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Sustainable Technology in The Implementation of Prefabricated Concrete Schools

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ABSTRACT

Prefabricated schools are educational structures of great significance and utility, especially given our country's current challenges. They expedite construction, reduce environmental impacts, and enhance educational activities with strong structural integrity and comfortable, flexible, and healthy design. A compelling comparison can be made with traditional concrete schools. With advancements in technology and information in engineering and the construction industry, Building Information Modeling (BIM) technology has emerged, playing a vital role in prefabricated concrete engineering through 3D modeling simulations.

Numerous challenges are encountered, such as meeting client requirements, project delays, cost overruns, quality issues, stakeholder conflicts, labor shortages, safety concerns, increased change orders, material wastage, and project complexity. Developed countries utilize BIM to mitigate these challenges and profoundly improve the AEC industry's performance. BIM tools provide a comprehensive building visualization, empowering stakeholders to make informed decisions that ensure efficiency, sustainability, and cost savings. These features motivate engineers and contractors to rely on them as essential engineering applications.

This research involves modeling a school building in the Revit program, studying work flow between Revit and ETABS program, and conducting a dynamic analysis of the model from Revit. It also emphasizes the benefits of prefabricated construction and BIM technology, facilitated by Revit. The study emphasizes how important it is to visualize the building's actual form before beginning the design and decision-making processes.in summery, this study provides the possibility of growth and application in the industrialization of the construction industry and raise the project's overall quality. The development of tools and plugins programmed to reduce interoperability problems between various software packages allows for integrating all design activities.

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1. Introduction

Prefabricated school buildings are educational facilities that are built in advance, off-site, and under rigorous quality supervision. The structural sections are constructed inside the factory and then shipped to the construction site to be installed in the school.[1].

The prefabricated school building is different from the on-site concrete construction because its components are built in a factory rather than on the construction site and transported, assembled, and installed. Construction is done in specialized factories that set up the right conditions for implementation to get the best specifications for the finished products regarding structural quality, mold, and price. After production, these components are transported to the construction site, where they are connected precisely and engineering-appropriately using cranes to place each component in its proper location. [2], [3].

Prefabricated sandwich panels and galvanized metal profiles are two of the most important parts of prefabricated buildings. Cement panels are placed between two layers of high-density polystyrene insulation to form wall panels.[4]. Polystyrene ensures thermal and sound insulation, and cement panels are considered one of the best materials that resist water and fire[5], [6].

Prefabricated schooling buildings, such as those for schools, kindergartens, universities, institutes, and training centers, are considered among the best alternatives for traditional concrete educational structures because they provide a wide range of flexible plans and modern designs. A prefabricated school may have classrooms, offices, a cafeteria or dining hall, libraries, conference rooms, office spaces for administration, gyms, storage areas, restrooms, changing areas, and toilets. Because they can be disassembled and moved to any other location, prefabricated educational buildings are strong, economical, of excellent quality, and easy to build [7]–[10].

With these advantages, they are ideal structures for school building. Thanks to portable classrooms that can be easily moved to the desired location, environmentally friendly and durable school buildings can be created with a guarantee of safe use for many years. However, prefabricated school buildings can be built not only in areas with some deficiencies, but also in places where school buildings have been destroyed after natural disasters and due to wars [11]–[13]

The application of BIM technology to building prefabricated structures can significantly change the prefabricated construction industry. With BIM technology, traditional 2D designs can be transformed into 3D visualizations, allowing for more thorough design processes. By standardizing component production and advancing the factory-scale mass production of prefabricated buildings, designers can use BIM technology to create inventory models for prefabricated building components. BIM technology improves the effectiveness of prefabricated building design while also lowering the possibility of mistakes being made at various stages of the design process. Additionally, it helps to speed up construction timelines by increasing the mechanization of prefabricated construction facilities. BIM technology can use its proprietary software to conduct collision checks and identify anomalies in the construction layout, greatly reducing the need for design plan revisions. Consequently, it is essential to reduce rework and project losses caused by inadequate design [14].

Using off-site construction methods is the suggested strategy for achieving the benefits of the proposed BIM-based strategy. This is mostly because, to achieve the "ideal" installation plan, specialized construction methods similar to those used in off-site construction are required. Higher productivity and greater accuracy in the actual execution of the installation plan are provided by these specialized techniques. In plainer terms, BIM creates a virtual and computational environment where construction professionals can evaluate various plans before actual construction starts. In contrast, off-site construction allows professionals to carry out real construction tasks in an organized and effective manner within a user-friendly and strictly regulated factory setting. When BIM and off-site construction are used together, their mutual benefits are increased, especially in improving sustainability by lowering construction waste[15].

2. Characteristics of BIM Technology Applied to Prefabricated Buildings:

A key characteristic and advantage of BIM technology lies in its ability to achieve informatization and collaborative management It helps the easy integration of various professional design models within the same environment by acting as a three-dimensional visual platform for the sharing of design information among project participants. This makes it easier for project participants and professional designers to collaborate. BIM model resources using the International Federation of Construction (IFC) standard are stored in the collaborative platform for prefabricated design and construction based on BIM technology. The design team uses the BIM platform to coordinate the parametric design of the building model in order to improve the accurate send of information across various project phases. With this method, they can detect problems and errors early on in the design phase, which helps to prevent and reduce design errors that occur between components. It thus greatly improves design quality and efficiency and provides technical support for the duration of the construction process [16].

