Enabling
ZERO WASTE

Bryn Ivor Lodge, Castleton

Noddir gan Lywodraeth Cymru
Sponsored by Welsh Government

ADEILADU ARBENIGRWYDD YNG NGHYMRU
CONSTRUCTING EXCELLENCE IN WALES

Enabling Zero Waste: Castleoak

Contents

Bryn Ivor Lodge, Castleton

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.

Bryn Ivor Lodge care home, Castleton, was a £6.1million project undertaken by Castleoak on behalf of Barchester Healthcare. It involved the demolition of an existing garden centre and associated buildings, followed by the construction of an 80 bed timber frame care home. The care home was manufactured off site at Castleoak's timber frame manufacturing facility in Ebbw Vale.

During the programme there were several distinct peaks of waste generation. At the start of the project the segregation of waste did not take place. This is understood to have resulted from a number of factors including pressures to start on site and a temporary agency site manager being in place. They perhaps did not buy in to the EZW project and Castleoak's own policies and procedures.

The project recorded recycling rates of 100% for bricks, inert waste, tiles and plasterboard waste. With a recycling rate of 88%, by weight, the construction phase achieved Welsh Government's current target that a minimum of 70% of all waste, by weight, shall be prepared for reuse, recycled or recovered by 2015/16. 12% of waste produced was sent for energy recovery in R1 classified facilities. The waste comprised of:

- Cardboard waste: 5.88m^3 (20% of total cardboard waste)
- Timber waste: 15.56m^3 (10% of total timber waste)
- Mixed general waste: 53.88m^3 (14.9% of total mixed general waste)

The Welsh Government aims for 100% diversion of construction and demolition waste from landfill by 2050. This project met the landfill targets on the construction phase. However, 70 tonnes (67%) of demolition waste was disposed of to landfill, preventing the project as a whole from achieving the 100% diversion target. Overall the project achieved 78% diversion of waste from landfill, by weight.

Whilst the above targets have been achieved, further focus is considered to be required on waste prevention and reuse rather than relying on the effectiveness of waste management infrastructure. A 1.4% reduction of waste needs to be achieved year upon year by the construction sector in order to meet the Towards Zero Waste target. Cost savings on this project attributed to consideration of the waste hierarchy and effective waste management were over £170,000. These are detailed in section 5.5 and equate to almost 2% of the project budget, highlighting how important the consideration of waste can be to project finances and profitability.

Other successes on the project include:

- Achieving a c.£170,000 cost saving due to consideration of the waste hierarchy
- 9% was saved on the cost of waste disposal on this project through waste segregation
- The project was 20.7% and 6.9% less wasteful than the established SMARTWaste benchmarks for a healthcare building, per 100m^2 and per £100k respectively
- The benefits of Building Information Modelling (BIM) have been made apparent to Castleoak
- Reuse of onsite materials due to a detailed pre-demolition survey undertaken by BRE on behalf of CEW
- Preventing the removal of excavated materials from site

Recommendations for contractors include:

- It being 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 segregation of waste at source is clear to all members of the site team
- Focussing on and discussing waste at all stages of a project, with all involved on site

Recommendations for clients include:

- A need to be aware how their decisions, including the purely aesthetic, can have knock on impacts
- Ongoing communication with design consultants and contractors is important
- Pressure applied to complete can cause a fall in adherence to site practices, such as waste segregation

Recommendations for designers include:

- Consideration to the standard sizes of materials during design
- Engagement with contractors to improve material understanding
- Awareness of how intricate design affects waste
- Awareness of how BIM will lead to more design decisions being made earlier

If the Environment (Wales) Bill were applied to this project up to 93.66m^3 (41.7tonnes) of material would require an alternate disposal solution. This shows the need to research alternate 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 is a Constructing Excellence in Wales (CEW) initiative which provides practical, positive and proactive assistance to construction, demolition and civil engineering projects in Wales. The aim is to establish if, and how, the construction industry can achieve the zero waste targets established in the Welsh Government's waste strategy, Towards Zero Waste.

CEW provides EZW project participants with technical advice, expertise and guidance on waste management and Building Information Modelling (BIM) to help overcome barriers to waste minimisation and design for deconstruction. Each project is provided with a bespoke and tailored package to best suit its needs.

CEW is working in collaboration with the construction industry to provide a detailed insight into the achievability of zero waste. The goal being to share best practice solutions and opportunities, along with identifying any barriers associated with achieving the Welsh Government's targets. CEW offers practical assistance to construction project design and site teams to explore viable solutions to achieving zero waste and EZW project objectives to:

- Understand and evidence when and how wastes occur during the construction process
- Understand current strategies, methodologies and opportunities for the diversion from landfill of site wastes
- Analyse the feasibility/viability of achieving zero waste to landfill in the current environment
- Work to develop solutions to prevent and minimise the generation of on-site waste, generating a reduction in waste management, disposal and landfill costs
- Support changes to behaviour and processes that encourage prevention and minimisation of waste
- Achieve site efficiencies from waste management opportunities/solutions
- Minimise site traffic through reduction in supplies and materials allowing for cost savings
- Disseminate solutions and opportunities from the development of effective waste management strategies
- Provide learning and education opportunities regarding alternative waste management techniques which can be disseminated for future projects ensuring continual benefits

2.2 Castleoak

Castleoak has over 30 years of experience working exclusively in the care and retirement living sector with an award winning reputation for successful delivery of care homes, assisted living and extra care apartments, care villages and specialist care schemes.

Castleoak design and construction services cover from project inception through to furnishing and equipping. A full multi-award winning development solution is also available, encompassing land sourcing and acquisition, demographics, project feasibility analysis, planning permission and tailored funding solutions.

3 Project Background

Bryn Ivor Lodge care home was a project undertaken by Castleoak on behalf of Barchester Healthcare. It involved the demolition of a garden centre and associated buildings followed by the construction of an 80 bed timber frame care home. The care home was manufactured off site at Castleoak's timber frame manufacturing facility in Ebbw Vale. The gross internal floor area of the care home is just over 4,000m^2.

