Comparative study on Design and Analysis of Industrial Shed with Steel and Aluminium Members

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***Abstract*—The research evaluates and contrasts how steel and aluminum perform in industrial shed construction through their material characteristics, structural performance, construction expenses, and effects on the environment. The study aims to evaluate the advantages and disadvantages of each material based on its performance capabilities and its ability to endure and sustain over time to provide suitable recommendations for material selection that meets different construction needs. The research demonstrates that steel provides superior strength which makes it suitable for large structures requiring weight support but the material requires ongoing upkeep because of its tendency to rust. Aluminum provides greater corrosion resistance while being lighter than steel which makes it suitable for small structures and coastal areas although its initial costs are higher. The research shows that steel has lower initial costs while aluminum needs more investment but offers durability and requires minimal upkeep. Both materials can be recycled and aluminum production requires less carbon emissions during its manufacturing process. The material choice process requires assessment of project needs and environmental factors and life cycle expenses. Future studies should explore hybrid material solutions and seek new methods to enhance sustainable development practices.**

Keywords—Aluminum, Construction, Corrosion, Durability, Steel, Sustainability

I. INTRODUCTION

A. *Significance of Selection of Raw in Design and Construction of Industrial Sheds*

The industrial shed performance evaluation uses these materials to determine their construction expenses and operational lifespan which reaches 100 years. The material specifications demand precise strength requirements which include protection against environmental threats that include corrosion and extreme temperature conditions and the materials must meet structural performance standards. Steel and aluminum serve as the preferred material choices because their properties provide valuable advantages to the user. Each material possesses distinct properties which enable its use in particular applications [3].

Steel serves as the primary material choice for large architectural structures because it possesses both high tensile strength and load-bearing capabilities. The material can adapt to any design requirement because it can be molded into various dimensions and shapes through its structural application. Steel requires maintenance efforts that increase its service life because it tends to corrode in environments with high humidity and coastal conditions.

The lightweight properties of aluminum make it better than steel because aluminum weighs less than these advanced defense systems which protect against corrosion. The material proves suitable because it can withstand both high humidity conditions and areas which have corrosive materials present. The building achieves high energy efficiency because it uses better thermal insulation materials which architects select to design energy-efficient structures. The initial costs of aluminum materials exceed those of steel materials which makes aluminum expensive for use. The material has lower weight capacity than steel which prevents its usage in applications that require heavy-duty performance. A side-by-side bar chart or radar chart should display these features to provide readers with an instant performance comparison of these materials across different attributes.

The selection of construction materials determines both the physical characteristics and mechanical properties of a structure while also impacting environmental sustainability. Aluminum acts as a sustainable material because it can be recycled and its production process emits fewer greenhouse gases which makes it a popular choice for environmentally friendly projects that prefer steel. Steel is recyclable too. However, it has relatively higher environmental incidences than aluminum during production.

B. *Objectives for the comparative study of steel and aluminum members*

The research study aims to compare steel and aluminum material properties which industrial sheds. The analysis aims to assess material properties through multiple evaluation methods which include structural integrity testing and cost-effectiveness assessment and environmental impact evaluation and sustainability measurement. The research work aims to compare steel and aluminum through mechanical testing which evaluates their strength and weight and their response to external forces including temperature changes and wind and seismic loads. The study of bearing capacity and material performance establishes which materials meet requirements for designing industrial sheds that must endure high loads and extreme environmental conditions.

The study will investigate whether steel or aluminum provides more economical value for constructing industrial sheds. The factor assesses total costs which include initial material costs and production expenses and maintenance expenditures that extend through the entire operational period until equipment becomes unusable. Businesses face higher initial expenses for aluminum whereas they achieve greater savings through reduced maintenance needs and extended product lifespan because aluminum maintains its condition against environmental harm. The research investigates how steel and aluminum thermal and corrosion performance under different environmental conditions whereas thermal conductivities and expansion coefficients and moisture and chemical resistance values determine industrial shed performance and longevity. For areas with heavy-duty load requirements steel proves to be the most effective solution while aluminum offers superior protection against corrosion and outstanding insulation performance in certain specific areas.

The research study will assess how steel and aluminum production activities affect environmental ecosystems. The environmental impact of steel recycling will be lower than aluminum recycling because steel production requires more resources than aluminum production. Sustainability becomes an increasingly relevant aspect in the construction industry today; hence, an understanding of such will go a long way in making responsible choices when it comes to materials used.

II. STRUCTURAL DESIGN CONSIDERATIONS

The process of structural design chooses materials which determine how a structure will behave under various load conditions. The inherent properties of steel and aluminum determine how these materials will respond to different loading scenarios. The section examines design requirements through three main factors, which include load types and cross section characteristics and connection details for both materials.

A. Load Considerations

The live load impacts of the variable loads can be seen through the calculation of occupancy together with movable furniture and temporary items and their effects. The building usage will create a live load that ranges between 2 to 5 kN/m for every meter square of space.

Dead Loads: The permanent loads of this category include all structural elements and their weight and they remain fixed because of the building's total weight which includes beams columns floors and all other components. The total dead load of a building will depend on the materials used for construction between steel and aluminum which creates different weight distribution patterns in the structure according to [22].

Wind Loads: The wind effects create multiple dimensions that depend on the building heights and the geographical position and the wind exposure assessment. The wind load calculation will use this equation according to reference [23]:

$$F_{wind} = 0.613 \cdot C_p \cdot A \cdot V^2 \tag{2}$$

where F_{wind} is the wind force, C_p is the wind pressure coefficient, A is the projected area, and V is the wind speed.

Seismic Loads: The earthquake forces at a building site create dynamic forces which depend on two factors the building height and the building's design and location. The seismic loads can be determined through calculations which use this specific formula: [24]:

$$F_{seismic} = W \cdot S \cdot I \tag{3}$$

where $F_{seismic}$ is the seismic force, W is the weight of the building, S is the seismic response factor, and I is the importance factor.

