (12.24% o gyfanswm clirio'r safle), 47.38 yn bren, 3.67m^3 yn frics, 2.01m^3 yn blastig, 0.2m^3 yn ddodrefn, 2.34m^3 yn wastraff ffreutur a 0.73m^3 yn ffrydiau gwastraff eraill na chawsant eu nodi ar SMARTWaste.

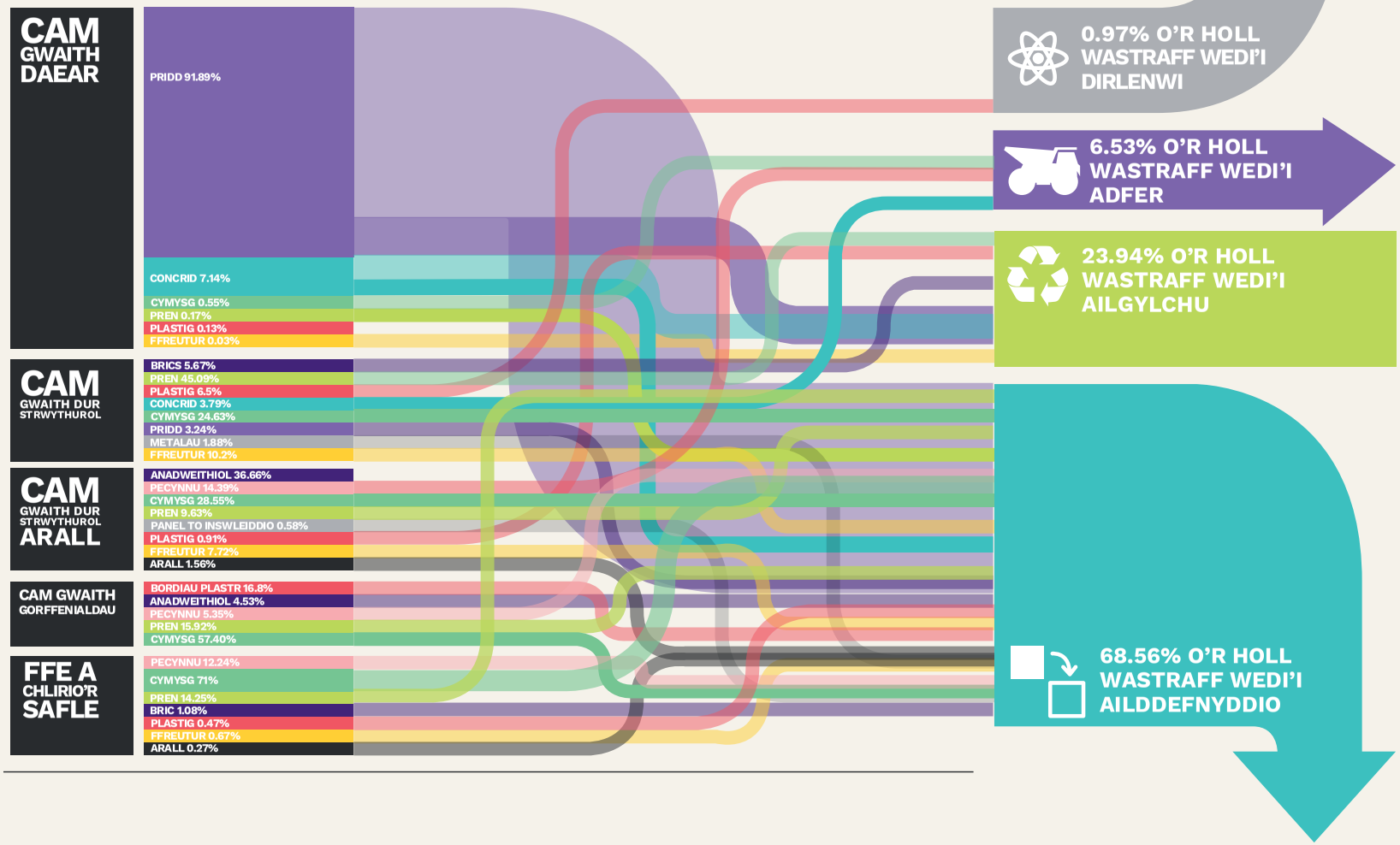
Oherwydd yr holl ddeunydd diogelu llawr a ddefnyddiwyd drwy'r prosiect, argymhellodd CEW ddefnyddio cynllun derbyn yn ôl peilot gan Protec. Mae'r gwasanaeth yn cynnig symud shitiau diogelu oddi ar y safle gyda 100% ohono'n cael ei ailgylchu'n gynhyrchion newydd. Roedd hyn yn costio tua £343.00 y dunnell o wastraff diogelu.

Penderfynodd Kier ddefnyddio'r shitiau Protec ar brosiectau eraill gan osgoi gorfod dosbarthu'r deunydd fel gwastraff ac osgoi ei dirlenwi. Prynodd Kier gyfanswm o 750 o shitiau diogelu, 7.5m^3, gan Protec.

Ystyrir bod y swm helaeth o wastraff cymysg a gofnodwyd dros y cyfnod hwn wedi deillio mae'n debyg o'r pwysau i gwrdd â'r terfyn amser trosglwyddo.

CANOLFAN IÂ CYMRU

CYRCHFAN PEN DRAW GWASTRAFF A SYMUDWYD O'R SAFLE



5.2 Dadansoddiad yn ôl rhaglen

Rhwng Hydref 2014 ac Ebrill 2015 penderfynodd y datblygwyr ohirio'r gwaith adeiladu oherwydd cyfyngiadau ariannol. Ychydig iawn o waith oedd yn cael ei wneud ar y safle dros y cyfnod hwn heb fawr ddim gwastraff oherwydd bod y safle wedi'i gau.

Yn ystod y rhaglen roedd cyfnodau penllanw penodol o ran cynhyrchu gwastraff. Eglurir y rhesymau posib dros y cyfnodau penllanw hyn isod:

5.2.1 Penllanw Mawrth 2014

Ym mis Mawrth roedd y rhan fwyaf o'r gwastraff yn cynnwys pridd, 2570m^3 i gyd, o ganlyniad i symud pridd drwy waith tyllu. Storiwyd yr holl wastraff pridd ar y safle a'i ddefnyddio nes ymlaen fel llenwad. Roedd y 7.71m^3 o wastraff a gynhyrchwyd ym mis Mawrth yn gymysg. Roedd gweddill y gwastraff yn cynnwys 0.37m^3 o becynnau, 1.29m^3 o bren a 0.37m^3 o fetel sgrap.

5.2.2 Penllanw Awst 2014

Ym mis Awst cynhyrchwyd bron i 28m^3 o wastraff. Roedd 13.89m^3 yn wastraff pren, 5.32m^3 yn wastraff cymysg, 2.2m^3 yn bridd, 1.1m3 yn fetel sgrap, 3.49m^3 yn blastig a'r 1.5m^3 oedd yn weddill yn wastraff anadweithiol a phecynnu.

Dros y cyfnod hwn roedd y gwaith tyllu'n dod i ben a allai fod yn rheswm dros y cynnydd mewn gwastraff pren wrth i'r estyll pren gael eu tynnu allan a'u gwaredu.

Mae gweithwyr hefyd yn cynhyrchu gwastraff plastig a metel sgrap o ganlyniad i dorion peipiau a bariau ynghyd â deunydd pecynnu brics a ffitiadau. Mae ffrydiau gwastraff pecynnu cwrs gwrthleithder (DPC) hefyd yn cael eu cynhyrchu fel rhan o'r gwaith hwn.

Ychwanegwyd ychydig o isbridd, 2.2m^3, i'r pentwr pridd gwreiddiol a'i ailddefnyddio wedyn fel llenwad.

5.2.3 Penllanw Gorffennaf 2015

Yng Ngorffennaf cynhyrchwyd cyfanswm o 60.95m^3 o wastraff. Roedd bron i hanner y gwastraff yn gymysg (29.37m^3). Roedd 9.14m^3 yn wastraff brics, 6.9m^3 yn becynnu, 6.42m^3 yn bren a 4.56m^3 yn wastraff plastig. Cynhyrchwyd 4.56m^3 o wastraff ffreutur hefyd, y mwyaf o'r gwastraff hwn i gael ei gynhyrchu drwy'r prosiect sy'n dangos bod y gweithwyr wedi cyrraedd penllanw yn y mis hwn o ran mynychu'r safle.

5.2.4 Tachwedd 2015

Cynhyrchwyd 157.14m^3 o wastraff yn ystod y mis hwn. Dengys y rhaglen fod y cyfnod hwn yn benllanw ar gyfer y crefftau gorffen. Roedd y 104.57m^3 a gynhyrchwyd ym mis Tachwedd yn cynnwys gwastraff cymysg. Roedd y ffrydiau gwastraff eraill yn cynnwys 22.47m^3 o wastraff pecynnu, 16.97m^3 o bren, 5.51m^3 o frics, 3.67 m^3 o goncrid, 0.79 o blastig, 2.14m^3 o wastraff ffreutur a 1.02m^3 o ffrydiau gwastraff amhenodol eraill.

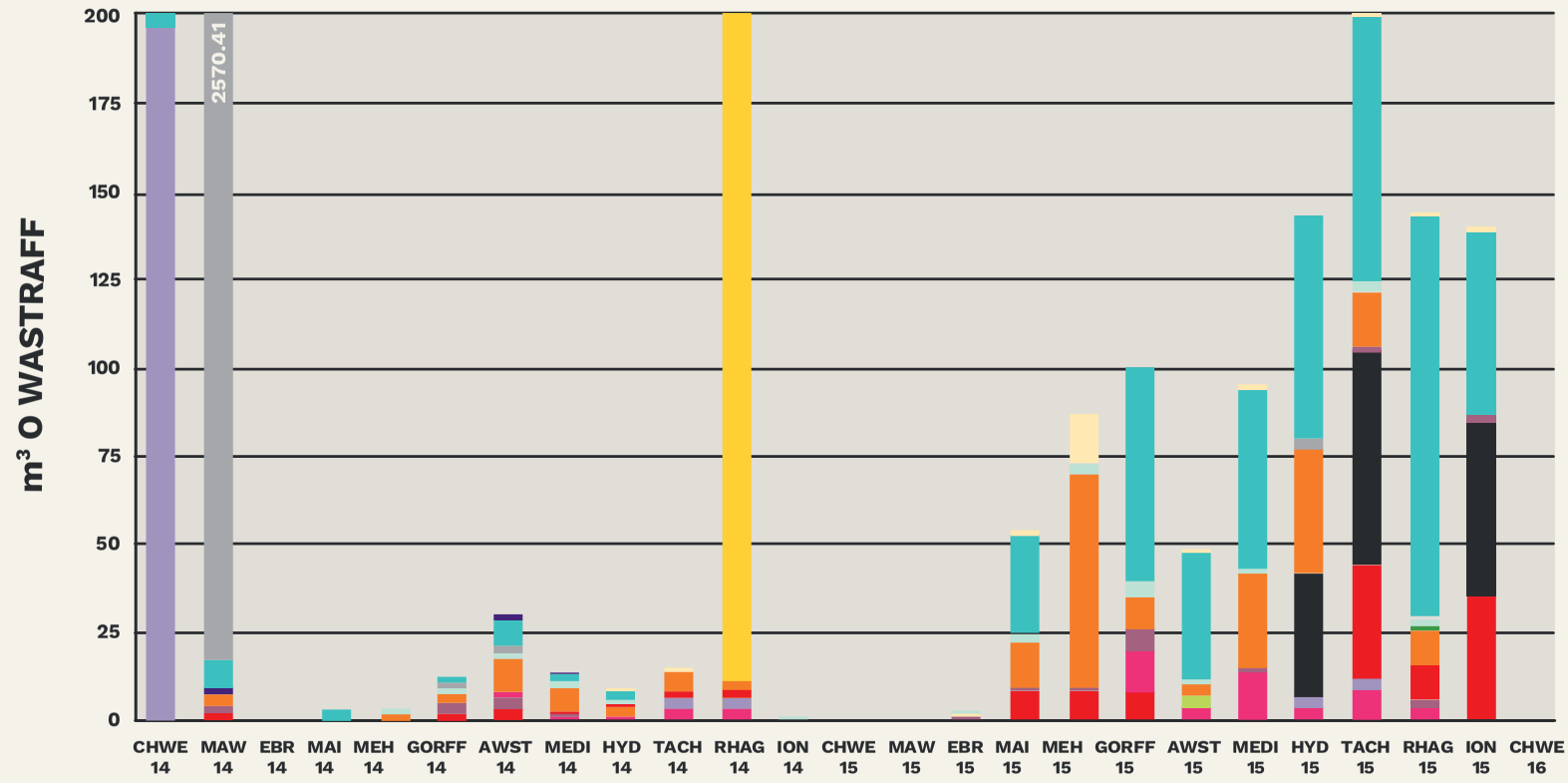
Mae'r symiau helaeth o wastraff a gynhyrchwyd, dros ddwy ran o dair yn wastraff cymysg, yn dangos yr effaith y mae cyfyngiadau amser yn ei gael ar berfformiad a rheoli gwastraff fel bo'r gweithwyr yn gallu cwblhau'r prosiect ar amser.

5.2.5 Penllanw Ionawr 2016 (clirio'r safle)

Cynhyrchwyd 189.27m^3 o wastraff yn ystod clirio'r safle. Roedd 111m^3 o'r gwastraff yn gymysg ei natur. I osgoi cynhyrchu symiau mawr o wastraff cymysg ar y safle, mae angen pwysleisio i'r tîm ar y safle bod angen gwahanu gwastraff fel nad yw sgipiau gwastraff cymysg yn gadael y safle.

Yn ôl yr hyn a ddeallwn y rheswm dros yr holl wastraff cymysg oedd y pwysau amser i drosglwyddo.