The construction programme was originally supposed to start in February 2014 with a completion date of March 2015. The project programme was delayed through ongoing discussions with the planning department at Newport Council to raise the level of the building by 500mm and move the building by 3m to reduce the volume of excavated soil. The project therefore commenced in June 2014 with a handover to the client in June 2015.

At the start of the EZW project the care home design had been finalised, the original planning permissions were in place, contractor, tier one sub-contractors, suppliers and waste management contracts had all been appointed.

3.1 Cost

The project cost value was £6.1 million.

3.2 Contract type

The design and build was carried out by Castleoak.

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 Castleoak project team was 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 BRE SMARTWaste
- Preparation of a Building Information Model (BIM) of the site, prepared from information supplied by McCanns
- 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
- Prevent excavation through raising the building level
- Identify a waste champion to review and ensure that legal compliance and waste management best practices are met
- Prevent the spoilage of materials on site by keeping them dry and secure
- Undertake toolbox talks to raise awareness of waste prevention and reduction
- Introduce segregated cardboard skips when packaging waste increased on site
- Identify where the timber waste resulted from and how off site construction could reduce wastage

Associated documentation and guidance regarding the above was also provided.

Building Information Modelling (BIM) was also carried out as part of the project to identify clash detections and to 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

5.1.1 Demolition Phase

The former garden centre buildings on the site were demolished by Cuddy Demolition. An additional pre-demolition survey, undertaken by BRE as part of EZW, identified that the base pads could be retained on site and reused as aggregate. Rather than be disposed of as waste. This allowed for a waste saving of approximately 712m^3 (890 tonnes). Disposal to landfill of this saved material would have cost £15,094.40 based on £21.20/m^3 including landfill tax. This would have increased the waste management costs for the project by 84%.

Existing access roads and carparks were reused for the new building. This prevented the need to dispose of the existing road and carparks, and prevented the construction of new roads. In total 6000 tonnes, 2490m^3, of material remained in situ and prevented disposal which would have cost £52,780 (at £21.20/m^3).

The demolition of the former garden centre resulted in 184m^3 of waste, 27% of total waste arisings. The waste was reported as:

- 44m^3 timber waste
- 48m^3 metal waste
- 92m^3 mixed construction waste

A significant amount of the waste produced as a result of the demolition work, 70 tonnes, was sent to landfill. This had not been discussed or agreed with the site team during the pre-contract meeting. The reason reported by Cuddy was that landfill was the best available option for the waste.

14.62 tonnes of the timber waste, (33%), was sent to South Wales Wood Recycling Ltd. a wood recycling company based in Bridgend. They shred timber waste producing large woodchips, used to manufacture chipboard, and finer material which is used for animal bedding.

5.1.2 Construction Phase

In total 673m^3 of waste was generated by the construction phase of the project.

5.1.2.1 Groundworks

In total 33m^3 of waste, 5% of total waste arisings, resulted from the groundworks phase. The majority of which was of a mixed nature, 29.3m^3. Brick waste accounted for 3.6m^3 of the total and was disposed of in a segregated inert skip at a 23.5% cost saving on a mixed waste skip.

5.1.2.2 Structural Works

In total, just less than 235m^3 of waste, 35% of total waste arisings, was produced from these activities. The majority of which was disposed of as mixed construction waste 118.8m^3, closely followed by 63.9m^3 timber and 36.7m^3 of inert waste. 1.8m^3 of tiles was disposed of as waste as a result of ordering the wrong specification. Similarly, 5.5m^3 of bricks were wasted due to the use of the wrong specification product when constructing the lift shaft.

5.1.2.3 Finishing Trades

In total the finishing trades produced 220m^3 of waste, 33% of total waste arisings. Details by trade or activity are as follows.

5.1.2.3.1 Plasterboard partitioning and cladding

29.3m^3 of plasterboard waste was produced from this activity, 4% of total waste arisings.

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

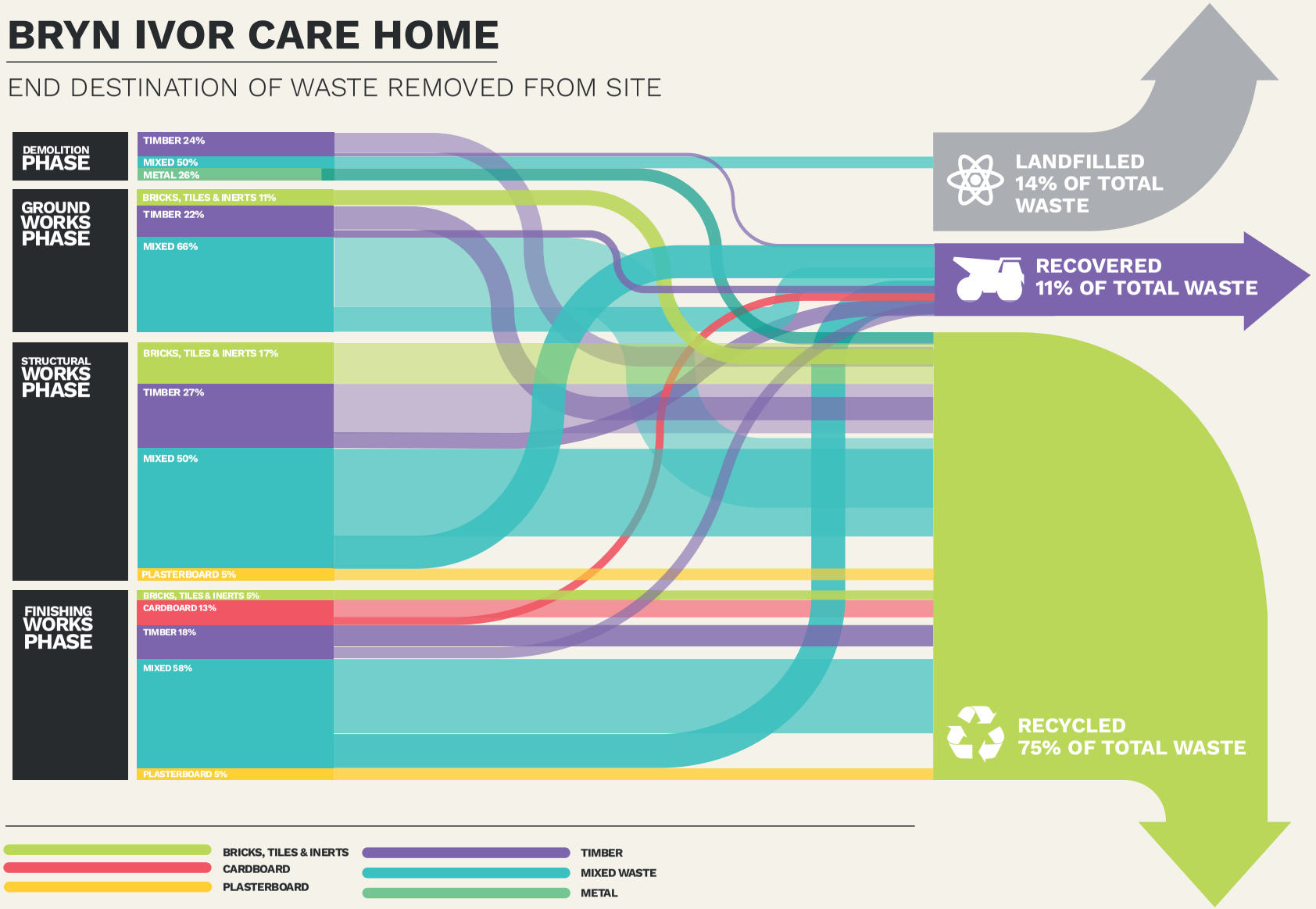
The majority of waste from these activities was reported as mixed 62.5m^3. Timber waste accounted for 25.7m^3 of waste, 18.4m^3 cardboard and 11m^3 inert waste. A total of 106.6m^3, 15.9% of total waste arisings.

