

VŠB-Technical University of Ostrava
Faculty of Civil Engineering
BIM ENGINEERING

**GRAPHIC DETAIL OF THE BIM FOR VIRTUAL
AND AUGMENTED REALITY**
GRAFICKÝ DETAIL PRO BIM VE VIRTUÁLNÍ
A ROZŠÍŘENÉ REALITĚ

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Diploma Thesis Assignment

Student: **Arunkumar Manoharan**

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Title: **Graphic detail of the BIM for Virtual and Augmented reality**
Grafický detail pro BIM ve virtuální a rozšířené realitě

The thesis language: English

Description:

The subject of the diploma thesis is to create an Building Information Model in graphic detail in the phase of use, based on the available 3D drawing documentation of the new building. It will be a building model with the need to model all elements of the technical infrastructure of the building. Part of the thesis will also be the classification of all building elements into Naviswork manage software and exporting it in virtual and Augmented reality.

The text part will contain:

1. recapitulation of the theoretical starting points related to the addressed issue;
2. basic knowledge about the building and classifying it using the tools like Clash detective, Quantification and timeliner.
3. analysis of graphic details of the Building Information Model
4. Virtual and Augmented reality.
5. achieved results and their evaluation

The graphic part will include: Information model of the building

The final scope and content will be specified during the preparation of the diploma thesis.

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STUDENT DECLARATION

I declare that I have prepared the entire diploma thesis, including the appendices, independently under the supervision of the supervisor of the diploma thesis and I have listed all the documents and literature used.

In Ostrava on

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ANNOTATION

The subject of the diploma thesis is to create a Building Information Model in graphic detail in the phase of use, based on the available 3D drawing documentation of the new building and try to analyse the model using the Navisworks Manage software to try out the BIM tools like clash detection and time liner and try establishing the model in VR and AR environment.

KEY WORDS

BIM

AR

VR

BEP

Navisworks Manage

LOD

2D

3D

IFC

MEP

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Arunkumar Manoharan

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LIST OF ABBREVIATIONS

BIM – Building information modelling/management.

VR – Virtual reality

AR – Augmented reality

CAD – Computer Aided Drawing

AEC – Architectural, Engineering, Construction

2D – Two Dimension

3D – Three Dimension

LOD – Level of Development

MEP – Mechanical, Electrical and Plumbing

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CONTENTS

INTRODUCTION	10
I. THEORETICAL PART	11
1 DEVELOPMENT OF VISUALIZATION IN AEC	12
1.1 EARLY CIVILIZATIONS.....	12
1.2 20 TH CENTURY	12
1.3 CAD SOFTWARE	13
1.4 BIM.....	13
2 BIM	14
2.1 ROLE OF BIM	15
2.2 BIM TOOLS.....	16
2.2.1 <i>Design Tools</i>	16
2.2.2 <i>Collaboration Tools</i>	17
2.2.3 <i>Analysis Tools</i>	17
2.2.4 <i>Quantity Takeoff Tools</i>	17
2.2.5 <i>Document Management Tools</i>	17
2.3 LOD	17
2.4 IFC	18
2.5 AUTODESK REVIT	19
3 NAVISWORK MANAGE.....	22
3.1 CLASH DETECTION	23
3.2 TIME LINER.....	23
3.3 QUANTIFICATION	24
4 VR.....	25
4.1 BIM + VR	25
4.1.1 <i>Benefits of VR in BIM</i>	25
5 AR.....	28
5.1 BIM + AR	29

II. PRACTICAL PART.....	31
6 PURPOSE OF THE PRACTICAL PART	32
6.1 SPECIFICS OF THE UNIVERSITY KINDERGARTEN	32
7 BIM ANALYSIS	35
7.1 NAVISWORKS.....	38
7.1.1 <i>Append</i>	38
7.1.2 <i>Clash detective</i>	40
7.1.3 <i>Time Liner</i>	42
7.1.4 <i>Stimulate</i>	43
8 VR.....	44
8.1 REVIT TO VR	44
8.2 NAVISWORKS TO VR	45
9 AR.....	49
9.1 NAVISWORKS TO AR	49
CONCLUSION	54
BIBLIOGRAPHY	55
LIST OF FIGURES	57

INTRODUCTION

“It all depends on what you visualize.” – Ansel Adams

Visualization, whether through your senses or any means of interpretation, is the spark for any built model in the AEC industry. With new developments in technology, the construction industry went through enormous changes in visualization. Pen and pencil were the basic tools for the visualization of any model until the introduction of computers. The role of computers and technology suddenly transferred the industry. The outputs they provided have eliminated many of the basic errors, which previously occurred in the process of the construction industry.

When the models changed from 2D to 3D the progression of BIM came to play. The technology digitalized every part of the construction process making the hustle more efficient and error-free. The significant improvements in digitalization and visualization led to a growing eagerness to integrate both in the same platform. This paved the path for the topic of this thesis.

The main theme of the work relies on the BIM model and its analysis for some progressive and design challenges using the well-known software Naviswork Manage from Autodesk. After the full analysis of the model, the provided results will be visualized in virtual and augmented (VR/AR) environments.

The target doesn't stop with publishing the results in VR and AR environments. The scope of the thesis also covers exploring the possibilities of working with BIM tools within these environments. Lastly, this work also explains the difficulties faced while working with BIM tools and technologies.

I. THEORETICAL PART

1 DEVELOPMENT OF VISUALIZATION IN AEC

The history of visualization in the construction sector is long and varied. Early civilizations like the Egyptians, Greeks, and Romans used sketches, blueprints, and scale models to plan and build their structures. Drawings and models are still used today to illustrate buildings and other structures.(1)(2)

1.1 Early civilizations

In ancient Greece and Egypt, architects and builders relied on the skill of hand-drawn sketches to bring their construction projects to life. These sketches were the starting point for designing and planning impressive structures such as temples, amphitheatres, pyramids, and other monumental buildings. Greek architects would use papyrus or wax tablets to capture the basic layout and proportions of their buildings, while Egyptian architects would often create sketches on papyrus or limestone to show the layout and dimensions of their grand structures.

Scale models of temples, amphitheatres, and other public structures were often made in Ancient Greece out of clay or wood. These models were extremely detailed and faithfully portrayed the building's proportions and design. To show off the suggested design to the general public, they were frequently placed in open spaces like town squares or government buildings. Egyptian architects used materials like clay or wood to create scale models of temples, pyramids, and other massive structures. These replicas were frequently utilized in religious rituals and were also buried with the pharaohs as a symbolic representation of the buildings they had constructed while living.(2)

1.2 20th century

Early in the 20th century, new visualization methods including isometric drawing and orthographic projection were created thanks to technological advances. These methods improved the entire design and building process by enabling architects and engineers to produce more thorough and precise plans and drawings.

1.3 CAD software

Visualization in the construction sector advanced further with the introduction of computers in the later half of the 20th century. In order to construct accurate 2D and 3D models of buildings and structures, computer-aided design (CAD) software was developed. This permitted improved stakeholder collaboration and communication as well as the early detection of potential design problems.

AutoCAD is a helpful computer software that's widely used in the construction industry. It helps architects, engineers, and builders create and edit detailed and accurate 2D and 3D drawings and models of buildings and other structures. It has a lot of great tools and features that make it easy for professionals to create designs. There are drawing tools for creating different shapes and lines, editing tools for making changes to designs, 3D modeling tools for creating complex 3D models, and collaboration tools for sharing and discussing designs with other team members. Using AutoCAD can help make the design process more accurate and efficient, which can save time and money in the long run.

After AutoCAD, there was a big wave of new designing and modeling softwares that helped the AEC sector with improving the digital models. Consequently, it served the stakeholders to understand the model better than in the lines as each software has its own set of rendering tools which allowed for more detailed visualizations of buildings.

1.4 BIM

Building Information Modeling (BIM) first appeared as a novel method of managing and visualizing construction projects in the 1990s. Using BIM, a 3D modeling tool, stakeholders may see the building as it will be built, identify potential conflicts or problems, and streamline the design and construction processes. BIM integrates data about materials, systems, and components.(2)

Today, visualization technologies continue to evolve, with new tools and techniques such as virtual reality, augmented reality, and 3D printing being used in the construction industry. These technologies enable stakeholders to visualize and communicate building designs and concepts, leading to more efficient and cost-effective construction processes. (2)

2 BIM

Building information modeling is a digital process that involves the creation, management, and sharing of all the structural and functional elements of a built environment throughout the facility's full lifecycle. BIM enhances stakeholder collaboration and communication, boosts productivity and accuracy, and lowers errors and rework.(3)(1)

With the aid of BIM, designers, architects, engineers, contractors, and facility managers may collaborate on a single digital platform where they can instantly access and change the same data. This strategy decreases information loss and enhances the effectiveness of decision-making.(3)(1)

Conceptual design, detailed design, building, and operation are just a few of the stages of a construction project where BIM can be used. The BIM model may contain details on the building's geometry, components, systems, tools, maintenance needs, and other pertinent information.(1)

The US National Building Information Modeling Standard defines BIM as follows:

"Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder." (4)

A detailed digital representation of a constructed facility with significant information depth is called a building information model. The building components' three-dimensional geometry is often included at a certain level of detail. It also includes intangible items like zones and places, a hierarchical project structure, or timelines.

The types of components, materials, technical characteristics, costs, and the connections between the components and other physical or logical entities are only a few examples of semantic information that is generally attached to an object. Therefore, the process of developing such digital building models as well as the processes of preserving, utilizing, and exchanging them during the built facility's lifetime are collectively referred to as "building information modeling".(1)

2.1 Role of BIM

The use of computer technology in the design, engineering, building, and operation of built facilities is greatly enhanced by the application of the BIM approach. Building information models, or BIM, are detailed digital representations that are used to store, update, and communicate information in place of drawings.

The setup and control of the construction process, the integration of simulations, the coordination of design operations, and the transfer of building information to the operator are all significantly enhanced by this method. It is possible to eliminate tedious and error-prone work and boost efficiency and quality in building projects by minimizing the manual re-entering of data and enabling the ensuing re-use of digital information. (5)

The move to digital, model-based product development and manufacturing has already been made by other industry sectors, such as the automotive industry, which has allowed them to realize major efficiency benefits. The Architecture Engineering and Construction sector, however, faces some unique and difficult boundary conditions.

To begin with, the chain of processes and value creation is not under the control of a single organization, but rather is distributed across several businesses, including architectural offices, engineering consultancies, and construction companies. These normally only work together throughout the course of a specific construction project and not for an extended period. But there is a good progression in the pathway to transfer to this world of digitalization. BIM plays a major role in tracking each process that belongs to the root of a single project by the value and quality and quantity of information and time added to the project. (1)

2.2 Advantages of BIM

Building information modeling, or BIM, is a digital depiction of a building's structural and operational details. It is a strong instrument with many benefits for those who use it. Some of the main benefits of BIM include:(6)

Improved Collaboration: BIM enables stakeholders to collaborate and share data in real-time, which leads to better communication and decision-making. This lessens the possibility of mistakes and misunderstandings occurring throughout a building's design, construction, and use.(5)

Enhanced Efficiency: By giving precise and thorough information about the building, BIM can help to simplify the design and construction process. This information can be utilized to optimize workflows and cut waste.(5)

Cost savings: BIM can assist in lowering the cost of design revisions and rework by giving a more accurate depiction of the building. Additionally, it can aid in cost-saving measures and energy-use optimization.(5)

Better sustainability: By giving precise information about a building's performance, BIM can aid in optimizing the energy use of a structure. This can increase the building's sustainability and assist lower its carbon footprint. (5)

Enhanced Safety: BIM can assist in identifying potential hazards and enhancing safety throughout a building's development and use.

Better Maintenance and Facility Management: BIM can offer useful information regarding the parts, systems, and machinery of a building that can be used to optimize maintenance and facility management. This extends a building's lifespan and decreases downtime.(5)

2.3 BIM tools

Building Information Modeling tools are software programs that enable building and infrastructure project managers to design and maintain digital models of their structures. These technologies offer a variety of capabilities that support better team collaboration, visualization and simulation of project designs, and management of project data and information. (6)(3)

2.3.1 Design Tools

With the aid of design tools, architects, engineers, and other design experts can produce 3D models of proposed structures. Software like Autodesk Revit, ArchiCAD, and SketchUp are some examples of these tools; they offer a variety of design capabilities such as parametric modeling, object libraries, and building performance analysis. (1)

2.3.2 Collaboration Tools

Regardless of where they are located, project teams can collaborate on a common project model using collaboration tools. These technologies include programs like Tekla BIMsight, Navisworks, and BIM 360 that allow teams to communicate in real time, share project information, and spot design inconsistencies.

