AN APPROACH FOR EXTENDING BUILDING INFORMATION MODELS (BIM) TO SPECIFICATIONS

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ABSTRACT

The Construction industry accounts for a tenth of global GDP. Still, challenges such as slow adoption of new work processes, islands of information, and legal disputes, remain frequent, industry-wide occurrences despite various attempts to address them. In response, IT-based approaches have been adopted to explore collaborative ways of executing construction projects. Building Information Modelling (BIM) is an exemplar of integrative technologies whose 3D-visualisation capabilities have fostered collaboration especially between clients and design teams.

Yet, the ways in which specification documents are created and used in capturing clients' expectations based on industry standards have remained largely unchanged since the 18th century. As a result, specification-related errors are still common place in an industry where vast amounts of information are consumed as well as produced in the course project implementation in the built environment. By implication, processes such as cost planning which depend on specification-related information remain largely inaccurate even with the use of BIM-based technologies.

This paper briefly distinguishes between non-BIM-based and BIM-based specifications and reports on-going efforts geared towards the latter. We review exemplars aimed at extending Building Information Models to specification information embedded within the objects in a product library and explore a viable way of reasoning about a semi-automated process of specification using our product library.

Keywords: BIM, specifications, product libraries.

1. INTRODUCTION

Widespread fragmentation has been highlighted as a key issue responsible for some of the recurrent inefficiencies of the construction industry as reported in several studies and investigations (Arayici, Egbu & Coates, 2012), famous among which are the Latham and Egan reports (Egan, 1998; Latham, 1994). This is in part attributable to complexities in the trades and systems required in the distinct phases of design, construction and facilities management, all of which are supported by three key documents (Potter, 2002):

- construction drawings: pictorial representations of the components, and structure of buildings and their properties;
- bills of quantities: which indicate the quantity of labour and materials utilised in planning and which result in the eventual estimation of construction costs;
- specifications: the written representations of the quality of materials and associated workmanship.

These documents determine the roles and responsibilities of many project actors in the built environment - Architects, Engineers, Construction Managers, Quantity Surveyors, as well as Tradesmen, each with vested, albeit varied, interests in the contents of any one or a combination of the three construction documents. Although traditional forms of drawings, bills of quantities and specifications have been heavily relied upon for design and construction (Rosen, Kalin, Weygant & Regener Jr, 2010), their proliferation, inconsistency and inaccuracy have resulted, invariably, in workplace conflicts and construction delays (Botts, Percivall, Reed & Davidson, 2007; Egan, 1998; Gelder, 2001; Latham, 1994).

As a result, several systems and processes pertinent to information usage and management have been developed which are aimed at addressing the characteristic conflicts and inefficiencies in construction. Two of the more popular technologies [Computer Aided Design (CAD) and Building Information Modelling (BIM)] are credited with improvements in the quality of construction drawings and measurements of material quantity from drawings and specifications for use in tender/contract preparation during quantity takeoff (Kirkham, 2007). Yet, methods of specifying have not advanced to the same extent as other aspects of building design and construction, even though specification documents are important sources of BIM information (Jernigan, 2007; Rosen et al., 2010).

2. TRENDS IN SPECIFICATION

The number of vendors offering specification-based applications have increased noticeably in the past four years. This is closely associated with increased awareness that collaborative work practices have been instrumental to time and cost reductions in construction project delivery (Smith, Love & Wyatt, 2001). In turn, these improvements are supported by the systematic adoption of software tools in construction project management in a manner that has promoted efficiency.

Contextually, specifications are grouped into two main classes: BIM-based and non-BIM-based specifications. Generally, specifications produced with word/document processor-based tools, such as Microsoft Word templates, PDFs, etc, are of the non-BIM-based class. On the other hand, BIM-based specifications are targeted at improving specification users' experience by linking specification properties, like text, to the components that comprise Building Information Models. While the overarching focus of this paper is on BIM-based efforts, we take a cursory view at one exemplar of non-BIM-based specifications to underscore the impact of current efforts at automating specifications.