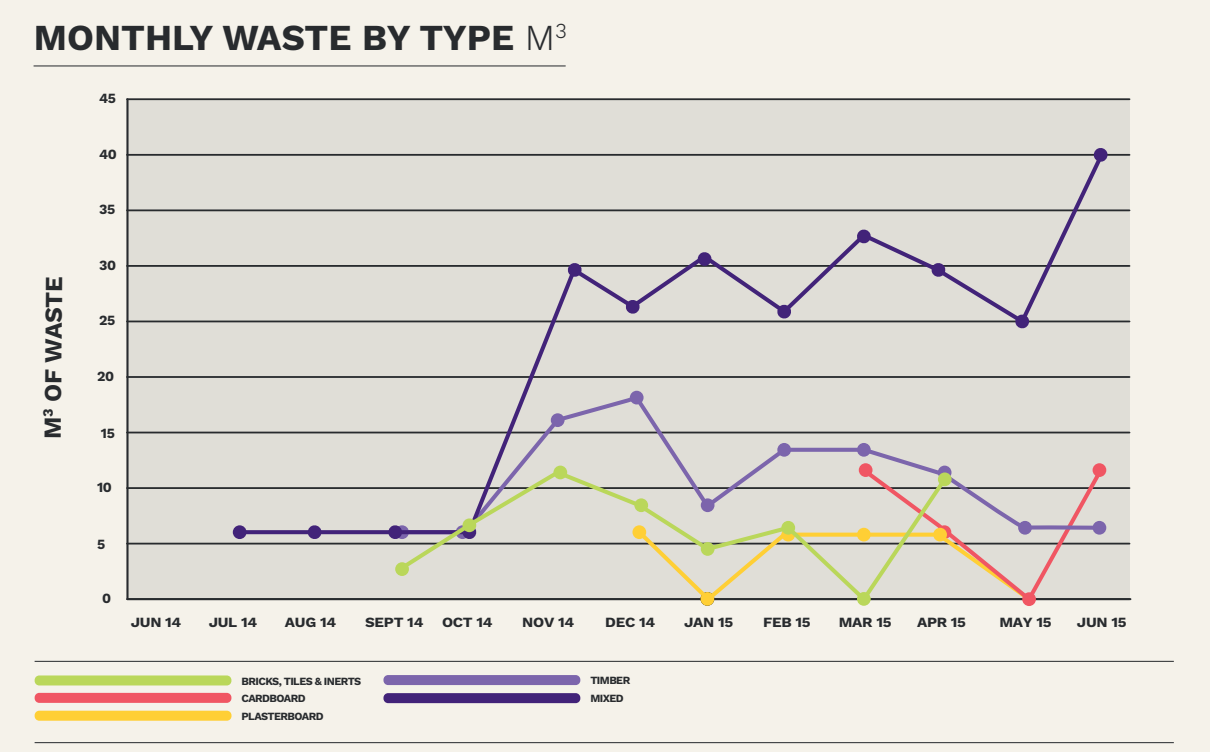
5.1.2.3.3 FFE and site clearance

In total, just less than 92m^3 of waste was produced from these activities, 14% of total waste arisings. The majority of the waste produced was of a mixed nature, 66m^3. The remainder comprised timber waste 14.68m^3 and 11m^3 of cardboard. The significant amount of mixed waste recorded is likely a result of time pressures arising from the handover deadline.

BRYN IVOR CARE HOME

END DESTINATION OF WASTE REMOVED FROM SITE





5.2 Analysis by programme

At the start of the project the segregation of waste did not take place. It is understood that this may have occurred as a result of a temporary agency site manager being in place. They were perhaps not invested in the EZW project or Castleoak's own policies and procedures. Segregation of waste improved on the site from September when a permanent Castleoak site manager took up their post.

During the programme there were distinct peaks in waste generation. The reasons behind these peaks are detailed below.

5.2.1 June 2014 Peak

In June significant quantities of mixed construction waste 92m^3, timber waste 44m^3 and metal waste 48m^3 were produced directly related to the demolition of the former garden centre buildings. Segregation of timber waste from mixed waste achieved a cost saving of 21.5% per skip.

