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DEVELOPING ADAPTIVE CONSTRUCTION PROJECT MANAGEMENT BASED ON SUSTAINABLE NATURAL RESOURCES

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Master's Thesis

Supervisor

Assoc.Prof. Dr. Sepanta NAİMİ

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The thesis titled “DEVELOPING ADAPTIVE CONSTRUCTION PROJECT MANAGEMENT BASED ON SUSTAINABLE NATURAL RESOURCES” prepared by RIYAM ALTAEE and submitted on 30/09/2022 has been **accepted unanimously** for the degree of Master of Science in Civil Engineering.

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ABSTRACT

DEVELOPING ADAPTIVE CONSTRUCTION PROJECT MANAGEMENT BASED ON SUSTAINABLE NATURAL RESOURCES

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Adaptive construction project Management is considered a major challenge in project construction management. It represents one of the economic development issues due to the use of sustainable concepts. This industry in Iraq faced the problem of overrun costs. For that, the present study investigates the various factors that affect construction projects and especially the type of material effect. The main challenge in this research is to use the sustainable concepts of used materials in construction projects to implement the adaptive selection automatic method. Three processes have been used in the research methodology, the first is the Delphi method which is used to specify the weight of material preferable rank. The second method is used the MCDM technique which presents the best material choice using materials characteristics. Finally, the third is the BIM method which specifies the cost calculation method. The results observe two effective materials, they are solid concrete blocks due to their low cost and high compressive strength and lightweight concrete wall due to high thermal efficiency and the effect of lower usage concrete (due to the low load on the structure). The factors such as size and type of construction project are considered influencing factors that can increase the total cost of building. The evaluation process of these parameters provides flexibility in using materials. According to the expert's opinion, it is significant results due to the best choice of sustainable materials for implementing the building in Iraqi environment.

Keywords: MCDM, Building Cost, Sustainable Materials, Adaptive Concept, BIM.

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ABBREVIATIONS

AM	:	Adaptive Management
AHP	:	Analytical Hierarchy Process
BIM	:	Building Information Modelling
CIFOR	:	Centre For International Forestry Research
MCDM	:	Multiple Criteria Decision Making
USAID	:	United States Agency for International Development
APM	:	Agile Project Management,
DM	:	Decision Makers
NRM	:	Natural Resource Management
DMU	:	Decision Making Unit
WMF	:	Work Motivational Factors
DEA	:	Data Envelopment Analysis
HSEE	:	Health, Safety, Environment and Ergonomics
RE	:	Resilience Engineering
MEP	:	Mechanical, Electrical, and Plumbing
AEC	:	Architectural, Engineering, and Construction
LOD	:	Level Of Development
MOO	:	Multi-Objective Optimization Approach
WSM	:	Working Stress Method

TOPSIS	:	Technique for Order of Preference by Similarity to Ideal Solution
AF	:	Appropriateness Function

1. INTRODUCTION

1.1 OVERVIEW

The term "adaptive management" (AM) refers to a method that involves a methodical, iterative process of making sound decisions in the face of uncertainty, with the goal of gradually lowering uncertainty via the use of system monitoring. In this manner, the decision-making process achieves one or more of the objectives of resource management while simultaneously accumulating information for the future management of the resource, either passively or actively. This kind of management is a methodical strategy that takes into account uncertainty and learning in order to enhance environmental management policies and practices[1]. It is possible to trace its roots all the way back to the early 1900s and the thoughts that Frederick Taylor had for scientific management. Different points of view on adaptive management are supported by similar ideas that may be found in other fields, such as business, experimental research, systems theory, and industrial ecology[2]. All of the components of an adaptive strategy include putting one or more of these options into action, monitoring the outcomes to learn about the consequences of management activities, and finally utilizing the findings to update knowledge and change management actions. Instead of just following the path of least resistance, an adaptive strategy entails trying out a variety of approaches in order to reach management objectives while making educated guesses about the likely effects of each option. Long-term resource systems can only be established and maintained via the joint efforts of managers, scientists, and other stakeholders[3]. Because of its potential benefits, adaptive management is an intriguing strategy to employ in contexts where there is a great deal of unpredictability. There are issues with the planning and the building itself. Some of the key reasons for the issues include the lack of quality control during construction and the use of untrained personnel. Diverse cracking, differential settling, and corrosion of reinforcing bars are the results [4]. Rebuilding and fixing up the building components is also more expensive. The literature was scoured for clues about the factors that play a role in the preliminary planning phase of construction cost estimates. Budgets for huge projects can run into the hundreds of crores or thousands of dollars, and they typically require cutting-edge technology and a flexible approach to resource management [5]. Due to the resource-intensive nature of construction management, resource management is a challenging effort. Technology has advanced rapidly, and a vast array of new building materials has become widely accessible. Most nations devote significant resources to developing cutting-edge methods for studying and creating novel materials. There is little evidence that analytically links the mechanical performance of materials to factors like particle shape and size, which are correlated with gradation. All of these things have a substantial impact on the economy, and they can cause serious harm or even death[6].

1.2 ADAPTIVE MANAGEMENT

There is a considerable body of research that discusses the theory behind and use of various different AM frameworks in natural resource management. In this lesson, we will cover the principles of AM without offering a comprehensive overview, which would be the subject of a completely different class. We believe that if we introduce students to the conceptual underpinnings of AM early on in their undergraduate studies, it will better prepare them to apply AM concepts and methods in later semesters as well as to think critically about the decision-making process pertaining to natural resource management[7]. Over the course of the past three decades, the objectives of environmental conservation and recovery have broadened beyond the protection of individual species and habitats to encompass the protection of entire ecosystems. This paradigm shift was in part spurred by the understanding that focusing on species or habitats was insufficient, and that life-sustaining processes occur on far broader geographical dimensions. interact with a far larger number of the components of the ecosystem than was customarily catered for in restoration and conservation efforts at the time. However, the idea of "ecosystems" is in and of itself a shifting target[8]. This is not only due to the fact that it continues to adapt and diminish to suit human wants for space and resources, but also due to the fact that people cannot survive without Nature. An adaptive management strategy is required whenever judgments need to be made on how to accomplish a difficult goal in the face of uncertainty. This practically always applies to ecosystem recovery since both the desired results (such as the reactions of species to remediation operations) and the driving variables (such as human behavior and weather-dependent processes) are typically unexpected[9]. When these factors interact with one another, there is a greater potential for uncertainty. As a consequence of this, advancement calls for a methodical approach known as adaptive management, which may be summarized as "learn-and-adjust-as-you-go" (AM). It is analogous to relying on plum line soundings to guide a huge ship over unfamiliar reefs in the ocean. A 'theory of change' is defined, which is an explanation of why and how a desired change is expected to occur in a particular setting. Next, activities are taken to bring about that change, progress is tracked in comparison to the goals that have been set, and a different course of action is taken if the desired change is not achieved[10].

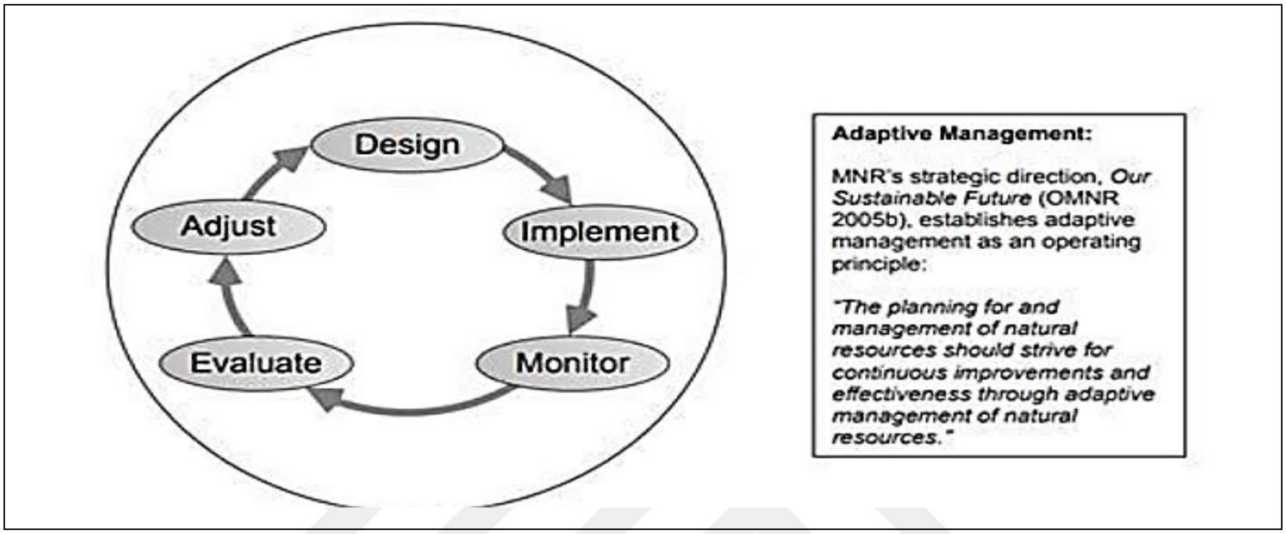

Figure 1.1: Adaptive Management Framework[11]

The widespread misconception that the term "adaptive management" refers to a certain method or procedure is reflected in the many of contexts and settings in which it has been implemented, as well as in the myriad of ways in which people understand and use the term "adaptive management." The United States Agency for International Development (USAID), for instance, provides a comprehensive definition that places an emphasis on the utilization of evidence to inform decision-making[12]: "a methodical technique to make judgments and modifications as a result of fresh knowledge and context changes." The 2020 Strategic Plan for the United States Agency for International Development (USAID). The foundations of adaptive management, on the other hand, were built on the idea of using data to inform action in the face of ongoing unpredictability: "a structured process that allows for taking action under uncertain conditions based on the best available science, closely monitoring and evaluating outcomes, and re-evaluating and adjusting decisions as more information is learned" "a methodical approach that enables decision-making in the face of uncertainty based on the most recent scientific finding" 2009, Department of Fish and Wildlife of the State of California[13]. When making judgments and taking action, it's important to base them on data gleaned via monitoring, assessment, and research. We may benefit from the larger concept of adaptive management, in that it reminds us that all management must be flexible - not merely execute plans, but also adjust them when circumstances or understanding change. When it comes to making judgments and taking action based on data, both of these strategies may be quite beneficial. A general use of this word obscures the significant adjustments that high-level adaptive management calls for in terms of plan, manage, monitor, and evaluate in order to be effective. Adaptive management demands changes in these areas[14].

1.3 PROBLEM STATEMENT

The term "adaptive project management," or APM for short, refers to a framework for making decisions that may be used at different stages of a building project. It is a form of project management that reacts to needs by modifying and adjusting the response. The approach of the method enables the management to enhance their judgments and practices throughout the entirety of the project life cycle by drawing on the lessons learned from the results of prior projects. When the process is adaptable, organized, and iterative according to a systematic method, the technique may accept uncertainty. Even though the plan is predicated on agile project management, APM enables the group to react to unanticipated roadblocks and devise new and improved ways to achieve the project's goals. The material challenge may be used to assist lessen the negative aspects of building, and the natural materials that are used should be used for the effective components. In order to arrive at a solution that is really sustainable, this must be achieved in every respect by adjusting the complexity of the structure and acknowledging nearly any trade-offs that may exist among the interconnected systems. The aim of constructing an adaptive building model based on natural resources that is strong, aesthetically pleasing, and ecologically benign in accordance to the conditions of Iraq.

1.4 OBJECTIVE OF STUDY

The application of Building Information Modelling, also known as BIM, in the management of adaptive building projects that are based on sustainable natural resources is the purpose of the current research. The usefulness of BIM in this kind of construction sector may be demonstrated by using qualitative and quantitative methods, which can be carried out by conducting interviews with construction industry specialists and using a case study.

1.5 THESIS ORGANIZATION

This thesis has five chapters. Chapter one includes an introduction to the adaptive construction project management and their details.

Chapter two presents a general view of the criteria for the selection of adaptive construction project management in different studies collected from vary researches.

The experimental program, including the studied parameters, the work methodology, are presented in Chapter three.

Chapter four discusses the result and the calculation of the work. Chapter five is the conclusion.

2. LITERATURE REVIEW

The idea that one of the primary goals of the so-called "new ecology" is to acknowledge the dynamic nature of the natural world is one of its guiding principles. According to recent studies, the majority of natural systems are malleable, non-linear, intricate, and rarely predictable, and they have the potential for changes that are irreversible. When describing the operation of ecosystems and their ongoing evolution, words such as climax, equilibrium, and optimality are no longer appropriate. As a direct result of the creation of this new ecology, a large number of scholars have started looking into the linkages that exist between natural and social systems in order to provide a fresh approach to the administration of environmental issues. Two scientific concerns have come to the forefront as a direct result of the new management style that has been implemented. People who were working on resources that were considered common property initially developed the method. Their basic concept is that the great majority of natural resources are utilized by a variety of different types of consumers (often in a sustainable manner). This has two different repercussions[15]:

a) The control of natural resources by the state and the privatization of such resources should not be regarded the only two management alternatives for resources.

b) Any effort to manage the environment need to involve participation from a wide variety of interested parties.

In every circumstance, there is a need to take into account the ecological, social, and economic aspects of resource extraction. In this way, effective stakeholder interactions may serve as the foundation of an environmental management strategy that makes use of different resource applications. An environmental problem cannot be satisfactorily solved by employing a solution that is founded on the standards of a single discipline. Rather, environmental disagreements can only be addressed if all of the relevant stakeholders get together to find solutions that are acceptable to both sides and are suitable in the given circumstances. The field of ecological economics, which came into existence in the early 1990s, is another factor that helps to the creation of a new strategy for environmental management. Co-evolution is one of the core ideas behind this strategic approach. This highlights how changes in the natural environment have an effect on how humans utilize resources[16]. Each and every strategy for the management of the environment need to incorporate the intricate and varied feedback loops that exist between societal and natural systems. Because of this, a new strategy for environmental management has emerged, the fundamental objective of which is to coordinate the activities of humans and natural forces. Because it seeks to increase understanding of environmental dynamics and the predicted growth of social systems in resource use, this kind of environmental management is more "adaptive" than any other sort of environmental management that has come before it. As a direct consequence of this, novel strategies and methods for addressing environmental and social factors are now being contemplated[17].

2.1 ADAPTIVE MANAGEMENT CYCLE

The actions and processes of management and decision-making that take place during the course of a project's life cycle are collectively referred to as the "project management cycle" (including key tasks, roles and responsibilities, key documents and decision options). Although the method was first developed for the purpose of managing projects, it may also be utilized in the formulation and execution of management plans. Conducting a comprehensive situation analysis is the first step in the process of management planning. This step entails determining which habitats, species, and potential locations are present in the region, as well as analyzing population trends and threats by making use of previously compiled descriptions and inventories. A comprehensive problem analysis is helpful in determining whether or not the underlying reasons of problems regarding biodiversity may be addressed by management activities, as well as in determining whether or not these underlying causes can be identified[18]. The primary reasons for the decline in biodiversity are climate change and air pollution; management efforts alone will not be sufficient to reverse this trend. On the other hand, the effects of these dangers can be mitigated with the assistance of adaptation strategies. The scenario analysis is also essential for developing a sense of what is at risk in terms of economic development, social and political issues, and security and stability concerns in the region that contains the protected area that is placed there. The following image (Figure 2.1) from the California Department of Fish and Wildlife depicts this amount of change, while the following graphic (Figure 2.2) from ecological management combines explicit design and utilization of a model.

Figure 2.1: The Adaptive Management Cycle with three Levels of Adaptation. Californian Department of Fish and Wildlife[13]

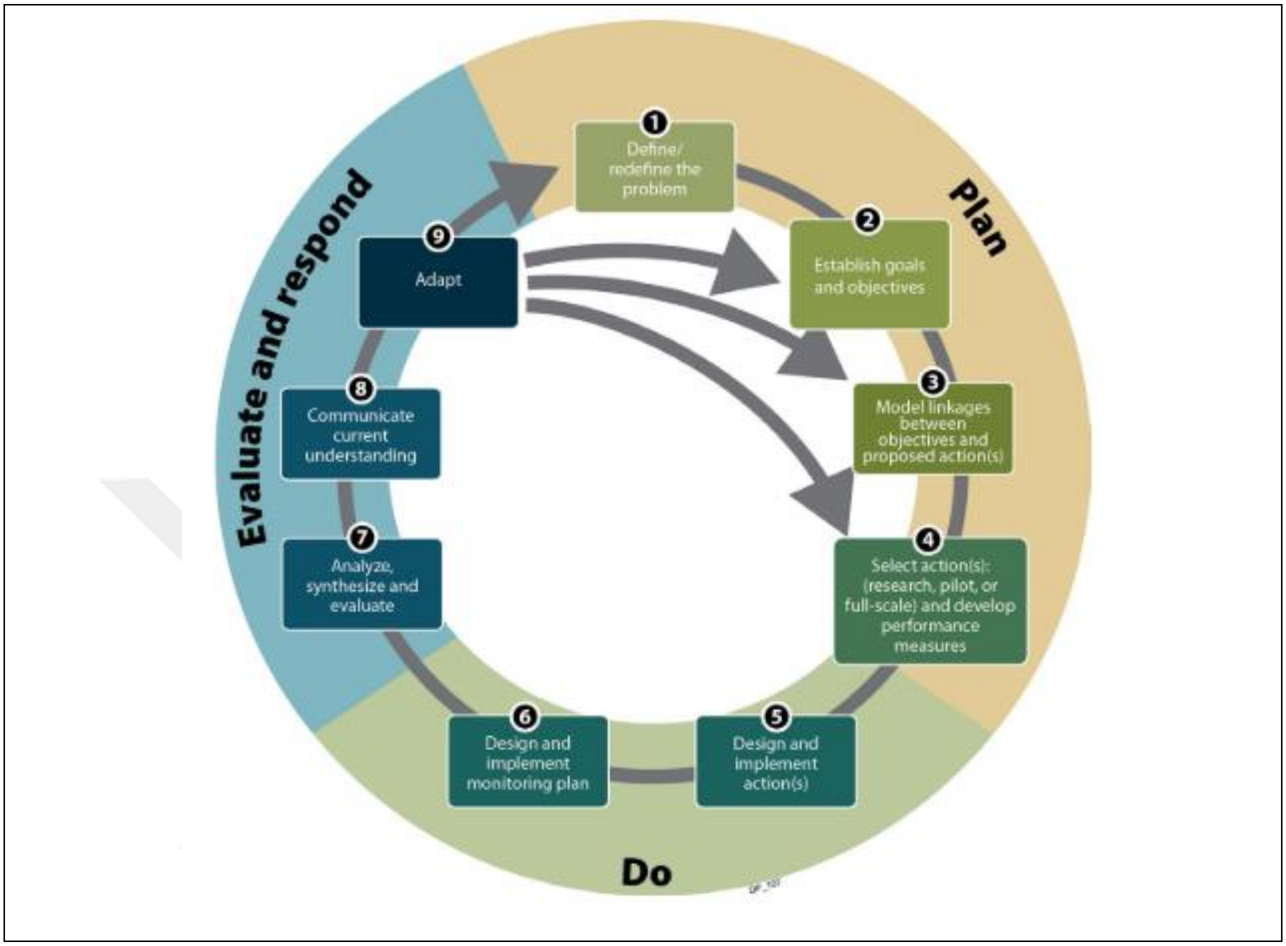

Figure 2.2: The Adaptive Management Process [19]

Changes to the sorts of activities, methods, and even the results that are wanted, as well as how the theory of change is understood, are all examples of what may be included into adaptive management. It employs a technique of repeated adaptation, which is led by suggestive change theories and contributes to the modification of those ideas. The following is one manner in which adaptive management is distinct from traditional management[20]:

a) The traditional, single-loop learning approach to using data Adaptive management goes beyond simply using data to identify and address implementation flaws and gaps.

b) Learning from a theoretical trial and error - Adaptive management employs conceptual models to guide trials and revises models depending on the results of these trials. This "learning from a theoretical trial and error" method is known as "learning from a theoretical trial and error."

c) Choices made on a whim - The designation should not be used as an excuse for insufficient planning that does not make use of the evidence that is available.

Adaptive management is something that should be considered in circumstances when there is a great deal of unpredictability and change. As a consequence of this, it is pertinent for particular kinds of interventions and implementation scenarios, such as the current epidemic that is occurring all over the world. After a certain amount of time has passed during which adaptive management has been implemented and increased knowledge and learning have taken place, it is possible that there will be less uncertainty and that more conventional methods of planning, management, monitoring, and evaluation will be able to be used. Alternately, it is possible that persistent shifts in conditions make it impossible to know 'what works' in terms of certain types of interventions, thereby necessitating constant adaptive management, at least for certain aspects of the intervention[21]. This would mean that the intervention as a whole would have to be managed in an ever-evolving manner.

