CHAPTER 55

Diagrid Structure in High-Rise Building: A BIM Implementation, Risk Assessment and Safety Measures

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ABSTRACT

The evolving demand for innovative, efficient, and sustainable construction practices has led to the use of diagrid structures in high-rise buildings. Known by their diagonal grid patterns that eliminate the need for vertical columns, diagrids have major benefits in structural efficiency, material optimisation, cost-effectiveness and visual appeal. This study addresses the potential of diagrid structures in high-rise construction, highlighting their implementation using Building Information Modelling (BIM) tools. The performance of diagrid structures and traditional column-beam systems will be compared in this study. In order to provide useful insights for the adoption of diagrid structures in the Indian construction industry, this study aims to create a Project Management Framework (PMF) specifically designed for their lifecycle management by utilising BIM tools and sophisticated analysis techniques. In order to assess performance under a variety of load conditions, such as wind, seismic and gravity loads, the methodology involves using Autodesk Revit to create detailed 3D models of diarid and conventional structures, followed by structural analysis in ETABS. A comparison of energy consumption is made possible by Autodesk Insight's energy simulations, which are based on variables like location, material characteristics and orientation. Additionally, 5D analysis incorporates cost data for resource and expense management, while Navisworks 4D simulations show the construction timeline. By providing adaptable recommendations and a solid framework, this study contributes to the growing adoption of diagrid structures, promoting innovation, sustainability and efficiency in high-rise construction in India and beyond.

Keywords: Diagrid structures; High-rise buildings; Building Information Modelling (BIM) tools; Project Management Framework (PMF).

1.0 Introduction

Diagrid structures are becoming more and more popular as high-rise building demand creative and efficient structural systems rises.

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Triangulated in nature, diagrids improve lateral stability, maximise material use, and provide more design freedom. These buildings provide structural efficiency as well as aesthetic appeal, so removing the need for traditional vertical columns. Engineers and architects search for answers that strike a compromise between strength, material efficiency, and sustainability as urbanisation keeps buildings higher. Among the major benefits of diagrid buildings are better lateral stability, less material consumption, and alignment with environmentally friendly building techniques. High-rise buildings choose them since their geometric structure improves resistance against dynamic forces. In the Indian construction industry, the adoption of diagrid structures is gaining momentum, particularly with the integration of Building Information Modeling (BIM). BIM facilitates precise structural modeling, risk assessment, and project management, streamlining the construction process. Autodesk Revit, widely used in structural design, plays a crucial role in modeling and analyzing diagrid structures, allowing for better planning and execution.

Optimizing high-rise building designs for the Indian construction industry tends to become better in terms of efficiency and sustainability at a lower base cost. Traditional structural systems often lack integrated approaches that combine structural design with advanced project management tools, leading to inefficiencies. This study aims to resolve these problems, where BIM tools are used to study diagrid structures for energy efficiency, sequencing (4D analysis) and cost estimation (5D analysis)

Thus, this study intent to evaluate the feasibility and effectiveness of diagrid structures in high-rise construction, emphasizing their practical implementation through BIM. It explores their structural integrity, safety performance and efficiency in comparison to conventional structures. Additionally, the research investigates the integration of 4D and 5D BIM methodologies with energy performance analysis to enhance project scheduling, cost estimation and operational efficiency. By addressing these aspects, this study seeks to develop a structured framework for the design, analysis and practical application of diagrid structures, contributing to advancements in high-rise construction technology. Leveraging BIM tools such as Autodesk Revit and Navisworks, this research provides a comprehensive approach to optimizing diagrid adoption in modern construction.

The structure of this paper first explores diagrid structures by analyzing their performance and integration with BIM technologies. The literature review identifies key advancements in diagrid systems while highlighting existing research gaps in their practical implementation. The methodology involves a detailed workflow-3D modeling in Autodesk Revit, structural analysis in ETABS, and 4D & 5D BIM analysis in Navisworks to evaluate the constructability, scheduling efficiency and cost implications. By developing a structured project management framework (PMF), this study aims to provide practical guidelines for optimizing diagrid adoption in high-rise construction. The findings contribute to enhancing efficiency, reducing material waste and promoting sustainable design practices in modern construction projects.

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2.0 Literature Review

The evolution of structural systems in high-rise buildings has led to the adoption of diagrid structures as an alternative to traditional frameworks. Ali & Moon (2007) highlighted the benefits of diagrid systems, including enhanced lateral stiffness and reduced material usage. Their study demonstrated how diagrids, through their diagonally interconnected members, eliminate the need for conventional vertical columns, leading to both aesthetic and functional advantages. Moon *et al.* (2007) introduced a methodology for preliminary diagrid design, showing that diagrid angles between 60° and 70° optimize lateral resistance, reducing bending moments and improving overall structural efficiency.

