Could Autodesk Revit Be Automated for Code Compliance Checking and Demonstration with A Focus on Fire Safety Regulations?

Ross Harrell
Technological University Dublin, C11377066@mydit.ie

Malachy Mathews
Technological University Dublin, malachy.mathews@tudublin.ie

Follow this and additional works at: https://arrow.tudublin.ie/bescharcrep

Part of the Architectural Technology Commons

Recommended Citation
2018-05-01

Could Autodesk Revit Be Automated for Code Compliance Checking and Demonstration with A Focus on Fire Safety Regulations?

Ross Harrell
Malachy Mathews

Follow this and additional works at: https://arrow.dit.ie/bescharcon
Part of the Architectural Technology Commons
Could Autodesk Revit Be Automated for Code Compliance Checking and Demonstration with A Focus on Fire Safety Regulations?

Author 1: Ross Harrell  
Author 2: Malachy Mathews  
School of Architecture  
Technological University Dublin, Ireland  
E-mail: Author 1 C11377066@mydit.ie Author 2 malachy.mathews@dit.ie

Abstract

Often a subject to ambiguity and interpretation, building codes and compliance with them require years of expertise to understand and to integrate into good design. Automation of code compliance through Building Information Modelling (BIM) removes the human aspect from these processes and ensures building codes are correctly adhered to. In this paper, the author reviews current code compliance systems implemented internationally and, with a focus on fire codes, compares them to the current fire certificate application in The Republic of Ireland. By conducting interviews with an Executive Fire Prevention Officer of Dublin Fire Brigade and a Fire Consultant practicing in Ireland, the author determines the process of the two professionals and attempts to automate the demonstration of compliance for 4 items from these processes. The author attempts to contain these solutions within a Revit Template File. By doing so, the solutions can be applied to any number of BIM models, demonstrating compliance for each design and, in turn, making a leaner compliance checking process for designers. By checking 4 items from the processes the author hopes to show that in theory, Revit can be automated for code compliance checking and demonstration.

Key Words: Fire Safety, Automated Building Code Compliance, Revit.
1. Introduction

Building codes are often subject to ambiguity and interpretation on a life experience basis. To break down these building codes to their most basic form so that a computer can understand and decipher whether a building design complies with them ensures that all designs are judged equally and not left to human judgement, which can be prone to error (Preidel & Borrmann, 2016). Automated code compliance checking can be difficult as the domain experts, familiar with the codes, often do not demonstrate a level of competency in computer code-writing that would allow them to manipulate software to execute tasks they require. This, therefore, creates a disconnect between the software and the end-user. Using an industry-leading architectural BIM tool, Autodesk Revit 2018, the objective of this paper is to demonstrate that compliance with part B of the Irish Building Regulations (Fire Safety) of a BIM model can theoretically be demonstrated using the on-hand tools provided by the software.

In light of recent disasters such as the Grenfell Tower fire in London or incidents closer to home, such as the instance of fire safety audits commissioned by the Department of Education have found breaches of fire safety standards at five recently-built primary schools in Ireland (RTÉ, 2017), It is time we moved beyond relying on manual checking of building designs for code compliance. The building codes can be ambiguous in wording and people can be subjective towards them, leading to misinterpretation and inconsistent understandings of compliance (Preidel & Borrmann, 2016)

Designers use a handful of software packages with the same underlying principles, for example the likes of Autodesk’s Revit and Graphisoft’s Archicad start project files from template files, which can host project standards, styles and in Revit’s case, families, which minimise project setup time once used. BIM software can report parametric information to the user. The goal of this paper is to show that if compliance data can be extracted from the model and relayed back to the user to demonstrate compliance, building codes, with a focus on fire safety regulations, can be automated within these BIM software tools, specifically focusing on Revit 2018.