2.2 SUSTAINABLE NATURAL RESOURCE MANAGEMENT

Not only are they used as a setting for the production of food, but agriculture and natural resources are also regarded as major contributors to the economic well-being of smaller rural towns. Within the framework of the concept of sustainable rural livelihood, national resources are seen as natural capitals that are essential to the way of life of rural families and communities[22]. Despite the significance of the phenomenon, the combination of numerous factors has reduced the capabilities of agriculture and put natural resources in jeopardy. The number of people living in metropolitan areas and the size of the consumer base are both growing, but at the same time there is an increase in the demand for natural resources and a decrease in public support for environmental management. The production of food in both agricultural settings and natural ecosystems has suffered as a direct result of human activities such as deforestation, soil degradation, and a lack of available water. 2011 was declared by the United Nations to be the International Year of Forests, with the goal of drawing attention to the vital significance of environmentally responsible forest management around the globe. The Food and Agriculture Organization of the United Nations (2010) estimates that around 13 million hectares of forest are lost or converted to other land uses each year[23]. According to the findings of this organization, deforestation is accountable for around 20 percent of the world's total emissions of greenhouse gases. In addition, it may cost the economy of the entire world up to $5 billion per year. According to the Centre for International Forestry Research, the primary causes of deforestation are the expansion of infrastructure and agricultural production, as well as human settlements and activities such as mining, the production of charcoal and fire, the construction of roads, and grazing livestock in pastures (CIFOR). These are connected to policies and efforts of the government in some way, either directly or indirectly. The vulnerability of rural families may be enhanced as a result of the depletion of natural resources, which may then lead to a rise in the wasteful use of natural resources. These complexities can be better understood and managed by employing multi-paradigmatic approaches to sustainable agriculture and natural resource management (NRM), which incorporate and link multiple paradigms of social actors or their knowledge. These approaches can be found in the field of natural resource management (NRM). It is essential for these parties to have the intent to establish a systemic relationship[24].

2.3 ADAPTIVE LEADERSHIP STRATEGIES

Because of the complexities, dangers, and different aspects of the project, project managers have a difficult job when tasked with managing projects to help a business accomplish its strategic objectives and maintain its competitive edge. Blaskovics (2016) argues in [25] that the ineffective leadership strategy is the primary reason of the failure of many initiatives. The notion of adaptive leadership states that leaders have a responsibility to facilitate the adaptation of their followers to the many changes, problems, and concerns that are faced by the company. The members of the team, rather than predetermined steps or established protocols, are viewed as the primary drivers of successful project completion in this idea[26]. It is not possible to assist projects by relying on tools and procedures as a stand-alone method for mobilizing the project processes. According to Mensah et al, in [22] theory, adaptive leadership can be broken down into six primary actions:

a) Get on the balcony;

b) Identify the Adaptive Challenges;

c) Regulate the Distress;

d) Maintain Disciplined Attention;

e) Return the Work to the People;

f) Protect Leadership Voices from Below

Project managers need to be familiar with all six of these characteristics in order to properly manage projects. The relationships between project leaders and followers, the process of managing projects, the organization of the project, and its ultimate success are all based on the six qualities. When a team leader "goes on the balcony," they are referring to themselves taking a step back from the current situation in order to evaluate the adaptive difficulties that lie ahead. Adaptive challenges may not take the form of technical issues, which require technical expertise, but rather complicated problems, which require a different kind of decision-making approach. This highlights the importance of team leaders employing soft skills in addition to project tools and methodologies. The ability to motivate and urge followers to engage in all elements of the success process is an example of a soft talent. Team leaders use these traits to lead their teams[27]. The adaptive leadership paradigm includes a component known as Get on the Balcony. This component helps the project manager to study and grasp the challenges that are currently being faced. The second habit requires leaders to make use of an adaptable leadership approach in order to identify the adaptive problem. There are some project managers that choose to center their management approach on the utilization of tools and processes to tackle any and all issues pertaining to the project. Building relationships, being willing to take on responsibilities, and being imaginative are all examples of non-technical characteristics that positively connect with the success of a project.

2.4 TYPES OF ADAPTIVE MANAGEMENT

This section has shed light on a range of strategies that have been successful in some situations while shedding light on others that have not been successful. However, because each AM application must be adapted to the specific circumstances of the target location, they must all be distinct to some extent. Inevitably, the phrase has been applied to a diverse array of methods, some of which may not meet all of the requirements outlined in figure 2.3, while others may be qualitatively distinct in a variety of other ways.

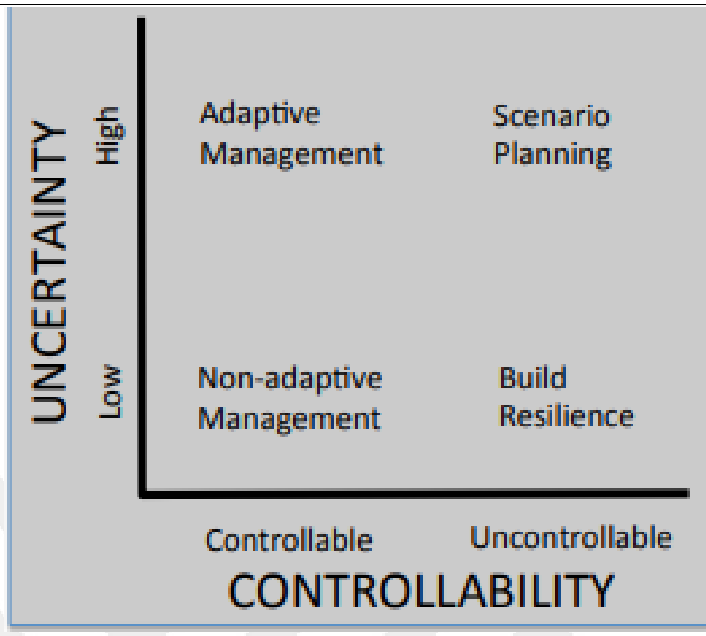

Figure 2.3: Adaptive Requirements [23]

Several distinct kinds of AM can be distinguished from one another by the following modifiers:

a) The term "evolutionary problem solving" may be used to describe nearly any change in management that occurs as a direct result of "learning by shared experience." This change occurs as a result of a cumulative process of comparing, choosing, and adjusting techniques that appear to be successful.

b) The term "passive" activity management (AM) refers to the practice of basing subsequent actions on collected information that is accessible at each decision point. To use the example of Puget Sound as a reference, beginning in the middle of the 1990s, twenty ferry terminals needed to be reconstructed and extended.

Midway through the 1980s, natural resource managers started applying AM (for example, Walters 1986), and now, very few people would argue that any other management strategy to ecosystem recovery is more effective than AM[28]. In the meantime, a programmatic approach to implementation has become synonymous with AM. This approach is typically comprised of recurring cycles that include five or six steps, including the following: assessing options, designing actions, implementing actions, monitoring effects, evaluating impacts, and adapting strategies accordingly, before returning to step one. This programming approach has a long history in corporate management and is generally used in the management of public health; nevertheless, it did not become established in conservation and restoration until the early 2000s[29]. It is widely used in the management of public health. There have been many additional versions proposed; however, the one that is now utilized the most is based on a version that was written down in 2005 by the Conservation Measures Partnership. This version is known as Open Standards for the Practice of Conservation. In 2009, the Puget Sound Partnership decided to accept this version, and since then, it has been modified to better fit the local context. The idea is continually developing, such as by making the part that research plays in the process more transparent. Levin et al. (2009) in [13] provided a definition of ecosystem-based management. Reiter et al. (2013) added a management phase to that description, and they termed their new protocol the Integrated Assessment and Ecosystem Management Protocol[19].

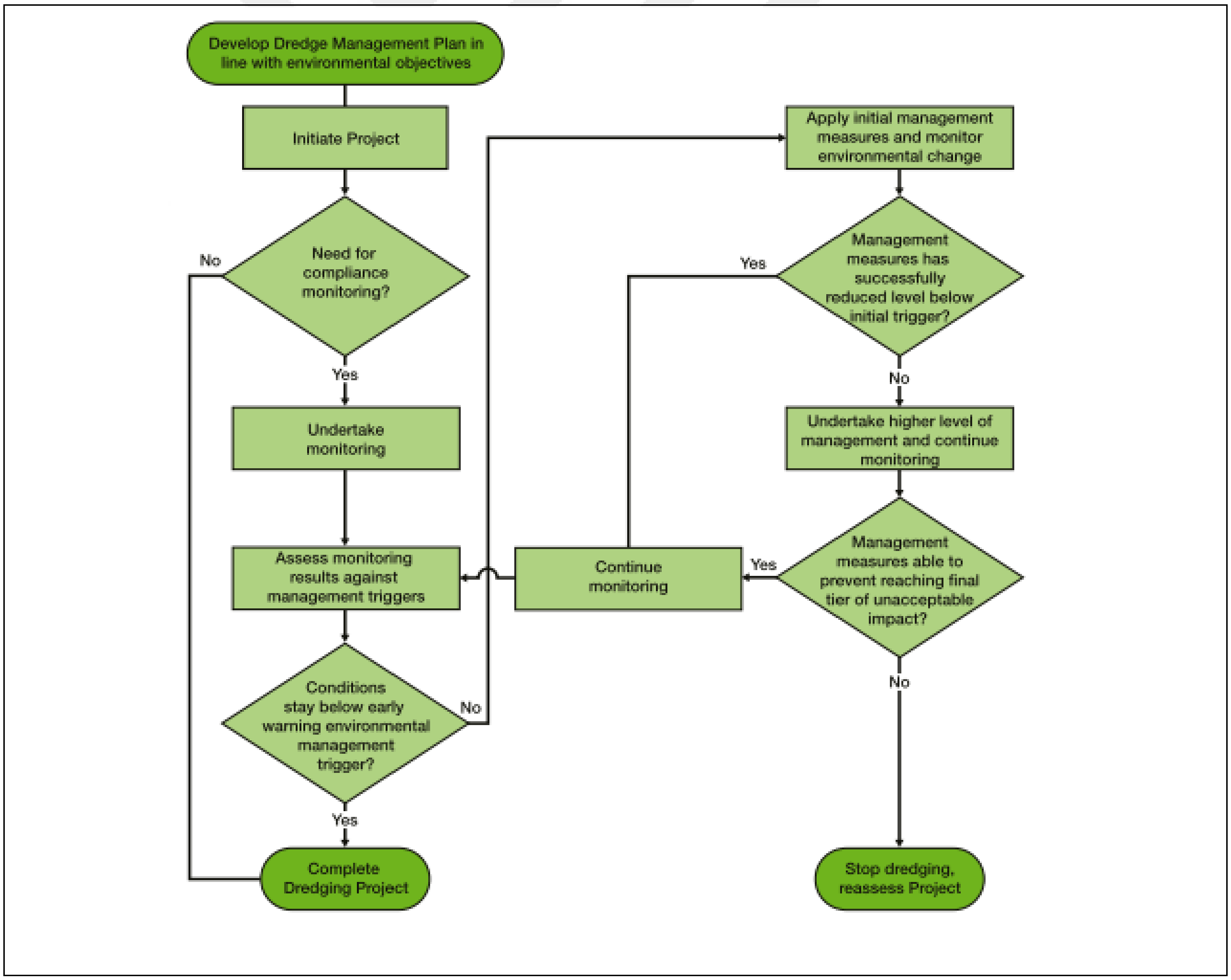

Figure 2.4: Integrated AM Cycles [30]

2.5 ADAPTIVE ALGORITHM

In the next part, an adaptive method for evaluating the effectiveness of each decision making unit (DMU) in the field of project management will be presented. In this thesis, the efficiency of each DMU that is taken on as an operator for a project has been evaluated based on RE variables as well as job security considerations[31]. The research was conducted by designing a questionnaire, and then the data collected from the questionnaire was disseminated to the project managers working at a significant construction site in Iran. An algorithm has been used in order to predict the effect that RE and job security will have on the efficiency of DMUs based on the data that has been collected, and then a sensitivity analysis has been done in order to illustrate the effects that each factor will have on the efficiency scores that operators have[32].

2.5.1 Job Security

When determining efficiency, both in the context of project management and human resource management, the workforce must be taken into account. Recent research has focused on determining the variables that impact operators' performance across a range of sectors, particularly in terms of work motivational variables (WMF) like job security[32]. used data envelopment analysis to study the influence that human variables like job security, job happiness, and job stress have on performance evaluation (DEA). According to the findings of a workplace investigation, employees' health-related behaviors were affected by their concerns over the security of their jobs. They developed a novel technique for measuring worker performance that is based on two factors: job stability and HSEE. HSEE stands for health-related safety and environmental exposures. They employed HSEE as an input in the method, and job security as an output; job security was assessed using HSEE, and then it was used to examine operator performance. Also, Blader and Tyler (2009) asked employees about their perspectives on occupational stability, which is an important factor in preserving a good social personality. They asserted that having a secure employment not only motivates employees to contribute to the development of the firm, but also impacts their opinions of the profitability of the business. Individual variations in the significance of organizational attachment, job security, and work performance were investigated by Mado et al. (2016)[33] .According to what they claimed, workers who are anxious about their employment are unable to carry out their obligations effectively due to their worry; past study has shown that the positive association between these two qualities has been investigated.

2.5.2 Resilience Engineering

Only a limited number of research, to the best of our knowledge, have investigated the use of RE concepts inside building endeavors. The researchers employed social network analysis in safety net-works to differentiate the link between construction safety management and resilience for the purposes of performance and risk evaluation[34]. In some studies, only resilience was investigated; however, neither RE nor the factors that determine RE were discussed at all. Recent researchers in a wide number of fields have conducted research and analyses focusing on RE aspects. RE themes are discussed at length in the scholarly works. The article on recognizing the issues and constraints in the method of building resilience engineering and its adaptive capabilities was published in 2012. At a chemical manufacturing facility, the RE factors were sorted into nine distinct groups.

2.6 BIM SOFTWARE PROGRAMS

In the domains of architecture, construction, plant, and civil engineering, BIM software is a sort of 3D design and modeling software that may help with the optimization of the work required to build projects in these areas. This is done by aiding in the improvement of design choices and building performance. It is also simpler to manage the design and construction of pipelines, structures, and processes because to this software's digitization of the construction site and connections between data from construction to handover[35]. This software also improves the predictability, productivity, and profitability of workflows. in light of this, it is supporting the successful execution of projects by improving the quality of design and encouraging cooperation. The following four stages are included in the process of using BIM software[36]:

a) Planning, which involves combining data collected from the actual world with reality capture technology in order to produce BIM models.

b) Designing include carrying out conceptual design, analysis, and details in addition to documentation for the purpose of informing logistics and timetables.

c) Construction: communicating building ideas and designs to various trades and contractors in order to maximize productivity.

d) Operating: Transferring data from the building information model (BIM) to the operations and maintenance departments so that it may be used for subsequent upgrades or deconstructions

BIM models are composed of intelligent objects that, when modified, ensure that the entire design is brought up to date across the board regardless of who is working with them. Analyzing or exploring design possibilities, visuals, and documentations may be accomplished with the use of BIM models[37]. The computer-generated BIM model was constructed using building information modeling (BIM) software, which integrated data from several different infrastructure systems into a unified whole. In other words, a BIM model is a digital copy of a building's blueprints. It's the act of "making" something big from scratch and then depicting it from the start till the end. Revit and other software built specifically for BIM provide designers with assistance in designing, simulating, visualizing, and collaborating in order to make the most of the benefits offered by the linked data included inside a BIM model.

Revit is a single program that was designed specifically for Building Information Modeling. It has capabilities for: architectural design; MEP (mechanical, electrical, and plumbing); structural engineering; construction; and more[38].

The word "Information" is the most important concept in BIM. The core of BIM are the object models that make up BIM models. Revit is responsible for the creation of these objects, which are made up of data that designers may examine in a variety of perspectives:

a) 2D sketches

b) 3D models

c) Schedules (lists)

Because each view is presenting the same data, each time Revit detects that a single piece of data has been altered in one view, it immediately updates that data in all other views as well. Objects can also have connections to other kinds of things. To restate, any modifications made to one item are reflected in all of the objects that are connected to that object. According to the findings of the study, it was possible to conduct an analysis of the management and organizational characteristics that were included within the design process of an energy and user-oriented retrofit. This was made possible as a result of the early adoption of information modeling that occurred during the initial phases of the design. Because BIM models were utilized to such an extent degree, conducting frequent reviews with the many practitioners who were engaged in the design and construction processes was a breeze. There is no question that advancements in the quality of information, visualization tools, cost estimation, and energy analysis have unquestionably contributed to a decision-making process that is more informed from the earliest stages of the design process onward, with the goal of reducing inefficiencies that occur during the construction stage[39].

However, maintaining coherence between ever-growing groups of technical reports and drawings, even when using computer-aided drafting tools and document control systems, is an extremely difficult task. This is due to the mutual interactions between the complexity of contemporary buildings and the ever-increasing targets of energy, environmental, and construction quality that are required in the modern process of sustainable design. In addition, during the various phases of the executive design process, several specialists and other collaborators frequently carry out work together in a collaborative capacity. Their coordinated actions should, in an ideal world, supply each specialist with the right design knowledge he or she needs, the intended use he or she looks for, and the matching environment, so that they may do evaluations and offer input on consulting or change.

BIM is a technique that lowers mistakes by detecting conflicts and encourages interoperability and shared processes; nevertheless, in order to fully profit from the advantages of this approach, numerous more procedures are required, including the following: On the one hand, it is necessary for practitioners who do not use the same design standards or tools to share workloads; on the other hand, more advances in the same interoperability among various software and tools should be investigated and realized[40].

Elghaish et al., [41] they conducted a case study on the application of BIM at an organizational level within a small home design-build firm that was situated in the southern region of the United States. The research was conducted using a method known as direct observation, in which the researchers watched the deployment of BIM over the course of three years. The business that was examined had a number of divisions that collaborated effectively, carried out around 200–220 residential construction projects yearly, and charged an average of 200,000–250,000 US dollars for each project. The material, which is laid out in the form of a case study, identifies BIM Implementation on an organizational level. The case study reveals additional difficulties associated with the implementation of BIM at the organizational level, as well as the measures that the firm took to address these difficulties. The research offers companies that specialize in residential construction the chance to investigate the BIM implementation tactics used by their peers. A BIM roadmap was developed with the goal of implementing BIM in an all-encompassing manner throughout the organization. Many variables influence the capacity of a small residential D&B firm to use holistic BIM, according to the research. Financial backing, a clear understanding of the resources needed, There are a number of factors to think about before deciding on a software solution for your business, including the potential effects of that solution on your present processes and those of your team members, as well as whether or not the bus system you're using now is compatible with the program. During the course of the investigation, it became apparent that only a small amount of research had been carried out to investigate how BIM may be implemented in the residential sector inside the United States.

Hashemi et al. [42] offered a strategy for developing a BIM education program centered on collaborative online projects. As the influence of BIM on the AEC industries has expanded over the years, countries throughout the globe have started to prioritize BIM education and include it into university curricula. On the other hand, several studies have highlighted a variety of issues that are present within the BIM education curriculum. For instance, Building Information Modeling (BIM) should not be restricted to only modeling work. The approach features a procedure for the development of courses as well as guidelines for the course's overall design. A learning program for Autodesk Revit that lasted for five weeks and served as an example implementation was designed. Following that, such a program was put through its paces so that its efficacy could be evaluated. As can be seen in figure 2.5, the course project that has been chosen for this BIM class is a dwelling in Taiwan that is 7 stories tall and comes from the Skill Evaluation Center.

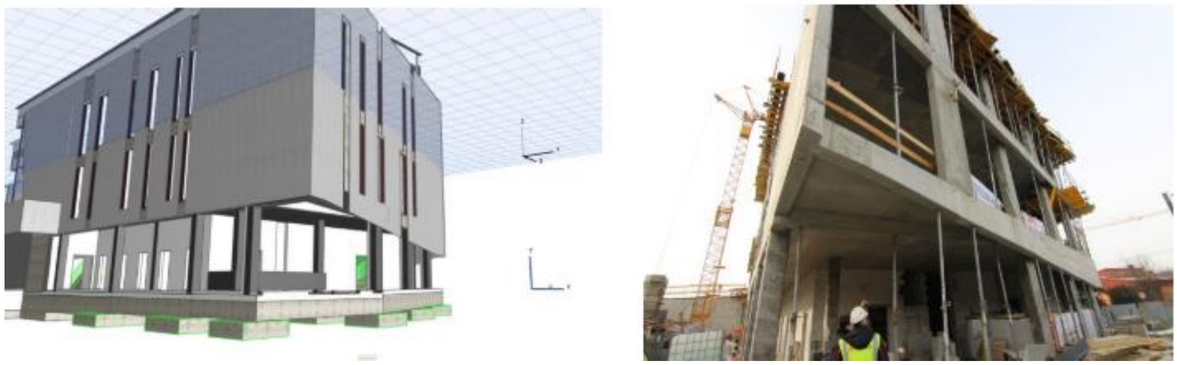

Figure 2.5: Building Information Modelling (BIM) Residential Project[37].

Despite the fact that the findings of the case study demonstrated that such a strategy is capable of having a favorable influence on the efficiency of the learning process, there are still some limitations associated with this research. A statistical investigation of the effects that works have might be carried out in subsequent investigations.

Harshil S. Thakkar et al. carried out research on the advantages that would be gained from implementing BIM in the residential project prior to its construction. As a result, the authors decided to base their case study on a residential project that was situated in Gujarat, India.