Four of the products currently in use in industry are Specbuilder Pro (*non-BIM-based*), E-Specs, BIMdrive and NBS Create, each produced in Australia, the United States of America, Canada and the United Kingdom respectively. These four are exemplars of current efforts in industry and research aimed at creating increased awareness of the importance of Specifications. Such awareness is crucial to enhancing the development and deployment of specifications in a manner that takes cognizance of the unique challenges of the built environment and encourages integration of specification functionalities alongside advances in Building Information Modelling.

2.1 Specbuilder Pro

Specbuilder Pro is a Windows-based specification application (NATSPEC, 2013[a]). The application simplifies the traditional complexities associated with developing specification documents by empowering users to prepare draft specifications based on pre-populated specification templates (NATSPEC, 2012). Although it is built around a Word-based platform, it provides sufficient flexibility by allowing users to click (tick) on relevant aspects of the specification templates that are of relevance to the project in question. The user base includes project stakeholders such as: building owners, architects, interior designers service and structural engineers (NATSPEC, 2007). Users are able to either purchase a CD version of the software for download and installation on local drives or use an online version (Specbuilder Live) which serves the same function, but without the need for downloading any application (NATSPEC, 2013[b]).

The merits of the template-type approach demonstrated in Specbuilder Pro include a substantial reduction in human-related errors owing to error-checked information in the pre-populated template which comply with prevailing building codes and standards as well as robustness that permits:

- a familiar user interface for creation of office-edited worksections,
- merging of two or more specifications, and
- ease of editing and stylization of documents (NATSPEC, 2012).

As a result, there is significant reduction in time for specification development. Nevertheless, the quality of the final specification document is still largely dependent on users' experience and expertise as well as on the complexity of the project's requirements. Also, the information in the template is generic and care has to be taken in editing the work sections to ensure conformance to specific project requirements. Moreover, direct BIM capabilities are not available in the current version of Specbuilder Pro.

2.2 e-SPECS

e-SPECS is a product of InterSpec, a construction management and service firm, which enables users to interact with BIM models by providing product and material requirement extraction capabilities (e-Specs, 2013). As such, when added as a plug-in to a BIM software such as Autodesk Revit, e-SPECS retrieves model information related to assembly codes, descriptions and parameters embedded within generic Revit families and synchronises this information to the e-Specs software itself.

With the *e-SPECS for Revit* plug-in, for example, changes within the model are automatically made to the specification document (after the plug-in refresh button has been clicked). Thus, the accuracy of the Specification information is as accurate as the associated component/BIM object contained within the model. For example, if a stair family within a model is selected, the view e-Specs functionality within the plug-in allows users to view (on a Word-type pop-up page) the corresponding specification sections linked to the selected family from within the Revit template.

The basis for the automation within e-SPECS is the functionality of the Binding Manager which effectively makes connections between a Revit object and an e-Spec section through Assembly Codes. A specifications project manual can thus be created once the model information is extracted and transferred to the e-SPEC interface. Thus, with e-SPECS, there is actual interaction between model and Specification document.

Notwithstanding, the constant need to manually refresh e-Specs both within the Revit platform and in the e-SPECS environment in order to see the most updated information (while frequently moving between both platforms) may prove counterproductive and substantially increase the tendency for errors on large-scale projects. Also, heavy dependence on assembly codes implies that users of e-SPECS require substantial knowledge of code-based editing of worksections.

2.3 BIMdrive

Digicon Canada, makers of BIMdrive, describe it as a software developed with a BIM-based approach to specifying in mind (Watson, 2013). Like e-SPECS, BIMdrive employs a checkbox approach while tailoring generic specifications to conform with project and, by implication, model requirements. Unlike e-SPECS, however, BIMdrive does not depend on the use of Assembly Codes. This independence is highlighted by the description of BIMdrive as a standalone software with potential for integration with BIM models in future releases of the product. The main benefit of the software, from a regional perspective, is its interface with other national standards (Canadian Master Specification (CMS) and National Master Specification (NMS) texts), hence, the learning curve for industry practitioners in transitioning from a purely-based specification system to BIMdrive will be far less steep than it would be with similar systems. According to the BIMdrive Quick Start Reference Guide (2011), some merits of the application are:

- Checking and validation of users' actions in order to alert them in the event of conflicts in specification clauses or even omission of mandatory specification criteria,
- Increased speed and accuracy in the development of specification documents,
- A reporting functionality that has the capacity of producing specification-based Project Management reports.