GWASTRAFF MISOL YN ÔL MATH m³



ADEILADU ARBENIGRWYDD YNG NGHYMRU

CONSTRUCTING EXCELLENCE IN WALES

6 Dadansoddiad yn ôl opsiwn rheoli gwastraff

6.1 Atal

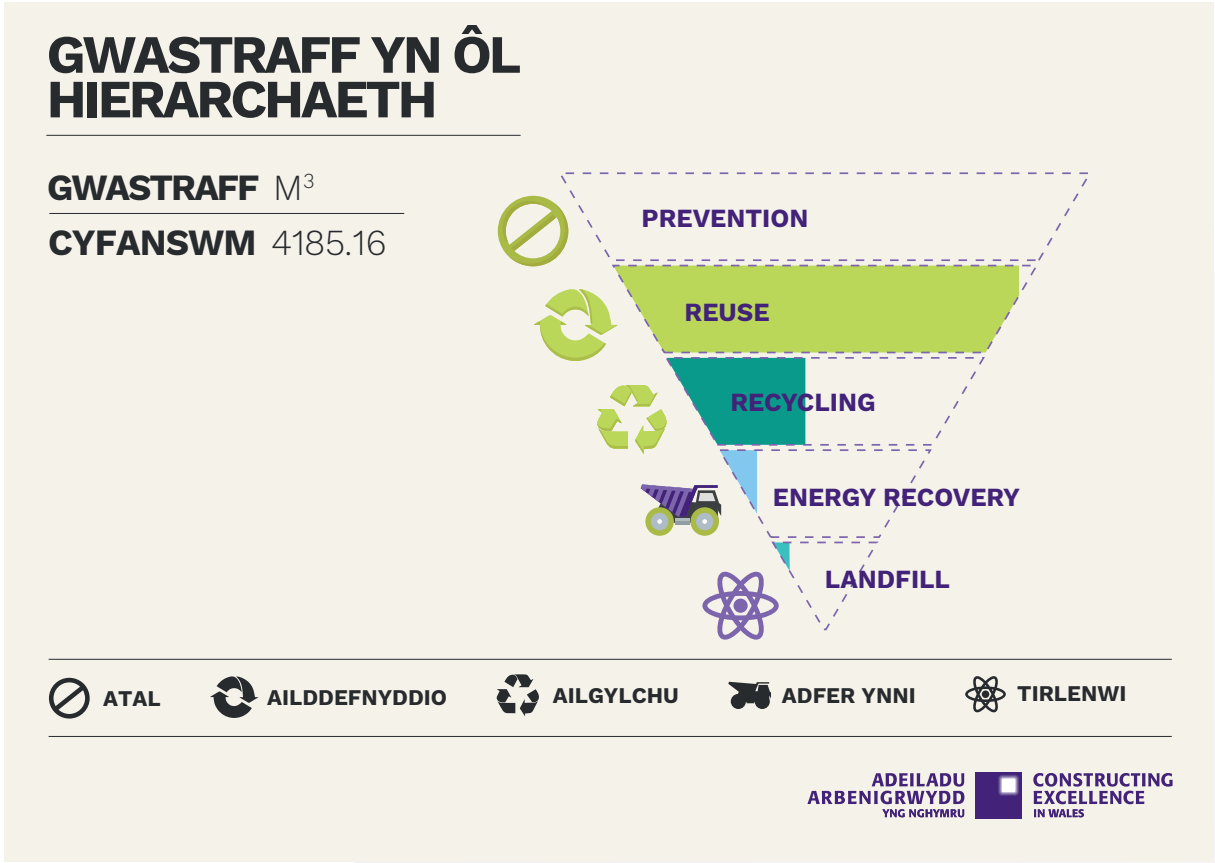
6.1.1 Deunydd pecynnu

Ar anogaeth y tîm EZW, cysylltodd Richard Kemble Ltd (y contractwyr plastro) â'r gadwyn gyflenwi plasterbord i ofyn iddynt becynnu cyn lleied â phosib ar y plasterbord wrth ei ddosbarthu i'r safle. Storiwyd yr holl blasterbord yn yr adeilad i'w ddiogelu rhag y glaw. Amcangyfrifir y gwnaed tua 1.5 m^3 o arbedion gwastraff drwy wneud hyn.

Cynhyrchodd contractwyr Millstream 100 o flychau cardbord, 17kg i gyd, a 6000 o fagiau lapio gan roi cyfanswm o 15kg. Anfonwyd yr holl becynnu gwastraff i safle Millstream i gael ei swmpwasgu a'i ailgylchu.

6.1.2 Ymarfer canfod gwrthdaro (grisiau concrid)

Yn dilyn ymarfer BIM i groeswirio'r wybodaeth 2D gyda'r model, canfuwyd nad oedd dyluniad y grisiau concrid yn ffitio'r seddi teras ffrâm ddur – roedd rhai grisiau'n torri drwy'r seddi ac ni chaniateir hyn oherwydd mae'n creu perygl baglu. Diwygiwyd hyn yn y cam dylunio gyda'r grisiau'n cael eu hailddylunio cyn eu castio. Cyfrifwyd yr arbedion o ran amser a chost deunyddiau'r gwaith diwygiedig pe bai'r grisiau anghywir wedi cyrraedd y safle i fod rhwng tua £30,000 a £40,000, hanner cost wreiddiol y grisiau. Nid yw Kier wedi darparu unrhyw arbedion maint / pwysau.



6.1.3 Eraill

Dyma'r mesurau atal eraill a ddefnyddiwyd:

- Saernïo'r paneli cladin allanol ymlaen llaw
- Ymarfer BIM i ganfod unrhyw wrthdaro â seddi'r arena
- Mae defnyddio BIM yn golygu bod modd cydgysylltu'r darluniau a'r rhaglenni'n well gan leihau unrhyw anghysondeb gyda'r wybodaeth adeiladu a allai arwain at wastraff ar y safle, ac angen cywiro gwallau adeiladu
- Cynllun gosod estyniad y rinc iâ, wedi'i ddylunio ar sail mesuriadau brics a blocs safonol
- Mae'r elfennau adeiladu wedi cael eu safoni gymaint â phosib o waliau gwaith blocs a pharwydydd mewnol
- Y concrid agored yn y ffrâm strwythurol i aros gan olygu bod llai o angen gorffeniadau pellach
- Cysylltu'r draenio newydd i'r cyfleusterau ystâd presennol gan olygu llai o waith draenio newydd
- Manylion inswleiddio perfformiad uchel gan felly leihau trwch y waliau a lleihau ôl-troed yr adeilad
- Dewis cyflenwyr fydd yn derbyn cynhyrchion heb eu defnyddio (a heb gael difrod) yn ôl
- Stydiau metel ar y waliau allanol a mewnol i'w torri oddi ar y safle
- Paciau o fordiau sment i'w prynu yn eu meintiau cywir
- Llwytho deunyddiau'n ofalus allan i'r ardal adeiladu

6.2 Ailddefnyddio

6.2.1 Pridd

Cafodd 2573.35m^3 o bridd wedi'i dyllu ei gadw ar y safle a'i ailddefnyddio wedyn fel llenwad. Oherwydd bod y safle ar ben hen safle tirlenwi trefol, archwiliwyd y deunydd a dyllwyd am unrhyw halogi. Wrth dyllu ar gyfer y system ddraenio cafodd y pridd ei ddychwelyd i lenwi'r ddaear a dyllwyd.

6.2.2 Reseiclo, Cynllun Ailgylchu Pren Cymunedol

Casglwyd ychydig dros 273m^3 (93.4 tunnell) o wastraff pren gan Reseiclo, cynllun ailgylchu pren cymunedol yng Nghasnewydd. Mae'r cwmni di-elw hwn yn ailddefnyddio 28% o'r cynhyrchion pren a gesglir ganddynt o safleoedd ledled Cymru. Ar sail y pwysau a gasglwyd o'r rinc iâ, mae'n debyg yr ailddefnyddiwyd 26 tunnell o bren. Dyma'r canrannau ailddefnyddio, ailgylchu ac adfer:

Bwrdd wedi'i wneud o wastraff pren IAW

- 28% ar gyfer ailddefnydd gradd uchel (DIY, cynhyrchion pren a phaledi)
- 3% ar gyfer ailddefnydd gradd isel (coed tân, priciau tân, rhandiroedd)
- Y 69% arall wedi'i dorri'n sglodion a'i adfer ar gyfer tanwydd

Ailddefnyddiwyd cyfanswm o 76.47m^3, 26.04 tunnell o bren drwy'r cynllun Reseiclo gan arbed £3,213 o'i gymharu â gwaredu'r deunydd mewn sgipiau.

6.2.3 Paledi

Roedd Millstream Ltd, y contractwr a fu'n cyflenwi a ffitio'r seddi yn y stadiwm, wedi eu pecynnu mewn cratiau pren haenog mawr gyda chardbord a phlastig i'w diogelu a gwaelodion o baledi plastig. Nododd Millstream fod 24 o baledi plastig 7m^3 (1.05 tunnell o bwysau) wedi eu derbyn yn ôl i'w hailddefnyddio. Ailddefnyddiwyd y cratiau pren haenog hefyd, gan arbed 6.4m^3 (2.2 tunnell).

Ailddefnyddiodd cwmni Massey Cladding 20 o baledi drwy'r contract gan arbed 6m^3 rhag llenwi sgip. Ailddefnyddiwyd 8kg o fetel traul drwy'r prosiect hefyd.

Ailddefnyddiwyd cyfanswm o 19.4m^3 o baledi a chynhyrchion pecynnu drwy'r prosiect.

Mae elfennau eraill a ailddefnyddiwyd gan Kier yn cynnwys pyst sylfaen concrid a ddefnyddiwyd fel rhwystrau rheoli traffig cyn cael eu malu a'u hailgylchu ar gyfer y safle, 200m^3 i gyd.

Dengys y ffigurau i gyd fod 2869.22m^3 o wastraff adeiladu wedi cael ei ailddefnyddio drwy'r prosiect.

6.3 Ailgylchu

Mae'r cyfraddau ailgylchu gan gwmni llogi sgipiau Olivers ar gyfer gwastraff adeiladu yn cynnwys:

- Cyfraddau ailgylchu 95% ar gyfer brics (34.81m^3), anadweithiol (1.98m^3), teils a serameg (2.65m^3) a choncrid (9.99m^3). Ailgylchwyd cyfanswm o 49.43m^3 o wastraff anadweithiol a'i anfon i Chwarel y Bryn i'w brosesu ymhellach, yn ôl cofnodion sgipiau Olivers.
- Anfonwyd 100% o bren (26 m^3) i Chwarel y Bryn (Hengoed).
- Anfonwyd 85% o wastraff cymysg (486.48m^3) i Chwarel y Bryn.
- Anfonwyd 100% o fetelau (2.01m^3) i SR Recycling (Penalta).
- Anfonwyd 80% o blastig (13.28m^3) i Chwarel y Bryn.
- 90% o becynnu (80.55m^3). Anfonwyd gwastraff pecynnu wedyn i Chwarel y Bryn (cwmni Cwmpawd Gwyrdd ar gyfer prosesu pellach).

Anfonwyd yr holl wastraff anadweithiol, pren, plastig a chardbord o safle sgipiau Olivers yn Hengoed i Chwarel y Bryn i'w brosesu ymhellach.

Ailgylchwyd cyfanswm o 657.75m^3 o wastraff gan sgipiau Olivers a Chwarel y Bryn.

Sefydlwyd contract rheoli gwastraff ar wahân ar gyfer y gwastraff ffreutur a swyddfa. Y cwmni a ddewiswyd oedd MJ Church o Fryste. Rhoddir dadansoddiad isod o'r gwastraff a ddaeth o'r Rinc Iâ.

- (6.57 m^3) ar gyfer plastig – cyfradd ailgylchu o 90%, wedi'i anfon i Plastic Experts (Hampshire)
- (0.35 m^3) ar gyfer caniau alwminiwm – cyfradd ailgylchu o 100% ac wedi'i anfon i Thamesdown Recycling (Swindon).

Ailgylchwyd cyfanswm o 6.92m^3 o wastraff gan MJ Church.

Cafodd y gwastraff plasterbord ei symud o'r safle gan RKC fel rhan o'r pecyn gwaith plastro. Cafodd 128.58 m^3 o wastraff plasterbord ei ailgylchu gyda 100% yn cael ei ailgylchu drwy ddolen gaeedig, yn ôl cofnodion Atlantic Recycling. Roedd 3.09m^3 o'r gwastraff plasterbord yn fordiau Siniat ac wedi'i gynhyrchu gan Massey Cladding.

Cafodd gweddill y torion pyst sylfaen eu malu ar y safle i greu cerrig agreg ar gyfer ailgylchu. Defnyddiwyd y deunydd mâl fel llenwad ar y safle i lefelu'r ddaear y tu allan i'r adeilad. Defnyddiwyd ychydig dros 200m^3 o goncrid mâl i gyd.

Fel rhan o'r cynllun Galluogi Dyfodol Diwastraff edrychodd y prosiect a fyddai modd gwahanu panel cladin cyfansawdd metal er mwyn cynyddu'r cyfraddau ailgylchu, Darparodd Biffa wasanaeth i wahanu'r inswleiddiad o banel cladin cyfansawdd metal. Ailgylchwyd 1.96m^3 (100%) o inswleiddiad Rockwool yn ôl yn gynnyrch defnyddiol. Anfonwyd gweddill y 3.84m^3 o shitiau metal i gwmni John Ford & Sons i'w hailgylchu. Roedd y cynllun wedi sicrhau bod yr holl wastraff, 5.8m^3, yn cael ei ailgylchu. Er bod y cynllun hwn yn llwyddiannus efallai na ystyriwyd ei fod yn economaidd hyfyw.

O ganlyniad i'r cydweithrediad rhwng Massey Cladding ac EZW, cafodd 3.84m^3 o fetel a 1.96m^3 o inswleiddiad Rockwool ei ailgylchu drwy ddolen gaeedig yn ôl yn gynnyrch Rockwool. Ailgylchwyd 0.017m^3 o wastraff pecynnu hefyd fel rhan o'r gweithgareddau hyn.

Dengys y ffigurau i gyd fod 1002.15m^3 o wastraff adeiladu wedi cael ei ailgylchu drwy'r prosiect.

6.4 Adfer ar gyfer Ynni

Anfonwyd cyfanswm o 273.17m^3 o wastraff o'r prosiect i'w adfer ar gyfer ynni.

Anfonodd Reseiclo 197.05m^3 o wastraff pren o'r safle i gwmni South Wales Wood Recycling (SWWR) ym Mhen-y-bont. Mae SWWR yna'n torri'r coed yn sglodion a'i werthu fel tanwydd neu i wneud bordiau llawr, yn ôl sut fath ydyw.

Yn ôl adroddiadau MJ Church anfonwyd 2.81m^3 o wastraff ffreutur i'w adfer ar gyfer ynni.

Anfonwyd gweddill y gwastraff i Barc Trident yng Nghaerdydd o safle sgipiau Olivers. Mae gan Barc Trident statws dosbarth R1 ac felly'n cwrdd ag amodau adfer ynni'n hytrach na gwaredu, yn unol â'r Gyfarwyddeb Fframwaith Gwastraff.

6.5 Tirlenwi

Yn ôl cwmni Olivers anfonwyd 9% o wastraff gweddilliol, 40.62m^3, y prosiect i gael ei dirlenwi yn safle Bryn Pica, Aberdâr.

Ni allai Olivers ddarparu dadansoddiad o'r ffrydiau gwastraff tirlenwi.