2. Research Objectives

The research objectives of this paper are as follows:

2. Interview two parties, public and private sector, to understand current practices and determine clauses of the regulations or elements of the fire certificate application which could be automated.
3. Create a Revit project template to report on model geometry and parameters and critically evaluate this from the perspective of the end user, in the process, testing it on two BIM
models of various scale to inform the evaluation.

3. Literature Review (cite references)
A study by Fiatech confirmed that when human interpretation is involved in the code compliance process, inconsistencies are expected (Solihin & Eastman, 2015). Solihin & Eastman state that an officer’s experience and locality often colour their judgement and understanding of the building codes they are checking a design against. This is why we must move towards automation of code compliance. However, Dimyadi says “human intuition and human expert knowledge often play a significant role in the design” but believes these clauses cannot be easily captured as rules (Dimyadi, 2016). As found in Australia during the inception of DesignCheck, it was found that some clauses required intrinsic information to be extracted from the design, which is “difficult if not impossible” to acquire all of the required information at once. It seems the current systems used internationally such as DesignCheck, E-PlanCheck and the USA SmartCodes all deal with more prescriptive building codes.

In creating the systems reviewed later on in this paper, there is a disconnect where the software developers are not the ones directly involved in the rule interpretation (Solihin & Eastman, 2015). A very limited number of design and fire professionals are trained to understand scripting. As noted by Solihin, clauses within the building regulations often seem easy to implement, however this is not the case. This is because many of the clauses are non-prescriptive. (Solihin, 2004)

An issue being addressed in recent years is the output from the models produced by designers. The level of complexity of information to be extracted from the design does not exist with IFC models (Balaban, Kilmci, & Çagas, 2012). This problem is exacerbated by the fact that the conventional rule based approach used by software like Solibri does not suit a lot of clauses as “they cannot be easily captured as rules” (Dimyadi, 2016). It is necessary to analyse the clauses in the guidance documents and prioritise the prescriptive ones that would suit rule-based checking systems, reducing the amount of manual checking required.

3.1. Current Practice in The Republic of Ireland
- According to the Building Control Act of 1990, applicants are required to submit the following supplementary documents along with their Fire Certificate Application:
  - A Site/Layout Plan.
  - A block plan, showing the surrounding area and site entrances.
  - Floor plans for each storey of the building in question.
  - Elevations of each façade.
  - Sections. • A specification document that outlines the fire safety measures required to comply with the requirements of Part B.
These are submitted as 2D drawings in hard copy format. Each element has a long list of requirements to demonstrate compliance with the building regulations. Using the tools provided in Autodesk Revit 2018, the production of the required drawings can be quite easily produced in their current required format.

3.2. International Code Compliance Checking

3.2.1 CORENET
As far back as 1995, the Ministry of National Development of Singapore and the Building Control Authority tried to realise automated code compliance checking with the use of the Construction and Real Estate Network (CORENET) (Teo Ai Lin & Cheng Tai Fatt, 2005). The initial aim was to “streamline the fragmented work processes in the construction industry” (Teo Ai Lin & Cheng Tai Fatt, 2005).

It provided a “necessary infrastructure for exchange of information” between the construction team and regulatory authorities, similar to the that of a Common Data Environment (CDE). CORENET allowed for designers to carry out code compliance checks as well as the regulatory officers to undertake audits on the designer’s submissions.

3.2.2 E-Plan Check System
This system was the evolution of the CORENET system from 1995, evolving to carry Industry Foundation Class (IFC) 2x2. Incepted in September 2000 (Khemlani, 2005) with a look to “lay the foundation for the impending change” of 2D to 3D in the AEC industry (Teo Ai Lin & Cheng Tai Fatt, 2005). The adoption of IFC files was to ensure the longevity of the system as an increasing number of CAD vendors adopt it. However, the IFC model is not enough for the Artificial Intelligence of E-PlanCheck to confirm compliance with Singapore codes. This is because “the IFC model only represents the basic building information that can be modelled by a BIM application during the design stage” (Khemlani, 2005).