As BIMdrive is a standalone software, like NATSPEC's Specbuilder Pro, it requires visualisation of the building model independent of the application.

2.4 NBS Create

The NBS has both authored and maintained specifications in the United Kingdom for over four decades and are the makers of the NBS Create software. Like BIMdrive, NBS Create is said to have been developed with a BIM-focus in mind (Hamil, 2011). The driver for the software is said to be years of customer requests for better, more efficient ways to specify:

> *"One regular customer request was to enable the assembly of the specification automatically; more specifically, the ability to add more detailed clauses to the specifications based upon the choices made in outline description clauses. For example, if in a heating system outline clause you specify a condensing boiler, can the condensing boiler product clause and its corresponding execution and commissioning clauses be automatically added to the specification. This customer request was entirely reasonable, but to deliver this meant the creation of a complex information model and NBS Create was born."*
>
> *(Hamil, 2011)*

Nevertheless, one merit of the software is the intuitiveness and simplicity that provides users the option of developing specifications from mere outlines till the point when information is more specific and where users can decide on the exact pre-populated clauses and sections that are directly relevant to the project in question. Furthermore, it addresses the randomness often associated with specification assembly where users typically delete what they perceive as sections that are not relevant and paste those thought to be of relevance. The software guides users' specification assembly based on prior decisions made during system outline clause completion.

Although the similarities between the functionalities of NBS Create and e-SPECS are strong, users are better able to specify based on building models with e-SPECS than they can with NBS Create. This distinction is based on the approach to specification assembly by e-SPECS which connects the model to the specification so that a changes to one tool is a change to the other. Furthermore, NBS Create is web-based and may not be well suited to organization who prefer managing their specification contents locally.

3. EVOLVING AN UNDERSTANDING OF SPECIFICATIONS: A CONCEPTUAL APPROACH

Recently, much effort has gone into making Building Models more accurate. Yet, it is debatable that the usefulness of the models will be simply limited to the visualisation capabilities of the tools, rather than on increased efficiencies in the construction process, if emphasis is not placed on making the models more about the components they simulate (specifications). This section of the paper uses a model from a project managed by the Queensland Government's Project Services Department at Toowoomba, Queensland. Figure 1 is one part of an 10x2 unit housing development and most of the components that comprised the completed project were modelled. Initially, we show how product information in a COBie spread sheet is mapped to a product library (see Duddy et al., 2013) and how that information is embedded in the previously generic model object. Thereafter, a more elaborate description of the underlying process is given (section 3.2).

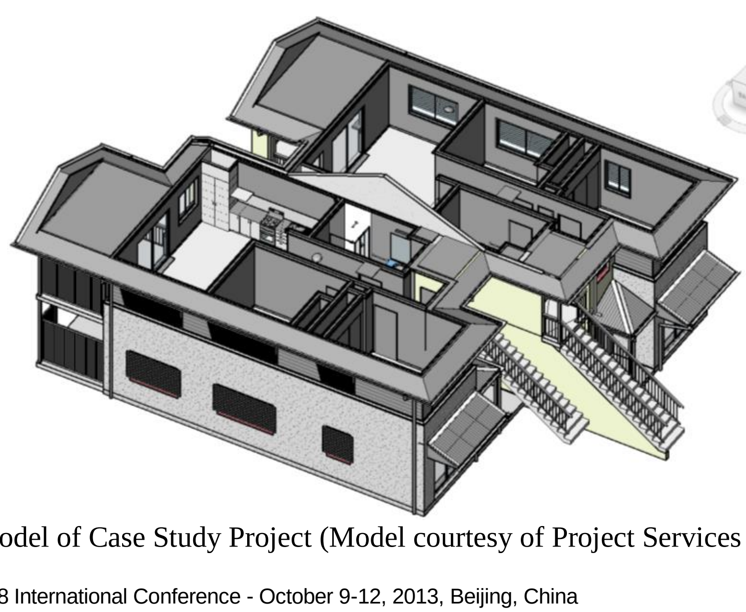

Figure 1: Revit Model of Case Study Project (Model courtesy of Project Services Department, 2010)