Jani & Patel (2013) further analyzed the design and efficiency of diagrid structures in high-rise steel buildings using ETABS modeling. Their study concluded that diagrid systems can reduce material consumption by up to 20% while significantly improving lateral stiffness, reinforcing their economic and structural feasibility. Sustainability and energy efficiency are also significant considerations in diagrid system adoption. Asadi & Adeli (2017) explored the role of diagrids in sustainable high-rise buildings, demonstrating their ability to enhance energy efficiency by improving daylight penetration and natural ventilation, which in turn reduces operational costs. Rahila & Narayanan (2021) conducted an optimization study on multi-storey diagrid buildings using ETABS software to analyze different configurations. Their findings confirmed that shorter diagrid modules improve lateral stiffness, while longer modules enhance material efficiency, striking a balance between performance and cost. However, while these studies presented strong arguments for the structural and economic viability of diagrids, they often failed to integrate seismic performance considerations with sustainability aspects, creating a gap in understanding their full lifecycle impact.

In terms of seismic resilience, Kiran & Yogesh (2022) compared diagrid and conventional structures, concluding that diagrid frameworks experience 20-30% lower storey displacement under lateral loads, making them structurally superior in high-rise applications. Asadi *et al.* (2018) conducted a nonlinear time-history analysis to assess seismic performance and loss estimation in steel diagrid structures. Their study found that while diagrids offer superior resilience, they may experience higher floor accelerations, necessitating damping systems for improved performance. Vhanmane & Bhanuse (2020) examined material efficiency in diagrid buildings, showing that diagrid systems use significantly less steel while maintaining high structural stability, making them a cost-effective choice for high-rise construction. However, while these studies confirm the structural resilience of diagrid systems, most do not provide a comprehensive analysis of their performance in different seismic zones or compare their long-term behavior under dynamic loading conditions.

BIM has revolutionized construction management, yet its integration with diagrid systems remains underexplored. Azhar (2011) reviewed the trends, benefits, risks, and challenges of BIM adoption in the AEC industry, finding that BIM enhances design

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coordination, cost estimation, and project efficiency while reducing construction errors and rework. Criminale & Langar (2017) analyzed challenges in BIM implementation, identifying cost, interoperability, and training as the major barriers to adoption. Akkoyunlu (2018) explored parametric BIM façade module development for twisted diagrid structures, demonstrating that automated BIM workflows improve constructability and material efficiency.

Shahabian & Fadai (2019) developed an intelligent parametric BIM solution for diagrid structures, proving that algorithm-driven BIM modeling reduces material wastage by 15-20% and enhances structural efficiency. Misal *et al.* (2022) examined BIM integration in G+20 residential towers, confirming that 5D BIM analysis improves cost forecasting and scheduling efficiency, leading to better project management outcomes. Despite these findings, there is a lack of specific studies on the integration of 4D and 5D BIM with diagrid structures to optimize scheduling and cost estimation. Monteiro & Martins (2020) studied BIM-based quantity take-off methodologies, emphasizing that modeling guidelines improve material estimation accuracy and reduce procurement costs. Najid *et al.* (2024) proposed a framework for optimizing construction projects, finding that integrating BIM and data-driven scheduling techniques significantly enhances workflow efficiency. Leung & Tam (2015) demonstrated that extending daily working hours by two hours can lead to a 37.2% reduction in construction time, improving project delivery efficiency. However, research on the direct impact of BIM-driven scheduling and cost estimation on diagrid construction efficiency remains limited. Abanda *et al.* (2020) explored the use of a 4D/5D BIM-based framework for construction project scheduling risk management, emphasizing that current risk management techniques in construction suffer from fragmentation and lack of real-time assessment.

While studies have examined various aspects of diagrid structures, several critical gaps remain. Research on their dynamic and seismic performance often overlooks extreme conditions and long-term sustainability under seismic forces. Though diagrid systems are recognized for material efficiency, real-world assessments of their lifecycle sustainability and cost benefits are lacking. Despite BIM's potential for design accuracy, constructability, and safety management, its application in diagrid projects remains underexplored. Additionally, most studies focus on either structural performance or energy efficiency, failing to integrate structural, energy, and safety analyses into a comprehensive framework. Comparisons with conventional structures primarily assess isolated factors like material savings and load distribution rather than a holistic performance, safety, and sustainability comparison. Furthermore, there is a lack of research on 4D and 5D BIM applications for managing diagrid project timelines and budgets. Finally, standardized BIM-integrated project management frameworks tailored for diagrid structures are missing, despite their unique fabrication, transportation and assembly challenges.

3.0 Methodology

This study follows a structured stepwise approach to model, analyze and evaluate diagrid and conventional structures.