DesignCheck employs a platform called the EXPRESS Data Manager (EDM) which contains data models and schemas. In particular “rule based schemas which define rules to validate models using the EXPRESS language” and “defines entities, rules, functions and procedures based on the building code” (Lee, Lee, Park, & Kim, 2016). An independent platform called FORNAX is used to apply higher level semantics relevant to code checking requirements. Otherwise, the IFC would represent a collection of spaces in E-PlanCheck with no relationships to one and other.

3.2.3 Australia DesignCheck
DesignCheck is similar to E-Plan Check in that it enables easy code compliance assessment for designers, aiming to reduce the risk of non-compliance by removing the human element of code checking (Ding, Drogemuller, Rosenman,
Marchant, & Gero, 2006). However, it is focused on accessibility code compliance of the design. DesignCheck can produce intermediate results for the earlier design stages to ensure compliance throughout them and produce a final compliance report for the at the completion stage of the model. The intermediate checks are checked against different rule sets: Early, Detailed and Specification stage design rules, as designers have “different interests and concerns” at each of these stages (Ding, Drogemuller, Rosenman, Marchant, & Gero, 2006).

It is worth noting, that like the CORENET system and E-PlanCheck system, DesignCheck’s main interface is housed in a Java application outside the user’s design tools. Similar again, it accepts exported IFC files, requiring the user to leave their BIM tool and make changes after the report is received.

3.2.4 ByggSøk Norway

Norwegian designers in 2009 adopted CORENET’s e-PlanCheck and tested against several hospital and housing projects in Norway, Denmark and Finland to test for planning and zoning compliance (Henttinen, Sunesen, & Building SMART, 2010). Using a combination of E-PlanCheck and Solibri Model Checker the designers performed spatial and accessibility checks on the models, using a black-box approach (Lee, Lee, Park, & Kim, 2016). This is a term used in software testing where the functionality of that software is tested without peering into its internal structures. As noted by Henttinen, Sunesen & Building SMART, professionals within the industry have a hard time accepting compliance reports from a system when they cannot see the process but do not want to delve deep into the inner workings of a program to perform these kinds of checks (Henttinen, Sunesen, & Building SMART, 2010). It must be determined to what level a “black box approach” is acceptable.

3.2.5 USA International Code Council SmartCodes

Work consistent with Norway began in the USA in 2000 with an emphasis on health, safety and welfare (Malsane, Matthews, Lockley, Love, & Greenwood, 2015). SmartCodes was an initiative driven by the International Code Council (ICC), AEC3 and Digital Alchemy. This initiative focused on the translation of paper-based codes to machine interpretable rules. A customised .XML file editor allowed building code officials to highlight objects, their properties and constraints, a methodology to assist in marking up electronic copies of building codes. (Malsane, Matthews, Lockley, Love, & Greenwood, 2015) This built up a library of properties which resulted in consistency of building code terminology, reducing individual interpretation. These rules can be applied through Solibri Model Checker or similar BIM tools.

All of the above strategies require the use of a BIM tool in which the design of the model does not take place. Exporting the model to receive a report on the compliance of the design may lead to errors such as human error in overlooking a part of the report. This is with
exception to CORENET’s E-PlanCheck. Using a Revit Template, EPlanCheck allow the designer to see compliance with accessibility codes as they design and allow the designer to iron out these issues without the need to export to IFC or XML, keeping the model in its native format. A guide provided by the Building and Construction Authority of Singapore assists “qualified persons in developing BIM models to meet the new requirements of (BIM) submission” (Ann, 2016). It shows designers how to use the BIM template provided by the organisation to prepare for submission.

3.3. Recent Developments in Code Checking

The fire protection industry has known and been using very limited forms of BIM years in advance of Architects and Structural Engineers (Gregory & Shino, 2013). 3D modelling has been used to design active fire suppression systems such as sprinkler and alarm systems. Customised programs allow for hydraulic calculations, scheduling of system components and development of structural supports for these systems before the adoption of BIM by the AEC industry. Since these tools were only used by the fire protection industry and not much more than 2D outputs went to the design teams, the benefits were only seen by the consultant, saving them hours of manual work which significantly improved the designer’s efficiency with the use of automation (Gregory & Shino, 2013).

