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GUIDELINES FOR ARCHITECTURAL ALUMINIUM SYSTEM SUPPLIERS: TOWARDS A MORE EFFICIENT DESIGN PROCESS WHEN GENERATING BUILDING INFORMATION MODELS.

MSc Facade Engineering Research Dissertation

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ABSTRACT

BIM has both advantages and disadvantages to an aluminium systems supplier but the risk of not adopting the technology far outweighs the disadvantages. BIM is a powerful tool and can create real value to the industry during the design of a project; however for this value to be fully extracted, better guidance needs to be given to the suppliers in the construction chain on how to deliver high quality content. The technology is successfully forcing collaboration and ownership during design, manufacturing, installing, maintaining and dismantling of a project, but BIM is only as good as the information fed into the model from the beginning.

A new work methodology, or set of guidelines, needs to be produced to supplement existing standards. These guidelines can be used by the aluminium system suppliers to ensure that the product models they produce are presented and formatted in a standardised manner. This means that the maximum benefit will be gained from their use during the design process predominantly, but also in further stages of construction.

These guidelines developed as part of this dissertation give aluminium system suppliers clear instructions on naming conventions, level of detail and visual content, supporting parameters, model sizes, and distribution of the content. The guidelines cover the entire product ranges of all aluminium system suppliers, and give design guides to generate 3D BIM product models for windows, doors, curtain walling, framing, brise soleil and rain screen. The guidelines produced in this dissertation are to be seen as creating an acceptable level of competence within BIM for content creation.

If an aluminium system supplier was in a position to offer all of its product range in BIM models from using these guidelines then they would have a real competitive advantage when it comes to getting specified on future BIM projects.

ACKNOWLEDGEMENTS

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NOMENCLATURE

BIM	Building Information Modelling
COBie	Construction Operations Building Information Exchange
IFC	Industry Foundation Classes
CAD	Computer Aided Drawing
2D	Two Dimensional
3D	Three Dimensional

1 INTRODUCTION

1.1 DEFINITION OF BIM

"Building Information Modelling (BIM) is the process of generating and managing data about the building, during its life cycle. Typically BIM uses three-dimensional, real-time, dynamic building modelling software to increase productivity in the design and construction stages." (NBS, 2012)

1.2 INTRODUCTION

BIM is not a new technology *(Building Magazine, 2012)* but has been slow and problematic to adopt in the UK construction industry compared to other industries. This is because the construction is a very stubborn industry and it is very reluctant to adopt any new ways of thinking when it comes to the construction process *(CW staff, 2012)*. To-date BIM has mainly been driven by the architects and main contractors, however they have little understanding of what BIM really is and they remain sceptical about the value of BIM *(Light, D, 2012)*. It therefore remains under discussion and hasn't yet been widely adopted.

The Government has a different idea when it comes to BIM. In May 2011 when the Cabinet Office released the latest 'Government Construction Strategy', this mandated the use of collaborative BIM on all government construction projects by 2016 in an attempt to reduce construction costs by between 15%-20%.

"Government will require fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016. A staged plan will be published with mandated milestones showing measurable progress at the end of each year."(Cabinet Office, 2011)

Several private retail companies have also begun to come around to the idea of BIM and have formed a task group known as BIM for Retail. The group contains a number of major retailers with a common interest in the use of the technology and an aim to demonstrate the value of BIM and share best practice. It is made up of companies such as John Lewis, Asda, and Waitrose, and is supported by leading consulting engineers Ramboll and Architects HOK who act as facilitators *(BIM Task Group, 2012)*. The group has growing interest with other large companies such as Marks and Spenser and B&Q both known to be attempting to become members *(Construction News, 2012)*.

These bodies have such belief in BIM is because it promotes collaboration throughout the design process and allows information to be shared readily throughout the supply chain – up-to and beyond the construction phase into facilities management. This streamlines the construction process and drives down waste; subsequently reducing the costs involved for the ultimate client and reducing construction lead times *(BIM Task Group, 2012)*.

This move by the Government and Retail group demonstrates the worth of BIM to an architectural aluminium system supplier and so the industry needs to act on adopting the technology. Those system suppliers who do not currently have an active involvement in BIM by supplying architects and main contractors with product models for use in BIM project models, run the risk of not being specified on future construction work *(Building Magazine, 2012)* now the industry is making a definitive step towards using BIM.

1.3 THE NEED FOR A SET OF GUIDELINES FOR A SYSTEMS SUPPLIER

In preparation for this dissertation, key members of major architectural aluminium systems supplier, Kawneer UK, were contacted on their current understanding of BIM and how / if a set of guidelines would be beneficial when generating product BIM models. Opinions were sought were from Phil Randles (Managing Director), Vince Murphy (Technical Director) and Craig O'Connell (New Product Development Team Leader) who would all be key decision makers in the implementation of BIM.

1.3.1 SUMMARY OF INTERVIEWS

The key points raised by all those interviewed were –

- There is an awareness of BIM in general and everyone has a level of understanding of what it facilitates.
- It was agreed that BIM is something that architectural aluminium system suppliers need to actively get involved in.
- It was understood that the key driver for adopting BIM would be future specification on projects.
- It was stated that there is no guidance on exactly what information is expected to be in BIM product models, or how the information needs to be relayed.
- It was indicated that a central standard set of guidelines will be critical so that the information in a BIM product model is presented and formatted in a standardised manner.

For the full interview statements see Appendices 1 to 3.

1.3.2 SYSTEMS SUPPLIERS IN THE SUPPLY CHAIN

It is clear from the opinions of these key personnel within Kawneer that there is currently a severe lack of industry guidance for architectural aluminium system suppliers on how to generate their content and structure the information within the models, and that a clear set of guidelines would be beneficial.

There are many publications, journals, articles, and conversations around BIM, and it is very much a hot topic in the construction industry *(Building Magazine, 2012)*, however without these guidelines it is difficult for system suppliers to deliver the content required for BIM to be a success.

System suppliers fit into the construction supply chain at a very early stage -

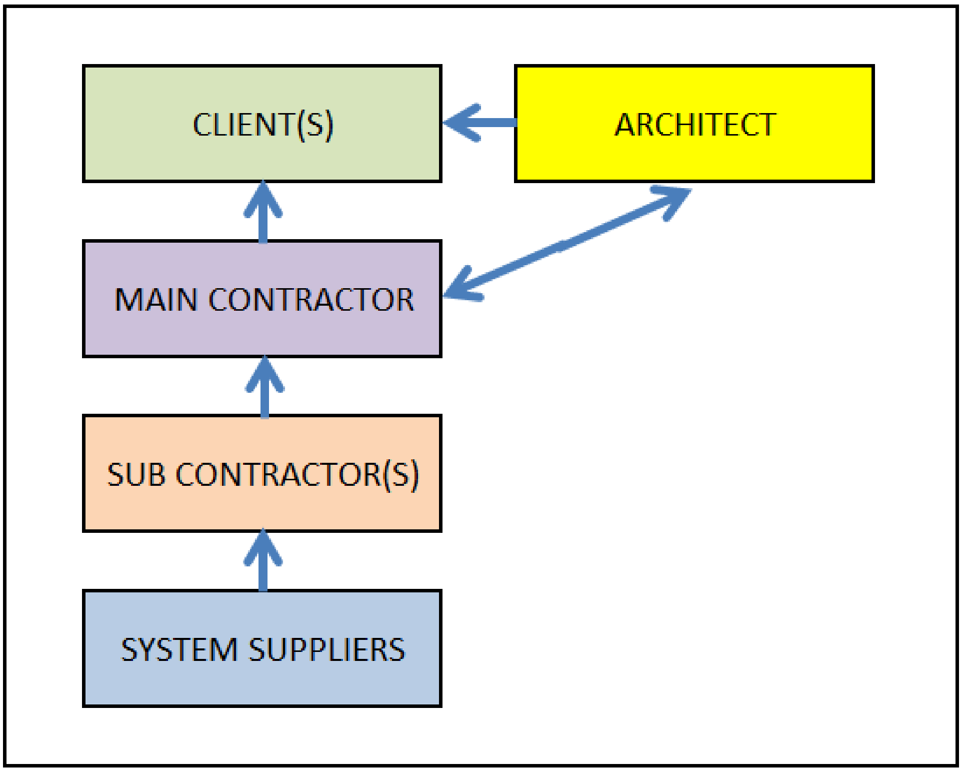


Figure 1.3.2.1 – Construction Supply Chain

It is very important that the information that they provide to the rest of the supply chain is of a high quality with few errors, otherwise mistakes made at the beginning could potentially be carried through the entire design process creating problems later down the line. This could prove costly for the client and generate delays in the delivery of a project *(BIM Task Group, 2012)*.

Architects and Main Contractors are playing a key role in the adoption of BIM more than any other in the construction industry, and they are subsequently pressuring System Suppliers lower down the supply chain into investigating BIM and start creating their content *(Building Magazine, 2012).*

Some Main Contractors, including Laing O'Rourke and Skanska, who seem to have adopted the technology quicker than others, have already made statements that their suppliers have to be using BIM to be part of their supply chain -

"To reinforce its commitment to BIM, Skanska Technology has taken the bold step of announcing that going forward; it will only support BIM projects." (Skanska, 2012)

"We are using sophisticated Building Information Modelling (BIM) technology on an increasing number of projects to build structures virtually, before construction starts on site. We are committed to achieving this capability on all projects by 2012."(Laing O'Rourke, 2012)

Many System Suppliers have good partnerships with main contractors and some have strategic agreements with them *(Kawneer, 2012)*. If to remain part of this supply chain means to generate BIM content, then it is important that the system suppliers have a good set of guidelines to ensure the right level of detail is supplied.

Major architects are also starting to mandate the use of BIM on their projects. For example Capita Symonds recently announced –

"Capita Symonds is mandating the use of BIM across all its design services divisions from 1 July 2012. The firm, the UK's seventh largest consultant with a turnover of £276m, said it had already completed eight projects using the process. The mandate is for the company's architecture, services, structures, civils and industrial divisions to use BIM level

two - which incorporates 3D modelling, clash detection and other data. The rest of the business, including project managers, QSs, landscape architecture and planning - will follow suit by December 2012." (Withers, I, 2012)

Capita Symonds are one of a long list of architects making it clear that BIM is something that they expect to be using on all their projects in the very near future, and so once again, system suppliers need to start moving and generating their content if they want to remain getting specified with these architects. An architect however, will not specify a system suppliers product without good quality models being provided to them.

Therefore, the decisions required from a systems supplier when starting out in BIM are key to their success. The first decision they have to make is what 3D modelling software platform to select. There are a number of software packages available on the market including Autodesk Revit, Graphisoft ArchiCAD, Bentley Architecture and Vectorworks *(Building Magazine, 2011)*. All software packages perform a very similar function but Autodesk Revit seems to be becoming the most popular package to work with, and subsequently has the highest market share within the industry *(Arun Roy, 2011)*.

The second decision, and arguably the most important decision, is what schedule requirements are required from the BIM product content and therefore what parameters need to be imbedded within the models. It is important that information is relevant and well thought out before being programmed into a model to make sure that what the end user gets out of the model is exactly what they require and in a usable format. The models have to contain both physical and functional data that is reliable for use through the whole construction process when the different disciplines are working with the model.

1.4 CURRENT PRACTICE OF ALUMINIUM SYSTEMS SUPPLIERS

Some of the larger architectural aluminium system suppliers have now begun to explore BIM, including Kawneer and Schuco, but they mainly handle the generation of their BIM content on a project by project basis *(Kawneer, 2012)*. Many of these system suppliers rely heavily on government funded construction projects and so they are beginning to realise that ignoring BIM is not a viable option.

The major UK system suppliers and their market share are as detailed *(Kawneer, 2012)* –

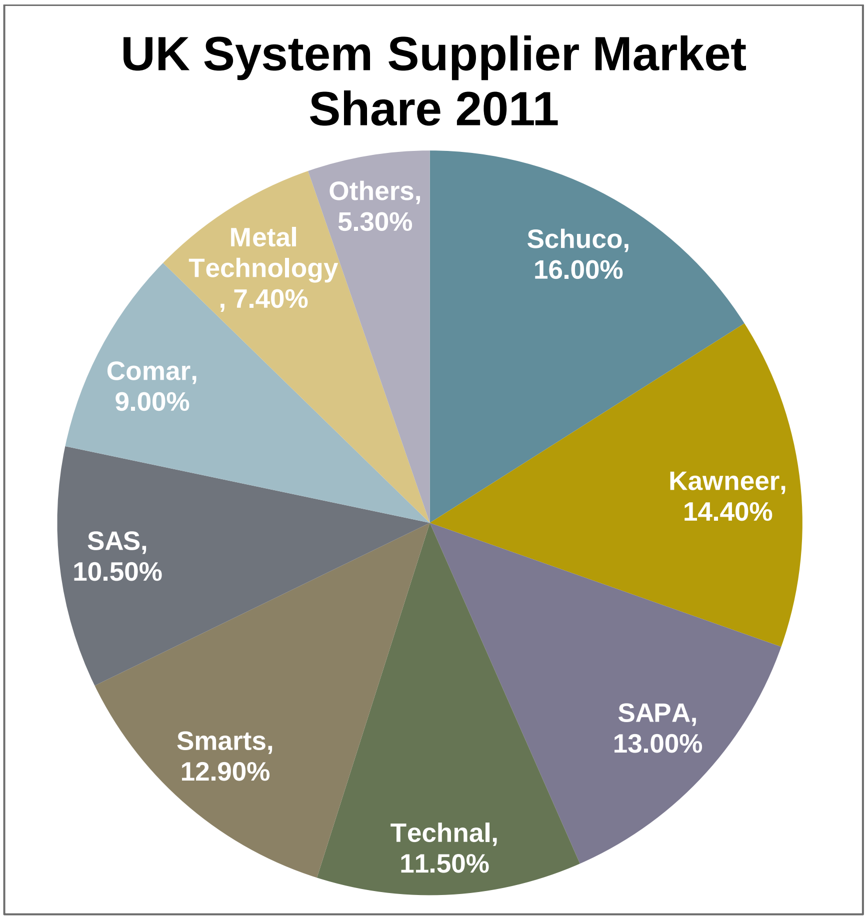


Figure 1.4.1 – UK System Supplier Market Share 2011

Second largest system supplier Kawneer has started supplying models to the market place already, however these models are very much first attempts with some ill-defined parameters and poor functionality *(Kawneer, 2012)*.

In 2011, 50% of Kawneer's UK turnover came from Education and Healthcare projects. A lack of involvement in BIM by 2016 could result in these business projects being taken away. Kawneer would then need to find business elsewhere in a very competitive market *(Kawneer, 2012).*

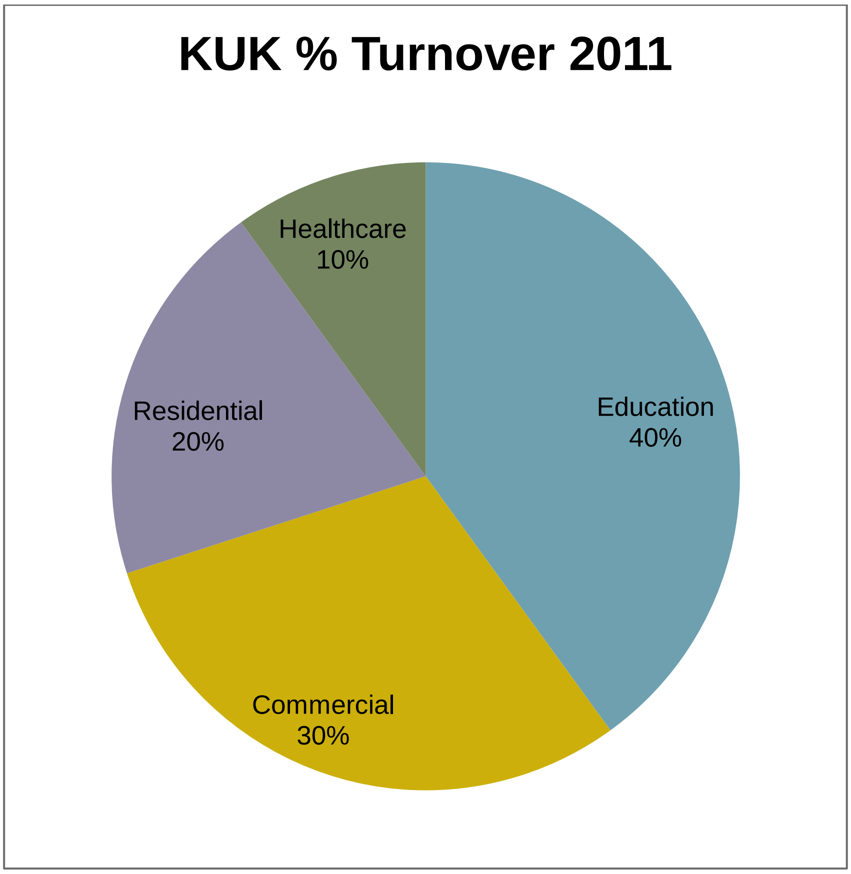


Figure 1.4.2 – Kawneer UK's % Turnover by Sector 2011

It is a similar story for Kawneer's major competitors. These businesses must act quickly to respond to the Government's promise in order to keep their place in the market, and not lose market share to those companies that are beginning to invest into BIM technology.

In 2008, Bew-Richards released what they call the BIM maturity diagram. The diagram contains four levels of maturity within BIM – Level 0 being the lowest level of maturity which consists of companies using basic 2D drawings to exchange data, and Level 3 being the highest level of maturity consisting of companies that have a fully operational collaborative BIM process in place *(BSI, 2012)*.

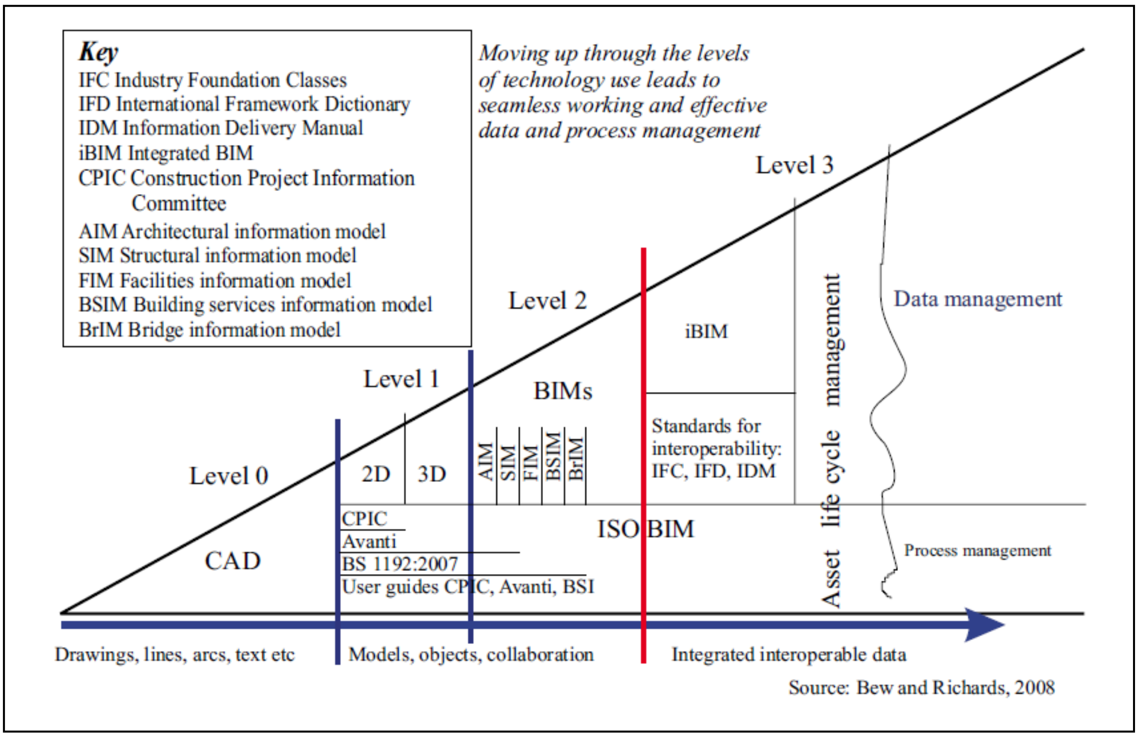


Figure 1.4.3 – Bews and Richards Core Maturity Model

Most system suppliers are contained within Level 1. They have a good level of 2D data exchange with standard structures and formats; however the commercial data such as project price estimations is managed separately in a different package and is not integrated with the drawings.