B. Cross-Sectional Properties and Member Dimensions

Steel and aluminum possess different cross-sectional characteristics which affect their performance during loading. The moment of inertia (I) serves as the primary factor which both materials use to resist bending. The rectangular section has then moment of inertia expressed as [25]:

$$I = \frac{b \cdot h^3}{12} \tag{4}$$

Steel sections provide greater strength because their smaller dimensions can handle the same loads which require larger dimensions for aluminum materials to achieve matching load capacity. The comparison here shows that the aluminum beam cross-section will always exceed the steel beam cross-section when both beams need to support identical bending moments because aluminum has lower strength-to-weight ratio than steel. The design of cross-sectional dimensions requires consideration of material properties because this process will result in operational efficiency and reduced construction expenses.

C. Connection Detailing and Joint Design

The design of connections and joints between members is vital in the overall stabilization of a structure. Steel and aluminum connections show distinct differences in their detailing specifications:

1) Steel Connections:

Most connection types use either bolted joints or welded joints as their standard method of connection. The steel material which possesses high weldability creates permanent connections which withstand both shear strength and tensile strength requirements [26].

2) Aluminum Connections:

Aluminum demonstrates lower weldability than steel which requires the use of bolted connections. The lower fatigue resistance of aluminum requires special considerations during dynamic loading conditions.

The correct method of establishing connection details enables force transfer from one structural member to another which results in the complete structure remaining stable.

The typical moment of inertia shown in Figure 3 demonstrates the relationship between steel and aluminum structural sections. Steel enables smaller and lighter structural components to handle equivalent bending stresses because of its superior moment of inertia compared to aluminum [27].

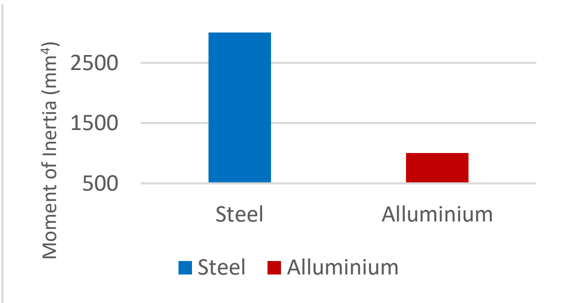

Fig. 1. Steel and aluminum sections of moment of Inertia are the very essence of comparison

Structural design for steel and aluminum materials needs to achieve precise equilibrium between three factors which are load resistance and material characteristics and connection design specifications. The superior strength and weldability of steel materials combines with the lightweight attributes of aluminum materials which need specific size requirements for their connection components.

III. ANALYSIS OF INDUSTRIAL SHED STRUCTURES

The intended purpose of shed structures is to provide support for buildings which have extensive open interior spaces. The design process and modeling methods and structural performance under different load scenarios are affected by the selection of steel or aluminum as building materials. This section evaluates the design methods for steel and aluminum shed construction and their finite element modeling (FEM) techniques and their performance under various load conditions.

A. *Comparison of Design Methodologies for Steel and Aluminum Sheds*

The one-dimensional design methodology evaluates materials selection together with cross-section and member size decisions which will maintain system stability through its entire process. The design must undergo testing to confirm its stability when facing various load conditions.

The design process for a steel shed differs from that of an aluminum shed because engineers must consider the different mechanical properties of these materials, including their respective weights. Steel Sheds: The exceptional strength and stiffness characteristics of steel enable engineers to construct structural members which require only tiny cross-sectional areas. The limit state design method functions as the primary steel structure design approach which incorporates safety factors to determine whether a building can withstand all expected loads without collapsing. Welded connections create durable and robust joints which enhance the steel system properties according to present research [28].

Aluminum Sheds: Buildings require larger cross sections when using aluminum because it provides less tensile strength than steel while remaining lightweight. The design process for aluminum buildings depends on joint quality through bolted connections while engineers assess how material properties affect fatigue performance over time. Engineers use the allowable stress design method to establish aluminum design standards, which compare actual material stresses against predetermined stress limits.

IV. COST ANALYSIS

Cost analysis becomes so critical with respect to materials for construction of industrial sheds since it includes all expenses related to initial costs of the materials, cost of construction, and costs of long period maintenance and lifecycle. The material costs, fabrication costs, construction costs, and maintenance costs are compared here between different steel and aluminum structures.

A. *Material Costs, Fabrication, and Construction Expenses*

The cost of steel per unit weight is lower than the cost of aluminum. The price of steel ranges from $500 to $800 per ton because different market conditions and various steel grades affect its availability. The construction industry uses prefabrication to manufacture steel structures in factories which helps to decrease onsite construction costs [11]. The material expenses for steel construction projects increase because steel needs corrosion protection through galvanizing or coating processes.

Aluminum costs more than steel because its price ranges from $2,000 to $3,000 per ton. The material's lightweight properties lead to decreased expenses for transporting goods and building foundations. The construction expenses of a project increase because aluminum requires advanced manufacturing techniques which include bolting and special welding processes.

The total expense of construction work can be determined through the following formulae [25] as:

$$C_{total} = C_{material} + C_{fabrication} + C_{construction} \quad (6)$$

where $C_{material}$, $C_{fabrication}$, and $C_{construction}$ represent material, fabrication, and construction costs, respectively.

B. *Maintenance and Lifecycle Cost Comparison*

Steel: Steel structures require continuous restoration work to protect against corrosion and rust damage which occurs in challenging environments because the protective coatings will eventually degrade and need to be replaced at regular intervals. Steel maintenance expenses typically range from 1 to 3 percent of the total construction expenses for each subsequent year.

