Project Report

Castleton Care Home - BIM Model

for

Constructing Excellence in Wales

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castleoak

Care Home, Castleton - BIM Model

Gillard Associates Ltd was appointed by Constructing Excellence in Wales to take part in the Enabling Zero Waste project commissioned on behalf of Welsh Assembly Government to investigate the use of Building Information Modelling (BIM) in reducing waste in construction.

Our role was to prepare a BIM model to inform and educate participants in two case studies on the subject of waste management, by either helping with onsite decision making, or by looking at virtual scenarios post construction.

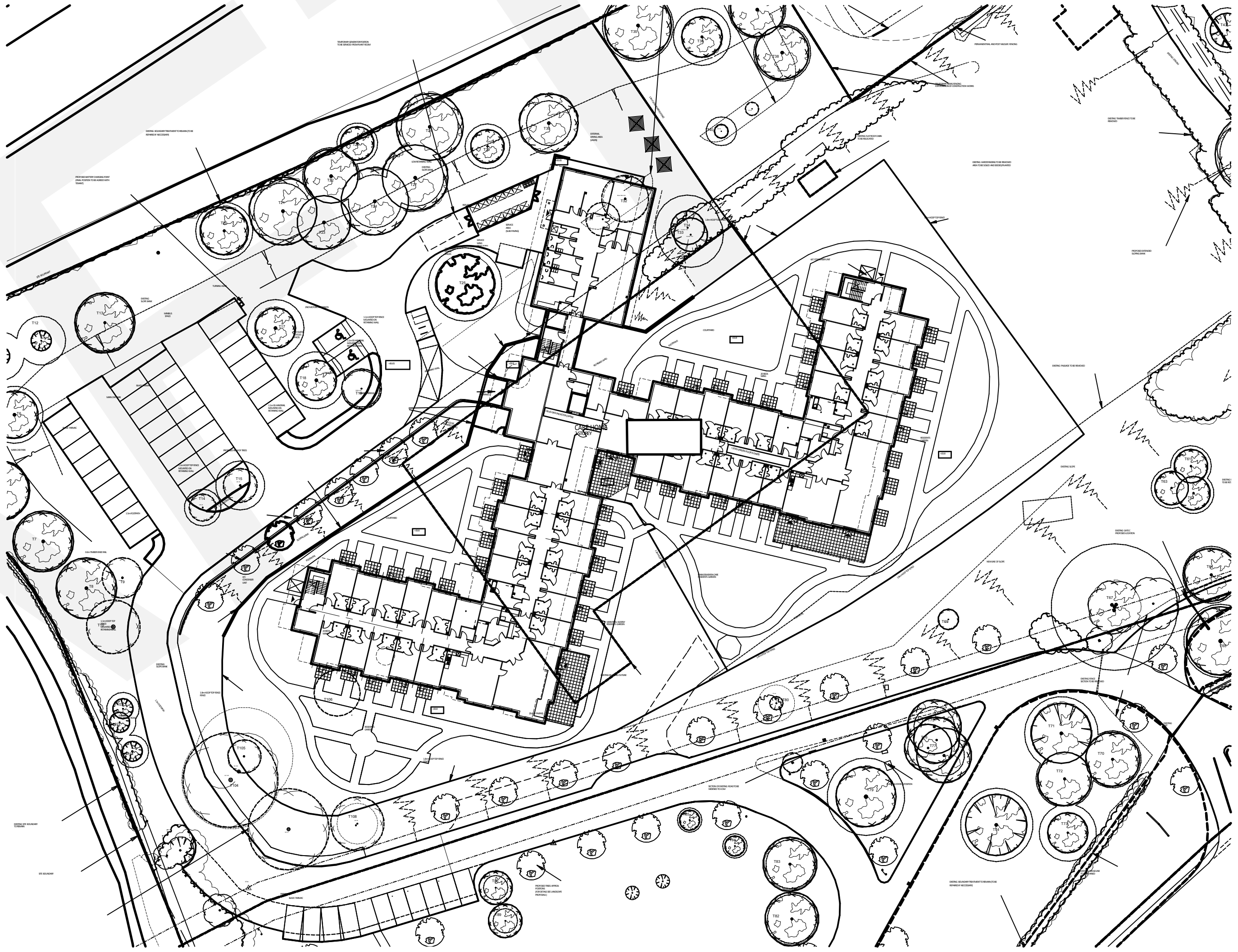
This report aims to demonstrate the process in which the BIM Model for the Castleton project was assembled, the opportunities it has generated for reducing waste in construction and the possible learning outcomes subjects for ongoing analysis and discussion.

Castleoak are a well established firm of design and build contractors who deliver buildings using timber frame, a modern method of construction. After 15 years of providing building solutions Castleoak have refined their production processes to a point where the operation is streamlined and efficient.

Castleoak specialise in the design and construction of Barchester Care Homes of which Castleton is one example. The design of Barchester homes has been developed over a twenty year period and its continued success is dependent on answering the needs of its clients, who are in need of care provision at various levels of intensity.

Castleton is arranged so that the ground level is for more independent clients, whereas the upper level is for more dependent clients. Whilst both types of client have varying needs this is delivered in suites which are formulaic - the rooms are generally arranged on a double loaded corrider with communal spaces at corners and inter sections. This is obvious from a helicopter view as two arms springing from a central core which also has a boiler and service area adjacent (see image above).

The degree of repetition in the planning of a single site, as well as repetition of the basic formula from one site to another, with the need for consistency in servicing whilst recognising personal preferences of individual clients, makes this sort of building very suitable for BIM development. It is hoped that this report will be able to demonstrate the advantages of BIM in streamlining even further the delivery of the finished product, by enabling efficiencies in design, documentation, materials procurement,and quality control.



The process of design and construction requires that the building is subdivided in different disciplines which are handled by various specialists and subcontractors. Those will return even more complex information which must be checked, co-ordinated and approved. This whole process creates a huge amount of information which is de-centralized, without a self-checking process and it is communicated in form of drawings and written documents, requiring a strict and tiresome form of control for revision and validation.

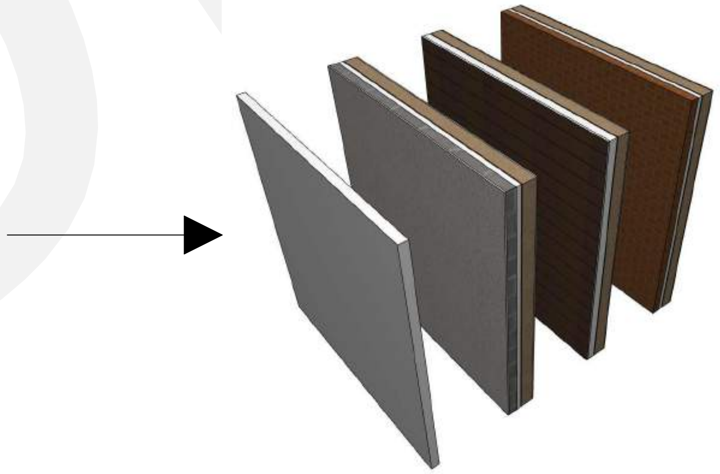
After getting to know the project, it was clear for Gillard Associates that assembling a BIM model would be an excellent opportunity to demonstrate the capabilities of this technology in co-ordination, clash detection and visualisation.

BIM model assembly:

The contractor works under a traditional Design and Build process. The project in question was already given planning approval and the process of detail design was also in motion.