The system suppliers that have begun working in BIM however are very much in the early stages; they have very little understanding of the performance requirements from the models and they rely heavily on external resources for content development. These system suppliers are on the borderline between Level 1 and Level 2 with some degree of

3D and Product Management data exchange, in the form of spreadsheets, but are in no way advanced enough to be classed as solid level 2 maturities *(Kawneer, 2012)*.

Schuco recently released an interview in their trade magazine 'Schuco Partner 06/2012' with Architect, Scott Brownrigg. One of the questions asked of the architectural practice was whether they thought Schuco was a front runner in introducing BIM disciplines to which they replied –

"Yes, I believe that they're pretty advanced. I have no direct experience of any other systems company being at the same place, although I do know that there are a lot of people in the supply chain in other areas who are really pushing this forward" (Schuco, 2012)

Whereas this is a very biased Schuco article, it does show that Schuco are progressing with the subject.

1.5 AIMS AND OBJECTIVES

The aim of this dissertation is to create a clearly defined set of guidelines for architectural aluminium system suppliers when developing company specific Building Information Modelling content.

It is achieved through the following aims and objectives –

OBJECTIVE		**RESEARCH METHOD**	**REFERENCE CHAPTER**
1	Survey the views, use, knowledge level and awareness of Building Information Modelling both present and planned, including main drivers for its adoption.	Desk based review of literature and publications. Interviews with key personnel from system suppliers.	Chapter 1
2	Review Building Information Modelling and how it is used to reduce costs in construction.	Desk based review of literature and publications.	Chapter 2
3	Map Building Information Modelling through the design process.	Desk based review of literature and publications.	Chapter 2
4	Identify who is responsible for managing and/or designing the model.	Desk based review of literature and publications.	Chapter 2
5	Appraise current regulations for information delivery in Building Information Modelling.	Desk based review of current standards and publications.	Chapter 3

6	Define and compare the current development of product models as a design tool for architects and main contractors.	Desk based review of current system supplier models examining their pros and cons.	Chapters 4
7	Discuss the level of information to be contained within the models to contribute to a more efficient design process.	Desk based review for discussing the modifications required to the current work methods. Interviews with Main Contractors.	Chapter 5
8	Establish an acceptable level of competence in BIM as a system supplier by devising a clearly defined list of parameters and performance requirements.	Desk based review for presenting the results of the dissertation in a format that can be used by system suppliers.	Chapter 6
9	Examine the opportunity for differentiation with respect to the competition.	Desk based review on the use of the guidelines.	Chapter 7

Table 1.5.1 – Aims and Objectives

This dissertation focuses on the use of Autodesk Revit software as the preferred software base by the system suppliers.

2 BIM IN THE DESIGN PROCESS

2.1 WHAT IS BIM?

Moving away from traditional methods of design is not something many people in the industry voluntarily want to do, which is why BIM is being very slow to adopt *(NBS, 2012)*. Current practice is usually for a design team consisting of architects, contractors and engineers to work separately - which is not a collaborative working process and can lead to badly co-ordinated data exchange. The adoption of BIM will eradicate this for the reason that it is a collaborative working process, with all the different functions working together on the same 3D model, therefore nothing can be hidden from each of the parties involved in the design *(Mott MacDonald, 2012)*.

BIM can facilitate efficient design and design management, energy analysis, on site construction activity, operation and then handover to the client through structured and co-ordinated data exchange *(Construction News, 2012)*. By using BIM, information is pulled together and presented in a format that is clear and easily accessible, with the idea being that all parties within the construction team can work on the same BIM model ensuring they have access to all the information they need when they require it and are notified when there are any changes that concern them *(NBS, 2012)*.

Going back to Bew-Richards maturity diagram, BIM has three different levels. Level 1 is now common practice across all construction projects with all information delivered using 2D CAD and commercial information completed in a separate package. The Government's announcement that all public funded construction work will be delivered using BIM by 2016, relates to level 2 BIM. Level 2 BIM necessitates 3D BIM models for each separate discipline of the building, and a means to integrate these BIM models so that all parties involved can access them *(BSI, 2012)*.

Level 2 BIM requires the delivery of all BIM data to the client on completion of the project to assist in operation and maintenance of the building *(NBS, 2012)*. The current proposed minimum format for this is a spreadsheet known as COBie, and this can be with or without the 3D models.

The purpose of the COBie spread sheet is to provide the client with any information they may require for the following activities –

- Operation
- Maintenance and Repair
- Replacement
- Security and Surveillance
- Regulations and Compliance

In order to achieve this it should contain information such as descriptions, locations, supplier details, materials, sizes, performance characteristics, locations, indicative costs, warranties and maintenance schedules *(BIM Task Group, 2011)*. There are examples of COBie online, and templates can be downloaded from sources such as the BIM task group website.

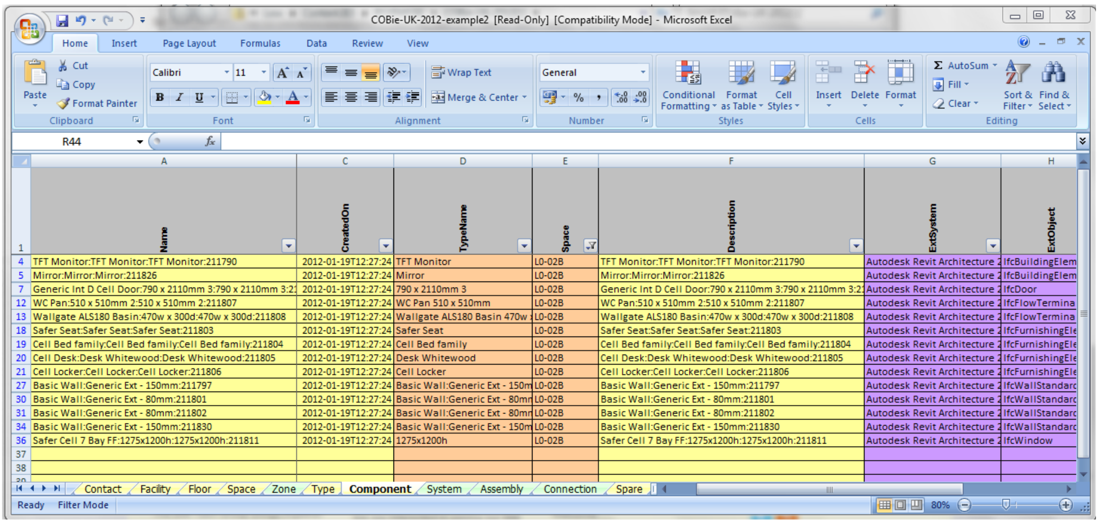
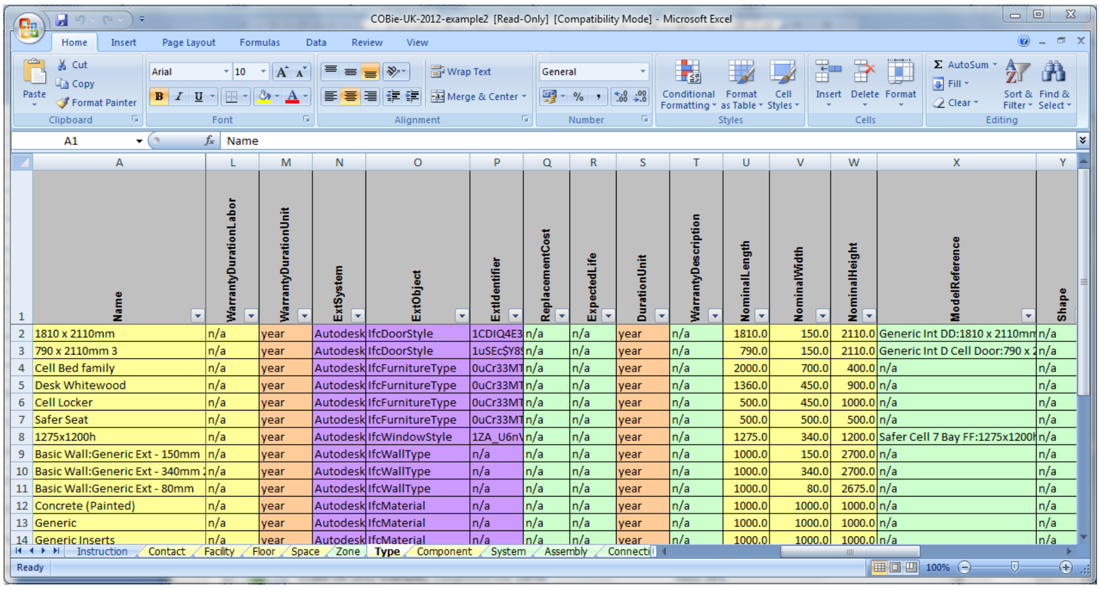


Figure 2.1.1 – ‘Component’ Tab of COBie Spreadsheet



	Name	WarrantyDurationLabor	WarrantyDurationUnit	ExtSystem	ExtObject	ExtIdentifier	ReplacementCost	ExpectedLife	DurationUnit	WarrantyDescription	NominalLength	NominalWidth	NominalHeight	ModelReference	Shape
2	1810 x 2110mm	n/a	year	Autodesk	IfcDoorStyle	1CDIQ4E3	n/a	n/a	year	n/a	1810.0	150.0	2110.0	Generic Int DD:1810 x 2110mm	n/a
3	790 x 2110mm 3	n/a	year	Autodesk	IfcDoorStyle	1uSEc$Y8	n/a	n/a	year	n/a	790.0	150.0	2110.0	Generic Int D Cell Door:790 x 2	n/a
4	Cell Bed family	n/a	year	Autodesk	IfcFurnitureType	0uCr33MT	n/a	n/a	year	n/a	2000.0	700.0	400.0	n/a	n/a
5	Desk Whitewood	n/a	year	Autodesk	IfcFurnitureType	0uCr33MT	n/a	n/a	year	n/a	1360.0	450.0	900.0	n/a	n/a
6	Cell Locker	n/a	year	Autodesk	IfcFurnitureType	0uCr33MT	n/a	n/a	year	n/a	500.0	450.0	1000.0	n/a	n/a
7	Safer Seat	n/a	year	Autodesk	IfcFurnitureType	0uCr33MT	n/a	n/a	year	n/a	500.0	500.0	500.0	n/a	n/a
8	1275x1200h	n/a	year	Autodesk	IfcWindowStyle	1ZA_U6n\	n/a	n/a	year	n/a	1275.0	340.0	1200.0	Safer Cell 7 Bay FF:1275x1200h	n/a
9	Basic Wall:Generic Ext - 150mm	n/a	year	Autodesk	IfcWallType	n/a	n/a	n/a	year	n/a	1000.0	150.0	2700.0	n/a	n/a
10	Basic Wall:Generic Ext - 340mm 2	n/a	year	Autodesk	IfcWallType	n/a	n/a	n/a	year	n/a	1000.0	340.0	2700.0	n/a	n/a
11	Basic Wall:Generic Ext - 80mm	n/a	year	Autodesk	IfcWallType	n/a	n/a	n/a	year	n/a	1000.0	80.0	2675.0	n/a	n/a
12	Concrete (Painted)	n/a	year	Autodesk	IfcMaterial	n/a	n/a	n/a	year	n/a	1000.0	1000.0	1000.0	n/a	n/a
13	Generic	n/a	year	Autodesk	IfcMaterial	n/a	n/a	n/a	year	n/a	1000.0	1000.0	1000.0	n/a	n/a
14	Generic Inserts	n/a	year	Autodesk	IfcMaterial	n/a	n/a	n/a	year	n/a	1000.0	1000.0	1000.0	n/a	n/a

Figure 2.1.2 – 'Type' Tab of a COBie Spreadsheet

Level 3 BIM is known as fully integrated BIM or iBIM. Level 3 BIM is the highest level of maturity and is one open collaborative model containing all information such as programme data, commercial elements, engineering elements, and project lifecycle management information. Level 3 BIM is also required to be compliant with IFC (Industry Foundation Classes) which means it facilitates interoperability without becoming dependant on vendor specific file formats. This would allow data exchange across the construction industry without the worry of what software is being used.

It will be some time before the industry is at Level 3 sophistication and it has a long way to go before it achieves this fully-integrated BIM. Architects, main contractors, sub-contractors are all at different stages and all need to be at the same level of competence to manage the transition from Level 2 to Level 3 *(Pinsent Masons, 2012)*.

2.2 HOW BIM IS USED IN THE DESIGN PROCESS

If used correctly then collaborative BIM has the potential to dramatically reduce the cost of construction. The majority of this cost can be cut during the design process through performance prediction, and subsequently will reduce the overall lead time of delivering a project *(Solibri, 2012)*.

Firstly, BIM reduces the amount of rework that has to be done on the design due to being able to build the project in a virtual 3D environment first (*Juan Rodriguez, 2012)*. Any conflicts or clashes in the building structure can be identified well before any site construction begins (*Juan Rodriguez, 2012)* and then design revisions can be made to the design much earlier and much quicker *(Building Magazine, 2011).* Changes to design become exponentially more expensive later in the construction process when they usually unbudgeted for. Conflicts have a negative effect on both budget and schedule, and reducing conflicts is likely to have the biggest impact on cost reduction *(Construction News, 2012)*.

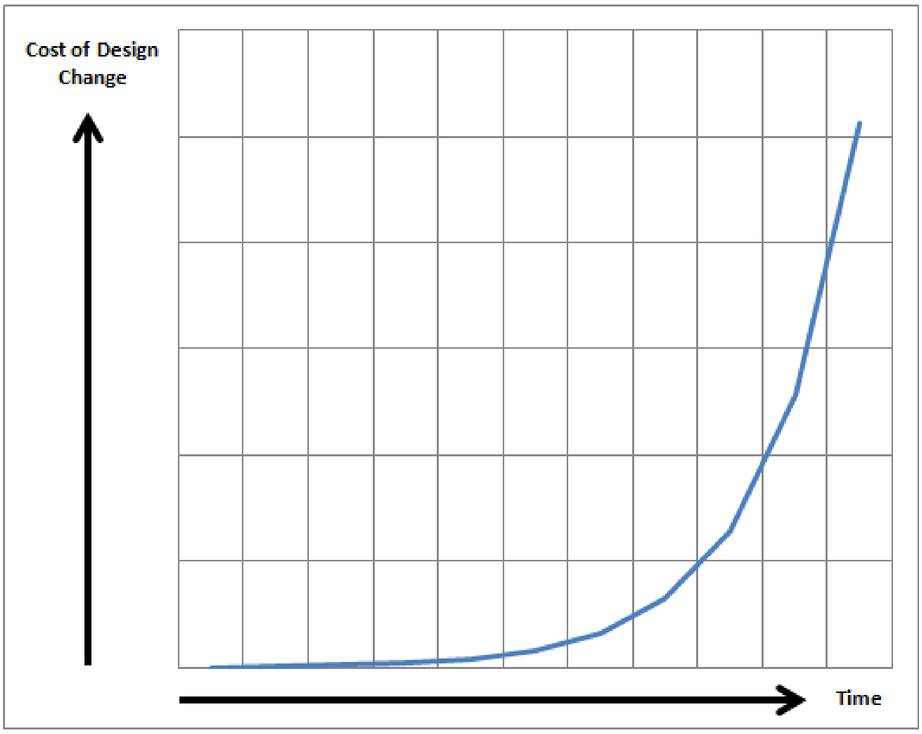


Figure 2.2.1 – Graph of Cost of Design Change vs. Time

The technology removes any potential on-site error through poor design co-ordination and provides a much more consistent construction programme, reducing the amount of unplanned work on-site. This is achieved through review of the 3D model in the design phase and greatly reduces the overall construction costs of a project *(Juan Rodriguez, 2012)*.

BIM offers the ability to generate take-offs and schedules of items such as materials, product counts and measurements directly from the model. As changes are made in the model, this data can be extracted both quickly and reliably, and can be used to provide accurate cost estimates for the client to ensure they are getting the best value for money *(NBS, 2012)*. This saves time during the design process by improving the productivity of the architect and main contractor as they don't have to collate information from several different sources to send out for tender. This improved productivity ultimately reduces the cost of design and increases the return on investment for the client.

Reduction in claims is another cost reducing advantage of BIM. Increasing the predictability of the building during its construction and beyond will reduce any future claims and disputes which will benefit all parties within the supply chain *(Mott MacDonald, 2012)*.

BIM enables better and continuous evaluation of the design in terms of aesthetics, performance and specification fulfilment. This is through increased communication of the design to the client and all other parties at all stages of the design process *(Building Magazine, 2011).*

Finally, BIM can be used for sustainable and environmental design, energy analysis and for reducing the life-cycle costs of a building. It can do this by performing integrated analysis for energy, carbon and thermal assessments. Design decisions can be made at an early stage on issues such as products and building layout *(Building Magazine, 2011)*. For example – as the building is built in a 3D environment then effect of daylight can be simulated on the building and the amount of natural light the building gets internally can be recorded; by optimising these results then energy consumption from artificial lighting can be reduced *(Autodesk, 2005)*.

To try and quantify the above benefits of BIM, the ‘Stanford University Centre for Integrated Facilities Engineering’ compiled a study in 2007 in America on 32 major projects using BIM, and released the following figures *(Stanford University, 2007)*–Up to 40% elimination of unbudgeted change.

- Cost estimation accuracy within 3%.
- Up to 80% reduction in time taken to generate a cost estimate.
- A savings of up to 10% of the contract value through clash detection.
- Up to 7% reduction in project time.

2.3 ADVANTAGES OF BIM TO A SYSTEMS SUPPLIER

There are several primary benefits of getting involved in BIM to an architectural aluminium system supplier, and without the guidance on how to develop company specific Building Information Modelling content then these advantages will never be appreciated.

The first and probably most important advantage is getting locked into the design specification at an early stage. A systems company that has a comprehensive set of models will be greatly favoured when being specified on a project due to the industries intentions towards BIM. It is unlikely that the specification will change at a later stage if the competing supplier does not have the right competence level and cannot provide the content models. The very nature of how BIM works, with all parties working on the same model, then if the content put into the BIM model works from the beginning then where is the reason to switch specification to a competitor system *(Schuco, 2012)*.

Being locked into the specification at an early stage means the systems suppliers also get the benefit of early design involvement on a project. Usually system suppliers are included too late and design changes are subsequently inevitable due to build-ability and product performance issues; costing time and money to the client and reducing the effectiveness of the design process *(Schuco, 2012)*. If the products are programmed into a BIM software program such as Revit with the correct parameters and limitations, poor design will be eliminated earlier in the process.

A well-defined set of product models enables structured data to be transferred and reused throughout the design chain. If a BIM model contains all the relevant information in a usable and structured format, this information can be used by everyone to design, test, optimise and then even manufacture, install and maintain a building *(Building Magazine, 2012)*. The quality of the data starts with the system supplier as they are so early in the supply chain. This sharing of data drives down waste by co-ordinating design activities from the various suppliers in the construction process *(Construction News, 2012)* – which will transform the design process.

