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# Review on Comparative Study on Design and Analysis of Industrial Shed with Steel and Aluminium Members

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***Abstract: Industrial sheds are crucial in various sectors like manufacturing, logistics, and infrastructure where structural efficiency, economy, durability, and sustainability are among the main design considerations. Steel has been the main construction material for industrial sheds because of its high strength, easy availability, and reliable design codes. But, the demand for lightweight structures, corrosion resistance, quicker construction, and reduced environmental footprint has led to a growing interest in aluminum as a potential structural material. This review paper offers a detailed comparison of the structural systems of steel and aluminum in industrial shed applications. The authors thoroughly evaluate the latest work done on structural performance, load-bearing behavior, wind and seismic response, durability, cost-effectiveness, constructability, and life-cycle environmental impacts of both materials. Results from finite element analyses, experimental studies, and design-oriented investigations suggest that while steel has the upper hand in terms of stiffness and initial cost, aluminum still delivers superb benefits in the form of weight reduction, corrosion resistance, modular construction, and carbon emission reduction. Among others, the review discusses the current problems, research needs, and limitations in design pertaining to the use of aluminum as a material and advocates for the development of refined design practices and codes. Thus, the paper helps in the material selection process for industrial shed design which is optimized.***
***Keywords: Industrial sheds, Steel structures, Aluminum structures, Comparative analysis, Structural performance etc.***

## I. INTRODUCTION

Industrial sheds are the backbone of modern industrial and infrastructure development, covering a wide range of applications from manufacturing units and warehouses to logistics centers, power plants, workshops, and storage facilities. Among their main characteristics are large clear spans, minimal internal obstructions, lightweight roofing systems, and rapid construction requirements. The structural design of industrial sheds, therefore, must cope with various environmental actions like wind, seismic forces, temperature alterations, and corrosion, requiring careful material selection and optimized structural configuration to ensure safety, durability, and economic viability [1].

The most common construction material for industrial sheds has always been steel due to its high strength, ductility, predictable structural behavior, and the existence of well-established design codes. Pre-engineered buildings made of steel (PEBs) are the most accepted choice for their material efficiency, lower construction time, and cost-effectiveness in long-span applications [1,15]. Numerous studies have shown that the steel industrial sheds are not only stiffer but also have higher load-bearing capacity when subjected to gravity, wind, and seismic forces, thereby making them fit for heavy-duty industrial usage [2]. On the other hand, steel structures suffer from corrosion, necessitating regular maintenance, and during the production process, they release large amounts of greenhouse gas which raises the issue of sustainability in the long run [14].

Sustainable construction and life-cycle performance are getting more attention and the use of aluminum instead of steel in industrial constructions is becoming a trend. Aluminum alloys have a number of advantages such as low weight, high resistance to corrosion, ability to be easily worked and very good recyclability. Its weight is only about one third that of steel which results in a significant decrease in dead load, foundation size, and transportation costs [3,11]. Hence, this is why aluminum is being considered for use in modular, prefabricated, and low to medium load industrial shed applications [10].

Aluminum has been the main focus of recent research comparing steel systems in terms of structure performance and economic feasibility.

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Although it has been found that aluminum has a lower elastic modulus, the member sizing and design optimization can allow for achieving structural performance comparable to steel in terms of strength and stability [3,6]. Finite element method-based studies on aluminum hollow sections and frame members have shown that aluminum structures can successfully pass the tests under bending and combined loading conditions provided they are designed through advanced analysis methods [12].

Durability is a primary factor that strongly determines the choice of materials used for industrial sheds. Among the various metals, aluminum stands out due to its remarkably high resistance to corrosion in hostile environments, thereby lessening the need for maintenance and thereby prolonging the service life [7]. On the other hand, steel constructions almost always require either protective coatings or galvanization leading to increased costs both initially and over the long run. Research on galvanic corrosion and bimetallic joints has pointed out even more the significance of detailing when it comes to mixing steel and aluminum parts in hybrid structures [16].