Aluminum: The exceptional ability of aluminum to resist corrosion enables organizations to reduce their maintenance expenses which leads to significant cost savings when compared to steel. The material exhibits greater susceptibility to destruction because of two factors which are impact and fatigue. The annual maintenance expenses associated with aluminum typically range from 0.5 percent to 1 percent of the total initial construction expenses.

TABLE I. COST COMPARISON OF STEEL VS. ALUMINUM FOR INDUSTRIAL SHEDS

Cost Factor	Steel	Aluminum
Material Cost (per ton)	$500 - $800	$2,000 - $3,000
Fabrication Cost	Lower, due to simple welding	Higher, due to complex joints
Construction Cost	Moderate	Higher due to intricate methods
Maintenance Cost (annual)	1-3% of initial cost	0.5-1% of initial cost

The initial costs to manufacture steel products are lower than those needed to create aluminum products that provide advantages in lightweight construction and easier maintenance throughout their entire lifespan [33]. The total expense of using aluminum throughout its complete life cycle requires assessment of its initial costs which must be paid before starting the project.

V. THERMAL AND CORROSION PERFORMANCE

The two factors of thermal performance and corrosion performance lead to their essential role in material selection for constructing industrial sheds which need to maintain their structural integrity and durability. The distinct thermal and corrosion performance characteristics of steel and aluminum make them suitable for different environmental applications.

A. *Thermal Conductivity and Expansion Characteristics*

Steel: The thermal conductivity of steel which measures approximately 50 W/m·K allows this metal to conduct heat at high speeds. The property better serves regions which experience extreme winter cold and extreme summer heat because the steel material undergoes expansion followed by contraction. CTE or Coefficient of Thermal Expansion has an approximate value of 12×10−6/°C12, thus, resulting in dimensional changes under the temperature fluctuations [34].

Aluminum: The thermal conductivity of aluminum reaches approximately 205 W/m·K which enables aluminum to function almost as effectively as steel for cooling structures that protect against extreme temperature changes. The coefficient of thermal expansion which engineers refer to as alpha measures approximately 23×10−6/°C for this material which shows greater expansion than steel when temperatures rise.

The relationship between temperature change (ΔT) and dimensional change (ΔL) in materials can be described by the following equation [35]:

$$\Delta L = L_0 \cdot \alpha \cdot \Delta T \quad (7)$$

where: ΔL is the change in length, L0 is the original length, α is the coefficient of thermal expansion, ΔT is the temperature change.

B. Durability and Corrosion Resistance

The term corrosion describes a destructive process which most commonly occurs with steel close to coastal areas where moisture exists because steel develops iron oxide or rust through its reaction with oxygen and water.

Protective materials for metallic structures require application of coatings which include galvanizing and paints and powder coatings. The rate of corrosion depends primarily on environmental conditions and the selection of protective coatings.

The application of oxygen to aluminum results in natural oxide layer formation which protects the metal from corrosion damage. The product demonstrates strong performance in wet environments and saltwater environments although it experiences localized corrosion through galvanic reactions with other metals. The results from Fig. 5 demonstrate that steel and aluminum expand when they undergo identical temperature changes; steel exhibits less expansion than aluminum across the same distance. Aluminum demonstrates increased thermal expansion through its significantly greater thermal expansion coefficient. [36].

TABLE II. THERMAL AND CORROSION PROPERTIES OF STEEL VS. ALUMINUM

Property	Steel	Aluminum
Thermal Conductivity (W/m·K)	50	205
Coefficient of Thermal Expansion ($\times 10^{-6}$ /°C)	12	23
Corrosion Resistance	Moderate (requires coating)	High (naturally resists corrosion)
Corrosion Rate (in humid climates)	High without coating	Low, stable oxide layer

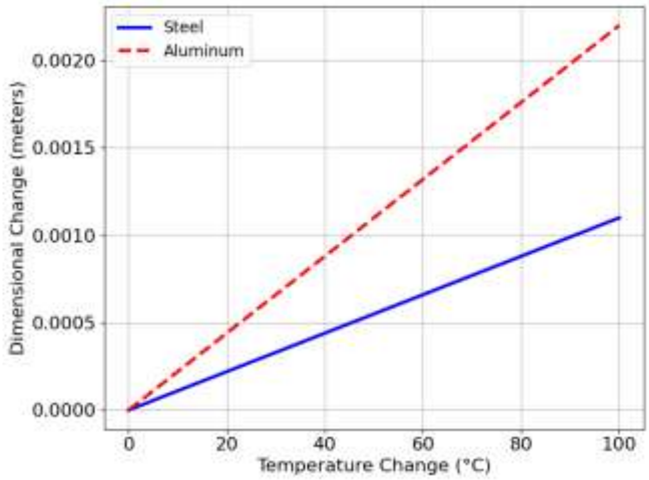

Fig. 2. The thermal expansion of steel and aluminum under the same temperature change

Steel provides acceptable strength; however, exposure to corrosion requires protection from coatings which must be applied in extreme environmental conditions. Aluminum exhibits the highest expansion rate during temperature fluctuations yet its corrosion resistance makes it suitable for environments with high humidity and salt contact.

VI. SUSTAINABILITY AND ENVIRONMENTAL IMPACT

When constructing industrial sheds, all decisions about material selection and energy usage and green building compliance requirements must be evaluated based on the sustainable environmental effects of steel and aluminum materials.

A. Recyclability and Carbon Footprint

Steel is highly recyclable because more than 90 percent of steel products undergo recycling after their operational lifespan ends. The production of steel requires excessive energy since both mining activities and metallurgical processing need substantial energy resources. Recycling technology has made progress because recycled steel usage has grown which reduces the total environmental damage from operations.

Aluminum shares with steel the property of being highly recyclable because 75 percent of all aluminum produced throughout history remains in active use. The production process of aluminum requires large amounts of energy that results in electricity generation before the extraction of bauxite ore. The energy-intensive smelting processing gives most to the carbon footprint of the process of aluminum production [16].

