Universidade do Minho
Escola de Engenharia

Tiago António Dias da Silva Santos

BIM in Design for Manufacturing and Assembly: Bridging the gap in AECO Industry 4.0

BIM A+
European Master in
Building Information Modelling

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Tiago Santos
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Master Dissertation
European Master in Building Information Modelling

Work conducted under supervision of:
Bruno Acácio Ferreira Figueiredo

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

RESUMO

A construção civil está a passar por mudanças, a falta de mão de obra é um sinal das alterações que estão afetando o mundo. Desde a crise financeira de 2008, a construção sofre e anseia por encontrar soluções para fazer face à nova procura de habitações e à falta de resposta à atual procura de mercado. A mudança para construção em fábrica tem vindo a ser debatida recentemente com o desenvolvimento na tecnologia, onde Building Information Modeling (BIM) lidera esta nova transição. Projeto para Manufatura e Montagem (DfMA) é a ideia neste contexto, potencializando o projeto e a produção de componentes pré-fabricados (Off-site construction), para serem posteriormente montadas e transportadas para o local, proporcionando uma solução viável para o problema apresentado.

Esta dissertação resulta de uma colaboração com o Grupo Casais, uma empresa de construção portuguesa sediada na cidade de Braga. O objetivo era desenvolver processos de pré-fabricação sustentáveis, para serem aplicados em atuais e futuros projetos. Neste contexto, a integração de ferramentas BIM em projeto e fabricação de sistema de paredes divisórias, com várias aplicações e combinações. O objetivo deste processo desenvolve-se na possibilidade de maximizar a repetição dos elementos pré-fabricados a serem utilizados e sistematizar a sua montagem no local. Portanto, beneficiada implementação de DfMA, maximiza-se recursos e tempo, sem comprometer todas as especialidades envolvidas, aproveitando as vantagens da construção em fábrica.

A solução desenvolvida utiliza a Programação Visual para gerar um processo de divisão e ordenação de espaços pela sua disposição, para posteriormente transformar em dados. Para além disso, através da investigação utilizou-se parâmetros com o objetivo de ajudar a organização e classificação (dentro de limites específicos) das componentes da construção. Este método permite sistematizar os conhecimentos necessários para definir uma ferramenta computacional para a otimização da fabricação dos espaços de um determinado projeto. Com este objetivo em mente, a investigação teve como foco o desenvolvimento de modelos computacionais que maximizem a saída de todas as informações.

Esta investigação visa completar a ligação da pré-fabricação entre arquitetura e engenharia aplicando DfMA por meio de ferramentas BIM. O resultado visado permite a aplicação num projeto que não foi preparado para ser pré-fabricado, tornando-o uma solução que permite a transição. Com a sistematização de um conjunto de modelos computacionais em uma Interface de Programação de Aplicativos (API) BIM, o objetivo foi coordenar e incorporar todas as informações que constam no modelo para otimizar e gerar dados que possam auxiliar na pré-fabricação e planeamento da fabricação das componentes.

Palavras-chave: (BIM, Projeto para Manufatura e Montagem, Pré-fabricação, Programação Visual)

ABSTRACT

The construction industry is changing, the lack of man labour is a sign of the changes that are affecting the world. Since the financial crisis of 2008, the construction suffers and eagers to find solutions to face the new demand for housing and the lack of response to the current market gap. The shift for off-site construction is being talked recently with new development in technology with Building Information Modelling (BIM) leading this new transition. Design for Manufacturing and Assembly (D is the idea in this process, enhancing the design and production of the building parts in-house to be later assemble and transported to the site, providing a viable solution to the challenge presented.

This dissertation result from a collaboration with Grupo Casais, a Portuguese construction company based in the city of Braga. The aim was to develop sustainable prefabrication processes, to be applied in current and future projects. Namely, the integration of BIM tools for the design and manufacturing of partitions walls system with a high degree of combinatorial application. The goal of the process contemplates the possibility of maximizing the repetition of prefabricated elements to be used and systematize their assembly on site. Therefore, by following the principles of DfMA to incorporate the maximization of resources and time, without compromising stakeholders and benefiting from the advantages of offsite construction.

The solution developed uses Visual Programming to generate a process to divide and sort rooms by their typology, to later export as data. Additionally, through the research it used parameters with the aim of helping in grouping and sorting (within specific constrains) the building parts. This method allows to systematize the knowledge needed to define a computational tool for the manufacturing optimization of the rooms of a given project. With this goal in mind, the research was focused on the development of computational models that maximize the output of all the information.

This research aims to bridge the gap of prefabrication between architecture and engineer by applying DfMA through BIM tools. The desirable outcome can be applied to a project that was not prepared to be prefabricated, hence making it a reliable solution to make the transition. With the systematic definition of a set of computational models in a BIM Application Programming Interface (API), the aim was to coordinate and cooperate all the information available inside the model to optimize and generate information that can further help in the prefabrication and planning of building components.

Keywords: (BIM, DfMA, Off-site construction, Prefabrication, Visual Programming)

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1. INTRODUCTION

The construction industry is changing, the lack of man labour is a sign of the changes that are affecting the world. Since the financial crisis of 2008, the construction suffers and eagers to find solutions to face the new demand for housing and the lack of response to the current market gap. The shift for off-site construction is being talked recently with new development in technology with Building Information Modelling (BIM) leading this new transition. Design for Manufacturing and Assembly (DfMA) is the idea in this process, enhancing the design and production of the building parts in-house to be later assembled and transported to the site, providing a viable solution to the challenge presented.

This dissertation results from a collaboration with a construction company, that is tackling the transition to DfMA through the development of in-house methods and processes. Despite of what architecture and engineering offices apply to a project, the solution developed employs fabricated principles to a project that was not meant to. Consequently, the solution transports the partition wall system of the building to a assemble factory, and by developing a process of distributing and grouping, it was possible to optimize the elements (for mass production) to be assembled and transported for the site.

The solution developed was a manual process which was time-consuming and could led to hazards. Acknowledging that, the use of BIM could optimize the process and provide solution to it, by cooperating with Visual Programming to generate information inside the model. Additionally, the definition of parameters with the aim of grouping and sorting (within specific constrains) the building parts and their data, will systematize the knowledge needed to define a computational tool for the manufacturing optimization of the rooms of a given project. With this goal in mind, the research was focused on the development of computational models that maximize the output of all the information and provide a methodology for the integration of DfMA through BIM tools.

The aim of the dissertation was to mind the gap between traditional construction methods and the construction in industry 4.0, where the process is automated and digitalized, creating collaboration through data exploration. Therefore, the principle of digitalization and BIM proofs the need to improve and optimize the process of information and management. Furthermore, a digital process allows all stakeholders to be involved in the integration of DfMA by providing a production tool through the BIM model.

1.1. Scope and motivation

Nowadays, it is urgent to define more sustainable construction processes, the adoption of prefabrication systems in the construction industry. With higher developments in technology and research, and with the current market shifting towards BIM, there is a huge opportunity to make developments in this area. In regards of educating Architects and Engineers towards the use of this systems is resourceful and time consuming. To improve the industry, it is needed to develop knowledge and methods that consider prefabrication processes in all the stages of the project. The construction market urges to shift to prefabrication in order to fight the lack of man labour and optimise the resources and reduce material waste. Since the current pandemic off-site construction has become more pertinent, due to the high restrictions of agglomerates of people.

This dissertation result from a collaboration with Grupo Casais, a Portuguese construction company based in the city of Braga. The aim was to develop sustainable prefabrication processes, to be applied in current and future projects. Namely, the integration of BIM tools for the design and manufacturing of partitions walls system with a high degree of combinatorial application. The goal of the process contemplates the possibility of maximizing the repetition of prefabricated elements to be used and systematize their assembly on site. Therefore, by following the principles of DfMA it is expected to the incorporate the maximization of resources and time, without compromising stakeholders and benefiting from the advantages of offsite construction.

1.2. Objectives and methodology

This research aims to bridge the gap of prefabrication between architecture and engineer by applying DfMA through BIM tools. The desirable outcome can be applied to a project that was not prepared to be prefabricated, hence making it a reliable solution to make the transition. With the systematic definition of a set of computational models in a BIM Application Programming Interface (API), the aim was to coordinate and cooperate all the information available inside the model to optimize and generate information that can further help in the prefabrication and planning of building components. Consequently, the research focusses on following an in-house process developed by the Casais to group multiple similar bathrooms and optimize the typology to be easily replicated and mass produced. The following list stat all the objectives that this dissertation focus:

1. Literature analysis of integration of DfMA in BIM and its applicability in the context of Offsite construction;
2. Creating guidelines to optimize projects to DfMA, by mapping a process of analysis and convert to information and apply in the context of BIM;
3. Create a set of rules to define an algorithm strategy to manage a set-by-step process in an on-going project to be optimized to DfMA;
4. Generate and automate process of developing partition wall to be produced as DfMA in a project;
5. Analise panelling system customization to be produced and assemble. Working with information to decision making and model analysis;

The study focusses on the analysis of the state of art literature in regards of the topics that belong to off-site construction and DfMA. Consequently, BIM was an analysis as a set of methodologies process and software's that contribute for the development. Then the case study provided by Casais was analysed so as all the documentation that was developed in-house. Therefore, the analysis of the case study and the methodology, gave boundaries and an idea of how the process contributes to the outcome.

Furthermore, the heavy use of Visual Programming Language systematic definition of a set of computational models in Dynamo (Computational attractor system using the environment data from Autodesk Revit), allow to apply the ideologies develop by the company and combining shared parameter with information to be later exported as resource for design decision. Since, for DfMA there are a lot of stakeholders that need to be consulted before applying changes, the parameters serve as tools in decision making.

For the research a residential project was provided by the construction company as case study. Additionally, the file was a CAD drawing so as all the documentation related to the process for DfMA. Consequently, all the resources used in the model were imported to Revit to be then model with basic walls and slabs that surrounds the room wall to work with IFC, creating a link for a new file to be added to the reference model. Lately, all the optimization process was shown during the dissertation was applied to the Revit file. The use of shared parameter and the collaboration of them were the key criteria to compile all the information in regards of the methodology developed.

The last step was to provide information output in datasheets (Excel) and the use of Power Query and Power Pivot to work with the data form the file Revit schedules into graphics and tables with information in regard of DfMA, that can lead to design optimization and manufacturing automatization.

1.3. Structure of the dissertation

The dissertation is divided in three main chapters, the first is an introduction to off-site construction and DfMA, then a second dedicated on the analyses of the case study and methodology, and lastly a chapter dedicated on developments of the code and explanation of the process and results.

The first chapter is a literature review of the developments on off-site construction and DfMA, dedicated to the analysis of the methodologies and advantages. Further understanding of the liabilities of this process were considered, where the problems that come with the implements in the architecture and engineering companies, and even the lack of solutions and resources, were detected. Additionally, the advantages of BIM and potentially uses for this method of construction were analysed, focusing on the technology developments and the integration with BIM dimensions.

The second chapter is focused on the analysis of the partition wall system which will be the case study of the dissertation. In this chapter it was analysed the process generated from the company Casais, where the walls that to be standardized and mass produced were studied in regards of their properties and application in the room. Additionally, bathroom layouts were surveyed, given the properties of this space, concentrating the investigation on the types of bathrooms and their similarities, to be further applied in the process of DfMA, and ultimately to be sent to the technicians.

The third chapter is the digital systemisation of the process analysed in the chapter 2. The digital process was divided in three milestones, where the process is conducted and generated in phases to achieve the desirable outcome. The first milestone was the reception of information and preparation of the file to be suitable to DfMA. The second milestone focus on defining parameters to identify the typologies of the bathroom with the use of a hierarchical code of parameters. The third code was based on a code that detects sub-typologies of the room, by identifying small variations in the typologies that were created previously. Consequently, after the information being added to the model, a last chapter is dedicated to treat and organise the information, in order to be a useful resource for production stage.

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2. BIM AND OFF-SITE CONSTRUCTION

The roots of the off-site construction stem from the end of World War I that affected the construction industry by major shortages of skilled labour and building materials and this shortage triggered a need for search of new methods of construction (Ezcan, Isikdag and Goulding, 2012).

This chapter focus on the developments in BIM and Off-site construction as a resource which potentialize it´s use in developments in the future of construction. It is structured as a literature review of the current technologies and process, which explores the market uses to empower BIM as a design driven tool to the development of this century old topic. This literature Review creates an analysis of BIM assessments, and his technological advances shows the key factor for taking advantage of current available tools to optimize for future and current challenges in which Off-site construction faces.

2.1. Off-site Construction

Since the financial crisis of 2008 the construction sector suffered from a loss of 20% of man labour. Table 1 shows the current market gap between people who work in the construction sector between 2008 and 2020. This problem outstands with the current pandemic that, during the time this dissertation was written, has suffer in the past months from a reduced number of workers and a slow decrease in productivity, even if there is a lack of information. The construction productivity is directly related with how effective, fast and on budget can a building be constructed.

Table 1 - Employment: total and by sector of economic activity (NACE Rev.2)

Sectors	**Total**		**Construction**	
Years	**2008**	**2020**	**2008**	**2020**
European Union 27	193 164 600	197 153 600	15 967 000	12 840 000
Germany	38 541 500	41 716 000	2 563 500	2 276 600
Portugal	5 116 600	4 814 100	539 600	297 100
Italy	23 090 300	22 903 800	1 952 500	1 357 900

Off-site construction involves the fabrication and assembly of construction elements to be later transported to the construction site, being light-steel, wood, and composite material more favoured in the development. With high hopes for on the current technology, the promise of lower project costs, shorter schedules, improved quality, and more efficient use of labour and material, proofs the outgoing interest by the community in making the switch. The expansion of this process is being due to building codes that hinder innovation as well conventional design and construction process and practice.

Following the study released by National Institute of Building Sciences (2014), by comparing 8 cases of use of Off-site construction, there are significant advantages in the use of techniques for modular construction during the building process. The cost average has dropped 16%, compared to typical construction framework, and an average schedule reduction by 45%. According with Construction Users Roundtable (Modular Building Institute, 2010) in 2007 the most important advantages of Off-site construction were:

1. Controlled environment, more quality check and control, easier access to tools and material deliveries;
2. Less environmental impacts due to the reduction in material waste, air and water pollution;
3. Compressed project schedules that result from changing the sequencing of workflow;
4. Less in work conflicts by better scheduling and by creating an in-house assembly of craftsman;
5. Bigger on-site dock by reducing the on-site storage and fewer losses or misplacements of construction material;
6. Increased in safety of the workers through reduced exposures to inclement weather, temperature extremes and ongoing or hazardous operations;

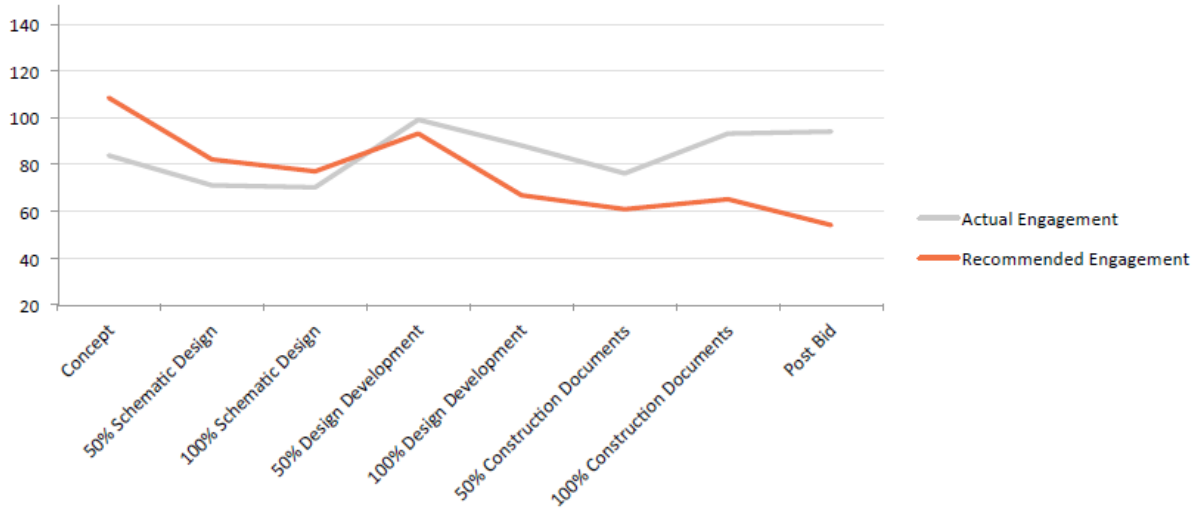


Figure 1 – Graphic that represents the feedback of the engaging the off-site contractor in the process (Smith and Rice, 2017)

The figure 1 shows results that represent how the process of transition to off-site construction technologies is applied to later stages of the operation, and how the workers engaged on the project observed what would be the best time to think about Off-site construction process. When the project team makes decisions of changing the construction strategy to a modular type, it's more likely that to have an negative impact on the project schedule and cost. The late design changes, lack of collaboration and an adversarial climate for project delivery leads to difficulties in realizing the benefits of off-site construction (National Institute of Building Sciences, 2014). The study that was realized attest that the biggest barrier to Off-site construction is the design and construction culture.

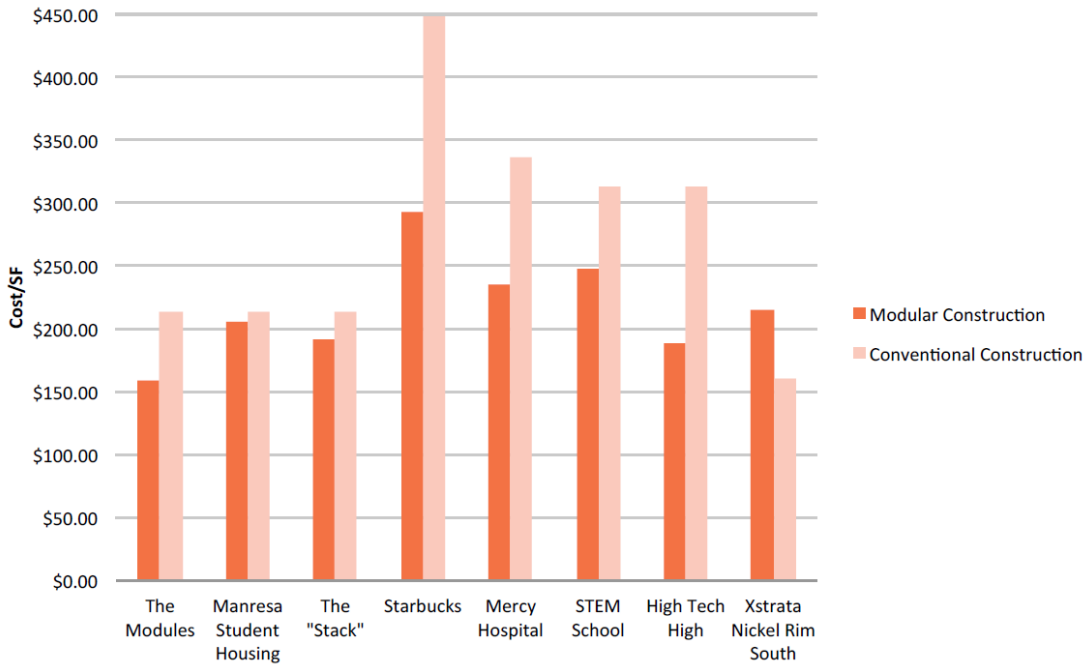


Figure 2 - Cost per square-foot comparison analysed by Cumming Corp. (Smith and Rice, 2017)

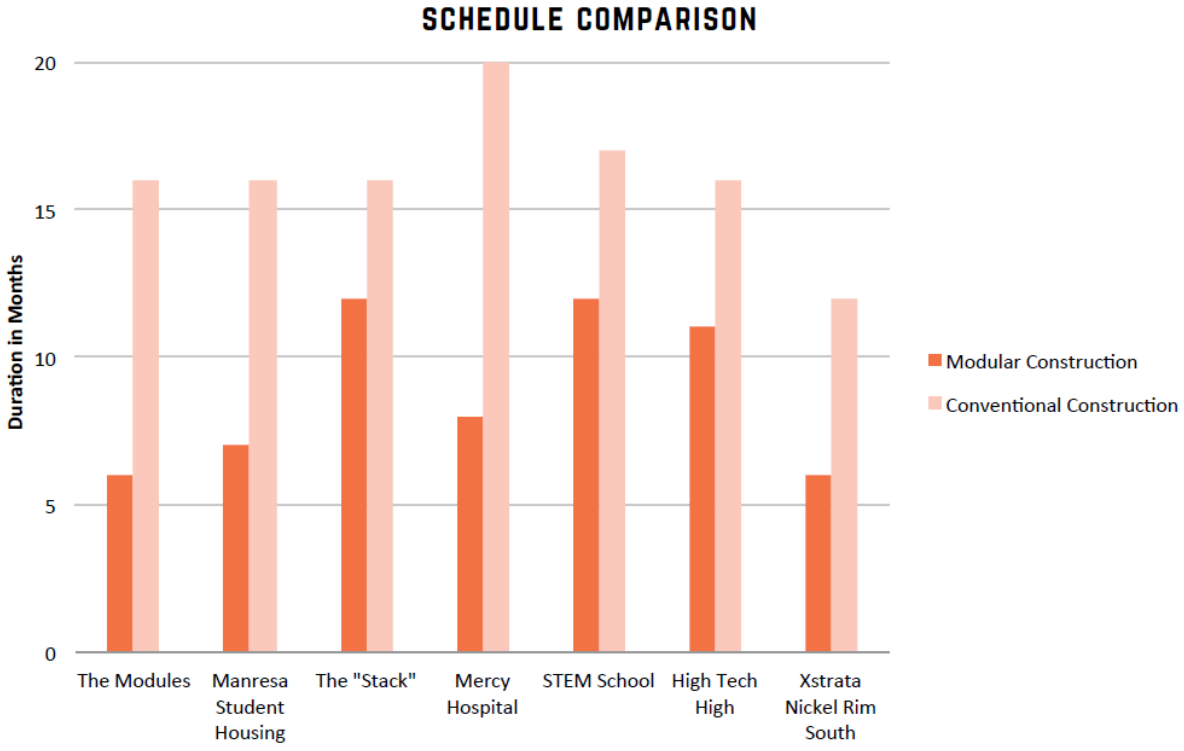


Figure 3 - Schedule comparison in months analysed by Cumming Corp (Smith and Rice, 2017)

The literature review helped to frame a set of problems that need to be addressed in order to implement Off-site construction processes in more types of projects:

1. Need for a higher level of technology information application – Need of tools to keep a track of the building attributes;
2. Earlier prefabricated systems which has a bad reputation – Related with post war architecture and related with social housing;
3. Designers and contractors lack of experience – Limited expertise in Off-site construction, making it harder to implement;
4. Hard to make modifications – Requires the project to be stable since the beginning, since it can't be changed through the process;
5. Transport limitation – Some elements can´t be transported, hence the fact that the system needs to be optimized to be moved;
6. Demanding task – Some tasks take more time that previewed, creating delays when the system is connected to another;
7. Higher Initial Cost – Higher initial cost to be expend in expertise and in a more detailed design to be then applied in the construction site;
8. Aesthetic – Repetitive design and lack of innovation;

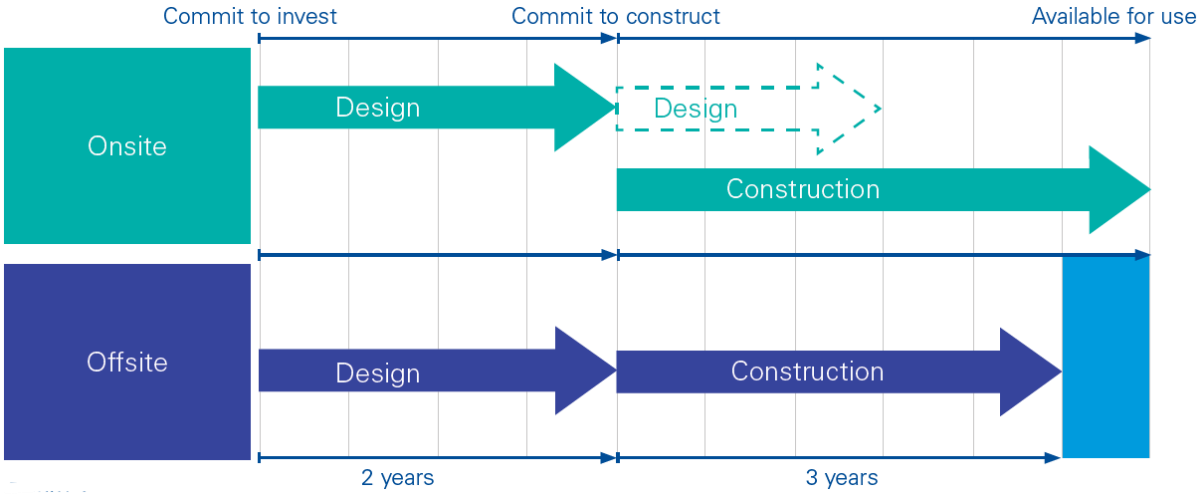


Figure 4 – On site construction compared with offsite construction, over 5 years (Southern, 2016)

2.2. BIM relation with Off-site Construction

BIM is shifting the construction industry into breaking new grounds and promoting new technologies and new building techniques through sharing information in a BIM model. The research focused on BIM is mainly concentrated in improving model abilities of acquiring, storing and sharing the construction related data. These improvements not only increase its information management abilities, but also give BIM a role as a facilitator for new technologies and building methods. (Ezcan, Isikdag and Goulding, 2013).

The literature review by Yin et al. (2019) showed the impact of BIM as a mediator which reduces the gap and improves the Off-site construction process. It improves design quality, promotes collaboration, communication and manage, and stores the information in one place, benefiting the technology for Off-site construction implementation. With BIM, an accurate virtual model of a building is constructed with precise geometry and relevant data needed to support the procurement, fabrication, and on-site installation activities. Mullett (Mullet, 2017) defined 8 tools that express the advantages of implementation of BIM systems in Off-site construction:

1. Visualization - Real time visualization of the model and of the components which belongs to the BIM model;
2. Modelling - Ability to generate parametric families which helps to optimize the process of module creation and direct implementation in the main model;
3. Code reviews - Ability to store information in regards the building code and providing access to the information inside the model;
4. Fabrication/ shop drawings - Create drawings form BIM model to be used as tools in the construction site;
5. Communication - BIM promotes collaboration and communication between multiple stakeholders.
6. BIM 4D - Provides tools for a complete time schedule of construction phase, allowing better coordination in the construction site;
7. BIM 5D - Cost estimating and bid of quantity can be created with schedules and be automatically updated during the process;
8. Clash Detection: Coordination of collisions between multiples stakeholders, system to detect flaws in the model and to better communicate problems;

Table 2 - Summary matrix that positions BIM benefits for overcoming barriers in OSM processes. (Lawson and Ogden, 2010)

BIM Benefits / OSM Barriers	Optimized Schedules	Reduced Costs	Improved Design	Better Training	Better Collaboration	Better Logistics	Reduced Design Errors	Accurate& Extensive Amount of Information	Reduced Modification
Need for high level of IT integration					●			●	
Bad reputation	●	●	●						
Limited experience				●	●				●
Modification Difficulties			●				●	●	●
Transportation problems	●		●			●			
Longer lead-in times	●		●		●	●	●	●	
Higher costs		●	●		●	●	●		●
Poor aesthetics			●					●	

Yin et al. (2019) compile all literature reviews and analysis of BIM for Off-site construction. In this paper, they state that there are five summarizing topics in which BIM development can improve this matter: The interaction between BIM and Off-site Construction; BIM for DfMA; BIM enabled logistic planning; BIM enabled assembly planning; as-built BIM for construction control. The interaction between BIM and Off-site Construction can be pre-modelled as BIM objects into a BIM library, this process allows these objects to be parametric families containing information in regards of the modular object that can adapt in different context by changing some parameters.

BIM to DfMA is considered one of the most constrained process due to the needs of the integration of different stakeholders into the design stage. This methodology aims to improve the manufacturing and assembly of prefabricated construction elements. However, due to different configuration between off-site and on-site construction process, BIM tools face some difficulties. Considering that most elements in on-site are made cast-in-situ construction materials, as in off-site the elements need to be assembled in factory, this makes the base families worked in different way, as more information need to be added to off-site construction.

BIM enabled logistic planning, by easing the definition of a supply chain for the several construction stages, enhancing the integration of prefabricated building. The information about the building elements at each stage should be collected in real-time through cloud-system to control and manage the process in-site, this can also be applied in the management of the prefabricated pieces in off-site manufacturing, through the definition of codes that help to keep track of the elements. Thus, creating an overall identifying system for the assembly and positioning of the elements before and after delivery.

BIM enabled assembly planning - Scheduling the construction is one of the most important roles so the manufactures can do their role, as following along the assembly schedule. Assembly planning combines BIM 4D capabilities to track construction development by preparing scheduling and cooperation with stakeholders and with the contractors.

As-built BIM for construction control – The prefabricated elements need quality control and assessment on as-built information collection. In most projects, the quality inspection is conducted manually, which leads to low efficiency and accuracy. Laser scanning is a good tool to collect information on site, since the manual assessment data cannot be stored properly for later management analysis.

Figure 5 – A typical supply chain of OSC projects (Yin et al., 2019)

BIM is extendable to management activities and to their information exchange which improves the overall transition for offsite construction. It has a lot to offer to the overall switch to this paradigm and during the off-site construction management there are a new step in the construction part that needs to be considered during the overall process, such as manufacturing, storage, and transportation. This processes in addition to the existing ones (design, construction, operation) demands effective communication, technologies, and tools to improve cooperation.

The number of papers related with Off-site construction and BIM are scattered and does not contain new inputs to the matter. This shows how unique the subject is for the construction industry. With the urge to create this change, there is a barrier that block the transition to mind the gap. The fact there is a lack of expertise in the subject, but more important, the ability to address the issue without compromising the design part or construction.

Despite the advances that BIM has introduced in the design process and in the construction industry, it still does not provide tools that focus on Off-site construction, makes this transition harder. As shown previously, Off-site construction is a decision that needs to be taken since the beginning, because it does affect the overall phases of the building, not allowing the user to make changes in later stages. The idea of BIM as a tool with parametric capabilities is not the main point of the overall use of it in the Off-site construction, but it provides a better design decision, automatic correlation between parts of the project, cost detection and quantification of the elements, allowing the early stage to be more accessible to all the stakeholders and providing the clients with decision making information.

2.3. Design for Manufacturing and Assembly

Design for Manufacturing and Assembly (DfMA) can be described as a set of design guidelines combined with an evaluation and optimization methodology for improving the design of a product regarding how it is made. (Kuzmanovska and Aitchison, 2019)

DfMA is a design process in which the elements of the building will be standardized and design to be as effortless and cost effective to be produced. This process is a design decision empowered by the architecture, architects can design a building to be enabled to be or not DfMA if it is thought since the design stage. However, architecture is a service where the main goal is to match client desires and generates design proposals, on the opposites manufacturing is non-service that maximizes productivity and money/cost average per element by maximizing the output.

DfMA convert a building into a prefabricated design driven which elements needs to be modular and repetitive to be mass produced. Exploit designs rationalize, materials optimization, scheduling deliveries or on-site management to maximize productivity makes this a solution in Off-site construction. Manufacturing and Prefabrication will not get overtaken by DfMA, the process and techniques might differentiate between different components of the building. Leveraging digital tools in parametric design, architects have taken mass customisation as a design strategy to realize greater individual artistic expression. (Smith, 2019)

Embracing the principles of manufacturing – standardisation to mass customisation – has the potential to empower architects to be able to respond to the current demand and have greater impact on delivering democratic housing design for the masses. (Smith, 2019)

After literature review, it was necessary to analyse the process of standardisation and customisation by evaluating which types of process exist and how they are applied in the construction site. Smith (2019) create the following list is a result of the different types of customisation and manufacturing processes and how they directly affect the construction industry and architectural design of customized elements:

1. Made-to-Stock - As stated by the name, this process stock elements as strategy by lowering complexity and increase repetition;
2. Assembled-to-Stock - Customisation is introduced in design and standardisation. The concept of assembly line production and mass customisation are established in this process;
3. Made-to-Order – Elements are made to be deliver in site on time. This process has a determined design and engineering option apply to the process that allows to be customized without changing the production line;
4. Engineered-to-Order – Customizable elements that can't be mass produced due to the unique application. This process thrives to provide competitive prices and delivery time to their output;

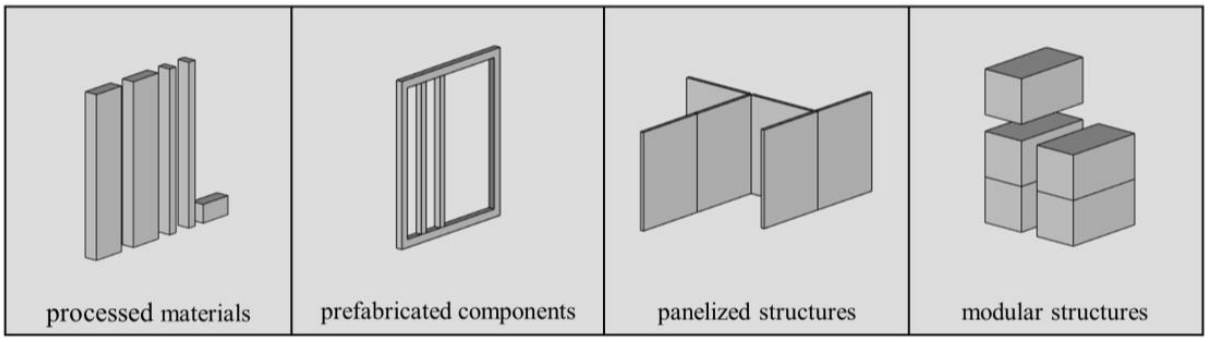


Figure 6 - Classification of prefabricated systems used on construction (Teribele and Turkienicz, 2019)

The figure 6 shows the types of prefabricated elements that can be mass produced using DfMA. This process is the ones that can be assembled-to-stock to be applied in construction site. This element can be unique and at the same time being produce in assembly line, making it a good fit for DfMA using BIM tools. However, since this element is not considered a made-to-stock components, it's not easily fitted inside the BIM modelers software, making the process of manufacturing components easier than generating it in BIM. There is a gap between these type of elements compared to family-based components: Made-to-Stock elements contain a base of restrictions and dimensions and contain some cases where the structural frame is system inside, which is frequently used for manufacturers; Assembled-to-Stock can be used in certain elements inside the building, which usually don't get standardized firstly because of the in-site process currently existing, second because they are more frequently used to extract information, rather to be used as a base for DfMA.

Following Smith (2019) research, the application of components as DfMA in the construction requires to go through three levels of manufacturing, following phases to generate the prefabricated modules in the building: parts, sub-assembly and assembly.

1. Parts: Stand-alone material or components of the construction that need to be sub-assemble in factory before moving to the construction.
2. Sub-assemblies: This refers to components, panels or modules that are pieced together with parts to create elements to be assembled on site.
3. Assembly: This is the act of setting sub-assemblies together on site in their final location and stitching.

2.4. BIM in Design for Manufacturing and Assembly

The DfMA assessment consist of a linear iterative optimization process based on already defined design details. This process can only be applied after their formal characteristics, such as design and structural parts being formally defined to be applied in the construction part of the building. The figure 7 shows how important the work process of DfMA operates in the architectural team. The process considers the architecture and engineering team working collaboratively together to maximize and formalize all the parts of the building before advancing to the next stage.

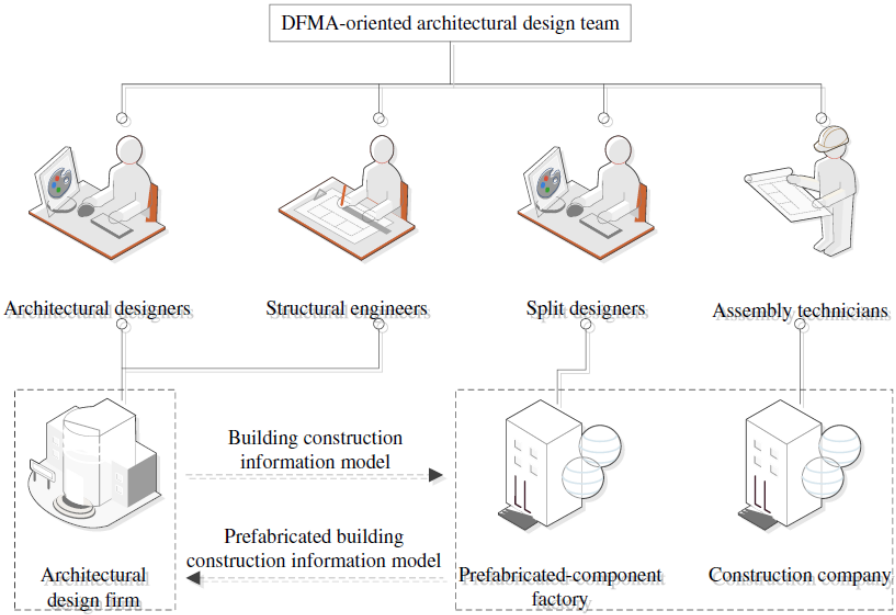


Figure 7 - DfMA -oriented architectural design team (Yuan, Sun and Wang, 2018)

The figure 7 is a schema presenting the role position for DfMA and the framework for collaboration. After analyzing the role of the architect and engineering as promoters of the process the split designer and the assembly technician, will manufacture and assembly the components for the building. BIM allows the communication and management of the process during the design for manufacturing procedure, to generate components of the building and to manage and control them in the assembly phase. The exchange of information between multiple stakeholders is one of the biggest advantages of BIM especially during all the process.

BIM is a key technology capable of supporting DfMA, and DfMA makes BIM more suitable for prefabricated buildings. DfMA-oriented parametric design, a new design philosophy, is the organic combination of DfMA and BIM parametric design. (Yuan, Sun and Wang, 2018)

The automation of DfMA is the most crucial step that turns the information in design, since it's a time-consuming task involving elements, parts and assembled components. Towards achieving this procedure, it is important to define a process which combines BIM functionalities to maximize the output and provide a better performance. The first step in achieving DfMA is by establishing a reference model with all the stakeholder's information, then to proceed towards the detail design analysis of the basic model. This fundamental step allows the elements to be later added in the process as part of the

manufacturing and assembly process. From the parametric precast components and assembly functions in BIM, there is a need to check the elements that will be manufactured. The elements contained inside the BIM library can be adapted to be prefabricated using the BIM re-development or BIM family template. The last step is exporting the information as drawing and optimized prefabricated building information model.

Parametric modelling improves the design and modelling productivity by providing an effective and optimized method, improving building manufacturing with the use of parametric objects retaining design content in response to external and internal spurs. Parametric modelling is limited in its applicability in DfMA for construction focus design detailing due to the complexity of the components and their haziness, since there is a lot of detail inside each component. These parametric elements need to be created in a hierarchical way to avoid the manual position of it, minimizing the number of manual inputs in the model.

Research on the subject focus in automatization of the process in executing parametric components for building manufacturing elements. These elements are considered in BIM as system type of families with specific roles in the construction, that don't contain enough information to be exported as DfMA. Due to their layer based composed properties, the representation of the part of the assembly is not a part neither are shown as part of the components. One example of this elements is wall type system. The discoveries in this subject focus on process to develop and create a gap on the manufacturing process of this elements, minimizing the manual input.

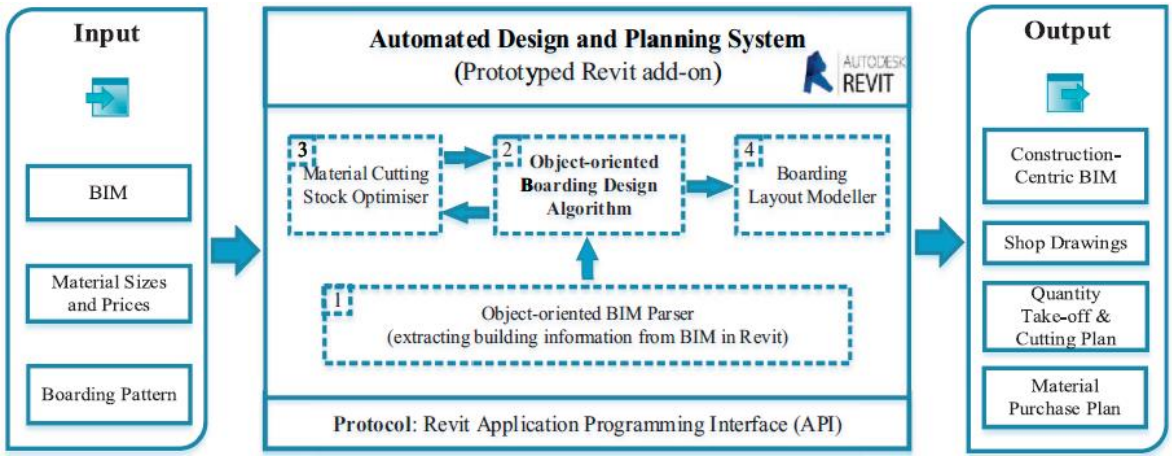


Figure 8 - System Architecture (Liu et al., 2018)

The figure 8 shows a workflow process of generating frame system and boarding for wall created by Liu Et. Al. In this process, it's possible to analyze the three stages of automation in system families, where the inputs are the BIM model and external factor provider for manufacturing. Then, the parametric design optimizes of the parts into assembly components using API to be exported as information for construction. However, the process of developing BIM for DfMA is not as linear. A model may not be suitable for such task if there is a variation of the components. As stated before, to maximize the potential of DfMA, it should exist a lot of repetition in the elements to maximize manufacturing. In the next chapter this idea will be analyzed with use of a practical case.

3. DFMA APPLICATION IN PRACTISE

The previous chapter makes an introduction of the BIM and DfMA which will be the main topic of this dissertation. To understand this process and to understand the problem, which was studied, this research was conducted with the help of Grupo Casais, a construction company based in the city of Braga, Portugal. This construction company has one split company named TopBIM which consist in a technical team that creates and develops DfMA. Inside the group there is a technical team which manufactures and assembles the prefabricated elements called Blufab.

This thesis main topic of research was proposed by the company to tackle a problem which they face when implementing DfMA process. The TopBIM team has a manual workflow of the procedure of assessment of the building, which lead to a time-consuming method and loss of information. The goal was to automize the process of generating information and use it as design driven procedure that contains data regards the building project and apply in an architecture project already developed without compromising this class.

3.1. DfMA in partition walls system

TopBIM developed a workflow for partition wall system which consist of manufacturing room walls in factory and deliver to the construction site. The idea was to apply all the principles learned before and apply the concept in closed room of the building. The type of room which was defined to be the tested was the bathroom since it can have multiple repetitive elements and can be standardized multiple types. However, bathrooms design deals not only with the layout of the bathroom furniture, but also with the infrastructural data, such as plumbing system that runs in between walls and the fact that there are multiple variation of bathroom depending of the dimensions.

Figure 9 – Blufab prefabricated bathroom by partition wall system

Bathrooms are complex compartments in the building, for being closed spaces which makes the process for DfMA an improvement of productivity in terms of collaborating in this space. The design of bathrooms has a mutual correlation and collaboration between architects and engineers since, there needs to have a structure, space disposition and plumbing system. Hence making it a priority in automatization using BIM.

Traditional methods of construction in bathroom develops around the collaboration of multiple employees inside the same space. The cut of the profiles and the assembly need to be done in site, to be later applied inside the room. The hot and cold water, that comes from the celling will be attached to the plumbing of the room to later pass underneath the profiles and connect to each sanitary. The elements that are connected to the wall will expel the waste through the sewer to later connect to the main sewer line of the building. To close all the space 2 panels of gypsum board will reinforce and surround all the space creating the finish face of the wall, the finish material will be applied on top of this walls.

The new process allows the fabrication of the frames of the wall to be conducted in factory and later transported with the board cut to the place it fits, since was already measured to fit in that specific wall with the fixtures marked. Later, the frames are carried and put on place, to then apply the infrastructure underneath that will be attached to a prefabricated piece to attach the sanitary, preestablished from factory. The boards are cut with desirable dimensions, to fit in the prefabricated component.

To develop a new workflow, it was used an in-house residential project with five levels, which contains approximately 500 bathrooms. This amount of bathroom made the company evaluate the number of different rooms which are contained inside the building, reducing the total number of variations of the design of the minimum bathrooms possible. However, since this process was not automated a technician use a CAD plan of the building exported from the BIM model, that was provided from the architecture firm, to be the assessment for DfMA.

The CAD plan was the only available resource, even if doesn´t contain enough information. However, it can serve as further improvement in the BIM model, then it was possible to detect the location of the rooms and walls, since it was the only file that was provided between the architecture firm and the construction company. Consequently, the task of the technician got more complex because of this huge barrier that the file takes from the workflow. However, the task liberation was developed with the use of this resource by creating a set of steps to achieve the design optimization for DfMA:

1. Map all the bathroom inside the CAD drawing and remove the one which are unique, since they will not be adaptable for DfMA;
2. Separate the Bathrooms in Groups by dimensions and disposition. Separate in the CAD file to then overlap in multiple blocks;
3. Find relation between bathrooms to reduce the number of different types;
4. Set similar bathrooms which may be inverted in new sub-types;
5. Find a fit modular bathroom of each type;

3.2. Process workflow using DfMA

In this chapter, the manual workflow will be analysed to be transpose to a digital process optimized with the use of BIM. The problem starts with the creation of a hierarchical approach to separate all the rooms in different types of categories, since all the room have different attributes and disposition. The bathroom has different types of organization, but the elements which are inside the room are similar with two elements being the mandatory to be considered bathroom: toilet and lavatory.

The first process starts with the separation of the rooms by selecting previously their geometry, through the number of faces. Consequently, the faces represent the number of walls inside the bathroom and can be splitted in different groups. Then all the bathrooms were selected by size and dimensions, then divided in another groups, so in the end, the selected few can be detected by the formal disposition of the space (Fig.10).

This process was done manually with some uncertainties in some cases, some elements didn´t fit the criteria. This creates a problem of human error in the process that will generate future difficulties. Nonetheless, with the use of this process the 500 bathrooms that exist inside the model, could be sorted in 30 groups, reducing the gap of unique types. However, since the rooms belong in groups, there is a need to detect all the smaller variation in the BIM model which can be mass produced and manufactured, without compromising the architecture and structural part of the building.

Figure 10 - TopBIM floor plan of the residential case study with the marks of each bathroom

The process stands to find the number of similar compartments and why they are different, to later find a middle term block that will fit the position which they have in the project. Some block, as the figure 11 shows, can be a type with more than one variation. Some rooms are dependent of their spatial position, which can be inverted in relation with the spaces. In terms of grouping elements by type this doesn't create a problem however, in DfMA the wall, which is inverted makes already a different component, that needs to be thoughtful in the design and assembly process. The reason sub-types are crucial is due to all the parts that belongs to the group be the same, yet the way they are assemble is different depending on the disposition of the elements.

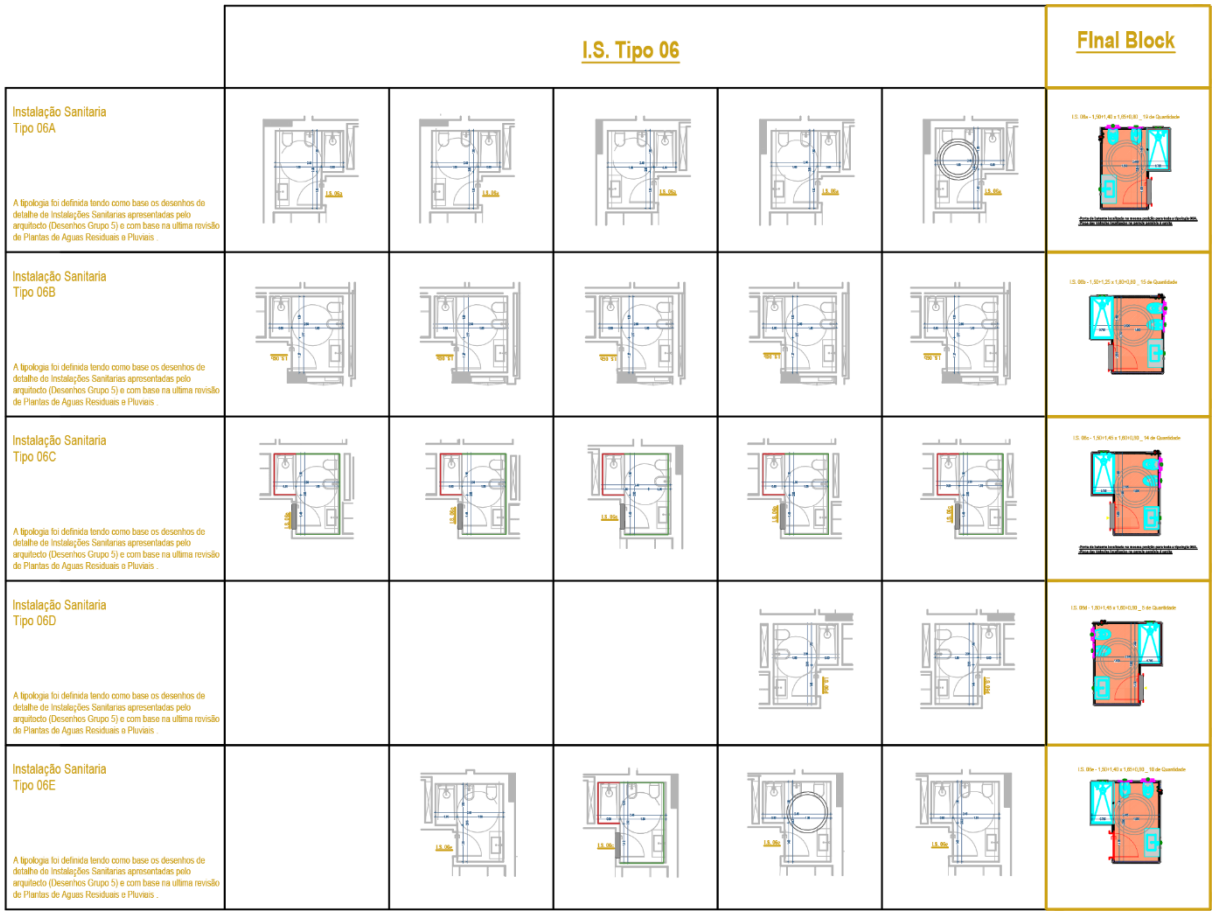


Figure 11 - Room type grid with final block

The figure 11 shows how this process was created in manual form, where they pick each room similar in all floors of the building and stack them on side of each other to identify similarities. The table represents a typology, and the rows represent the subtypes of each selected type. The columns are the different variation of room with similar proportions and dispositions. The end column it's the final block chosen, which is a block that can fit in all the spaces available by that sub-type, this is one of the most demanding parts of the work and one that can´t be easily achieve on BIM. However, the fact that these changes were done to be standardized and mass produced, could be more efficient if were done using BIM, since the new changes could be sent as IFC to the architecture and engineer office to request for modifications. This method will be more certain in the design optimization of all the parts, thanks to the detection system of elements code inside the file. Therefore, the changes were done as report and the drawing file was used as recognition system, making time consuming task with likelihood of hazards.

3.3. DfMA in partition walls system of bathroom walls

The manufacturing process which Blufab developed define prefabricated components for each element that exist in the bathroom. A toilet element is a standardized component that can be produced multiple times, independently of the type of bathroom that will be implemented. The only difference stands in the element toilet, since it might have different manufacturer specifications, that can lead to different cut holes for the fixtures.

The number of existing partitions walls system in the bathroom are directly correlated with the number of individual elements inside the bathroom. Elements like Toilet, Bidet and Lavatory are unique component that will be replicated multiple times. However since, they are prefabricated as a unique element they need to be assemble in a group of walls to be part of the bathroom type wall. To achieve this role wall needs to be split in three parts.

1. Profiles - Create the frame around the wall and the in-between in their spawn;
2. Structural panelling board - Attached to the profiles, creates the support for all the plumbing of each element and to the overall system inside the bathroom. The element profile of the bathroom enters in this category since they will be replicated more often, they are manufactured with the plumbing system of each element and with the mechanical system that might be needed to support the element;
3. Finishing panelling board – Attached usually in an opposite direction of the structural panelling, they contain all the finishing material of the bathroom and contain the fixtures for the elements to be assemble;

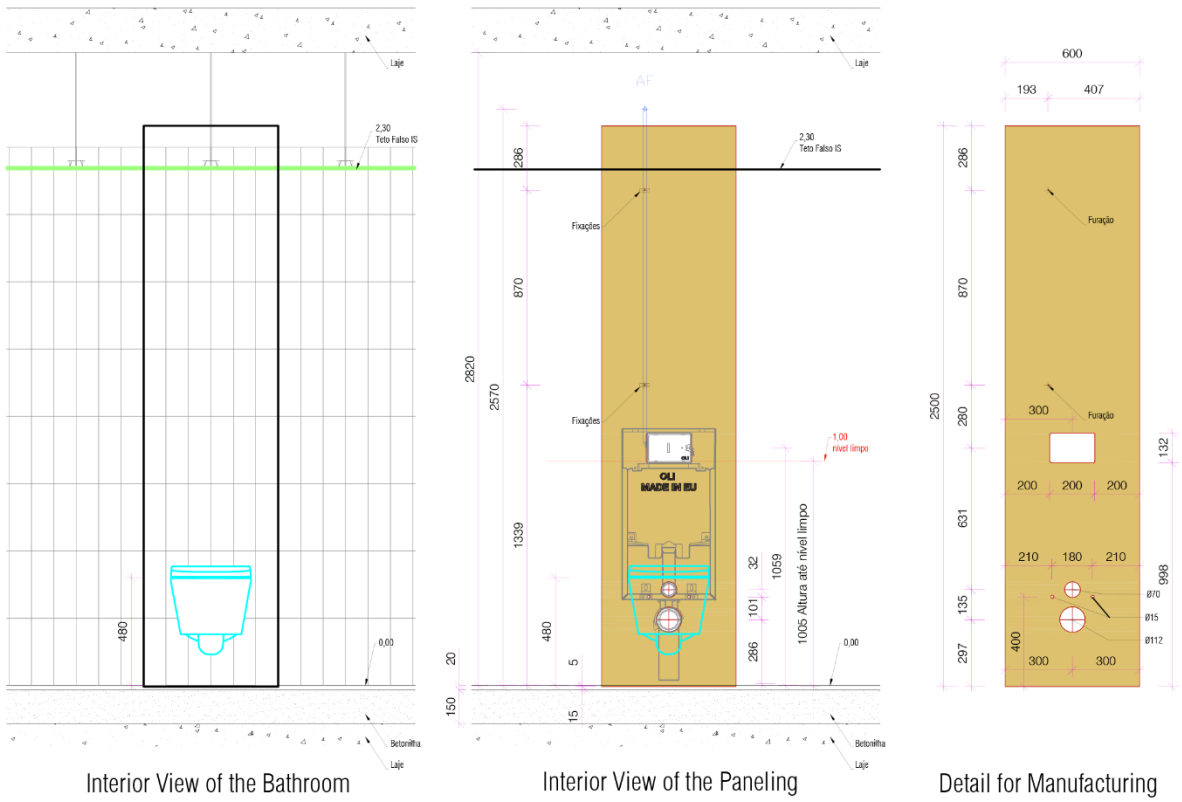


Figure 12 - TopBIM board panelling DfMA with the information for the fixtures

The figure 13 shows the composition of all the part together in the manufacturer process. Taking the consideration of the elements that belong to the group the interior board as seen, contains all the plumbing and fixtures for each component, as contains the flush for the toilet. These elements are then attached to this profile frame that add-up to another one in some cases. When the wall is empty this process, simplifies as just the space between profiles need to be taken in account, but there are two elements that need to be rethink: firstly, the wall which contains the door, and the walls that surround the shower and bathtub.

