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BIM TUDublin
bim@tudublin.ie

Joe McNally
Technological University Dublin

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The potential impact of BIM on early design stages of Residential Apartment Construction in Ireland: A Computational Design Approach

[1]Joe McNally and [2]Avril Behan

[1,2]School of Multidisciplinary Technologies, Dublin Institute of Technology, Bolton Street, Dublin 1, Ireland

E-mail: [1] c10356363@mydit.ie [2]avril.behan@dit.ie

Abstract−The current housing crisis and demand for residential accommodation in Ireland has required a change in the construction industry. The introduction by the Irish Government of the temporary fast track planning arrangement for large scale housing developments delivers a key commitment of the Governments action plan for housing and homelessness. Under these new provisions, planning applications can be made directly to An Bord Pleanála (ABP) and not to a local planning authority as was previously the case. This introduction has required the design team to provide sufficient information to enable ABP to offer an opinion and give direction on any amendments required to allow the project to proceed to the application stage. If significant changes are requested, this will result in major redesign work for the architect and other design team members.

By adopting BIM methodologies at this early stage, the design team has the potential to automate the process through early design collaboration and improved coordination. This paper will begin by focusing on the current usage of BIM processes during early stages of residential design in both Ireland and the UK and investigate through a literature study the impact BIM has currently made on the sector. The paper will propose the potential use of adopting computational design tools and methods to enhance the delivery of architectural designs through BIM methodologies. A graphical programming tool, Dynamo, will be used to demonstrate the integration into a stage BIM workflow. The experimental research will be appraised by selected industry professionals and feedback will be gathered to evaluate the potential future for computational design tools in the field of architectural design of residential units.

Keywords−Building Information Modelling, Computational Design, Dynamo

I INTRODUCTION

It is known that there is a current housing shortage in Ireland. Focus Ireland's latest figures on homelessness and rough sleepers are only a brief indication of the crisis. The aim of Initiative Ireland's "Housing 2031" report [1] was to establish an accurate view of housing supply and demand within the Republic of Ireland and how this might be expected to change in the future. The report found that the collapse in the Irish construction sector in 2007 partially resulted in the industry suffering from a significant shortage of residential housing stock with fewer than 5,000 homes built annually. This low number is partly due to restrictive lending practices and the high cost of finance. The report indicates an average of 34,000 new housing units per annum will be required between now and 2031 to meet the demand.

The National Planning Framework (NPF) [2] is the Government's high level strategic plan for shaping Ireland's future growth and development by 2040. The Economic and Social Research Institute (ESRI) predict, using current trends, that Ireland's population will grow by just under 900,000 people by 2040. These figures highlight the enormous pressure that will be placed on the AEC industry to deliver

sustainable housing and accommodation to provide for this growth.

The Royal Institute of Architecture Ireland (RIAI) carried out a research report on the current timelines for Housing Delivery [3] in Ireland. The report showed that for numerous structural and administrative reasons it still takes upwards of three years for new homes to become available to purchase or rent. The report reviewed the time spent on each RIAI Work Stage for housing / apartment projects in Ireland by using a common timeline across many developments and architectural practices. Interviews with Architects were held to examine their role at each work stage in order to try to identify factors which may have resulted in a delay to the timely progression of a given development project onto its next stage. The report highlighted that some Local Authorities required Architects to present sets of drawings and models to demonstrate how a scheme would look and operate when complete. This requires the Architect, design team and client to expend time and money in taking the scheme through to completion only for it to be revised following pre-planning meetings. This highlights a very inefficient approach to design and leads to repetitions during this phase of the project.

On the 23rd of June 2017 the Minister for Housing, Planning, Community and Local Government, Eoghan Murphy., T.D signed the necessary Commencement Order and associated supporting Regulations which enabled planning applications for large scale housing developments of 100 units or more to be made directly to An Bord Pleanala: *"The intention behind the planning related provisions of the 2016 Act is to facilitate the provision of increased housing supply through greater streamlining efficiencies in the planning system." Eoghan Murphy* [4].

Under the new fast-track planning procedures it will essentially involve a two-stage process. The Board will be required to complete pre-application consultations with the developers and the relevant planning authority. This will potentially result in planning decisions in respect of such strategic housing developments being decided within an overall period of six months from the commencement of formal pre-application consultations with the Board. The new fast track planning system has the intention of providing speed and certainty to the planning system. The RIAI report highlights cases where the planners in some planning authorities required detailed drawings to be submitted ahead of any pre-planning meetings. If the Architect and design team were expected to prepare the full application in advance of having the first pre-planning application meeting with the Local Authority, this would lead to serious delay and cost implications for applicants [3].

Responding to the current housing crisis in Ireland and the introduction of a new planning system, Section 2 of this research paper will focus on the current usage of BIM processes during early stages of a residential design. It will also propose the potential adoption of a new workflow from other types of construction that may help streamline the current residential design processes. The paper will review current BIM processes in residential construction in both Ireland and the UK and investigate through a literature study the impacts BIM has currently made from more traditional methods in the industry.

In Section 3, the paper will propose the potential use of adopting computational design tools and methods to enhance the delivery of architectural designs through BIM methodologies. Through advancements in digital technologies this new design approach has the potential to streamline and automate many tasks at early stages of the design process. Section 4 of the paper will review the theory of computational design and will be tested using the graphical programming tool Dynamo by demonstrating how it can be integrated into an early stage BIM workflow. Experimental research will be carried out using some current processes being adopted in the industry and a workflow will be developed with the aim of improving design decisions and communication between designers, developers and the whole design team.