The equation below shows how steel and aluminum production create carbon footprints which scientists measure to assess their environmental damage [32]:

$$Carbon\ Footprint = (EnergyConsumption) \times (EmissionFactor) \quad (8)$$

B. Compliance with Green Building Standards

Stainless steel and aluminum can be used in green buildings that meet LEED and BREEAM certification standards. The standards require energy-efficient operation through their recycled materials while they establish specific performance guidelines. The construction of energy-efficient buildings can use steel and aluminum materials which will lead to major reductions in carbon emissions and significant enhancements of environmental sustainability.

TABLE III. ENVIRONMENTAL IMPACT OF STEEL VS. ALUMINUM

Aspect	Steel	Aluminum
Recyclability	High (90% recycled content)	High (75% recycled content)
Carbon Footprint	High due to energy-intensive production	High due to energy-intensive production
Green Building Compliance	Can meet LEED, BREEAM standards	Can meet LEED, BREEAM standards

VII. MODEELING AND ANALYSIS

A. Key Structural Design Aspects

Ford Manufacturing Facility located in USA, Michigan, is one Wall and Cladding system which uses Brickwork up to 2.1m and 6.3m which is covered by steel and aluminum building materials. Roof Slope and Protection system has a 9.91° slope which uses GI sheets and aluminum material which is resistant to corrosion without requiring additional protection. The system requires 1.5m purlin and 2.1m girt spacing because aluminum material enables economical weight distribution changes. Pinned supports create Support Conditions which steel material delivers high stability while aluminum material decreases foundation requirements.

B. Design Deatils

The researchers used both steel and aluminum materials to study the structural behavior of an industrial warehouse through ETABS software. The research project requires designing three distinct 3D building structures which will be tested under both static and dynamic loading conditions.

Common Parameters for Steel and Aluminum Structures :-

- Dimensions : Length = 60 m, Bay Spacing = 6 m, Width = 24 m, Eave Height = 8.402 m.
- Brickwork : 2.1 m from the ground, Remaining 6.3 m = cladding.
- Roof Slope:- 9.91°.
- Roofing : GI sheets for protection.
- Purlin Spacing : 1.523 m.
- Girt Spacing : 2.1 m.
- Support Condition : Pinned.

Plan Layout Of Warehouse Structure:

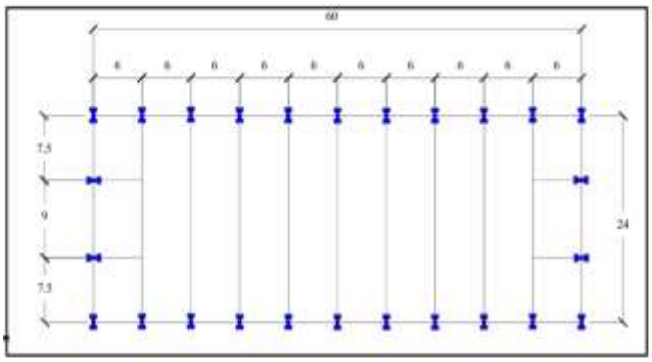

Fig.6. Plan of model

Elevation Of Warehouse Structure :

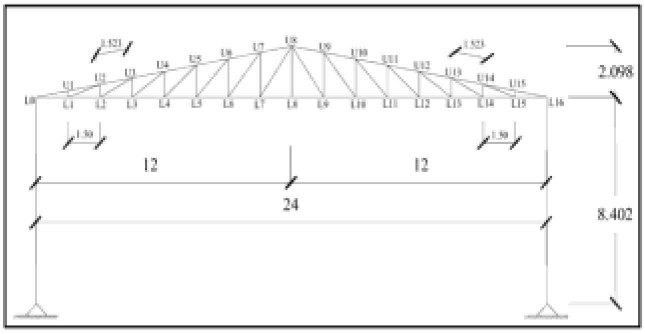

Fig.7. Elevation of model

C. Loading Calculations

The construction of the industrial warehouse requires dead load and live load calculations which apply to both steel and aluminum structural members. Both materials follow the same load calculations based on the IS 875-1987 standard.

Dead Load Calculation (IS 875-1987 Part-I) (pages 25 to 30):

1. *Total Load on Purlin :-*
- Weight of Sheet = 0.058 kN/m²
- Weight of Fixing = 0.025 kN/m²
- Weight of Services = 0.100 kN/m²
- Total weight per unit area = 0.058+0.025+0.100 = 0.183kN/m².

2. *Total Weight on Purlin :-*
- Spacing of Purlin = 1.523 m
- Total Weight on Purlin = weight (kN/m²) × spacing of Purlin.

Total Load Calculation :-
Total weight on purlin = 0.183 kN/m² × 1.523 m
= 0.278 kN/m

3. *Weight of Purlin :-*

Assumed at 0.10 kN/m for both steel and aluminum structures.

Weight of Truss :-

Weight of truss = (Span/3+5) × 10 = (24/3+5) × 10
= 0.130 kN/m2
= 0.103 × plan length = 0.103 × 1.5
= 0.154 kN/m

4. *Conversion to Uniform Load :-*

The value of 0.103 kN/m² represents the truss system's distributed dead load per unit area, derived from IS 875 guidelines.

5. *Total Dead Load :-*

Sum of all calculated loads = 0.278 + 0.1 + 0.154 = 0.532 kN/m

Dead Load (Steel & Aluminum) :- 0.532 kN/m

6. *Live Load (Steel & Aluminum) :-*

The general formula for calculating live load (LL) requires the application of a correction factor which depends on the slope of the roof. The factor for a roof slope of 9.91° becomes active at this point:

- 750 is the basic live load (in kN/m²),
- 20 is the correction factor per degree of roof slope,
- (9.91 – 10) adjusts the live load based on the angle.