Figure 13 - Room type grid with final block

The element of door is a simple component, however its function that need stands as a connector to both side of the partition wall, as it's a system that works inside the room, leaving the interior exposed. The door needs to be the element that will make the transition between the two partition walls closing the gap that exists in the construction detailing. However, when the wall is a sliding door, this element instead of not only unite the partition wall, but it needs to move along the space inside both. This creates a problem already in architecture, but when taken to DfMA it gets even worse, as new information has been added, these elements can collide with the substructure of the partitions walls and make them a barrier to standardize the process. The solution is changing and playing with the different type of doors to fight this problem on some occasions.

The bathtub and shower partition wall system make part of a bigger group that is assembled to protect from future infiltration. The bathtub and shower sink are a group composed of a wall system connected

by common corner that connects all the sides where they intersect. Blufab came with the solution of foldable wall, that takes these elements and connects in the corners and then unite all the side of the bath as a unique group to be easier transported to the site. This solution makes much easier to manufacture the component multiple times, as bath tube is a already manufactured components, makes it already a optimize to be replicated in the manufacturing process.

Shower and bathtub partition wall system are already more trackable inside the model and in the cad drawing, then other components families. This blocks usually have a fixed place in the bathroom, which can´t be moved and goes along with the model. The biggest turn back is the fact that when fitted in the corner, makes the element directly connected to the width of the bathroom. In an optimized solution, such as final blocks, this is a problem that needs to solved, or by accepting the manufacturer dimension or rather by the length desirable to the room.

Figure 14 - Blufab bathtub prefabricated block

3.4. Partition wall system tracking in DfMA

Figure 15 - Bluefab tracking code with QR code in wall (WC24)

The elements detecting system is one of the most important parts of the process. All the elements that are created to DfMA need to have a code to be detected in the site. To keep the track on the components a code is assigned to each wall, that will fit in each room, the code represents the wall code and which room will be attached, the figure 15 shows the code created by Blufab to keep track of the wall of the project.

This process when done manually can lead to errors when keeping track of the position and location of the element. The issue being the outdated files and manually assemble of the code in the drawings, leading to concurrence of information, and lost and displacement of the elements. BIM can tackle this task much easier, by creating a code directly in the family wall system, make it readable in the site construction. The implementation of BIM makes the partition wall system always up-to-date and easily trackable by exporting as an IFC and opened in any software used on-site.

4. OPTIMIZATION OF BIM MODEL FOR DESIGN FOR MANUFACTURING AND ASSEMBLY

In this chapter the main goal was to define a design optimization strategy that automize the manual process analysed in the previews chapters. The automatization starts with the use of BIM as the design resource tool to achieve the maximum optimization of the process, avoiding mistakes and human errors. With the resource of a BIM model, the process was taken using the same residential cased study stated in the process above, to compare the results and to use the accumulated knowledge in the creation of the process.

To maximize the output for DfMA the process was divided in three milestones: IFC Interoperability, Typologies Generation and Sub-Typologies. Each represents a group of steps to achieve certain functions. To achieve these milestones, the software selected was Revit, since it optimizes the process using parameters which can be created inside their interface, providing information and integration during the methodology. This software contains a visual programming extension named Dynamo, that can automatize using nodes with written code that are specified to work with Revit. These parameters are then exported as information inside Revit, which combining multiple codes will provide a solution to the problems stated above.

The figure 16 represents a diagram of the optimization process and the relation between all the nodes that were developed during the investigation. The code is divided in 3 phases being the first one the creation of the data and the working file; the second the creation of the typologies; last one the sub-typologies. The image represents the connection trough a dark line and using dash line the middle stages that were used to achieve a desirable result. In each sub-chapter of this chapter all the methods will be analysed in a direct correlation of the overall structure defined in the diagram.

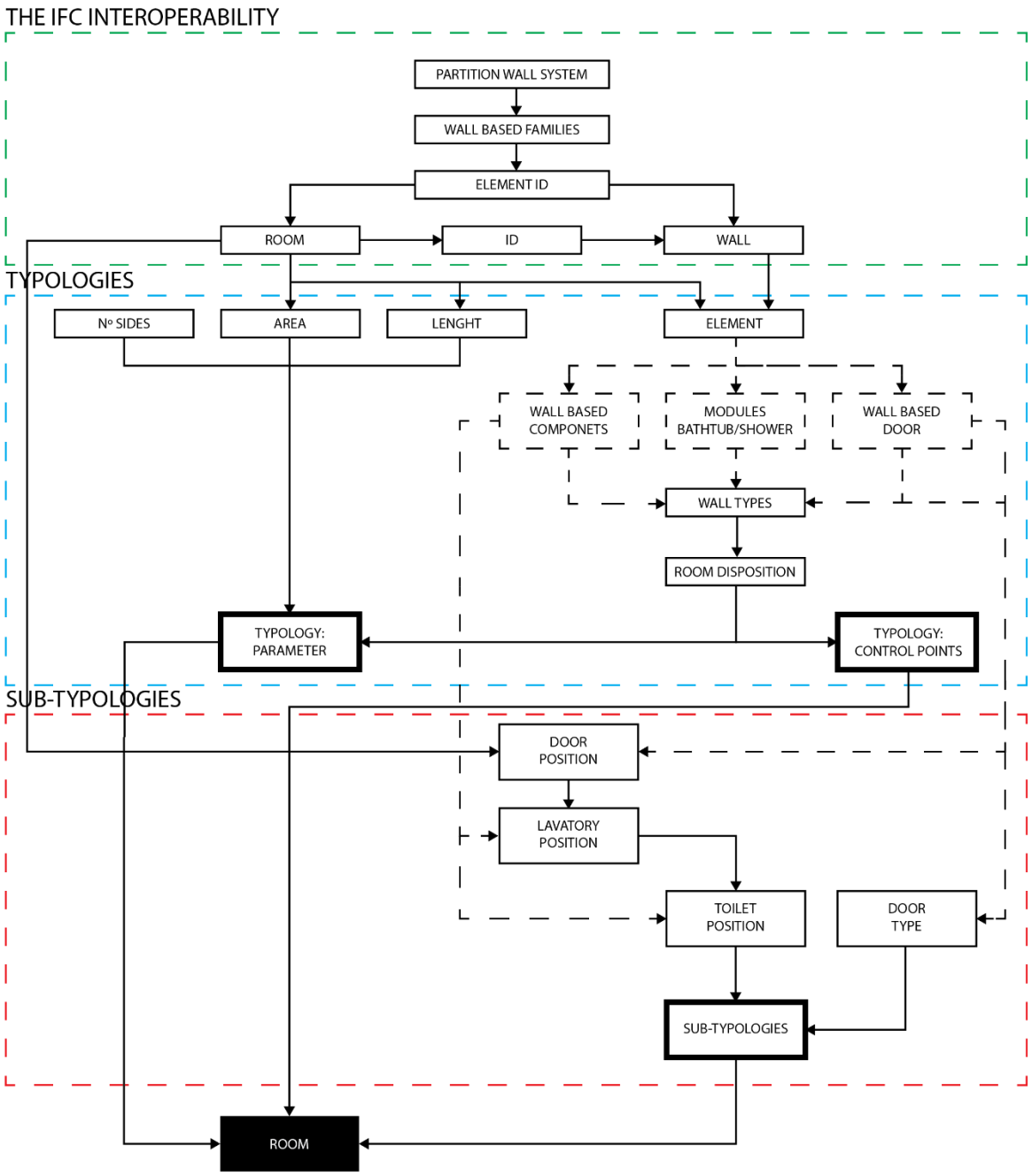


Figure 16 - Diagram of the relations of all the codes

4.1. The IFC Interoperability – Milestone 1

This chapter will focus on how to transform the information received and prepared to DfMA. When the project is transferred to the split designer a new BIM model will be created, that will work autonomously from the Reference Model. Since this new file will work only for DfMA, the changes and information that need to be added should be only applied to the new file. One of the preliminary works that needs to be done by the split design is to detect if every bathroom as the same name, to then pass to the second stage. The file needs to be attached as Link IFC to be introduced in the BIM software as necessary information. It´s important not to exceed the amount of information in the model, since there are a lot of operations that need to be done to achieve the result.

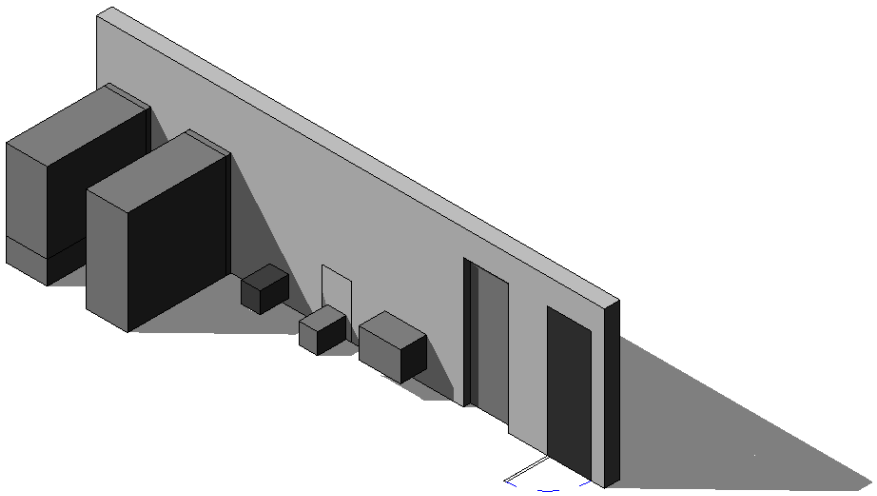


Figure 17 - Revit with all LOD 200 families

To prepare the information and all the details towards reaching the results, it was generated a LOD 200 family types of all the sanitary pieces of the bathroom and door slides (Fig.17). A simple and low detail family type of elements was helpful in creating relations with the elements by creating rectangular angles, that will further be analysed and will help in additional decision making in the model. The block of the bathtub and shower are independent family types, in opposite, all the other components are wall-based families. Consequently, and since the file is a new file, the only elements that will be added will be the bathtub and the shower in the beginning of the process.

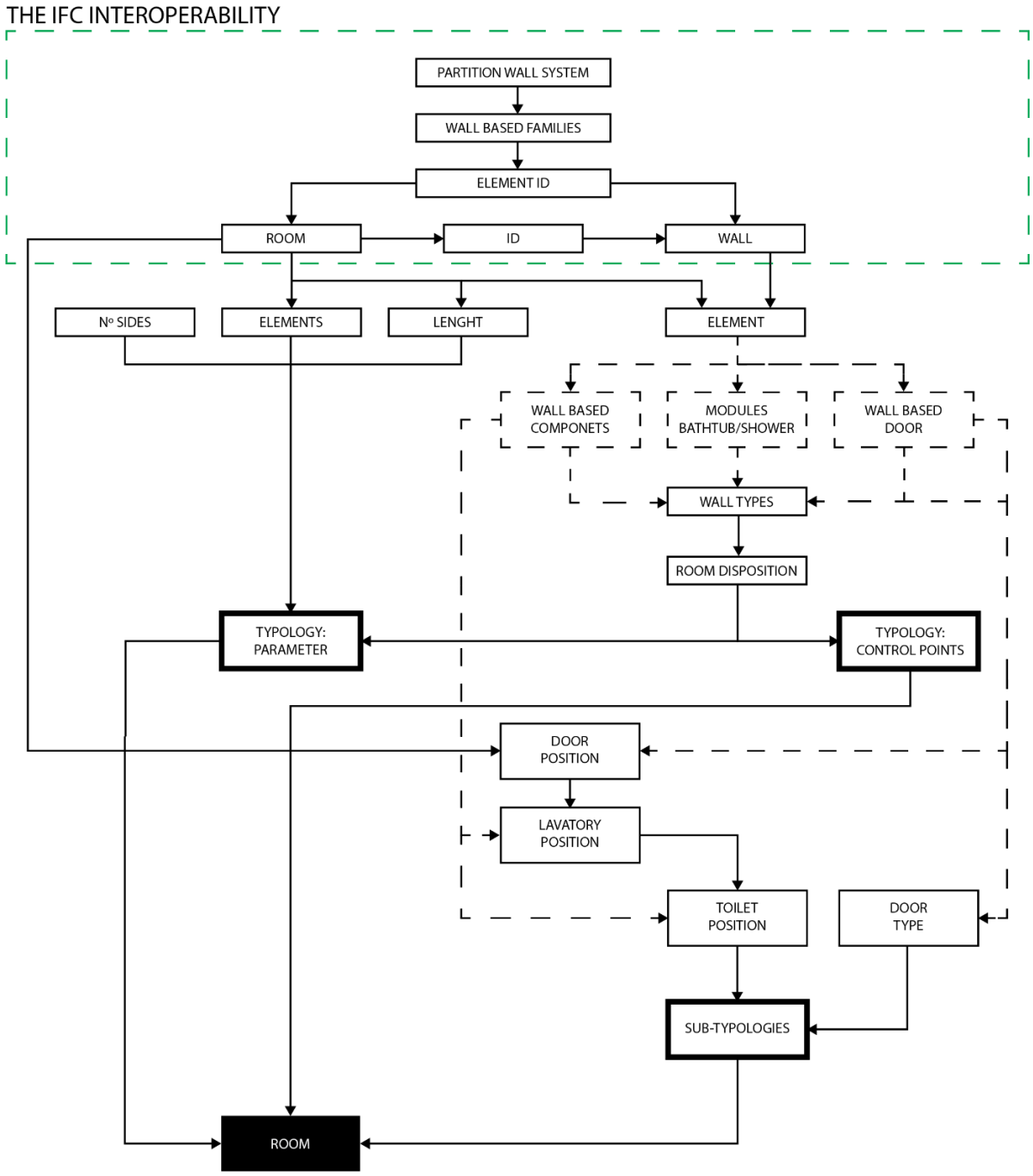


Figure 18 – Diagram with IFC interoperability relations

4.1.1. Partition wall generating system

The first step was to develop an automated process of generating the panelling system from the interior wall of the room (Fig.18). When exporting the IFC as a linked file, the room volume, which is a representation of the space inside, generates a boundary independently of the surrounding walls, doors, or any other elements of the building. The two element families of the bathtub and shower, as shown in previews, are different elements that need to be concerned in terms of their relationship with DfMA. These two elements have different parts and assembly system compared to others, making this element the first one that needs to be added to the design.

After applying this family block to the BIM Model, a Dynamo code consisting in mapping the boundary geometry of the room and the boundary geometry of the bathtub and shower. The followings will generate the new wall system for the partition walls. The process works by developing a new wall system and then applying a generic wall type, that consist in three layers, to be used as base wall for DfMA.

The figure 19 shows the selection of the two components: room and furniture. In this code the elements that are equal to the following type or name will be selected from all sources of information. This allows the selection of all the rooms that are considered bathrooms, the example detects all the room with the name equal to "I.S." (means WC in Portuguese). As for the furniture the two elements which are bathtub and shower will be select form the list of elements. The output of the code above is the selection made using the select node parameters to pick only these elements from the list.

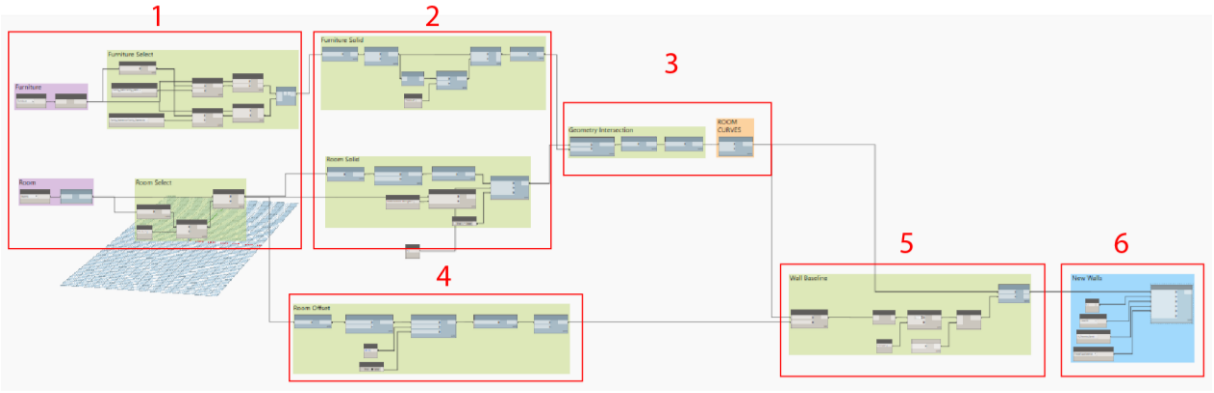


Figure 19 – Code with steps to generate partition wall systems

The figure 20 is a visual representation of the next stage, using the bathroom perimeter curves and bathtub curve, two solids will be generated. These solids will be overlapped since the bathtub block will be inside the bathroom main volume. Then, by applying a Boolean operation know as slit, the elements of the bathtub will be divided from the main volume. The result is two blocks attached to each other, to extract the curves of the volume they need to select the bottom face of the solids and extract the perimeter curves.

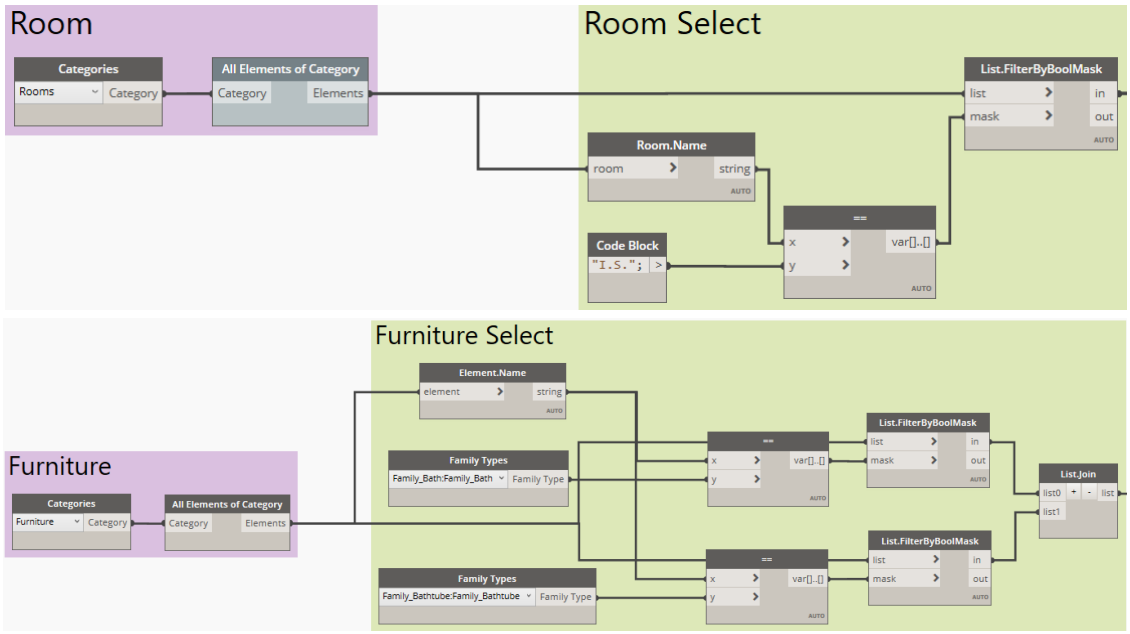


Figure 20 - Step 1: select elements that belong in bathroom

The process used the previews list of elements as the source to achieve the result. From the room list it was used the node “Room.FinishBoundary” that allows to detect the inner line of the room geometry to be used to generate the base surface of the solid, then by just extruding the volume from their height the solid is generated. The block is a group of multiple volumes that needs to be unified as one volume, to be then intersect. However, the height of this block needs to match the height of the room, otherwise the outcome will not be the desirable one, since the room will go after the slab dimensions.

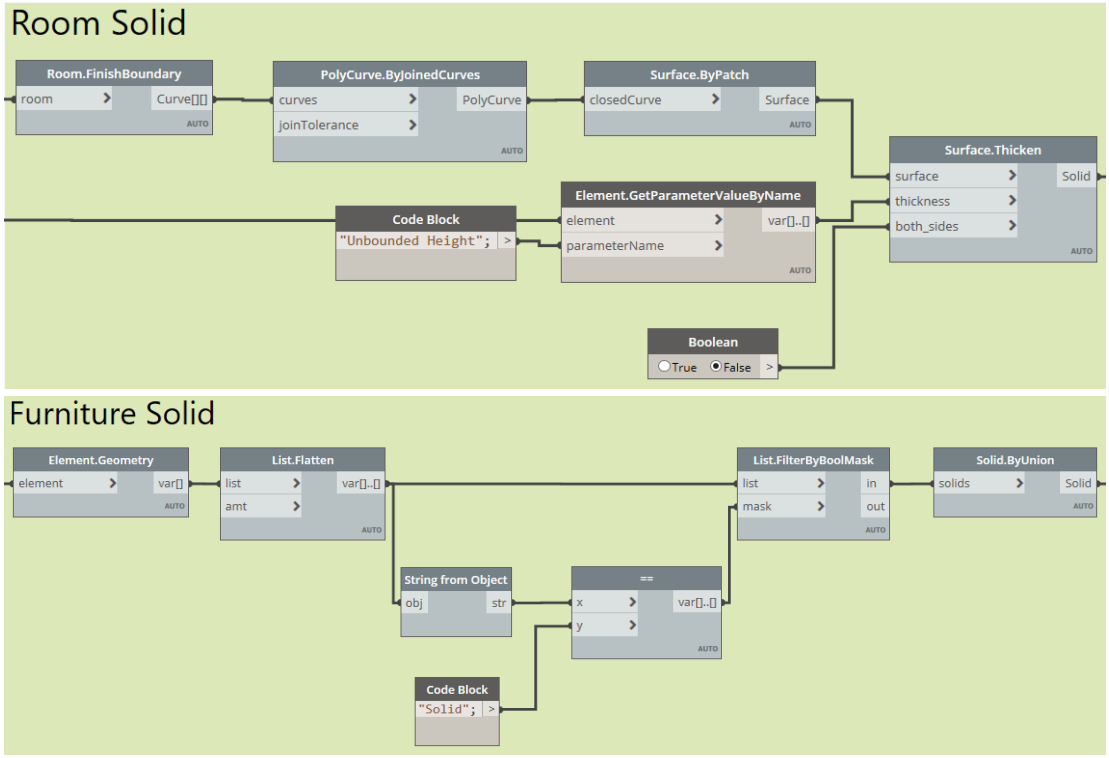


Figure 21 - Step 2: create solid form the selection

The next stage the process starts form outing the volume of the room on top, the one that needs to be split and the geometry of the bathtub on the bottom part to split then, then using plan surface the base surface of the model will then be extracted. The end part is an extraction of the perimeter curves of the surface to be used as base for the new wall elements that will be generated. Selecting the two lines from the bathtub volume base and from the new room boundary the two list were joined as a new list of elements.

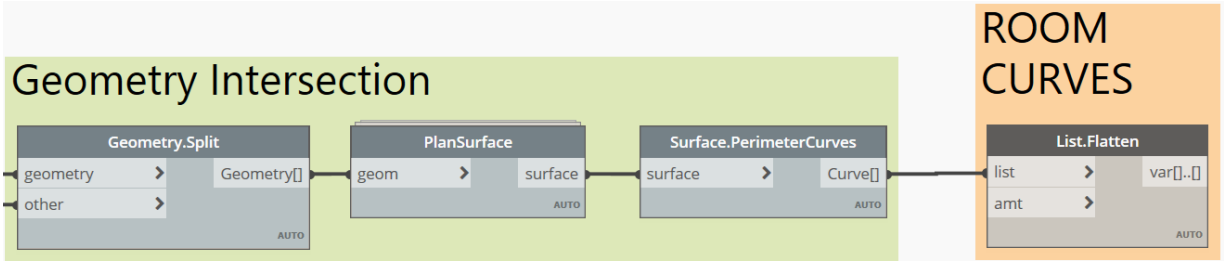


Figure 22 - Step 3: Split the room lines

Then two lines will coexist in the middle, are duplicated since the intersection of both create a collision that need to be tracked. Using an offset perimeter curve of the exterior boundary, when this new element intersects the new result, they will report with true value by simply removing the true value form the main list, the lines that are left are the exterior wall of the wall, that will be then used to generate the new wall system. This process makes the creation of wall much simpler, since often wall from linked files doesn't contain information enough of information to simply create the wall or even has too much information, that make this process harder. To have a better DfMA the less information that is imported the better the workflow.

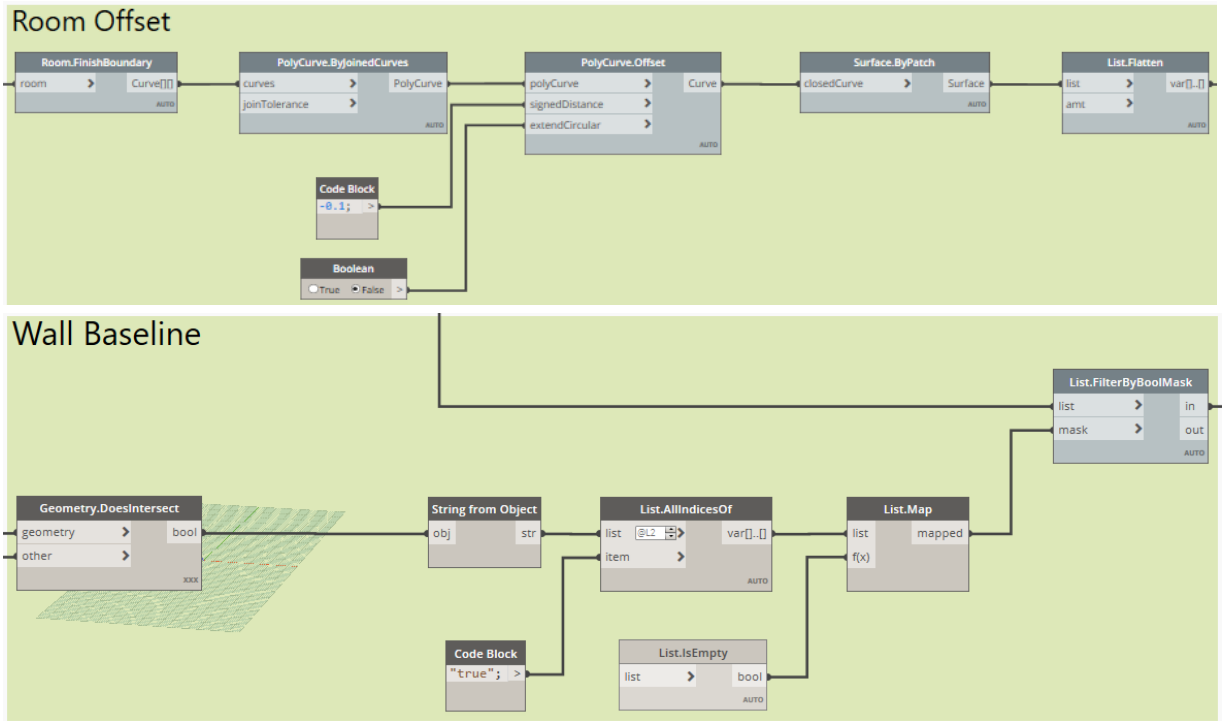


Figure 23 - Step 4 and 5: Room offset and remove the interior lines

The last step is combining the lines that were created and select each one by floor and apply the code "Wall.ByCurveAndLocation" created in the package WombatDynamo developed by Woods Bagot (Fig.24). That, consist in a code that basically generates a wall using Curve as the base, then the ask for a Level that the wall will follow, lastly it will ask for the Location line that will provide the boundary of the wall in relation with the desirable face of the wall. However, to proceed there was the need to create a generic wall for the elements, so the basic wall for DfMA is a partition wall with three parts: two boards of gypsum board that makes the finish face and metal profiles that makes the structure. All together these elements have 70mm of thickness.

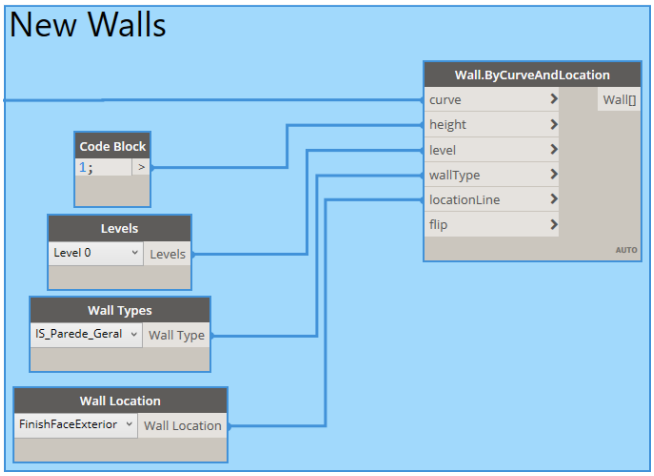


Figure 24 - Step 6: Create walls from the lines

The figure 25 shows the result of the components that were created and how the information shows as result in this step-by-step process. The result is a bathroom with smaller partition walls in the core area, which is the transition of the wall with the bathtub or shower. This process is important, not only helps to quantify all the number of walls that exist in the bathroom that need to be DfMA, but it does help in the manufacturing process by providing to these elements to work autonomously form the rest of their group. This action will help in the future part of the process, as the code develops in the transition to further information.

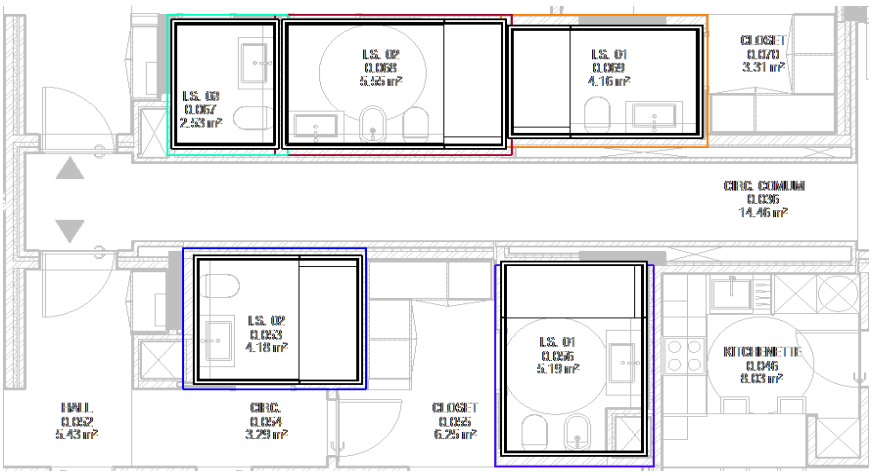


Figure 25 - Result of the code

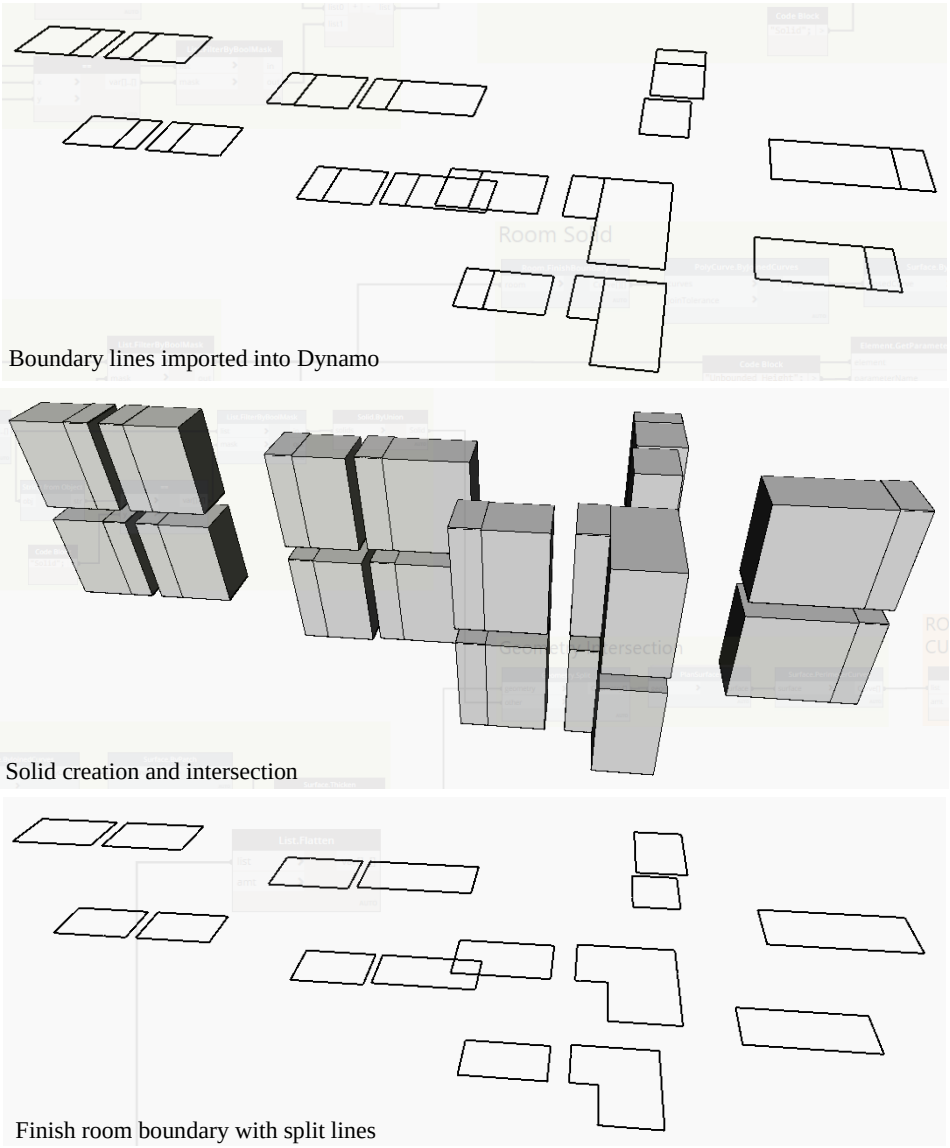


Figure 26 - Visual representation of the process: boundary lines with bathtub/shower; solid creation; room boundary with lines split

Figure 26 represents the method to apply the partition wall in the room by dividing the initial boundary with new lines. However, due to the fact, that the file that was provided was a CAD drawing the process change to a more manually approach, since all the walls and room didn´t exist. Consequently, the file was saved as IFC and imported back to the drawing, to be then applied the steps stated above, to test the veracity of the code. The result is what is proofed above, even if the walls that were created manually and not from an initial IFC file or even ".rvt". The process of splitting wall can also be done manually, however this solution is not recommendable, as the split command can lead to misplacements of dimensions, leading to discrepancies.

4.1.2. Apply wall-based families

After the generation of the wall, the wall-based families inside the room need to be attached to their new walls in this stage, since this process can´t be done automatically. The fact that the wall and the elements are directly connected makes each element created to be only attached to an existing wall, making this process work in manual way, since there isn´t a solution to exchange elements that were originally attached to a wall. The elements can keep it up on the wall, it's important to attach these elements. Consequently, when new wall was generated inside the new file, made the reference that exist with the original wall disappear, removing any information that was created previously.

The figure 27 shows the room with all the wall-based families inside it. This task is one of the most time consuming as the elements need to be in the exact place as the original elements, making this one of the making each element to be applied individually in the process. The elements door and sliding door are the biggest concern, as further in the process was detect that if the door position was not correct, it will have implication if it belongs to the room or not. In remind, this method proofs how negatively affects the procedure by simply evidence human error as a problem in the design process.

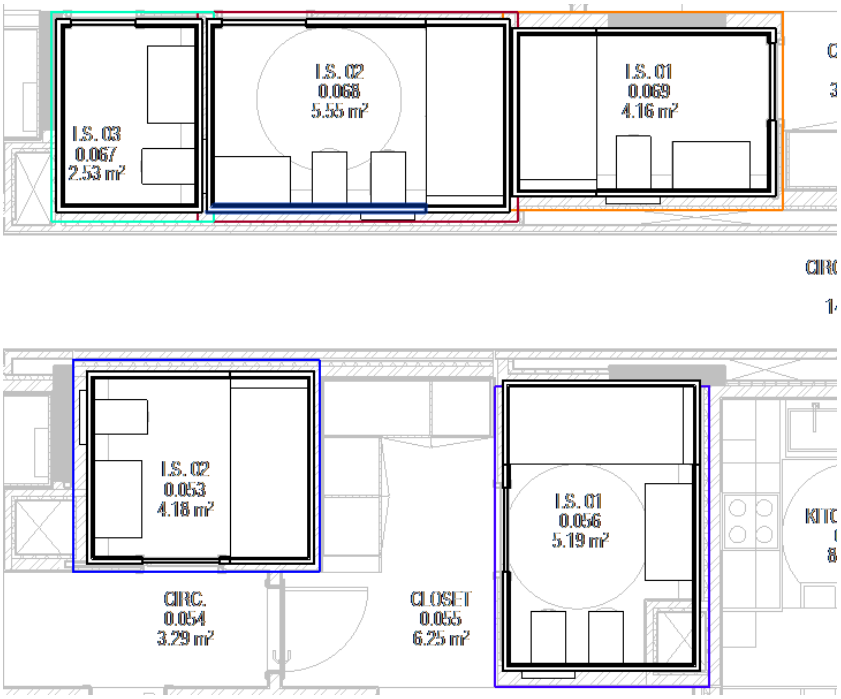


Figure 27 - Room with elements applied

4.1.3. Apply Element ID to Rooms and Walls

This step is one of the most useful in the control and tracking of all the process for DfMA, specially in keeping the trace of the elements not only in the procedure, but in on-site. In the previews chapter was the analyses the codification of the walls to be sent to the site, there was one point that stated that BIM can generate automated codification for each element, this code is the "Element ID". This ID allows to detect the element inside the Revit interface and can be exported when send as IFC, making an asset in element detecting, not only during the DfMA, but also during the assemble on site.

The importance of the code is resumed in the automatic generation, since any new elements will automatically have an Element ID. However, this ID is not visible in the user interface, since it´s the code that the software uses to detect elements in his API. This process output uses this parameter as source, by using Dynamo to retrieve the information of the ID and apply to a selected parameter of the elements.

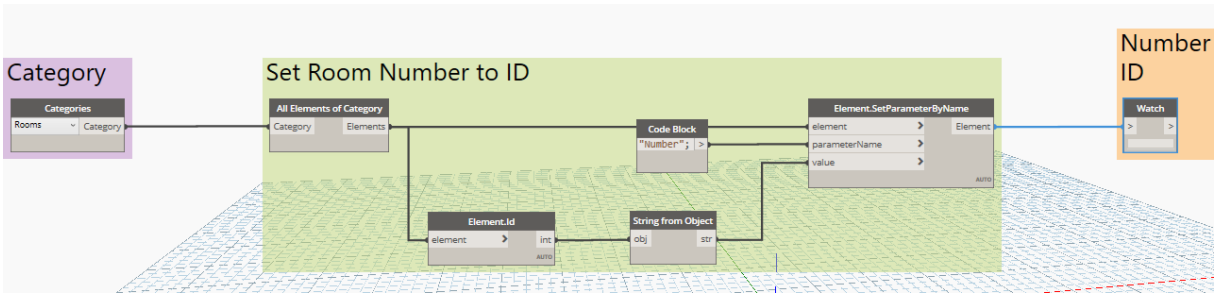


Figure 28 - Code to apply element ID to rooms

The figure 28 represents the code to select the rooms and apply the Element ID in a new parameter, in this case the parameter chosen was the room number. The room number is a visible parameter in the room tag, making it detectable in all the process, and to keep visual tracking on the elements. The parameter needs to be always a shared parameter to export the information as when needed in the schedule, making this parameter already a shared one. The Element ID is always attached as a value which consist in a group of numbers, making it a good fit to be used as a code to detect element.

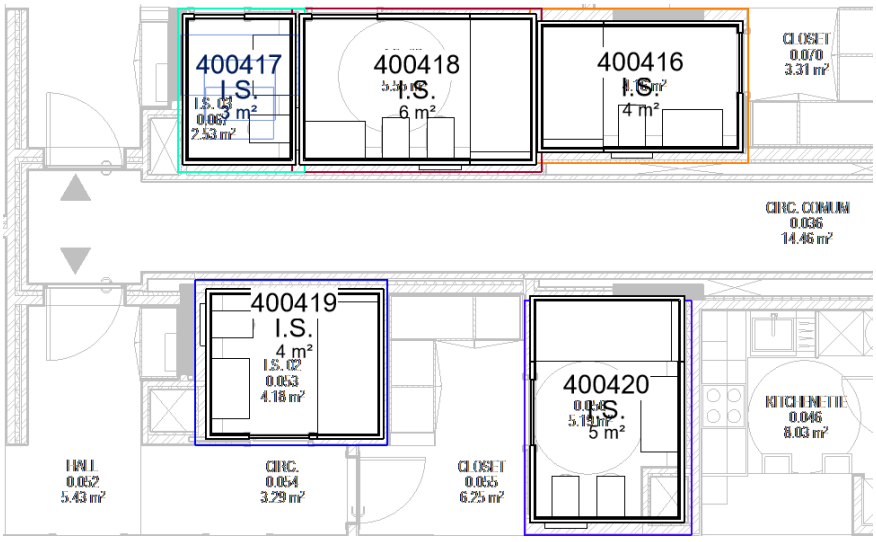


Figure 29 - Visual representation of the result – Element ID to rooms

In the wall the method was similar except the fact that, there isn´t a visual parameter which could be used to show the tag visible, therefore was named to a new parameter called “TypeID”. The most important aspect to retain from this code is the fact that the wall is more important in terms of assembly in site, since they will be the fabricated, transported and assembled. The ID from the room is more important to generate the needed information for DfMA. Therefore, the result pass from combining this two ID in different ways to maximize the output.

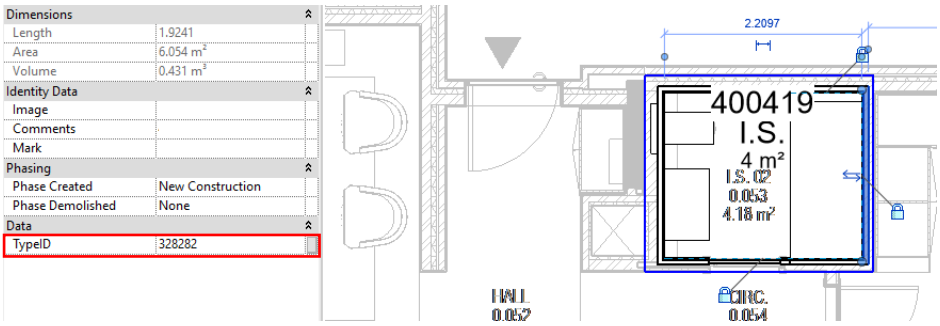


Figure 30 - Result of the parameters – Type ID to walls

4.1.4. Apply Room ID to Walls

The next code represents the process to create a connection between the Room ID with the walls (Fig.31). This step is essential since both elements are not linked in between each other. The importance of this step relies on the information that can be provided, as DfMA needs to be exported as information for the construction company to assemble the modules. Using BIM as the source of information make it possible to dimensioning, export bid of quantities, stock control and provides guidance on site. This step is important to generate the codification to be assemble in the factory and on site.

To achieve this result, it's important to apply a process of intersection between multiple elements to detect if they belong or not to the same room. However, this is a tough process that uses a lot of interaction to identify the potential outcome. The solution found pass by creating multiple intersection by level, reducing the time needed to achieve the result.

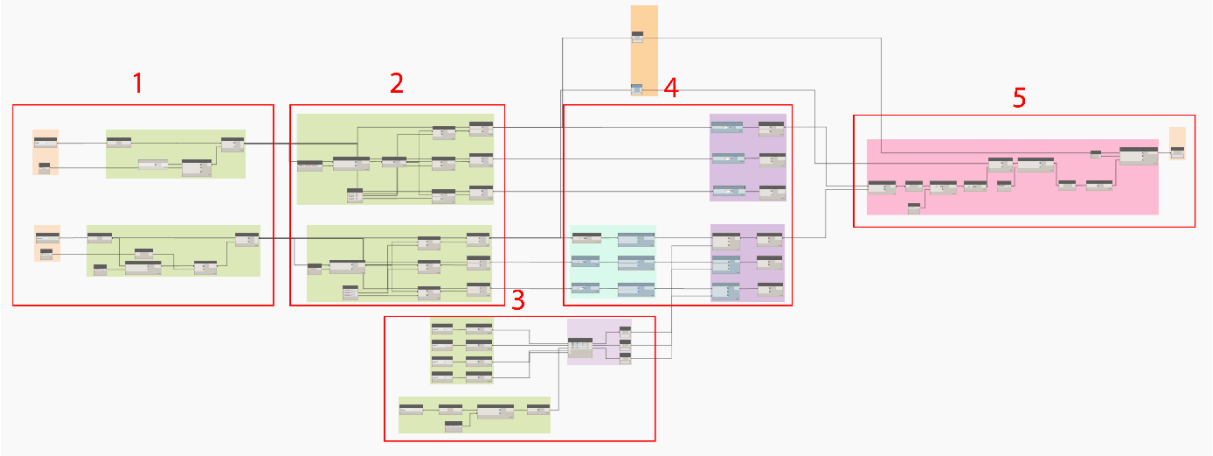


Figure 31 - Code with steps to apply Room ID to the walls

The code starts with finding all the elements that contains in the name "IS_" in the case of the wall type and "I.S." in the case of the room (Fig. 32). These elements need to be divided by the level, reducing the number of intersections between both, making the process of thinking faster. The level is a number which is given between the top part of each slab, that often doesn't detect which is the height limits, so to achieve that and to avoid collision between the room and the upper slab, it's important to define the maximum height

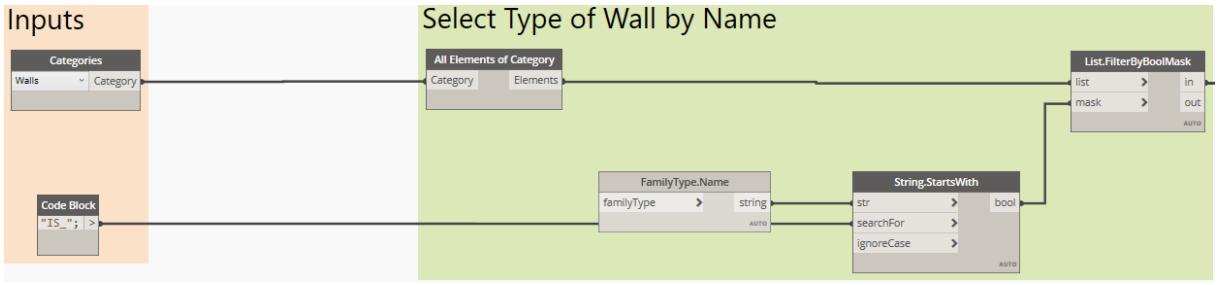


Figure 32 - Step 1: Selection of the wall that belongs to IS

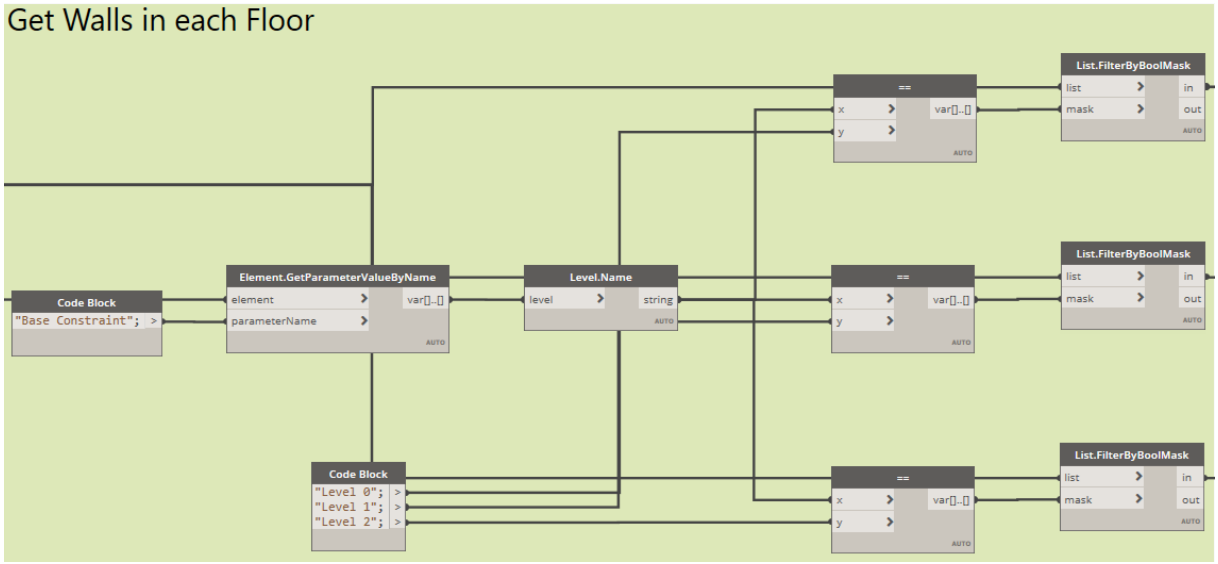


Figure 33 - Step 2: Select wall by level

The code that is shown in figure 34 selects the slab from the model and apply a process of detecting the thickness. This thickness is given as a value, and changes between slabs. This small step is important since the elements will always try to connect to the next floor, colliding with the wall that might be on top. The reason to be used here instead of the previews one, was due to the room being created without height boundary when imported using the IFC. The fact that when operating the other code will give a direct height that is undefined, creating the need to be adjusted to the fit on the bottom of the slab. However, Revit the room height can´t be changed but the solid which will be created can adapt his height to the code created.

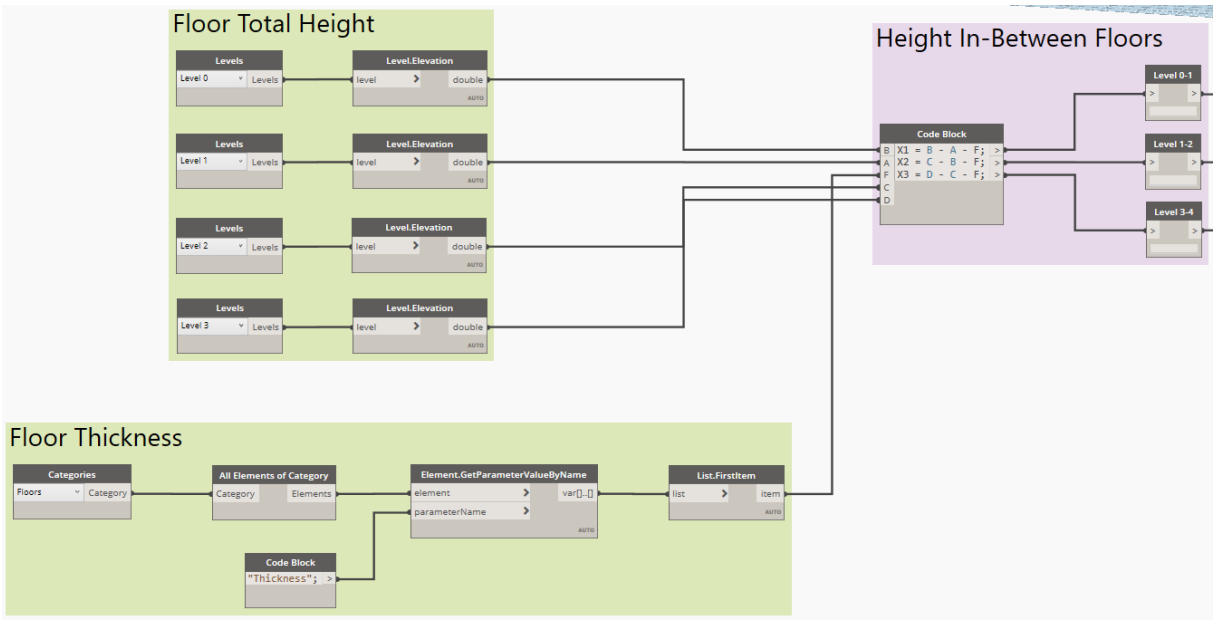


Figure 34 - Step 3: Detect the height and subtract the slab thickness

The next step was to create and generate the volume of the objects. In case of the walls the elements were linked using “linkElements” created by Bimmorph.Nodes which creates a solid form the wall which was selected. The room need to apply the height created with the connection to the slab and apply to the correspondent floor selection to unify all the height. The volume then will be created by applying the code “Room.FinishBoundary” which will be joined to create a polycurve to then taken the result and extrude as a solid with the height generated.