2.3.3 Analysis Tools

Project teams can test different design concepts and model how a building will perform. These resources include programs like Autodesk Insight, IES VE, EnergyPlus, and Navisworks that let teams assess the energy efficiency, daylighting, acoustics, and other aspects of a building.

2.3.4 Quantity Takeoff Tools

Measurement and estimation of the amounts of materials needed for a building project are made possible by quantity takeoff tools, which are used by project teams. These technologies include programs like PlanSwift, Bluebeam Revu, and Navisworks Quantification, which allow teams to execute takeoffs from the 3D model and get precise estimates.

2.3.5 Document Management Tools

Project teams can handle data and information for projects using document management technologies. The ability to save, exchange, and track project documentation, drawings, and other data is provided by programs like Newforma, Procore, and Aconex. (1)

2.4 LOD

Building information modeling uses the term LOD (Level of Development) to define the level of accuracy and detail of the data present in a BIM model. The American Institute of Architects (AIA) defines LOD as a numerical index (0-500) that indicates the degree of correctness and completeness of the data provided in a BIM model.

The idea of LOD was created to give project teams a standard language to use when discussing the amount of accuracy and detail needed at various phases of a project. The

various levels of LOD are used to characterize the level of accuracy and detail of a model at various design and building stages.(5)

Although there are several different LOD standards in use in the sector, the AIA LOD system which establishes five levels of detail is the most widely adopted one:

1. LOD 100: Conceptual - The model is utilized at this level to give an approximate concept of the project's form, size, and placement.
2. LOD 200: Schematic Design - The model covers the general sizes, forms, and locations of the main components at this level.
3. LOD 300: Detailed Design - At this level, the model accurately and thoroughly describes the dimensions, locations, numbers, and orientations of all significant components.
4. LOD 400: Assembly and Fabrication - The model comprises specific information about the size, shape, placement, and orientation of every component and is utilized for fabrication, assembly, and construction at this level.
5. LOD 500: As-Built - At this level, the model has accurate and thorough data on the size, shape, position, amount, and orientation of every component, along with information on how effectively they function, maintain, and work.

Depending on the requirements of the project and the stakeholders involved, different levels of detail may be needed. Project teams can effectively express the level of precision and detail needed at various stages of the project by employing a common LOD system, which improves collaboration and decision-making. (5)

2.5 IFC

IFC stands for Industry Foundation Classes, which is a standardized data format used in the architecture, engineering, and construction industry. The transmission of digital building information models between various software programs used by architects, engineers, contractors, and owners is made possible by this open, impartial, and non-proprietary file format.

The International Organization for Standardization (ISO), a global industry organization devoted to encouraging the adoption of open BIM standards, developed IFC in partnership with the buildingSMART alliance. IFC4 was launched in 2013 and is the most recent version.

For describing data from the building and construction sector, including geometry, spatial relationships, materials, characteristics, and other pertinent details, IFC offers a data schema. It enables a full and integrated BIM model that can be used throughout the building lifespan by supporting the portrayal of both physical and functional features of building components. IFC files are frequently employed for data exchange between various BIM software programs, enabling project teams to cooperate and work in a shared data environment. This interoperability encourages effective stakeholder communication and collaboration, which can result in better project outcomes, fewer errors, and increased efficiency in the building process. (5)

2.6 Autodesk Revit

Autodesk Revit is a powerful architectural design, building information modeling, and construction management software. For designing, visualizing, and conveying intricate architectural designs and construction plans, it provides a complete solution. Architects, engineers, contractors, and other building industry professionals use Revit extensively to expedite their design, documentation, and communication workflows.

Autodesk first released Revit as a parametric 3D modeling program for building design and construction in 2000. It has grown over time into a full-fledged BIM platform that enables users to produce intelligent 3D models with all the necessary data about a construction project, including geometry, spatial relationships, building components, materials, and performance data. (7)

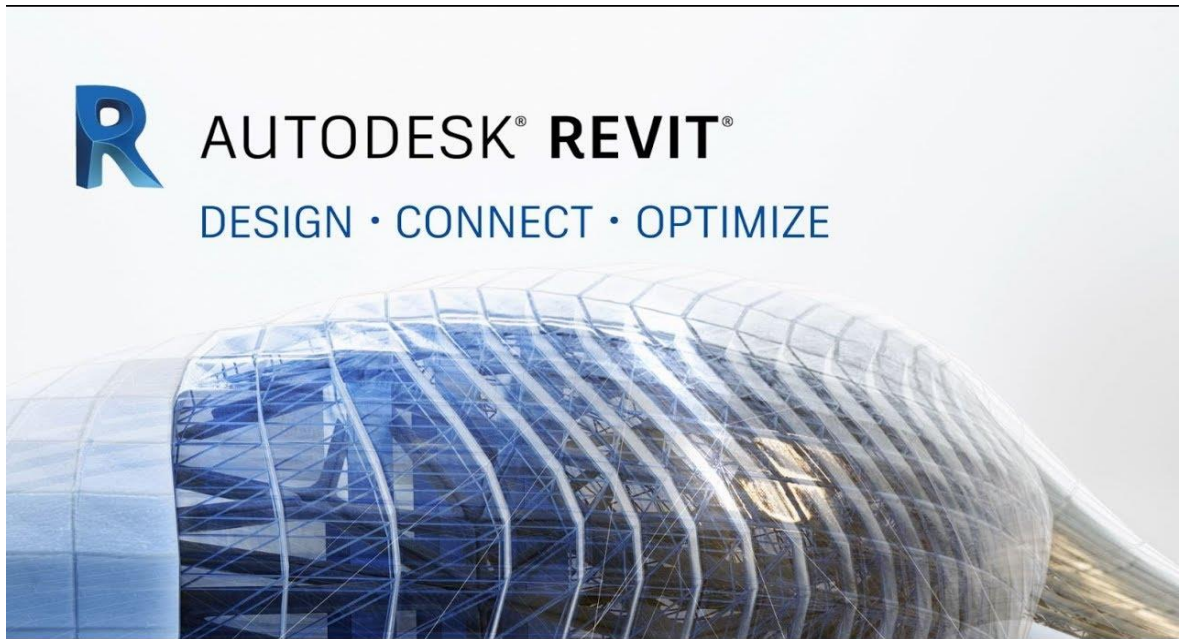


Figure 1. Autodesk Revit

The parametric modeling capabilities of Revit are one of its most notable characteristics. In other words, users can describe the specifications of different architectural parts and components, such as walls, doors, windows, roofs, and stairs, and alter them in a flexible and natural way. This enables speedy creation of precise and uniform documentation and timetables, as well as simple iteration and experimentation during the design phase.

For assessing and modeling numerous aspects of a building project, such as energy efficiency, lighting, acoustics, and structural integrity, Revit also provides a variety of tools and functions. With the use of these capabilities, users may reduce the possibility of mistakes and conflicts during construction while also optimizing their designs for cost-effectiveness, safety, and sustainability.

The capacity of Revit to encourage collaboration and communication among project stakeholders is one of its main benefits. Using cloud-based platforms like Autodesk BIM 360 or Autodesk Drive, multiple team members can share and access Revit models from anywhere. This makes it possible for real-time coordination, evaluation, and feedback while also assisting in ensuring that everyone is using the most recent information possible.

Overall, Autodesk Revit is a strong and adaptable technology that may greatly improve and streamline the design and construction of buildings. It is an essential software tool for

architects, engineers, and construction professionals due to its parametric modeling capabilities, analysis and simulation tools, and collaborative features. (7)

3 NAVISWORKS MANAGE

Navisworks Manage is project management software that allows accessing simulation tool, quantification tools, and collision detective tool. It enables AEC professionals to examine integrated models to obtain greater control over project outcomes.

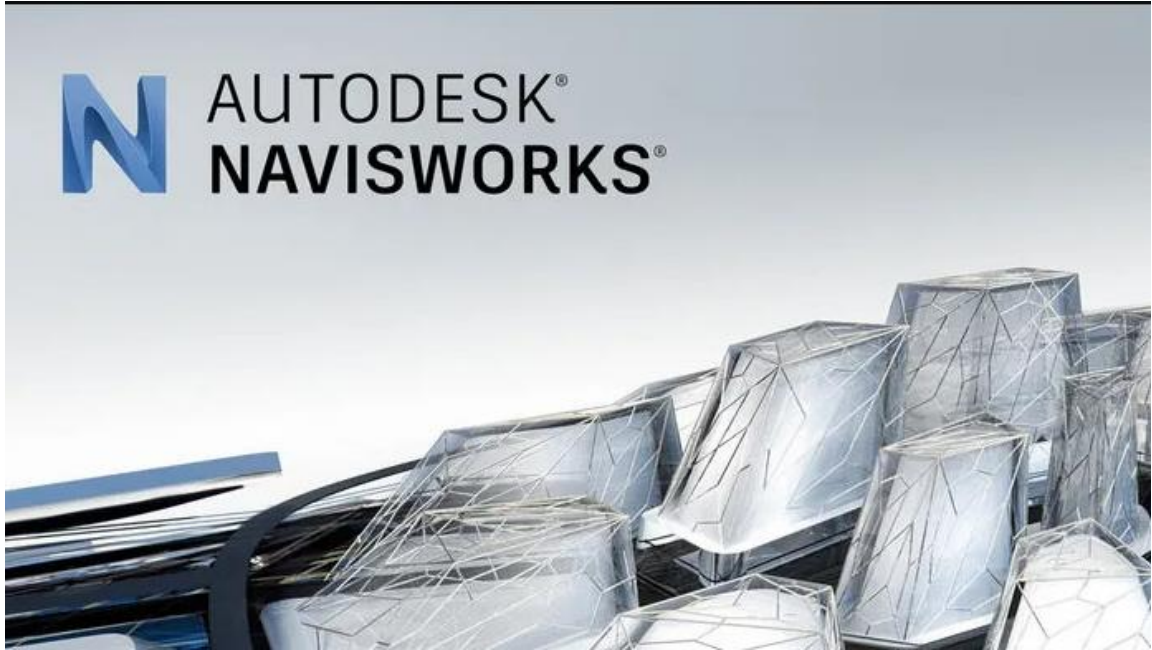


Figure 2. Autodesk Navisworks

The main functionalities include visualization, 4D simulation, navigation, animation creation, information exchange, collision analysis, and clash report data management capabilities. Navisworks is not a modeling or authoring tool in the same way that Revit or ArchiCAD are. It can read over 50 different file formats that are imported into the program. (7)

Architects, engineers, contractors, and owners use Navisworks as comprehensive project review tool to combine data and 3D models from several sources into a single model. It is a component of Autodesk's BIM system and enables users to combine various file formats and data sources to produce a coordinated 3D model that can be used for collision detection, construction simulation, and project visualization. (8)

Users can merge 3D models from many software platforms, such as Autodesk Revit, AutoCAD, MicroStation, and SketchUp, using Navisworks. This program offers a platform

for cooperative project management that enhances collaboration, lowers risk, and guarantees that every team member has access to the most recent project data.

The strength of Navisworks lies in its ability to open files from a range of design and engineering tools, as well as its ability to share and coordinate these various file types into a unified data-rich intelligent model. The aggregated file composite model can then be made selectively available or viewed by all stakeholders involved to improve the design review and coordination process. Furthermore, Navisworks transforms and compresses most files to up to 80% of their original size, making sharing and collaborating much easier.

This upcoming section will go over the various file types and explain the distinctions between them. It will also look at some common workflows and recommended practices for file sharing and aggregation. (7)(8)

3.1 Clash Detection

Conflicts and their early detection are among the construction projects' top worries. Manual collision detection takes time and requires a mix of excellent design knowledge and experience. Building information modeling is a type of digital technology that helps designers and builders simulate a digital space using a database of information before construction ever starts. On construction sites, it assists in preventing and resolving conflicts before they occur, including but not limited to using personal computers.(8)

3.2 Time Liner

Users of Navisworks Manage can integrate 3D models with project schedules and build dynamic simulations of the construction sequence using the application called Time Liner. The Time Liner tool aids in project team visualization, potential delay detection, and building process optimization.