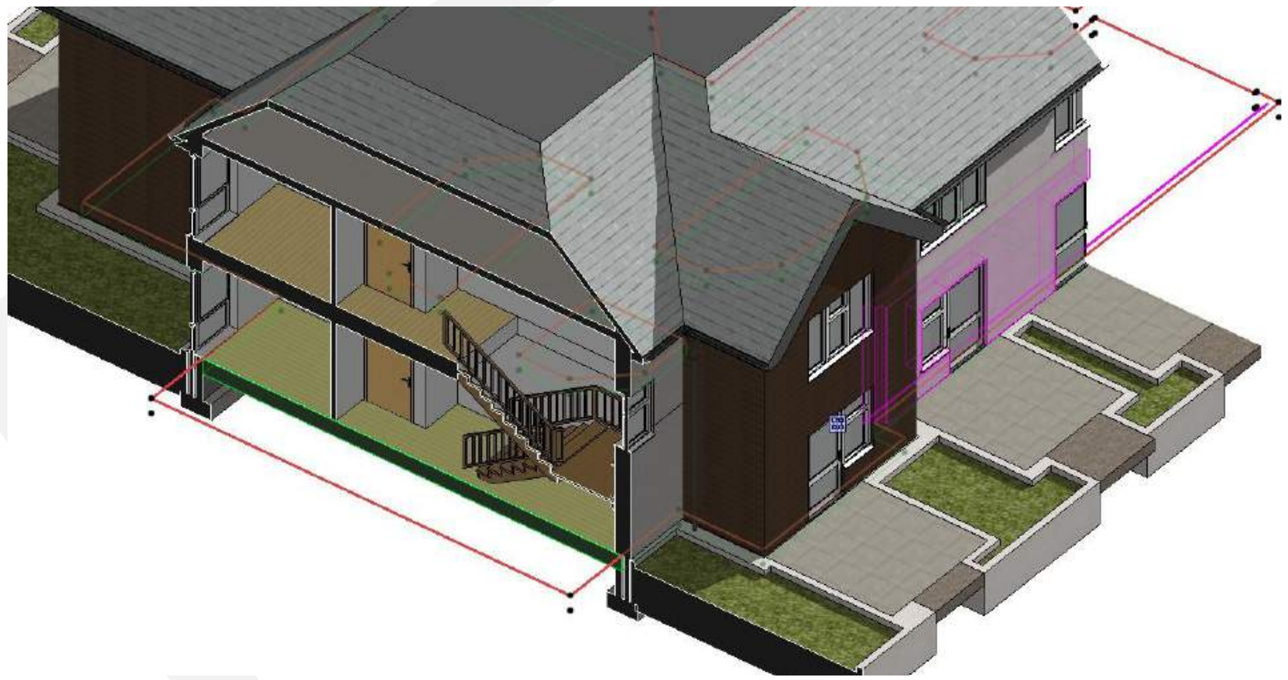
At the beginning, Gillard Associates was handled the available 2D data package that consisted in site plan, general plans, elevations and generic detailed building envelope sections. No 3D or BIM data was available and the model was started from scratch.

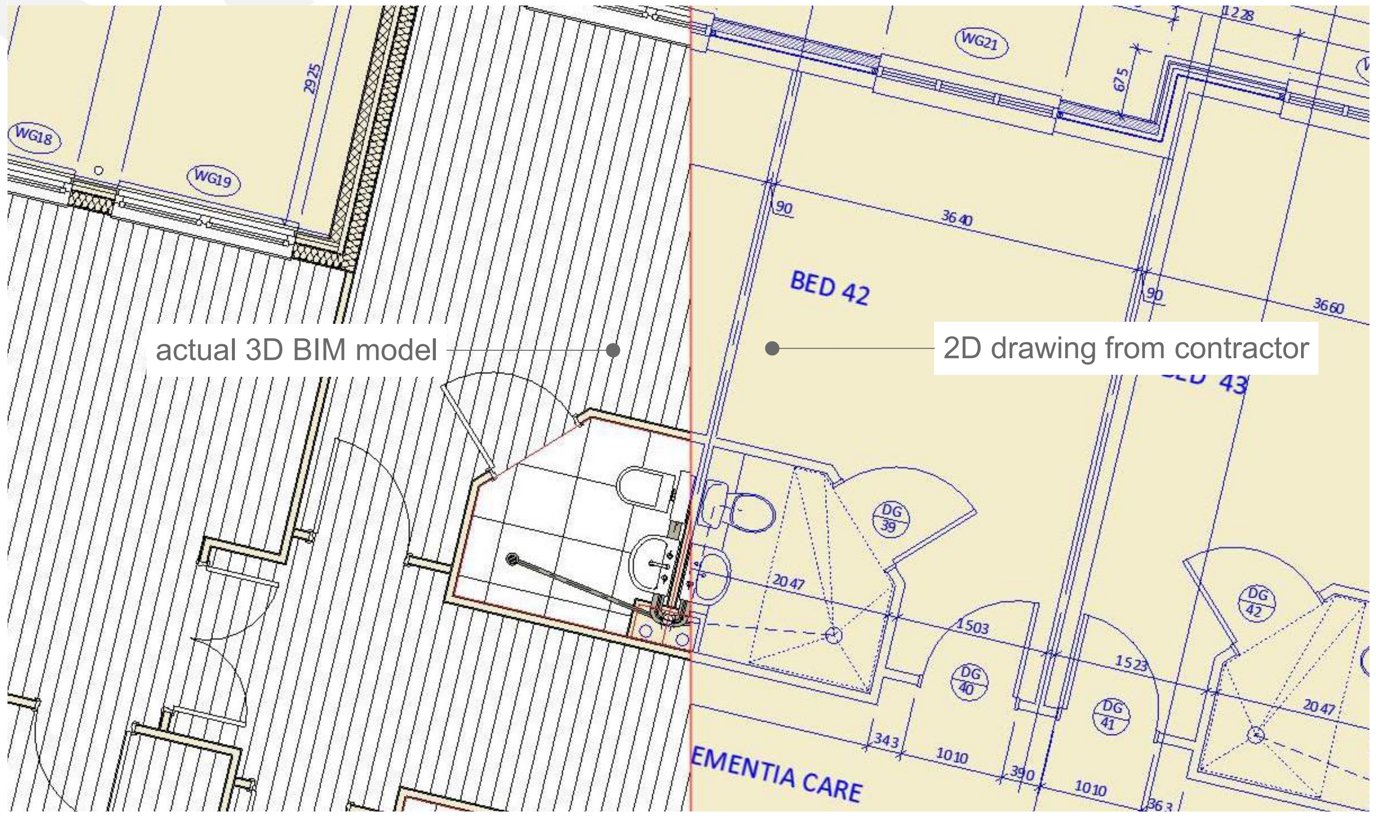
GA started with an analysis of the construction elements of the building, creating equivalent BIM elements for each type of roof, wall, windows, doors and floor types.
Each of these “element types” have in-built information based on the specification provided regarding their construction type, external and internal finishes and assembly materials quantities. More information can be added on the fly, at any time, to account different issues like building cost and carbon cost for example.



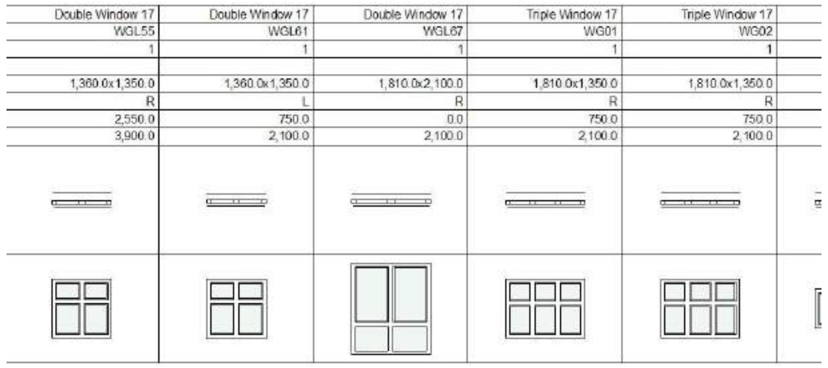
With all the construction elements defined to an acceptable level of detail, the model was assembled using the plans and elevations provided.

Walls, roofs and floor types were initially drawn as reference elements as there were no certainty regarding their final composition. Later, they were “upgraded” to their final state including structure, insulation and linings.





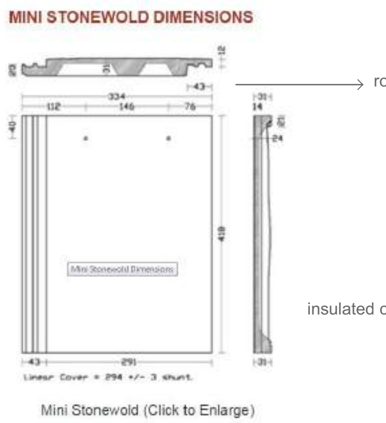
BIM objects were created to match the doors and windows types and easily populate the model. That also resulted in an automatic schedule of openings.

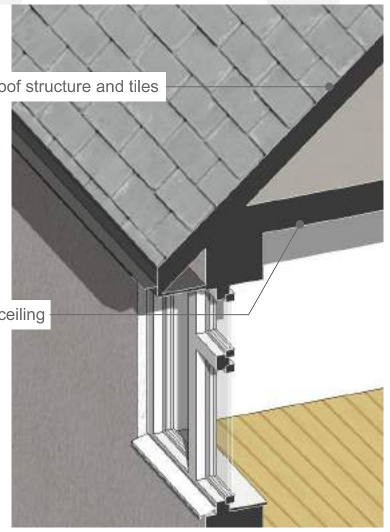


Double Window 17	Double Window 17	Double Window 17	Triple Window 17	Triple Window 17
WGL55	WGL61	WGL67	WG01	WG02
1	1	1	1	1
1,360.0x1,350.0	1,360.0x1,350.0	1,810.0x2,100.0	1,810.0x1,350.0	1,810.0x1,350.0
R	L	R	R	R
2,550.0	750.0	0.0	750.0	750.0
3,900.0	2,100.0	2,100.0	2,100.0	2,100.0

The technical specification for the construction elements were taken from the drawings provided and researched online. It was incremented or modified during the model construction and management.