Looking at things from an environmental angle, material sustainability has taken a prominent position in structural design. Life-cycle assessment studies have indicated that although aluminum has a larger initial embodied energy, its long service life, recyclability and lighter structures can all lead to lower overall carbon emissions during the building's lifetime when compared to steel [13,14]. Further, comparative carbon emission analyses have indicated that aluminum alloy structures have huge potential in cutting down the environmental impact of industrial buildings, especially in the case of joining regions aspiring for carbon neutrality [14].

Even though there are certain benefits, the use of aluminum in the construction of industrial sheds is still constrained by a few factors such as the higher cost of its initial materials, reduced resistance to buckling due to the alloy's lower stiffness, and fewer codal provisions when compared to steel design standards [9]. On the other hand, recent research endeavors have been directed towards the formulation of dependable design methodologies, analysis of component-based joints, and the application of performance-based design practices for aluminum structures [9,18]. Moreover, the progress in manufacturing technologies, such as additive manufacturing, has also played a significant role in enhancing the mechanical properties and increasing the application range of aluminum alloys in structural engineering [8].

As the necessity for more efficient, stronger, and eco-friendly industrial buildings keeps on increasing, it becomes an absolute necessity to conduct a thorough comparison of steel and aluminum structural systems. The present review paper takes a critical look at the recent research on the structural performance, lifetime, economic factors, and environmental impacts of steel and aluminum sheds for industries. The goal of the paper is to present a coherent picture of the results from analytical, experimental, and life-cycle studies, to point out the areas where research is still needed and to offer help in making the right material choice for future industrial shed design [1–18].

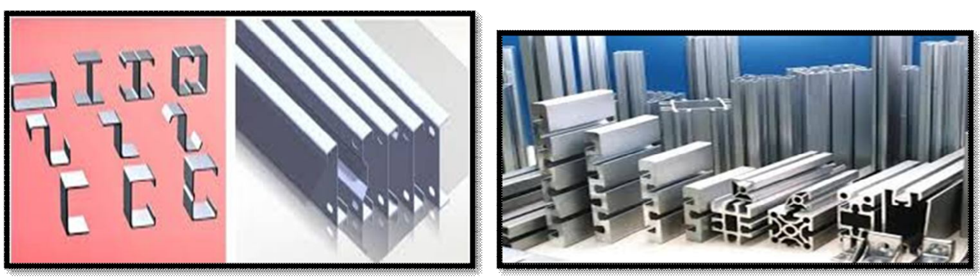

Fig.1. Steel and Aluminum Section

## II. PROBLEM IDENTIFICATION

The traditional steel systems have been the most common choice for the industrial sheds due to their proven characteristics like strength, stiffness, and familiarity with the codes. On the other hand, the concerns about long-term sustainability and life-cycle efficiency have been raised because of the increase in material costs, corrosion-related maintenance, and the steel structures' high embodied carbon [1,14]. Even though aluminum alloys have some advantages, such as being lighter, more resistant to corrosion, and more recyclable, their use in industrial structures still is limited due to higher initial cost, lower elastic modulus, and insufficient design guidelines compared to steel [3,7]. Researchers often study only one aspect like strength, cost, or durability, and do not provide a comprehensive comparative evaluation of those factors under the same loading and geometric conditions [6,10]. Besides, the effects of wind, seismic actions, and serviceability criteria on the performance of aluminum industrial sheds are not sufficiently documented [2,12]. Thus, a comparative assessment of steel and aluminum industrial shed systems, in a way that aids informed material selection and optimized structural design, is badly needed [1–18].

### A. *Existing System*

1) Traditional steel structural systems are mostly applied in the construction of industrial sheds, which includes hot-rolled sections, cold-formed members, and pre-engineered buildings (PEBs) [1,14].
2) The steel's superiority in strength, stiffness, and ductility, as well as the well-established codes like IS 800, IS 875, and IS 1893 are the main reasons for choosing it [1,2].
3) The current systems give priority to long-span capability, easy production, and compatibility with heavy industrial loads and cranes [11].
4) Design methodologies are backed by a vast amount of research, standard detailing, and the presence of experts through the industry [5].
5) Galvanizing, painting, and fireproofing are the common methods for corrosion protection, which together provide durability in normal environments [4].
6) The marketability aspect is usually based on the whole life cost considering the initial construction cost only, thus the lifecycle performance is overlooked [3,9].