Time Liner connects the 3D model with the project schedule to produce a dynamic simulation and uses a Gantt chart interface to illustrate the project schedule. To demonstrate how the project will develop over time, the simulation can be replayed in real time or fast-forwarded. The simulation can also be stopped at any time to look over the model and find any potential conflicts or problems.(7)

3.3 Quantification

Quantification is an essential process in construction projects, which involves measuring and estimating the quantities of materials required for construction. Project teams can measure and estimate the amounts of materials needed for the project using the quantification tool provided by Autodesk Navisworks.

Teams working on a project can perform takeoffs from the project's 3D model using Navisworks' quantification tool. The application allows project teams to choose and measure particular model elements, such as walls, floors, and ceilings, and then create a list of amounts for these elements. Additionally, the tool enables users to build unique measurement sets that can be applied to measuring materials, like steel or concrete.

The flexibility of the Navisworks Quantification tool to interact with other software programs like Microsoft Excel is one of its main advantages. Project teams can use the quantities produced by the tool for estimating, budgeting, and purchasing by exporting them to Excel. Project teams can generate reports and visualizations of the quantities monitored using Navisworks' Quantification tool. By ensuring that stakeholders have a clear grasp of the materials needed for the project, this can enhance project communication.(7)

4 VR

The term "virtual reality technology" refers to the creation of a virtual reality environment using electronic devices like computers, which provides users with a realistic sensory experience in terms of vision, hearing, touch, and other senses, enhances their sensory level, and immerses them in it. VR technology has a wide range of potential applications in fields like engineering, healthcare, education, and entertainment. Using VR technology, project designers can increase the degree of realism in their models, experience the effects of building before it begins, and efficiently communicate with one another, among other things. (9)

4.1 BIM + VR

The usage of VR in the construction industry is becoming more widely accepted. With the use of virtual reality (VR), users may fully immerse themselves in a manipulable, 1:1-scale, 3D/BIM model that gives them a sensation of presence in a future building.

Professionals in the fields of architecture, engineering, and construction management are aware that VR applications help clients see ideas early, cutting material costs from budgets and lowering the number of workers required for projects. For instance, a VR tour can be used with a BIM model to verify the maintenance schedule from a facility management perspective (7D/BIM model) or the constructability assessment from a project team perspective (4D/BIM model), aiding decision-making. (10)(9)

4.1.1 Benefits of VR in BIM

➤ Improved Visualization

3D building design visualization in virtual reality can offer a really immersive experience. It enables interested parties to digitally tour a structure before it is built, giving them a greater knowledge of the area and how it will operate.(9)

➤ Better Communication

By offering a common forum for debating design concepts, construction methodology, and project phasing, VR can help stakeholders communicate more effectively. Regardless of where they are physically located, it enables design teams to work in real time.(9)

➤ **Enhanced Coordination**

Before construction even starts, VR can assist in finding conflicts and spotting potential problems in the building design. Early detection and resolution of these problems can reduce the need for rework, which reduces both time and expense.(9)

➤ **Increased Efficiency**

VR can reduce the time and cost of physical prototyping, testing, and mock-ups. With VR, stakeholders can evaluate designs and give feedback without using physical models, saving time and money on making and shipping them.(9)

➤ **Enhanced Safety**

Virtual reality (VR) technology may imitate real-world circumstances and offer training opportunities for construction workers and other stakeholders, assisting them in getting ready for dangerous situations and working more safely on-site. (11)(9)

4.2 Prospect by Iris VR

Architects, designers, and other professionals may quickly create and examine immersive virtual reality (VR) experiences of their ideas using the Prospect software platform, which was created by Iris VR. The platform was created with the express purpose of facilitating the development of VR experiences for architectural and construction projects.(12)

Prospect's simplicity of use is one of its best qualities. Users of the platform can quickly import 3D models from a variety of design applications, such as Revit, SketchUp, Rhino, and 3ds Max. After importing, users may quickly and simply use a drag-and-drop interface to build a realistic VR experience. Users may now build VR experiences without having to have advanced programming or technical knowledge.(12)

Prospect's facilitation of collaboration is another important element. Users of the platform may share their VR experiences with coworkers and clients, giving them a more immersive and engaging method to explore and interact with the design. This can facilitate better communication and teamwork and aid in spotting possible problems or areas for development early in the design process.(12)

Prospect also comes with a number of features and tools that are intended to improve the VR experience. For instance, the platform offers support for spatial audio, which enables users to perceive voices and sounds in the virtual environment as originating from certain places.(12)



Figure 3. Prospect Iris VR

5 AUGMENTED REALITY

Augmented Reality (AR) is a subset of Virtual Environment (VE), often known as Virtual Reality (VR). Virtual Reality technologies totally immerse a user inside a synthetic environment, and the user is unable to perceive the real world around him when immersed. In contrast, Augmented Reality is the process of overlaying digital or computer-generated information, such as photos, music, video, and touch or haptic sensations, in a real-time environment. Technically, augmented reality can be used to enhance all five senses, although its most common current application is visual. Unlike Virtual Reality, Augmented Reality allows users to see the real environment while having virtual things placed on or composited with it.

5.1 Advantages of AR

With the aid of gadgets like smartphones, tablets, and smart glasses, augmented reality (AR) technology superimposes digital data on the real world. AR has a number of benefits, including:

Enhanced User Experience: By giving users more context and information about the real environment, augmented reality can improve the user experience. To give consumers additional knowledge about their surroundings, AR can be used to overlay information about restaurants or landmarks onto a map, for instance.(13)

Better Education and Training: AR can be used to create interactive, fun training experiences. AR can be used, for instance, to replicate surgical procedures or to present detailed instructions for putting complex machinery together.(14)

Enhanced Efficiency: AR can be utilized to improve efficiency by streamlining processes. AR can be used, for instance, to give employees access to real-time information on a production line's progress or the location of items in a warehouse.(14)

Better Visualization: AR may be used to make dynamic, realistic 3D models of items and structures. For architects and designers, it might be helpful to conceptualize and test plans before they are built.(14)

Marketing and advertising: Interactive and interesting marketing and advertising campaigns can be made with augmented reality. Customers may use AR to try on virtual clothes or see how furniture would look in their homes, for instance.

Accessibility: Through the application of augmented reality, more accessible experiences can be made for those with disabilities. For instance, augmented reality (AR) can be utilized to provide audio descriptions of real-world settings or to assist those who are visually impaired in navigating their environment.(13)

5.2 BIM + AR

In BIM, AR technology can be used to superimpose 3D models of building designs onto an actual environment, giving project stakeholders a more immersive and interactive view of the building design. By superimposing real-time data on the construction site, such as the location of pipes, wires, and other building components, AR can also be used to provide on-site instruction to construction employees.(15)

When presenting the building design to clients and other stakeholders who might not be accustomed to reading 2D plans and drawings, AR technology can be especially helpful. Project stakeholders can experience the building design in a more immersive way by employing augmented reality, which helps them comprehend the layout and functionality of the structure. (15)

Construction and facilities management can both benefit from the usage of augmented reality technologies. Construction workers and facility managers can more easily spot and address problems, such as conflicts between building components and other concerns, by superimposing real-time data onto the construction site.(15)

A more immersive and interactive way to envision building plans and manage construction projects is provided by augmented reality, which is an exciting advancement in building information modeling. AR technology is anticipated to become a more crucial tool for building design and construction as it develops.(15)

5.3 GAMMA AR

The Augmented Reality (AR) technology known as Gamma AR employs cutting-edge algorithms to produce a more lifelike and immersive AR experience. It is intended to get beyond some of the drawbacks of conventional AR, like bad tracking and occlusion.

Gamma AR's capacity to track the location and orientation of objects in the real world with a high degree of accuracy is one of its distinguishing characteristics. This is accomplished by combining methods for sensor fusion, machine learning, and computer vision. This makes it possible to link virtual items to actual objects in a way that looks more organic and realistic.

The capability of Gamma AR to handle occlusion is another important characteristic. When real-world items, such as walls or furniture, appear to block or obscure virtual objects, this phenomenon is known as occlusion. To detect occlusion and modify the depiction of virtual objects to make them seem more realistic, Gamma AR uses sophisticated algorithms. This may contribute to an immersive and captivating AR experience.(16)

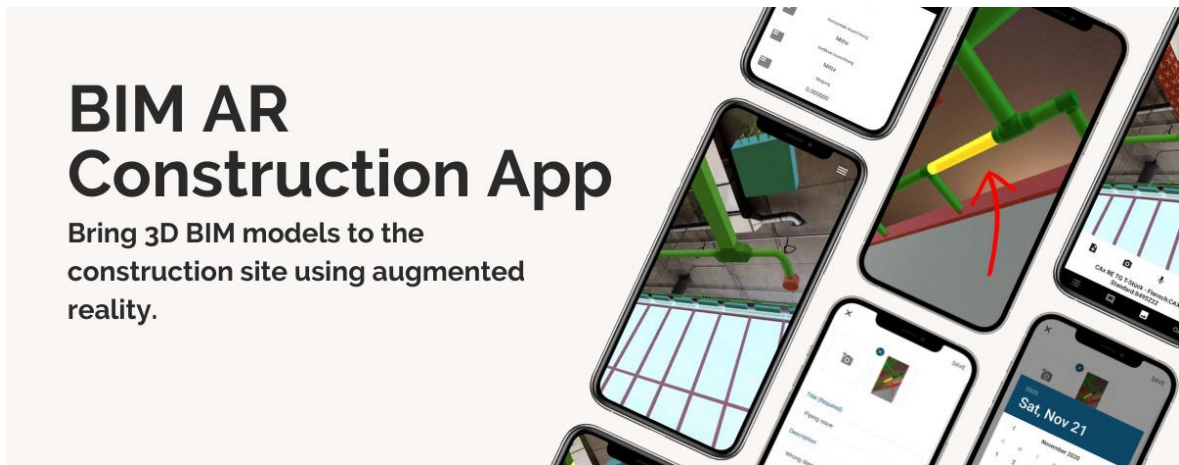


Figure 4. GAMMA AR

Gamma AR is also intended to be very adaptive and adjustable. Simple animations to intricate interactive simulations may all be made using it to provide a variety of AR experiences. Additionally, it can be applied in a number of sectors, such as manufacturing, marketing, education, and entertainment.(16)

In summary, Gamma AR marks a substantial development in augmented reality technology, providing a more immersive and realistic experience while overcoming many of the drawbacks of conventional augmented reality. The technology is projected to become more crucial in a variety of industries and applications as it continues to advance.(16)

II. PRACTICAL PART

6 PURPOSE OF THE PRACTICAL PART

The practical part will put the above-mentioned information into practice. For this purpose, there was chosen a simple model of university kindergarten granted by the university. This allowed me to perform more complex tasks and explore options in AR and VR.

The practical part is essentially divided into four subparts:

- description of the building of the university kindergarten,
- analysis of the building using BIM tools,
- transferring BIM to VR
- transferring BIM to AR

For fulfilling the goals of the thesis – to analyze the given model using BIM software and explore options for visualizing it in VR and AR – several tools and softwares were needed.

Namely:

- Autodesk Revit
- Autodesk Navisworks Manage
- Prospect by IRIS VR
- Gamma AR
- Vive VR glasses
- Computers
- Tablets and mobile phone devices

6.1 Specifics of the University Kindergarten

VSB–Technical University of Ostrava developed VSB-TUO Kindergarten as a company preschool for the education of children of staff and students. It is in a freshly constructed ground-floor structure with a school garden in the middle of Ostrava-Poruba's university campus. Kindergarten offers a full-day preschool education program for children aged three to seven.

The kindergarten building meets the highest requirements for facilities of this type. During its design, the requirements for the maximum functionality of all spaces, interior equipment that resonates with the aesthetic sensibility of children, zones with sofas for parents, and sufficient facilities for teaching and administrative staff were considered.



Figure 5. SKOLKA Front

There are a total of three departments in the kindergarten, each of which is dominated by one of the colors – blue, green, and yellow. Two large departments each have a capacity of 25 children, a small department has a capacity of 10 children. The total capacity of the facility is therefore 60 children.



Figure 6. SKOLKA Back

Each department consists of an area for controlled activities (tables and chairs) and a part for play and relaxation activities (carpet). Each department also has a separate facility, which

includes a children's changing room, a washroom and toilet, a shower, a storage room for beds, a cleaning room, and an office. In addition to the school administration office, the kindergarten also has a canteen dispensary.