Mini Stonewold	Technical Data	
Size	418 x 334 mm	
Minimum Pitch & Headlap	17.5° 22.5°	at 100 mm headlap at 75 mm headlap
Maximum Pitch	90°	subject to fixing specification
Maximum Headlap	125 mm	
Minimum Gauge	293 mm	
Maximum Gauge	318 mm 343 mm	below 22.5° 22.5° and over
Hanging Length	397 mm	approx
Linear Cover of 1 Slate	294 mm	
Covering Capacity (net)	10.7 slates/m² 9.9 slates/m²	at 318 mm gauge at 343 mm gauge
Laid Weight	52 kg/m² 49 kg/m²	at 318 mm gauge at 343 mm gauge
Weight per 1000 Slates	5.10 tonnes	approx



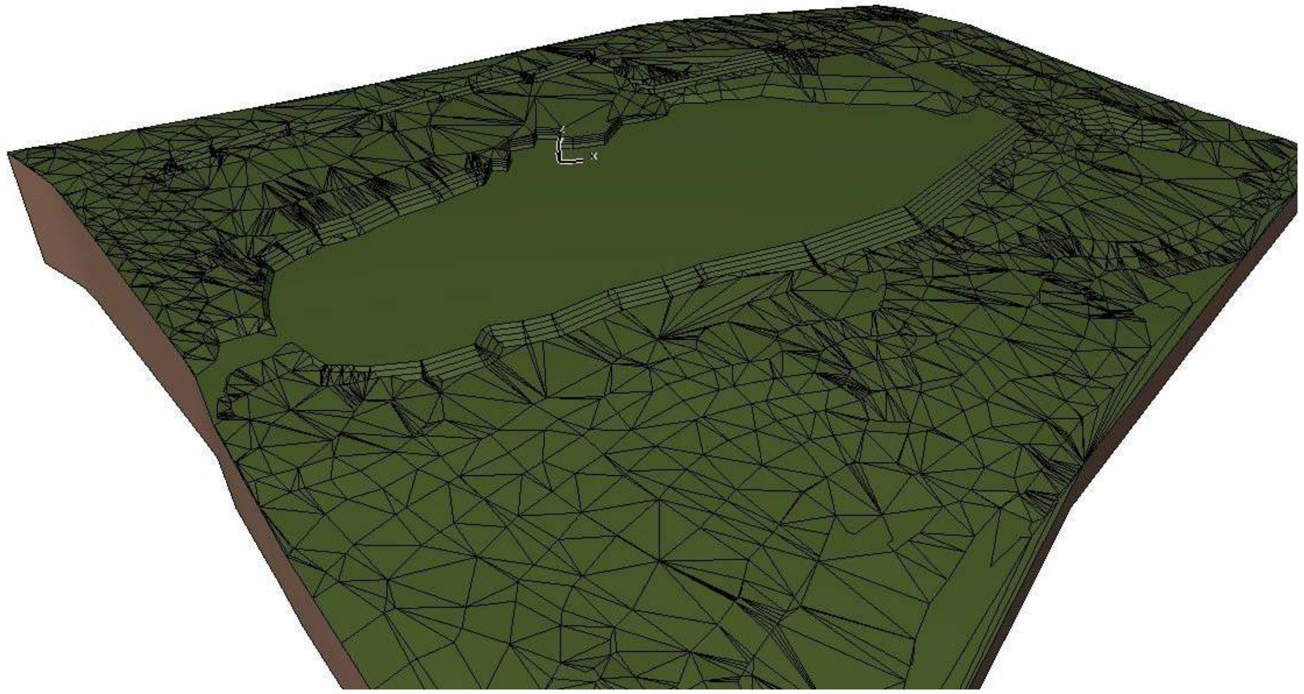


Terrain modelling

The topography plays an important part on this project. The site is quite steep and the cut and fill operations performed in it were substantial. Gillard Associates received the terrain data after the levels were decided upon therefore no input was possible regarding the position of the building on site. Nevertheless, the site was modelled in 3D using the curves provided, and could be demonstrated that using boolean operations the amount of cut and fill is calculable enabling optimisation of site levels.

2D curves used as reference to model the terrain

The 3D terrain final model:



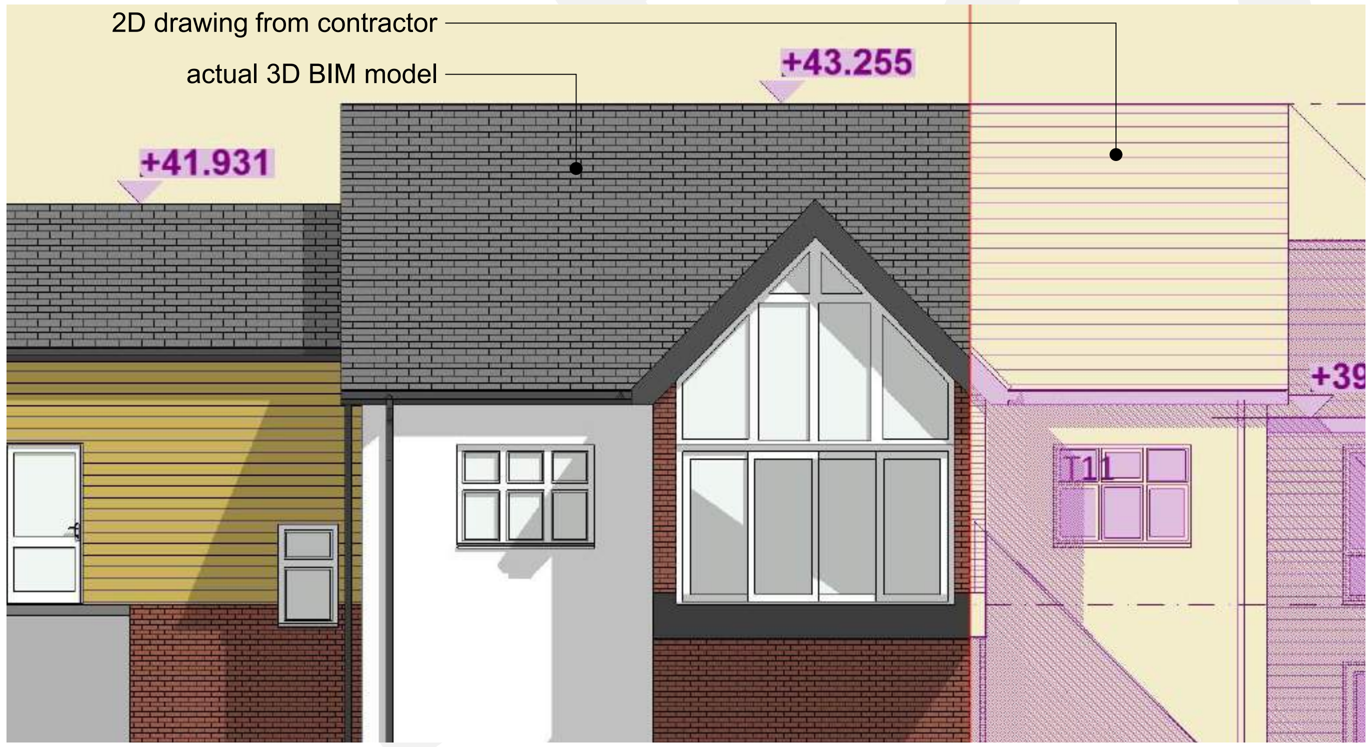
GILLARD ASSOCIATES
architecture and design

Roof Coordination

One of the characteristics of this project is its roof complexity. The roof is a result of two conflicting design issues: the need for an economical layout (double aisles of flats served by a central corridor) and the planning requirement for the building to retain a domestic appearance (which was solved by breaking its long volume with different roof shapes). As a result, the resulting geometry is a complex mix of sloped and flat roof sections.

It was commented by the contractor that the planning stage was particularly lengthy because there were concerns on how the building would look. If a BIM model was available at the time of the planning discussions, an easier agreement could have been reached with the planning authority with no extra cost.

Solving such complex elements using only 2D drawings is time consuming and there is no warranty that critical parts of the roof construction will not be overlooked. Gillard Associates cross-checked the roof plans and elevations with extra attention to the generic details (where they applied).