With the introduction of project review software such as Autodesk Navisworks and Solibri ModelChecker, 4D BIM allows designers to coordinate architectural, structural and mechanical model designs are harmonious ensuring any design issues are assessed prior to construction. One such issue, take-off of compartment wall penetrations is easily resolved through this process. Traditionally, fire stopping of these penetrations would be calculated for tender by “applying a simple rule of thumb percentage of the overall project cost” or “by comparing 2D M&E and architectural plans” (Yeo, 2018). Compartment walls are simply grouped together within Solibri and using user-defined “rules” within Solibri, penetrations from the M&E model can be scheduled against the compartment wall “group”, giving an accurate indication of requirements for fire-stopping within a building design, reducing risk and increasing cost accuracy.

![Figure 1: Coordination of Architectural, Mechanical and Sprinkler models through Navisworks (3D Fire Design, LLC, 2017)](image1)

![Figure 2: Development of rules run penetration check. (Yeo, 2018)](image2)
Adoption of BIM tools by architectural and structural designers has allowed the development of passive fire suppression design to gain traction within 3D modelling (Gregory & Shino, 2013). Building elements which are commonly seen as the architect’s responsibility to design such as walls and doors and elements seen as the fire consultant’s responsibility such as dampers and penetration sealants, are now being fed information within the BIM, through the use of parameters. This means that the door or wall now hosts information such as its thermal properties, unique identification number and fire resistance. This information can then be easily demonstrated through the use of filters that are applied to views within a model. This information can be utilised by designers using workflows as described above used by Yeo. They can establish if the limit the number of penetrations allowed by the building regulations has been exceeded (Gregory & Shino, 2013).

Other BIM tools, such as visual scripting tool Dynamo, can be used to assess building code compliance. Dynamo is an open source programming environment which “enables designers to create and explore parametric conceptual designs and automate tasks” (Autodesk, 2018). This has created a community that shares scripts which can be downloaded and modified to suit the user’s needs. This tool can be used, for instance, to undertake a fire exit risk assessment of a building design as demonstrated by Vermeulen. Data is fed into the model such as room function parameters, whether or not the rooms function is for circulation (e.g. a lobby or corridor), and giving each door a specific value for “exit type” parameter (normal exit or emergency exit). Vermeulen then creates a custom script which results in Dynamo calculating the shortest route between these two door types. The result is output in the form of an evacuation plan, in which the Dynamo curves are translated to detail lines in Revit (Vermeulen, Fire Exit Risk Assessment with Revit and Dynamo, 2017).

4. Methodology
Beginning with the understanding of current practice in the Irish AEC industry, the author made it a priority to interview two professionals working in this domain. These professionals were a Fire Safety Consultant and an Executive Fire Prevention Officer, both practicing in Ireland. The reason for this is to acquire an understanding of their processes in determining a buildings compliance with Fire Safety Regulations, how they differ being Public and Private practices and whether there are elements of the processes that are manual or automated in the present day. From the interview with the interviewees, it will be determined by the author which elements can be improved and reduced to create a leaner process which would save the designer and
consultants time, if possible. The author will try to understand the process that is undertaken once each party receive the drawings and fire certificate application from the Architect and how this process could be improved with the introduction of BIM tools and procedures.

By culminating the two interviews, a review of the results will determine 5 elements of the two processes which could be enhanced by the use of BIM software. By attempting to automate these 5 elements through BIM tools, the author will then decide through a series of tests on two models, residential scale and commercial scale, if this could theoretically be implemented across all elements of the building regulations, deeming the experiments a success or a failure through these tests.

