POLITECNICO DI TORINO

Corso di Laurea Magistrale in Architettura Costruzione Citta
Anno Accademico 2019/2020

TESI DI LAUREA MAGISTRALE

The BIM Approach For Data Optimization

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July 2020

ABSTRACT

The research carried out for this thesis aims to study the different BIM approaches for data optimization. Based on the BIM model, through the better integration and coding of all the information, using the related BIM technology to complete the work in different phases. In particular, the present work is focused on the case study of the Torre Regione Piemonte. The work is divided into different phases: At first, Integrating all traditional 2D drawings building information into a central BIM model for data management. The purpose is to complete all building information in a better way by using the BIM software. Based on the BIM model, extract the information of different architectural elements, further integrate and encode the information, and use the relevant BIM technology to complete the different work of different phases. For example, the application for construction and maintenance. The final objective of the present thesis is to through the study, understand the advantages of BIM in storing, maintaining, and exchanging information. And how to use BIM technology, improve building quality, improve construction efficiency, and so on. In the end, summarize and look forward to the latest BIM technologies in the future.

ABSTRACT

La ricerca condotta per questa tesi ha lo scopo di studiare i diversi approcci BIM per l'ottimizzazione dei dati. l'utilizzo la relativa tecnologia BIM per completare il lavoro in diverse fasi si basa sullo sviluppo modello BIM, attraverso una migliore integrazione e codifica di tutte le informazioni. In particolare, il presente lavoro si concentra sul case study della Torre Regione Piemonte.Il lavoro è suddiviso in diverse fasi: inizialmente, l'integrazione di tutti i disegni 2D tradizionali che creano informazioni in un modello BIM centrale per la gestione dei dati.Lo scopo è quello di completare tutte le informazioni sulla costruzione in modo migliore utilizzando il software BIM. Sulla base del modello BIM, è possibile estrarre le informazioni di diversi elementi architettonici, integrare e codificare ulteriormente le informazioni e utilizzare la tecnologia BIM pertinente per completare i diversi lavori di diverse fasi, ad esempio l'applicazione per la costruzione e la manutenzione. L'obiettivo finale della presente tesi è quello di comprendere, attraverso lo studio, i vantaggi del BIM nella memorizzazione, manutenzione e scambio di informazioni e come utilizzare la tecnologia BIM, migliorare la qualità dell'edificio, migliorare l'efficienza della costruzione e così via. Alla fine, riassumere e non vedere l'ora delle ultime tecnologie BIM in futuro.

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1.Introduction

1.0:The main objectives of thesis research

This Master's degree thesis is part of the research approach of “drawing to the future laboratory”, DISEG (Department of Structural, Building and Geotechnical Engineering), Politecnico di Torino, Italy. Where different students contribute with other thesis for the different research directions.

The main objectives of the present thesis research are listed below:

- Investigating the BIM process.

- Developing a BIM model for construction activity and maintenance activity.

- Extracting information from the BIM model for specific uses (For example: schedules, tables, drawings, etc).

- Looking forward to the latest BIM technologies in the future.

1.Introduction

1.1:Introduction of BIM

1.1.1:What is BIM?

BIM (Building Information Modeling) is a data tool used in engineering design, construction, and management. Through the integration of data and information models of buildings, it is shared during the entire life cycle of project planning, operation, and maintenance. And transmission, so that engineering and technical personnel can correctly understand and efficiently respond to various building information, provide a basis for collaborative work for the design team and all construction entities including construction and operating units, and improve production efficiency, save costs and shorten Play an important role in the construction period.[00]

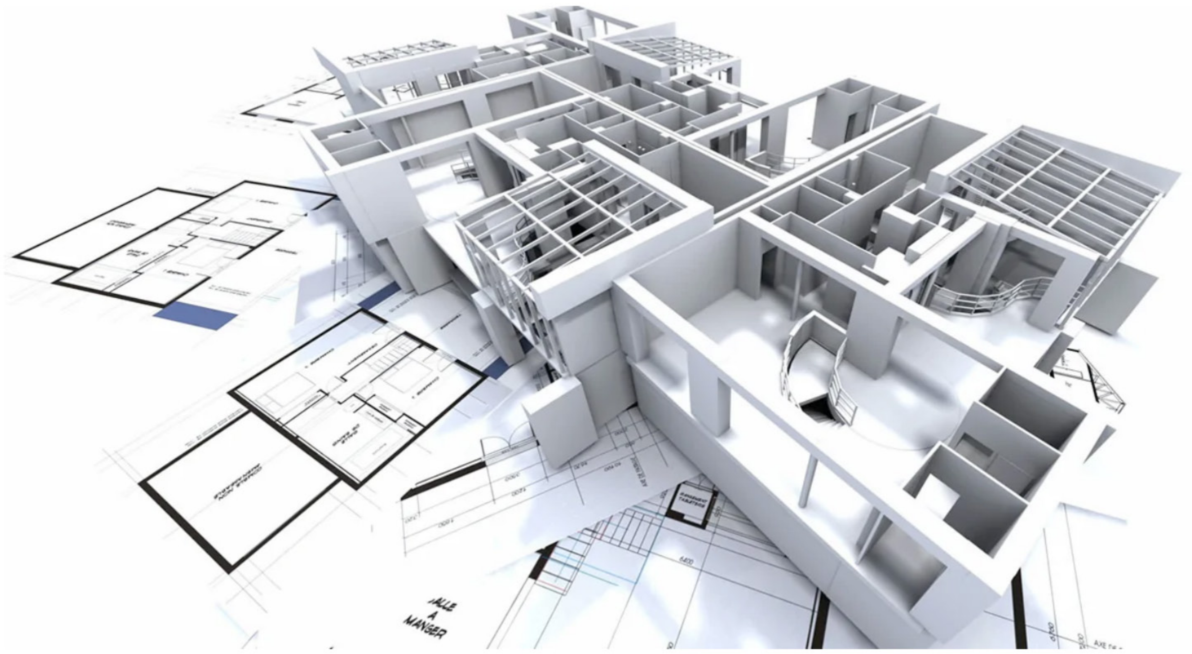

Figure 1： The concept of the Building Information Modeling[01]

The core of BIM is to provide a complete and consistent construction engineering information database for this model by

1.Introduction

establishing a virtual three-dimensional model of construction engineering and using digital technology. [02] The information database contains geometric information, professional attributes, and status information describing building components, and also includes status information of non-component objects (such as space, motion behavior). Through this three-dimensional model containing construction engineering information, the degree of integration of construction engineering information is greatly improved, thereby providing a platform for engineering information exchange and sharing for relevant stakeholders of construction engineering projects.

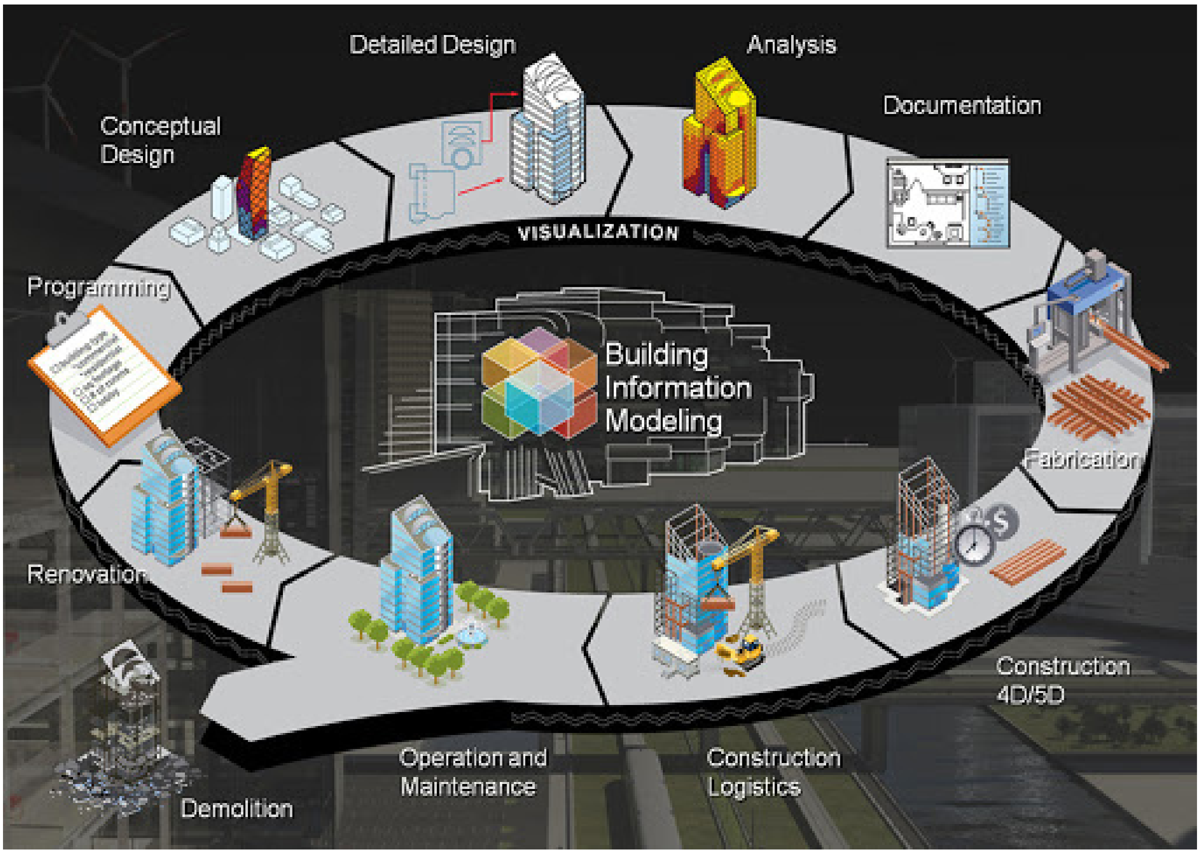

Figure 2： The workflow of the Building Information Modeling[03]

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1.1.2:CAD vs BIM

Computer-Aided Design (Computer-Aided Design) refers to the use of computers and graphics equipment to help designers carry out design work.

In the design, a large number of calculations, analysis, and comparisons of different schemes are usually carried out with a computer to determine the optimal scheme; Designers usually start designing with sketches, and the heavy work of turning the sketches into work drawings can be handed over to the computer; The design results automatically generated by the computer can quickly make graphics so that the designer makes judgments and modifications; The computer can be used to process graphics data related to the editing, enlargement, reduction, translation, copying, and rotation of graphics.

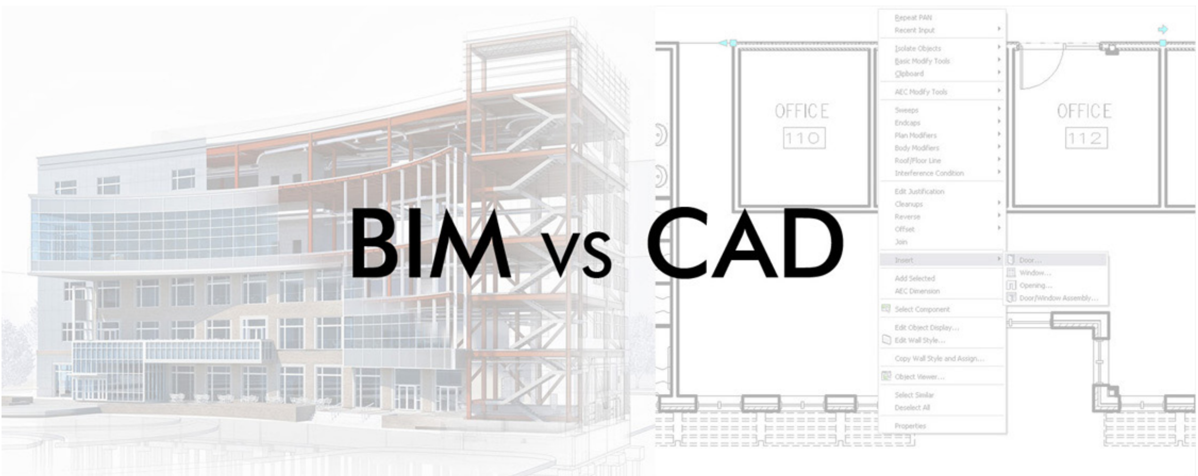

Figure 3： The BIM Vs The CAD[04]

The original focus of CAD applications was to represent 2D geometry via graphical elements, such as lines, arcs, symbols, etc.[05] When comparing CAD with BIM, it can get the following advantages of BIM:

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- The drawing method of BIM software is different from the traditional way of composing points, lines, and surfaces in CAD. It adopts a component-oriented way to carry out building components and treats walls, openings or ceilings, beams, columns, etc. As an independent, a component can independently establish the properties of the component, such as dimensions, materials, etc, and can provide us with information on each space.

- BIM software combines many drawings such as floor plans, elevations, perspectives, etc. into a construction project, so it can provide us with different types of building information and present the structure of the building in 3D.

- The model created by BIM software can analyze and record the construction project data in the unit of space and can define the attributes for space, and define the attributes of the internal components of the space, such as walls, objects, and so on.