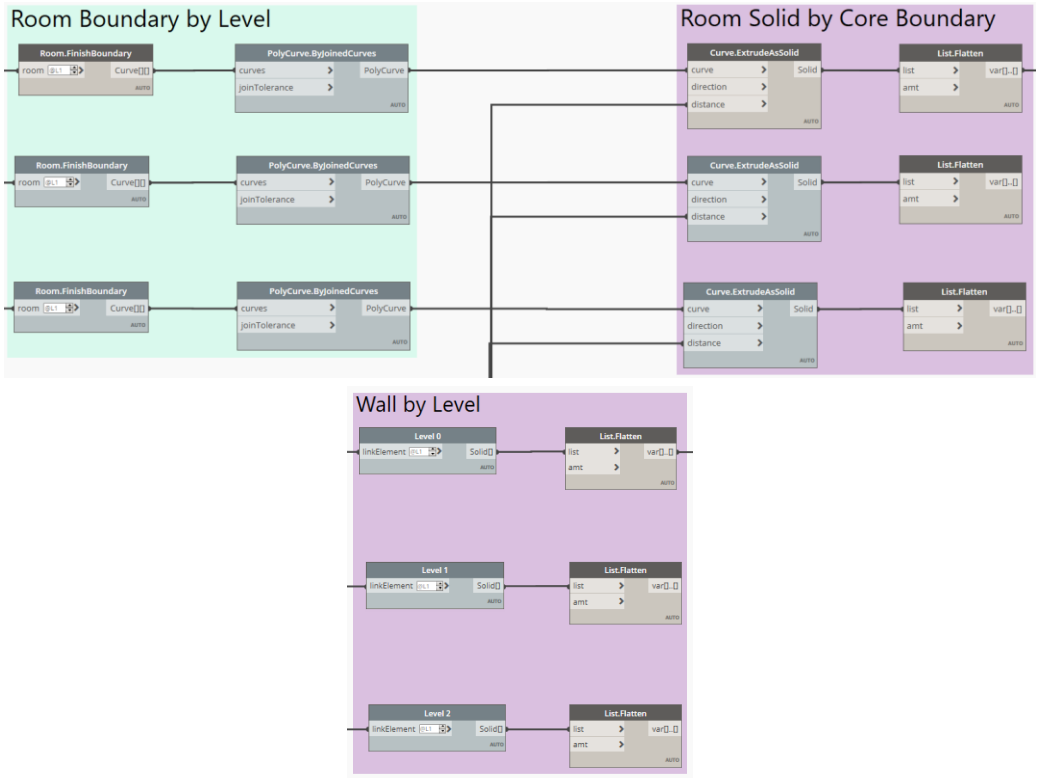


Figure 35 - Step 4: Room elements extrusion and wall link elements

The next code picks the volumes of each element and intersect them in relation with their level and base (room) or base constraint (wall). The walls are the element which serve as the base for intersection as they will intersect with all the rooms to detect which wall belongs to. The result is a list of true and false, meaning the true is the element that belongs to this list. However, the next steps will define how the procedure of selecting the elements that are true works, as this part of the code will pally multiple time through the investigation. The figure 36 shows the steps taken to control this information, the procedure works by detect when all the true happens, this will select only the first level of the list, meaning the result will contain 230 elements instead of these elements multiply by the number of walls. Then the code will transform this first list in an index number to be taken from main list the elements that belong to. Then the room "Number" needs to be translated as a string which will be the value in a new parameter called "Room_ID".

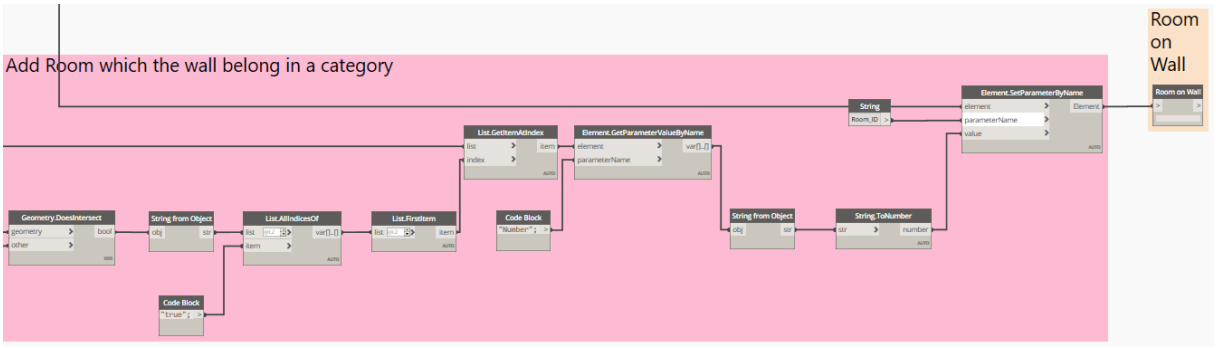


Figure 36 - Step 5: Intersection of the elements and application to a parameter

The figure 37 shows the result of the adding the component to the parameter type. In the room number we can sport the element ID of it and detect that in "Room_ID" it shows the same code. This makes the code useful during the process, because there is always the possibility to detect which room the wall belongs, even if the wall type might change, as it will happen in the next set of codes.

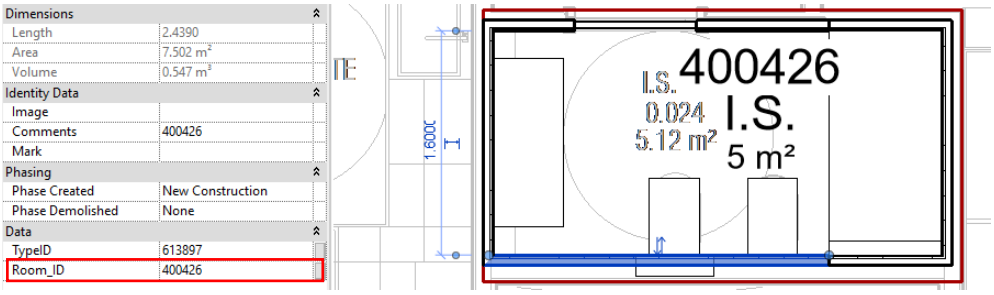


Figure 37 - Result checking

4.1.5. Conclusions

The codes that were developed during this chapters were important to elaborate information which parameters that can be used to guide on BIM, making them resourceful for the overall process of exchanging information. This set of codes are not dependent of each other, however the first one will need to be always the code to applied to the wall of the project, since without them all the other steps are not possible.

The result is already an optimization of the process of generating codes for assembly, since it's a unique and unchangeable code that were assigned to the elements that belongs to the project in Revit API. The fact that these elements are unique makes the process easier to export information in a reliable way, by removing manually assign tasks, that can lead to human error. The base codes were already created, now the split designer neds to create the typologies, which will be analysed in the next chapter in order to full fill the role for DfMA.

4.2. Typologies Definition – Milestone 2

This chapter will focus on how to transform the various types of information inside the model and define multiple typologies automatically. The process is an optimized procedure of chapter 3.2, where the split designer manually separates the elements and groups them, creating the typologies. The big problems being the fact that procedure was a time-consuming task and can lead to hazards, in the serialization of the rooms.

Finding the Typologies is the main part of this dissertation as it´s the most reliable asset in DfMA. This process as multiple ways to be achieved, not only because exist a certain number of parameters that needs to be created, but also needs to find a way to hierarchical position them to get the fittest result. The biggest problem was how to understand and detect the bathroom disposition, and how they affect the typologies. This is one of the most demanding process but certainly, the step to divide in fewer groups.

TopBIM manual process to create typologies found around 30 different types of bathrooms. The hierarchical process was often unclear and not straight forward, but the parameters that were used were the same: bathroom disposition, area, dimensions, and number of walls. These four parameters can be quantified using available tools and information inside the room to extract each one of them. The first step was to get the values for each parameter in relation with the room, the second part to collaborate all the parameter in a hierarchical way to achieve the typology.

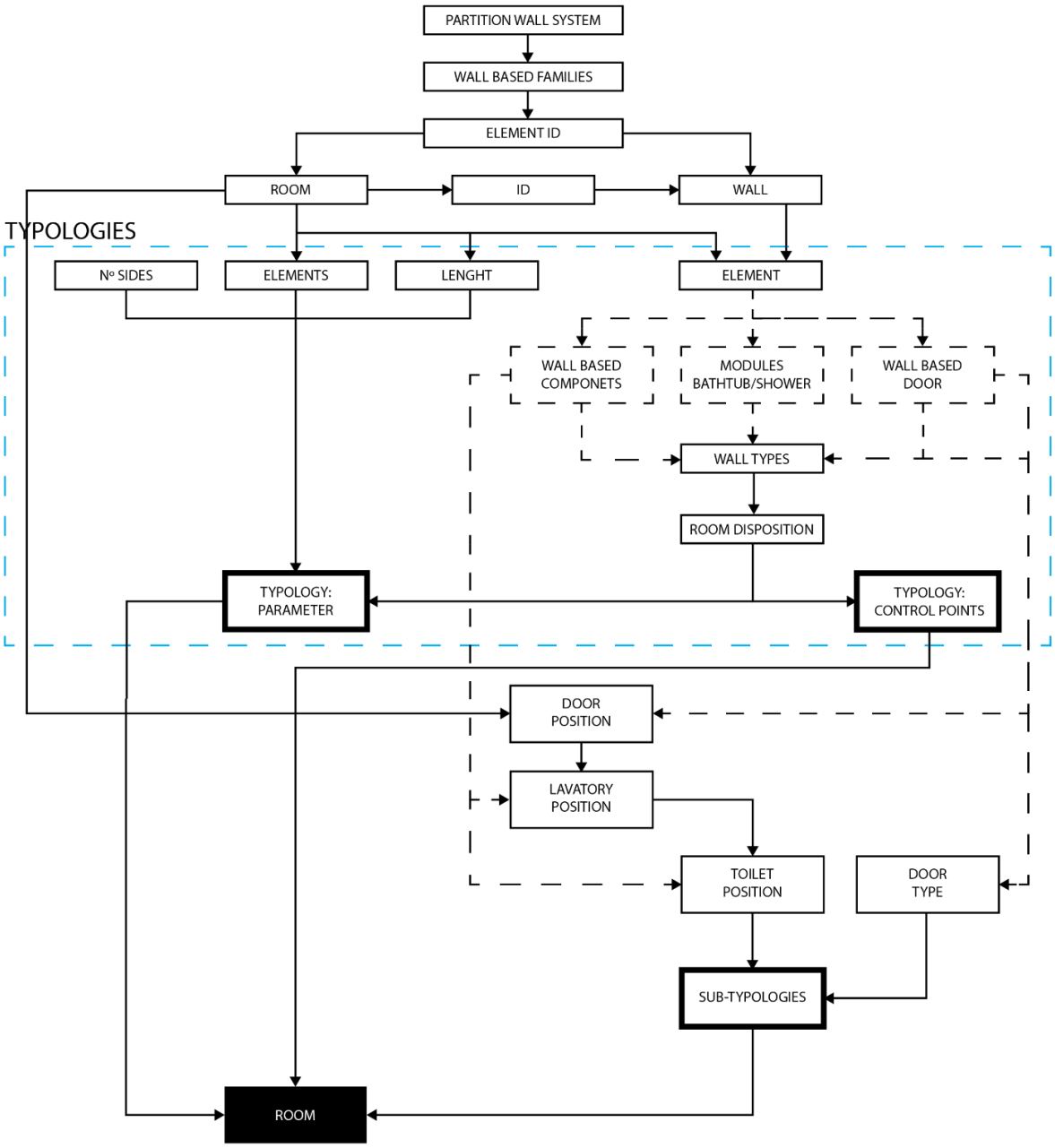


Figure 38 - Diagram with Typologies relations

4.2.1. Detect element families inside room

The first step is to identify elements position in the bathrooms and provide them with a unique identifier for each unique type (Fig.38). However, the position sometimes can be hypothetical, with a lot of small variation which will lead to different results. In DfMA, the fittest the information the better, and in this situation, the code needs to go abroad the parameter and need to define as a different type of wall, defined by the physical position of the elements in relation in the bathroom. Introducing this topic, the bathroom position can be detected by the surrounding elements, which will define what are the differences between the existing compartments.

One important aspect to notice in this process is the fact that there is only one way that a room can be consider bathroom and its by having toilet and lavatory. These two elements are the ones who define the bathroom, they can contain more elements inside or not, but these ones are obligatory. Therefore, the maximum elements that a bathroom can contain are by having a bathtub or shower and a bide. There is a relation between the elements and the type of bathroom, since lower areas tend to have a fewer number of elements and larger area more elements.

The main problem is how this information can be extracted, and how it can be helpful in the process of generating typologies. Therefore, all the results should contain a certain solution to quantify all the elements, creating the correlation between the type with a parameter. To achieve this result, the code needs firstly to detect what types of bathrooms exist and create a process to export this information to be used in DfMA. In previews chapter 3.3 it was examined that the partition wall system can have multiple solutions, but a wall is always a combination of multiple elements or not, since some wall can be empty. The figure 40 shows four different bathrooms organizations:

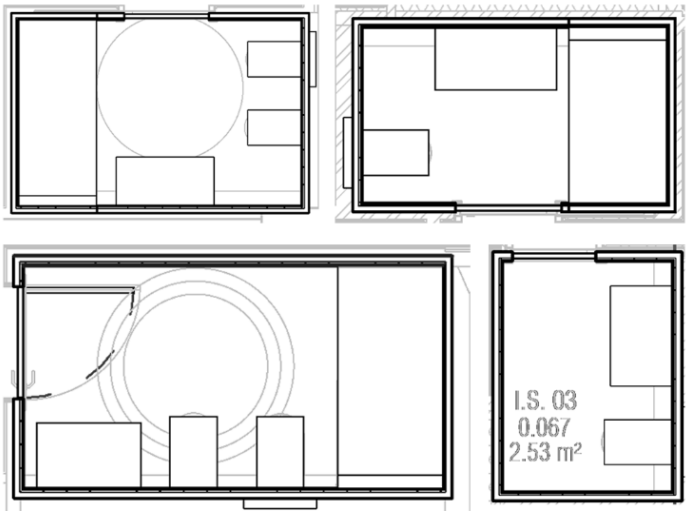


Figure 39 - Different bathrooms organizations

The bathroom organization is correlated with the occupation and disposition of the elements. However, not all the bathrooms are equal and even with similar organizations the outcome might be different, the important aspect is not the size and dimension, but what makes them similar. Therefore, the wall occupation is the unique element that can be equal and different in all the bathroom, containing similar walls in different areas. This concept allows similar walls in different type of bathroom to be detected and mass produced while serves as information to further bid of quantities and supply management.

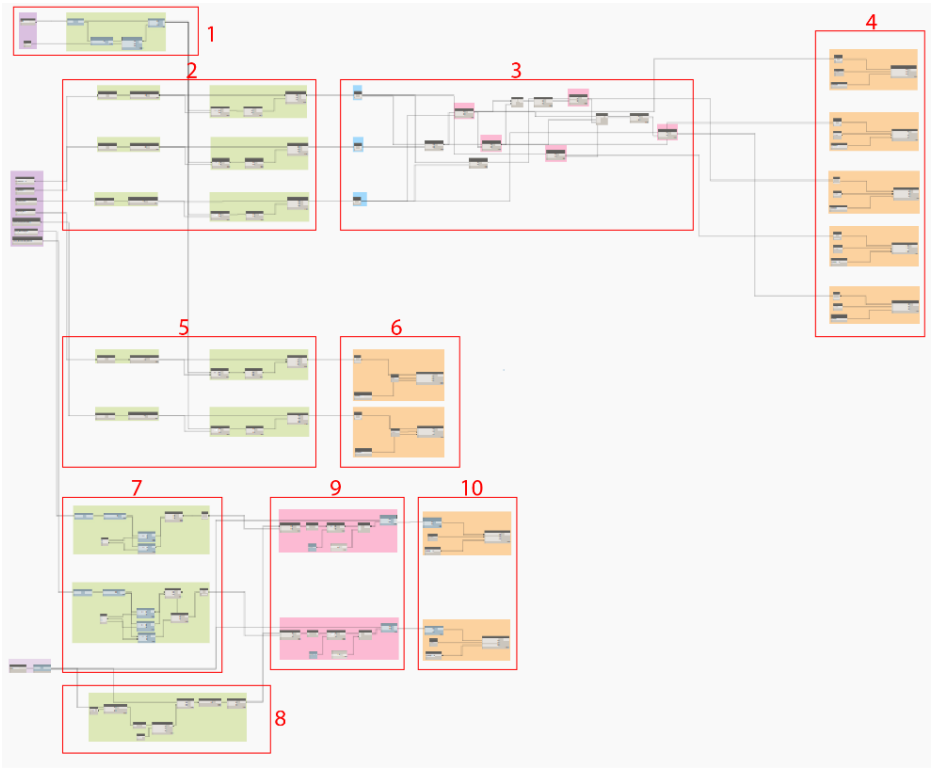


Figure 40 - Wall by elements code preview

Taking this process and apply to a code, the next step was to convert the wall that exist in the model, and if they contain one or more elements, to detect them and report as a different wall that declares what encompasses inside it (Fig.40). The creation of this parameter steps away from the analysis of what is inside the room and considers how many elements are gather in the same wall. The code will use a group-based ideology, where wall with components will be taken first, then the door types and in the end the bathtub and shower. Each group have different process for DfMA, since components are attached to wall and contain prefabricated modules for each element; doors are different, since they need to be subtracted from the main wall and sometimes works inside other walls; and bathtub and shower are a unique type of prefabricated modules that works by themselves.

The first step in the code is to select all the walls that belong to the bathroom and provide a list that will be intersect for all unique items. Each individual component that belongs to the bathroom (toilet, bide and lavatory) will be selected and detect in each wall using the code “Get Host Elements” that finds in which wall they are connected, since it´s a wall-based family. This result will show which wall the elements will be connected, but since they will intersect all the existing walls without taking in consideration if there are more elements inside, they need to pass from a serialization.

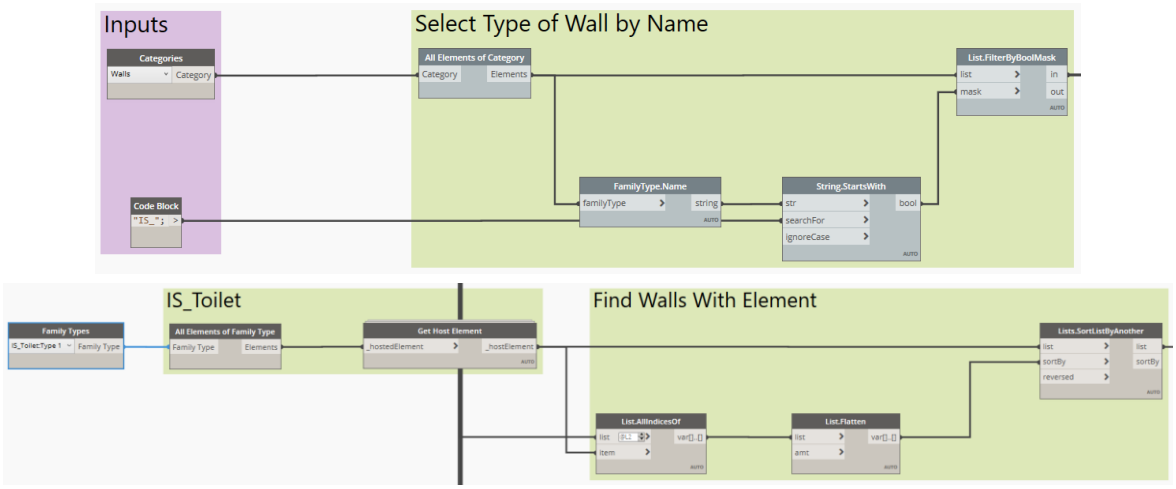


Figure 41 - Step 1 and 2: Get bathroom wall and select all index of Toilet

The figure 42 represents the five types of walls with the different types of components inside the room. In bathroom, there are two elements that can be on wall separately toilet and lavatory, they can also be together in the same wall, but the bidet can only be near the toilet or with all of them together, the following list shows the combinations that exist, and how they were classified “TBL” Toilet, Bidet and Lavatory.

1. “TB” Toilet and Bidet;
2. “LT” Lavatory and Toilet;
3. “T” Toilet;
4. “L” Lavatory;

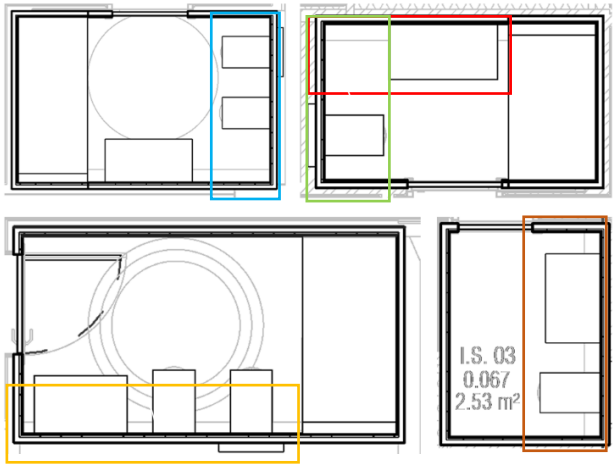


Figure 42 - Different walls inside bathroom

After analysing the different wall, it´s possible to detect that in the code there are walls with more combination and the process to achieve that uses the node “List.SetIntersection” to create a list with the common element which are equal. When the three components are intersected together a unique list that will be defined as “TBL”, which means that contains all the elements inside it, will be created. Then the second list will be a intersection with the list before subtracted using the node “List.SetDifference”, that provides as output the result of the intersection of the list with toilet and bidet, the result on “TBL” will

be subtracter with the result in “TB”. Therefore, the same procedure will be applied to “LT” by combining the Lavatory and Toilet and apply difference from the results on “TBL” and “TB”. Lastly the “T” (toilet) and “L” (lavatory) will be subtracted to all the previews items intersected.

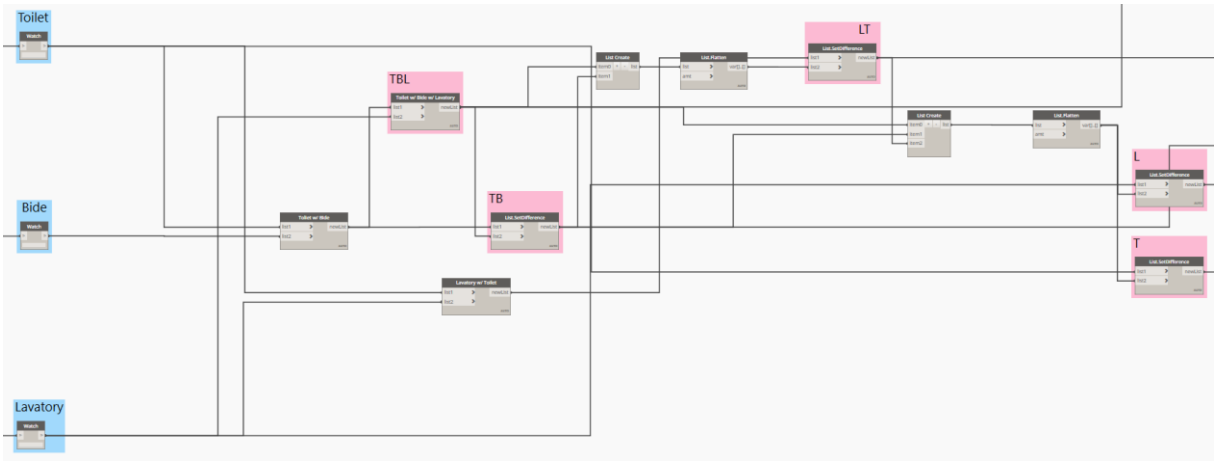


Figure 43 – Step 3: Hierarchical selection of walls

The next step was the creation of Wall Types with the name that represent their unique types and use them to be an identifier of the change that were done. Then, by using the node “Element.SetParameterByName” the elements that were selected form each list will be then replaced by this unique family types, thus helping not only in visualizing the result, but also to be detectable in the model.

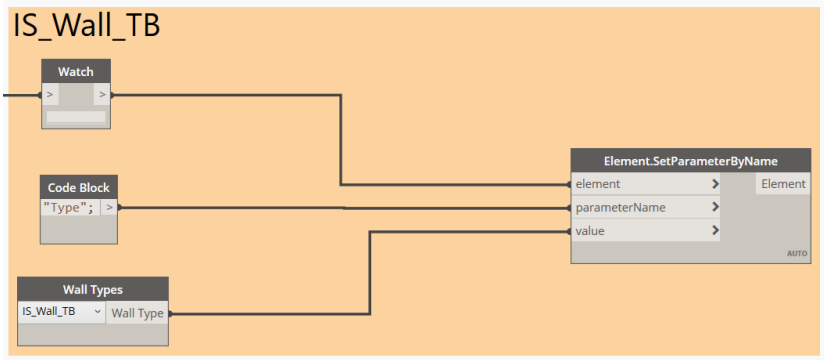


Figure 44 - Step 4: Substitute the wall for IS_Wall_TB

The next step was the creation of Wall Types with the name that represent their unique types and use them to be an identifier of the change that were done. Then, by using the node “Element.SetParameterByName” the elements that were selected form each list will be then replaced by this unique family types, thus helping not only in visualizing the result, but also to be detectable in the model.

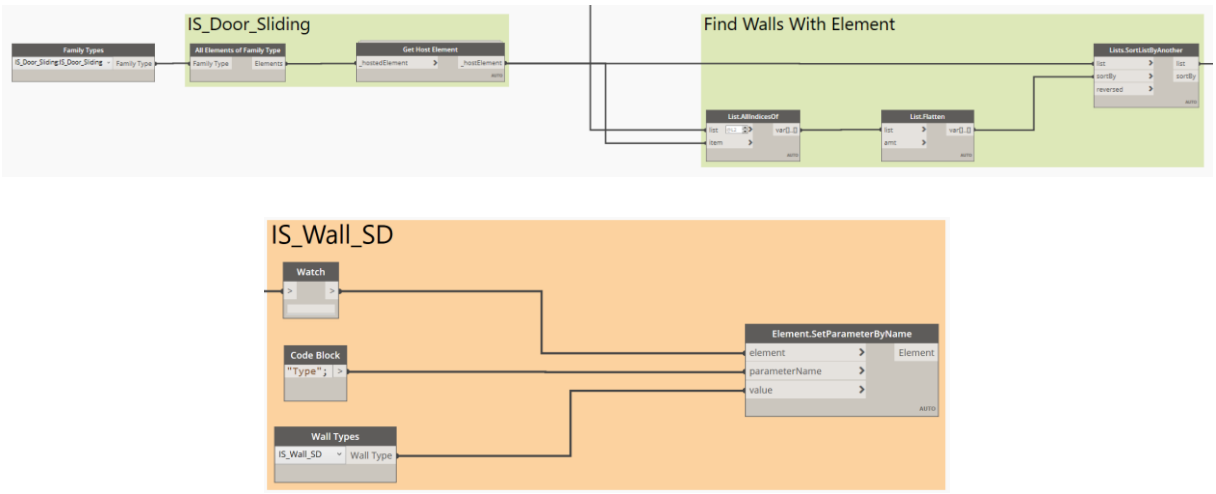


Figure 45 - Step 5 and 6: Identify the wall with the component sliding door and change them to a related family

The next step is to change the wall near the bathtub and shower to their unique wall type. However, this families are not wall-based, so the process to achieve this result needs to use an intersection between solids to export of the detected walls. Therefore, the step that was created in the beginning of splitting the room with the bathtub and shower was important for this procedure, because this module is autonomous in relation with all the bathrooms. This means that as opposite of the DfMA walls created by the components, this wall will never go work and be autonomous. The process starts by creating a solid from the family of bathtub or shower and create a unique volume to be later intersected with the room solid.

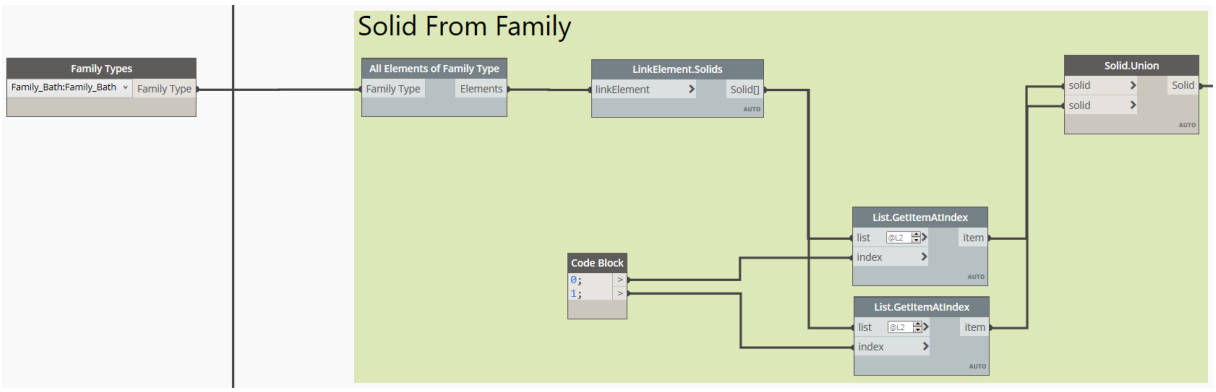


Figure 46 - Step 7: Create a solid form the component

After creating the solid from the module of the bathtub and shower, it was needed to generate a solid for the bathroom walls. The code above shows which elements need to be taken form the list of walls, then it was need to applicate the node “LinkElement.Solids” created by Bimorph Nodes that virtually creates the solid from the following walls.

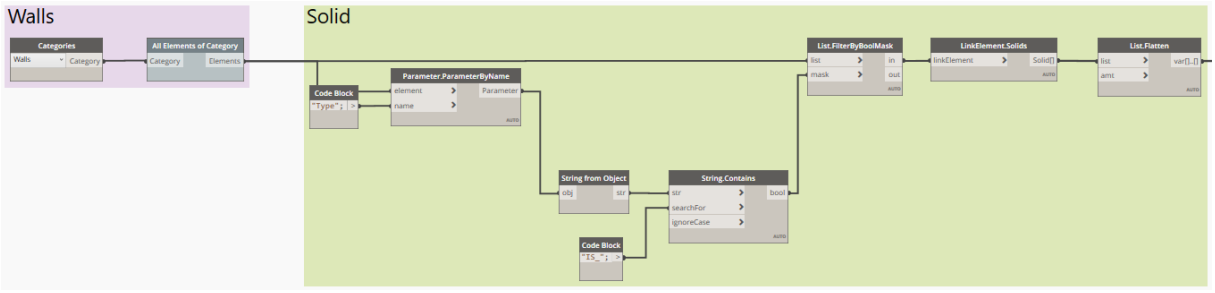


Figure 47 - Step 8: Create a solid from the wall

The last step in this code was to intersect the volume of the walls with the volume of the family and get as result a list of walls. Then the wall that contain this element need to be changed for the respective type. All the empty walls will keep the generic wall type, but now all the rest have a unique type that defines them, this process is still not complete, since more variation might happen with the fact that might exist wall with doors and components. However, this doesn't apply to this case, due to the walls with components being opposite of the ones that serves as the entrance. The figure 49 shows all the rooms with colour on coarse mode of all the changes that were made in the file to each wall type.

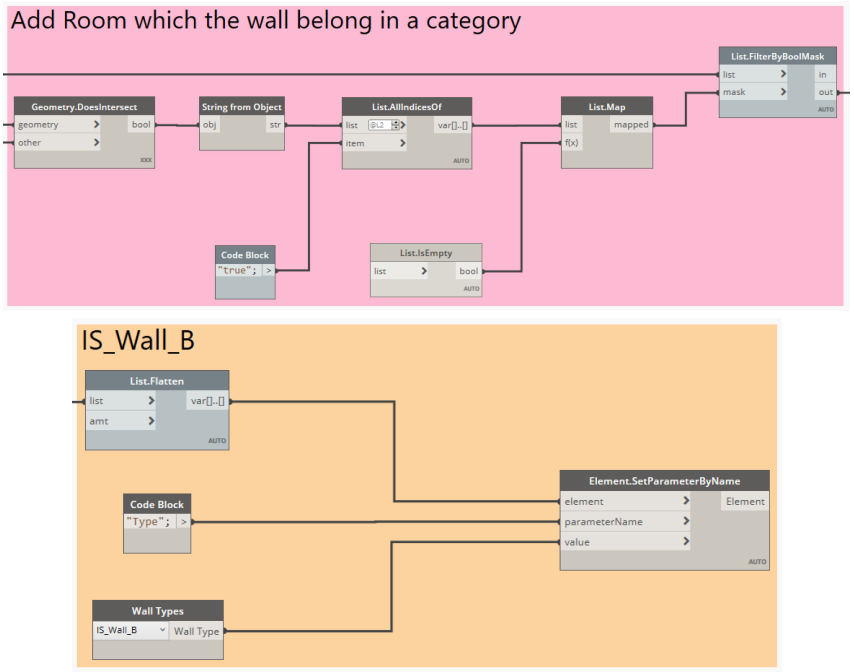


Figure 48 - Step 9 and 10: Get index form intersection and change them to a related family

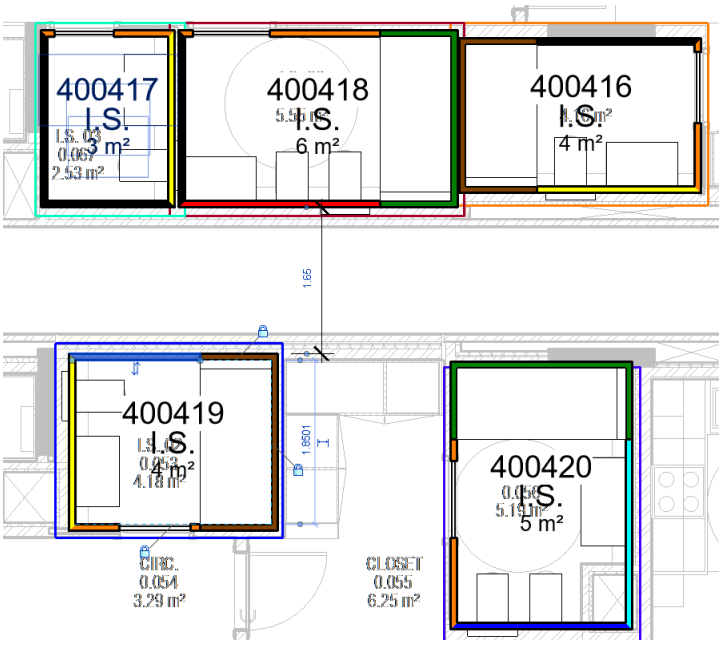


Figure 49 - Plan view of the changes done in the model

4.2.2. Room Disposition

The next code is a continuation of the previews one, that detect four types of disposition in the bathroom in regards of the type of wall that exist in the model (Fig.50). This code further improves the use of the wall in a combination of four variations to export as four types of wall disposition, regards the spatial position of them. The principle is to detect the combination of wall that are inside and combine with other parameter to group the multiple parameters inside the room.

The code selects all the wall inside the model and use the types that were previously created to define a new parameter. From the previews code there were five wall types, and a combination one of two together makes the room be spitted in four dispositions, where “TBL”, “TB” and “TL” are already unique types of walls with a lot of information that defines them as compartments, and the wall “T” can also be consider, since it doesn´t need to find the pair.

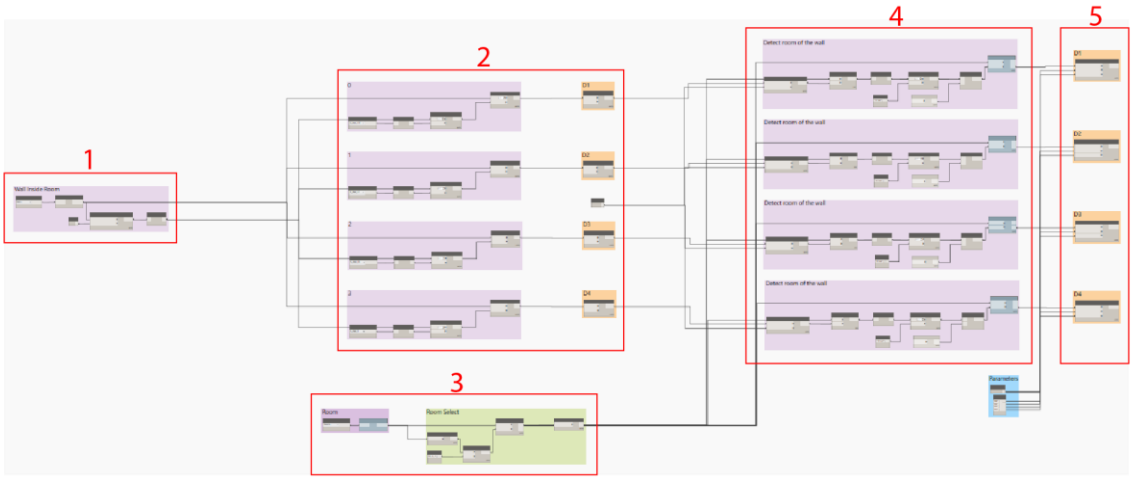


Figure 50 - Room disposal code preview

The first step was to pick the walls in the model and get their "Type". Then the value needs to be transformed in a string to be picked from the list individually. The selected wall type family will be then transformed in a string to be later detected all the index of this parameter value in the list of walls. Therefore, the list needs to be connected to the main one and all the elements that are in the index will be shifted into four sub-list of elements.

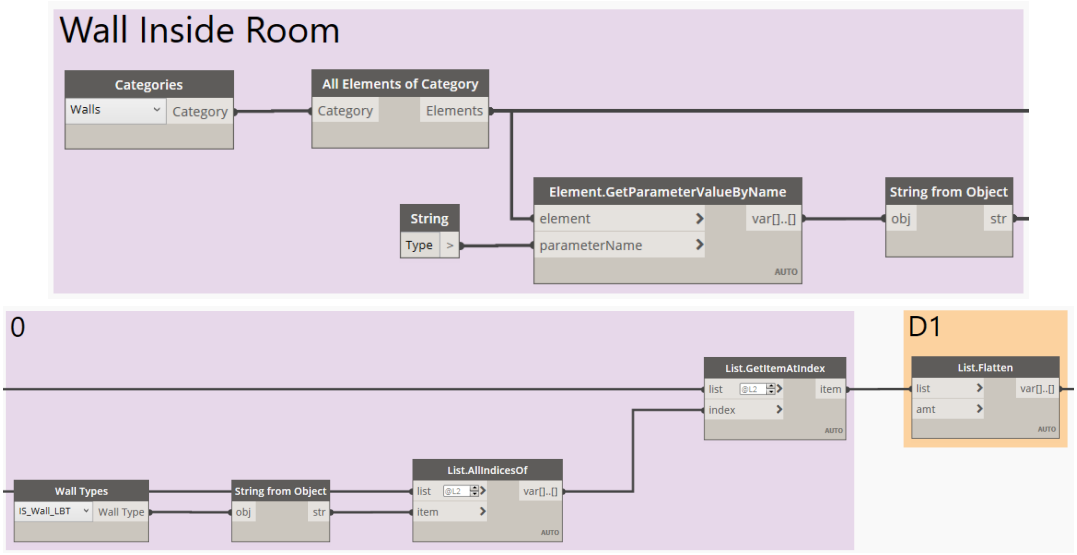


Figure 51 - Step 1 and 2: Wall type detection and list partition

The next stage is a process to select all the rooms that belong to the bathroom and find their "Element ID". Consequently, this output will be intersected with the information inside the "Room_ID" parameter in the walls, since it was created to detect where the wall belongs in the room. The result will be given as true or false, being true the walls which belong to that room. The last step is to detect in the index the empty list and apply a node to clean all the elements that don´t belong in the list providing as output, the rooms that contain that specific wall.

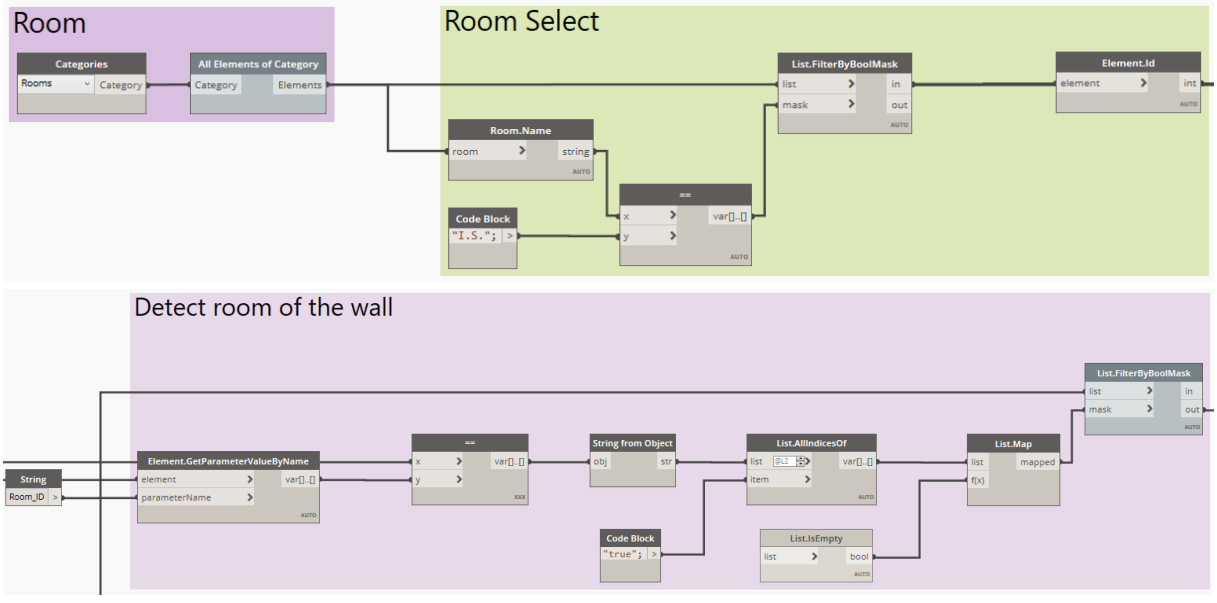


Figure 52 - Step 3 and 4: Get the room Id and find the wall that belong to the group

The last step is the application of each result to a shared parameter named “Disposition”, where each one of the four results will have a unique identifier to detect what are the bathroom composition. The figure 54 shows the parameter applied in the room “400426”, that will serve as guideline to all the process and future additions.

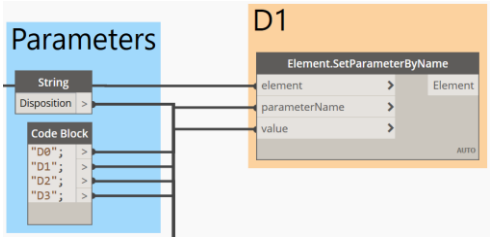


Figure 53 - Step 5: Apply value to parameter

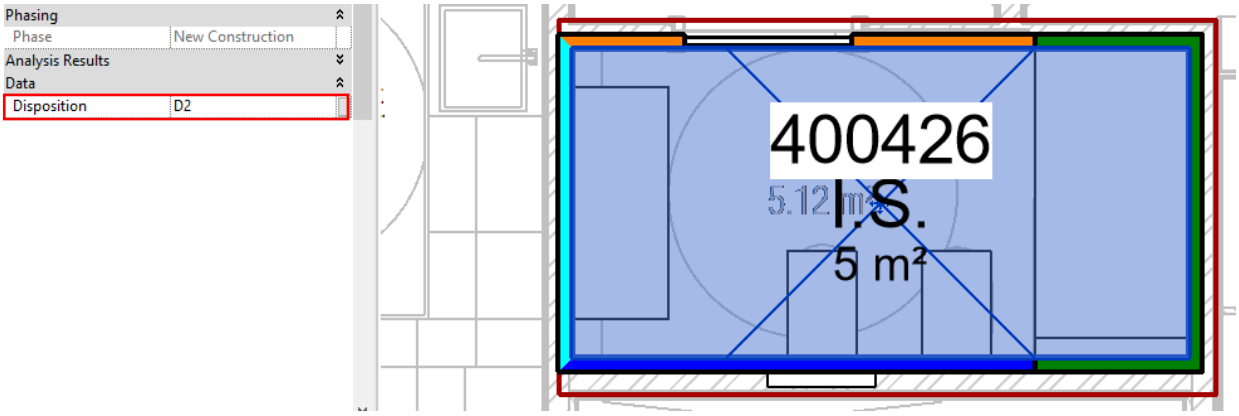


Figure 54 - Parameter applied to the room

4.2.3. Detect number of sides of the room

The next step was to create a layer in the definition of typologies by detecting the number of wall that each room contains. With this process it´s easier to separate the multiple elements that exist inside the wall and export the information as a parameter that contains the data related. This code allows to split rooms that contain four or more walls in sub-list of values.

This process works by selecting all the wall that belongs to the bathroom and then extract the perimeter curve by using the node “Room.Boundaries” developed by Archilab. After extracting the curve, they will be joined as polycurve to be then transformed as a surface. The surface purpose was to clean the curves and extract only the edges that quantifies the room, since there are split walls inside the bathroom. Therefore, another clean code was applied named “Λ CurveLoop.Simplify” created by Spring Nodes which reduce the number curves inside the surface. The result is exported as a quantification of the number of curves using “PolyCurve.NumberOfCurves”.

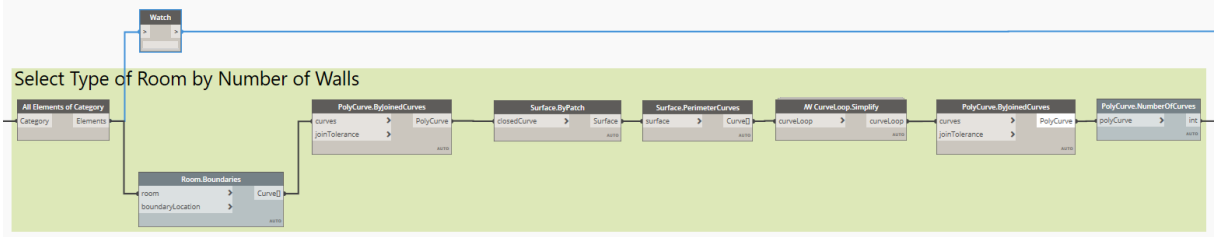


Figure 55 - Code to detect number of sides in a room

The last step was to create a shared parameter named “Sides” and export the number of rooms as a string with the information for each room. The figure 57 shows the result of the addition of the parameter to the process to achieve the typologies.

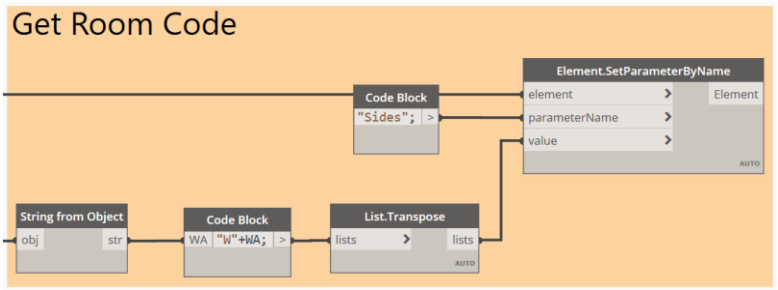


Figure 56 - Export the information as a parameter

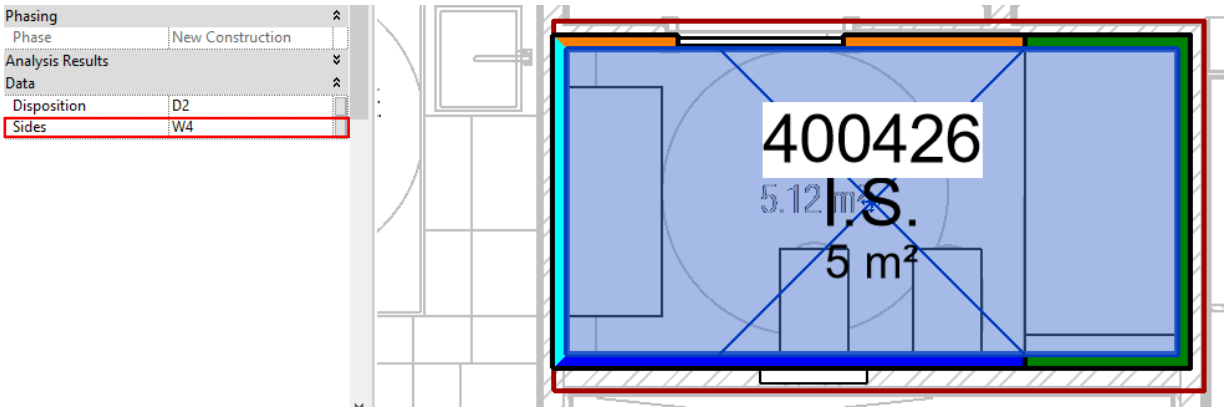


Figure 57 - Parameter applied to the room

4.2.4. Detect area of the room

The parameter “Area” of the room already exists and can´t be changed since its already connected to the room information, so the problem was how to get the value as rounded so it can be grouped form approximately value. The following process is a code to transform room area into a new parameter that can group bathrooms.

The first step was to select all the rooms that belong to the bathroom. Consequently, it proceeds to select the “Area” parameter of the selected rooms, later it needed to detect the number string and apply the node “Math.Round” to get the approximately area of the compartment. However, the number that came

as an outcome contains some repetition of "0", so they were taken of the list and replaced with nothing, giving them an integer number as result.

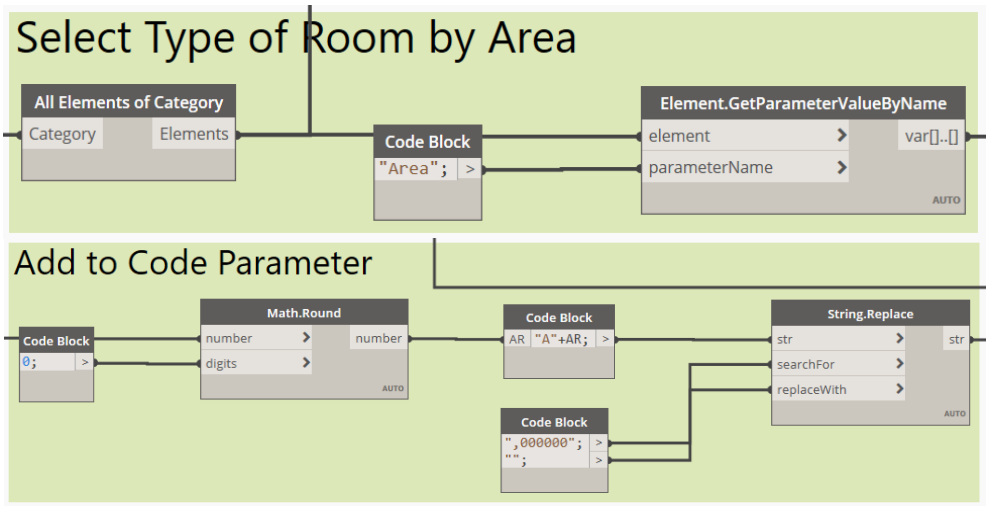


Figure 58 - Select area parameter and round

Last step was to create a shared parameter for the room named "Area Code", that will export the information values into room properties in the model with the value equal to the "Area". However, the parameter generated is a string and the predefined in the room is a numerical string which when added as tag of the room can appear with the value rounded. The figure 60 shows the result of the applied code parameter.

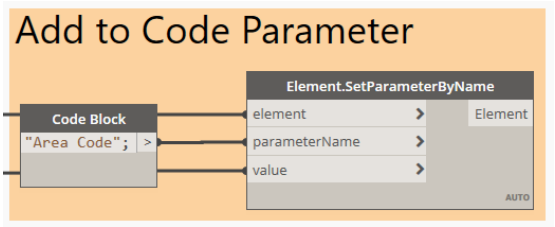


Figure 59 - Apply value to the parameter

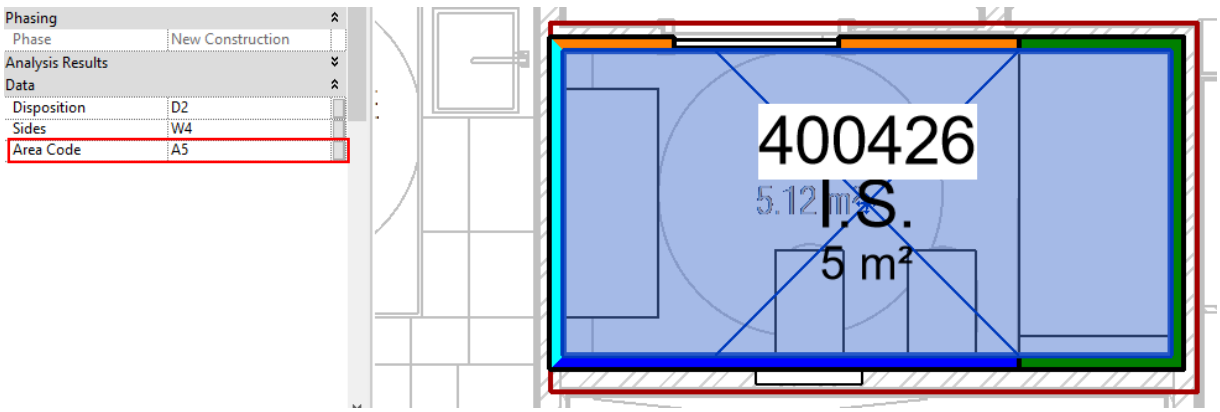


Figure 60 - Parameter applied to the room

4.2.5. Detect maximum length of the room

To detect the dimensions of the room it was necessary to identify what was the maximum distance of it, since it will translate to the length of the bathroom. However, it's not recommendable to detect the width of the room, since in cases where the room have different number of walls, the boundary can't be simplified to a unique value, in matter of facts the "Area Code" parameter can untie this problem by combining with the maximum distance, it´s possible to have an overall concept of the dimension of the room.