In Section 5 the experimental research will be appraised by selected industry professionals through semi-structured interviews. Finally, the gathered data will be evaluated to appraise the potential future for computational design tools in the field of architectural design of residential units.

II BIM FOR RESIDENTIAL DESIGN & CONSTRUCTION

The Global BIM Study [5] carried out by the Irish BIM Innovation Capability Programme (BICP) identified that the implementation of BIM in the construction industry is accelerating globally with 50% of 27 countries reviewed having regulatory

requirements or planning their implementation in the near future. The report found that the BIM market is expected to reach almost $8 billion by 2020 a growth of 13% from 2015.

The Global BIM Study highlights that the UK, through their ambitious BIM programme is recognised as a global leader in the adoption of BIM with wide-scale uptake in recent years including the release of their BIM Level 2 mandate and suite of Publicly Accessible Standard (PAS1192) documents. Like the Economic and Social Research Institute (ESRI) predicted growth in Ireland, the UK is experiencing a growth in population as highlighted in the NHBC Foundation report. Between 2006 and 2016 the UK population increased by 7.9%; the fastest 10-year growth for 100years [6].

The Centre for Digital Built Britain commissioned a study on the use of BIM in the UK house building industry to consider the opportunities and barriers to its wider uptake [7]. The report found that awareness of BIM is starting to spread through the construction industry, driven by the previously mentioned UK Government mandate. The 'National BIM Survey' carried out by NBS in 2012 found 31% of respondents were using BIM [8]. By 2017, NBS reported that 62% of respondents were using BIM [9]. In the 2017 survey, participants were asked how they thought their organisation would use BIM in the future. Ninety percent thought they would be using BIM in the next year, and 95% thought they would be using BIM in the next three years.

Many examples can be found in the UK were BIM adoption on residential buildings has proven a success. In 2017, Nottingham City Homes became the first developer to use BIM technology to build social housing, when it built The Meadows, a £5.5m, 54-home regeneration scheme in Nottingham. The former head of development at Nottingham City Homes stated that on a per-unit basis, the development cost 5% less than a development built at the same time using traditional methods [10]. Another example is the Haggerston Phase 2 building which consisted of a 430-unit development across two land parcels. BIM was used for early massing models by the environmental team for daylighting and solar analysis. Design options were used extensively, allowing the designers to present various options quickly to the client, without excessive repetitions of work. The quantifiable benefits in using BIM allowed for the creation of accommodation scheduling and the exploration for façade material options with quantity and cost take-offs [11].

Ireland can learn not only from the UK but other jurisdictions, such as the French Government where BIM is significantly adding to their government programme in delivering 500,000 homes in 2017 [5]. Ireland is also now committing to BIM with the release of the Roadmap to Digital Transition for the Construction Industry for 2018-2021 by the National BIM Council. The Roadmap looks to achieve 20% reduction in cost, 20% reduction in programme and 20% increase in construction exports. The release of the roadmap is seen as a positive leap towards BIM focused technologies & workflows in Ireland. According to the Minister for Business, Enterprise and Innovation, Heather Humphreys T.D the Irish Government recognise the importance of BIM and sees the benefit of how it brings together technology, process improvements and digital information to radically improve project outcomes and asses operations [12].

The uptake and adoption of BIM on residential developments in Ireland can be demonstrated through the BICP Case Study by Dr Barry McAuley [13] on the Cherrywood Development in which a collaborative BIM process was developed between a number of design disciplines. BIM was used from early stages of planning and enabled a greater understanding of the design due to the extensive analysis performed at early stages compared to traditional methods. Through the application of BIM at the planning stage it enabled better future proofing of the design. This ensured that the statutory planning bodies had access to a functional design to assist with their final planning decision. BIM has permitted a transparency that could not have been realized through the application of existing 2D processes.

In this paper the researcher will focus further on BIM and applying a method called computational design that uses visual programming tools to further enhance and develop building designs for residential developments. With the ongoing development of digital media and technologies, designers have the opportunity to envisage the performance of a building during the process of design. They also have a means of realising geometric forms through the use of computational design [14]. The following section of this paper will review the term computational design and examine

the chosen tool that will be used to investigate the methodology further.

III COMPUTATIONAL DESIGN

In recent decades, the interrelations between architecture and computation have fostered new design concepts and design methods, which challenge existing design and building processes. Specifically, the increased use of parametric methods and scripting allow for the development of modelling techniques [15].

Computational design involves the application of computational methods to design problems, whether related to presentation, analysis or aesthetic expressions. Michael Kilkelly of ArchSmarter describes computational design as the application of computational strategies to the design process. While designers traditionally rely on intuition and experience to solve design problems, computational design aims to enhance that process by encoding design decisions using a computer language [16].

Companies are always looking for opportunities to simplify, optimize and improve their design processes with the aim in reducing labour-intensive tasks [17]. One such company is UK-based design firm Aedas who have been working with computational design strategies since 2004. Aedas R&D (Research & Design) Group focuses on research into Computational Design. The Computational Design & Research (CDR) group at Aedas created digital design applications for architecture, master planning and interiors, based on scientific research and computing theories. Aedas have developed a participatory of digital designs by combining interactivity, real-time processes, portability and scientific rigour. These techniques have guaranteed seamless integration within the design process and enabled designers to enhance the depth of their work [18].