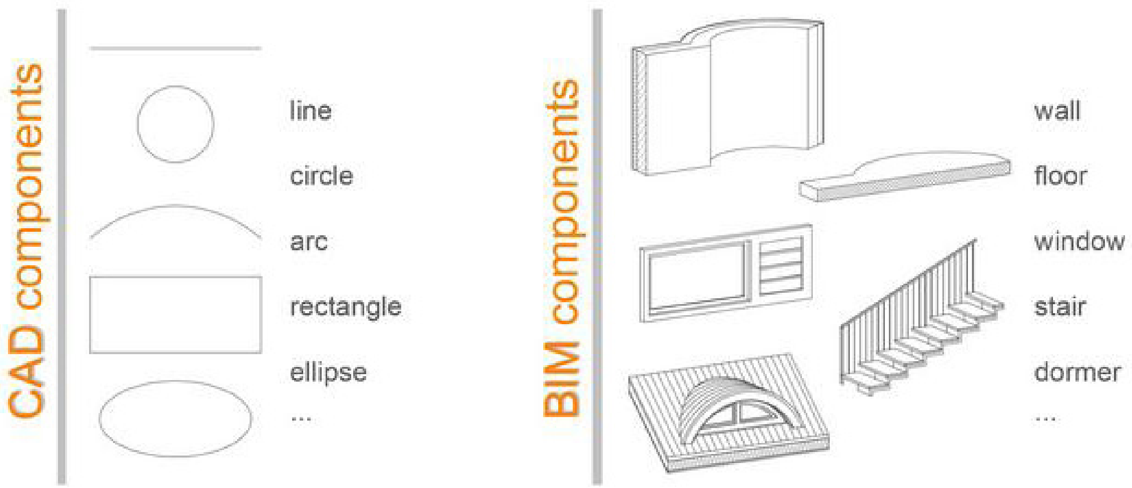

Figure 4： The components information between two software[06]

1.Introduction

1.1.3:Interoperability

In the construction industry, the one-time project team is composed of different organizations, disciplines, and stages. Through the interoperability of BIM, different discipline tools share information. At the same time, the collision problems of various specialties are coordinated in the early stage of building construction. It can avoid the collision problem between various professions due to the inadequate communication between various professional designers.

Figure 5：The Interoperability of BIM[07]

1.1.4:Level of Detail/Development (LOD)

Level of Detail is essentially how much detail is included in the model element. [08]

Level of Development is the degree to which the element's geometry and attached information have been thought through – the degree to which project team members may rely on the information when using the model.[09]

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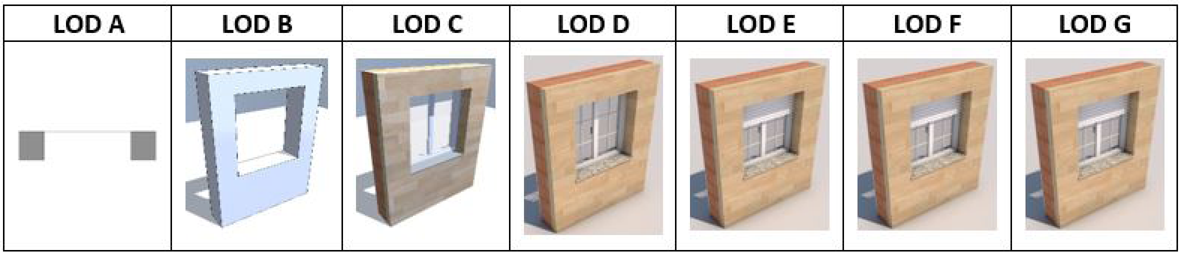

Figure 6 : The concept of LOD for BIM[10]

LOD 100: The Model Element may be graphically represented in the Model with a symbol or other generic representation but does not satisfy the requirements for LOD 200. Information related to the Element (i.e. cost per square foot, the tonnage of HVAC, etc.) can be derived from other Model Elements.

LOD 200: The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.

LOD 300: The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.

LOD 350: The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, orientation, and interfaces with other building systems. Non-graphic information may also be attached to the Model Element.

LOD 400: The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element.

LOD 500: The Model Element is a field verified representation (i.e., as-built) in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements.[11]

During the case study of this thesis, the LOD UNI 11337 from italy is selected to follow.

1.1.5:CDE

Models, data, records, and documents in general in an information management system need to be collected according to a structured organization. The concept of Common Data Environment (CDE), introduced in the UK design regulation BSI 1192-1:2007 [12], is recalled digitally in PAS 1192-2:2013.

CDE is defined as the place where all the subjects involved in a specific job order can store, share, manage, and process information to carry out their activities. [13] The structure assumed in the UK standard system is based on 4 scopes of action— work in progress, share, publish, archive—in which the information transits through subsequent gates of approval.

1.Introduction

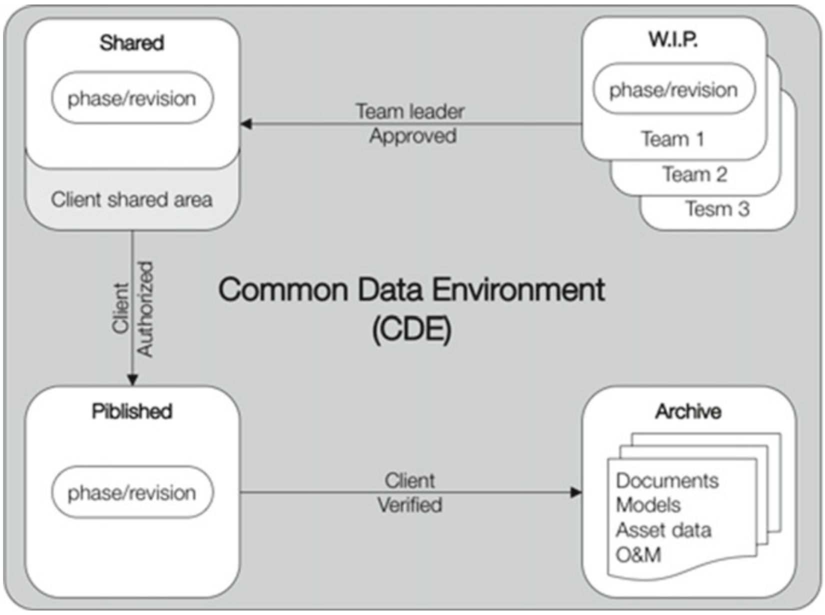

Figure 7： The CDE structure of BSI 1192 standard[14]

1.Introduction

1.2:The developing of BIM in China

Although China's BIM application has just started, it has developed rapidly. Many companies have a very strong BIM awareness, and several BIM application benchmark projects have emerged. At the same time, the development of BIM has gradually been strongly promoted by the government.

Jiangsu Theatre is the best example of BIM-based integrated design in China in recent years.

Figure 8： The architectural design of Jiangsu Theatre[15]

Project Overview:
The Jiangsu Theatre Project is a large-scale cultural complex that integrates functions such as performing arts, conferences, displays, and entertainment. The total land area is 196.633 million m^2, with a total construction area of 271386 m^2 and a building height of 47.3 meters.[16]

With the intervention and support of BIM technology, the multi-professional design of complex facade curved surfaces. Through calculation, the structure of the opera house is adopted as a hyperboloid structure, and the building structure is made of shell-like concrete.

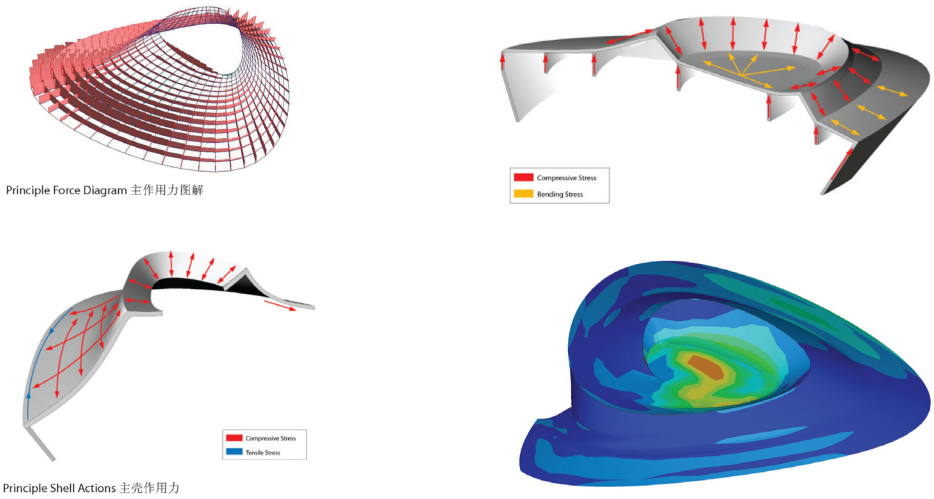

Figure 9： The structure design of the auditorium[17]

The design of the auditorium is based on BIM acoustic analysis. To ensure the accuracy of the acoustic analysis, the completed auditorium BIM model is directly imported into Autodesk Ecotect software and acoustic software for further professional acoustic analysis. In the analysis process, the use of accurate BIM models and certain data format conversions can obtain accurate acoustic analysis results in a short time and feedback to the designer for better design adjustments. The acoustic simulations, based on the ray-tracing method, indicate that the design has appropriate volume, dimensions, and distributions of surfaces to achieve the acoustic conditions of world-class opera houses.[18]

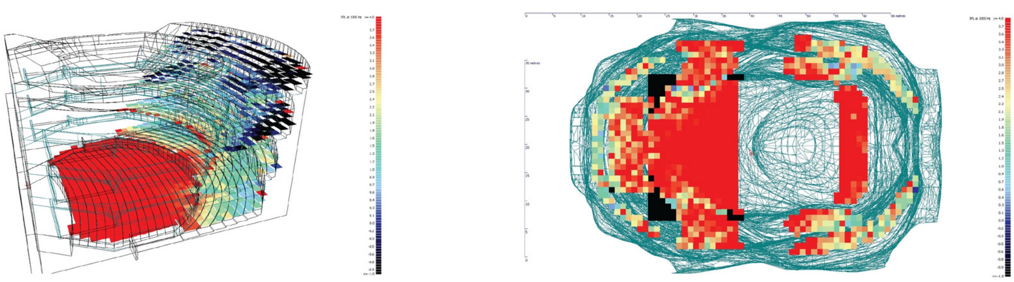

Figure 10： The acoustic design of the auditorium[19]

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The Opera has been designed to meet the highest acoustic and visual standards for vocal and acting performances, allowing for unamplified presentations of Chinese and European Operas to an Audience of 2,349 Visitors. The design of the space incorporated an avant-garde design based-upon a traditional barrel-typology, creating an intimate and very festive atmosphere. Three balconies over curved stalls in a horseshoe layout resemble the grand traditional houses, crowned by a modern interpretation of a chandelier in the center of the space. Elegant curvatures of balconies and wall claddings integrate this space of grandeur into the dynamic formal language of the ensembles' Architecture.[20]

Sightlines and distances have been carefully optimized to allow for excellent visual conditions for every seat despite the comparably large seating capacity, allowing for recognition of the actor's facial expressions even from rear rows. Further, the volumes and surface reflection angles provide the space with sufficient clarity for speech presentations as well as sufficient reverberation for instrumental performances, creating excellent acoustic environments for Opera performance. Large light positions at the side walls address the special requirements of Chinese Operas; multiple lighting catwalks in the audience chamber ceiling allow for a large spectrum of illumination scenarios. The Opera has a full layout with two side- and one rear stage, plus an additional full-scenery rehearsal stage with full acoustic separation, and a full understage layout. A variable orchestra pit allows for most different instrumentation scenarios.

The Concert Hall with a total capacity of 1,550 seats employs a vineyard typology to minimize the distance between audience and orchestra and provides a world-class acoustic environment.

1.Introduction

Seating in a terraced arrangement around the orchestra stage allows for optimized listening conditions and close interaction with the performers. The Volume/reverberation and shape of the interior have been optimized for unamplified instrumental performances. The ceiling with its folded structures optimizes reflection directions and sound distribution within the volume of the concert hall; provisions for choir positions behind the orchestra, a full-size orchestra stage, and an organ as part of the space layout allow for the full spectrum of instrumental performances. A special feature is the roof lighting feature from the central "eye" of the concert's hall enclosing shell allowing for performances and rehearsals under the light of the day; a louver array allows diffusing or blacking-out of daylight if not desired.

Figure 11： The photo of the Jiangsu Theatre[21]

1.Introduction

1.3:Case Study — Torre Regione Piemonte

Figure 12： The model of Tower[24]

The Piedmont Region Headquarters (Grattacielo della Regione Piemonte) is a skyscraper topped out in 2015 in Turin, Italy, which will house the administration offices of the Piedmont Region.[22] The building was designed by Massimiliano Fuksas. Premises selected for the construction of the building is represented by an area already used by former Fiat Avio, not far from the trade center of Lingotto, in the district of Nice Millefonti in Turin. The skyscraper, third in height in Italy after the 231-meter Unicredit Tower in Milan [23] (of which 152 in body and 79 in spire and the Isozaki tower of 209.20 meters in Milan, has 42 floors.)

