Integrated Planning and Development of KSRTC Bus Terminal Thrissur

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Abstract

This project focuses on the comprehensive planning, design, and structural analysis of a modern, sustainable bus terminal to enhance urban mobility and transportation efficiency. The proposal integrates essential infrastructure, including a fully functional terminal building, dedicated parking zones for buses, cars, and bikes, and a pedestrian-friendly walkway connecting the terminal to the railway station for seamless multimodal connectivity. The objective is to create a user-friendly, structurally sound facility that ensures optimal traffic flow and passenger convenience. Structural analysis ensures safety and compliance with IS codes, while quantity surveying and cost estimation assess material requirements and feasibility. Preliminary findings show that the integrated design improves space utilization, reduces congestion, and enhances the passenger experience. By incorporating sustainability and structural optimization, the project offers a cost-effective, efficient, and future-ready transport hub for Thrissur.

Keywords: Bus Terminal, Integrated Planning, Structural Analysis, Urban Mobility, Transportation Infrastructure, Cost Estimation, Civil Engineering.

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1. Introduction

The Integrated Planning and Development of KSRTC Bus Terminal, Thrissur aims to create a modern, efficient, and sustainable transport hub that enhances urban mobility and connectivity. With increasing urbanization and transportation demands, the need for a well-planned terminal that optimizes space utilization, minimizes congestion, and improves passenger experience is crucial. This study focuses on the architectural and functional design, structural analysis, and cost estimation of the proposed terminal while ensuring compliance with relevant standards and codes.

The project incorporates essential infrastructure, including a fully functional terminal building, designated parking for buses, cars, and bikes, and a pedestrian-friendly walkway connecting the terminal to the nearby railway station. By integrating these components, the design promotes seamless multimodal transport connectivity. Structural analysis ensures the safety and stability of the terminal, while quantity surveying and estimation evaluate material requirements and project feasibility. Sustainability features, such as rainwater harvesting and solar panels, are incorporated to enhance environmental efficiency.

Figure 1: KSRTC Bus Terminal Thrissur

The proposed design aligns with modern transportation infrastructure standards and provides a cost-effective, future-ready solution to meet Thrissur's growing urban demands. This study serves as a foundation for future developments in transport planning, emphasizing the need for well-integrated, sustainable, and passenger-centric urban transit solutions. Figure 1 shows the existing KSRTC Bus Terminal in Thrissur, providing a visual representation of the site for which the integrated planning and development are being proposed.

1.1. Objectives of the Study

This study focuses on the following objectives:

- To develop an efficient and well-structured bus terminal that enhances urban mobility and meets the growing transportation demands of Thrissur.
- To propose architectural and functional designs that enhance passenger convenience, including waiting areas, ticketing facilities, and commercial spaces.
- To optimize space utilization and traffic flow through strategic planning of parking zones for buses, cars, and bikes, reducing congestion and improving accessibility.
- To conduct structural analysis of the terminal building ensuring stability, safety, and compliance with IS codes.
- To propose architectural and functional designs that enhance passenger convenience, including waiting areas, ticketing facilities, and commercial spaces.

1.2 Scope of the Study

The research focuses on the integrated planning and development of the KSRTC Bus Terminal, Thrissur, aiming to create a modern, efficient, and sustainable transportation hub. The study covers various aspects of terminal design, structural analysis, and cost estimation, ensuring an optimized and well-planned infrastructure. Key areas of investigation include:

- Enhancing traffic flow and integrating a pedestrian-friendly walkway to the railway station.

- Efficient space utilization for waiting areas, ticketing zones, commercial spaces, and parking.
- Ensuring stability and adherence to IS codes through structural analysis.
- Improving circulation plans for better accessibility and travel experience.

1. Softwares

1.1. Software Used

The various softwares used in this project work are described below.

Auto-CAD

AutoCAD is a powerful computer-aided design (CAD) software essential for drafting, designing, and modeling in civil engineering projects. In the Integrated Planning and Development of KSRTC Bus Terminal, Thrissur, AutoCAD plays a vital role in creating precise 2D and 3D representations of the terminal layout, infrastructure components, and functional zones. It is used to develop architectural plans, including the terminal building, waiting areas, ticketing zones, commercial spaces, and pedestrian pathways. The software enables detailed structural drafting, such as floor plans, elevations, and sectional views, ensuring accuracy in construction. Additionally, AutoCAD helps in designing efficient parking layouts for buses, cars, and bikes, optimizing traffic circulation within the terminal premises. It also aids in mapping the pedestrian-friendly walkway connecting the bus terminal to the nearby railway station, enhancing multimodal connectivity. The software's advanced tools facilitate space optimization, dimensioning, and layering, ensuring that every aspect of the design is well-structured and meets industry standards. Furthermore, AutoCAD allows seamless integration with structural analysis software like STAAD.Pro and visualization tools like 3ds Max, enabling a comprehensive approach to planning, analysis, and presentation. By leveraging AutoCAD, the project ensures precision, efficiency, and ease of modification, contributing to the development of a well-planned and sustainable transportation hub. Figure 2 shows the interface of AutoCAD, representing the software environment used for drafting and designing various structural and architectural elements of the project.

