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Increasing efficiency in 5D BIM by Utilising '*BIM Interoperability Tools – Classification Manager*' to append ICMS cost codes

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**Abstract** – This paper discusses **Building Information Modelling (BIM)**, notably the **5th Dimension of BIM**, which covers cost management functionality in the BIM workflow. The research proposes an efficient digitised workflow that can facilitate the appendage of an **International Quantity Surveying (QS) Cost Code** to a consistent parameter in the objects of the model. This paper firstly outlines how QSs are currently inserting 'user defined' information by adding their cost **Work Breakdown Structure (WBS)** to an existing parameter, such as the 'keynote' or 'assembly code'. The QS also has the ability to create a QS specific parameter (**QS IDentification**), by adding an additional shared/project parameter to the model. QS WBSs are usually specific to the jurisdiction of the project, such as the 'Uniformat' in the United States or the 'New Rules of Measurement' in the United Kingdom. The **International Construction Measurement Standard (ICMS)** is an international standard produced by a coalition of global cost management professional bodies. ICMS seeks to provide a global standard for cost planning and cost reporting, from project conception through to the operation of the finished project. A subsequent edition will relate the standard to BIM and provide a global digitised cost management schema. In preparation for an ICMS digitised schema, this research explores a change to the current 5D BIM workflow, whereby, the 5D BIM QS can utilise the '**BIM Interoperability Tools**' Revit Add-in, to efficiently append an ICMS cost code to a new **QSID** parameter in the object properties. This will provide efficiencies downstream in the QSs software providing users with the ability to extract **QTO** in line with these cost codes.

*Keywords* – BIM, building information modelling, international measurement standard, quantity surveying

## I INTRODUCTION

This research outlines briefly how different types of Quantity Surveying (QS) Work Breakdown Structures (WBSs), based mainly on the country or jurisdiction they cover, are used to breakdown construction costs into functional elemental cost holding categories. There is a new International Construction Measurement Standard (ICMS) which was first published in 2017, it provides a universal system for comparing international project costs within an international elemental schema. It is envisaged that this schema (or WBSs) will provide efficiency in international construction cost comparison and benchmarking. The review of literature also addresses the 5th Dimension (5D) of Building Information Modelling (BIM) and how a QS WBS can be embedded in BIM, to enable

automated Quantity Take-Off (QTO). In section IV the authors outline a number of different ways QS WBSs can be easily appended to the BIM in Autodesk Revit.

Autodesk [1] note that there is another, even simpler, way to assign classifications through a Autodesk Revit add-in tool known as 'Classification Manager'. This process provides the Revit user with an easier interface to assign codes and even add their own content via a custom database. This research outlines how the ICMS was built in the custom database of Autodesk's Classification Manager and assigned to objects in the model, to enable more effective automated QTO.

## II LITERATURE REVIEW

### a) *Standardisation in Construction Measurement*

The International Organisation for Standardisation (ISO) are the leading authority on the production of global standards [2]. ISO [3] notes that standards are strategic tools that reduce costs by minimizing waste and errors and increase productivity. The need for standardisation to address market requirements is accepted in many sectors as a means to help companies to access new markets, level the playing field for developing countries and facilitate free and global trade [4]. The World Trade Organisation (WTO) “obliges governments to use international standards as a basis for regulation, yet leaves a degree of flexibility with respect to the choice of standard, and the manner of its use” [5].

Standardisation in QS provides a consistent approach to cost planning and the production of Bills of Quantities (BOQs). Good practise in construction cost planning and cost control requires that the QS allocates the overall estimated costs into a number of cost holding categories known as ‘elements’ or WBSs. These elements are based on the functional components of the design, such as the substructure; external walls; internal walls and doors & windows [6, 7]. Different jurisdictions have alternative elemental classification categories but operate in a similar manner. In Ireland the elements are organised in accordance to the National Standard Building Elements (NSBE). In the UK these elements are arranged according to the framework from the Building Cost Information Service (BCIS). Elemental costs can be compared to the elemental totals in similar projects. They may also be compared to the cost of the corresponding element in the previous estimate to isolate areas in the design that could have increased/decreased in cost [6, 7].