### B. *Drawbacks*

1) Steel constructions experience corrosion as the main form of damage, particularly when located near the sea, in chemical areas or in places with high humidity, thus making maintenance more expensive [4,16].
2) Steel's heaviness is one of the prime factors leading to increased foundation and seismic forces, eventually compromising its structural efficiency [3,12].
3) Fire and corrosion protection considerably increase the costs of lifecycle, which are often neglected [9,14].
4) Present-day systems hardly ever consider aluminum or mixed steel-aluminum options, and thus limit the possibilities for innovation and improvement [5,7].
5) The production process of steel is the prime source of high embodied CO2 emissions, which gives rise to environmental issues [13,18].
6) Revising design according to the new wind and seismic codes usually yields more steel usage, hence making the cost effectiveness lower [2,15].

## III. LITERATURE REVIEWS

### A. *Literature Survey:*

Šáran, K. et. al. (2023), This research provides an extensive literature review on the subject, focusing on the comparison of long-span pre-engineered building (PEB) industrial sheds and conventional steel structural systems. According to the authors, the mainly steel-based PEBs will dramatically save the material cost—up to 50% or as low as 25%—thanks to the optimized tapered sections and to the efficient load paths. Among the merits of PEBs, the review puts forward the advantages—i.e., faster construction timelines, improved quality control through off-site fabrication, and reduced labor requirements. On the contrary, it points out that PEB systems require great design precision and state-of-the-art fabrication facilities. A lifecycle cost analysis indicates that although higher initial planning is necessary, PEBs usually end up costing less in total. The paper also notes the environmental good caused by the lower steel requirement and the smaller amount of construction waste; however, it adds that the economic viability is highly dependent on local fabrication and transportation costs.

Hirekhan, S. G., et. al. (2023), This study analyzes variations in wind pressure for steel industrial sheds applying various codal provisions, namely IS 875 (1987 and its revised versions) and MBMA guidelines. The authors point out that the new wind codes usually lead to higher design wind pressures, particularly for large and exposed structures, resulting in more steel consumption. The research points out that designers who rely on old practices might not apply sufficient wind loads, thus putting the structure's safety at risk. The study presents various strategies to reduce weight like better bracing systems and careful selection of members. The results underscore the decision about the right design codes as a determining factor for safety, serviceability, and cost-effectiveness of steel industrial sheds.

Mehta, P., et. al. (2021), In this study, the finite element method was employed to conduct a comparison between the structural behavior of steel frames and aluminum frames in industrial sheds. The findings demonstrated that the steel constructions have higher stiffness and lower deflections when subjected to service loads, thus they are more applicable for the heavy-duty industry. The aluminum constructions are constrained with larger section sizes that are necessary to meet the strength and deflection limits, but on the other hand, they cut down considerably the dead weight and foundation reactions.

The seismic analysis indicates that due to the lesser weight of aluminum, the seismic forces are lowered, however, the higher flexibility results in more displacements. The authors say that aluminum is a potential option for the secondary members, modular systems, and areas with high corrosion while steel is still the option for primary load-bearing frames unless hybrid systems are introduced.

Yan, Y., et. al. (2019), The paper compares the lifecycle cost and durability of steel and aluminum structural systems. Steel initially has cheaper material costs but it will need tough corrosion protection and periodic maintenance which will eventually lead to an increase in the total cost. On the other hand, the aluminum has a higher initial cost but at the same time its corrosion resistance and maintenance needs are very low, particularly in coastal and industrial areas. Life-cycle assessments covering 20–30 years prove that aluminum structures can cost less if used in very harsh environments. The authors suggest considering maintenance schedules, environmental exposure, and recycling credits in the economic evaluations instead of only focusing on the initial construction costs.

Sun, Y. et. al. (2020), The selection of materials for industrial buildings subjected to wind and seismic loads is examined through a comparison of steel and aluminum. The research points out that steel has a better strength-to-cost ratio in long-span and heavy-load applications. The low weight of aluminum leads to lower loads on the foundation and thus, better constructability. The environmental analysis claims that aluminum not only has great recyclability but also has a lower embodied carbon when recycled content is used. The author suggests using hybrid structural systems composed of steel primary frames and aluminum secondary members to optimize cost, weight, and lifespan. A sensitivity analysis indicates that the costs of local materials and the availability of specific sections have a considerable impact on the feasibility, thus reinforcing the necessity of selecting materials that are specific to the project.