A system supplier that is proficient in the generation of BIM content will gain credibility as a company in facilitating efficient design. With the use of BIM becoming increasingly mandatory throughout the construction industry, it is important that if a system supplier is supplying models to architects and main contractors, to guarantee that they are not going to cause problems due to inaccurate and poor functioning models later in the construction activities. The credibility of the architects and main contractors in design also increases if they have suppliers in their chain that are providing good quality models that bring successes to the client *(Mott MacDonald, 2012)*.

2.4 DISADVANTAGES OF BIM TO A SYSTEMS SUPPLIER

Although BIM has plenty of benefits to an architectural aluminium system supplier it also has some key weaknesses that need to be considered.

Primarily there is the lack of trained personnel in content creation in BIM. Whereas there is no doubt that the industry has picked up speed on the use of BIM there is still a lack of skill sets in the subject, which has forced system suppliers to consultancy resource if they want to program their models *(Doug Bevill, 2010)* as they have little knowledge of how they should behave. In order to bring the skills in house then system suppliers need to provide training in using the chosen software package *(Building Magazine, 2011)* and on content creation; however these courses are now readily available through companies such as Autodesk but at a cost.

Some companies may wish to hire in a BIM facilitator to co-ordinate the use of the technology throughout the business *(Building Magazine, 2011)*. Whilst a system supplier is in their infancy within BIM and are in the stages of implementation, then the design process may be longer than necessary whilst the teething issues are being resolved. Having an expert within the organisation will reduce this time as much as possible so as not to leave the system supplier open to risk whilst they aren't 100% proficient in content creation. These experts will then attract another annual wage which won't have necessarily been accounted for *(Building Magazine, 2012)*.

For a system supplier that has just begun investing into BIM the capital investment can clearly be very high. Not only do they have to provide a level of training for their staff, they have to purchase both hardware and software in which to use. Annual licences for the software packages cost several thousand pounds, and the hardware required to run them must be far in advance of traditional 2D CAD machines; this means that they must be up to date and powerful enough to use the software effectively *(NBS, 2011)*. Many of the smaller system suppliers will subsequently not want to invest this very readily; however the rising pressure to use BIM from Government regulations and market pressure will inevitably mean that if they do not then they will not be a specified option in future construction works.

To back up this last statement an interview was carried out with Mark Wheatley, Technical Director of Senior Architectural Aluminium Systems who are currently around the sixth largest systems supplier. He was asked what effect BIM would have on them. Mark commented - "*The main concern with BIM is that people are moving at very different rates, the bigger hitters are driving this forward at a much higher pace. This may exclude the smaller companies with less capital like us to invest in advancing technology on dealing with BIM managed projects". (Mark Wheatley, 2012).*

As most system suppliers are handling BIM on project by project basis, use is usually dependant on the size of the project. The recession has forced many of the UK system suppliers to battle for projects much smaller than some of them are used to, and many of the larger construction projects are going to overseas bespoke system suppliers such Permasteelisa, Josef Gartner, Schneider, Lindner and Structal and Yuanda *(Davis Langdon, May 2011)*. Whereas the UK system suppliers have more standard products that lend themselves towards BIM more than the bespoke products, they are not getting specified on projects that are large enough to warrant the investment, which can usually be hidden in the tender.

The final disadvantage to a system supplier from using BIM is a risk of design information leakage. BIM models are parametric models and so contain a lot of extra information to standard 2D drawings; if this information was leaked to a competitor then they would gain a lot of information about the product and its performance specification. Although this information is often leaked anyway due to many system suppliers posting their information online to download, or through customers of more than one system supplier, any steps to try and reduce this is always taken - and getting involved in BIM would mean the systems suppliers having to put another process in place.

2.5 OWNERSHIP OF THE MODEL

Who owns the project model and who is responsible for it is as of yet still a big question to be answered. As there are a number of disciplines working on the same model, making revisions and having their own level of input, it is difficult to make any one party liable for it *(Building Magazine, 2012)*. All parties should be made aware of their responsibilities and liabilities when entering into a contract on a project that utilises BIM.

Until now there are arguments for one of two parties to lead and manage the co-ordination of the BIM model – the client or the main contractor. There have been successful case studies for both ownership options *(Schuco, 2012)*.

For example, 122 Leadenhall Street, (or more commonly known as ‘The Cheese Grater’) in London the 3D BIM model was owned by Laing O’Rourke.

Figure 2.5.1 – 122 Leadenhall Street ‘The Cheese Grater’, London

Laing O'Rourke claim that without BIM then they would not have won this £300m project and it subsequently strengthened their belief in the technology as mentioned in Chapter 1.3.4. Laing O'Rourke said that the 3D model allowed them to explain how they were going to build the tower and demonstrated a more efficient and collaborative design process, it also cut the construction process down by six months *(Building Magazine, 2012)*. However, Heathrow Terminal 5, another successful BIM project by Laing O'Rourke, was owned by the client BAA who invested considerable belief in the technology within its early introduction into the industry *(Schuco, 2012)*.

As Level 2 BIM necessitates 3D BIM models for each separate discipline of the building such as facade, services, etc., it is important that whoever owns the model is the only one responsible for integrating these BIM models so that all parties involved can access them. This means that the separate models are only loaded into the overall BIM model when they are complete, and so other disciplines are not making design decisions on other parties' models that are part complete which could be very disruptive to the design process *(NBS, 2012)*.

2.6 SO WHAT DOES BIM MEAN TO A SYSTEMS SUPPLIER?

BIM has both advantages and disadvantages to an aluminium systems supplier but the risk of not adopting the technology far outweighs the disadvantages. BIM is a powerful tool and can create real value to the industry during the design of a project; however for this value to be fully extracted then better guidance needs to be given to the suppliers in the construction chain on how to deliver high quality product content for use in project BIM models. The technology is successfully forcing collaboration and ownership during design, manufacturing, installing, maintaining and dismantling of a project, but it is only as good as the information fed into the model from the beginning.

BIM will bring real value to the aluminium systems suppliers in that it will enable them to be locked into the design specifications and it will build their credibility in the design process if they are producing high quality product BIM models for use by main contractors, who in particular seem to have implemented BIM with a level of success already.

Systems suppliers should be striving to be comfortable part of Level 2 in the Bews and Richards core maturity diagram in time with the Government's commitment of collaborative 3D BIM in 2016. The guidelines produced as part of this dissertation will go a long way to helping them achieve this target.

3 CURRENT PUBLISHED STANDARDS

3.1 BS ISO 29481-1:2010

BS ISO 29481-1:2010 Building Information Modelling – Information Delivery Manual.

This standard is part one of a planned two part standard and it aims to specify a methodology and format for the development of the overall project models. Released in May 2010, it is a complicated standard and is intended for guidance to all parties in the construction process; it isn't therefore specific enough for an architectural aluminium system supplier. It does however offer best practice on how to exploit formal methods of information delivery.

3.2 BS 1192:2007

BS 1192:2007 Collaborative production of architectural, engineering and construction information – Code of Practice.

Released in December 2001, it establishes the methodology for managing the production, distribution and quality of construction information, including that generated by CAD systems, by using a disciplined process for collaboration and a specified naming policy. This is essentially the BIM concept.

It is directed at all parties involved in the preparation and use of information throughout the design, construction, operation and deconstruction throughout the project lifecycle and the supply chain.

3.3 AEC (UK) BIM Standard

AEC (UK) BIM Standard - A practical & pragmatic BIM standard for the Architectural, Engineering and Construction industry in the UK.

This standard has been formulated by a committee of personnel from various companies within the industry that are highly experienced in BIM software and its implementation. The committee consists of members from companies including BDP, HOK, Mott MacDonald, Buro Happold, Atkins and Ramboll UK. It was released in November 2009 and was accompanied by two further standards called 'AEC (UK) BIM Standard for Autodesk Revit' and 'AEC (UK) BIM Standard for Bentley Building' which are specific platform standards.

The scope of the standard is to build on BS1192:2007 and act as a starting point for the structuring of BIM data; and as such it is intended as a BIM software production standard.

The standard goes into detail and gives guidance on various topics. It talks about naming conventions for overall BIM models and the importance of labelling BIM data so that it is clear, concise and identifiable quickly when using it throughout the construction process, and across different disciplines. However it states that library object naming is not due until the next release.

Perhaps the most useful section to a system supplier in the standard is on the component grades and level of detail, as it discusses the generation of models in three levels of detail – low, medium and high resolution. It describes how modelling in this way allows easier component management, and how simple swapping of the grade - should additional or less detail be required - ensures the most efficient use of PC processing power at any particular stage.

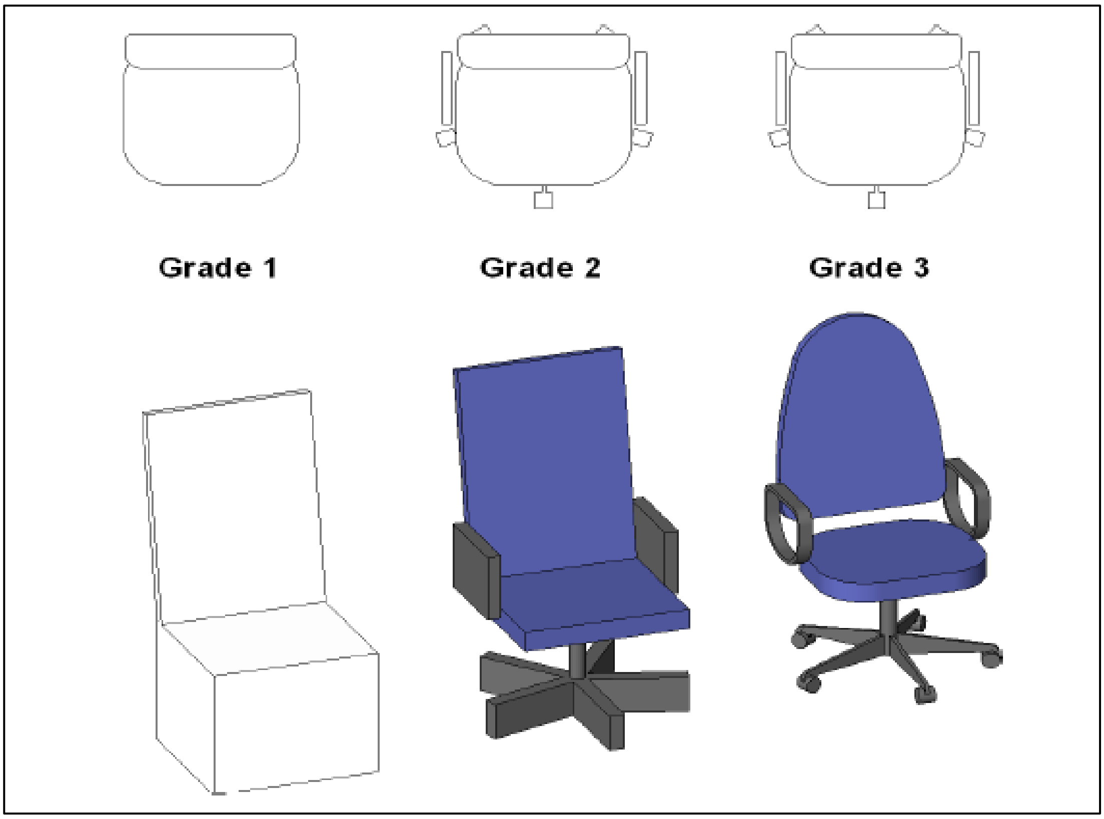


Figure 3.3.1 – Graded component creation in AEC BIM Standard

Grade 1 (Low) resolution is a simple placeholder with a minimum level of detail to allow the model to be identifiable. Grade 2 (Medium) resolution is sufficiently modelled to identify the type of chair and the component materials. Grade 3 (High) resolution contains the highest level of visual information when viewed in the software, particularly when zoomed in.

3.4 BS8541-2:2011

BS8541-2:2011 Library objects for architecture, engineering and construction – Part 2: Recommended 2D symbols of building elements for use in building information modelling.

This standard was first published in September 2011. It is intended for those concerned with symbols and conventions on drawings and 2D BIM models, whether just an end user or designer and developer of the conventions in the construction industry.

As such it is aimed at those in the lower part of BIM Level 1 in the Bews and Richards Core Maturity Model. Further work is required to develop the standard for 3D symbols to be used in 3D models, and allow for manufacturers' objects, information and data. This is something this dissertation aims to achieve for aluminium system suppliers.

3.5 SUMMARY OF STANDARDS REVIEWED

There are a number of standards on BIM currently available to the industry, however none of these cover specific product content by suppliers in the industry. They are all top level standards about the technology in general and they would not be useful to an architectural aluminium system supplier when it comes to decisions such as what parameters need to be included in the models, or what graphical information is required from the models.

A new work methodology, or set of guidelines, needs to be produced to supplement existing standards. These guidelines can be used by the aluminium system suppliers to ensure that the product models they produce are presented and formatted in a standardised manner. This means that the maximum benefit will be gained from their use during the design process predominantly, but also in further stages of construction.

4 APPRAISAL OF CURRENT SYSTEMS SUPPLIER BIM MODELS

As previously described in Chapter 1.4, it is major architectural aluminium system suppliers Kawneer and Schuco that seem to be leading the charge with content creation. In 2011, Kawneer provided 3D BIM models to Laing O'Rourke for use in tendering on a project called 'Royal Sussex County Hospital' in Brighton. This £420,000 project BIM model is owned by Laing O'Rourke, and Kawneer chose the Autodesk Revit software platform to develop their models in.

Figure 4.0.1 – Royal Sussex County Hospital

The project consists of a range of system supplier products including aluminium unitised curtain walling, windows, doors and solar shading; and so Kawneer needed to develop a range of product specific content to be used by the main contractor.

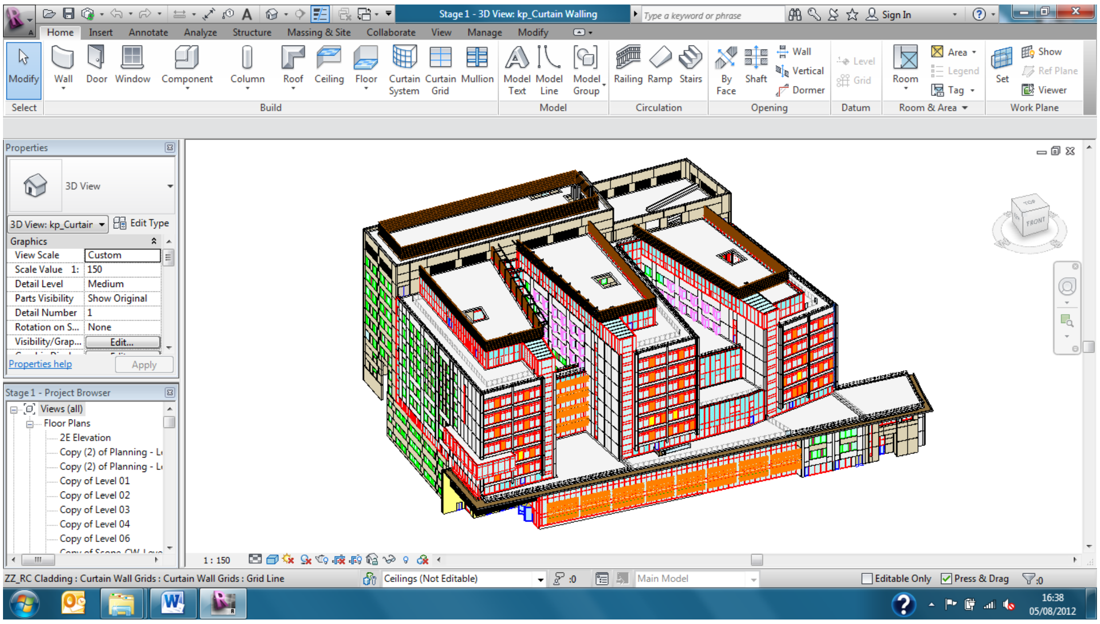


Figure 4.0.2 – Royal Sussex County Hospital in Autodesk Revit

A problem faced by Laing O'Rourke and Kawneer is one that has been seen before – a lack of guidance makes the process of creating content a long process, with neither the main contractor nor the system supplier absolutely certain on how the models need to perform, or the level of detail required.

The models produced by Laing O'Rourke and Kawneer are a good benchmark for the current competency level of all aluminium system suppliers currently in BIM development.

4.1 LEVEL OF DETAIL AND VISUAL CONTENT

Information available on the generation of product content often describes three different levels or grades of detail; these grades are known as low, medium and high. The higher the detail level the more complex the model and subsequently, the larger its overall size. The idea behind the levels of detail is that certain aspects of the content can be toggled on and off to allow a better performance of the overall 2D and 3D project models when completing tasks such as zooming in or out and rotating on the screen *(AEC (UK) BIM Standard 2009. AEC).* Using one of the systems on the Royal Sussex County Hospital as an example, we can see these levels of detail in a 2D plan view. The system in question is an aluminium fixed light window.

When the window is viewed in low level of detail, it is merely an outline shape of the correct dimension and gives no aesthetic detail for use by the owner of the model in various views. When used in this form, it becomes a place holder within the model and can be used for clash detection. However, it does not give aesthetic detail such as extrusion numbers, gaskets, thermal break technology or hardware. When used in this level of detail the supporting parameters built into the model remain the same as it is still extremely important that things such as scheduling, cost estimates, design co-ordination, clash detection and sustainable design are all able to be completed accurately and efficiently otherwise the BIM model will fail.

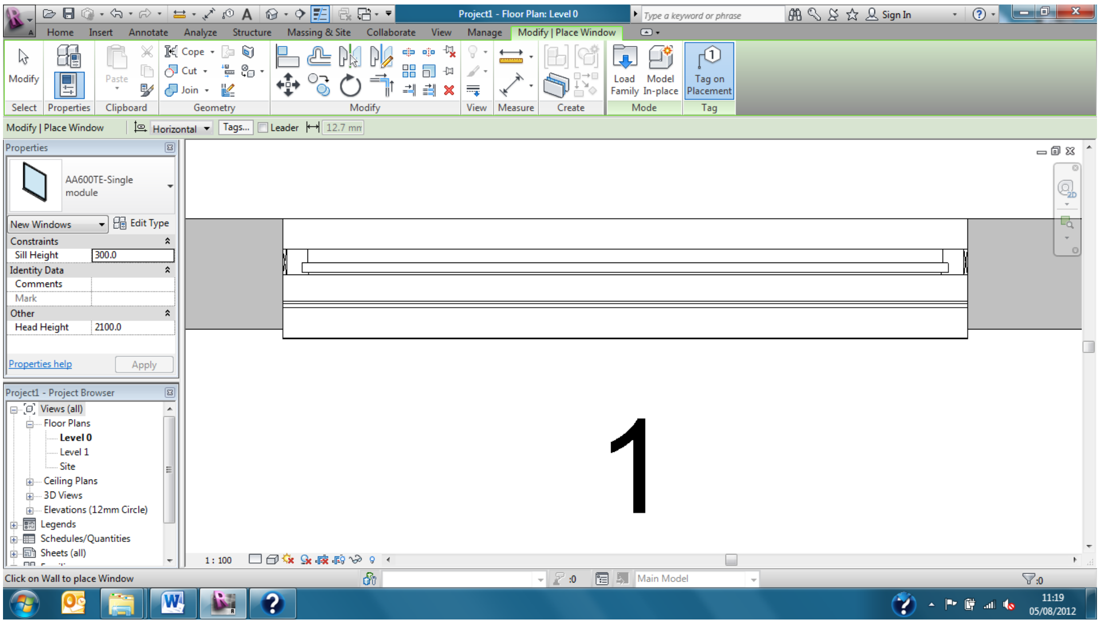


Figure 4.1.1 – Window in low level of detail.