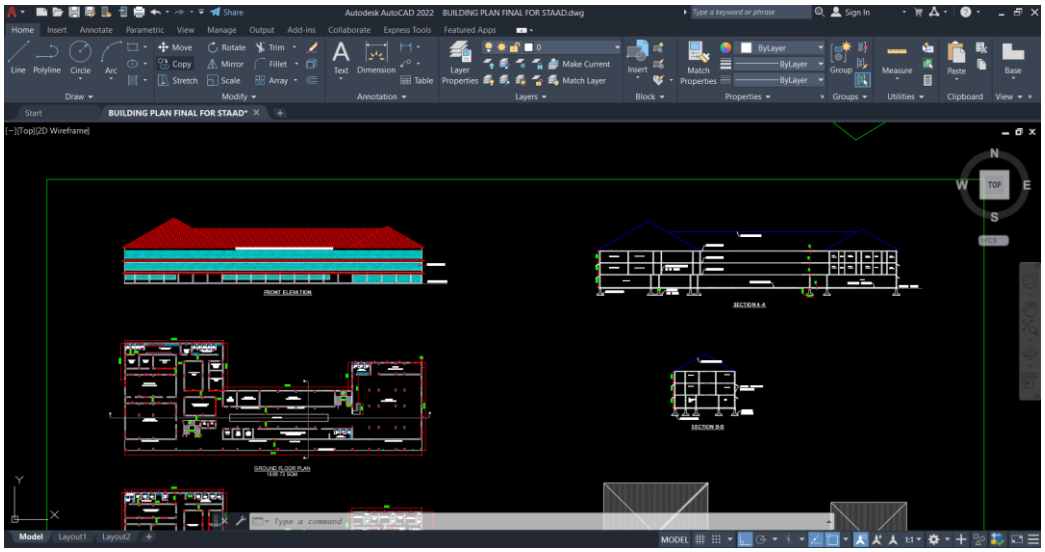

Figure 2: Auto-CAD

STAAD PRO

STAAD.Pro is a widely used structural analysis and design software that plays a crucial role in ensuring the stability, safety, and efficiency of civil engineering structures. In the Integrated Planning and Development of KSRTC Bus Terminal, Thrissur, STAAD.Pro is employed for analyzing and designing the structural components of the terminal building, ensuring compliance with IS codes and other relevant engineering standards. The software enables precise evaluation of various load conditions, including dead loads, live loads, wind loads, seismic forces, and vehicle-induced vibrations, which are critical for a high-traffic transportation hub. By using finite element analysis, STAAD.Pro helps determine stress distribution, deflection, and reinforcement requirements for key structural elements such as beams, columns, slabs, and foundations, ensuring that the structure remains safe and durable under all loading conditions. The software also provides advanced material optimization tools, allowing the selection of the most efficient structural configurations while maintaining cost-effectiveness. Additionally, STAAD.Pro facilitates accurate modeling of the terminal's complex infrastructure, enabling engineers to visualize potential structural issues before actual construction begins. Its integration with AutoCAD for design inputs and MS Excel for quantity estimation further enhances workflow efficiency, making it a vital tool in the project's planning and execution. By leveraging the capabilities of STAAD.Pro, the project ensures that the KSRTC Bus Terminal is not only structurally sound but also designed to withstand future expansions and increased usage, contributing to the development of a sustainable and well-engineered transport facility. Figure 3 shows the interface of STAAD.Pro, illustrating the software workspace used for structural analysis and design in the project.

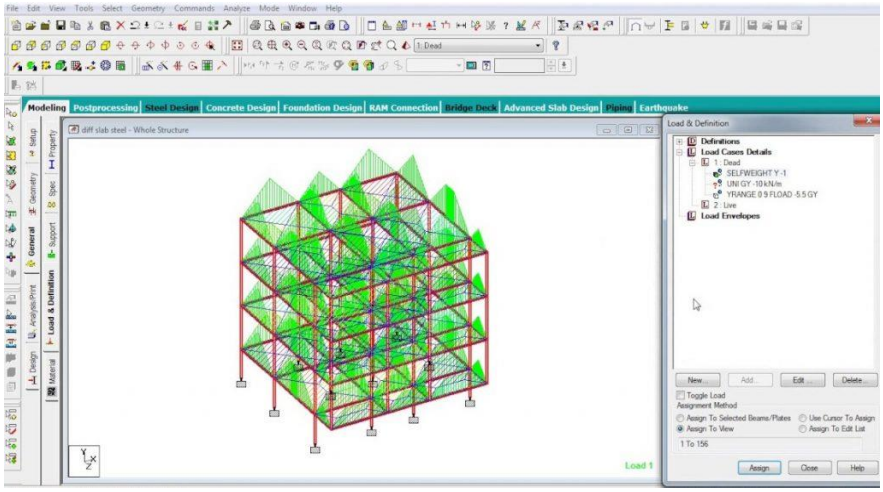

Figure 3: STAAD PRO

MS EXCEL

MS Excel is an essential tool in civil engineering, widely used for data management, cost estimation, and project planning. In the Bus Integrated Planning and Development of KSRTC Terminal, Thrissur, MS Excel plays a crucial role in quantity surveying, structural data analysis, and financial planning, ensuring efficient resource allocation and cost control. One of its primary applications in the project is preparing the Bill of Quantities **(**BOQ**)**, which helps in estimating the materials required for construction, labour costs, and overall project expenditure. By

utilizing built-in formulas and functions, engineers can perform precise calculations for material takeoff, reinforcement detailing, and cost breakdowns, significantly reducing manual errors and improving accuracy. Additionally, MS Excel's data visualization tools, such as pivot tables, charts, and graphs, enable a clear representation of financial data, construction timelines, and resource distribution, which aids in better decision-making. The software also assists in tracking project progress by maintaining construction schedules, work logs, and budget reports, allowing real-time monitoring of resource usage and preventing cost overruns. Its ability to automate repetitive calculations and generate structured reports improves workflow efficiency, making it a vital tool in civil engineering project management. Furthermore, Excel seamlessly integrates with AutoCAD and STAAD.Pro, allowing easy transfer of design-related data for structural validation and analysis. By leveraging MS Excel, the project ensures accurate cost estimation, systematic planning, and effective financial management, ultimately contributing to the development of a structurally sound, economically viable, and efficiently managed transportation hub that meets modern urban infrastructure standards. Figure 4 shows the interface of MS Excel, which is used in the project for various calculations, cost estimation, and data management.