= 750 – 20(9.91 – 10)
= 0.751 kN/m2
= 0.751 × 1.523 = 1.143 kN/m
= 2/3 × 1.143
= 0.762 kN/m

7. *Wind Load Calculation (IS 875-1987 Part-III) (page 49-50)*

1. Basic Wind Speed :- $V_b = 39\,\text{m/s}$

2. Design Wind Speed: $V_z = K_1 \times K_2 \times K_3 \times V_b$

Design wind pressure = $P_z = 0.6\,V_z^2$
Wind pressure on roof = $(C_{pe} - C_{pi})$
Where:-
Cpe = Coefficient of external wind pressure
Cpi = Coefficient of internal wind pressure
K1 = Risk coefficient (Based on a mean probable design life of 50 years)
K2 = Terrain height and structure size factor
K3 = Topography factor

For all general building and structure, Mean probable design life = 50 years

Risk coefficient K1 = 1.0

Terrain category = 3 ……... (As height of building 10 m)

Class B ……..…. (As horizontal or vertical dimension in between 20 to 50 m)

K2 = 0.99

K3 = topography factor

K3=1

= 1.0 × 0.99 × 1.0 × 39

= 38.61 m/s

Design wind pressure = Pz = 0.6 × (Vz)2

$$= 0.6 \times 38.61^2$$
$$= 894\ \text{N/m}^2$$

8. *Wind Pressure on Roof :-*

$$\text{Wind pressure} = (C_{pe} - C_{pi}) \times P_z$$

The values for Cpe and Cpi depend on specific building shape, orientation, and open/closed nature of the structure.

Basic Wind Speed :- 39.00 m/s
Design Wind Speed :- 38.61 m/s
Design Wind Pressure :- 894 N/m²

D. Modelling

ETABS functions as a standard tool which engineers use to analyze and design steel and aluminum structures that include Industrial Sheds Constructed with Steel and Aluminum Members. The software enables users to create precise models of warehouses and industrial facilities and various structural systems.

ETABS provides users with multiple section properties and material options and international design standards to create effective steel and aluminum member models needed for their optimization work. C-sections and I-sections and tapered sections can be customized by users to achieve better structural performance through design modifications. The design of industrial sheds which use aluminum members becomes possible in ETABS through user-defined web and flange dimensions which create lightweight yet strong structural components with optimal strength-to-weight ratio and material efficiency. The structural analysis process uses beams and columns as line elements, while slabs and walls and shear walls operate as plate elements to simplify design work.

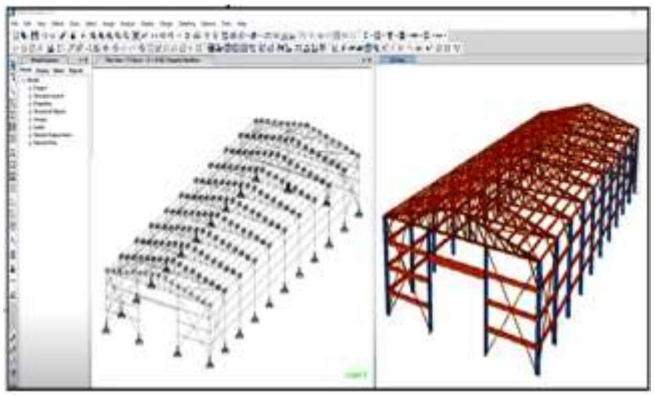

Fig.8. Modelling and Rendered View of steel Structure

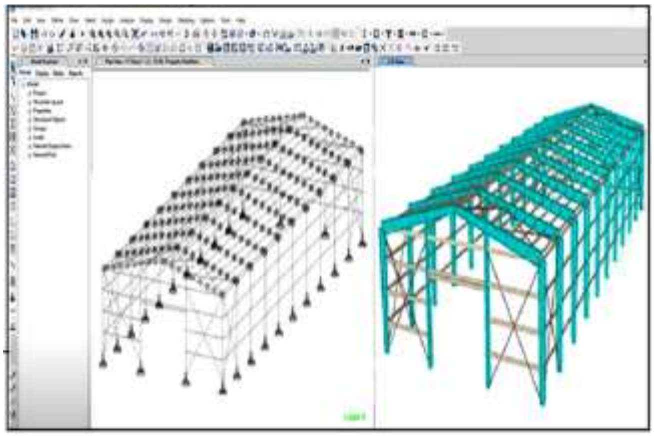

Fig.9. Modelling and 3D View of Aluminum Structure

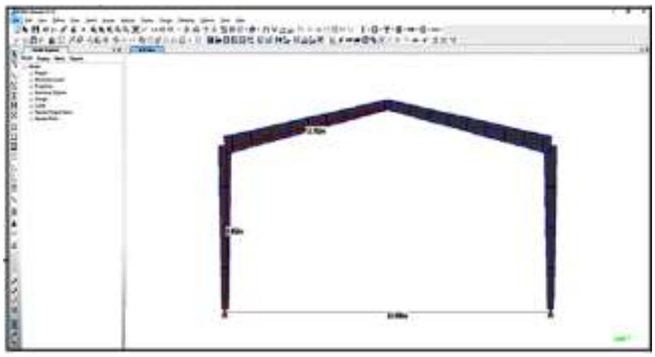

Fig.10. Assembled Tapered Section

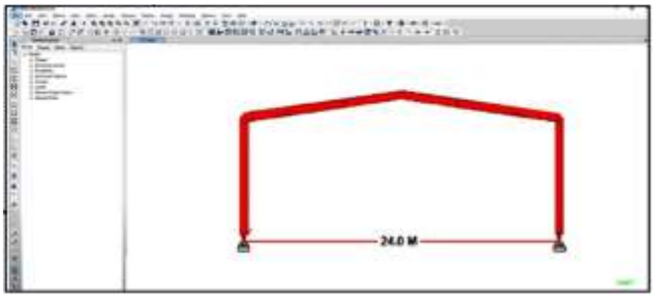

Fig.11. Assembled I-Section OF CSB Section

The Tapered section functions as a structural component which demonstrates changes in its cross-sectional size throughout its entire length. The system achieves optimal material efficiency because it strengthens essential areas while decreasing overall weight. The system probably finds application in long-span beams and portal frames and cantilever structures because it boosts performance while reducing material expenses.