The reuse of the garden centre's base pads as aggregate allowed for a waste saving of approximately 712m^3 (890 tonnes). Disposal to landfill would have cost £15,094.40 based on £21.20/m^3 including landfill tax. This would have increased the waste management costs for the project by 84%.

5.2.2 November Peak

In total 57.8m^3 of waste was produced in November. The majority of which was mixed construction 28.9m^3 (50%) followed by timber 16m^3 (28%). In December 58.8m^3 of waste was produced, of which 26.6m^3 (45%) was mixed.

In November there was a peak in inert waste, 12.8m^3. This corresponds with the construction of a lift shaft with the wrong specification of brick. The lift shaft was therefore demolished and the bricks were disposed of at a cost of 2.5 times that of the purchasing cost.

5.2.3 March and April Peaks

During the March and April period the waste produced on site reached its construction phase peak at 64.3m^3 each month. This corresponds to the period of greatest trade activity as Section A of the build was being rushed to completion. Time saving is often prioritised over waste segregation during this final phase which could explain the mixed nature of the waste.

The majority of the waste was of a mixed nature, 33m^3 in March and 29.3m^3 in April. Large quantities of damaged concrete blocks were noted in the skips, and in April 11m^3 of inert waste was produced. The brick waste was mainly the result of the demolition of the lift shaft due to site error in the use of the wrong brick specification. Cardboard waste from packaging was also high in March, 11m^3, and so it was recommended that the site introduce segregated cardboard skips.

5.2.4 June 2015 Peak

A peak in mixed construction waste, 40.4m^3, occurred in June. From site visits undertaken during this period it is considered likely that on-site segregation of waste reduced as a result of pressure to realise project completion, and to clear the site for handover.

Eleven skips of mixed waste were removed from site during June. Tonnages for these eleven were 13% less than the average mixed waste skip for the rest of the project. This suggests that there were greater voids in the skips, implying significant quantities of packaging waste and protective wrap, some of which could have been disposed of in the cardboard skip at 35% lower cost.

5.3 Analysis by waste management option

5.3.1 Prevention

The initial location of the care home had been approved by the local planning authority. It would have involved the removal of 4,550m³ of soil at a cost of £21.20/m³. Analysis of alternate location options showed that by raising the building by 500mm and moving it 3m a cut and fill balance could be achieved. Preventing the removal of excavated materials from site saved £96,460 in waste management costs, not including associated costs, for example labour, plant hire and fuel. This would have been nearly five and a half times the actual waste management cost.

Existing access roads and carparks were reused for the new building. This prevented the need to dispose of the existing road and carparks, and prevented the construction of new roads. In total, 2490m³ of material remained in situ and prevented disposal which would have cost £52,780 (at £21.20 per m³). A similar quantity of new material was saved from being brought to site to develop 3000m² of new roads and carparks.

5.3.2 Surplus Material

Surplus materials were stored on site during the construction phase within a secure container. During the last week of the project 2.2 tonnes of surplus materials were donated to the Swansea surplus centre, equivalent to at least 2 skips. The Swansea surplus centre accepts donations of reusable surplus materials for distribution to community and social projects. It removes the need for disposal to landfill, saving £340 in disposal costs and 891kg of embodied carbon. Items donated include:

Festoon Lights	Wall Tiles	Composite Shiplap Cladding
Rockwool 150mm	Dust Bins	Red Facing Brick
Red Facing Brick	Brass Hinges (with screws)	Silver Hinge

5.3.3 Reuse

Reuse of the garden centre's base pads as aggregate allowed for a waste saving of approximately 712m³ (890 tonnes). Disposal to landfill would have cost £15,094.40 based on £21.20/m³ including landfill tax. This would have increased the waste management costs for the project by 84%.

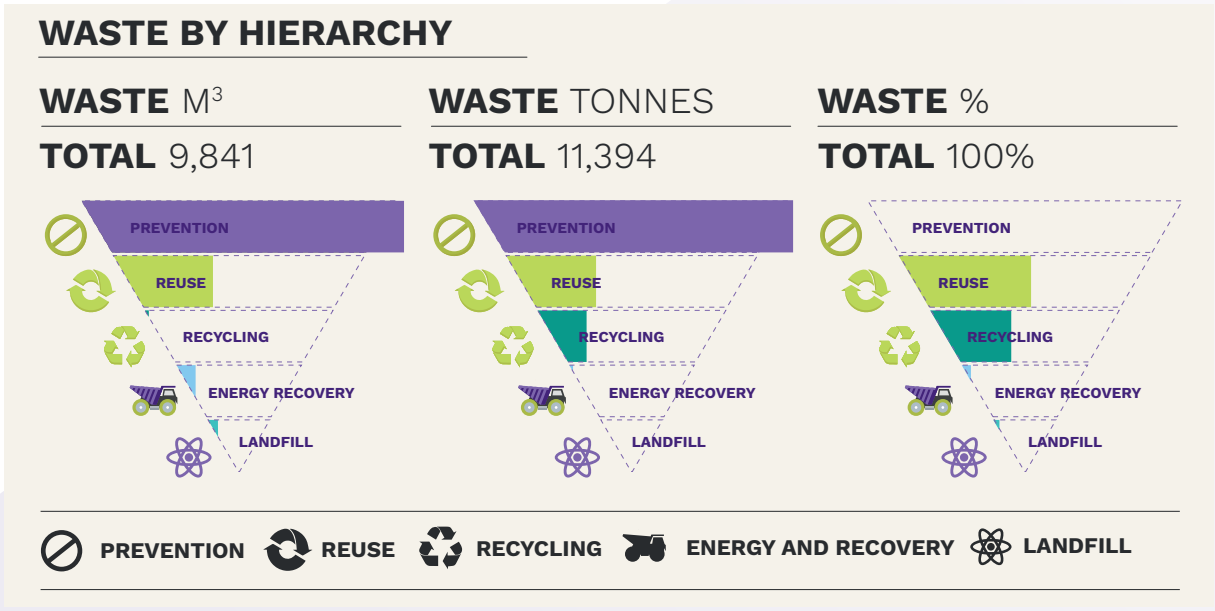
Wooden pallets were removed from site by Scott Pallets. Of the 461 pallets removed 261 went on to be reused (4.7 tonnes, 106m³). Disposal of these 261 pallets was free and saved £2,436 in disposal costs.