The kindergarten has sufficiently large spaces, the layout of which fully suits a variety of group and individual guided and free activities. The ventilation and lighting of the classrooms are ensured in accordance with the given hygiene standards and regarding the ongoing activities. Health and hygiene facilities (washrooms, toilets) and equipment for children to rest (beds) correspond to the number of children and are safe for health.

The building is a single-story RCC building fully equipped with amenities with an area of 1050sq.m.



Figure 7. Skolka Side

7 BIM ANALYSIS

The first task was to analyze the given model using BIM softwares. As I was given access to the architectural and MEP models in the Trimble connect systems, I downloaded them into IFC format. For the purpose of using them in Autodesk Revit, I tried converting them using multiple methods:

- the “manage links” option, to open as IFC in Revit,
- trying to convert IFC to RVT files.

7.1 Autodesk Revit

The given model which is in the IFC format was converted to “. rvt” files to explore and study about the building.

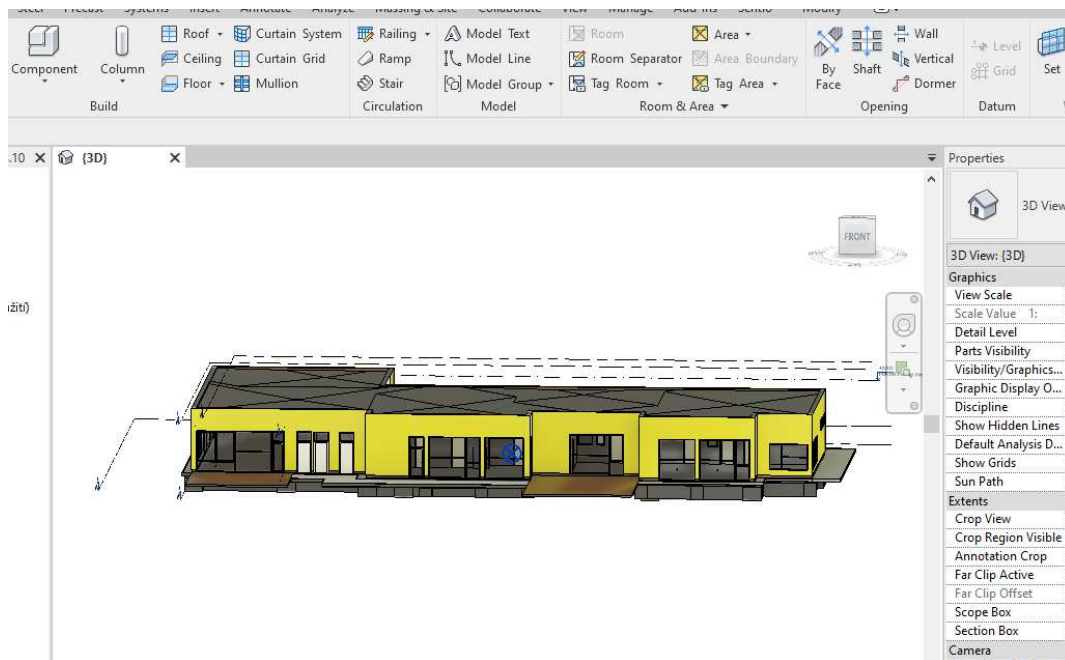


Figure 8. Revit model

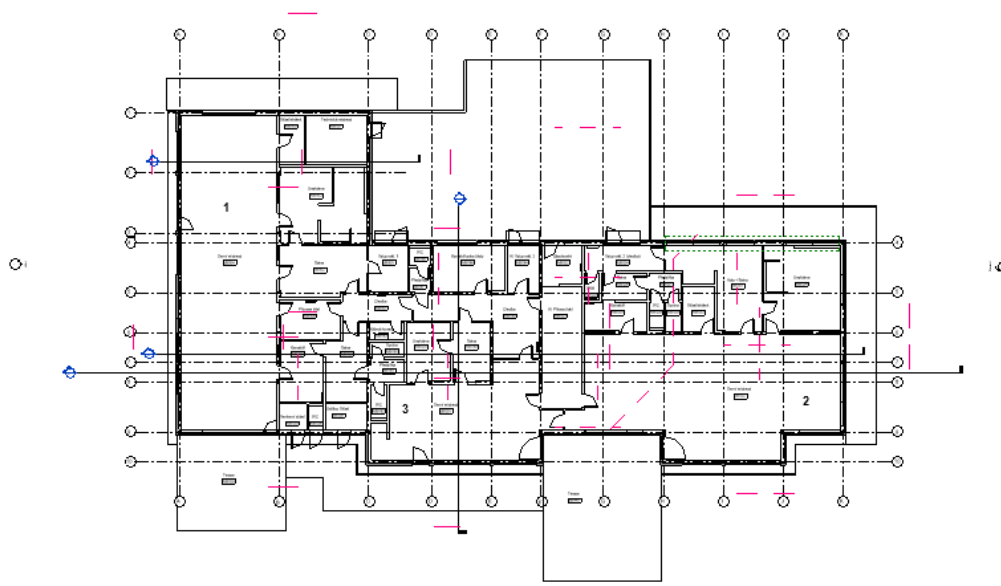


Figure 9. Floor Plan

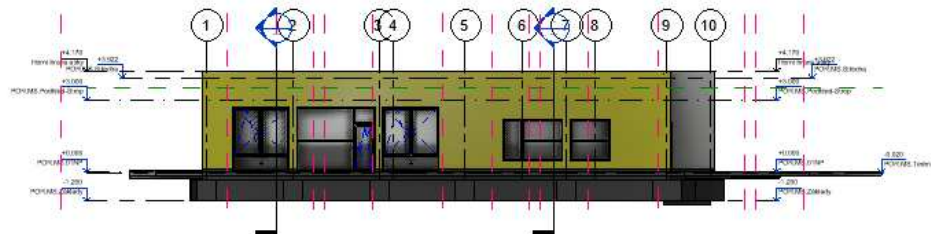


Figure 10. Elevation 01

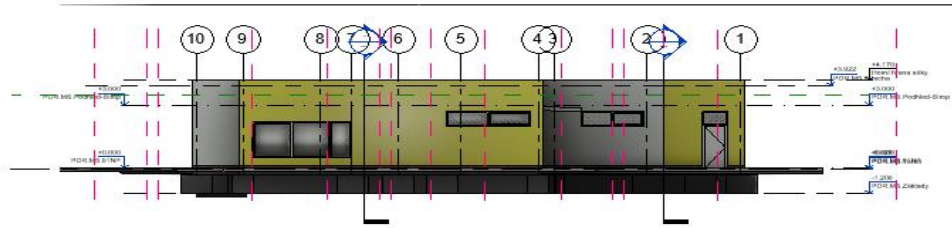


Figure 11. Elevation 02

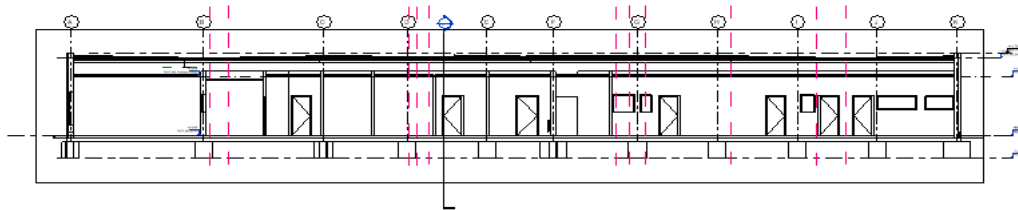


Figure 12. Section 01

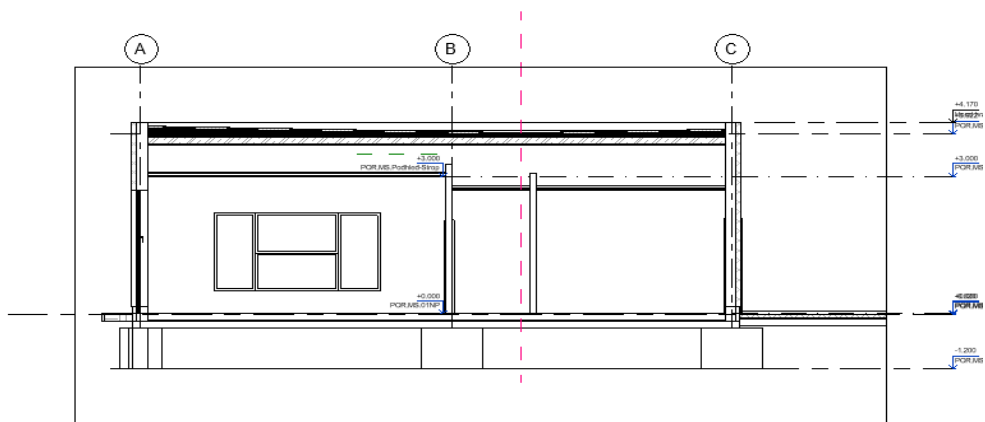


Figure 13. Section 02

7.2 Navisworks

As the main motive of the thesis is to try out the BIM integrated software tools to be tested using the model, I converted the model from IFC or RVT files into NWD or NWF files which are the native files of Navisworks Manage in Revit.

There is also an alternative way to open the IFC files directly in Navisworks.

This part of the thesis will describe the possibilities of using different tools in Navisworks. Specifically:

- append,
- clash detective,
- time liner,
- and stimulate.

7.2.1 Append

The append tool helps the three different models, namely Architectural, structural, and MEP models, to combine and create a single model, ready to be used in Naviswork Manage. It is done by clicking the append or merge tool in the toolbar as shown in Figures 1 to 3.