In our example, the roof of the building has been deliberately hidden to reveal the interior of the model. The specification was developed using NATSPEC's basic template. The research takes the approach of capturing specifications by utilising property set definitions of the components in a product library with which this research is closely associated - see Duddy et al., (2013)

3.1 Modelling Product Library Information with COBie

The following is a step-by-step guide to using COBie as a starting point for embedding proprietary specification information. The same process is followed in the supported BIM authoring software

1. Proprietary product specification information is entered into a COBie spreadsheet (in line with industry standards and at various level of details, from generic product information to specific manufacturers' product information). This information will make up the template information for that product in the product library.
2. Information from the COBie sheet is mapped into the product library interface as a product template.
3. Template information is used to enhance the model specification of objects in one of two ways:
   - By exporting the information from the product library to the BIM-tool and using the imported object and its properties from within the BIM tool to update generic object specifications.
   - By consulting the object library from within the BIM software and importing desired specifications contained in the property set definitions in the library product

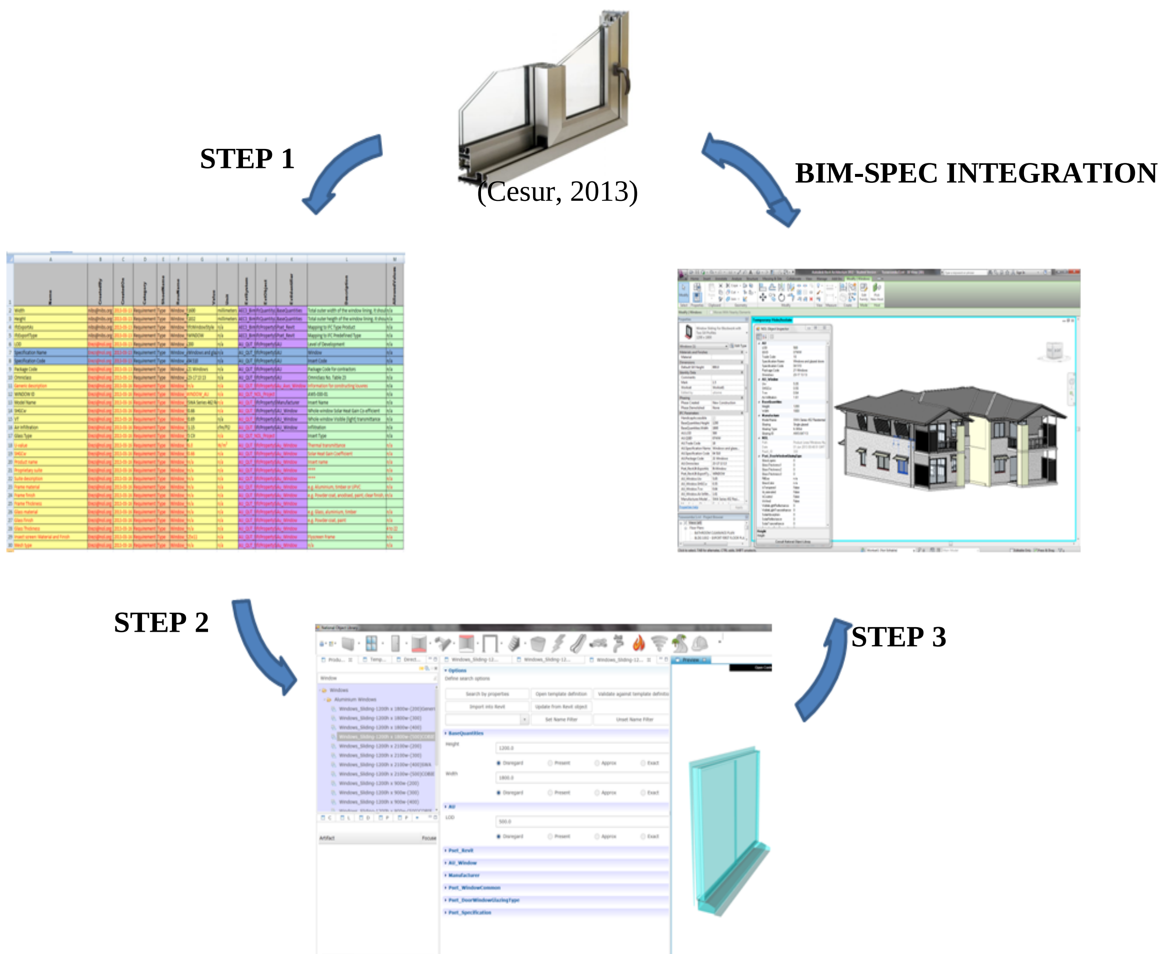

Figure 2: BIM-Specifications Integration Cycle

It is arguable that this approach will be time-consuming if a user needs to follow the process each time specification information is required to be embedded in a generic BIM-object. However, the value in the approach is the ability to use and reuse specifications from within the BIM authoring tool once that information has been imported from the product library.

3.2 Product specs transformation

In Figures 3.1-3.4, the process of embedding product-specific information in the Toowoomba model is shown and the breakdown of the procedure is given for each step.

For our purpose, we assume that the desired properties for all external windows in the model are according to the AWS-Series 452 specifications (AWS, 2013). It is on the basis of the information in the AWS specification document that data is extracted and embedded in the COBie spreadsheet. Steps 1 through 4 illustrate the process.

1. Information from the COBie sheet is mapped (transformed) to the product library interface as a product template, hence there is no data-loss as the embedded data is housed in excel spreadsheets. This step occurs prior to user modelling and merely illustrates how the product information is embedded in the product library in the first instance.