The BIM model was built using the information gathered throughout the project. As a result, the BIM model may be simply adapted to accommodate any changes that may be made during the construction of the building. After the original design has been completed, revisions may be made for future alterations. The proprietors provided us with the 2D AutoCAD drawings that we acquired. These sketches were then loaded into the student edition of Autodesk Revit 2021, where a 3D model was subsequently built. The LOD of the model is different for each individual component of the model. As may be seen in figure 2.6.

Figure 2.6: 3D BIM Model[43].

According to the findings of the study, the other residential developments located in the state are quite comparable. In the previous research that was done on the Application of BIM in India, the majority of the time, surveys or interviews with industry professionals were used to study the benefits of using BIM. Nevertheless, the purpose of this study was to determine the advantages that may be gained in the actual implementation of BIM before building takes place.

The authors were able to identify all eight of the mistakes by using the BIM model. If BIM had been used, it would have been relatively simple to detect the errors before construction. For example, some of the errors included interference between the structural elements and the MEP elements, errors in dimensioning, changes in the location points of the components, and other similar issues. Due to the fact that the BIM was not utilized at the construction site during the project, it was necessary to perform reworks for a number of the errors that were made. During the phases of designing and building, reworks were carried out; as a result, this led to a rise in both expense and risk. Following the finding of the mistakes, both the cost to construct the BIM model and the cost to correct the mistakes were determined. The ratio of the benefits to the costs was then calculated once the data had been thoroughly examined. The selected project had a B/C ratio of 1.44 and a 2-week construction delay. This comparison supports the idea that the project's expenses might have been significantly reduced, and the project timeline could have been compressed, if BIM had been used from the start. However, the study was not governed to a considerable extent, and it was assumed that the chosen project is representative of all building projects being undertaken across the entirety of the nation. As a result of the lack of standardized rules provided by the Indian government for effectively implementing the BIM, some assumptions were also utilized in the process of calculating the cost of certain pieces of work. All of these factors might be the determining element in determining whether or not the BIM model would have the same effect on every project. Finally, the BIM process is difficult to apply in India because this method is still in its early phases in India; nevertheless, if builders, contractors, architects, and project managers are able to overcome these problems, it may have a huge influence on the Indian construction sector. If BIM is effectively implemented and more extensive study is done on it or in major projects, the construction industry in India and other construction industries across the globe that have traits in common with the Indian construction industry would be able to understand its advantages[44].

3. METHODOLOGY

The term "adaptive project management" refers to a methodical and organized strategy that aims to enhance the quality of decisions and processes by basing such improvements on the results of decisions taken in previous phases of the project. The adaptive strategy is meant to continuously adjust itself to new circumstances in accordance with the status of the project. The adaptive method is not static and adapts itself continuously to the many diverse factors that might be found in a project. Adaptive project managers understand that every project is unique and therefore require a customized strategy to successfully complete each one. In this particular piece of work, the process may be summed up in the diagram, which can be found in figure 3.1.:

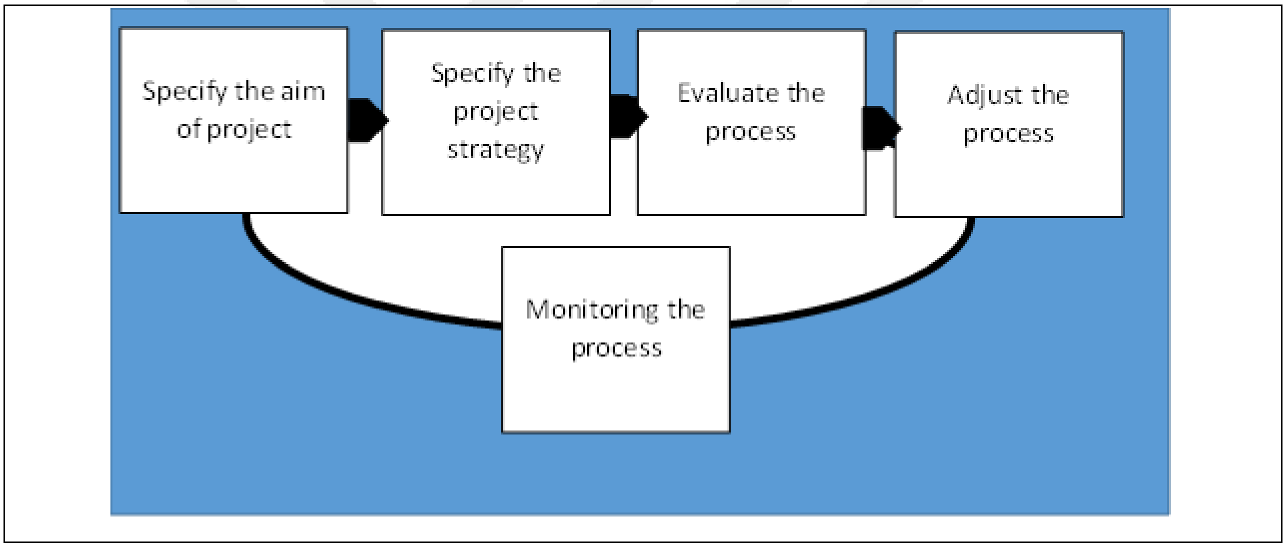

Figure 3.1: The General Methodology of the Present Thesis developed by the researcher

The steps can be explaining by five steps of methodology.

3.1 SPECIFY THE AIM OF PROJECT

The ability to offer focus and direction, develop strategic alignment, and accomplish the best quality delivery of projects across teams requires abilities in project management. Those talents are crucial. The successful completion of a project depends on efficient project management. If we do not have it, we will be left with disorganized management, unclear goals, and high-adjust projects that will be delivered late, over budget, and outside the scope of their original intent. Efficiency in the use of resources is one of the primary considerations. Utilizing the finite resources of the Earth in a way that is both sustainable and reduces negative effects on the surrounding ecosystem is what we mean when we talk about resource efficiency. It enables us to produce more with less resources and to give more value with the same amount of effort. It is a proven truth that a green building achieves the greatest level of success in terms of resource efficiency when the principles behind it are incorporated and put into practice during the design process, which is when the selection of materials, products, and systems takes place. It is possible to optimize function while also optimizing the use of natural resources by developing designs that are resource efficient and employing materials that are resource efficient. Using materials in which more than fifty percent more of the log is turned into structural timber than is the case with standard dimensional lumber is one way in which engineered wood products may assist in the process of optimizing the use of resources. The benefits of such items, however, have to be weighed against the quantity of energy that is used in the production process, and our decision must be based on this comparison. The elimination of waste on construction sites is one of the primary objectives of resource-efficient building practices. There will invariably be some materials left over when the construction process is complete. Maintaining compliance with a waste management strategy for construction helps cut down on the amount of garbage sent to landfills. This may be accomplished by making use of the recycling facilities that are accessible as well as the markets that are looking for recyclable products. This would assist reduce the trash generated during building by at least two thirds, which might result in financial savings for the construction industry as well as less pressure on available landfill space. The tables 3.1 and 3.2 provide a concise summary of the many types of materials that are utilized in the building industry.

Table 3.1: The Used Materials in Building Construction and Their Products [42,43,44,45]

	Wall Materials	Applications
1	Fired Bricks (including clay bricks, fly ash bricks, shale bricks, and coal gangue bricks)	Walls, bases, columns, brick arches, etc..
2	Fired Hollow Bricks and Blocks	Non-load bearing walls, and insulating walls
3	Aerated Concrete Blocks	Walls of buildings and Insulation
4	Aerated Concrete Boards (exterior wallboards, or partitions)	Outer walls and partition walls
5	Foam Concrete Blocks	The same with aerated concrete
6	Common small sized concrete hollow blocks	The inner walls and load-bearing walls
7	Small-sized lightweight aggregate concrete hollow blocks	The insulating walls (<3.5 MPa)
8	Lightweight concrete wall boards	The wallboards
9	Lightweight	Self-supporting outer walls, partitions, insulating walls
10	Concrete sandwich boards	Load bearing outer walls or non-load bearing outer walls
11	Paper Gypsum boards, fiber gypsum boards, hollow gypsum boards and decorative boards	Inner partition walls, or the boards inside composite walls
12	Glass fiber reinforced cement boards (GRC Boards)	Inner partition walls
13	Natural stone	Random rubble walls
14	Solid concrete blocks	Load bearing walls
15	Dressed stone	Ashlar masonry walls
16	Glass Block	Insulation, cladding, glazing, and even as a structural component.

Table 3.2: Natural Building Materials for Sustainable Construction

	material	details
1	Adobe	Adobe is made up of dirt mixed with water, and sometimes other fibers as well, to add additional strength.
2	Straw Bale	Straw is a renewable resource with excellent insulation properties that has the added benefit of being fire-resistant.
3	Cob	Cob structures are made with clay or sand, local earth, and added fibers like straw.
4	Wood	Wood continues to be one of the most commonly used building materials.
5	Cord wood	Using cord wood is resource-efficient because this type of wood may not have any other value.
6	Bamboo	This includes a concrete replacement for rebars and as pins for straw bale building
7	Masonry	Brick and stone are used for foundations, floors, walls, walkways, and landscaping.
8	Earth Bags	These are also referred to as sandbags. Long used by the military, they provide a strong protective barrier, especially against flooding.
9	Earth	Earth is used to construct different types of homes.
10	Reclaimed Materials	These helps reduce building waste. Modern-day construction causes massive amounts of waste during the building process.

3.2 BIM MODEL

In the field of construction design, the Building Information Model, or BIM, is considered as an alternative method for designing that makes it simple to provide digital drawings that include all of the relevant information about a proposed project before it is built. BIM is an innovative design tool that has brought about many changes in the construction industry, particularly in regards to the procurement of projects, the execution of projects, and the administration of facilities. This demonstrates that BIM has the potential to become the standard in the construction sector in the future. As a result of the BIM's suitability as a tool for the administration of construction projects, project managers are strongly encouraged to make use of the software while managing their respective projects. The use of BIM helps decrease risks, which ultimately leads to the successful completion of projects. This has been demonstrated to be the most significant advantage gained by utilizing BIM thus far. It is essential to keep in mind that BIM may be utilized throughout the entirety of a project, from the planning stage all the way through operation and maintenance. Because of its adaptability, high level of precision, and lightning-fast performance, Revit is one of the most well-known software for its comprehensiveness in virtually all areas of engineering. Revit is software that is used for Building Information Modeling (BIM). The process of storing all of the facts, information, and analysis may be made more manageable by developing information modeling. The outputs of the project as well as the structure at ground level will be utilized in the creation of a realistic image. For more details to be included in the translation, further information about the source content is necessary. There are panels on the side of the structure. The fundamentals of controlling the duration of the project and its associated costs, as well as any current approaches, were analyzed, and recommendations were provided. It has been acknowledged that the present difficulties, which result in extended AEC manufacturing times and increased costs. After that, for an actual project, a neighborhood designer and a construction management company were brought on board to collaborate with a BIM model. Both the strategy and the model were scrutinized in this study. An information analysis that was developed using 3D models to illustrate how this new method of project delivery may aid raise a project's period of time and price management has been constructed. The most significant problems associated with BIM, in addition to the answers to these problems, have been identified. In the latter part of the presentation, the benefits of finishing the project using BIM were discussed. In general, certain suggestions have been made regarding the usage of BIM in the future. The most significant obstacles to the implementation of BIM were also explored. These are the steps that need to be taken in order to use the Revit program.

Step 1: Draw the wall lines of the building

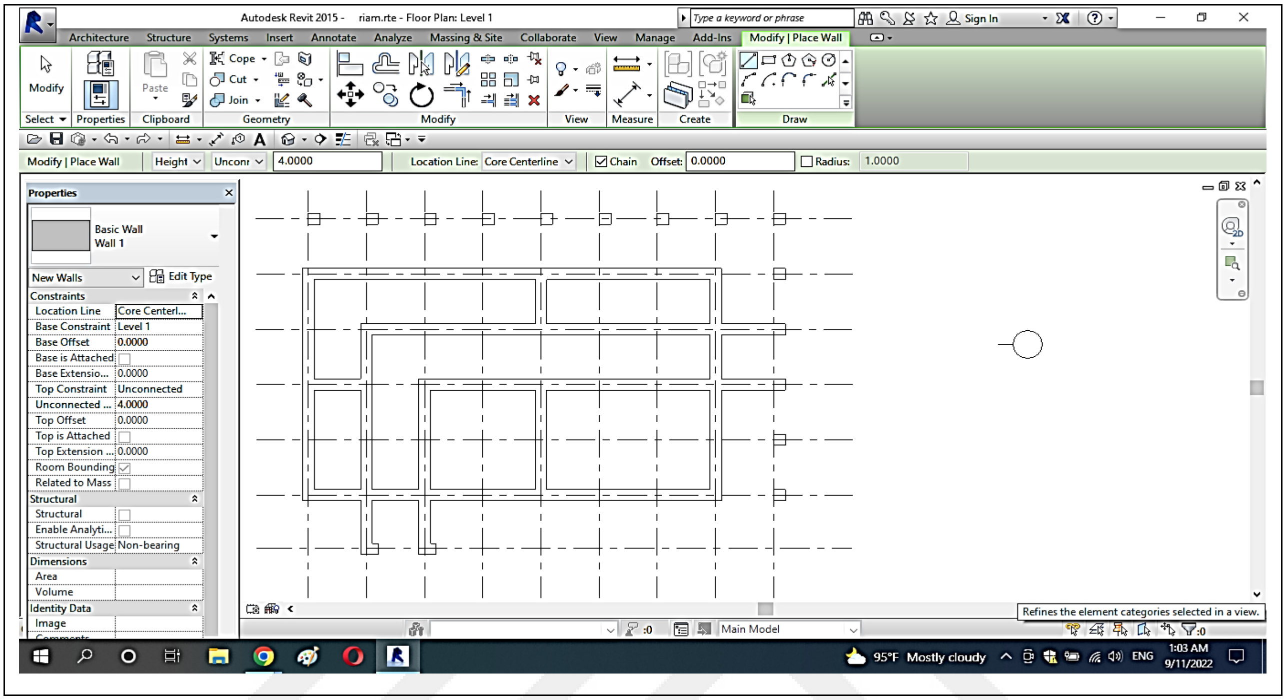

Figure 3.2: The Grids and Wall Lines of The Building

Step 2: Draw the doors and windows

We can choose anything that is suitable for the layer on the page for the material by selecting it from the list of ready-made materials or by creating a new material. Go to the Section List Building) Sections (then to 1 Section and choose it, then we will see a picture of a section from them to see the layers of the type intended for the external wall, then go to the Section List Building) Sections (then to 1 Section and choose it, then we will see a picture of a section from them to see the layers of the type intended for the external wall, then choose and determine a line separating the wall so that we can see them inside in an interior sector