5.3.4 Recycling

The recycling rates reported by Atlantic Waste for construction waste included:

- 100% of the brick, inert and tile waste (55m³)
- 80% of cardboard waste (23.5m³)
- 100% of plasterboard waste (22.92m³)
- 90% of timber waste (140m³) - additionally 200 wooden pallets (3.6tonnes, 81.5m3) removed by Scott Pallets were recycled
- 80% of mixed general waste (289m³)

This corresponds with 85.5% of construction waste by volume, 88% by weight.



5.3.5 Energy Recovery

Two energy recovery facilities were used by the waste management company, Trident Park – Cardiff and Weener Energie – Weener, Germany. Both facilities are classified R1 and therefore meet the efficiency standards to be considered energy recovery rather than disposal; as set out in the Waste Framework Directive.
The Weener facility is approximately 590 miles further (by road) from the site in Castleoak than Trident Park. Although apparently financially effective, transportation of waste over such distances has a high carbon and environmental cost.

14.5% of construction waste, by volume, was sent for energy recovery which comprised of:

- 20% of cardboard waste (5.88m^3)
- 10% of timber waste (15.56m^3)
- 20% of mixed general waste (72.22m^3)

5.3.6 Landfill

Atlantic Waste reported that no construction waste received from the site was sent to landfill. 70 tonnes of demolition waste was sent to landfill. This had not been discussed or agreed with the site team during the pre-contract meeting. The reason reported by Cuddy was that landfill was the best available option for the waste.

5.4 Analysis by individual waste stream

5.4.1 Timber

The site produced a total of 155.6m^3 of timber waste.

This material was taken to Atlantic Waste at 17.6% lower cost per skip compared to a mixed waste skip, and 90% was recycled. The remainder went to energy recovery.

Twenty-seven skips of timber waste were removed from site compared to a target of ten that had been estimated at the start of the project. Timber waste was produced starting in September with the frame erection in August and experienced a peak during the building of the complex roof structure. The intricate nature of the roof design, intended to mimic a row of housing, led to significantly more offcuts than expected. Rationalisation of the design using BIM could have saved on the number of offcuts and hence wastage.

The building design utilises a prefabricated timber frame manufactured off site at Castleoak's timber frame manufacturing facility in Ebbw Vale. The prefabrication consists of flooring, walls and roof joists. Internal walls, however, are built and cut on site. It has been discussed with the company why the internal walls are built on site when the room sizes are predesigned. Factory manufacture would reduce waste and ensure quality control for these elements. Castleoak are exploring the factory option for internal walls and are assessing feasibility.

Timber was also used over the weather proof material on the outside of the building before it was clad. All the timber used was cut to size on site, producing off-cuts. Other aspects of the build could be prepared offsite, such as skirting boards and hand rails. These items are currently purchased in a standard size and cut to fit on site. Waste cut-offs are then disposed of in the timber skip instead of being reused in the factory.
Economies could be achieved through design with standard material sizes in mind. Room dimensions based on standard material lengths or sizes would reduce wastage through cut-offs and reduce time spent on installation.

It was intended that the bracing delivered with the timber frame would be returned to the factory for reuse. Unfortunately, some bracing was found to have been disposed of within the timber skip. This could have been avoided through better instruction or/education of site operatives to encourage them to follow through with procedures intended to boost reuse and recycling.

Wooden pallets were removed from site by Scott Pallets. Of the 461 pallets removed:

- 261 went on to be reused (4.7 tonnes)
- 200 were recycled (3.6 tonnes)

The cost of this scheme was based on a fee of between £1.50 - £2 per pallet which could not be reused. In total £356 was spent. Disposal of the pallets in timber skips would have cost approximately £4,300, based on 15 pallets per skip. A total saving of £3,945.

5.4.2 Bricks

Brick waste was only recorded as being produced in September and December. However, it is known that further waste bricks were produced but were instead recorded leaving site as inert waste. Recorded brick waste for the site was therefore 5.51m^3 (5.04 tonnes) disposed of at an average cost of £130 per skip, a 23.5% saving on a mixed waste skip. 100% of the brick waste was recovered by reprocessing to produce aggregate by Neal Soils.

The source of the brick waste was mainly site error, including the use of the incorrect specification of bricks to construct a lift shaft. Demolition of the lift shaft produced 12.8m^3 of waste which was disposed of at 2.5 times the cost of purchasing the bricks.

5.4.3 Tiles

Tile waste was produced during the roofing works. The design of the roof, which is intended to mimic a row of housing, required tiles to be cut to fit. This led to significant quantities of off-cuts and shows how key design is in terms of reducing or producing site waste. Tiles were removed from site under the description of inert waste. The tile waste was taken by Atlantic Waste and crushed by Neal Soils to produce aggregate material at a recovery rate of 100%.

5.4.4 Plasterboard

Good practice was seen by the plaster boarding contractor Gray Drylining Ltd. Offcuts were stored on site to be used elsewhere. Gray produced 22.92 m^3 (12.92 tonnes) of plasterboard waste. This was taken to Atlantic Waste who reported recycling rates of 100%. Plasterboard waste could be significantly reduced through consideration at the design stage. Rooms could be designed with dimensions suitable based on standard plasterboard sizes. This approach would be similar to the design of straw bale housing, where building dimensions are dictated by straw bale dimensions.

5.4.5 Cardboard

Cardboard waste increased once furniture, fixtures and fittings were brought onto site. The site was encouraged to begin using cardboard skips which offered a cost saving of 35% on a mixed waste skip. The use of cardboard skips contributed 26% of the total waste management cost savings which are attributed to segregation. Atlantic Waste reported an 80% recycling rate for the cardboard with the remaining 20% being sent for energy recovery.

The site recorded 29.38m^3 (2.62 tonnes) of cardboard waste once the segregated skips had been introduced. Total cardboard waste is likely to have been significantly higher as segregation only began in the ninth month of the year-long project. Also, waste segregation reduced during the final month of construction. This can be seen in the 13% lower tonnage of the mixed skips suggesting greater voids in the skips, implying cardboard packaging may well have been present.