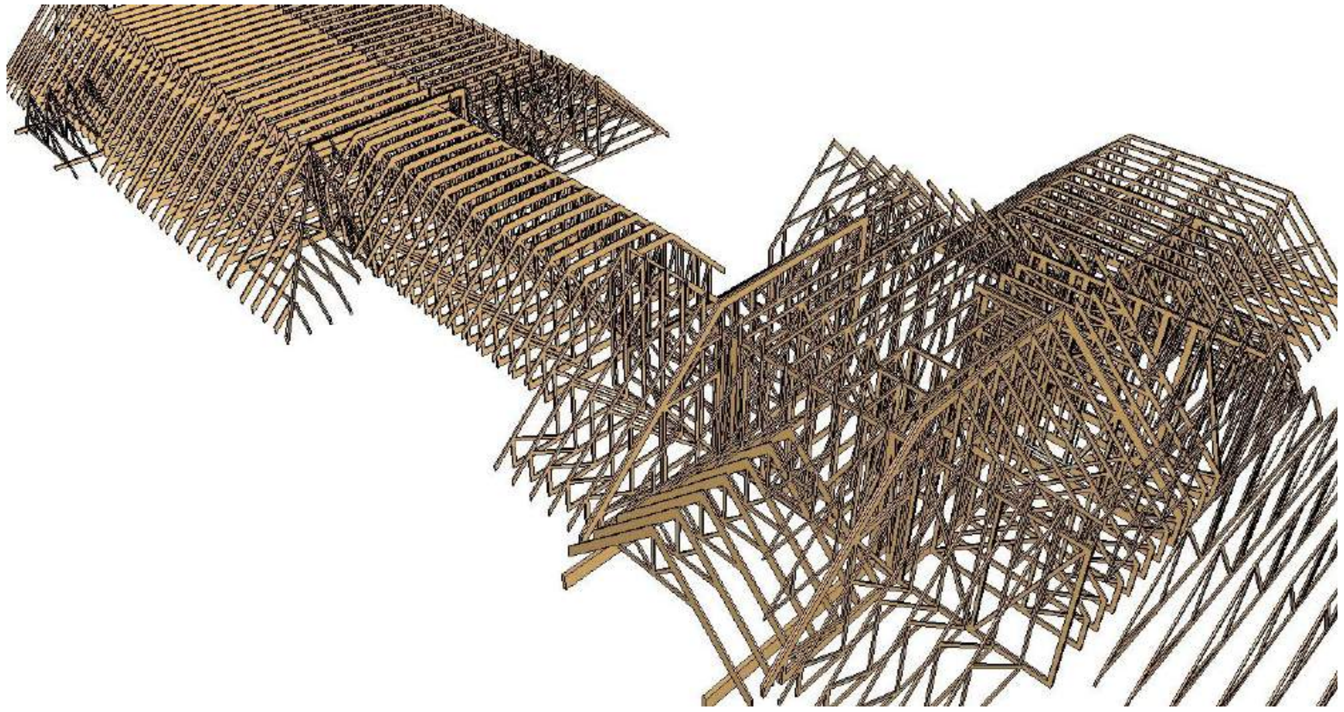


Differences between the roof levels in the plans and elevations were identified. To make the roof geometry match in 3D, small adjustments in the roof angles would be necessary, departing from the 45 degrees indicate in the drawings.

Roof Structure

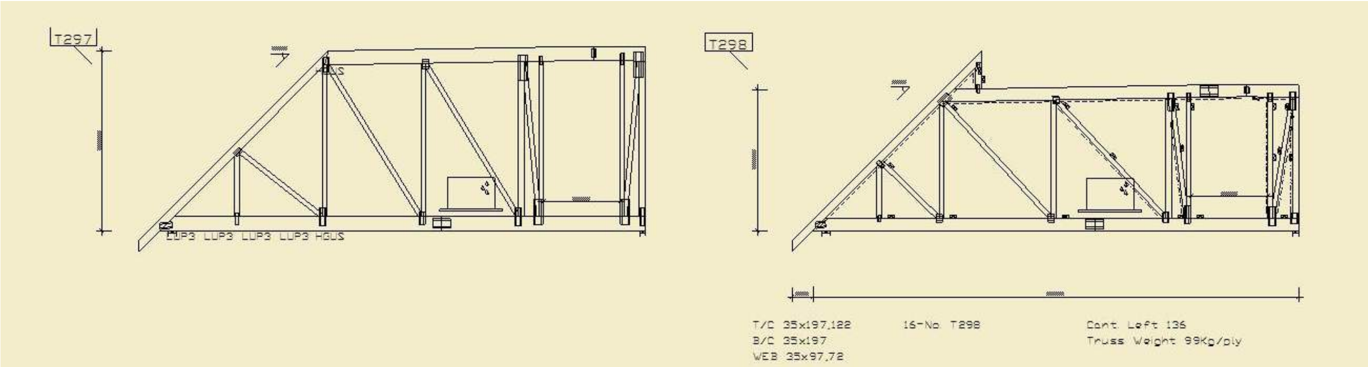
The complexity of the roof shapes would inevitably lead to a complex roof structure which could benefit of the BIM capabilities of 3D coordination and clash detection.

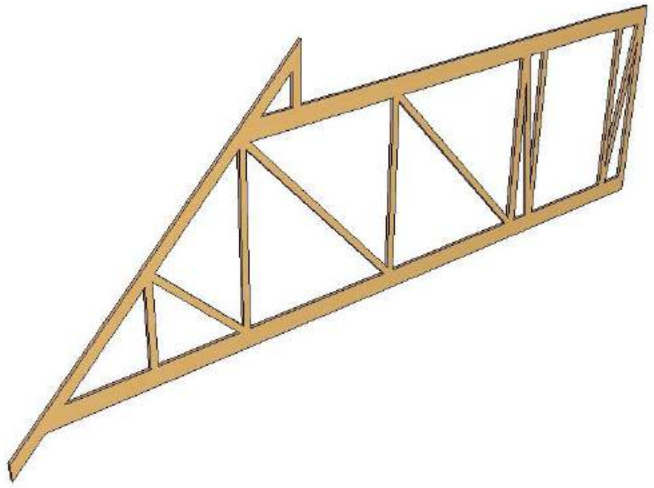
The roof structure was designed by the company's TF designers in a specialist software with output as either Autodesk 2D DWG or pdf files. However, 3D data could not be exported because there was no translation possible to a usable file format. Because of that, the process of bringing the roof into the BIM model became a lengthy and repetitive process.



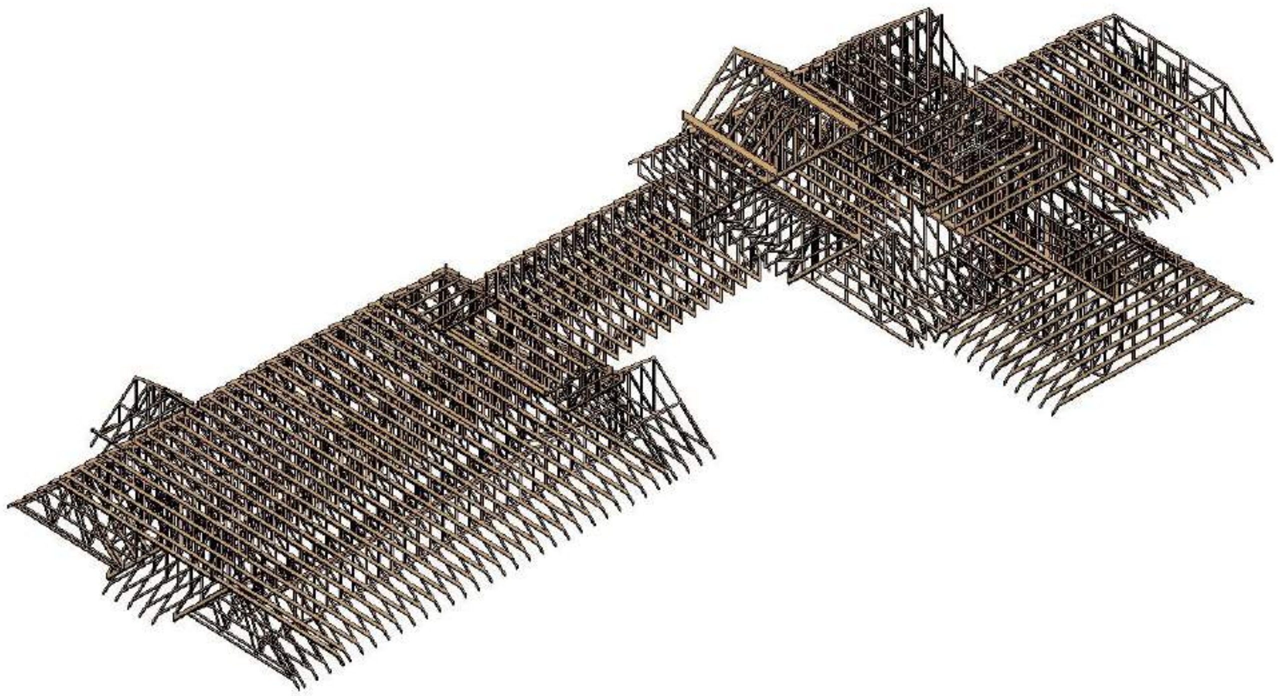
It was agreed (for the purpose of this exercise) that only a portion of the roof would be modelled to avoid excessive cost and time. For the purpose of this exercise, the parts of the building modelled were the technical block (containing the boiler room, kitchen, staff bathrooms and toilets, and the laundry) plus the entrance hall.