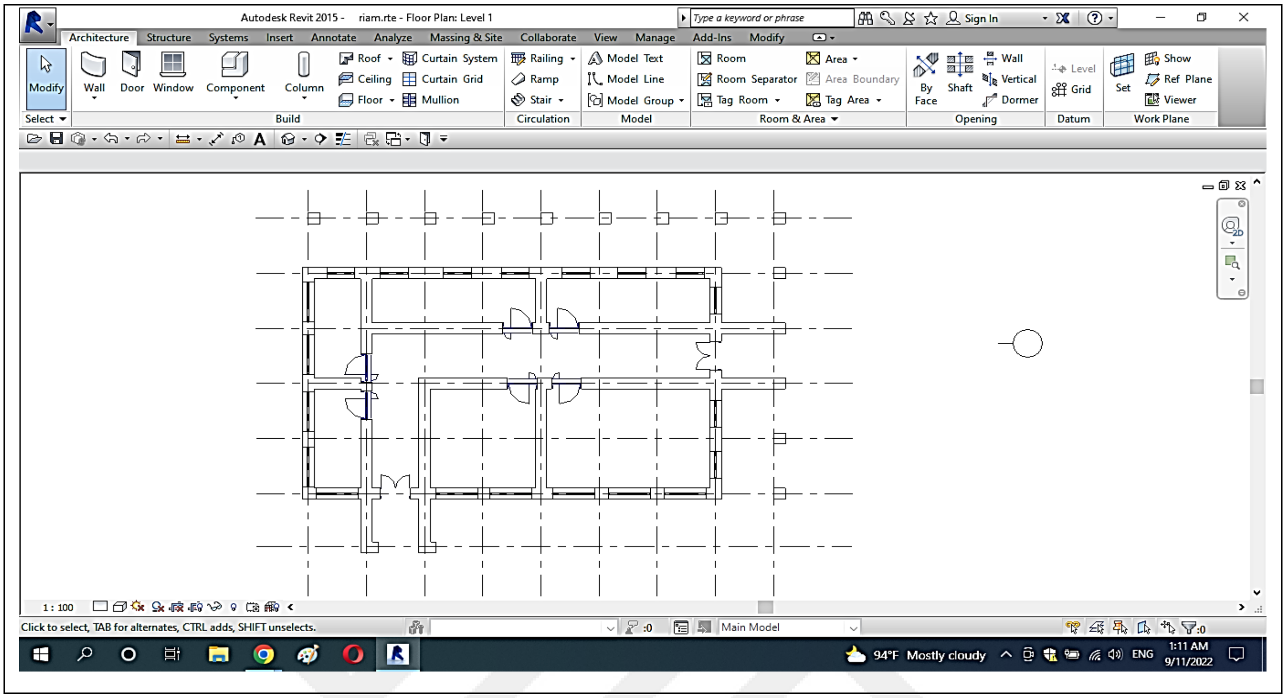

Figure 3.3: The Doors and Windows Drawing

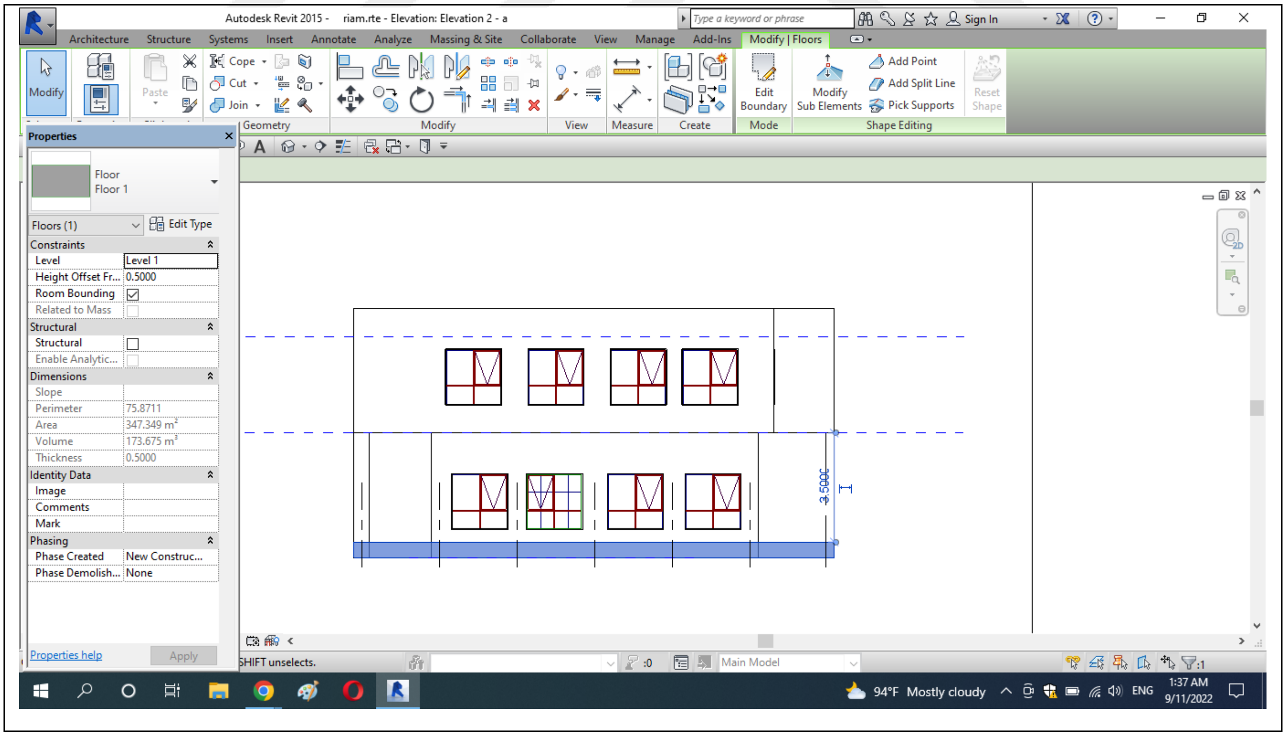

Figure 3.4: Specify The Building Levels

Step 3: Extend the walls height

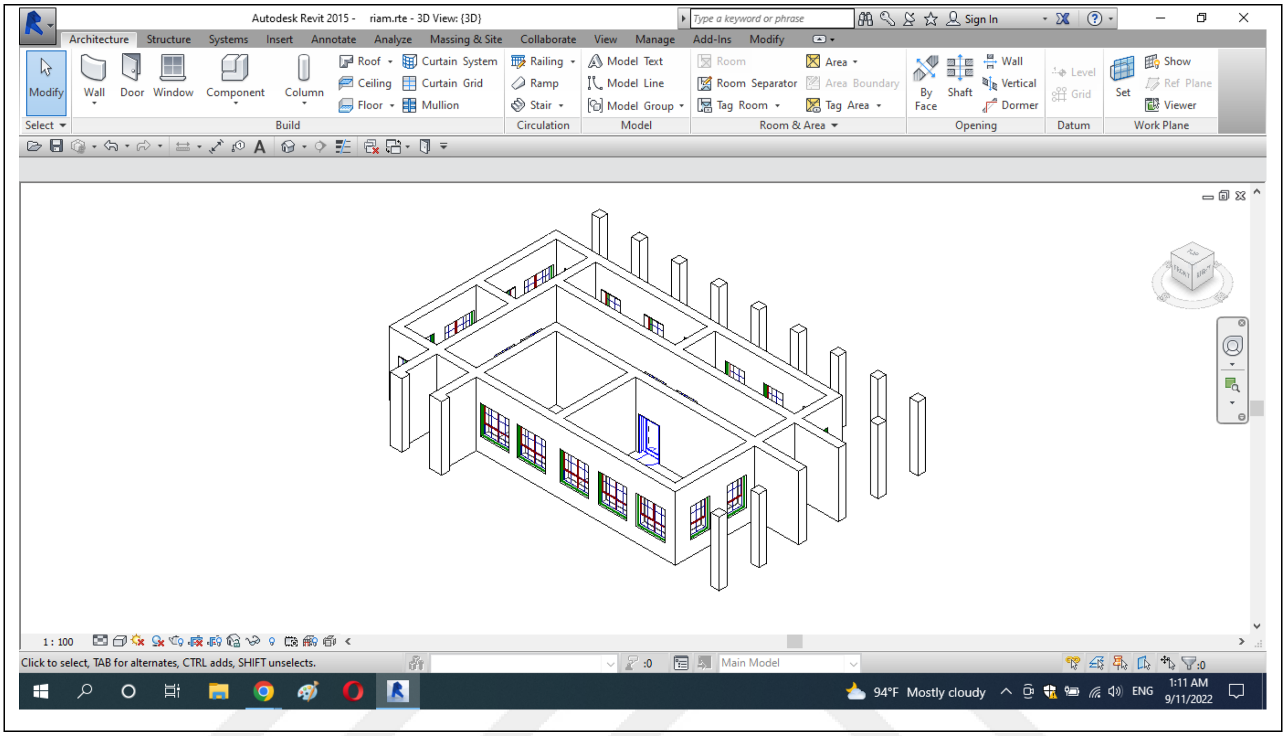

Figure 3.5: Specify The Walls Height of The Building

Step 4: Insert The Floor

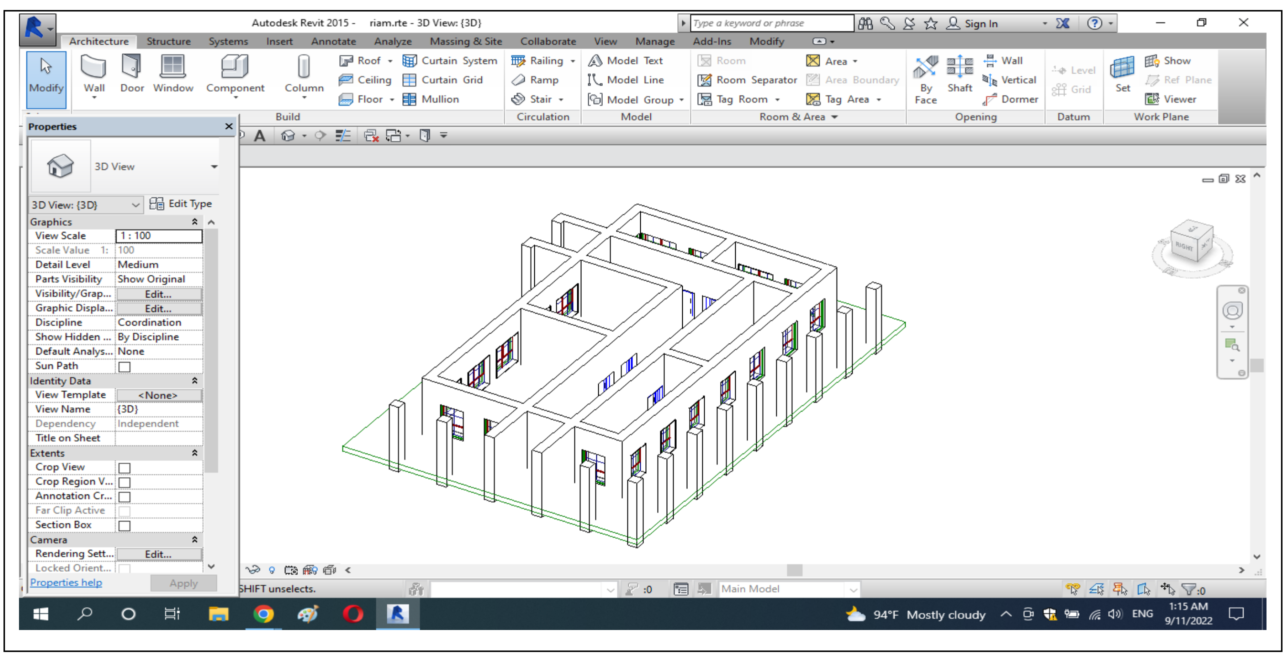

Figure 3.6: Draw Floor Under The Walls

Step 5 Draw the second floor

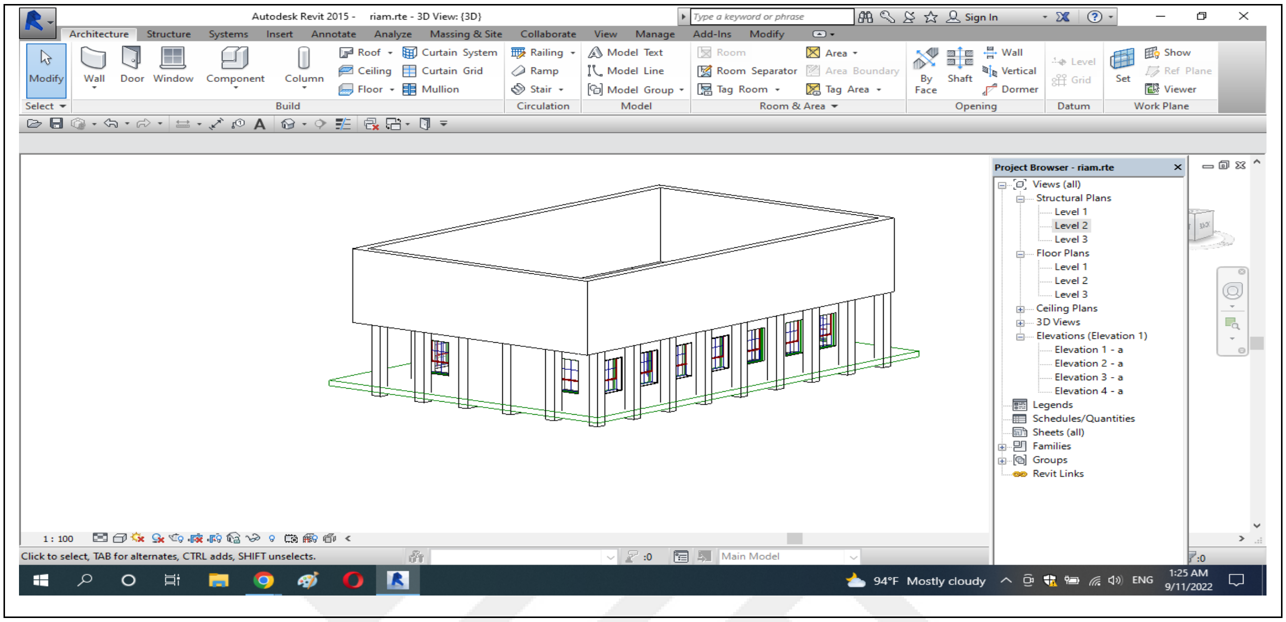

Figure 3.7: Draw The Second Floor Over The Walls

Step 6: apply the windows and doors in the second floor.

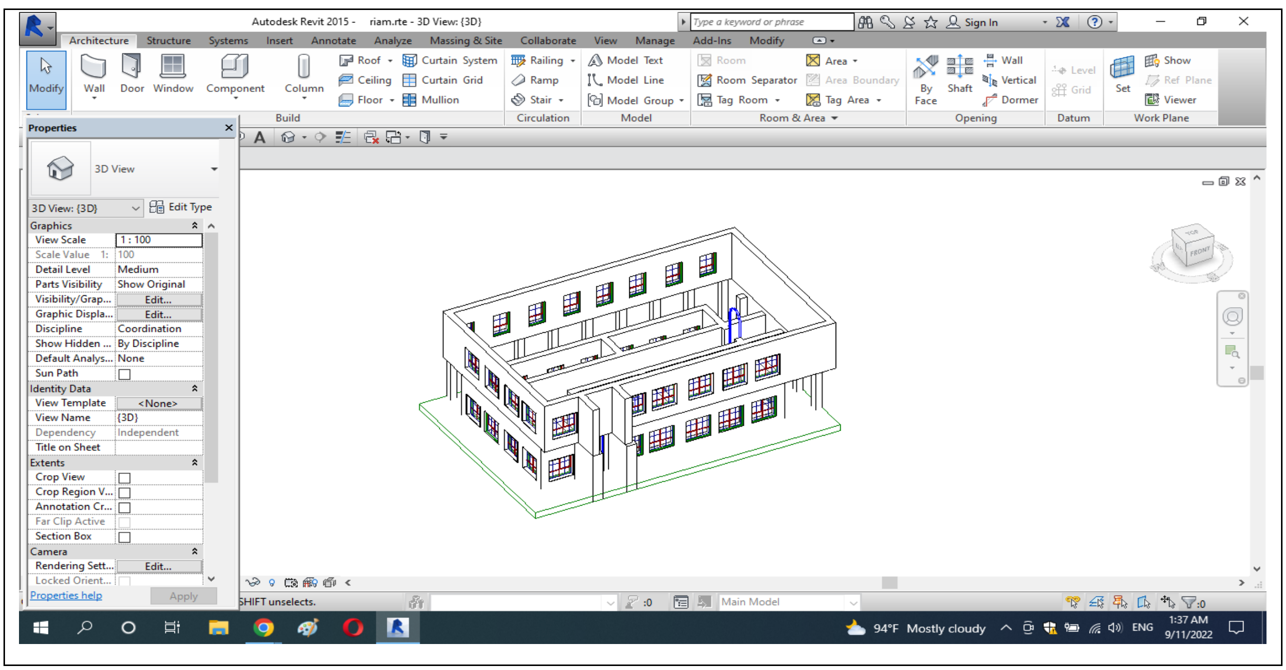

Figure 3.8: Draw The Second Floor Windows

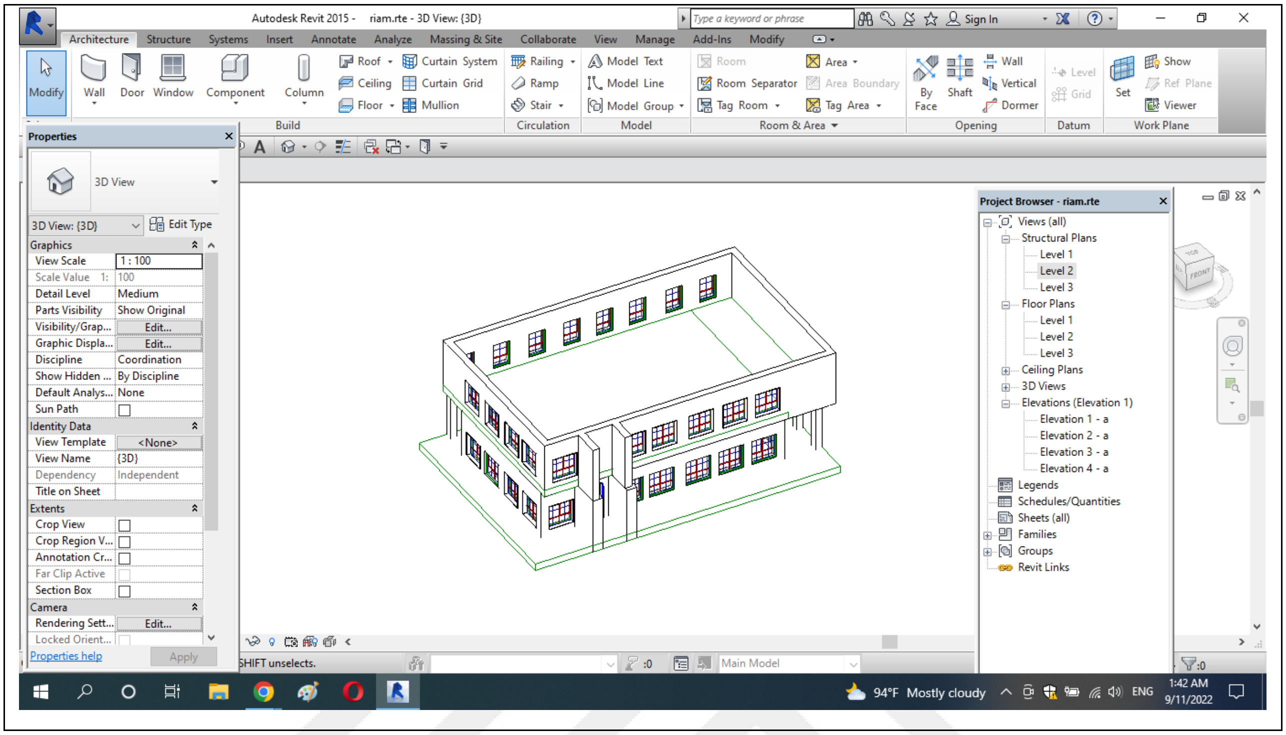

Figure 3.9: The Second Floor Revit Drawing

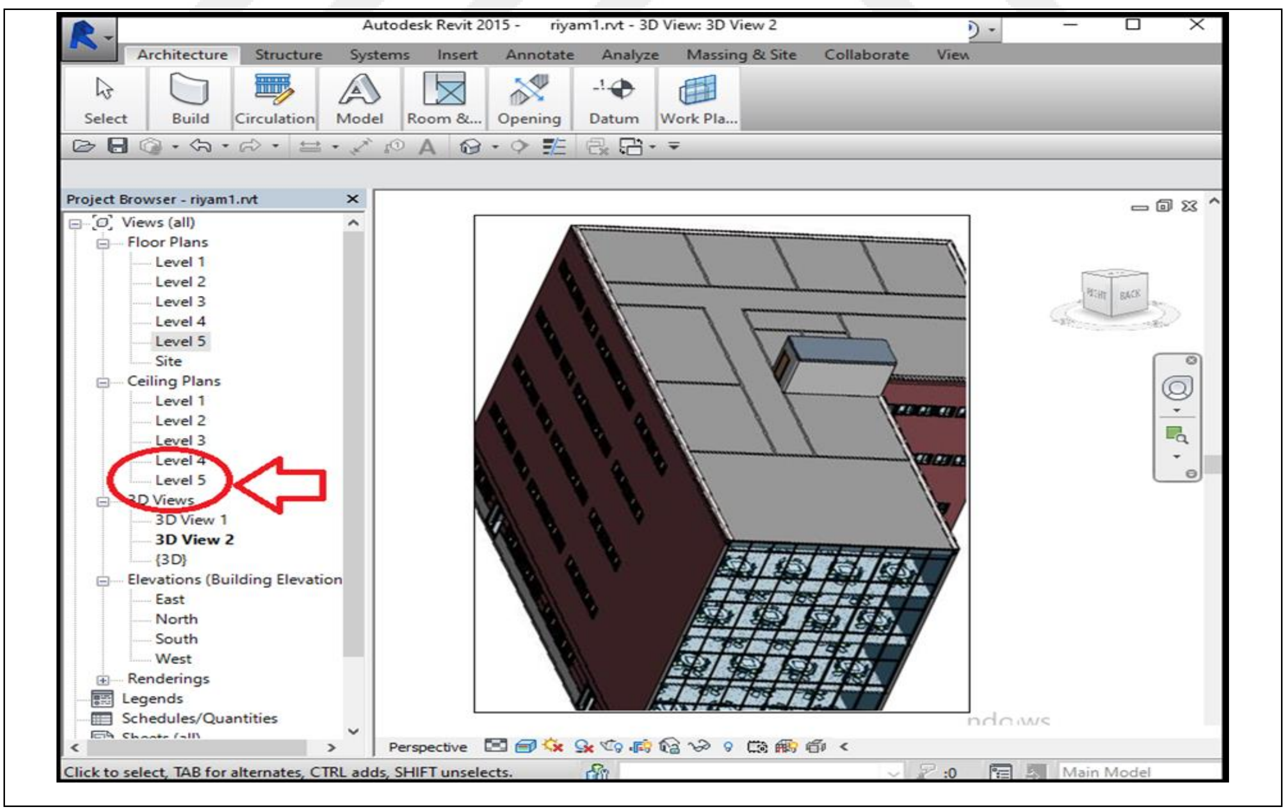

Figure 3.10: The Second Case Building Results

Drawing the floors and assigning the appropriate types of layers to them is the fifth step. The method for assigning floors is analogous to the method for assigning walls; it is based on the kind of architectural flooring, but it must take into consideration a crucial element as well. Characteristics As a consequence of this, if you wish to paint the floor of the first level, you must first create a type that has the same name, and then apply that type whenever it is required. Note: We will apply this method again in the subsequent few topics of this chapter. Although the specifics of the task will change, we will continue to utilize the same basic idea of drawing floors and how to allocate them in each of these examples. The repetition in this instance will, of course, be applicable to several works, including stairwells and designating a floor for gardening.

When establishing the layers with all of their measurements, you are required to supply the materials, as well as their types and colors. After selecting the layer from the list of materials in the column on the left, we click the button in the top-right corner of the box to proceed to the material page. After applying the icon for the Stair command, choosing a kind, shape, or the form of the letters L or U, you may finally make the staircase. In the event that two points are discovered, both of them have to be taken into account when determining the points. We will begin at the highest position and work our way down to the lowest point, which will be painted by the computer automatically. Creating floors in the same way that was mentioned earlier, but basing them only on the size of the steps, is still another approach for creating a staircase. Then, repeat the job on the floors in accordance with the number of staircases that have the proper one, and it will be constructed and drawn automatically, leaving just the ceiling to be removed in order for the stairs to be able to pass through.

Step 7: Tables and bills of quantities:

It is possible to establish limits, quantities, and expenditures by clicking the QUANTITIES / SCHEDULES button while investigating the project. This button is accessible by selecting the QUANTITIES / SCHEDULES option from the menu that appears. This feature allows us to designate the table type, such as whether it is for doors, windows, columns, or plinths, and it also schedules new quantities.

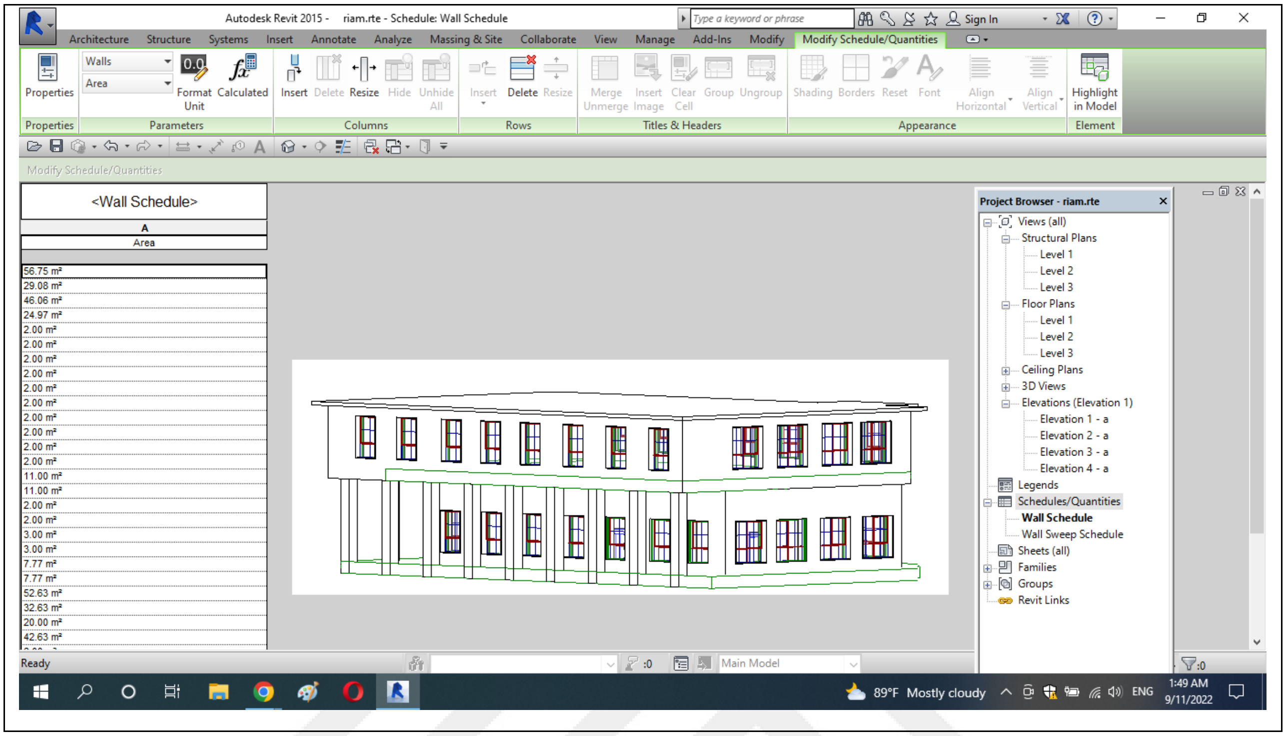

Figure 3.11: Bills of Quantities in BIM- Rivet Drawing Result

3.3 MULTI-CRITERIA DECISION-MAKING FOR MATERIALS SELECTION

The majority of decisions that need to be made in real life involve balancing many criteria and objectives, some of which are in direct opposition to one another. For instance, one must make concessions in order to find a balance between the performance and expense of a motor vehicle, or between the enjoyment of eating rich meals and one's overall health and well-being. When choosing materials, you may encounter the same kinds of conflicts between the qualities of the materials and performance measurements. The selection of materials is unquestionably one of the most important aspects of the numerous domains in which MCDM was implemented (other domains included the selection of computer software, projects, and systems, respectively). The process of finding materials that are acceptable for use in an engineering design is an essential step, and it is a multi-dimensional challenge that requires several "boxes" to be checked at the same time. Changing the materials that are used in a technology that has already been established is an unusual occurrence that might be termed a revolution. In addition, selecting materials is the initial step in resolving a number of engineering selection difficulties, such as selecting processes, machines, tools, material handling equipment, suppliers, and employees.