To generate the code all the bathroom walls were selected and then the same process of generating the number of sides was applied. The code joins the curves from the room boundary, transforms into a surface, and then extracts the curve simplified with the use of the code "Λ̸W CurveLoop.Simplify" created by SpringNodes, makes possible to extract the curve lengths of the room.

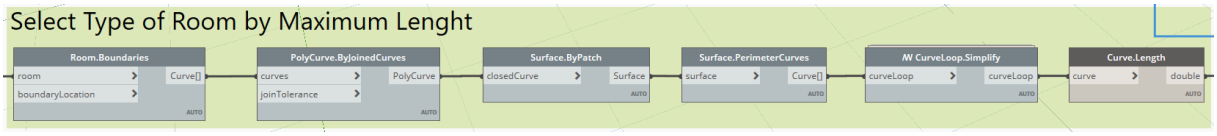


Figure 61 - Select room curves

The code extracts from the list of curves of each room, the element with maximum value and round it to a decimal case. Then it needs to be transformed into a number integer using "Math.Floor", the result will be then export into a new shared parameter named "Length". The figure 63 shows the application of the code in the room parameter list.

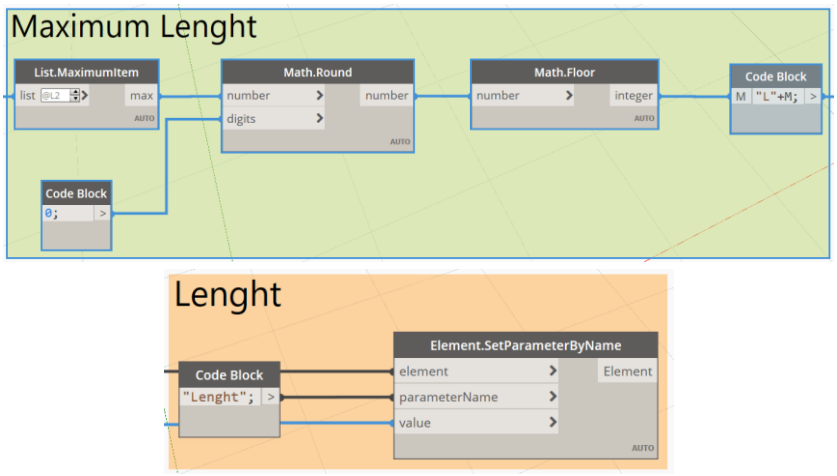


Figure 62 - Select curve with maximum length and add as parameter

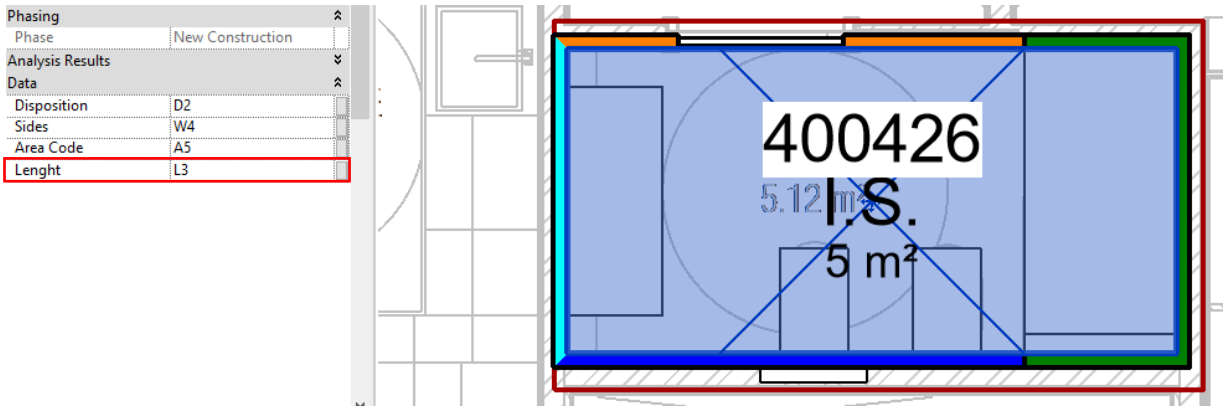


Figure 63 - Parameter applied to the room

4.2.6. Sequential code to define typologies – parameter

The next code combines all the previous parameters and merges them as a unique list to create the typologies (Fig.64). Typologies are by all the means the process of divided the multiple compartments in different room areas, where they will have closer and unique characteristics that can´t be transposable. To generate this code, it will be used the four parameters created in the previous chapters and based on the case studied process done by TopBim.

The figure 64 shows the process for generating the hierarchical approach of the code, this compiles of four steps and a last one will contain the list subdivided that will attributed to a shared parameter. To start, all the parameters of the room will be selected one by one in sequence, the logic of the steps that were firstly created started with “Sides”, “Length”, “Area Code” and “Disposal”.

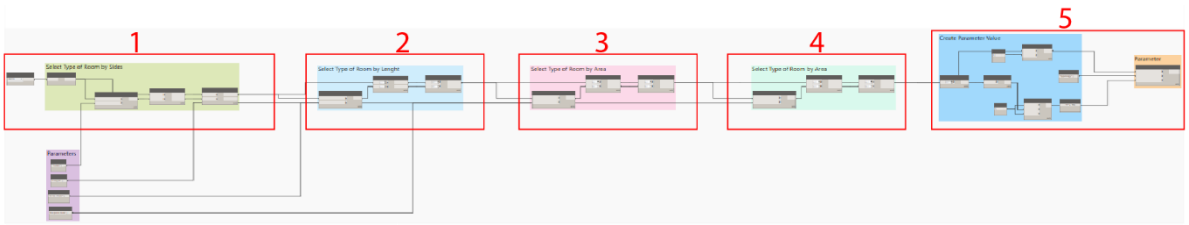


Figure 64 - Creating typologies code

The figure 65 shows a repetition of each different parameter in a different step. To better understand the concept two nodes are key to settle this hierarchical list “List.SortByKey” and “List.GroupByKey”, there function is to take from the list of rooms the specific parameter and sort them by the value, to be then grouped by the result in a new list. What this code creates is multiple sub-lists of each different result, that will be stacked on top, since when applying again the same process, they will create a sub-list from the sub-list that was sorted before. Making this a hierarchical code, because as further information goes the more the number of sub-lists will be generated, making the final parameter being a sub-sub-sub-list of all the rooms.

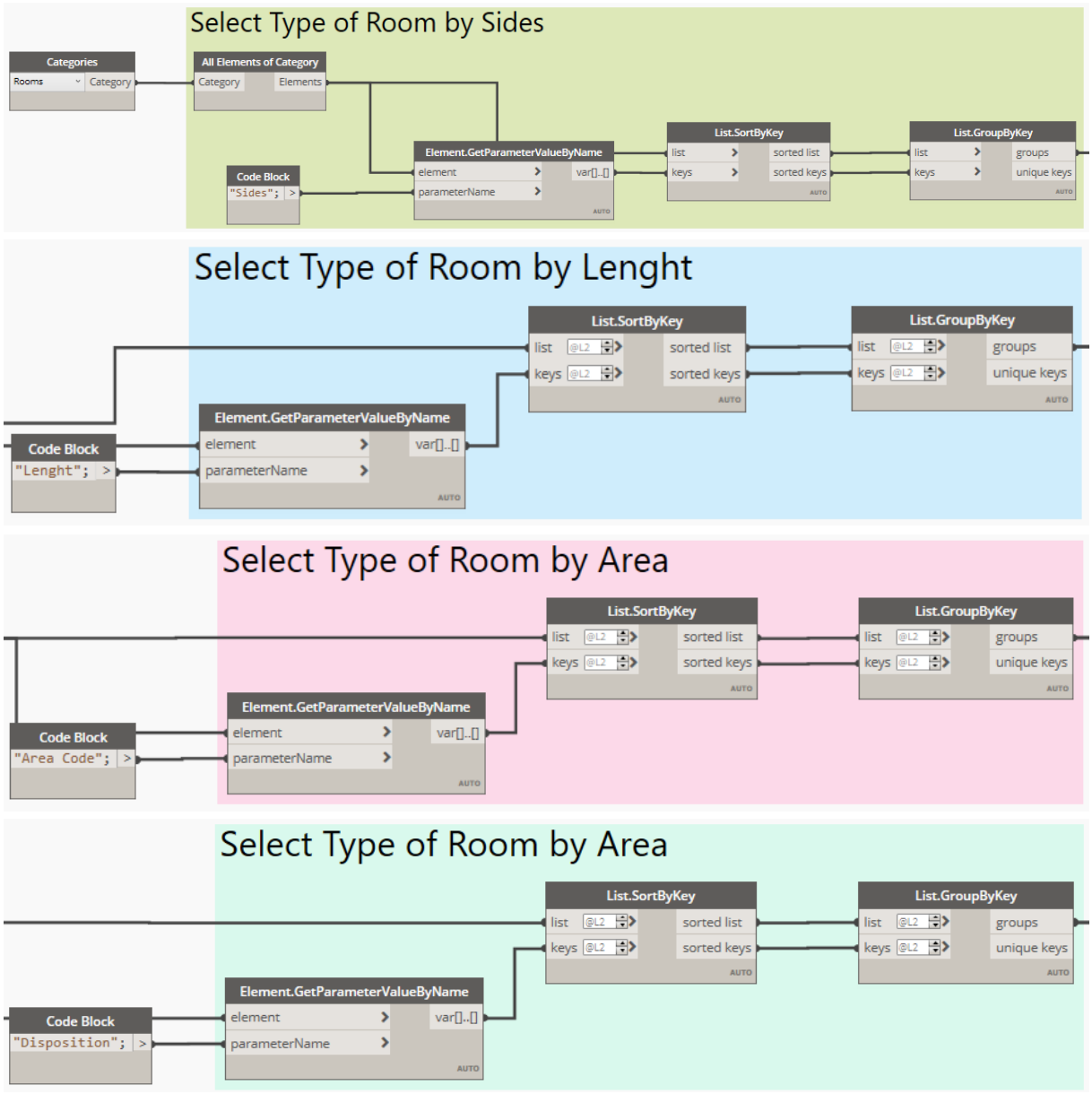


Figure 65 - Step 1, 2, 3 and 4: Short room list by parameter

After creating the final list, the last list will be counted to create a range of number that starts on 1 and will extend to the number that will be given in the node “List.Count”, in this case 27. Then, by applying the sequence of number in a code block they will generate the value for the parameter “Typology”. The last step was to flatten the list to the last one and introduce in the node “Elements.SetParameterByName” with the list sorted as was generated and then applying the value to the shared parameter “Typology”.

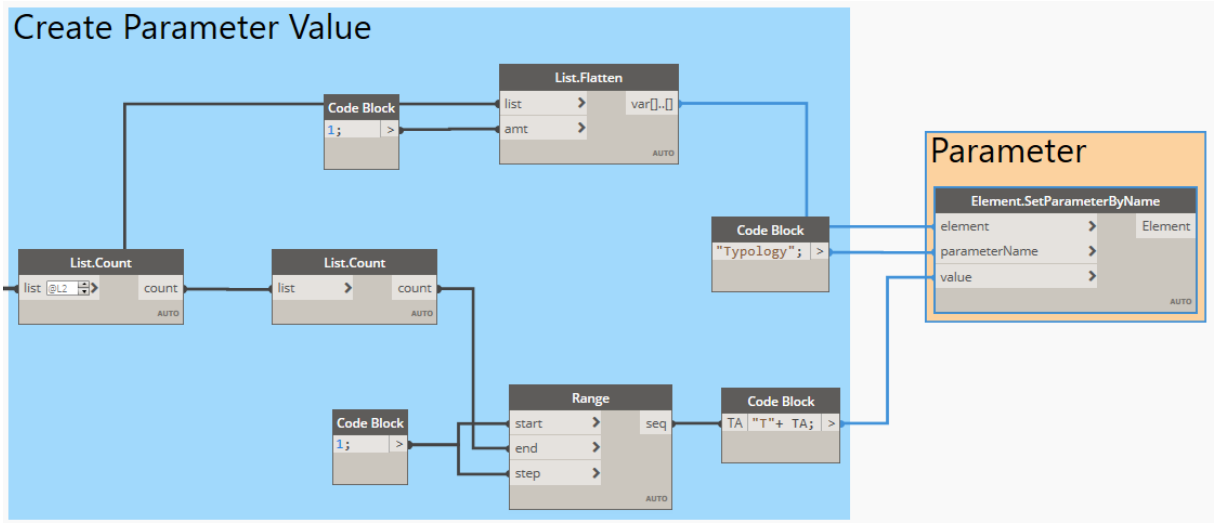


Figure 66 - Step 5: Apply parameter to the room

During this code the four parameters were tested in different position and different sequence, but no matter which code goes first the result will always be 27, so it means the hierarchical code disposition doesn't alter the code and it´s only affected by the values of the parameters. The code disposition by sequence is more likely to be an intuitive way to stack similar room together with smaller number ranges between then, rather than an uncontrollable number generated for the typologies (Fig.67)

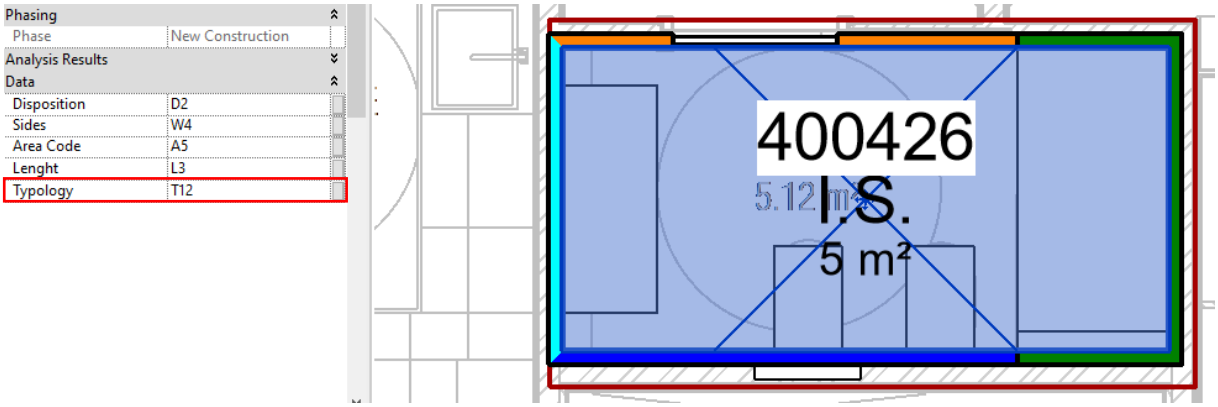


Figure 67 - Parameter applied to the room

After analysis of the rooms, it was detected that some rooms could be consider from the same typologies, due to problem that exist inside the parameter. During the investigation there was an understanding that dimensions are directly correlated with the occupation of the room, since the big area usually contains more elements inside. However, there is no boundary to this limitation since there is not a specific area boundary that defines if belongs to a new typology.

The figure 68 represents the problem of the code, it shows 2 room with different colour schemas, which were generated for the bathroom typology, each colour schema represents a different typology "T6" on the Left and "T7" on the right, The problem can be detected in open eyes, as the parameter of area shows a round number of four on the left and three on the right, this is the main cause for the generation of different typologies. The fact that these typologies were created was caused by the math round, which

trick the program to think that they are different, when it´s the opposite. Therefore, to test the limits of the software understanding the spatiality of the room, a different code was created to solve this problem.

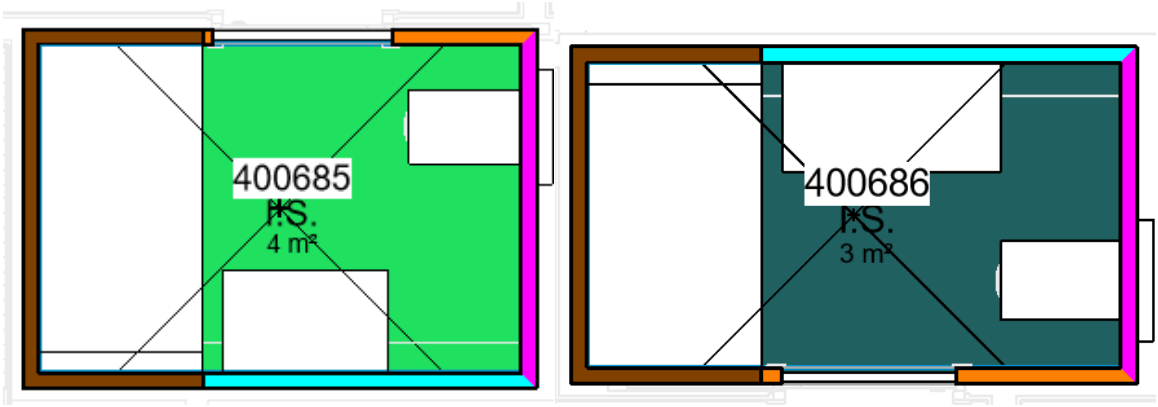


Figure 68 - Identical bathrooms, different typologies

4.2.7. Sequential code to define typologies – point coordinates

The next code was developed to solve the problem that was found in the previous chapter, even if the smallest difference exists, the idea of DfMA is to uniformalise all the elements in a unique component that will be mass produced (Fig.69). The typologies serve as first layer to take all the compartments and unify them in a unique group, since previously there was a problem which led to the creation of more typologies there was the need to solve this problem with a different solution.

The code developed stacks all the bathrooms on top of each other and then, by finding the limit point of the room will group all of them by the dimensions. This means that if the elements are near or even on stacked the code will split them in multiple groups and will use the room parameter “Disposition” as tiebreaker between elements that are not clear in the group that they belong.

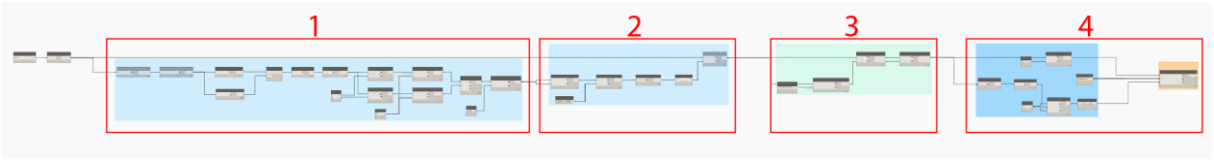


Figure 69 - Code to generate typologies overview

The code starts with use of creating a bounding box in all the rooms that belong to the bathroom. This process creates a cube around all the boundaries of the room. Then, with the use of the code “Cuboid.Widht” and “Cuboid.Length” it´s possible to get the dimensions of the cuboid. However, most of the elements are rotated, since they don´t face all the same direction, it was necessary to create a new list using “List.Transpose” to get the first item in the list as the lower one. Then by math round the elements, to 1 decimal case all the elements will be position in a grid with 0.1 of space between all the points.

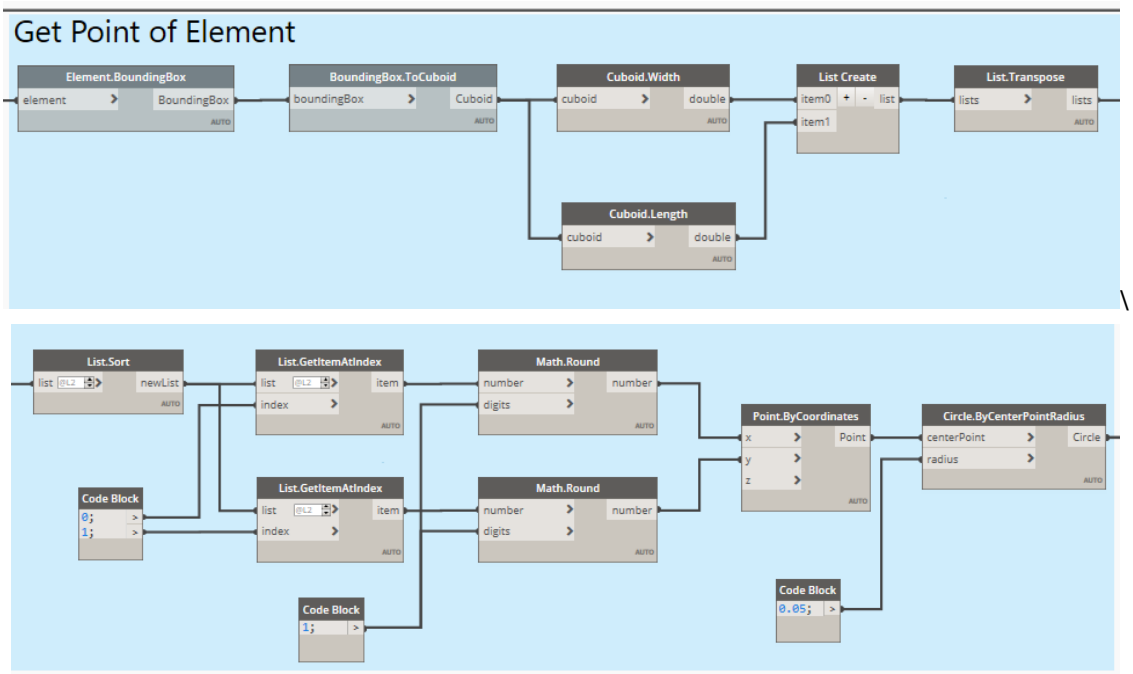


Figure 70 - Step 1: Create point by coordinates

The first item of the list will be then position as the “x” and the last item will be position as “y” of the room. Therefore, by using the two dimensions, a list of point will be created with the coordinates provided. The figure 71 shows all the room rounded and stacked on top of each other then. It’s possible to detect all the groups of point that are almost touching, by creating a node with circumference around the point and giving a 0.05 radius, the circles will intersect in the tangent between each other. Through simply looking in naked eye it´s possible to detect all the rooms that are almost touching in the list.

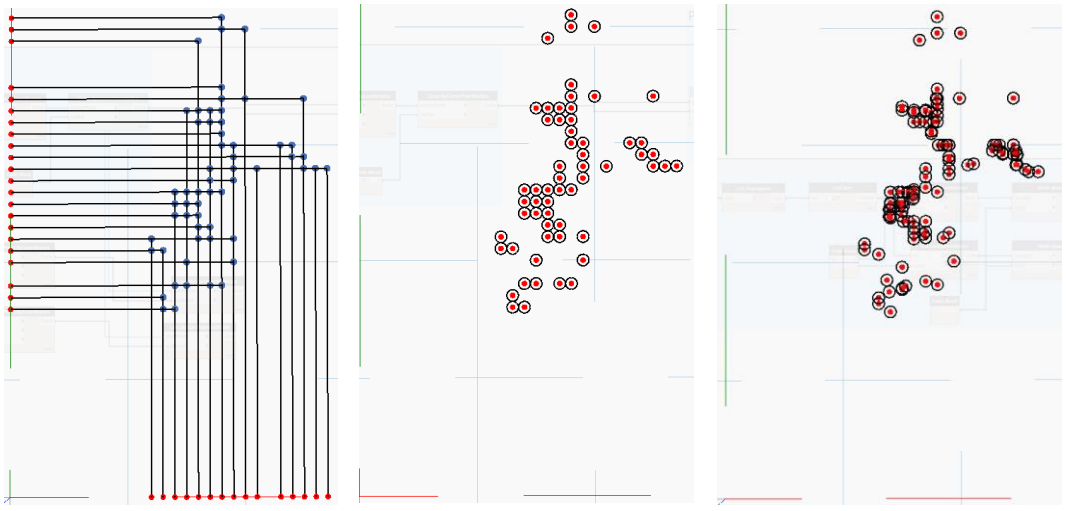


Figure 71 - Room stack overview (left); Point in the grid with rounded numbers (centre); Points in the grid without round number (right)

The next step was to intersect all the circles and take a result which consist in true if they intersect, then a list of all the intersection will be created, for each point that was intersect an x number of results will appear on the list. Then a Python code as shown in the figure 73, created by the user Howard in Stack Overflow, takes the common intersection of a group, and detects as a list of indexes the circles that intersect each other. To later take the value from the list of points which belong to each room.

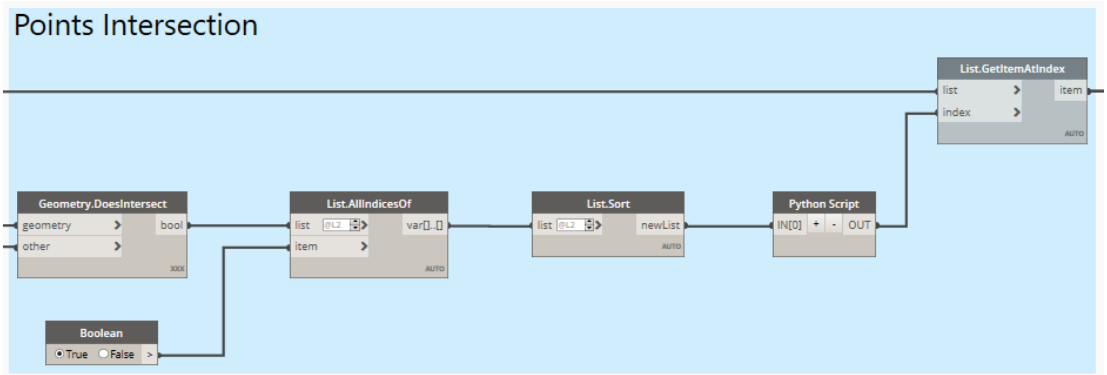


Figure 72 - Step 2: Circles intersection and sub-list creation

Python Script

```
# Adapted from https://stackoverflow.com/a/4842897/8091631

intersections = IN[0]

out = []
while len(intersections) > 0:
    first, rest = intersections[0], intersections[1:]
    first = set(first)
    lf = -1
    while len(first) > lf:
        lf = len(first)
        rest2 = []
        for r in rest:
            if len(first.intersection(set(r))) > 0:
                first |= set(r)
            else:
                rest2.append(r)
        rest = rest2
    out.append(first)
    intersections = rest
OUT = out
```

Figure 73 - Python script to detect intersections

The codes generated to detect the “Area”, “Sides” and “Length” were substituted by the point location code. However, the code of “Disposition” will be used as the decider of the typology’s selection, by creating a sub-list with the same process of the previews chapter. The same process applied to the previews code is applied to this one, since it works by creating sub-lists. The result will be then extracted as the total number of different typologies, in this case, 25 different variations were detected. The result will be then exported with the parameter “Category”. The figure 75 shows the same room that were shown in the previews chapter with the new parameter applied.

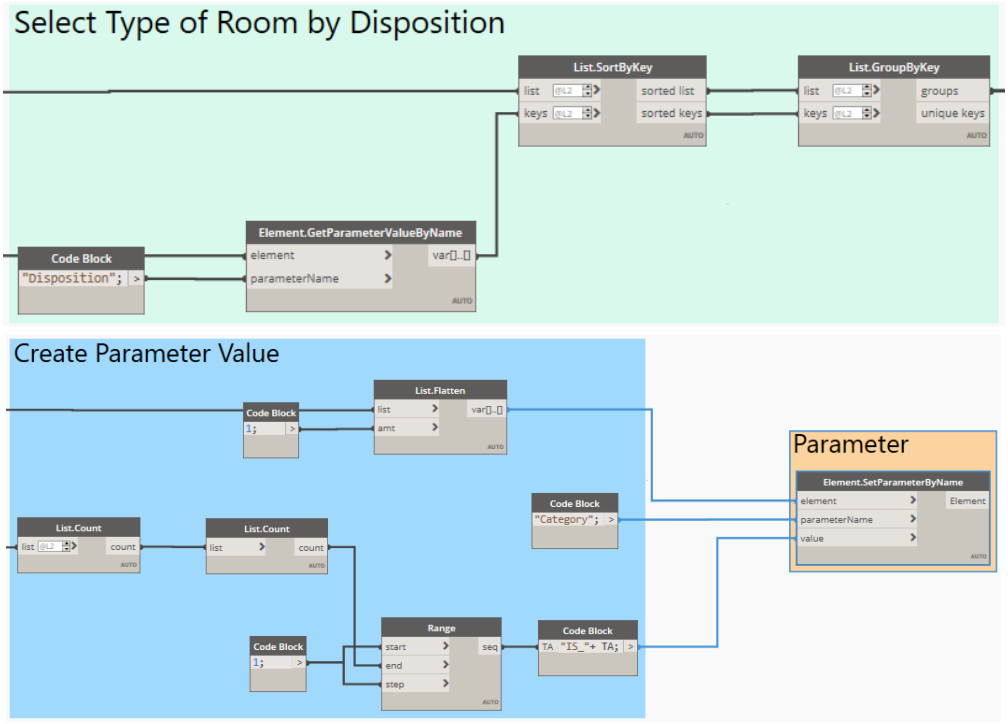


Figure 74 - Step 3 and 4: Sub-list from the parameter "Disposition"; Create parameter with the value "Category"

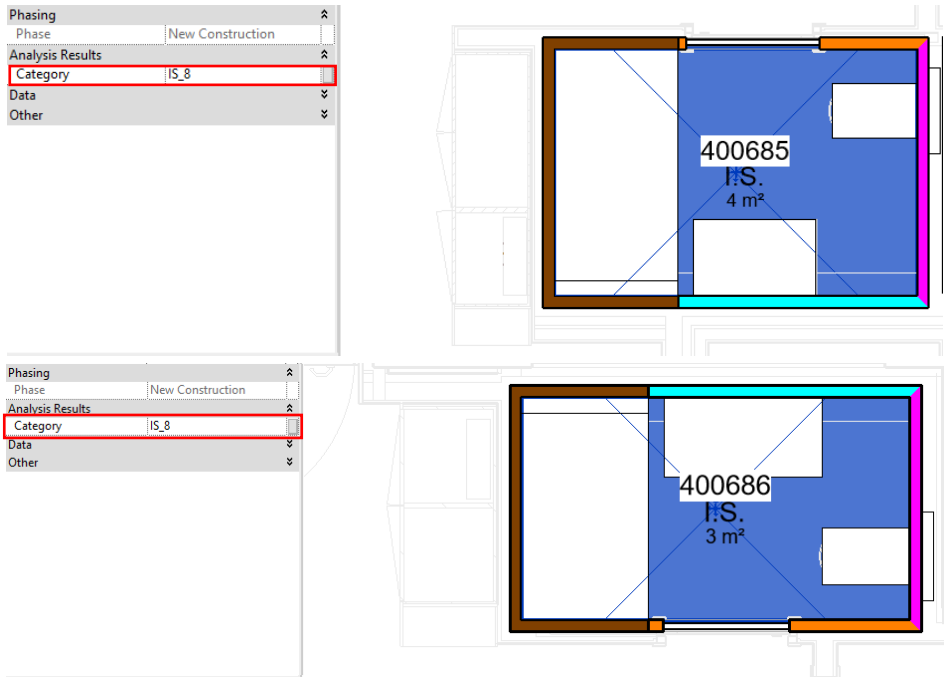


Figure 75 - Analysis of the results in the bathrooms

Concluding, both processes were important to understand better the results of this method of reducing the number of typologies. However, it's not a finished process, as the sub-category which are the variation on disposition, inside the room will be extremely important and will create more variation. In DfMA if a wall is inverted, it will contain the same elements but a different process of assembly. The results of this code were limited by the number of results that exist, if there are more variation inside the

room, it could not be useful as in this case, since the more element exist in the model, less the number of variations between the two. There isn´t a viable solution to the problem so the combination of both codes can be adaptable to each type of assignment.

4.3. Sub-Typologies Definition – Milestone 3

Since the number of typologies are a generic approach to the multiple bathrooms that exist in the building the next stage is taking this step a in DfMA further, by detecting what are the differences in the disposition of the room, that makes them unique in comparison with other groups. Taking in consideration all the typologies that were created during this process, there is a need to detect further relations between elements through a code that can link elements and then divide them in multiple sub-groups.

The idea of this code is to understand the spatial disposition of the elements and consider the relation between them, since in DfMA the elements that exist inside the room can be produced as the same when a wall is different, the relation with them in the wall is something that correlates to the assembly part. Consequently, this unique code will group these elements by detection them, in relation with their axis, gathering information that will formalize a sub-typology group. The code will start by creating a generic code to detect in which position the room is facing by combining the direction in x and y axis.

This process is an approach of what was analysed in the chapter 3.2 and the unique subcategories that were created in the room detection system developed by TopBIM. Therefore, the biggest role is to divide into step-by step process. The detection of the relation between door and lavatory will get, not only the direction of the room, but the location of the lavatory in relation with the door; Further it will be analysed the toilet position in relation with the lavatory to detect the place of this element in relation with it; Lastly it will detect the door type in each room.

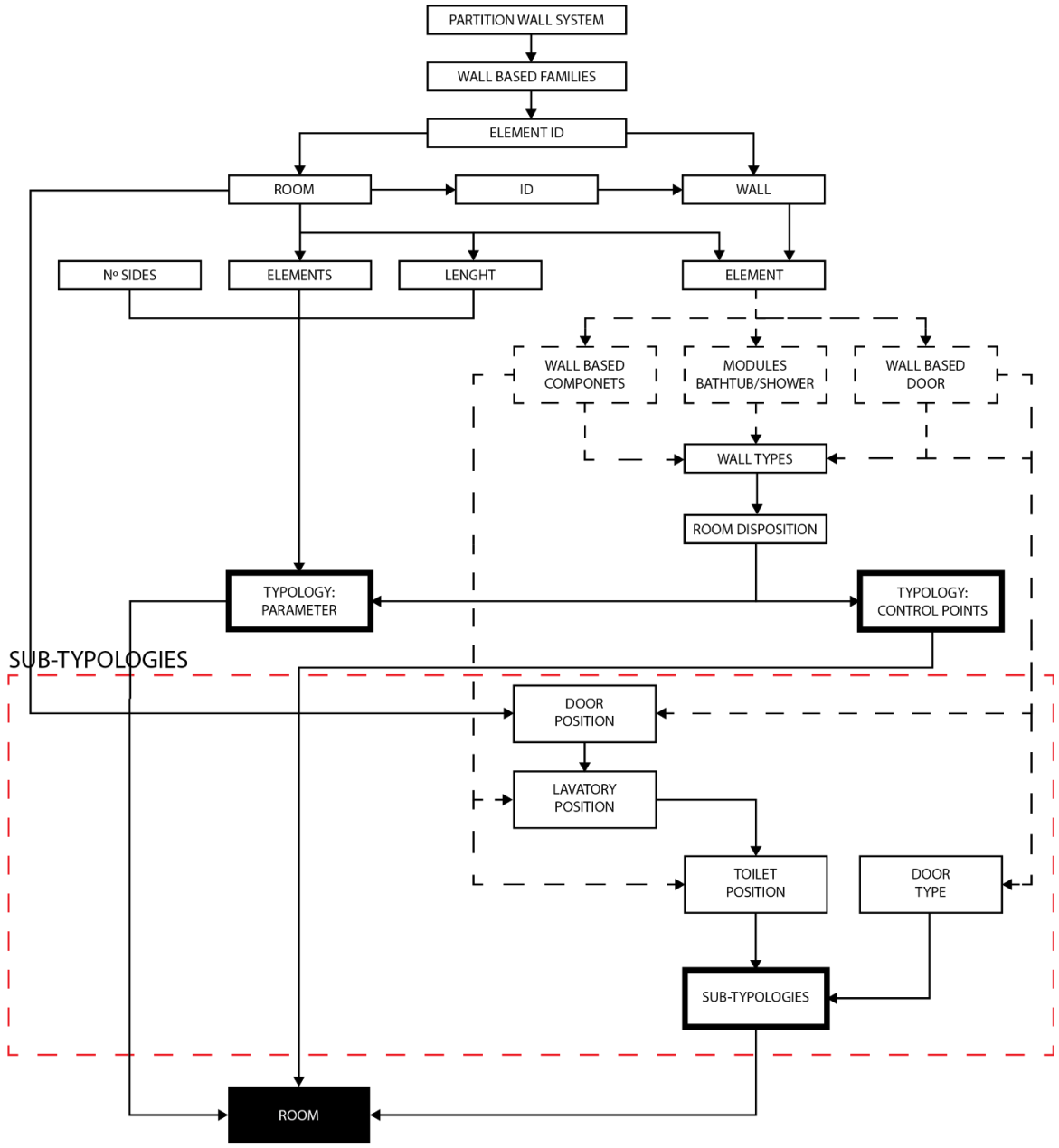


Figure 76 - Diagram with sub-typologies

4.3.1. Element Position

The next code will create two parameters to later create a relation between them, this operation uses the principle of cartesian coordinates to detect where the room is facing (Fig.76). The relation with the elements will be created through the wall types that contain doors and lavatories, allowing to develop a relation between elements and their directions with others. The code is divided in two processes, the door position and the lavatory position that will be combined in two different outputs to be related in relation with the related direction that are facing.

The figure 77 shows the all the code steps, the underneath part will work separately to get two different results, The principle of the code was to divide by level the rooms, since due to the amount of information that exist in the model, it´s better to reduce the number of iterations. After this process the composition worked by creating the same code applied to all the walls that contain lavatory and doors. The walls that contain doors, will be selected by the wall types containing them, and in the rooms with the wall type of lavatory the following wall types were selected “L”, “LT” and “LBT”. The result will be given by two new parameter that will have a value of geographic coordinates, that will further understand.

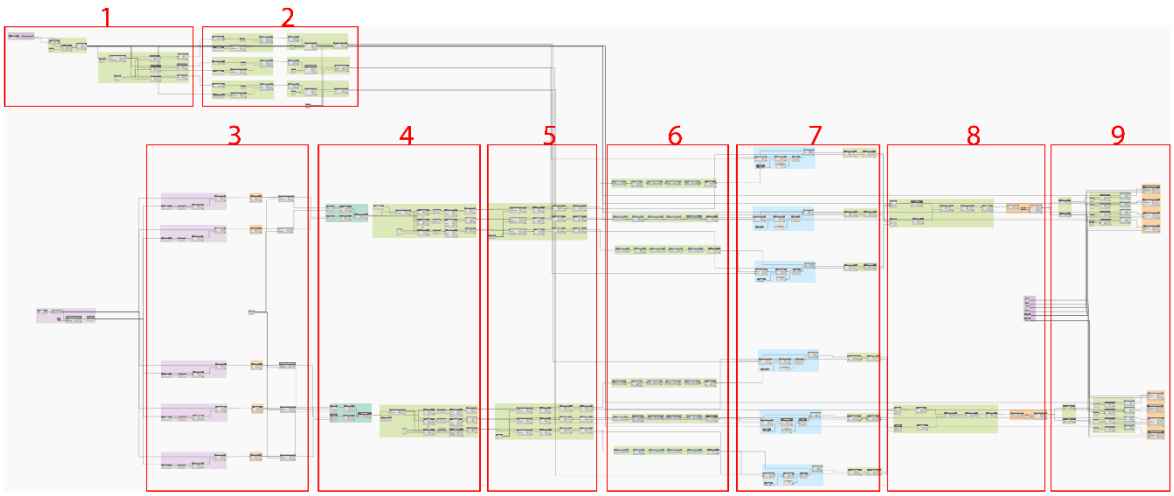


Figure 77 - Lavatory position code overview

The figure 78 show a group of codes that selects all the rooms that belong to the bathroom, then it uses a group of nodes to detect the level which they belong, this way it´s possible to group the elements by floor. Then the second code detects the room boundary and generates a curve that will be extruded as a surface. After getting all the surfaces of the solid a node was used to identify the middle point of the surface. Then spheres were generated in this point using “Sphere.ByCenterPointRadius” with a small radius. This code will intersect with the output of the rooms, to detect which surface belong to each wall. This process was created to always have the surface normal, the direction of the surface, faced always to the inside of the room.

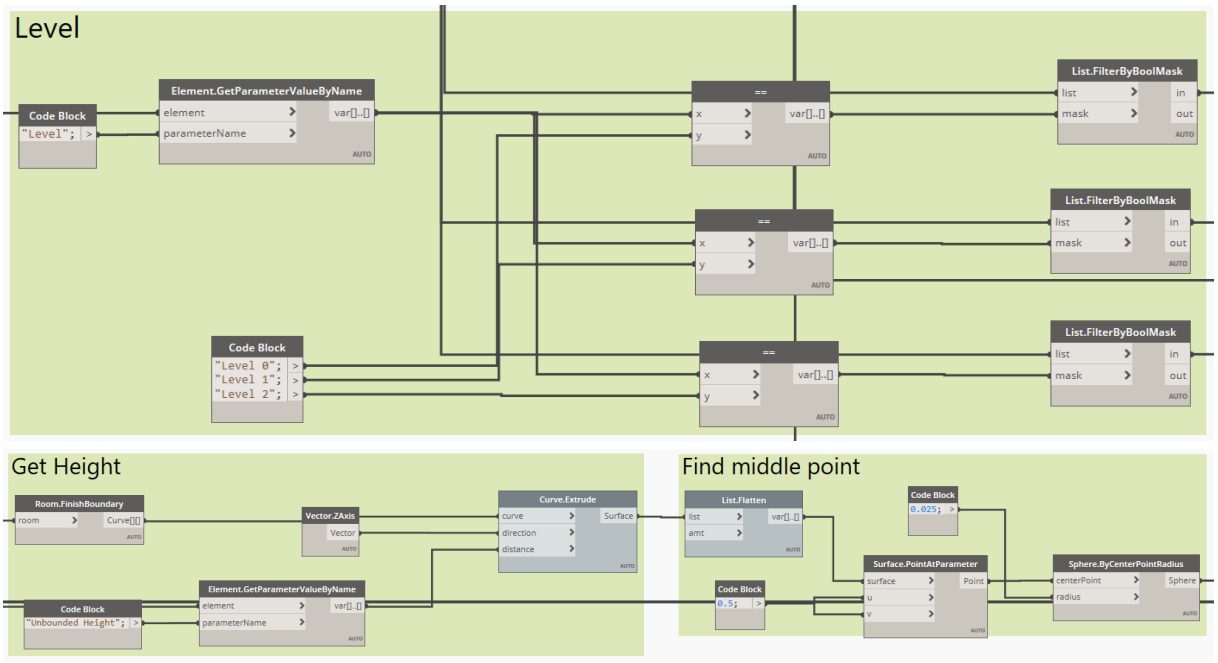


Figure 78 - Step 1 and 2: Select rooms by level and surface creation

The codes in the figure 79 selects all the wall types that exist inside the model that belong to the door and lavatory. Then, with the value of the parameter “Room_ID”, it´s possible to detect which wall belong to that specific room. Therefore, the wall elements will be then sorted not by their element ID, but by the “Room_ID” that was created, thus sorting the two groups of elements using this information, to generate a sub-list that can be attached to them. The walls will be later distributed by floors using the predefined parameter “Base Constraint” which will separate then by the floors.

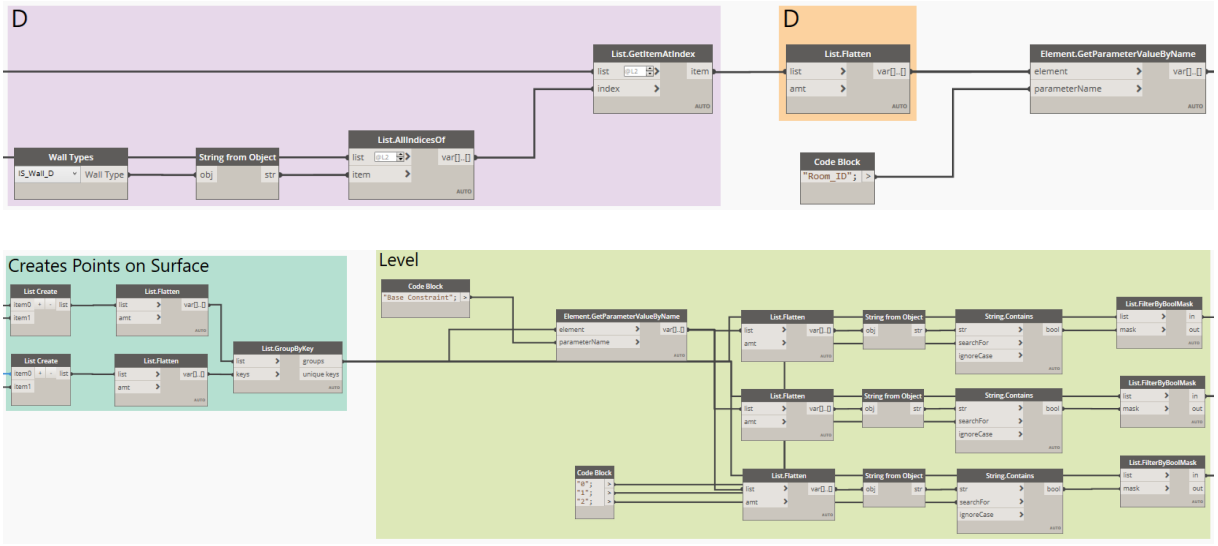


Figure 79 - Step 3 and 4: Select wall types and divided them by floor

The codes in figure 80 will pick all the elements in the multiple groups and divided them by floor, generating a list the elements sorted by the room ID. Since the walls need to intersect the spheres that were created, the next step was to generate a room solid from the existing elements to intersect the objects. However, since the rooms that contain doors have an open in the door location, it was necessary to use a different method to generate the volume. The code uses "Geometry.BoundingBox", which is a node that creates a box that fits all the elements inside it, then by converting to a "BoundingBox.ToCuboid" the elements will create a physical volume of the bounding box created.

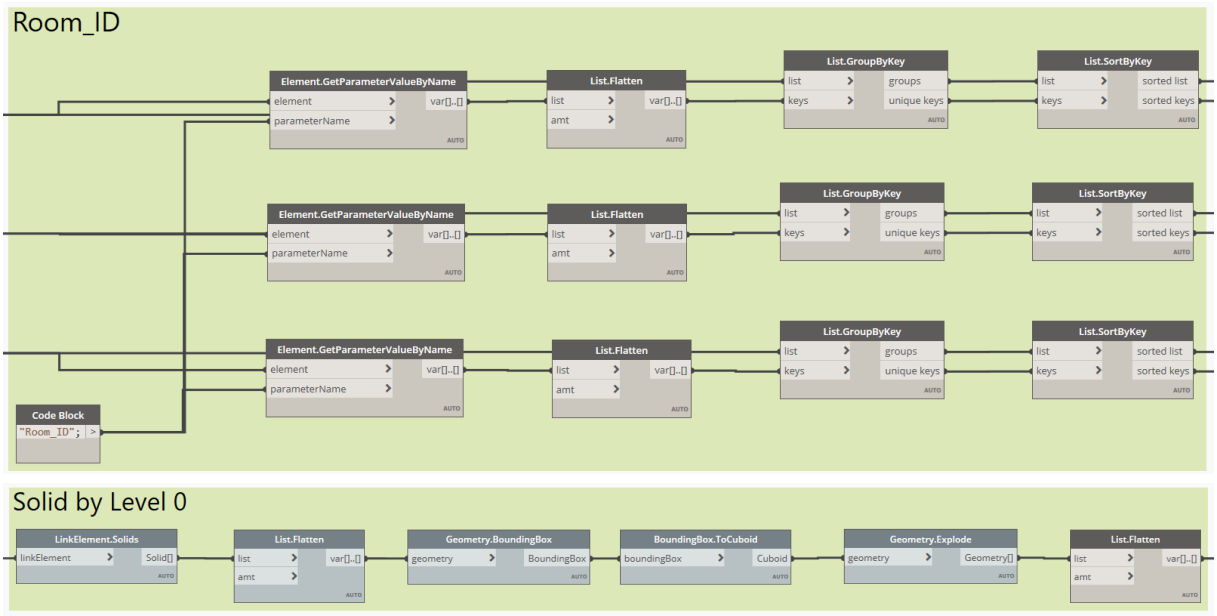


Figure 80 - Step 5 and 6: Select the room ID in each level and create a solid from the selected

After the creation of the spheres and the solid, these two elements need to be intersected using "Geometry.DoesIntersect" being the spheres the priority, since the outcome desired is the use of the surfaces created using the room boundary. After the intersection there is a serialisation process combing true and false and the output will be given to the surfaces. Consequently, the output needs to be grouped and sort again using the "Room_ID" to go to the next stage. The elements that belong to each floor need to be join in one unique list, by combining then in two groups, one with all the surfaces and the other one with the list of "Room_ID". Therefore, the elements that belong to this group now need to be sorted using the parameter, making it a list with all the surfaces in the parameter order.

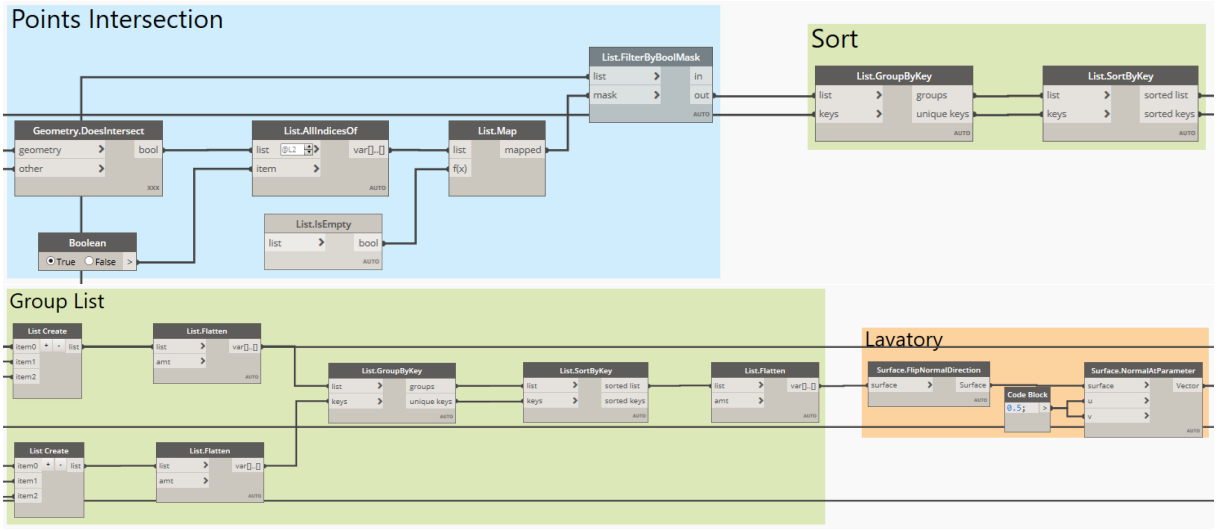


Figure 81 - Step 7 and 8: Intersect surfaces with wall and detect surface normal

The track of "Room_ID" is the most important part of the code and the key factor, since the elements need to be exported as a room parameter, the track of this information makes the process be detected and can lead to the last stage of the code. The extraction of the surface normal gives a vector with the direction of the line, this line will move in an axis and the value which will be provided from this vector will help to detect the direction of the room.

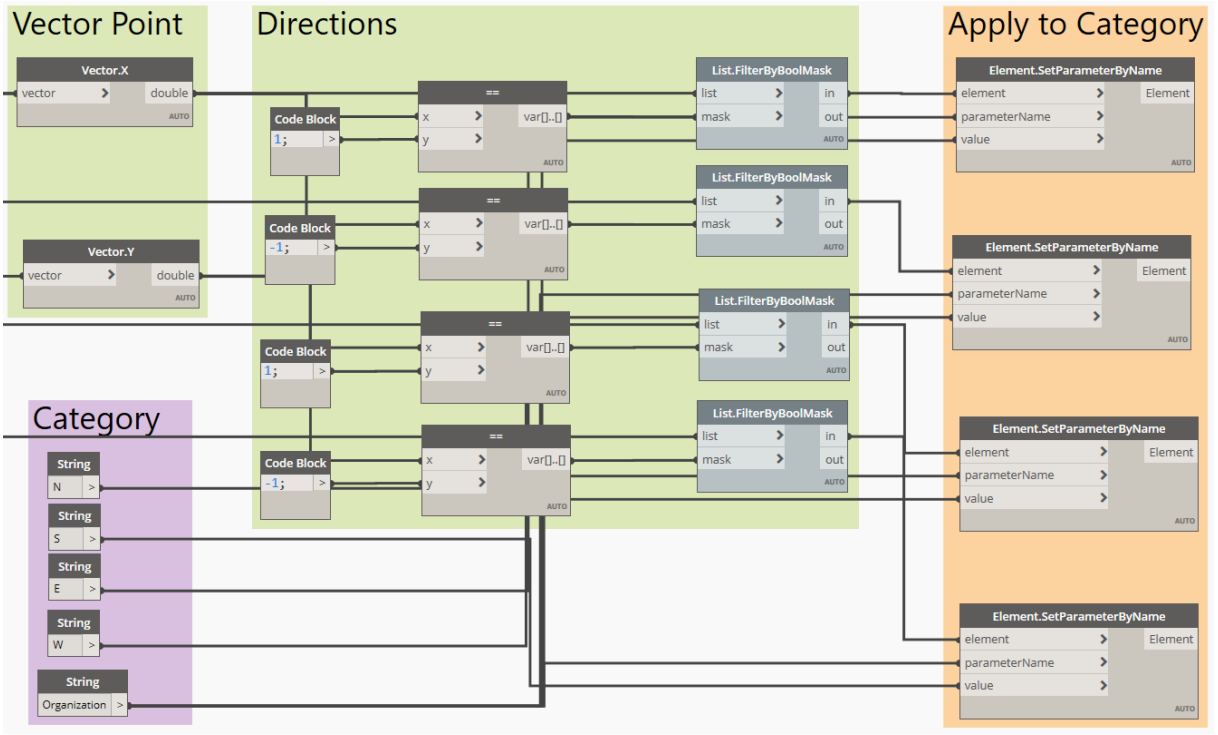


Figure 82 - Cartesian coordinates system detection and output as parameter

The last part of the code is unique, since combines cartesian coordinates with the use of the x and y axis, due to the software not being able to detect the angle of the direction which the element is pointing. Subsequently, it doesn't detect the angle of rotation of the elements, to detect the relative position of the elements, proving that the use of angle doesn't give proper information, since the result shows the angles at 0, 90 and 180 degrees, never going abroad the last value. If a room faces upward or even downward the result will always be equal, due to the detecting of the angle to the shortest rotation.