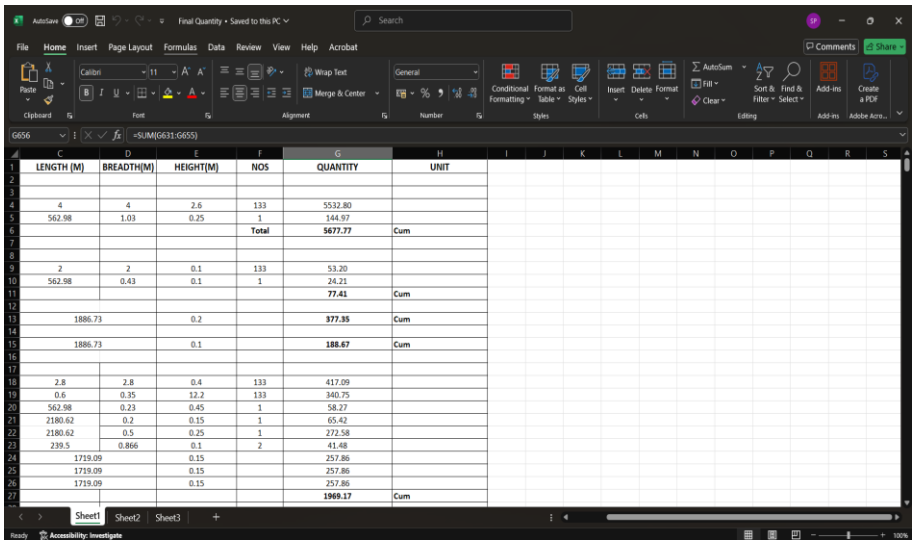

Figure 4: MS Excel

3. Project Methodology and Design Implementation

The Project Methodology and Design Implementation for this study involves a detailed assessment of the KSRTC Thrissur Bus Stand redevelopment, encompassing project planning, structural analysis, cost estimation, and quantity surveying. The objective is to develop a functional, sustainable, and efficient design that meets transportation demands while optimizing structural integrity and cost-effectiveness.

3.1 Bus Terminal Planning

The project planning and design were carried out based on an existing site investigation report obtained from the relevant authorities, which included details of soil exploration, borehole testing, and feasibility analysis. The provided report contained Standard Penetration Test (SPT) results and laboratory test data as per IS 2720, which

helped in understanding the soil characteristics, bearing capacity, and suitable foundation type for the proposed structure. Using this information, the preliminary design and layout of the bus stand were prepared in AutoCAD, ensuring optimal land utilization and efficient passenger movement while complying with IS codes and transportation infrastructure guidelines.

The bus terminal building was designed with a ground floor area of 1886.73 square meters and first and second floors of 1719 square meters each. The ground floor includes key facilities such as a large canteen, air-conditioned and non-air-conditioned waiting areas, KSRTC office, police head post, booking and ticket counters, and various commercial spaces to support business activities. A mini food court and canteen were incorporated to accommodate up to 300 people at a time. Additionally, provisions were made for separate wash areas for men and women, a dedicated washroom for disabled individuals, a driver's resting area, a janitor's room, and a medical clinic. Figures 5 and 6 illustrate the detailed ground floor, first floor, and second floor plans, providing a comprehensive layout of the proposed design. Figures 7 and 8 present the elevation and sectional elevation views, highlighting the overall building form and its structural characteristics.

The first and second floors were designed to include separate dormitories for men and women, along with single and double-bed rooms, providing accommodation for approximately 100 people within the terminal. Separate living spaces for KSRTC workers were also incorporated into the design. Detailed elevation and section drawings were created to ensure clarity in construction and execution.

As part of the proposal, a walkway was designed to provide seamless connectivity between the bus terminal and the railway station. Additionally, a four-story mechanical car parking facility was proposed to accommodate both public vehicles and KSRTC users, ensuring efficient space utilization and improved traffic management.