Traditionally, "trial-and-error" procedures and/or relying on prior experience have been used to choose a new material or replace an old material whose properties enable greater performance. A new material may be selected in this manner, as can an existing one. The usage of MCDM methods will assist to keep costs down by preventing the use of inappropriate materials. This may or may not lead to the adoption of an optimum design solution, but it will assist to keep costs down.

In the process of selecting materials, MCDM addresses the necessity of having a numerically structured plan. The MCDM serves as a basis for choosing, classifying, and ranking items, as well as providing assistance with the overall evaluation. It is also vital to make use of MCDM if the application being used is either complicated or advanced, as well as whenever the materials and/or program being used are new.

Applications in the fields of aerospace, electronics, nuclear power, and biomedicine, among others, make use of cutting-edge technology. In these fields, product differentiation and competitive advantage may frequently be achieved with just modest improvements in material performance.

Design engineers have yet to embrace the decision theory formalisms, despite the theory's long history and broad adoption in other fields of study. Reason for this is because engineers dispute on how much decision-making is involved in engineering design and how much of a role tradition theory of decision-making plays for engineers. As a result of this, several procedures that are widely used in engineering design give outcomes that are blatantly problematic.

Decisions regarding the choice and substitution of materials necessitate the simultaneous consideration of competing advantages and limitations, which in turn necessitates compromises and trade-offs, in contrast to the exact sciences, where there is typically only one correct answer to a problem. As a result, a variety of satisfactory solutions are possible. Imagine that you are entrusted with choosing a material from the fictitious possibilities in order to produce a lightweight design that is both practical and affordable. Should we go with the material that is the lightest or the one that is the cheapest?

Solutions that lie along the line are not considered dominated, however solutions that are inside the line are considered dominated. This is due to the fact that there is always another solution along the line that is superior to the dominated solution in at least one respect. The line in question is known as the "Pareto-front," and the solutions that lie along it are referred to be "Pareto-optimal." All Pareto-optimal solutions are no dominated. As a result, it is essential to identify solutions that are as near to the Pareto front as feasible, and that are as far along it as possible. This is a more difficult task in MOO issues that involve limitations and have a wide variety of solutions that fall inside the feasible range. Converting all of the criteria except for one into constraints during the modeling phase is one way to find points on the Pareto front. Alternatively, one could invent weightings for the criteria and optimize the weighted sum, but this would simplify the consideration and result in the loss of information. When it comes to solving MADM and MODM difficulties, multiple approaches are typically taken in practice. A genetic algorithm may be used in MOO as one approach to enumerate points along the Pareto-front over the course of numerous iterations. After this, another method can be used to rank the quality of the trade-offs based on the specific application that is being modeled. In order to solve MOO difficulties, you need to correctly formulate the problem in the first place. In the majority of actual optimization issues, there is some degree of imprecision and ambiguity, and a precise definition of the issue can often only be provided once the issue has been resolved.

Since 2006, it has been discovered that there has been advancement in the study of material evaluation and selection challenges using MCDM approaches. A more detailed approach is needed when choosing materials since there are typically several options for a given application and because materials influence many elements of product design, such as shape, manufacturing method, and performance. Over the next years, it is projected that this tendency will continue to grow. A cost-based approach can be used if one uses the "Ashby" materials selection chart technique, which is described in Chapter 3. The approach also offers the adaptability of being able to study a variety of materials in a single glance and enabling competing materials to be rapidly detected. Both of these benefits contribute to the method's overall versatility. Due to the fact that it is only possible to examine two or three criteria at the same time, as was covered in the part before this one, it is impossible to state with certainty that the material that was chosen is the best option.

3.4 STEPS IN MCDM METHODOLOGY MCDM

consist of a number of interconnected stages, each of which is performed in sequential order. In this article, we have made an effort to offer a general model of MCDM by illustrating the fundamental idea behind the methodology through the use of a sequential set of phases. It is a form of decision support system that can provide assistance in advancing along a strategic route in order to arrive at the best possible option at the end. The Generic MCDM Model, which is a flow graph displaying the processes that are fundamentally included in all of the MCDM solutions, is presented below, followed by the comprehensive elaboration of each of those phases in turn.

The first step is to identify the problem area and define it. During the process of issue definition, the characteristics of the decision-making problem that is being considered are taken into account. These qualities include, but are not limited to, the number of possibilities, attributes, and restrictions. The information that is now accessible on the decision-making problem will serve as the foundation for selecting the multi-criteria decision-making procedures that are most appropriate and will be used to address the problem. The second step is to elicit the criteria. It is essential to make an accurate identification of the evaluation criteria that are appropriate to the MCDM method selection process since these factors have a significant impact on the final decision.

Step 3: Evaluate the different options. If there is another option that is superior to it in one or more aspects while being on par with it in the others, then that alternative is considered to be dominated. The dominant approach, which does not call for any assumptions to be made or any attribute transformations to be performed, is able to eradicate the procedures of the dominated MCDM. The following steps are required to complete the Sieve of Dominance: Compare the first two options, and if one of them is dominated by the other, get rid of the dominated option; then compare the option that was left standing with the third option, and get rid of any options that were dominated; finally, introduce the fourth option, and continue this process until the last option has been compared. It's possible for a group of non-dominated alternatives to have attribute values that are unsatisfactory or impossible to achieve. To get rid of the options that cannot be used, the conjunctive technique is utilized, in which the DM determines the minimum and maximum values for each of the characteristics that are acceptable to him or her. Any alternative that has a value for the criterion attribute that is lower than the cut off values will be discarde. The DM will provide cut off values, which will serve as the primary factor in determining which options remain. MCDM techniques that are capable of doing feasibility evaluations continue to be candidates for further selection since they have this ability.

Defining the preferences on the evaluation criteria is the fourth step. In most cases, once the initial screening process has been finished, it is assumed that numerous MCDM approaches will remain; otherwise, we may immediately pick the only one that is still available to handle the problem of decision making. This step ensures that the criteria are prioritized in the correct order. It will assist us in determining the criteria that have the highest importance and, as a result, will have the most significant influence on the decision that is ultimately made, and vice versa.

Step 5: Select the MCDM procedure to use for Selection In this stage of the process, one of the MCDM approaches will be chosen from the pool of current methods that are often put to use. Because of its ease of use and broad application across a variety of contexts, the WSM has been selected as the most appropriate MCDM technique. In a similar vein, we may choose to employ more sophisticated strategies when confronted with difficult challenges. It is vital to carefully consider both the benefits and drawbacks of the strategy before making a decision. Evaluation of the MCDM approach is the sixth step. The appropriateness function (AF) that was introduced by Li in 2007 is the mathematical formulation that is utilized in the ranking of the various MCDM techniques. The approach that yields the highest AF, as determined by equation (*I*) which is suggested as a solution method to present the optimum results.

$$AF = \sum w_i I_i \qquad \text{.......... eq. 3.1}$$

where, $I_i = \{b_1, b_2 ......b_n\}$, $b_i = 1, \quad c_{ji} = a_i \quad or \quad b_i = 0, \quad c_{ji} \neq a_i$ and

$$I = 1,2\ldots\ldots n\,;\; j = 1,2\ldots\ldots m$$

where (*I)* is the number of evaluation criteria that are used to examine the decision making methods in relation to the given problem, *W (W1,W2,W3*) is the weighting vector on the evaluation criteria, bi is the value of the th I characteristic of the decision problem, and Cij is the value of the th I characteristic of the th j method, where I is the number of evaluation criteria that are used to examine the decision making methods in relation to the given problem, and the

MCDM approach with the highest AF will be chosen as the way that is going to be used to find the best solution to the decision making issue that has been presented. Apply the Selected Methodology to the Problem as the Seventh Step at this stage, all of the mathematical computations that are specific to each methodology's application are brought together and included. We have covered the calculations of WSM, AHP, and TOPSIS in this particular piece of work. Step 8: Results and an analysis of those results The last step is essentially the consequence of all of the stages that came before it, particularly the step that came immediately before it. In this study, we compared and contrasted the effectiveness of three distinct approaches. It is recommended that a sensitivity analysis be carried out on the algorithm for the selection of the MCDM method in order to evaluate the algorithm's resistance to changes in its parameters, such as shifts in the DM's preferences and the data that are fed into it.

4. RESULTS AND DISCUSSION

The overall cost of a project is calculated based on the sum of its estimated construction costs and its actual construction expenses. In the present study, an attempt was made to address the issue of determining which type of construction material is most suited for use in building projects. When it comes to building projects, one of the most difficult obstacles to overcome is the collusion that occurs between the many components that determine the cost condition. The cost factors for this project have been selected according to the criteria outlined in tables 4.1 and 4.2, which rate the efficiency of each cost component. These elements were implemented in a real-world scenario within the framework of the building industry in Iraq. The chosen case study investigates the relative cost-effectiveness of ten different kinds of materials. The primary objective of this study is to identify the kinds of materials that may be chosen depending on the parameters that are considered to be ideal. The materials have been divided into two distinct categories: the materials that have historically been utilized, and the materials that have increased qualities. The current thesis makes use of Revit software to create a case study, calculate the cost performance value for construction projects, and specify the wall cost based on the different materials available. This is done with the intention of placing a high priority on cost performance based on the adaptive concept. the adaptable notion that was employed throughout this thesis, most notably in the material selection as well as the alternate materials that were offered. The researcher estimated the key effective factors for each group by using the Multiple Criteria Decision Making (MCDM) technique included inside the MATLAB program. This was done based on the classification of the groups. Real-world case studies allowed for the discovery and evaluation of effective materials, which were then associated with the BIM methodology.

4.1 SPECIFY MATERIAL VARIABLES

Materials that can be produced in adequate numbers without using up non-renewable resources, harming the environment, or disrupting the steady-state equilibrium of vital natural resource systems are known as sustainable materials. They are used across our consumer and industrial sectors. To put it another way, sustainable materials are good for the environment. For example, foam concrete (FC), which consists of high-volume cement and supplementary cementitious material (SCM), has seen widespread application in the field of building engineering due to the fact that it has a low density and a good thermal insulation performance, both of which are considered to be sustainable. Brick, stone, concrete, and clay blocks, as well as cast-in-place concrete, rammed earth, and earth-filled constructions have all been used in the construction of walls. These materials are considered to be environmentally friendly. Walls in contemporary homes can be constructed from any number of different sorts of materials. But certain ones are more popular than others when it comes to bringing a one-of-a-kind beauty to the outside and interior walls of homes. Walls have to be aesthetically pleasing in addition to being robust and long-lasting in order to be considered successful. There is a wide variety of wall material that is designed specifically for this application. Concrete is, by far and away, the most prevalent material for usage in wall construction. It is hardy, long-lasting, and has a remarkable resistance to both the wind and the flames.

Table 4.1: The Influence Material Properties Used in this Research

No.	Wall Materials	Properties
M1	Fired Bricks (including clay bricks, fly ash bricks, shale bricks, and coal gangue bricks)	Compressive strength: 10-30 MPa; thermal conductivity: 0.78W/(m*K);
M2	Hollow Bricks	Compressive strength: 7.0-15.0 MPa; thermal conductivity: 0.78W/(m*K);
M3	Aerated Concrete Blocks	compressive strength 2.2-3.0 MPa; thermal conductivity: 0.16 W/(m.K);
M4	Concrete sandwich boards	Compressive strength: 3-5 MPa; Thermal conductivity: 1.01 W/(m^2*K)
M5	Foam Concrete Blocks	compressive strength 2-3.0 MPa; thermal conductivity is 0.12 W/(m*K)
M6	Common small sized concrete hollow blocks	Compressive strength: 3.5 to 15 MPa; Thermal conductivity: 0.26 W/(m*K)
M7	Solid concrete blocks	Compressive strength: 7.5 to 12.5 MPa Thermal conductivity: 1.23 W / (m^2. K);
M8	Lightweight concrete wall boards	Compressive strength: 10-20 MPa; thermal conductivity: 0.35 – 0.5 W/(m*K)
M9	Natural stone	Compressive strength: 19-139 MPa; Thermal conductivity: 1.26-1.33 W/(m*K)
M10	Clime sand brick	Compressive strength: 6.0-14.0 MPa; thermal conductivity: 0.17W/(m*K);

Sculptural designs on the structure might be made out of precast concrete, which is manufactured away from the actual construction site. In areas of the country that are prone to hurricanes, outside walls can be constructed using concrete. Because the outside walls will be preserved, the home will be able to recover from the disaster much more quickly; the only thing that will need to be replaced is the roof. Additionally, utilizing concrete as a construction material is a functional strategy in the context of building in an area with a lot of noise since concrete is very good at absorbing sound. A natural appearance may also be achieved by employing genuine stone or stone veneer in the construction of buildings in some nations. The outcome is really amazing. Stone is an appropriate building material for use in environments with severe climates since it offers insulation. Because it does not retain stains over time, it is very simple to clean. Therefore, only water and detergent are required for an effective cleaning. Although it is as robust as brick and metal, the price tag is much higher. Installing and repairing surfaces made of natural stones is an expensive endeavour. So, it is important to have it fixed properly. Stone veneer may not be as long-lasting as actual stone, but its lower cost is one reason why many people opt to use it instead of natural stone. Brick is the most common building material for use in the construction of walls in Iraq. This insulation material is effective, not to mention economical and simple to work with. the table below present the features of selected materials for this study

4.2 COLLECTING DATA

With the ultimate purpose and goal of attaining a consensus, the Delphi Strategy is a crucial project management strategy that describes a way of information gathering in which the opinions of individuals whose opinions are most valuable—typically industry experts—are sought. The Italian mathematician and scientist Andreas Delphi created the Delphi Technique in the 16th century. In order to acquire comments that are unhindered by phobias or identifiability, surveys of these specialists in the construction sector are often conducted on an anonymous basis. A series of questions relating to the project are posed to the experts. These questions are often posed to the expert by a third-party facilitator, however this is not always the case. The purpose of this is to elicit fresh ideas pertaining to particular aspects of the project. In most cases, the replies from all of the experts are compiled in the form of an overall summary, which is then given to the experts for evaluation, along with the chance to offer further comments on the topic.

This approach often ends in consensus within a number of rounds, and this technique typically helps limit prejudice, as well as minimizes the potential that any one individual may have an excessive amount of effect on the outcomes. This strategy was previously utilized in project management to fulfil the adaptable idea. The goal of adaptive project management is to respond rapidly and effectively to the requirements and realities of the project. It is necessary to plan, schedule, as well as define significant milestones and dependencies while using this technique. However, this strategy provides a great lot of flexibility along the path to the end goal, making it easy to adjust to changing needs as they appear. In order to do this, the Delphi method was utilized to evaluate instruments employed in the production of new ideas and to choose the direction that the study would go in the future. For the purpose of determining the extent of consensus and mediating differences of opinion about a subject, the approach uses the assistance of a panel of knowledgeable individuals. The experts take into consideration the criteria that are laid forth in Table 4.1. The most important question that needed to be answered was whether or not these metrics were sufficient for calculating the cost of projects based on the various kinds of materials. The impact of a wide variety of characteristics was observed, as can be shown in table 4.2. The weight of preference to the costumer classified based on the importance of the material to the costumer. The performance ranked as one represents the higher performance material, two is lowest reached to rank five which represent the lowest perforation of material to the costumer. Many materials required for this study came from the many different projects that have been handed in to their office over the course of the last decade. The preparation and utilization of a data sheet was done in order to collect all of the required information from each project. The vast bulk of Iraq's construction engineering was scrutinized throughout this investigation. The compilation of projects was submitted by engineering companies and government entities that are involved in construction projects.

Table 4.2: The Delphi Method Results

No.	Wall Materials	Weight of preference to the costumer	Used features
M1	Fired Bricks (including clay bricks, fly ash bricks, shale bricks, and coal gangue bricks)	1	1.External walls 2.Internal walls 3.roofs
M2	Hollow Bricks	5	1.External walls 2.Internal walls 3.roofs
M3	Aerated Concrete Blocks	4	1.Internal walls
M4	Concrete sandwich boards	3	1.Internal walls
M5	Foam Concrete Blocks	5	1.External cover walls
M6	Common small sized concrete hollow blocks	2	1.External walls 2.Internal walls
M7	Solid concrete blocks	4	1.External walls 2.Internal walls
M8	Lightweight concrete wall boards	4	1.External walls 2.Internal walls
M9	Natural stone	1	1.External walls
M10	Clime sand brick	4	1.External walls 2.Internal walls
Note: 1: very effective material, 2: effective material. 3: used material with 4: used material with some provisions, 5: used material with high provisions			

The construction design and the estimates of the various material cost possibilities can give a baseline reference for later project monitoring and management, which is necessary for cost control on a project. The criteria that are used to evaluate and ensure that the appropriate level of construction quality is met are provided by the contract and work requirements. The final or comprehensive cost estimate serves as a benchmark for the evaluation of the project's progress in terms of its financial health throughout its duration. If the final costs of the project come in at or below the specific estimate of those costs, then it may be said that the finances of the project are under control. The occurrence of overruns in certain cost categories not only indicates the existence of potential issues but also provides details on the nature of the issues that are currently being faced. Construction planning and control that is expense-oriented places an emphasis on the many categories that are factored into the overall cost projection. This approach is especially useful for projects that include relatively few actions and a significant amount of repetition, such as the grading and paving of highways. The conventional cost estimate is often translated to a project budget for the objectives of controlling and monitoring the entire cost. For instance, in Iraq, the traditional wall material is brick. In order to do this, the management team uses the project budget that was created based on the information that was gathered. The other components of the comprehensive cost estimate will be included in the price of the job. Project-related expenses are recorded in specific work cost accounts so that they may be contrasted with the original cost estimates that were given for each category. As a result, the core of a cost management system is often individual work cost accounts. As an alternative, task cost accounts may be broken down or divided into work pieces that are connected to certain planned activities and cost accounts. This would be a third way to approach the problem. In most cases, the budget for the project will include, in addition to the monetary amounts associated with costs, information on the material quantities inputs associated with each work account. With this information, it will be possible to compare the actual materials utilized to the needs that were anticipated. As a consequence of this, differences in the costs of certain products may be attributed to shifts in either the unit pricing or the amounts of material that are utilized.

Table 4.3: Results of Delphi Survey to Specify the Cost of Materials and the life span of each material

No.	Wall Materials	Working Life/year	Cost USD
M1	Fired Bricks (including clay bricks, fly ash bricks, shale bricks, and coal gangue bricks)	45	100
M2	Hollow Bricks	50	80
M3	Aerated Concrete Blocks	40	70
M4	Concrete sandwich boards	28	95
M5	Foam Concrete Blocks	27	110
M6	Common small sized concrete hollow blocks	55	85
M7	Solid concrete blocks	46	72
M8	Lightweight concrete wall boards	38	95
M9	Natural stone (Marble)	55	87
M10	Lime sand brick (it is a product that uses lime instead of cement).	45	77

4.3 BUILDING DECISION MATRIX

The researcher applies the Multiple Criteria Decision Making (MCDM) approach to evaluate the materials after first providing the material details. The process of making judgments using several criteria in conjunction with a structured approach to problem-solving is referred to as multi-criteria decision making (MCDM). The primary purpose of this stage is to determine which of the several potential solutions to the cost issue is the best option for the material that will be used to back up the decisions that will be made. When there is not one single solution that is ideal for these difficulties, it is often essential to employ the decision maker's desire to discriminate between the various possible options. This is the case with adaptive management programs. Finding a solution to the problem might be construed in a variety of different ways. It might equate to selecting the "best" alternative material from among a group of alternatives (where "best" can be understood as "the most favoured option" of a decision maker). The choice matrix, which consists of four essential components, was described in Tables 4.3 and 4.4:

a) Alternatives (the materials) to be ranked or chosen from

b) Criteria by which the alternatives are evaluated and compared

c) Weights representing the relative importance of the criteria

d) Decision-makers and potentially others, whose preferences are to be represented

Table 4.4: The Decision Matrix for Traditional Used Materials

No.	Cost $	Weight of preference to the costumer	Working Life/year	compression strength (MPa)	thermal efficiency
M1	100	1	45	20	0.78
M4	95	3	28	4	1.01
M5	110	5	27	2.5	0.12
M8	95	3	38	15	0.825
M10	77	4	45	10	0.17

Table 4.5: The Decision Matrix for Materials which have better Characteristics

No.	Cost $	Weight of preference to the costumer	Working Life/year	compression strength (MPa)	thermal efficiency
M2	80	5	50	11	0.78
M3	70	4	40	2.6	0.16
M6	85	2	55	9.25	0.26
M7	72	4	46	10	1.23
M9	87	1	55	25	1.3

A decision matrix evaluates and prioritizes a list of materials and is a decision-making tool. the managers first establish a list of weighted criteria and then evaluates each option against those criteria. it is a list of properties values in rows and columns that allows an analyst to systematically identify, analyse, and rate the performance of relationships between sets of values and information. elements of a decision matrix show decisions based on certain decision criteria. the matrix is useful for looking at large masses of decision factors and assessing each factor's relative significance by weighting them by importance.