Peko, J., et. al. (2017), The assessment of steel and aluminum construction systems focusing on mechanical performance and cost-effective usage is the main aim of this comparative study. Steel provides greater rigidity and capacity for load carrying whereas aluminum gives significant weight reduction and resistance to rust. One of the points the authors make is that aluminum needs more massive sections to attain the same strength level which can have an adverse effect on the efficiency of the design. It is still considered that lightweight and corrosion exposure applications could be done in steel-friendly industrial use only. On the other hand, dual-material solutions are recommended as a good way to utilize the properties of both materials for their merit.

Georgantzia, E., et. al. (2021), This review presents a summary of aluminum alloys in relation to their usage as structural materials, by giving a detailed account of the advancements in the properties, design, and applications of materials. The writers mention the high strength-to-weight ratio, corrosion resistance, and recyclability of aluminum as its major advantages. On the other hand, they also present the challenges like the lower elastic modulus, fire resistance, and lack of codal guidance as drawbacks. The review piece signals the importance of developing design standards along experimental validation to promote the use of aluminum in structures where it bears the load. The study backs up the trend of utilizing more aluminum in constructions that are modular, prefabricated, and environment-friendly.

Habib, N., et. al. (2025), The present paper investigates additive manufacturing (AM) as a method of making aluminum components and their drawbacks. The authors say that AM has better geometric flexibility and material efficiency than traditional machining. Mechanical testing reveals that AM parts are equally as strong as the best-designed traditional parts with the possibility of altering the properties depending on the application. On the other hand, the disadvantages of AM in terms of anisotropy, surface finish, and cost are discussed. The study proposed that the use of AM aluminum parts in light structural applications is a possibility if the aspects of design and quality control are taken care of. The results open up a wide range of applications for both future industrial and modular construction.

Skejić, D., et al. (2024), This paper presents a guide for the trustworthy construction of aluminum structures. It covers the properties of the material, the design of the joints, fatigue life, and resistance to fire. The authors point out the discrepancies between the different design codes and suggest unified rules. The focus is on performance-oriented design and sophisticated numerical modeling. The research ends with the statement that aluminum can be not only safe but also economically used in structural applications, like industrial sheds, if adequate design standards and testing procedures are applied.

Cascino, A., et. al. (2025), This research makes a comparison of the load-bearing capability and cost efficiency of steel-welded and modular aluminum rack structures. Steel systems are found to be stiffer, while the aluminum modular ones are light and can easily be assembled and have a wider range of applications. Cost analysis for the entire lifecycle of the structure indicates that aluminum systems are able to compete when the aspects of reusability and savings from maintenance are taken into account. The authors suggest the use of modular aluminum structures in those industrial environments that are flexible and require frequent changes in the configuration.

Thoresen A. et. al. (2024), Thoresen assesses both steel and aluminum as materials for low-volume structural production. Steel is considered to be economically beneficial for large-scale production, while aluminum boasts benefits in terms of customizability, corrosion resistance, and lower tooling costs. The research comes to a close stating that aluminum is acceptable for specialized, low-volume industrial applications, where adaptability and sustainability are the most important factors

Feng, R., et al. (2023), This study performs finite element analysis on web-opened aluminum alloy RHS and SHS sections. The findings show a decrease in stiffness close to the openings; however, if adequate reinforcement is applied, the performance is still within the range of acceptability. The research encourages the use of aluminum in lightweight structural systems that are well-detailed and have been optimized.

Yan Y., et. al. (2024), The authors of this paper do a comparison of carbon emissions which when using steel and aluminum structures. The initial carbon footprint of primary aluminum is high due to the high energy consumption involved in its production, but if recycled aluminum is used instead the emissions will be greatly cut down. The case of steel is that of initially lower emissions but higher impacts from maintenance. The authors put forth the idea of carbon assessment based on the entire lifecycle of materials as a means for selecting the most sustainable material.