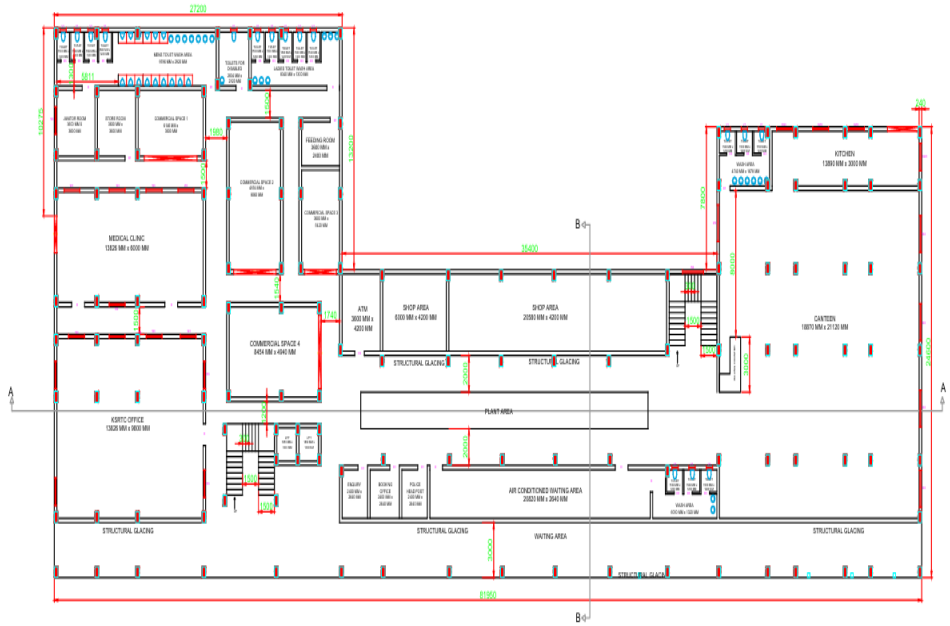

Figure 5: Ground Floor Plan of Building

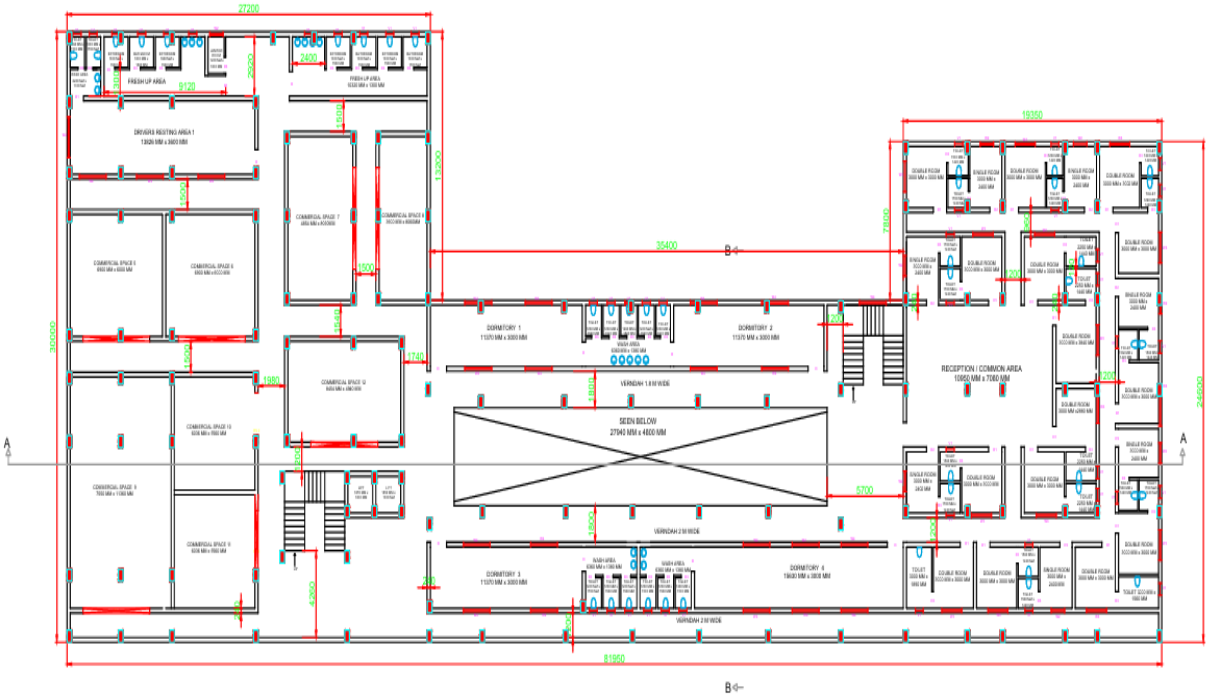

Figure 6: First and Second Floor Plan of Building

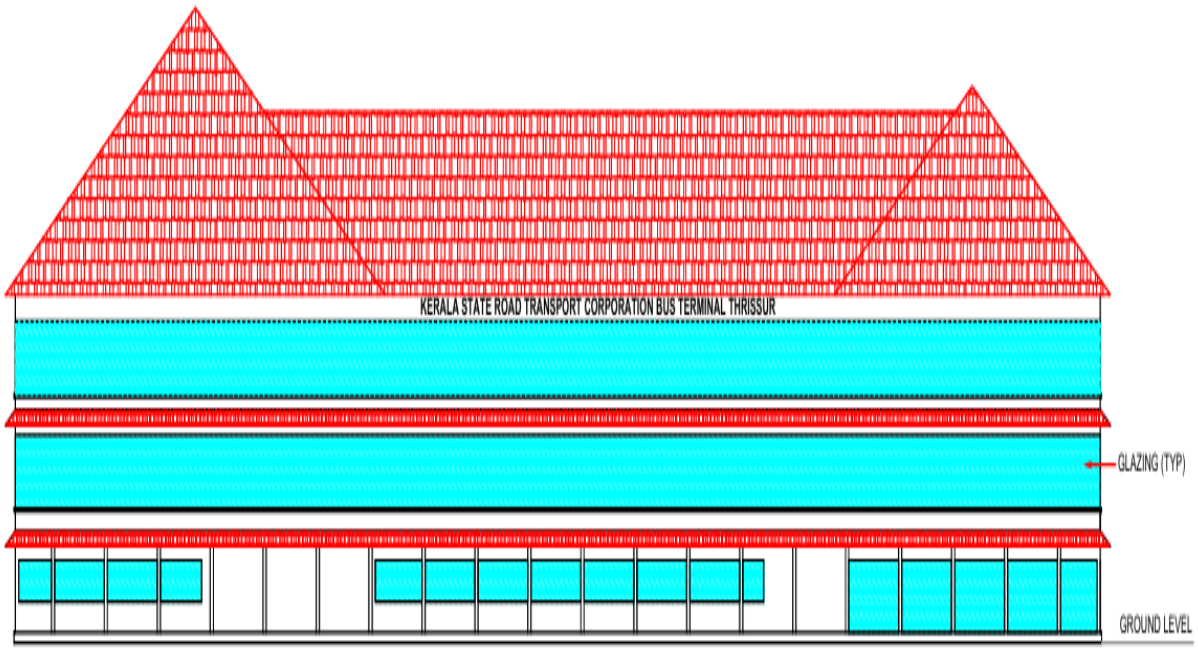

Figure 7: Elevation of Building

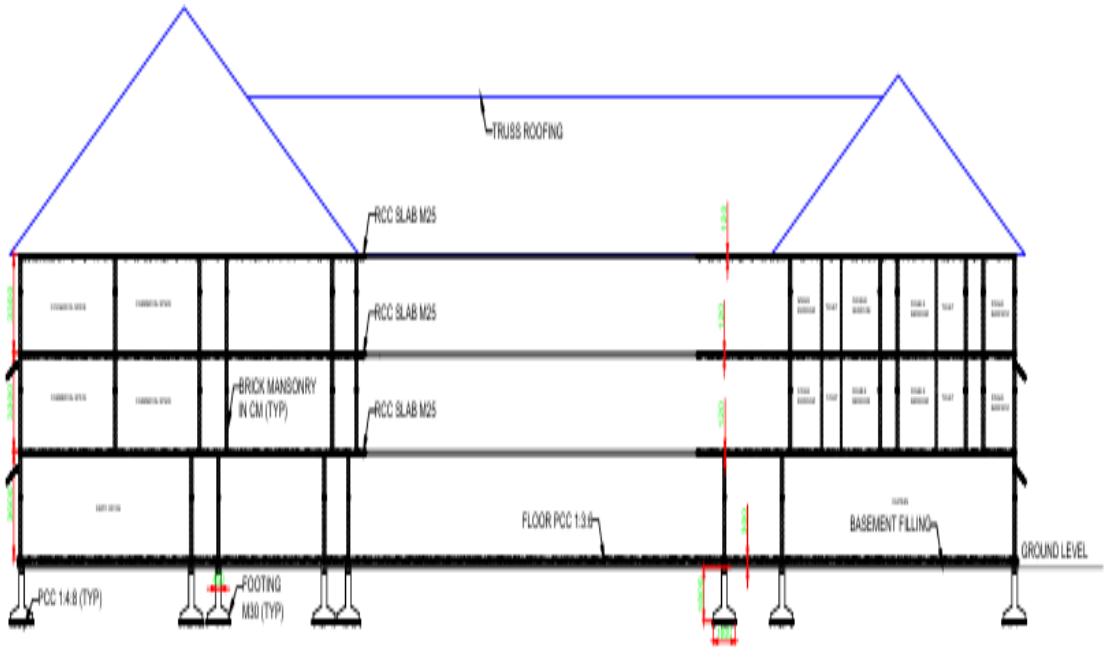

Figure 8: Elevation Section of Building

3.2 Structural Analysis Of KSRTC Bus Terminal

The structural analysis of the KSRTC Thrissur Bus Terminal was conducted using STAAD.Pro to ensure the building's stability, strength, and structural integrity under various loading conditions. The analysis included dead loads, live loads, wind loads, and seismic loads, adhering to IS codes and engineering standards. The AutoCAD layout of the terminal was manually transferred to STAAD.Pro for modeling, and the materials used for the structure were selected as reinforced concrete, with properties and constants as per IS codes.

The analysis considered multiple load cases, including self-weight, dead load, live load, and load combinations generated using STAAD.Pro built-in auto-load generator. A total of 8 basic load cases and 26 combination load cases were analyzed, including seismic loads acting in different directions. The axial force, bending moment, shear force, and deflection of the structure were thoroughly evaluated to ensure structural stability. Figure 9 illustrates the axial force analysis of the building, Figure 10 presents the bending moment distribution, Figure 11 depicts the shear force analysis, and Figure 12 shows the deflection of the structure, providing a comprehensive visualization of the structural response under applied loads.