When the window is viewed in medium level of detail then it is actually no different to the low level in terms of both visual and parameter information. This is not necessarily the correct way in which it should perform as there is no benefit from using this level of detail as a user of this model. Medium detail should contain more visual information such as profile shapes and size tolerances as it should have advanced aesthetics and realism than the low level. Increasing the level of detail decreases the level of performance of the overall 3D BIM model, so fine aesthetic detail should be left out of the medium level.

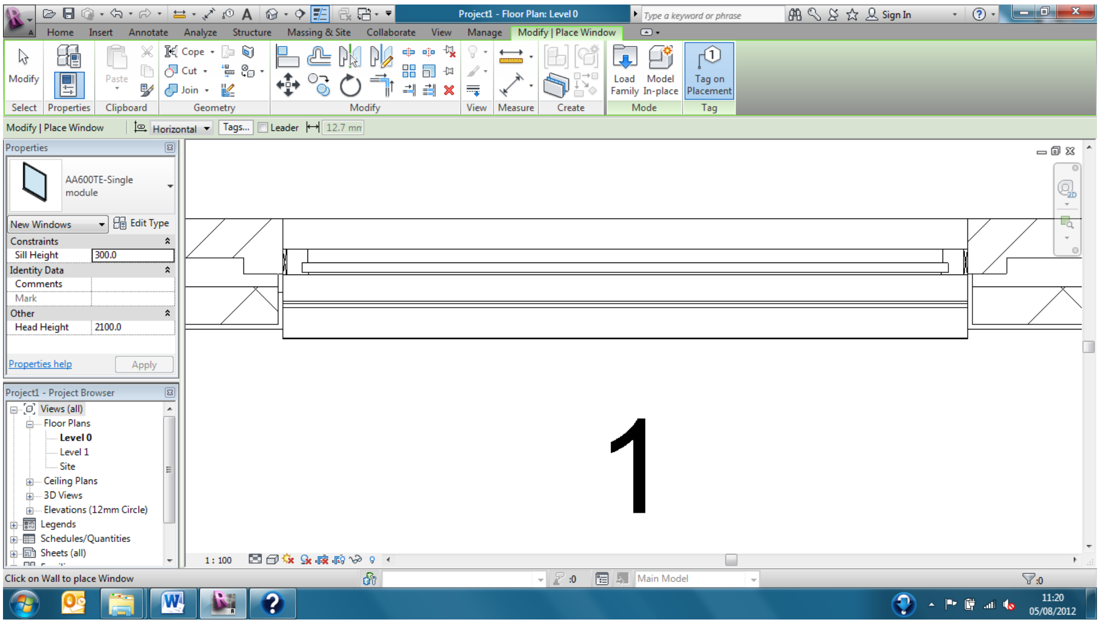


Figure 4.1.2 – Window in medium level of detail.

The high level of detail needs to contain the greatest aesthetic detail and realism. This will be used to generate exploded section views and detail drawings and so must contain a high level of visual information. The window example from Kawneer shows the profile outline and wall thicknesses, the thermal break shapes, the profile numbers and dimensional tolerances. This is a good attempt at a high level of detail but it is still lacking some key visual information such as any protruding hardware shapes including hinges and handles. Although it may not be advisable to contain accurate 3D geometry of the smaller components on a system, it is relevant to include them the 2D section to show any potential clashes with things such as internal fixtures and fittings or wall plaster.

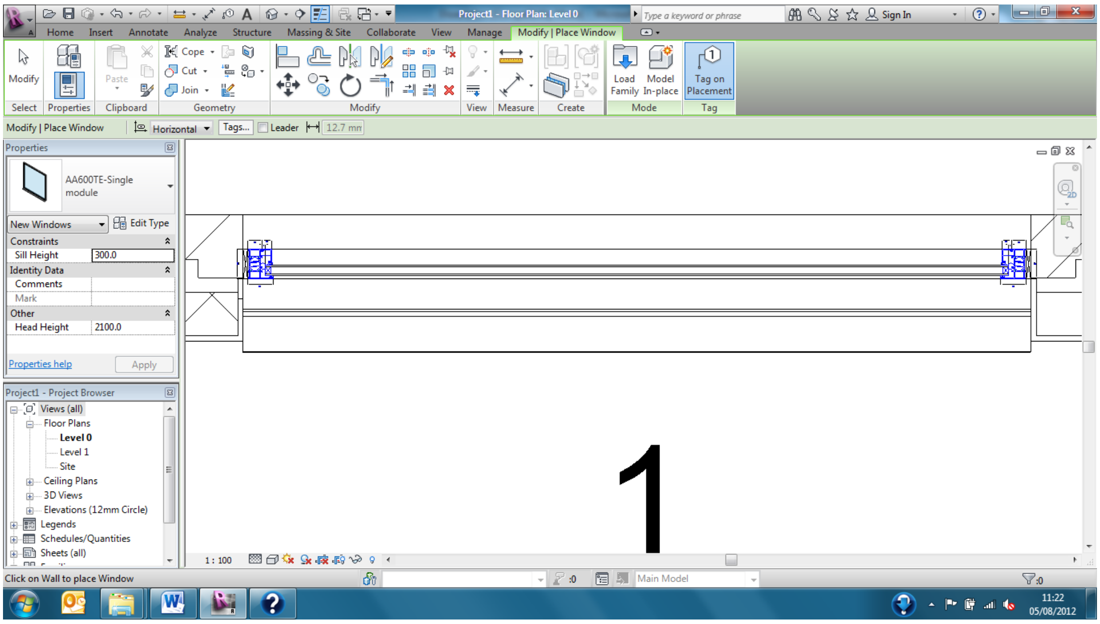


Figure 4.1.3 – Window in high level of detail.

When the product BIM models are viewed in 3D, the level of detail rules become less important to an aluminium systems supplier, because the products they supply are not necessarily complicated components in 3D and aesthetically comprise mainly of rectangular shapes. It is not necessary to model items such as hardware and accessories, as these should be kept for the 2D views and the supporting parameters where this detail is of most importance. The biggest benefit of 3D BIM modeling is for clash detection and checking interfaces, and so the product models can be modeled as a relatively simple respresentation of the product.

The window being evaluated is acceptable in terms of its 3D geometry as it can be used for the these benefits and is also good enough to visually show the design. The detail doesn't change whether it is viewed in low, medium or high levels of detail.

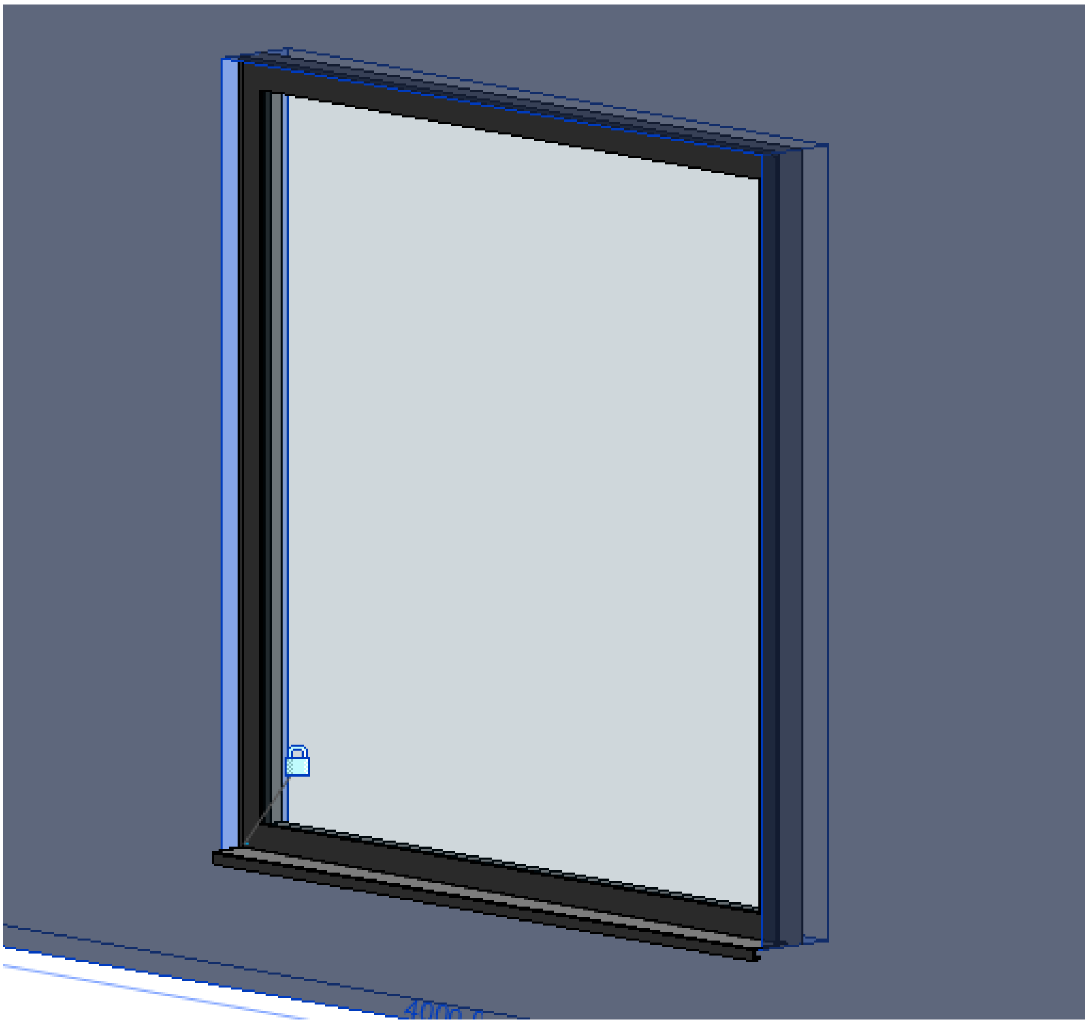


Figure 4.1.4 – Window in 3D View

4.2 PARAMETERS

The parameters built into a Revit BIM model are split between type and instance parameters. A type parameter is one that is shared across all models of that particular content 'type' within a project. An instance parameter is one that belongs to an individual 'instance' regardless of whether there are several models of the particular content model within the project. The parameters can then be further split down into various different categories such as text, dimensions, aesthetics, structural, constraints, construction and others depending on what you want the parameter to do (*Shawn C.* Zirbes*, 2010)*.

The performance of the product BIM models relies heavily on the supporting parameters programmed into them, and if the models do not contain the right level of information then the concept of BIM will not work effectively. This is because access to supporting information remains restricted across the various parties in the construction process if it is not available in the models being used, meaning it reduces communication of the design to the client and all other parties during all stages of the design process. Parameters are extremely important as they are used to define performance and specification of the models, and it is these that are used to perform any integrated analysis such as thermal assessments.

In this particular window model, the parameters are not very well defined as they have been predominantly entered into the text parameter section. Although there is technically nothing wrong with having many text parameters, they rely heavily on the end user to input the data if they have not been pre-programmed, and what the end user enters could be outside the possibility of the product.

An additional note about the parameters is that they are not very well named and therefore not very user friendly to someone using the model for the first time. If this happens the parameter is unusable and it will be ignored, which may mean a fundamental part of the window design is left undefined.

Here is the list of parameters of the window, and as they are viewed in the Autodesk Revit software.

1. Construction Type
2. Window Size (O/A)
3. Window Pane / Panel Specification
4. Wind Loading Information
5. Type / Manufacturer Reference
6. Type Description
7. Thermal Performance
8. Supplier / Fabricator Information
9. Structural Opening
10. Specification
11. Sill Height
12. Security Requirements
13. Maintenance Regime
14. Light Transmittance
15. Ironmongery
16. Frame Finish
17. Frame Type
18. Fire Rating
19. Comments / Notes
20. Acoustic Rating
21. Pressing Appearance
22. Frame Appearance
23. Wall Thickness
24. Set out Interior to Inside Frame
25. Pressing Thickness

26. Pressing Fall

27. Frame Offset Head

28. Frame Offset Cill

29. Frame Offset Jamb

30. Length of Pressing Drip

31. Height

32. Weight

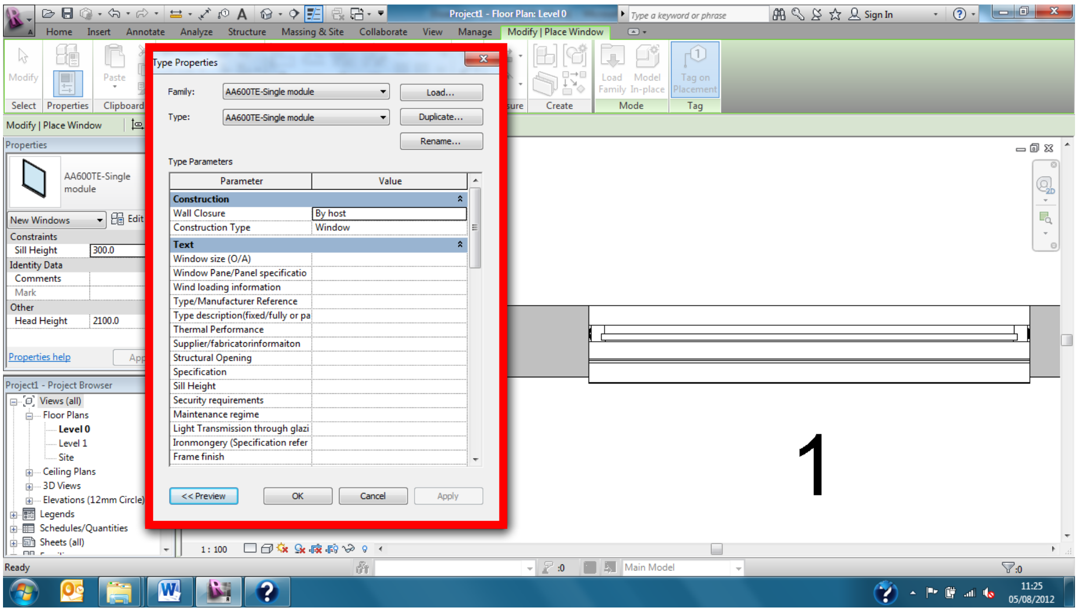


Figure 4.2.1 – List of parameters in the window model

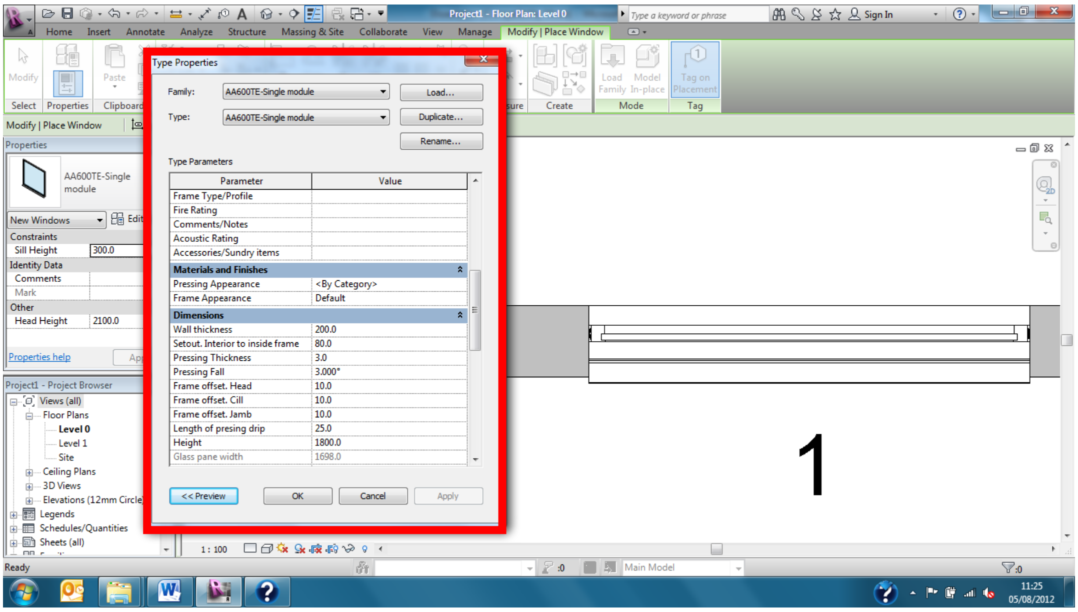


Figure 4.2.2 - List of parameters in the window model

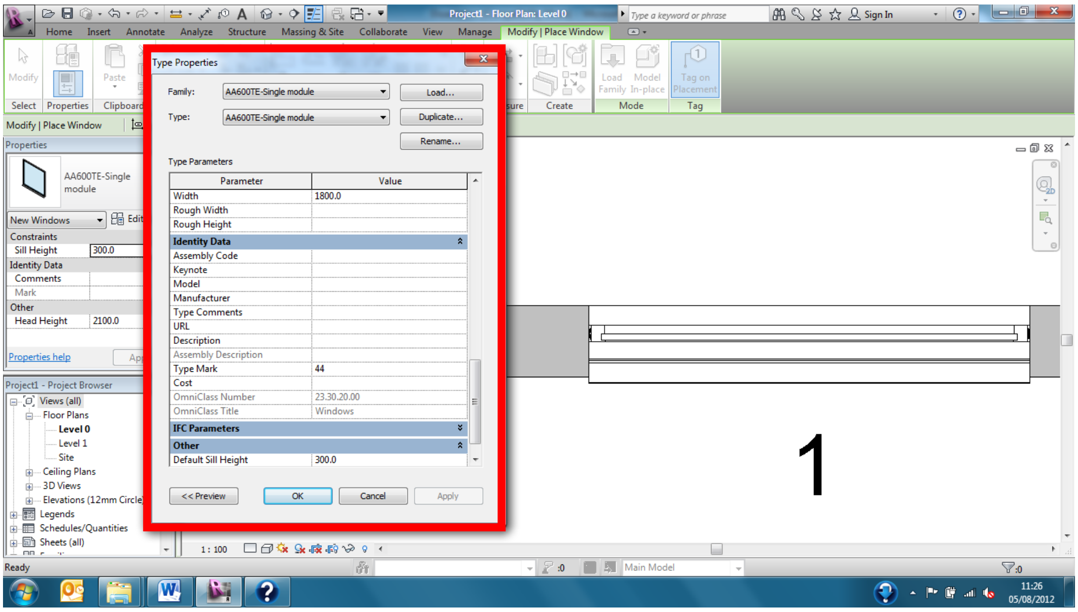


Figure 4.2.3 – List of parameters in the window model

Ignoring the naming, the parameters have actually covered the majority of the technical features of a window product, so the content range is good. The user of the model can identify sizes, finishes, security performance, thermal performance, acoustics and security, however there are a few key parameters missing such as maintenance regime, accessories and hardware and supplier information. Without a complete list of parameters then the right level of information is not being shared as the BIM technology intends.

4.3 NAMING

Naming conventions are important because when inserting product models into the chosen software to create the overall project BIM models, whether it be a window, door, rain screen or curtain wall, the models need to be easily accessed and identified, and they are also important when performing schedules and take-offs form the software. There exists good practice naming conventions for naming of the overall 3D building models but not for individual product content *(AEC (UK) BIM Standard 2009. AEC)*.

The window model being used as an example is called '**AA600TE-Single module'**. The 'AA600TE' is the name of the Kawneer product series and the 'single module' is the type. This naming does not clearly identify what the product model is and could be difficult to identify in a window schedule or when trying to insert a particular window type into a BIM project model, e.g. it could be a single module of any window type such as casement, fixed light, tilt turn or pivot.

This is an easy fix as it just means renaming the models, but prior thought needs to be given to how they should be named. Products are selected from a drop down menu of pre-loaded types in the software, so selecting a product should be efficient and easy otherwise the user will not want to use the models and will always seek to find an improved set of models – which could be a competitors.