Every roof element was re-done in 3D using the 2D drawings supplied by the roof structure designer.



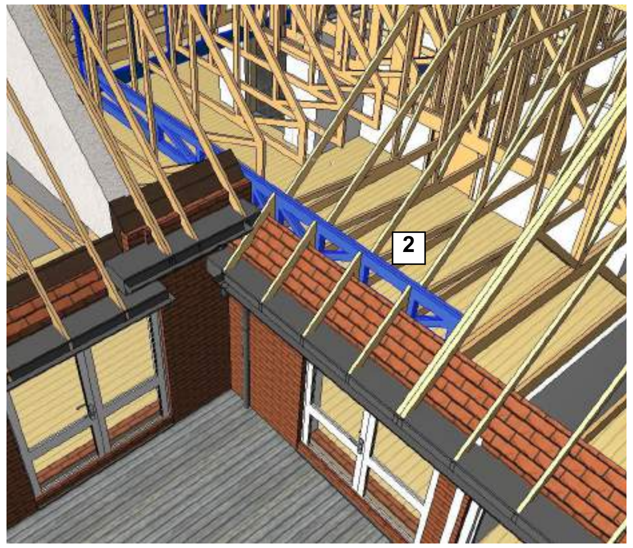


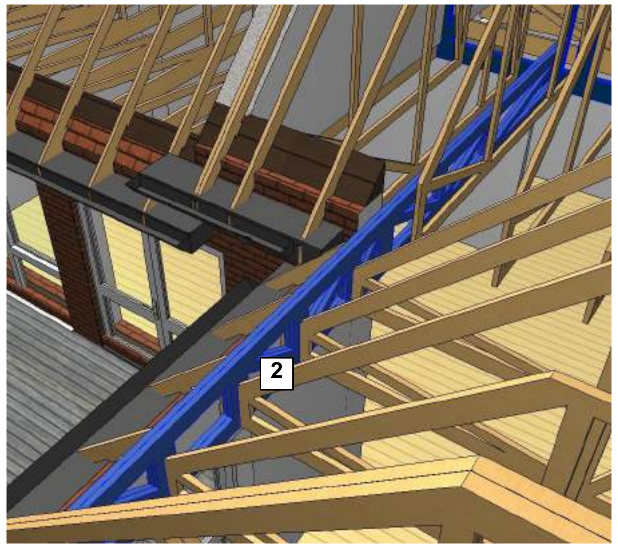
Each one of the approximately 300 truss elements was put in place following the plans supplied by the contractor.



Below there are some issues that have arisen and were discussed with the roof structural designers

1 - rafters extend beyond soffits 2 - discontinuity on rafters geometry

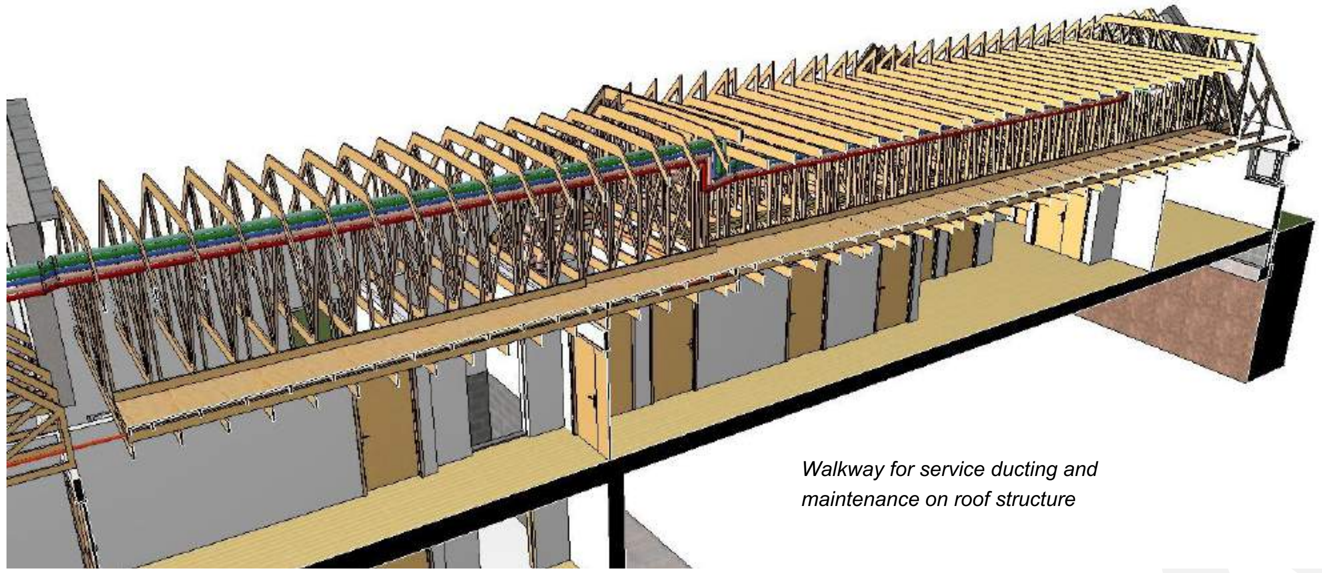




M&E Systems

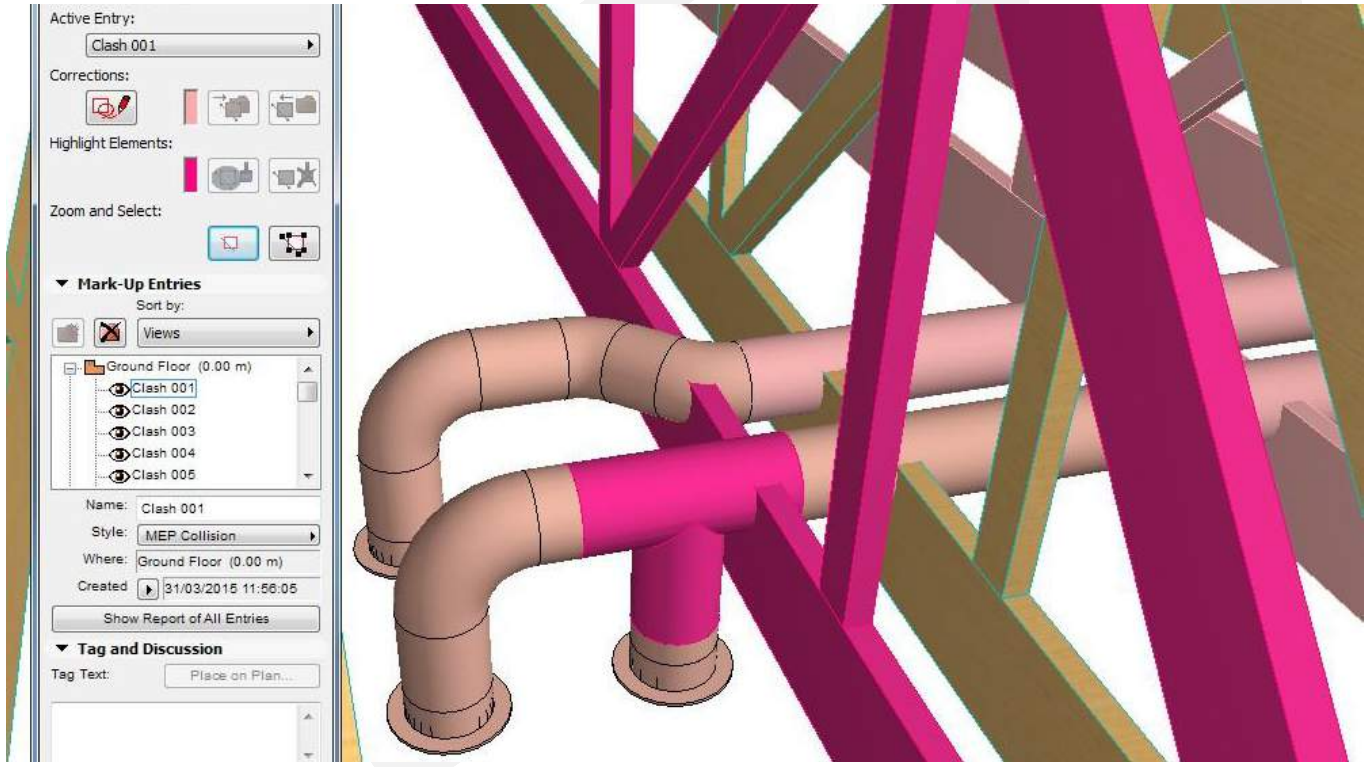
The mechanical ventilation, plumbing and electrical systems are notorious for causing delays and conflicts on site. As a rule in design and build contracts, detailed M&E design is considered too costly at an early stage therefore only schematics are generally provided by the mechanical engineers.