Ryan Cameron of DLR Group, who is a recognised industry leader in computational design, described during an interview with Hansonwade for the Advanced Computational Building Design 2017 gathering [19] the challenges facing the wider adoption of computational design. He described that learning vs training is a big challenge and that architects need to understand what the data means for them if they are to succeed. In the interview Cameron discusses that it is important, as architects, designers and BIM users, to start thinking in terms of project specific goals, instead of finding ways to just flex the tools. Computation allows you to record the different program changes that occur during the early design process which can improve on the next project and future endeavours. [19].

Axel Kilian of Princeton University argues that even though computational design is mostly still used and viewed as a problem-solving method that comes into play once the task has been clearly defined. The potential within a design challenge lies in the variation that it can help address during the challenge definition [20].

This parametric design approach has been used on some well-known projects in Ireland such as the Aviva Stadium, which was developed from start to finish adopting parametric and computational design methods. Initial conceptual designs included studies undertaken using Rhinoceros, a computational design tool, to explore the development and logic of the form's geometry [21]. Once the logic for the stadium's geometry was defined, the parametric modelling framework developed for Rhinoceros was rebuilt in Bentley's Generative Components (GC), a BIM system, to be further developed [22]. With the Aviva Stadium having a parametric framework, responses to design changes were quicker and easier to manage and using this approach allowed repetitive tasks to be automated. By adopting the use of computational design tools, it allowed for an integrated workflow from conception to completion, which ultimately gave the Architect and design team more control over the design and project. Further computational design tools will be explored in the following Section 4 of the research paper.

IV COMPUTATIONAL DESIGN TOOLS & POTENTIAL USE

Computational design is a broad term that encompasses many activities, ranging from design generation to task automation. The common thread is the use of a visual programming tool [16]. Most computational design environments rely on visual programming as opposed to traditional text-based programming. With visual programming, programs are assembled graphically rather than writing code. Outputs from one node are connected to inputs on another. A program or "graph" flows from node to node along a network of connectors. The result is a

graphic representation of the steps required to achieve the end design [16].

There are many visual programming tools that are in the industry today such as Grasshopper for Rhino and Generative Components for Bentley as mentioned in the previous section. This study uses Dynamo due to its integration into Autodesk's Revit, which resides as a plugin within the Revit package. Dynamo BIM is a visual programming platform developed as an open source download. It reduces the requirement to understand computer programming by providing a node-based environment. Dynamo aims to be accessible to both non-programmers and programmers. It gives users the ability to visually script behaviour, define custom pieces of logic, and script using various textual programming languages [23]. Dynamo was originally developed as a data manipulation tool for Autodesk Revit. However the open-source strategy and the demand by users has led to many additional software connections [17].

The power of using Dynamo BIM has been investigated in previous Irish studies such as Johnathan Reinhardt's *"The Automation of BIM for Compliance Checking: A Visual Programming Approach"*. Reinhardt applied Dynamo to diagnose the problem of manual checking, and proposed and evaluated an automated solution [24].

Dynamo can be used on a variety of projects such as the Cardiff Innovation Centre's atrium and facade design. On this BIM Level 2-aspring project all design consultants used Revit which was used to develop the conceptual design and took advantage of its ability to incorporate and produce large amounts of metadata. However, Revit was found to have certain limitations, which prompted the use of Dynamo [25]. Dynamo allowed the design architect to set up coordinates and guidelines enabling the software to automatically create and manipulate the atriums design. To enable the design team to test and validate several different design options on the facade, an elevation was drawn in Excel and a Dynamo script was developed to automatically switch the type of facade panels in Revit when the colour of corresponding cells in Excel were updated [25]. The adoption of Dynamo on this atrium and façade design reduced the amount of manual editing and allowed the team to quickly change its concept designs.

V RESEARCH METHODOLOGY

This paper will use Experimental Design to demonstrate the potential of visual programming tools at early stages of concept design. The objective of the Experimental Design Research is to demonstrate using the visual programming software Dynamo, how algorithmic scripts can streamline the design process for residential design. These computational techniques can potentially give the designer and developer a better platform for communication between the design team allowing for better exploration of design ideas. The aim of adopting this approach is to reduce the time spent during the initial design stages, specifically on the decision-making process between the parties involved.

The methodology has been divided into two stages. In the first stage the research aims to explore a number of potential uses for computational design tools. The objectives are outlined below:

1. The first experiment will demonstrate the use of computational design tools for site feasibility studies and early stage building exploration. Dynamo BIM and Revit will be used as the main software tools. Autodesk's generative design tool "Project Fractal" will also be explored.
2. The second experiment will investigate a space planning data cycle using Revit and Dynamo BIM script definitions. As a visual communicator a project dashboard will be created using Microsoft Power BI. A "Live-Link" will be developed between Revit-Dynamo-Excel to transfer data and allow for any design iterations to be made.

In the second stage, the researcher will conduct semi-structured interviews in which the experimental model and workflows will be presented to selected industry professionals. Through standardised questions, feedback will be collected on the potential of adopting the demonstrated tools and methods. The researcher aims to collect data from individuals that can provide feedback on areas such as positive and negative impacts on the design process, the implications on the planning process and potential of improving the delivery of housing in Ireland.

VI EXPERIMENTAL DESIGN

Experiment 01:

The first experiment explored in this research focused on the early stages of a feasibility study. The aim of this experiment was to demonstrate the potential automation of site feasibility and context modelling, and exploration of design options using a computational design approach.