Next shows screen shots from the Autodesk Revit software for when selecting a product to insert into a model and for viewing it in a product schedule. They clearly show how it can be difficult to identify a particular product with poor naming which has no real meaning.

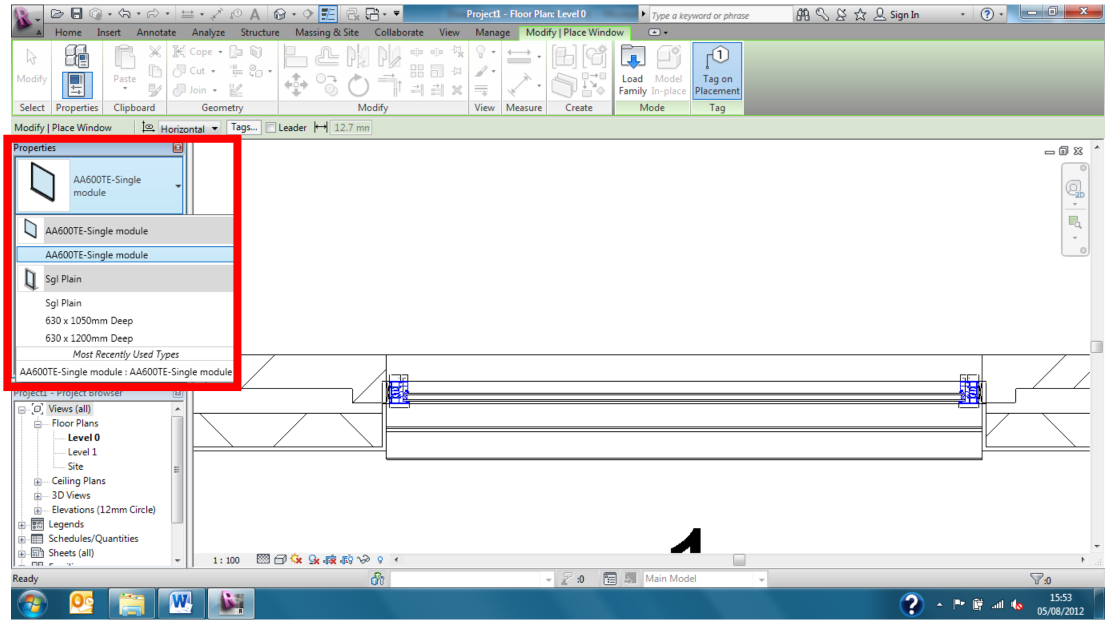


Figure 4.3.1 – Selecting a product model

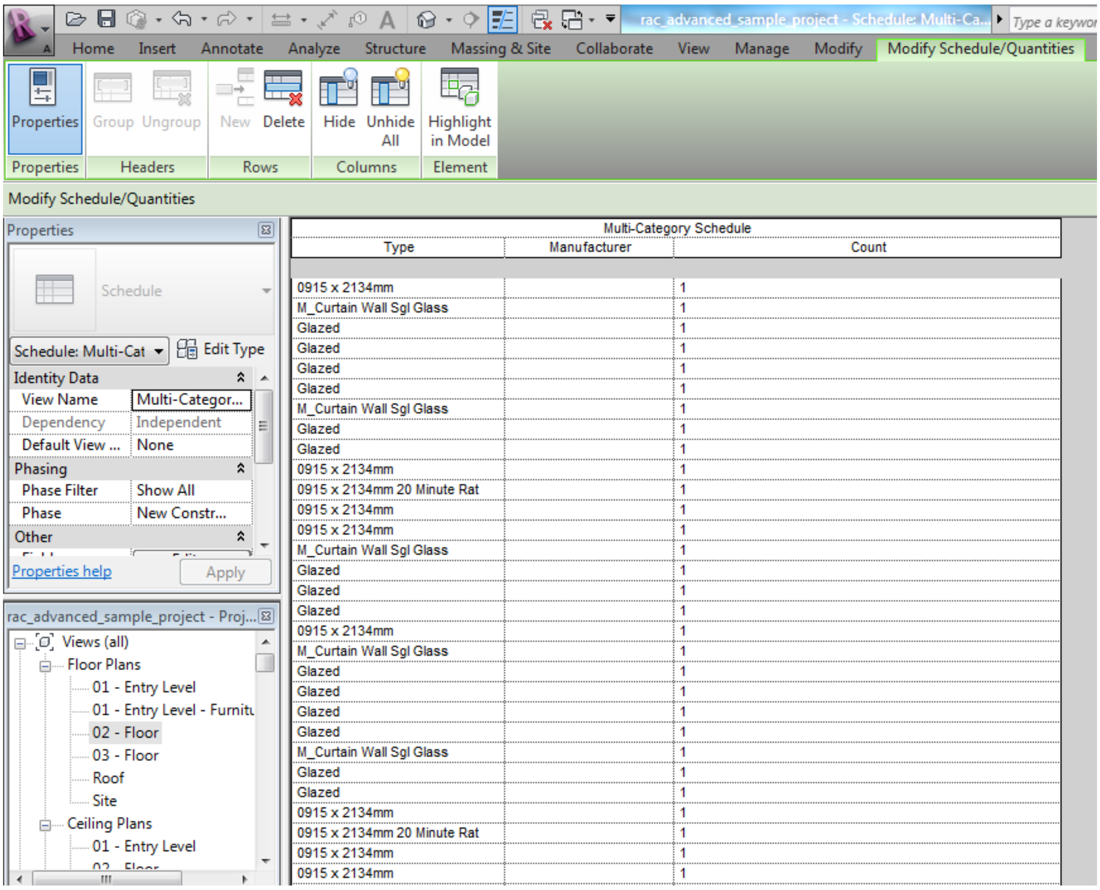


Figure 4.3.2 – Product Schedule from a Sample Project

4.4 ONLINE CONTENT DATABASES

Since the introduction of BIM into the construction industry, it is not only system suppliers that have been faced with the challenge of generating product specific content; there are many other suppliers of construction products used on a building project. In order for clients, architects or main contractors to access these models for use on their projects there has been an advent of online content databases which can be accessed to download the models. Two of the most successful databases are ‘The NBS National BIM library’ and ‘Autodesk SEEK’. The main difference between the two is that the NBS National BIM library is software platform neutral *(NBS, 2012)* whereas the Autodesk SEEK database is Autodesk Revit specific *(Autodesk, 2012)*.

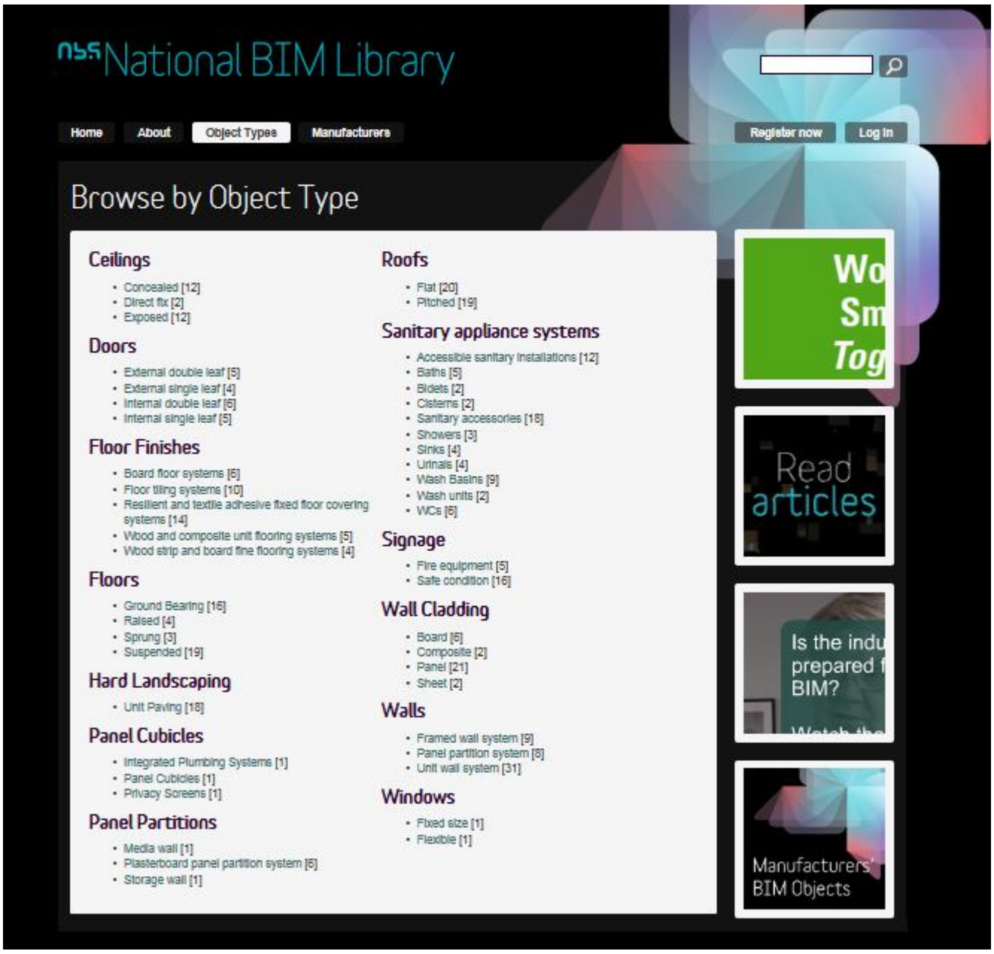


Figure 4.4.1 – The NBS National BIM Library website page

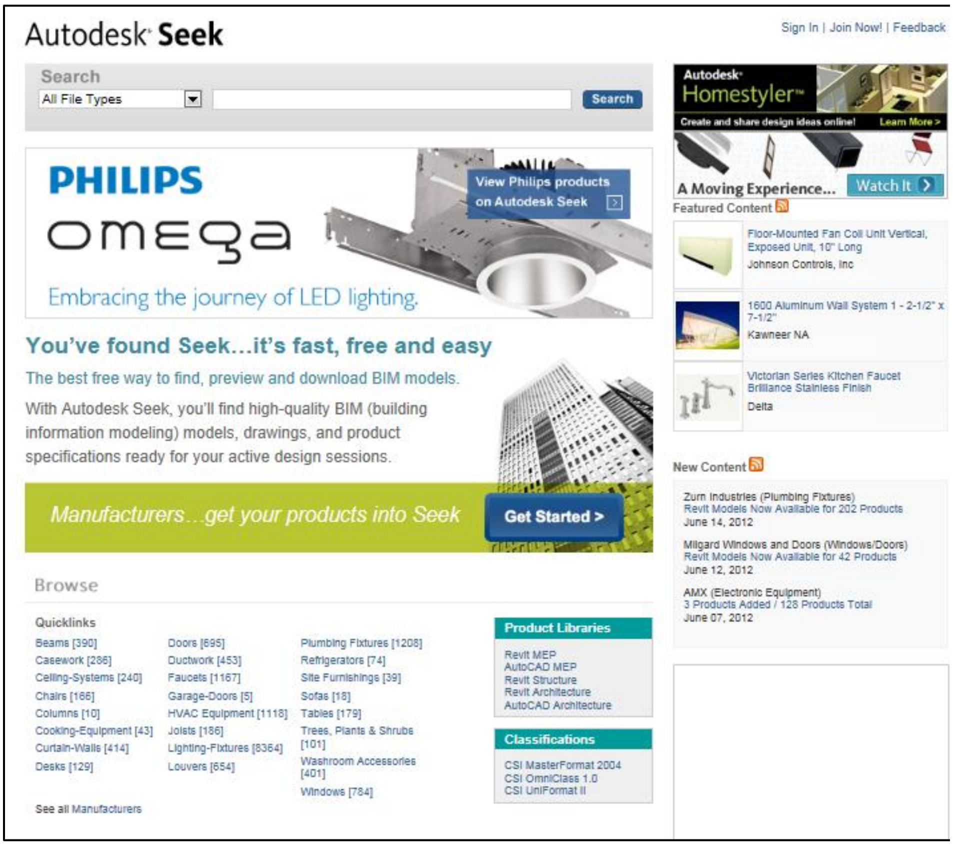


Figure 4.4.2 – The Autodesk SEEK website page

These online databases don't currently contain any product models of UK aluminium system suppliers, but they do contain models from different types of suppliers in the construction industry, as well as generic models to replace content not currently available. The content can be downloaded from these websites and loaded into the chosen software package.

Other companies allow models to be downloaded from their websites instead of these online databases. This is usually after access is granted to their restricted information via the use of a username and password. This can be a good method of attempting to keep the information confidential from competitor companies. The content models contain design information that is sensitive to the system supplier and so this would be the recommended form of accessing these models to reduce the risk of design information leakage.

4.5 CONTENT IN OTHER COUNTRIES

Other countries, particularly North America, have succeeded in BIM projects with strong case studies for their success *(NBS, 2012)*. Kawneer's North American location, for example, is already providing architects and contractors product content for use in 3D BIM project models *(Kawneer, 2012)*.

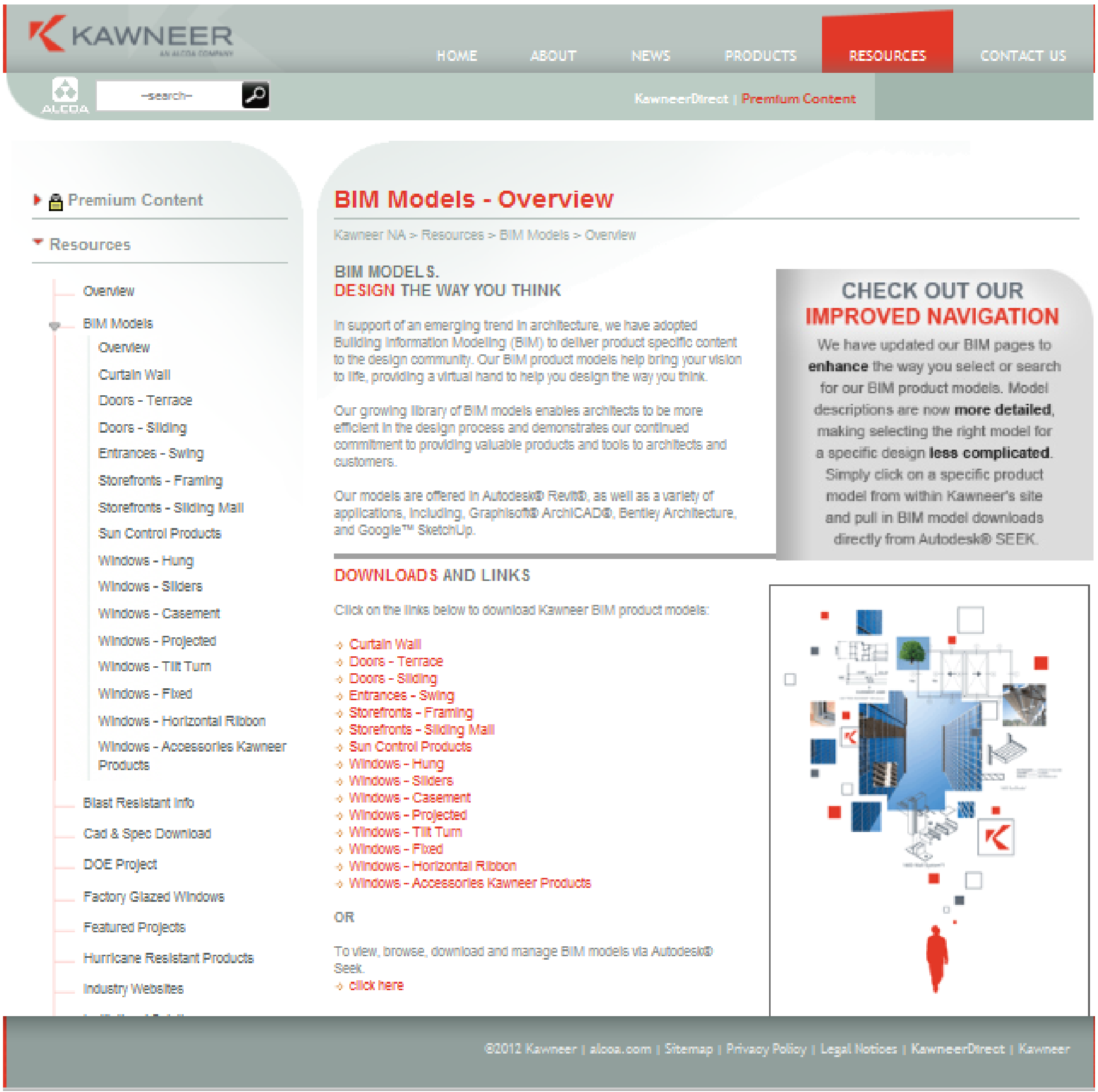


Figure 4.5.1 – Kawneer North America website

Models are downloadable from their website and are available for all of their product range. These models are also available on the Autodesk SEEK online database *(Autodesk, 2012)*.

Taking Kawneer's North America models as a comparison to those produced recently in the UK it is possible see that they are not too dissimilar. Although the USA are more advanced in the introduction of BIM they are certainly no more advanced in the development of content. Therefore it would not be unreasonable to assume that they would also benefit from a set of guidelines on content creation.

This is a BIM model of the Kawneer North America 990 Sliding Door, downloaded from their website and viewed in detail level 'fine'.

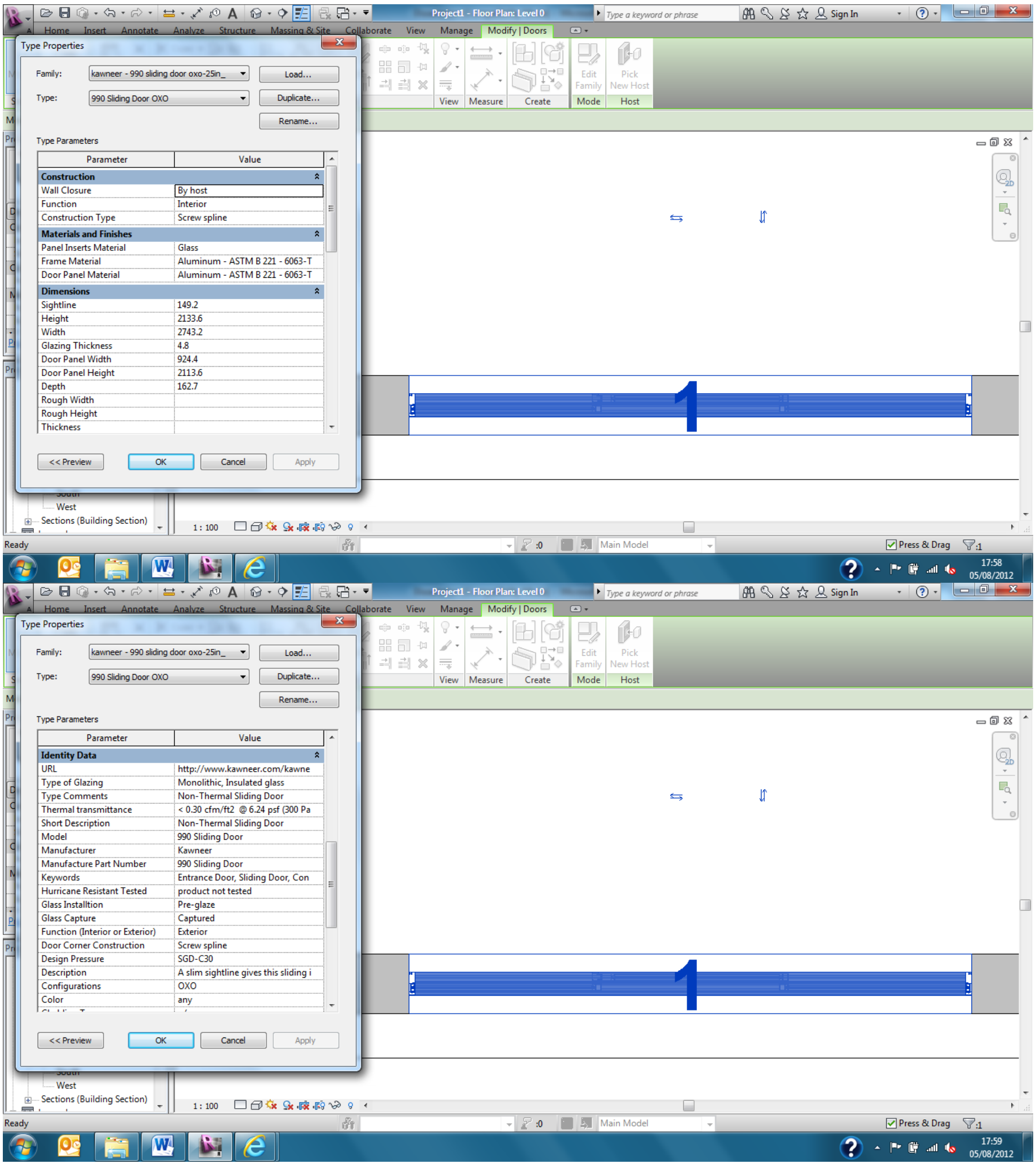


Figure 4.5.2 – Kawneer NA 990 Sliding Door

The first obvious difference is that the parameters are much better defined with drop down menu options available to complete the parameter content, this means that data cannot be entered that does not fall outside the specification of the product. The actual parameters contained in the model however do not differ too much to those in the UK models and there is still an issue with how they are named. The parameters contained in the Kawneer North American model are –

- Function
- Construction Type
- Panel Insert Material
- Frame Material
- Sightline
- Height
- Width
- Glazing Thickness
- Panel Width
- Panel Height
- Depth
- Thickness
- Type Of Glazing
- Type Comments
- Thermal Transmittance
- Short Description
- Model
- Manufacturer
- Manufacturer Part Number
- Keywords
- Hurricane Tested

- Glass Installation
- Glass Capture
- Corner Construction
- Design Pressure
- Description
- Configurations
- Colour

Overall BIM adoption levels are lower in Europe than North America *(McGraw-Hill Construction, 2010)* so taking lessons from good points of the models produced by Kawneer North America, such as parameter definition, will be useful in developing the guidelines for UK systems suppliers.