Presently no single universal WBS or method of measurement is used by those responsible for the preparation or recording of construction costs [8]. The variance in standard WBSs on construction projects from region to region and even within different sectors of the construction industry can lead to discrepancies in cost comparisons.

### b) *International Construction Measurement Standards*

The property sector realised that a range of discrepancies existed in the measurement of both Gross Internal Floor Area (GIFA) and Gross External Floor Area (GEFA). To address this issue, the International Property Measurement Standard Coalition (IPMSC) was formed [9]. The first

property measurement standards for office buildings was produced in 2014.

Following on from the establishment of the IPMSC, it became apparent that similar issues existed in the construction sector. The inaugural meeting of the International Construction Measurement Standard Coalition (ICMSC) was held in Washington in 2015. The aim of the coalition is to “develop and implement a common standard for construction measurement which enhances transparency, investor confidence and public trust in the sector” [10].

A working group was established consisting of 27 independent experts from 17 different countries [10]. This working group is referred to as the Standard Setting Committee (SSC). The remit of the SSC is to draft and consult with industry on a new International Construction Measurement Standard (ICMS). The first ICMS was published in 2017, this provides a universal system for comparing international project costs on a “side-by-side” basis for the first time. The first edition of the ICMS establishes a basis for the comparison of international construction measurement costs, across the various construction sectors. For consistency, The ICMS took the definition of GIFA and GEFA as defined within IPMS.

In subsequent editions it is envisaged that the ICMS will be expanded for Life Cycle Costing (LCC) and the integration of construction cost information within BIM. Each of the organisations of the coalition have agreed to adopt and promote the use of the ICMS. The standard is backed by the United Nations (UN), International Monetary Fund (IMF) and the European Union (EU).

### c) *5D Building Information Modelling (5D BIM)*

Fung et al. [11] and Underwood & Isikdag [12] state BIM has the potential to foster efficiency in Architecture, Engineering and Construction (AEC), by changing prevailing 2 Dimensional (2D) work practices to technologies and processes that promote integration and collaboration across the construction disciplines. Eastman et al. [13] note that the BIM design application produces a 3 Dimensional (3D) visualisation of the building and is used by Architects to create the design. However 3D BIM is more than a 3D visualisation, because it is what is contained in the model, or the objects of the model, that is of importance, such as its u-value, fire rating, specification and potentially a QS Identification (QSID) or WBS.

Boon [14] and Ajibade & Venkatesh [15] determine that by appending time and cost information to 3D BIM, a 4 Dimensional (4D) time model and 5 Dimensional (5D) cost model can be produced, respectively. 5D BIM is the responsibility

of the QS and provides capabilities in the automation of QTO, which has the potential to save considerable time when producing cost plans and BOQs [16, 17, 18]. Sylvester & Dietrich [19] and Crowley [20] agree that with 5D BIM, practitioners can move from manual tasks such as measurement, to validating automated quantities and utilising them in their construction estimates. Wijayakumar & Jayasena [21] state that to carry out effective 5D BIM, QTO must be generated from the BIM to suit QS requirements and measurements rules. Matipa et al. [22] and Wijayakumar & Jayasena [21] define this process as ‘model mapping’, where the objects in the model have a QS WBS appended, so that when the quantities are generated from the model they are extracted per the QS WBS. Unfortunately BIM objects do not come pre-processed with a WBS, also known as a ‘QS Identification’ (QSID), thus, the QS must add these to the BIM themselves.