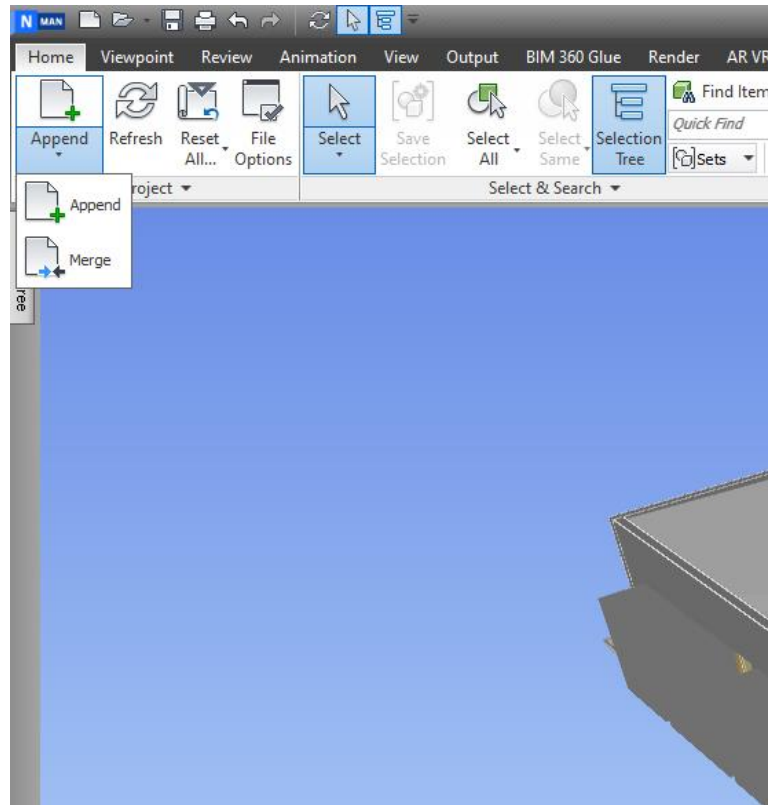


Figure 14: append 1

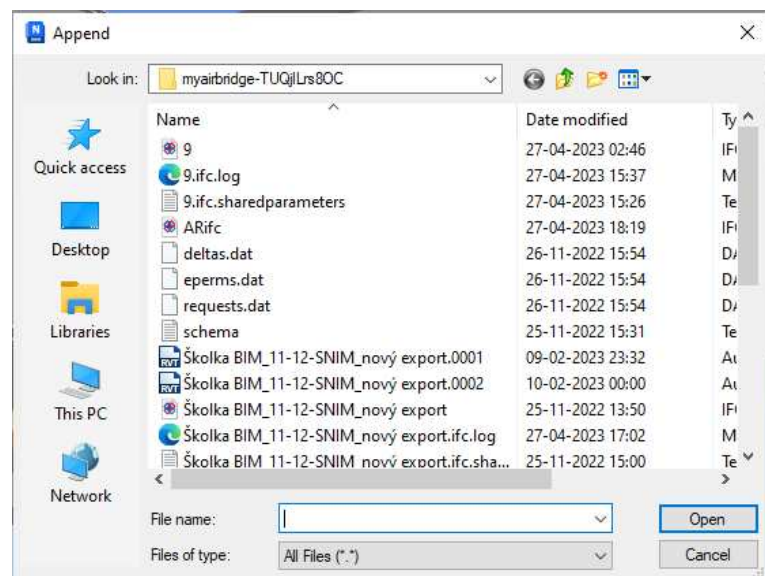


Figure 15: append 2

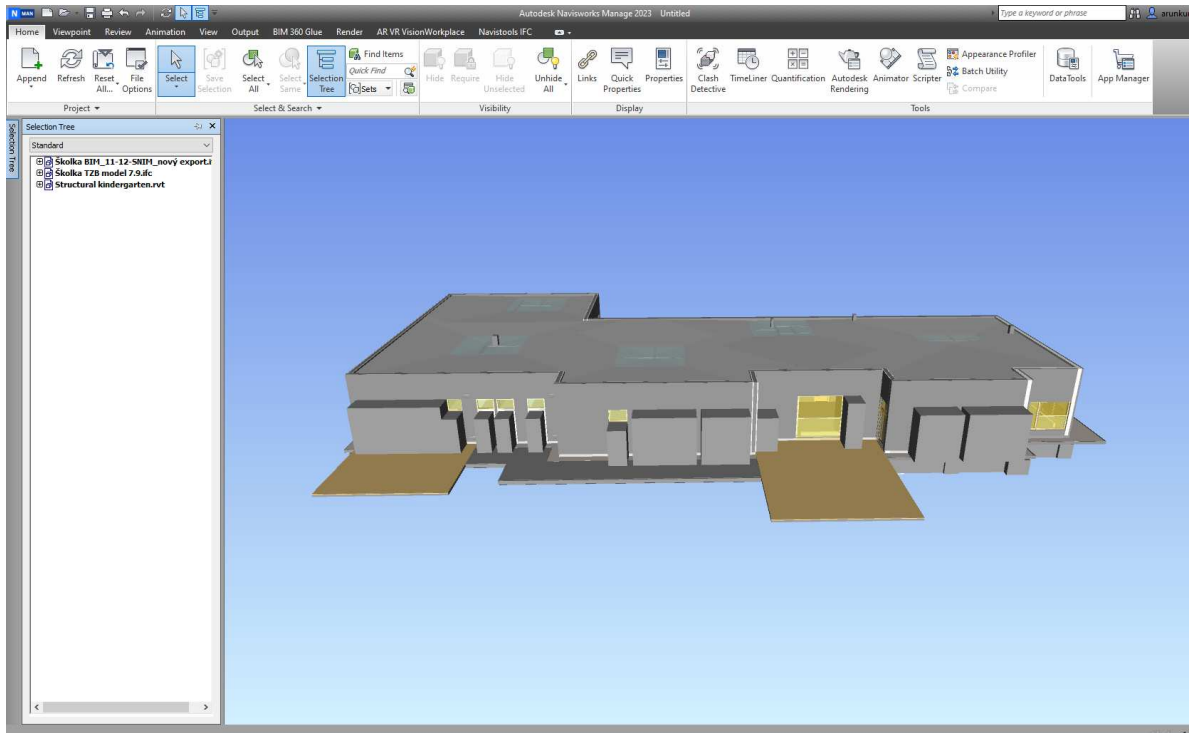


Figure 16: append 3

Now the model is available to be worked with also in all the other tools of Navisworks.

7.2.2 Clash Detective

To run the collision detection test, it is necessary to start by clicking the clash detective tool and follow some rules in what way the test should be made.

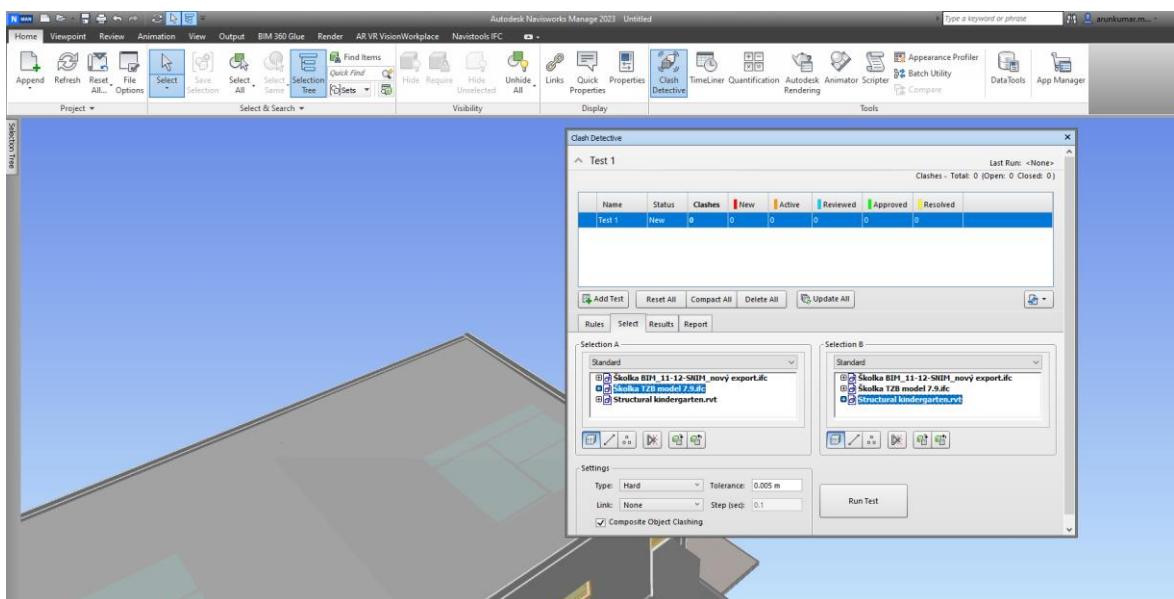


Figure 17: clash detective 1

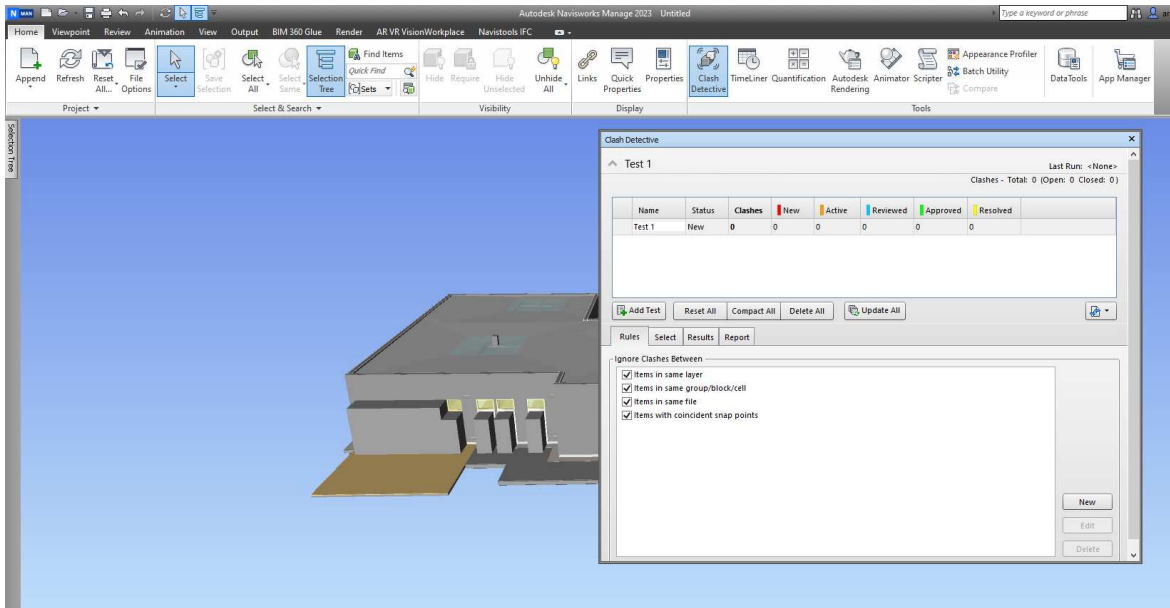


Figure 18: clash detective 2

After clicking the run test button in the menu, the results will be shown.

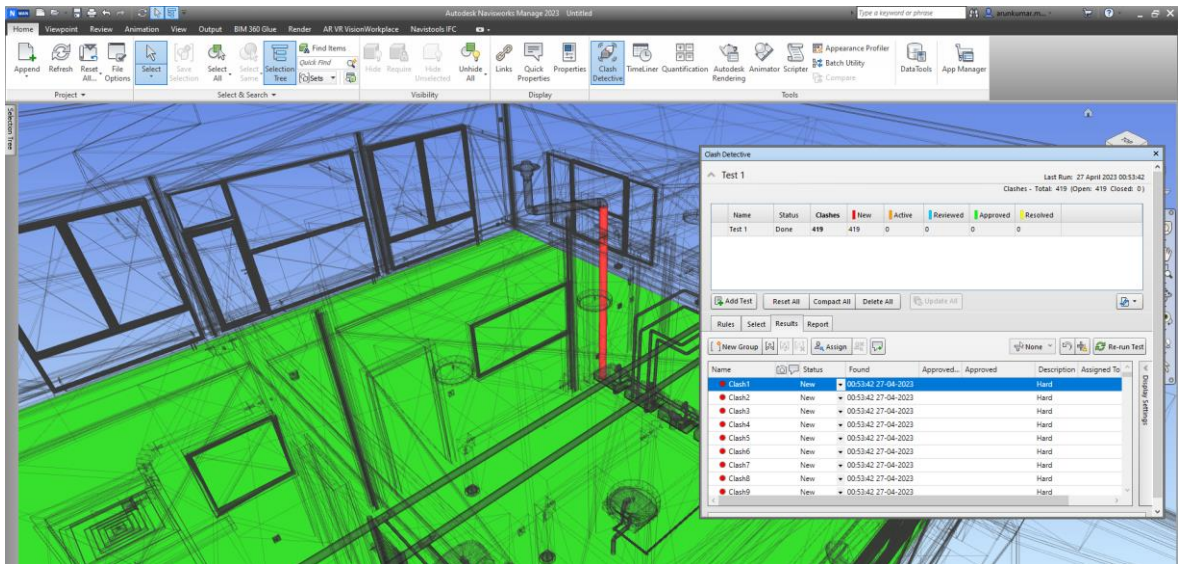


Figure 19: clash detective 3

From here, there is a possibility of saving the reports of the clash detections using the report menu in the widget screen as shown in Fig. 7. That allows to choose specific options of the content which are needed for the report delivered in XLS format.

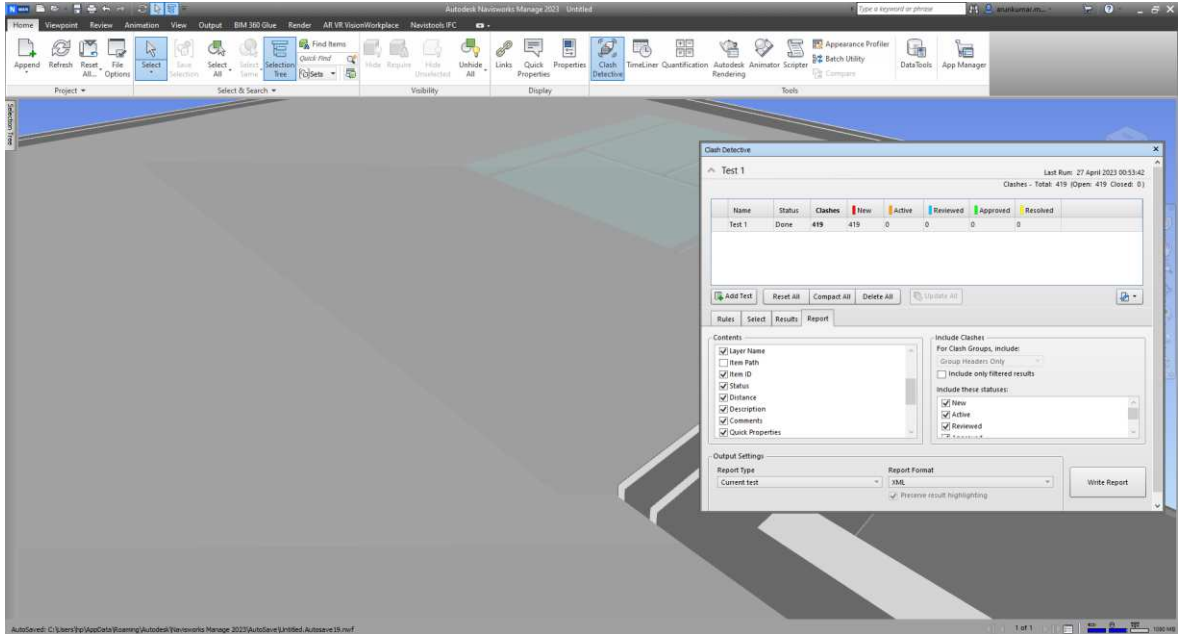


Figure 20: Clash Detective 4

7.2.3 Time Liner

By using the Time Liner tool it is possible to schedule the construction process of the whole building step by step. Clicking the time liner option in the home tab, there are multiple options to add a task and attach an entity for the task with the calendar.