There is a consensus of opinion that as long as sufficient space is left on the roof/ceiling volumes there will be no major clashes with the building fabric.


Walkway for service ducting and maintenance on roof structure

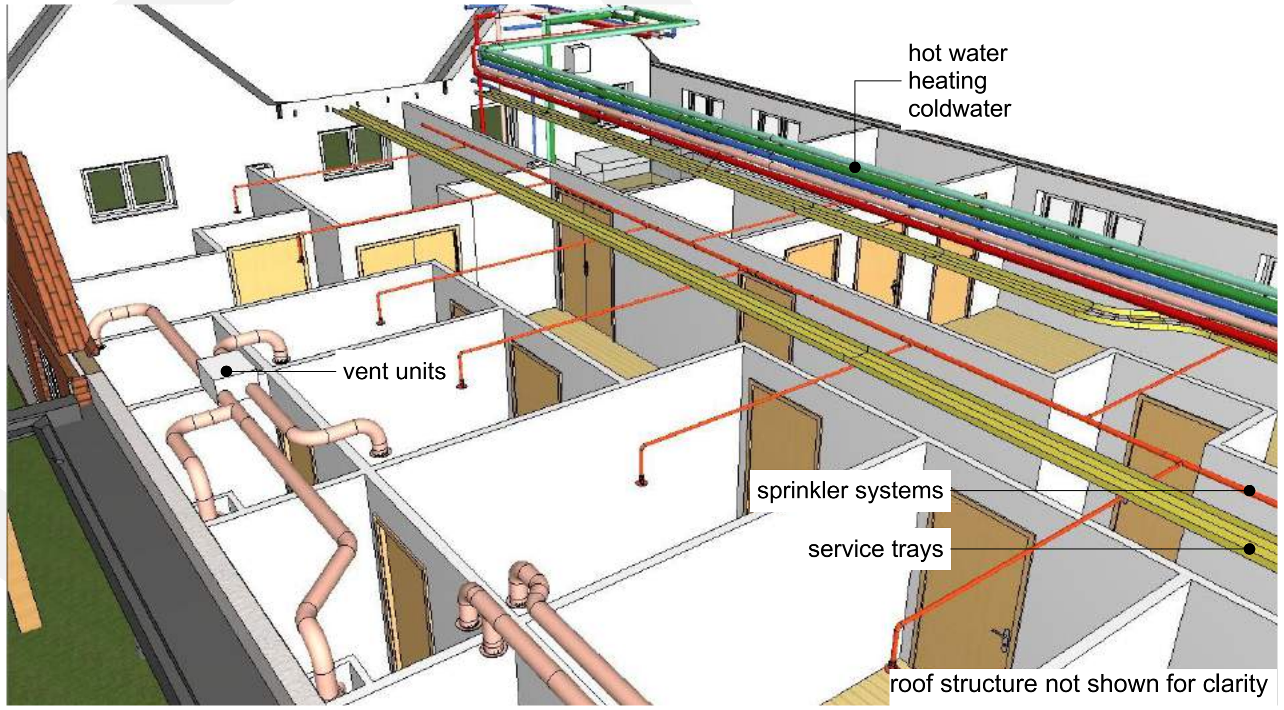
This is a valid strategy but to avoid waste of materials, time and workmanship it needs to be followed by a detailed 3D model of the proposed M&E systems that in its turn will be checked against the architectural design. Clash detection and case-by-case design can happen in advance ensuring the use of the best routes and more economical layouts.

Automatic clash detection in action

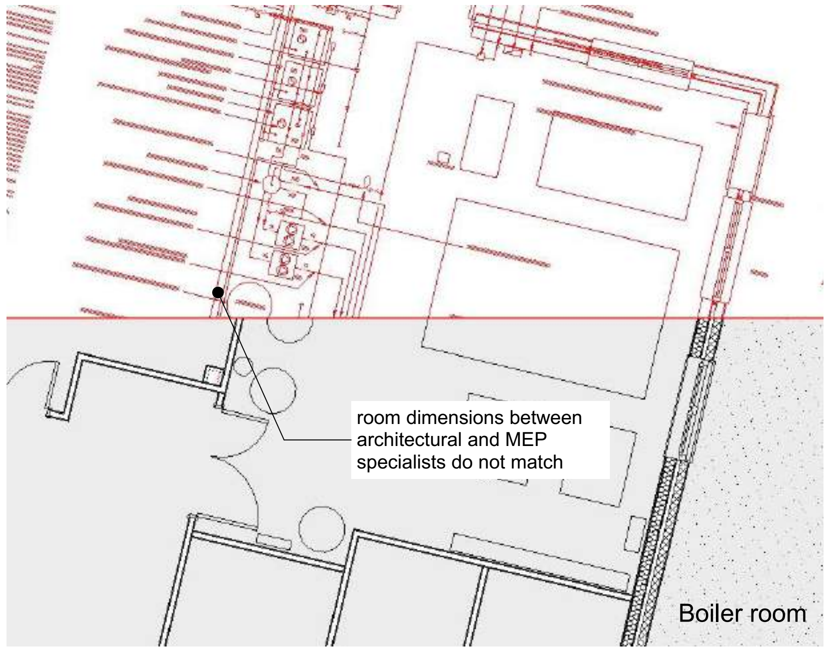


In the case of the Castleton project, no such 3D data was available. Gillard Associates was handed 2D schematics plans and sections that were used to generate the BIM M&E elements. It was agreed that (for reasons of time shortage for the EZW programme) the M&E systems to be modelled would be restricted to the ones under the roof structure of the technical aisle and the modular bathrooms that repeat all over the building. They are as follows:

- Ventilation system in the service aisle
- Sprinker system in the service aisle
- Waste system for bathrooms in the service aisle and modular bathrooms
- Hot water (flow and return), heating (flow and returen), and cold water: only the general distribution of these services over the walkway, in the service aisle