Integrating traditional construction with new fields like economics, information, green technology, and environmental protection could be accelerated by prefabricated buildings. The construction industry could experience reforms, structural changes, and the development of new business models as a result of this integration, which will promote economic growth and improve living condition The development of prefabricated buildings should follow a step-by-step, quality-first approach, focusing on quality, efficiency, industrialization, and safety.The growth of technological innovation and intelligent construction, the use of project general contracting, and the adoption of mature technology systems are essential . establishing industry standards and developing compare demonstration projects are the objectives. Prefabricated buildings change the traditional construction method by moving the building process to a prefabrication factory instead of the usual on-site brick-by-brick construction method [11].

3. Significance of research

The study of BIM's (Building Information Modeling) developments in the architecture, engineering, and construction (AEC) industry is of the utmost significance. Building life cycles have been shortened, accurate 3D modeling is now possible, and BIM has enhanced collaboration between disciplines. It offers benefits such as increased productivity, consistency, and data coordination, which improve visualization, simulation, and error reduction. BIM technology promotes sustainability and effective off-site construction techniques in addition to streamlining the design, analysis, and documentation phases. The study presented here shows how effectively creating structural designs can be done using BIM by using a case study. This demonstrates how BIM technology has the potential to improve the construction industry by speeding up procedures and increasing accuracy, making it an important development in the industry.

4. Construction Elements:

Structural design is the most important component influencing the building. The building is designed to be industrial and fully assembled on-site. This process includes a more effective construction process, through which the timetable for completing the construction process is reduced, waste production is reduced at the implementation site, and monitoring and tracking each material is usually evaluated at the end of the cycle, life of each substance[10].

4.1. Wall and Envelope:

The walls consist of high-performance insulating panels that contain layers and provide durability and strength compared to traditional types of insulation.

The walls consist of high-performance insulating panels that contain layers and provide durability and strength compared to traditional walls and traditional types of insulation, which are custom-made panels that can be manufactured according to the required need and shape.

5. Previous experiences and studies:

This chapter looks at recent research on lean construction practices, computer simulation in the construction industry, and the use of Building Information Modeling (BIM) in our BIM-integrated simulation framework for Just-In-Time production planning. To start, even though modern tools for the analysis of construction projects can be integrated with computer simulation techniques, issues with modeling simulations and the use of suspect data continue to prevent simulations from being widely used in construction management. In addition, it is crucial to prioritize the application of lean principles, involving all stakeholders throughout the supply chain, despite significant advancements within the construction industry, including improvements in management practices and technical innovations. Although there are benefits to BIM in the construction industry.

Usually, creating a building's structural design is closely related to the overall design process. The success of structural design in construction depends on developing a shared basis for collaboration because architects and engineers use different approaches in their design work, Building Information Modeling (BIM) is an approach that fosters collaboration and improves structural knowledge acquisition without giving up other essential design principles. According to H. P. Khungar, the suggested BIM approach aims to align these processes in order to meet the requirements of both the present and future integrated design environments [15].

According to Vittoria Ciotta, investigating the use of BIM (Building Information Modeling) in structural engineering has the potential to significantly address the challenges that structural engineers typically find due to their traditional cultural background. These obstacles frequently involve process recognition, multidisciplinary collaboration, and information management issues. Additionally, practical research on BIM is not only focused on research goals but also on improving professional practices. The ability to establish standardized information processes and manage information flows effectively is one of the key differences between BIM and traditional methods [16].

6. Methodology:

The school model shown in the following figure will be modeled on the Revit program and then transferred to the ETABS program. The analysis and structural design process will be carried out, and the study results will be presented. Where the ground floor plan consists of four classrooms; each room can accommodate approximately 42 students, a room for teachers and an administrative room.