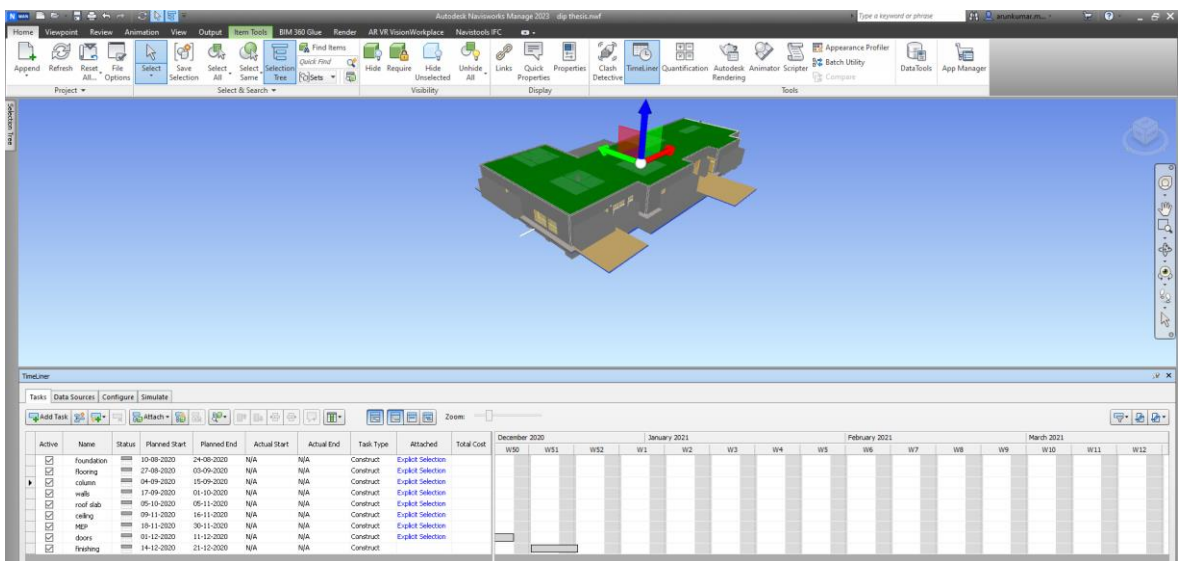


Figure 21: Time liner

7.2.4 Stimulate

Navisworks has this amazing tool called stimulate which converts the time-lined sequences into a video format. Stimulate tool also offers an option for the rendering process, to save the video in accordance with the preferred quality.

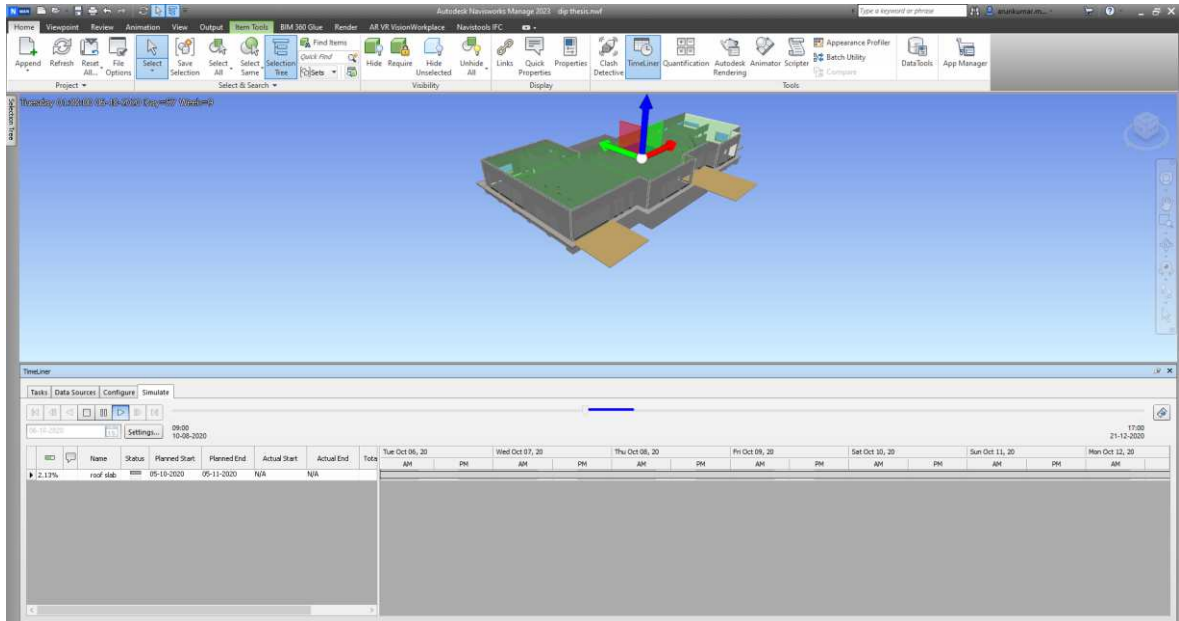


Figure 22: Stimulate

8 VR

Virtual Reality is another dimension of visualization in the construction industry. There are many hardware and software possibilities in how to try out VR. The downside often is their price as they're usually expensive.

8.1 Revit to VR

To visualize a building model in VR, the model should undergo some technical conversions from the construction software tools like Autodesk Revit and Navisworks manage.

First, it is needed to test compatibility with the VR visualization. It is done by converting the classic Revit format file (.rvt) to an IFC file, or the direct Revit file can be loaded into it. After that is necessary to install the Prospect by Iris VR plugin for the Autodesk products. This allows to run and convert the model in the VR environment. The result was amazing as it came up so well.



Figure 23: Revit to VR

The results proved that the model can be explored completely and the information of each floor, family, and elements but only in a particular model like Architectural, Structural, and MEP Revit model.

8.2 Navisworks to VR

After testing all the BIM tools from Navisworks like Append, Time liner, Stimulate, and Clash Detective the results are saved as a single model in (.nwf) format. Now the Prospect by IRIS VR plugin is installed and opened in the Navisworks software in the status toolbar.

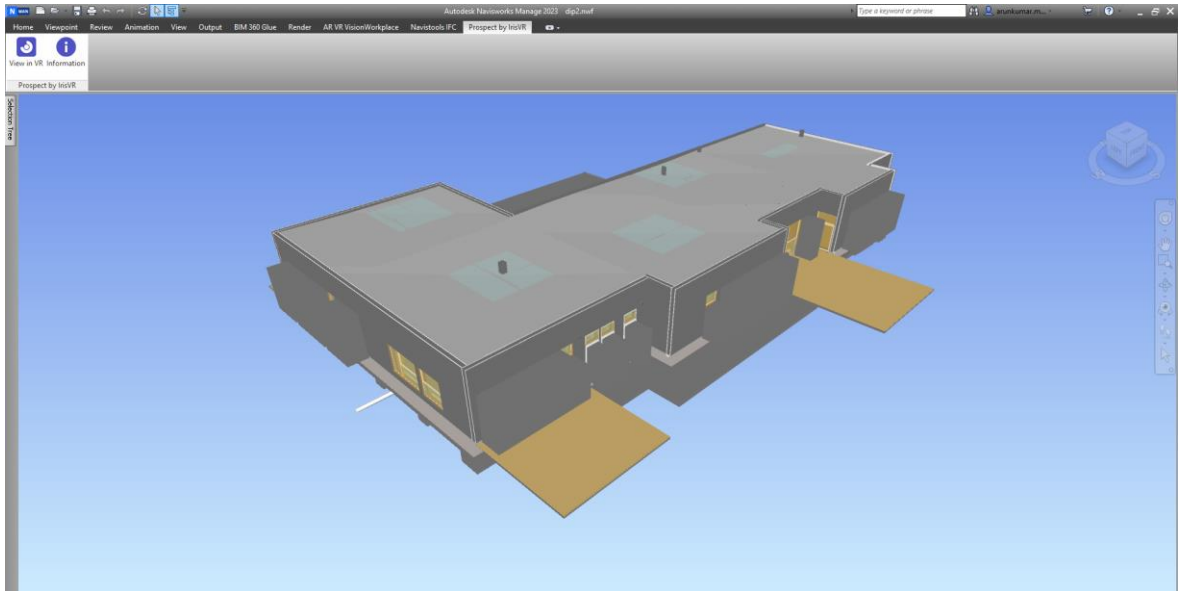


Figure 24: Prospect by IRIS VR

Clicking on the Iris VR software tool in Navisworks will open a new window of the respective software where it connects to an Autodesk account. Now the model is uploaded in its actual format and then the VR software converts the model and publishes it to the VR environment.

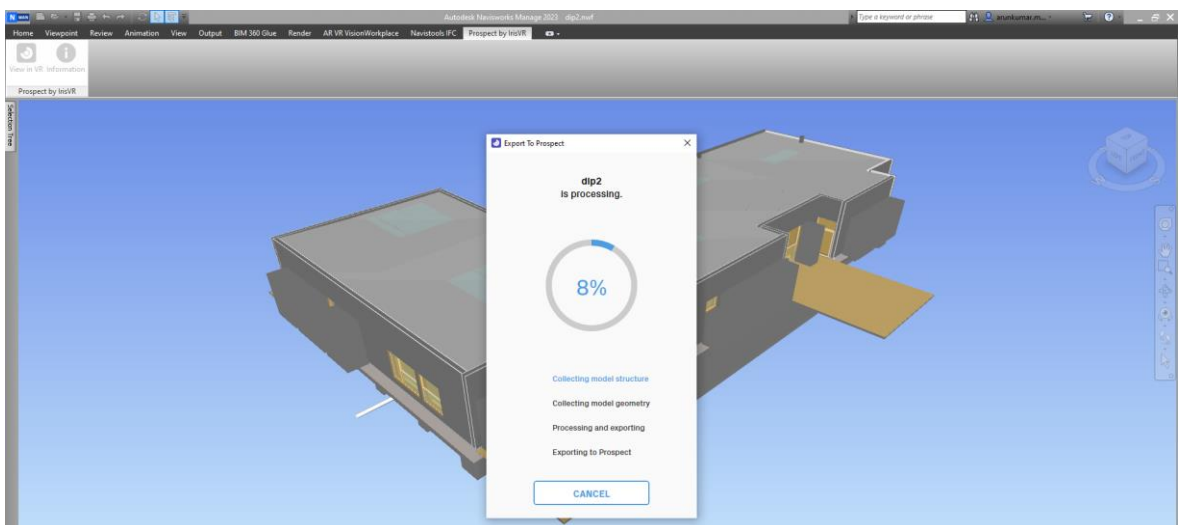


Figure 25: export to Prospect by IRIS VR 2

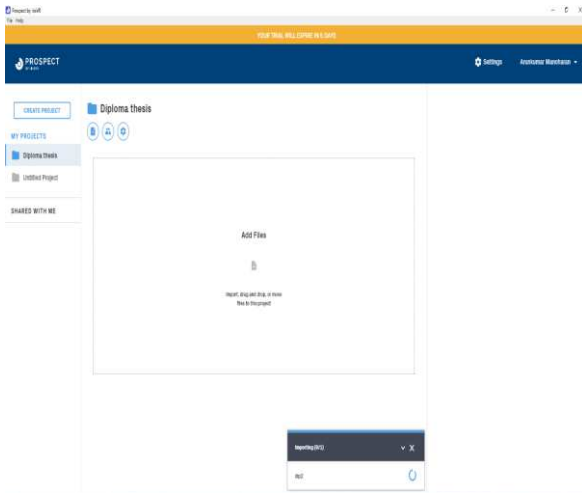


Figure 26: Prospect by IRIS VR 2

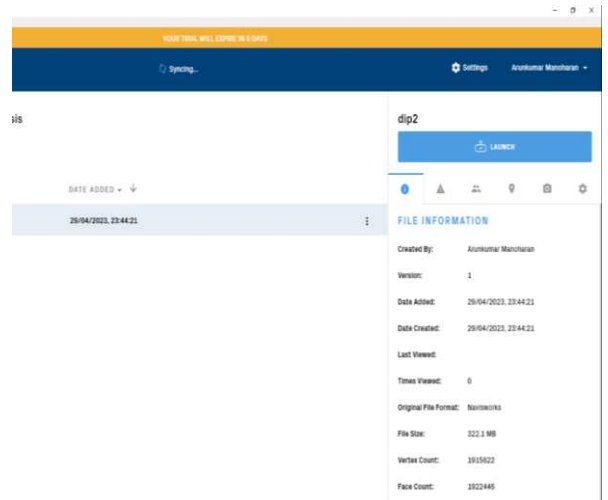


Figure 27: Prospect by IRIS VR 3

As the model was converted from Navisworks, now it is possible to see how well BIM tools worked in a VR environment.