Sharma, L., et. al. (2024), A comparison of traditional steel buildings with PEB systems is made in this study. PEBs show less steel consumption, quicker construction, and cost reduction. Conventional systems offer flexibility but use up more material. The writers state that PEBs are the better option for industrial sheds that need efficiency and speed.

Tokede O. , et al. (2025), In this paper, different materials for moment-resisting frames are evaluated. Steel has the advantage of being very ductile while aluminum reduces the seismic mass. Hybrid systems exhibit better performance which indicates the integration of materials as the future direction.

### B. Literature Summary

1) Thorough analyses have been conducted to compare steel and aluminum in terms of their industrial and long-span shed applications regarding strength, weight, cost, and durability.
2) Steel shelters have become the preferred option because of their great load-bearing and deflection resistance, together with the availability of the well-established design codes (IS 800, IS 875).
3) The advantages of pre-engineered steel buildings (PEBs) include less material consumption, quicker construction, and lower total costs during the lifecycle.
4) Construction and seismic regions benefit from aluminum structures' lightness, corrosion resistance, and recyclability.
5) According to finite element analysis, steel produces smaller deformations, whereas aluminum allows for smaller foundation sizes due to its own lower weight.
6) In their comparisons of the environmental and economic aspects of certain products, the recyclability of aluminum has been pointed out as a strong sustainability advantage when recycled content is used.
7) Steel primary members and aluminum secondary components in a single structure that combines both materials have become more and more common to recommend.
8) Material selection is still dictated by context, as research shows that environmental exposure, cost, and performance requirements must be considered.

### C. Research Gap

1) Limited comparative studies that specifically deal with industrial sheds, utilizing both steel and aluminum under identical geometric and loading conditions, are few in number.
2) The majority of research assesses the properties of materials separately rather than considering the overall structural performance.
3) The study of the long-term performance of aluminum structures under various conditions such as fatigue, fire exposure, and repeated loading is still in its early stages.
4) Economic studies that are currently available often do not consider full lifecycle costs such as maintenance, recyclability, and environmental impact.
5) Codal limitations and the absence of unified design guidelines prevent aluminum from being widely used in industrial structures.
6) Only a few studies have been conducted on hybrid steel–aluminum systems that focus on optimizing performance as well as cost efficiency.

7) The role of local environmental conditions like wind, seismicity, and corrosion in material selection is poorly represented.
8) An extensive, software-driven comparative analysis that considers these things is required to facilitate appropriately informed engineering choices.

## IV. RESEARCH METHODOLOGY

### A. *Criteria for selecting this study*

1) The rapid growth of industries has led to an increase in the need for large industrial sheds that are economical, good for the environment, and have a long life span.
2) Steel is the most common material used for this purpose but its rising maintenance costs and the negative impact on the environment are forcing the industry to look for alternatives.
3) Aluminum has many good properties, like being very light, not getting rusty, and being easy to recycle, but still it is not widely-used.
4) There are only a few studies that make comparisons between steel and aluminum under identical conditions of geometry, loading, and boundary.
5) The new wind and seismic codes demand the re-evaluation of the material's efficiency and the safety margins.
6) On the other hand, factors such as lifecycle cost, sustainability, and carbon emission are becoming more and more critical in the structural design process.
7) With regards to industrial sheds, the engineers do not have any specific decision frameworks when it comes to choosing between steel, aluminum, or hybrid systems.
8) The current study fills the gap by offering a comparison based on software that is codal and performance-oriented, which will in turn assist in making a more informed choice of the material.

### B. *Method of Analysis*

1) An industrial shed structure has been created in ETABS software using the same geometry for both steel and aluminum buildings.
2) Material characteristics are recognized according to IS 800/IS 801 for steel and IS 8147 for aluminum, with IS 875 and IS 1893 for loading.
3) Dead, live, wind, and seismic loads according to the code are applied.
4) Load cases are prepared for the Ultimate Limit State (ULS) and Serviceability Limit State (SLS).
5) Static and dynamic (response spectrum) analyses are done.
6) The result of the structure is examined i.e. deflection, member forces, stress, and stability.
7) Member sizes are optimized by auto-selection.
8) Comparative evaluation is done based on weight, performance, cost indicators, and structural efficiency.