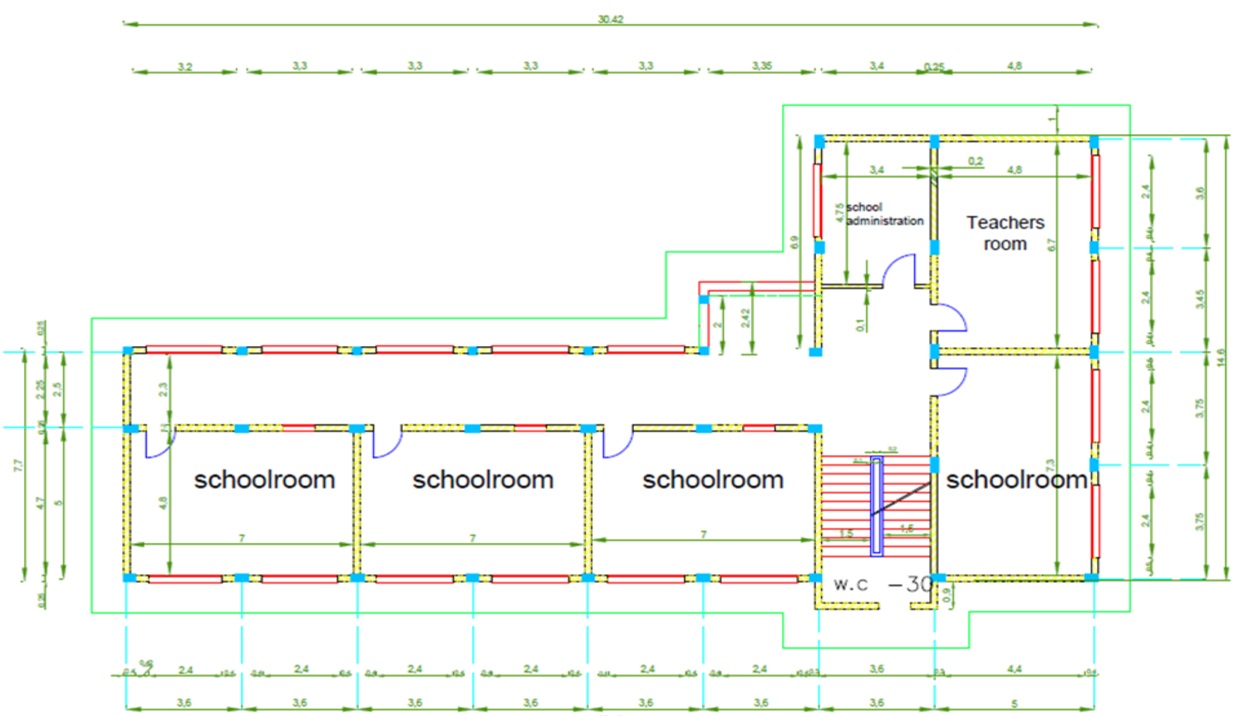

Figure 1. Ground floor

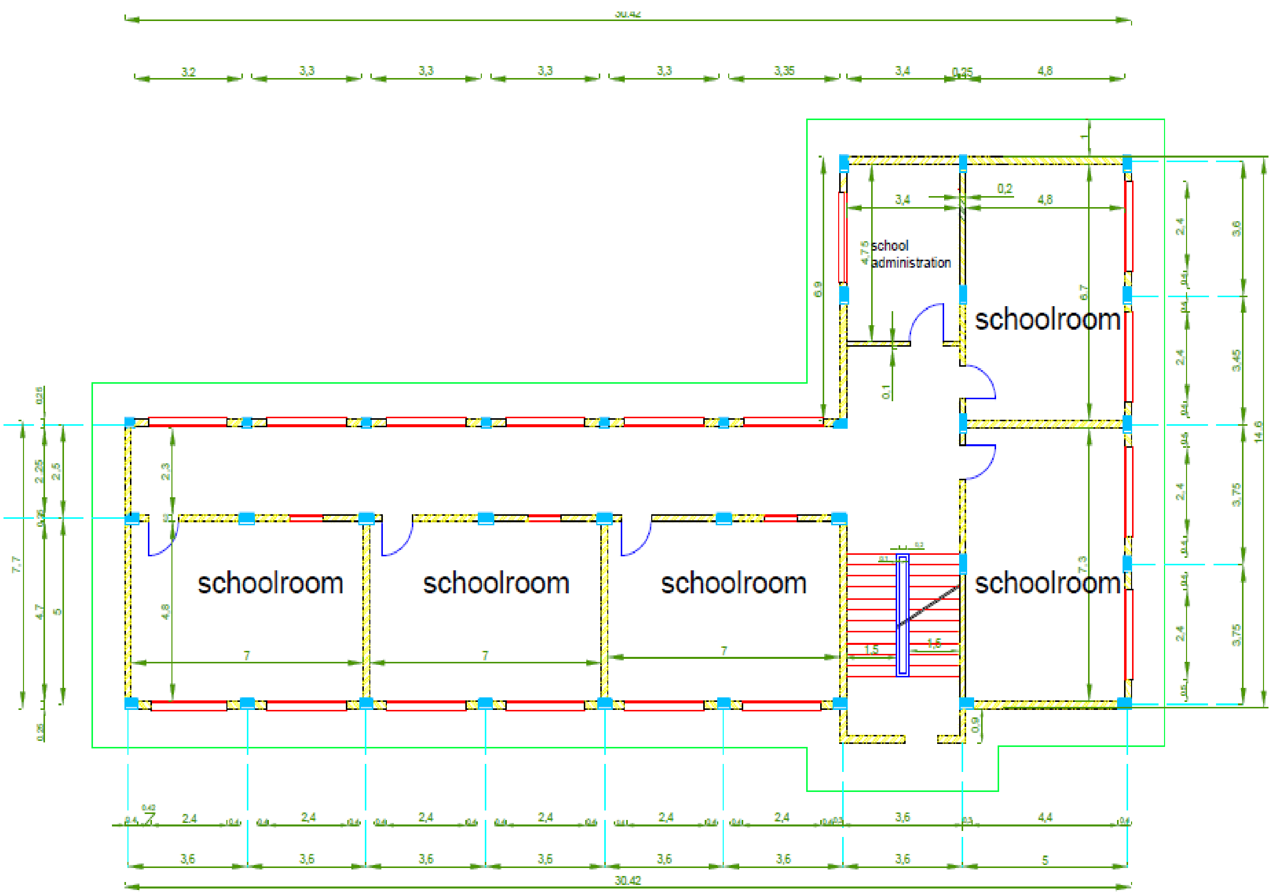

Figure 2: First and second floor

As the building consists of columns, beams, walls and prefabricated slabs. As shown in the following figures, with careful implementation and within international conditions and codes to ensure the safety of students. With proper connection of the elements and a seismic design that guarantees the solidity of the structure in case it is exposed to any seismic or any similardanger.

Figure 3. Illustrative photos of creating a prefabricated building

Figure 4. Illustrative photos of creating a prefabricated building

We modeled the facility on the Revit program, defining the prefabricated sections and structural axes, and preparing the file to transfer it to the ETABS program.

Autodesk Revit is not just an architectural design tool. It is an essential design tool for Building Information Modeling, or BIM for short. The entire construction work can be designed and modeled as in reality in Revit, from the original architectural design to all the necessary structural, electrical, mechanical, quantities, and schedules. The construction industry is beginning to see that Revit can help advance industrial construction as manufacturing processes are applied to construction.