When the client was fitting out the last part of the building they were encouraged to take back packaging which could be reused, which they agreed to.

5.4.6 Mixed Construction Waste

361.12m³ (185.02 tonnes) of mixed construction waste was produced on site. This waste was removed by Atlantic Waste who reported 80% was recycled and 20% went for energy recovery. A maximum target of 70 general waste skips had been set, the site came in below target using 67 skips. Mixed waste skips were removed at a total cost of £11,390.

During an initial period of poor housekeeping on site mixed waste increased as all waste was placed into general skips. It is understood that this is likely to have been a result of a temporary agency site manager being in post who was perhaps not invested in the EZW project, and Castleoak's own policies and procedures.

Segregation of waste improved on site from September. Following some site visits it was discussed how to improve segregation including:

- Improved general housekeeping
- Moving materials being stored in front of the skips to elsewhere
- Replacing signage which had been removed or damaged

Extra labour was employed during January as housekeeping issues around the storage of materials and waste compound needed resolving. This helped to improve housekeeping at the site and the segregation of waste.

5.4.7 Inert Waste

Inert waste produced totalled 47.7m³ (53.8 tonnes) which had a reported recycling rate of 100%.The material was processed by Neal Soils to produce aggregate material. As mentioned previously some brick and tile waste was recorded as inert waste so the true volume is likely to be less. Disposal of brick and tile waste as inert waste did not incur any additional cost or saving as all three categories of skip were charged at the same rate by Atlantic Waste.

5.5 Analysis by cost

5.5.1 Actual Waste Management Costs

The construction phase of the project used a total of 120 skips at a total cost of £17,870. This cost was divided between six skip types at four average rates. Four plasterboard skips were removed by the sub-contractor as part of their package. The percentage of skip type and the associated percentage of cost for the other 116 are shown below:

Skip Type	% of Total No of Skips	% of Total Cost
Mixed Waste	57.8	63.7
Timber	23.3	21.2
Bricks, Tiles & Inerts	12.1	10.2
Cardboard	6.9	4.9

Mixed waste was the most used skip type, 57.8%, and naturally incurred the greatest percentage of cost. However, the greater cost of each skip contributes to general waste skips representing a 5.9% greater proportion of the cost.

5.5.2 Potential Waste Management Costs

Without waste segregation the cost of disposing of 116 mixed waste skips would have been £19,720. This is £1,850 more than the actual cost, which means a saving of 9% was achieved through waste segregation.

The former garden centre buildings present on the site were demolished by Cuddy Demolition. An additional pre-demolition survey was undertaken by BRE as part of EZW which identified that the base pads could be retained on site and reused as aggregate. This allowed for a waste saving of approximately 712m³ (890 tonnes). Disposal to landfill would have cost £15,094.40 based on £21.20/m³ including landfill tax. This would have increased the waste management costs for the project by 84%.

The initial location of the care home had been approved by the local planning authority. It would have involved the removal of 4,550m^3 of soil at a cost of £21.20/m^3. Analysis of alternate location options showed that by raising the building 500mm and moving it 3m a cut/fill balance could be achieved. This prevented the removal of excavated materials from site saving £96,460 in waste management costs, nearly 550% of the actual cost.

Existing access roads and carparks were reused for the new building. This prevented the need to dispose of the existing road and carparks, and prevented the construction of new roads. In total, 2490m^3 of material remained in situ and prevented disposal which would have cost £52,780 (at £21.20 per m^3).

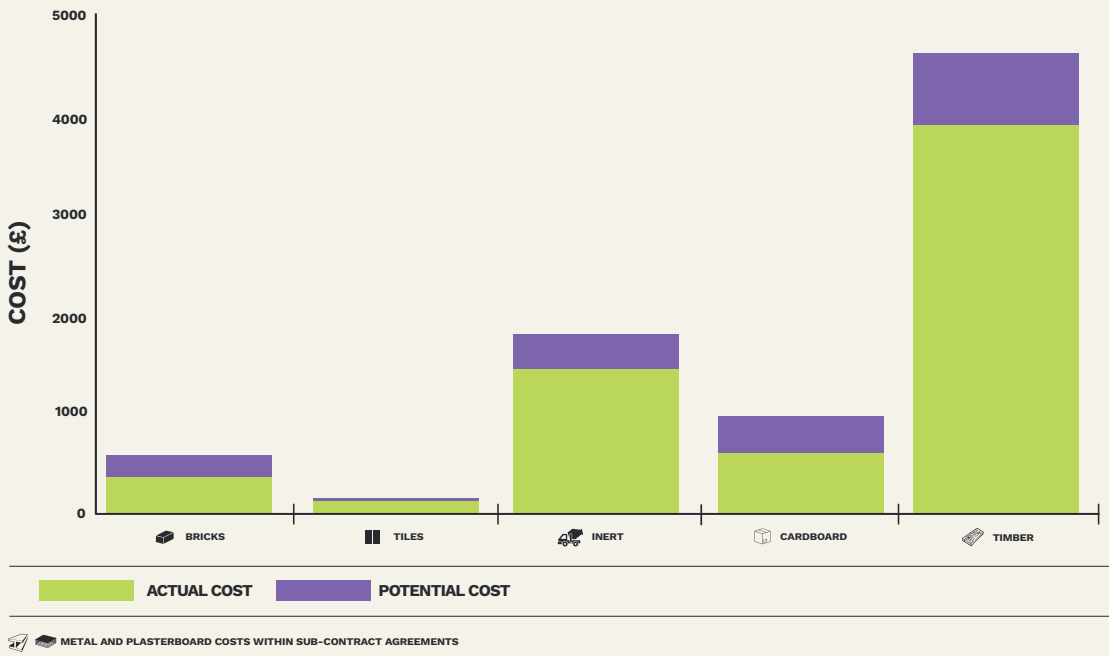
Wooden pallets were removed from site by Scott Pallets. The cost of this scheme was based on a fee of between £1.50 - £2 per pallet which could not be reused. In total £356 was spent. Disposal of the pallets in timber skips would have cost approximately £4,300, based on 15 pallets per skip at £140 a skip. A total saving of £3,945.