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Name	CreatedBy	CreatedOn	Category	SheetName	RowName	Value	Unit	ExtSystem	ExtObject	ExtIdentifier	Description	AllowedValues
2	Width	nibs@nibs.org	2013-03-13	Requirement	Type	Window_	1600	mm	AEC3_BimS	IfcQuantityL	BaseQu	Total outer wi	n/a
3	Height	nibs@nibs.org	2013-03-13	Requirement	Type	Window_	1832	mm	AEC3_BimS	IfcQuantityL	BaseQu	Total outer he	n/a
4	IfcExportAs	nibs@nibs.org	2013-03-13	Requirement	Type	Window_	IfcW	n/a	AEC3_BimS	IfcPropertyS	Pset_Re	Mapping to IF	n/a
5	IfcExportType	nibs@nibs.org	2013-03-13	Requirement	Type	Window_	WINI	n/a	AEC3_BimS	IfcPropertyS	Pset_Re	Mapping to IF	n/a
6	LOD	Erezi@nol.org	2013-03-13	Requirement	Type	Window_	200	n/a	AU_QUT_N	IfcPropertyS	AU	Level of Devel	n/a
7	Specification Name	Erezi@nol.org	2013-03-13	Requirement	Type	Window_	Wind	n/a	AU_QUT_N	IfcPropertyS	AU	Window	n/a
8	Specification Code	Erezi@nol.org	2013-03-13	Requirement	Type	Window_	04 51	n/a	AU_QUT_N	IfcPropertyS	AU	Insert Code	n/a
9	Package Code	Erezi@nol.org	2013-03-13	Requirement	Type	Window_	21 W	n/a	AU_QUT_N	IfcPropertyS	AU	Package Code	n/a
10	Omniclass	Erezi@nol.org	2013-03-13	Requirement	Type	Window_	23-17	n/a	AU_QUT_N	IfcPropertyS	AU	Omniclass No.	n/a
11	Generic description	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	n/a	n/a	AU_QUT_N	IfcPropertyS	Au_Aws	Information fo	n/a
12	WINDOW ID	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	WIND	n/a	AU_QUT_NOL_Project			AWS-030-01	n/a
13	Model Name	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	SWA	n/a	AU_QUT_N	IfcPropertyS	Manufac	Insert Name	n/a
14	SHGCw	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	0.66	n/a	AU_QUT_N	IfcPropertyS	AU_Win	Whole windo	n/a
15	VT	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	0.69	n/a	AU_QUT_N	IfcPropertyS	AU_Win	Whole windo	n/a
16	Air Infiltration	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	1.15	cfm/	AU_QUT_N	IfcPropertyS	AU_Win	Inflitration	n/a
17	Glass Type	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	5 Clr	n/a	AU_QUT_NOL_Project			Insert Type	n/a
18	U-value	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	6.0	W/n	AU_QUT_N	IfcPropertyS	Au_Win	Thermal trans	n/a
19	SHGCw	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	0.66	n/a	AU_QUT_N	IfcPropertyS	Au_Win	Solar Heat Gai	n/a
20	Product name	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	n/a	n/a	AU_QUT_N	IfcPropertyS	Au_Win	Insert name	n/a
21	Proprietary suite	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	n/a	n/a	AU_QUT_N	IfcPropertyS	Au_Win	****	n/a
22	Suite description	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	n/a	n/a	AU_QUT_N	IfcPropertyS	Au_Win	****	n/a
23	Frame material	Erezi@nol.org	2013-03-16	Requirement	Type	Window_	n/a	n/a	AU_QUT_N	IfcPropertyS	Au_Win	e.g. Aluminiu	n/a