Giving the fact that the angles doesn't provide enough information, the process created works by extracting two values, the vector in x and the vector in y, these two coordinates will provide a list with values equal to -1, 0 and 1. Taking in consideration the cartesian coordinates the coordinate (0,0) represents the centre point, then the point (-1,0) and (1,0) represent the x axis, if the x is positive the room element is facing right since x positive moves right, and if it is negative it moves to the left. Taking on this representation and converting to geographic coordinates when the element faces the right direction its facing East, and when facing left is facing West, by doing this process in the room door, dictates the spatial position of the room in relation with the entrance. This process can be applied to North when y (0,1) is positive and to South when y (0,-1) is negative.

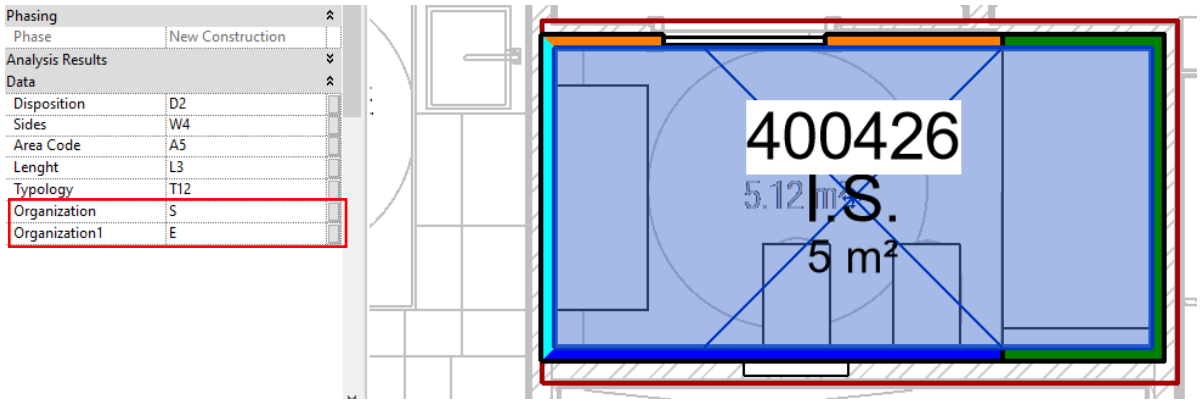


Figure 83 - Parameter applied to the room

To continue the code there is a need to create two new shared parameter "Organization" and "Organization1", that will take all the information in regards of their geographic coordinate system and split all door and lavatory by their direction (Fig.83). This process when applied to both selection lavatory and doors, will always give the spatial position of the elements in the overall context of the project. The next stage is how these two groups will then correlate and create a spatial relation between them, detecting if the lavatory is on the right or left in relative with the door.

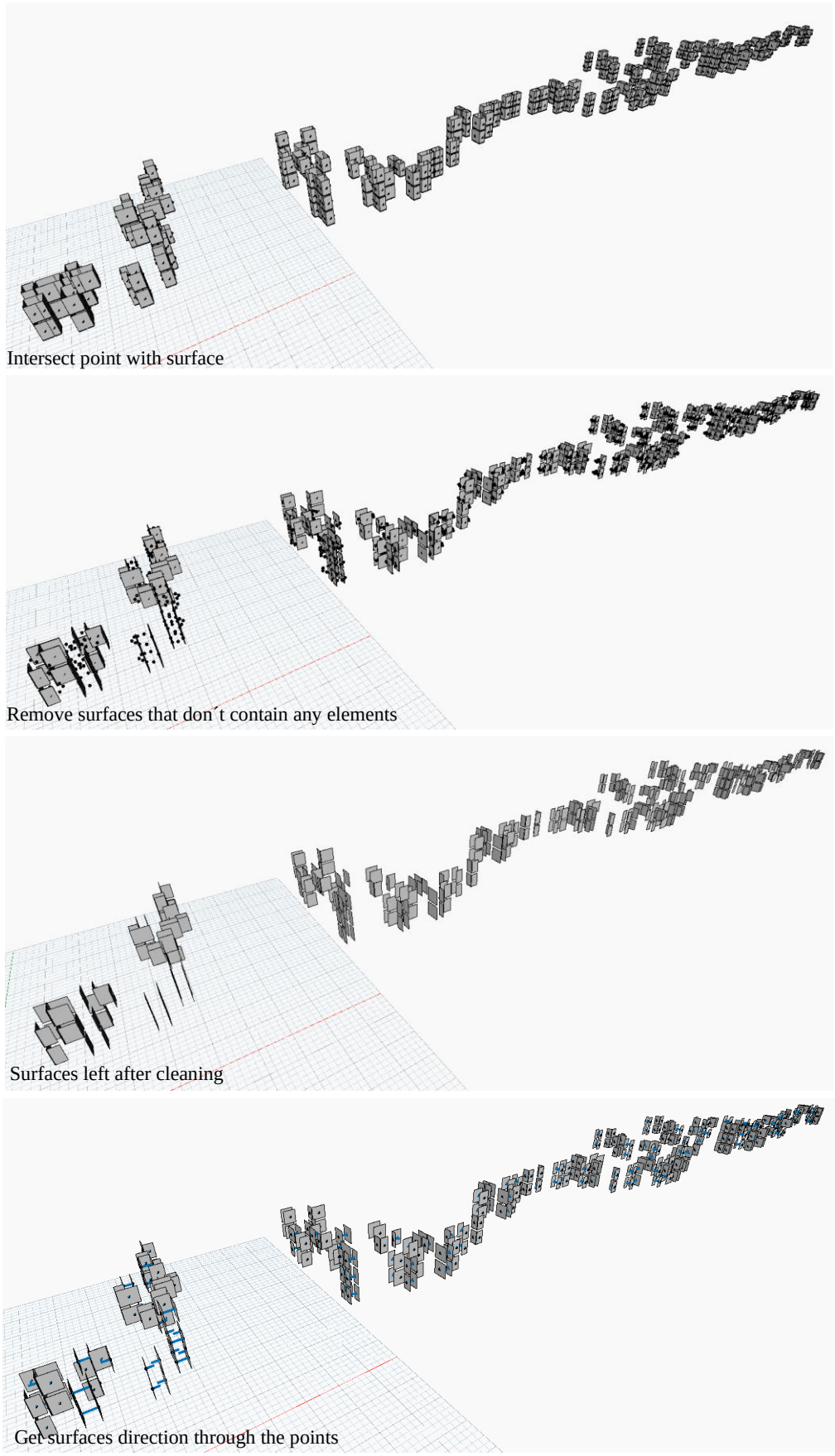


Figure 84 - Step by step process representation of the following code

4.3.2. Lavatory Position

The next code created to add a new parameter named “Lavatory Position” which consist in the relation between the two parameters of the previous chapter (Fig.85). The parameter named “Organization” refers to the door position and the “Organization1”to the lavatory position. This code will divide all the elements that are facing each geographic coordinate and relate the other element in relation with the spatial position in relation with the door, providing the information of the element faces right front or left.

The process works by selecting all the room in the project that belong to the bathroom and by selecting firstly the parameter “Organization”, which are related with the door position. Then by selecting the elements in the parameter a sub-list of elements will be created composing of four different value that each belonging to a different room, then by isolating them by each coordinate it´s possible to create a correlation with each one of them.

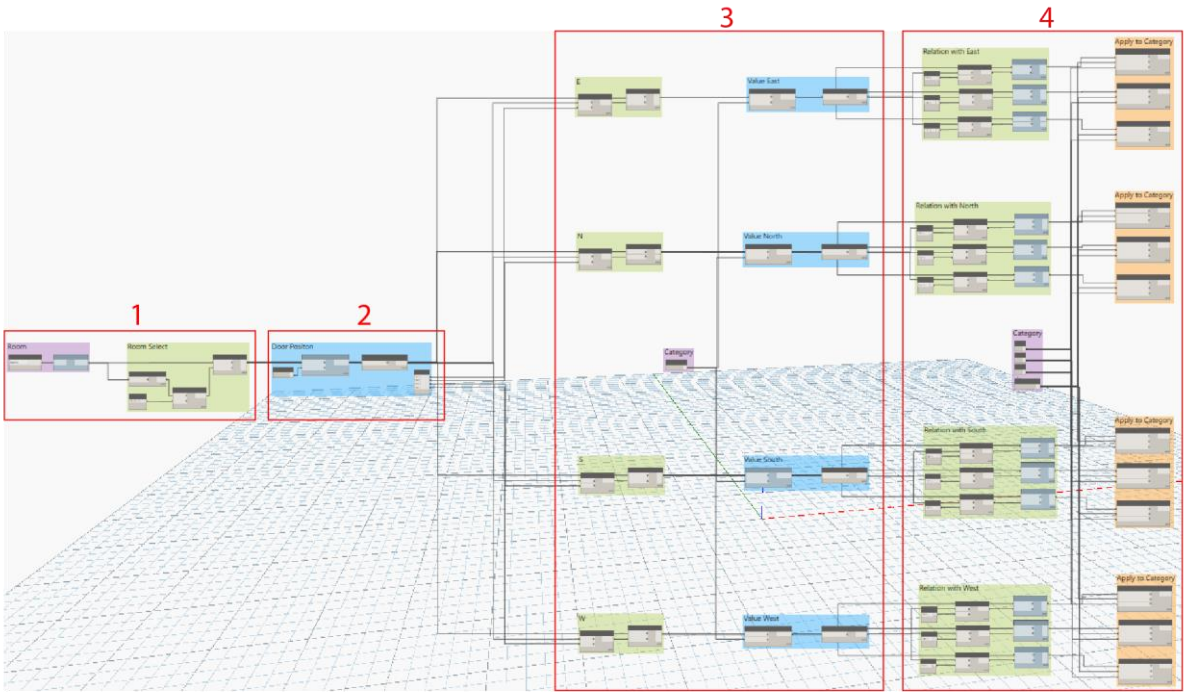


Figure 85 - Overall view of the code with the steps

Selecting all the elements inside each room a sub-list using the parameter “Organization1” (lavatory position) will give the direction of each element in relation with the first one. Therefore, the result was given as three different values, since no element is near the door, neither was detected before any elements in room that shares the same wall type of the door.

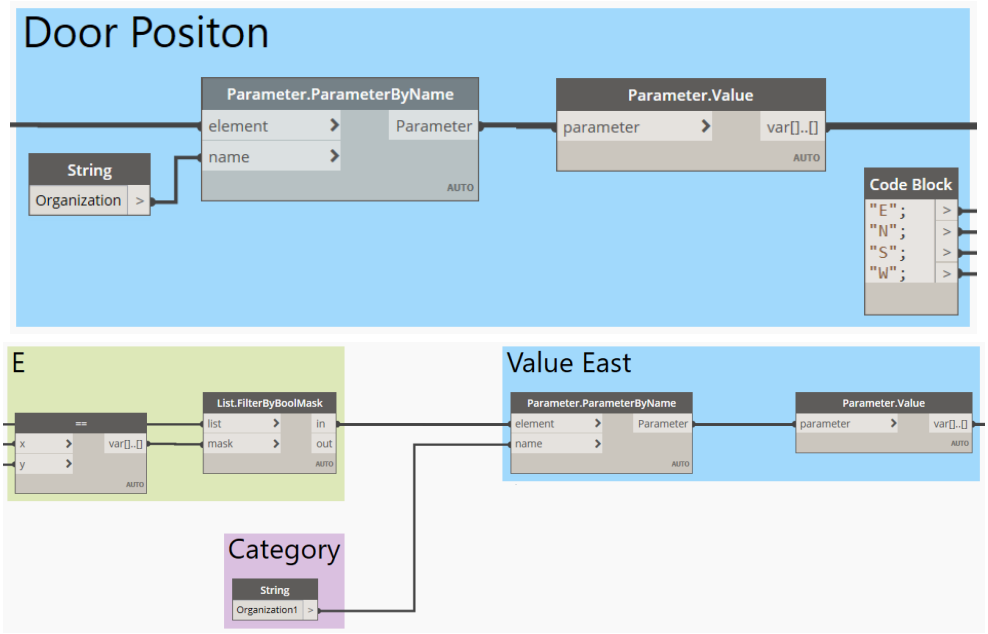


Figure 86 - Step 2 and 3: Select the element that belong to "Organization" and "Organization1"

The next step is the most important since the elements will be judge by the relation to each geographic coordinate. The process starts by isolation each sub-list of elements in relation with the value of the parameter "Organization1" and creates a methodology process of isolating the components and compare them with the previous selection. Taking the element in the coordinate East the value West will faces in opposite direction since, it´s considered in front of the element. The figure 87 show all the relation between all coordinates, for example, in the East, North is on the right side and South on the left. To the other parameter the same principle is applied, with different procedures.

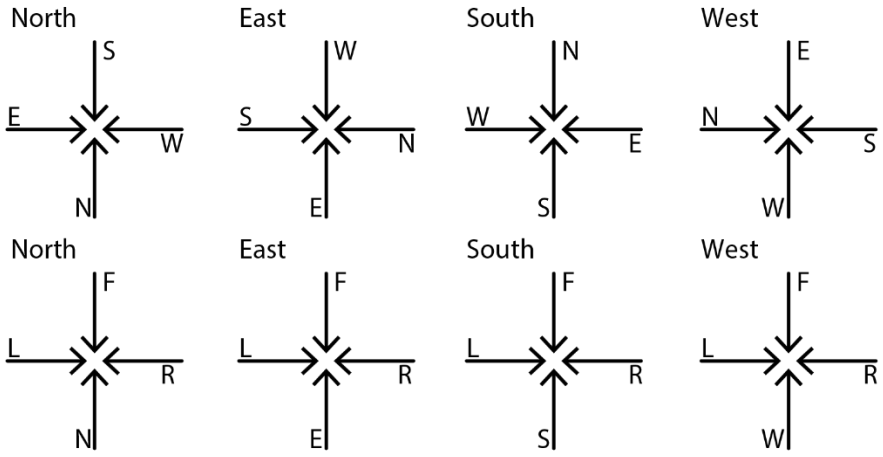


Figure 87 - Relation between the elements in the geographic coordinates

To achieve the last result and define this new parameter, the elements on each sub-list need to be isolated in a unique coordinate. Then, by applying the principle above, it was needed to detect if exist three different values for the elements, therefore they can be separated in sub-list of elements. The next stage was to select the components and give a unique value in a new parameter named "Lavatory Position" that will have three different outputs "F", "R" and "L". With this new information added, this parameter

serves to detect if an element in a category is on the same position or not, since it provides more information. However, as stated before this code only applies to one element of the room, there is the need to apply a different code to detect the other element of the room, which is the toilet.

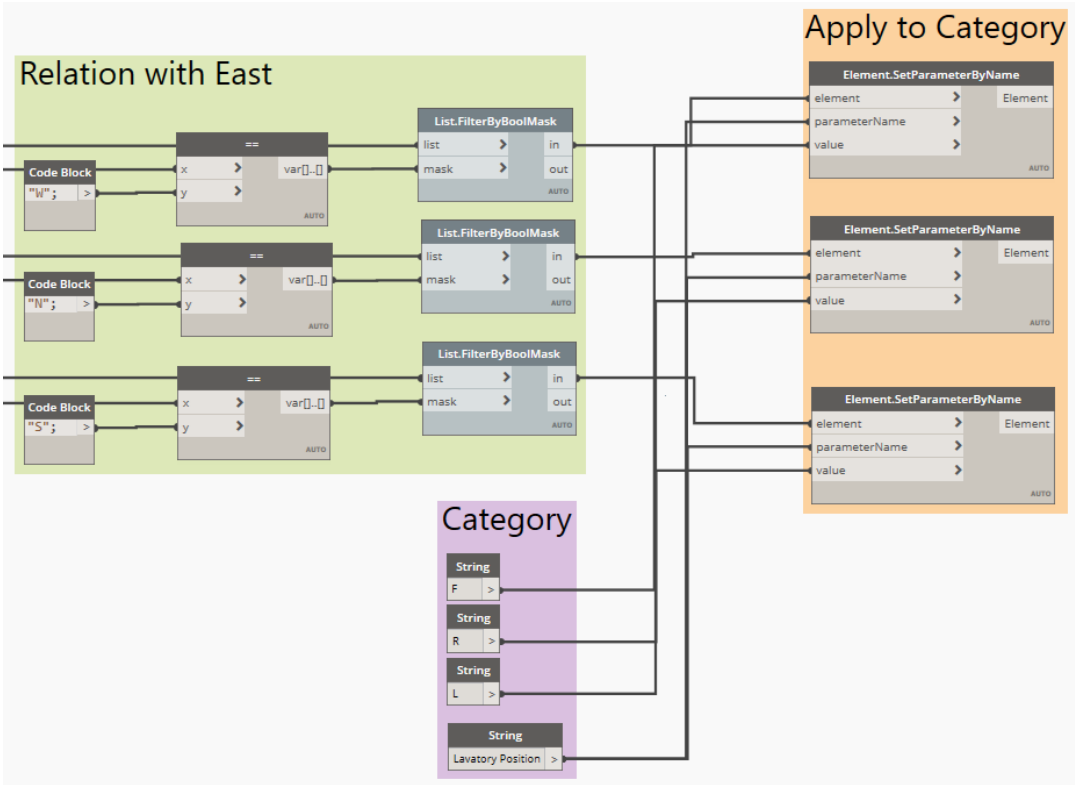


Figure 88 - Step 4: Separate the element by coordinates and export as a value

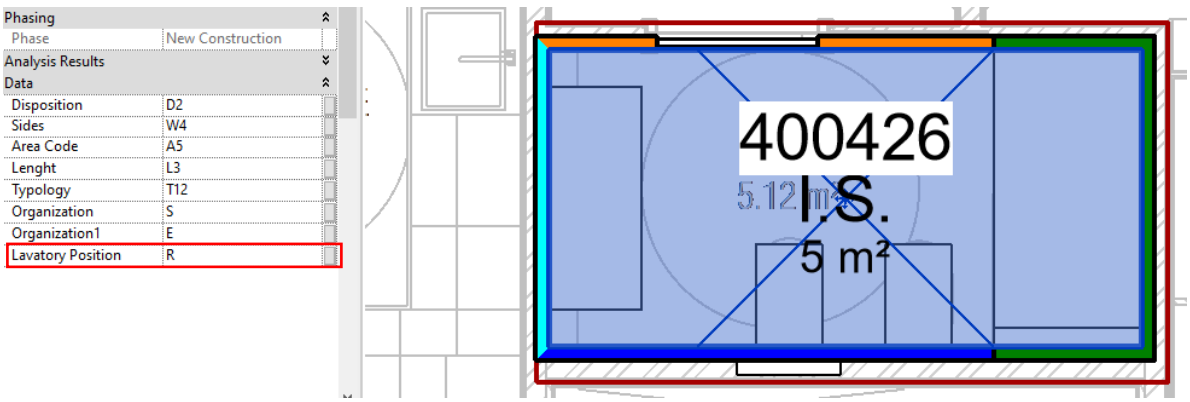


Figure 89 - Parameters applied to the selected room

4.3.3. Toilet position

The next code was created with the same principle of the previews one, with the difference of instead of using the walls as reference it will use the elements as the core of the process (Fig.90). Working on collaboration this code will pick the elements that belong to the lavatory and toilet and use them in a list containing all the reference, to then detect the spatial position of the toilet in relation with the lavatory. To do that, most of the wall elements need are in different wall and since the typology already detects if the element sits in another wall, the principle of this code was only to detect if the toilet is on the right or left of the room, since it will represent if that specific wall is mirror in relation with other similar wall of the same category.

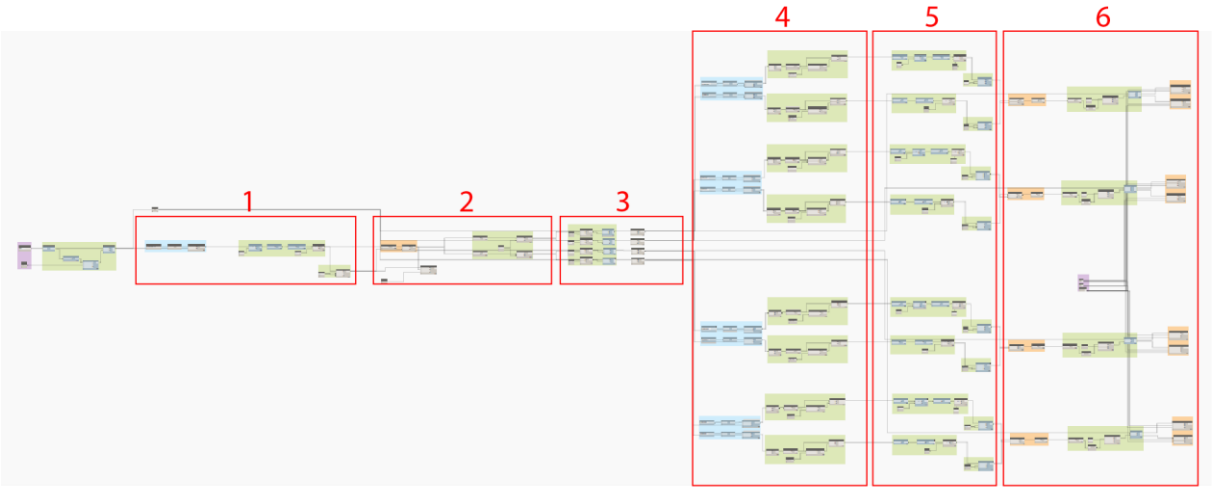


Figure 90 - Code overview with each step

The code starts by once again selecting all the room that belong to the bathroom. Then works by choosing the element Lavatory and detect where exist in each room using Archilab node “Elements in Room”, that detect exact place where it was taken. The code works by finding a point on the surfaces of the element that was selected, and use it as base line. To generate this, point the first part need to recreate the solid form the elements, then explode the geometry, to be get the selected surface that attach to the wall. After detecting it the node will try to find the position on the list where the surfaces stand and export it as output.

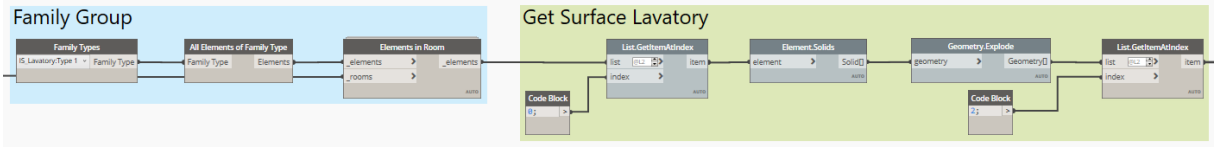


Figure 91 - Step 1: Select lavatory inside the room

The next code selects the surface direction and then detects a point on the surface to be then exported as vector points. A similar process as the previous code, where the vector point will be detected in the surface when finding the point on the surface. Then, the point information will be exported as vector in x and y axis to be later correlated as cartesian coordinates for the elements.

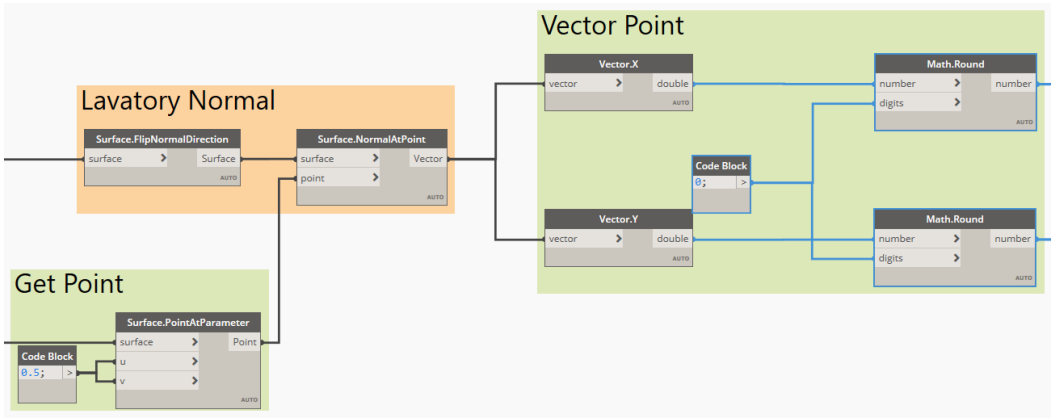


Figure 92 - Step 2: Get surface normal and vector value

The code detects the elements in vector x and divide them as positive or negative and exports as a sub-list from the room, with the information of the surface direction. Then the same process is applied to the vector y. This process will detect the direction where the lavatory is facing. Consequently, the vector x will represent the coordinates of East and West, and the vector in y will represent the coordinates of North and South.

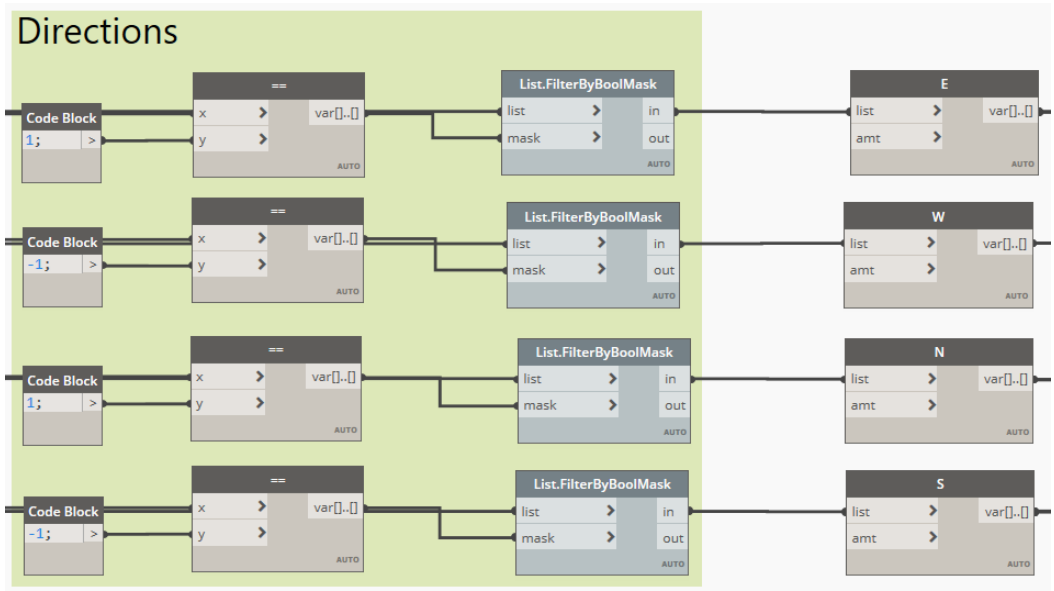


Figure 93 - Step 3: Get the geographical coordinates of the elements

The next code will apply the selection process for the toilet and apply the same process as for the lavatory. The output will be cartesian coordinates in relation with the room, all the elements that belong to wall-based family toilet and lavatory need to pass again for the same process of detecting which direction they are facing since what will connect them will be a line between points. For this reason, the element needs to be sorted always by the parameter “Room_ID”, to keep always of their room position.

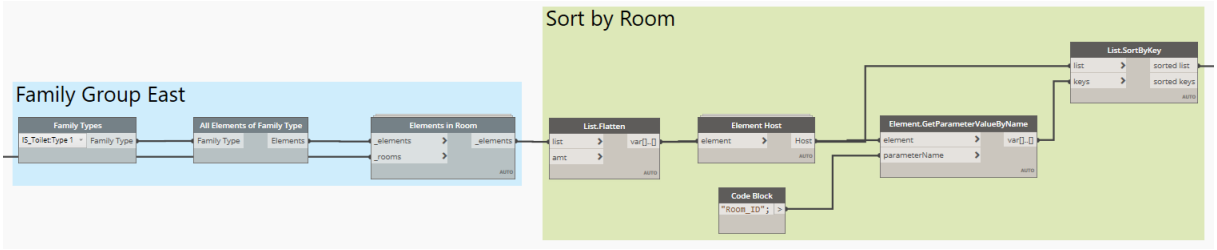


Figure 94 - Step 4: Select toilet inside the room

The code now needs to use the element solid of toilet and explode to find the surface which attach to the wall element. However, instead of taking the point as vector, it will be a normal point on the surface, since the two elements will be connected not by spatial position, but by line direction between them. Consequently, a middle point in the surface was created to pass the line coming from the lavatory to detect the direction where the element stands.

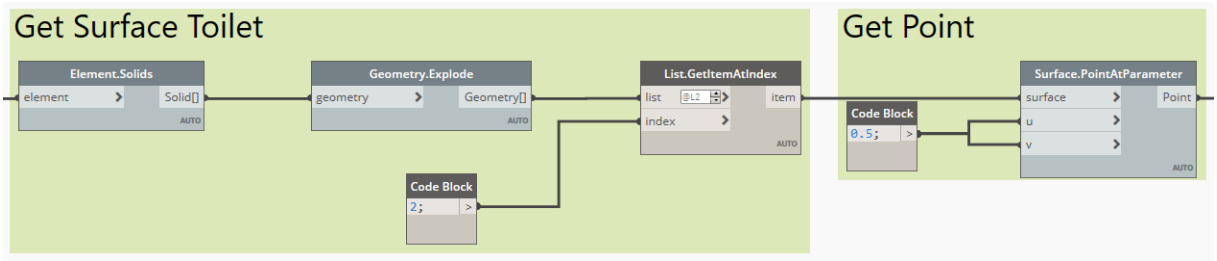


Figure 95 - Step 5: Select point on surface

The last step was to create a line by the two points on each element of the room. Consequently, the output will be a line in spatial relation with three coordinates (x, y and z), that will serve as direction which the line will take. The values will be different from the previous code, since exist more numerical values the 0 or 1. Subsequently, the typology parameter defines already the type of room, and the lavatory position the room position, then it need another information to detect the relation between the elements in the wall, so if the elements is on one direction it will be positive and if goes for other it might be negatives. So, instead of detecting the coordinates, the elements will identify if they are position on the right or left of the lavatory, since the wall are stablished, and the lavatory position already placed. The principle of coordinate play with the idea if the lavatory is on East and West the value of x defines and if it is position in North and South the value of y will detect. Later the information was exported as a shared parameter named “Toilet Position” with the added value of “R” (right) or “L” (left).

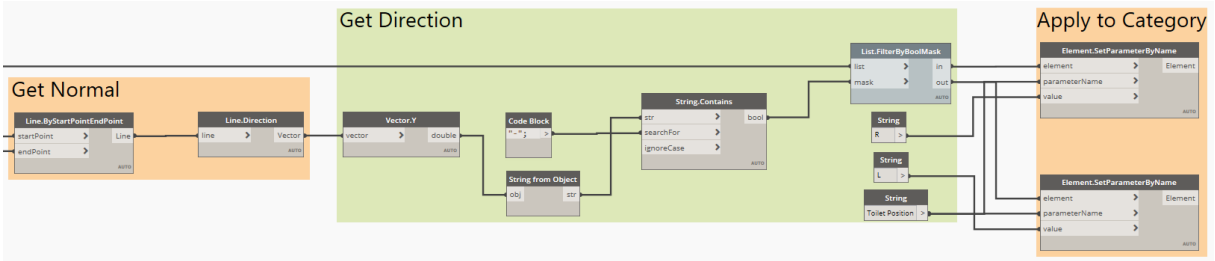


Figure 96 - Step 6: Applying the value to a shared parameter

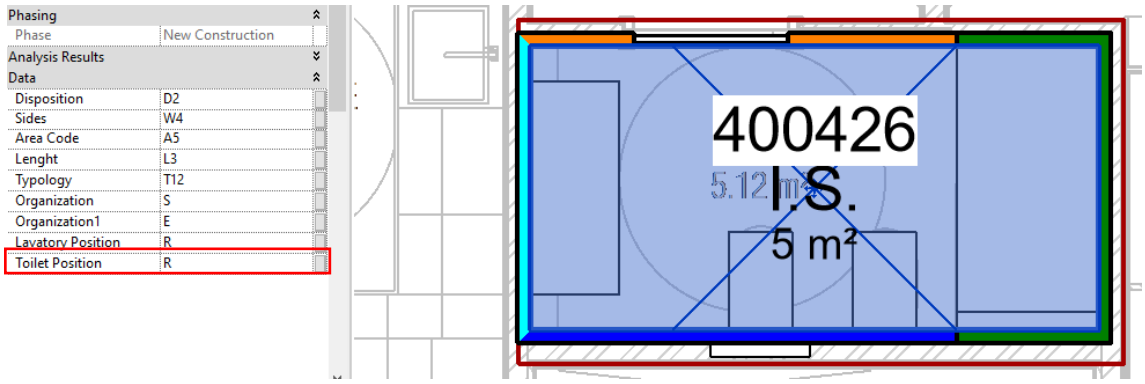


Figure 97 - Parameter applied to the room

4.3.4. Door type

The figure 98 shows the last parameter of the code to detect the sub-categories is the door type. This code will select all the wall that contain a different door type and creates a list of elements to split them in a new parameter. Since, the doors have a direct relation with the type of organization inside the model, such as sliding door can have a higher impact in surrounding elements since it run inside the wall, for this reason this parameter should be visible and be detectable in the sub-category.

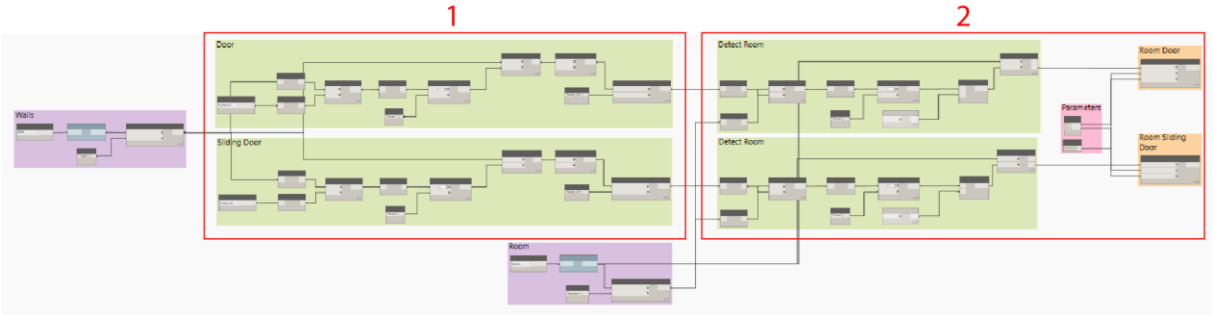


Figure 98 - Code overview with the steps

The code works by selecting all the wall types that contain doors and then detect the “Wall_ID” of each elements type. Using the list intersection, it´s possible to detect all the element in the bathroom. Then, by using the “Room_ID the element will provide a list of the walls and the room which they belong. This process is applied to both types of walls as the code progresses.

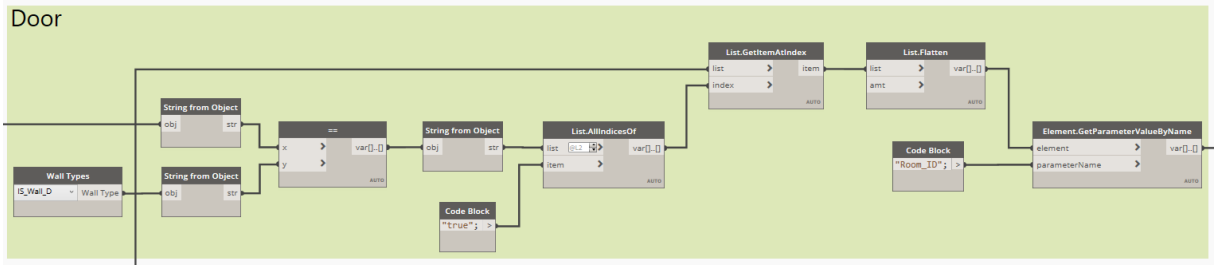


Figure 99 - Step 1: Detect the walls that contains doors

After selecting all the room that belong to the bathroom the code takes the parameter “Number” which contains the Element ID and creates a string with that information. Connecting both codes and create an intersection, the code will detect which walls belong to each room, since a string can’t be transferred directly to ID. However, since the code is made by the room list, the list of indexes that will be generated from this code will pick the elements in the list that contain that specific wall. The same process was applied to both wall types. The late part of the code was the process to export the information as output for a shared parameter named “Door Type” and give then a value as “S” (sliding door) or “D” (door) depending of the wall selected.

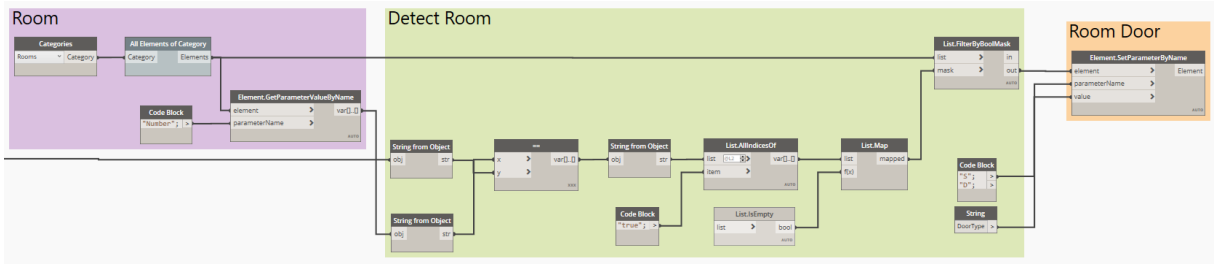


Figure 100 - Step 2: Detect the walls inside the room and export as a parameter

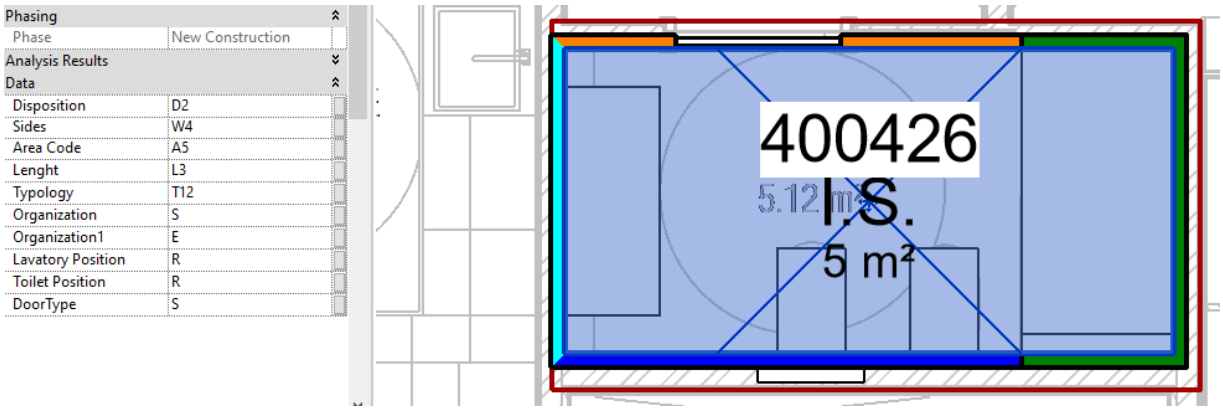


Figure 101 - Parameter applied to the room

4.3.5. Create sub-category

The next code combines the multiple parameters in a hierarchical approach with all the information that was gathered during the preview’s codes (Fig.102). The following parameters were used in the creation of the last one: “Lavatory Position”, “Toilet Position” and “Door Type”. This code follows the same ideology of the one shown in the chapter 4.2.5. Consequently, the following element need to be exported as a new parameter called “SubCategory”.

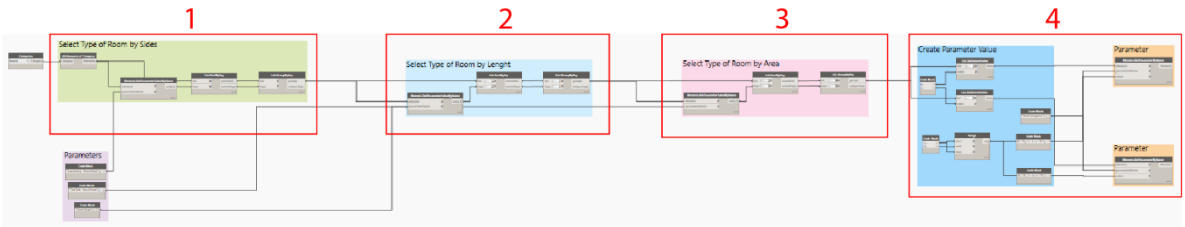


Figure 102 - Code overview with the steps

The code follows with the selection of all the elements that belong to the bathroom, and they will be split by the first parameter "Lavatory Position", since it's the first code that will detect how the spatial position of the bathroom will work, this code gives an output of three values, and then they need to be divided in sub-list divided by each value of the parameter.

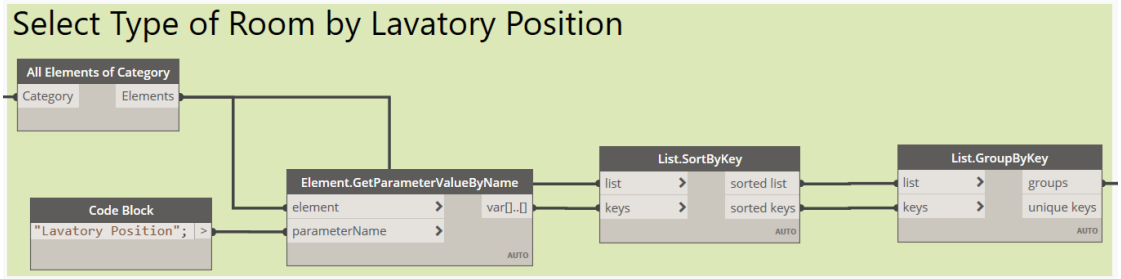


Figure 103 - Step 1: Select room by value Lavatory Position

The next step introduces the parameter "Toilet Position" which will divide the room is two more list, making a total of six sub-list. This allows to detect if in relative with the first parameter, the elements are inverted or not in relation with the bathroom. The last parameter, and final of the code was the introduction of the "Door Type" to divide the elements in two list in base of the value of the parameter, making a total of 12 different sub-list off elements.

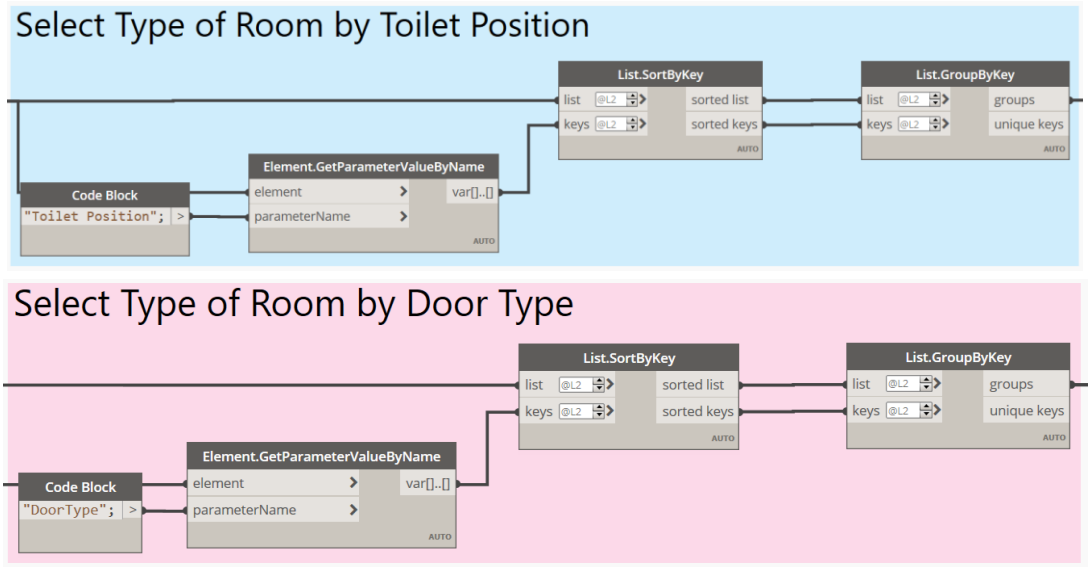


Figure 104 - Step 2 and 3: Select room by value Toilet Position and Door Type

Then the code needs to be split in halfway since by the list the code had the doors in odd number and sliding doors in pair number. By picking the elements in three level of the list, it was possible to divide them in multiple groups, to be later divided according to the door type. The value was created with the range to six numbers and applying and the end of the sequence the type of the door as value “S” or “D” in the new shared parameter “SubCategory”.

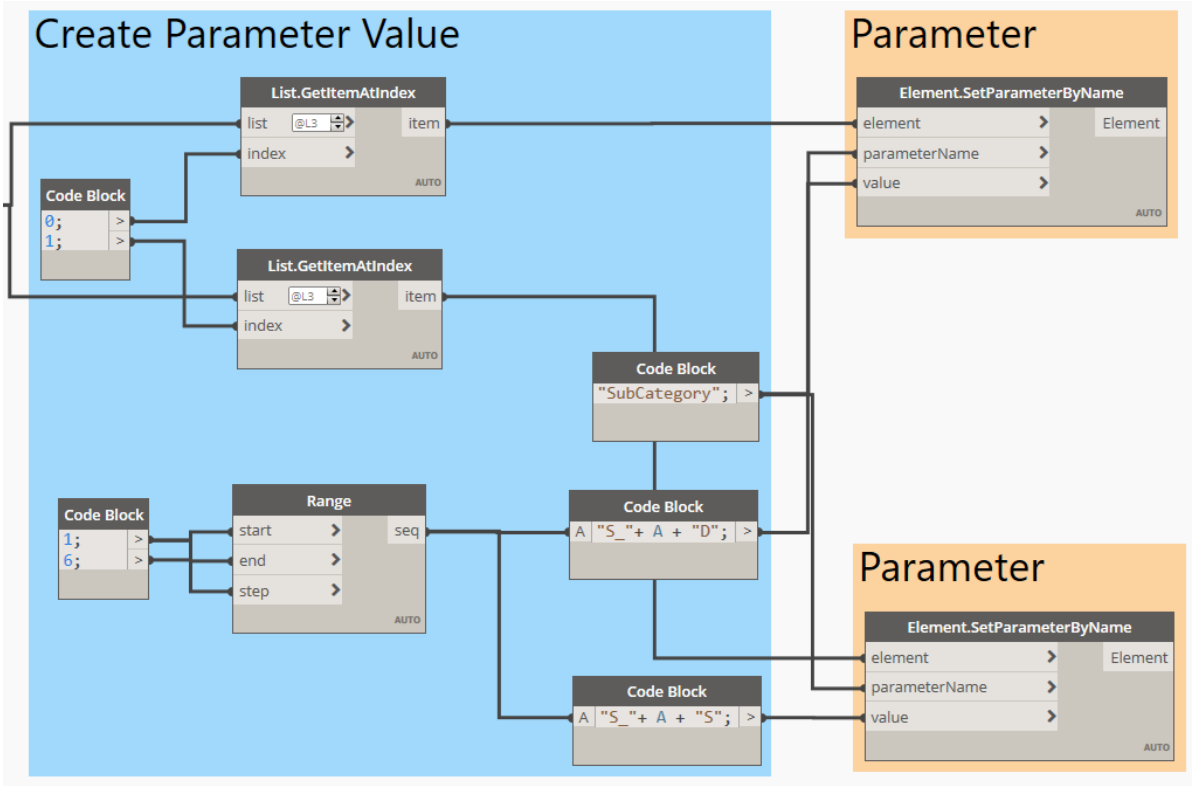


Figure 105 - Step 4: Apply parameter to the room

After getting all the list of rooms, the sub-categories might not contain all the information. However, the, since the room need to be firstly separated by typologies to work, making this new parameter further information to the rooms, to detect how it´s distributed without takins in consideration how the elements are physically position (Fig.106). The use of this information works in regards of the parameters created to help to make better design decision in further improvement of the process of DfMA.

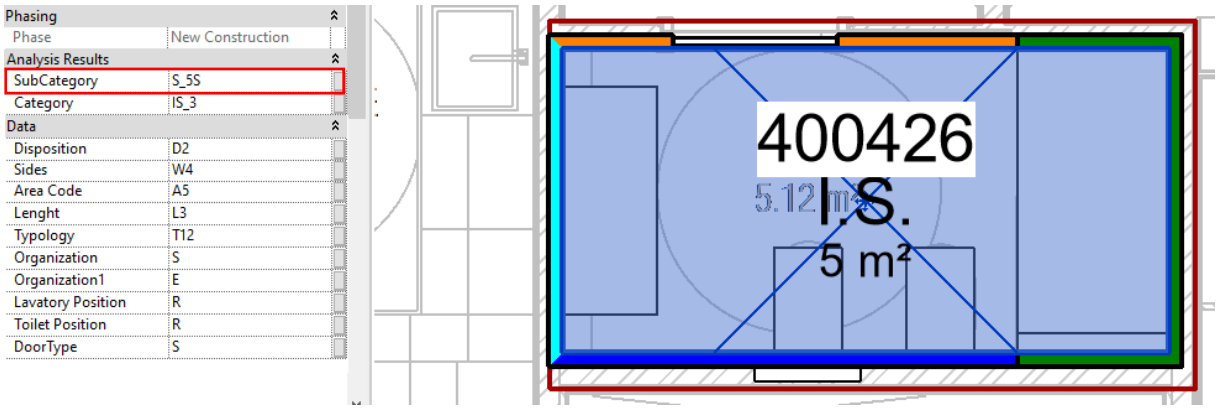


Figure 106 - Parameter applied to the room

4.4. Export information

This chapter will focus on elaborating the information exported and manipulating it to be readable, helping to make better decisions for DfMA. To export this information two schedules inside Revit were created, with the information necessary to understand all the project, one containing the wall schedule and other the room schedule. These schedules were exported with the main information that is relative to the parameter created through the dissertation that not only helped to identify typologies but serves as information to the graphical part.

Table 3 - Schedule of the parameters applied to each room and wall

<Room Schedule>

A	B	C	D	E	F	G	H
Category	SubCategory	Number	Area	Room Lenght	Perimeter	Name	Level
IS_1	S_3S	400414	5 m²	3	9.74	I.S.	Level 0
IS_1	S_1S	400418	6 m²	3	9.70	I.S.	Level 0
IS_1	S_5D	400445	5 m²	3	9.80	I.S.	Level 0
IS_1	S_6D	400461	6 m²	3	10.01	I.S.	Level 0
IS_1	S_6D	400463	6 m²	3	10.00	I.S.	Level 0
IS_1	S_2S	400482	5 m²	3	9.70	I.S.	Level 0
IS_1	S_3S	400577	5 m²	3	9.74	I.S.	Level 1
IS_1	S_1S	400588	6 m²	3	10.00	I.S.	Level 1
IS_1	S_1S	400594	6 m²	3	10.40	I.S.	Level 1

<Wall Schedule>

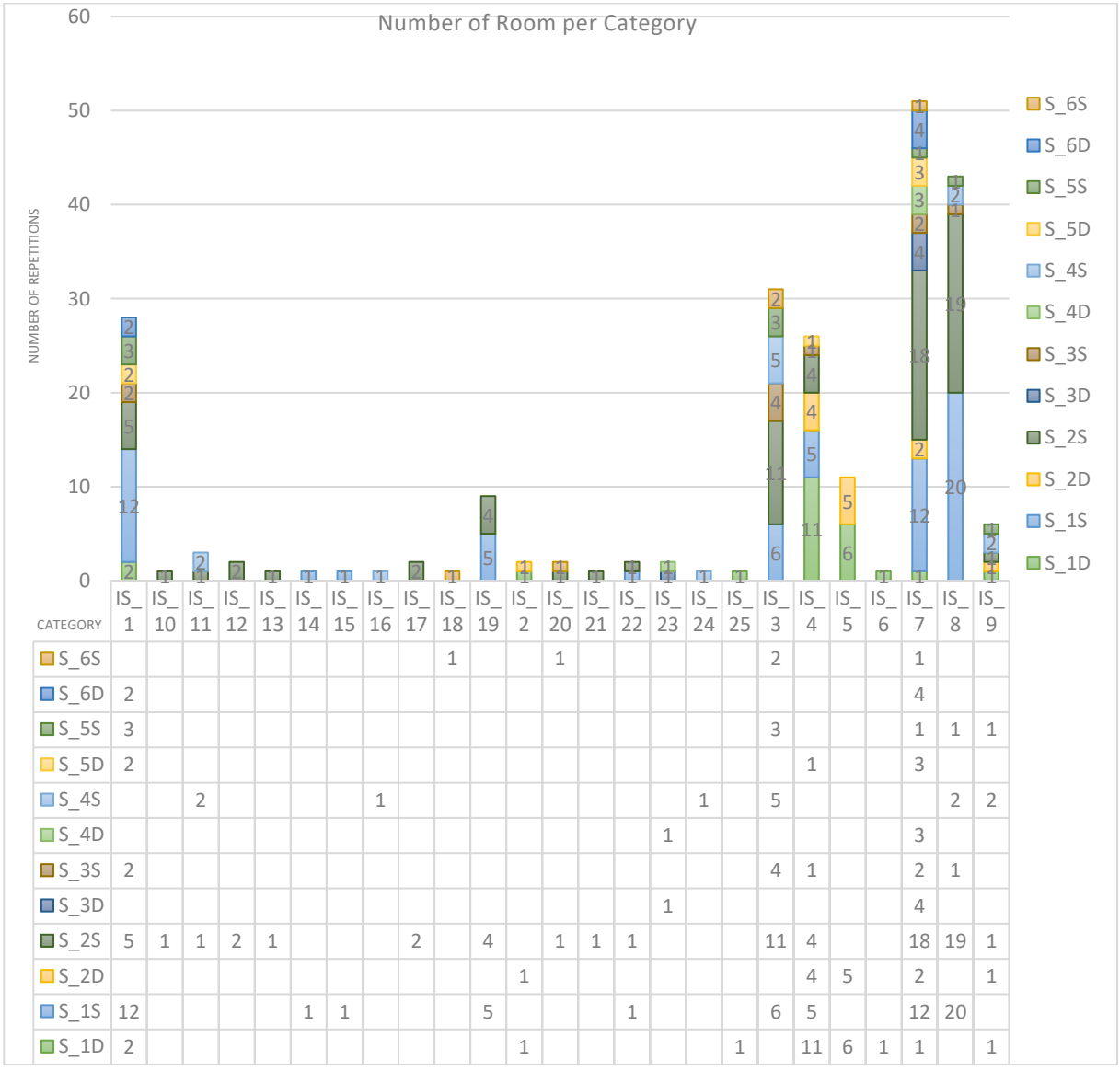
A	B	C	D	E	F	G
Room_ID	Type	Length	Base Constraint	Width	Item	TypeID
400431	IS_Wall_SD	1.49	Level 0	0.07	Sliding Door	327821
400435	IS_Wall_D	1.41	Level 0	0.07	Door	327837
400436	IS_Wall_SD	1.74	Level 0	0.07	Sliding Door	327841
400445	IS_Wall_D	1.77	Level 0	0.07	Door	327887
400446	IS_Wall_D	1.67	Level 0	0.07	Door	327892
400448	IS_Wall_SD	1.59	Level 0	0.07	Sliding Door	327896
400447	IS_Wall_SD	2.54	Level 0	0.07	Sliding Door	327900
400453	IS_Wall_SD	3.34	Level 0	0.07	Sliding Door	327908
400449	IS_Wall_SD	1.59	Level 0	0.07	Sliding Door	327912

Schedules that were created on Revit will be exported as ".txt" to be later add to the Excel (Table 3). The tool used to elaborate and work with the desirable information was Power Query, since allows to import the information as data. All the parameters and chosen to allow to have further information inside the data and at the same time create comparison between the multiple results achieved. One point which was crucial in the connection of both schedules was the parameter "Number" in the room schedule and the "Room_ID" in the wall schedule. This parameter contains the same value, which makes the elements on the wall list to be inside the wall schedule, this process opens new exploration of the data that was added. Power Pivot worked the information inside the model and create multiple sources of information generation by transforming the values in number and names.