The QS WBS utilised on a 5D BIM project is dependent on the jurisdiction where the project takes place. As discussed in section II(a), there are many different WBSs depending on the country or jurisdiction they encompass. Monteiro & Martins [17] argue it would be near to impossible for BIM software manufacturers to add all the WBS codes into the objects, for every global standard, due to the amount of standards that exist. Current practice is that the QS adds these codes themselves in the 3D authoring application (pre-processing) or append them in the 5D estimating tool (post-processing), to suit the WBS they require [17 20]. Subsequently the QS can filter their QTO based on this WBS and create a coded cost estimate [23].

The ability of different BIM software varies in this regard, from being able to access and select model quantities, to comprehensive model mapping functionality, where users can define and edit rules or codes by which the quantities can be extracted [24]. If pre-processing was carried out by the Architect in their design software, even to just identify what objects are below ground or above ground, or to establish the QS WBS as a user defined parameter, this would be beneficial to the QS downstream.

Drogmuller & Tucker [23] state the most common method of carrying out processing of model quantities is in a 5D tool. However, some Architectural software, such as Autodesk Revit, has efficient functionality in this regard, providing users with a means to add a QS WBS to an existing parameter, such as the ‘keynote’ or ‘assembly code’. In Revit you also have the ability to set up a new project parameter or use the add-in tool ‘Classification Manger’ to simply select and assign a WBS. If these codes were appended in the design authoring application (either by the Architect or by the QS) the subsequent downstream extraction and validation of quantities would be significantly easier.

#### d) *Adding QSID in Revit (Pre-Processing)*

The following subsections briefly outline common ways a QS or Architect can add a QSID (QS WBS) to the model in Autodesk Revit. Video tutorials, prepared by the authors in conjunction with this paper, outline these methods in more detail and are available via the following You Tube link: [https://www.youtube.com/channel/UCBdgiUIQqg6s\\_pdzOOpA8SA?view\\_as=subscriber](https://www.youtube.com/channel/UCBdgiUIQqg6s_pdzOOpA8SA?view_as=subscriber)

#### Keynote

The Keynote parameter in Revit is set up by default to assign the MasterFormat number. The MasterFormat is a US specification classification schema and thus is not applicable outside the US. Autodesk [1] note that most people use this Keynote parameter to add their own custom information. The keynote is a text file (.txt) embedded in the programme files of Revit, it can be accessed via the ‘*Keynote Settings*’ in the ‘*Annotate*’ ribbon panel. Users have the opportunity to change the default MasterFormat, by copying the MaterFormat keynote text file, changing the content, and subsequently assigning the new text file to the project. The new revised keynote file can then be utilised to assign a more appropriate classification to any object or objects in the model. For more information on this click on the following YouTube link: <https://www.youtube.com/watch?v=ukzC4vKG0Pg&t=687s>

#### Assembly Code + Assembly Description

These parameters are used to assign the UniFormat cost classification structure. UniFormat is a US Cost WBS and is not relevant outside that jurisdiction. However, similar to the keynote, these text (.txt) files can be manipulated to suit any WBS. For example, the ICMS could be substituted by copying and amending the default UniFormat text file. This is carried out in the ‘*Assembly Code Settings*’ via the ‘*Manage*’ ribbon panel. The primary difference to the keynote, is that the assembly code is also linked to an assembly description, which correspondingly will be populated once the assembly code is selected. It is important that the same formatting is utilised from the original UniFormat text file, so as the new text file can be loaded without any errors. A good example of this is outlined in the following YouTube video:

<https://www.youtube.com/watch?v=ukzC4vKG0Pg&t=687s>

#### Adding a Project Parameter

The QS (or any Revit user) also has the ability to create a QS specific parameter (QSID), by adding

an additional shared/project parameter to the model. It is fairly common for additional parameters to be added to the object properties in the model, for example, a fire rating to a door or a u-value to a wall. Common practice in this regard, is to set up a ‘*Shared Parameter*’ in the ‘*Manage*’ ribbon panel. This shared parameter can be then assigned by adding it as a ‘*Project Parameter*’. This process makes available a user defined, i.e. QSID, in the type properties of the objects. For more information, click the following You Tube link: <https://www.youtube.com/watch?v=uP3pIeeILVc&t=179s>

