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Comparative Study on the Economic Efficiency of RCC and Pre-Engineered Structures: A Case Study on the STCET Auditorium

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ABSTRACT: Industrial steel structure (PEB) constructions are very popular to their advantages over conventional RCC construction. Industrial steel structure Construction the better properties of both steel and concrete along with lesser cost, speedy construction, better quality control, sustainability etc. Hence the aim of the present study is to compare of a G+2 story assembly RCC structure and steel structure. Both structures are designed for same loading condition. Beam and column sections are made of RCC, Steel (PEB) sections. STAAD PRO software is used for analysis and design and analysis results are compared. Cost effectiveness based on structural cost for Steel structure and RCC structure determined. Study concludes that the industrial steel structures (PEB) are best suited types of constructions in terms of structural cost.

KEYWORDS: Industrial steel structure (PEB), RCC, Analysis and Design

I. INTRODUCTION

GENERAL

In the realm of construction, the choice between traditional reinforced concrete (RCC) structures and modern pre-engineered buildings (PEBs) is a critical decision, particularly when it comes to large-scale projects such as auditoriums. Both options offer distinct advantages and drawbacks, especially concerning cost. A comparative study on the cost implications of RCC auditoriums versus pre-engineered auditoriums provides valuable insights for developers, architects, and project managers aiming to optimize budget allocation while ensuring structural integrity and functionality. By examining factors such as material costs, labour expenses, construction timeframes, and long-term maintenance requirements, this study aims to shed light on the financial considerations that influence the selection between these two construction methodologies.

PRE-ENGINEERED AUDITORIUM

Pre-engineered auditoriums utilize the construction technique of pre-engineered buildings (PEB), where structural components are prefabricated off-site and assembled on location. This method, known for its efficiency and cost-effectiveness, has gained prominence in the USA, where 60% of non-residential low-rise buildings employ PEB systems, as indicated by a Metal Building Associations survey. Despite its widespread use globally, PEB is a relatively recent concept in India, introduced in the late 1990s with economic liberalization. The Indian market shows significant potential, with a current manufacturing capacity of 0.35 million tons per annum and a compound growth rate of 25 to 30%. While India excels in PEB fabrication, there is room for improvement in structural design and aesthetic considerations compared to global standards. Nevertheless, Indian building codes adhere to stringent safety standards, continuously evolving with updates to IS-standards. Pre-engineered auditoriums typically employ a structural system where components are manufactured off-site and then assembled on location. This method enhances efficiency, reduces construction time, and ensures cost-effectiveness compared to traditional construction. The key components, such as steel frames, roofing, and wall panels, are pre-designed and fabricated, allowing for quick assembly at the construction site. This approach offers flexibility in design, durability, and can accommodate large, open spaces required for auditoriums. Pre-engineered steel buildings can be fitted with different structural accessories including mezzanine floors, canopies, interior partitions etc. and the building is made waterproof by use of special mastic beads, filler strips and trims. This is a very versatile buildings systems and can be finished internally to serve any functions and accessorized externally to achieve attractive and unique designing styles. It is very advantageous over conventional

buildings and is helpful in the low-rise building design. Pre-engineered buildings are generally low-rise buildings however the maximum eave height can go up to 25 to 30 meters. Low rise buildings are ideal for offices, houses, showrooms, shop fronts etc. The application of pre-engineered buildings concept to low-rise buildings is very economical and speedy. Buildings can be constructed in less than half the normal time especially when complemented with the other engineered sub systems.

II. APPLICATIONS

More than 70% of all single storey non-residential construction, in the USA, utilizes pre-engineered buildings. The applications of pre-engineered buildings range from small car parking sheds to 90 m (+) wide clear span aircraft hangars to low-rise multistorey buildings. Almost every conceivable building use has been achieved using the pre-engineered building approach

III. OBJECTIVES OF THESE IDEAS

Assessing Thermal Comfort: Thoroughly evaluate the factors that influence thermal comfort in homes, from temperature and humidity to air movement and radiant heat, to gain a comprehensive understanding of their impact on occupants. Analyzing Building Design: Study how design elements like orientation, building shape, window placement, insulation, and materials selection contribute to creating optimal thermal comfort levels in residential spaces. Using Advanced Tools: Utilize cutting-edge simulation software or computational models to predict and analyze the building's thermal performance under various climatic conditions, ensuring a well-informed and optimized design approach. Implementing Passive Strategies: Propose passive design strategies, such as natural ventilation, shading devices, thermal mass utilization, and efficient building envelope design, to improve thermal comfort without relying heavily on mechanical systems. Considering Environmental Impact: Emphasize how the proposed design strategies can reduce the environmental impact of the residential building, with a focus on carbon emissions, resource consumption, and overall ecological footprint. Evaluating Economic Feasibility: Assess the cost-effectiveness of different thermal comfort strategies in residential buildings, considering initial investment, operational costs, and potential long-term savings.