Gathering context for site feasibility studies:

Dynamo user Davitt Lamon [26] previously demonstrated a workflow in which Open Street Mapping (OSM) files were used to create building masses in Revit. The aim of this workflow was to automate the process of gathering site information and give the designer 3D context at the early stages of a design. OSM data was used in this context for demonstration purposes rather than using an accurate data source such as Ordnance Survey Ireland.

To begin, the OSM data of a chosen site was collected in which building points were formed and exported. Using the "File Path" node the gathered OSM data was inputted to the Dynamo definition.

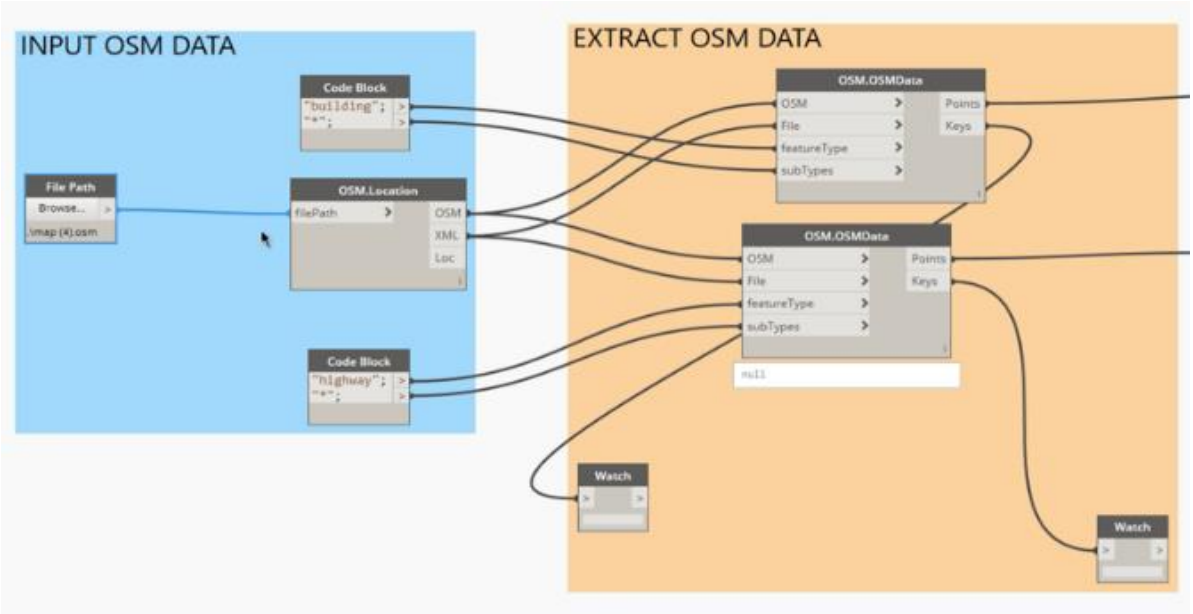

Fig. 1: Inputting and extracting OSM data to the Dynamo definition.

Using Timothy Logans "Elk" nodes the points were extruded and turned into individual families within Revit. Using Code Blocks within Dynamo the user has the control to adapt the extruded family heights, which is a benefit in terms of the different planning regulations of a chosen site. A Revit generic model building mass was used and added to the Dynamo script. When all data had been added to the definition the script was run.

The Dynamo script displayed the 3D information taken from the entered OSM data. On returning to Revit the Dynamo geometry was visible and initial design studies could commence. Using Revit's built-in Solar and Energy analysis functions, early stage studies were performed which could give a designer further knowledge on possible site constraints and surrounding context.

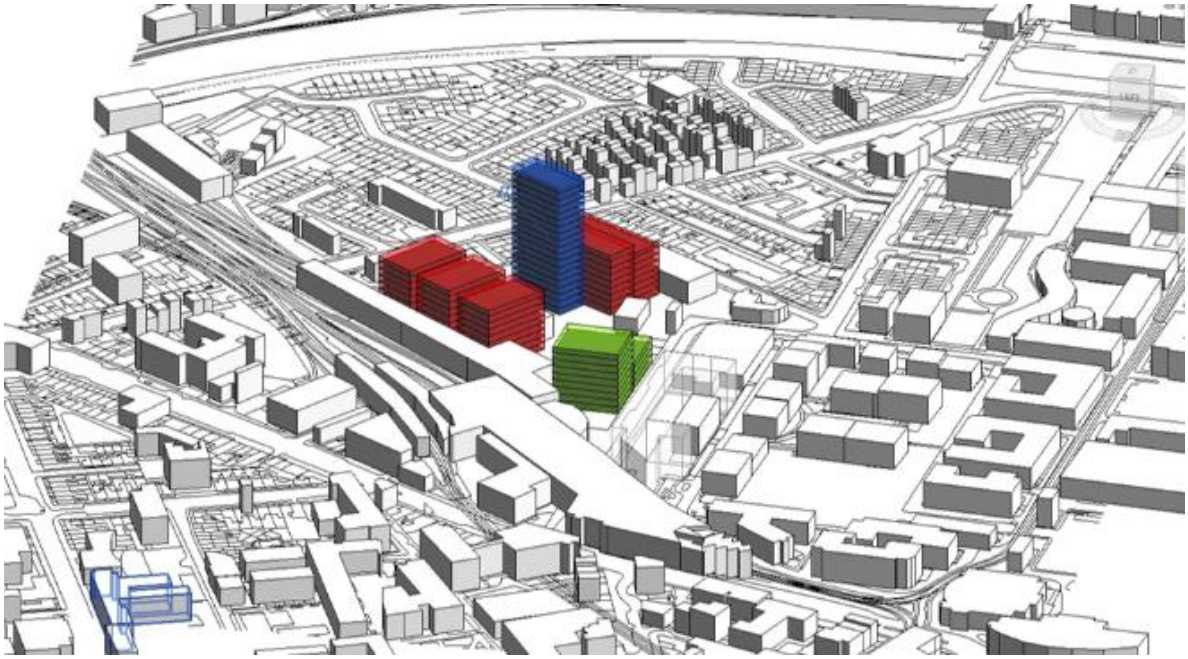

Fig. 2: Early stage Solar and Energy analysis could be performed.