#### Using Revit Schedules

By adding a QSID, via any of the methods outlined above, the user can select and assign a QS WBS to any or all of the objects in the model. This can be carried out by selecting the object, selecting all instances of that object and then assigning the QSID, by selecting the applicable Keynote or Assembly code or typing in the appropriate code into the relevant project parameter. To increase the speed of this process, it is recommended that the user sets up a material take-off schedule and appends the following fields; *family name*; *type name* and the *QSID*. Once a schedule is set up, the QSID can be easily coded in the schedule by selecting an object (or group of objects) and assigning the code to the relevant field.

#### Classification Manager

Autodesk [1] note that the processes outlined above are effective, but they have developed an add-in tool (Classification Manager) which they claim provides greater efficiency and flexibility to adding QSIDs to BIM. This process provides the Revit user with an alternative to the other methods outlined in section II(d), by providing users with an easier interface to assign codes and even add their own content via a custom database. Section IV below outlines how the ICMS was built in the custom database of Autodesk’s Classification Manager and assigned to objects in the model.

### III METHODOLOGY

Design science was selected as the research strategy because there was significant participation from the researcher proposing a technological solution to a practical problem. Johannesson & Perjons [25] state in design science a ‘solution’ to a field problem takes the form of what is known as an artificial construct (‘artifact’), which they describe “as an artificial object made by humans to solve practical problems”, i.e. a ‘technological solution’ that can affect change in human behaviour.

Hervner et al. [26] state that in design science research learning must be specified clearly by

articulating the proposed process in creating the practical solution. In this research, section IV outlines a process that assigns a QSID utilising Autodesk’s BIM Interoperability Tools.

Hervner et al. [26], Holmstrom et al. [27] and Johannesson & Perjons [25] all articulate well defined frameworks for a design science methodology, albeit using different terminology. These strategies outline four common phases; 1. diagnosing a problem; 2. proposing (developing) a solution; 3. implementing the solution & evaluating the process in action; and 4. specifying learning. In this paper the first 2 phases of a design science research strategy is presented. The review of literature presents the background and context of the research and outlines a number of ways a QSID can be added to BIM. The following section articulates a different 5D technological process utilising Autodesk’s ‘Classification Manager’. This is proposed as a design science technological solution while subsequent research in this area will include primary research to evaluate the solution in action.

### IV RESEARCH PROJECT – CLASSIFICATION MANAGER

Autodesk [1] note in their whitepaper that ‘Classification Manager’ is a “user-friendly add-in for Revit that allows people to easily organise and manage classification data across multiple Revit models, no matter which system is used”. The classification data that comes with the add-in can be applied to Revit elements from classification schema such as UniFormat, MasterFormat, OmniClass and UniClass. This Revit add-in also allows the user to create their own classification schema from editable MicroSoft (MS) Excel custom spreadsheets. Classification Manager and all its associated program files, including the classification databases, can be downloaded for free from [www.biminteroperabilitytools.com](http://www.biminteroperabilitytools.com). The following steps outline how ‘Classification Manager’ can be utilised to create a custom ICMS database and subsequently to assign codes from that database to an applicable parameter in the object properties of the model.

#### a) *Downloading Classification Manager and Setting up ICMS database*

Firstly as noted above, Classification Manager can be downloaded from <https://www.biminteroperabilitytools.com/classificationmanager.php>. Illustrated in Figure 1, ‘Classification Manager’ is then available (as an add-in tab) in the ‘BIM Interoperability Tools’ panel of Autodesk Revit.