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- *Step 1:* Diagrid structures are designed for structural efficiency and material optimization. Steel ISLB beams are selected for their high strength-to-weight ratio, ensuring stability in tall buildings. The diagonal beam configuration eliminates vertical columns, optimizing space utilization and load transfer efficiency. A central core is incorporated to balance gravity loads and accommodate building services such as elevators and staircases.
- *Step 2:* Autodesk Revit is used to create 3D models for both diagrid and conventional structures, leveraging its BIM capabilities for accurate geometric representation.
- *Step 3:* 3D models are exported to ETABS, a software specialized in analyzing storey displacement, storey drift and structural performance under wind, seismic, and gravity loads.
- *Step 4:* Energy performance analysis is conducted using illuminance analysis and daylighting factors ensuring improved natural light penetration and reduced dependency on artificial lighting.
- *Step 5:* 4D and 5D BIM Simulations in Navisworks 4D and 5D BIM simulations are conducted in Autodesk Navisworks to enhance project planning and cost management. 4D analysis integrates construction scheduling with the 3D model, providing a visual timeline to detect conflicts before execution. 5D analysis incorporates cost estimation, improving budget tracking and resource allocation.
- *Step 6:* A Project Management Framework (PMF) is developed using PMBOK (Project Management Body of Knowledge) principles to effectively handle scheduling, resource allocation, and risk management for diagrid structures. This framework ensures that key project aspects such as scope, time, cost, and risks are well-coordinated. BIM tools play a crucial role in this process, with 4D BIM helping in project sequencing and coordination, while 5D BIM supports budgeting and cost control. By applying this approach, the framework provides a practical and efficient way to implement diagrid structures in high-rise construction, ensuring better planning, cost-effectiveness and sustainability.

This methodology combines BIM-based modeling, advanced structural analysis and project management techniques, ensuring diagrid structures are optimized for efficiency, safety and sustainability.

4.0 Data Analysis and Findings

This section provides a comprehensive evaluation of the comparative performance of diagrid and conventional structural systems in high-rise buildings. The analysis covers structural performance, energy efficiency, construction scheduling, and cost estimation. Advanced software tools, including Revit, ETABS and Navisworks, were utilized to evaluate different aspects of the structures. This study focuses on the design and analysis of a G+25 diagrid high-rise structure for mixed-use development, incorporating office and retail spaces. The project is located in Mumbai, India, which falls under Seismic Zone III, requiring a structural system that

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ensures adequate lateral stability and resilience against seismic forces. The building spans a total floor area of 150,000 sq. ft., designed to maximize functional efficiency while maintaining structural integrity.

Figure 1: Diagrid Model in Revit

Figure 2: Conventional Model in Revit

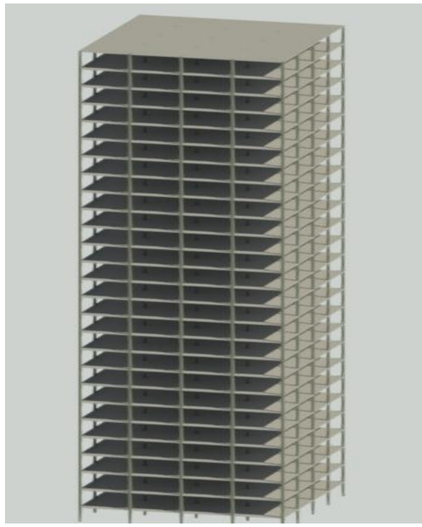

Table 1: Common Building Configuration

Plan dimension	24 m X 24 m (G + 25)
Height of typical storey	3 m
Slab thickness	150 mm
Column size	500 mm X 500 mm
Beam size	500 mm X 300 mm
Live load	3 KN/m2
Earthquake data	IS 1893 (part 1) – 2002
Type of soil	Medium soil
Safety factor	1.5
Response reduction factor	5
Type of structural systems	1) Rigid frame structural system 2) Shear wall structural system
Seismic Zone Factor	0.36

4.1 Structural analysis of diagrid and conventional structure in ETABS

The structural models were analyzed in ETABS to assess their performance under lateral and vertical loads. Both the diagrid and conventional structures were designed with

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identical floor plans and dimensions for a precise comparison. The diagrid structure consists of 25 storeys, each 3 meters high, with ISLB 600 sections used for diagonal members. A Revit model (Figure 1) was developed to visualize its framework and load distribution before exporting it to ETABS for analysis. Similarly, a conventional framed structure model (Figure 2) was created to study its column-beam arrangement and evaluate its structural efficiency against the diagrid system. The specifications of both structures are detailed in Table 1.

4.2 Storey displacement and storey drift analysis

Storey displacement and drift analyses were conducted to evaluate the lateral stability of both structural systems. Figure 3 presents the maximum storey displacement, with the X-axis representing storey levels and the Y-axis indicating lateral displacement (mm). The results show that the diagrid structure experiences 30-40% lower displacement than the conventional framed structure due to its efficient lateral load transfer mechanism. The displacement values highlight the superior lateral stiffness of the diagrid system, minimizing excessive movement and improving overall stability. Similarly, Figure 4 illustrates storey drift with storey levels on the X-axis and storey drift (unitless) on the Y-axis. The diagrid structure demonstrates significantly lower storey drift compared to the conventional system, ensuring better structural integrity under seismic and wind loads. Lower inter-storey drift reduces structural damage and enhances occupant safety.