Making the spatial model for the building allows us to implement the complete and accurate executive drawings, with the quantities and costs for each item. It allows us to take quick and clear steps when designing and implementing. Using BIM technology, driven by Revit, promotes modern precast concrete detailing through a single source of truth for the entire project lifecycle.

Precast concrete is a practical and efficient technique to drive concrete construction with the required aesthetics at low costs. These products can be fabricated at an offsite location with any form or size. This process improves project schedules, mitigates site disruption, diminishes safety issues and improves productivity.

Major benefits of employing BIM (Revit program) In the study presented in this research. In it, we explain how we can integrate the different construction programs in a way that ensures the integrity of the design with complete ease and clarity for all stages of implementation and the importance of using BIM purification in prefabricated buildings using the Revit program and exporting it to the ETABS program and achieving the required conditions for the merge and transfer process.

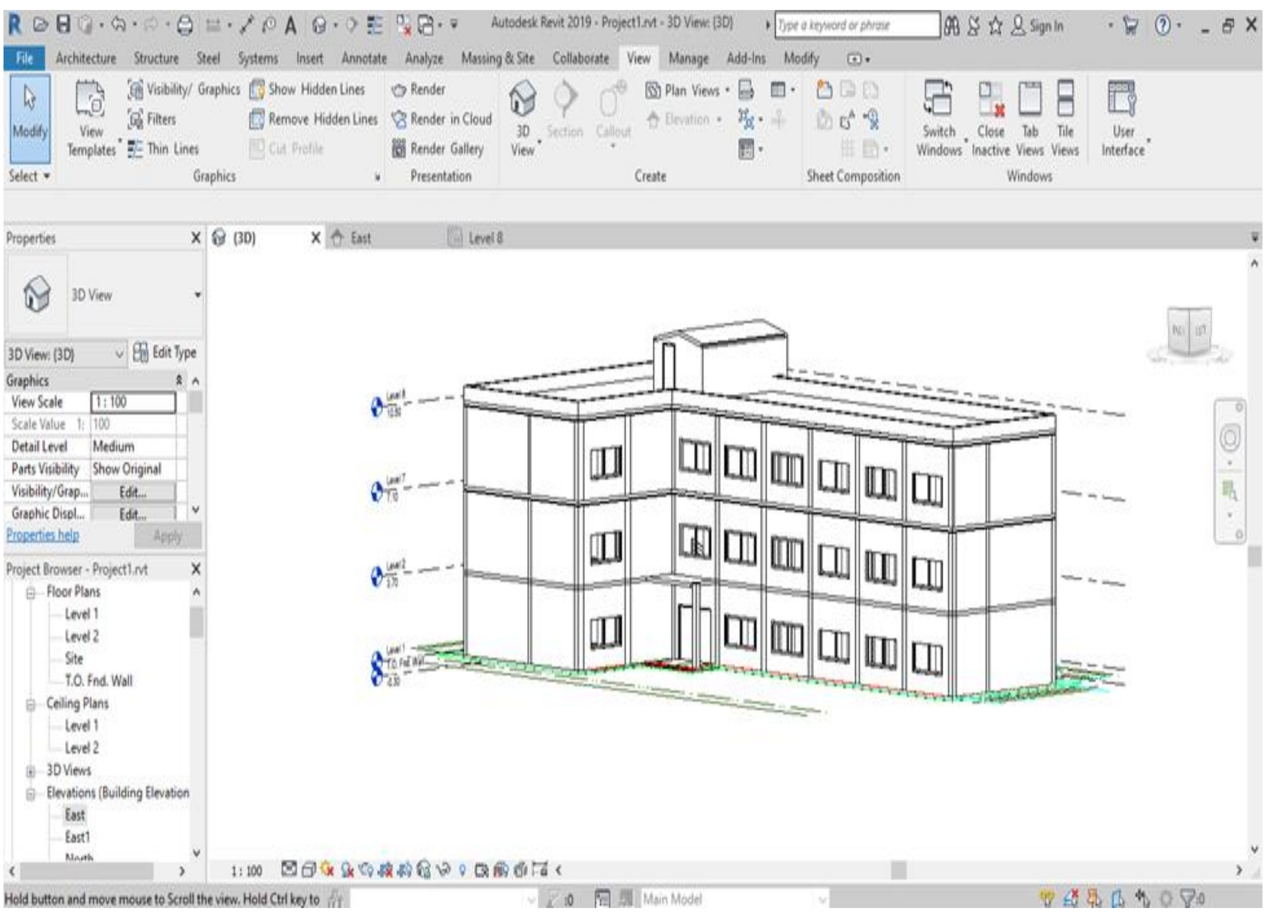

Figure 5. Physical revit model front side

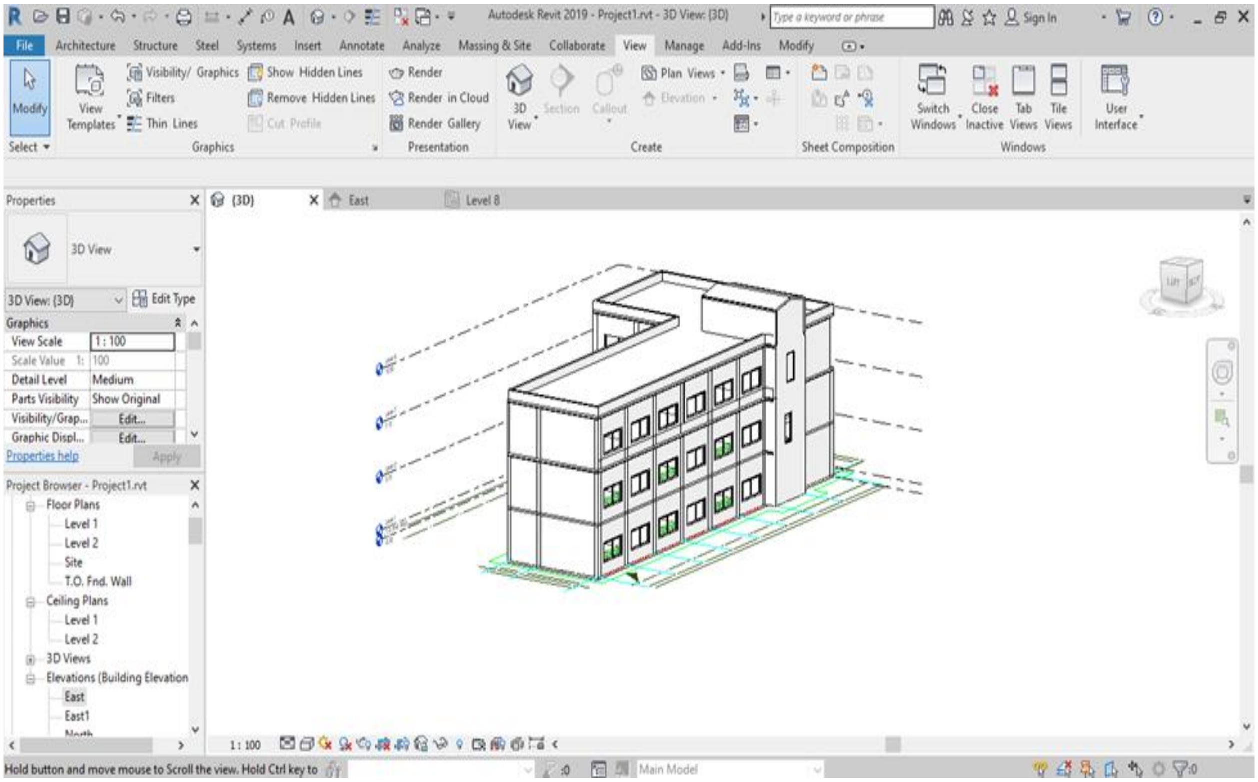

Figure 6. Physical revit model back side

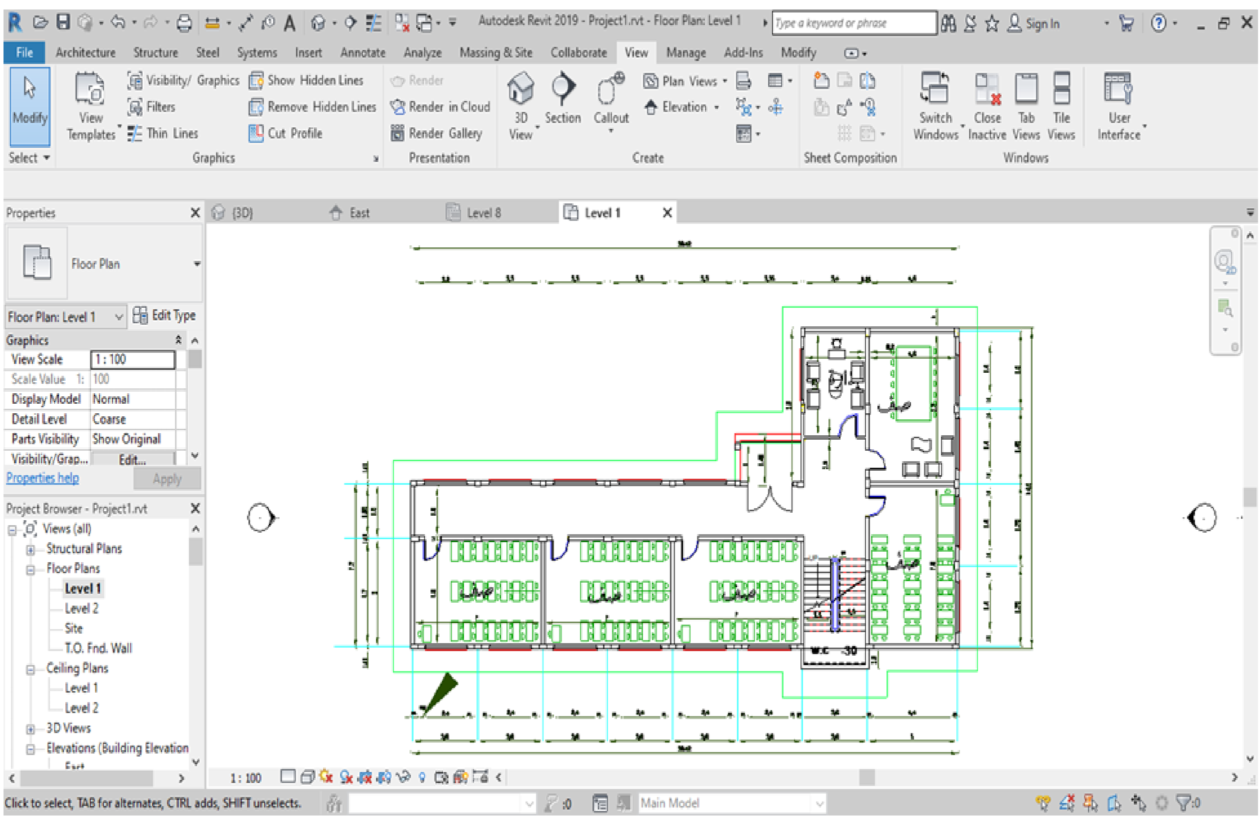

Figure 7. plan view of the revit model the ground floor of the school

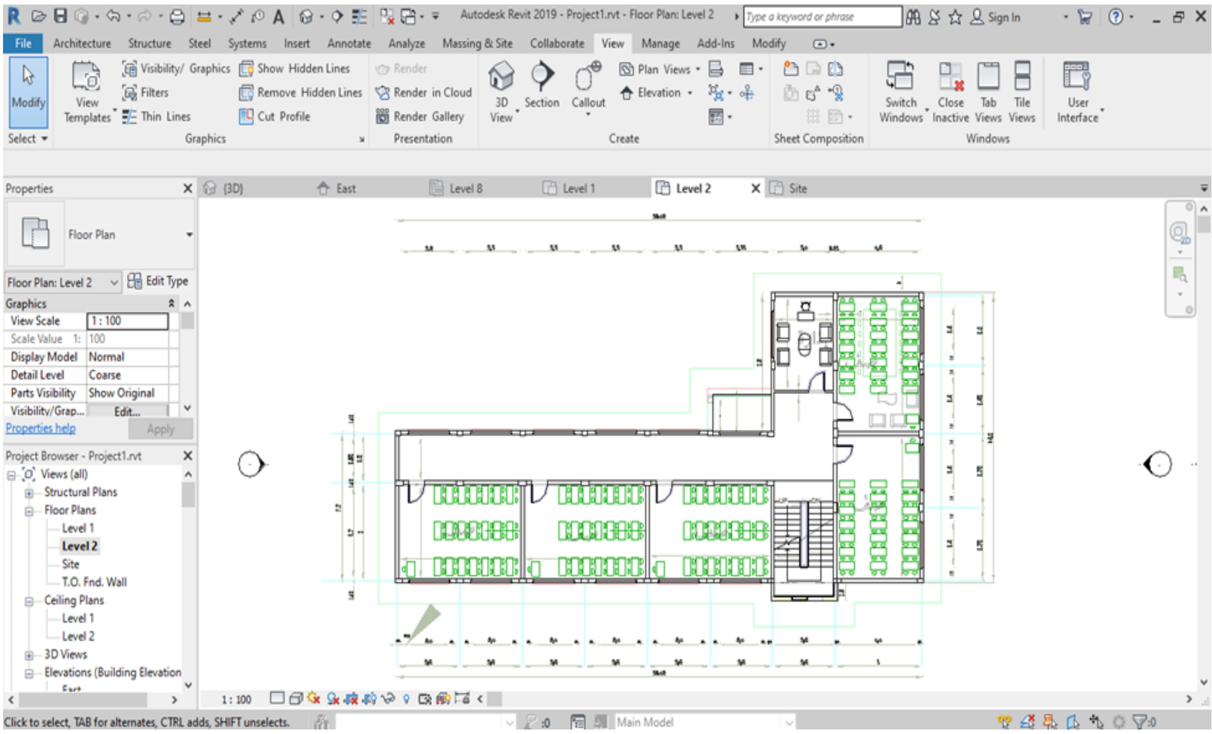

Figure 8. Plan view of the Revit Model the First and second floor

The model was transferred to the ETABS program according to the scientific controls of the transfer method to maintain the three-dimensional modeling to ensure the correct structural design and accurately simulate reality.