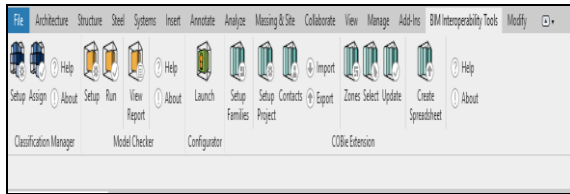


Fig. 1: Screenshot of Classification Manager in Revit

Once Classification Manager is downloaded, a number of Classification Excel Databases can be accessed in the Autodesk program files (*Program Files/Autodesk/BIT/2019/Classification Manager* – Figure 2), such as the US classifications schema, MasterFormat & OmniClass, and the UK’s UniClass classification. Also available, is a ‘Custom’ database, where users can add their own specific data or jurisdictional coding structure.

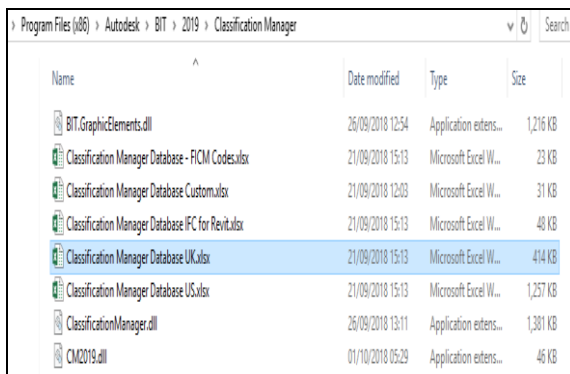


Fig. 2: File Location in Autodesk Program Files

The authors utilised this functionality, by inputting data from the ICMS into ‘*Classification Manager Database Custom.xls*’. An example screenshot of the completed ICMS database is illustrated in Figure 3. The spreadsheet comprises of column A which includes the ICMS codes; column B which outlines an associated code description and column C which sets out the hierarchy of levels to the codes and descriptions. Rows 1 through 6 contain the name of the database and the name of the parameters of the classification schema (in this case ICMS). It is important that the ‘*Number Parameter*’ and the ‘*Description Parameter*’ fields are filled out in B5 and B6 respectively.

|    | A                     | B  | C     |
|----|-----------------------|--|-------|
| 1  | TITLE                 | ICMS Building  |       |
| 2  | DESCRIPTION           | International Construction Measurement Standard - Building                         |       |
| 3  | VERSION               | Version 1  |       |
| 4  | FUNCTION              | Element  |       |
| 5  | NUMBER PARAMETER      | Classification.ICMS_B.Number   |       |
| 6  | DESCRIPTION PARAMETER | Classification.ICMS_B.Description  |       |
| 7  | NUMBER                | DESCRIPTION  | LEVEL |
| 8  | ICMS Building         | International Construction Measurement Standard - Building (Version 1)             | 1     |
| 9  | 1                     | Capital Construction Costs   | 2     |
| 10 | 1_01                  | Demolition, site preparation and formation   | 3     |
| 21 | 1_02                  | Substructure   | 3     |
| 44 | 1_03                  | Structure  | 3     |
| 45 | 1_03_010              | Structural removal and alterations   | 4     |
| 46 | 1_03_020              | Basement suspended floors (up to top of ground floor slabs)                        | 4     |
| 47 | 1_03_020_010          | structural walls and columns   | 5     |
| 48 | 1_03_020_020          | beams and slabs  | 5     |
| 49 | 1_03_020_030          | staircases   | 5     |
| 50 | 1_03_030              | Frames and slabs (above top of ground floor slabs)                                 | 4     |
| 51 | 1_03_030_010          | structural walls and columns   | 5     |
| 52 | 1_03_030_020          | upper floor beams and slabs  | 5     |
| 53 | 1_03_030_030          | roof beams and slabs   | 5     |
| 54 | 1_03_030_040          | staircases   | 5     |
| 55 | 1_03_030_050          | fireproofing to steel structure  | 5     |
| 56 | 1_03_040              | Tanks, pools, sundries   | 4     |
| 57 | 1_04                  | Architectural works   Non-structural works   | 3     |
| 58 | 1_04_010              | Non-structural removal and alterations   | 4     |
| 59 | 1_04_020              | External elevations:   | 4     |
| 60 | 1_04_020_010          | non-structural external walls and features   | 5     |
| 61 | 1_04_020_020          | external wall finishes except cladding   | 5     |
| 62 | 1_04_020_030          | facade cladding and curtain walls  | 5     |
| 63 | 1_04_020_040          | external windows   | 5     |
| 64 | 1_04_020_050          | external doors   | 5     |
| 65 | 1_04_020_060          | external shop fronts   | 5     |
| 66 | 1_04_020_070          | roller shutters and fire shutters  | 5     |
| 67 | 1_04_030              | Roof finishes, skylights and landscaping (including waterproofing and insulation); | 4     |
| 68 | 1_04_030_010          | roof finishes  | 5     |
| 69 | 1_04_030_020          | skylights  | 5     |