Parametric Building Exploration:

Many good designers challenge and redefine the design definition, but much could be gained from playing rapidly through a range of very different scenarios beyond the initially defined starting condition to gain insight into the dependencies of the given constraints [20]. Adopting a parametric approach to building exploration was used in the second part of this experiment. Once the site context information had been gathered, the next step was to define and explore building type options for the chosen site. The aim was to use Dynamo to generate different but related instances of the same design solution to quickly generate options by experimenting with different parameters values, thus allowing the designer to visualize and explore a wide range of design possibilities.

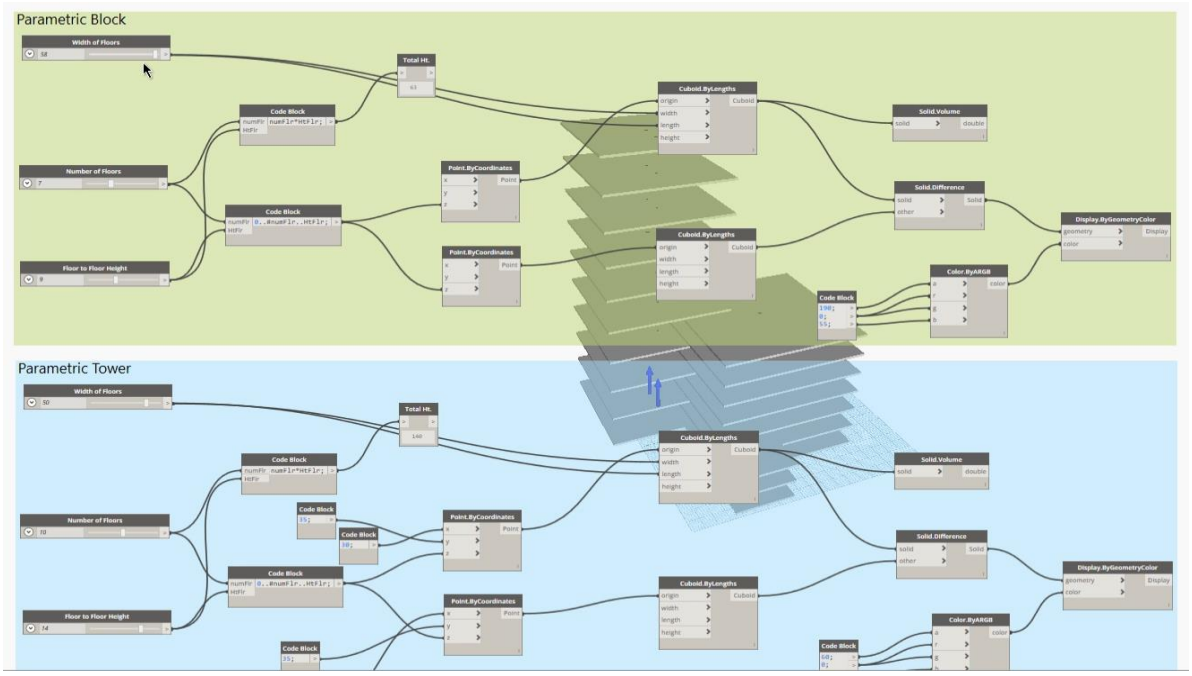

Fig. 3: Dynamo definition with parametric values for width, height and floors for building design

A parametric Dynamo definition was created (Fig.3) to initially explore building design options. To further enhance the design exploration, the Dynamo definition was sent to Autodesk's Project Fractal. Project Fractal is a cloud-based computational design solution that leverages Dynamo Studio to capture project goals, constraints, and building expertise to produce design options for exploration and elaboration [27].

Autodesk are currently still in the early development stages of the software in which they describe that the potential power of Project Fractal could allow for fast integrated analysis to be run using parameters inputted from Dynamo definitions which could create several design options. This information could give technical feedback on a range of architectural, engineering and commercial requirements. The generative design tool could further expand on building design options to automate the decision process [27].