4.6 SUMMARY OF STRENGTHS AND WEAKNESS

After reviewing current product BIM models produced by architectural aluminium system suppliers, it's clear that they have both strengths and weaknesses.

- The models have started to be developed with the 2D and 3D level of detail in mind allowing the user to switch between different levels of resolution, but these visual information rules are a long way from being set.
- The models contain a good level of built in parametric data; however there are some key parameters missing and the parameters need to be better assigned within the models and better named for understanding.
- The naming of the models is not sufficient and a method of naming product models needs to be established
- A safe and secure method of distributing the models to the various users' needs to be defined.

5 MODIFICATIONS REQUIRED TO CURRENT WORK METHODS

Standards and work methods currently existing do not give the architectural aluminium system suppliers enough guidance in order to generate their content. The following modifications and additions to the current work methods would greatly assist them in content creation.

5.1 WHAT PARAMETERS?

As already explained, the performance of the product BIM models rely heavily on the parameters programmed into them, and so in order to gain guidance for developing the parameters required in the models, Laing O'Rourke was contacted to give their opinion on what would be useful in a product model. Correspondence was with Tom Van Den Driessche; Tom is a BIM Engineer at Laing O'Rourke and worked on the 'Royal Sussex County Hospital' in Brighton which was explained in Chapter 4.

Following on from the lessons learnt in trying to determine a level of competence for the models for the hospital, Tom was ideally positioned to give accurate advice on what parameters should be contained in the models in order to get the most efficient use out of them in future projects.

The following table was created following a telephone call with Tom and highlights what he saw as the minimum required parameters, the ideally required parameters and the potentially useful additional parameters *(Tom Van Den Driessche, 2011)*.

Schedule Type	Minimum Required Parameters	Ideal Additional Parameters	Potentially Useful Additional Parameters
Window Schedule and/or Curtain Wall Schedule	Type/Manufacturer Reference	Sill Height	Specification
	Type Description (Fixed/fully or part open able/Sash/ Casement etc.)	Window Size	Maintenance Regime
	Structural Opening	Frame Type/Profile	Supplier/Fabricator Information
	Window Pane/Panel specification	Frame Finish	Wind Loading Information
	Fire rating	Ironmongery	Accessories/Sundry Items
	Security Requirements	Light Transmittance	
	Thermal Performance (Specification reference)		
	Comments/Notes		
	Acoustic Rating		
Door Schedule	Door Set/Type	Minimum effective clear width	Specification

	Set/Type Description (including panel requirements)	Finish Details	Accessories/Sundry Items
	Manufacturer reference		
	Min door leaf sizes		
	Structural Opening		
	Fire Rating		
	Security/Access Control		
	Acoustic Rating		
	Ironmongery Set		
	Durability Rating		
	Door Swing (left or right handed)		
	DDA Compliant		
	Door weight		
	Door undercut		
	Comments/Notes		
Rain Screen Schedule	Manufacturer reference	Weight	Specification
	Finish	Location	Accessories/Sundry Items
	Size (L x W x T)		
	Thermal Performance		
	Fire rating		

	Acoustic Rating	[redacted]
	Type/Build Up	
	Comments/Notes	

Table 5.1.1 – Suggested Parameters from Laing O'Rourke

This table provided an excellent starting point for developing the guidelines for the parameters that need to be contained in the product BIM models by aluminium systems suppliers.

5.2 WHAT TO AVOID

As well as a lack of guidance on how to create the BIM content there is also a lack of guidance on areas to avoid when generating content for systems suppliers. There are several issues that need to be avoided to ensure efficient use of the models and these should be clearly identified in current work methods. The table below highlights the common errors and recommended actions to avoid them *(Bimstore, 2012)*.

Common errors when creating content	**Recommended Action**
Lack of prior planning to the model	Before creating a model you should be very clear on what visual and technical parameters you want to include in your content.
Unnecessary information	Before adding information to the model you need to think 'is it really necessary?' as too much information can over-constrain the model and severally hamper its performance. Planning the data somewhat avoids this.
Not utilising the features of the chosen software platform.	When using the software to generate the content the packages have various protocols and features that ensure high quality deliverables that are not unnecessarily large files, ignoring these mean that the model will not function efficiently and is likely to be discarded by the end user so they should be utilised as much as possible.

Ignoring the course, medium and fine levels of detail.	During the planning stage think about what you want to include in the levels of detail and what you feel will be necessary visual information on each level. Hampering the performance of the overall 3D model whilst navigating it will again lead to the scrapping of the poor content.
Overuse of formulas	Do not have extensive use formulas and conditions, will add to the overall models size and affect its performance in the overall 3D model.
Poor naming of the content	Make the names of the models meaningful so they can be located quickly and easily during use.
Failure to test the content after creation.	Ensure adequate testing has been performed on the models by inputting different data into the parameters and making sure they perform in the way you would expect.

Table 5.2.1 – Common Errors and Recommended Actions when creating content

5.3 NAMING MODIFICATIONS

A naming standard is required for individual product content and not just the overall 3D models. It has already been explained how naming conventions are important to identify and access products quickly and easily, and in generating schedules and take-offs.

The naming guidance that currently exists for the complete BIM models can be used as a template for the product models but need to be adapted, as the names produced from these standards would be too long for this purpose.

The name should be made up of a number of fields that at a minimum include –

- The manufacturer. E.g. Kawneer, Schuco, Reynaers.
- The product system. E.g. Window, Door, Curtain Wall.
- The product type. E.g. Casement, Pivot, Tilt turn.
- The product name. E.g. AA541, AWS 75.

If the models were named in this way, then they would be clearly identified and easily located in any BIM software. The naming of each product model needs to be unique and should be kept as short as possible *(Bimstore, 2012)*.

5.4 LEVEL OF DETAIL MODIFICATIONS

Although level of detail is actually well covered in the current BIM standards, in particular the AEC (UK) BIM Standard, there needs to be a supplement to the standards covering specific architectural aluminium system supplier products including windows, doors, curtain walling, brise soleil and rain screen.

For each product type, there should be a guideline for when to include certain geometry and content at each grade of resolution in both 2D and 3D model views. Clear rules need to be in place as detail levels determine when certain visual information is displayed in the various project views, and if the models are created incorrectly then it can severely impede performance. Only absolutely necessary information should be modelled and assigned to the appropriate level of detail.

For example, 2D plan views, it is not appropriate to include hardware shapes in a low grade resolution, and nor is it necessary to show any curves or other intricate shapes; these should be kept for the high resolution grade *(Bimstore, 2012)*.

5.5 WHY THE MODIFICATIONS FOR SYSTEMS SUPPLIERS?

Put simply, if more architectural aluminium system supplier specific modifications were made to the current work methods, the system suppliers would have a much clearer idea of how to plan and develop the creation of their product ranges into BIM models. The models produced from these modified work methods would contain the right level of detail and supporting information to be used effectively in BIM, and allow the greatest efficiencies out of the technology, particularly during the design phase of a project.

The current lack of relevant advice makes the job of producing a library of product content extremely difficult for systems suppliers because there is no standardised work methodology to work with. Guidelines were developed for traditional 2D design, and so they now need to be developed for 3D BIM models due to the increasing popularity of the technology.

6 DEVELOPMENT OF THE GUIDELINES

These guidelines are developed specifically for UK aluminium system suppliers and using them will provide the following benefits –

- Clear guidance on naming conventions for the models.
- Clear guidance on the level of detail for the models.
- Clear guidance on the parameters the models need to contain.
- Clear guidance on the size of the models.
- Clear guidance on how to distribute the models.

The guidelines should be regarded as design guides for creating product specific building information models; however they do not tell the user how to use the BIM software packages in order to generate the content, and so investment in training will still be mandatory by the systems suppliers to program the models. Nor do they cover actual interfaces with other suppliers in the construction industry as this would produce too many variables and would always be project specific.

The purpose of these design guides is to define standards for both 2D and 3D components to the BIM product models. They ensure that the models are consistent and useful to an end user, and that they are an accurate representation of the product whilst containing the right level of supporting information.

The use of the design guides will ensure that the product model is usable throughout the entire BIM process, from early design stages through construction management to maintenance and operation of the building and ultimately to demolition or re-use.

They have been formulated from the research completed in the earlier chapters of this dissertation and the appraisal of current BIM content models.

6.1 GUIDANCE ON NAMING CONVENTIONS

For an end user to clearly identify the models when inserting into a project or running schedules, the following naming convention should be adhered to.

The name of the model should be generated from a number of fields in this order -

Field One = The product system. E.g. Window, Door, Curtain Wall.

Field Two = The product type. E.g. Top Hung Casement, Horizontal Pivot, Tilt Turn.

Field Three = The manufacturer. E.g. Kawneer, Schuco, Reynaers.

Field Four = The product name. E.g. AA541, AWS 75.

To separate the fields, a hyphen should be used **(-)** and they should be written using 'Title Casing' for additional clarity.

So as an example, the Kawneer window that was appraised as part of Chapter 4 was an aluminium fixed light window. This would then assume the following name –

- **Window – Fixed Light – Kawneer – AA600TE**

Which as you can see is far clearer than the 'AA600TE-Single module' which it was previously named.

Other examples of this naming convention would be –

- Door – Open In Single Swing – Kawneer – 190
- Curtain Wall – Zone Drained Stick – Kawneer – AA100
- Window – Tilt Turn – Schuco – AWS75

If the naming is completed in this way, then selecting a product to insert into a 3D BIM model from a drop down menu or identifying a product in a schedule, is straight forward due to the clarity of the naming structure.

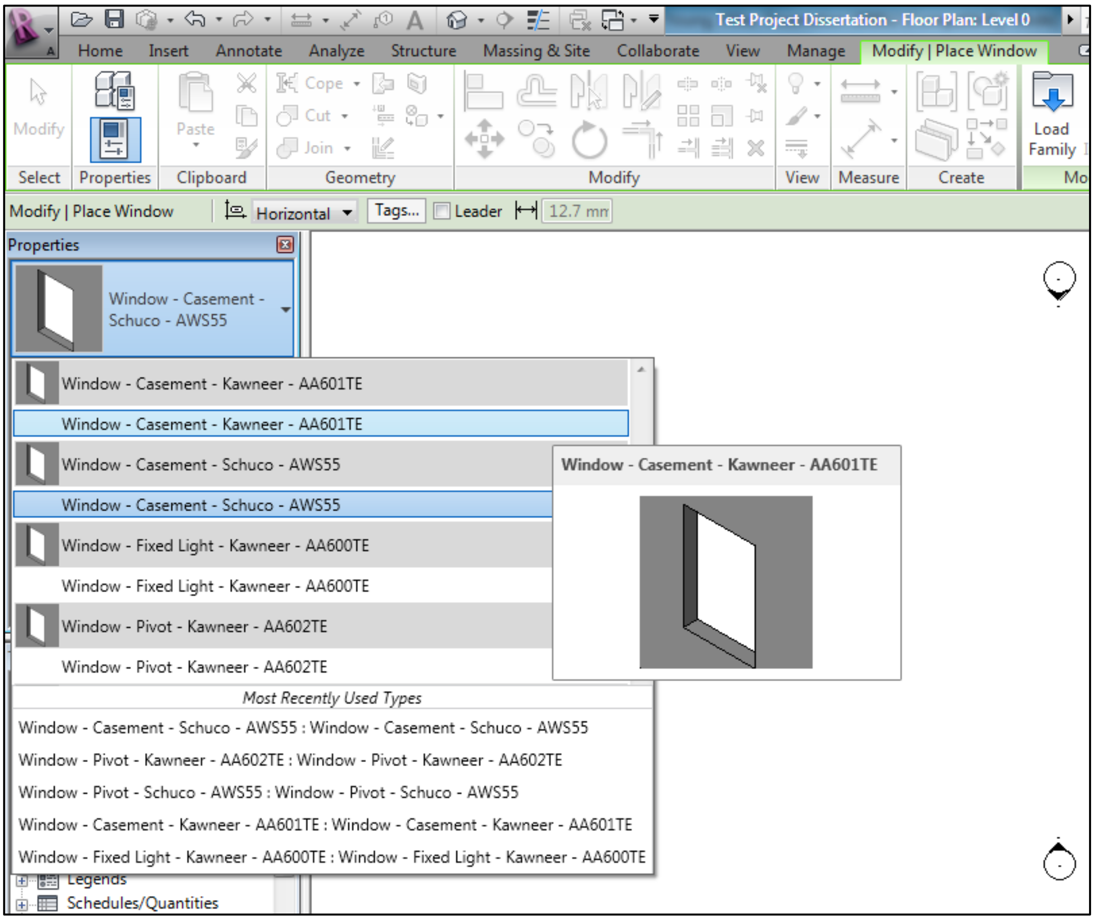


Figure 6.1.1 – Selecting a Product in Autodesk Revit

6.2 GUIDANCE ON THE LEVEL OF DETAIL AND VISUAL CONTENT

Product BIM models that include too much intricate visual information can severely impact the performance of that model; therefore it is only necessary to include this detail geometry in the high level of detail. For decisions such as determining what level of detail to assign certain visual information to, then the following recommendations have been documented *(Bimstore, 2012)* –

If the geometry is….	**Set detail level…..**
Smaller than 25mm	High
25mm – 75mm	Medium
Larger than 50mm	Low

Table 6.2.1 – Geometry and Level of Detail

These guidelines for modelling geometry are a good starting point but they are dependent on the type of product being modelled, however, it is important that levels of detail are always used when generating product content.

Due to the large array of system supplier products, creating rules for every single scenario is unfeasible. In general, the following design guides should be adhered to as to what visual content to include in the various levels of detail –

	Level of Detail		
Product	**Low**	**Medium**	**High**
Window	Shape should be a simple square edged outline in plan. No curved geometry shown.	Shape should include actual profile, thermal break and gasket detail in plan.	Shape should include actual profile, thermal break, gasket and hardware detail in plan. Supplier reference codes should also be shown.
	Shape should be a simple square edged outline in elevation. No curved geometry shown.	Shape should include actual profile, thermal break and gasket detail in elevation. The shape at the cill should also be detailed.	Shape should include actual profile, thermal break, gasket and hardware detail in elevation, including the cill detail. Supplier reference codes should also be shown.
	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.
	Infill should be shown as two lines to show thickness.	Infill shape should be detailed as to show its actual build up.	Infill shape should be detailed as to show its actual build up.

	Interface detail is a simple box filling up the structural tolerance space.	Interface detail is a simple box filling up the structural tolerance space.	Interface detail is a simple box filling up the structural tolerance space.
Door	Shape should be a simple square edged outline in plan. No curved geometry shown.	Shape should include actual profile, thermal break and gasket detail in plan.	Shape should include actual profile, thermal break, gasket and hardware detail in plan. Supplier reference codes should also be shown.
	Shape should be a simple square edged outline in elevation. No curved geometry shown.	Shape should include actual profile, thermal break and gasket detail in elevation. The shape at the threshold should also be detailed.	Shape should include actual profile, thermal break, gasket and hardware detail in elevation, including the threshold detail. Supplier reference codes should also be shown.
	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.

	Infill should be shown as two lines to show thickness.	Infill shape should be detailed as to show its actual build up.	Infill shape should be detailed as to show its actual build up.
	Interface detail is a simple box filling up the structural tolerance space.	Interface detail is a simple box filling up the structural tolerance space.	Interface detail is a simple box filling up the structural tolerance space.
Brise Soleil	Shape should be a simple square edged outline in plan. No curved geometry shown.	Shape should include actual profile and bracket detail in plan.	Shape should include actual profile and bracket detail in plan. Supplier reference codes should also be shown.
	Shape should be a simple square edged outline in elevation. No curved geometry shown.	Shape should include actual profile and bracket detail in elevation.	Shape should include actual profile and bracket detail in elevation.
	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.

Rain Screen	Shape should be a simple square edged outline in plan. No curved geometry shown.	Shape should include actual build up detail in plan.	Shape should include actual build up detail in plan. Supplier reference codes should also be shown.
	Shape should be a simple square edged outline in elevation. No curved geometry shown.	Shape should include actual build up detail in elevation.	Shape should include actual build up detail in elevation.
	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.
Curtain Walling	Shape should be a simple square edged outline in plan. No curved geometry shown.	Shape should include actual profile, thermal break and gasket detail in plan.	Shape should include actual profile, thermal break, gasket and hardware detail in plan. Supplier reference codes should also be shown.

	Shape should be a simple square edged outline in elevation. No curved geometry shown.	Shape should include actual profile, thermal break and gasket detail in elevation. The shape at the cill should also be detailed.	Shape should include actual profile, thermal break, gasket and hardware detail in elevation, including the cill detail. Supplier reference codes should also be shown.
	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.	3D shape should be a simple representation as viewed from the outside and inside with no hardware / accessories as these are detailed in the parameters and 2D views.
	Infill should be shown as two lines to show thickness.	Infill shape should be detailed as to show its actual build up.	Infill shape should be detailed as to show its actual build up.
	Interface detail is a simple box filling up the structural tolerance space.	Interface detail is a simple box filling up the structural tolerance space.	Interface detail is a simple box filling up the structural tolerance space.

Table 6.2.2 – Levels of Detail in the Product Models

Different levels of detail may be required for different users, so it is useful to be able to dynamically switch between them to keep a large building model small and light, yet be able to focus into a greater level of detail for key areas if required by a particular group.