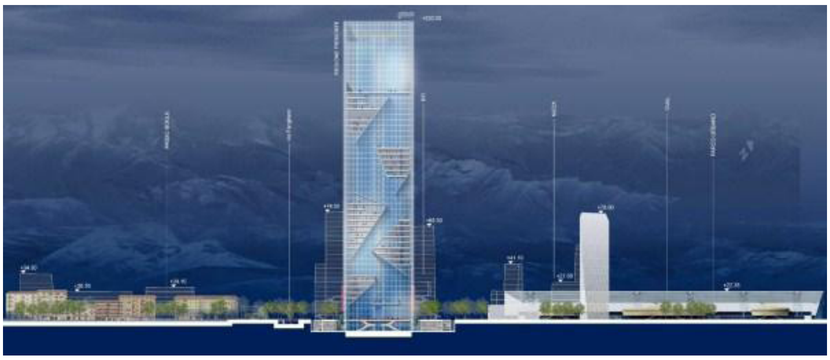

Figure 13： The rendering of the facade design[25]

1.Introduction

The construction of a new residential district capable of housing about 5,000 inhabitants and the new Lingotto railway station with a bridge structure that will connect the current existing port will also be planned. [26]

The total surface on which the skyscraper stands is approximately 70,000 m² and approximately 60,000 m² of ancillary spaces and external works are planned, which also includes the establishment of commercial establishments to boost the development of the neighborhood. [27]

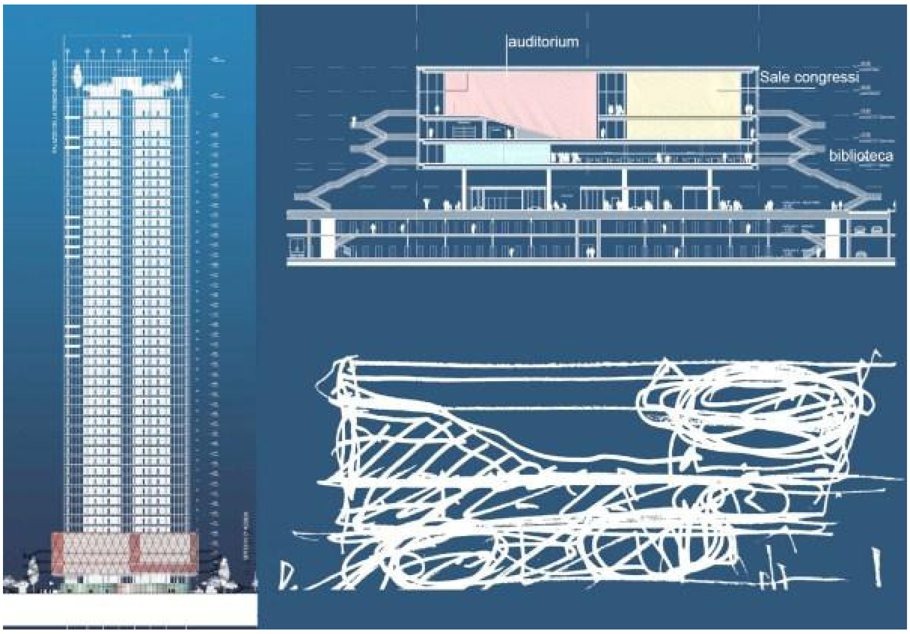

Figure 14： The sketch of the concept design[28]

2.Methodology

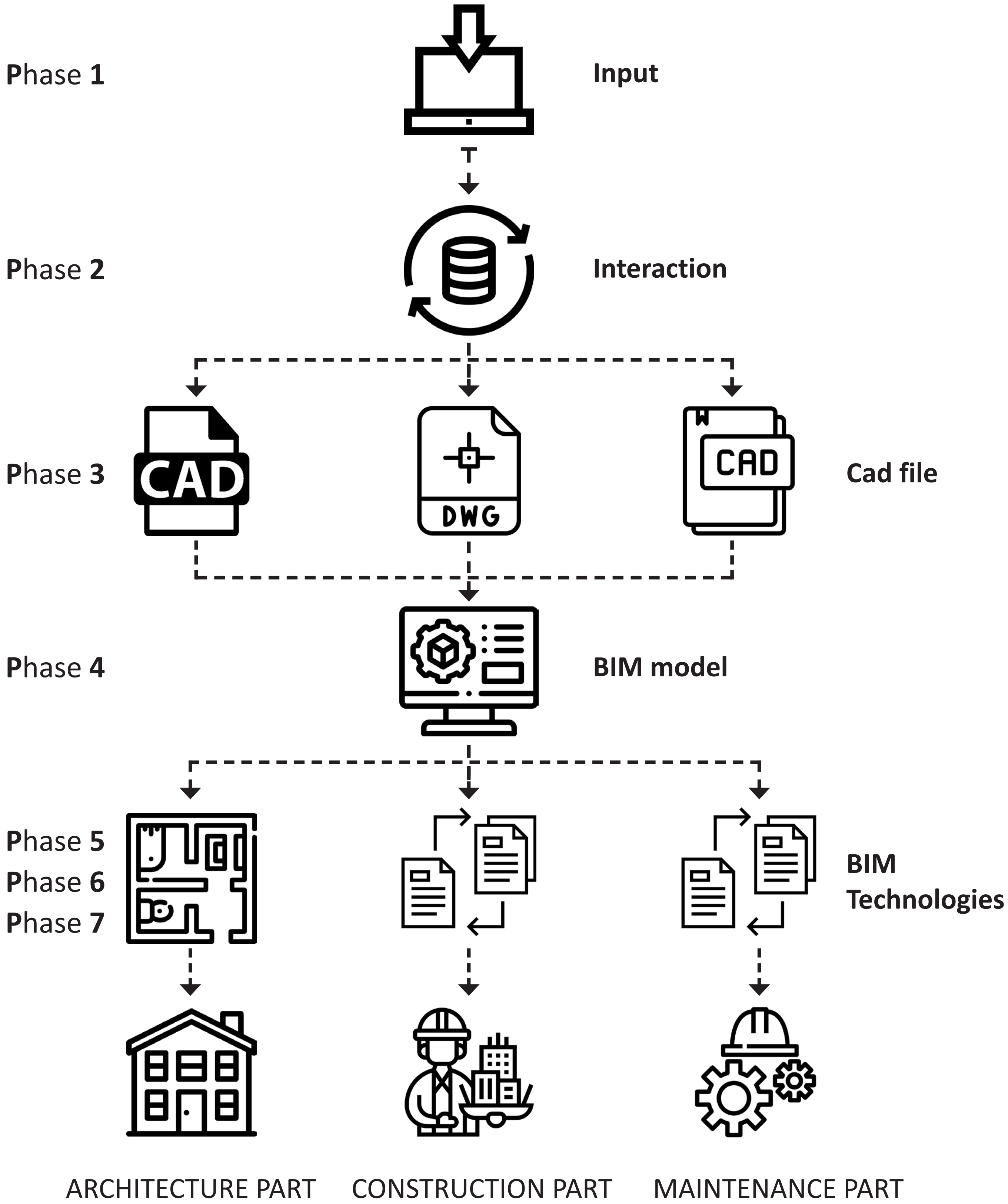

Figure 15： The main workflow of the methodology[29]

2.Methodology

2.0: The workflow in methodology

Following the workflow diagram on the previous page, it contains all the works on a different phase in methodology. All work can be divided vertically into three parts, they are the architecture part, the construction part, and the maintenance part.

The phase 1: Represents the input of all building information.

The phase 2: Represents effective interaction with all building information.

The phase 3: After completing the interaction of information, different information is classified into different types, in the traditional way of 2D drawings.

The phase 4: Integrate all traditional 2D drawings building information into a total BIM model for data management.

The phase 5: Based on the BIM model, through the extraction of different building information, to complete the drawing of the plan and elevation in the BIM software. This is the basic work for the architecture part.

The phase 6: Based on the BIM model, extract the information of different architectural elements, further integrate and encode the information, and use the relevant BIM technology to complete the construction work.

2.Methodology

The phase 7: Based on the BIM model, extract the information of different architectural elements, further integrate and encode the information, and use the relevant BIM technology to complete the maintenance work.

2.Methodology

2.1: Architecture Part

The first step to complete is modeling, using BIM software to complete the establishment of the entire model. In this study, REVIT is used to complete the modeling work.

After analyzing all the technical drawings of the construction project graphically in the form of horizontal and vertical sections, views, and detail drawings. Which needed to complete the modeling work of L12-L45.

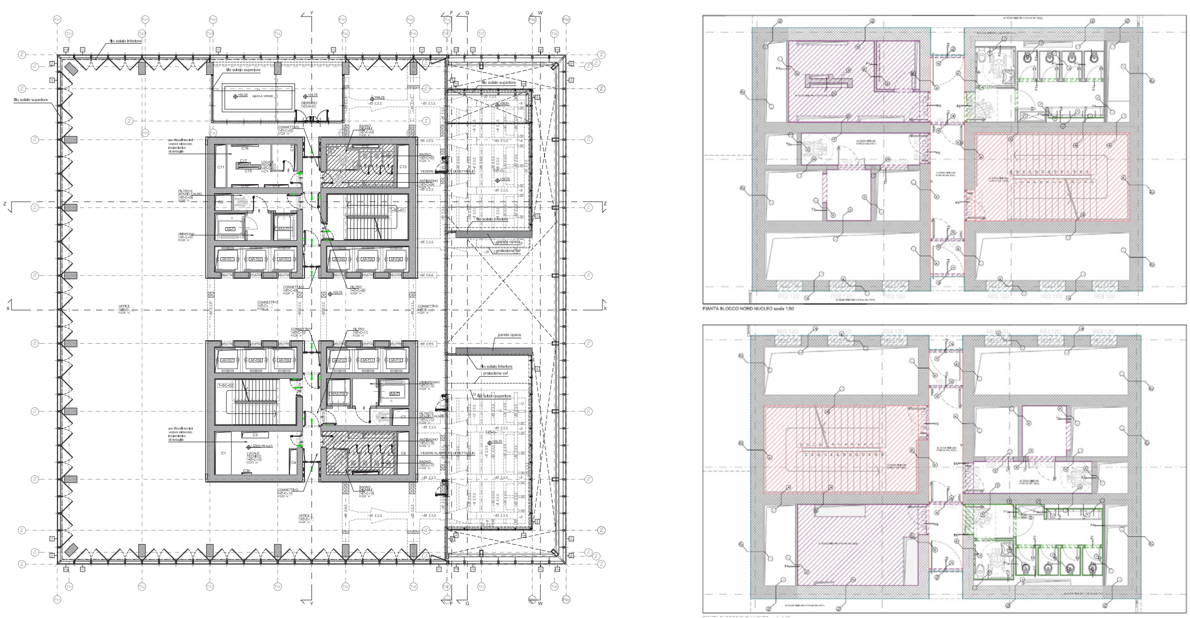

Figure 16： The original CAD drawings of the floor plan[30]

The process of analyzing CAD drawings can be regarded as a process of integrating information. It is known that the BIM model is a carrier that integrates all building model information. In this model, including all the required building information. Compared with the traditional architectural design process, this process requires longer time, because it is necessary to integrate all previous architectural design information. Which contains

2.Methodology

all relevant information required for building planning, construction, and operation. After completing this work, using a comprehensive digital representation (building information model) to store, maintain, and exchange information.

In the beginning, the BIM model is not blank. It is a grass model with some basic structural components.

So the modeling that needs to be completed includes walls, floors, glass curtain walls, and a few doors.

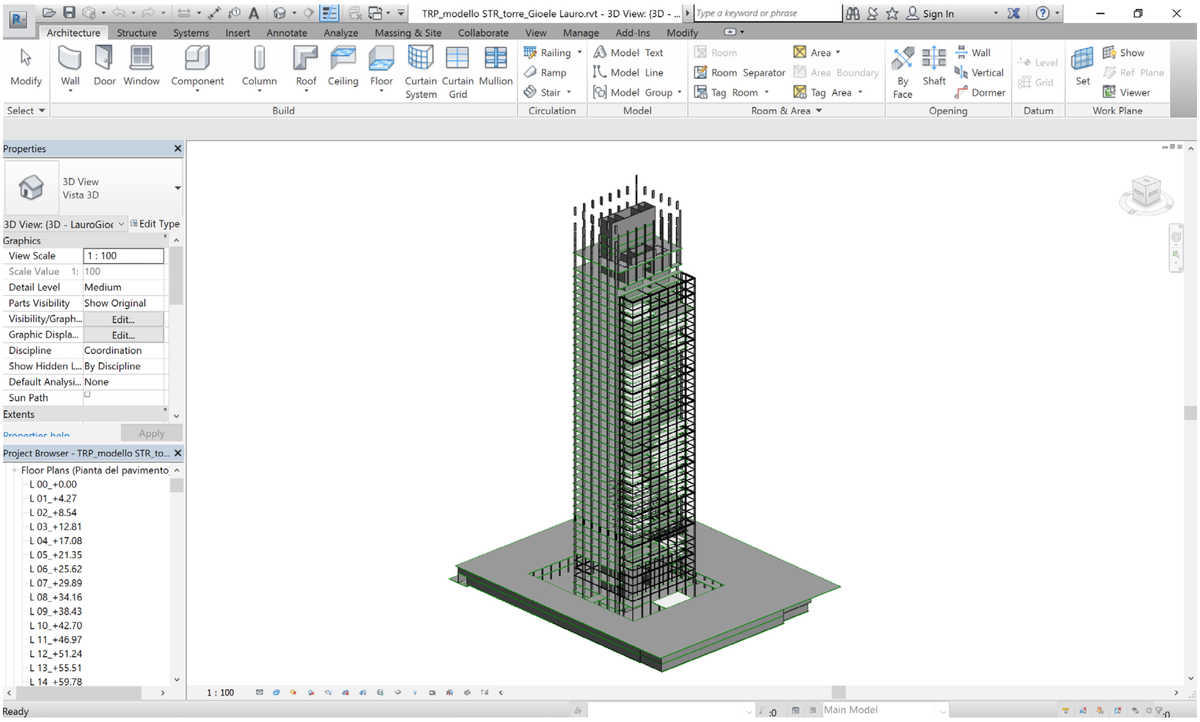

Figure 16： The original BIM model[31]

Based on the obtained building information, completing the modeling of the floor plan. Different types of walls are added to the plan, and finally, all the building information in the plan is completed.

2.Methodology

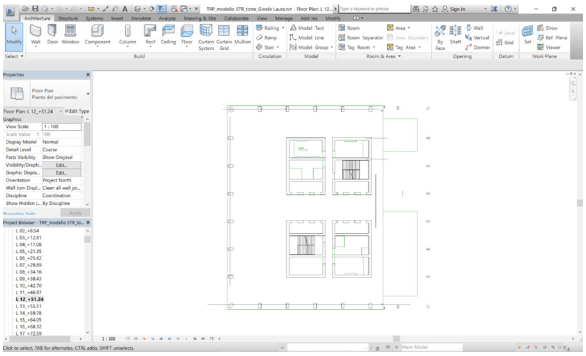

Figure 18： The original floor plan[32]

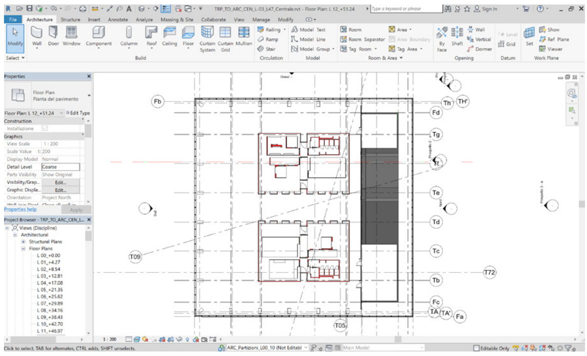

Figure 19： The completed floor[33]

According to the existing original CAD drawings, completing the facade modeling. It includes the drawing of all-glass curtain walls of the four main facades.