ATTRIBUTES|500 ATTRIBUTES|400 ATTRIBUTES|300 ATTRIBUTES|200

Ready 100%

Figure 3: COBie spreadsheet for AWS-Series 452

2. The user selects a generic model object (in this case an AWS-Series 452 window) within the model and clicks the product library's plug-in ("External Tool") to assess the product library.

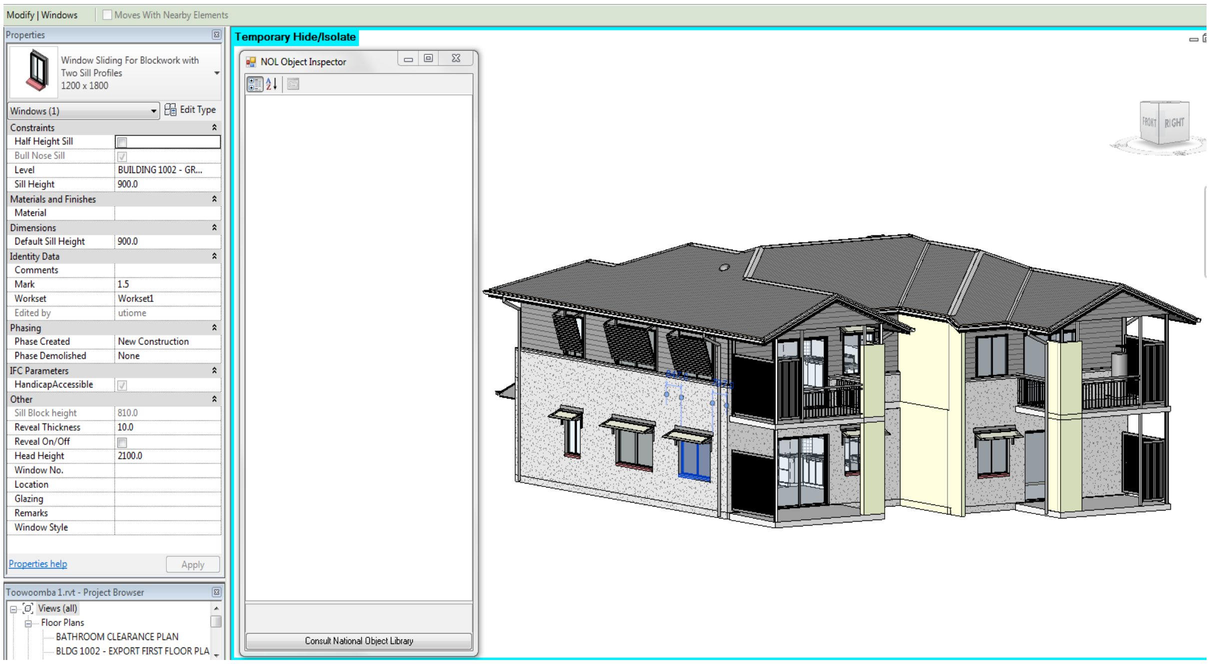

Figure 4: Highlighted model window with original property sets

3. The library automatically provides a list of windows that closely match the BIM window specifications. The user can either select a library window (in our case, a 1200x800 Aluminium sliding window) or search for specific properties in line with project