Fig 3: ICMS codes input into ‘Classification Manager Database Custom.xls’

b) Adding ICMS Classification Parameters to Revit

The next step in this process is to add parameters into the Revit Model for the ‘*Number Parameter*’ (cell B5) and the ‘*Description Parameter*’ (cell B6) from the custom ICMS database (Figure 3). It is important that these are added as ‘*text*’ parameters and are exactly the same name in Revit as they are in the Excel database, otherwise they cannot be populated. In this research a ‘*shared*’ text parameter was added in the Revit Model for ‘*Classification.ICMS\_B.Number*’ and ‘*Classification.ICMS\_B.Description*’. Subsequently these shared parameters were applied as ‘*project*’ parameters in the model. Once this is carried out, these two parameters will be available in the object properties of the model, as illustrated in Figure 4 in the ‘*Text*’ fields.

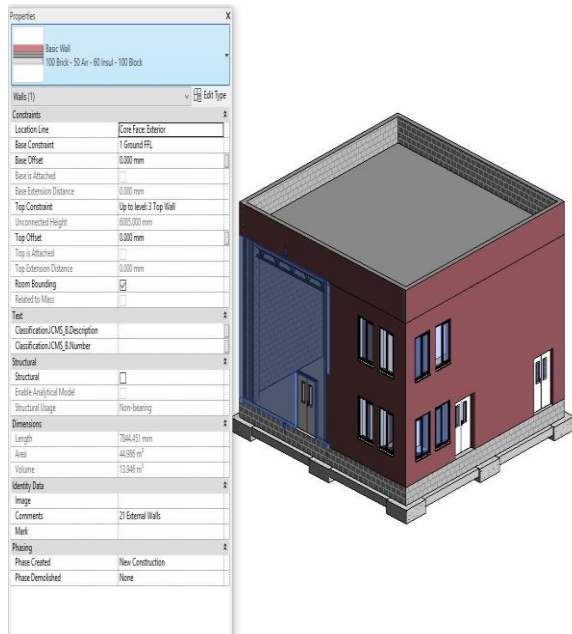


Fig 4: ICMS Project Parameters added in Revit

c) *Setting up ICMS database*

The next steps, illustrated in Figure 5, outlines how to setup the ICMS database in the model. Firstly the user must click the 'BIM Interoperability Tools' (1) panel; select 'Setup' (2) in Classification Manager; then 'Browse' (3) to the location of the Custom Excel file and then click 'Finish' (4). This process links the custom ICMS database to the project model and now the user can assign the ICMS codes to the model.