As this paper is intended to provide an “innovative BIM solution and evaluate it in a work setting.” (Kehily & Underwood, 2015), it is intended to use the “Design Science” method of research. The solution will be delivered in the form of an “ITC solution” for the Built Environment Industry but will also be a “partial product rather than a fully realised ready for business ICT solution” which aligns with the suggestion of Kehily & Underwood in using the Design Science research method.

The software the author has chosen to use is Autodesk Revit 2018. This was decided based on the authors experience with the software, having used it in a commercial architectural practice for three years and having used the software for a total of seven. The prominence the software in the Irish AEC industry was also a deciding factor. As is common knowledge amongst Revit users, Project Template files, extension “.rte”, host a number of elements including view templates, loaded families, defined settings (units, fill patterns, line styles, view scales etc.) and geometry (Autodesk, 2015). It is thought that a project template could be constructed similar to that used currently by CORENET in Singapore for e-submission preparation. This template would be used as a basis for future fire certificate applications in Ireland to streamline and digitalise the application process. The template will house the necessary elements required to demonstrate compliance or noncompliance with five chosen elements of the fire safety regulations, determined from the interviews as the most suitable to be delivered through BIM tools. Once the template is constructed, two projects have been chosen to test the template on, a fictitious residential building designed using Revit and a BIM model of a live building project in Dublin, Ireland. The models will be loaded into the Revit template with the desired outcome being that model views will demonstrate compliance with fire safety regulations. Using a quantitative research method, it will be visible whether the methods chosen to demonstrate compliance have done so successfully.

5. Results and Conclusions

5.1 Interviews
As a prerequisite to the development of the BIM template, a Senior Executive Fire Prevention Officer (FPO) from Dublin Fire Brigade (DFB)
and a private Fire Safety Consultant (FSC) were interviewed using a “structured” interview style. This would form the basis for prioritising the development of certain code automation within the template. It would also provide the answers to the same questions from both parties. The FPO from DFB was interviewed first. The author intended the interview to take a quantitative style however the FPO guided the interview into a qualitative style with interesting insights into the topic. The interviewer begun by asking about the FPO’s own experience and background and to state his job role, he had, at the time of the interview, been working for DFB since 2002, amounting to 16 years in the current role. They assess fire certificate applications, deal with licencing application and facilitate the enforcement role for the fire service. The FPO then explained the process that is undertaken when a fire certificate application is received. There are two aspects to the application process:

- **Validation:** This takes the form of a checklist exercise to ensure a complete set of drawings are received accompanied by a compliance report, explaining how the building and system design complies with the regulations. This stage is also used to ensure that the right guidance document has been referred. If the application does not meet these requirement the application can be invalidated with the application and fee returned to the applicant.

- **Assessment:** This is a huge process which the FPO found hard to encapsulate into a single line description:

  “it’s a huge process, I think even if you were to watch me undertake an assessment over my shoulder I’d have a hard time explaining to you, step by step, the process that is happening in my head. The process relies on years of experience.” (Executive Fire Prevention Officer with Dublin Fire, 2018)

  In this case, if the application failed, the application and fees would not be returned.

  It was noted that the DFB has ISO 9001 accreditation. This requires a company to outline their set of working procedures and document these procedures. When it came to describing the assessment process, it states “the fire officer will perform his assessment”, so to an outsider, it is still quite unclear even when written down. (Executive Fire Prevention Officer with Dublin Fire, 2018)

  The interviewer then asked the FPO for examples within his process of checks that are still manual or tedious to undertake that would be open to automation. He replied admitting there is scope to improve productivity by streamlining aspects of the process. Currently in within DFB, there are elements of automation already taking affect. He believed difference of opinion between FPOs on
regulations and guidance needs to be addressed and stated that DFB has been “developing a standard set of procedures and guidance notes for situations that are encountered regularly within applications. Dublin City Council (DCC) are driving towards automation, automating areas of Building Control, the FPO gave the example of the BCMS system, using surveying tools to automate the production of standard site inspection reports. To answer the interviewer, the FPO gave three examples where automation may be possible:

1. Diagram 17 in TGD Part B: Compartmentation
2. Section B2 of TGD Part B: Material Classification
3. Requirement of hose rails within a retail unit over 500m² (one per 500m²)

Interestingly, a hard copy set of drawings are received and compared against the consultants’ drawings to make note of any discrepancies between the two sets. This task is completed before the FSC would check the drawing for compliance with the building regulations. This seems quite primitive. This process is similar to that of the FPO’s two-stage process, Validation that the drawings meet the minimum requirements of the professional in each instance before moving onto stage two where the compliance checking begins. However, due to the level of authority of the FSC within their firm, if there is any level of uncertainty they would consult with senior staff to clarify the issue. This was not the case with the FPO as their number of years of experience and seniority within DFB lend them an advantage in this case.

When asked about the manual aspects of their checking procedure, the FSC made note that checking fire ratings of walls and doors, ensuring clear openings are compliant, ensuring that travel distances comply, checking critical dimensions of stairs are time consuming. However, the most time-consuming element of their process is the analysis of external spread of fire. The FPO believed that the checking of fire ratings for materials and external fire spread conditions could be automated and would trust if these elements were automated for designers.

Similar to the FPO, the FSC stated they wouldn’t rely on automation as in many cases the solution for fire code compliance is not “straight forward” and “required interpretation
in different ways” (Fire Safety Consultant, 2018). There are so many elements within a building design that are interdependent in relation to each clause within Part B that would “allow an automation of code compliance to be used instead of traditional” methods such as “sitting down, manually checking and reviewing the fire strategy”. It seems the desire is there for automation to develop but a lack available time from the public or private sector to develop a system by which this can become a reality.

“How do you bring the years of practical experience to that a fire officer is applying to his decision making?” (Executive Fire Prevention Officer with Dublin Fire, 2018)

By rewriting the codes so that they are prescriptive? Because the codes are not black and white, many building designs require a fire engineered solution due to the ambiguous nature of clauses within Part B of the regulations. Prescriptive codes are far better suited to code compliance checking systems as suggested by Dimyadi, 2016. He also states in his research, aligning with the FPO’s views, that “human intuition” and “expert knowledge” often play a significant role in design, but they cannot be easily captured as rules” (Dimyadi, 2016). The author deduced, based on this research and the two interviews, to limit the scope of the paper to prescriptive clauses within Part B of the regulations.

5.2 Revit Template

To prepare the BIM template for testing, guidance was followed as per Autodesk Knowledge Network in setting the template up initially. The Architectural Revit Template was used as the base file for the Fire Code Compliance Template. To begin, line styles, such as fire egress paths, were created. Basic wall types were made, for designers to build upon, named “generic non-fire-rated”, “½ hour”, “1 hour” and “2 hour” with generic materials. This part would require the designer to input the specific materials, however the wall types have fire ratings designated to them in the “fire rating” parameter input.

Figure 4: Type Properties for “Generic - 1 Hr” Wall Type.

Standard annotation families that are preloaded into the template were then modified by the author to convey information relevant to the fire certificate application. This required the addition of labels to represent fire ratings as defined in the properties of the wall types set up earlier.
Views were then set up for the fire certificate application. This includes plans, sections and elevations of the test building, as seen above. View templates would be applied to the views to automate the creation of these views for the designers.

5.2.1 Rated Walls and Doors
According to the Building Control Act of 1990, demonstration of fire ratings of building elements should be demonstrated within the application. As discussed with the FPO from DCC, this is generally demonstrated through the use of a colour code overlaid on the walls shown on plan drawings. Through the use of filters within Revit, the author applied a “rule based” filter to the created plan views. The author instructs Revit to apply a solid hatch pattern to the wall elements depending on what is entered in the “Fire Rating” parameter field as applied prior to this stage. This can be included within a view template, which can then be applied to other drawings, automating this process for future projects.

As seen below, once these filters are created an applied to the plan view, fire ratings of walls are clearly indicated for evaluation by a professional. To demonstrate the fire rating of the doors, the tags created earlier on during setup clearly display the fire rating of the door type.