### C. *Comparison and Analysis*

| Parameter | Steel Structures | Aluminum Structures | Literature Support |
|---|---|---|---|
| Structural Performance | High stiffness and strength; lower deflections and better load-carrying capacity for long-span and heavy-duty industrial sheds. | Lower stiffness; requires larger sections to control deflection; suitable for secondary members and moderate spans. | Mehta & Gupta (2021); Peko et al. (2017); Sun (2020) |
| Weight & Foundation Demand | Higher self-weight increases foundation size and seismic mass, leading to higher base shear. | Significantly lower self-weight reduces foundation reactions and seismic forces. | Mehta & Gupta (2021); Sun (2020); Cascino et al. (2025) |
| Durability & Maintenance | Prone to corrosion; requires protective coatings and periodic maintenance, especially in aggressive environments. | Excellent corrosion resistance; lower maintenance needs and longer service life in coastal/industrial environments. | Yan & Shan (2019); Georgantzia et al. (2021); Saai et al. (2023) |
| Cost & Sustainability | Lower initial material cost; higher lifecycle cost due to maintenance and corrosion protection. | Higher initial cost; competitive or lower lifecycle cost due to recyclability and reduced maintenance. | Yan & Shan (2019); Sun (2020); Yan & Shan (2024) |

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## V. DISCUSSION

### A. *Synthesis of findings from literature*

The synthesis of findings from the reviewed literature indicates that steel and aluminium each offer distinct advantages for industrial shed construction depending on structural, environmental, and economic requirements. Steel remains the dominant material for long-span and heavy-load industrial sheds because of its very high stiffness, strength, and well-established design codes, resulting in the lower deflections and the reliable performance of the structure. However, studies report consistently that steel has heavier self-weight, more foundation demand, and more maintenance surface area because of the corrosion protection that is needed. On the other hand, the aluminum structures bring to light the entire range of advantages in the areas of reduced dead weight, corrosion resistance, easy and eco-friendly fabrication, and recycling thus making them suitable for coastal, seismic-prone, and modular applications. It is true that aluminum requires larger sectional dimensions to satisfy the serviceability and buckling criteria; nevertheless, its lower maintenance and lifecycle costs can counterbalance the higher initial material expenses. A number of research studies have proposed hybrid steel–aluminium systems as a way to combine the efficiency of steel's load-bearing with the durability and sustainability of aluminum; thus, stressing the need for context-sensitive material selection.

### B. *Methodology for future research directions*

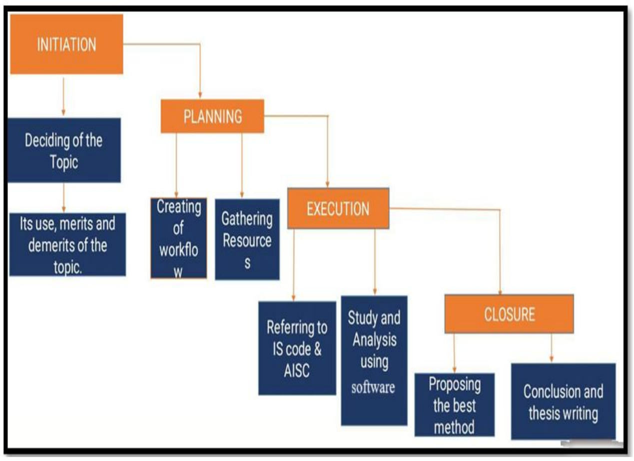


Fig. 1. Flow Diagram of system

The principal focus of the evaluation and planning of aluminum and steel structures alike is to verify the comparison of strength and weight per unit. The characteristics of aluminum alloy are almost equal to those of steel. This is the only reason why the designed structure will be able to perform well throughout its life cycle. The structure should, however, be constructed with proper safety measures such that it:

- Will bear all the load that will be placed on it.
- Will not get damaged by the movement caused during and after the construction process.
- Will not only be safe but also have alternate load paths that can prevent total failure in case of accidental loading.