4.4 INFLUENCE FACTORS AFFECTING CONSTRUCTION COSTS

There are a great number of elements that influence the estimation of the construction costs, each of which can have a considerable effect on the total cost of the project. The preparation of a cost estimate for any project involving construction is a very complicated procedure that comprises of a large number of different variable components. The shape of a structure has a significant bearing on its overall cost. The dimensions, contours, and intricacies of a structure are all aspects of its morphology that are examined. The primary aspects of building design that have an effect on costs include the plan form, the size of the building, the wall-to-floor ratio, the degree of circulation space, the story heights, the overall height of the structure, and the grouping of buildings. It is possible to generalize and say that larger structures with straightforward, rectangular, and regular floor plans and elevations will have lower costs per square meter of floor space than smaller buildings with intricate shapes, such as curved or angular ones. The use of economies of scale allows for the allocation of fixed overhead costs across a greater "productive" area. A straightforward setting out and solutions that may be constructed foster increased plant utilization, leading to increased output and less waste. The views expressed by respondents on the influence of architectural attributes on total construction costs are illustrated in Figure 4.1. In addition to the kind of air conditioning system, the type of lighting control system, and the type of solar energy system all have rates ranging from 70 to 87 percent, but the external finishing and isolations, such as shadow, have the biggest rate influence.

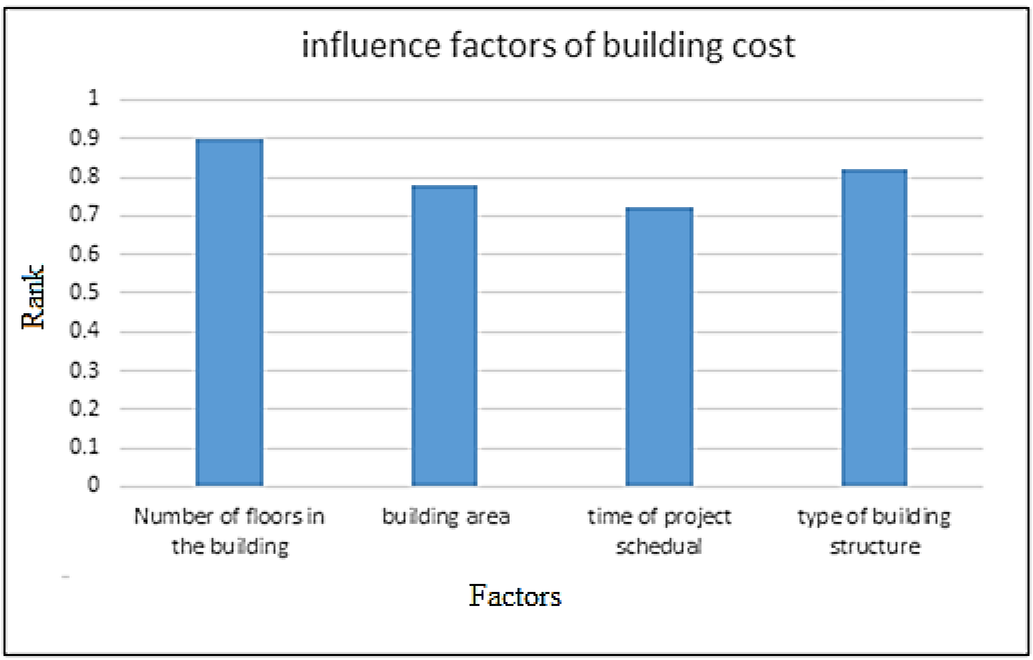

Figure 4.1: The Main Influence Factors

A data sheet was developed and put into use in order to compile all of the necessary information on each project. The vast majority of colleges in Iraq that provide building engineering degrees were looked at. A collection of projects was collected from various engineering firms and government agencies that were involved in building projects. The number of typical square feet on each level is the first item in the input list, and it bears a direct and direct linear relationship to the total cost of the building. The space on average floors was segmented into many categories, each of which had 150 square meters, with the exception of the first, which has the potential to grow to either 200 or 250 square meters. The number of floors becomes an important component as well; in the real case study, it spans from one to two levels, but in the BIM model, it extends to five levels. In spite of the fact that the number of projects in the later categories is lower than the number of projects in the first category, it still offers a clear signal in the training of the model that increasing the number of floors in a building result in an increase in project costs.

4.5 THE CASE STUDY RESULTS

A data sheet was developed and put into use in order to compile all of the necessary information on each project. The vast majority of colleges in Iraq that provide building engineering degrees were looked at. A collection of projects was collected from various engineering firms and government agencies that were involved in building projects. The number of typical square feet on each level is the first item in the input list, and it bears a direct and direct linear relationship to the total cost of the building. The space on average floors was segmented into many categories, each of which had 150 square meters, with the exception of the first, which has the potential to grow to either 200 or 250 square meters. The number of floors becomes an important component as well; in the real case study, it spans from one to two levels, but in the BIM model, it extends to five levels. In spite of the fact that the number of projects in the later categories is lower than the number of projects in the first category, it still offers a clear signal in the training of the model that increasing the number of floors in a building result in an increase in project costs. It is possible to lessen the amount of surplus material used and waste produced by a building by employing an adequate structural system and making the proper selection of structural materials. This will also boost the structure's flexibility to be put to various purposes. The minimum needed levels of durability for various architectural parts are specified by the Building Code, and this will be a significant motivator for the selection of the materials to be used. In addition to this, the requirements for durability and maintenance should be taken into consideration simultaneously over the estimated lifetime of the building's service. There are certain materials that, at first glance, do not appear to offer great levels of durability; but, with the appropriate degree of maintenance, these materials may really operate quite well for many decades. Material deterioration/decay: Because the growth of molds or fungi, as well as corrosion of some materials, can cause the rapid deterioration of certain materials, it is essential that the materials chosen have the required level of durability for the area in which they will be used. This is especially true in environments that are humid or when the materials are continuously wet. The selection of construction materials should have a positive impact on the building's thermal performance so that it requires less energy to heat and cool it. This may be accomplished by providing adequate insulation and thermal mass inside the structure. The building that served as the subject of this investigation was a two-levels structure that is located in Baghdad, Iraq, as seen in figures 4.2 and 4.3.

Figure 4.2: The Used Real Case

Figure 4.3: Side View of the Used Real Case

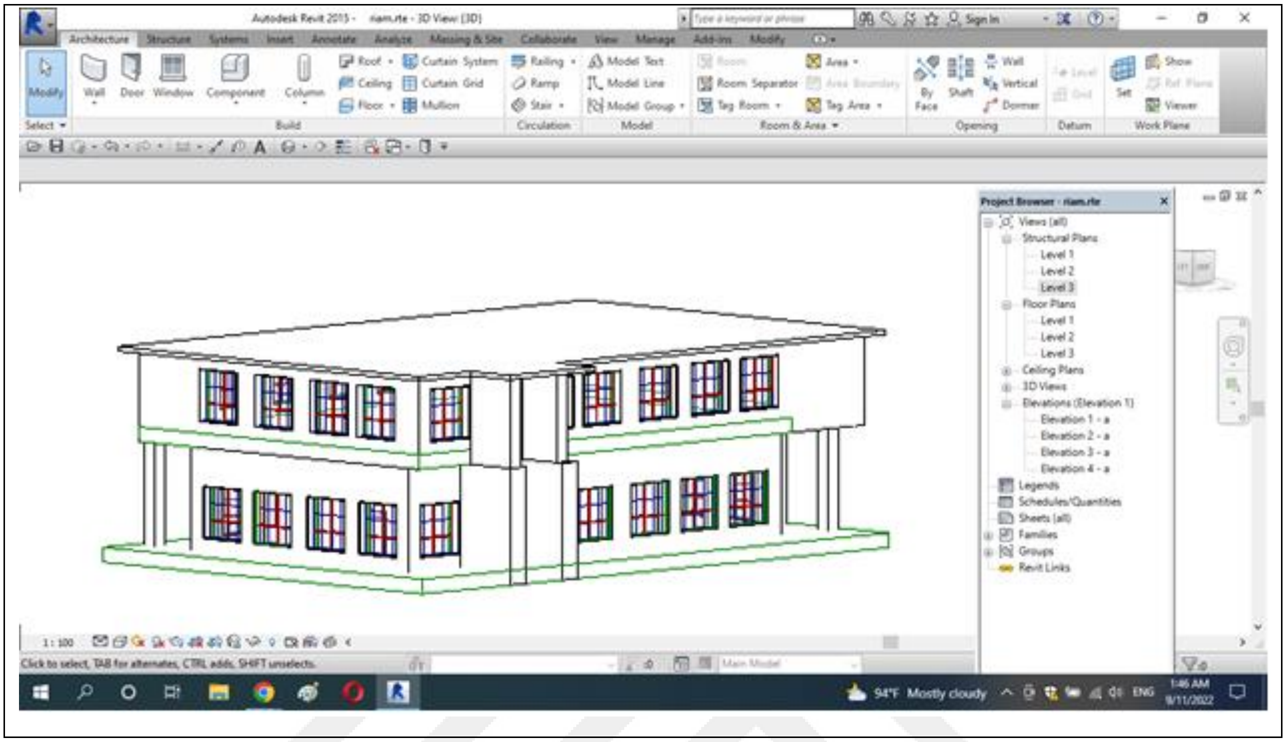

Figure 4.4: The Revit drawing of the real case study

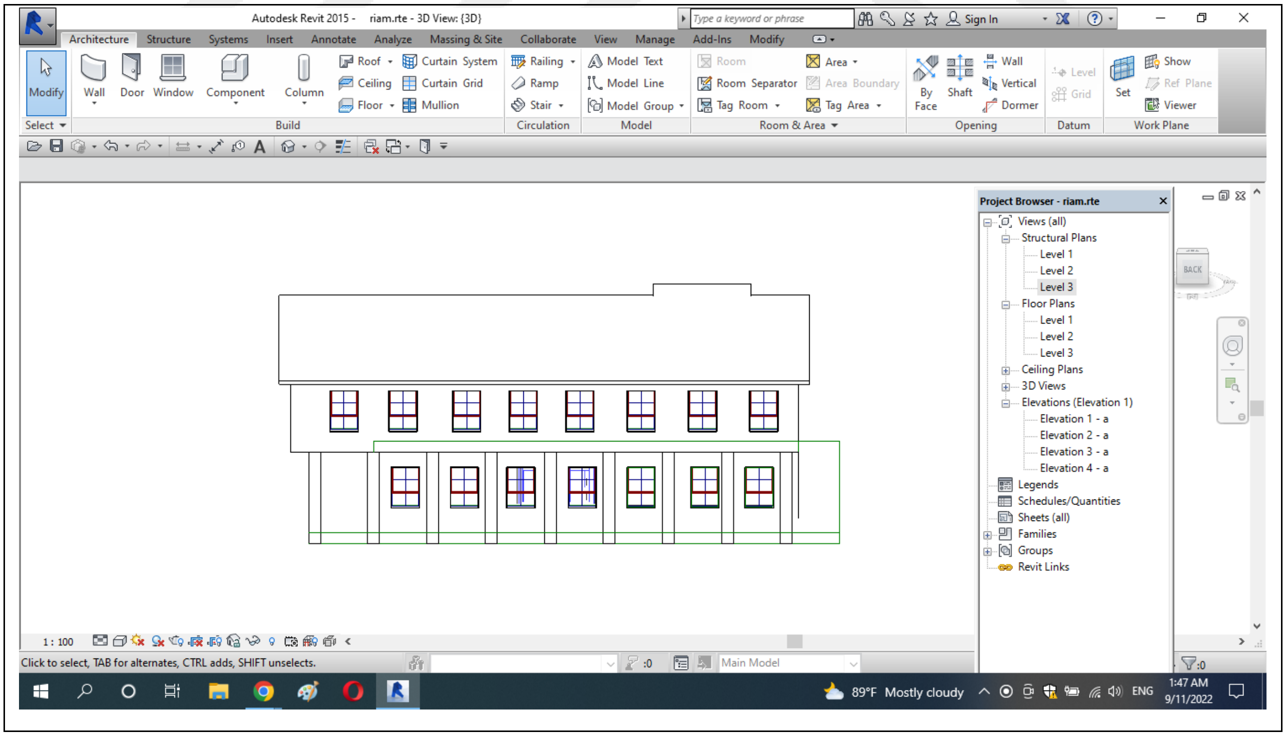

Figure 4.5: The Side View Revit Drawing of the real case study

A comparison between the building cost in both of Revit drawing results and the actual cost results using different materials presented in table 4.6.

Table 4.6: Comparison of Materials Cost in (USD) between the actual building cost and Revit results

project	floors number	wall area	M1	M4	M5	M8	M10
Revit building result	first	339	33850	32158	37235	32158	26065
Revit building result	second	343	40166	38158	44183	38158	30928
Revit building result	all building	682	68200	64790	75020	64790	52514
actual case study	first	352	41189	39129	45308	39129	31715
actual case study	second	364	36411	34590	40052	34590	28036
actual building	all building	716	83790	79600	92169	79600	64518

The results observe a 4.77% error and as was said earlier, the objective of the phase devoted to testing the cost model is to determine whether or not the model that was developed was successful and whether or not the desired level of generality was achieved. The ideal model, which provided more accurate cost predictions without compromising precision, was produced through a process of trial and error guided by the guidance that came before it. This model delivered more precise cost projections. The tabular representations of tables 4.7 and 4.8 display the system's numerical output, respectively.

Table 4.7: Test Results of Three Types of Buildings for first group of materials

project	floors number	wall area(m^2)	M1	M4	M5	M8	M10
building size 150m2	1	315	31500	29925	34650	29925	24255
building size 150m2	2	599	70025	66523	77027	66523	53919
building size 200m2	1	360	36000	34200	39600	34200	27720
building size 200m2	2	684	80028	76027	88031	76027	61622
building size 250m2	1	405	40500	38475	44550	38475	31185
building size 250m2	2	769	89996	85497	98996	85497	69297

Table 4.8: Test Results of Three Types of Buildings for second group of materials

project	floors number	wall area(m^2)	M2	M3	M6	M7	M9
building size 150m2	1	315	25200	22050	26775	22680	27405
building size 150m2	2	599	56020	49017	59521	50418	60921
building size 200m2	1	360	28800	25200	30600	25920	31320
building size 200m2	2	684	64022	56020	68024	57620	69624
building size 250m2	1	405	32400	28350	34425	29160	35235

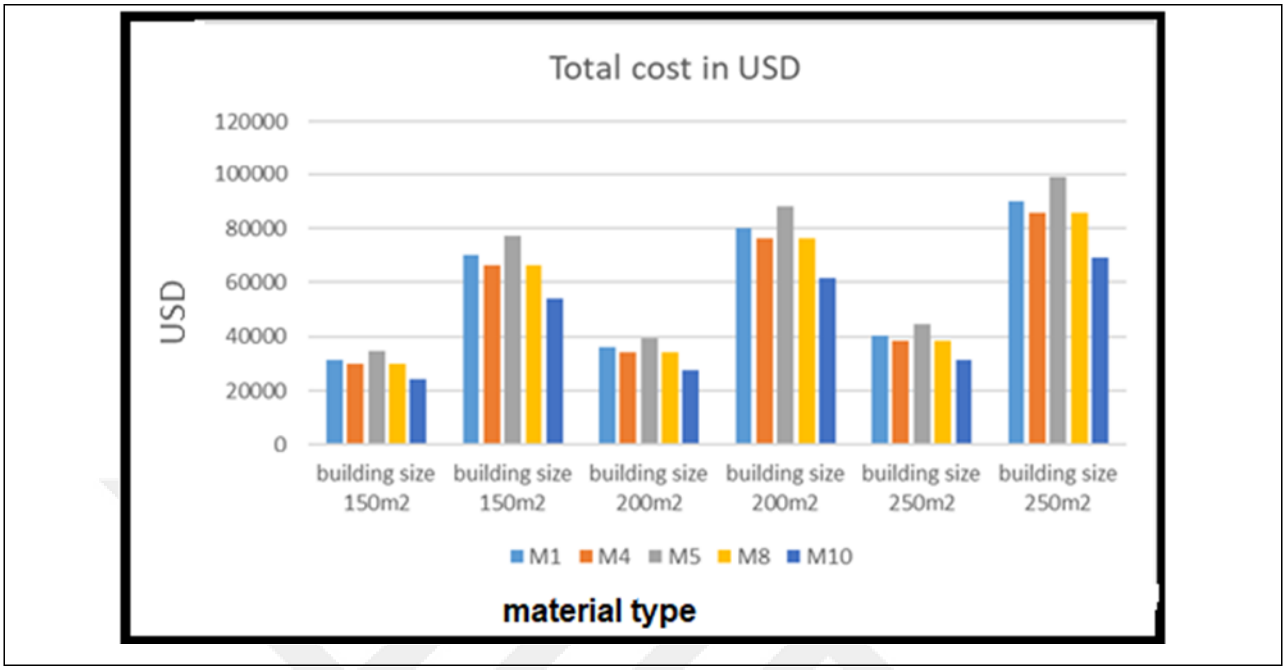

Figure 4.6: Comparison Between Building Costs for three types of buildings of first group

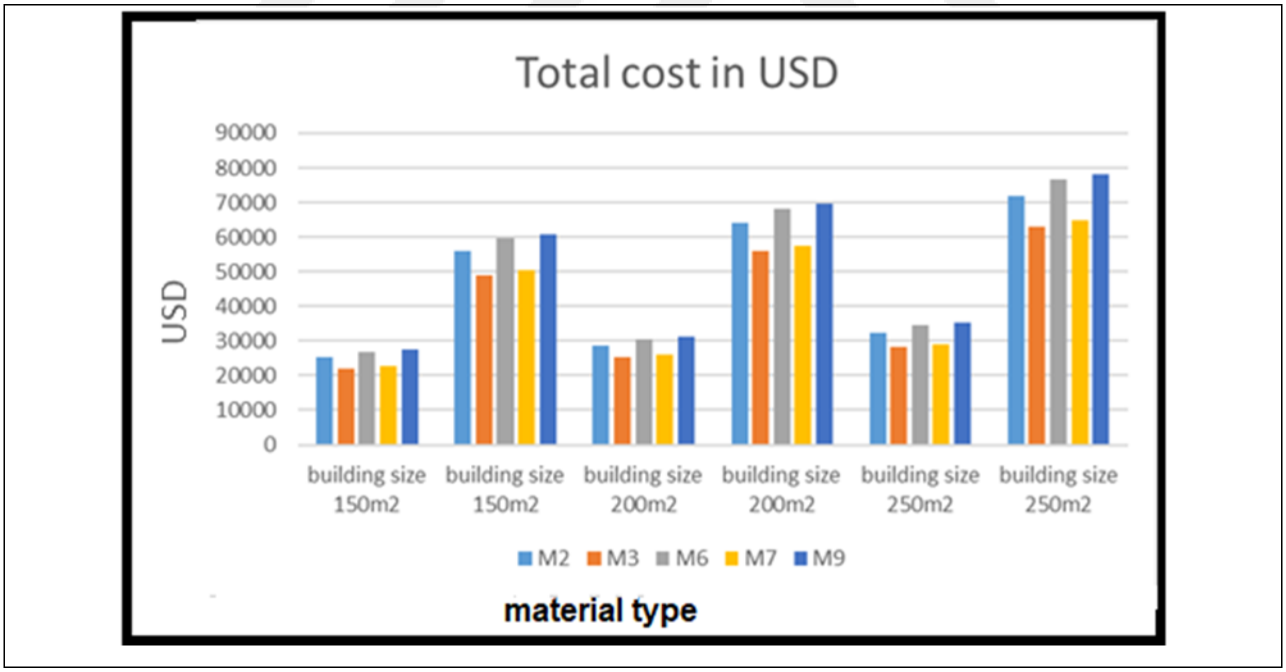

Figure 4.7: Comparison Between Building Costs for three types of buildings of second group

By comparing the cost results, it can be seen that the materials M3 and M10 represent the best choice for implementing the building in Iraqi environment. These materials represent good alternative for traditional used brick in Iraq.