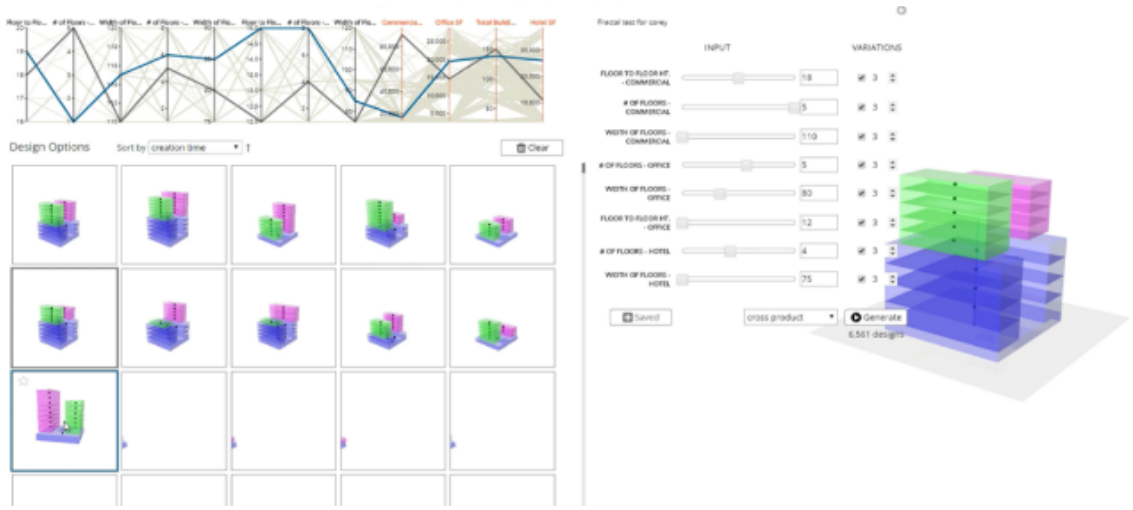

Fig. 4: Project Fractal demonstration with generated design options [28].

Experiment 02

The second experiment explored in this research focused on improving the communication between the designer and developer / client by reviewing the potential use of a space planning data cycle workflow and creating a project dashboard as an effective communication tool.

Creating a Space Planning Data Cycle:

The first objective of this experiment was to implement the Planning Guideline Design Standards for New Apartments in Ireland [29] for use in BIM modelling and Dynamo. The implementation of these guidelines, along with the National Planning Framework for Ireland [2], aims to transform and develop the cities, towns and key urban areas in Ireland. It was essential that the design requirements used in this experiment for the space planning data cycle met the minimal requirements for residential units set out in the guidelines. The initial requirements were added to an Excel spreadsheet to include each apartment unit type sorted by type using specific colours.

The Dynamo definition that was explored in this experiment was developed by Kyle Martin of Shepley Bulfinch [30] and manipulated to suit this research. The space planning data cycle aimed to highlight the role programming can play on the early design process in architecture where the size, shape, purpose and adjacency between each space determines the overall form and function of the building. BIM provides the ideal platform for programming because of its ability to organise and position spaces that are fully embedded with information [30].

Using the Dynamo definition (Fig.5), massing families were populated in Revit from the Excel Spreadsheet (Fig.6). The Dynamo definition organised the massing blocks according to their pre-determined assigned department and unit type, in which the colour-codes gave visual clarity based on the previously developed Excel information.

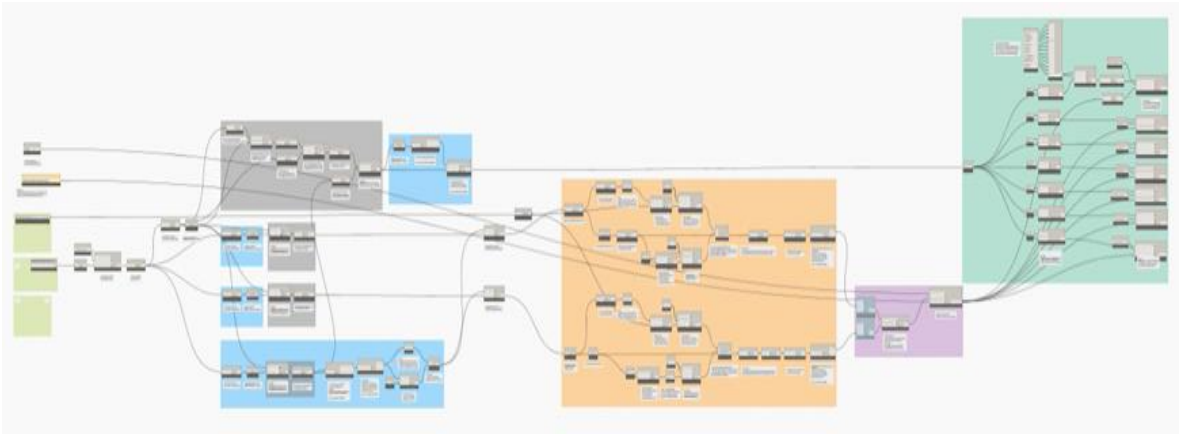

Fig. 5: Space Planning Data Cycle Dynamo definition [30].

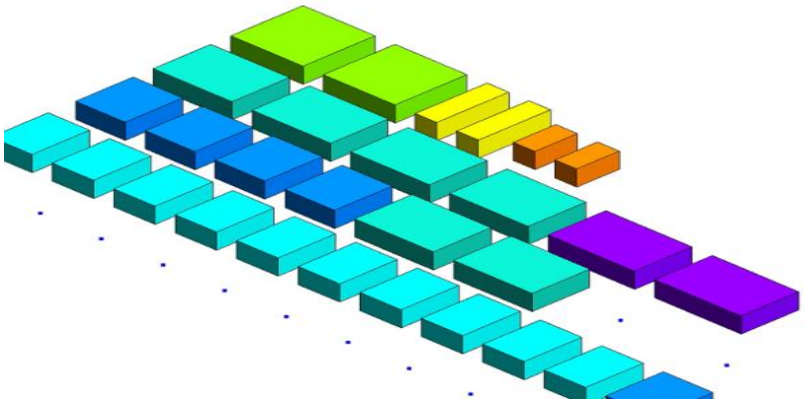

Fig.6: Colour coded massing blocks within Revit.