Figure 3: Maximum Storey Displacement Graph for G+25 Buildings

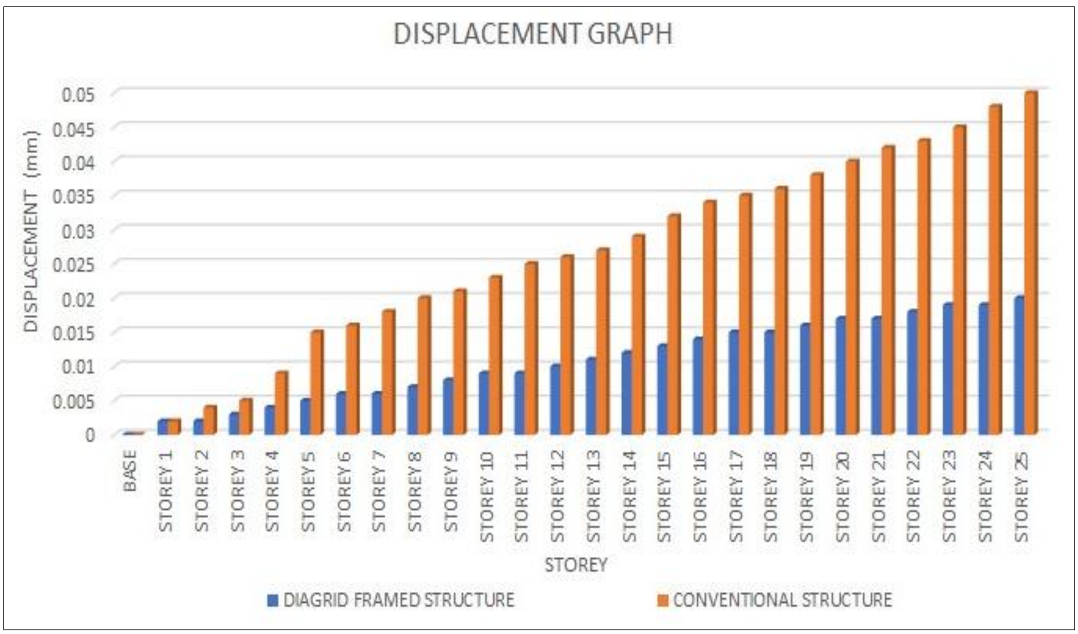

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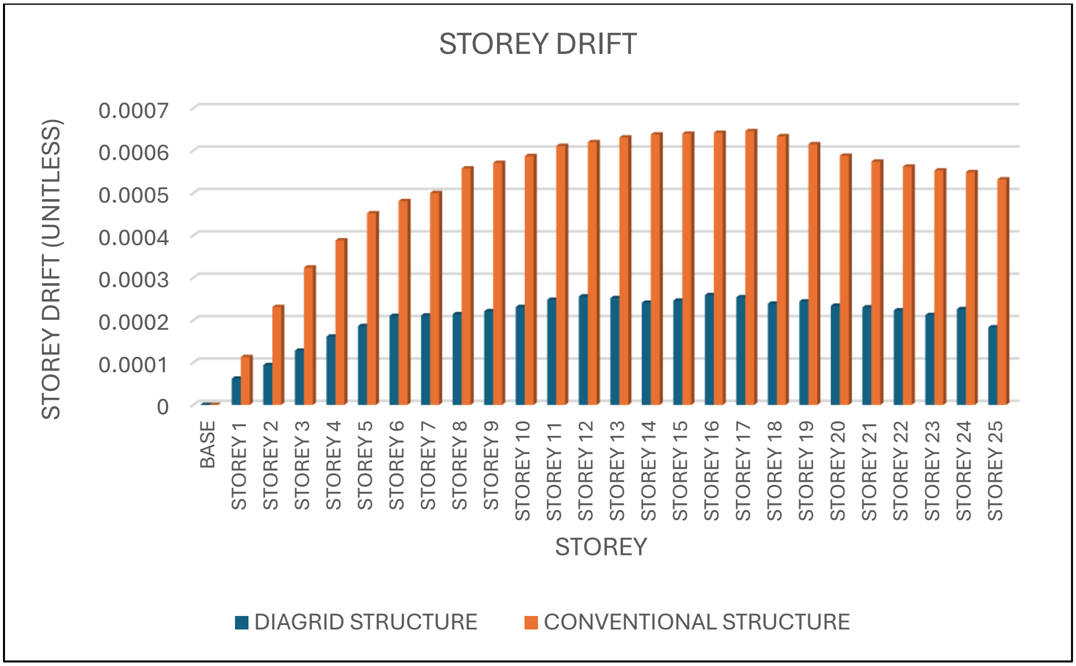
Figure 4: Maximum Storey Drift Graph for G+25 Buildings



As observed from the graph and confirmed by previous studies (Moon, 2011), effectively control lateral deformations due to their diagonally interconnected members, which enhance stiffness and load distribution. However, this study further validates these findings by conducting simulations under specific conditions relevant to high-rise construction in the Indian context, considering material properties, seismic factors, and construction methodologies unique to the region. By doing so, it provides additional insights into the practical applicability of diagrid systems beyond theoretical studies.

4.3 Energy analysis

High-rise buildings require substantial energy for lighting, cooling, and ventilation, making energy efficiency a crucial factor in sustainable design. This study evaluates the illuminance and daylight factor performance of diagrid and conventional structures using Revit Insight, focusing on natural light distribution, artificial lighting demand, and glare control. Figures 5 and 6 illustrate the illuminance analysis, measuring the amount of light reaching a surface. At 9:00 AM, the diagrid structure achieves 60% daylight coverage, reducing artificial lighting needs, while the conventional structure provides sufficient daylight in only 39% of the space. By 3:00 PM, the conventional structure attains 48% daylight exposure, surpassing the diagrid's 36%, but at the cost of higher glare levels.