IV. ADVANTAGES

REDUCED CONSTRUCTION TIME: Buildings are typically delivered in just a few weeks after approval of drawings. Foundation and anchor bolts are cast parallel with finished, ready for the site bolting. Our study shows that in India the use of PEB will reduce total construction time of the project by at least 50%. This also allows faster occupancy and earlier realization of revenue.

FLEXIBILITY OF EXPANSION: Buildings can be easily expanded in length by adding additional bays. Also, expansion in width and height is possible by redesigning for future expansion.

LARGE CLEAR SPANS: Buildings can be supplied to around 80M clear spans.

QUALITY CONTROL: As buildings are manufactured completely in the factory under controlled conditions the quality is assured.

LOW MAINTENANCE: Buildings are supplied with high quality paint systems for cladding and steel to suit ambient.

ENERGY EFFICIENT ROOFING AND WALL SYSTEMS: Buildings can be supplied with polyurethane insulated panels or fibre glass blankets insulation to achieve required "U" values.

ARCHITECTURAL VERSATILITY: Building can be supplied with various types of fascias, canopies, and curved eaves and are designed to receive precast concrete wall panels, curtain walls, block walls and other wall systems.

SINGLE SOURCE RESPONSIBILITY: As the complete building package is supplied by a single vendor, compatibility of all the building components and accessories is assured. This is one of the major benefits of the pre-engineered building systems.



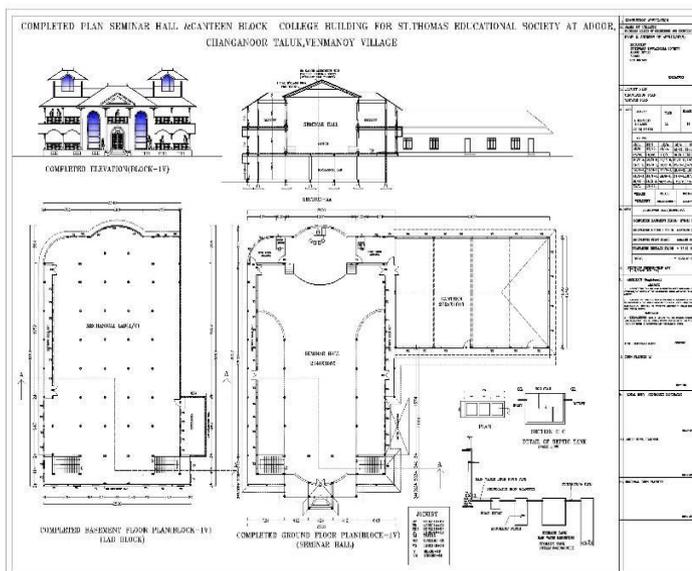
V. METHODOLOGIES

A comparative study on the cost of construction of RCC (Reinforced Concrete) and pre-engineered structures would typically involve analysing various factors such as materials, labour, construction techniques, durability, maintenance costs, and overall project timelines. It would aim to provide insights into which construction method offers better cost-efficiency in different situations. Here we take structural cost for comparison of this case study. Data includes the area of proposed site is calculated using google earth and got an approximate value is obtained, furthermore environmental conditions, accessibility to main roads, current situation and existing structures in the site is checked. Existing plan and cost of structural factors are considered. Design the steel structure using AutoCAD, calculate the analysis is done with the help of STAAD PRO and 3D of the auditorium is rendered in the Revit Architecture Cost estimation in project management is the process of forecasting the financial estimate that is needed for the comparison of RCC structure and Pre-Engineered structure. Here we take structural estimate for the comparison of both the structure. The rendered model of the proposed project is created using Revit. Depending on the need and requirements of the proposed project. Discuss cost comparison of both structures. and compare the estimated result for comparative study of both Pre- Engineered and RCC structure.

VI. AIM AND SCOPE

The project aims for comparative study on the efficiency of RCC structure and Pre-Engineered structures. Following are the main objectives of the project.

- To design and analyse pre-engineered building replacing the existing RC auditorium of (STCET).
- Planning and design of steel structure.
- Structural efficiency and cost estimation.
- Study of design of various elements of building.
- Drafting of plan, elevation, and section using AutoCAD.
- Planning of various components of a building with column positioning
- Introduction of STAAD Pro
- Modelling of the building in the STAAD Pro giving all boundary conditions (supports, loading etc...)
- Study of analysis Data of the software
- Manual load calculation truss
- Introduction of Autodesk Revit to create 3D model of the structure.
- Structural estimation and costing of the building.
- Faster construction and customizable designs.
- Flexibility in future expansions as the need to accommodate bigger crowd arises
- Less usage of concrete contributing less to global warming



STAAD PRO ANALYSIS

The analysis of beams and columns in these framed structures are done using STAAD PRO V8i SS6. We have already computed the loads acting on various beams in the structure. These loads are given as uniform force. The wind load is not considered as per IS code the height of the building is less than 10m. Also, the seismic load is also not considered as its value gets negligible as when we consider the soil belongs to zone II as per IS Code.