Savings =

£1850 (segregation)
+ £15,094 (pad reuse)
+ £96,460 (cut/fill balance)
+ £52,780 (existing road reuse)
+ £360 (surplus donations)
+ £3,945 (wooden pallets)

Total Saving = £170,489

POTENTIAL AND ACTUAL WASTE COST BY TYPE



5.6 Analysis against benchmarks

Waste data is available in the SMARTWaste system for hundreds of 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.

5.6.1 Demolition Phase

Demolition projects on SMARTWaste average 26.6m^3/100m^2 and 3.0m^3/£100k. The construction phase of the project achieved figures of 4.6m^3/100m^2 and 3.0m^3/£100k, meaning that the Bryn Ivor project was 82.7% and 82.6% less wasteful than the established benchmarks. Suggesting that the demolition produced significantly less waste than average.

Bryn Ivor Lodge	SMARTWaste average*	Difference
4.6m^3/100m^2	26.6m^3/100m^2	82.7%
3.0m^3/£100k	17.4m^3/£100k	82.6%

*(based on 29 projects)

5.6.2 Construction Phase

New build healthcare projects on SMARTWaste average 15.4m^3/100m^2 and 8.6m^3/£100k. The construction phase of the project achieved figures of 12.2m^3/100m^2 and 8.0m^3/£100k, meaning that the Bryn Ivor project was 20.7% and 6.9% less wasteful than the established benchmarks. Suggesting that the construction phase was more waste efficient than the construction of the average healthcare building.

Bryn Ivor Lodge	SMARTWaste average*	Difference %	BREEAM Credits**	
12.2m^3/100m^2	15.4 m^3/100m^2	20.7	1credit <13.3m^3	3credits <3.4m^3
8.0m^3/£100k	8.6m^3/£100k	6.9	2credits <7.5m^3	Exemplary <1.6m^3

*(based on 20 projects)

**(awarded by volume of waste per 100m^2)

6 Modelling

6.1 Building Information Modelling (BIM)

As part of EZW, CEW commissioned Gillard Associates to prepare a BIM model. The aim was to inform and educate participants on the subject of waste management either by helping with onsite decision making or by looking at virtual scenarios post construction.

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.

6.2 Using BIM

Castleoak were not able to provide any 3D or BIM data, so the model was developed from scratch by Gillard Associates (GA). GA used parametric modelling, creating equivalent BIM elements for each construction element i.e. windows, doors. Modelling in this way allows for automatic scheduling of these elements.

Automatic scheduling makes it easier to track quantities of different elements used in a project. Allowing the contractor tighter control of the budget and it makes tracing discrepancies easier. Significantly it reduces the need for over ordering due to a greater degree of confidence in order quantities.

Terrain modelling was undertaken after the initial planning application. The process used Boolean operations to demonstrate the amount of cut and fill, enabling the optimisation of site levels. This led to a reapplication to the planning authority to raise building levels and prevent the need for soil removal from site.

A particular concern of the planning authority was the roof design and the desire for the building to have a domestic appearance. Availability of a BIM model would have helped with the visualisation of the roof and may have helped achieve an easier agreement with planning authorities. Development of the model highlighted discrepancies in the plan and elevation drawings, specifically ridge heights and roof angles.

The roof structure was designed by Castleoak's timber frame designers in specialist software which produces 2D outputs in the form of AutoDesk dwg files or as pdf files. There were no 3D outputs. Modelling the structure highlighted issues with the design, such as:

- Rafters extending beyond soffits
- Discontinuity of rafter geometry

Accurate modelling of the roof structure is important when it comes to installation of M&E systems. Ventilation, plumbing and electrical systems are well known for causing delays on site due to clashes. Designers aim to limit this by providing more than adequate space in roof/ceiling voids. But to avoid wasting time, materials and workmanship M&E systems can be checked for clashes against the architectural design within BIM. This ensures the use of optimal routes and economic layouts.

In the case of Bryn Ivor when the 2D drawings were modelled, the M&E model did not match the architectural model in some areas, for example the boiler room. Design requirements and changes had not been communicated between disciplines leading to a discrepancy in room dimensions. Such a difference could lead to the need for abortive works, rebuilding of floors and walls, along with delays to the programme of works.

Similar problems were found when modelling the timber frame, for example, with openings and the floor cassettes. Had a BIM environment been in place earlier time could have been saved on design reworking and prevented inaccurate scheduling.

6.3 BIM Outcomes

The initial location of the care home would have involved a significant cut requiring the removal of 4,550m^3 of soil. Analysis of alternate location options utilising the 3D model showed that by raising the building 500mm and moving it 3m a cut/fill balance could be achieved. Thus, providing a significant saving in time and money for the project.

Areas of opportunity for Castleoak were highlighted by Gillard Associates:

1. Design; Earlier involvement may have helped planning authorities to visualise the development, smoothing the planning process.

2. Scheduling; BIM can provide accurate information for material procurement reducing the need for over ordering.

3. Quality Control; BIMx offers the opportunity to perform virtual/visual checks during and after construction.

4. Parametric Objects; The design of repetitive spaces or objects within a BIM software application can be rationalised by the use of parametric or intelligent modelling, in which all or any attribute can be varied or fixed depending on set criteria.

7 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 93.66m^3 (41.7 tonnes) of material would require an alternate disposal solution. As such, research will need to be carried out to understand what alternate disposal options, along with the appropriate infrastructure, are necessary to enable the necessary changes required by legislation.