An I-Beam (or H-Beam) functions as a structural element which possesses an "I" or "H" shaped cross-section that provides exceptional strength compared to its weight. The material serves as an optimal choice for primary load-bearing components because it maintains exceptional strength-to-weight relationships. The system finds common use in columns and main beams and girders because it maintains structural integrity while distributing loads and preventing bending and shear failures.

The two sections together improve the design because they increase strength while decreasing material requirements and they create optimal weight distribution which results in greater efficiency and lower costs for the structure.

VIII. RESULTS AND DISCUSSION

The structural analysis and design of the considered structure were carried out using the ETABS software, which is highly efficient and user-friendly. ETABS provides a comprehensive database for modeling and analyzing steel and aluminum structures with precision.

The software results provide graphical representations which show structural performance through load distribution and deflections and stresses and member forces. The advanced analysis tools in ETABS ensure accurate evaluation and optimization of steel and aluminum sections which enhances overall design efficiency and structural integrity.

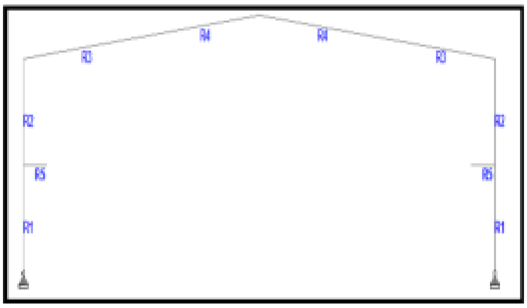

Fig. 12. Typical Section of aluminum IS 8147:1976 Frame

Table V: Sectional Details of aluminum Frame

Profile	Length (m)	Weight (t)
Tapered Member No: 1	12	5.006
Tapered Member No: 2	37.68	26.925
Tapered Member No: 3	37.68	23.763
Tapered Member No: 4	12	6.616
ST ISMB300	7.5	3.243
ISA 75X75X6	502.65	8.150604
ISA 50X50X6	501.143	22.04178
ST 200Z60X2	3680	20.16215
Total	-	115.9015

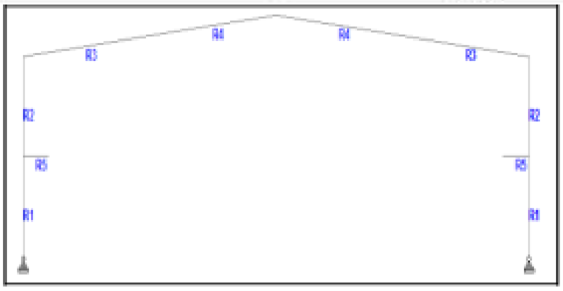

Fig. 13: Typical Section OF aluminum- AISC/LRFD Frame

Table VI: Sectional Details of aluminum IS 8147:1976 Frame

Profile	Length (m)	Weight (t)
Tapered Member No: 1	12	5.006
Tapered Member No: 2	28.68	20.49387
Tapered Member No: 3	28.68	18.08712
Tapered Member No: 4	12	6.616
ST ISMB300	7.5	3.243
ISA 75X75X6	506.851	8.218725
ISA 50X50X6	506.843	22.29248
ST 200Z60X2	3680	20.16215
Total	-	104.3854

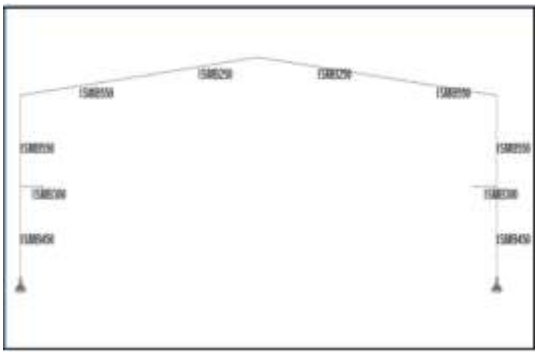
Fig. 14:: Typical Section of CSB-IS 800:2007 Frame

Table VI : Sectional Details of CSB-IS 800:2007 Frame

Profile	Length (m)	Weight (t)
ST ISMB250	48.1	17.554968
ST ISMB300	10	4.324
ST ISMB450	24	17.016
ST ISMB550	74.02	75.124717
ISA 75X75X6	583.03	36.78454
ISA 50X50X6	587.02	25.67551
ST 200Z60X2	6140	33.640115
Total	-	212.1185

Table VII: Comparison Of Weight Between steel & AL Frame

Frame Type	Weight (kN)
Steel Frame (IS 800:2007)	1394.289
Aluminum Frame (IS 800:2007)	935.619
Aluminum Frame (AISC LRFD)	879.151

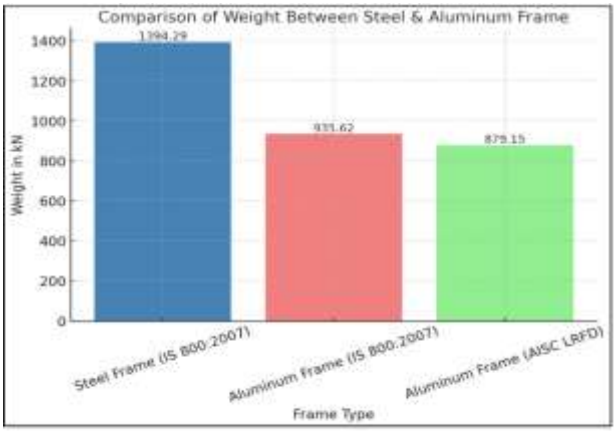

Fig. 15: Weight Correlation

The study results demonstrate that when an Industrial Shed is built with Steel and Aluminum Members according to Indian standards its weight decreases by 33 percent and its weight drops by 37 percent when constructed according to American standards because of the design parameters. The use of aluminum members in the construction process demonstrates the ability to achieve major weight reductions while maintaining necessary structural performance requirements.