Once the pre-determined unit numbers were within Revit the user could re-position, stack and arrange the units to suit the chosen design. The blocks could also be overlaid within a site as demonstrated in the previous experiment to carry out investigations such as adjacency studies and solar analysis. When the designer was satisfied with the space planning unit model the massing families could be scheduled using the existing parametric values from the original spreadsheet. This gave the designer crucial information regarding unit mix ratios and unit aspects to ensure that the design standards were being adhered to. Favourable designs could be archived and documented, or iterations could be easily made by updating the initial Excel spreadsheet to further develop the design.

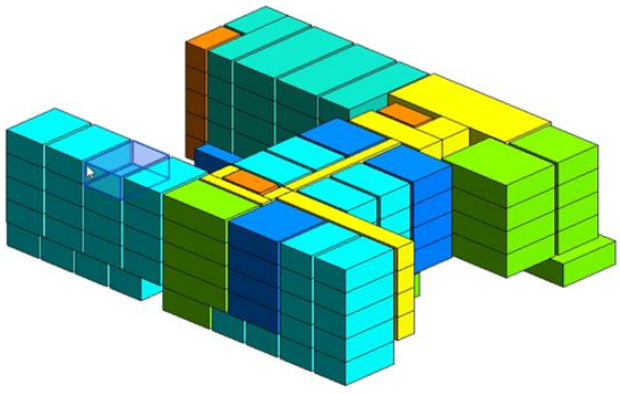

Fig. 7: Arranged 3D model with unit type parameters for each mass family

Project Dashboard with Live-Link:

The information and parameters that were extracted from the 3D space planning model were used to create a project dashboard using Microsoft's Power BI. Power BI is a free tool from Microsoft that allows the user to build advanced models and reports that could visualise their input data. Such a project dashboard has the potential to be used as a communication tool between the designer and developer/client. Having an effective communication tool between designers and developers could enhance the decision process of building designs and allow the designer to present the design visually and with data to back it up for the developer/client to provide feedback.

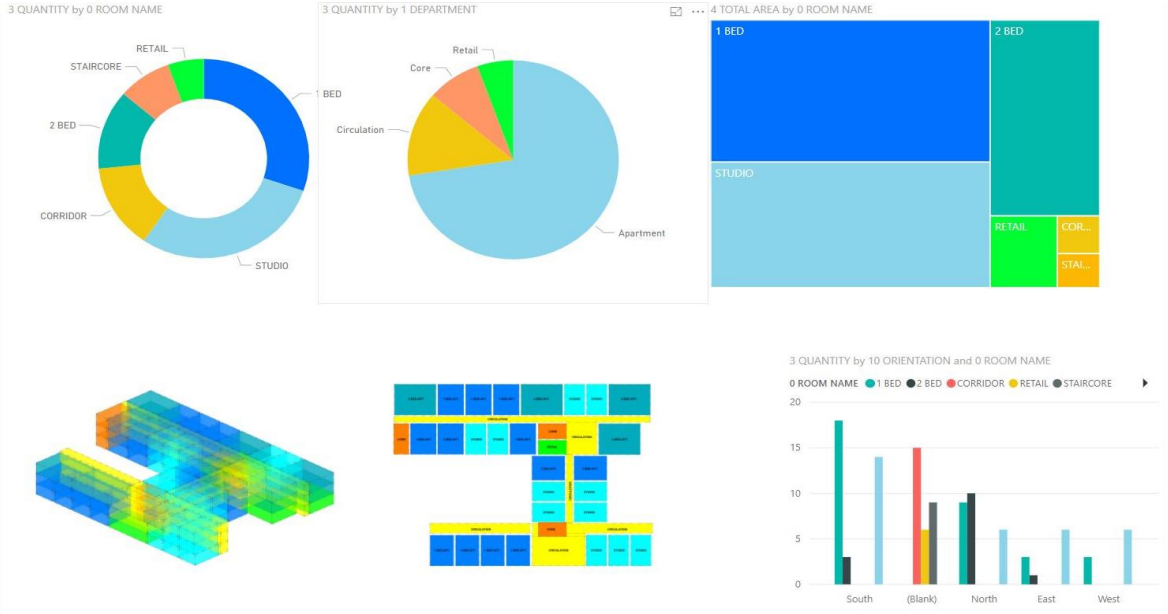

Fig. 8: Power BI used as a Project Dashboard communication tool

Using computational design tools and processes it was also possible to create using a simple Dynamo script, a live-link between the original space planning excel spreadsheet and the Revit model. This can provide an open link between the client's feedback and the design which could allow the designer to make iterations easily that could quickly be turned around and presented on the project dashboard. This further addition completes a full design cycle.

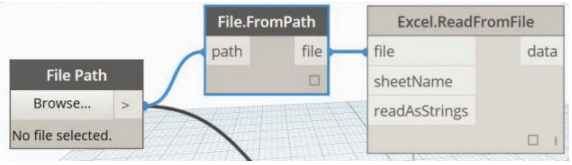

Fig. 9: Nodes used in Dynamo to create Excel export script.

VII EVALUATION OF METHODS

To evaluate the workflows demonstrated in the experiments, data was collected in the form of qualitative interviews using 4th Generation Evaluation stakeholder research. To receive credible feedback a total of ten participants were interviewed. The participants were made up of three Architects that have experience working on early stage residential designs, two Architectural Technologist that work daily using BIM tools and methodologies. One BIM Manager was also interviewed that has experience implementing BIM processes into an organisation and finally four members of both Fingal and Dublin County Council that work within the planning and design departments within their organisation.