8 Key challenges

8.1 Waste

The main challenges around site waste were:

- Lack of commitment to segregation – site operatives and site management
- Design – complex roof design leading to significant quantities of waste and offcuts
- Site errors – incorrect specification of bricks used for the lift shaft, incorrect material ordering
- Late uptake of BIM – much of the design work was completed before the EZW programme started. This meant, the early adoption of BIM on the project wasn't possible and therefore limited its effectiveness at Bryn Ivor Lodge. It was always expected that a 'retrospective' BIM on this project would help influence future Castleoak timber frame designs

8.2 Behavioural/cultural Challenges

Castleoak is an ISO14001 and BS8555 certified company. As such the company has in place an environmental policy, procedures and a dedicated environmental team. Even with this commitment it was sometimes difficult to ensure all operatives, and levels of the supply chain, were bought in to responsible waste management procedures at all times. Findings during the project have highlighted the impact and importance that waste aware operatives and supply chain have on waste generation.

Pre-let meetings were held and waste was discussed during the meetings. However, if the sub-contractor does not follow through with the agreed site and contractual agreements this can lead to deviation in waste expectations. It is imperative that management and sub-contractors take ownership of waste management, and that waste management is an active part of their role before and during construction.

Through conversations with sub-contractors and toolbox talks, commitment to the EZW scheme was achieved. However, it is unclear how this commitment was then communicated to all site operatives and how committed they were. 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.

8.3 Time

As 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. There can then be an impact on environmental and waste performance. Preparation for residents began before construction was fully completed so presented issues for the site team with regards to waste management and segregation levels.

Whilst construction continued, the client received furnishings and fitting deliveries to site, the packaging for which went into the mixed waste skips. The extra waste, combined with the pressure of the handover deadline, lead to a reduction in waste segregation. In the final two months only 14% of waste was segregated compared to a monthly average of 51% and a peak of 90% segregation.

8.4 Design

The roof design would have benefitted from the application of BIM. Clash detection and rationalisation could have been achieved before work began on site. Being aware of clashes in advance removes the need for ad hoc solutions worked out on site, which are often wasteful. Similarly, standardised design and use of BIM would have made the complexity of the roof design clearer in advance. This would have made the site teams aware of the potential waste and time issues. With such issues in mind they would then have been able to conduct an informed value engineering process.

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

Miles Thomas, Environmental Manager – Castleoak

An extremely challenging site and programme meant that construction efficiency and focus on waste reduction was important to deliver a more sustainable product to our Customer. We have estimated that our initial plans would have resulted in significantly more than 8000m^3 of material leaving site at a cost of more than £100k. With the help of EZW we soon identified huge opportunity to reduce this waste impact.

The waste savings of more than 8000m^3 were achieved through collaborative working between the client, contract, design team, supply chain and with the help of Constructing Excellence in Wales. Many features of the existing site were kept to reduce waste generation further, and high recycling rates were achieved through use of Green Compass / PAS402 Certified companies and Local Authority recycling collections. We have been delighted by these savings and it has certainly solidified and strengthened our processes on commitment to maximising on site reuse.

EZW provided us with more focus on on-going waste management on site. The regular visits by an EZW representative were particularly helpful for the site based colleagues. A good rapport was built up which was appreciated by the team.

Although many improvements were made during and since our work with EZW we do feel that more opportunities were missed and for long periods, the focus on the EZW was sometimes lost because of other demands on the team and business. With hindsight we should have provided more time and resource to assisting EZW and the site team to deliver further waste and efficiency savings.

The inadequate waste management by our demolition contractor and subsequent landfill of many tonnes of potentially recyclable materials acted as a big reminder to the project team to realise the impact and risk that waste management can have on the business.

From a wider sustainability perspective, the work at Bryn Ivor Lodge has helped influence many more of our schemes and processes.

- Incorporation of aspects of BIM and a push to increase its use within Castleoak
- Greater appreciation of design, in particular roof design on our schemes which has influenced work on efficient design and buildability, for example at our Winnersh Care Home
- Strengthen procedures around the selection of demolition and groundwork contractors
- Improvements in reporting and compliance of demolition and groundwork contractors
- Changes in on-site environmental inspections
- Developing more tool box talks for operatives
- On the lookout for surplus-centre type operations around the country
- Work with customers to help us reduce packaging waste towards the end of projects

Castleoak would certainly welcome the opportunity to work with EZW again on future projects in Wales to review our work post-Castleton and identify further areas for improvement and efficiencies in the business.

9 Successes

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

9.1 Achieving Welsh Government's Waste Targets

Towards Zero Waste (TZW), the Welsh Government's overarching strategy document on 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 100% reuse, recycling or other material recovery, the construction phase of this project has met the 2015-16 and 2019-20 targets. Providing 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. This project met the landfill targets on the construction phase. However, 70 tonnes (67%) of demolition waste was disposed of to landfill, preventing the project as a whole from achieving the 100% diversion target. Overall the project achieved 78% diversion of waste from landfill.

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.

9.2 BIM

The benefits of BIM have been made apparent to Castleoak. They have taken on board the suggestions and recommendations from the BIM consultant, Gillard Associates used as part of EZW, and are hoping to use BIM in future projects.

9.3 Cost Savings

Cost savings on this project attributed to effective waste management were £170,000. These are detailed in section 5.5 and show how important consideration of waste can be to project finances and profitability.

The majority of this saving £96,460 was achieved by preventing the removal of excavated materials from site. This highlights the importance of considering waste prevention at the design stage to achieving substantial waste and cost savings.

Reuse of onsite materials allowed for approximately £15,094 of saving, purely from disposal costs. Investment in detailed pre-demolition surveys like that undertaken in this case by BRE can reap major financial returns.

Similarly, investment of time in the establishment of a segregated waste compound and effective site practices can achieve financial benefits. 9% was saved on the cost of waste disposal on this project through waste segregation. With improved site practices and use of segregated skips from day one on site, this saving could have been greater.

10 Conclusion and recommendations

The Bryn Ivor Lodge has performed well against established SMARTWaste benchmarks and Welsh Government targets for the construction phase. Whilst targets 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.

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 the final stages before handover.

10.1 Client Recommendations

Design can have a significant impact on waste arisings. In this case the client's requirements for the structure to resemble a line of housing led to significant waste and issues in construction. Clients need to be aware how their decisions, including the purely aesthetic, can have knock on impacts on design and therefore waste.

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.

10.2 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.

10.3 Contractor Recommendations

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.

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. 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 take-back 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 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.