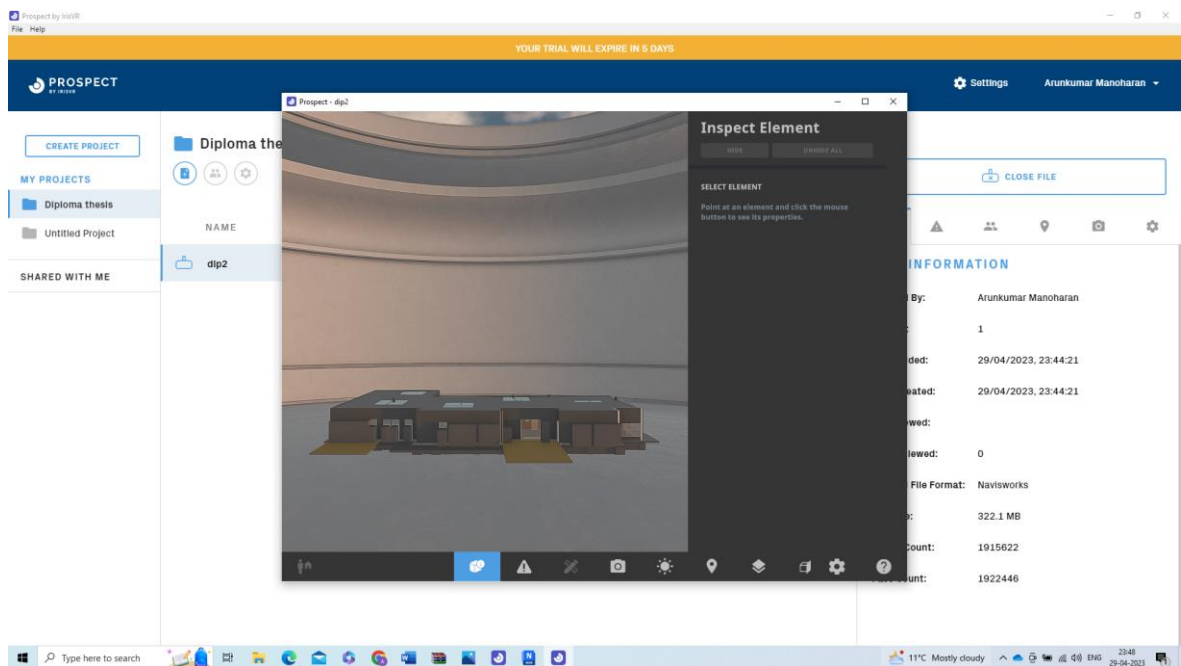


Figure 28: Prospect by IRIS VR 4



Figure 29: VR

- The advantage is that the architectural model, structural model, and MEP model were visible in VR.
- Also, in each model the annotation tools can be used.
- In the VR environment the models could be hidden using the Inspect tool as shown in Figure 17.



Figure 30: VR – inspect element

- The important tool is the viewpoint option which allows showing the clash detective results.

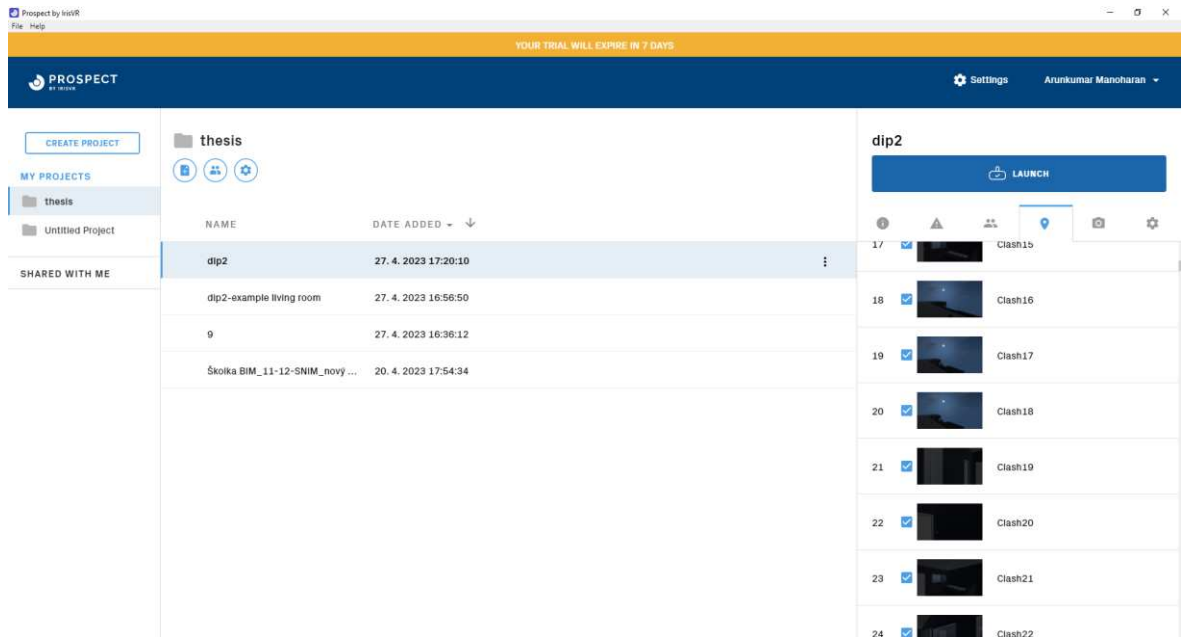


Figure 31: clash detective in VR

9 AR

The last part to be tried out in this work is Augmented Reality. It wasn't easy as virtual reality to try out the AR, because the software and the hardware costs were much higher than first expected and for some reason, it was not available.

9.1 Navisworks to AR

Nevertheless, after consultations it was decided to go with trying out AR using miniature devices like tablets and mobile phones. There are more applications available in the market for such technology. For the thesis, the app GAMMA AR was chosen.

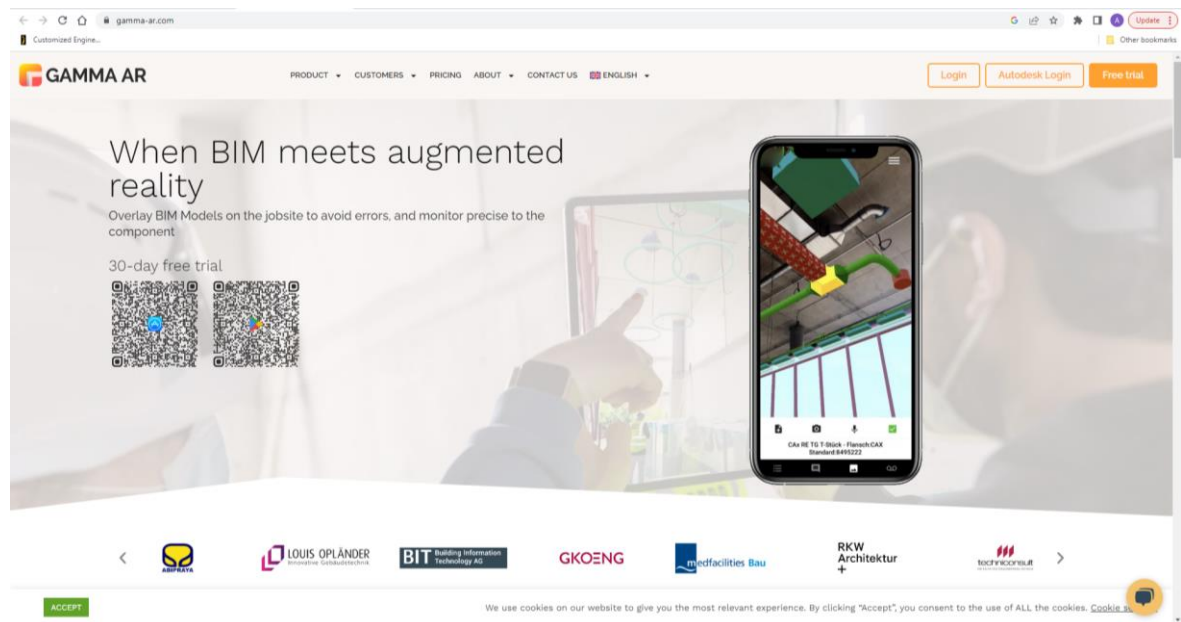


Figure 32: Gamma AR

This user-friendly application helps to convert the BIM models into the AR environment very simply in a few clicks. The given BIM model is transferred to the IFC file and then uploaded to the cloud of the software application and then loaded into it.

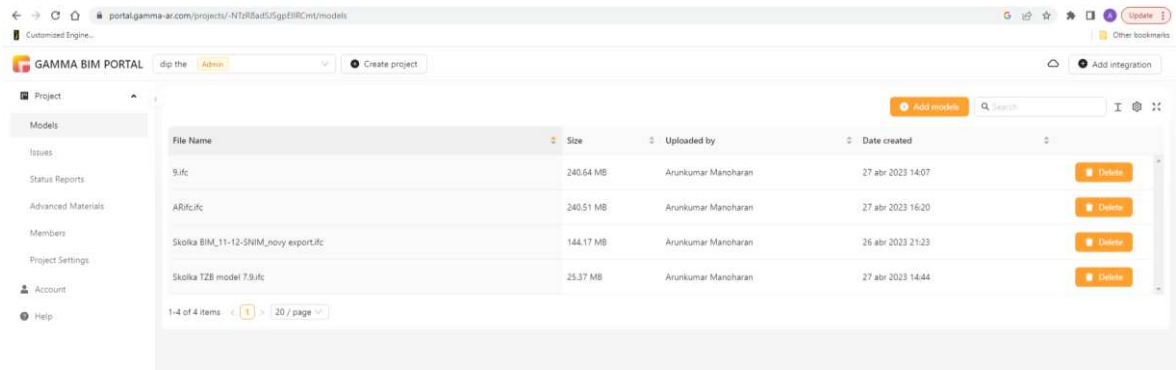


Figure 33: Gamma BIM portal

To publish the model in AR, an Android or Apple version of this software application is downloaded to the mobile device in accordance with the operating system. An Autodesk account is needed for using the website and the mobile device application.

Now on the mobile device, the uploaded models will be shown, downloading it, and loading it will be the next step to do. After that, the model will be already loaded inside the mobile device.

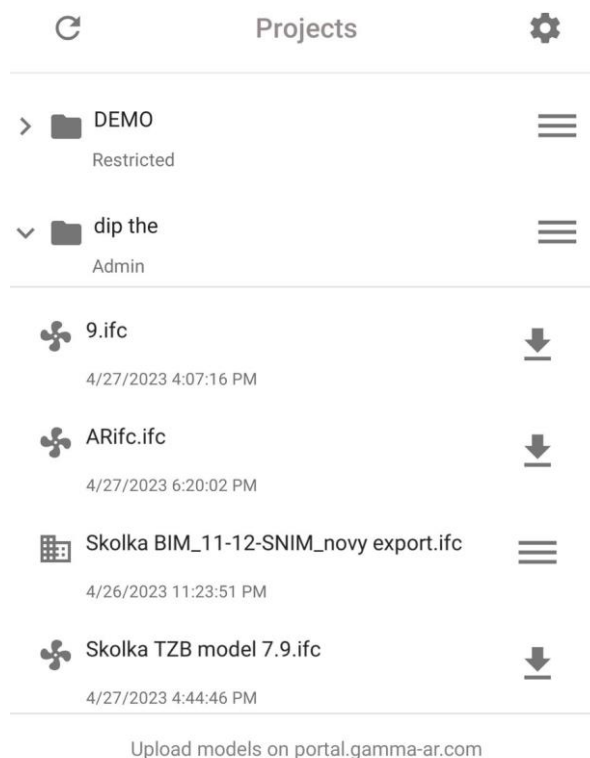


Figure 34: Gamma AR – loading projects

Now the application will ask to select a well accessible wall and align it with the model in the application. This will result in showing the appended models together with the real time model. And the results will be published together on the mobile device.