The power of using Excel, beside the work with the Power Query and PowerPivot, consist of the availability of the software in-house. Since, it is part of a must have package inside any company the use of this as part of the process makes it the more reliable solution. With the combination of information and graphic power it was possible to extract a complete list of elements and information (added as appendix) and dynamic tables as shows in the next figures.

The table 4 show the number of rooms that exist in each category. This graph represents the number of rooms divided by their subcategories, created by the codes to detect the different variation between all of them. With the use of this schedule, it´s possible to detect the bathrooms that can be standardized, and mass produced, since there is a lot of repetition on the number of subcategories in that category. The following categories stand out to be the more successful for DfMA: IS_1, IS_19, IS_3, IS_4, IS_5, IS_7 and IS_8. Consequently, this will be the rooms that will be focused in the optimization for DfMA.

Table 4 - Number Rooms in the same category

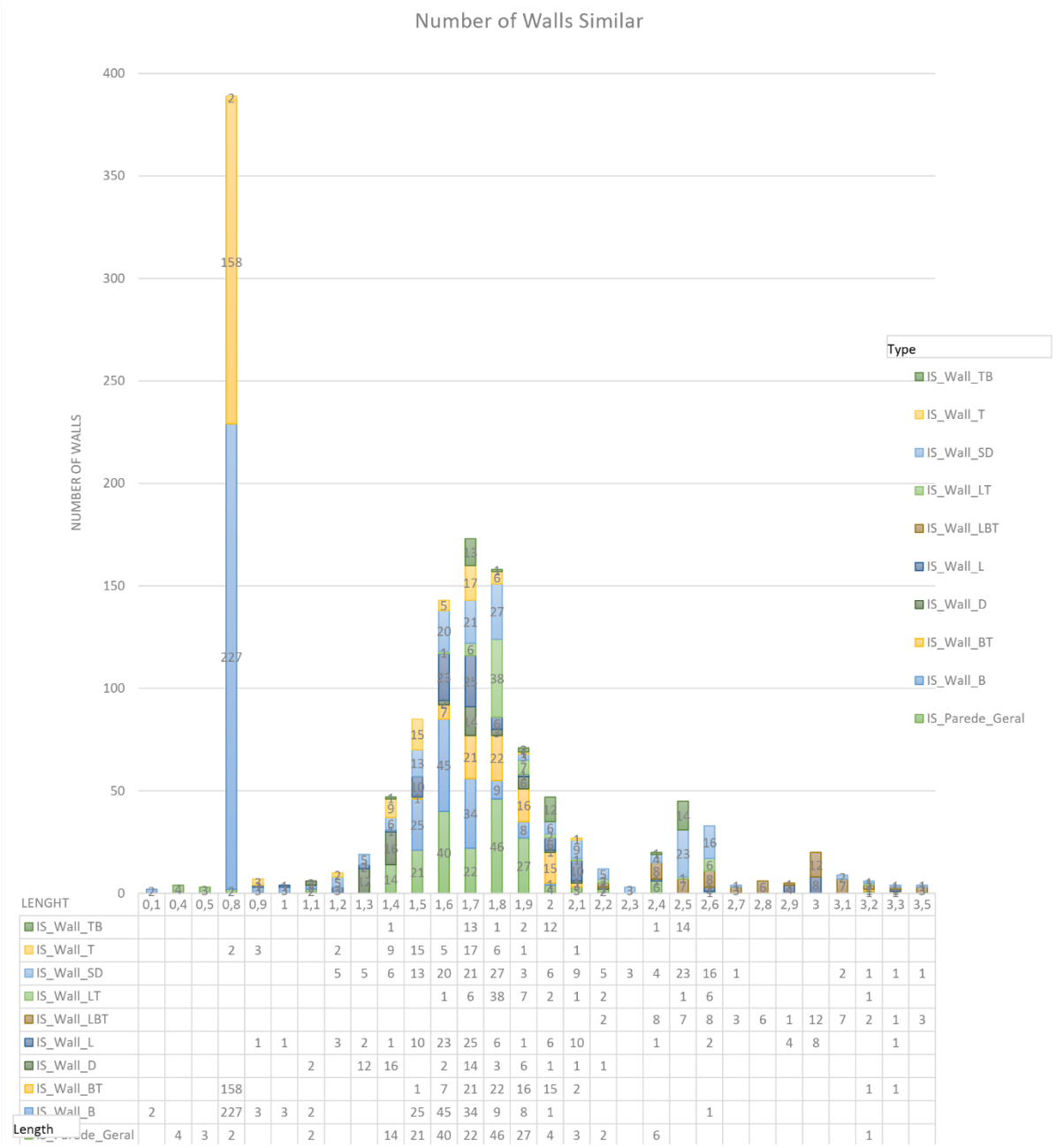


CATEGORY	IS_1	IS_10	IS_11	IS_12	IS_13	IS_14	IS_15	IS_16	IS_17	IS_18	IS_19	IS_2	IS_20	IS_21	IS_22	IS_23	IS_24	IS_25	IS_3	IS_4	IS_5	IS_6	IS_7	IS_8	IS_9
S_6S										1			1						2				1		
S_6D	2																						4		
S_5S	3																		3				1	1	1
S_5D	2																			1			3		
S_4S			2					1									1		5					2	2
S_4D																1							3		
S_3S	2																		4	1			2	1	
S_3D																1							4		
S_2S	5	1	1	2	1				2		4		1	1	1				11	4			18	19	1
S_2D												1								4	5		2		1
S_1S	12					1	1				5				1				6	5			12	20	
S_1D	2											1						1		11	6	1	1		1

The table 5 shows the walls with the biggest repetition in relation with the length. This connection was created by the amount of wall types that contain each room, and cross with the length of the various compartments to be later mass produced the ones with more repetition. These walls can be assembled in factory and even if they don´t belong to a category they can still be mass produced to go to the site. The following walls can be mass produced due to their amount of repetitions independently of their multiple lengths: Walls that belong to bathtub and shower (IS_Wall_BT and IS_Wall_B), as analysed before can be multiplied in every single room making them a great fit in DfMA; Then there are a lot of

"IS_Parade_Geral (Generic wall) with the same dimension that can be mass produced; Some Sliding door walls and door (IS_Wall_SD and IS_Wall_D) also fit the criteria; Finally all the other bathrooms that contain the wall based components encompass some fewer duplications, but mostly there are elements that can be mass produced in factory using by the following result.

Table 5 - Number of walls similar



LENGHT	0,1	0,4	0,5	0,8	0,9	1	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2	2,1	2,2	2,3	2,4	2,5	2,6	2,7	2,8	2,9	3	3,1	3,2	3,3	3,5
IS_Wall_TB										1			13	1	2	12				1	14									
IS_Wall_T				2	3			2		9	15	5	17	6	1		1													
IS_Wall_SD								5	5	6	13	20	21	27	3	6	9	5	3	4	23	16	1				2	1	1	1
IS_Wall_LT												1	6	38	7	2	1	2			1	6						1		
IS_Wall_LBT																		2		8	7	8	3	6	1	12	7	2	1	3
IS_Wall_L					1	1		3	2	1	10	23	25	6	1	6	10			1		2			4	8			1	
IS_Wall_D							2		12	16		2	14	3	6	1	1	1												
IS_Wall_BT				158							1	7	21	22	16	15	2											1	1	
IS_Wall_B	2			227	3	3	2				25	45	34	9	8	1						1								
IS_Parede_Geral		4	3	2			2			14	21	40	22	46	27	4	3	2		6								1		

The table 6 shows average the walls in each category. This process serves to help the rooms that belong to the categories to detect the average wall size in a way to mass produced the entire room. The following ones were selected as the room that could be standardized and mass produced: IS_1, IS_19, IS_3, IS_4, IS_5, IS_7 and IS_8. The flowing list shows the rooms selected above, and what is the average wall length for each type of wall inside it. This process allows to a room to be adjust in the BIM model software the specific category to fit in all the similar compartments.

Table 6 - Average length of the walls in each category

TYPE	IS_Parede_General	IS_Wall_B	IS_Wall_BT	IS_Wall_D	IS_Wall_L	IS_Wall_LBT	IS_Wall_LT	IS_Wall_SD	IS_Wall_T	IS_Wall_TB
IS_9	1,65			1,90			1,87	1,50		
IS_8	1,80	1,07	1,08		1,59			1,68	1,58	
IS_7	1,67	1,10	1,23	1,69			1,90	1,94		
IS_6	1,80		1,07	1,30	2,90				1,70	
IS_5	1,79	1,06	1,10	1,38	2,97					1,70
IS_4	1,67	1,11	1,13	1,34		2,95		1,25		
IS_3	0,65	1,07	1,15		1,90			2,32		2,21
IS_25	2,10			2,00	2,00				2,10	
IS_24	2,00				1,60			2,00	1,60	
IS_23	0,40		1,13	2,15	2,10					1,70
IS_22	2,20				1,20			2,20	1,20	
IS_21	1,75						2,10	1,40		
IS_20	1,85	0,93			0,95			1,90	0,80	
IS_2	1,20	1,03		1,10			2,20			
IS_19	1,40				1,76			1,76	1,40	
IS_18	1,60						1,70	1,50		
IS_17	1,70		1,10			3,10		3,10		
IS_16	3,20		1,23			3,20		2,10		
IS_15		1,17			3,30			3,30	1,90	
IS_14	1,90	1,17					3,20	3,20		
IS_13	2,10		1,23			2,60		2,60		
IS_12	1,70		1,20			3,50		1,50		
IS_11	1,43	1,18					1,93	1,43		
IS_10	1,50				1,80			1,80	1,50	
IS_1	1,97	1,13	1,24	1,87		2,57		2,49		

All the information provided and analysed in this chapter was developed and generated with the use of the parameter created through the course of this dissertation. This data was adjusted in Excel to serve as design decision for manufacturing and optimization. The advantages and combinations of the parameter are limited to the amount, but if the data that comes from this source was manipulated to helps in making better design decision, since it will improve the model for DfMA. This process was one case study used to achieve the desirable result, there are more opportunities in this ideology of exporting data, that can be analysed in the future.

The data of the model can also be transferred as detail drawing with all the information that was shown in previous chapter. This concept allows to export the information to be used directly in the fabrication and assembly of the elements, providing documentation to assemble each partition wall. The process works by selecting all the room and exports as drawing with elevation and plan. However, the

optimization of this process happens by developing fewer different elements in factory and more repetition of wall. The result will be new information added to the model such as the profiles position and the panelling for each type of wall.

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5. CONCLUSIONS

In conclusion of this dissertation, DfMA as a lot of potential when developed in BIM. During the study all the information analysed was important to have a broad knowledge of the state of the art of both topics, and how they can intersect and collaborate to achieve a more efficient, economical, and sustainable design and construction process. The change to off-site construction and to DfMA improves and makes it more accessible the transition for a modular and prefabricated construction systems. Therefore, the focus on the understanding of the process with an experienced construction company, provide in-bounds how the process is conjugate with the technicians.

The process developed in-house was already suitable and proofed, when connected with BIM the solution resembles what was achieved. The amount of experience provided by the construction company allowed to have an insight how to detect and group all the typologies, making the information more helpful, since it optimizes not only the rooms that belong to the bathroom, but to all the compartments that fits inside the building. The digitalization of the process is more demanding when the partition walls contain infrastructural elements that elevates the level of information inside it, making bathrooms a better fit to test the solution. However, kitchen can be considered as a group of walls that contains some installations but, in all the case it´s still consider a broader space and besides the demand of structural elements in regards the modularity of their cabinets doesn't contain the direct relation of infrastructure that bathrooms contain. This compartment, usually surrounded by walls, makes it harder not only to work inside but to install the sanitary, being a better fit for DfMA.

The codes created to the digitalization of DfMA were often inaccurate due to limitation and lack of solution that could solve the problems, so as lack of programming skill, being one of these examples is the walls generation. This process of creating walls using Dynamo creates a concurrence of events in relation with BIM since the wall elements need to be generated using a line as base reference. The ideal process was to select the wall that intersect that room and convert it to a partition wall, by simply changing the type of wall. The code generated could be improved in a way that doesn't create problems, but due to the walls being split, it wasn´t possible to do that. Consequently, the problem of not allowing the software to splited wall, is a bit step back in DfMA, since one of the criteria is being able to transport the wall to the site, if the software can´t detect where the wall need to split, how can an element be split to be carried to the construction, without compromising the overall process. This process is something that should be available since the current methods is done by using wall to break another wall.

Another functionality to be computationally implemented was the definition of typologies by points of location. For this code multiple solutions were created until a final proposal was achieved. One of the reason this code had a problem due to the points that are connected in an intersection chain, touching multiple elements in continuality, making the points that are touched a unique group, even when the extremes are further from each other. Acknowledging that, different solutions were experimented to face this issue, by finding central point or divide them by cores. However, none of the solution tested was near the use of the parameter "Room Disposition" as the solution which divide the points chain in new groups, allowing the elements to be divided in multiple typologies.

The final block, a type of bathroom of each typology that can be replicated multiple times was not solved, as multiple problems were found in the process. The final block should be the fittest type of bathroom, but since inside each typology there are a lot of small variations makes this process a bit complex. Consequently, the room to fit in the criteria, needs to be equal or approximate to most common dimension, that will be gathered and analysed in groups with all the information in regards off the room.

The idea of developing a final block is the desirable goal for DfMA, as the more repetitions there are, the more optimized and standardized the process will be. However, find this value come with certain boundaries, the first problem faced was Revit and Dynamo constrains. Revit wall types are an element that can't be moved beside the interface of the software. To create different walls the process, need to pass from a component where the elements will be developed using the boundary line to be later transposed to wall. As shown previously in the chapter 4.1.1 where from the room boundary the walls were created.

The walls in this code were developed with the use of the node of room boundary and then the wall attach to the line to be later replicate the wall as DfMA. Consequently, the process to create a single-family type pass from the idea of taking the element in this code and detect in the list of elements, the line that can be expandable or retractable to fit in these criteria. This implementation faces some difficulties such as detecting the lines that need to be fit in the criteria. Since all the rooms have different positions and some walls are closed between each other, the software do not detect this kind of information.

Project Refinery is an extension of Dynamo that allow to optimize design solutions with the use of information to find the fittest result for a given goal. However, this extension comes with the problem stated before, the information that need to be fitted need to be added in the software before even making the calculation. The fact that the rooms are line that are already implemented in the model, and there isn´t any value which can be manipulated to provide a better solution such as point location, makes it a setback. Since, the representation of the walls are lining that don´t have enough information of the point limit to move and to fit in the room. The last part of the problem is the fact that to move a wall, it needs to be modelled again, since the software can´t move an element using Dynamo everything that was done before need to be done again to detect if the result was the desirable, leading to concurrency of process.

Without further developments in this research on this topic and no following solution found for the problem stated above, the better answer was by making manual adjustments in the model and use the data created to be a guideline in the decision making. With the resource of other BIM software and tools it is possible to detect the fittest result of a compartment working in collaboration with the stakeholder, without forcing changes that could affect the state of the building. The use of clash detection as a source to detect when a room is more suitable or not, or if doesn't collide with other elements, optimizes all the typologies in comparison of using Project Refinery. Consequently, it was important how the information gathered in the project could be helpful in making decisions, hence the solution found in this investigation.

The investigation delegated bridges the gap in digitalization of the process of DfMA to Architecture, Engineering, Construction and Operation (AECO) industry, since the goal was to optimize the methodology and digitalized more the workflow, improving collaborating with the use of information. The steps developed during this dissertation were the beginning of the process, where only information is manipulated, further developments come with the transition to a model-based process, where the partition wall will be transformed in families with more information. These families will contain profiles disposition, the elements places, the fixtures, and panelling mapping.

The walls as an assemble components with information and model objects, can be exported as detail drawings to be produced in factory and be transported to the site. However, the next stage for this process, is a collaboration between BIM and automatic robotic manufacturing or BIM and CNC. The advantages the automatization for manufacturing and assemble is the mass production of custom solution. CNC process allows the information to be exported from the model to be able to collaborate with machinery but leaving the assemble stage to human intersection. Additionally, this process is more likely to be adopted as the cutting of the panelling and the profiles can be done automatically by adding the information relatable in the machine to cut the elements in series.

As the AECO industry is always evolving, this work results are a little step in DfMA implementation with BIM and also a contribution to pave the way to structure information management for the shift to prefabricated construction. Therefore, the research developed will provide assets to bridge the gap for Industry 4.0 and create a process which can still be customisable but optimized to be more efficient and more resourceful.

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LIST OF ACRONYMS AND ABBREVIATIONS

AECO	Architecture, Engineering, Construction and Operation
API	Application Programming Interface
BIM	Building Information Modelling
CAD	Computer-Aided Design
CNC	Computer numerical control
DfMA	Design for Manufacturing and Assembly
ID	Identity
IFC	Industry Foundation Classes
IS	Instalação Sanitária – WC in portugueses
LOD	Level of Development
OFC	Off-site Construction
OSM	Off-site Manufacturing
QR	Quick Response
WC	Water Closet

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APPENDIX

APPENDIX 1: TABLE WITH ROOM SCHEDULE WITH CATEGORY AND SUBCATEGORY EMBEDDED

Category	SubCategory	Number	Area	Room Lenght	Perimeter	Name	Level
IS_1	S_3S	400414	5 m²	3	9.74	I.S.	Level 0
IS_1	S_1S	400418	6 m²	3	9.70	I.S.	Level 0
IS_1	S_5D	400445	5 m²	3	9.80	I.S.	Level 0
IS_1	S_6D	400461	6 m²	3	10.01	I.S.	Level 0
IS_1	S_6D	400463	6 m²	3	10.00	I.S.	Level 0
IS_1	S_2S	400482	5 m²	3	9.70	I.S.	Level 0
IS_1	S_3S	400577	5 m²	3	9.74	I.S.	Level 1
IS_1	S_1S	400588	6 m²	3	10.00	I.S.	Level 1
IS_1	S_1S	400594	6 m²	3	10.40	I.S.	Level 1
IS_1	S_1S	400597	6 m²	3	10.00	I.S.	Level 1
IS_1	S_1S	400603	6 m²	3	10.40	I.S.	Level 1
IS_1	S_5D	400606	6 m²	3	10.01	I.S.	Level 1
IS_1	S_1S	400618	6 m²	3	10.38	I.S.	Level 1
IS_1	S_1S	400633	5 m²	3	9.63	I.S.	Level 1
IS_1	S_1S	400649	6 m²	3	10.38	I.S.	Level 1
IS_1	S_1D	400662	5 m²	3	9.70	I.S.	Level 1
IS_1	S_1D	400664	6 m²	3	10.00	I.S.	Level 1
IS_1	S_1S	400672	6 m²	3	10.38	I.S.	Level 1
IS_1	S_2S	400681	5 m²	3	9.70	I.S.	Level 1
IS_1	S_1S	400803	6 m²	4	10.56	I.S.	Level 2
IS_1	S_5S	400811	6 m²	3	10.10	I.S.	Level 2
IS_1	S_2S	400821	6 m²	3	10.10	I.S.	Level 2
IS_1	S_2S	400827	5 m²	3	9.66	I.S.	Level 2
IS_1	S_2S	400828	6 m²	3	10.07	I.S.	Level 2
IS_1	S_5S	400833	6 m²	3	9.98	I.S.	Level 2
IS_1	S_1S	400839	6 m²	3	10.40	I.S.	Level 2
IS_1	S_5S	400842	6 m²	3	10.00	I.S.	Level 2
IS_1	S_1S	400848	6 m²	3	10.40	I.S.	Level 2
IS_2	S_2D	400423	5 m²	3	9.76	I.S.	Level 0
IS_2	S_1D	400639	5 m²	3	9.76	I.S.	Level 1
IS_3	S_1S	400420	5 m²	3	9.54	I.S.	Level 0
IS_3	S_5S	400426	5 m²	3	9.61	I.S.	Level 0
IS_3	S_6S	400438	5 m²	3	9.60	I.S.	Level 0
IS_3	S_4S	400441	5 m²	3	9.80	I.S.	Level 0
IS_3	S_2S	400442	6 m²	3	9.60	I.S.	Level 0
IS_3	S_3S	400447	5 m²	3	9.80	I.S.	Level 0
IS_3	S_4S	400456	5 m²	3	9.80	I.S.	Level 0
IS_3	S_2S	400457	6 m²	3	9.60	I.S.	Level 0
IS_3	S_2S	400466	6 m²	3	9.60	I.S.	Level 0

IS_3	S_4S	400467	5 m²	3	9.80	I.S.	Level 0
IS_3	S_5S	400476	5 m²	3	9.80	I.S.	Level 0
IS_3	S_3S	400485	5 m²	3	9.60	I.S.	Level 0
IS_3	S_3S	400585	5 m²	3	9.76	I.S.	Level 1
IS_3	S_2S	400586	5 m²	3	9.40	I.S.	Level 1
IS_3	S_1S	400608	6 m²	3	9.60	I.S.	Level 1
IS_3	S_2S	400612	5 m²	3	9.40	I.S.	Level 1
IS_3	S_4S	400614	5 m²	3	9.80	I.S.	Level 1
IS_3	S_4S	400622	5 m²	3	9.80	I.S.	Level 1
IS_3	S_1S	400628	6 m²	3	9.94	I.S.	Level 1
IS_3	S_2S	400629	5 m²	3	9.30	I.S.	Level 1
IS_3	S_1S	400636	5 m²	3	9.54	I.S.	Level 1
IS_3	S_2S	400653	5 m²	3	9.60	I.S.	Level 1
IS_3	S_2S	400656	5 m²	3	9.80	I.S.	Level 1
IS_3	S_2S	400658	5 m²	3	9.30	I.S.	Level 1
IS_3	S_1S	400659	6 m²	3	9.60	I.S.	Level 1
IS_3	S_1S	400667	6 m²	3	9.60	I.S.	Level 1
IS_3	S_2S	400676	5 m²	3	9.80	I.S.	Level 1
IS_3	S_6S	400678	6 m²	3	10.22	I.S.	Level 1
IS_3	S_5S	400684	5 m²	3	9.60	I.S.	Level 1
IS_3	S_3S	400813	5 m²	3	9.80	I.S.	Level 2
IS_3	S_2S	400820	6 m²	3	10.30	I.S.	Level 2
IS_4	S_2D	400421	6 m²	3	10.67	I.S.	Level 0
IS_4	S_2S	400429	6 m²	3	10.90	I.S.	Level 0
IS_4	S_2S	400430	6 m²	3	10.44	I.S.	Level 0
IS_4	S_2D	400434	6 m²	3	10.56	I.S.	Level 0
IS_4	S_1D	400443	6 m²	3	10.70	I.S.	Level 0
IS_4	S_2D	400451	6 m²	3	10.56	I.S.	Level 0
IS_4	S_2S	400455	6 m²	3	10.56	I.S.	Level 0
IS_4	S_1D	400459	6 m²	3	10.86	I.S.	Level 0
IS_4	S_1D	400464	6 m²	3	10.86	I.S.	Level 0
IS_4	S_1S	400468	6 m²	3	10.60	I.S.	Level 0
IS_4	S_1D	400600	6 m²	3	10.80	I.S.	Level 1
IS_4	S_1D	400609	6 m²	3	10.86	I.S.	Level 1
IS_4	S_1S	400615	6 m²	3	10.44	I.S.	Level 1
IS_4	S_1D	400617	6 m²	3	10.56	I.S.	Level 1
IS_4	S_1D	400637	6 m²	3	10.67	I.S.	Level 1
IS_4	S_2S	400644	6 m²	3	10.74	I.S.	Level 1
IS_4	S_1S	400645	6 m²	3	10.44	I.S.	Level 1
IS_4	S_1D	400648	6 m²	3	10.56	I.S.	Level 1
IS_4	S_1D	400660	6 m²	3	10.70	I.S.	Level 1
IS_4	S_5D	400665	6 m²	3	10.86	I.S.	Level 1
IS_4	S_1S	400668	6 m²	3	10.60	I.S.	Level 1
IS_4	S_1D	400671	6 m²	3	10.56	I.S.	Level 1
IS_4	S_1S	400808	6 m²	3	10.56	I.S.	Level 2
IS_4	S_3S	400825	6 m²	3	10.66	I.S.	Level 2
IS_4	S_1D	400845	6 m²	3	10.63	I.S.	Level 2
IS_4	S_2D	588806	6 m²	3	10.56	I.S.	Level 0
IS_5	S_1D	400415	6 m²	3	10.84	I.S.	Level 0
IS_5	S_2D	400435	6 m²	3	10.77	I.S.	Level 0
IS_5	S_2D	400473	6 m²	3	10.62	I.S.	Level 0

IS_5	S_1D	400488	6 m²	3	10.80	I.S.	Level 0
IS_5	S_1D	400591	6 m²	3	10.62	I.S.	Level 1
IS_5	S_1D	400619	6 m²	3	10.77	I.S.	Level 1
IS_5	S_1D	400630	6 m²	3	10.84	I.S.	Level 1
IS_5	S_2D	400650	6 m²	3	10.77	I.S.	Level 1
IS_5	S_2D	400679	6 m²	3	10.80	I.S.	Level 1
IS_5	S_1D	400687	6 m²	3	10.80	I.S.	Level 1
IS_5	S_2D	400836	6 m²	3	10.60	I.S.	Level 2
IS_6	S_1D	400673	6 m²	3	10.62	I.S.	Level 1
IS_7	S_3S	400416	4 m²	3	8.36	I.S.	Level 0
IS_7	S_1S	400422	5 m²	3	8.80	I.S.	Level 0
IS_7	S_1S	400432	4 m²	3	8.14	I.S.	Level 0
IS_7	S_6D	400439	4 m²	3	8.40	I.S.	Level 0
IS_7	S_2S	400440	4 m²	2	7.77	I.S.	Level 0
IS_7	S_2S	400444	4 m²	3	7.82	I.S.	Level 0
IS_7	S_4D	400446	4 m²	3	8.40	I.S.	Level 0
IS_7	S_2S	400450	4 m²	3	8.29	I.S.	Level 0
IS_7	S_2S	400458	4 m²	3	7.88	I.S.	Level 0
IS_7	S_1S	400460	4 m²	3	7.82	I.S.	Level 0
IS_7	S_1S	400462	4 m²	3	7.82	I.S.	Level 0
IS_7	S_2S	400465	4 m²	3	7.88	I.S.	Level 0
IS_7	S_1S	400470	4 m²	3	8.40	I.S.	Level 0
IS_7	S_6D	400477	4 m²	3	8.40	I.S.	Level 0
IS_7	S_2S	400481	4 m²	3	8.27	I.S.	Level 0
IS_7	S_4D	400483	4 m²	3	8.40	I.S.	Level 0
IS_7	S_6D	400484	4 m²	3	8.40	I.S.	Level 0
IS_7	S_1S	400579	4 m²	3	8.20	I.S.	Level 1
IS_7	S_1S	400581	4 m²	3	8.02	I.S.	Level 1
IS_7	S_1S	400583	4 m²	3	7.97	I.S.	Level 1
IS_7	S_1S	400592	4 m²	3	8.02	I.S.	Level 1
IS_7	S_3D	400595	4 m²	3	8.40	I.S.	Level 1
IS_7	S_5D	400596	4 m²	3	8.40	I.S.	Level 1
IS_7	S_1S	400601	4 m²	3	8.02	I.S.	Level 1
IS_7	S_2S	400604	4 m²	3	8.29	I.S.	Level 1
IS_7	S_2S	400605	4 m²	3	7.82	I.S.	Level 1
IS_7	S_2S	400607	4 m²	3	7.92	I.S.	Level 1
IS_7	S_2S	400610	4 m²	3	8.02	I.S.	Level 1
IS_7	S_3D	400623	4 m²	3	8.40	I.S.	Level 1
IS_7	S_2S	400624	4 m²	3	8.02	I.S.	Level 1
IS_7	S_2S	400627	4 m²	3	8.00	I.S.	Level 1
IS_7	S_3S	400631	4 m²	3	8.36	I.S.	Level 1
IS_7	S_2S	400638	5 m²	3	8.80	I.S.	Level 1
IS_7	S_1S	400647	4 m²	3	8.14	I.S.	Level 1
IS_7	S_5D	400654	4 m²	3	8.40	I.S.	Level 1
IS_7	S_6S	400655	4 m²	2	7.77	I.S.	Level 1
IS_7	S_2S	400661	4 m²	3	7.82	I.S.	Level 1
IS_7	S_5S	400663	4 m²	3	7.82	I.S.	Level 1
IS_7	S_2S	400666	4 m²	3	7.88	I.S.	Level 1
IS_7	S_1S	400670	4 m²	3	8.40	I.S.	Level 1
IS_7	S_6D	400677	4 m²	3	8.40	I.S.	Level 1
IS_7	S_2S	400680	4 m²	3	8.27	I.S.	Level 1

IS_7	S_2D	400682	4 m²	3	8.40	I.S.	Level 1
IS_7	S_4D	400683	4 m²	3	8.40	I.S.	Level 1
IS_7	S_5D	400815	5 m²	3	9.00	I.S.	Level 2
IS_7	S_3D	400817	4 m²	3	8.37	I.S.	Level 2
IS_7	S_2D	400832	4 m²	3	8.44	I.S.	Level 2
IS_7	S_2S	400837	4 m²	3	8.02	I.S.	Level 2
IS_7	S_1D	400840	4 m²	3	8.30	I.S.	Level 2
IS_7	S_3D	400841	4 m²	3	8.27	I.S.	Level 2
IS_7	S_2S	400846	4 m²	3	8.02	I.S.	Level 2
IS_8	S_2S	400427	3 m²	3	7.70	I.S.	Level 0
IS_8	S_2S	400428	4 m²	2	7.80	I.S.	Level 0
IS_8	S_2S	400431	4 m²	2	7.70	I.S.	Level 0
IS_8	S_1S	400436	4 m²	3	7.80	I.S.	Level 0
IS_8	S_2S	400437	4 m²	2	7.80	I.S.	Level 0
IS_8	S_2S	400448	4 m²	2	7.90	I.S.	Level 0
IS_8	S_1S	400449	4 m²	2	7.72	I.S.	Level 0
IS_8	S_2S	400454	4 m²	2	7.70	I.S.	Level 0
IS_8	S_1S	400469	4 m²	2	7.70	I.S.	Level 0
IS_8	S_1S	400474	3 m²	2	7.60	I.S.	Level 0
IS_8	S_2S	400475	4 m²	2	7.90	I.S.	Level 0
IS_8	S_1S	400480	4 m²	3	7.98	I.S.	Level 0
IS_8	S_2S	400486	4 m²	2	7.90	I.S.	Level 0
IS_8	S_1S	400487	3 m²	3	7.70	I.S.	Level 0
IS_8	S_1S	400582	3 m²	2	7.56	I.S.	Level 1
IS_8	S_1S	400587	4 m²	2	7.92	I.S.	Level 1
IS_8	S_1S	400589	4 m²	2	8.10	I.S.	Level 1
IS_8	S_2S	400590	3 m²	2	7.56	I.S.	Level 1
IS_8	S_1S	400598	4 m²	2	8.10	I.S.	Level 1
IS_8	S_2S	400599	3 m²	3	7.68	I.S.	Level 1
IS_8	S_2S	400613	4 m²	2	7.82	I.S.	Level 1
IS_8	S_1S	400616	4 m²	2	7.70	I.S.	Level 1
IS_8	S_2S	400620	3 m²	3	7.69	I.S.	Level 1
IS_8	S_1S	400621	4 m²	2	7.90	I.S.	Level 1
IS_8	S_2S	400642	3 m²	3	7.70	I.S.	Level 1
IS_8	S_2S	400643	4 m²	2	7.70	I.S.	Level 1
IS_8	S_1S	400646	4 m²	2	7.60	I.S.	Level 1
IS_8	S_2S	400651	4 m²	3	7.80	I.S.	Level 1
IS_8	S_1S	400652	4 m²	2	7.80	I.S.	Level 1
IS_8	S_4S	400657	4 m²	2	7.84	I.S.	Level 1
IS_8	S_1S	400669	4 m²	2	7.70	I.S.	Level 1
IS_8	S_1S	400674	3 m²	2	7.60	I.S.	Level 1
IS_8	S_2S	400675	4 m²	2	7.90	I.S.	Level 1
IS_8	S_4S	400685	4 m²	2	7.90	I.S.	Level 1
IS_8	S_1S	400686	3 m²	3	7.70	I.S.	Level 1
IS_8	S_2S	400805	5 m²	3	8.85	I.S.	Level 2
IS_8	S_3S	400807	4 m²	2	7.70	I.S.	Level 2
IS_8	S_5S	400819	4 m²	3	8.67	I.S.	Level 2
IS_8	S_1S	400826	4 m²	2	7.80	I.S.	Level 2
IS_8	S_1S	400834	4 m²	2	8.10	I.S.	Level 2
IS_8	S_2S	400835	3 m²	2	7.55	I.S.	Level 2
IS_8	S_1S	400843	4 m²	2	8.10	I.S.	Level 2

IS_8	S_2S	400844	3 m²	3	7.68	I.S.	Level 2
IS_9	S_4S	400417	3 m²	2	6.43	I.S.	Level 0
IS_9	S_2D	400425	3 m²	2	6.66	I.S.	Level 0
IS_9	S_4S	400632	3 m²	2	6.43	I.S.	Level 1
IS_9	S_1D	400640	3 m²	2	6.66	I.S.	Level 1
IS_9	S_2S	400806	3 m²	2	6.56	I.S.	Level 2
IS_9	S_5S	400824	3 m²	2	6.53	I.S.	Level 2
IS_10	S_2S	400831	2 m²	2	6.28	I.S.	Level 2
IS_11	S_4S	400419	4 m²	2	8.12	I.S.	Level 0
IS_11	S_4S	400634	4 m²	2	8.12	I.S.	Level 1
IS_11	S_2S	400812	4 m²	2	8.30	I.S.	Level 2
IS_12	S_2S	400433	7 m²	3	11.70	I.S.	Level 0
IS_12	S_2S	400471	7 m²	3	11.70	I.S.	Level 0
IS_13	S_2S	400452	7 m²	3	10.78	I.S.	Level 0
IS_14	S_1S	400478	7 m²	4	11.52	I.S.	Level 0
IS_15	S_1S	400453	7 m²	4	11.80	I.S.	Level 0
IS_16	S_4S	400479	8 m²	4	11.92	I.S.	Level 0
IS_17	S_2S	400489	6 m²	4	11.10	I.S.	Level 0
IS_17	S_2S	400688	6 m²	4	11.10	I.S.	Level 1
IS_18	S_6S	400626	2 m²	2	5.98	I.S.	Level 1
IS_19	S_2S	400578	2 m²	2	6.01	I.S.	Level 1
IS_19	S_2S	400580	2 m²	2	6.01	I.S.	Level 1
IS_19	S_1S	400584	2 m²	2	6.00	I.S.	Level 1
IS_19	S_1S	400593	2 m²	2	5.91	I.S.	Level 1
IS_19	S_1S	400602	2 m²	2	5.91	I.S.	Level 1
IS_19	S_2S	400611	2 m²	2	6.00	I.S.	Level 1
IS_19	S_2S	400625	2 m²	2	6.00	I.S.	Level 1
IS_19	S_1S	400838	2 m²	2	5.91	I.S.	Level 2
IS_19	S_1S	400635	2 m²	2	5.91	I.S.	Level 2
IS_20	S_2S	400804	3 m²	2	7.21	I.S.	Level 2
IS_20	S_6S	400818	3 m²	2	7.07	I.S.	Level 2
IS_21	S_2S	400814	3 m²	2	6.73	I.S.	Level 2
IS_22	S_2S	400809	3 m²	2	6.67	I.S.	Level 2
IS_22	S_1S	400822	2 m²	2	6.57	I.S.	Level 2
IS_23	S_4D	400810	5 m²	3	9.90	I.S.	Level 2
IS_23	S_3D	400823	5 m²	3	9.78	I.S.	Level 2
IS_24	S_4S	400816	3 m²	2	6.92	I.S.	Level 2
IS_25	S_1D	400829	4 m²	2	7.91	I.S.	Level 2

APPENDIX 2: TABLE WITH WALL WITH TYPE OF WALL AND DIMENSIONS

Room_ID	Type	Length	Base Constraint	Width	Item	TypeID
400414	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	341135
400414	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	341222
400414	IS_Wall_SD	1.82	Level 0	0.07	Sliding Door	328175
400414	IS_Wall_BT	1.82	Level 0	0.07	Bathtub	328318
400414	IS_Wall_LBT	2.36	Level 0	0.07	Toilet+Bidet+Lavatory	613095
400414	IS_Parede_Geral	2.36	Level 0	0.07	Commom Wall	613156
400415	IS_Wall_BT	0.80	Level 0	0.07	Bathtub	343860
400415	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	613688
400415	IS_Wall_D	1.35	Level 0	0.07	Door	328159
400415	IS_Wall_BT	1.67	Level 0	0.07	Bathtub	328302
400415	IS_Wall_TB	1.71	Level 0	0.07	Toilet+Bidet	343818
400415	IS_Parede_Geral	1.75	Level 0	0.07	Commom Wall	343730
400415	IS_Wall_L	3.02	Level 0	0.07	Lavatory	343793
400416	IS_Wall_B	0.84	Level 0	0.07	Shower	342976
400416	IS_Wall_B	0.84	Level 0	0.07	Shower	614257
400416	IS_Wall_SD	1.67	Level 0	0.07	Sliding Door	328151
400416	IS_Wall_B	1.67	Level 0	0.07	Shower	328274
400416	IS_Parede_Geral	1.82	Level 0	0.07	Commom Wall	342935
400416	IS_Wall_LT	1.82	Level 0	0.07	Toilet+Lavatory	614144
400417	IS_Wall_SD	1.44	Level 0	0.07	Sliding Door	328143
400417	IS_Parede_Geral	1.44	Level 0	0.07	Commom Wall	343099
400417	IS_Parede_Geral	1.92	Level 0	0.07	Commom Wall	343132
400417	IS_Wall_LT	1.92	Level 0	0.07	Toilet+Lavatory	343190
400418	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	614010
400418	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	614110
400418	IS_Wall_BT	1.92	Level 0	0.07	Bathtub	328270
400418	IS_Parede_Geral	1.92	Level 0	0.07	Commom Wall	343308
400418	IS_Wall_LBT	2.24	Level 0	0.07	Toilet+Bidet+Lavatory	343268
400418	IS_Wall_SD	2.24	Level 0	0.07	Sliding Door	612097
400419	IS_Wall_B	0.84	Level 0	0.07	Shower	614594
400419	IS_Wall_B	0.84	Level 0	0.07	Shower	614695
400419	IS_Wall_SD	1.45	Level 0	0.07	Sliding Door	328139
400419	IS_Parede_Geral	1.45	Level 0	0.07	Commom Wall	342831
400419	IS_Wall_B	1.92	Level 0	0.07	Shower	328282
400419	IS_Wall_LT	1.92	Level 0	0.07	Toilet+Lavatory	342799
400420	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	328135
400420	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	342484
400420	IS_Wall_BT	1.97	Level 0	0.07	Bathtub	328278
400420	IS_Wall_TB	1.97	Level 0	0.07	Toilet+Bidet	342407
400420	IS_Wall_L	2.11	Level 0	0.07	Lavatory	614403
400420	IS_Wall_SD	2.11	Level 0	0.07	Sliding Door	614518
400421	IS_Wall_B	0.12	Level 0	0.07	Shower	342272
400421	IS_Wall_B	0.80	Level 0	0.07	Shower	342346
400421	IS_Wall_B	0.87	Level 0	0.07	Shower	342310
400421	IS_Wall_D	1.29	Level 0	0.07	Door	328119

400421	IS_Wall_B	1.57	Level 0	0.07	Shower	328286
400421	IS_Wall_B	1.75	Level 0	0.07	Shower	342241
400421	IS_Parede_Geral	1.82	Level 0	0.07	Commom Wall	342139
400421	IS_Wall_LBT	2.74	Level 0	0.07	Toilet+Bidet+Lavatory	342174
400422	IS_Wall_B	0.84	Level 0	0.07	Shower	328167
400422	IS_Wall_B	0.84	Level 0	0.07	Shower	613247
400422	IS_Wall_LT	1.84	Level 0	0.07	Toilet+Lavatory	341566
400422	IS_Wall_SD	1.84	Level 0	0.07	Sliding Door	613284
400422	IS_Wall_B	1.87	Level 0	0.07	Shower	328314
400422	IS_Parede_Geral	1.87	Level 0	0.07	Commom Wall	341607
400423	IS_Parede_Geral	0.48	Level 0	0.07	Commom Wall	341982
400423	IS_Wall_B	0.84	Level 0	0.07	Shower	341934
400423	IS_Wall_B	0.84	Level 0	0.07	Shower	613351
400423	IS_Parede_Geral	1.11	Level 0	0.07	Commom Wall	613448
400423	IS_Wall_D	1.12	Level 0	0.07	Door	328163
400423	IS_Wall_B	1.47	Level 0	0.07	Shower	328310
400423	IS_Parede_Geral	1.95	Level 0	0.07	Commom Wall	342060
400423	IS_Wall_LT	2.24	Level 0	0.07	Toilet+Lavatory	341770
400425	IS_Parede_Geral	1.60	Level 0	0.07	Commom Wall	341269
400425	IS_Parede_Geral	1.60	Level 0	0.07	Commom Wall	341415
400425	IS_Wall_D	1.87	Level 0	0.07	Door	341329
400425	IS_Wall_LT	1.87	Level 0	0.07	Toilet+Lavatory	341459
400426	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	340787
400426	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	613752
400426	IS_Wall_BT	1.67	Level 0	0.07	Bathtub	340786
400426	IS_Wall_L	1.67	Level 0	0.07	Lavatory	340788
400426	IS_Wall_SD	2.44	Level 0	0.07	Sliding Door	340789
400426	IS_Wall_TB	2.44	Level 0	0.07	Toilet+Bidet	613897
400427	IS_Wall_B	0.84	Level 0	0.07	Shower	340578
400427	IS_Wall_B	0.84	Level 0	0.07	Shower	340582
400427	IS_Wall_T	1.47	Level 0	0.07	Toilet	340577
400427	IS_Wall_B	1.47	Level 0	0.07	Shower	340579
400427	IS_Wall_SD	1.69	Level 0	0.07	Sliding Door	613593
400427	IS_Wall_L	1.69	Level 0	0.07	Lavatory	613657
400428	IS_Wall_B	0.84	Level 0	0.07	Shower	340261
400428	IS_Wall_B	0.84	Level 0	0.07	Shower	614805
400428	IS_Wall_L	1.54	Level 0	0.07	Lavatory	340273
400428	IS_Wall_SD	1.54	Level 0	0.07	Sliding Door	614869
400428	IS_Wall_B	1.67	Level 0	0.07	Shower	340263
400428	IS_Wall_T	1.67	Level 0	0.07	Toilet	340272
400429	IS_Wall_BT	0.80	Level 0	0.07	Bathtub	340265
400429	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	614981
400429	IS_Wall_SD	1.30	Level 0	0.07	Sliding Door	328127
400429	IS_Parede_Geral	1.69	Level 0	0.07	Commom Wall	340268
400429	IS_Parede_Geral	1.72	Level 0	0.07	Commom Wall	340266
400429	IS_Wall_BT	1.77	Level 0	0.07	Bathtub	328294
400429	IS_Wall_LBT	3.07	Level 0	0.07	Toilet+Bidet+Lavatory	340267
400430	IS_Wall_BT	0.80	Level 0	0.07	Bathtub	339449
400430	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	339451
400430	IS_Wall_SD	1.25	Level 0	0.07	Sliding Door	339388
400430	IS_Parede_Geral	1.51	Level 0	0.07	Commom Wall	615811

400430	IS_Parede_Geral	1.54	Level 0	0.07	Commom Wall	339447
400430	IS_Wall_BT	1.77	Level 0	0.07	Bathtub	339399
400430	IS_Wall_LBT	3.02	Level 0	0.07	Toilet+Bidet+Lavatory	339448
400431	IS_Wall_B	0.84	Level 0	0.07	Shower	339445
400431	IS_Wall_B	0.84	Level 0	0.07	Shower	615908
400431	IS_Wall_SD	1.49	Level 0	0.07	Sliding Door	327821
400431	IS_Wall_L	1.49	Level 0	0.07	Lavatory	615930
400431	IS_Wall_B	1.67	Level 0	0.07	Shower	328326
400431	IS_Wall_T	1.67	Level 0	0.07	Toilet	339446
400432	IS_Wall_B	0.84	Level 0	0.07	Shower	339390
400432	IS_Wall_B	0.84	Level 0	0.07	Shower	615998
400432	IS_Wall_B	1.54	Level 0	0.07	Shower	328330
400432	IS_Parede_Geral	1.54	Level 0	0.07	Commom Wall	339439
400432	IS_Wall_LT	1.84	Level 0	0.07	Toilet+Lavatory	339440
400432	IS_Wall_SD	1.84	Level 0	0.07	Sliding Door	615976
400433	IS_Wall_BT	0.80	Level 0	0.07	Bathtub	339433
400433	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	616192
400433	IS_Wall_SD	1.50	Level 0	0.07	Sliding Door	339392
400433	IS_Parede_Geral	1.69	Level 0	0.07	Commom Wall	339431
400433	IS_Parede_Geral	1.72	Level 0	0.07	Commom Wall	339429
400433	IS_Wall_BT	1.97	Level 0	0.07	Bathtub	328338
400433	IS_Wall_LBT	3.47	Level 0	0.07	Toilet+Bidet+Lavatory	339430
400434	IS_Wall_B	0.80	Level 0	0.07	Shower	339434
400434	IS_Wall_B	0.84	Level 0	0.07	Shower	616167
400434	IS_Wall_D	1.43	Level 0	0.07	Door	339391
400434	IS_Wall_B	1.57	Level 0	0.07	Shower	328334
400434	IS_Wall_B	1.59	Level 0	0.07	Shower	339437
400434	IS_Parede_Geral	1.63	Level 0	0.07	Commom Wall	339438
400434	IS_Wall_LBT	3.00	Level 0	0.07	Toilet+Bidet+Lavatory	339436
400435	IS_Wall_B	0.80	Level 0	0.07	Shower	339428
400435	IS_Wall_B	0.84	Level 0	0.07	Shower	339425
400435	IS_Wall_D	1.41	Level 0	0.07	Door	327837
400435	IS_Wall_B	1.57	Level 0	0.07	Shower	339403
400435	IS_Wall_TB	1.72	Level 0	0.07	Toilet+Bidet	616391
400435	IS_Parede_Geral	1.75	Level 0	0.07	Commom Wall	339427
400435	IS_Wall_L	2.98	Level 0	0.07	Lavatory	339426
400436	IS_Wall_B	0.84	Level 0	0.07	Shower	616494
400436	IS_Wall_B	0.84	Level 0	0.07	Shower	616555
400436	IS_Wall_B	1.47	Level 0	0.07	Shower	328346
400436	IS_Wall_T	1.47	Level 0	0.07	Toilet	339421
400436	IS_Wall_SD	1.74	Level 0	0.07	Sliding Door	327841
400436	IS_Wall_L	1.74	Level 0	0.07	Lavatory	339420
400437	IS_Wall_B	0.84	Level 0	0.07	Shower	339396
400437	IS_Wall_B	0.84	Level 0	0.07	Shower	339414
400437	IS_Wall_L	1.59	Level 0	0.07	Lavatory	616685
400437	IS_Wall_SD	1.59	Level 0	0.07	Sliding Door	616767
400437	IS_Wall_B	1.62	Level 0	0.07	Shower	328355
400437	IS_Wall_T	1.62	Level 0	0.07	Toilet	339412
400438	IS_Wall_B	0.84	Level 0	0.07	Shower	339395
400438	IS_Wall_B	0.84	Level 0	0.07	Shower	339418
400438	IS_Wall_B	1.57	Level 0	0.07	Shower	328351

400438	IS_Wall_L	1.57	Level 0	0.07	Lavatory	339416
400438	IS_Wall_TB	2.54	Level 0	0.07	Toilet+Bidet	616586
400438	IS_Wall_SD	2.54	Level 0	0.07	Sliding Door	616648
400439	IS_Wall_B	0.84	Level 0	0.07	Shower	339408
400439	IS_Wall_B	0.84	Level 0	0.07	Shower	616822
400439	IS_Wall_B	1.67	Level 0	0.07	Shower	328359
400439	IS_Wall_D	1.67	Level 0	0.07	Door	339397
400439	IS_Wall_LT	1.84	Level 0	0.07	Toilet+Lavatory	339409
400439	IS_Parede_Geral	1.84	Level 0	0.07	Commom Wall	616874
400440	IS_Wall_B	0.84	Level 0	0.07	Shower	339186
400440	IS_Wall_B	0.84	Level 0	0.07	Shower	339190
400440	IS_Wall_B	1.56	Level 0	0.07	Shower	339187
400440	IS_Parede_Geral	1.56	Level 0	0.07	Commom Wall	339191
400440	IS_Wall_LT	1.64	Level 0	0.07	Toilet+Lavatory	615296
400440	IS_Wall_SD	1.64	Level 0	0.07	Sliding Door	615327
400441	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	339005
400441	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	615738
400441	IS_Wall_BT	1.67	Level 0	0.07	Bathtub	338983
400441	IS_Wall_L	1.67	Level 0	0.07	Lavatory	339006
400441	IS_Wall_SD	2.54	Level 0	0.07	Sliding Door	338972
400441	IS_Wall_TB	2.54	Level 0	0.07	Toilet+Bidet	615638
400442	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	615141
400442	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	615199
400442	IS_Wall_BT	1.97	Level 0	0.07	Bathtub	338978
400442	IS_Wall_TB	1.97	Level 0	0.07	Toilet+Bidet	339002
400442	IS_Wall_SD	2.14	Level 0	0.07	Sliding Door	338973
400442	IS_Wall_L	2.14	Level 0	0.07	Lavatory	339003
400443	IS_Wall_B	0.80	Level 0	0.07	Shower	338995
400443	IS_Wall_B	0.84	Level 0	0.07	Shower	615367
400443	IS_Wall_D	1.27	Level 0	0.07	Door	338975
400443	IS_Wall_B	1.57	Level 0	0.07	Shower	338980
400443	IS_Parede_Geral	1.82	Level 0	0.07	Commom Wall	338994
400443	IS_Parede_Geral	1.85	Level 0	0.07	Commom Wall	338992
400443	IS_Wall_LBT	2.84	Level 0	0.07	Toilet+Bidet+Lavatory	338993
400444	IS_Wall_B	1.47	Level 0	0.07	Shower	338981
400444	IS_Parede_Geral	1.47	Level 0	0.07	Commom Wall	338989
400444	IS_Wall_SD	2.58	Level 0	0.07	Sliding Door	338977
400444	IS_Wall_LT	2.58	Level 0	0.07	Toilet+Lavatory	338988
400445	IS_Wall_D	1.77	Level 0	0.07	Door	327887
400445	IS_Wall_BT	1.77	Level 0	0.07	Bathtub	338982
400445	IS_Wall_BT	3.27	Level 0	0.07	Bathtub	338984
400445	IS_Wall_LBT	3.27	Level 0	0.07	Toilet+Bidet+Lavatory	338985
400446	IS_Wall_B	0.84	Level 0	0.07	Shower	338888
400446	IS_Wall_B	0.84	Level 0	0.07	Shower	338937
400446	IS_Wall_D	1.67	Level 0	0.07	Door	327892
400446	IS_Wall_B	1.67	Level 0	0.07	Shower	328363
400446	IS_Wall_LT	1.84	Level 0	0.07	Toilet+Lavatory	616980
400446	IS_Parede_Geral	1.84	Level 0	0.07	Commom Wall	617050
400447	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	338464
400447	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	617468