3.2.1 Analysis Results

- Maximum Node Displacement:
  - X-Direction: 40.450 mm under 1.5 DL + 1.5 Seismic (X Direction)
  - Y-Direction: 12.324 mm under 1.5 DL + 1.5 LL
  - Z-Direction: 37.191 mm under 0.9 DL + 1.5 Seismic (Z Direction)
- Beam Displacement Summary:
  - Maximum Beam Displacement: 41.904 mm under 1.5 DL + 1.5 Seismic (X Direction)

- Minimum Beam Displacement: 35.210 mm under 0.9 DL - 1.5 Seismic (X Direction)

- Axial Forces, Bending Moments & Shear Forces:
  - Structural elements were analyzed to ensure they withstand the applied loads without failure.
  - The bending moment and shear force values remained within permissible limits, ensuring the structural stability of the building.

The analysis results provided node displacement summaries, beam displacement details, and overall structural response under various loading conditions. The maximum and minimum displacements, rotations, and forces were extracted to verify that the structure remains within permissible limits. Additionally, seismic load combinations were analyzed to assess the terminal's resistance to earthquake forces. The structural design ensures that the building can withstand various forces and environmental conditions while maintaining safety and durability.

The final results confirmed that the structure meets safety requirements and is optimized for long-term performance. This comprehensive structural analysis plays a crucial role in ensuring that the redeveloped KSRTC Thrissur Bus Terminal is a safe, efficient, and sustainable facility for public transportation.