#### *1)* Defining the Project Scope and Objectives

- Identify building type and requirements :- First of all, decide on the dimensional and structural arrangement (like truss systems, frame elements) and the environmental conditions such as wind and seismic loads, etc.
- Set objectives :- To mention a few, the objectives can be related to the reduction of the structure weight, the reduction of the requirement for funds, and the efficiency of the bearing loads.

#### *2)* Modeling in ETABS

- Produce two different models of the structure :- One consisting of steel members and the other containing aluminum members.
- Use ETABS to present the geometry that is to be built, that is, the design of the building (beams, columns, walls, etc.) based on the industrial design, which includes height, width of the area, and location of load areas.
- Choose materials :- Select standard steel & Aluminum and their respective mechanical properties.

*3)* Load Application and Combinations

• Loads must be defined in compliance with the respective standards :- Dead Loads :- The weight of the materials themselves, Live Loads :- human presence and equipment weight. Environmental Loads :- Wind and earthquake loads (as mentioned in IS 875 and IS 1893). Load combinations are created :- For Ultimate Limit State (ULS) and Serviceability Limit State (SLS) both use the standard load combinations for design.

*4)* Analysis and Design Optimization in ETABS

• Static Analysis is applied for dead and live loads. Seismic forces Response Spectrum. Results for the two models are evaluated :- Deflections, stress distributions, and load factors are compared. Member stability is checked to uncover potential buckling problems. In ETABS, the auto-selection feature is used to determine the most efficient member sizes for both materials.

*5)* Comparative Results Interpretation

• Structural Performance :- Assess the differences in weight, load-bearing capacity, deflections, and member stability of steel and aluminum structures.

*6)* Conclusion and Recommendations

• Present the recommendations for the best material considering the specific industrial building's needs along with the performance, cost, and ecological impact assessment.

### *C. Steel and Aluminum for Warehouse Design*

• Strength & Load-Bearing :- Steel's elasticity modulus is very high which makes it perfect for massive loads and aluminum suitable for moderate ones.

• Weight & Installation:- The low density of aluminum allows easier handling, reduces foundation load, and accelerates assembly.

• Corrosion Resistance:- The protection of steel through coatings is a necessity while aluminum exposure outdoors is facilitated due to its natural corrosion resistance.

• Thermal Properties :- The great conductivity and expansion of aluminum necessitate a careful joint design for stability.

### *D. Design Details*

This research incorporates the analysis of both steel and aluminum materials through the application of ETABS software to evaluate the structural performance of an industrial warehouse. The investigation is based on the design of three different types of 3D building structures that are all subjected to both static and dynamic forces.

The analysis covers comparing the performance of these materials under varying load conditions which include, besides dead and live, seismic loads too. The evaluation encompasses the study of structural behavior, stability, and load-bearing capacity, deflections, and stresses plus overall performance of each material.

The research intents to supply information about the industrial warehouse that is the most efficient in terms of materials' strength, lightness, cost-effectiveness, and resistance to dynamic forces such as wind and earthquakes, thus helping the engineers make the right design choices based on their findings.

### *E. Material-Specific Details*

• Steel: Very strong structural steel, suitable for very heavy loads, giving long life and high ductility.

• Aluminum: Very light but with a very good strength-to-weight ratio, resistant to corrosion and often used in cases of light loads or special environmental conditions where the weighting is critical.

## VI. CONCLUSION

The review article suggests that the decision on which structural material to use for industrial sheds should consider performance needs, environmental exposure, economic factors, and long-term sustainability instead of just the initial cost. Steel is still the material of choice for large and heavy industrial sheds because of its high strength, stiffness, and extensive codal provisions, which guarantee reliable load-bearing capacity and structural stability. Nevertheless, its vulnerability to corrosion and higher maintenance requirements lead to increased lifecycle costs, especially in harsh environments.

On the other hand, aluminum is considered having lower stiffness and higher upfront material cost but it provides the most important advantages including lighter weight, corrosion resistance, fabricating ease, and recyclability which consequently results in lower foundation loads and maintenance requirement. The studies reviewed all point out aluminum's ability of use in coastal, seismic, modular, and lightweight industrial applications. Moreover, hybrid steel–aluminum systems are seen as a feasible solution, bringing together the structural efficiency of steel with the durability and sustainability of aluminum. In conclusion, this review makes it clear that the decision regarding material choice for industrial shed designs must be made on a lifecycle basis considering the particular context to arrive at optimized- resilient- and sustainable designs.