7 Dadansoddiad yn ôl ffrydiau gwastraff unigol

Rhoddir isod ddadansoddiad o'r ffrydiau gwastraff unigol a'r rhagolygon % a gofnodwyd ar SMARTWaste:

Deunydd gwastraff a gynhyrchwyd (IAW)	Ffigyrau gwirioneddol m^3	Rhagolygon SMARTWaste
Gwastraff adeiladu cymysg	572.28	259.5
Pren	299	188.1
Plasterbord	131.67	40.2
Deunydd pecynnu	91.8	108.5
Brics	38.68	9
Concrid	200	52.1
Deunydd inswleiddio (diberygl)	19.26	22.9
Metel	5.87	27.7
Anadweithiol	209.79	65.2
Gwastraff ffreutur	18.49	34
Pridd	2573.35	1363
Metel	2.02	27.7
Gwastraff arall	3.48	46.3
Plastig (heb gynnwys pecynnu)	16.33	Dim rhagolygon
Teils	2.94	Dim rhagolygon
Dodrefn	0.2	Dim rhagolygon

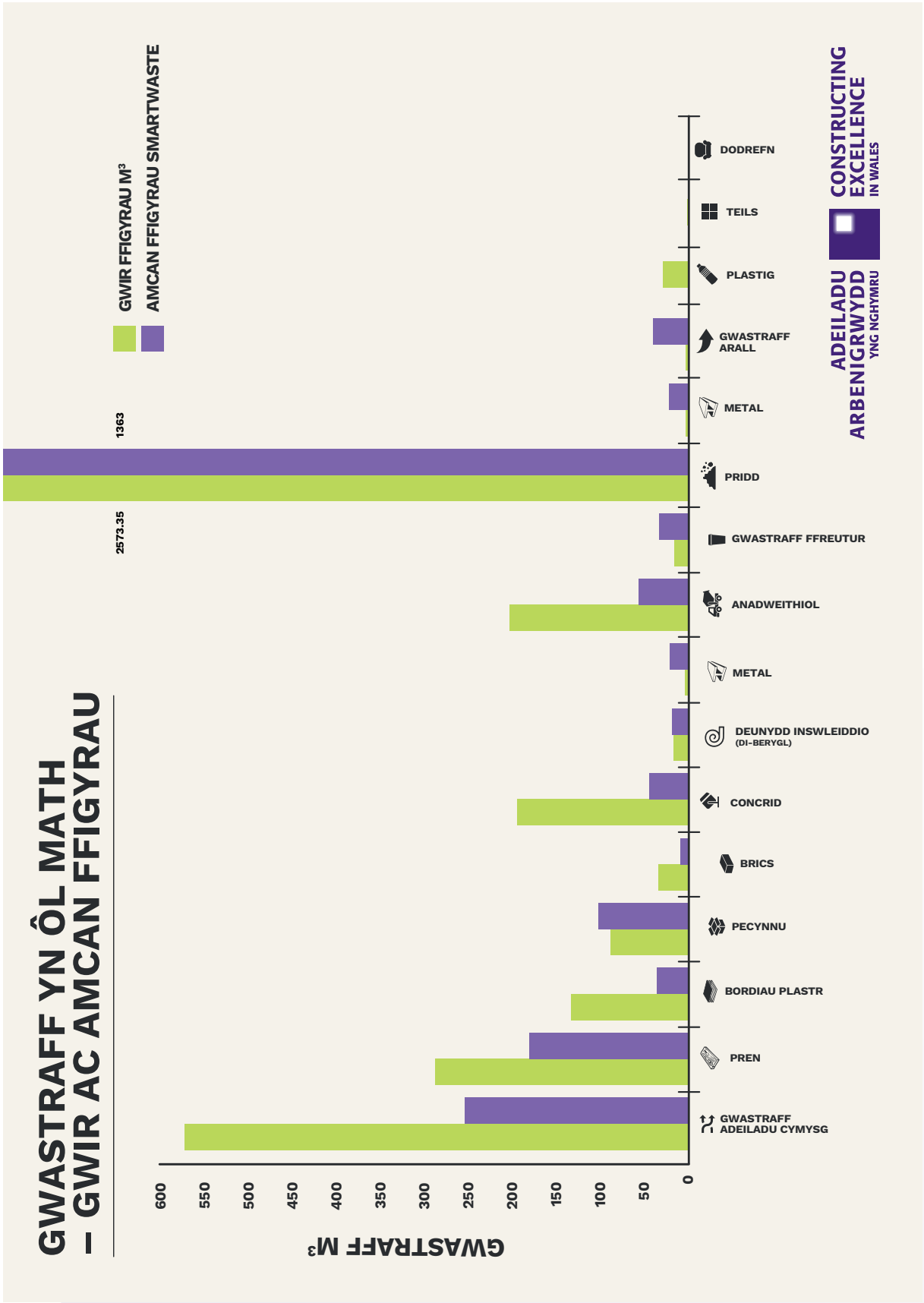
7.1 Gwastraff cymysg

Ni wahanwyd llawer iawn o'r gwastraff a waredwyd o'r safle a chafodd ei anfon fel gwastraff cymysg i'w brosesu ymhellach. Proseswyd y gwastraff cymysg gan gwmni sgipiau Olivers gan adrodd cyfradd ailgylchu o 85% yn ystod y gwaith o adeiladu'r Rinc Iâ. Mae gwastraff cymysg yn effeithio ar ansawdd y cynhyrchion y gellir eu creu drwy ailgylchu. Gellir adfer mwy o ffrydiau wastraff os cawsant eu gwahanu ar y dechrau gan greu cynhyrchion ailgylchu o ansawdd gwell a phris uwch.

Pan ddechreuodd y tîm EZW ar y safle cafwyd bod y rhan fwyaf o'r gwastraff yn wastraff adeiladu cymysg, ac eithrio gwastraff pren. Yn y sgipiau wrth ymyl terfyn y safle, daethpwyd o hyd i wastraff nad oedd wedi dod o'r safle (teils ystafell ymolchi, carpedi a matras). Felly symudwyd y sgip yn nes i'r safle adeiladu a chodwyd ffens o'i chwmpas. Drwy symud y sgipiau ni fyddai'r broblem yn codi eto. Roedd gwahanu gwastraff yn dal i fod yn broblem unwaith i'r compownd symud. Roedd llawer o wastraff pren yn cael ei roi yn y sgip gwastraff cymysg. Ar ôl siarad â'r gweithwyr ar y safle daeth yn glir fod y gwastraff pren yn cael ei roi yn y sgip gwastraff cymysg oherwydd ei bod yn nes iddynt. Gan hynny symudodd dîm y safle'r sgip gwastraff cymysg i fod yr un bellaf yn y compownd a symud y sgipiau gwahanu gwastraff yn nes. Gwellodd yr arferion gwahanu gwastraff yn sylweddol ar ôl hyn.

Enwebodd Kier bencampwr gwastraff ar y safle a fyddai'n hyrwyddo gwahanu'n feunyddiol a llwyddodd hyn hefyd i wella a sbarduno arferion gwahanu. Yn dilyn gohirio'r gwaith adeilad, penodwyd rheolwr safle dros dro newydd ar gyfer y safle ac yn anffodus nid oedd yn ymwybodol o'r cynllun EZW.

Yn ystod y toriad yn y gwaith, ni chafodd unrhyw ffrydiau gwastraff eu symud o'r safle gan Kier, ond er mwyn gwneud yr adeilad yn ddiddos roedd Massey Cladding yn dal i fod ar y safle. Roedd y contractwyr yn rhoi gwastraff mewn dau fin ailgylchu 1,100ltr a dau


GWASTRAFF YN ÔL MATH – GWIR AC AMCAN FFIGYRAU
GWIR FFIGYRAU M³
AMCAN FFIGYRAU SMARTWASTE
1363
2573.35
GWASTRAFF M³
600
550
500
450
400
350
300
250
200
150
100
50
0
DODREFN
TEILS
PLASTIG
GWASTRAFF ARALL
METAL
PRIDD
GWASTRAFF FFREUTUR
ANADWEITHIOL
METAL
DEUNYDD INSWLEIDDIO (DI-BERYGL)
CONCRID
BRICS
PECYNNU
BORDIAU PLASTR
PREN
GWASTRAFF ADEILADU CYMYSG
ADEILADU ARBENIGRWYDD YNG NGHYMRU
CONSTRUCTING EXCELLENCE IN WALES

fin gwastraff cymysg 1,100ltr a gasglwyd gan BIFFA. Rhoddir dadansoddiad isod o'r gwastraff a grewyd gan Massey. Mae'r data wedi'i ddarparu gan BIFFA ond mae'n aneglur faint o gasgliadau a ddigwyddodd. Gofynnwyd am ddadansoddiad manwl gan BIFFA ond nid oeddent yn gallu rhoi'r wybodaeth yma.

Yn y Ganolfan Iâ roedd biniau gwastraff llai ond nid oedd y rhain wedi eu codio yn ôl lliw nac ychwaith wedi eu harwyddo i ddangos ffrwd wastraff i'w gwahanu. O ganlyniad nid oedd hyn yn helpu i annog yr arferion gwahanu.

7.2 Pren

Cynhyrchodd y safle gyfanswm o 299m^3 o wastraff pren.

Anfonwyd y rhan fwyaf o'r gwastraff pren i gynllun ailgylchu pren Reseiclo gyda'r gweddill, 26m^3, yn cael ei symud o'r safle gan gwmni sgipiau Olivers.

Symudwyd 68 llond sgip o wastraff pren o'r safle gan Reseiclo yn erbyn targed o 47 a gofnodwyd ar SMARTWaste ar ddechrau'r prosiect. Cynhyrchwyd mwy o wastraff pren ar y safle i gyd-ddigwydd â'r gwaith estyll pren a'r gwaith saer.

Casglodd Scott Pallets 120 o baledi ym mis Mawrth 2015. Mae Scott Pallets yn trwsio'r paledi ac yn eu gwerthu i'w hailddefnyddio. Ailddefnyddiwyd cyfanswm o 17m^3 o baledi o ganlyniad i'r cynllun.

O ganlyniad i gyflenwad o gerrig pafin defnyddiwyd 51 o baledi i'w symud. Cysylltodd y tîm EZW â Kilsaran, gweithgynhyrchydd y cerrig pafin, i weld a oedd modd symud y paledi o'r safle a'u hailddefnyddio i ddosbarthu nwyddau eraill. Ateb Kilsaran oedd nad oedd y cynllun derbyn yn ôl yn ariannol hyfyw oherwydd bod y lorïau a'r deunydd yn dod o Iwerddon. Felly symudwyd y paledi o'r safle gan Scott Pallets ynghyd â'r holl baledi eraill a symudwyd o'r safle, fel y dywedwn yn flaenorol.

Ailddefnyddiwyd y pren o'r gwaith estyll gan y gweithwyr daear lle'r oedd hynny'n bosib. Cyn cael ei waredu yn y pen draw gan Reseiclo.

Cafodd yr ardal seddi goncrid a'r grisiau eu gwneud oddi ar y safle gan atal defnyddio'r pren fel estyll ar y safle. Cafodd fframiau'r drysau eu gwneud oddi ar y safle i leihau torion pren. Nid yw Kier wedi darparu unrhyw feintiau atal ar gyfer y gweithgareddau hyn.

7.3 Gwastraff anadweithiol (concrid, brics, blocs, teils a serameg)

Cofnodwyd gwastraff yn y sgipiau anadweithiol gan yrwyr sgipiau Olivers gan nodi amcan-ffigyrau'r dadansoddiad mewn Nodiadau Trosglwyddo Gwastraff. Roedd y deunydd yn y sgip anadweithiol yn cynnwys y mathau canlynol o wastraff:

- Brics 17 01 02
- Teils a serameg 17 01 03
- Concrid 17 01 01
- Anadweithiol 17 01 07

Roedd y safle hefyd yn cadw deunyddiau anadweithiol fel blocs a physt concrid i'w malu ar y safle cyn eu defnyddio i lenwi a chodi'r ddaear y tu allan i'r adeilad. Cafodd 200 m^3 o gerrig agreg mâl, gan gynnwys y deunyddiau uchod, eu hailgylchu a'u hailddefnyddio nes ymlaen ar y safle.

7.4 Brics a Blocs

Cynhyrchwyd cyfanswm o 38.68m^3 (46.44 tunnell) o wastraff brics o'r Rinc Iâ, a gofnodwyd mewn dau gyfnod rhwng Awst a Rhagfyr 2014 (6.03m^3) a Gorffennaf a Rhagfyr 2015 (32.63m^3).

Roedd targed o 9m^3 wedi'i ddarogan ar gyfer gwastraff brics cyn y gwaith adeiladu. Cododd problem lle nad oedd ansawdd y blocs yn ddigon da i gael eu defnyddio yn yr ardaloedd lle'r oedd y gwaith blocs yn weladwy oherwydd bod rhai wedi cael eu tolcio a'u difrodi. Gwnaed argymhellion y gellid defnyddio'r blocs oedd wedi cael difrod yn yr ardaloedd oedd i'w plastro ond, er hynny, cafwyd blocs yn y sgip. Ar ôl trafod gyda'r cwmni gosod brics i weld pam oedd hyn yn digwydd, yr ateb oedd mai problem cyfyngiadau amser oedd hyn. Roedd archwilio'r blocs a'u symud i ardaloedd eraill yn colli amser oherwydd bod gosodwyr brics yn cael eu talu fesul metr.

7.5 Teils

Cynhyrchwyd cyfanswm o 2.94 m^3 o wastraff teils o'r Ganolfan Iâ. Cynhyrchwyd y gwastraff o'r mannau gyda theils yn y toiledau, ystafelloedd ymolchi ac ystafelloedd newid y chwaraewyr.

7.6 Plasterbord

Cynhyrchwyd cyfanswm o 131.67 m^3 o wastraff plasterbord. Cyflenwodd Richard Kemble Ltd, y contractwr, eu sgipiau eu hunain gan gwmni Atlantic. Rhagorodd y prosiect ar y targed gwreiddiol o 87m^3 (68%).

7.7 Metel

Cofnodwyd cyfanswm o 5.87m^3 o wastraff metel o'r prosiect, 2.02m^3 o'r holl wastraff a gofnodwyd ar SMARTWaste, gyda gweddill y 3.85m^3 yn cael ei ailgylchu fel rhan o dynnu'r shitiau cladin. Cynhyrchwyd yr holl wastraff metel yn ystod y cam strwythurol a'r gwaith cladin ar yr adeilad.

7.8 Deunyddiau Pecynnu

Cynhyrchwyd cyfanswm o 91.8m^3, 18 tunnell, o wastraff pecynnu drwy gydol y prosiect. Cynhyrchwyd 34.97m^3 (39%) wrth glirio'r safle.