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Figure 5: Illuminance Analysis Results for Diagrid Structure

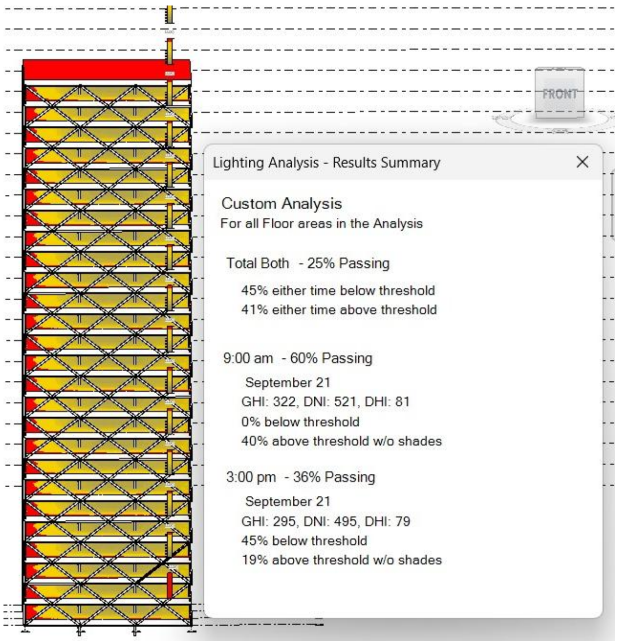


Figure 6: Illuminance Analysis Results for Conventional Structure

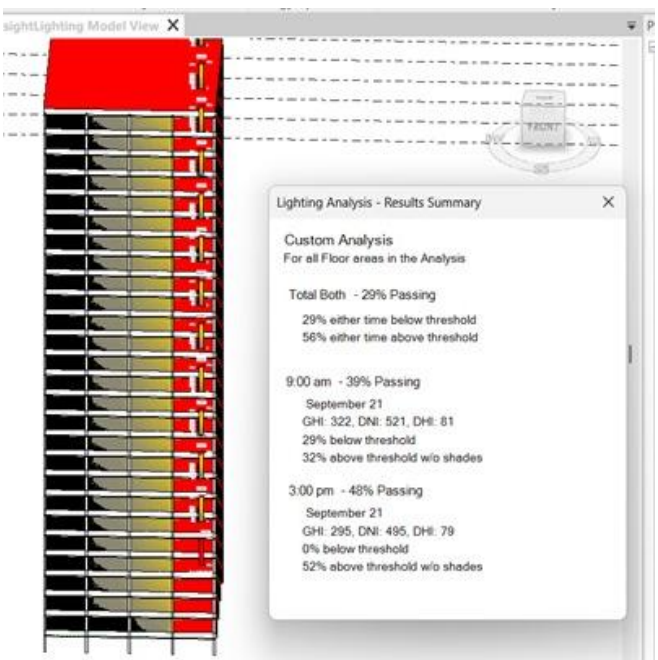


Figure 7: Daylight Factor Results for Diagrid Structure

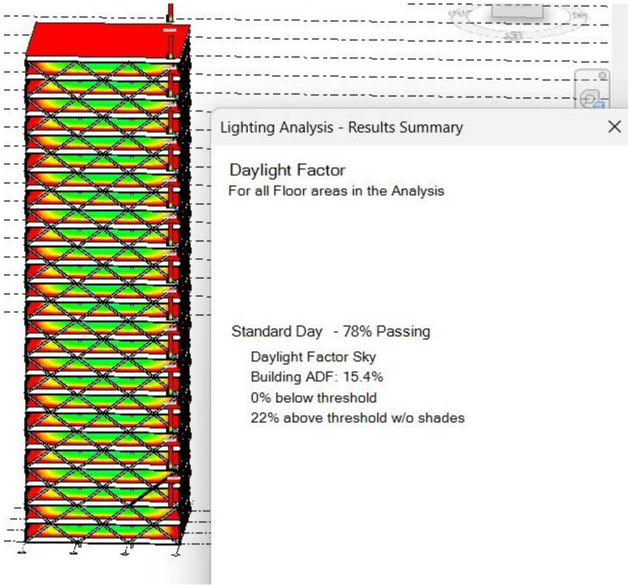
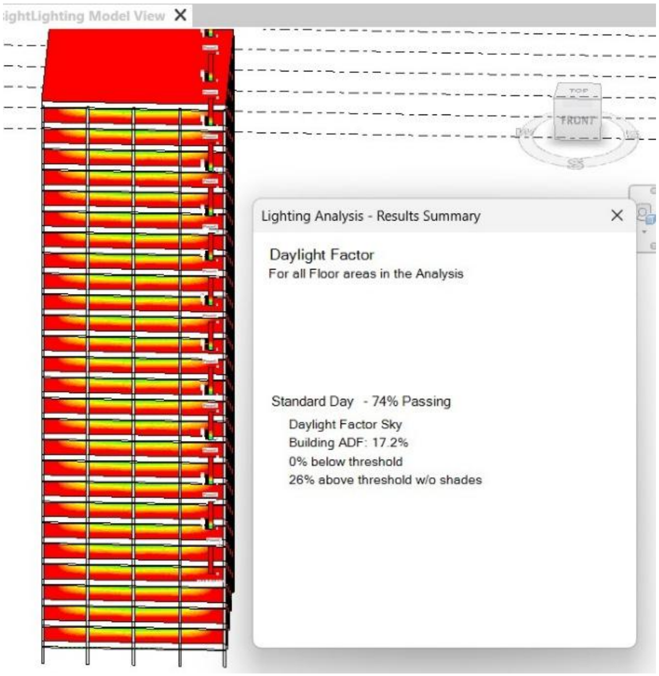