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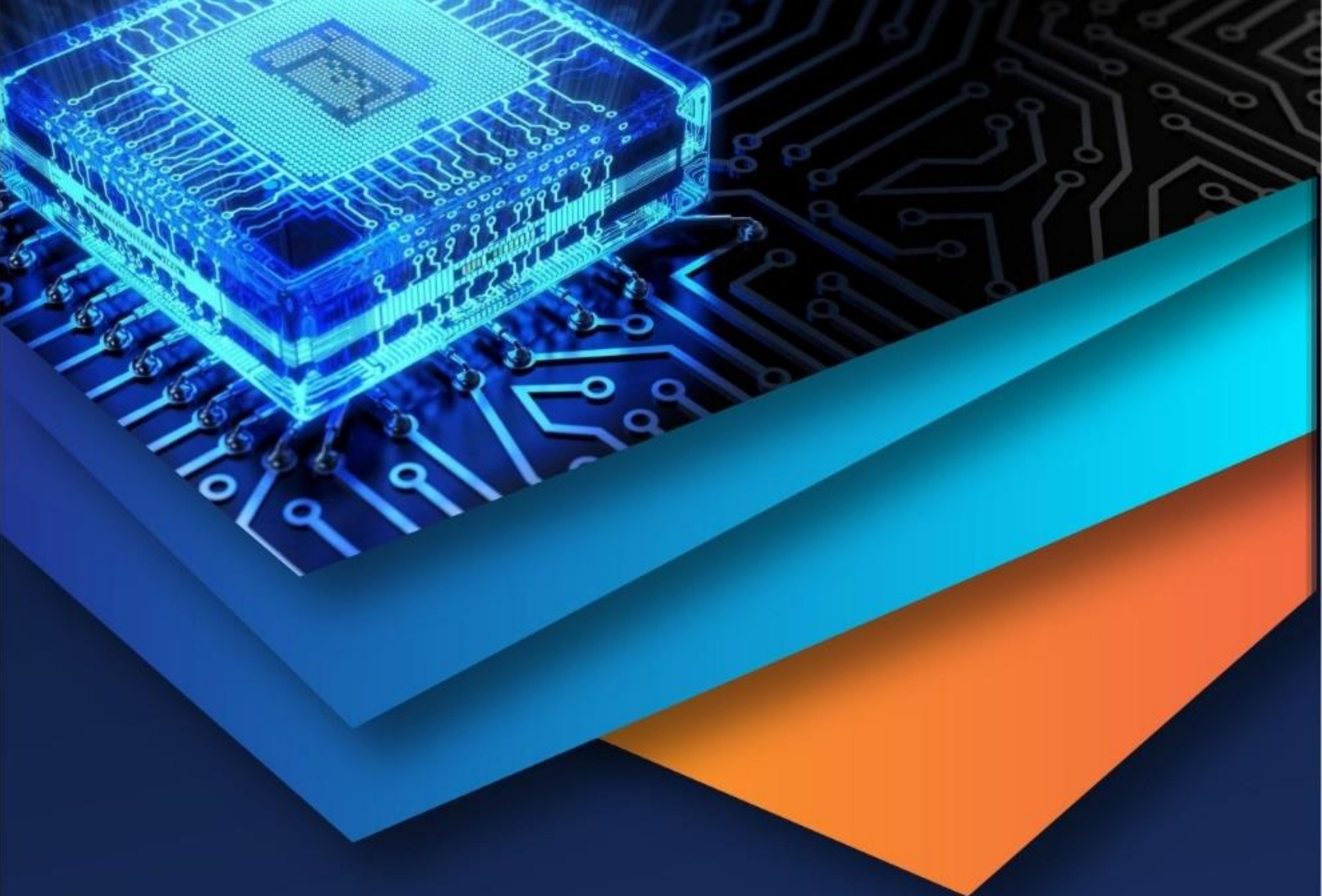

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