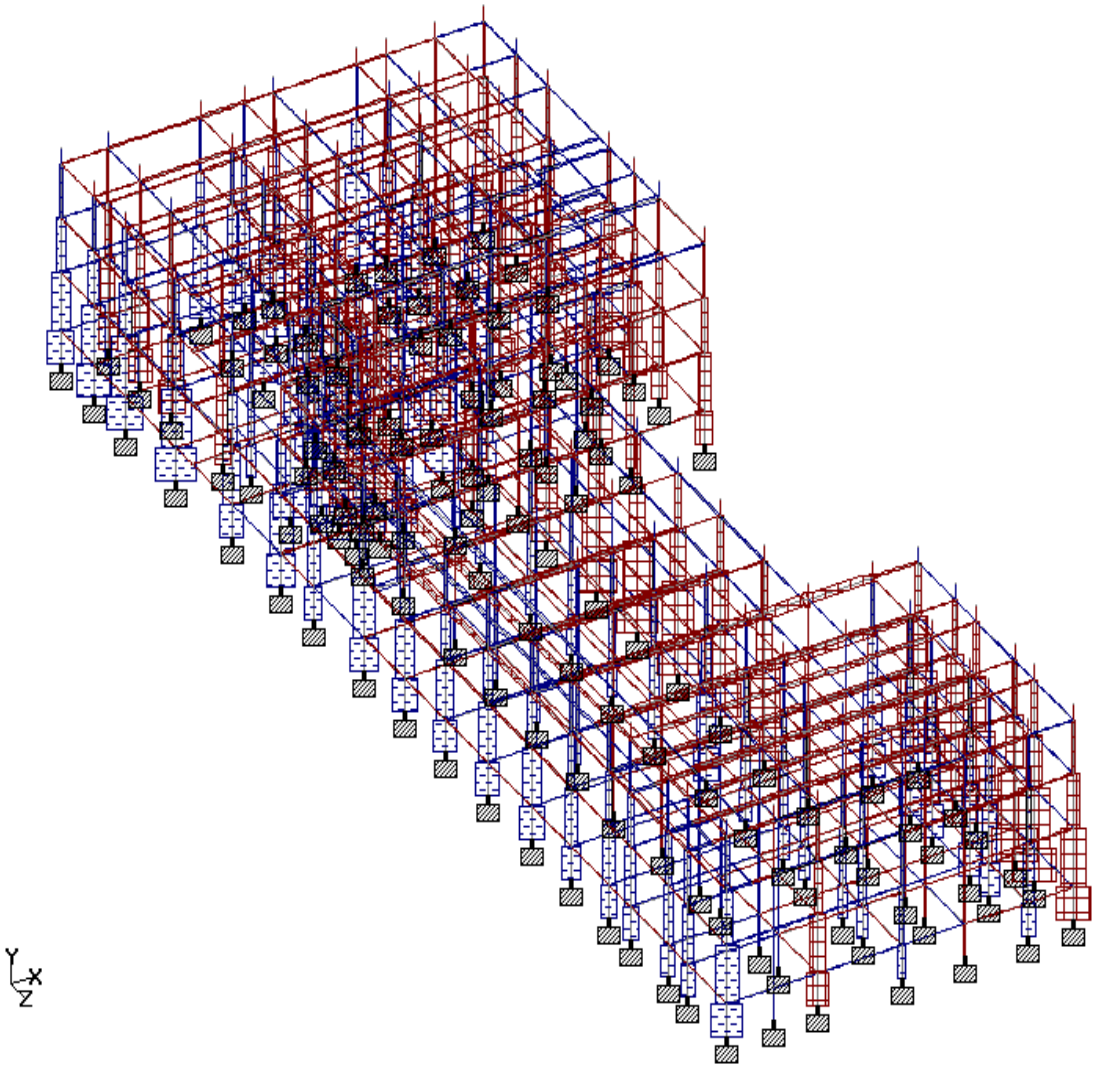

Figure 9: Axial Force Analysis of Building

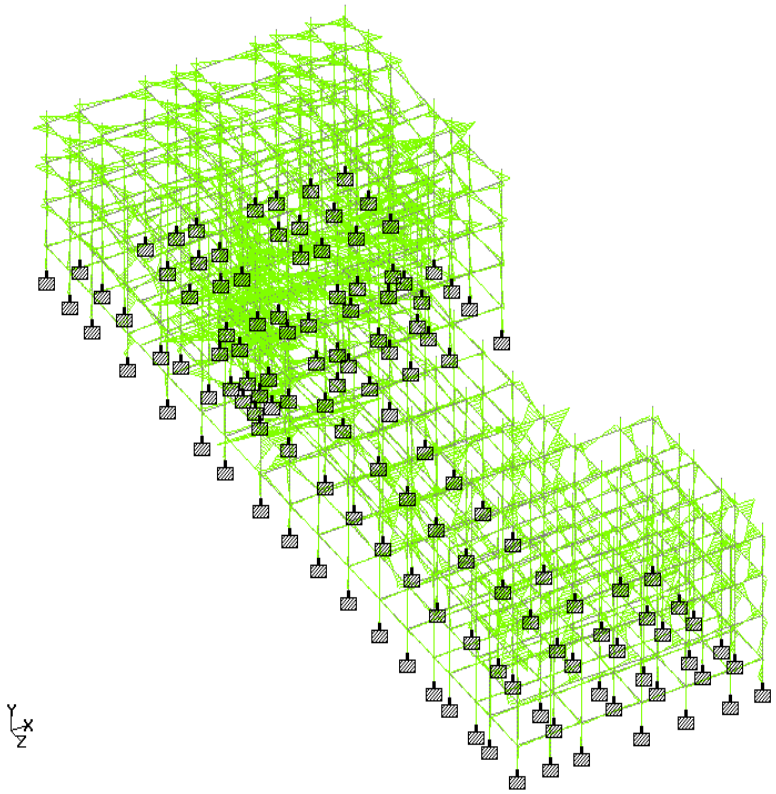

Figure 10: Bending Moment of Building

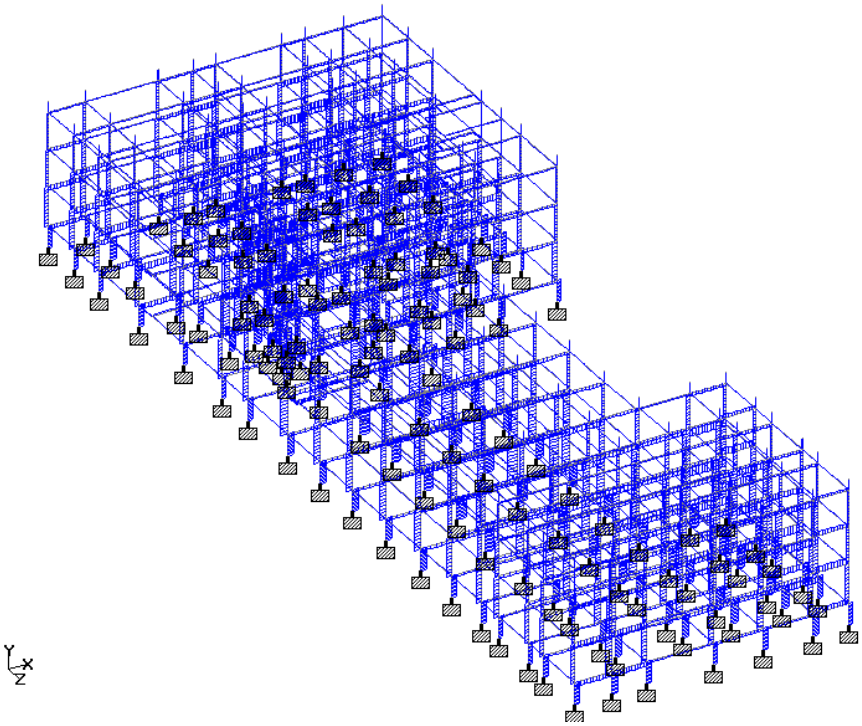

Figure 11: Shear Force of Building

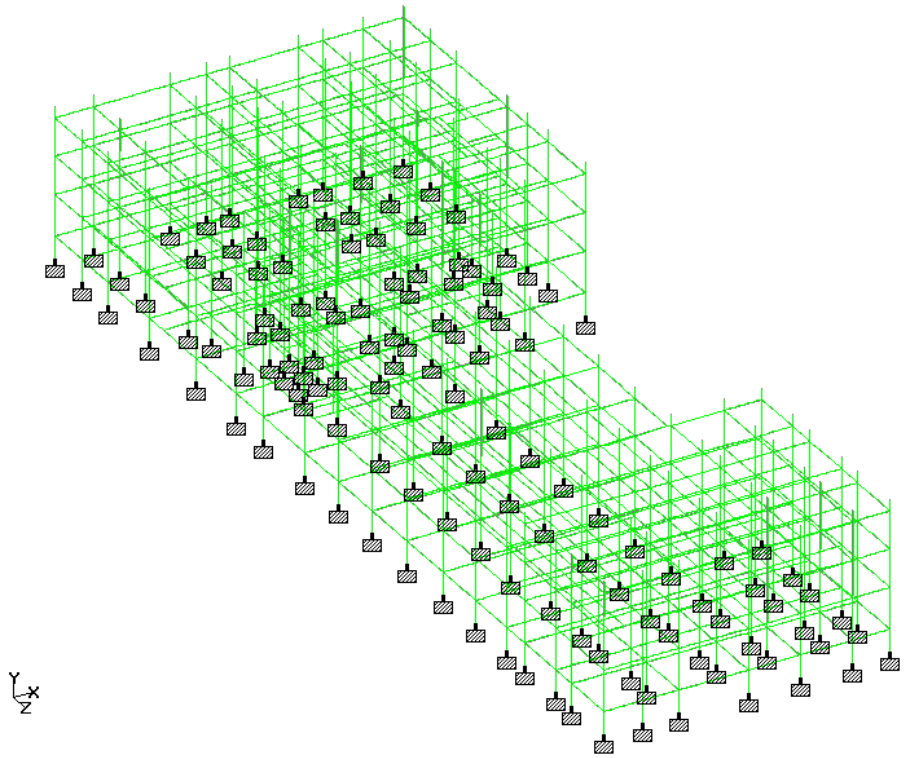

Figure 12: Deflection of Building

3.3 Cost Estimation And Quantity Sureying

The cost estimation and quantity surveying for the KSRTC Thrissur Bus Terminal were conducted to ensure efficient material usage, cost-effectiveness, and proper financial planning. The estimation included calculations of material quantities, unit rates, and total costs for the construction of the terminal building, the multi-level car parking (MLCP), and the walkway bridge.

The quantity surveying was carried out for major structural elements such as earthwork excavation, concrete works, reinforcement, brick walls, and flooring. For earthwork excavation, the footing dimensions were considered as 4 meters by 4 meters for 133 units, resulting in a total excavation of 5532.8 cubic meters. The plinth beam had a length of 562.98 meters, a breadth of 1.03 meters, and a height of 0.25 meters, with a total excavation volume of 144.97 cubic meters. The overall earthwork excavation for the project was estimated to be 5677.77 cubic meters.

Concrete works, including both Plain Cement Concrete (PCC) and Reinforced Cement Concrete (RCC), were estimated in detail. The PCC in the foundation and plinth beam required 77 cubic meters, while RCC was used for various structural components. The footings required 417 cubic meters, the columns 340 cubic meters, the plinth beam 58 cubic meters, the lintel 65 cubic meters, the floor beams 272 cubic meters, and the slabs for each floor 1719 cubic meters.