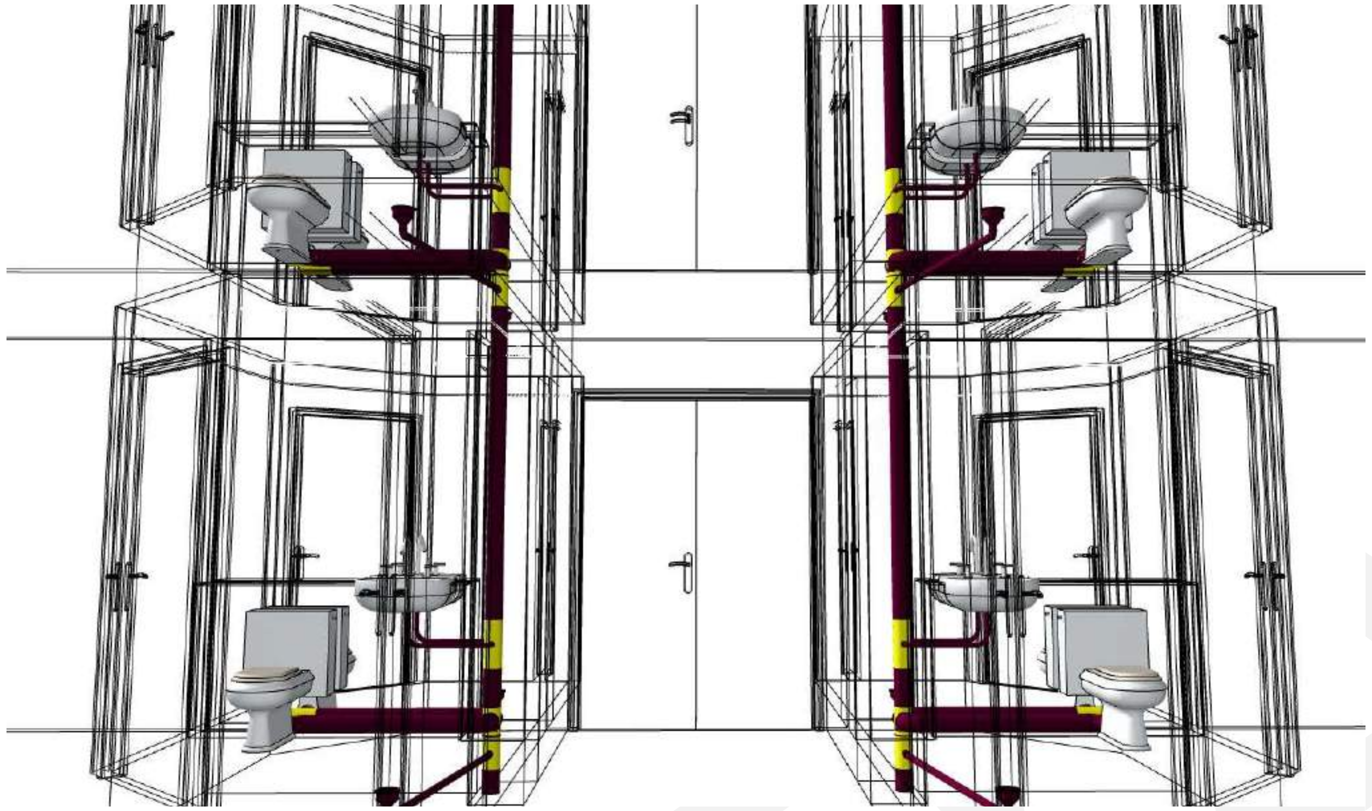
Boiler room: An example of how an overlooked schematic design that will be updated on a later stage can cause clashes was found in the boiler room. Generally those technical rooms are dimensioned based on the preliminary requirements from the MEP consultants. But the space allowance is likely to change as the desing is refined and if an efficient exchange of information method is not put in place, problems can arise.



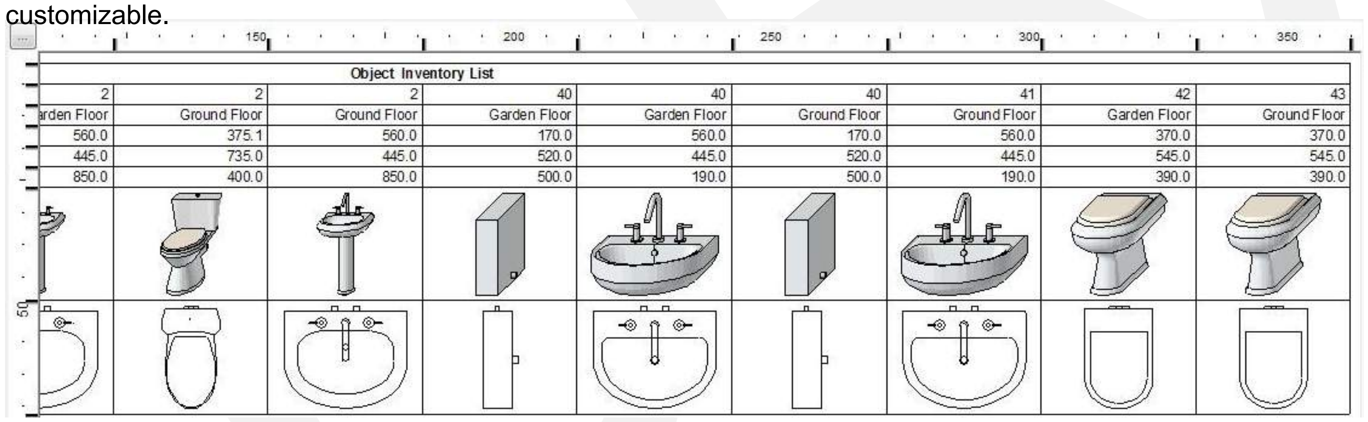
In this case there was a significant discrepancy between the dimensions of the boiler room as shown on the architectural and MEP specialist drawings. Such difference on the space allocated for machinery could have mean abortive work, rebuilding of walls and floors, and delays on the completion targets.

Scheduling

In a BIM environment it is easy to keep track of the quantities of different elements used in a project. In the case of M&E systems this is even more relevant. Repetitive design or bespoke solutions are accounted equaly, yielding the exact number of elements necessary to complete the proposed design. That gives the contractor a tighter control of the budget and any discrepancy will be quickly traced and its causes identified.



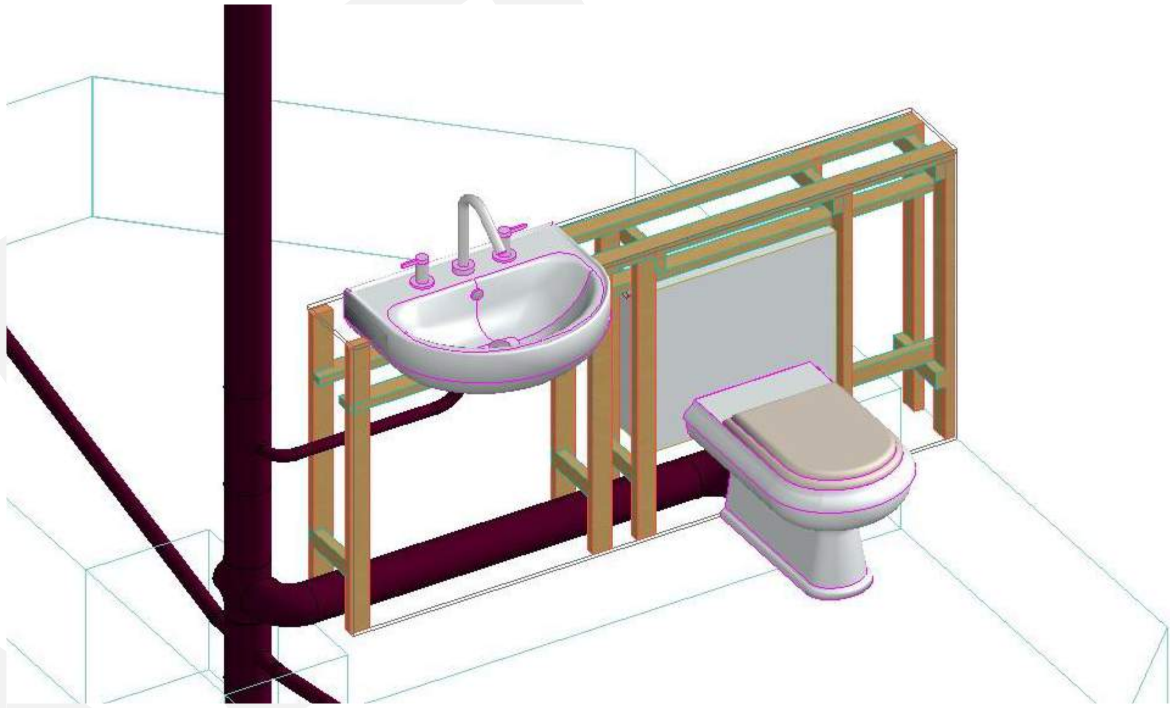
To demonstrate the ability of the BIM software, sanitary schedules were generated automatically and are fully customizable.



Object Inventory List

2	2	2	40	40	40	41	42	43
rden Floor	Ground Floor	Ground Floor	Garden Floor	Garden Floor	Ground Floor	Ground Floor	Garden Floor	Ground Floor
560.0	375.1	560.0	170.0	560.0	170.0	560.0	370.0	370.0
445.0	735.0	445.0	520.0	445.0	520.0	445.0	545.0	545.0
850.0	400.0	850.0	500.0	190.0	500.0	190.0	390.0	390.0

It was commented by the developer that even repetitive construction elements - like the modular bathrooms - are not safe from problems. Generally, joiners laid the woodwork structure for boxing the sanitaryware in a uneven patttern. Therefore if a stud is located in a inconvenient position the whole pipework must go around it, creating delays and demanding extra materials. One way to solve this problem is to design the modular bathrooms with an detailed joinery structure which could have critical "no-block" areas. Visualising it in 3D would give the workers on site substantial help to understand the design.