7.9 Paneli Eurobond/Paneli Inswleiddio Waliau

Defnyddiwyd paneli Eurobond fel cladin ar rannau isaf yr adeilad. Mae'r cynnyrch yn cynnwys inswleiddiad Rockwool cyfansawdd gyda chroen metel rhag y tywydd (gweler y llun ar y dde). Er mwyn gwahanu'r bordyn inswleiddio o'r metel, roedd angen prosesu'r cynnyrch ymhellach. Ni allai'r cynnyrch fynd yn ôl i'r gweithgynhyrchydd i'w wahanu oherwydd nid oedd gan y cwmni drwydded i dderbyn gwastraff wedi'i gynhyrchu oddi ar y safle.

Yr opsiwn felly oedd dod o hyd i gwmni rheoli gwastraff oedd yn fodlon gwahanu'r deunyddiau a gyda thrwydded i drin y gwastraff. Symudwyd y deunyddiau i safle trosglwyddo gwastraff BIFFA lle cawsant eu gwahanu'n fetel a Rockwool. Ailgylchwyd y 100% o'r metel gyda'r inswleiddiad Rockwool yn cael ei dderbyn yn ôl gan Rockwool lle'r oeddent yn ei brosesu'n ôl i greu'r cynnyrch.

Pwysau'r paneli gwastraff a symudwyd o'r safle	Cost	TAW
3.33 tunnell	£1,443.20	£287.58

Tabl: *Costau y gwastraff Cladin*

Fel y gwelwn o'r tablau uchod, er bod yr ymarfer hwn yn sicrhau bod 100% o'r gwastraff yn cael ei ailgylchu drwy ddolen gaeedig, mae cwestiwn efallai ynghylch hyfywedd economaidd y cynllun.

7.9.1.1 Cynllun derbyn yn ôl Euroclad

Gyda chymorth gan Massey Cladding, cysylltodd CEW ag Euroclad Ltd sy'n darparu'r systemau cladin a thoeau metel ar gyfer y Ganolfan Iâ. Roedd Euroclad hefyd yn cyflenwi'r paneli inswleiddio solid a'r plasterbord diddos (Siniat) i'r safle. Darparodd Euroclad wasanaeth o leihau'r pecynnu gan gynnig cynllun i dderbyn yr holl becynnu a ddefnyddiwyd gyda'i gynhyrchion yn ôl. Cafodd fagiau tunnell hyblyg eu darparu i Massey Cladding er mwyn gallu gwahanu'r gwastraff yn blastig, cardbord, paledi pren ac estyll cynnal. Roedd y cwmni'n barod iawn i ddarparu'r gwasanaeth hwn ac yn gwbl ddi-dâl o ystyried eu bod yn ymrwymedig i'r cynllun Galluogi Dyfodol Diwastraff.

Roedd Euroclad hefyd yn cynnig gwasanaeth i dderbyn yr inswleiddiad Rockwool yn ôl gyda'r gwastraff yn cael ei ddychwelyd i'r broses weithgynhyrchu gan sicrhau dolen gaeedig.

7.9.1.2 Plasterbord Siniat

Defnyddiwyd bordiau Siniat diddos fel rhan o'r cladin allanol. Roedd y gwastraff yn cynnwys torion a bordiau wedi cael difrod. Oherwydd bod yr adeilad o ddyluniad gyda rhannau gordo ac onglog, nid oedd yn bosib ailddefnyddio'r torion.

Trefnodd Euroclad i sgipiau plasterbord ar wahân cael eu defnyddio ar gyfer gwastraff y bordiau Siniat, drwy Reconomy, brocer gwastraff. Roedd Siniat wedi argymell Reconomy a fyddai'n sicrhau ailgylchu dolen gaeedig 100% drwy dderbyn y gwastraff yn ôl i'w ailbrosesu gan Siniat. Yn ôl yr adroddiadau gwastraff gan Reconomy aeth y gwastraff Siniat i gwmni Ailgylchu Atlantic.

Ar ôl ymchwilio cafwyd nad oedd y deunydd wedi'i anfon yn ôl i Siniat i gael ei ailbrosesu. Roedd hyn yn siomedig iawn oherwydd roedd Euroclad wedi ymrwymo i'r cynllun EZW ac wedi ceisio sicrhau bod eu gwastraff i gyd yn cael ei ailgylchu drwy ddolen gaeedig, ond cawsant eu siomi gan y brocer gwastraff.

Math o ddeunydd	Math o gynhwysydd a maint	Nifer y casgliadau	Pwysau cyfartalog	Cyfanswm amcan-bwysau (kg)	Cyrchfan	
Paledi pren	1.8 x 1.2 m	20	Amh.		Euroclad	Ailddefnyddio
Plasterbord (siniat)	12 yard skip	3	3.093 tunnell		Atlantic	Safle trosglwyddo
Inswleiddiad (rockfibre)	1m^3 bags	14	55 kg	770	Knauf Queensferry	Proses adfer
Estyll cynnal	1m^3 bags	41	8 kg	328	Euroclad	Ailddefnyddio
Cardbord	1m^3 bags	11	11 kg	121	Atlantic	Ailgylchu
Deunydd lapio plastig	1m^3 bags	12	6 kg	72	Graig Environmental Recycling	Ailgylchu

8 Gwastraff Ffreutur a Swyddfae

O brosiectau EZW blaenorol dangoswyd fod gwastraff bwyd o'r ffreutur yn gallu canfod ei ffordd i mewn i sgipiau ar y safle gan halogi a lleihau'r cyfraddau ailgylchu. Argymhelliad y tîm EZW oedd sefydlu gwasanaeth ffreutur ar wahân.

Casglwyd y gwastraff gan MJ Church mewn biniau 1,100ltr gyda system wahanu'n cael ei sefydlu y tu allan i ffreutur y safle. Cynhyrchwyd cyfanswm o 18.49m^3 o wastraff ffreutur. Anfonwyd holl wastraff y ffreutur i Safle Trosglwyddo Warmley ym Mryste. Rhoddir dadansoddiad canrannol a chrynodeb o'r gyrchfan pen-draw isod.

Cyflenwodd gwmni Amber finiau olwynog ar gyfer gwastraff swyddfa'r prosiect ond nid oes unrhyw ddata wedi'i ddarparu hyd yma.

Ffrwd wastraff	Gwastraff %	Cyrchfan y gwastraff
Papur a chardbord	11.53	Mark Lyndon (Nottingham)
Plastig	2.01	Plastic Experts (Gosport)
Caniau	0.008	Thamesdown Recycling (Swindon)
Gwastraff cyffredinol	86.44	Ffatri wastraff EFR (Spremburg, Yr Almaen)

9 Dadansoddiad yn ôl cost

9.1 Costau Rheoli Gwastraff Gwirioneddol

Defnyddiodd y prosiect 273 o sgipiau a 126 o finiau 1100ltr am gyfanswm cost o £71,371. Mae'r ffigyrau hyn yn cynnwys wyth sgip plasterbord a anfonwyd i Atlantic am £3,362.40 ac a symudwyd o'r safle gan yr isgontractwr plastro fel rhan o'u pecyn gwaith.

Daeth yr arbedion o ddefnyddio gwasanaeth symud Reseiclo i £3,212.96.

Cwmnïau rheoli gwastraff a brocera	Costau	Nifer y sgipiau a'r biniau
Cwmni Llogi Sgipiau Olivers	£44,776	185
Atlantic	£3,362	8
Reseiclo (ailgylchu pren)	£14,944	68
BIFFA	£1,443	3
Scott Pallets	£675	8
Reconomy	£600	1
MJ Church	£3,824	125 o finiau 1100ltr
Amber	£1,747	1 bin 1100litr
Cyfanswm	£71,371	273 sgip a 126 o finiau 1100ltr

Symudwyd y paledi pren o'r safle gan Scott Pallets. Ailddefnyddiwyd cyfanswm o 120 o baledi a gwariwyd £675 ar y cynllun. Byddai gwaredu'r paledi mewn sgipiau pren wedi costio tua £1280 ar sail 15 paled i bob sgip, a chyfanswm o wyth sgip. Arbediad o £605.

Mae canrannau'r mathau o sgip a chanran y gost gysylltiedig ar gyfer y ffrydiau gwastraff ar wahân eraill fel a ganlyn:

Math o sgip	% o gyfanswm nifer y sgipiau	% o gyfanswm y gost
Gwastraff cymysg	60 %	634 %
Pren	30 %	250 %
Brics, teils a gwastraff anadweithiol	6 %	7 %
Plasterbord	4 %	5 %

Gwastraff cymysg oedd y math o sgip a ddefnyddiwyd amlaf, 60% o'r sgipiau, ac a achosodd y ganran fwyaf o gost wrth reswm.

9.2 Costau Rheoli Gwastraff Posib

Ar sail y ffigurau cost gan gwmni Olivers, heb wahanu gwastraff byddai wedi costio £50,440 i waredu 185 o sgipiau gwastraff cymysg. Mae hyn £5,664 yn fwy na'r gost wirioneddol sy'n golygu y gwnaed arbedion o 11% drwy wahanu gwastraff.

Pe bai pob un o'r 185 o sgipiau a symudwyd o'r safle gan gwmni Olivers wedi cael eu gwahanu gallai £37,810.60 fod wedi cael ei wario ar wastraff gan arbed £6965.40.

Arbedion	
Ymarfer canfod gwrthdaro	£30,000
Drwy wahanu	£5,664
Paledi pren	£605
Arbedion pren / Reseiclo	£3,212.96
Cyfanswm yr arbedion	£39,481.96

COSTAU RHEOLI GWASTRAFF

CYFANSWM	£71,371	273 O SGIPIAU	126 O FINIAU 1100ltr

ADEILADU ARBENIGRWYDD YNG NGHYMRU
CONSTRUCTING EXCELLENCE IN WALES

10 Dadansoddiad yn erbyn meincnodau

Mae data gwastraff ar gyfer prosiectau a gwblhawyd yng Nghymru ar gael ar y system SMARTWaste. Gall prosiectau adrodd ar sail cyfaint neu dunelli o wastraff ar gyfer amrywiaeth eang o wahanol fathau o brosiectau. Dadansoddwyd y data i greu dangosyddion perfformiad ar gyfer y gwastraff a gynhyrchwyd am bob £100k a phob 100m2 ar gyfer cyfaint a / neu dunelli o wastraff a gynhyrchwyd.

Mae BREEAM (BRE Environmental Assessment Method) yn ddull asesu amgylcheddol a ddefnyddir yn eang ar gyfer adeiladau a chymunedau. Mae'n rhoi sylw i faterion amgylcheddol a chynaliadwyedd a defnyddir credydau fel rhan o'r meini prawf asesu.

Mae prosiectau hamdden ar SMARTWaste yn 23.4m3/100m2 a 15.9m3/£100k ar gyfartaledd. Roedd ffigurau'r prosiect hwn yn 49.23m3/100m2 a 41.81m3/£100k, sy'n awgrymu bod y prosiect yn llai gwastraff-effeithlon na chodi'r adeilad hamdden cyfartalog. Ond mae'n debyg bod hyn wedi digwydd oherwydd natur unigryw a chymhleth y Ganolfan Iâ.

Canolfan Iâ Cymru	Cyfaint gwastraff am bob 100m²	Cyfartaledd m³/£100k
Prosiectau hamdden cyfartalog ar SMARTWaste*	23.4m³	15.9m³
Canolfan Iâ Cymru	49.23m³	41.81m³
Gwahaniaeth	25.83m³	25.91m³

**(ar sail naw prosiect)*

11 Modelu

11.1 Modelu Gwybodaeth Adeiladu (BIM)

Caiff ei gydnabod yn eang yn y sector amgylchedd adeiledig fod trosi darluniau'n adeilad ar y ddaear yn aml yn achosi gwrthdaro annisgwyl, yn enwedig gyda gwaith cysylltu cymhleth a gwasanaethau mecanyddol a thrydanol. Mae'n arfer cyffredin i unrhyw wrthdaro gael ei ddatrys yn adweithiol ar y safle, gan wastraffu deunyddiau ac amser yn aml. Drwy ddefnyddio meddalwedd, nod BIM yw dileu'r gwastraff hwn.

Fodd bynnag mae BIM yn ymwneud yn gymaint â phobl a phroses ag â meddalwedd gan roi cyfle i fod yn fwy effeithlon a hefyd i fabwysiadu dulliau gweithio gwell. Mae'r dull cydweithredol sydd ei angen i greu dyluniad effeithiol drwy BIM yn sicrhau bod gwybodaeth yn llifo'n gyson rhwng y gwahanol grefftwyr. Mae BIM yn golygu bod y gweithwyr yn gallu delweddu mewnbwn ei gilydd gan annog cyd-ddealltwriaeth a pherthynas weithio dda.

Fel rhan o'r cynllun EZW, comisiynodd CEW gwmni Arup i wneud gwaith ychwanegol yn defnyddio BIM. Y nod oedd canolbwyntio ar rai o'r prif elfennau fel Dylunio ar gyfer Dadadeiladu (D4D), lleihau gwastraff a rhoi pwyslais ar gael cynllun gosod gwaith blocs a lleihau gwastraff y pyst sylfaen concrid.

11.1.1 Dylunio ar gyfer dadadeiladu

Er mwyn cwrdd â thargedau Llywodraeth Cymru o ddod yn wlad ailgylchu uchel erbyn 2025 a dod yn wlad gwbl ddiwastraff erbyn 2050, bydd dewis deunyddiau a rheoli gwastraff yn chwarae rôl allweddol i gyrraedd yr amcanion hyn. Er mwyn cynyddu cynaliadwyedd unrhyw brosiect adeiladu rhaid i bob cam o'r prosiect ddangos pwyslais cryf ar reoli gwastraff gan gynnwys yn y camau cynllunio, dylunio, gweithgynhyrchu, adeiladu, dadadeiladu ac ailadeiladu.

Un o'r prif bwyntiau gweithredu yng Nghynllun Sector Adeiladu a Dymchwel Llywodraeth Cymru (Tachwedd 2012) yw Dylunio ar gyfer Dadadeiladu (D4D). Y nod yw annog y diwydiant adeiladu i ddylunio ar gyfer diwedd bywyd prosiectau a sicrhau bod y deunyddiau a ddefnyddir yn y gwaith adeiladu'n cynnwys canran uchel o gynnwys wedi'i ailgylchu.

Roedd CEW mewn partneriaeth â thîm dylunio ac adeiladu'r Ganolfan Iâ eisiau ystyried y posibilrwydd o ddylunio mewn D4D yn ôl-weithredol drwy Fodelu Gwybodaeth Adeiladu (BIM). Edrychodd yr ymarfer ar ddarparu dull drwy BIM o gofnodi gwerth deunyddiau ar gyfer ailgylchu a diffinio dull sy'n amlinellu'r ffordd fwyaf diogel o ddadadeiladu'r prosiect.