Table VIII: Steel Quantity For Purlin

Type of Frame	Weight (kN)
CSB FRAME (Hot Rolled Steel Section) IS 800:2007	333.796
PEB FRAME (Cold Formed Steel Section) IS 800:2007	144.19
PEB FRAME (Cold Formed Steel Section) AISC LRFD	105.09

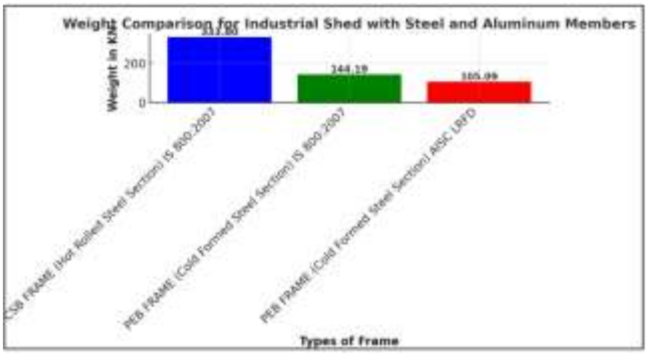

Fig. 16: Steel Quantity required for Hot Rolled Section and Cold Formed Steel section used for Purlin members

The study results demonstrate that aluminum purlin weight according to Indian standards shows a 56.80% reduction while American standards show a 68.51% reduction when compared to steel structures. The research shows that aluminum components provide better material efficiency because they reduce material requirements without compromising structural safety in industrial sheds built with steel and aluminum materials.

Table IX: Steel Quantity for Grit Members

Types of Frame	Weight (KN)
CSB FRAME (Hot Rolled Steel Section) IS 800:2007	352.118
PEB FRAME (Cold Formed Steel Section) IS 800:2007	56.807
PEB FRAME (Cold Formed Steel Section) AISC LRFD	39.439

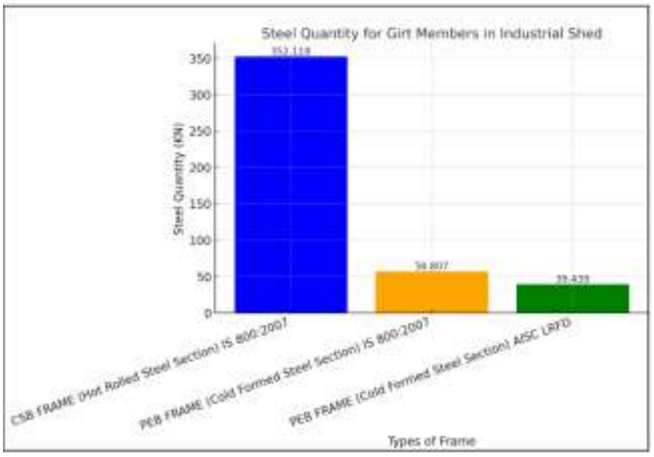

Fig. 17: Quantity of steel required for Hot Rolled Section and Cold Formed Steel used for Girt members

The Girt Member weight in an aluminum structure according to the Indian code structure (IS 800:2007) shows an 83.86% reduction and the American code structure (AISC LRFD) shows an 88.79% reduction when compared to the Girt Member weight of steel structures. The industrial shed demonstrates lightweight benefits of aluminum members which maintain structural integrity when combined with steel and aluminum components.

Table X: Maximum Shear Force In Kn

Types of Frame	Shear Force (kN)
CSB Frame (IS 800:2007)	403.064
PEB Frame (IS 800:2007)	204.744
PEB Frame (AISC LRFD)	151.018

Fig. 18: Maximum Shear Force

The research study examines industrial shed construction through the use of steel and aluminum materials. The maximum shear force in PEB structures according to Indian code standards shows a 49.27% reduction, while the American code standards show a 62.53% reduction of maximum shear force in PEB structures compared to CSB structure.

Table XI: Maximum Support Reaction in KN

Types of Frame	Support Reactions (KN)
CSB FRAME (IS 800:2007)	193.067
PEB FRAME (IS 800:2007)	159.603
PEB FRAME (AISC LRFD)	121.266

Fig. 19: Maximum Support Reaction

The research shows that the Maximum Support Reaction of steel and aluminum Industrial Shed construction design according to Indian code standards decreases by 17.33 percent while the American code standards produce a 37.18 percent reduction.

Table XII : Cost Analysis

Types of Frame	Weight of Frame (kN)	Purlin Weight (kN)	Grit Member Weight (kN)	Total Weight (kN)	Total Weight (kg)	Rate of Steel (₹/kg)	Total Cost (₹)
CSB FRAME (IS 800:2007)	1394.289	333.796	352.118	2080.2	2,12,118.30	55	1,16,66,506
PEB FRAME (IS 800:2007)	935.619	144.19	56.807	1136.62	1,15,900.73	55	63,74,540.3
PEB FRAME (AISC LRFD)	879.151	105.09	39.439	1023.68	1,04,384.65	55	57,41,155.7