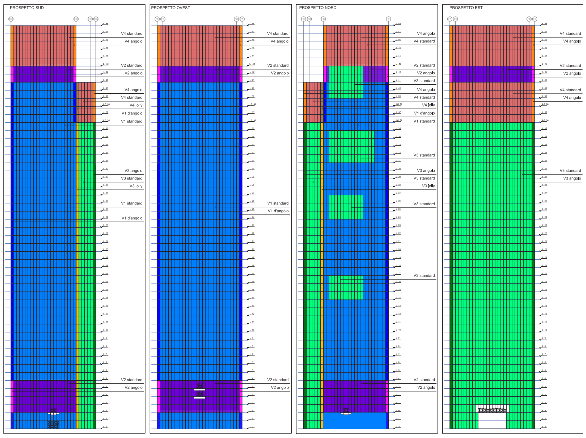

Figure 20： The original CAD drawings[34]

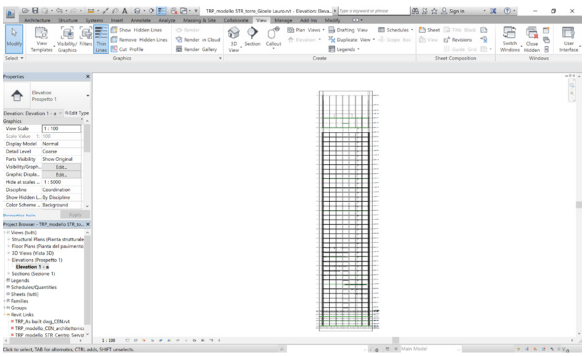

Figure 21： The original elevation[35]

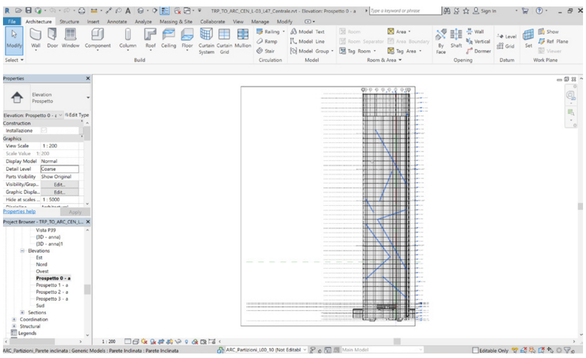

Figure 22： The completed elevation[36]

There is an important concept in BIM modeling, which is the workset. Worksets are portions into which projects can be subdivided within Revit models.[37] A workset is a collection of building elements (such as walls, doors, floors, stairs, etc.) or graphic elements (views or sheets are worksets). When collaborative work is enabled in the file, each element in the project is contained in one and only one workset. So during the modeling, each element should be placed in the corresponding workset.

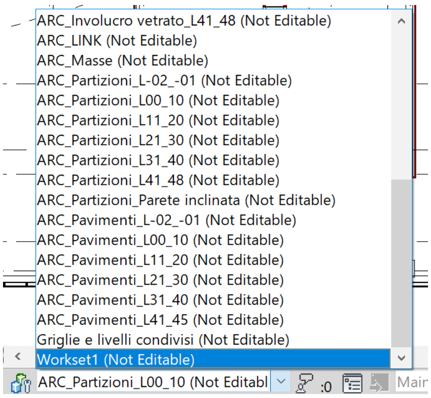

Figure 23: The worksets[38]

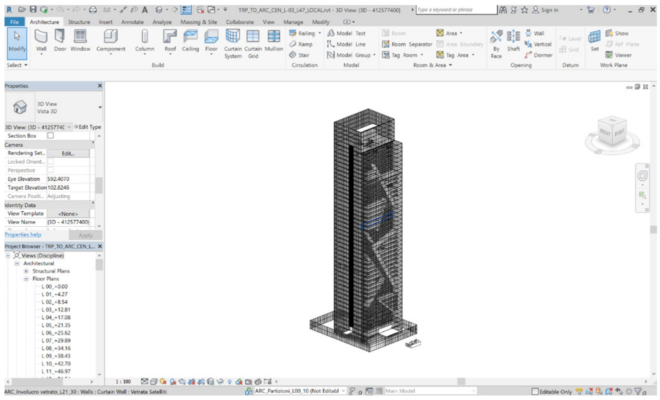

Figure 24: The completed BIM model[39]

2.Methodology

2.2: Construction Part

According to the first step of the work, after completed the establishment of the model in Revit. The following table is all the elements in the model. This includes all walls, floors, doors, and glass curtain walls.

1： Walls		
Cartongesso F1	Finitura b	M1(1) – 12cm
Cartongesso F1a	Finitura c	M1(2) – 10cm
Cartongesso F1b	Finitura d	M1(3) – 5cm
Cartongesso F1c	Finitura b	M1(4) – 2cm
Cartongesso F1d	Finitura e	M1(5) – 1.5cm
Cartongesso F1e	Finitura f	Pannello HPL
Cartongesso F2	Finitura g	TI – 20cm
Cartongesso F2a	Finitura g1	T2 – 20cm
Cartongesso F2b	Finitura g2	T* – 15cm
Cartongesso F2c	Finitura h	
Cartongesso F3	Fondazione – 30cm	
Cartongesso F3a	Generico – 5cm	
Cartongesso F3b	Generico – 15cm	
Cartongesso F3c	Generico – 20cm	
Cartongesso F4	Generico – 30cm	
Cartongesso F5	INT 18cm	
Cartongesso F5a	INT 23cm	
Cartongesso F6	INT 5cm vetro	
Di sostegno – Calcestruzzo	INT 11cm cartongesso	

2： Floors
Flottante – 20cm

3： Curtain Walls
Vetrata satelliti
Vetrata satelliti 2
Facciata box parcheggio
Facciata box parcheggio 1.20m
Facciata box parcheggio 1.89m
Facciata box parcheggio 1.44m
Facciata torre
Generico

4： Doors	
Porta scorrevole 485x250	Porta Una Anta 100x210
Porta Bagni H 70x210	Porta Una Anta – aperta 70x210
Porta Bagni H 90x210	Porta Una Anta – aperta 90x210
Porta Bagni H 140x210	Porta Una Anta – aperta 120x210
Porta box	Scorrevole H 90x210
Porta M 80.5x210	Scorrevole Semplice 90x210
Porta M 90.5x210	Scorrevole Semplice 100x210
Porta M 120.5x210	Picture Door 120x210
Porta M 123.5x210	
Porta M 8123.5x240	
Porta M 2 ante 136.5x210	
Porta Rasomuro 120x210	
Porta Rasomuro Interno 70x210	
Porta Una Anta 80x210	
Porta Una Anta 80x210 R S2	
Porta Una Anta 80x210 T S2xA5xL5	
Porta Una Anta 90x210	
Porta Una Anta 90x210 R2	
Porta Una Anta 90x210 T S2xA5xL5	

Table 1: The table of the original model elements

The core work of the construction part is to create a corresponding code for each element in the model. According to each corresponding code, analysis and realize all the information of the element during the construction phase, including its main activities, object, construction duration, construction starting time and ending time, and its assembly plans. This means that when getting the code of an element, getting all the relevant information about it. This can help the design team and the construction team to query the element information faster and better control its progress in the construction process.

For the creation of element codes, it should contain the following core information.

2.Methodology

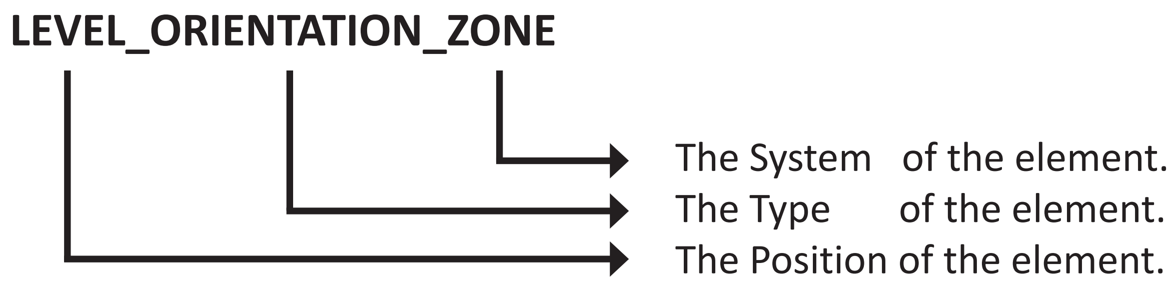

Figure 25: The information of the code[40]

The first is the **position**, the position of the element, which is the level in the building where the element is located.

Second is the **type**, the orientation of the element in the building, such as north, east, west, or south.

The last one is the **system**, which is the zone where the element is located. Since there are many types of elements in the building, it needs to make a more detailed proposal to the system.

After integrated all the information, it can get the following codes:

The Code for Construction Management		
	L4.W.?	
L4	W	?
Position	Type	System
Level	Orientation	Zone
L1/L12/L24	W/E/S/N	???

Table 2: The table of the code for Construction Management

2.Methodology

Due to this case study, the modeling of walls, doors, windows and curtain walls have been completed in the modeling, so dividing the system into four categories, corresponding to walls, doors, floors and curtain walls, respectively. Which means to proposal 4 codes for systems(zone).

Proposal the system（zone）			
CW	**W**	**F**	**D**
Curtain Walls	Walls	Floors	Doors
Vetrata satelliti 2	Cartongesso F1a	Flottante – 20cm	Porta scorrevole 485x250
Facciata box parcheggio	Cartongesso F1b		Porta Bagni H 70x210

Table 3: The table of the proposed code of the system

So after proposal the codes for systems(zone), the final codes are completed. The entire code consists of three parts, which are position, type, and system.

The Code for Construction Management		
L4.W.CW		
L4	W	CW
Position	Type	System
Level	Orientation	Zone
L1/L12/L24	W/E/S/N	CW/W/F/D

Table 4: The table of the codes for Construction Management

For example, **L4.W.CW** ,it is the final code after the proposal according to the related information of the element.

2.Methodology

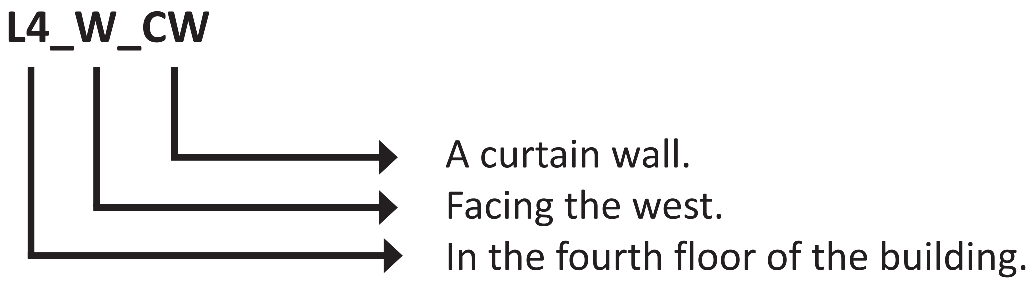

Figure 26: The information of the code[41]

The next step is the proposal for the activity of the different architectural elements. It is known that elements from production to transportation, and then to the installation in the site requires some different steps.

So here is the proposal for the activities that all the elements should follow these steps.

1.Extraction of the raw materials.
2.Transportation to the factory.
3.Manufacture of the product and components.
4.Assembly of the product and system.
5.Transportation to the site.
6.Installation and construction at the site. According to the architectural plans.

The next information that needs to be provided for the elements is the timetable of the construction, which including the construction duration, starting time, and ending time.

According to related documents(A-012_Piano manutenzione progetto esecutivo),it can find the relevant timetable.

2.Methodology

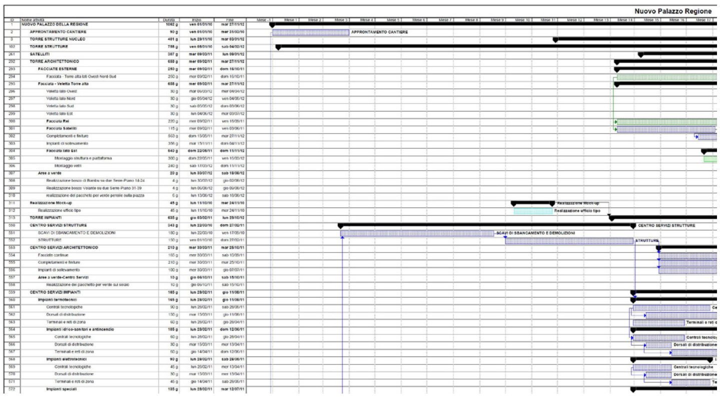

Table 5: The timetable for executive project

For example, the relevant information of floors for construction management can be provided on the following table.

The Construction Management				
Level	Object（Floors）	Duration(days)	Starting time	Ending Time
L1	Flottante – 20cm	8	Monday 29/11/10	Monday 06/12/10
L2	Flottante – 20cm	8	Tuesday 07/12/10	Tuesday 14/12/10
L3	Flottante – 20cm	8	Wednesday 25/12/10	Wednesday 22/12/10
L5	Flottante – 20cm	8	Thursday 23/12/10	Thursday 30/12/10
L6	Flottante – 20cm	8	Friday 31/12/10	Friday 07/01/11

Table 6: The table of the informations of floors

The next information that needs to be provided for the elements is the assembly plans. The proposal an assembly plan, however, because of lacking the relevant support documents, this proposal may not be established, and the correct support information is lacking.