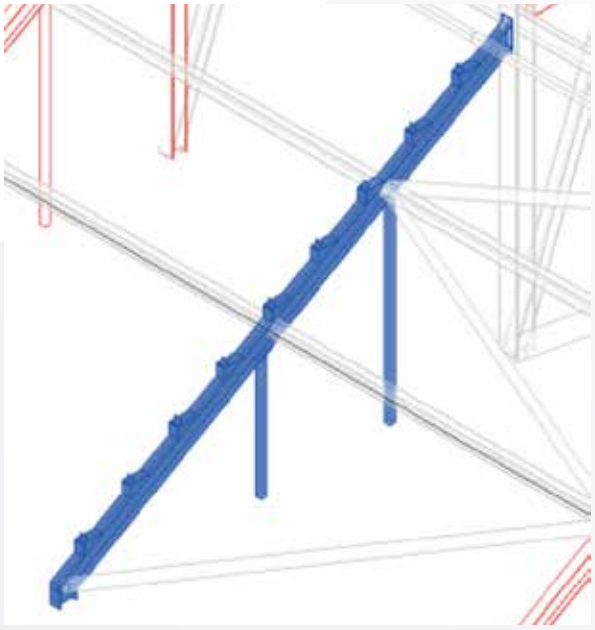
I ddechrau nid oedd gan y Ganolfan Iâ unrhyw elfennau dadadeiladu yn ei dyluniad. Fodd bynnag mae gan ffrâm ddur yr adeilad bosibilrwydd uchel o gael ei hailddefnyddio'n hytrach na'i hailgylchu.

11.1.2 Manteision mabwysiadu BIM ar gyfer D4D

O'u defnyddio'n gywir mae technolegau BIM yn gadael i'r diwydiant adeiladu gofnodi, tracio a storio'r holl ddefnyddiau a ddefnyddir mewn adeilad o gronfa ddata ganolog. Gall y data gynnwys amrywiaeth o wybodaeth fel hyd, gradd, pwysau, technegau adeiladu sylfaenol y gwaith gosod, costau a llawer mwy. Gall perchnogion adeiladau ddefnyddio'r data gwerthfawr hwn yn y dyfodol i asesu a fyddai'n bosib ailgylchu elfennau o'r gwaith adeiladu wrth ddadgomisiynu prosiect.

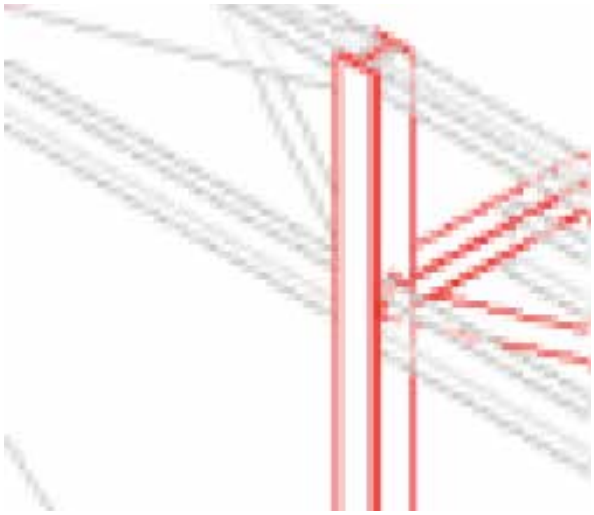
Graddiwyd ffactor ailddefnyddio'r dur i roi syniad o'i ailddefnydd posib yn y dyfodol. Er enghraifft, sgôr isel, canolig neu uchel fel y disgrifiwn isod;

Sgôr isel – elfennau dur pwrpasol a grewyd yn benodol ar gyfer y prosiect hwn gydag opsiynau prin i'w hailddefnyddio ar brosiectau eraill, e.e. strwythur cynnal seddi bloc, a thrawstiau cyplog llydan.



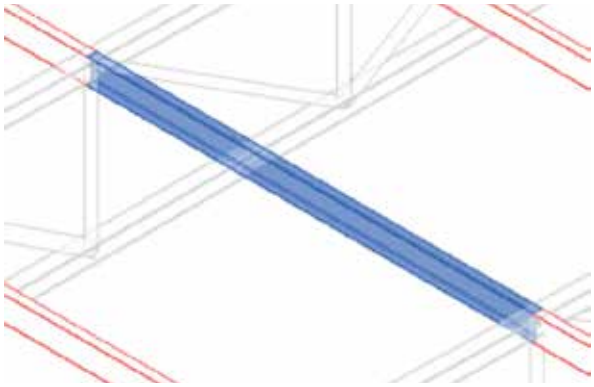
Ailddefnydd Isel

Sgôr canolig – elfennau dur a allai gael eu trosglwyddo i brosiectau eraill ond sydd efallai angen mân waith i'w haddasu, e.e. mae gan y colofnau dur uniadau lluosog na fydd efallai eu hangen ar brosiectau eraill.



Ailddefnydd Canolig

Sgôr uchel – elfennau syth syml gydag uniadau syml, e.e. trawstiau syth rhwng y trawstiau cyplog.



Ailddefnydd Uchel

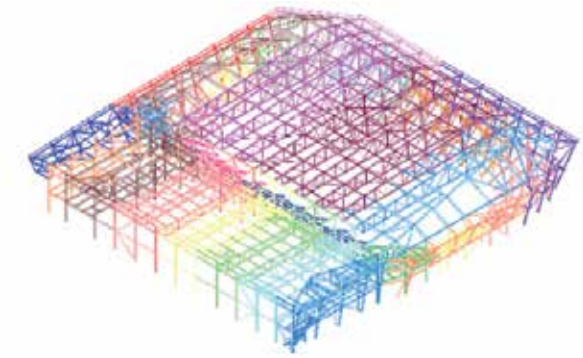
Drwy gyflwyno'r ffactor ailddefnyddio i'r data BIM, bydd gan ddefnyddwyr yr adeilad yn y dyfodol syniad da ymhell cyn y cam adeiladu o ba elfennau a fyddai'n ailddefnyddiol.

11.1.3 Y broses ddadadeiladu

Pan godir adeiladau, fe'u cynllunnir a'u codir mewn ffordd benodol fel bo'r ategwaith cynnal iawn ar gael, y peiriannau cywir yn cael eu defnyddio a gweithdrefnau iechyd a diogelwch yn cael eu dilyn. Os yw'r diwydiant adeiladu i gael mynediad llawn at ddeunyddiau ailddefnyddiol o adeiladau yn y dyfodol, fel y gwaith dur y soniwn amdano uchod, mae'n hanfodol bod yr arferion presennol yn cynnig ffordd o gofnodi'r gweithdrefnau adeiladu angenrheidiol i ddatgymalu adeilad yn ddiogel ac effeithlon er mwyn adfer gymaint o ddeunyddiau ailgylchol â phosib.

Mae technolegau BIM yn llwyfan perffaith er mwyn gallu ychwanegu data i helpu'r broses hon. Cafodd yr elfennau yn y prosiect IAW eu grwpio o ran pryd y cawsant eu gosod. Ychwanegwyd y dyddiadau dechrau a gorffen i'r elfennau dur i ddangos amserlen y broses adeiladu. Cafodd y gwerthoedd hyn yna eu gwrthdroi i ddefnyddio meddalwedd delweddu i ddangos y broses ddadadeiladu a welir yn y lluniau dadadeiladu.

Gall gwrthrychau yn yr amgylchedd BIM hefyd gynnig data defnyddiol i ddefnyddwyr yn y dyfodol ar unrhyw ofynion penodol wrth ddadadeiladu'r strwythur. Er enghraifft a oes angen unrhyw ategwaith, pa beiriannau sydd eu hangen i wneud y gwaith a'r drefn gywir o ddatgymalu'r strwythur. Ar hyn o bryd nid yw'r meddalwedd allan-o'r-bocs a ddefnyddir i greu delweddu llinell amser yn gallu trosi'r data hwn yn ddelweddau ystyrlon i roi rhybudd cyn y broses ddadadeiladu. Wedi dweud hynny gellir creu atebion pwrpasol ar-lein sy'n gallu categoreiddio'r holl ddata ar ddeunyddiau ailgylchol sy'n gysylltiedig â holl elfennau adeilad. Mae'r opsiynau pwrpasol hyn yn gostus ond gallent fod yn fantais enfawr i'r tîm rheoli cyfleusterau.



Elfennau'r ffrâm ddur wedi'u lliwio ar sail dyddiadau gosod a'u defnyddio ar gyfer y llinell amser dadadeiladu

11.1.4 Crynodeb

Dangosodd yr astudiaeth hon y gellir defnyddio Dylunio ar gyfer Dadadeiladu (D4D) yn ôl-weithredol i ddylunio ac adeiladu model drwy ddefnyddio BIM a phroses gofnodi glir. Mae defnyddio BIM ar y prosiect hwn wedi bod yn ddull effeithlon i'r tîm ar gyfer mesur deunyddiau yn yr amgylchedd adeiledig y gellir yna eu hasesu ar unrhyw adeg i nodi eu gwerth ailgylchol. Er bod ailddefnyddio elfennau adeiladu'n broses oddrychol mae BIM yn cynnig ffordd o'i dilysu fel posibilrwydd. Er nad yw technolegau oddi ar y silff yn

darparu'r gofynion i ddangos y broses ddadadeiladu mewn ffordd ystyrlon, mae BIM yn cynnig dull o'i chofnodi ar gyfer ei defnyddio yn y dyfodol.

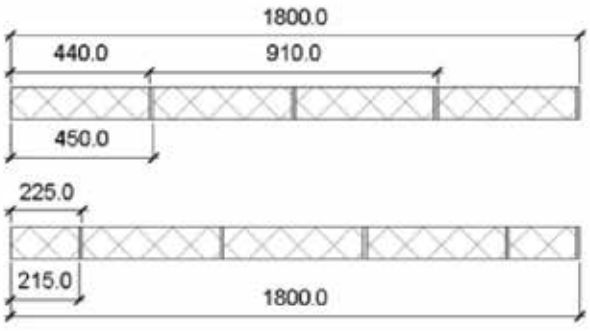
11.2 Astudiaeth o BIM ar gyfer Canolfan Iâ Cymru er mwyn lleihau gwastraff

Edrychodd yr ymarfer hwn ar ymarferoldeb defnyddio Modelu Gwybodaeth Adeiladu (BIM) ar y prosiect IAW, yn y cam ôl-ddylunio, i weld a oedd yn bosib lleihau gwastraff o ddeunyddiau ailadroddus a diffinio prosesau ar gyfer eu hailddefnyddio ar brosiectau yn y dyfodol.

Amcanion yr Astudiaeth

- Adnabod ac asesu deunyddiau adeiladu ailadroddus a ddefnyddiwyd ar y cynllun
- Defnyddio methodoleg BIM i fesur y gwastraff a gynhyrchwyd drwy'r broses ddylunio ac adeiladu'n defnyddio'r deunyddiau hyn
- Datblygu atebion ymarferol i helpu dylunwyr i atal a lleihau gwastraff ar brosiectau yn y dyfodol.

Mae modd swmp-archebu eitemau adeiladu fel gwaith brics a blocs, plasterbord a phren, mewn meintiau penodol, a'u codi ar y safle fel bo angen. Fodd bynnag mae'r eitemau hyn wedi eu hadnabod fel y rhai sy'n cynhyrchu canran uchel o wastraff sgipiau oherwydd bod angen eu torri ar y safle. Roedd blocs yn enwedig yn un o'r prif ddeunyddiau adeiladu a ddefnyddiwyd ar waliau mewnol y Ganolfan Iâ ac yn eitem i'w phrofi ar gyfer lleihau gwastraff yn y broses ddylunio.



Mesuriadau'r gwaith blocs

Ar sail mesuriadau'r gwaith blocs a ddangosir ar y chwith, cynigiodd Arup seilio eu cyfrifiadau ar sail uned safonol hafal i hanner bloc (225x225mm gan gynnwys mortar).

11.3 Cyfrifiadau Gwastraff

Ar y cyfan mae'r parwydydd mewnol wedi eu hadeiladu'n bennaf drwy osod waliau blocs concrid o wahanol siapiau ac o wahanol hyd. Elfen sylfaenol y waliau hyn yw blocs concrid sy'n dod mewn gwahanol hyd, ond sydd fel rheol yn 440mm o hyd x 215mm o uchder gan integreiddio'n daclus â'r mesuriadau safonol ar gyfer drysau a ffenestri. Ar gynlluniau prosiectau a gwblhawyd mae'n brin iawn gweld hyd waliau wedi eu dylunio i gyd-fynd â hyd y gwaith blocs oherwydd mae blocs concrid yn gymharol rad i'w prynu ac i adeiladu gyda nhw. Ar y prosiect IAW mae'r llawr gwaelod yn cynnwys 220 o waliau blocs concrid sydd, ar y cyfan, yn 4840mm o uchder a hafal i 4840 o flocs i gael eu torri ar y lefel honno. Mae hyn yn golygu llawer iawn o amser yn torri blocs ac efallai'n cynhyrchu gwastraff.

Fodd bynnag mae technoleg BIM yn cynnig dull o restru gwybodaeth am wahanol elfennau mewn amrywiaeth o ffyrdd, gan gynnwys data ar eitemau unigol fel yn atodlen waliau 1 isod. Mae'r rhestr yn nodi data adeiladu sylfaenol y waliau concrid a gynhwysir yn yr amgylchedd modelu. Mae'r data yn yr atodlen yn cynnwys lefel y wal, y math o wal a'i hyd; a gall y contractwr a syrfewyr meintiau ddefnyddio'r cwbl i gyfrifo meintiau a chostau ar gyfer y prosiect.