Analysis of Building

- Step 1: Creation of nodal points. Based on the column positioning of plan we entered the node points into STAAD file.
- Step 2: Representation of beams and columns. By using the add beam command we had drawn the beams and columns between the corresponding node points.
- Step 3: 3D view of structure. Here we have used the Transitional repeat command in Y direction to get the 3D view of a structure.
- Step 4: Supports and property assigning. After the creation of structure, the supports at the base of structure and specified as fixed. Also, the materials were specified, and cross sections of beams and columns members were assigned.
- Step 5: Assigning different loads and load combinations.
- Step 6: Analysis. After the completion of all the above steps we performed the analysis and checked for errors.

BUILDING DATA FOR ANALYSIS

1	TYPE OF BUILDING	ASSEMBLY BUILDING
2	NO. STORIES	G+2
3	FLOOR HEIGHT	3.9 m
4	SIZE OF COLUMN	800×500×12
5	SIZE OF BEAM	800×500×12
6	WALL THICKNESS	24CM

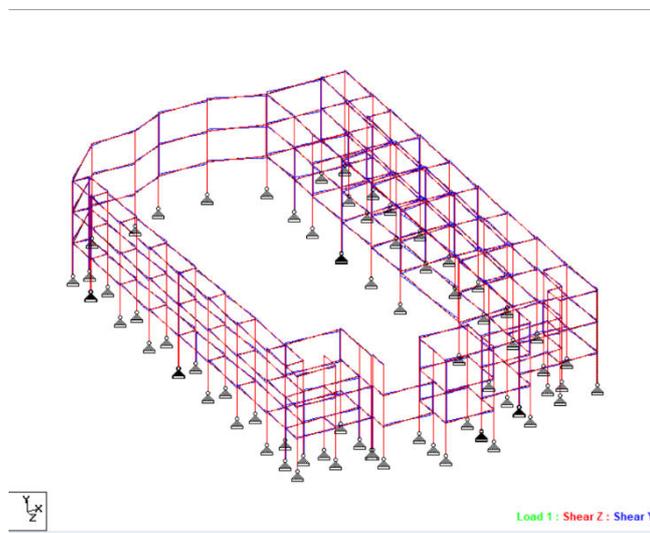


Figure: Shear stress

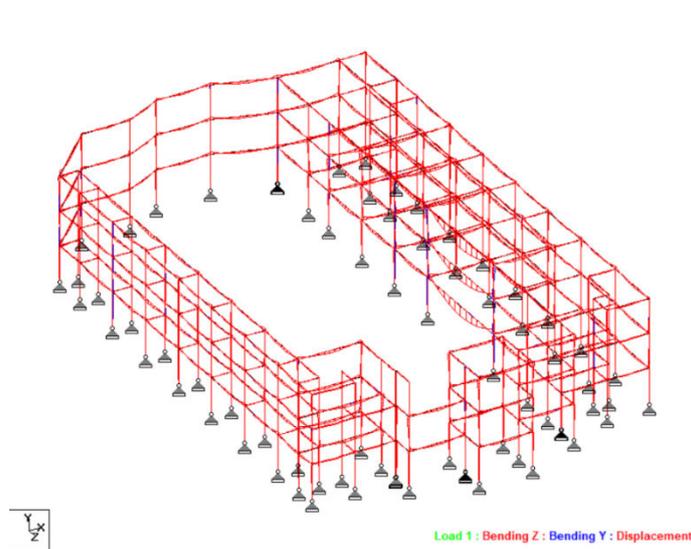
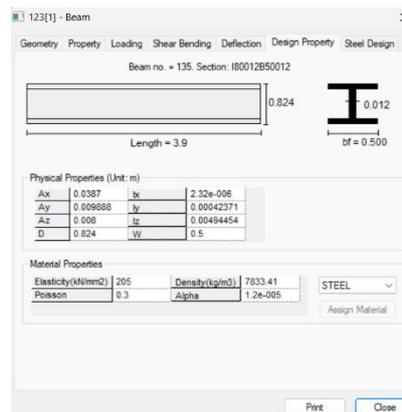


Figure Bending moment and displacement



VII. RESULTS AND DISCUSSIONS

Steel structure has been designed in Staad to replace the RCC auditorium structure Steel structure designed, has been analysed with displacements, bending moments and shear force

COST COMPARISON

	RCC	STEEL	VARIATION
BEAM	594916	760200	-28
COLUMN	893654	13255328	-52
SLAB	884778	80328	91

Economy efficiency of the steel structure has been compared to that of existing RCC. Cost of steel beam & column sections are higher by 28% and 52% respectively, even though the number of sections could be reduced compared to RCC. A major saving in cost is observed in casting the composite slab, giving 91% saving from the cost of construction of RCC slab.



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