For example, the assembly plan of floors for construction management can be a proposal on the following table.

2.Methodology

The proposal assembly plan				
Team	Men	Hours Men	Duration	PREDECESSOR
Team 1	3	8x8=64 Hours	8 Days	
Team 2	3	8x8=64 Hours	8 Days	Team 1
Team 2	3	8x8=64 Hours	8 Days	Team 2

Table 7: The table of the proposal assembly plan

After integrating all the above information, it can get the following table. It is known that each code corresponds to all the information of the element.

The Construction Management					
Floors					
CODE	Activities	Object	Duration(days)	Starting time	Ending Time
L-1.W.F	1.Extraction of the raw materials. 2.Transportation to the factory. 3.Manufacture of the product and components. 4.Assembly of the product and system. 5.Transportation to the site. 6.Installation and construction at the site. According to the architectural plans.	Flottante –20cm	8	Monday 29/11/10	Monday 06/12/10
L0.W.F		Flottante – 20cm	8	Tuesday 07/12/10	Tuesday 14/12/10
L1.W.F		Flottante – 20cm	8	Wednesday 25/12/10	Wednesday 22/12/10
L2.W.F		Flottante – 20cm	8	Thursday 23/12/10	Thursday 30/12/10
L3.W.F		Flottante – 20cm	8	Friday 31/12/10	Friday 07/01/11
L4.W.F		Flottante – 20cm	8	Saturday 08/01/11	Saturday 15/01/11
L5.W.F		Flottante – 20cm	8	Sunday 16/01/11	Sunday 23/01/11
L6.W.F		Flottante – 20cm	8	Monday 24/01/11	Monday 31/01/11
L7.W.F		Flottante – 20cm	8	Tuesday 01/02/11	Tuesday 08/02/11
L8.W.F		Flottante – 20cm	8	Wednesday 09/02/11	Wednesday 16/02/11
L9.W.F		Flottante – 20cm	8	Thursday 17/02/11	Friday 15/02/11
L10.W.F		Flottante – 20cm	8	Saturday 26/02/11	Saturday 05/03/11
L11.W.F		Flottante – 20cm	8	Sunday 06/03/11	Sunday 13/03/11
L12.W.F		Flottante – 20cm	8	Monday 14/03/11	Monday 31/03/11
…		Flottante – 20cm	8	…	…

Table 8: The table of the floor for Construction Management

2.Methodology

2.1: Maintemance Part

The work of the maintenance part is creating code for the cleaning of the exterior curtain wall. It is known that from the construction part, the code contains a series of information. For the maintenance code, the information includes the activity and the duration of the cleaning. And the code includes the position, type, and the system.

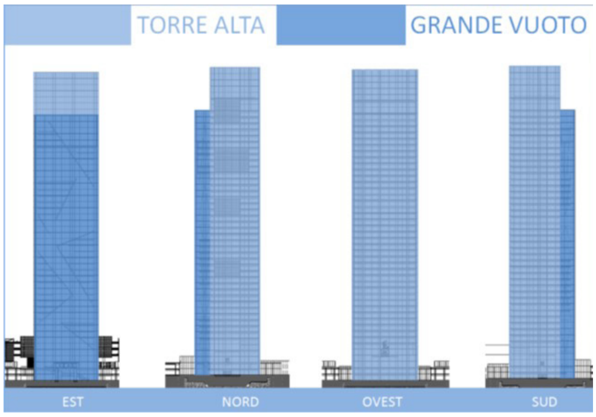

Figure 27: The concept design of facade[42] Figure 28: The elevations of towers[43]

According to the design of the facade, and the analysis of the structure of the exterior curtain walls, it is clear that the facade is divided into different parts. So here the following table, the areas of all the curtain walls, that divided according to the structure of the facade design.

The Tower (The Exterior Curtain Wall)					
Torre Alta			Grande Vuoto		
Facciate Esterne	Velette		Facciate Esterne	Velette	
	Esterne	Interne	Facciata V6	Esterne	Interne

Table 9: The table of the structure for the tower

2.Methodology

So the proposal for the system is according to the different areas. Here from the following table that including all the code of the system.

The Tower (The Exterior Curtain Wall)						
Areas	Torre Alta			Grande Vuoto		
	Facciate Esterne	Velette		Facciate Esterne	Velette	
		Esterne	Interne	Facciata V6	Esterne	Interne
Code	**TFE**	**TVE**	**TVI**	**GFE**	**GVE**	**GVI**

Table 10: The table of the code of the system

So according to the following table, the following table includes the code for the cleaning of the exterior curtain wall.

The Code for Cleaning of The Exterior Curtain Wall		
L4.W.TVE		
L4	W	TVE
Position	Type	System
Level	Orientation	Zone
L1/L12/L24	W/E/S/N	TFE/TVE/TVI/GFE/GVE/GVI

Table 11: The table of the code for cleaning activity

For example, **L4.W.TVE** , it is the final maintenance code after the proposal.

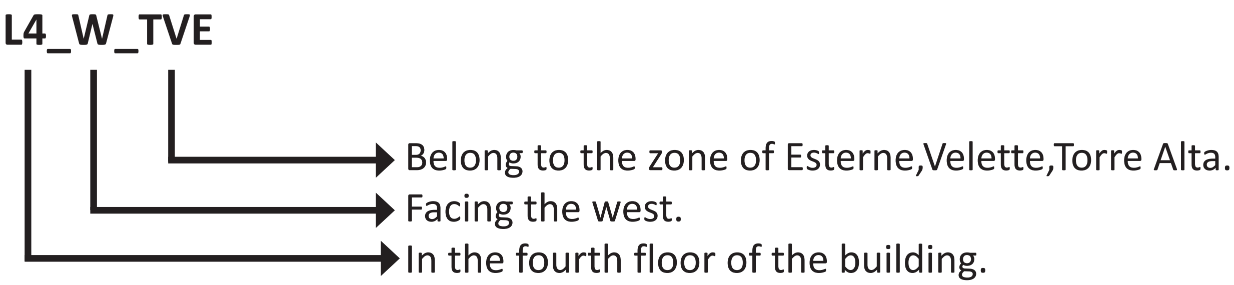

Figure 29: The information of the code[44]

2.Methodology

According to the reference, to make it easier for operators to finish the cleaning work, this façade is divided into 9 different areas with different colors and names.

The name of the 9 areas are:

Area Z1/Area Z2/Area Z3/Area Z4/Area Z5/Area Z6/Area Z7/Area Z8/Area Z9

So the next step is creating a more detailed code according to the different areas.

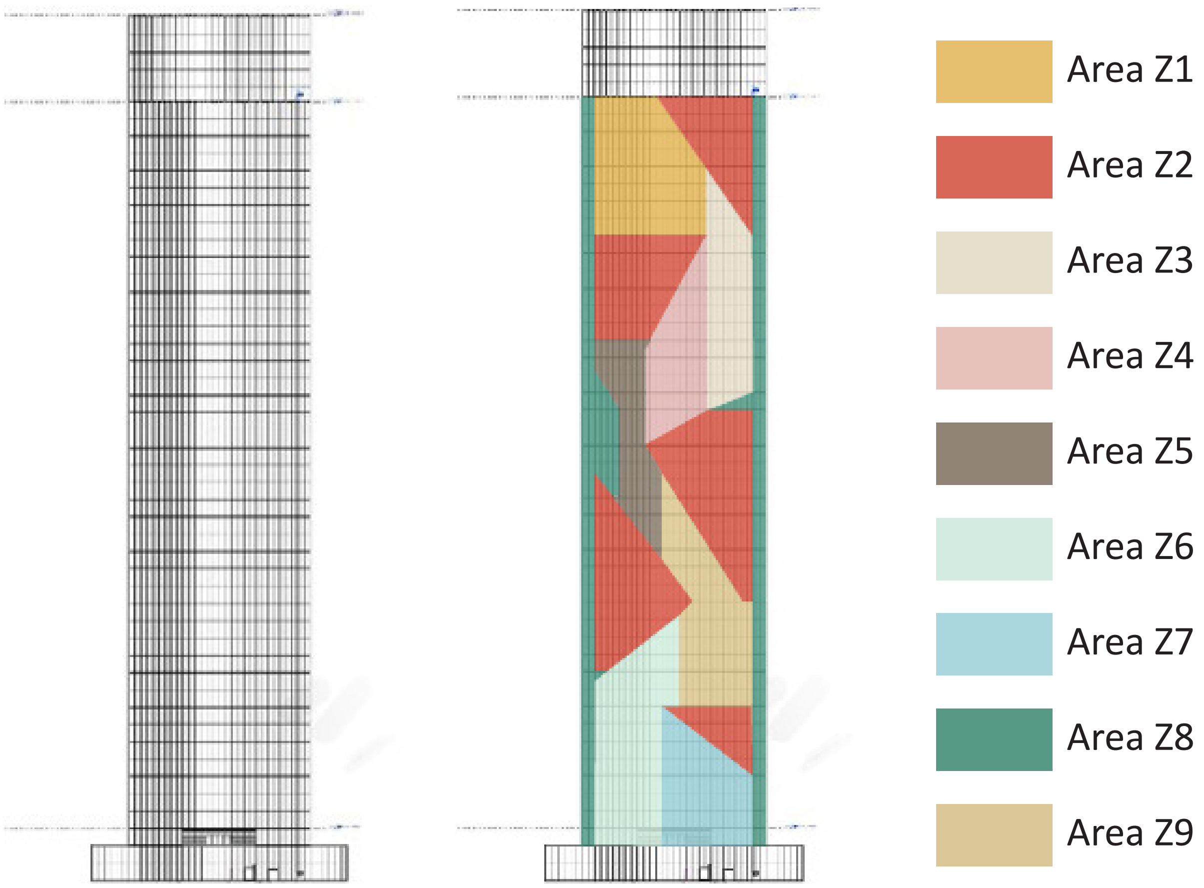

Figure 30: The scheme of the division of the facade V6[45]

2.Methodology

The Tower (The Exterior Curtain Wall)						
Areas	Torre Alta			Grande Vuoto		
	Facciate Esterne	Velette		Facciate Esterne	Velette	
		Esterne	Interne	Facciata V6	Esterne	Interne
Code	**TFE**	**TVE**	**TVI**		**GVE**	**GVI**

Table 12: The table of the detailed code of the system

So that is the cleaning code for Facciata V6. For example, **L4.W.GVE.Z1** is the final maintenance code after our proposal.

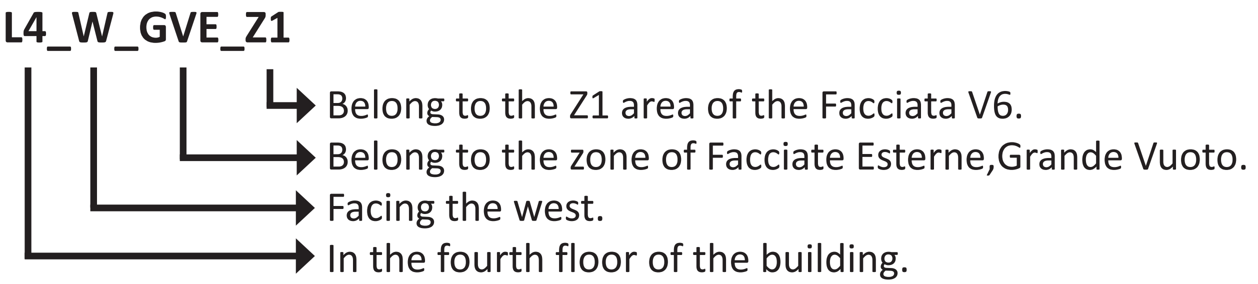

Figure 31: The information of the code[46]

The Cleaning Code for Facciata V6			
L4.W.GVE.Z1			
L4	W	GVE	Z1
Position	Type	System	Area
Level	Orientation	Zone	Facciata V6
L1/L12/L24	W/E/S/N	GVE	Z1/Z2/Z3/Z4/Z5/Z6/Z7/Z8/Z9

Table 13: The table of the code for Facciata V6

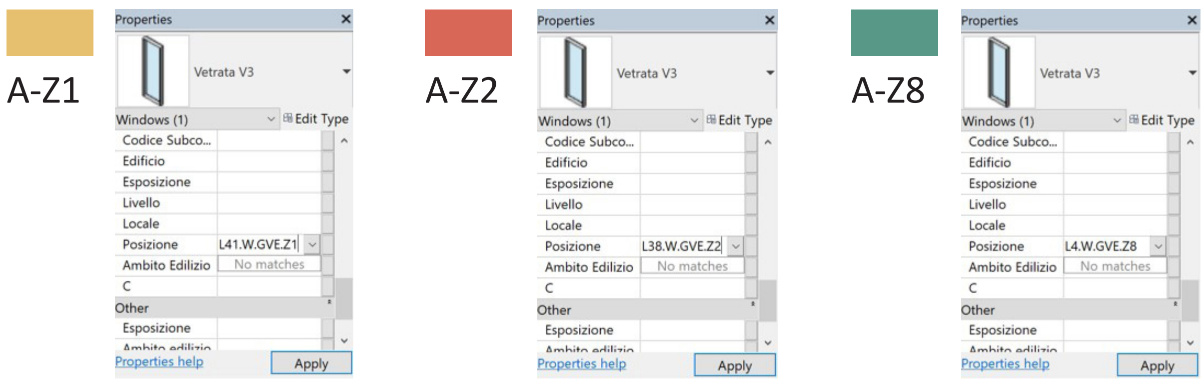

Figure 32: The information of the curtain wall in Revit[47]

2.Methodology

The activity for cleaning the façade requires operators to work accurately, and at the same time, it is necessary to comply with relevant laws and regulations. The façade areas indicated above can be reached with cable access and positioning system. For maintenance, the operators will move by vertical theories, from top to bottom, through a system of ropes anchored on the roof. The perimeters of the roof above the facades in question are prepared with anchors suitable for the access and positioning system utilizing ropes, following UNI EN 795.[48]

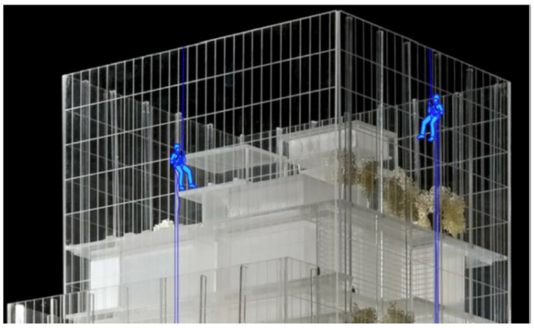

Figure 33: Descent from the top[49]

For the operators, qualifications exclusively personnel enabled to perform temporary work at height with the use of positioning and access systems via ropes must be used to carry out the maintenance operations described in this Manual.