Below is an example of a tilt turn window and how it should be represented in each of the three levels of detail as described in Table 6.2.2 –

Product	Low	Medium	High
Window	Shape should be a simple square edged outline in plan. No curved geometry shown.	Shape should include actual profile, thermal break and gasket detail in plan.	Shape should include actual profile, thermal break, gasket and hardware detail in plan. Supplier reference codes should also be shown.

Table 6.2.3 – Appropriate Levels of detail for a window

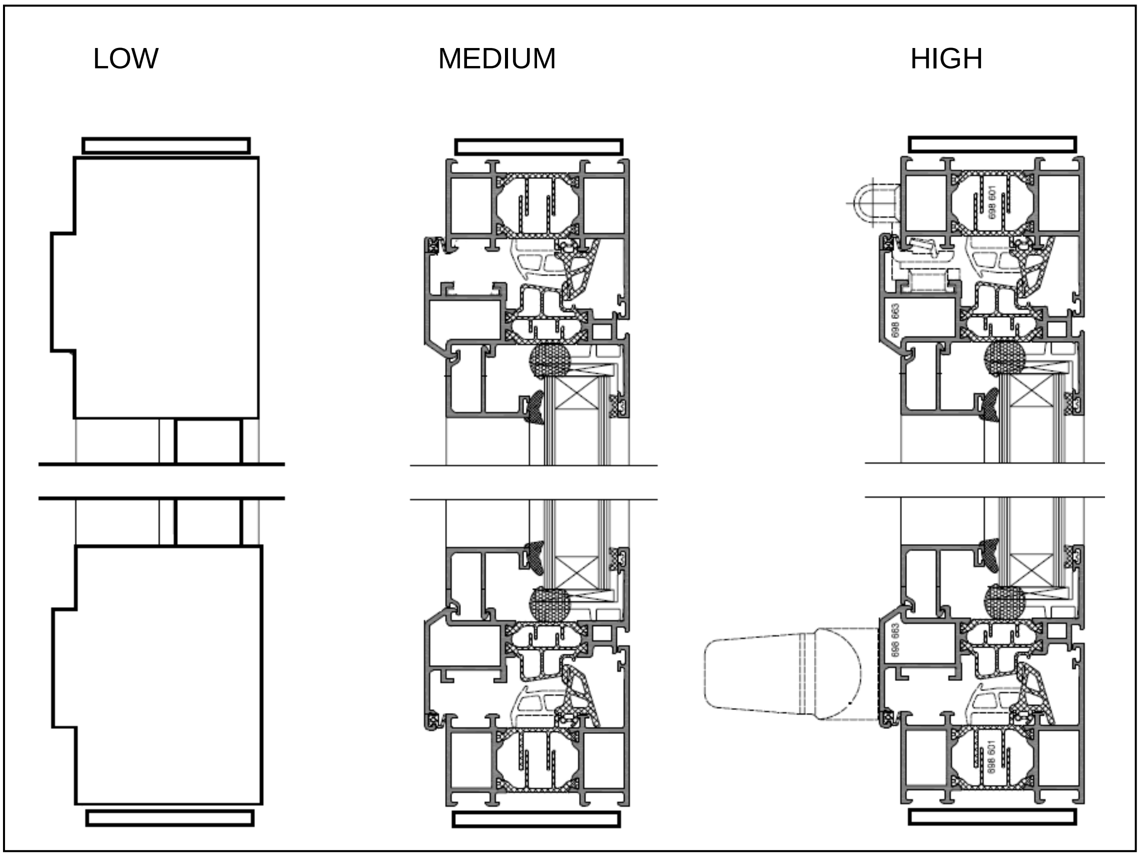


Figure 6.2.4 – Appropriate Levels of Detail for a Tilt Turn Window

6.3 GUIDANCE ON THE PARAMETERS

Developed from the opinions of Tom Van Den Driessche at Laing O'Rourke, the following parameters should be contained within the product BIM models. The parameters explained below are for all system supplier product ranges – windows, doors, curtain walling, brise soleil and rain screen.

Product	Parameter Name	Parameter Description	Parameter Type	Editable Or Fixed
Window	Manufacturer	The supplier of the window.	Text	Fixed
	Type Description	The type of window is it. E.g. Top Hung Casement, Horizontal Pivot, etc.	Text	Fixed
	Structural Opening	The structural opening size.	Dimensions	Editable
	Structural Tolerance at the Head / Cill / Jamb	The tolerance between the structure and the window frame.	Dimensions	Editable
	Height	The height of the window.	Dimensions	Editable
	Width	The width of the window.	Dimensions	Editable
	Frame Setback	The distances from the inside face of the wall to the back of the window frame.	Construction	Editable
	Sill Height	The height of the sill from the floor level.	Construction	Editable
	Frame Depth	The depth of the window frame.	Dimensions	Fixed
	Frame Thickness	The width of the window frame.	Dimensions	Editable

	Security Rating	The security rating of the window system. E.g. BS7950, ENV1627 WK1, etc.	Other	Editable depends on hardware
	Fire Rating	The fire rating of the window. E.g. EI30, EI60, EI90, etc.	Other	Fixed
	Smoke Control	Does the window deliver smoke control?	Other	Fixed
	Thermal Transmittance	The U-Value of the window.	Other	Editable
	Acoustic Rating	The acoustic rating of the window. E.g. 47db, etc.	Other	Fixed
	Finish	The finish of the window. E.g. PPC, Anodised, etc.	Materials and Finishes	Editable
	Ironmongery	The ironmongery used on the window. E.g. Handle, Hinge, etc.	Construction	Editable
	Glass/Panel Specification	The specification and description of the infill.	Text	Editable
	Glass/Panel thickness	The thickness of glass/panel used in the window.	Dimensions	Editable
	Light Transmittance	The light transmittance of the glass.	Other	Editable
	Maintenance Regime	Any maintenance regimes associated with the window.	Text	Fixed
	Wind Loading Information	The maximum design wind load of the window.	Constraints	Fixed

	Comments/Notes	Any additional comments or notes about the window.	Text	Editable

Table 6.3.1 – Parameters for Windows

Product	**Parameter Name**	**Parameter Description**	**Parameter Type**	**Editable or Fixed**
Door	Manufacturer	The supplier of the door.	Text	Fixed
	Type Description	The type of door is it. E.g. Inward Opening, Outward Opening, Sliding, Swing,	Text	Fixed
	Door Swing	Does the door swing from the left or the right.	Construction	Editable
	Structural Opening	The structural opening size.	Dimensions	Editable
	Structural Tolerance at the Head / Cill / Jamb	The tolerance between the structure and the door frame.	Dimensions	Editable
	Height	The height of the door.	Dimensions	Editable
	Width	The width of the door.	Dimensions	Editable
	Effective Clear Width	Effective clear opening width. Width less the frame and door vent.	Dimensions	Editable
	Primary Single Door Leaf Size	The size of the door leaf.	Dimensions	Editable
	Primary Single Door Leaf Weight	The weight of the door leaf.	Construction	Editable
	Frame Setback	The distances from the inside face of the wall to the back of the door frame.	Construction	Editable
	Frame Depth	The depth of the door frame.	Dimensions	Fixed
	Frame Thickness	The width of the door frame.	Dimensions	Editable

	Security Rating	The security rating of the door system. E.g. PAS24	Other	Editable depends hardware
	Fire Rating	The fire rating of the door. E.g. EI30, EI60, EI90, etc.	Other	Fixed
	Smoke Control	Does the door deliver smoke control?	Other	Fixed
	Thermal Transmittance	The U-Value of the door.	Other	Editable
	Acoustic Rating	The acoustic rating of the door. E.g. 47db, etc.	Other	Fixed
	Durability Rating	The duty rating of the door. E.g. Severe, Heavy, Medium, Light, etc.	Other	Fixed
	DDA Compliant	Is the threshold DDA complaint. Yes/No.	Other	Fixed
	Finish	The finish of the door. E.g. PPC, Anodised, etc.	Materials and Finishes	Editable
	Ironmongery	The ironmongery used on the door. E.g. Handle, Hinge, Automatic Gear, etc.	Construction	Editable
	Glass/Panel Specification	The specification and description of the infill.	Text	Editable
	Glass/Panel thickness	The thickness of glass/panel used in the door.	Dimensions	Editable
	Light Transmittance	The light transmittance of the glass.	Other	Editable
	Maintenance Regime	Any maintenance regimes associated with the door.	Text	Fixed

	Wind Loading Information	The maximum design wind load of the door.	Constraints	Fixed
	Comments/Notes	Any additional comments or notes about the door.	Text	Editable

Table 6.3.2 – Parameters for Doors

Product	Parameter Name	Parameter Description	Parameter Type	Editable or Fixed
Brise Soleil	Manufacturer	The supplier of the brise soleil.	Text	Fixed
	Type Description	The type of brise soleil is it. E.g. Single blade, Outrigger Cassette, etc.	Text	Fixed
	Span	The span of the brise soleil.	Dimensions	Editable
	High Blade Position	Distance from the top of the structure and the centre of the first blade.	Construction	Editable
	Outreach	The outreach of the brise soleil in an outrigger type.	Construction	Editable
	Number of blades	The number of blades in an outrigger type	Construction	Editable
	Pitch of blades	Distance between blades in an outrigger type.	Construction	Editable
	Size of Blades	The depth of the brise soleil blades.	Dimensions	Editable
	Angle of Blades	The angle at which the blades are installed.	Construction	Editable
	Blade Profile	The shape of the blade. E.g. Round, Elliptical, Flat, etc.	Construction	Editable

	Finish	The finish of the brise soleil blades. E.g. PPC, Anodised, etc.	Materials and Finishes	Editable
	Tie Supported	Is there additional support back to the structure? Yes/No?	Construction	Editable
	Maintenance Regime	Any maintenance regimes associated with the brise soleil.	Text	Fixed
	Wind Loading Information	The maximum design wind load of the brise soleil.	Constraints	Fixed
	Comments/Notes	Any additional comments or notes about the brise soleil.	Text	Editable

Table 6.3.3 – Parameters for Brise Soleil

Product	**Parameter Name**	**Parameter Description**	**Parameter Type**	**Editable or Fixed**
Rain Screen	Manufacturer	The supplier of the rain screen.	Text	Fixed
	Type Description	The build-up of the rain screen.	Text	Fixed
	Height	The overall height of the rain screen.	Dimensions	Editable
	Width	The overall width of the rain screen.	Dimensions	Editable
	Fire Rating	The fire rating of the rain screen.	Other	Fixed
	Thermal Transmittance	The U-Value of the rain screen.	Other	Editable

	Acoustic Rating	The acoustic rating of the rain screen.	Other	Fixed
	Finish	The finish of the rain screen panels.	Materials and Finishes	Editable
	Panel Specification	The specification and description of the rain screen panels.	Text	Editable
	Panel Thickness	The thickness of panel used in the rain screen.	Dimensions	Editable
	Panel Height	The height of panel used in the rain screen.	Dimensions	Editable
	Panel Width	The width of panel used in the rain screen.	Dimensions	Editable
	Panel Weight	The weight of the rain screen panels.	Construction	Editable
	Maintenance Regime	Any maintenance regimes associated with the rain screen.	Text	Fixed
	Wind Loading Information	The maximum design wind load of the rain screen.	Constraints	Fixed
	Comments/Notes	Any additional comments or notes about the rain screen.	Text	Editable

Table 6.3.4 – Parameters for Rain Screen

Product	**Parameter Name**	**Parameter Description**	**Parameter Type**	**Editable or Fixed**
Curtain Wall	Manufacturer	The supplier of the curtain wall.	Text	Fixed

	Type Description	The type of curtain wall is it. E.g. Stick, Unitised, etc.	Text	Fixed
	Structural Opening	The structural opening size.	Dimensions	Editable
	Structural Tolerance at Head / Cill / Jamb	The tolerance between the structure and the outer curtain wall mullion.	Dimensions	Editable
	Height	The overall height of the curtain wall.	Dimensions	Editable
	Width	The overall width of the curtain wall.	Dimensions	Editable
	Mullion Setback	The distances from the inside face of the wall to the back of the curtain wall mullion.	Construction	Editable
	Grid Configuration	The light code for the number of mullions and transoms.	Construction	Editable
	Mullion Depth	The depth of the curtain wall mullion.	Dimensions	Editable
	Mullion Thickness	The width of the curtain wall mullion.	Dimensions	Fixed
	Transom Depth	The depth of the curtain wall transom.	Dimensions	Editable
	Transom Thickness	The width of the curtain wall transom.	Dimensions	Fixed
	Security Rating	The security rating of the curtain wall system. E.g. BS7950	Other	Editable depends hardware

	Fire Rating	The fire rating of the curtain wall. E.g. EI30, EI60, EI90, etc.	Other	Fixed
	Thermal Transmittance	The U-Value of the curtain wall.	Other	Editable
	Acoustic Rating	The acoustic rating of the curtain wall. E.g. 47db, etc.	Other	Fixed
	Finish	The finish of the curtain wall. E.g. PPC, Anodised, etc.	Materials and Finishes	Editable
	Glass/Panel Specification	The specification and description of the infill.	Text	Editable
	Glass/Panel thickness	The thickness of glass/panel used in the curtain wall.	Dimensions	Editable
	Light Transmittance	The light transmittance of the glass.	Other	Editable
	Maintenance Regime	Any maintenance regimes associated with the curtain wall.	Text	Fixed
	Wind Loading Information	The maximum design wind load of the curtain wall.	Constraints	Fixed
	Comments/Notes	Any additional comments or notes about the curtain wall.	Text	Editable

Table 6.3.5 – Parameters for Curtain Wall

If using the Autodesk Revit software, the parameters should all be defined as 'type' parameters as these keep the model file size down to a minimum, making the models more user friendly (*Shawn C.* Zirbes*, 2010)*.

The new parameters define the 3D models with all the information required from an end user in order to perform the various activities within BIM. When the supporting parameters are programmed into the model, the end user can easily manipulate these to achieve their required design. This is what the new parameters detailed as part of the guidelines would look like in the Autodesk Revit software for a simple ‘Fixed Light’ window model -

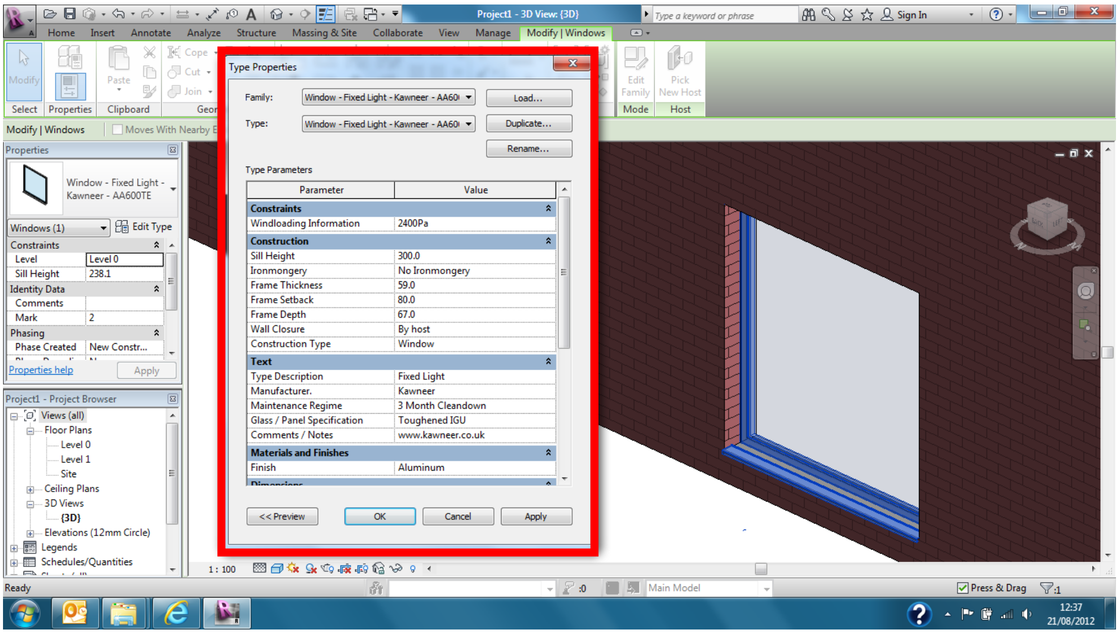


Figure 6.3.6 - The New Parameters shown in a Window Model

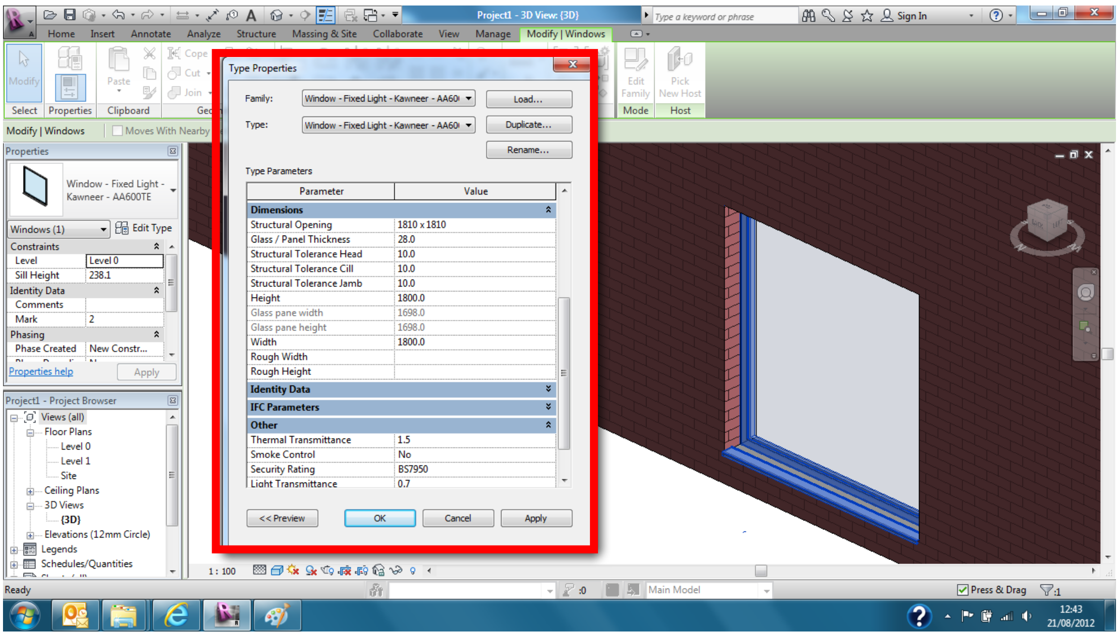


Figure 6.3.7 - The New Parameters shown in a Window Model

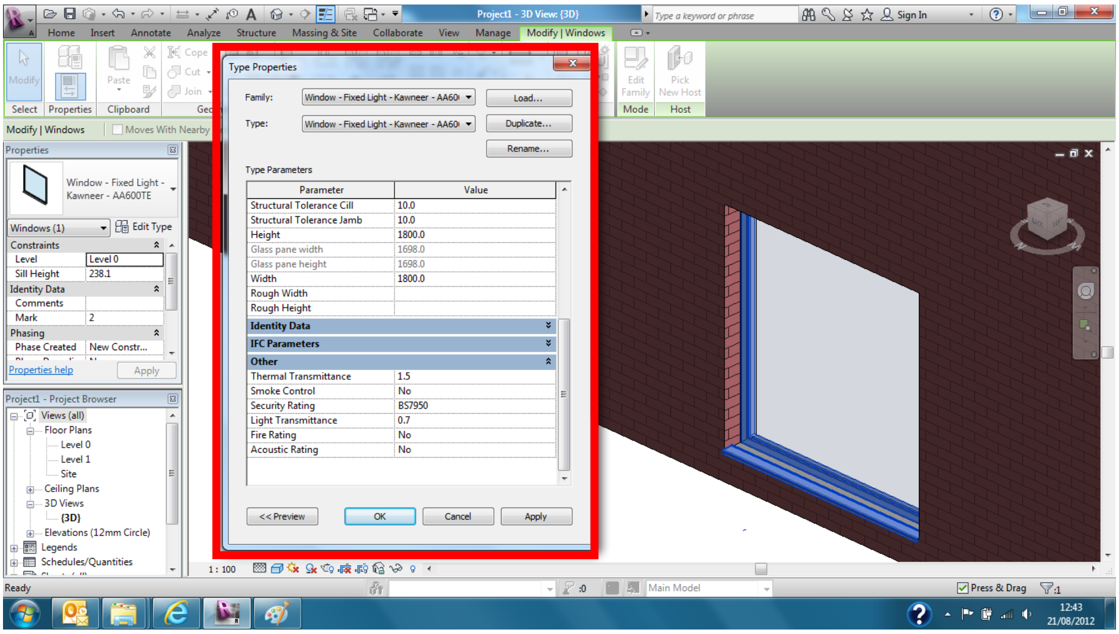


Figure 6.3.8 – The New Parameters shown in a Window Model

6.4 GUIDANCE ON THE SIZE OF THE MODEL

The more detail contained within a product BIM model, the larger its file size will be, which subsequently means the more slow the performance will be. Therefore it is recommended to keep the file size as small as possible by avoiding unnecessary information contained within the models.