400447	IS_Wall_BT	1.67	Level 0	0.07	Bathtub	328371
400447	IS_Wall_L	1.67	Level 0	0.07	Lavatory	338468
400447	IS_Wall_SD	2.54	Level 0	0.07	Sliding Door	327900
400447	IS_Wall_TB	2.54	Level 0	0.07	Toilet+Bidet	617404
400448	IS_Wall_B	0.84	Level 0	0.07	Shower	338563
400448	IS_Wall_B	0.84	Level 0	0.07	Shower	617174
400448	IS_Wall_SD	1.59	Level 0	0.07	Sliding Door	327896
400448	IS_Wall_L	1.59	Level 0	0.07	Lavatory	617274
400448	IS_Wall_B	1.67	Level 0	0.07	Shower	328367
400448	IS_Wall_T	1.67	Level 0	0.07	Toilet	338559
400449	IS_Wall_B	0.84	Level 0	0.07	Shower	338303
400449	IS_Wall_B	0.84	Level 0	0.07	Shower	617615
400449	IS_Wall_B	1.58	Level 0	0.07	Shower	328375
400449	IS_Wall_T	1.58	Level 0	0.07	Toilet	338333
400449	IS_Wall_SD	1.59	Level 0	0.07	Sliding Door	327912
400449	IS_Wall_L	1.59	Level 0	0.07	Lavatory	617538
400450	IS_Wall_B	0.84	Level 0	0.07	Shower	337387
400450	IS_Wall_B	0.84	Level 0	0.07	Shower	617959
400450	IS_Wall_B	1.67	Level 0	0.07	Shower	328383
400450	IS_Parede_Geral	1.67	Level 0	0.07	Commom Wall	337420
400450	IS_Wall_SD	1.78	Level 0	0.07	Sliding Door	327936
400450	IS_Wall_LT	1.78	Level 0	0.07	Toilet+Lavatory	617918
400451	IS_Wall_B	0.80	Level 0	0.07	Shower	337856
400451	IS_Wall_B	0.84	Level 0	0.07	Shower	618218
400451	IS_Wall_D	1.43	Level 0	0.07	Door	327940
400451	IS_Wall_B	1.57	Level 0	0.07	Shower	328392
400451	IS_Parede_Geral	1.59	Level 0	0.07	Commom Wall	337731
400451	IS_Parede_Geral	1.63	Level 0	0.07	Commom Wall	337677
400451	IS_Wall_LBT	3.00	Level 0	0.07	Toilet+Bidet+Lavatory	337641
400452	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	327932
400452	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	618014
400452	IS_Wall_BT	2.06	Level 0	0.07	Bathtub	328387
400452	IS_Parede_Geral	2.06	Level 0	0.07	Commom Wall	337905
400452	IS_Wall_LBT	2.64	Level 0	0.07	Toilet+Bidet+Lavatory	337936
400452	IS_Wall_SD	2.64	Level 0	0.07	Sliding Door	618106
400453	IS_Wall_B	0.84	Level 0	0.07	Shower	338184
400453	IS_Wall_B	0.84	Level 0	0.07	Shower	617887
400453	IS_Wall_B	1.87	Level 0	0.07	Shower	328379
400453	IS_Wall_T	1.87	Level 0	0.07	Toilet	338231
400453	IS_Wall_SD	3.34	Level 0	0.07	Sliding Door	327908
400453	IS_Wall_L	3.34	Level 0	0.07	Lavatory	617748
400454	IS_Wall_B	0.84	Level 0	0.07	Shower	327944
400454	IS_Wall_B	0.84	Level 0	0.07	Shower	618331
400454	IS_Wall_L	1.49	Level 0	0.07	Lavatory	337347
400454	IS_Wall_SD	1.49	Level 0	0.07	Sliding Door	618362
400454	IS_Wall_B	1.67	Level 0	0.07	Shower	328396
400454	IS_Wall_T	1.67	Level 0	0.07	Toilet	337301
400455	IS_Wall_BT	0.80	Level 0	0.07	Bathtub	336842
400455	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	618480
400455	IS_Wall_SD	1.25	Level 0	0.07	Sliding Door	327948
400455	IS_Parede_Geral	1.57	Level 0	0.07	Commom Wall	337054

400455	IS_Parede_Geral	1.60	Level 0	0.07	Commom Wall	336889
400455	IS_Wall_BT	1.77	Level 0	0.07	Bathtub	328400
400455	IS_Wall_LBT	3.02	Level 0	0.07	Toilet+Bidet+Lavatory	336933
400456	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	336705
400456	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	618562
400456	IS_Wall_BT	1.67	Level 0	0.07	Bathtub	328437
400456	IS_Wall_L	1.67	Level 0	0.07	Lavatory	336732
400456	IS_Wall_SD	2.54	Level 0	0.07	Sliding Door	327952
400456	IS_Wall_TB	2.54	Level 0	0.07	Toilet+Bidet	618590
400457	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	618685
400457	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	618743
400457	IS_Wall_BT	1.97	Level 0	0.07	Bathtub	328405
400457	IS_Wall_TB	1.97	Level 0	0.07	Toilet+Bidet	336569
400457	IS_Wall_SD	2.14	Level 0	0.07	Sliding Door	327956
400457	IS_Wall_L	2.14	Level 0	0.07	Lavatory	336626
400458	IS_Wall_B	0.84	Level 0	0.07	Shower	327965
400458	IS_Wall_B	0.84	Level 0	0.07	Shower	336427
400458	IS_Wall_B	1.57	Level 0	0.07	Shower	328409
400458	IS_Parede_Geral	1.57	Level 0	0.07	Commom Wall	336470
400458	IS_Wall_SD	1.68	Level 0	0.07	Sliding Door	618831
400458	IS_Wall_LT	1.68	Level 0	0.07	Toilet+Lavatory	618868
400459	IS_Wall_B	0.80	Level 0	0.07	Shower	336257
400459	IS_Wall_B	0.84	Level 0	0.07	Shower	618899
400459	IS_Wall_D	1.27	Level 0	0.07	Door	327969
400459	IS_Wall_B	1.57	Level 0	0.07	Shower	328413
400459	IS_Parede_Geral	1.90	Level 0	0.07	Commom Wall	336215
400459	IS_Parede_Geral	1.93	Level 0	0.07	Commom Wall	336145
400459	IS_Wall_LBT	2.84	Level 0	0.07	Toilet+Bidet+Lavatory	336185
400460	IS_Wall_B	0.84	Level 0	0.07	Shower	327977
400460	IS_Wall_B	0.84	Level 0	0.07	Shower	335928
400460	IS_Wall_B	1.47	Level 0	0.07	Shower	328423
400460	IS_Parede_Geral	1.47	Level 0	0.07	Commom Wall	335981
400460	IS_Wall_LT	1.75	Level 0	0.07	Toilet+Lavatory	619029
400460	IS_Wall_SD	1.75	Level 0	0.07	Sliding Door	619066
400461	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	619115
400461	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	619179
400461	IS_Wall_D	1.88	Level 0	0.07	Door	327973
400461	IS_Wall_BT	1.88	Level 0	0.07	Bathtub	328427
400461	IS_Parede_Geral	2.44	Level 0	0.07	Commom Wall	335684
400461	IS_Wall_LBT	2.44	Level 0	0.07	Toilet+Bidet+Lavatory	335760
400462	IS_Wall_B	0.84	Level 0	0.07	Shower	328110
400462	IS_Wall_B	0.84	Level 0	0.07	Shower	619493
400462	IS_Wall_B	1.47	Level 0	0.07	Shower	328470
400462	IS_Parede_Geral	1.47	Level 0	0.07	Commom Wall	335542
400462	IS_Wall_LT	1.75	Level 0	0.07	Toilet+Lavatory	619276
400462	IS_Wall_SD	1.75	Level 0	0.07	Sliding Door	619536
400463	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	335303
400463	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	619669
400463	IS_Wall_D	1.87	Level 0	0.07	Door	328114
400463	IS_Wall_BT	1.87	Level 0	0.07	Bathtub	328466
400463	IS_Wall_LBT	2.44	Level 0	0.07	Toilet+Bidet+Lavatory	335215

400463	IS_Parede_Geral	2.44	Level 0	0.07	Commom Wall	619602
400464	IS_Wall_B	0.80	Level 0	0.07	Shower	335198
400464	IS_Wall_B	0.84	Level 0	0.07	Shower	619813
400464	IS_Wall_D	1.27	Level 0	0.07	Door	327989
400464	IS_Wall_B	1.57	Level 0	0.07	Shower	328462
400464	IS_Parede_Geral	1.90	Level 0	0.07	Commom Wall	335144
400464	IS_Parede_Geral	1.93	Level 0	0.07	Commom Wall	335148
400464	IS_Wall_LBT	2.84	Level 0	0.07	Toilet+Bidet+Lavatory	335140
400465	IS_Wall_B	0.84	Level 0	0.07	Shower	619872
400465	IS_Wall_B	0.84	Level 0	0.07	Shower	619894
400465	IS_Wall_B	1.57	Level 0	0.07	Shower	328458
400465	IS_Parede_Geral	1.57	Level 0	0.07	Commom Wall	334827
400465	IS_Wall_SD	1.68	Level 0	0.07	Sliding Door	327985
400465	IS_Wall_LT	1.68	Level 0	0.07	Toilet+Lavatory	334857
400466	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	334730
400466	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	620009
400466	IS_Wall_BT	1.97	Level 0	0.07	Bathtub	328454
400466	IS_Wall_TB	1.97	Level 0	0.07	Toilet+Bidet	334776
400466	IS_Wall_SD	2.14	Level 0	0.07	Sliding Door	327981
400466	IS_Wall_L	2.14	Level 0	0.07	Lavatory	620070
400467	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	334565
400467	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	620155
400467	IS_Wall_BT	1.67	Level 0	0.07	Bathtub	328450
400467	IS_Wall_L	1.67	Level 0	0.07	Lavatory	334324
400467	IS_Wall_SD	2.54	Level 0	0.07	Sliding Door	327993
400467	IS_Wall_TB	2.54	Level 0	0.07	Toilet+Bidet	620213
400468	IS_Wall_BT	0.80	Level 0	0.07	Bathtub	334172
400468	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	334239
400468	IS_Wall_SD	1.30	Level 0	0.07	Sliding Door	327997
400468	IS_Parede_Geral	1.54	Level 0	0.07	Commom Wall	620307
400468	IS_Parede_Geral	1.57	Level 0	0.07	Commom Wall	334164
400468	IS_Wall_BT	1.77	Level 0	0.07	Bathtub	328446
400468	IS_Wall_LBT	3.07	Level 0	0.07	Toilet+Bidet+Lavatory	334168
400469	IS_Wall_B	0.84	Level 0	0.07	Shower	334078
400469	IS_Wall_B	0.84	Level 0	0.07	Shower	620380
400469	IS_Wall_SD	1.49	Level 0	0.07	Sliding Door	328001
400469	IS_Wall_L	1.49	Level 0	0.07	Lavatory	620432
400469	IS_Wall_B	1.67	Level 0	0.07	Shower	328442
400469	IS_Wall_T	1.67	Level 0	0.07	Toilet	334110
400470	IS_Wall_B	0.84	Level 0	0.07	Shower	328005
400470	IS_Wall_B	0.84	Level 0	0.07	Shower	620560
400470	IS_Wall_B	1.67	Level 0	0.07	Shower	328489
400470	IS_Parede_Geral	1.67	Level 0	0.07	Commom Wall	333795
400470	IS_Wall_LT	1.84	Level 0	0.07	Toilet+Lavatory	333799
400470	IS_Wall_SD	1.84	Level 0	0.07	Sliding Door	620514
400471	IS_Wall_BT	0.80	Level 0	0.07	Bathtub	333659
400471	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	620724
400471	IS_Wall_SD	1.50	Level 0	0.07	Sliding Door	328013
400471	IS_Parede_Geral	1.69	Level 0	0.07	Commom Wall	333580
400471	IS_Parede_Geral	1.72	Level 0	0.07	Commom Wall	333474
400471	IS_Wall_BT	1.97	Level 0	0.07	Bathtub	328479

400471	IS_Wall_LBT	3.47	Level 0	0.07	Toilet+Bidet+Lavatory	333531
400473	IS_Wall_B	0.80	Level 0	0.07	Shower	333318
400473	IS_Wall_B	0.84	Level 0	0.07	Shower	333197
400473	IS_Wall_D	1.33	Level 0	0.07	Door	328037
400473	IS_Wall_B	1.57	Level 0	0.07	Shower	328494
400473	IS_Wall_TB	1.72	Level 0	0.07	Toilet+Bidet	620806
400473	IS_Parede_Geral	1.75	Level 0	0.07	Commom Wall	333283
400473	IS_Wall_L	2.90	Level 0	0.07	Lavatory	333247
400474	IS_Wall_B	0.84	Level 0	0.07	Shower	620870
400474	IS_Wall_B	0.84	Level 0	0.07	Shower	620892
400474	IS_Wall_B	1.47	Level 0	0.07	Shower	328498
400474	IS_Wall_T	1.47	Level 0	0.07	Toilet	332813
400474	IS_Wall_SD	1.64	Level 0	0.07	Sliding Door	328022
400474	IS_Wall_L	1.64	Level 0	0.07	Lavatory	332780
400475	IS_Wall_B	0.84	Level 0	0.07	Shower	328047
400475	IS_Wall_B	0.84	Level 0	0.07	Shower	332388
400475	IS_Wall_L	1.59	Level 0	0.07	Lavatory	621094
400475	IS_Wall_SD	1.59	Level 0	0.07	Sliding Door	621176
400475	IS_Wall_B	1.67	Level 0	0.07	Shower	328506
400475	IS_Wall_T	1.67	Level 0	0.07	Toilet	332221
400476	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	328043
400476	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	332685
400476	IS_Wall_BT	1.67	Level 0	0.07	Bathtub	328502
400476	IS_Wall_L	1.67	Level 0	0.07	Lavatory	332516
400476	IS_Wall_SD	2.54	Level 0	0.07	Sliding Door	620989
400476	IS_Wall_TB	2.54	Level 0	0.07	Toilet+Bidet	621045
400477	IS_Wall_B	0.84	Level 0	0.07	Shower	332028
400477	IS_Wall_B	0.84	Level 0	0.07	Shower	621222
400477	IS_Wall_D	1.67	Level 0	0.07	Door	328051
400477	IS_Wall_B	1.67	Level 0	0.07	Shower	328510
400477	IS_Wall_LT	1.84	Level 0	0.07	Toilet+Lavatory	332032
400477	IS_Parede_Geral	1.84	Level 0	0.07	Commom Wall	621232
400478	IS_Wall_B	0.84	Level 0	0.07	Shower	328062
400478	IS_Wall_B	0.84	Level 0	0.07	Shower	331760
400478	IS_Wall_B	1.87	Level 0	0.07	Shower	328516
400478	IS_Parede_Geral	1.87	Level 0	0.07	Commom Wall	331514
400478	IS_Wall_LT	3.20	Level 0	0.07	Toilet+Lavatory	621474
400478	IS_Wall_SD	3.20	Level 0	0.07	Sliding Door	621545
400479	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	331816
400479	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	331925
400479	IS_Wall_SD	2.07	Level 0	0.07	Sliding Door	328066
400479	IS_Wall_BT	2.07	Level 0	0.07	Bathtub	328520
400479	IS_Parede_Geral	3.20	Level 0	0.07	Commom Wall	621330
400479	IS_Wall_LBT	3.20	Level 0	0.07	Toilet+Bidet+Lavatory	621404
400480	IS_Wall_B	0.84	Level 0	0.07	Shower	331363
400480	IS_Wall_B	0.84	Level 0	0.07	Shower	621687
400480	IS_Wall_B	1.58	Level 0	0.07	Shower	328524
400480	IS_Wall_T	1.58	Level 0	0.07	Toilet	331357
400480	IS_Wall_SD	1.72	Level 0	0.07	Sliding Door	328070
400480	IS_Wall_L	1.72	Level 0	0.07	Lavatory	621763
400481	IS_Wall_B	0.84	Level 0	0.07	Shower	328078

400481	IS_Wall_B	0.84	Level 0	0.07	Shower	330688
400481	IS_Wall_B	1.67	Level 0	0.07	Shower	328532
400481	IS_Parede_Geral	1.67	Level 0	0.07	Commom Wall	330770
400481	IS_Wall_SD	1.78	Level 0	0.07	Sliding Door	622036
400481	IS_Wall_LT	1.78	Level 0	0.07	Toilet+Lavatory	622097
400482	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	331093
400482	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	621921
400482	IS_Wall_BT	1.72	Level 0	0.07	Bathtub	328528
400482	IS_Parede_Geral	1.72	Level 0	0.07	Commom Wall	331020
400482	IS_Wall_SD	2.44	Level 0	0.07	Sliding Door	328074
400482	IS_Wall_LBT	2.44	Level 0	0.07	Toilet+Bidet+Lavatory	621857
400483	IS_Wall_B	0.84	Level 0	0.07	Shower	330158
400483	IS_Wall_B	0.84	Level 0	0.07	Shower	330202
400483	IS_Wall_D	1.67	Level 0	0.07	Door	328086
400483	IS_Wall_B	1.67	Level 0	0.07	Shower	328540
400483	IS_Wall_LT	1.84	Level 0	0.07	Toilet+Lavatory	622340
400483	IS_Parede_Geral	1.84	Level 0	0.07	Commom Wall	622450
400484	IS_Wall_B	0.84	Level 0	0.07	Shower	330957
400484	IS_Wall_B	0.84	Level 0	0.07	Shower	622230
400484	IS_Wall_D	1.67	Level 0	0.07	Door	328082
400484	IS_Wall_B	1.67	Level 0	0.07	Shower	328536
400484	IS_Parede_Geral	1.84	Level 0	0.07	Commom Wall	330846
400484	IS_Wall_LT	1.84	Level 0	0.07	Toilet+Lavatory	622282
400485	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	329719
400485	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	622606
400485	IS_Wall_BT	1.57	Level 0	0.07	Bathtub	328548
400485	IS_Wall_L	1.57	Level 0	0.07	Lavatory	329760
400485	IS_Wall_SD	2.54	Level 0	0.07	Sliding Door	328094
400485	IS_Wall_TB	2.54	Level 0	0.07	Toilet+Bidet	622658
400486	IS_Wall_B	0.84	Level 0	0.07	Shower	330424
400486	IS_Wall_B	0.84	Level 0	0.07	Shower	622511
400486	IS_Wall_SD	1.59	Level 0	0.07	Sliding Door	328090
400486	IS_Wall_L	1.59	Level 0	0.07	Lavatory	622539
400486	IS_Wall_B	1.67	Level 0	0.07	Shower	328544
400486	IS_Wall_T	1.67	Level 0	0.07	Toilet	330039
400487	IS_Wall_B	0.84	Level 0	0.07	Shower	328098
400487	IS_Wall_B	0.84	Level 0	0.07	Shower	329527
400487	IS_Wall_B	1.47	Level 0	0.07	Shower	328552
400487	IS_Wall_T	1.47	Level 0	0.07	Toilet	329462
400487	IS_Wall_SD	1.69	Level 0	0.07	Sliding Door	622764
400487	IS_Wall_L	1.69	Level 0	0.07	Lavatory	622841
400488	IS_Wall_B	0.80	Level 0	0.07	Shower	328942
400488	IS_Wall_B	0.84	Level 0	0.07	Shower	329379
400488	IS_Wall_D	1.42	Level 0	0.07	Door	328102
400488	IS_Wall_B	1.57	Level 0	0.07	Shower	328556
400488	IS_Wall_TB	1.72	Level 0	0.07	Toilet+Bidet	622944
400488	IS_Parede_Geral	1.75	Level 0	0.07	Commom Wall	329114
400488	IS_Wall_L	2.99	Level 0	0.07	Lavatory	329325
400489	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	328106
400489	IS_Wall_BT	0.84	Level 0	0.07	Bathtub	623075
400489	IS_Wall_BT	1.72	Level 0	0.07	Bathtub	328560

400489	IS_Parede_Geral	1.72	Level 0	0.07	Commom Wall	329110
400489	IS_Wall_LBT	3.14	Level 0	0.07	Toilet+Bidet+Lavatory	329172
400489	IS_Wall_SD	3.14	Level 0	0.07	Sliding Door	623151
400577	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344877
400577	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344878
400577	IS_Wall_SD	1.82	Level 1	0.07	Sliding Door	344512
400577	IS_Wall_BT	1.82	Level 1	0.07	Bathtub	344522
400577	IS_Wall_LBT	2.36	Level 1	0.07	Toilet+Bidet+Lavatory	624970
400577	IS_Parede_Geral	2.36	Level 1	0.07	Commom Wall	624995
400578	IS_Wall_T	1.38	Level 1	0.07	Toilet	357087
400578	IS_Parede_Geral	1.38	Level 1	0.07	Commom Wall	357138
400578	IS_Wall_SD	1.77	Level 1	0.07	Sliding Door	357117
400578	IS_Wall_L	1.77	Level 1	0.07	Lavatory	357170
400579	IS_Wall_B	0.84	Level 1	0.07	Shower	357295
400579	IS_Wall_B	0.84	Level 1	0.07	Shower	634240
400579	IS_Parede_Geral	1.57	Level 1	0.07	Commom Wall	357198
400579	IS_Wall_B	1.57	Level 1	0.07	Shower	357261
400579	IS_Wall_SD	1.84	Level 1	0.07	Sliding Door	357246
400579	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	634197
400580	IS_Parede_Geral	1.38	Level 1	0.07	Commom Wall	356491
400580	IS_Wall_T	1.38	Level 1	0.07	Toilet	356551
400580	IS_Wall_L	1.77	Level 1	0.07	Lavatory	356531
400580	IS_Wall_SD	1.77	Level 1	0.07	Sliding Door	356578
400581	IS_Parede_Geral	1.57	Level 1	0.07	Commom Wall	356953
400581	IS_Wall_BT	1.57	Level 1	0.07	Bathtub	356993
400581	IS_Wall_SD	2.58	Level 1	0.07	Sliding Door	356896
400581	IS_Wall_LT	2.58	Level 1	0.07	Toilet+Lavatory	356926
400582	IS_Wall_B	0.84	Level 1	0.07	Shower	356766
400582	IS_Wall_B	0.84	Level 1	0.07	Shower	633043
400582	IS_Wall_B	1.47	Level 1	0.07	Shower	356699
400582	IS_Wall_T	1.47	Level 1	0.07	Toilet	356797
400582	IS_Wall_L	1.62	Level 1	0.07	Lavatory	356824
400582	IS_Wall_SD	1.62	Level 1	0.07	Sliding Door	633080
400583	IS_Parede_Geral	1.55	Level 1	0.07	Commom Wall	356172
400583	IS_Wall_BT	1.55	Level 1	0.07	Bathtub	356263
400583	IS_Wall_LT	2.58	Level 1	0.07	Toilet+Lavatory	356187
400583	IS_Wall_SD	2.58	Level 1	0.07	Sliding Door	356231
400584	IS_Wall_T	1.37	Level 1	0.07	Toilet	356344
400584	IS_Parede_Geral	1.37	Level 1	0.07	Commom Wall	356434
400584	IS_Wall_SD	1.77	Level 1	0.07	Sliding Door	356388
400584	IS_Wall_L	1.77	Level 1	0.07	Lavatory	356460
400585	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344671
400585	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	631068
400585	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	344549
400585	IS_Wall_L	1.67	Level 1	0.07	Lavatory	344669
400585	IS_Wall_SD	2.52	Level 1	0.07	Sliding Door	344477
400585	IS_Wall_TB	2.52	Level 1	0.07	Toilet+Bidet	631148
400586	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	631242
400586	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	631342
400586	IS_Wall_TB	1.97	Level 1	0.07	Toilet+Bidet	355625
400586	IS_Wall_BT	1.97	Level 1	0.07	Bathtub	355729

400586	IS_Wall_L	2.04	Level 1	0.07	Lavatory	355657
400586	IS_Wall_SD	2.04	Level 1	0.07	Sliding Door	355694
400587	IS_Wall_B	0.84	Level 1	0.07	Shower	355824
400587	IS_Wall_T	0.94	Level 1	0.07	Toilet	630981
400587	IS_Wall_B	1.04	Level 1	0.07	Shower	631052
400587	IS_Wall_L	1.30	Level 1	0.07	Lavatory	355919
400587	IS_Parede_Geral	1.77	Level 1	0.07	Commom Wall	355891
400587	IS_Wall_SD	2.33	Level 1	0.07	Sliding Door	355867
400588	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	355593
400588	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	627189
400588	IS_Parede_Geral	1.77	Level 1	0.07	Commom Wall	355590
400588	IS_Wall_BT	1.77	Level 1	0.07	Bathtub	355592
400588	IS_Wall_LBT	2.54	Level 1	0.07	Toilet+Bidet+Lavatory	355591
400588	IS_Wall_SD	2.54	Level 1	0.07	Sliding Door	627125
400589	IS_Wall_B	0.84	Level 1	0.07	Shower	355597
400589	IS_Wall_B	0.84	Level 1	0.07	Shower	627303
400589	IS_Wall_SD	1.59	Level 1	0.07	Sliding Door	355598
400589	IS_Wall_L	1.59	Level 1	0.07	Lavatory	627223
400589	IS_Wall_T	1.77	Level 1	0.07	Toilet	355596
400589	IS_Wall_B	1.77	Level 1	0.07	Shower	355600
400590	IS_Wall_B	0.84	Level 1	0.07	Shower	355585
400590	IS_Wall_B	0.84	Level 1	0.07	Shower	627031
400590	IS_Wall_B	1.46	Level 1	0.07	Shower	355584
400590	IS_Wall_T	1.46	Level 1	0.07	Toilet	355586
400590	IS_Wall_SD	1.62	Level 1	0.07	Sliding Door	355587
400590	IS_Wall_L	1.62	Level 1	0.07	Lavatory	627012
400591	IS_Wall_B	0.80	Level 1	0.07	Shower	355583
400591	IS_Wall_B	0.84	Level 1	0.07	Shower	626969
400591	IS_Wall_D	1.42	Level 1	0.07	Door	355577
400591	IS_Wall_B	1.48	Level 1	0.07	Shower	355581
400591	IS_Wall_TB	1.72	Level 1	0.07	Toilet+Bidet	355580
400591	IS_Parede_Geral	1.75	Level 1	0.07	Commom Wall	355578
400591	IS_Wall_L	2.90	Level 1	0.07	Lavatory	355579
400592	IS_Wall_B	0.84	Level 1	0.07	Shower	626862
400592	IS_Wall_B	0.84	Level 1	0.07	Shower	626893
400592	IS_Wall_B	1.57	Level 1	0.07	Shower	355567
400592	IS_Parede_Geral	1.57	Level 1	0.07	Commom Wall	355568
400592	IS_Wall_SD	1.75	Level 1	0.07	Sliding Door	355569
400592	IS_Wall_LT	1.75	Level 1	0.07	Toilet+Lavatory	355570
400593	IS_Wall_T	1.38	Level 1	0.07	Toilet	355574
400593	IS_Parede_Geral	1.38	Level 1	0.07	Commom Wall	355576
400593	IS_Wall_SD	1.72	Level 1	0.07	Sliding Door	355573
400593	IS_Wall_L	1.72	Level 1	0.07	Lavatory	355575
400594	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	355562
400594	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	626789
400594	IS_Parede_Geral	1.87	Level 1	0.07	Commom Wall	355563
400594	IS_Wall_BT	1.87	Level 1	0.07	Bathtub	355565
400594	IS_Wall_LBT	2.64	Level 1	0.07	Toilet+Bidet+Lavatory	355561
400594	IS_Wall_SD	2.64	Level 1	0.07	Sliding Door	626764
400595	IS_Wall_B	0.84	Level 1	0.07	Shower	355496
400595	IS_Wall_B	0.84	Level 1	0.07	Shower	627463

400595	IS_Wall_B	1.67	Level 1	0.07	Shower	355416
400595	IS_Wall_D	1.67	Level 1	0.07	Door	355521
400595	IS_Parede_Geral	1.84	Level 1	0.07	Commom Wall	355543
400595	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	627494
400596	IS_Wall_B	0.84	Level 1	0.07	Shower	355605
400596	IS_Wall_B	0.84	Level 1	0.07	Shower	627365
400596	IS_Wall_B	1.67	Level 1	0.07	Shower	355602
400596	IS_Wall_D	1.67	Level 1	0.07	Door	355606
400596	IS_Parede_Geral	1.84	Level 1	0.07	Commom Wall	355607
400596	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	627328
400597	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	355180
400597	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	627727
400597	IS_Parede_Geral	1.77	Level 1	0.07	Commom Wall	355040
400597	IS_Wall_BT	1.77	Level 1	0.07	Bathtub	355080
400597	IS_Wall_LBT	2.54	Level 1	0.07	Toilet+Bidet+Lavatory	355060
400597	IS_Wall_SD	2.54	Level 1	0.07	Sliding Door	627651
400598	IS_Wall_B	0.84	Level 1	0.07	Shower	355249
400598	IS_Wall_B	0.84	Level 1	0.07	Shower	627531
400598	IS_Wall_SD	1.59	Level 1	0.07	Sliding Door	355253
400598	IS_Wall_L	1.59	Level 1	0.07	Lavatory	627554
400598	IS_Wall_T	1.77	Level 1	0.07	Toilet	355245
400598	IS_Wall_B	1.77	Level 1	0.07	Shower	355347
400599	IS_Wall_B	0.84	Level 1	0.07	Shower	354876
400599	IS_Wall_B	0.84	Level 1	0.07	Shower	627975
400599	IS_Wall_B	1.46	Level 1	0.07	Shower	354839
400599	IS_Wall_T	1.46	Level 1	0.07	Toilet	354912
400599	IS_Wall_SD	1.69	Level 1	0.07	Sliding Door	354944
400599	IS_Wall_L	1.69	Level 1	0.07	Lavatory	627851
400600	IS_Wall_B	0.80	Level 1	0.07	Shower	354806
400600	IS_Wall_B	0.84	Level 1	0.07	Shower	628048
400600	IS_Wall_D	1.42	Level 1	0.07	Door	354626
400600	IS_Wall_B	1.57	Level 1	0.07	Shower	354745
400600	IS_Parede_Geral	1.72	Level 1	0.07	Commom Wall	354699
400600	IS_Parede_Geral	1.75	Level 1	0.07	Commom Wall	354648
400600	IS_Wall_LBT	2.99	Level 1	0.07	Toilet+Bidet+Lavatory	354678
400601	IS_Wall_B	0.84	Level 1	0.07	Shower	628164
400601	IS_Wall_B	0.84	Level 1	0.07	Shower	628213
400601	IS_Wall_B	1.57	Level 1	0.07	Shower	354320
400601	IS_Parede_Geral	1.57	Level 1	0.07	Commom Wall	354324
400601	IS_Wall_SD	1.75	Level 1	0.07	Sliding Door	354350
400601	IS_Wall_LT	1.75	Level 1	0.07	Toilet+Lavatory	354388
400602	IS_Wall_T	1.38	Level 1	0.07	Toilet	354540
400602	IS_Parede_Geral	1.38	Level 1	0.07	Commom Wall	354594
400602	IS_Wall_SD	1.72	Level 1	0.07	Sliding Door	354508
400602	IS_Wall_L	1.72	Level 1	0.07	Lavatory	354571
400603	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	354092
400603	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	628320
400603	IS_Parede_Geral	1.87	Level 1	0.07	Commom Wall	354132
400603	IS_Wall_BT	1.87	Level 1	0.07	Bathtub	354265
400603	IS_Wall_LBT	2.64	Level 1	0.07	Toilet+Bidet+Lavatory	354058
400603	IS_Wall_SD	2.64	Level 1	0.07	Sliding Door	628280

400604	IS_Wall_B	0.84	Level 1	0.07	Shower	353928
400604	IS_Wall_B	0.84	Level 1	0.07	Shower	629069
400604	IS_Wall_B	1.67	Level 1	0.07	Shower	353927
400604	IS_Parede_Geral	1.67	Level 1	0.07	Commom Wall	353929
400604	IS_Wall_LT	1.78	Level 1	0.07	Toilet+Lavatory	353930
400604	IS_Wall_SD	1.78	Level 1	0.07	Sliding Door	629106
400605	IS_Wall_B	0.84	Level 1	0.07	Shower	353177
400605	IS_Wall_B	0.84	Level 1	0.07	Shower	353184
400605	IS_Wall_B	1.47	Level 1	0.07	Shower	353178
400605	IS_Parede_Geral	1.47	Level 1	0.07	Commom Wall	353185
400605	IS_Wall_LT	1.75	Level 1	0.07	Toilet+Lavatory	630065
400605	IS_Wall_SD	1.75	Level 1	0.07	Sliding Door	630090
400606	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	630124
400606	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	630134
400606	IS_Wall_D	1.88	Level 1	0.07	Door	353176
400606	IS_Wall_BT	1.88	Level 1	0.07	Bathtub	353179
400606	IS_Parede_Geral	2.44	Level 1	0.07	Commom Wall	353180
400606	IS_Wall_LBT	2.44	Level 1	0.07	Toilet+Bidet+Lavatory	353181
400607	IS_Wall_B	0.84	Level 1	0.07	Shower	353146
400607	IS_Wall_B	0.84	Level 1	0.07	Shower	353150
400607	IS_Wall_B	1.56	Level 1	0.07	Shower	353147
400607	IS_Parede_Geral	1.56	Level 1	0.07	Commom Wall	353151
400607	IS_Wall_SD	1.71	Level 1	0.07	Sliding Door	629768
400607	IS_Wall_LT	1.71	Level 1	0.07	Toilet+Lavatory	629970
400608	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	629640
400608	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	629695
400608	IS_Wall_BT	1.97	Level 1	0.07	Bathtub	353120
400608	IS_Wall_TB	1.97	Level 1	0.07	Toilet+Bidet	353139
400608	IS_Wall_SD	2.14	Level 1	0.07	Sliding Door	353117
400608	IS_Wall_L	2.14	Level 1	0.07	Lavatory	353140
400609	IS_Wall_B	0.80	Level 1	0.07	Shower	353136
400609	IS_Wall_B	0.84	Level 1	0.07	Shower	630010
400609	IS_Wall_D	1.27	Level 1	0.07	Door	353118
400609	IS_Wall_B	1.57	Level 1	0.07	Shower	353121
400609	IS_Parede_Geral	1.90	Level 1	0.07	Commom Wall	353135
400609	IS_Parede_Geral	1.93	Level 1	0.07	Commom Wall	353133
400609	IS_Wall_LBT	2.84	Level 1	0.07	Toilet+Bidet+Lavatory	353134
400610	IS_Parede_Geral	1.57	Level 1	0.07	Commom Wall	353102
400610	IS_Wall_B	1.57	Level 1	0.07	Shower	353105
400610	IS_Wall_LT	2.58	Level 1	0.07	Toilet+Lavatory	353103
400610	IS_Wall_SD	2.58	Level 1	0.07	Sliding Door	353104
400611	IS_Wall_T	1.37	Level 1	0.07	Toilet	353108
400611	IS_Parede_Geral	1.37	Level 1	0.07	Commom Wall	353110
400611	IS_Wall_L	1.77	Level 1	0.07	Lavatory	353109
400611	IS_Wall_SD	1.77	Level 1	0.07	Sliding Door	353111
400612	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	629282
400612	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	629400
400612	IS_Wall_TB	1.97	Level 1	0.07	Toilet+Bidet	353093
400612	IS_Wall_BT	1.97	Level 1	0.07	Bathtub	353097
400612	IS_Wall_L	2.04	Level 1	0.07	Lavatory	353094
400612	IS_Wall_SD	2.04	Level 1	0.07	Sliding Door	353095

400613	IS_Wall_B	0.84	Level 1	0.07	Shower	629618
400613	IS_Wall_T	0.94	Level 1	0.07	Toilet	353731
400613	IS_Wall_B	1.06	Level 1	0.07	Shower	353728
400613	IS_Wall_L	1.23	Level 1	0.07	Lavatory	629593
400613	IS_Parede_Geral	1.77	Level 1	0.07	Commom Wall	353729
400613	IS_Wall_SD	2.28	Level 1	0.07	Sliding Door	353730
400614	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	353779
400614	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	629547
400614	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	353778
400614	IS_Wall_L	1.67	Level 1	0.07	Lavatory	353780
400614	IS_Wall_SD	2.54	Level 1	0.07	Sliding Door	353777
400614	IS_Wall_TB	2.54	Level 1	0.07	Toilet+Bidet	629488
400615	IS_Wall_BT	0.80	Level 1	0.07	Bathtub	353069
400615	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	353071
400615	IS_Wall_SD	1.25	Level 1	0.07	Sliding Door	353022
400615	IS_Parede_Geral	1.51	Level 1	0.07	Commom Wall	629131
400615	IS_Parede_Geral	1.54	Level 1	0.07	Commom Wall	353067
400615	IS_Wall_BT	1.77	Level 1	0.07	Bathtub	353028
400615	IS_Wall_LBT	3.02	Level 1	0.07	Toilet+Bidet+Lavatory	353068
400616	IS_Wall_B	0.84	Level 1	0.07	Shower	353065
400616	IS_Wall_B	0.84	Level 1	0.07	Shower	629221
400616	IS_Wall_SD	1.49	Level 1	0.07	Sliding Door	352975
400616	IS_Wall_L	1.49	Level 1	0.07	Lavatory	629193
400616	IS_Wall_B	1.67	Level 1	0.07	Shower	352979
400616	IS_Wall_T	1.67	Level 1	0.07	Toilet	353066
400617	IS_Wall_B	0.80	Level 1	0.07	Shower	353054
400617	IS_Wall_B	0.84	Level 1	0.07	Shower	629010
400617	IS_Wall_D	1.43	Level 1	0.07	Door	353024
400617	IS_Wall_B	1.57	Level 1	0.07	Shower	352981
400617	IS_Parede_Geral	1.59	Level 1	0.07	Commom Wall	353057
400617	IS_Parede_Geral	1.63	Level 1	0.07	Commom Wall	353058
400617	IS_Wall_LBT	3.00	Level 1	0.07	Toilet+Bidet+Lavatory	353056
400618	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	628951
400618	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	628997
400618	IS_Parede_Geral	1.86	Level 1	0.07	Commom Wall	353051
400618	IS_Wall_BT	1.86	Level 1	0.07	Bathtub	353053
400618	IS_Wall_LBT	2.64	Level 1	0.07	Toilet+Bidet+Lavatory	353052
400618	IS_Wall_SD	2.64	Level 1	0.07	Sliding Door	353101
400619	IS_Wall_B	0.80	Level 1	0.07	Shower	353050
400619	IS_Wall_B	0.84	Level 1	0.07	Shower	353047
400619	IS_Wall_D	1.41	Level 1	0.07	Door	352976
400619	IS_Wall_B	1.57	Level 1	0.07	Shower	353029
400619	IS_Wall_TB	1.72	Level 1	0.07	Toilet+Bidet	628910
400619	IS_Parede_Geral	1.75	Level 1	0.07	Commom Wall	353049
400619	IS_Wall_L	2.98	Level 1	0.07	Lavatory	353048
400620	IS_Wall_B	0.84	Level 1	0.07	Shower	628845
400620	IS_Wall_B	0.84	Level 1	0.07	Shower	628873
400620	IS_Wall_B	1.47	Level 1	0.07	Shower	352982
400620	IS_Wall_T	1.47	Level 1	0.07	Toilet	353043
400620	IS_Wall_SD	1.68	Level 1	0.07	Sliding Door	352977
400620	IS_Wall_L	1.68	Level 1	0.07	Lavatory	353042

400621	IS_Wall_B	0.84	Level 1	0.07	Shower	353026
400621	IS_Wall_B	0.84	Level 1	0.07	Shower	353036
400621	IS_Wall_SD	1.59	Level 1	0.07	Sliding Door	628555
400621	IS_Wall_L	1.59	Level 1	0.07	Lavatory	628590
400621	IS_Wall_B	1.67	Level 1	0.07	Shower	352984
400621	IS_Wall_T	1.67	Level 1	0.07	Toilet	353034
400622	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	353025
400622	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	353040
400622	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	352983
400622	IS_Wall_L	1.67	Level 1	0.07	Lavatory	353038
400622	IS_Wall_TB	2.54	Level 1	0.07	Toilet+Bidet	628687
400622	IS_Wall_SD	2.54	Level 1	0.07	Sliding Door	628760
400623	IS_Wall_B	0.84	Level 1	0.07	Shower	353030
400623	IS_Wall_B	0.84	Level 1	0.07	Shower	628521
400623	IS_Wall_B	1.67	Level 1	0.07	Shower	352985
400623	IS_Wall_D	1.67	Level 1	0.07	Door	353027
400623	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	353031
400623	IS_Parede_Geral	1.84	Level 1	0.07	Commom Wall	628436
400624	IS_Parede_Geral	1.57	Level 1	0.07	Commom Wall	352459
400624	IS_Wall_B	1.57	Level 1	0.07	Shower	352576
400624	IS_Wall_LT	2.58	Level 1	0.07	Toilet+Lavatory	352492
400624	IS_Wall_SD	2.58	Level 1	0.07	Sliding Door	352536
400625	IS_Wall_T	1.37	Level 1	0.07	Toilet	352706
400625	IS_Parede_Geral	1.37	Level 1	0.07	Commom Wall	352772
400625	IS_Wall_L	1.77	Level 1	0.07	Lavatory	352738
400625	IS_Wall_SD	1.77	Level 1	0.07	Sliding Door	352805
400626	IS_Parede_Geral	1.48	Level 1	0.07	Commom Wall	351435
400626	IS_Wall_SD	1.48	Level 1	0.07	Sliding Door	351495
400626	IS_Parede_Geral	1.66	Level 1	0.07	Commom Wall	351473
400626	IS_Wall_LT	1.66	Level 1	0.07	Toilet+Lavatory	351518
400627	IS_Wall_B	0.84	Level 1	0.07	Shower	351553
400627	IS_Wall_B	0.84	Level 1	0.07	Shower	624625
400627	IS_Parede_Geral	1.47	Level 1	0.07	Commom Wall	351591
400627	IS_Wall_B	1.47	Level 1	0.07	Shower	351740
400627	IS_Wall_SD	1.84	Level 1	0.07	Sliding Door	351624
400627	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	624543
400628	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	345428
400628	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	624173
400628	IS_Wall_BT	1.84	Level 1	0.07	Bathtub	344870
400628	IS_Wall_TB	1.84	Level 1	0.07	Toilet+Bidet	344872
400628	IS_Wall_SD	2.44	Level 1	0.07	Sliding Door	345456
400628	IS_Wall_L	2.44	Level 1	0.07	Lavatory	624163
400629	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	345060
400629	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	624313
400629	IS_Wall_TB	1.97	Level 1	0.07	Toilet+Bidet	345056
400629	IS_Wall_BT	1.97	Level 1	0.07	Bathtub	345058
400629	IS_Wall_L	1.99	Level 1	0.07	Lavatory	345059
400629	IS_Wall_SD	1.99	Level 1	0.07	Sliding Door	624380
400630	IS_Wall_BT	0.80	Level 1	0.07	Bathtub	344931
400630	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	624716
400630	IS_Wall_D	1.35	Level 1	0.07	Door	344509

400630	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	344519
400630	IS_Wall_TB	1.71	Level 1	0.07	Toilet+Bidet	344930
400630	IS_Parede_Geral	1.75	Level 1	0.07	Commom Wall	344928
400630	IS_Wall_L	3.02	Level 1	0.07	Lavatory	344929
400631	IS_Wall_B	0.84	Level 1	0.07	Shower	344908
400631	IS_Wall_B	0.84	Level 1	0.07	Shower	623631
400631	IS_Wall_SD	1.67	Level 1	0.07	Sliding Door	344508
400631	IS_Wall_B	1.67	Level 1	0.07	Shower	344514
400631	IS_Parede_Geral	1.82	Level 1	0.07	Commom Wall	344907
400631	IS_Wall_LT	1.82	Level 1	0.07	Toilet+Lavatory	623442
400632	IS_Wall_SD	1.44	Level 1	0.07	Sliding Door	344506
400632	IS_Parede_Geral	1.44	Level 1	0.07	Commom Wall	344911
400632	IS_Parede_Geral	1.92	Level 1	0.07	Commom Wall	344912
400632	IS_Wall_LT	1.92	Level 1	0.07	Toilet+Lavatory	344913
400633	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344507
400633	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	623545
400633	IS_Wall_BT	1.92	Level 1	0.07	Bathtub	344513
400633	IS_Parede_Geral	1.92	Level 1	0.07	Commom Wall	344915
400633	IS_Wall_LBT	2.24	Level 1	0.07	Toilet+Bidet+Lavatory	344914
400633	IS_Wall_SD	2.24	Level 1	0.07	Sliding Door	623686
400634	IS_Wall_B	0.84	Level 1	0.07	Shower	623218
400634	IS_Wall_B	0.84	Level 1	0.07	Shower	623244
400634	IS_Wall_SD	1.44	Level 1	0.07	Sliding Door	344505
400634	IS_Parede_Geral	1.44	Level 1	0.07	Commom Wall	344906
400634	IS_Wall_B	1.92	Level 1	0.07	Shower	344516
400634	IS_Wall_LT	1.92	Level 1	0.07	Toilet+Lavatory	344905
400635	IS_Wall_T	1.38	Level 2	0.07	Toilet	358055
400635	IS_Parede_Geral	1.38	Level 2	0.07	Commom Wall	358057
400635	IS_Wall_SD	1.72	Level 2	0.07	Sliding Door	358054
400635	IS_Wall_L	1.72	Level 2	0.07	Lavatory	358056
400636	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344504
400636	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344900
400636	IS_Wall_BT	1.97	Level 1	0.07	Bathtub	344515
400636	IS_Wall_TB	1.97	Level 1	0.07	Toilet+Bidet	344899
400636	IS_Wall_SD	2.10	Level 1	0.07	Sliding Door	623258
400636	IS_Wall_L	2.10	Level 1	0.07	Lavatory	623290
400637	IS_Wall_B	0.12	Level 1	0.07	Shower	344896
400637	IS_Wall_B	0.80	Level 1	0.07	Shower	344898
400637	IS_Wall_B	0.87	Level 1	0.07	Shower	344897
400637	IS_Wall_D	1.29	Level 1	0.07	Door	344502
400637	IS_Wall_B	1.57	Level 1	0.07	Shower	344517
400637	IS_Wall_B	1.75	Level 1	0.07	Shower	344895
400637	IS_Parede_Geral	1.82	Level 1	0.07	Commom Wall	344893
400637	IS_Wall_LBT	2.74	Level 1	0.07	Toilet+Bidet+Lavatory	344894
400638	IS_Wall_B	0.84	Level 1	0.07	Shower	344511
400638	IS_Wall_B	0.84	Level 1	0.07	Shower	624920
400638	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	344883
400638	IS_Wall_SD	1.84	Level 1	0.07	Sliding Door	624948
400638	IS_Wall_B	1.87	Level 1	0.07	Shower	344521
400638	IS_Parede_Geral	1.87	Level 1	0.07	Commom Wall	344884
400639	IS_Parede_Geral	0.48	Level 1	0.07	Commom Wall	344891

400639	IS_Wall_B	0.84	Level 1	0.07	Shower	344890
400639	IS_Wall_B	0.84	Level 1	0.07	Shower	624848
400639	IS_Parede_Geral	1.11	Level 1	0.07	Commom Wall	624883
400639	IS_Wall_D	1.12	Level 1	0.07	Door	344510
400639	IS_Wall_B	1.47	Level 1	0.07	Shower	344520
400639	IS_Parede_Geral	1.95	Level 1	0.07	Commom Wall	344892
400639	IS_Wall_LT	2.24	Level 1	0.07	Toilet+Lavatory	344887
400640	IS_Parede_Geral	1.60	Level 1	0.07	Commom Wall	344879
400640	IS_Parede_Geral	1.60	Level 1	0.07	Commom Wall	344881
400640	IS_Wall_D	1.87	Level 1	0.07	Door	344880
400640	IS_Wall_LT	1.87	Level 1	0.07	Toilet+Lavatory	344882
400642	IS_Wall_B	0.84	Level 1	0.07	Shower	344864
400642	IS_Wall_B	0.84	Level 1	0.07	Shower	344868
400642	IS_Wall_T	1.47	Level 1	0.07	Toilet	344863
400642	IS_Wall_B	1.47	Level 1	0.07	Shower	344865
400642	IS_Wall_SD	1.69	Level 1	0.07	Sliding Door	624768
400642	IS_Wall_L	1.69	Level 1	0.07	Lavatory	624805
400643	IS_Wall_B	0.84	Level 1	0.07	Shower	344852
400643	IS_Wall_B	0.84	Level 1	0.07	Shower	623758
400643	IS_Wall_L	1.49	Level 1	0.07	Lavatory	344862
400643	IS_Wall_SD	1.49	Level 1	0.07	Sliding Door	623798
400643	IS_Wall_B	1.67	Level 1	0.07	Shower	344853
400643	IS_Wall_T	1.67	Level 1	0.07	Toilet	344861
400644	IS_Wall_BT	0.80	Level 1	0.07	Bathtub	344854
400644	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	623844
400644	IS_Wall_SD	1.22	Level 1	0.07	Sliding Door	344503
400644	IS_Parede_Geral	1.69	Level 1	0.07	Commom Wall	344857
400644	IS_Parede_Geral	1.72	Level 1	0.07	Commom Wall	344855
400644	IS_Wall_BT	1.77	Level 1	0.07	Bathtub	344518
400644	IS_Wall_LBT	2.99	Level 1	0.07	Toilet+Bidet+Lavatory	344856
400645	IS_Wall_BT	0.80	Level 1	0.07	Bathtub	344847
400645	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344849
400645	IS_Wall_SD	1.25	Level 1	0.07	Sliding Door	344796
400645	IS_Parede_Geral	1.51	Level 1	0.07	Commom Wall	625548
400645	IS_Parede_Geral	1.54	Level 1	0.07	Commom Wall	344845
400645	IS_Wall_BT	1.77	Level 1	0.07	Bathtub	344803
400645	IS_Wall_LBT	3.02	Level 1	0.07	Toilet+Bidet+Lavatory	344846
400646	IS_Wall_B	0.84	Level 1	0.07	Shower	344843
400646	IS_Wall_B	0.84	Level 1	0.07	Shower	625598
400646	IS_Wall_SD	1.44	Level 1	0.07	Sliding Door	344452
400646	IS_Wall_L	1.44	Level 1	0.07	Lavatory	625582
400646	IS_Wall_B	1.67	Level 1	0.07	Shower	344523
400646	IS_Wall_T	1.67	Level 1	0.07	Toilet	344844
400647	IS_Wall_B	0.84	Level 1	0.07	Shower	344797
400647	IS_Wall_B	0.84	Level 1	0.07	Shower	626027
400647	IS_Wall_B	1.54	Level 1	0.07	Shower	344524
400647	IS_Parede_Geral	1.54	Level 1	0.07	Commom Wall	344837
400647	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	344838
400647	IS_Wall_SD	1.84	Level 1	0.07	Sliding Door	626020
400648	IS_Wall_B	0.80	Level 1	0.07	Shower	344832
400648	IS_Wall_B	0.84	Level 1	0.07	Shower	625755

400648	IS_Wall_D	1.43	Level 1	0.07	Door	344798
400648	IS_Wall_B	1.57	Level 1	0.07	Shower	344525
400648	IS_Parede_Geral	1.59	Level 1	0.07	Commom Wall	344835
400648	IS_Parede_Geral	1.63	Level 1	0.07	Commom Wall	344836
400648	IS_Wall_LBT	3.00	Level 1	0.07	Toilet+Bidet+Lavatory	344834
400649	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	625889
400649	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	625944
400649	IS_Parede_Geral	1.86	Level 1	0.07	Commom Wall	344827
400649	IS_Wall_BT	1.86	Level 1	0.07	Bathtub	344829
400649	IS_Wall_LBT	2.64	Level 1	0.07	Toilet+Bidet+Lavatory	344828
400649	IS_Wall_SD	2.64	Level 1	0.07	Sliding Door	352431
400650	IS_Wall_B	0.80	Level 1	0.07	Shower	344826
400650	IS_Wall_B	0.84	Level 1	0.07	Shower	344823
400650	IS_Wall_D	1.41	Level 1	0.07	Door	344453
400650	IS_Wall_B	1.57	Level 1	0.07	Shower	344804
400650	IS_Wall_TB	1.72	Level 1	0.07	Toilet+Bidet	626103
400650	IS_Parede_Geral	1.75	Level 1	0.07	Commom Wall	344825
400650	IS_Wall_L	2.98	Level 1	0.07	Lavatory	344824
400651	IS_Wall_B	0.84	Level 1	0.07	Shower	626195
400651	IS_Wall_B	0.84	Level 1	0.07	Shower	626250
400651	IS_Wall_B	1.47	Level 1	0.07	Shower	344527
400651	IS_Wall_T	1.47	Level 1	0.07	Toilet	344819
400651	IS_Wall_SD	1.74	Level 1	0.07	Sliding Door	344454
400651	IS_Wall_L	1.74	Level 1	0.07	Lavatory	344818
400652	IS_Wall_B	0.84	Level 1	0.07	Shower	344801
400652	IS_Wall_B	0.84	Level 1	0.07	Shower	344812
400652	IS_Wall_SD	1.59	Level 1	0.07	Sliding Door	626475
400652	IS_Wall_L	1.59	Level 1	0.07	Lavatory	626482
400652	IS_Wall_B	1.62	Level 1	0.07	Shower	344529
400652	IS_Wall_T	1.62	Level 1	0.07	Toilet	344810
400653	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344800
400653	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344816
400653	IS_Wall_BT	1.57	Level 1	0.07	Bathtub	344528
400653	IS_Wall_L	1.57	Level 1	0.07	Lavatory	344814
400653	IS_Wall_TB	2.54	Level 1	0.07	Toilet+Bidet	626305
400653	IS_Wall_SD	2.54	Level 1	0.07	Sliding Door	626339
400654	IS_Wall_B	0.84	Level 1	0.07	Shower	344806
400654	IS_Wall_B	0.84	Level 1	0.07	Shower	626564
400654	IS_Wall_B	1.67	Level 1	0.07	Shower	344530
400654	IS_Wall_D	1.67	Level 1	0.07	Door	344802
400654	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	344807
400654	IS_Parede_Geral	1.84	Level 1	0.07	Commom Wall	626643
400655	IS_Wall_B	1.56	Level 1	0.07	Shower	344791
400655	IS_Parede_Geral	1.56	Level 1	0.07	Commom Wall	344795
400655	IS_Wall_SD	2.47	Level 1	0.07	Sliding Door	344790
400655	IS_Wall_LT	2.47	Level 1	0.07	Toilet+Lavatory	344794
400656	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344786
400656	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	625256
400656	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	344768
400656	IS_Wall_L	1.67	Level 1	0.07	Lavatory	344787
400656	IS_Wall_SD	2.54	Level 1	0.07	Sliding Door	344760