There are also relevant requirements for the composition of the operation team. That the team must include at least two people: the manager and the operator.

The supervisor is responsible for the correct preparation of the lowering weapons and the construction site operations; Must supervise the execution of the operator's access, positioning, and exit operations and be available for any further operation involving work with ropes, including the organization and direction of the emergency maneuvers provided for based on risk assessment.

2.Methodology

The operator must be perfectly familiar with the maneuvers to act on the ropes and the recovery maneuvers of a companion in difficulty.

After the operator reaches the relevant area, cleaning operations must be carried out in the following ways: Sutter Professional DU compatible with glass, diluted in water, and applied with fleece and removed with glass wipers.[50]

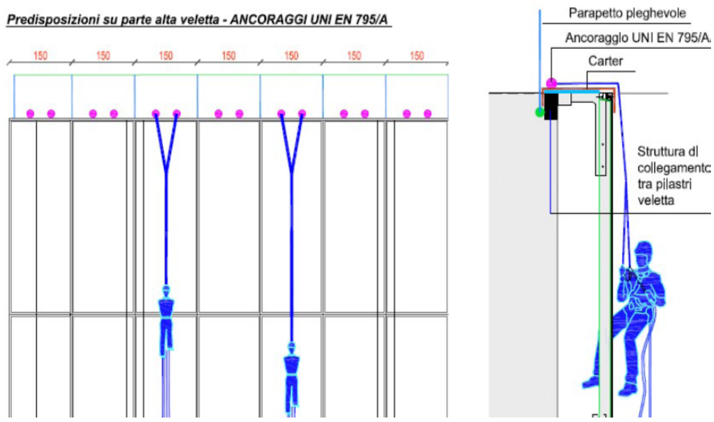

Figure 34: Scheme of descent from the top[51]

For the main working method of the operators, for maintenance interventions on the facade, mode A-B is preferably adopted (access from above, exit from below). This mode is the simplest and easiest for operators.

The activities of the operator should follow the following process:

1:The operator wears the harness and is equipped with all the PPE necessary to climb the safety ladder according to the prescriptions and methods indicated in the Legislative Decree.

2:The operator, having reached the top of the window, secures himself to the lifeline and lifts the support rail so that he can travel the entire perimeter of the veil to the point of descent to be performed.

3:The operator makes the anchor using the devices installed at the top.

4:The operator connects the work and safety rope to the harness.

5:The operator positions and fixes the casing on the crown.

6:Upon reaching the workplace, the operator locks in the designated position according to the prescriptions and methods indicated in the Legislative Decree.

7:The operator performs the work.[52]

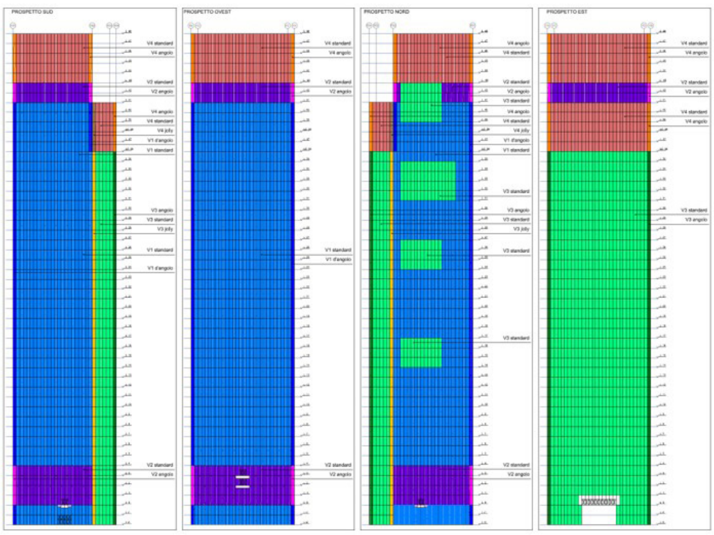

Figure 35: The original CAD drawings[53]

2.Methodology

The next step moving on the calculation of the total area for the curtain wall. According to architecture drawings, it is possible to calculate the area of the four facades, after getting the information of the areas, then propose the time required to clean each façade.

It is known that the total areas of the four facades are provided,and after the calculation, the area for one single element:6.405m². And then proposal the cleaning time for one element. The following table shows the relevant calculation process and the final time for the cleaning activity.

Proposal the time for cleaning activity	
The area of one single curtain wall	6.405 m²
The proposal time for cleaning one element	10 minutes
The amount of the curtain walls of the façade V6	1350
The time for cleaning the façade V6	1350 X 10 = 13500 minutes
The total time for cleaning V6 façade	225 hours

Table 14: The table of the proposal time for cleaning

In the same way, we can get the total cleaning time of the other three facade.

The Total Area for The Curtain Walls		Time for Cleaning the façade（Hours）
South Façade	9372.825㎡	244
West Façade (Facciata V6)	8646.750㎡	225
North Façade	9372.825㎡	244
East Façade	9607.500㎡	250

Table 15: The table of the time for cleaning the facade

According to related documents: the information on the best maintenance frequency is provided on the following table:

2.Methodology

Items to be maintained	Minimum Frequency	Recommended Frequency
Cleaning Curtain Facades	Every Year	Half Year
Anchor System Check and Maintenance	Every 2 Years	Every Year

Table 16: The table of the maintenance information

3. Results

3.1:The results that find out from the case study

In the first step, after completing the transfer from Autocad drawings to BIM models.

It is known that this step is to gather all kinds of information from the drawings into one model. This information involves a wide range of stakeholders from different fields of expertise. It mainly includes technical drawings of the construction project in a graphical manner in the form of horizontal and vertical sections, views, and detail drawings. All the drawings are typically created by experts from different design disciplines and across multiple companies.

So this is an advantage of BIM for the management of building model information. Among them, information management is not just the management of building information in one stage, it includes the effective management of model information in all stages of the entire building life cycle.

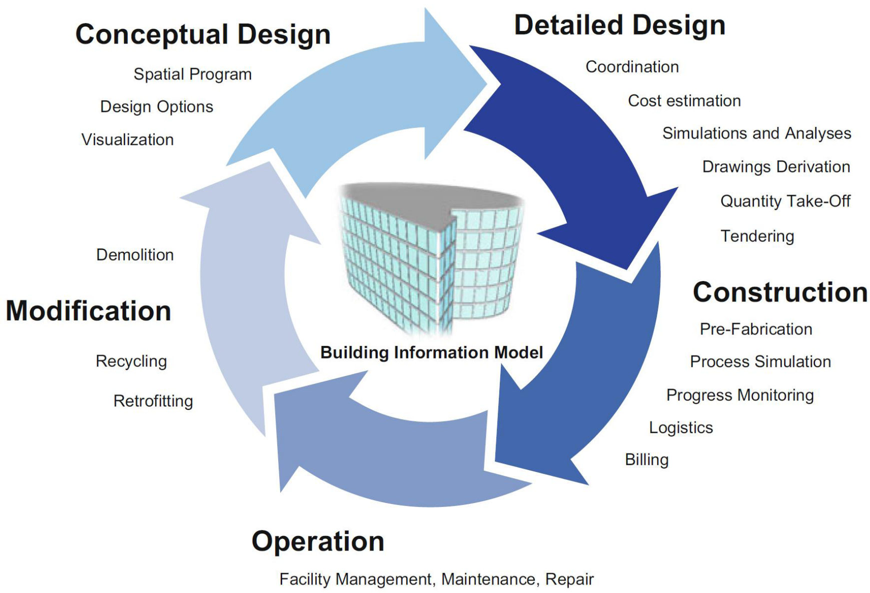

Figure 36: The workflow based on the BIM[54]

3. Results

Therefore, BIM is established to advance most of the planning work to the early design stage. Through a comprehensive digital building model, the demand can be better coordinated, and the ability to perform calculations and analysis at the early stage of the design is increased so that a more comprehensive evaluation can be performed. The impact of design decisions and identifying and resolving possible conflicts as early as possible, thereby significantly reducing the work required in the later stages and improving the overall design quality.

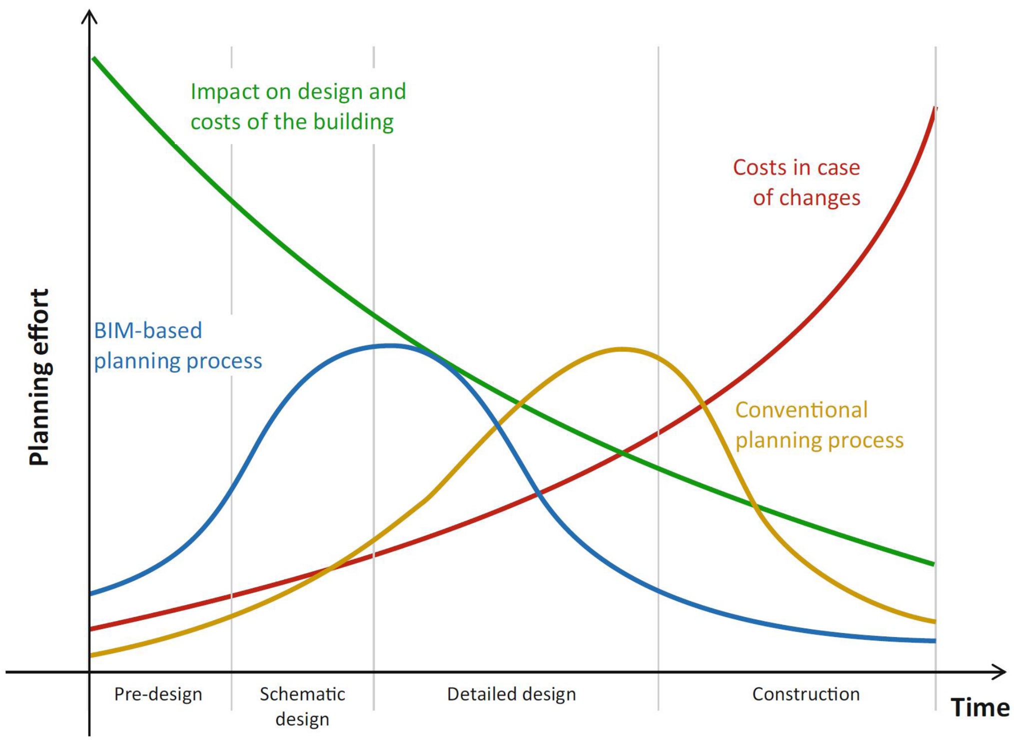

Figure 37: The timetable of planning effort and design decisions[55]

One of the most significant advantages of using BIM compared to conventional 2D processes is that most technical drawings (such as horizontal and vertical sections) are drawn directly from the model, so they are automatically consistent with each other. BIM does not need to record information in drawings but uses a comprehensive digital representation (building information model) to store, maintain, and exchange information. This approach dramatically improves the coordination of the design activities, the integration of simulations, the setup and control of the construction process, as well as the handover of building information to the operator. [56] This can avoid cumbersome and error-prone work, thereby improving the productivity and quality of construction projects.

The building information model contains all relevant information required for building planning, construction, and operation. Compared with the conventionally drawn plan, the three-dimensional model has obvious advantages:

Using 3D models instead of separate plans and parts to plan and construct buildings. Then generate graphics from the 3D model to ensure that the individual graphics always correspond and remain consistent. This greatly reduces the error rate when making changes to the design. Then, various simulations can be used in the design process, including structural analysis, building performance simulation, evacuation simulation, or lightning analysis. To further confirm whether the architectural design complies with relevant codes and regulations.

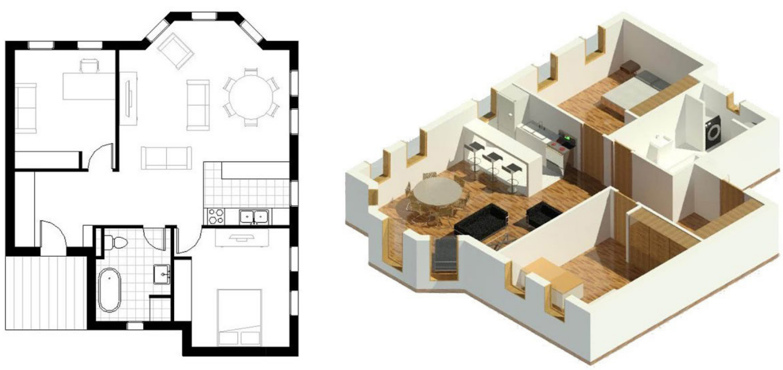

Figure 38: From 3D model to the plans[57]

3. Results

For 3D models, collision analysis can be performed to determine whether the various parts of the model or the architectural elements within the model overlap.[58] For example, when planning wall openings and penetrations for pipes, pipelines, or other technical installations.