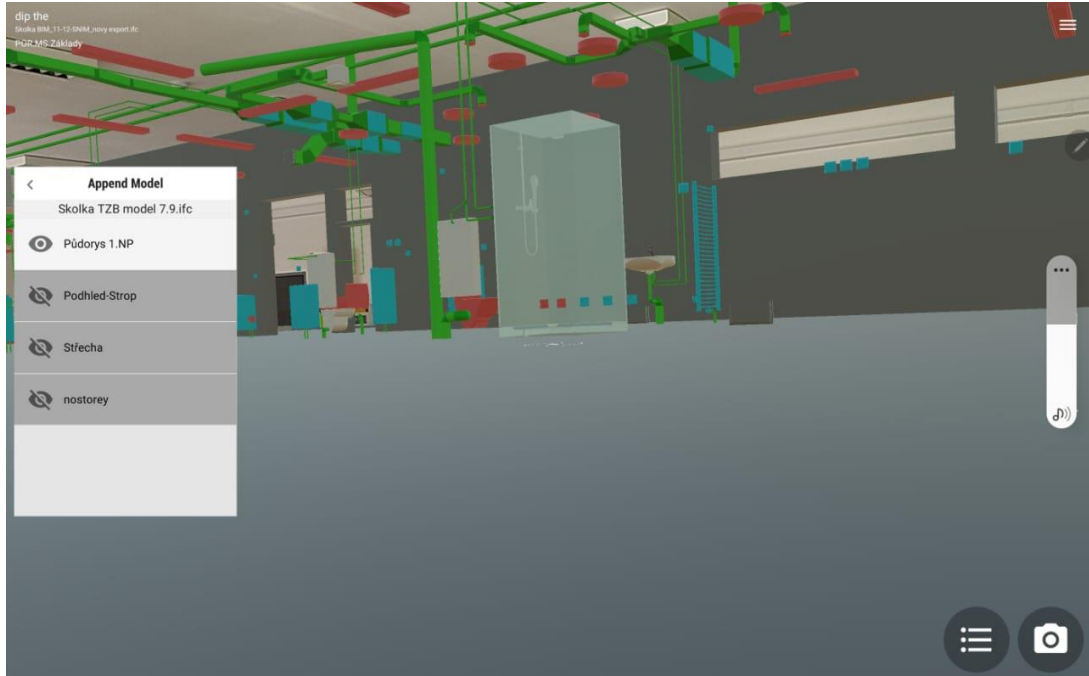


Figure 35: Gamma AR – append model

The published models can also be edited using the append tools built in the app, which will help to add one model over the other model, say MEP over the architectural model.

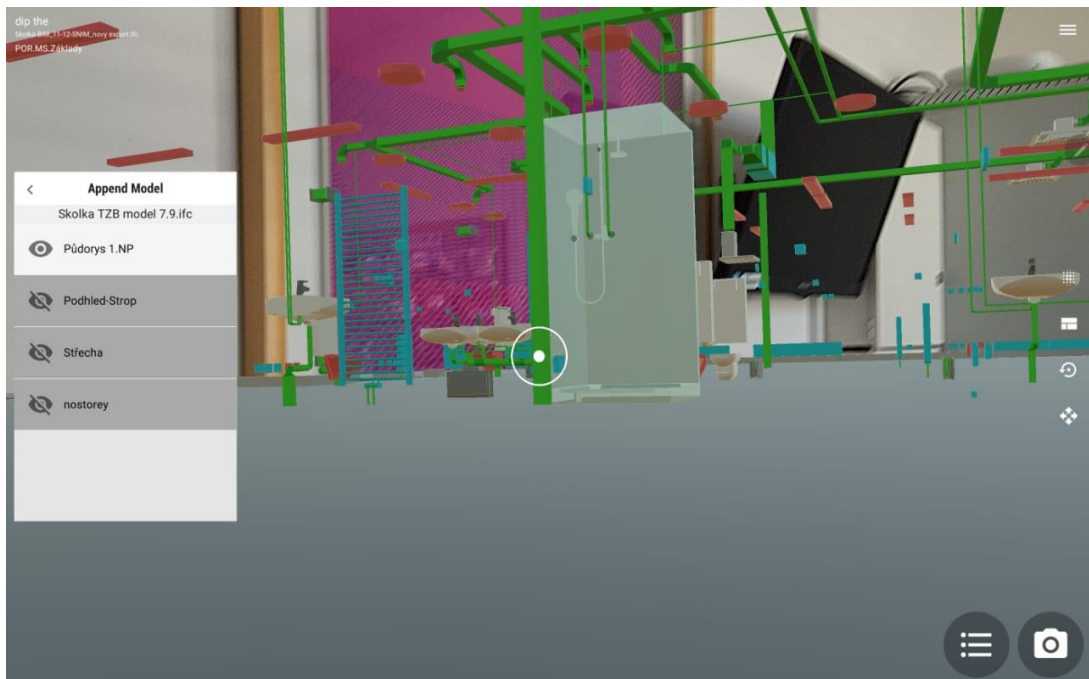


Figure 36: Gamma AR – append model 2

Now to see it as Augmented, the Architectural model can be hidden so that the real time building will be shown, but the MEP elements will be immersed into the natural environment.

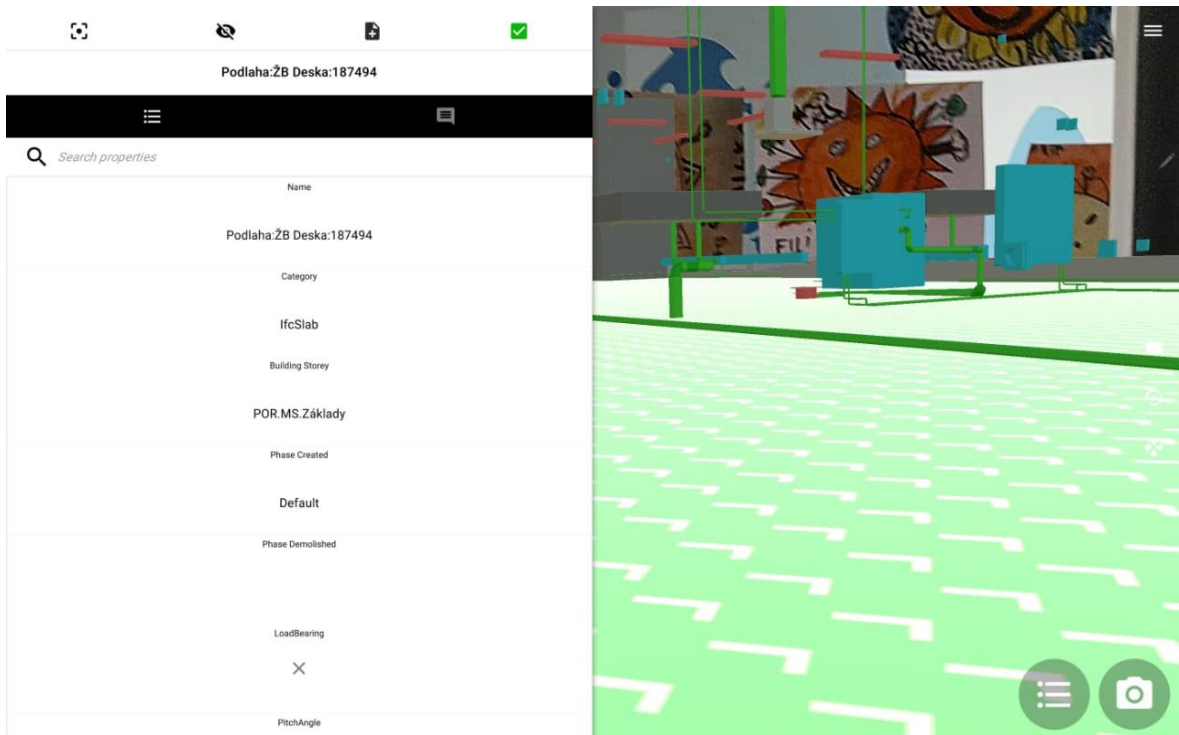


Figure 37: Gamma AR 2

10 SUGGESTIONS

As we know the key for the development of the industry lies on the development of the technology it is important know the best hardware drives that would work with the software programs available ready in the market. I use an old machine but fortunately it could run all the advanced software programs but not with the VR and AR software programs since the low disk space of the graphics. The other main issue faced while using the AR and VR output is the coordination of the VR and AR model to the real time environment. It does not resolve also with the IFC file formats. The other important difficulty while converting the Navisworks file to IFC was the file converts to single element so it was difficult to view in AR and VR. So, it is suggested to work with the Navisworks file to use in the VR and AR for conversion.

From the work done above it is proved that the work progress in the construction industry will be so smooth when we use the AR technology which would restrict the collisions inside the building and stimulate the process of construction up to date. The VR technology helps the AEC professionals to provide better presentation of the software to the stakeholders and to understand the building even better.

CONCLUSION

The scope of this thesis work was to achieve the BIM visualization techniques using the given Revit model. At first, the model was analyzed using the BIM software called Navisworks. There were used tools such as clash detection, time liner, and the append. Then using provided Virtual and Augmented reality tools, the achieved results from Navisworks and Revit are published to the virtual and augmented environments. This allowed to use some of the BIM tools inside the VR and AR platforms.

While trying out the different Autodesk tools it was so important to check out the versions of the software and the file format used to save the project. Even though the model was converted to IFC or their own version of the file format, the project would open a null result sometimes, because the mother file in the concerned computer was missing. So, while transferring the model from one computer to the other, it is important to copy the whole mother files used for the project.

The other main concern was the conversion of Revit and Navisworks files to the IFC file format. The whole model would combine into a single element when tried to convert into IFC file format.

And coming to the software and hardware equipment for VR and AR, it was expensive to buy both. Also, the AR and VR platforms provide limited or no trial versions to try out the BIM tools in the AR and VR environment.

For further research, there is a chance of collaborating the platforms to the BIM software so that every step and procedure tried in the BIM software reacts in the VR and AR platform, which would be the next step in the visualization of BIM technologies.

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LIST OF FIGURES

Figure 1. Autodesk Revit.....	20
Figure 2. Autodesk Navisworks.....	22
Figure 3. Prospect Iris VR	27
Figure 4. GAMMA AR.....	30
Figure 5. SKOLKA Front	33
Figure 6. SKOLKA Back.....	33
Figure 7. Skolka Side.....	34
Figure 8. Revit model	35
Figure 9. Floor Plan	36
Figure 10. Elevation 01	36
Figure 11. Elevation 02.....	37
Figure 12. Section 01	37
Figure 13. Section 02	37
Figure 14: append 1	39
Figure 15: append 2	39
Figure 16: append 3	40
Figure 17: clash detective 1	40
Figure 18: clash detective 2	41
Figure 19: clash detective 3	41
Figure 20: Clash Detective 4	42
Figure 21: Time liner	42
Figure 22: Stimulate.....	43
Figure 23: Revit to VR.....	44
Figure 24: Prospect by IRIS VR.....	45
Figure 25: export to Prospect by IRIS VR 2.....	45
Figure 26: Prospect by IRIS VR 2	46
Figure 27: Prospect by IRIS VR 3	46
Figure 28: Prospect by IRIS VR 4.....	46
Figure 29: VR	47
Figure 30: VR – inspect element	47
Figure 31: clash detective in VR.....	48
Figure 32: Gamma AR.....	49
Figure 33: Gamma BIM portal	50

Figure 34: Gamma AR – loading projects	50
Figure 35: Gamma AR – append model	51
Figure 36: Gamma AR – append model 2	51
Figure 37: Gamma AR 2.....	52