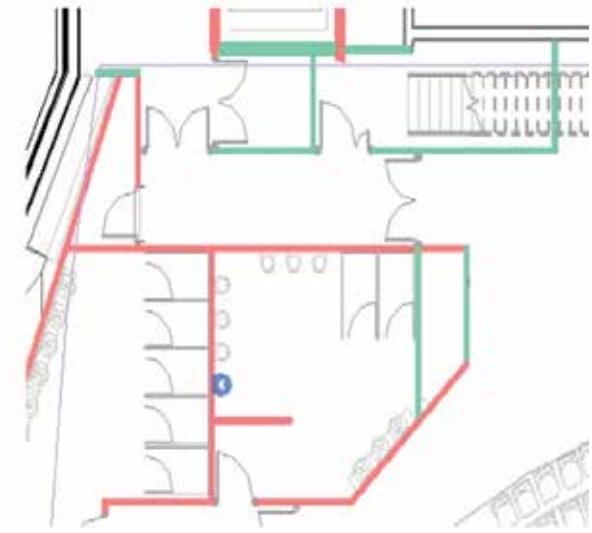
Constraints	
Location Line	Core Centerline
Base Constraint	Level 01
Base Offset	0.0
Base is Attached	☐
Base Extension Distance	0.0
Top Constraint	Up to level: Level 01 Soffit
Unconnected Height	3233.0
Top Offset	333.0
Top is Attached	☐
Top Extension Distance	0.0
Room Bounding	☑
Related to Mass	☐
Text	
Structural	
Structural	☐
Enable Analytical Model	☐
Structural Usage	Non-bearing
Dimensions	
Length	4000.0
Area	12.932 m²
Volume	1.371 m³

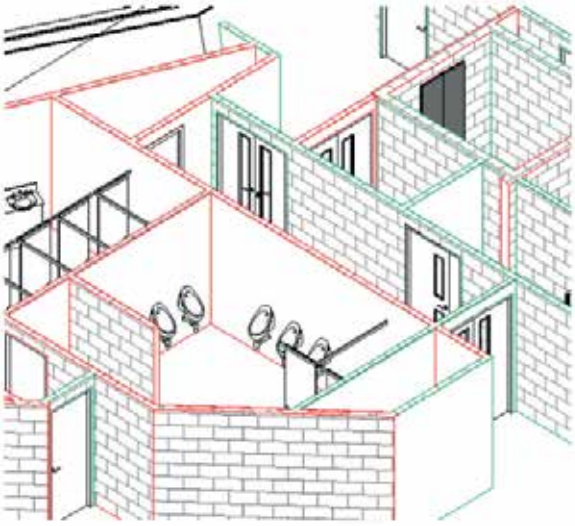
Data ar barametrau'r waliau. Mae pob elfen o fewn y BIM yn cynnwys sawl darn o wybodaeth a data y gellir eu defnyddio mewn amrywiaeth o ffyrdd.

Gellir hefyd addasu'r atodlenni hyn i gyflawni cyfres o gyfrifiadau penodedig. Ar gyfer yr astudiaeth achos wastraff hon, aseswyd hyd y wal yn erbyn nifer y blocs (llawn 450mm neu hanner 225mm) oedd ei angen i bob cwrs a defnyddiwyd hyn wedyn i gyfrifo hyd unrhyw dorryn o ganlyniad.

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	

***Atodlen 1**: Atodlen waliau'n rhestru'r mathau a'r gwahanol hydoedd, er enghraifft ar gyfer y wal 4767mm o hyd yn Ffigwr 1 uchod rydym wedi cyflawni'r cyfrifiadau canlynol: Nifer y blocs llawn = 4767 / 450 = 10.59 (angen 10 o flocs llawn gyda 267m dros ben) Nifer yr hanner blocs = 4767 / 225 = 21.18 (angen 21 o hanner blocs gyda 42mm dros ben).*





Cynlluniau codau lliw a Gweddluniau 3D. Drwy ddefnyddio data parametrig i ymateb i werthoedd cysylltiedig â chod lliw gallwn nodi'n gyflym pa waliau fydd yn cynhyrchu gwastraff blocs drwy dorion, a ddangosir yn goch.

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	155
2380	5	10	WASTE	130
6305	14	28	OK	5
2377	5	10	WASTE	127

***Atodlen 2**: Atodlen waliau'n rhestru hydoedd a chanlyniadau cyfrifo gwastraff.*

Mae atodlen 2 uchod yn dangos y cyfrifiadau syml hyn ar waith gan ddarparu gwybodaeth ddylunio awtomatig i wella'r broses o wneud penderfyniadau. Mae'r atodlen hefyd wedi'i chreu er mwyn gallu defnyddio lliw a thestun i adnabod lle mae hyd y blocs yn awgrymu gwastraff a lle mae angen cwtogi neu gynyddu eu hyd i leihau unrhyw wastraff. Mae'r hyd sydd ar ôl yn seiliedig ar hyd hanner blocs gyda goddefiad o +/- 30mm. Mae atodlen 3 yn dangos rhai waliau lle cwtogwyd eu hyd i leihau unrhyw wastraff.

Mae'n hawdd addasu'r broses hon i ffynonellau data eraill fel gweddluniau 3D, drychiadau a chynlluniau. Dengys yr enghreifftiau ar y dde, yn weledol drwy liw, lle mae modd adnabod waliau fel rhai a allai gynhyrchu gwastraff ac mae angen efallai gwneud newidiadau iddynt. Mae technoleg BIM yn cynnig dull o gadw'r mathau hyn o weddluniau i'w defnyddio ar ddechrau prosiect yn y dyfodol ac i annog llai o wastraff.

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
2730	6	12	OK	30
2730	6	12	OK	30
1740	3	7	WASTE	155
2380	5	10	WASTE	130
6305	14	28	OK	5
2377	5	10	WASTE	127

***Atodlen 3**: Atodlen waliau'n dangos canlyniadau cyfrifo gwastraff.*

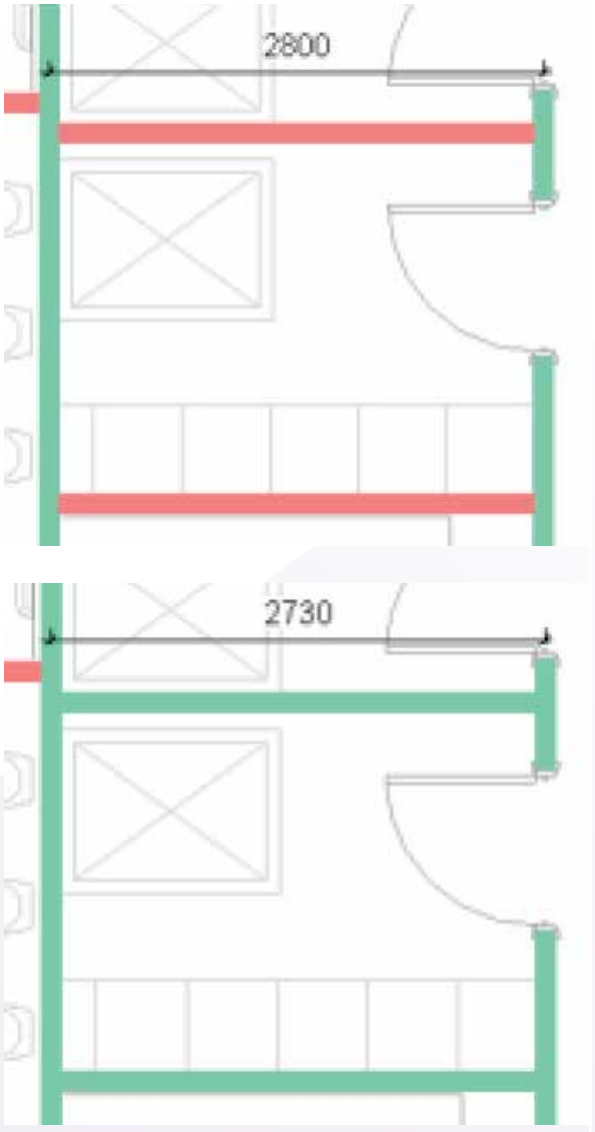
Gellir addasu'r fformiwlâu penodedig yn yr atodlenni ymhellach i gyfrifo faint o flocs sydd ei angen, faint o wastraff sydd yng nghyfanswm y blocs a chost bosib y gwastraff hwnnw. O fynd gam ymhellach gellir cyfuno hyn â faint o oriau gweithio sydd ei angen i dorri'r holl flocs ychwanegol.

Gellir hefyd cyfrif cyfanswm gwastraff y prosiect o'r waliau concrid. Dengys y tabl yn Ffigwr 4 (isod) gyfanswm gwastraff y hydoedd blocs ar gyfer y prosiect. Dim ond am un cwrs yw hyn a dylid ei luosi â nifer y cyrsiau a osodwyd. Ar gyfer yr enghraifft hon, yr uchder o lawr i lawr yw 4890 sef 22 o gyrsiau. Mae hyn yn rhoi cyfanswm gwastraff hyd blocs o 773m.

***Atodlen 4**: Cyfanswm gwastraff y waliau blocs concrid.*

11.3.1 Gweithredu'r adnoddau

Mae'n hanfodol ennill ddealltwriaeth o'r adnoddau hyn cyn eu defnyddio ar brosiectau yn y dyfodol. Dengys yr enghreifftiau isod ganlyniad cwtogi hyd y wal er mwyn lleihau gwastraff. Yr hyn na welwn o'r delweddau yw na fydd mesuriadau ac arwynebedd yr ystafell efallai'n cydymffurfio â'r safonau a ddefnyddiwyd i'w creu. Rhaid cymryd gofal wrth weithredu'n ôl-weithredol.

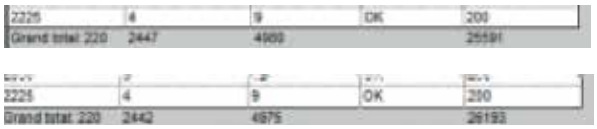


Delweddau 'cyn' ac 'wedyn' yn dangos cwtogi hyd y waliau.

Bydd achosion hefyd – yn enwedig gyda'r prosiect IAW hwn – lle bydd gan y waliau onglog, nid yn unig mewn cynllun a drychiad, hyd blocs wedi eu torri beth bynnag felly efallai na fyddai o fantais cwtogi'r hyd. Bydd strwythur crwm y ganolfan iâ hefyd yn achosi problemau oherwydd bydd y waliau cysylltiedig wedi eu cyfyngu oherwydd union ofynion y rinc iâ.

Wrth ddylunio adeilad, prif rôl y pensaer yw darparu'r holl ystafelloedd a'r ardaloedd cymunedol fel bo'r adeilad yn gallu gweithio'n effeithlon a rhoi profiad cadarnhaol i'r defnyddiwr. Gyda hyn mewn golwg nid yw bob amser yn bosib defnyddio hyd y waliau blocs i gyd-fynd â hyd y blocs eu hunain. Bydd sefyllfaoedd yn codi lle mae swyddogaeth, elfennau cyfochrog a lloriau'r ystafell yn bwysicach ac o reidrwydd yn cael mwy o flaenoriaeth gan y tîm dylunio.

Nid yw'r adnoddau yno i leihau deunyddiau ychwaith ond i leihau gwastraff. Weithiau bydd efallai angen cynyddu'r waliau i ddileu gwastraff yn effeithlon heb newid gormod ar ardaloedd yr ystafelloedd yr effeithir arnynt. Dengys y ddau dabl yn Ffigwr 1 isod gyfansymiau 'cyn' (tabl uchaf) ac 'wedyn' (tabl isaf) y llawr gwaelod ar gyfer ardal yn cynnwys 20 o waliau a gafodd eu diwygio. Mae'r ffigur ar y dde ym mhob tabl yn dangos bod y gwastraff hyd blocs wedi lleihau o 26.193m i 25.591m ond bod cyfanswm nifer y blocs oedd ei angen wedi cynyddu.



Atodlen yn rhoi cyfansymiau 'cyn' ac 'wedyn' ar gyfer ardal lle newidiwyd hyd 20 o waliau i leihau gwastraff.

11.3.2 Crynodeb

Dangosodd yr astudiaeth hon, drwy ddefnyddio BIM a'i dechnoleg ar brosiect, y gall timau dylunio ac adeiladu benderfynu, diffinio a gweithredu prosesau o'r cychwyn i helpu i leihau gwastraff. Gall gweithredu BIM helpu'n ddramatig i asesu'r deunyddiau ailadroddus a ddefnyddir.

Dangosodd yr astudiaeth y bydd cyfuno prosesau newydd â phrosesau awtomatig BIM yn helpu dylunwyr a chontractwyr i adnabod gwastraff yn gyflym a rhoi cyfle i wneud arbedion a chynyddu gwerth y cynllun. Drwy gyflwyno'r atodlenni penodedig a'r templedi gweddluniau, mae modd gwella'r broses ddylunio a gwneud penderfyniadau a chadw'r delweddau gweledol i'w hailddefnyddio ar brosiectau eraill.

Ar ei phen ei hun ni fydd yr enghraifft gwaith blocs yn cael effaith ddramatig ar leihau gwastraff. Ond drwy ddiwygio'r prosesau a'r templedi uchod i gyd-fynd â gwahanol ddeunyddiau adeiladu fel plasterbord, pren a theils nenfwd, gall y broses adeiladu gyfan ddechrau cael effaith fwy ar leihau gwastraff.

11.4 Lleihau gwastraff pyst sylfaen

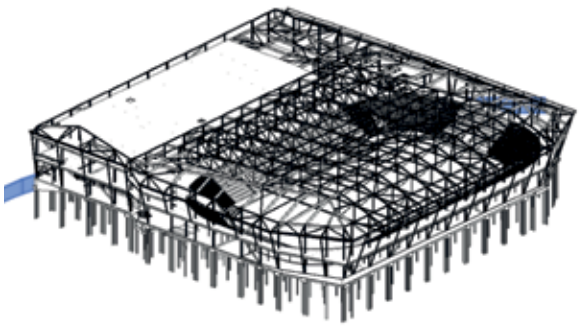
Defnyddiodd y prosiect byst concrid ar gyfer ei sylfeini a gawsant eu haddasu yn ystod y camau dylunio ac adeiladu i adlewyrchu newidiadau yn y dyluniad ac awgrymiadau gan yr isgontractwyr. Bydd yr astudiaeth achos hon yn edrych ar ymarferoldeb defnyddio Modelu Gwybodaeth Adeiladu (BIM) yn y cam ôl-ddylunio ac adeiladu i asesu a chymharu gwahanol ddyluniadau pyst sylfaen i weld a oedd yn bosib lleihau gwastraff.

Amcanion yr astudiaeth:

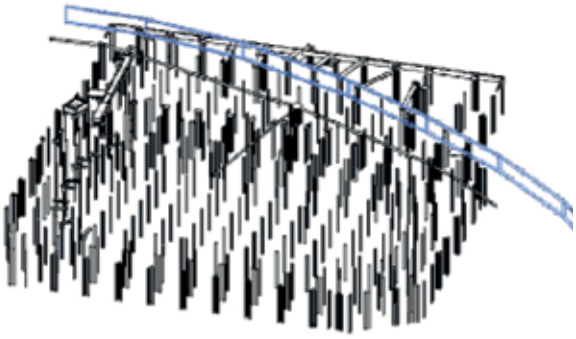
- Asesu'r gwahaniaeth ym maint y pyst rhwng y camau dylunio ac adeiladu
- Asesu faint o wastraff a gynhyrchwyd wrth osod y pyst concrid

11.4.1 Cymharu meintiau

Mae'r prosiect IAW wedi'i leoli ar dir wedi'i adennill oedd unwaith yn safle tirlenwi trefol. Oherwydd natur y tir wedi'i adennill a'r posibilrwydd y gallai'r safle symud a nwy ollwng wrth i'r adeilad setlo, codwyd wal gydrannol (gw. Ffigwr 2 isod) danddaearol fel mesur ataliol. I ganiatáu ar gyfer y wal hon a'r math o bridd yn yr ardal wedi'i hadennill, dyluniwyd y sylfeini'n defnyddio pyst concrid i sicrhau na fyddai setlo'n effeithio ar y strwythur ac i groesi'r wal gladdedig.