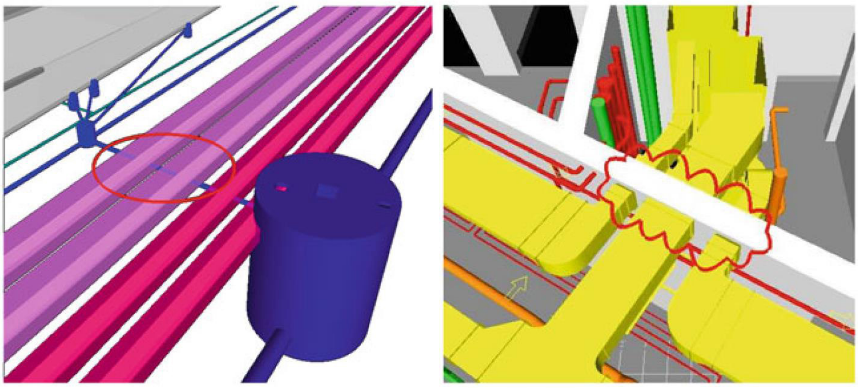

Figure 39: The collision analysis based on the BIM model[59]

The 3D model makes the architectural design more visual, and you can render the model more realistically in the early design. This facilitates communication with clients, helps architects to evaluate space design and related lighting conditions, and better understand the relevant building materials used.

Figure 40: The rendering of the interior design[60]

3. Results

BIM is a powerful tool during construction. Used in conjunction with a digital documentation workflow, BIM in the construction phase of a project gives the project staff a better way of working and provides many tools that were not available before.

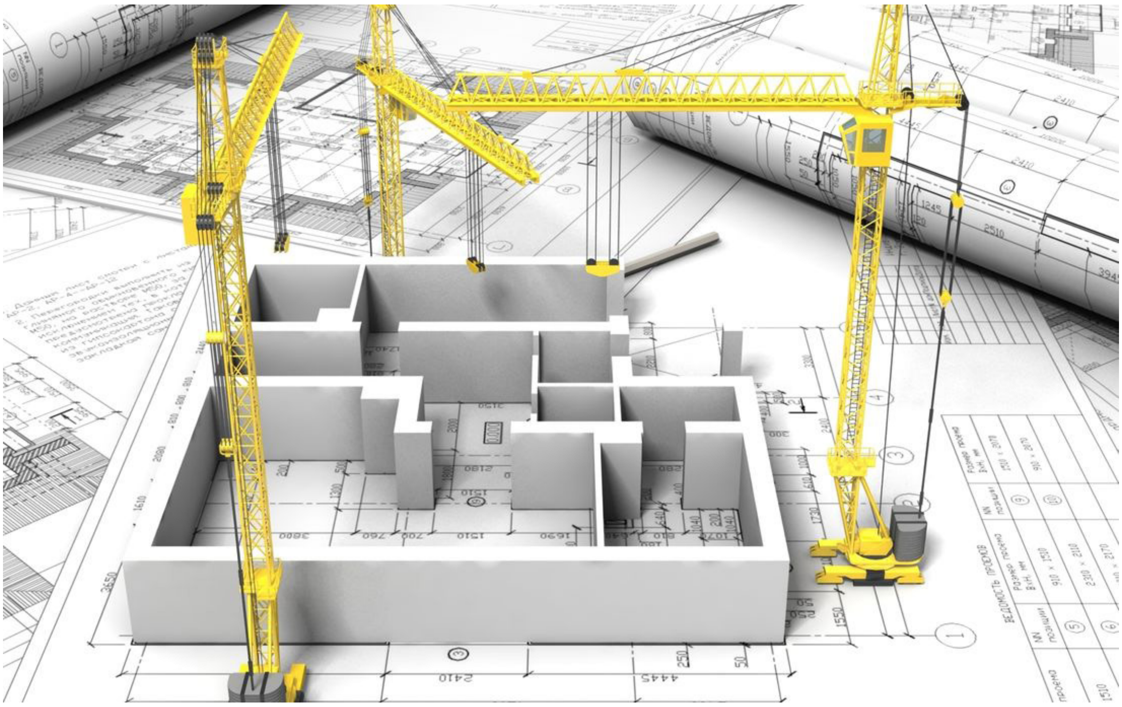

Figure 41: BIM for the construction management[61]

So how to correctly use BIM technology for construction management is an issue that needs to discuss in depth. Because now the software industry is looking specifically into how BIM applications can create value as a tool for construction to achieve better results. The BIM software industry continues to develop modeling tools. These tools are providing contractors with ways of finding and coordinating construction as well as identifying gaps in information exchange from model platforms to other systems such as estimating, scheduling, etc.

3. Results

After the case study, proposing codes for all the elements in the construction process, that is to say, each building element has a corresponding code, and all relevant information corresponding to it can be found through the code. During construction management, this is a kind of data management.

It is known that, during the construction phase of the project, various 2D information in the project will continue to increase. At this time, a special role is needed to manage and update information well. Any time this involves the use of a gatekeeper, a single person or team responsible for managing the information coming in and then distributing it to the rest of the team. The role of gatekeeper may be a project manager, project engineer, BIM manager, or other personnel.

The successful management and distribution of information depend on the manager's communication in all aspects, to make sure that the correct data is distributed to the relevant people, to manage the documentation. Usually, the design team will submit updated drawings. They are then responsible for transferring all the new drawing information onto the new ones, this process is complex and always take a lot of time and energy.

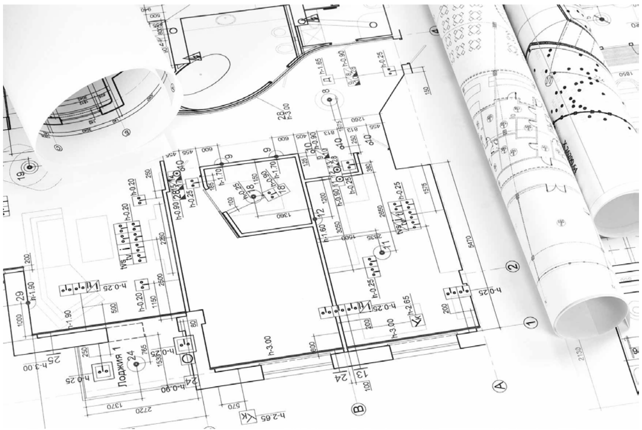

Figure 42: Data management in construction phase[62]

3. Results

If it can better classify and manage all the information in the early stage of the design, that is, track and code every architectural element. In this way, with the continuous design and construction of the building, at any stage, all architectural elements can be better managed and changed. For example, during the construction phase, if there are changes to the design, to replace all the doors and windows on one floor of the building. First to do is to find the codes of all the doors and windows on this floor with their corresponding positions, directions, and contained information. Then change them according to the needs of the design, and update the information in the code at the same time. In this way, whether it is to modify the design, find the object faster, and manage its later information, it is a more efficient and convenient method. In this way, it will help the design team modify the design more efficiently while saving lots of money and time for the manager during the construction phase.

BIM is changing rapidly now. While it remained predominantly the domain of technology specialists in architecture and engineering firms in the early twenty-first century, it is now steadily gaining relevance for a broad range of stakeholders in the design, construction, manufacture, and operation of built assets.

Building Information Modeling (BIM) is characterized by a well-structured creation and exchange of information. In the last years, the term has also been referred to as “Better Information Management”. Due to the high amount of involved parties, which by nature hold contradicting views and interests, the organization of information requirements represents a key factor in the context of project management. The major challenge and chance lie in improved project and information management achieved by applying BIM and thus, producing and using high-quality information.

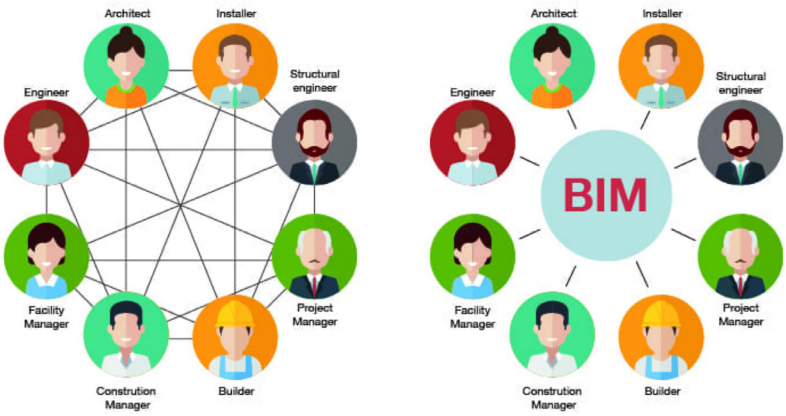

Figure 43: Data exchange between different participants [63]

In the course of planning and constructing buildings, a multitude of information emerges before the commissioning of the built facility. Since large building projects include thousands or even tens of thousands of documents, to extract information, classify information, transfer-related information to different departments, such as construction management, maintenance management, etc. In different directions. This process is usually very complicated, time-consuming, and error-prone.

To make the best use of Building Information Modeling (BIM) during a construction phase should begin with the questions:

- How to better complete the exchange of information during the entire building life cycle?

3. Results

- How can improve the project by using BIM methods?

- What technology it can to achieve by using BIM?

- How many different departments will participate in the overall project structure by using the BIM methods?

- How to organize different project actors to fulfill the project goals in the most efficient manner?

The design, construction, and operation of buildings is a collaborative process involving numerous project participants who exchange information on an ongoing basis.[64] By using a uniformly structured building information model, many of its work and communication processes can be significantly improved. The centralized management of model information simplifies the coordination between project participants and their communications and makes it easier to control the overall project schedule. Depending on which partner needs to deal with which project stages and/or parts of the information, different forms and cooperation methods can be used. Information from various project participants can be kept up to date and available in the shared information space, which allows everyone to access the same information, so communication between all participants is more reliable. This is more efficient than traditional paper-based workflows.

3. Results

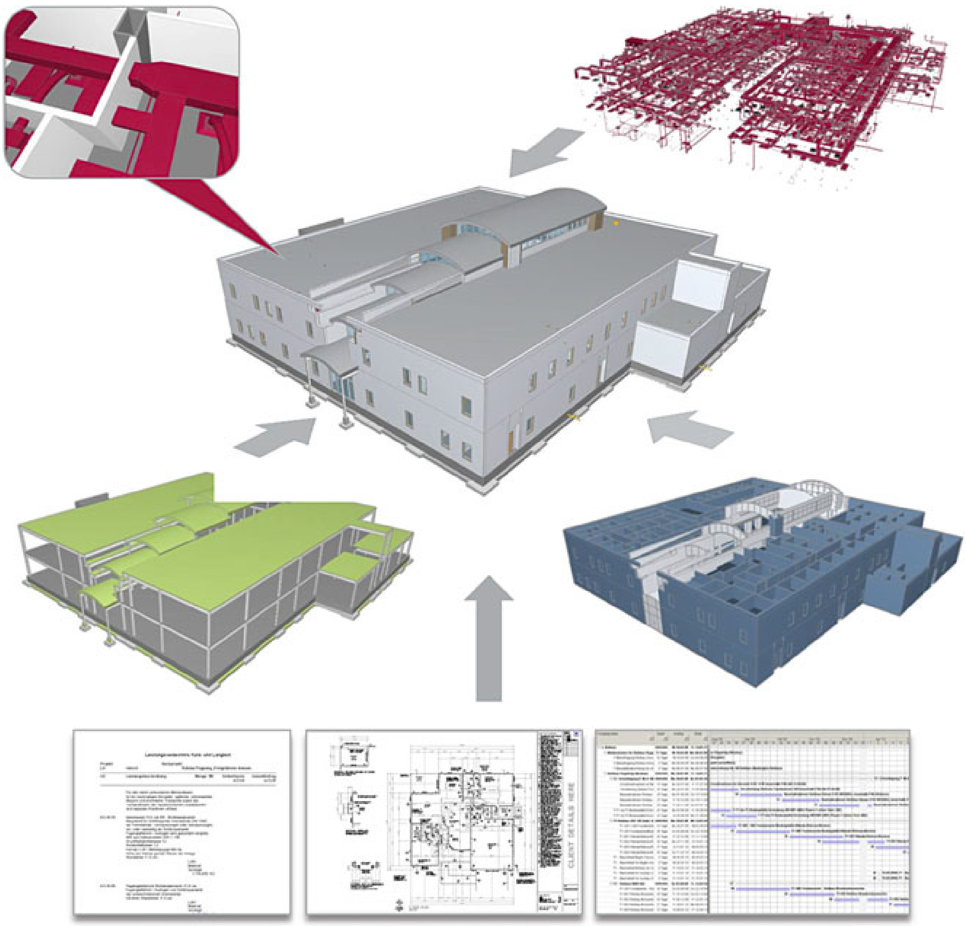

Figure 44: Information exchange between different project participants[65]

Facilities management usually is difficult and complicated work. Because tracking and managing facilities effectively are extremely difficult owing to the various facilities. For traditional building maintenance, the staffs usually use paper or information systems to record the facilities maintenance work. Which including 2D drawings information for inspection and maintenance. However, it is not easy for staff to use the traditional 2D CAD-based drawings information in the facility maintenance. At the same time, the information on the same facilities maintenance needs to repeat the record and this is an inconvenience for all staff. This process usually wastes a lot of time and money.

3. Results

To control and manage effectively the maintenance work in the building facilities, all the staff should be able to access the facility location to handle inspection and maintenance work at any location,and the maintenance management should under the real-time monitoring and control.