400656	IS_Wall_TB	2.54	Level 1	0.07	Toilet+Bidet	625314
400657	IS_Wall_B	0.84	Level 1	0.07	Shower	625185
400657	IS_Wall_T	0.92	Level 1	0.07	Toilet	351993
400657	IS_Wall_B	1.04	Level 1	0.07	Shower	351925
400657	IS_Wall_L	1.28	Level 1	0.07	Lavatory	625136
400657	IS_Parede_Geral	1.75	Level 1	0.07	Commom Wall	351945
400657	IS_Wall_SD	2.32	Level 1	0.07	Sliding Door	351975
400658	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	625480
400658	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	625514
400658	IS_Wall_TB	1.97	Level 1	0.07	Toilet+Bidet	352042
400658	IS_Wall_BT	1.97	Level 1	0.07	Bathtub	352212
400658	IS_Wall_L	1.99	Level 1	0.07	Lavatory	352086
400658	IS_Wall_SD	1.99	Level 1	0.07	Sliding Door	352124
400659	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	625059
400659	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	625084
400659	IS_Wall_BT	1.97	Level 1	0.07	Bathtub	344764
400659	IS_Wall_TB	1.97	Level 1	0.07	Toilet+Bidet	344783
400659	IS_Wall_SD	2.14	Level 1	0.07	Sliding Door	344761
400659	IS_Wall_L	2.14	Level 1	0.07	Lavatory	344784
400660	IS_Wall_B	0.80	Level 1	0.07	Shower	344780
400660	IS_Wall_D	1.27	Level 1	0.07	Door	344762
400660	IS_Wall_B	1.57	Level 1	0.07	Shower	344765
400660	IS_Parede_Geral	1.85	Level 1	0.07	Commom Wall	344777
400660	IS_Wall_B	2.65	Level 1	0.07	Shower	344779
400660	IS_Wall_LBT	2.84	Level 1	0.07	Toilet+Bidet+Lavatory	344778
400661	IS_Wall_B	1.47	Level 1	0.07	Shower	344766
400661	IS_Parede_Geral	1.47	Level 1	0.07	Commom Wall	344774
400661	IS_Wall_SD	2.58	Level 1	0.07	Sliding Door	344763
400661	IS_Wall_LT	2.58	Level 1	0.07	Toilet+Lavatory	344773
400662	IS_Wall_D	1.82	Level 1	0.07	Door	344457
400662	IS_Wall_BT	1.82	Level 1	0.07	Bathtub	344767
400662	IS_Wall_BT	3.17	Level 1	0.07	Bathtub	344769
400662	IS_Wall_LBT	3.17	Level 1	0.07	Toilet+Bidet+Lavatory	344770
400663	IS_Wall_B	0.84	Level 1	0.07	Shower	344500
400663	IS_Wall_B	0.84	Level 1	0.07	Shower	630417
400663	IS_Wall_B	1.47	Level 1	0.07	Shower	344554
400663	IS_Parede_Geral	1.47	Level 1	0.07	Commom Wall	344689
400663	IS_Wall_LT	1.75	Level 1	0.07	Toilet+Lavatory	344690
400663	IS_Wall_SD	1.75	Level 1	0.07	Sliding Door	630469
400664	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344687
400664	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	630612
400664	IS_Wall_D	1.87	Level 1	0.07	Door	344501
400664	IS_Wall_BT	1.87	Level 1	0.07	Bathtub	344553
400664	IS_Wall_LBT	2.44	Level 1	0.07	Toilet+Bidet+Lavatory	344685
400664	IS_Parede_Geral	2.44	Level 1	0.07	Commom Wall	630569
400665	IS_Wall_B	0.80	Level 1	0.07	Shower	344684
400665	IS_Wall_B	0.84	Level 1	0.07	Shower	630762
400665	IS_Wall_D	1.27	Level 1	0.07	Door	344476
400665	IS_Wall_B	1.57	Level 1	0.07	Shower	344552
400665	IS_Parede_Geral	1.90	Level 1	0.07	Commom Wall	344681
400665	IS_Parede_Geral	1.93	Level 1	0.07	Commom Wall	344682

400665	IS_Wall_LBT	2.84	Level 1	0.07	Toilet+Bidet+Lavatory	344680
400666	IS_Wall_B	0.84	Level 1	0.07	Shower	630658
400666	IS_Parede_Geral	0.84	Level 1	0.07	Commom Wall	630719
400666	IS_Wall_B	1.57	Level 1	0.07	Shower	344551
400666	IS_Parede_Geral	1.57	Level 1	0.07	Commom Wall	344676
400666	IS_Wall_SD	1.68	Level 1	0.07	Sliding Door	344475
400666	IS_Wall_LT	1.68	Level 1	0.07	Toilet+Lavatory	344677
400667	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344674
400667	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	630826
400667	IS_Wall_BT	1.97	Level 1	0.07	Bathtub	344550
400667	IS_Wall_TB	1.97	Level 1	0.07	Toilet+Bidet	344675
400667	IS_Wall_SD	2.14	Level 1	0.07	Sliding Door	344474
400667	IS_Wall_L	2.14	Level 1	0.07	Lavatory	630869
400668	IS_Wall_BT	0.80	Level 1	0.07	Bathtub	344665
400668	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344667
400668	IS_Wall_SD	1.30	Level 1	0.07	Sliding Door	344478
400668	IS_Parede_Geral	1.54	Level 1	0.07	Commom Wall	631394
400668	IS_Parede_Geral	1.57	Level 1	0.07	Commom Wall	344663
400668	IS_Wall_BT	1.77	Level 1	0.07	Bathtub	344548
400668	IS_Wall_LBT	3.07	Level 1	0.07	Toilet+Bidet+Lavatory	344664
400669	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344661
400669	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	631536
400669	IS_Wall_SD	1.49	Level 1	0.07	Sliding Door	344479
400669	IS_Wall_L	1.49	Level 1	0.07	Lavatory	631552
400669	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	344547
400669	IS_Wall_T	1.67	Level 1	0.07	Toilet	344662
400670	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344480
400670	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	631801
400670	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	344557
400670	IS_Parede_Geral	1.67	Level 1	0.07	Commom Wall	344655
400670	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	344656
400670	IS_Wall_SD	1.84	Level 1	0.07	Sliding Door	631779
400671	IS_Wall_BT	0.80	Level 1	0.07	Bathtub	344650
400671	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	631706
400671	IS_Wall_D	1.43	Level 1	0.07	Door	344481
400671	IS_Wall_BT	1.57	Level 1	0.07	Bathtub	344555
400671	IS_Parede_Geral	1.59	Level 1	0.07	Commom Wall	344653
400671	IS_Parede_Geral	1.63	Level 1	0.07	Commom Wall	344654
400671	IS_Wall_LBT	3.00	Level 1	0.07	Toilet+Bidet+Lavatory	344652
400672	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	631874
400672	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	631911
400672	IS_Parede_Geral	1.86	Level 1	0.07	Commom Wall	344645
400672	IS_Wall_BT	1.86	Level 1	0.07	Bathtub	344647
400672	IS_Wall_LBT	2.64	Level 1	0.07	Toilet+Bidet+Lavatory	344646
400672	IS_Wall_SD	2.64	Level 1	0.07	Sliding Door	356148
400673	IS_Wall_BT	0.80	Level 1	0.07	Bathtub	344644
400673	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344641
400673	IS_Wall_D	1.33	Level 1	0.07	Door	344484
400673	IS_Wall_BT	1.57	Level 1	0.07	Bathtub	344558
400673	IS_Wall_T	1.72	Level 1	0.07	Toilet	631942
400673	IS_Parede_Geral	1.75	Level 1	0.07	Commom Wall	344643

400673	IS_Wall_L	2.90	Level 1	0.07	Lavatory	344642
400674	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	631985
400674	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	632231
400674	IS_Wall_BT	1.47	Level 1	0.07	Bathtub	344559
400674	IS_Wall_T	1.47	Level 1	0.07	Toilet	344637
400674	IS_Wall_SD	1.64	Level 1	0.07	Sliding Door	344483
400674	IS_Wall_L	1.64	Level 1	0.07	Lavatory	344636
400675	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344486
400675	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344630
400675	IS_Wall_SD	1.59	Level 1	0.07	Sliding Door	632472
400675	IS_Wall_L	1.59	Level 1	0.07	Lavatory	632503
400675	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	344561
400675	IS_Wall_T	1.67	Level 1	0.07	Toilet	344628
400676	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344485
400676	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344634
400676	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	344560
400676	IS_Wall_L	1.67	Level 1	0.07	Lavatory	344632
400676	IS_Wall_TB	2.54	Level 1	0.07	Toilet+Bidet	632301
400676	IS_Wall_SD	2.54	Level 1	0.07	Sliding Door	632378
400677	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344624
400677	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	632614
400677	IS_Wall_D	1.67	Level 1	0.07	Door	344487
400677	IS_Wall_BT	1.67	Level 1	0.07	Bathtub	344562
400677	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	344625
400677	IS_Parede_Geral	1.84	Level 1	0.07	Commom Wall	632552
400678	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344620
400678	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344622
400678	IS_Wall_TB	1.87	Level 1	0.07	Toilet+Bidet	344489
400678	IS_Wall_BT	1.87	Level 1	0.07	Bathtub	344564
400678	IS_Wall_L	2.55	Level 1	0.07	Lavatory	632765
400678	IS_Wall_SD	2.55	Level 1	0.07	Sliding Door	632836
400679	IS_Wall_B	0.80	Level 1	0.07	Shower	344615
400679	IS_Wall_B	0.84	Level 1	0.07	Shower	344613
400679	IS_Wall_D	1.41	Level 1	0.07	Door	356620
400679	IS_Wall_B	1.58	Level 1	0.07	Shower	344565
400679	IS_Wall_TB	1.72	Level 1	0.07	Toilet+Bidet	632960
400679	IS_Parede_Geral	1.75	Level 1	0.07	Commom Wall	356661
400679	IS_Wall_L	2.99	Level 1	0.07	Lavatory	344612
400680	IS_Wall_B	0.84	Level 1	0.07	Shower	344492
400680	IS_Wall_B	0.84	Level 1	0.07	Shower	344602
400680	IS_Wall_B	1.67	Level 1	0.07	Shower	344567
400680	IS_Parede_Geral	1.67	Level 1	0.07	Commom Wall	344603
400680	IS_Wall_SD	1.78	Level 1	0.07	Sliding Door	633248
400680	IS_Wall_LT	1.78	Level 1	0.07	Toilet+Lavatory	633270
400681	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344610
400681	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	633169
400681	IS_Wall_BT	1.72	Level 1	0.07	Bathtub	344566
400681	IS_Parede_Geral	1.72	Level 1	0.07	Commom Wall	344608
400681	IS_Wall_SD	2.44	Level 1	0.07	Sliding Door	344491
400681	IS_Wall_LBT	2.44	Level 1	0.07	Toilet+Bidet+Lavatory	633096
400682	IS_Wall_B	0.84	Level 1	0.07	Shower	344595

400682	IS_Wall_B	0.84	Level 1	0.07	Shower	344596
400682	IS_Wall_D	1.67	Level 1	0.07	Door	344494
400682	IS_Wall_B	1.67	Level 1	0.07	Shower	344569
400682	IS_Parede_Geral	1.84	Level 1	0.07	Commom Wall	633420
400682	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	633472
400683	IS_Wall_B	0.84	Level 1	0.07	Shower	344607
400683	IS_Wall_B	0.84	Level 1	0.07	Shower	633377
400683	IS_Wall_D	1.67	Level 1	0.07	Door	344493
400683	IS_Wall_B	1.67	Level 1	0.07	Shower	344568
400683	IS_Parede_Geral	1.84	Level 1	0.07	Commom Wall	344604
400683	IS_Wall_LT	1.84	Level 1	0.07	Toilet+Lavatory	633325
400684	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344588
400684	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	633761
400684	IS_Wall_BT	1.57	Level 1	0.07	Bathtub	344571
400684	IS_Wall_L	1.57	Level 1	0.07	Lavatory	344589
400684	IS_Wall_SD	2.53	Level 1	0.07	Sliding Door	344496
400684	IS_Wall_TB	2.54	Level 1	0.07	Toilet+Bidet	633830
400685	IS_Wall_B	0.84	Level 1	0.07	Shower	344598
400685	IS_Wall_B	0.84	Level 1	0.07	Shower	633566
400685	IS_Wall_SD	1.59	Level 1	0.07	Sliding Door	344495
400685	IS_Wall_L	1.59	Level 1	0.07	Lavatory	633615
400685	IS_Wall_B	1.67	Level 1	0.07	Shower	344570
400685	IS_Wall_T	1.67	Level 1	0.07	Toilet	344594
400686	IS_Wall_B	0.84	Level 1	0.07	Shower	344497
400686	IS_Wall_B	0.84	Level 1	0.07	Shower	344585
400686	IS_Wall_B	1.47	Level 1	0.07	Shower	344572
400686	IS_Wall_T	1.47	Level 1	0.07	Toilet	344584
400686	IS_Wall_L	1.69	Level 1	0.07	Lavatory	634023
400686	IS_Wall_SD	1.69	Level 1	0.07	Sliding Door	634063
400687	IS_Wall_B	0.80	Level 1	0.07	Shower	344578
400687	IS_Wall_B	0.84	Level 1	0.07	Shower	344583
400687	IS_Wall_D	1.42	Level 1	0.07	Door	344498
400687	IS_Wall_B	1.57	Level 1	0.07	Shower	344573
400687	IS_Wall_TB	1.72	Level 1	0.07	Toilet+Bidet	634145
400687	IS_Parede_Geral	1.75	Level 1	0.07	Commom Wall	344580
400687	IS_Wall_L	2.99	Level 1	0.07	Lavatory	344582
400688	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	344499
400688	IS_Wall_BT	0.84	Level 1	0.07	Bathtub	634567
400688	IS_Wall_BT	1.72	Level 1	0.07	Bathtub	344574
400688	IS_Parede_Geral	1.72	Level 1	0.07	Commom Wall	344579
400688	IS_Wall_LBT	3.13	Level 1	0.07	Toilet+Bidet+Lavatory	344581
400688	IS_Wall_SD	3.13	Level 1	0.07	Sliding Door	634445
400803	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	367384
400803	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	640373
400803	IS_Parede_Geral	1.87	Level 2	0.07	Commom Wall	367427
400803	IS_Wall_BT	1.87	Level 2	0.07	Bathtub	367525
400803	IS_Wall_SD	2.71	Level 2	0.07	Sliding Door	367469
400803	IS_Wall_LBT	2.71	Level 2	0.07	Toilet+Bidet+Lavatory	640309
400804	IS_Wall_T	0.84	Level 2	0.07	Toilet	367196
400804	IS_Wall_B	0.84	Level 2	0.07	Shower	640471
400804	IS_Wall_L	1.04	Level 2	0.07	Lavatory	367021

400804	IS_Wall_B	1.04	Level 2	0.07	Shower	640455
400804	IS_Wall_SD	1.87	Level 2	0.07	Sliding Door	367154
400804	IS_Parede_Geral	1.88	Level 2	0.07	Commom Wall	367098
400805	IS_Wall_B	0.84	Level 2	0.07	Shower	366630
400805	IS_Wall_B	0.84	Level 2	0.07	Shower	640589
400805	IS_Wall_T	1.77	Level 2	0.07	Toilet	366675
400805	IS_Wall_B	1.77	Level 2	0.07	Shower	366749
400805	IS_Wall_L	1.96	Level 2	0.07	Lavatory	366712
400805	IS_Wall_SD	1.96	Level 2	0.07	Sliding Door	640647
400806	IS_Parede_Geral	1.57	Level 2	0.07	Commom Wall	366401
400806	IS_Wall_SD	1.57	Level 2	0.07	Sliding Door	366523
400806	IS_Parede_Geral	1.85	Level 2	0.07	Commom Wall	366461
400806	IS_Wall_LT	1.85	Level 2	0.07	Toilet+Lavatory	366564
400807	IS_Wall_B	0.84	Level 2	0.07	Shower	366273
400807	IS_Wall_B	0.84	Level 2	0.07	Shower	640968
400807	IS_Wall_L	1.49	Level 2	0.07	Lavatory	366212
400807	IS_Wall_SD	1.49	Level 2	0.07	Sliding Door	640955
400807	IS_Wall_T	1.67	Level 2	0.07	Toilet	366128
400807	IS_Wall_B	1.67	Level 2	0.07	Shower	366343
400808	IS_Wall_BT	0.80	Level 2	0.07	Bathtub	365905
400808	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	365781
400808	IS_Wall_SD	1.30	Level 2	0.07	Sliding Door	365878
400808	IS_Parede_Geral	1.52	Level 2	0.07	Commom Wall	640846
400808	IS_Parede_Geral	1.55	Level 2	0.07	Commom Wall	365855
400808	IS_Wall_BT	1.77	Level 2	0.07	Bathtub	365950
400808	IS_Wall_LBT	3.07	Level 2	0.07	Toilet+Bidet+Lavatory	365827
400809	IS_Wall_L	1.25	Level 2	0.07	Lavatory	365222
400809	IS_Wall_T	1.25	Level 2	0.07	Toilet	365313
400809	IS_Parede_Geral	2.23	Level 2	0.07	Commom Wall	365274
400809	IS_Wall_SD	2.23	Level 2	0.07	Sliding Door	365345
400810	IS_Parede_Geral	0.40	Level 2	0.07	Commom Wall	365584
400810	IS_Parede_Geral	0.41	Level 2	0.07	Commom Wall	365545
400810	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	365394
400810	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	639921
400810	IS_Wall_TB	1.67	Level 2	0.07	Toilet+Bidet	365498
400810	IS_Wall_BT	1.77	Level 2	0.07	Bathtub	365697
400810	IS_Wall_L	2.08	Level 2	0.07	Lavatory	639881
400810	IS_Wall_D	2.18	Level 2	0.07	Door	365458
400811	IS_Wall_B	0.84	Level 2	0.07	Shower	365065
400811	IS_Wall_B	0.84	Level 2	0.07	Shower	640025
400811	IS_Parede_Geral	1.87	Level 2	0.07	Commom Wall	364949
400811	IS_Wall_B	1.87	Level 2	0.07	Shower	365136
400811	IS_Wall_SD	2.49	Level 2	0.07	Sliding Door	365023
400811	IS_Wall_LBT	2.49	Level 2	0.07	Toilet+Bidet+Lavatory	640009
400812	IS_Wall_B	0.84	Level 2	0.07	Shower	364156
400812	IS_Wall_B	0.84	Level 2	0.07	Shower	639323
400812	IS_Wall_SD	1.48	Level 2	0.07	Sliding Door	364089
400812	IS_Parede_Geral	1.48	Level 2	0.07	Commom Wall	639237
400812	IS_Wall_LT	1.97	Level 2	0.07	Toilet+Lavatory	364008
400812	IS_Wall_B	1.97	Level 2	0.07	Shower	364116
400813	IS_Parede_Geral	0.54	Level 2	0.07	Commom Wall	364563

400813	IS_Parede_Geral	0.76	Level 2	0.07	Commom Wall	364596
400813	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	364518
400813	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	639184
400813	IS_Wall_TB	1.43	Level 2	0.07	Toilet+Bidet	364640
400813	IS_Wall_L	1.48	Level 2	0.07	Lavatory	639164
400813	IS_Wall_BT	1.97	Level 2	0.07	Bathtub	364331
400813	IS_Wall_SD	2.23	Level 2	0.07	Sliding Door	364680
400814	IS_Parede_Geral	1.37	Level 2	0.07	Commom Wall	364805
400814	IS_Wall_SD	1.37	Level 2	0.07	Sliding Door	364891
400814	IS_Parede_Geral	2.14	Level 2	0.07	Commom Wall	364737
400814	IS_Wall_LT	2.14	Level 2	0.07	Toilet+Lavatory	364848
400815	IS_Wall_B	0.84	Level 2	0.07	Shower	363842
400815	IS_Wall_B	0.84	Level 2	0.07	Shower	639417
400815	IS_Wall_D	1.77	Level 2	0.07	Door	363843
400815	IS_Wall_B	1.77	Level 2	0.07	Shower	363901
400815	IS_Wall_LT	2.04	Level 2	0.07	Toilet+Lavatory	363844
400815	IS_Parede_Geral	2.04	Level 2	0.07	Commom Wall	639514
400816	IS_Wall_T	1.57	Level 2	0.07	Toilet	363288
400816	IS_Wall_L	1.57	Level 2	0.07	Lavatory	363391
400816	IS_Wall_SD	2.03	Level 2	0.07	Sliding Door	363347
400816	IS_Parede_Geral	2.03	Level 2	0.07	Commom Wall	363437
400817	IS_Wall_B	0.84	Level 2	0.07	Shower	363667
400817	IS_Wall_B	0.84	Level 2	0.07	Shower	639620
400817	IS_Wall_B	1.67	Level 2	0.07	Shower	363543
400817	IS_Wall_D	1.67	Level 2	0.07	Door	363718
400817	IS_Wall_LT	1.82	Level 2	0.07	Toilet+Lavatory	363752
400817	IS_Parede_Geral	1.82	Level 2	0.07	Commom Wall	639682
400818	IS_Wall_T	0.82	Level 2	0.07	Toilet	362997
400818	IS_Wall_B	0.84	Level 2	0.07	Shower	363093
400818	IS_Wall_L	0.94	Level 2	0.07	Lavatory	635765
400818	IS_Wall_B	1.09	Level 2	0.07	Shower	635799
400818	IS_Parede_Geral	1.77	Level 2	0.07	Commom Wall	362966
400818	IS_Wall_SD	1.91	Level 2	0.07	Sliding Door	363118
400819	IS_Wall_B	0.84	Level 2	0.07	Shower	362828
400819	IS_Wall_B	0.84	Level 2	0.07	Shower	635991
400819	IS_Wall_B	1.77	Level 2	0.07	Shower	362707
400819	IS_Wall_T	1.77	Level 2	0.07	Toilet	362881
400819	IS_Wall_SD	1.87	Level 2	0.07	Sliding Door	362923
400819	IS_Wall_L	1.87	Level 2	0.07	Lavatory	636699
400820	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	362471
400820	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	636269
400820	IS_Wall_TB	1.87	Level 2	0.07	Toilet+Bidet	362340
400820	IS_Wall_BT	1.87	Level 2	0.07	Bathtub	362563
400820	IS_Wall_L	2.58	Level 2	0.07	Lavatory	362386
400820	IS_Wall_SD	2.58	Level 2	0.07	Sliding Door	636337
400821	IS_Wall_B	0.84	Level 2	0.07	Shower	362156
400821	IS_Wall_B	0.84	Level 2	0.07	Shower	635458
400821	IS_Parede_Geral	1.87	Level 2	0.07	Commom Wall	362019
400821	IS_Wall_B	1.87	Level 2	0.07	Shower	362258
400821	IS_Wall_SD	2.49	Level 2	0.07	Sliding Door	362113
400821	IS_Wall_LBT	2.49	Level 2	0.07	Toilet+Bidet+Lavatory	635400

400822	IS_Wall_T	1.25	Level 2	0.07	Toilet	361595
400822	IS_Parede_Geral	2.18	Level 2	0.07	Commom Wall	361558
400822	IS_Wall_SD	2.18	Level 2	0.07	Sliding Door	361639
400823	IS_Parede_Geral	0.37	Level 2	0.07	Commom Wall	361820
400823	IS_Parede_Geral	0.39	Level 2	0.07	Commom Wall	361840
400823	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	361700
400823	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	635177
400823	IS_Wall_TB	1.67	Level 2	0.07	Toilet+Bidet	361795
400823	IS_Wall_BT	1.76	Level 2	0.07	Bathtub	361942
400823	IS_Wall_L	2.06	Level 2	0.07	Lavatory	635127
400823	IS_Wall_D	2.13	Level 2	0.07	Door	361755
400824	IS_Parede_Geral	1.57	Level 2	0.07	Commom Wall	361322
400824	IS_Wall_SD	1.57	Level 2	0.07	Sliding Door	361386
400824	IS_Parede_Geral	1.84	Level 2	0.07	Commom Wall	361355
400824	IS_Wall_LT	1.84	Level 2	0.07	Toilet+Lavatory	361424
400825	IS_Wall_BT	0.80	Level 2	0.07	Bathtub	361192
400825	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	635528
400825	IS_Wall_SD	1.30	Level 2	0.07	Sliding Door	361142
400825	IS_Parede_Geral	1.56	Level 2	0.07	Commom Wall	361096
400825	IS_Parede_Geral	1.60	Level 2	0.07	Commom Wall	361022
400825	IS_Wall_BT	1.77	Level 2	0.07	Bathtub	361246
400825	IS_Wall_LBT	3.07	Level 2	0.07	Toilet+Bidet+Lavatory	361069
400826	IS_Wall_B	0.84	Level 2	0.07	Shower	360856
400826	IS_Wall_B	0.84	Level 2	0.07	Shower	635677
400826	IS_Wall_L	1.54	Level 2	0.07	Lavatory	360945
400826	IS_Wall_SD	1.54	Level 2	0.07	Sliding Door	635652
400826	IS_Wall_B	1.67	Level 2	0.07	Shower	360656
400826	IS_Wall_T	1.67	Level 2	0.07	Toilet	360897
400827	IS_Wall_B	0.84	Level 2	0.07	Shower	360474
400827	IS_Wall_B	0.84	Level 2	0.07	Shower	634981
400827	IS_Wall_B	1.57	Level 2	0.07	Shower	360339
400827	IS_Parede_Geral	1.57	Level 2	0.07	Commom Wall	360511
400827	IS_Wall_LBT	2.57	Level 2	0.07	Toilet+Bidet+Lavatory	360549
400827	IS_Wall_SD	2.57	Level 2	0.07	Sliding Door	635051
400828	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	359909
400828	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	634869
400828	IS_Parede_Geral	1.82	Level 2	0.07	Commom Wall	359810
400828	IS_Wall_BT	1.82	Level 2	0.07	Bathtub	359973
400828	IS_Wall_SD	2.52	Level 2	0.07	Sliding Door	359870
400828	IS_Wall_LBT	2.52	Level 2	0.07	Toilet+Bidet+Lavatory	634808
400829	IS_Wall_L	2.01	Level 2	0.07	Lavatory	360039
400829	IS_Wall_D	2.01	Level 2	0.07	Door	360115
400829	IS_Wall_T	2.09	Level 2	0.07	Toilet	360084
400829	IS_Parede_Geral	2.09	Level 2	0.07	Commom Wall	360147
400831	IS_Parede_Geral	1.46	Level 2	0.07	Commom Wall	358275
400831	IS_Wall_T	1.46	Level 2	0.07	Toilet	358374
400831	IS_Wall_L	1.82	Level 2	0.07	Lavatory	358341
400831	IS_Wall_SD	1.82	Level 2	0.07	Sliding Door	358430
400832	IS_Wall_B	0.84	Level 2	0.07	Shower	358665
400832	IS_Wall_B	0.84	Level 2	0.07	Shower	634711
400832	IS_Wall_B	1.67	Level 2	0.07	Shower	358600

400832	IS_Wall_D	1.67	Level 2	0.07	Door	358710
400832	IS_Parede_Geral	1.86	Level 2	0.07	Commom Wall	358745
400832	IS_Wall_LT	1.86	Level 2	0.07	Toilet+Lavatory	634676
400833	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	358121
400833	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	637353
400833	IS_Parede_Geral	1.77	Level 2	0.07	Commom Wall	358118
400833	IS_Wall_BT	1.77	Level 2	0.07	Bathtub	358120
400833	IS_Wall_SD	2.52	Level 2	0.07	Sliding Door	637279
400833	IS_Wall_LBT	2.53	Level 2	0.07	Toilet+Bidet+Lavatory	358119
400834	IS_Wall_B	0.84	Level 2	0.07	Shower	358125
400834	IS_Wall_B	0.84	Level 2	0.07	Shower	637587
400834	IS_Wall_SD	1.59	Level 2	0.07	Sliding Door	358126
400834	IS_Wall_L	1.59	Level 2	0.07	Lavatory	637529
400834	IS_Wall_T	1.77	Level 2	0.07	Toilet	358124
400834	IS_Wall_B	1.77	Level 2	0.07	Shower	358128
400835	IS_Wall_B	0.84	Level 2	0.07	Shower	358113
400835	IS_Wall_B	1.46	Level 2	0.07	Shower	358112
400835	IS_Wall_T	1.46	Level 2	0.07	Toilet	358114
400835	IS_Wall_L	1.62	Level 2	0.07	Lavatory	637175
400835	IS_Wall_SD	2.46	Level 2	0.07	Sliding Door	358115
400836	IS_Wall_B	0.80	Level 2	0.07	Shower	358111
400836	IS_Wall_B	0.84	Level 2	0.07	Shower	637095
400836	IS_Wall_D	1.33	Level 2	0.07	Door	358105
400836	IS_Wall_B	1.57	Level 2	0.07	Shower	358109
400836	IS_Wall_TB	1.70	Level 2	0.07	Toilet+Bidet	358108
400836	IS_Parede_Geral	1.74	Level 2	0.07	Commom Wall	358106
400836	IS_Wall_L	2.90	Level 2	0.07	Lavatory	358107
400837	IS_Wall_B	0.84	Level 2	0.07	Shower	637021
400837	IS_Wall_B	0.84	Level 2	0.07	Shower	637034
400837	IS_Wall_B	1.57	Level 2	0.07	Shower	358095
400837	IS_Parede_Geral	1.57	Level 2	0.07	Commom Wall	358096
400837	IS_Wall_SD	1.75	Level 2	0.07	Sliding Door	358097
400837	IS_Wall_LT	1.75	Level 2	0.07	Toilet+Lavatory	358098
400838	IS_Wall_T	1.38	Level 2	0.07	Toilet	358102
400838	IS_Parede_Geral	1.38	Level 2	0.07	Commom Wall	358104
400838	IS_Wall_SD	1.72	Level 2	0.07	Sliding Door	358101
400838	IS_Wall_L	1.72	Level 2	0.07	Lavatory	358103
400839	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	358090
400839	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	636916
400839	IS_Parede_Geral	1.87	Level 2	0.07	Commom Wall	358091
400839	IS_Wall_BT	1.87	Level 2	0.07	Bathtub	358093
400839	IS_Wall_LBT	2.64	Level 2	0.07	Toilet+Bidet+Lavatory	358089
400839	IS_Wall_SD	2.64	Level 2	0.07	Sliding Door	636849
400840	IS_Wall_B	0.84	Level 2	0.07	Shower	358086
400840	IS_Wall_B	0.84	Level 2	0.07	Shower	638035
400840	IS_Wall_B	1.62	Level 2	0.07	Shower	358083
400840	IS_Wall_D	1.62	Level 2	0.07	Door	358087
400840	IS_Parede_Geral	1.84	Level 2	0.07	Commom Wall	358088
400840	IS_Wall_LT	1.84	Level 2	0.07	Toilet+Lavatory	637983
400841	IS_Wall_B	0.84	Level 2	0.07	Shower	358133
400841	IS_Wall_B	0.84	Level 2	0.07	Shower	637807

400841	IS_Wall_B	1.62	Level 2	0.07	Shower	358130
400841	IS_Wall_D	1.62	Level 2	0.07	Door	358134
400841	IS_Parede_Geral	1.82	Level 2	0.07	Commom Wall	358135
400841	IS_Wall_LT	1.82	Level 2	0.07	Toilet+Lavatory	637868
400842	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	358074
400842	IS_Wall_BT	0.84	Level 2	0.07	Bathtub	638462
400842	IS_Parede_Geral	1.77	Level 2	0.07	Commom Wall	358071
400842	IS_Wall_BT	1.77	Level 2	0.07	Bathtub	358073
400842	IS_Wall_LBT	2.54	Level 2	0.07	Toilet+Bidet+Lavatory	358072
400842	IS_Wall_SD	2.54	Level 2	0.07	Sliding Door	638407
400843	IS_Wall_B	0.84	Level 2	0.07	Shower	358078
400843	IS_Wall_B	0.84	Level 2	0.07	Shower	638153
400843	IS_Wall_SD	1.59	Level 2	0.07	Sliding Door	358079
400843	IS_Wall_L	1.59	Level 2	0.07	Lavatory	638226
400843	IS_Wall_T	1.77	Level 2	0.07	Toilet	358077
400843	IS_Wall_B	1.77	Level 2	0.07	Shower	358081
400844	IS_Wall_B	0.84	Level 2	0.07	Shower	358066
400844	IS_Wall_B	0.84	Level 2	0.07	Shower	638590
400844	IS_Wall_B	1.46	Level 2	0.07	Shower	358065
400844	IS_Wall_T	1.46	Level 2	0.07	Toilet	358067
400844	IS_Wall_SD	1.69	Level 2	0.07	Sliding Door	358068
400844	IS_Wall_L	1.69	Level 2	0.07	Lavatory	638547
400845	IS_Wall_B	0.80	Level 2	0.07	Shower	358064
400845	IS_Wall_B	0.84	Level 2	0.07	Shower	638777
400845	IS_Wall_D	1.33	Level 2	0.07	Door	358058
400845	IS_Wall_B	1.57	Level 2	0.07	Shower	358062
400845	IS_Parede_Geral	1.72	Level 2	0.07	Commom Wall	358061
400845	IS_Parede_Geral	1.76	Level 2	0.07	Commom Wall	358059
400845	IS_Wall_LBT	2.90	Level 2	0.07	Toilet+Bidet+Lavatory	358060
400846	IS_Wall_B	0.84	Level 2	0.07	Shower	358052
400846	IS_Wall_B	0.90	Level 2	0.07	Shower	358053
400846	IS_Wall_B	1.57	Level 2	0.07	Shower	358048
400846	IS_Parede_Geral	1.57	Level 2	0.07	Commom Wall	358049
400846	IS_Wall_SD	1.69	Level 2	0.07	Sliding Door	358050
400846	IS_Wall_LT	1.74	Level 2	0.07	Toilet+Lavatory	358051
400848	IS_Parede_Geral	1.87	Level 2	0.07	Commom Wall	358044
400848	IS_Wall_BT	1.87	Level 2	0.07	Bathtub	358046
400848	IS_Wall_LBT	3.47	Level 2	0.07	Toilet+Bidet+Lavatory	358042
400848	IS_Wall_SD	3.47	Level 2	0.07	Sliding Door	358043
588806	IS_Wall_B	0.80	Level 0	0.07	Shower	333677
588806	IS_Wall_B	0.84	Level 0	0.07	Shower	620666
588806	IS_Wall_D	1.43	Level 0	0.07	Door	328009
588806	IS_Wall_B	1.57	Level 0	0.07	Shower	328475
588806	IS_Parede_Geral	1.59	Level 0	0.07	Commom Wall	333732
588806	IS_Parede_Geral	1.63	Level 0	0.07	Commom Wall	333777
588806	IS_Wall_LBT	3.00	Level 0	0.07	Toilet+Bidet+Lavatory	333717

APPENDIX 3: NUMBER OF WALL OF EACH TYPE IN EACH CATEGORY

Room Quantities		Type			
Category	SubCategory	IS_Parede_Geral	IS_Wall_B	IS_Wall_BT	IS_Wall_D
IS_1					
	S_1D	1		5	2
	S_1S	12		34	
	S_2S	5	6	9	
	S_3S	2		6	
	S_5D	1		5	2
	S_5S	3	3	6	
	S_6D	2		6	2
IS_10					
	S_2S	1			
IS_11					
	S_2S	1	3		
	S_4S	2	6		
IS_12					
	S_2S	4		6	
IS_13					
	S_2S	1		3	
IS_14					
	S_1S	1	3		
IS_15					
	S_1S		3		
IS_16					
	S_4S	1		3	
IS_17					
	S_2S	2		6	
IS_18					
	S_6S	2			
IS_19					
	S_1S	5			
	S_2S	4			
IS_2					
	S_1D	3	3		1
	S_2D	3	3		1
IS_20					
	S_2S	1	2		
	S_6S	1	2		
IS_21					
	S_2S	2			
IS_22					
	S_1S	1			
	S_2S	1			
IS_23					
	S_3D	2		3	1
	S_4D	2		3	1
IS_24					
	S_4S	1			
IS_25					
	S_1D	1			1

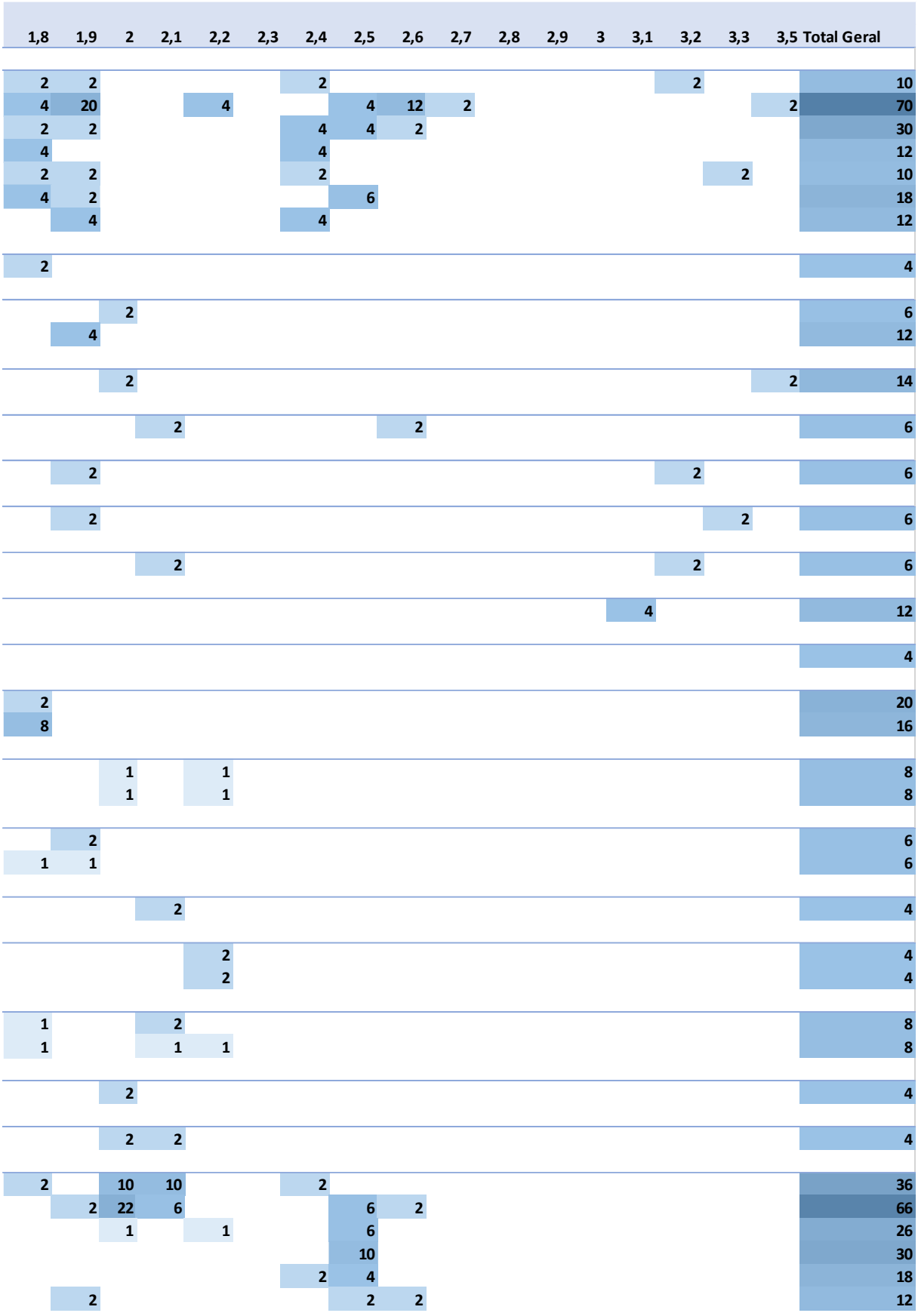
IS_Wall_L	IS_Wall_LBT	IS_Wall_LT	IS_Wall_SD	IS_Wall_T	IS_Wall_TB	Total Geral
	2					10
	12		12			70
	5		5			30
	2		2			12
	2					10
	3		3			18
	2					12
1			1	1		4
		1	1			6
		2	2			12
	2		2			14
	1		1			6
		1	1			6
1			1	1		6
	1		1			6
	2		2			12
		1	1			4
5			5	5		20
4			4	4		16
		1				8
		1				8
1			1	1		6
1			1	1		6
		1	1			4
1			1	1		4
1			1	1		4
1					1	8
1					1	8
1			1	1		4
1				1		4

IS_3					
	S_1S			18	
	S_2S			33	
	S_3S	2		12	
	S_4S			15	
	S_5S			9	
	S_6S		3	3	
IS_4					
	S_1D	20	32	3	11
	S_1S	10		15	
	S_2D	6	15		4
	S_2S	8		12	
	S_3S	2		3	
	S_5D	2	3		1
IS_5					
	S_1D	6	12	6	6
	S_2D	5	15		5
IS_6					
	S_1D	1		3	1
IS_7					
	S_1D	1	3		1
	S_1S	12	27	5	
	S_2D	2	6		2
	S_2S	19	45		
	S_3D	4	12		4
	S_3S	2	6		
	S_4D	3	9		3
	S_5D	3	9		3
	S_5S	1	3		
	S_6D	4	9	3	4
	S_6S	1	1		
IS_8					
	S_1S	1	53	6	
	S_2S	1	52	3	
	S_3S		3		
	S_4S	1	5		
	S_5S		3		
IS_9					
	S_1D	2			1
	S_2D	2			1
	S_2S	2			
	S_4S	4			
	S_5S	2			
Total Geral		197	360	244	58

6			6		6	36
11			11		11	66
4			4		4	26
5			5		5	30
3			3		3	18
2			2		2	12
	11					77
	5		5			35
	4					29
	4		4			28
	1		1			7
	1					7
6					6	42
5					5	35
1				1		7
		1				6
		12	12			68
		2				12
		18	18			100
		4				24
		2	2			12
		3				18
		3				18
		1	1			6
		4				24
		1	1			4
20			20	20		120
19			19	19		113
1			1	1		6
2			2	2		12
1			1	1		6
		1				4
		1				4
		1	1			4
		2	2			8
		1	1			4
105	60	65	172	61	44	1366

APPENDIX 4: NUMBER OF WALL IN EACH CATEGORY WITH THE SAME DIMENSIONS

Number of walls / Catgory	Dimensions 0,1	0,4	0,5	0,8	0,9	1	1,1	1,2	1,3	1,4	1,5	1,6	1,7
IS_1													
S_1D				2									
S_1S				22									
S_2S				10								2	4
S_3S				4									
S_5D				2									
S_5S				6									
S_6D				4									
IS_10													
S_2S											2		
IS_11													
S_2S				2							2		
S_4S				4						4			
IS_12													
S_2S				4							2		4
IS_13													
S_2S				2									
IS_14													
S_1S				2									
IS_15													
S_1S				2									
IS_16													
S_4S				2									
IS_17													
S_2S				4									4
IS_18													
S_6S											2		2
IS_19													
S_1S										10			8
S_2S										8			
IS_2													
S_1D			1	2			2				1		
S_2D			1	2			2				1		
IS_20													
S_2S				2		2							
S_6S				2	1		1						
IS_21													
S_2S										2			
IS_22													
S_1S								2					
S_2S								2					
IS_23													
S_3D		2		2									1
S_4D		2		2									1
IS_24													
S_4S												2	
IS_25													
S_1D													
IS_3													
S_1S				12									
S_2S				22								2	4
S_3S			1	9						1	1	2	4
S_4S				10									10
S_5S				6								2	4
S_6S				4								2	



1,8	1,9	2	2,1	2,2	2,3	2,4	2,5	2,6	2,7	2,8	2,9	3	3,1	3,2	3,3	3,5	Total Geral
2	2					2								2			10
4	20			4			4	12	2							2	70
2	2					4	4	2									30
4						4											12
2	2					2									2		10
4	2						6										18
	4					4											12
2																	4
		2															6
	4																12
		2														2	14
			2					2									6
	2													2			6
	2														2		6
			2											2			6
												4					12
																	4
2																	20
8																	16
		1		1													8
		1		1													8
	2																6
1	1																6
			2														4
				2													4
				2													4
1			2														8
1			1	1													8
		2															4
		2	2														4
2		10	10			2											36
	2	22	6				6	2									66
		1		1			6										26
							10										30
						2	4										18
	2						2	2									12

⊟IS_4													
S_1D	1			20	1			7	4		17	2	
S_1S				10			2	3		7	3		
S_2D	1			7	1			1	3		10		
S_2S				8			3	1		2	2	4	
S_3S				2				1			2		
S_5D				2				1			1		
⊟IS_5													
S_1D				12					6	1	3	8	
S_2D				10				2	3		5	6	
⊟IS_6													
S_1D				2				1			1	1	
⊟IS_7													
S_1D				2							2		
S_1S				20						8	10	4	
S_2D				4								4	
S_2S				27	1					8	20	18	
S_3D				8							2	6	
S_3S				4								4	
S_4D				6								6	
S_5D				6								4	
S_5S				2						2			
S_6D				8								8	
S_6S											2		
⊟IS_8													
S_1S				39	1	1		1	2	20	26	20	
S_2S				36	1		1	1		24	15	28	
S_3S				2						2		2	
S_4S				3	1	1		1			2	2	
S_5S				2									
⊟IS_9													
S_1D											2		
S_2D											2		
S_2S											2		
S_4S									4				
S_5S											2		
Total Geral	2	4	3	389	7	4	6	10	19	47	85	143	173

7	6						1	1	5	1	4						77
5											2	3					35
2								1			3						29
4											3	1					28
1												1					7
	2								1								7
6										1	5						42
4										2	3						35
1										1							7
2																	6
20	2						4										68
2	2																12
16	2						8										100
8																	24
4																	12
6																	18
6		2															18
2																	6
8																	24
						2											4
9					1												120
3		2			1		1										113
																	6
1					1												12
2	2																6
	2																4
	2																4
2																	4
	4																8
2																	4
158	71	47	27	12	3	20	45	33	4	6	5	20	9	6	4	4	1366

APPENDIX 5: NUMBER OF WALL OF EACH TYPE WITH THE SAME DIMENSIONS

Room Quantity	Rótulos de Coluna				
Rótulos de Linha	IS_Parede_Geral	IS_Wall_B	IS_Wall_BT	IS_Wall_D	IS_Wall_L
0,1		2			
0,4	4				
0,5	3				
0,8	2	227	158		
0,9		3			1
1		3			1
1,1	2	2		2	
1,2					3
1,3				12	2
1,4	14			16	1
1,5	21	25	1		10
1,6	40	45	7	2	23
1,7	22	34	21	14	25
1,8	46	9	22	3	6
1,9	27	8	16	6	1
2	4	1	15	1	6
2,1	3		2	1	10
2,2	2			1	
2,3					
2,4	6				1
2,5					
2,6		1			2
2,7					
2,8					
2,9					4
3					8
3,1					
3,2	1		1		
3,3			1		1
3,5					
Total Geral	197	360	244	58	105

IS_Wall_LBT	IS_Wall_LT	IS_Wall_SD	IS_Wall_T	IS_Wall_TB	Total Geral
					2
					4
					3
			2		389
			3		7
					4
					6
		5	2		10
		5			19
		6	9	1	47
		13	15		85
	1	20	5		143
	6	21	17	13	173
	38	27	6	1	158
	7	3	1	2	71
	2	6		12	47
	1	9	1		27
2	2	5			12
		3			3
8		4		1	20
7	1	23		14	45
8	6	16			33
3		1			4
6					6
1					5
12					20
7		2			9
2	1	1			6
1		1			4
3		1			4
60	65	172	61	44	1366

APPENDIX 6: AVERAGE SIZE OF WALL OF EACTH TYPE BY CATEGORY

Average dimension	Rótulos de Coluna				
Rótulos de Linha	IS_Parede_Geral	IS_Wall_B	IS_Wall_BT	IS_Wall_D	IS_Wall_L
IS_1					
S_1D	2,40		1,70	1,85	
S_1S	1,88		1,18		
S_2S	1,74	1,12	1,11		
S_3S	2,40		1,13		
S_5D	2,40		1,72	1,85	
S_5S	1,83	1,17	1,13		
S_6D	2,40		1,17	1,90	
IS_10					
S_2S	1,50				1,80
IS_11					
S_2S	1,50	1,20			
S_4S	1,40	1,17			
IS_12					
S_2S	1,70		1,20		
IS_13					
S_2S	2,10		1,23		
IS_14					
S_1S	1,90	1,17			
IS_15					
S_1S		1,17			3,30
IS_16					
S_4S	3,20		1,23		
IS_17					
S_2S	1,70		1,10		
IS_18					
S_6S	1,60				
IS_19					
S_1S	1,40				1,72
S_2S	1,40				1,80
IS_2					
S_1D	1,20	1,03		1,10	
S_2D	1,20	1,03		1,10	
IS_20					
S_2S	1,90	0,90			1,00
S_6S	1,80	0,95			0,90
IS_21					
S_2S	1,75				

IS_Wall_LBT	IS_Wall_LT	IS_Wall_SD	IS_Wall_T	IS_Wall_TB	Total Geral
2,80					2,02
2,60		2,60			1,79
2,48		2,48			1,67
2,40		1,80			1,67
2,85					2,04
2,50		2,50			1,71
2,40					1,70
		1,80	1,50		1,65
	2,00	1,50			1,43
	1,90	1,40			1,37
3,50		1,50			1,71
2,60		2,60			1,83
	3,20	3,20			1,97
		3,30	1,90		2,00
3,20		2,10			2,03
3,10		3,10			1,87
	1,70	1,50			1,60
		1,72	1,40		1,56
		1,80	1,40		1,60
	2,20				1,25
	2,20				1,25
		1,90	0,80		1,23
		1,90	0,80		1,22
	2,10	1,40			1,75

IS_22					
S_1S	2,20				1,20
S_2S	2,20				1,20
IS_23					
S_3D	0,40		1,13	2,10	2,10
S_4D	0,40		1,13	2,20	2,10
IS_24					
S_4S	2,00				1,60
IS_25					
S_1D	2,10			2,00	2,00
IS_3					
S_1S			1,19		2,15
S_2S			1,17		1,99
S_3S	0,65		1,12		1,63
S_4S			1,10		1,70
S_5S			1,09		1,67
S_6S		1,07	1,17		2,10
IS_4					
S_1D	1,76	1,12	1,07	1,34	
S_1S	1,53		1,13		
S_2D	1,63	1,09		1,38	
S_2S	1,63		1,13		
S_3S	1,60		1,13		
S_5D	1,90	1,07		1,30	
IS_5					
S_1D	1,80	1,06	1,10	1,40	2,98
S_2D	1,78	1,07		1,36	2,96
IS_6					
S_1D	1,80		1,07	1,30	2,90
IS_7					
S_1D	1,80	1,07		1,60	
S_1S	1,61	1,07	1,30		
S_2D	1,85	1,10		1,70	
S_2S	1,57	1,13			
S_3D	1,80	1,09		1,68	
S_3S	1,80	1,10			
S_4D	1,80	1,10		1,70	
S_5D	1,87	1,11		1,73	
S_5S	1,50	1,03			
S_6D	1,80	1,10	1,10	1,70	
S_6S	1,60	1,60			
IS_8					
S_1S	1,80	1,08	1,07		1,58
S_2S	1,80	1,07	1,10		1,61
S_3S		1,10			1,50
S_4S	1,80	1,02			1,45
S_5S		1,13			1,90
IS_9					
S_1D	1,60			1,90	
S_2D	1,60			1,90	
S_2S	1,70				
S_4S	1,65				
S_5S	1,70				
Total Geral	**1,67**	**1,09**	**1,17**	**1,56**	**1,87**

		2,20	1,20		1,70
		2,20	1,20		1,70
				1,70	1,26
				1,70	1,28
		2,00	1,60		1,80
			2,10		2,05
		2,15		1,97	1,64
		2,22		2,13	1,64
		2,43		2,23	1,53
		2,50		2,50	1,67
		2,47		2,47	1,64
		2,55		2,20	1,70
2,87					1,56
3,06		1,26			1,54
2,93					1,50
3,03		1,23			1,56
3,10		1,30			1,57
2,80					1,59
				1,70	1,59
				1,70	1,57
			1,70		1,56
	1,80				1,40
	1,93	1,93			1,49
	1,85				1,45
	1,94	1,94			1,51
	1,80				1,43
	1,80	1,70			1,43
	1,80				1,43
	1,87				1,47
	1,80	1,80			1,37
	1,80				1,43
	2,50	2,50			2,05
		1,63	1,61		1,34
		1,72	1,57		1,36
		1,50	1,70		1,33
		1,95	1,30		1,36
		1,90	1,80		1,50
	1,90				1,75
	1,90				1,75
	1,80	1,60			1,70
	1,90	1,40			1,65
	1,80	1,60			1,70
2,79	**1,93**	**1,97**	**1,53**	**2,06**	**1,54**