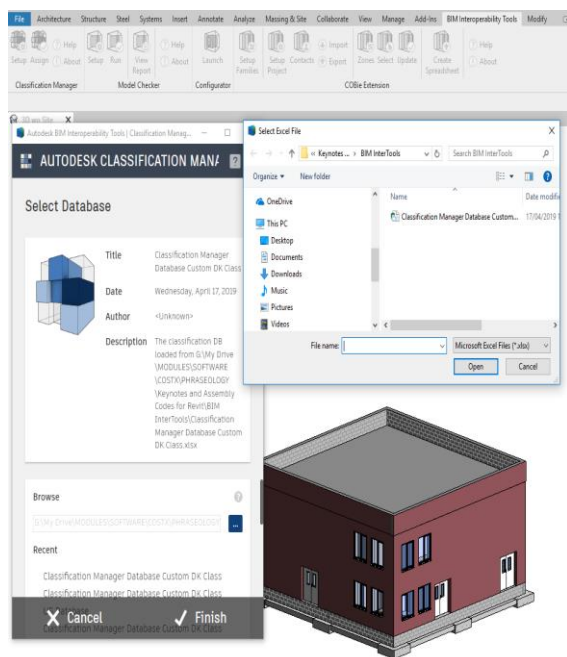


Fig 5: Setup ICMS database in Revit

d) *Assign ICMS Codes*

To assign the ICMS codes, the user must select the object that they intend to code (one of the external walls is selected as an example in Figure 6) by clicking 'Assign' in 'Classification Manager'. The database is then available for coding. The hierarchy level that was established via column C in Figure 3, provides a means to navigate through the codes and code descriptions. By clicking the relevant code (i.e. 1\_04\_020\_010 – non-structural external walls and features) both the ICMS number and description are populated in the object properties.

An easy way to carry this out is to set up a Revit schedule that includes both the ICMS number and ICMS description parameters and subsequently code the objects by highlighting applicable groups (i.e. walls, doors, etc.) of objects and assigning the codes en-mass.

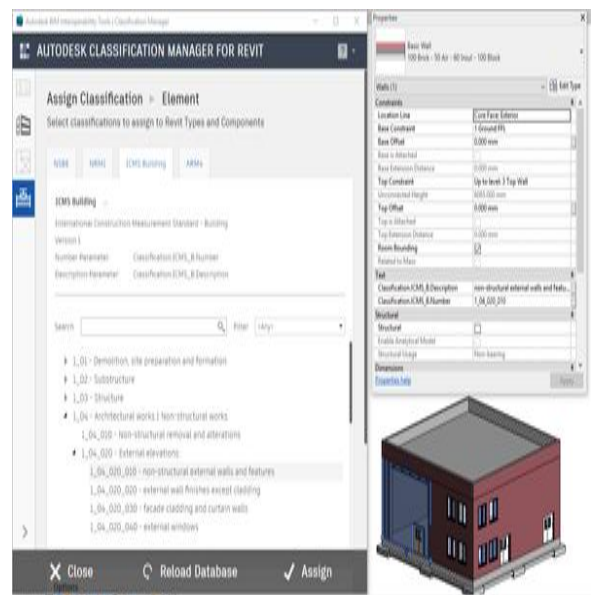


Fig 6: Assign ICMS Codes in Revit

V CONCLUSIONS AND RECOMMENDATIONS

This research addresses standardisation in QS WBSs and how the ICMS classification schema can be embedded effectively in BIM, utilising Autodesk's Classification Manager add-in. The review of literature outlines that there are many different types of QS standard WBSs published by numerous countries or jurisdictions. These WBSs are used to breakdown construction costs into functional elemental cost holding categories. The ICMS was first published in 2017 [10] and provides a global schema for comparing international project costs. It is hoped that this ICMS will provide efficiency in international construction cost comparison and benchmarking.

The review of literature also addresses 5D BIM and how a QS WBS can be embedded in BIM to

enable automated QTO. In section II(d) the authors outline a number of different ways QS WBSs can be easily appended to the BIM in Autodesk Revit.

This research illustrates and articulates an alternative approach in section IV utilising Autodesk's 'Classification Manager'. This process provides the Revit user with an easier interface to assign codes and even add their own content via a custom database. From a design science methodology perspective it outlines a technological solution to a practical problem. Future research is proposed to evaluate this technological process in action through subsequent primary research.

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