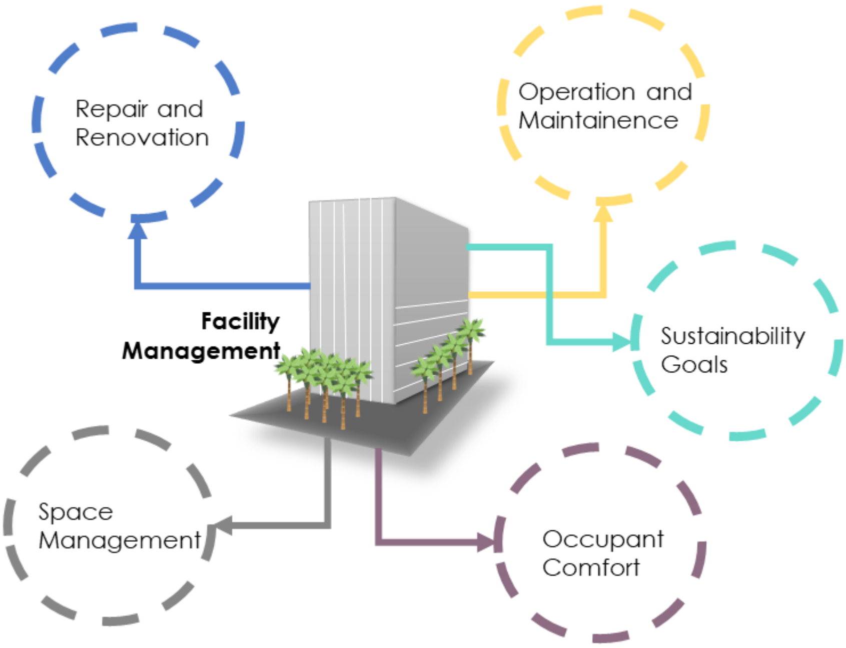

Figure 45: BIM for facility management[66]

For more efficient maintenance of facility equipment, the concept of building information modeling approach is applied and developed as 3D information models for managing and maintaining facilities in the study. With the integration of the BIM model with related information on facilities maintenance, the facility staff may improve the efficiency of maintenance and management work of facilities. This is also a good exchange of information for different participants, based on the central BIM model.

3. Results

The information for the facility maintenance comes from information for construction management. This is based on the continuous updating and exchange of modeling model information throughout the building life cycle. On the platform of the uniformly structured building information model, it can extract any information needed for the facility maintenance, and all this information is consistent, shared, and instantly updated. And this information can help us with more efficient facility maintenance.

4. Conclusion

4.1:BIM for the future

After analyzing the main results for the thesis research, we know how to use the different BIM approach for data optimization. Having a better understanding of the advantages of BIM in storing, maintaining, and exchanging information. And how to use BIM technology, improve building quality, improve construction efficiency, and so on.

Now thinking about the BIM for the future, it is always able, to begin with, some questions:

- What is the future direction of BIM?
- How will BIM innovate and apply in new construction fields?
- How BIM will change the design and construction community?

There is no doubt that BIM will continue to develop rapidly in various fields of architecture. In already mature areas, such as BIM for construction and BIM for facility management, BIM will continue to develop in-depth to provide better working methods for the construction industry. The development of BIM not only includes the update and improvement of BIM tools, but BIM will give people a new way of thinking, "Can we do it this way?" For the use of BIM for construction, the better use of the model and related information will provide a better way of working and better improve the design quality of the building. At the same time, because BIM technology has predictive, parametric, and other innovative properties, perhaps in the next few years, the use of BIM tools in construction will exceed the use of traditional 2D CAD.

4. Conclusion

At the same time, BIM can introduce some new innovative technologies into the daily life of architectural design. It is known that Virtual Walk-Throughs, laser-scanning drones, these new technologies provide new impetus for the development of the construction industry. How to use new technology to support the continuous development of architectural design, this is a question that can continue thinking. BIM modeling is an intelligent parametric modeling method. What is so promising about BIM is that it is not CAD, it is not drafting, and it is not lined on a paper representing the outline of a building. Rather, the model is the building. [67] With the continuous development of BIM technology, the model And model details are constantly being optimized. Perhaps in the future, it can get a more accurate, or near-perfect model before construction. Through the interpretation of model information, it can help architects better optimize architectural design. For example, by quickly scanning the QR code, it can immersive in the corresponding building space. This has great potential for BIM technology in the architectural design stage.

Figure 46: Example of QR code[68]

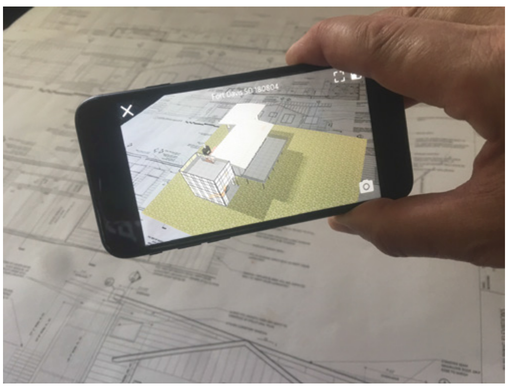

Figure 47: The AR model[69]

It is known that an important concept of BIM is interoperability, which provides a platform for all participants in the construction

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field. Different participants exchange information with different building information on this platform. This platform that enhances collaboration and allows teams to learn from each other during project development and learn more quickly through useful project information. Previously, interoperability is difficult to achieve because for different participants, they use different software to provide and simulate Data when the exchange of information is needed, often requires a lot of time and effort. Moreover, it is often difficult to update the information of different participants in time. In the future, to make the interoperability of building information better, more and more software will join BIM, a large platform, to better help different participants exchange and obtain information.

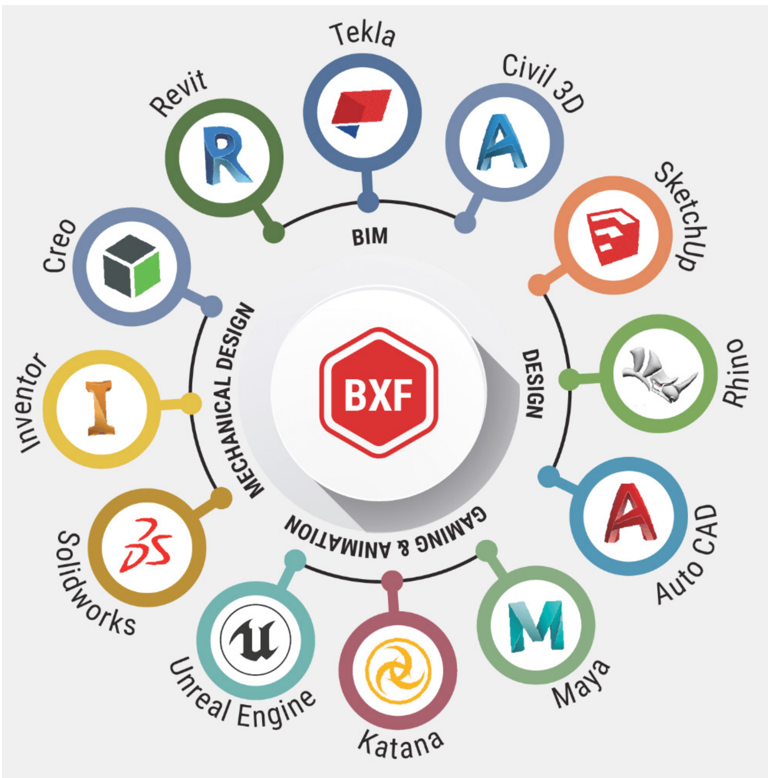

Figure 48: The interoperability between different software[70]

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Advanced technologies are being applied to BIM design processes, expanding the scope and role of digital design. [71] For the use of some very innovative technologies, a large 9number of ideas and processes have been produced throughout the design, construction, and operation of the building. For example , Digital realities. Not only can these technologies serve as independent innovative technologies for architectural design, but they can also join BIM's design workflow to exchange information and improve design quality.

With the construction of a 3D model in an infinite and infinitely scalable digital space, there is the opportunity to explore the resulting construct in a variety of immersive visualization modes. [72] Virtual reality (VR) is the latest technology to experience virtual reality. In most cases, you only need to carry a dedicated headset. After creating immersive and interactive virtual reality environments. The designer can get a better feeling of room-scale and spatial relations.

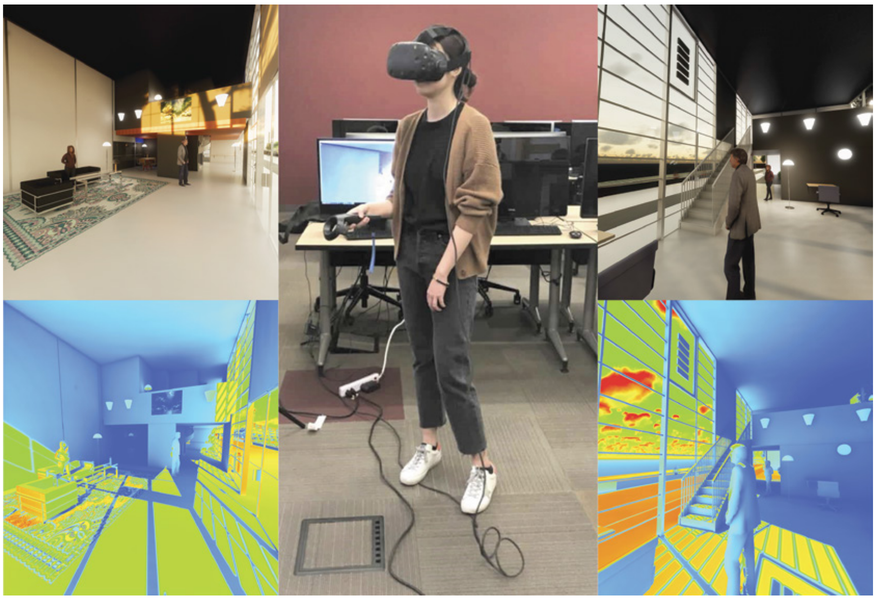

Figure 49: The virtual reality with VR headset[73]

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The boundaries between the virtual and real are increasingly blurred as technology becomes part of the very fabric of design and construction.[74] From a design perspective, digital reality is becoming a new delivery tool and has become an integral part of all stages of the design process. Traditionally, buildings are a manifestation of physical drawings and models. In the future, the performance-based design will enable myriad scenarios to be simulated, tested, and validated in advance of construction.[75] In the design process, people with different identities can better experience space, building materials, lighting, and so on. Provides a better way for designers and clients to communicate. Participants of the project can even make better decisions about architectural design without understanding the plan drawings. This greatly reduces the cost of the building design stage and saves a lot of manual measurement, interpretation, and input work.

Sustainable design is also an important part of BIM's future development. In recent years, more and more mainstream media have reported on the challenges of global warming to our living environment.

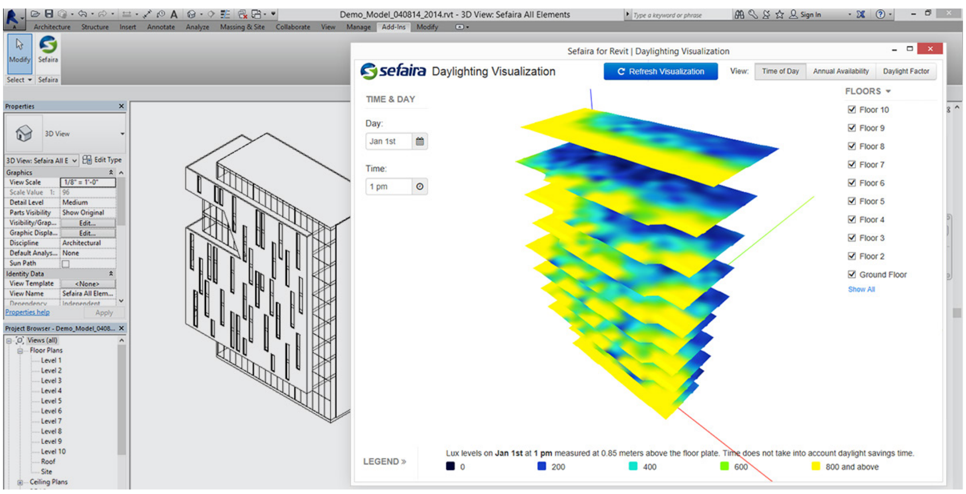

Figure 50: The Real-Time Daylight Visualisation Tool for AutoDesk Revit[76]

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A fundamental tenet of truly sustainable design is the integration of all the building systems within themselves as well as with the external economic and environmental realities of the project.[77] Through the better interpretation of the model information by the entire design team, analyze the type of building design, the insulation of the relevant building materials, the solar energy coefficient of the building, and the impact on the social and economic environment.

The future BIM model will be a system that interacts fully with key building information, climate information, user needs, and triple bottom line impact, so design integration and data return between all systems will be immediate and symbiotic. [78] Through the rational use of BIM technology, future sustainable buildings can be better completed. Makes a better balance between nature and people, architecture, and natural environment.

In the future, many problems will appear one after another. For example the increasing population of the earth, the impact of the greenhouse is the effect on the environment, the development, and utilization of new energy. If it can continue to innovate on BIM technology, better use BIM tools. Not only using BIM technology to better change the construction industry but also have the opportunity to change the entire world. In the field of architectural design, more building information can be transfer into better decisions, whether it is the material choice, safety choice, building type, or expected operating costs. Everyone will benefit from better and more useful information. High-quality energy-saving buildings are designed to reduce the impact on

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the environment. If it can use it in the right way and develop BIM technology, they can help everyone change our world better. Innovation is always a journey, not an end.

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Source: Graphic from the Revit model

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6. Acknowledgment

I would like to express my gratitude to all those who helped me during the writing of this thesis.

My deepest gratitude goes first and foremost to professor OSELLO ANNA, my supervisor, a respectable, responsible, and resourceful scholar, who led me into the world of BIM.

Second, I would like to express my heartfelt gratitude to professor DEL GIUDICE MATTEO, whose illuminating instruction and expert advice have guided me through every step of my writing of this thesis. He gave me lots of inspirations and encouragement. without his consistent and illuminating instruction, this thesis could not have reached its present form.

Last my thanks would go to my family for their loving considerations and great confidence in me all through these years. I also owe my sincere gratitude to my friends and my classmates who have selfless and generously helped me with my thesis.