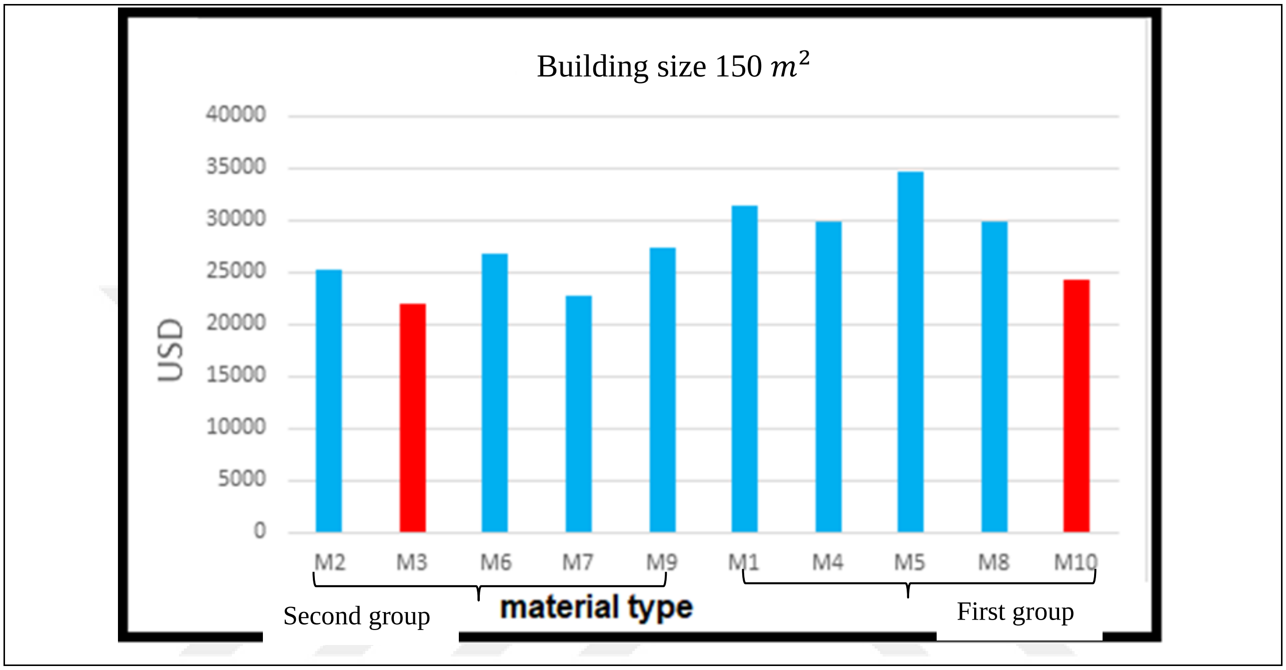

Figure 4.8: Comparison Between Actual Cost building based on different materials

The traditional survey and collected data tested by using MCDM technique. MCDM results present more significant selection materials, it presented the M7 and M8. These materials have higher compressive strength than the traditional method. They have (10-15) MPa while the materials selected by the traditional method were (2.5 to 10) MPa.

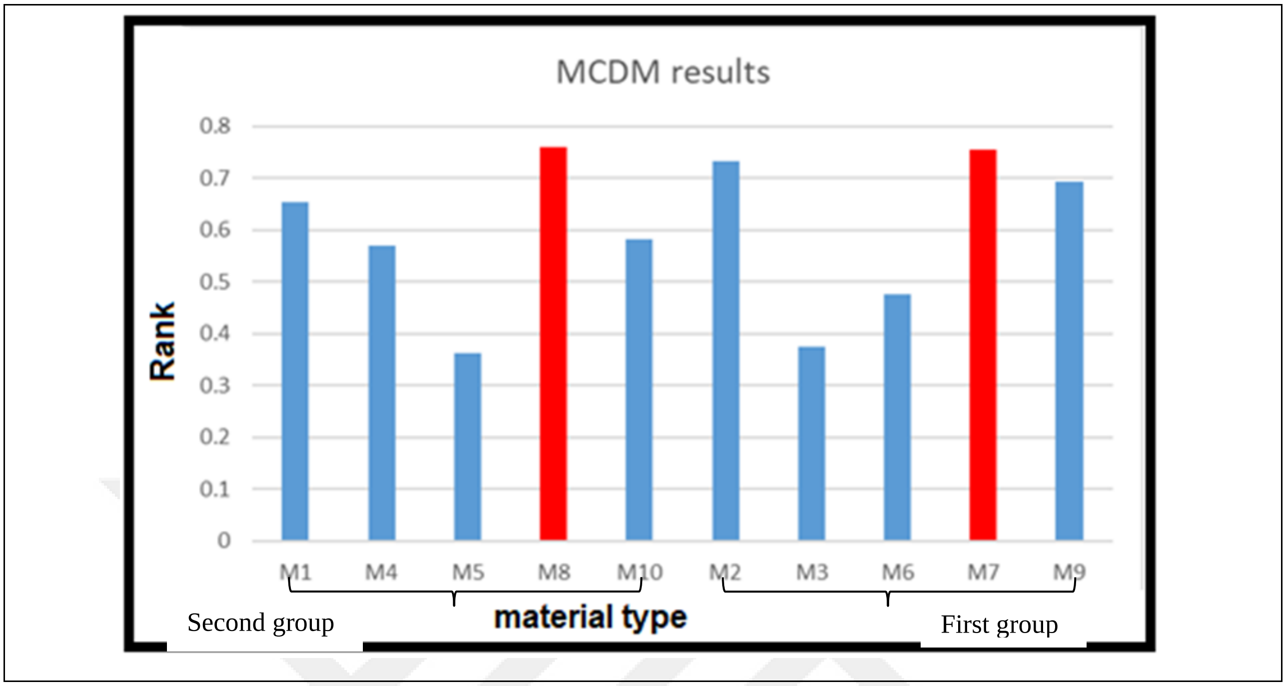

Figure 4.9: Comparison of MCDM Cost results

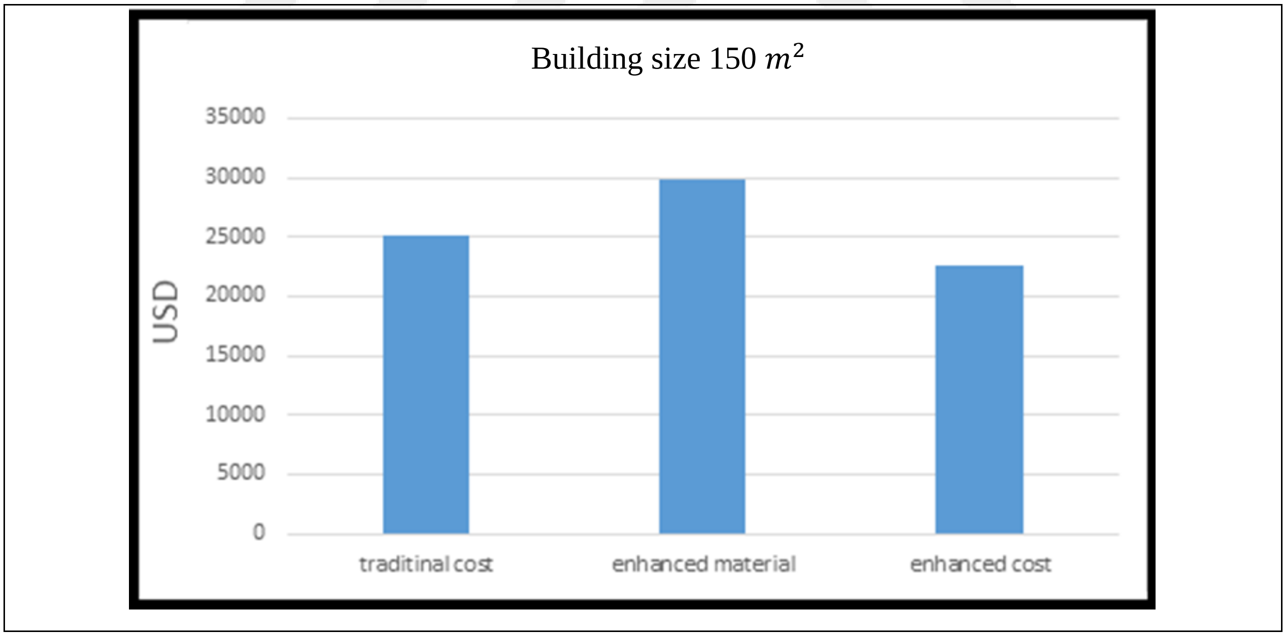

Figure 4.10: Comparison of MCDM Cost results

4.6 BIM CASE STUDY RESULTS

The BIM contains drawings made in Revit as well as additional documents (Building Information Model). A piece of design software known as Revit is called Revit. The majority of architects and engineers who have worked with other software that is comparable to Revit should already be familiar with the program's fundamentals. The building information modeling (BIM) program Revit creates a bridge between the 2D and 3D designs. Having a single model from which several drawings may be created is all that is required for this. The most significant distinction lies in the fact that Revit is largely geared for the architecture industry, which is connected to the BOQ. Creating project drawings and virtual models is made possible with the help of Revit, which is a software program. BIM was the impetus for the development of Autodesk Revit. It really is that straightforward: Revit is compatible with BIM. While other systems cater to the requirements of general model designers, Revit was developed expressly with the demands of engineers and architects in mind. BIM is, without a doubt, included in the curriculum in some capacity. This level of automation may be seen throughout the Revit application. It remembers information and adapts to new circumstances. As a direct result of this, it is possible to economize the time that would have been spent otherwise scrutinizing the designs to ensure that everything is in proper operating order. Our inquiry focuses on a residential structure that is five stories tall and has a floor space of roughly 400 square meters. This model represents the structure that we are looking at. The model is built in accordance with the instructions given in the third chapter, and the outcomes are presented in Figures 4.11 and 4.12.

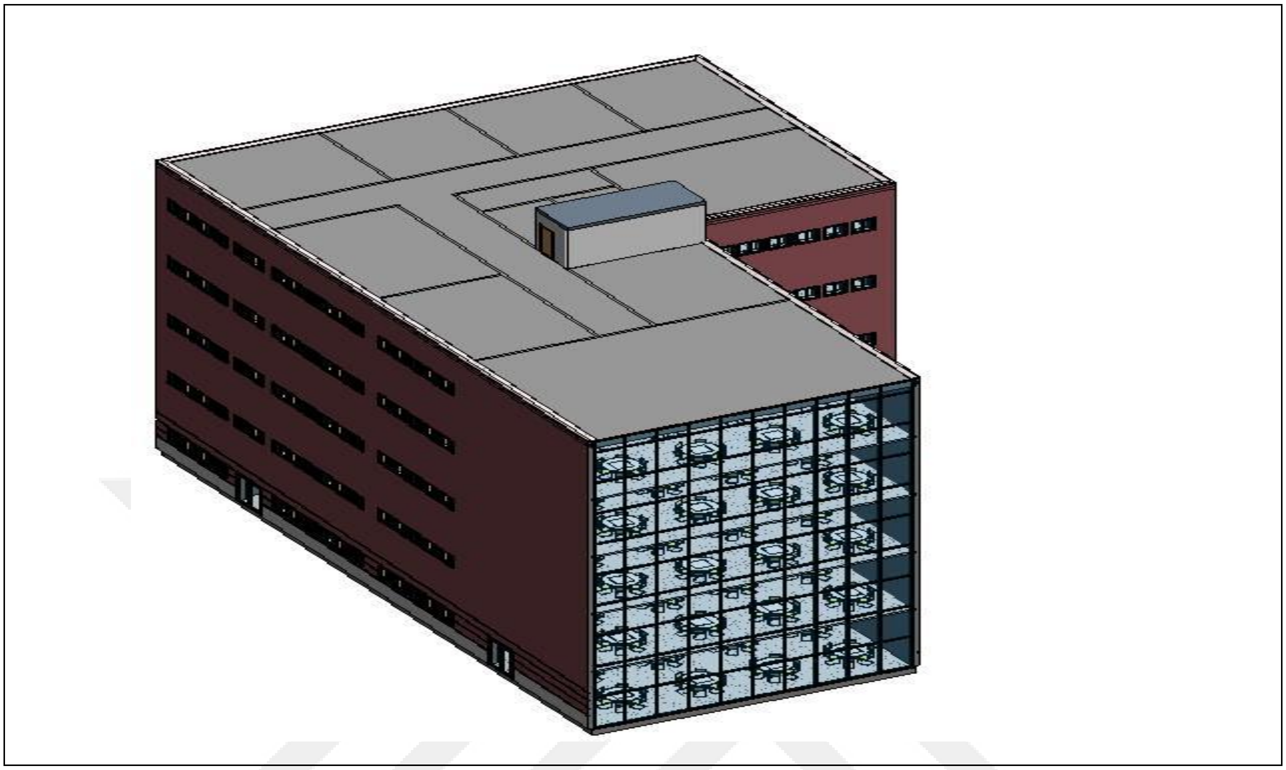

Figure 4.11: Top view of the second Case Study

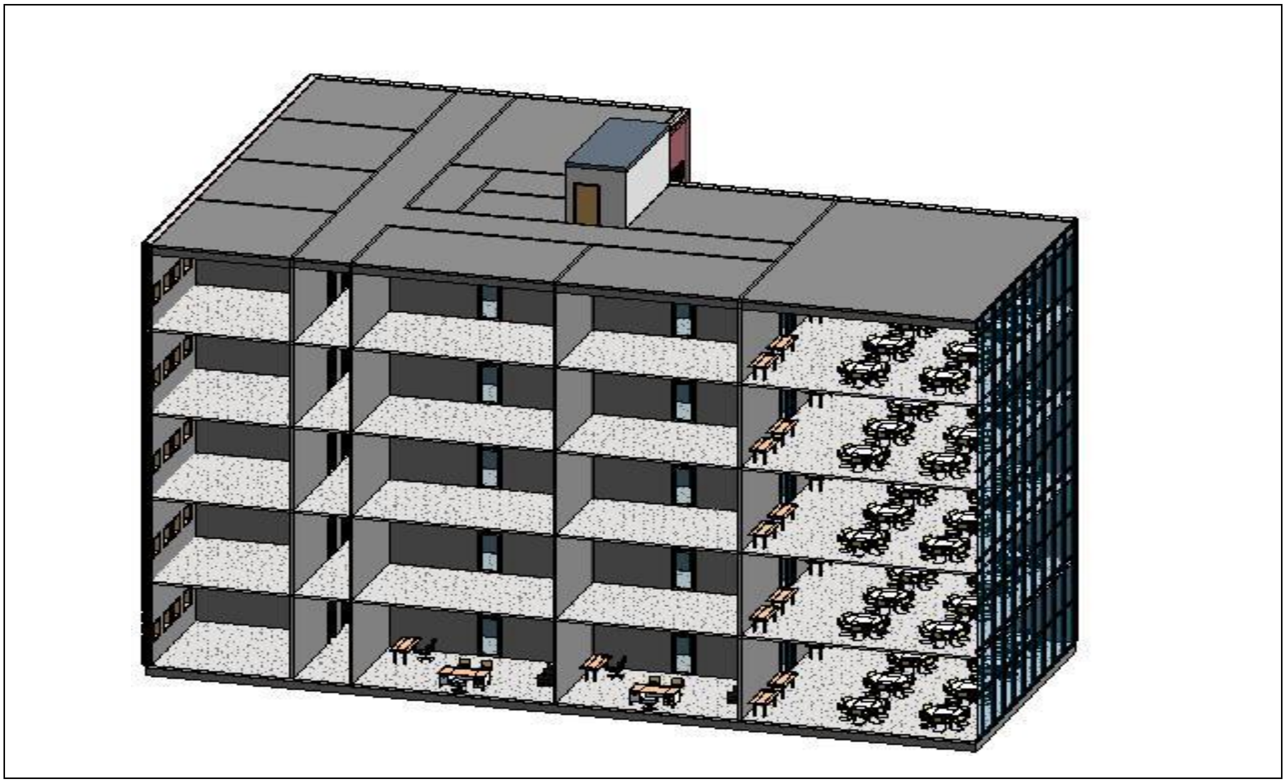

Figure 4.12: Section View of the second Case Study

The BIM contains the drawings in Revit in addition to additional data (Building Information Model). The Revit program is a piece of design software. The majority of architects and engineers who have previously worked with software that is analogous to Revit should already be familiar with its core concepts. The gap between 2D and 3D designs is bridged by the building information modeling program Revit. Having a single model from which other visuals may be derived is all that is required to do this. The primary distinction lies in the fact that Revit is targeted largely on the architecture industry, which is connected to the BOQ. Revit is a piece of design software that enables users to generate both physical and digital models of their projects. The Building Information Model served as inspiration for the creation of Autodesk Revit. Revit is compatible with BIM. In contrast to other systems, Revit was developed with the unique needs of engineers and architects in mind. It should come as no surprise that the program incorporates BIM. The automation that this provides is at the core of the Revit program. It remembers the data and reacts to any changes that occur. As a consequence of this, it frees up time that would have been spent in the alternative going over designs to check that everything is in proper functioning condition.

Table 4.9: The Wall Schedule of Revit Results

length (m)	100.58	material	total cost (USD)	material	total cost (USD)
		M1	339992.6	M2	271994.1
volume (m3)	726.48	M4	322993	M3	237994.8
		M5	373991.9	M6	288993.7
		M8	322993	M7	244794.7
		M10	261794.3	M9	295793.6

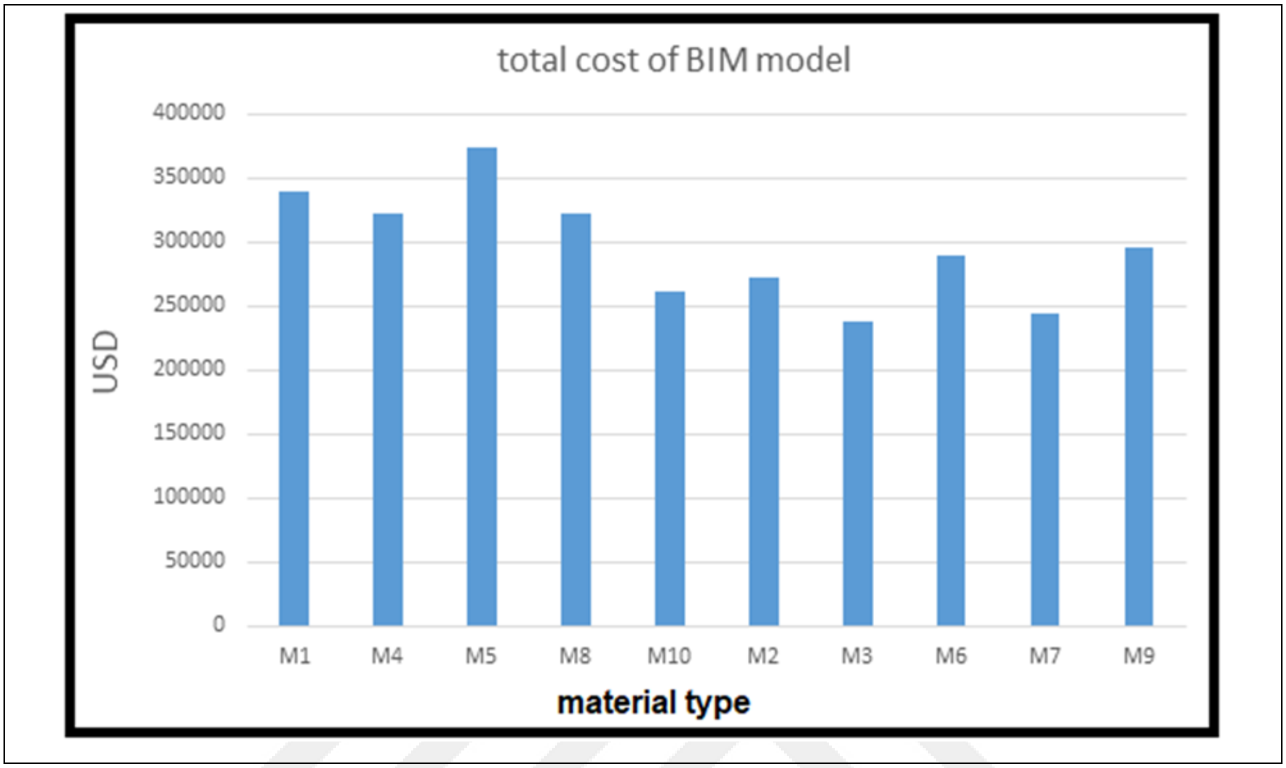

Figure 4.13: BIM Test Results

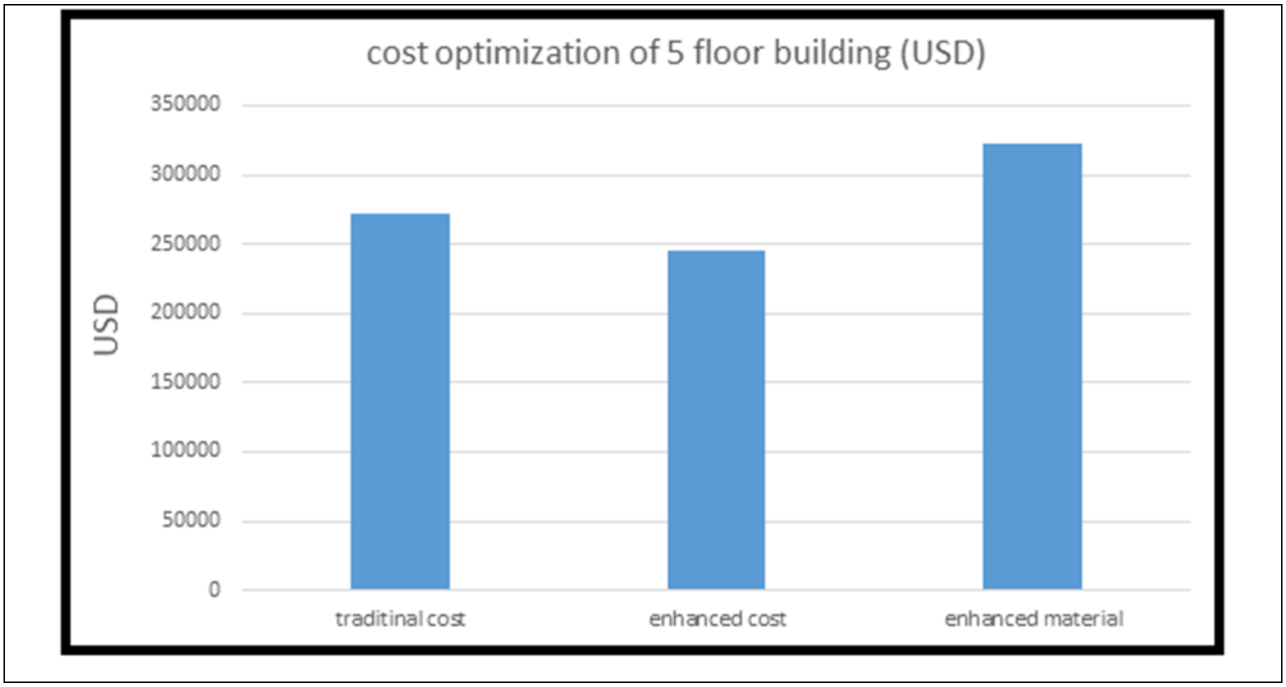

Figure 4.14: Optimal Selection of Material Results

5. CONCLUSION AND RECOMMENDATION

By developing a model that may assist parties participating in construction projects in acquiring overall cost information at the early phases of a project with minimal data, the purpose of this research was to provide a novel cost estimation approach that could be used for building projects in Iraq based on various types of materials. In order to accomplish this objective, the steps and procedures that are detailed below were carried out:

a) Through the use of a questionnaire survey, interviews with industry professionals, and an exploratory review of the relevant prior research, the most cost-effective materials for building projects were determined. The number of stories, the size of the building, the length of time it will take to complete the project, and the kind of building structure were selected as the most important factors that affect building expenses.

b) Creating an MCDM method entailed a number of processes, the first of which was to choose the application that would be used to construct the model. In addition to its simplicity of use and ability to extract findings, the MATLAB software was chosen for the main cost estimating. The data sets were encoded before being analysed.

c) In order to make a suitable decision in material selection, the MCDM technique can be used to improve the managers selection performance of used materials in projects.