spec requirements from the library products. Once satisfied with the product selection, the user clicks on the "Import into CAD" button for the window specifications to be embedded in the generic BIM object.

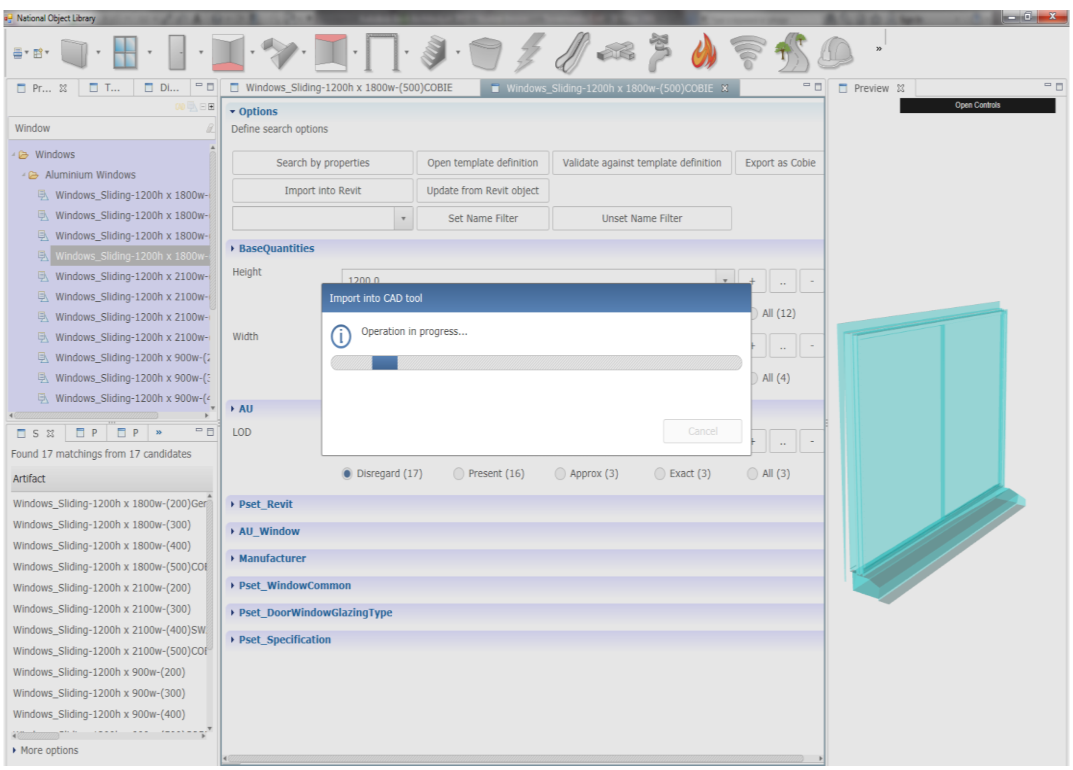

Figure 5: Exporting proprietary specs properties from product library to model object

4. New property sets, complete with property set definitions from the product library, can then be viewed on the BIM property window and the property inspector.

Methods of linking reference codes stored in the product definition which can then be used to semi-automatically build the specification document are under development.