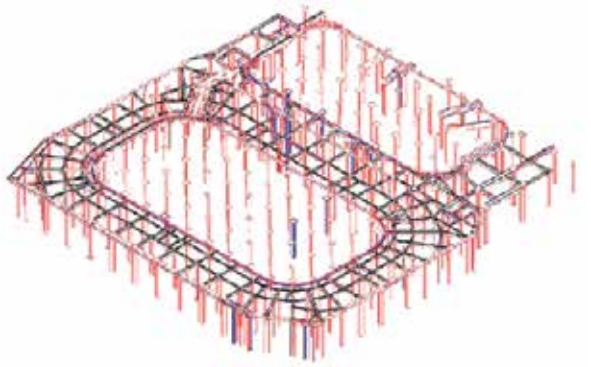


***Ffigwr 1**: Dyluniad yr adeilad wedi'i gynnal ar y pyst sylfaen concrid*



Ffigwr 2: Rhwystr tanddaearol. Cafodd y wal gladdedig danddaearol ei modelu gan dîm dylunio'r IAW i wella cydlyniant y dyluniad gorffenedig

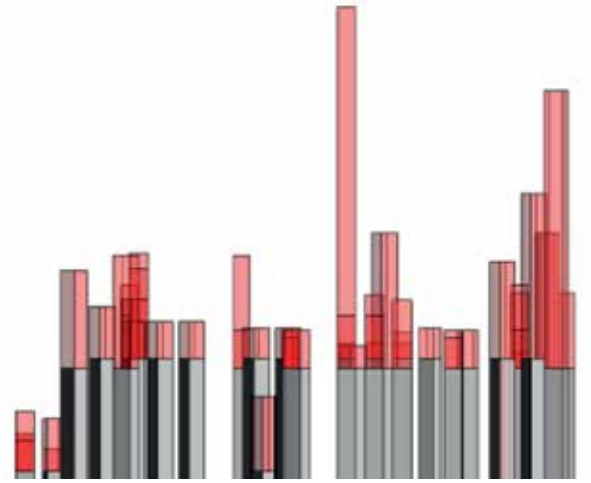
Wrth ddylunio pyst sylfaen mae dwy elfen allweddol sy'n penderfynu sut ddyluniad fydd y pyst, yn gyntaf lle mae angen i'r pyst gynnal pwysau'r adeilad, ac yn ail hyd y pyst sy'n dibynnu ar ddaeareg leol y safle. Ar gyfer y prosiect hwn defnyddiwyd cwmni Arup i ddylunio lleoliad y pyst i gyd-fynd â'r adeilad ac nid i gyd-fynd â hyd y pyst. Yr isgontractwr Keller oedd yn gyfrifol am ddyluniad terfynol hyd y pyst yn dilyn profion arolwg daearol.



Ffigwr 3: Newidiadau i ddyluniad cwmni Arup yn dilyn penodi isgontractwyr (coch gwreiddiol, glas diwygiedig)

Yn dilyn y broblem gyda'r dyluniad gan Arup awgrymodd isgontractwyr y pyst sylfaen ac isgontractwyr dyluniad y ffasâd ddiwygiadau a wnaed i'r dyluniad gwreiddiol cyn i'r gwaith adeiladu ddechrau. Roedd angen llond llaw o byst ychwanegol ar gyfer y dyluniad newydd a diwygiwyd ychydig ar rai o gapiau'r pyst a'r trawstiau daear.

Ar ôl i'r isgontractwr Keller durio tyllau prawf ar draws y safle, rhagnodwyd hyd dyluniad cyffredinol rhwng 13m a 23m ar gyfer yr holl byst ar y safle, gydag uchafswm hyd dyluniad disgwyliedig o 22.250m. Byddai'r pyst concrid a brynwyd yn cael eu dosbarthu i'r safle mewn hydoedd o 13m i gyflawni'r hydoedd dyluniad angenrheidiol.



Gwastraff o'r pyst concrid
Mae gwastraff wrth osod pyst concrid, yn anffodus, yn anochel oherwydd gall yr amodau tanddaearol, faint bynnag o brofion a wneir, newid yn ddramatig ar draws safle. Mae'r rhannau coch yn y graff uchod yn dangos faint o wastraff a gynhyrchwyd mewn un ardal o'r prosiect IAW.

Ar ôl i gwmni Keller osod y pyst i gyd yn eu lle, cofnodwyd pob postyn gan nodi hyd y darn gwreiddiol, ei hyd wedi'i osod yn ei le, maint y postyn a'r llwyth gweithio. Ychwanegwyd yr hydoedd i'r model i ddangos fersiwn orffenedig y pyst wedi'u gosod a fersiwn hyd y darnau gwreiddiol er mwyn gallu cofnodi a delweddu faint o wastraff a gynhyrchwyd.

Dengys y tabl isod (gw. Ffigwr 4) gofnod ar gyfer yr un data hwn o'r model. Mae'r tabl yn gadael i ni dynnu hyd y postyn ar ôl ei osod o hyd y darn gwreiddiol gan adael faint o bostyn sydd ar ôl ac y gellir ei ystyried i fod yn wastraff. Daethpwyd â chyfanswm o 9296m o ddarnau pyst sylfaen i'r safle.

Cynhyrchwyd cyfanswm o 597.4m o wastraff pyst sylfaen. Mae hyn yn cyfateb i 6.5% o'r holl ddarnau pyst a ddaethpwyd i'r safle.

Roedd y rhan fwyaf o'r hydoedd pyst oedd dros ben (nodir fel gwastraff pyst yn y tabl) rhwng 100mm a 500mm o hyd gyda 35 dros 3m o hyd a'r hiraf yn 6.9m o hyd. Mae'r broses o osod y pyst yn golygu y bydd gwastraff yn cael ei gynhyrchu oherwydd natur y ddaeareg o dan yr wyneb a hydoedd y darnau a ddewiswyd i osod y postyn. Weithiau bydd gormodedd o hydoedd yn wastraff oherwydd y darnau a ddaeth i'r safle neu ba hydoedd darnau oedd ar ôl pan gawsant eu gosod.

<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				8696.600 m	9296.000 m	597.400 m

Ffigwr 4: Rhannau top a gwaelod yr Atodlen Pyst Wedi'u Gosod yn dangos y cyfansymiau

11.4.2 Crynodeb

Prif fwriad yr astudiaeth hon oedd cymharu dyluniadau'r pyst a chynhyrchu gwastraff ar draws y camau dylunio ac adeiladu i weld a oedd modd dysgu gwersi i leihau gwastraff. Cododd dau rwystr ar ddechrau un yr astudiaeth fel nad oedd yn bosib dod i gasgliad clir ynghylch sut i wella'r arferion lleihau gwastraff.

Yn gyntaf nid oedd dyluniad gwreiddiol Arup yn cynnwys unrhyw hydoedd drwy eu defnyddio ar y prosiect. Nid oedd felly'n bosib cymharu maint na hyd ar draws y gwahanol gamau. Yn ail, oherwydd natur y safle wedi'i adennill a'r profion daearegol, cyflwynwyd goddefiadau eang i lwfa ar gyfer yr amrywiadau disgwyliedig yn hydoedd y pyst gorffenedig. Roedd hyn yn golygu nad oedd unrhyw hydoedd dyluniad yn eu lle i wirio, dim ond cofnod o'r hydoedd darnau a ddefnyddiwyd.

Llwyddodd yr astudiaeth i ddefnyddio'r dechnoleg BIM i gyfrifo a delweddu'r gymhariaeth rhwng yr hydoedd a ddaeth i'r safle a'r pyst gorffenedig ar ôl eu gosod, er mwyn creu delweddau a metrics syml i gofnodi'r gwastraff ar gyfer y prosiect.

12 Diogelu at y dyfodol – Cymhwyso Bil yr Amgylchedd

Mae'r prosiect wedi amlygu problemau y gallai'r diwydiant eu hwynebu yn y dyfodol. Yn benodol o ran y gwaharddiadau sydd i ddod ar losgi a thirlenwi gwastraff pren, papur, cardbord, gwydr, plastig, metal a gwastraff bwyd o dan Fil yr Amgylchedd (Cymru).

Pe bai'r Bil yn cael ei gymhwyso i'r prosiect hwn byddai angen ateb gwaredu arall ar gyfer hyd at 273.17m^3 o ddeunydd. Felly bydd angen ymchwil i ddeall pa opsiynau gwaredu eraill, ynghyd â'r seilwaith priodol, fydd angen eu hystyried er mwyn gallu gwneud y newidiadau fydd yn ofynnol o dan y ddeddfwriaeth.

13 Sialensiau allweddol

13.1 Gwastraff

Y prif sialensiau o ran gwastraff ar y safle oedd:

- Diffyg ymrwymiad i wahanu gwastraff
- Newidiadau mewn staff allweddol ar y safle
- Nifer fawr o gwmnïau rheoli gwastraff wedi eu defnyddio drwy gydol y prosiect
- Manylion deunyddiau – trafferthion wrth waredu deunydd cyfansawdd
- Seilwaith / Technoleg
- Anghysondeb ar ran y gwasanaethau rheoli gwastraff

13.2 Sialensiau ymddygiad / diwylliant

Gall newidiadau staff arwain at lai o ffocws ar wastraff. Oherwydd y newidiadau staff roedd hefyd yn anodd sicrhau bod y neges Galluogi Dyfodol Diwastraff yn parhau i fod yn rhan annatod o arferion y safle.

Rhaid cael dealltwriaeth bod pob gwastraff sy'n gadael y safle, p'un ai gan y gadwyn gyflenwi neu beidio, yn cael ei gofnodi ar SMARTWaste.

Mae angen adrodd cyfraddau ailgylchu / adfer penodol i'r safle gan gwmnïau rheoli gwastraff unigol yn hytrach na dibynnu ar gyfraddau cyffredinol.

13.3 Amser

Yn gyffredin â gweddill y sector adeiladu, roedd y cleient yn disgwyl cwblhau'r prosiect o fewn yr amserlen a gytunwyd. Mae hyn yn anochel yn arwain at bwysau masnachol ar y prif gontractwr a'u cadwyn gyflenwi ac, o ganlyniad, gall effeithio ar y perfformiad amgylcheddol a gwastraff.

13.4 Dyluniad

Yn dilyn ymarfer BIM i groeswirio'r wybodaeth 2d gyda'r model, canfuwyd nad oedd dyluniad y grisiau concrid yn ffitio'r seddi terasog ffrâm ddur – roedd rhai grisiau'n torri drwy'r seddi ac ni chaniateir hyn oherwydd mae'n creu perygl baglu. Newidiwyd hyn yn y cam dylunio gyda'r grisiau'n cael eu hailddylunio cyn eu castio. Cyfrifwyd yr arbedion o ran amser a chost deunyddiau'r gwaith diwygiedig pe bai'r grisiau anghywir wedi cyrraedd y safle i fod rhwng tua £30,000 a £40,000, hanner cost wreiddiol y grisiau. Ymarfer BIM rhannol oedd hwn, ni chafodd yr holl elfennau eu nodi drwy fodel BIM.

14 Sut y mae EZW wedi dylanwadu ar reoli gwastraff ar gyfer tîm y prosiect?

Derwyn Pugh, Rheolwr Contractau, Kier

O safbwynt personol a safbwynt y tîm y bûm yn gweithio gyda nhw i ddechrau yn y Ganolfan Iâ roedd yn fraint ac yn brofiad dysgu gwerthfawr gweithio gyda CEW ar y cynllun EZW. Aethom at y broses gyda meddwl agored ac roeddem yn fwy na hapus i dderbyn cyngor y cynghorwyr gwastraff profiadol ac i weithredu'r rhan fwyaf, os nad y cwbl, o'u hawgrymiadau. Mae angen strategaeth bywyd cyfan i wireddu holl fanteision dull cydgysylltiedig er mwyn gallu lleihau'r gwastraff a gynhyrchir ar y safle. Gan ddechrau gyda'r cleient, mae angen cynnwys yn gynnar a pharhau i addysgu'r tîm dylunio drwy'r cam caffael hyd at a chan gynnwys y gweithwyr ar y ddaear os ydym am gyflawni'r uchelgais o alluogi Dyfodol Diwastraff.

15 Llwyddiannau

Roedd nifer o lwyddiannau rheoli gwastraff ar y prosiect.

15.1 Cyflawni Targedau Gwastraff Llywodraeth Cymru

Nod Tuag at Ddyfodol Diwastraff (TZW), sef dogfen strategol drosfwaol Llywodraeth Cymru ar gyfer delio gyda gwastraff yng Nghymru, yw creu manteision i'r amgylchedd, yr economi ac i gymdeithas. Mae TZW yn gosod targed i'r diwydiant adeiladu a dymchwel yng Nghymru i baratoi ar gyfer ailddefnyddio, ailgylchu neu adfer fel arall o leiaf 70% o wastraff, yn ôl pwysau, erbyn 2015-16. Y targed ar gyfer 2019-20 yw 90%.

Drwy ailddefnyddio, ailgylchu neu adfer fel arall 99% o wastraff, mae cam adeiladu'r prosiect hwn wedi cwrdd â thargedau 2015-16 a 2019-20. Mae hyn yn helpu i ddangos tystiolaeth bod TZW yn cyflwyno targedau ailddefnyddio, ailgylchu neu adfer fel arall sy'n gwbl gyraeddadwy i'r diwydiant.

Erbyn 2050 mae Llywodraeth Cymru eisiau osgoi anfon 100% o wastraff adeiladu a dymchwel i'w dirlenwi. Llwyddodd y prosiect i osgoi anfon 99% o'i wastraff i gael ei dirlenwi yn ôl adroddiadau cwmni Llogi Sgipiau Olivers bod 9% o wastraff gweddilliol, 40.62m^3, a gynhyrchwyd gan y prosiect wedi'i anfon i'w dirlenwi ym Mryn Pica, Aberdâr.

Er llwyddo i gyflawni'r targedau uchod ystyrir bod angen mwy o ffocws ar ailddefnyddio ac atal gwastraff yn hytrach na dibynnu ar ba mor effeithlon yw'r seilwaith rheoli gwastraff. Rhaid gwastraffu 1.4% yn llai o flwyddyn i flwyddyn er mwyn gallu cyflawni'r targedau yn Tuag at Ddyfodol Diwastraff ar gyfer y sector.