The level of detail and the supporting parameters have already been described, and additions to these should be carefully considered prior to generation. For example it is not necessary, nor is it desirable to model every single screw in minute detail.

An acceptable file size is difficult to be specific about, but as a guide the majority should be kept well **below 1MB** where possible. A large project could easily have in the range of 300 – 500 windows on it, and so if every model was over 1MB then just the windows will generate a file in excess of 500MB. This will be difficult to transfer to others in the construction process. So again, it is not necessary to model every thread on every screw *(Bimstore, 2012).*

6.5 GUIDANCE ON HOW TO DISTRIBUTE THE MODELS

Handing over a BIM model is the same as giving a vast amount of information to the public domain; who and where it goes to is difficult to track and control. It could be suggested that it is controlled contractually to prevent the data being forwarded on, but this is not really practical as designers will need to share the product models as part of the overall BIM model. How the models are distributed is an important consideration.

There are a number of ways in which to distribute the product models to the end user. As well as the online databases such as ‘The National BIM Library’ and ‘Autodesk SEEK’ it has already been explained that some companies direct users to download specific product information from their websites instead. This is usually after access is gained to their restricted information via the use of a username and password, and this is recommended as the safest reasonable way to distribute the models.

Sharing models in this way, in reality, is never going to be 100% safe, as competitors have many ways in which they can obtain another business' intellectual property; mainly through having the same contacts in the industry. However, companies distributing content via websites can do their best to pick and choose who they want to give access to and subsequently only allow access to the BIM models to those trusted to that company.

6.6 SUMMARY OF THE GUIDELINES

These guidelines developed as part of this dissertation give system suppliers clear instructions on naming conventions, level of detail and visual content, supporting parameters, model sizes, and distribution of the content. The guidelines cover the entire product ranges of all aluminium system suppliers, and give the required information to generate 3D BIM product models for windows, doors, curtain walling, framing, brise soleil and rain screen, but they do not cover interfaces with other suppliers in the construction industry due to their project specific nature.

The guidelines produced in this dissertation are to be seen as creating an acceptable level of competence within BIM for content creation as an aluminium systems supplier.

7 DISCUSSION ON USE OF THE GUIDELINES

It is clearly evident from internet and library searches for guidelines on the generation of BIM models that there is a scarcity of information available to an aluminium systems supplier.

Information exists on the generation of overall BIM models, whether they are in 3D modelling software or spreadsheet format. Standards exist to detail the protocols for these sorts of models. However, none of these documents tell the systems suppliers what they need to take into account when generating the product BIM model content. There are some un-official guidelines on the internet for how to generate software specific product models but understanding these as an aluminium systems supplier is not covered, nor is there any guidance on what actually needs to be included in the models to gain best use out of them as an end user.

7.1 TESTING OF THE GUIDELINES

To gain an understanding of how effective the guidelines in this dissertation would be, they were given to two BIM co-ordinators in the industry to test and make comments. The two people contacted were Richard Scott-Smith, a BIM Implementation Manager for Atkins, and Joanne Lee, an Estimating Software Support Engineer and BIM Co-Ordinator for Kawneer UK.

The feedback -

Richard Scott-Smith's response was, "*I like the document - easy to follow. You lie in a difficult ground between writing a Standard (massive undertaking, and in many cases would be re-inventing the wheel) and writing a guide which is neither manual nor*

Standard. That definitely isn't to say it isn't a useful and even necessary document, and it is the best way to bring people into the fold. Giving them a standard or a manual (both of which by necessity are very large and often tedious documents) gets people nowhere".

Joanne Lee's response was, "*It looks like a clearly laid out and very useful guide. The Guidance on Naming Conventions is a simple chapter and you have made it clear how your thought process has evolved which makes the chapter very easy to follow. I think that the Guidance on the Level of Detail is good and I think this table could be useful as it's going to give guidelines to common scenarios within each system type. The Guidance on the Parameters is clearly laid out and contains very useful information".*

The feedback demonstrates that issuing the design guides would be useful to UK systems suppliers; however there are some limitations to their use in the fact that they do not tell you how to generate the models, more what they need to contain in order to be effective.

7.2 COMPETITOR DIFFERENTIATION

If a system supplier was in a position to offer all of its product range in BIM models from using these guidelines, they would have a real competitive advantage when it comes to getting specified on future BIM projects. If the Government stick to their commitment that all public funded construction must be delivered in BIM by 2016, and if the private sector continues to become increasingly interested in the technology, then system suppliers need a set of guidelines like these to ensure they are supplying high quality models into the construction process and they need them immediately.

The advantages of BIM have been made clear, and once the technology is fully adopted, those systems suppliers that do not have their product content in BIM models run the risk of not being specified. Architects and main contractors will not want to spend time and money producing generic product models when they can simply use the actual product model that contains all the necessary supporting information behind it in order to utilise the full benefits of BIM.

Understandably, not all systems suppliers will readily want to take up the generation of their content due to the early investment that is required as described in Chapter 2.4; however it would be better to begin now in 2012 and spread that cost over four years up to the Government's target date, than it is to panic and have to shell out one large lump sum that may not be feasible, especially if they are losing out on work *due* to the fact they don't have product content.

7.3 COMMON LANGUAGE

Even though the guidelines produced in this dissertation have been primarily developed with the use of Autodesk Revit, the principles apply to all software vendors and they are easily transferrable to provide guidance with the other software packages.

This transferability is important because as explained in Chapter 2.1, Level 3 BIM is required to be compliant with IFC which means it facilitates interoperability without becoming dependant on vendor specific file formats. This would allow data exchange across the construction industry without the worry of what software they are using.

Whichever software package is being used to generate the product BIM models, these guidelines still give advice to the systems suppliers on what the models should visually look like and what supporting information needs to be behind them.

8 CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK

8.1 CONCLUSIONS

The construction industry is evolving and Building Information Modelling is becoming increasingly mandatory on modern projects.

This dissertation has identified that there is a fundamental lack of standards and guidance currently available to architectural aluminium systems suppliers when generating their product content. Through the following early objectives, a clear and accurate set of design guides have been produced.

Objective 1- Survey the views, use, knowledge level and awareness of Building Information Modelling both present and planned, including main drivers for its adoption.

Through interviews with key decision makers in the implementation of BIM at Kawneer UK, it was made apparent that everyone was aware of BIM in general and has a level of understanding of what it facilitates. They agreed that BIM is something that architectural aluminium system suppliers need to actively get involved in. They understood that the key driver for adopting BIM would be future specification on projects. They stated that there is no guidance on exactly what information is expected to be in BIM product models, or how the information needs to be relayed. Everyone indicated that a central standard set of guidelines will be critical so that the information in a BIM product model is presented and formatted in a standardised manner which justified the reason for this dissertation.

Objective 2 - Review Building Information Modelling and how it is used to reduce costs in construction.

It was established that BIM reduces costs in the design process of a construction project by –

- Reducing the amount of rework that has to be done on the design due to being able to build the project in a virtual 3D environment first.
- Any conflicts or clashes in the building structure can be identified well before any site construction begins and then revisions can be made to the design much earlier and much quicker.
- The technology removes any potential on-site error through poor design co-ordination and provides a much more consistent construction programme, reducing the amount of unplanned work on-site.
- BIM offers the ability to generate quick and reliable take-offs and schedules of items such as materials, product counts and measurements directly from the model.
- Reducing claims by increasing the predictability of the building during its construction and beyond.
- BIM enables better and continuous evaluation of the design in terms of aesthetics, performance and specification fulfilment.
- It increases communication of the design to the client and all other parties at all stages of the design process.
- It can be used for sustainable and environmental design, energy analysis and for reducing the life-cycle costs of a building.
- It can perform integrated analysis for energy, carbon and thermal assessments, and so design decisions can be made at an early stage on items such as products and building layout.

Objective 3 - Map Building Information Modelling through the design process.

Research indicated that Building Information Modelling starts at the bottom of the construction process, with the suppliers. They feed those higher up the supply chain product with the content that goes into making up the overall project BIM model. What the system suppliers supply at the beginning is used throughout the entire BIM process, from early design stages through construction management to maintenance and operation of the building and ultimately to demolition or re-use.

Objective 4 - Identify who is responsible for managing and/or designing the model?

It has been determined that there are arguments for one of two parties to lead and manage the co-ordination of the BIM model – the Client or the Main Contractor. There have been successful case studies for both ownership options. All parties should be made aware of their responsibilities and liabilities when entering into a contract on a project that utilises BIM as when there are a number of disciplines working on the same model, then it is difficult to make any one party liable for it.

Objective 5 - Appraise current regulations for information delivery in Building Information Modelling.

Investigation has shown that there are a number of standards on BIM currently available to the industry, however none of these cover specific product content by suppliers in the industry. They are all top level standards about the technology in general and they would not be useful to an architectural aluminium system supplier when it comes to decisions such as what parameters need to be included in the models, or what graphical information is required from the models.

Objective 6 - Define and compare the current development of product models as a design tool for Architects and Main Contractors.

Current product BIM models produced by architectural aluminium system suppliers have both strengths and weaknesses. They have started to be developed with the 2D and 3D level of detail in mind, allowing the user to switch between different levels of resolution, but these visual information rules are a long way from being set. They contain a good level of built in supporting parametric data; however there are some key parameters missing and they need to be better assigned within the models and better named for understanding. The naming of the models is not sufficient; a method of naming product models needs to be established. A safe and secure method of distributing the models to the various users' also needs to be defined.

Objective 7 - Discuss the level of information to be contained within the models to contribute to a more efficient design process.

Guidance was required to give systems suppliers' advice on naming conventions, level of detail and visual content, supporting parameters, model sizes, and distribution of the product BIM models. The guidance needed to cover the entire product ranges of all aluminium system suppliers, and give the required information to generate 3D BIM product models for windows, doors, curtain walling, framing, brise soleil and rain screen.

Objective 8 - Establish an acceptable level of competence in BIM as a System Supplier by devising a clearly defined list of parameters and performance requirements.

The guidelines produced in this dissertation are to be seen as creating an acceptable level of competence within BIM for content creation as an aluminium systems supplier. The guidelines define standards for both 2D and 3D components to the BIM content models and they ensure that the models are consistent and useful to an end user. The guidelines also ensure and that the models are an accurate representation of the product whilst containing the right level of supporting information.

Objective 9 - Examine the opportunity for differentiation with respect to the competition.

Investigation has shown that if a system supplier was in a position to offer all of its product range in BIM models from using the guidelines produced in this dissertation, they would have a real competitive advantage when it comes to getting specified on future BIM projects. The systems suppliers that do not have their product content in BIM models run the risk of not being specified because of the growing popularity of the BIM technology in construction. Positive moves have been made by numerous public and private companies to make BIM mandatory on many future projects, as so it is absolutely necessary for systems suppliers to start generating their content models.

8.2 RECOMMENDATIONS FOR FUTURE WORK

The guidelines have been devised logically by addressing the current requirements of system suppliers in the generation of their content. However they should be regarded as live guidelines and as the BIM technology develops within the industry, as will the guidance on how to produce the 3D models. System suppliers will need to keep up with the technology in order to ensure they remain supplying the market with the data it requires.

A number of areas have been highlighted below as potentially benefitting from further investigation. These would be useful to further improve the next revision of the guidelines.

- Advanced research into content creation via automation and computer code. From just a few variable inputs the product content could potentially be generated through the click of a button.

- After the Level 2 BIM milestones have been met in 2016, the industry will be moving towards Level 3. The guidelines need to begin to incorporate linking the 3D models to commercial software such as system suppliers estimating packages.
- Detailing of interfaces needs to be investigated in product BIM models. Aluminium systems suppliers and other suppliers in the industry would benefit from guidance on linking their models together as one complete package on each project.

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APPENDIX

1 STATEMENT FROM PHIL RANDLES

“To an architectural aluminium systems supplier such as Kawneer, BIM has the potential to revolutionise the industry over coming years by increasing the speed and accuracy of the design to build process.

At present its use in the UK is sporadic but over the past 12 months pretty much every large main contractor is telling us to get ready to use it. In the past two weeks I have attended meetings with Laing O’Rourke, Balfour Beatty and Wilmott Dixon and all have proclaimed their intention to embed the use of BIM in their businesses. Interestingly, Kawneer is an American owned business and the take up of BIM by the architectural community in the US does seem to have been much wider than in the UK and rest of Europe so far but it is coming there’s no doubt about that.

The beauty of BIM is that it will facilitate the removal of the historic inefficiency, duplication and fragmentation of the process of designing and building. For the professionals involved in a building project, BIM will enable design and construction details to be handed from the design team (architects, etc) to the main contractor and subcontractors who are actually constructing the building in a common singular format. This will reduce the previous system of each part of the supply chain taking information from other parts formatting and reformatting this information so it can be used within their own systems. It will dramatically improve the speed and quality of the process with a reduction in information losses and much less rework when information is handed over from supply chain partner to supply chain partner.

Given the above it’s clear that we need to ensure that have our vast range product information available in BIM models for us by architects, main contractors and subcontractors. We already have a number of models available in BIM format but still have a vast amount of work to do over the coming year.

Whist the benefits are fairly obvious – why has adoption in the UK so far been slow to take off? I think the UK B&C supply chain is fragmented and ultimately BIM will only work to its fullest extent if everyone in the chain is capable. There has been no central mandate to use BIM although the government's recent pronouncement that BIM must be used on all large public sector projects by 2015 should prove to be a catalyst for adoption. What is clear however of late is that increasing numbers of architects and contractors are now seeing the benefits of BIM and as the traditional key decision makers in the UK B&C supply chain – further acceleration of use over the next 12 months is likely.

In terms of guidelines my knowledge at present is that this is an area that needs developing. At present contractors are telling us to be ready for BIM and whilst we have some models available we have had no guidance on exactly what information they expect to be in these models and they tend to be developed on a project by project basis depending on the contractor/architects individual desire. A central standard set of guidelines will be critical to BIM as ultimately it will only achieve its full potential if everyone in the supply chain uses it and the information is presented and formatted in a standardised manner – removing the need for reformatting and rework." *(Phil Randles, 2012)*

2 STATEMENT FROM VINCE MURPHY

Firstly from a business perspective it is starting to become clear, regardless of the industry's opinions of the benefits of BIM from a deliverables point of view, that BIM is gaining momentum.

To demonstrate the above point the government is making BIM compulsory on all public sector projects from 2016 with the Ministry of Justice stating that contractors on its framework must be using BIM by the middle of 2013. Some main contractors are starting to stipulate, not mandating at the moment, that any supply chain partners should be using BIM or certainly working towards its use.

There is currently a lack of understanding on the full capabilities of BIM within the industry and a possible reluctance to embrace with some standing back to see if it ends up being a fad. Still a great deal of education to be carried out to get the industry to fully understand what BIM is and the possible benefits of using it as a design and building management tool.

The drivers for the use of BIM, apart from being mandated by certain players within the supply chain, will be the demonstrable savings realised not only within the design process but also during the life of the building, as to gain the full benefit of BIM it also needs to become a tool for the FM companies to use to manage the whole life cycle of the building through to demolition. The government has stated that it estimates saving produced by the use of BIM being at least 5% with others within the industry claiming up to a 10% saving.

BIM is the creation of dynamic 3D models of products along with their associated geometry and functional characteristics which are then put together to create the overall building model. Due to all the supporting information that can be linked to the model it enables the management of products through the life cycle of the project and beyond. BIM enables the Architect to build a building virtually prior to any physical works taking place and thus facilitates the checking of product relationships which in turn can highlight such problems as clashes between interfacing products. The ideal would be that all supply chain partners in the whole building project have contributed to the overall building model.

Companies within the supply chain of the building project would develop a library of product models to enable Architects, Main Contractors and Designers to pull product from a supplier's library and in turn make the whole design process more efficient. Then later in the building process and building use the information would be used by Building Service Engineers and Facilities Management companies.

The benefit to suppliers who have created a comprehensive library of their products is that BIM can facilitate the integration of products at the early stages of the design process thus making it more likely that those products selected would end up being specified.

A set of guidelines produced specifically for system companies who need to generate BIM models would help de-mystify the process and help as an educational tool that could be used not only by the system company but also to educate other members of their specific supply chain partners i.e. hardware suppliers and fabricators. *(Vince Murphy, 2012).*

3 STATEMENT FROM CRAIG O'CONNELL

"My knowledge of BIM is from what I have seen in Trade Journals and more recently a shift in raising awareness through events at Industry Conferences. I am aware of the theory and justification which I shall try and put into words below, but as yet have no knowledge over the controller MC, architect or building designer?

I understand it to be a database of information regarding fittings and services related to building management, linking infrastructure and streamlining pre build development and post build maintenance. This I believe can take a few forms from a simple .XLS files containing key legacy data, such as contacts, manufacturer, model, service intervals etc. Through to a digitalised building model containing aspects of intelligence for components and in use services and in the future a cloud based model where each supplier can review the whole build.

In effect this holistic approach should look improve efficiencies through all levels; conceptualisation by ensuring correct selection and application of products, by varying means of specifiable features, performance, size, weight sustainability(?). This in turn should transfer into improvement in physical build and fit out timescales through to commission for occupation.

By improving the communicable link between differing aspects of the building suppliers, structure, envelope, services and internal fittings via the database it should serve to improve information flow to all participants managed through the building design and building maintenance. This in my opinion should increase building working life (improving sustainability) and minimise disruption to occupants during periods of repair through planned maintenance schemes.

Digitally recreating the building should also in future, if the technology exists, look to improve features such as clash detection, structural calculation, U-Values, carbon emissions, solar control…..

All of these industry facets working together, co-ordinating their efforts should convert into improvements in building times, especially important in converting investment into monetary returns if the building can be occupied effectively. All this effort in turn should lead to an improved comfort level for the occupants once placed, an importance that could be easily overlooked through traditional methods of design.

With regards to guidelines, as a leader of New Product Development, it is imperative that successful product deployment and acceptance in the market place is coupled with accurate published information. We need to ensure we are clear on the importance and type of information and how it is relayed. This information needs to fit within the development timescales and as such we should look to build into our working practices improving our own efficiencies in the process for Product Management.

We already use Product Development Management software to manage to our offer, understanding BIM requirements should mean that by adding key fields of relevant information we should look to be able to quickly extract this raw data in a pre-determined consistent format ready to pass over to the BIM experts for population in a software platform of choice." *(Craig O'Connell, 2012)*