Figure 8: Daylight Factor Results for Conventional Structure



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Figures 7 and 8 compare daylight factor (ADF%), showing the conventional structure with 17.2% ADF, allowing more natural light but causing uneven distribution and glare issues, whereas the diagrid structure maintains 15.4% ADF, ensuring better light uniformity and occupant comfort. Table 2 summarizes the results, confirming the diagrid system's efficiency in space utilization, daylight uniformity, and glare reduction, while the conventional structure offers higher daylight penetration with increased glare concerns.

4.4 Scheduling and cost analysis

This study integrates Primavera P6 for advanced schedule planning and Navisworks for cost analysis and timeliner simulation to systematically evaluate the performance of diagrid structural systems against conventional column-beam frameworks.

4.4.1 4D BIM analysis (construction scheduling)

The diagrid system enables completion in approximately 2.2 years, whereas the conventional structure takes around 2.8 years. This reduction in construction time is primarily attributed to prefabrication techniques, modular assembly, and optimized structural design, which minimize on-site construction activities. Conversely, the conventional structure follows a sequential construction approach, leading to longer durations due to extensive formwork, reinforcement, and curing requirements.

Table 2: Energy Efficiency Comparison: Diagrid vs. Conventional Structures

Parameter	Conventional Structure	Diagrid Structure	Comparison
Floor Space Utilization	Less (more internal columns)	More (fewer internal columns)	Diagrid is better – More open space and flexibility in interior design.
Daylight Utilization	Higher daylight penetration but uneven	Balanced daylight distribution	Diagrid is better – More uniform daylight exposure.
Artificial Lighting Need	Higher due to glare in some areas	Lower due to controlled lighting	Diagrid is better – Requires fewer artificial lights.
Glare & Over-illumination (%)	56%	41%	Diagrid is better – Less glare, improving occupant comfort.
Morning Performance (9:00 AM)	39% Passing	60% Passing	Diagrid is better – Better light distribution in the morning.
Afternoon Performance (3:00 PM)	48% Passing	36% Passing	Conventional is better – More light exposure in the afternoon.
Daylight Factor (ADF%)	17.2%	15.4%	Conventional is better – More daylight but causes glare.
Energy Efficiency	Higher lighting energy demand	Lower lighting energy demand	Diagrid is better – Saves more energy.

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4.4.2 5D BIM analysis (cost estimation)

The Cost estimation analysis, conducted through Navisworks, combines material, labor and equipment costs with scheduling data. Findings based on the CPWD Schedule of Rates 2023 (Mumbai Region) and 2024 market rates indicate that while diagrid structures involve higher upfront costs due to prefabrication and specialized steel sections, their long-term financial benefits outweigh these expenses. Lower material wastage, reduced labor costs, and enhanced construction efficiency contribute to overall budget optimization. The cost breakdown comparison is presented in Table 3, emphasizing a total savings of ₹12 Cr in diagrid structures.

Table 3: Cost Breakdown Comparison

Cost Type	Diagrid Structure (₹ Cr)	Conventional Structure (₹ Cr)
Material Cost	33.99	27
Labor Cost	24	16.5
Equipment Cost	17.25	8.5
Total Cost	₹75.25 Cr	₹52 Cr

4.4.3 Material consumption and cost savings

The quantity take-off analysis using Navisworks reveals a 17.5% reduction in steel consumption for diagrid structures, primarily due to optimized load distribution and efficient lateral force transfer. As shown in Table 4, column steel usage is reduced by 88.5%, while beam steel consumption decreases by 80%, significantly lowering material costs. Additionally, prefabrication reduces on-site labor and installation expenses, while the simplified structural framework minimizes formwork, reinforcement, and welding costs. A 6-month shorter construction time further decreases labor, equipment, and site management costs. These factors collectively result in substantial cost savings, making the diagrid system a more economical and efficient alternative to conventional structures. Research by Moon *et al.* (2007) supports this, stating that diagrid systems reduce material usage by 15 to 20% compared to conventional structures.