Dyma rai o lwyddiannau eraill y prosiect:

- Trafod â'r gadwyn gyflenwi a sefydlu cynllun derbyn yn ôl effeithiol drwy weithio ag Euroclad
- Mesurau atal gwastraff
- Torion y pyst sylfaen concrid a deunyddiau anadweithiol wedi eu cadw a'u malu ar y safle'n barod i'w hailddefnyddio
- Pridd o'r gwaith tyllu wedi'i storio ar gyfer ei ailddefnyddio
- Pencampwr gwastraff safle dynodedig
- Cynlluniau ailddefnyddio pren effeithiol gan Reseiclo a Scott Pallets
- Mae'r arbedion cost ar y prosiect yn dod i tua £40,000 drwy wahanu gwastraff; dylunio i ddileu gwastraff a thrwy ddefnyddio cynlluniau ailgylchu.

16 Casgliad ac argymhellion

Llwyddodd y prosiect i osgoi anfon 99% o wastraff i gael ei dirlenwi. Gan syrthio fymryn yn brin o'r nod dim gwastraff o gwbl, mae er hynny'n dangos llwyddiant ysgubol ac yn dangos ei bod yn bosib anfon dim gwastraff i gael ei dirlenwi. Llwyddodd y prosiect i ragori ar darged presennol Llywodraeth Cymru o sicrhau y caiff 70% o bob gwastraff, yn ôl pwysau, ei baratoi ar gyfer ei ailddefnyddio, ailgylchu neu ei adfer erbyn 2015/16 ac yn llawer gwell na'r targed gwastraff ar gyfer y dyfodol i ailddefnyddio, ailgylchu neu adfer 90% erbyn 2019-20. Er bod y targedau ar gyfer 2015-16 a 2019-20 wedi eu cwrdd, mae angen ffocws pellach ar atal ac ailddefnyddio gwastraff yn hytrach na dibynnu ar effeithlonrwydd y seilwaith rheoli gwastraff. Mae cyfleoedd i fod yn fwy effeithlon ac effeithiol ar y safle a photensial i wneud arbedion gwastraff a chost.

Mae arbedion cost ar gael i gwmnïau sy'n fodlon ystyried yr hierarchaeth wastraff ym mhob un o gamau prosiect. Atal yw'r lefel allweddol yn yr hierarchaeth er mwyn gwneud arbedion sylweddol, fel y mae'r prosiect hwn wedi'i ddangos. Mae BIM yn rhoi cyfle i ddyluniadau gael eu profi a'u newid gyda golwg ar atal unrhyw wrthdaro neu dorri a llenwi diangen, er enghraifft, sy'n gallu bod yn ddrud a gwastraffus.

16.1 Argymhellion i'r contractwr

Mae pwysigrwydd gwahanu gwastraff ar y dechrau wedi'i brofi ynghyd â chanolbwyntio ar drafod gwastraff ym mhob un o gamau prosiect, gyda phawb ar y safle. Mae ymgysylltu â holl aelodau'r tîm ar y safle'n bwysig wrth geisio cynnal arferion gorau a gwahanu ar adegau o bwysau ar y safle, yn enwedig yn y cyfnod terfynol cyn trosglwyddo.

Pwysigrwydd adnabod cyrchfannau pen draw'r gwahanol fathau o wastraff drwy drafod hyn gyda'r cwmni rheoli gwastraff sydd mewn golwg ar y dechrau a chyn llunio'r contract. Ar ôl ymchwilio i gynllun derbyn yn ôl ar gyfer plasterbord gan Siniat, cafwyd nad oedd y deunydd wedi'i anfon yn ôl i Siniat i gael ei ailbrosesu. Roedd hyn yn siomedig iawn oherwydd roedd Euroclad wedi ymrwymo i'r cynllun EZW ac wedi ceisio sicrhau bod eu gwastraff i gyd yn cael ei ailgylchu drwy ddolen gaeedig, ond cawsant eu siomi gan y brocer gwastraff.

Mae sefydlu'r compownd gwastraff yn rhan bwysig o'r strategaeth rheoli gwastraff a dylai fod yn un o brif bryderon pencampwr gwastraff y safle wrth gynllunio gwaith ar y safle. Dylai compowndiau gwastraff gynnwys sgipiau gwahanu gwastraff o'r diwrnod cyntaf ar y safle a dylid egluro eu pwrpas i bawb. Yn ddelfrydol ni ddylid defnyddio sgip gwastraff cymysg ond, lle bo'i hangen, dylid ei lleoli mor bell â phosib o waith y safle er mwyn cymell gweithwyr i beidio ei defnyddio.

Dylai gwastraff fod yn ystyriaeth wrth ddewis isgontractwyr. Dylai'r prif gontractwr ystyried eu dyletswydd gofal a sut y mae hefyd yn cynnwys yr opsiynau gwaredu gwastraff a ddewisir gan isgontractwyr. Dylid canolbwyntio ar sicrhau ymrwymiadau cytundebol gan nodi y dylid cadw at holl gamau'r hierarchaeth wastraff cyn gwaredu gwastraff i'w dirlenwi. Bydd hyn yn lleihau effaith bosib penderfyniadau'r isgontractwyr ar dargedau'r prosiect ar gyfer ailgylchu, ailddefnyddio ac adfer fel arall.

Roedd gwastraff pecynnu'n her sylweddol ar y prosiect hwn, fel y mae'n aml. Gall cyflenwyr chwarae rôl allweddol drwy becynnu llai cyn belled ag y bo'r contractwr yn cyfathrebu'r problemau gyda'i waredu i'w cyflenwyr. Yn aml iawn gellir trefnu cynllun derbyn pecynnu'n ôl gyda'r gweithgynhyrchydd neu'r cyflenwr ond mae angen rhagweld a chynllunio hyn fel bo'r cytundeb yn ei le cyn i'r gwastraff ddod yn broblem.

Mae pwysigrwydd cofnodi a diweddaru data gwastraff a nodiadau trosglwyddo gwastraff drwy SMARTWaste nid yn unig yn diogelu'r cwmni'n gyfreithiol, gall hefyd fonitro ffrydiau gwastraff ac yn y pen draw osgoi ac atal gwastraff. Drwy drafod ag isgontractwyr a chael sgyrsiau, gyda phwyslais ar arferion cadw tŷ a gwahanu gwastraff, mae'n bosib cael ymrwymiad i'r cynllun EZW. Mae cyfathrebu amcanion diwastraff i holl weithwyr y safle'n bwysig i sicrhau bod pawb wedi ymrwymo i'r cynllun. I'r perwyl hwn dylid trafod gwastraff a'i wahanu fel rhan o'r broses gynefino ar y safle ym mhob cam adeiladu a dymchwel.

Mae hefyd yn hanfodol bwysig bod y person sy'n gyfrifol am gynhyrchu rhagolygon gwastraff mewn cysylltiad rheolaidd â thîm y safle i sicrhau bod y rhagolygon yn gyraeddadwy, rhesymol a seiliedig ar berfformiad blaenorol. Pan fydd newid wedi digwydd i'r tîm rheoli ar y safle, mae'n bwysig bod aelodau newydd y safle'n cael eu briffio ar weithdrefnau ac arferion y safle cyn iddynt gymryd drosodd.

Bydd cofnodi data gwastraff ar y system SMARTWaste yn helpu'r cwmni i adolygu faint yn union o wastraff sydd wedi gadael y safle. Mae Kier wedi cyflwyno arfer

gwaith newydd lle mae'r holl ddata ar ddechrau'r prosiect yn cael ei gofnodi gan aelod penodol o dîm y safle, wedi'i hyfforddi ar ddefnyddio SMARTWaste, sy'n sefydlu cynllun rheoli gwastraff y safle a gwybodaeth am y cwmni rheoli gwastraff. Ar hyn o bryd mae Kier yn adrodd cyfradd ailgylchu gwastraff gyffredinol o 85% yn hytrach na'n defnyddio cyfraddau ailgylchu penodol i gwmni.

Bydd Bil yr Amgylchedd (Cymru) yn gwahardd gwaredu gwastraff pren, papur, cardbord, gwydr, plastig, metal a gwastraff bwyd drwy losgi neu dirlenwi. Bydd angen i gontractwyr ystyried sut i ddelio â'r gwastraff hwn oherwydd mae'n debyg y bydd y gost o'i waredu'n cynyddu i dalu am ymchwil i opsiynau gwaredu eraill. Fel y mae'r adroddiad hwn yn ei nodi, atal yw'r ateb mwyaf cost-effeithiol felly dylid ystyried dileu gwastraff drwy wneud mwy o ddefnydd o gynhyrchion wedi eu saernïo ymlaen llaw.

16.2 Argymhellion i'r cleient

Gall dyluniad a'r cynhyrchion a ddewisir gael effaith sylweddol ar wastraff. Bydd cynnwys y cleient yn gynnar i atal gwastraff yn cael effaith fawr ar y gwastraff a gynhyrchir drwy'r prosiect. Gellir rheoli hyn wrth roi sylw i faterion cadw tŷ a gwahanu gwastraff wrth ymweld â'r safle.

Gall penderfyniadau ynghylch amserlen gael dylanwad sylweddol ar brosiect. Gall y pwysau i gwblhau prosiect arwain at lai o ymdrech i lynu wrth arferion fel gwahanu gwastraff. Mae hyn yn effeithio ar gyfraddau ailddefnyddio, ailgylchu neu adfer y prosiect am gost a allai fod yn uwch na'r gost y mae'r cleient yn ceisio ei hosgoi, drwy gyflymu'r gwaith adeiladu.

16.3 Argymhellion i'r dylunydd

Dylai dylunwyr dalu mwy o sylw i feintiau safonol y deunyddiau yn y cam dylunio. Byddai mesuriadau safonol neu ddyluniad sy'n defnyddio deunyddiau mewn unedau lluosog yn lleihau faint o dorion a gynhyrchir. Gellir cymhwyso hyn i fesuriadau ystafelloedd neu hyd peipiau. Dylid annog mwy o drafod â chontractwyr i wella dealltwriaeth o ddeunyddiau. Dylid hefyd codi ymwybyddiaeth o sut y mae dyluniad cymhleth yn effeithio ar wastraff, yn enwedig uniadau cymhleth.

Mae BIM yn cynnig opsiwn hyfyw ar gyfer dileu gwastraff dylunio. Bydd defnyddio mwy ar BIM yn golygu gwneud penderfyniadau dylunio'n gynt gan wneud y broses yn fwy rhagweithiol nag adweithiol. Mae'n golygu ei bod yn hawdd delweddu mewnbwn pob crefftwr fel y gellir adnabod yn hawdd unrhyw wallau neu wrthdaro rhwng dyluniadau'r gwahanol grefftwyr . Mae gweithio'n effeithiol gyda BIM yn sicrhau llif cyson o wybodaeth gan annog cyd-ddealltwriaeth a pherthynas weithio dda.

17 Gwella prosesau

Drwy gydol y contract nodwyd bod wyth o wahanol gwmnïau rheoli gwastraff wedi eu defnyddio. Gall cymhlethdod y trefniadau hyn arwain at drafferthion wrth sicrhau bod y ddyletswydd gofal yn cael ei chwrdd, gyda chofnodi data ar wastraff a chyrchfannau gwastraff.

Roedd y plasterbord Siniat wedi'i gyflenwi gan Euroclad i Massey Cladding a ymrwymodd i ddarparu gwasanaeth i gasglu'r plasterbord Siniat gwastraff. Oherwydd bod y plasterbord Siniat yn cynnwys compownd silicon, gellir prosesu'r deunydd yn ôl i Siniat yn unig ac nid i'r plasterbord Gypsum arferol. Cysylltodd Euroclad â Siniat i holi am y ffordd orau o drefnu'r gwaith casglu a chawsant fanylion cyswllt ar gyfer Reconomy. Derbyniodd Euroclad gadarnhad llafar gan Reconomy y byddai'r plasterbord Siniat yn cael ei droi'n ôl yn fordiau Siniat. Yn dilyn ymchwilio ymhellach, ar sail adroddiad gan Reconomy, cafwyd bod y bordiau wedi mynd yn ôl i gwmni gwastraff Atlantic. Roedd Euroclad yna wedi cysylltu â Reconomy a ddywedodd y byddai'r gwastraff wedi mynd o Atlantic i Siniat. Drwy gysylltu ag Atlantic cafwyd ar ddeall nad ydynt yn anfon unrhyw wastraff i Siniat a bod holl gynnyrch Siniat yn cael ei waredu drwy weithgynhyrchu Gypsum.

Y gwelliant proses a nodwyd drwy'r cynllun EZW fyddai cytuno i lynu wrth y contractau gwastraff a gytunir ag isgontractwyr yn ystod y cyfarfodydd cyn gosod y contract. Er bod caffael gwastraff, cytundebau a'r ochr gyfreithiol yn rhan o gyfarfodydd cyn-gosod Kier, dylai rheolwyr safle Kier ôl-ddilyn yr isgontractwyr a chadarnhau bod y gweithwyr yn cadw at ofynion y contract, yr asesiadau risg a'r datganiadau dull, gan gynnwys glynu wrth reolau cadw tŷ a gwahanu gwastraff.

Tynnwyd sylw at y rheswm am y gwelliant hwn o ganlyniad i waith Massey Cladding ar y safle. Cytunodd Massey i'r holl wybodaeth a drafodwyd yn y cyfarfod cyn-gosod. Unwaith yr oeddent ar y safle cafwyd bod eu gwastraff yn mynd i mewn i sgipiau Kier. Cysylltodd y tîm EZW â rheolwr safle Massey Cladding ac nid oedd yn ymwybodol o'r cytundebau gwastraff. Cafodd y datganiad dull a gyflwynodd Massey Cladding i Kier ei adolygu gan Kier a'r tîm EZW, oedd yn cadarnhau na fyddai Massey Cladding yn creu unrhyw wastraff. Yna cyflenwodd Massey eu sgipiau eu hunain ar gyfer y gwastraff a gynhyrchodd y cwmni o'r prosiect. Mae'n bwysig nad yw'r ffactorau hyn yn cael eu rhoi heibio oherwydd gall effeithio ar y cyfrifon terfynol a'r cyrchfannau gwastraff i bawb.

Mae'n bwysig bod y staff sy'n goruchwylio rheoli'r gwastraff wedi eu hyfforddi ac yn ymwybodol o SMARTWaste a'r system rheoli gwastraff ar y safle. Gall y person perthnasol yna ddeall yr opsiynau rheoli gwastraff, y ffigyrau ailgylchu a monitro'r gwastraff yn erbyn y targedau.