5.1 RECOMMENDATIONS

Positive and promising search results were found when calculating the costs of construction projects. However, this strategy has to be revised because civil engineering places a significant emphasis on this specific field. The findings of this study should, however, be backed up by the provision of particular recommendations for decision-makers working in the construction business as well as by further investigation. It is important for all businesses participating in the construction process to have a better understanding of how cost estimates are developed depending on the materials used. There is a significant opportunity to use the natural resources that are readily available in building construction, and the estimating process should place a greater emphasis on making use of this recently developed strategy.

REFERENCES

[1] M. Wirkus, “Adaptive Management Approach to an Infrastructure Project,” *Procedia - Soc. Behav. Sci.*, vol. 226, no. October 2015, pp. 414–422, 2016, doi: 10.1016/j.sbspro.2016.06.206.

[2] O. Manoliadis and D. Oustadakis, “Application of Adaptive Process in Construction Project Management,” pp. 278–288, 2014.

[3] EUBIM Task Group, “Handbook for the introduction of Building Information Modelling by the European Public Sector,” *EU BIM Task Gr.*, p. 84, 2016, [Online]. Available: http://www.eubim.eu/downloads/EU_BIM_Task_Group_Handbook_FINAL.

[4] M.Reihanifar and S.Naimi, “Proje ve Maliyet Yonetimi Yontemleriyle Kalitenin ve Verimliligin Artirilmasinin İncelenmesi,” *Istanbul Aydin Univ. Derg.*, vol. 8, no. 29, pp. 51–65, 2016, doi: 10.17932/iau.iaud.m.13091352.2016.8/29.51-65.

[5] W. Alfaggi and S. Naimi, “An Optimal Cost Estimation Practices of Fuzzy AHP for Building Construction Projects in Libya,” vol. 8, no. 06, pp. 1194–1204, 2022.

[6] M. Celikag and S. Naimi, “Building construction in North Cyprus: Problems and alternatives solutions,” *Procedia Eng.*, vol. 14, no. December 2011, pp. 2269–2275, 2011, doi: 10.1016/j.proeng.2011.07.286.

[7] S. West, *Meaning and Action in Sustainability Science: Interpretive approaches for social-ecological systems research (PhD Thesis)*, no. December. 2016.

[8] M. J. Ribeirinho *et al.*, “The next normal in construction,” *Mckinsey Co.*, no. June, p. 84, 2020, [Online]. Available: https://www.mckinsey.com/~/media/McKinsey/Industries/Capital Projects and Infrastructure/Our Insights/The next normal in construction/The-next-normal-in-construction.pdf.

[9] M. Al-Siyabi, A. Alnuaimi, M. Khadem, and K. Alzebdeh, “Cost estimation practices prevalent in construction projects in Oman,” *J. Eng. Res.*, vol. 16, no. 2, pp. 115–129, 2019, doi: 10.24200/tjer.vol16iss2pp115-129.

[10] H. S. Najmi, “Project Management for Construction Projects,” *An-Najah Natl. Univ.*, vol. 130, no. 2, p. 556, 2011, [Online]. Available: http://dx.doi.org/10.1016/j.jaci.2012.05.050%0Ahttp://dx.doi.org/10.1016/j.ijproman.2016.11.003%0Ahttps://projectcontrolsonline.com/definition-and-importance-of-project-controls%0Ahttp://hdl.handle.net/2086/5486.

[11] B. H. Zingstra, “The Principles of Adaptive Management and the Project Cycle,” pp. 1–4.

[12] USAID WWF, “Building Material Selection and Use: An Environmental Guide,” pp. 1–19, 2016.

[13] N. Salafsky, , R. Margoluis, , & K. Redford,. Adaptive management. A tool for conservation practitioners. 2001, (Washington DC: Biodiversity Support Programme).

[14] A. M. G. Fernández *et al.*, "Applying adaptive case management to enable energy efficiency performance tracking in building construction projects," *CEUR Workshop Proc.*, vol. 2428, no. December 2015, pp. 142–153, 2019.

[15] C. Atombo, J. Cudjoe, K. Dzantor, and A. A. Agbo, "Integration of Sustainable Construction in Project Management: A Case Study in Ghana," *Int. J. Constr. Eng. Manag.*, vol. 4, no. 1, pp. 13–25, 2015, doi: 10.5923/j.ijcem.20150401.02.

[16] M. Azouz, "the Future of Green Building Materials in Egypt: a Framework for Action," *Resourceedings*, vol. 1, no. 1, 2018, doi: 10.21625/resourceedings.v1i1.180.

[17] D. Jugend and J. Figueiredo, "Integrating environmental sustainability and project portfolio management: Case study in an energy firm," *Gest. e Prod.*, vol. 24, no. 3, pp. 526–537, 2017, doi: 10.1590/0104-530X3451-16.

[18] P. A. Bullen, "Adaptive reuse and sustainability of commercial buildings," *Facilities*, vol. 25, no. 1–2, pp. 20–31, 2007, doi: 10.1108/02632770710716911.

[19] J. A. Wiens *et al.*, "Facilitating adaptive management in California's Sacramento-San Joaquin Delta," *San Fr. Estuary Watershed Sci.*, vol. 15, no. 2, 2017, doi: 10.15447/sfews.2017v15iss2art3.

[20] U. Klanšek and M. Pšunder, "Troškovna optimizacija terminskih planova za vodenje projekata," *Ekon. Istraz.*, vol. 23, no. 4, pp. 22–36, 2010, doi: 10.1080/1331677X.2010.11517431.

[21] P. Rogers and A. Macfarlan, "What is adaptive cruise control, and how does it work?," *Monit. Eval. Adapt. Manag.*, no. 2, p. 17, 2020, [Online]. Available: https://practicalmotoring.com.au/car-advice/what-is-cruise-control-how-does-it-work/%0Ahttps://www.extremetech.com/extreme/157172-what-is-adaptive-cruise-control-and-how-does-it-work.

[22] C. S. Singh, "Green Construction: Analysis on Green and Sustainable Building Techniques," *Civ. Eng. Res. J.*, vol. 4, no. 3, 2018, doi: 10.19080/cerj.2018.04.555638.

[23] M. Yılmaz and A. Bakış, "Sustainability in Construction Sector," *Procedia - Soc. Behav. Sci.*, vol. 195, pp. 2253–2262, 2015, doi: 10.1016/j.sbspro.2015.06.312.

[24] S. D. John Atkins, "Cost analysis and benchmarking," *RICS Guid. note, Glob.*, vol. 1, no. 2, p. 45, 2013.

[25] D. R. Smith, "Adaptive Leadership Strategies and Project Success of Construction Project Managers in Jamaica," *ProQuest Diss. Theses*, p. 161, 2020, [Online]. Available: https://www.proquest.com/dissertations-theses/adaptive-leadership-strategies-project-success/docview/2455589340/se-

2?accountid=14656%0Ahttp://gw2jh3xr2c.search.serialssolutions.com/directLink?&atitle =Adaptive+Leadership+Strategies+and+Project+Success+of+C.

[26] S. H. Ji, J. Ahn, H. S. Lee, and K. Han, “Cost Estimation Model Using Modified Parameters for Construction Projects,” *Adv. Civ. Eng.*, vol. 2019, 2019, doi: 10.1155/2019/8290935.

[27] E. Mubarak, “Leadership behaviors and its effects on employees’ happiness,” *Int. J. Sci. Eng. Res.*, vol. 5, no. 10, pp. 2010–2012, 2014, [Online]. Available: http://www.ijser.org.

[28] M. Padickakudy, “Evaluating the Importance of Sustainability in the Project Management,” 2019.

[29] K. H. Bjornen and J. R. Stacy, “Developing a 2 year oil and gas education program,” *SPE Prod. Oper. Symp. Proc.*, pp. 295–304, 2009, doi: 10.2118/120466-ms.

[30] I. Association and C. Iadc, “An Information Update from the IADC UNDERWATER DRILLING & BLASTING.”

[31] X. Zhu, X. Meng, and Y. Chen, “A novel decision-making model for selecting a construction project delivery system,” *J. Civ. Eng. Manag.*, vol. 26, no. 7, pp. 635–650, 2020, doi: 10.3846/jcem.2020.12915.

[32] P. Hashemi, R. Yazdanparast, A. Ghavamifar, and A. Azadeh, “An adaptive algorithm for performance assessment of construction project management with respect to resilience engineering and job security,” *J. Proj. Manag.*, vol. 3, pp. 23–38, 2018, doi: 10.5267/j.jpm.2017.10.002.

[33] A. Baldwin, CS.Poon, LY. Shen, S. Austin, I. Wong. Designing out waste in high-rise residential buildings: Analysis of precasting methods and traditional construction. Renewable energy. 2009 Sep 1;34(9):2067-73..

[34] R. R. Dong, “The application of BIM technology in building construction quality management and talent training,” *Eurasia J. Math. Sci. Technol. Educ.*, vol. 13, no. 7, pp. 4311–4317, 2017, doi: 10.12973/eurasia.2017.00860a.

[35] S. Azhar, “Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry,” *Leadersh. Manag. Eng.*, vol. 11, no. 3, pp. 241–252, 2011, doi: 10.1061/(ASCE)LM.1943-5630.0000127.

[36] WEF, “An Action Plan to Accelerate Building Information Modeling (BIM) Adoption,” *World Econ. Forum*, vol. 2, no. February, pp. 1–19, 2018.

[37] R. Zieliński and M. Wójtowicz, “Different BIM levels during the design and construction stages on the example of public utility facilities,” *AIP Conf. Proc.*, vol. 2078, no. March, 2019, doi: 10.1063/1.5092078.

[38] H. W. Ashcraft, “Building Information Modeling: A Framework for Collaboration

PROJECT MANAGEMENT,” *Constr. Lawyer*, vol. 28, no. 3, pp. 1–14, 2008.

[39] J. H. Woo, “BIM (Building information modeling) and pedagogical challenges,” *Proc. 43rd ASC Natl. Annu.* , p. 11, 2006, [Online]. Available: http://ascpro0.ascweb.org/archives/cd/2007/paper/CEUE169002007.pdf.

[40] H. Fitriani, A. Budiarto, S. Ajayi, and Y. Idris, “Implementing BIM in architecture, engineering and construction companies: Perceived benefits and barriers among local contractors in palembang, Indonesia,” *Int. J. Constr. Supply Chain Manag.*, vol. 9, no. 1, pp. 20–34, 2019, doi: 10.14424/ijcscm901019-20-34.

[41] F. Elghaish and S. Abrishami, “Developing a framework to revolutionise the 4D BIM process: IPD-based solution,” *Constr. Innov.*, vol. 20, no. 3, pp. 401–420, 2020, doi: 10.1108/CI-11-2019-0127.

[42] S. Tayefeh Hashemi, O. M. Ebadati, and H. Kaur, “Cost estimation and prediction in construction projects: a systematic review on machine learning techniques,” *SN Appl. Sci.*, vol. 2, no. 10, pp. 1–27, 2020, doi: 10.1007/s42452-020-03497-1.

[43] E. Namlı, Ü. Işıkdağ, and M. N. Kocakaya, “Building Information Management (BIM), A New Approach to Project Management,” *J. Sustain. Constr. Mater. Technol.*, vol. 4, no. 1, pp. 323–332, 2019, doi: 10.29187/jscmt.2019.36.

[44] M. of B. Building Performance, “Productivity benefits of Building Information Modelling (BIM),” *Branz*, 2012, [Online]. Available: http://www.building.govt.nz/UserFiles/File/Publications/Building/Technical-reports/nz-bim-productivity-benefits.pdf.

APPENDIX A

MATLAB CODE

```
clc;clear;close all

%%%%  influence factors of building cost
%Number of floors in the building
%building area
%time of project schedule
%type of building structure
%==============================================%


%M1 =   Fired Bricks (including clay bricks, fly ash bricks, shale bricks,
        %and coal gangue bricks) Compressive strength: 10-30 MPa; thermal
conductivity: 0.78W/(m*K);
%M2 =   Hollow Bricks   Compressive strength: 7.0-15.0 MPa; thermal
conductivity: 0.78W/(m*K);
%M3 =   Aerated Concrete Blocks compressive strength 2.2-3.0 MPa; thermal
conductivity: 0.16 W/(m.K);
%M4 =   Concrete sandwich boards    Compressive strength: 3-5 MPa; Thermal
conductivity: 1.01 W/(m2*K)
%M5 =   Foam Concrete Blocks    compressive strength 2-3.0 MPa;
        %thermal conductivity is 0.12 W/(m*K)
%M6 =   Common small sized concrete hollow blocks   Compressive strength:
        %3.5 to 15 MPa; Thermal conductivity: 0.26 W/(m*K)
%M7 =   Solid concrete blocks   Compressive strength: 7.5 to 12.5 MPa
        %Thermal conductivity: 1.23 W / (m². K);
%M8 =   Lightweight concrete wall boards    Compressive strength: 10-20 MPa;
thermal conductivity:
        %0.35 - 0.5 W/(m*K)
%M9 =   Natural stone   Compressive strength: 19-139 MPa; Thermal
conductivity: 1.26-1.33 W/(m*K)
%M10=  Clime sand brick Compressive strength: 6.0-14.0 MPa; thermal
conductivity: 0.17W/(m*K);

%============================================%
```

```
M1 =      [100    1  45      20      0.78  ];
M2 =      [80     5  50      11      0.78  ];
M3 =      [70     4  40      2.6     0.16  ];
M4 =      [95     3  28      4       1.01  ];
M5 =      [110    5  27      2.5     0.12  ];
M6 =      [85     2  55      9.25    0.26  ];
M7 =      [72     4  46      10      1.23  ];
M8 =      [95     3  38      15      0.825 ];
M9 =      [87     1  55      50      1.3   ];
M10=      [77     4  45      10      0.17  ];



Material_Matrix_Type = [ M1 M2  M3  M4  M5  M6  M7  M8  M9  M10];



Material_Matrix_val=length(Material_Matrix_Type(:,1));
for i=1:Material_Matrix_val
for j= 1:length(Weight_of_factors)
if Weight_of_criteria(1,j)== 0
Y(i,j)=min(Material_Matrix_Type(:,j))/Material_Matrix_Type(i,j);
else
Y(i,j)=Material_Matrix_Type(i,j)/max(Material_Matrix_Type(:,j));
end
end
end
for i=1:Material_Matrix_val
PWSM(i,1)=sum(Y(i,:).*Weight_of_factors);
PWPM(i,1)=prod(Y(i,:).^Weight_of_factors);
end
Preference_Score_of_Weighted_Sum_Model = num2str([PWSM])
Preference_Score_of_Weighted_Product_Model= num2str([PWPM])

for j=1:length(Material_Matrix_Type)
    aa= sum(Material_Matrix_Type(:,j))
    for i=1:length(Material_Matrix_Type)
```

```
Material_Matrix_Type(i,j)=Material_Matrix_Type(i,j)/sum(Material_Matrix_Type(
:,j));
    end
end
for i=1:length(Material_Matrix_Type)
Weight_of_factors(1,i)=(sum(Material_Matrix_Type(i,:)))/length(Material_Matri
x_Type);
end
%% calculating the consistency
for j=1:length(Material_Matrix_Type)
    for i=1:length(Material_Matrix_Type)
    Xc(i,j)=(Material_Matrix_Type(i,j).*Weight_of_factors(j));
    end
end
for i=1:length(Material_Matrix_Type)
EVMSV(i)=sum(Xc(i,:));
Lamda(i)=EVMSV(i)/Weight_of_factors(i);
end
```

APPENDIX B

Revit Wall Schedule Results

Count	Family and Type	Length (m)	Volume (m3)
1	Basic Wall: Exterior - Brick and CMU on MTL. Stud	23.16	162.49
1	Basic Wall: Exterior - Brick and CMU on MTL. Stud	15.24	109.64
1	Basic Wall: Exterior - Brick and CMU on MTL. Stud	9.14	64.57
1	Basic Wall: Exterior - Brick and CMU on MTL. Stud	18.9	141.54
1	Basic Wall: Exterior - Brick and CMU on MTL. Stud	34.14	248.24
5		100.58	726.48
1	Basic Wall: Generic - 8" Masonry	2.32	1.26
1	Basic Wall: Generic - 8" Masonry	5.81	3.55
1	Basic Wall: Generic - 8" Masonry	2.32	0.99
1	Basic Wall: Generic - 8" Masonry	5.81	3.43
4		16.27	9.23
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	3.15	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	3.91	0.24
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	3.15	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19

1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
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1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	3.15	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	3.91	0.24
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	3.15	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	3.91	0.24
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.07	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	3.15	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19

1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.19
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	3.91	0.24
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	1.08	0.2
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
1	Basic Wall: Interior - 3 1/8" Partition (1-hr)	0.53	0.09
65		88.96	11.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	6.85	4.21
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	23.16	13.54
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.15	8.8
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.99	8.78
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	14.02	8.19
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.99	9.61
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	6	3.68
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.5
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.41
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	6.85	4.21
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	23.16	13.54
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.13	8.8
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.99	8.78
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	14.02	8.19
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.99	9.61
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.5
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.41
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	6.85	4.21
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	23.16	13.54
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1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.99	9.61
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.5
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.41
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65

1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	6.85	4.21
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	23.16	13.54
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.13	8.8
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.99	8.78
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	14.02	8.19
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.99	9.61
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.5
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.41
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	23.16	13.54
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.13	8.8
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.99	8.78
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	14.02	8.19
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	15.99	9.61
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.5
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.59	3.41
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.96	3.65
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.9	3.68
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.9	3.19
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	4.62	2.86
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	6.85	4.21
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.99	3.67
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.88	3.67
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.88	3.18
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	4.62	2.86
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	6.85	4.21
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.99	3.67
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.88	3.67
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.88	3.18
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	4.62	2.86
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	6.85	4.21
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.99	3.67
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.88	3.67
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.88	3.18

1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	4.62	2.86
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	6.85	4.21
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.99	3.67
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.88	3.67
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	5.88	3.18
1	Basic Wall: Interior - 5 1/2" Partition (1-hr)	4.62	2.86
78		733.47	434.48
1	Curtain Wall: Storefront	14.02	
1		14.02	0
153		953.31	1181.83