The participants were chosen in order to receive the most beneficial feedback in terms of design, planning and organisational adoption. The individuals had some knowledge of computational design but limited experience using visual programming tools within their organisation.

The first aim of the interviews was to identify the positive and negative reaction to the demonstrated workflows presented. The second aim was to investigate if the participant saw the potential of adopting this workflow into a current design process and did they see this as a form of delivering faster designs for planning and construction. In accordance with the main research focus, the interviews aim was to gather feedback on the automation of tasks at conceptual design stages, on the computational design tools used, on adoption of such automated workflows into an organisation and on integration into the current design process using BIM with the potential of benefiting the delivery of housing in Ireland. To evaluate the demonstrated workflow methods, each experiments feedback was reviewed:

Experiment 01:
The feedback from design architects and technologists gave insight into how the proposed workflow could impact the design process. Gathering site context information at early stages of a design would benefit an architect by understanding the surrounding site constraints. Having the ability to carry out early stage shadow studies, without spending much time modelling the site context, would be of advantage to the designer. The architects interviewed all found that there was still a preconception that BIM tools are more beneficial at later stages of a project's development. All the three architects interviewed indicated that having these site context blocks could detract from designing a feasibility from scratch where their current process used software, such as Trimble's Sketchup, which is more intuitive and more like sketching. As for the technologists interviewed, both agreed that using these tools for site studies would automate many early stage modelling work as opposed to traditional methods. The BIM manager found that adopting these programming tools and methods into an organisation could prove to be a daunting idea, but by demonstrating and minimising the inputs for new users to the tools, the workflow could be very successful.

The individuals interviewed from Fingal and Dublin County Council, who were both architects and technologists were asked for feedback in terms of design and planning implications of the demonstrated experiment. One architect believed that the workflows may work very well for urban planning site studies to explore impacts of proposed developments and may have potential to very quickly create visual overviews of sites that can be presented to the public. All members agreed that the adoption of BIM, independent of implementing a visual programme tool, may prove difficult in some of the current councils. The roll out of BIM is still in its infancy and the participants felt it may take time for something like this be adopted. In terms of speeding up the planning process, each participant found that the automation of tasks would be beneficial, but this would not directly speed up the planning decision process rather it would be of benefit to the designer greater who is applying for the permission. In response to the feedback the researcher presented the findings of Johnathan Reinhardt's research into the automation of compliance checking as highlighted in Section 4 of this paper. The council members agreed the potential use of adopting this programming tool would undoubtedly automate compliance checking and ensure guidelines have been adhered to which would result in streamlining the planning process.

Experiment 02:
The feedback from design architects and technologists gave insight into how the proposed workflow could impact the design process. The concept of using BIM to carry out space planning studies was received positively as many of the participants interviewed worked with traditional methods and tools such as Computer Aided Design (CAD). The possibility of adopting the workflow in the experiment could allow a non-BIM user to develop the data required after which a Revit user could then create model variations of the design using the pre-determined unit numbers. Exporting the data from Revit into a project dashboard allows clients and/or developers to visualise the unit mixes in any design. One benefit of this is the potential of taking the clients requirements and showing the possible problems with their expectation of numbers. This may reduce the time spent on the decision process of any residential design. Using the colour coding as a way of sorting the apartment unit types can give the designer visual clarity while designing and could provide a greater understanding of the overall proposed scheme. The overall feedback from the architects, technologists and BIM manager interviewed was optimistic and many seen a great potential in adopting this into an organisational workflow.

The individuals interviewed from the County Councils made positive comments regarding the space planning data cycle in relation to the design and planning implications of the demonstrated experiment. One architect believed that opening the communication barrier between the designer and a potential planning body would give all parties a better understanding of the scheme. As previously mentioned in this paper, under the new fast track planning system, designers must meet with An Bord Pleanala and other planning consultants for the pre-planning application meetings. The adoption of a project dashboard to graphically represent a proposed scheme could be utilised in this instance. Another recommendation from one the architects interviewed was to adopt the space planning data cycle with the House Agency / Urban Agency "Quality Apartments and Urban Housing" publication [31] in which typologies could be tested across a number of sites to give a sense of orientation, light quality and so on.

VIII CONCLUSIONS

This paper sought to examine the potential use of adopting computational design tools and methods to provide a solution to the housing problems in Ireland. The review of the current adoption of BIM in Ireland showed that BIM may not solve the current housing crisis but improving the way we do design and construction may be part of the solution. With the introduction of the new fast track planning system the researcher aimed to establish tools and methods that have the potential on automating and streamlining early stages of the design process. The researcher focused on opening the communication line between the designer and client / developer with the aim of improving the decision process.

In this paper the researcher proposed a new approach to design, one that combines computational design with the BIM methodology and that can offer important benefits to architectural design. Adopting computational design offers a challenging but flexible new way of designing, one based on algorithmic logic. Using computational design tools, a wide range of design alternatives can be quickly explored. These tools provide an easy way to harness the power of computation in a design process without having to learn how to write code. They allow architects and designers to create their own tools. Understanding that each project we work on is unique with its own challenges. There is no one piece of software that can do everything needed in the design process. However, by creating our own tools, we can tailor our software to work for us [16].

As demonstrated in the research experiments and the interview feedback, the flexible nature of computational design workflows greatly promotes design exploration and have the potential to give the designer tools that can tailored and implemented in to design development for faster delivery of residential buildings in Ireland.

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