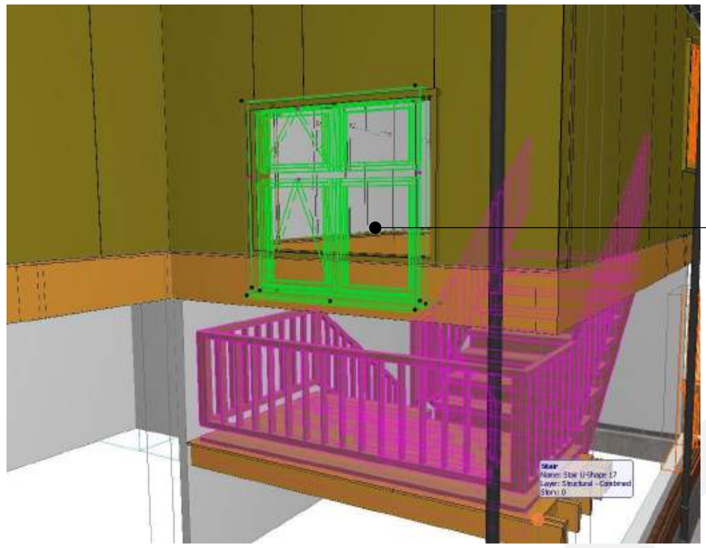


Timber frame structure

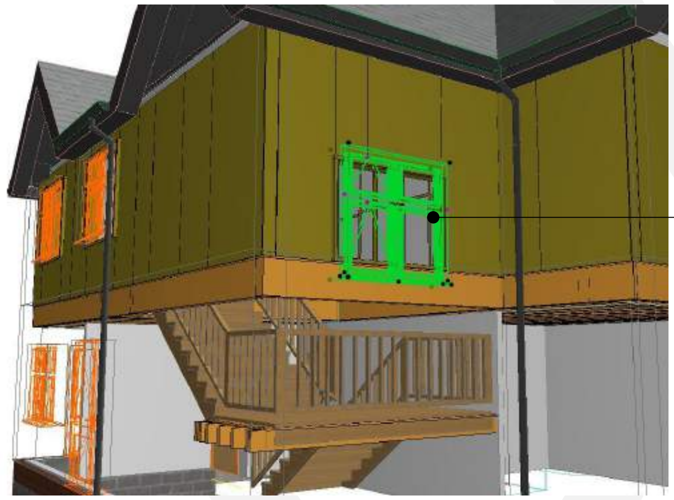
The timber frame structure was made available as a 3D model. It was imported in the BIM model for clash detection with the architectural design.

Some issues related to window sizes and timber structure were found.

discrepant sizes of openings



opening "digging" into the floor cassettes



opening "digging" into the floor cassettes

Have a BIM environment set in place these discrepancies could have been pinpointed much early on. That could save time spent reworking the desing or/and wrong schedule of openings.

Schedule of finishes:

Using the link between model and construction information, a schedule of external finished can be easily obtained:

Wall Finishes

Finish Type	Wall Type	Area (m2)
Facing brick	EW-1	3.82
Facing brick	EW-1	4.12
Facing brick	EW-1	10.53
Facing brick	EW-1	13.73
Facing brick	EW-1	4.79
Facing brick	EW-1	4.31
Facing brick	EW-1	11.93
Facing brick	EW-1	4.02
Facing brick	EW-1	9.48
Facing brick	EW-1	8.34
Render	EW-2	8.16
Render	EW-2	1.16
Render	EW-2	5.01
Render	EW-2	8.97
Render	EW-2	1.74
Render		
Render		
Render		
Render		
Render		
Render		
Render		
Render		
Render		
Render	[illegible]	[illegible]
Render	EW-2	3.57
Render	EW-2	1.27
Render	EW-2	10.84
Render	EW-2	1.54
Render	EW-2	1.49
Render	EW-2	12.30
Render	EW-2	1.54

Wall Finishes

Finish Type	Wall Type	Area (m2)
Facing brick	EW-1	75.07
Render	EW-2	627.28
Weatherboard	EW-3	1,158.82
		1,861.17 m²

Opportunities

Even though the outcome of the project was disappointing in one respect - ie, the construction of the BIM model was unable to be useful to the ongoing work on site - the level of co operation by Castleoak enabled Gillard Associates to identify areas of opportunity for the company to benefit from BIM implementation.

Design
It was reported that the planning application process was lengthy due to difficulties experienced with planning officers failing to visualise the overall design. BIM modelling would have helped understanding of the proposals and possibly resolved issues relating to the roof of the care home - the end result is possibly over complicated as a result and led to difficulties in resolving complex junctions.

Scheduling
Anecdotal evidence suggests that some materials are generally wasted due to inefficient procurement. As an example, ironmongery sets are often over ordered for fear of mis matches and delays caused by re ordering. BIM scheduling can reduce and even eliminate this wastage.

Boiler Room Design
An interesting by product of a workshop with the Castleoak in house M&E designers was the apparent lack of control over sub contractors installing boiler room equipment. Delays have been caused by items being placed in order of deliery (for example) reather than in optimum positions. Since many boiler rooms on different sites are repetitive, it would be easily possible to build an ideal model using actual equipment dimensions, and use this as a template for modular boiler room design.

Guest Room Quality Control
Although the client rooms are repetitive, there are many variants of colour, finish, types and quantities of electrical fittings, and the like. The demands on the QA for keeping track of small but important variations are enormous, but this could be aided by the use of BIMx files which provide virtual/visual checks on rooms during cosntruction and after completion.

Modular Bathrooms
Already mentioned is the notion that repetitive elements such as bathrooms are open to problems caused by 'rogue' tradesmen who are not aware of the knock on effects of un co ordinated work. The building industry is beset by the commonly held principle that the following tradesman will make good or cover up sub standard workmanship. BIM can help operatives visualise the overall picture, and their part in that picture, and this will foster respect for each other's inputs. A simple way of overcoming un co ordinated bathroom fit outs is the use of life size templates generated by BIM to control the construction of duct covers and service pipe positions.

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. For example, a bedroom suite requires minimum circulation around furniture, precise positioning of switches and lighting, and minimum bathroom layouts. All of these can be designed into an object or module making design time and construction 100% accurate and predictable. The design of care homes lends itself to this sort of modelling and could lead to a big increase in efficiency both in design and procurement.

Conclusions

If the EZW project was intended to investigate and demonstrate the possibilities of using BIM in reducing waste in construction - and waste can be defined in many ways - the result of the exercise yielded some interesting results.

It was expected that the Castleoak team would turn out to be very waste conscious (they employ an environmental awareness officer) and this proved to be the case. The amount of material actually disposed of in skips reflected the exemplary way in which the site was managed. This is reported elsewhere.

However, waste in the building industry can also be defined as wasted time and materials, and abortive work caused by poor co ordination of structure and services, lack of efficient materials procurement, and inefficient design solutions caused by constraints of poor information exchange between consultants.

The conclusions in this report are not intended to be critical of anyone in Castleoak's team - just observations which will hopefully encourage the organisation to investigate its processes which at present do not take full advantage of the BIM software solutions available.

Timber Frame Design
The TF roof design was notable for its complexity. The ability of the TF designers to model and generate solutions using minimum sections is not in doubt. However, the inability to export 3D files for inclusion in our BIM model suggests that implementation of BIM software in the firm will be difficult until this issue is resolved.

M&E Design
As already pointed out, resolution of the M&E design at an early stage (ie before the project gets to site) is crucial to reduce clashes with structure, and unintended usage of already allocated space. A visit to another Castleoak site showed how unplanned ductwork routing compromised storage spaces, and led to problems which had to be overcome in situ, requiring time which could have been saved had the routes been pre planned.

Collaboration
It is generally (and mistakenly) understood that BIM is about software. The BRE, in their BIM training programmes, are keen to point out that BIM is as much about people and process. BIM requires a collaborative approach to design to ensure that the right amount of information informs the process at any given time. On the Castleoak project, it was noticeable that there was a resistance to BIM, and its implementation by consultants. The lack of 3D information hampered the process of building the model (by Gillard Associates). There was sense that information exchange was hampered as well by fear that mistakes might be spotted and judgement made about the authors of potentially incorrect information. This extended to fear of liability issues, and owneership of the model, despite the fact that in this instance, the model was being constructed independently, and there was no risk of the data being used as part of the construction process.

The Future

It should not be inferred from the above that the experience of being involved in this project has been negative, at least as far as those Castleoak employees who we have come into contact with are concerned. Rather, there is a sense of pride in the product, and excitement that BIM might be able to not only achieve greater efficiencies, but better working methods, which might relieve some of the drudge of repetitive tasking and the burden of controlling unwilling sub contractors.

There was recognition that BIM was the future of building and optimism that Castleoak might be implementing the technology very soon.