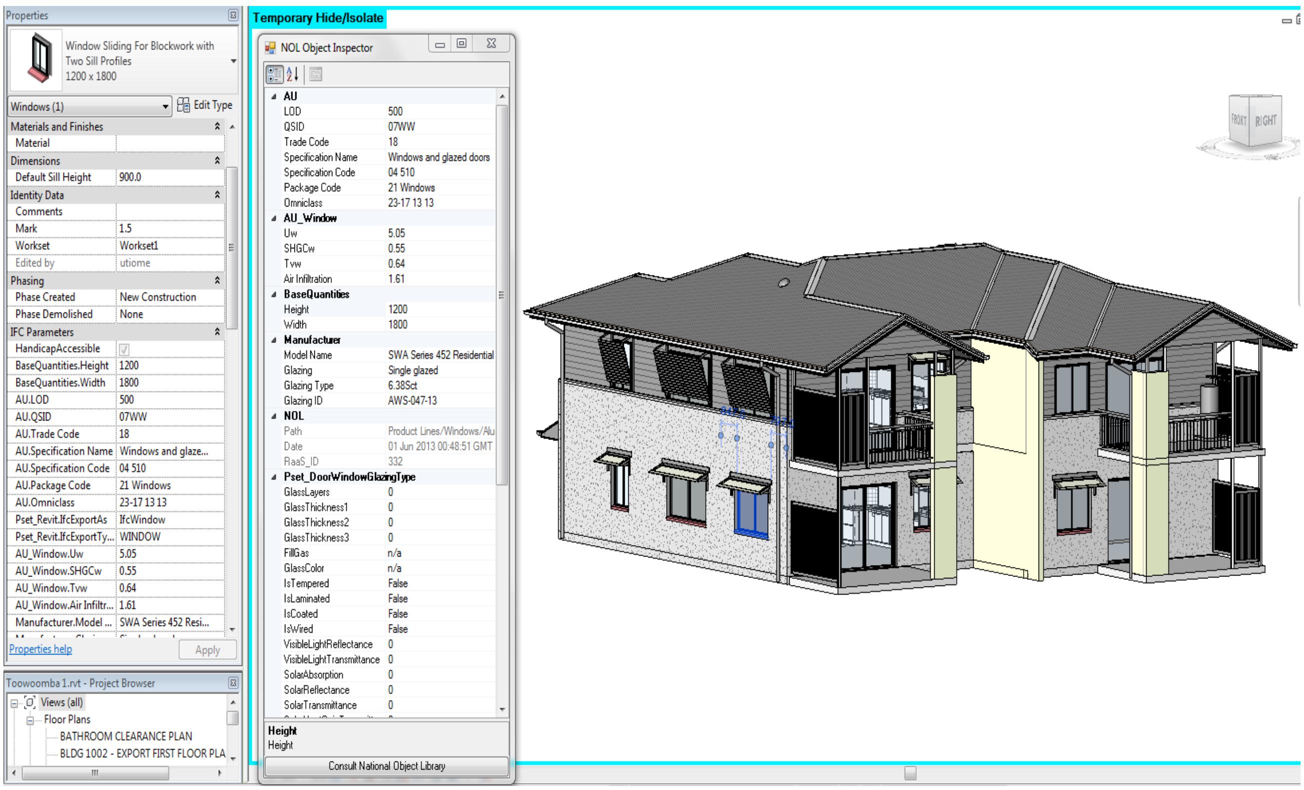

Figure 6: Model object with proprietary specs in Revit

The foregoing illustrations show how a user can export specification information (AWS window) from the product library for embedding within the generic model object (1200x1800 sliding window with two sills)

4. FUTURE WORK AND CONCLUSION

As interest in Building Information Modelling grows, so too the awareness of the need to link specifications to the model to harness the many other benefits of BIM. This research developed a conceptual approach to linking specification information by utilising information from a product library. The flexibility of the research approach is highlighted in very simple steps. The next stage of our investigation will focus on:

- generating a traditional specification document from within the model in a way that captures the product library properties that have been embedded in model objects.
- synchronising specification information such that changes to an object within the model are not only captured in the product library but are also reflected in the specification document that will be generated from within the model.
- Examining the feasibility of storing the specification information within the BIM model to provide new methods of viewing specification information with respect to BIM and improving interaction between users and the totla information available on a project.

Further investigation is needed to highlight the implications of linking specifications to BIM models in order to reveal any inconsistencies in producing a specification document.

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