Using the above processes, compartmentation can be demonstrated through the use of views with rule based filters applied. This can relay
back to the user the rooms which are designated for compartmentation but are not completely enclosed by building elements that reach the required fire rating for compliance with regulations.

**5.2.2 Evacuation**

As discussed previously in the paper, Dynamo’s open-source nature has led to a community of users sharing their scripts to perform mundane to extraordinary tasks. The following script, created by Vermeulen, 2016, allows the user to analyse the total length of a model line within Revit and run it against an analytical display style hosted in the view template applied.

Once the exit door is selected and model lines placed, the script can be run. The script divides up the total length of the model line into meter-long intervals which can be read by the analytical display styles already hosted within Revit. In the example below, the author uses, for the sake of demonstration, the single direction maximum travel distance for office spaces, 18m, to display a visual indicator of a non-compliant travel distance (see Figure 11). This is then rectified, with the additional evacuation path added into the model and the script re-run, resulting in a maximum travel distance of 45m, which is changed in the analytical display style, showing a compliant building design (see Figure 12).

**5.2.3 Occupancy Load Calculation**

Using Dynamo scripts, the calculation of occupancy loads can be automated. The following script requires the user to select the room in question and input the allowed square-
meters per person. This figure is the same as the occupancy load factor that is given in TGD Part B Table 1.1.

**5.2.4 Clear Opening Width (Doors)**

To display clear widths of door openings, this can either be achieved by placing a door tag with the parametric data displayed through the use of a label, or the information can be displayed as a column within a schedule. The author, created a door schedule with the relevant information displayed, using conditional formatting within Revit, to reveal non-compliant door types within test model 1 (see Figure 15).

This schedule can then be saved as a view within the template to be automatically available in future projects. It can clearly be seen from the process in Figure 15 the doors that are non-compliant with BS 9999:2017, Fire safety in the design, management and use of buildings. Code of practice, which the Technical Guidance Documents makes reference to. It states that doors must have a minimum clear width of 800mm (British Standards Institute, 2017). The doors shown on the resulting schedule in red are doors with non-compliant clear widths.

**5.3 BIM Model Test**

To test the Template file, a live BIM model for a current building project in Dublin will be used. This is a 5 storey, office block in Dublin, modelled to a Level of Detail (LOD) 200. This means the systems modelled are generic, however non-graphical elements such as identity parameters of building elements are filled out.
The first step undertaken by the author was creating a new Revit project using the created template. This existing model was then linked in to the new project file. This overlays the model into the new project. This would be the best solution for a firm to demonstrate compliance with codes without discarding their current office standard template, as the author found. This would allow the view templates created in the previous steps to display the model elements as desired to demonstrate compliance.

Once the levels within the project were adjusted to match those of the building project, the views set up within the template were populated as seen below. Fire rating filters were visible and compliance with codes can be deciphered. By simply executing the “tag all untagged” command within Revit, Fire ratings for doors were also displayed.

Having ran the tests on multiple computers to ensure consistency, it was noted by the author during the creation of the template, any packages that had to be installed to within Dynamo to run certain scripts did not carry around with the Revit Template. This would mean that a guidance document would need to be issued with the files to ensure all scripts could be run correctly. As seen below, once the model lines were placed to show the evacuation routes, the script ran smoothly,
demonstrating whether or not the distances were compliant.

Figure 20: Evacuation Path Calculated for Model 2

All the view templates created within the Revit project ran correctly. It should be noted that due to the level of detail the model was designed to, some parameters did not exist within families. This meant the author had to create these in order to complete the schedules or display a finished schedule, as seen below. In model 2, the doors all complied with the minimum clear width required.