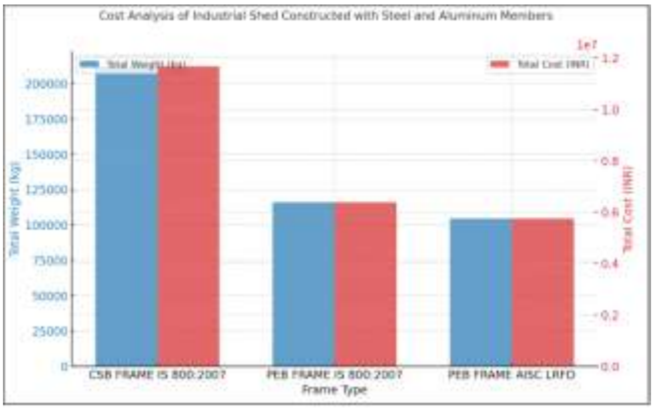

Fig. 20: Cost Analysis

The study shows that an Industrial Shed built with PEB steel and aluminum components according to Indian standards costs 45.36% less than the CSB structure while the American standards PEB building costs 50.78% less than the CSB structure. The material properties of steel and aluminum include their strengths and weaknesses. Industrial buildings use steel as their primary building material because it can resist extreme conditions and costs less than other materials. All of these become some cost-effective solutions for most industrial applications. The metal remains vulnerable to corrosion when it is exposed to high humidity and chemical environments which leads to the need for regular maintenance work and protective coating application. [38] Aluminum meets this requirement because its oxide layer protects against corrosion, which makes it suitable for use in coastal and high-humidity environments. The installation process will become simpler because aluminum weighs less than other materials; however, the price of aluminum remains high because its production requires both costly raw materials and energy-intensive manufacturing methods. Aluminum structures must use larger parts than steel components to achieve equivalent strength. This will affect overall design considerations.

A. Insights into Selection Criteria

The decision regarding steel or aluminum should be made baseding on project requirements which include ambient conditions and load-bearing requirement and budgetary considerations. Steel serves as suitable material for constructing substantial weighty structures whereas aluminum finds common application in areas which require protection against corrosion and need to decrease weight [39].

TABLE XIII. COMPARISON OF STEEL AND ALUMINUM FOR INDUSTRIAL SHEDS

Property	**Steel**	**Aluminum**
Strength	High	Moderate
Corrosion Resistance	Low (requires protection)	High (naturally resistant)
Weight	Heavy	Light
Cost	Lower material cost	Higher material cost
Maintenance	Requires periodic maintenance	Low maintenance

The steel and aluminum sheds were filmed under various loading conditions to show that steel is the better material for designing extremely heavy loads while aluminum causes less environmental harm [40].

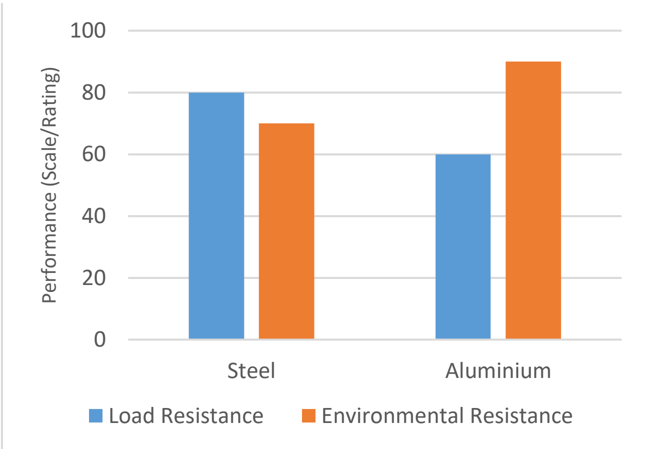

Fig. 21. Comparative Performance of Steel and Aluminum Sheds Under Different Loading Conditions

IX. CONCLUSION

Steel serves as a versatile material which provides vital support for our daily tasks. The use of aluminum members in industrial shed construction delivers multiple advantages which include reduced expenses and strengthened materials and long-lasting performance and adaptable architectural solutions and various operational applications and complete material reclamation. Aluminum exists as a sustainable material because people Can harvest it from local resources and recycle it an unlimited number of times. The study results derived from analytical and design procedures which assessed both traditional steel frameworks and aluminum-based systems lead to these established findings. Industrial Sheds that use Aluminum Members according to Indian standards display a weight reduction of 33% while American standards permit a weight reduction of 37% compared to standard steel buildings. The purlin weight in an Aluminum-integrated Industrial Shed as per Indian standards is reduced by 56.80% and as per American standards it is reduced by 68.51% compared to conventional steel structures.

Girt Member Weight Reduction: The weight of Girt Members in an Aluminum-integrated Industrial Shed according to Indian standards shows an 83.86% decrease. The weight reduction according to American standards reaches 88.79% when compared to standard steel structures.

Shear Force Reduction: Industrial Sheds that use Aluminum Members achieve a 49.27% reduction of maximum shear force according to Indian standards. American standards show that conventional steel structures experience a 62.53% reduction of maximum shear force.

Support Reaction Reduction: The maximum support reaction in an Aluminum-integrated Industrial Shed shows a 17.33% decrease according to Indian standards. The system shows a 37.18% decrease from typical steel designs according to American standards.

An evaluation of Industrial Shed costs which uses Aluminum Members shows that expenses decrease by 45.36% according to Indian standards. The cost analysis under American standards shows a 50.78% reduction when compared to standard steel structures. The use of aluminum members in industrial shed construction provides multiple advantages because it enhances structural performance and reduces building material weight and construction costs and environmental damage which establishes it as an environmentally friendly substitute for steel structures.

Future studies could focus on improving the cost-effectiveness of aluminum through innovative manufacturing techniques or exploring hybrid designs that combine the strengths of both materials. The development of modernized steel coatings and surface treatments about steel will function as essential components which enhance corrosion resistance capacity for broader steel application. The research will need to demonstrate which environmental standards both materials can maintain through their recycling and sustainable practices.

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