Reinforcement details were also considered to ensure structural stability. The total steel reinforcement required for the footings was estimated at 417.08 metric tons, for the columns at 340.74 metric tons, for the plinth beam at 58.26 metric tons, for the lintel at 65.41 metric tons, for the floor beams at 272.57 metric tons, and for the slabs at 257.86 metric tons per floor.

The brickwork calculations included walls of different thicknesses and deductions for openings such as doors, windows, and rolling shutters. The ground floor walls included 42.66 meters of 100mm thick walls and 562.98 meters of 200mm thick walls, with necessary deductions made for ventilators, doors, and windows. The first floor included an additional 135.99 meters of brick walls.

The cost estimation was based on material rates, labour charges, and other construction-related expenses. The site clearing and demolition for the bus terminal building were estimated at ₹5,00,000, while the earthwork excavation, at a rate of ₹450 per cubic meter for 5680 cubic meters, amounted to ₹25,56,000. The PCC work required 77 cubic meters at ₹8000 per cubic meter, totalling ₹6,16,000. The RCC work included footings at ₹10,500 per cubic meter, amounting to ₹43,78,500, columns at ₹15,000 per cubic meter, totalling ₹51,00,000, the plinth beam at ₹14,000 per cubic meter, costing ₹8,12,000, and the lintel at ₹12,500 per cubic meter, totalling ₹8,12,500. The cost breakdown for floor beams and slabs was included in the detailed estimation.

For the multi-level car parking and walkway bridge, the site clearing and demolition were estimated at ₹50,000. The concrete and reinforcement costs for these structures were calculated separately, ensuring that all necessary factors were considered.

The cost estimation and quantity surveying for the KSRTC Thrissur Bus Terminal ensured accurate financial planning and resource allocation. By carefully considering excavation, concrete works, reinforcement, brickwork, and structural components, a comprehensive budget was prepared to optimize costs without compromising the structural quality. The estimation also included provisions for the mechanical car parking and a pedestrian walkway to enhance connectivity and improve user convenience.

4. Results and Discussion

The results of the KSRTC Thrissur Bus Terminal project demonstrate that the proposed design effectively integrates structural, functional, and economic considerations, ensuring a well-planned and sustainable transportation hub. The project outcomes confirm that the design meets engineering standards, safety regulations, and financial constraints, while also enhancing passenger convenience and traffic efficiency.

The architectural and functional design ensures a modern, well-organized terminal that accommodates the increasing demands of public transportation. The layout effectively integrates bus bays, waiting areas, ticketing zones, commercial spaces, dormitories, and essential passenger amenities, promoting efficiency and user comfort. Seamless connectivity to the nearby railway station via a dedicated walkway bridge further enhances accessibility. Additionally, pedestrian-friendly walkways, smart technology integration, and green spaces contribute to improved passenger experience and environmental sustainability.

The structural analysis, conducted using STAAD.Pro, validates that the terminal's reinforced concrete and steel framework is capable of withstanding seismic loads, wind pressures, and heavy vehicular movement. The results confirm that foundations, columns, beams, slabs, and roofing structures have been designed with appropriate load-bearing capacities, ensuring long-term stability and safety. The application of seismic-resistant design principles and expansion joints ensures that the terminal can endure natural forces while maintaining structural integrity. The maximum node displacement of 40.45 mm confirms that deformations remain within permissible limits, ensuring a safe and durable structure.

The quantity estimation results provide precise calculations of earthwork, concrete, steel reinforcement, masonry, and finishing materials, ensuring efficient procurement and minimal material wastage. The total earthwork excavation required for the project was 5677.77 cubic meters, while the reinforced concrete elements required 417 cubic meters for footings, 340 cubic meters for columns, and 1719 cubic meters per floor slab. The use of MS Excel for quantity calculations has significantly enhanced accuracy in estimating resource requirements, leading to better planning and resource management.

The cost estimation results validate that the project remains financially feasible, with expenses distributed across site preparation, structural works, finishing materials, utilities, and additional facilities such as the Multilevel Car Parking (MLCP) and Walkway Bridge. The site preparation and excavation were estimated at ₹25,56,000, while reinforced concrete works accounted for ₹51,00,000 for columns and ₹43,78,500 for footings. The use of detailed cost breakdowns and rate analysis ensures that financial planning aligns with industry standards, preventing cost overruns while maintaining quality construction.

In conclusion, the results confirm that the KSRTC Thrissur Bus Terminal redevelopment is structurally sound, economically viable, and functionally efficient. The design effectively integrates modern infrastructure, passenger amenities, and sustainable planning to meet future transportation demands. The implementation of structural safety measures, optimized cost planning, and efficient space utilization ensures that the terminal will serve as a reliable and well-equipped transportation hub for years to come.

5. Conclusion

- The proposed KSRTC Thrissur Bus Terminal design effectively integrates structural stability, functionality, and economic feasibility, ensuring a modern and sustainable transportation hub.
- STAAD.Pro analysis confirms that the structural components can withstand seismic loads, wind forces, and heavy vehicular movement, ensuring long-term safety and durability.
- Efficient space utilization with well-planned bus bays, waiting areas, ticketing zones, dormitories, and commercial spaces enhances passenger convenience and terminal operations.
- Quantity and cost estimation validate optimal resource utilization, with accurate material calculations minimizing waste and ensuring financial feasibility.
- The inclusion of a pedestrian walkway and a multilevel mechanical car parking system improves traffic efficiency and connectivity.
- This study highlights the importance of sustainable and cost-effective planning in large-scale transportation projects and provides a framework for future transit hub developments.

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