Table 4: Steel Consumption Comparison between Diagrid and Conventional Structure

Structural Component	Conventional Steel Usage (tons)	Diagrid Steel Usage (tons)	Reduction (%)
Column Steel	98.4	11.25	**88.5%**
Beam Steel	108	21.6	**80%**
Total Structural Steel	1646.4	1357.64	**17.5%**

4.5 Project management framework

The Project Management Framework (PMF) developed in this study is inspired by the PMBOK Project Management Framework, which provides a structured approach to project

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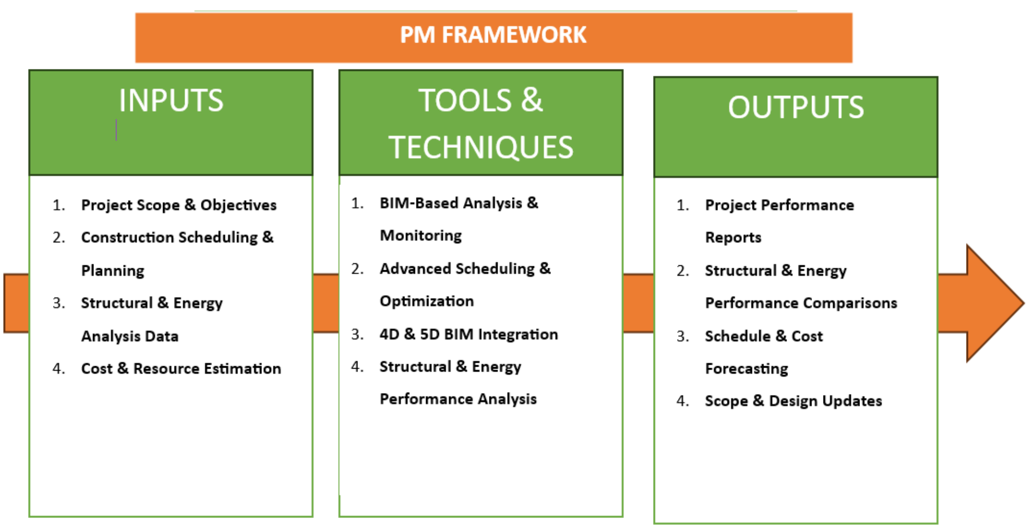
governance, risk management and execution. This framework is designed to address the unique challenges associated with high-rise diagrid structures by integrating structural analysis, cost estimation and scheduling to optimize efficiency, minimize risks and enhance overall project performance. Unlike conventional buildings, diagrid structures require intricate load distribution analysis due to their unique geometry. Cost estimation becomes more complex due to prefabricated components, reduced material consumption, and variations in labor costs, while scheduling is equally challenging as the prefabricated nature of diagrid elements influences sequencing and logistics. To overcome these challenges, a structured approach is necessary, leading to the introduction of the PMF, which systematically integrates Building Information Modeling (BIM) tools like Revit and Navisworks, scheduling tools like Primavera P6, and structural analysis software like ETABS in this study.

This framework is developed based on best practices from previous studies (Abanda *et al.*, 2020), BIM-based project controls and compliance with safety regulations such as IS 1893:2016 for seismic considerations. It incorporates key input parameters essential for project execution, including project scope and objectives, construction scheduling and planning, structural and energy analysis data, and cost and resource estimation. Project scope and objectives focus on lateral stability, load distribution and energy efficiency to ensure optimal structural performance.

Figure 9: Project Management Framework (PMF)



Construction scheduling and planning are carried out using Primavera P6, employing the Critical Path Method (CPM) to effectively sequence activities and prevent delays. Structural analysis data are gathered through ETABS, which assesses lateral stability, storey drift, and

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seismic resilience, while Energy analysis data through Autodesk Insight plugin from revit software is used for illuminance and daylight performance analysis to ensure energy efficiency. Cost and resource estimation are performed using 5D BIM integration, allowing precise breakdowns of materials, labor, and equipment costs. The PMF utilizes advanced digital tools for execution, including BIM-based analysis and monitoring, advanced scheduling and optimization, 4D and 5D BIM integration, structural analysis and energy performances. BIM-based analysis and monitoring in this study are conducted using Revit, which is used for 3D modeling, parametric design and seamless integration with structural analysis tools. It helps in analysing precise material specification and detailed visualization of structural components, ensuring better coordination before construction begins. Navisworks is used for 4D and 5D BIM simulations, where 4D BIM links the construction schedule with the 3D model, allowing for better sequencing and visualization of project timelines. 5D BIM integration enables cost estimation, budget tracking, and resource allocation, helping to improve financial planning and reduce project risks. Primavera P6 is used for detailed project scheduling and optimization, ensuring that all construction activities are well-coordinated and executed efficiently. The following Figure 9 illustrates the Project Management Framework (PMF), outlining its components and workflow.

5.0 Conclusions

This study highlights the structural and economic advantages of diagrid systems in high-rise construction. The findings confirm that diagrid structures offer superior lateral stability, seismic resilience and material efficiency compared to conventional structures. Their unique geometric configuration enhances load distribution, minimizing structural deformations under lateral forces. Additionally, energy performance analysis indicates that optimized daylight penetration in diagrid buildings reduces dependence on artificial lighting, contributing to overall energy efficiency.