Figure 21: Conditional format Schedule Applied to Model 2

6. Conclusion

A major issue that can affect the quality of information output in this process is the level of information that designers are feeding into their BIM models. Some of these solutions to Automating compliance rely on the designer to input information into parameter fields such as a wall’s “fire rating” or a door’s “function” in order to output the desired drawings or schedules. The author noticed during the research that a lot of the community-made Dynamo scripts required the building to be modelled with the script in mind for it to run successfully. Also, the live project that the template was tested on required parameters to be created within the family elements to ensure views would display as intended. This included line styles and the “clear width” parameter for the door families. This presents issues such as models failing in these compliance checks because of the way they were constructed, as experienced by the author on test models one and two. At the time of writing, there is no standardised way in the Republic of Ireland. This will only change if BIM is mandated in Ireland, as the UK Government has done “for all centrally-funded-public-sector capital projects” since 2016 (National BIM Council, 2017).

The objectives completed in this paper certainly prove that automation can be achieved for the current output requirements of a fire certificate application under the Building Control Act of 1990. Production of drawings and specifications can be automated through Revit 2018 to allow the designer to achieve compliance. It also proves that prescriptive elements, which from the research of Dimyadi, 2016, are the most suited of building codes to compliance checkers, can be automated within
Revit with assistance from Dynamo in some cases.

It was put to the FPO to close the interview: “Do you think DFB, DCC and you as a professional trust total automation of code compliance?” As we are talking about life safety and critical systems “I think it’s highly unlikely DFB or DCC would accept it.” An example was given of an applicant sending in an application with a fire engineering solution, provided using current fire engineering simulation software, such as CFast, this arrives to DFB in the form of a hard copy document including the results of the simulations. DFB does not have the software and they have to take the word of the Fire Consultant that the analysis has been undertaken correctly and the data that was input into the software and the output of the software is correct. “Most fire officers are extremely uneasy with that situation at present” (Executive Fire Prevention Officer with Dublin Fire, 2018). In his experience, many applicants are comfortable with “deceiving” them. For automation to be accepted by DFB and DCC, the local authority would need to “have total control over any automated process that comes in future and it would need to be at a national level.”

7. Future Development/ Progression
As the template begins to take shape, demonstrating compliance with the fire safety regulations necessary for fire certificate applications, it would be expected that the next stage of this paper would see the development of a web based application portal and an instructional guide on how to set up a project, using the template, for each BIM user. A web portal would be the best solution, based on the FPOs opinions on DFB and DCC’s potential concerns over automation software and results. The fire brigade would host the Revit template, dynamo scripts and the guide, on this website for designers to download and use to assist in the design of compliant structures to be prepared for submission. Once the BIM model was ready for submission, it would be uploaded to the web portal, similar to E-PlanCheck and issue a report to the user, confirming receipt of the model and issue an intermediate report of compliance or non-compliance. It is interesting to note that in the FPO from DFB mentioned automation of the fire certificate application process would not be a danger to their jobs, rather a welcome addition. This would allow the FPOs to focus more time towards site inspections, something he believes the public is currently crying out for:

“There’s only a finite amount of time to allow us to do the things we need to do and many thousands of building inspections that may not happen as a result.” (Executive Fire Prevention Officer with Dublin Fire, 2018)

Some professionals may have the concern that this will lead to loss of an understanding of the regulations and how they all relate to one another. Automation of design codes through BIM tools would ensure that codes were complied with, the understanding of their relationship would come from education.
8. Bibliography

3D Fire Design, LLC. (2017, January 1). (BIM) 3D Coordination. Retrieved April 7, 2018, from 3D Fire Design, LLC:
http://www.3dfiredesign.com/BIM-3d-coordination.php

CORENET. Singapore: Building and Construction Authority Singapore.

https://knowledge.autodesk.com

https://www.autodesk.com/products/dynamo-studio/overview


Henttinen, T., Sunesen, S., & Building SMART. (2010). use of OpenBIM Hospitals in Denmark Norway and Espoo Hospital in Finland. Retrieved March 22, 2018, from use of OpenBIM Hospitals in Denmark Norway and Espoo Hospital in