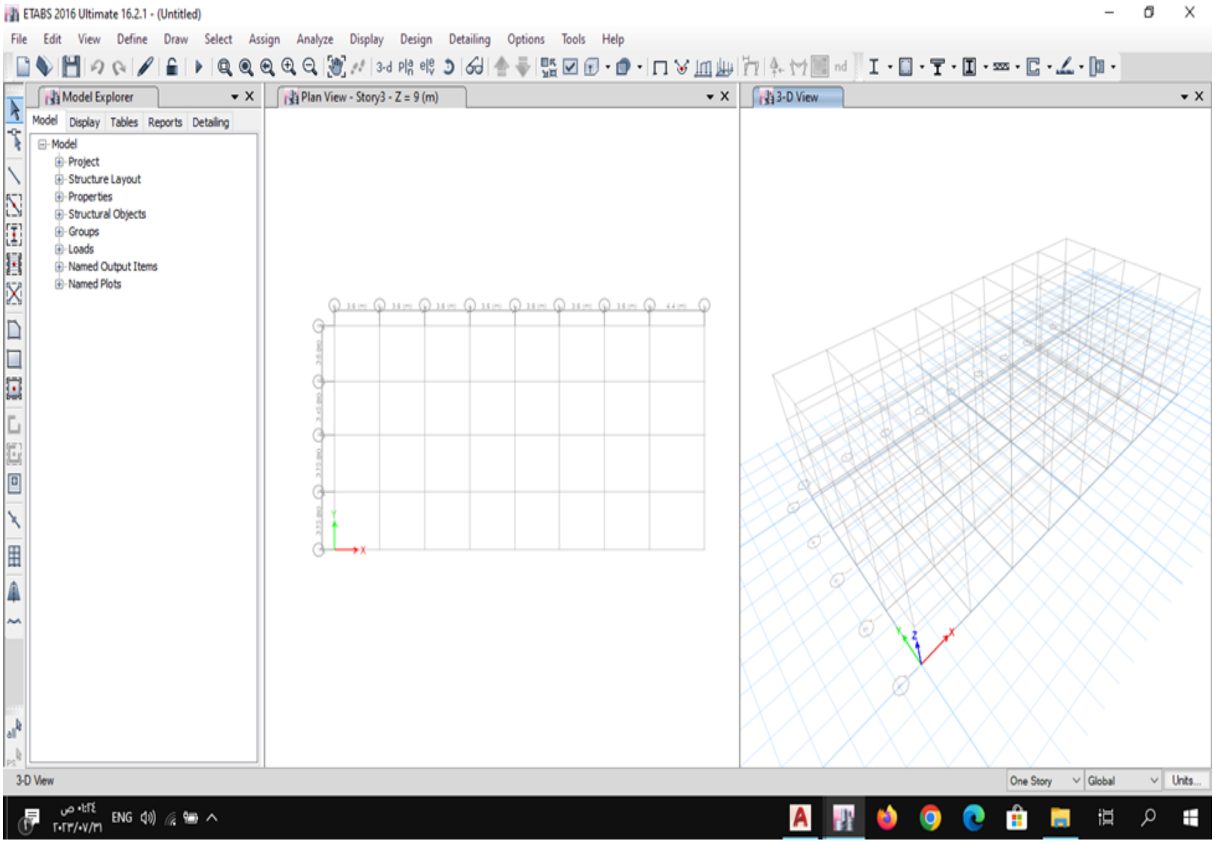

Figure 9. Analytical model of the ETABS

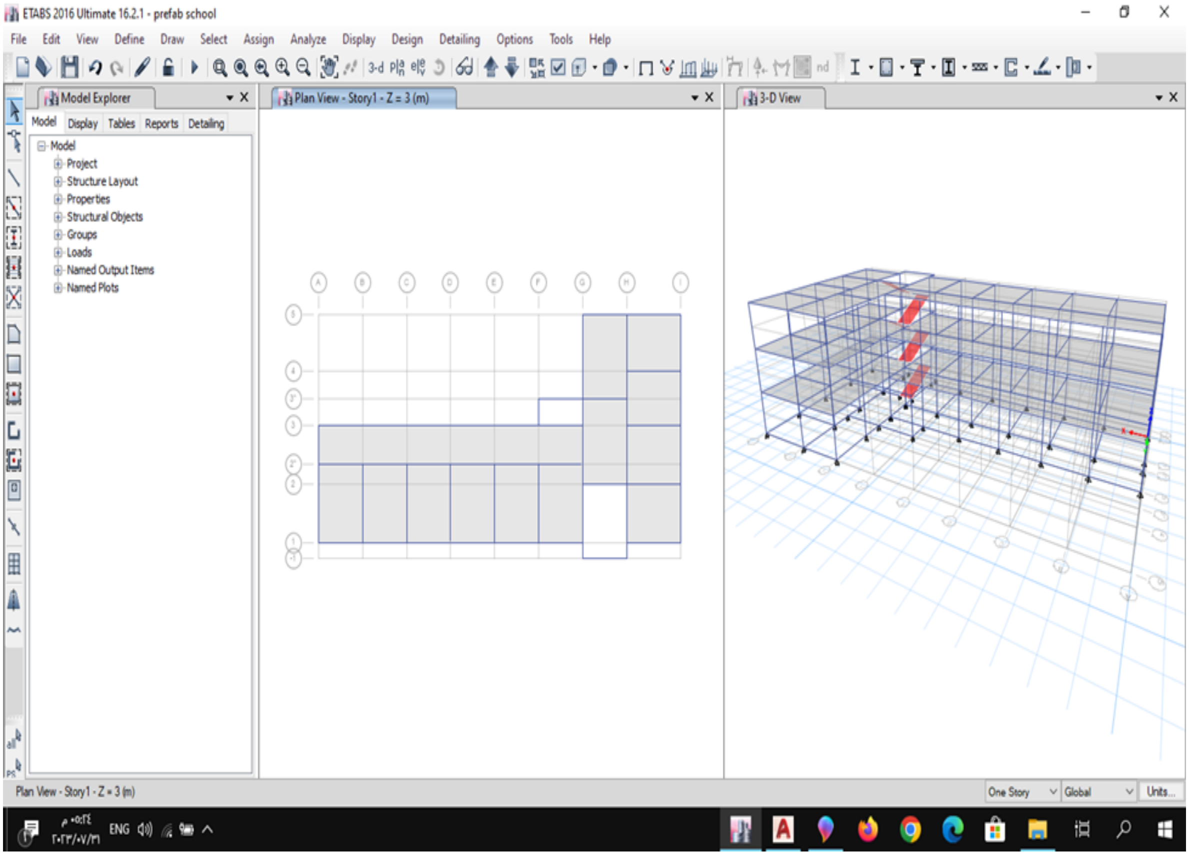

Figure 10. Analytical model of the ETABS

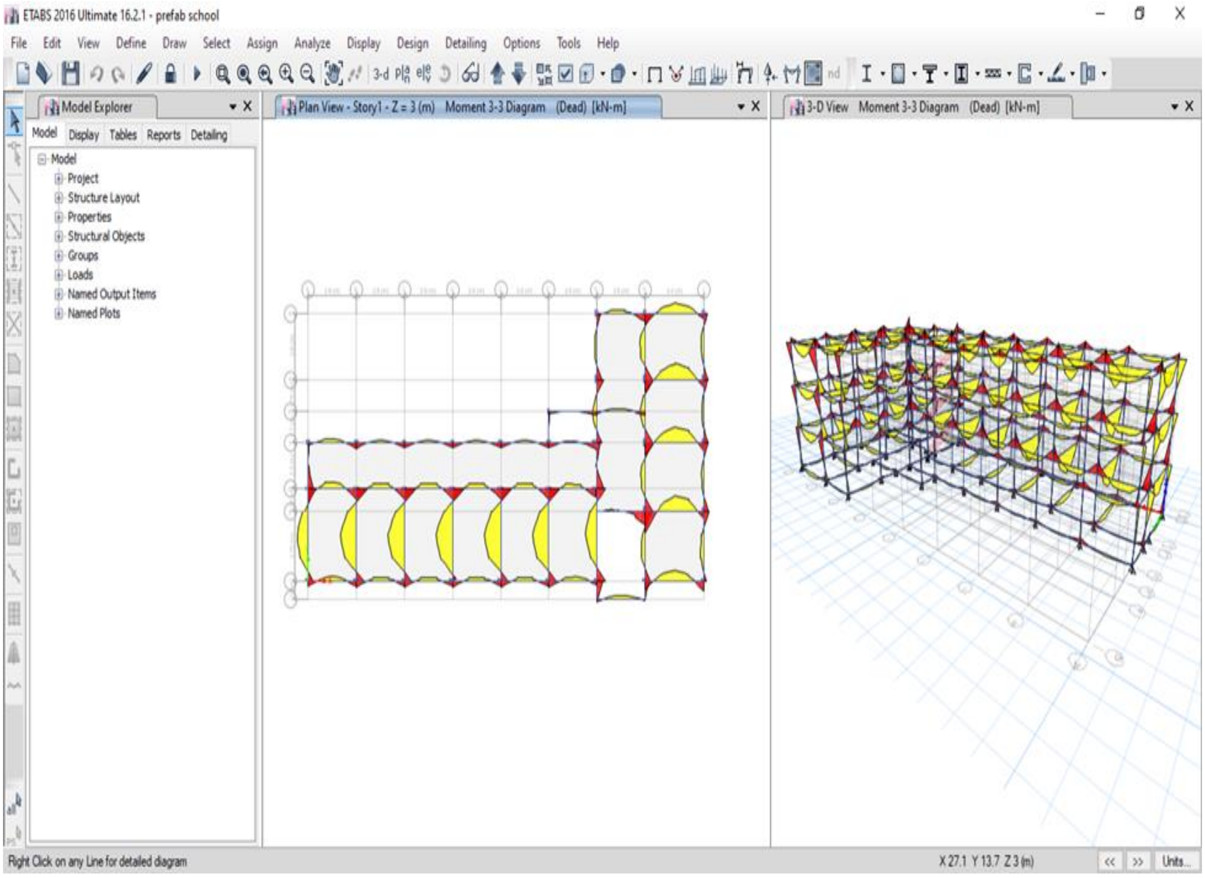

Figure 11: Analysis model at ETABS

The analytical results showed the quality and efficiency of the design to resist vertical and seismic forces, and all models created in the ETABS program were the necessary safety factors to ensure the same as those of the safety of the student model created in the Revit program. Then, they were transferred to the ETABS program.

7. Results and Discussion:

This section summarizes the connection between the software in use and the issues found. The insights offered in this paper can be extremely helpful to structural engineers as they select BIM tools to support their work. Users of a specific software program, such as Autodesk Revit or ETABS, typically explore the most advanced BIM tools offered by the same provider initially. The BIM tools, among those examined that currently demonstrate superior performance have been identified by this research. However, ongoing technological research in the field of BIM is constantly growing to produce better results, focusing on the study of interoperability in particular. The current study used various resources and looked at two types of data flow.

8. Conclusions:

The research project reviews the current interoperability between the most widely used BIM-based modeling and structural analysis tools for structural design. The main focus of the investigation's findings was on resolving the interoperability problems brought on by the transfer of models between software programs. Due to the similarity of their user interfaces, this benefit stands out in particular for Autodesk users of AutoCAD, Revit, and ETABS. ETABS takes precedence, displaying highly effective and accurate collaboration after evaluating the performance of both software options for the features under consideration.

The thorough evaluations of the effectiveness of every step of model transfer can provide valuable insights for prepared structural engineers who typically use conventional methods for their projects. The ease of the initial modeling task, the assurance of interoperability during the transfer of structural models between modeling and analytical systems, the use of modeling tool functionalities, and the capability of BIM tools to generate technical drawings and material quantity tables stand out as the primary benefits of using BIM tools for structural design.

9. Future recomandattion

Many significant recommendations can direct future researchers' work in Building Information Modeling (BIM) and its application in the architecture, engineering, and construction (AEC) industry. First, there needs to be more investigation into the potential of BIM in various project phases and across various software platforms. Researchers should concentrate on developing methodologies for seamless data exchange between BIM and structural analysis tools,
thus increasing interoperability and effectiveness, as this study has shown. Beyond the scope of the present case study, further investigation into the scalability and adaptability of BIM for various project types and sizes is required, for example, check Autodesk Revit's compatibility with other design programs like RISA, SAP2000, and SAFE.. Examining the long-term advantages and difficulties of BIM adoption through the AEC sector and its effects on sustainability and cost-effectiveness remains a crucial area of research. In addition, given that BIM's lifecycle utility is significant, researchers should look into how it can be used for other construction-related processes like facility management and maintenance.

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