A key aspect of this work was the integration of 4D and 5D BIM methodologies. The 4D BIM analysis shows that prefabrication in diagrid construction significantly reduces project duration, cutting approximately six months from the overall timeline. This efficiency minimizes labor dependency and accelerates project completion. Meanwhile, the 5D BIM cost assessment indicates that while the initial cost of diagrid structures is higher (₹75.25 Cr compared to ₹52 Cr for conventional systems), long-term savings in labor costs, reduced material wastage (17.5% of reduced steel usage) and operational efficiency overcome this investment. Over the building's lifecycle, these advantages make diagrid structures a cost-effective and high-performance solution for high-rise developments.

Beyond the direct structural benefits, diagrid systems contribute to the broader objectives of sustainable and resilient urban development. Their material optimization aligns with sustainable construction practices and promoting resource efficiency. These insights

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provide a valuable foundation for architects, engineers and project managers aiming to implement innovative structural solutions in high-rise construction.

5.1 Recommendations

While this study establishes the advantages of diagrid structures, future research should explore their potential through advanced technologies. Digital twin technology can be integrated to enable real-time monitoring, predictive maintenance, and performance analysis, ensuring enhanced building efficiency and longevity. Additionally, BIM-based energy simulations should be expanded to support the development of net-zero energy buildings, reinforcing the role of diagrid structures in sustainable construction. Automation and robotics in construction present another promising avenue for improving the implementation of diagrid structures. Advanced fabrication methods, such as automated welding and modular assembly, can enhance precision and reduce onsite labor requirements. Furthermore, integrating a comprehensive risk assessment framework within BIM can improve uncertainty management, allowing for better decision-making during design and construction implementation.

References

Abanda, H., Musa, A. M., Clermont, P., & Tah, J. H. M. (2020). A BIM-based framework for construction project scheduling risk management. *International Journal of Computer Aided Engineering and Technology, 12*(2), 182.

Akkoyunlu, T. (2018). Parametric BIM facade module development for diagrid twisted structures. In *35th International Symposium on Automation and Robotics in Construction (ISARC)*.

Ali, M. M., & Moon, K. (2007). Structural developments in tall buildings: Current trends and future prospects. *Architectural Science Review, 50*(3), 205–223.

Asadi, E., Li, Y., & Heo, Y. A. (2018). Seismic performance assessment and loss estimation of steel diagrid structures. *Journal of Structural Engineering, 144*(10), 04018179.

Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. *Leadership and Management in Engineering, 11*(3), 241–252.

Bais, N. S., & Khutemate, A. (2021). The effectiveness of diagrid structure over conventional frame structure for high-rise buildings. *International Research Journal of Engineering and Technology (IRJET), 8*(6), 4538–4542.

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Criminale, A., & Langar, S. (2019). Challenges with BIM implementation: A review of literature. In *53rd ASC Annual International Conference Proceedings* (Issue 7, Aug-2019).

Deshpande, R. D., Patil, S. M., & Ratan, S. (2015). Analysis and comparison of diagrid and conventional structural system. *International Research Journal of Engineering and Technology (IRJET), 2*(3), 2295–2300.

Fathy, A., & Abdrabou, A. (2019). Optimization of scheduling in high-rise buildings using BIM and prefabrication methods. *Journal of Construction Engineering and Management*.

Gao, X., & Chen, Y. (2016). Research on BIM technology in construction safety & emergency management. In *4th International Conference on Renewable Energy and Environmental Technology (ICREET)* (Vol. 112).

Khan, Y., & Sironiya, S. (2024). Enhancement of load bearing capacity in diagrid multistory building with observed torsion. *International Journal of Science, Engineering and Technology, 12*(2).

Leung, A. W. T., & Tam, C. M. (2015). Scheduling for high-rise building construction using simulation techniques. *Construction Informatics Digital Library*.

Misal, V. U., Diwani, H. B., Rane, T. R., Kadam, S. S., & Shashikumar, A. (2022). Planning, analysis and building information modeling (BIM) of G+20 residential tower. *International Journal of Research in Engineering, Science and Management (IJRESM), 5*(5).

Monteiro, A., & Martins, J. P. (2013). A survey on modeling guidelines for quantity take-off oriented BIM-based design. *Automation in Construction, 35*, 238–253.

Moon, K., Connor, J. J., & Fernandez, J. E. (2007). Diagrid structural systems for tall buildings: Characteristics and methodology for preliminary design. *The Structural Design of Tall and Special Buildings, 16*(2), 205–230.

Najid, S. V. P., Santhosh, A., Gupta, A., & Ansari, M. A. A. (2024). Framework for the optimization of construction project. *African Journal of Biomedical Research, 27*(4s).

Shahabian, A., & Fadai, A. (2019). Intelligent parametric BIM solution and optimizer for diagrid high-rise structures. In *Vienna Young Scientists Symposium (VSS2019)*, June 2019.

Thakur, A. S., Jadhav, P. P., Durge, J. U., Kadam, B. P., & Hipparkar, D. P. (2020). Analysis and design of G+3 storey and G+25 storey RC frame building structures as per Indian standard codes. *International Research Journal of Engineering and Technology (IRJET), 7*(2).

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