

‘Comparison of Light Gauge Structural Frame and Conventional Building Systems in High Rise Buildings in India’

Mr. PRANAV RAJPUT
Mr. SHREYANS BANSAL

DEPARTMENT OF ARCHITECTURE SCHOOL OF PLANNING AND ARCHITECTURE,
BHOPAL

Under the Guidance of

Prof. Dr. Sushil Kumar Solanki
Prof. Dr. Sanmarga Mitra
Prof. Ar. Vipendra Singh Thakur

ABSTRACT

Over the past century, the surge in high-rise construction driven by rapid population growth has prompted the demand for more efficient structural systems, leading to the global adoption of materials like Light Gauge Steel Frames (LGSF) across various building typologies. Drawing from existing literature and historical data, this study seeks to critically compare LGSF with traditional construction materials commonly used in India. Numerous studies conducted both domestically and internationally have explored the structural efficiency of LGSF, and this paper aims to identify research gaps related to its application in high-rise construction. It also assesses prior comparative research between LGSF and conventional systems within the Indian built environment.

Keywords- High Rise Construction, Light Gauge Steel Framing System, Conventional Building Systems, Structural Material, Hybrid Construction

INTRODUCTION

Promoting a city's image through tall buildings is an art that elevates its standing in the global economy. From Heidegger's viewpoint, a city's modern image is rooted in the fundamental process of "representing the world as an image." Therefore, creating a distinct image for a city in this globalized environment is crucial, not only for self-promotion but also for competing with other cities and attaining a more prominent role in the global economy (Lai, 2014). Various countries incentivize the development of comprehensive plans to initiate high-rise investment projects, showcasing their economic strength and international prestige. High-rise buildings have captivated people since ancient times. The construction of such structures originated long ago for defensive or religious uses (such as Roman temples and churches). In contemporary times, the development of these projects started in the late 19th century, initially serving residential or administrative purposes, later evolving to cater to hotels and other tourism-related needs. The term "high-rise" lacks a universal definition. However, it can be viewed from various perspectives. A structure that could pose significant challenges for evacuation due to its height is considered a high-rise building, as defined at an international conference on fire safety concerning high-rise buildings (Craighead, 2009). Typically, a high-rise is regarded as a structure that exceeds the reach of fire-fighting equipment. This height has been variably defined as between 75 feet (23 meters) and 100 feet (30 meters), equating to about five to ten stories (based on the floor-to-floor distance). The International Building Code (IBC) and the Building Construction and Safety Code categorize high-rise

buildings as those 75 feet or taller, measured from the lowest level accessible by fire department vehicles (IBC, 2006). This height criterion has undergone changes in subsequent IBC publications. Generally, buildings ranging from 23 meters (approximately six stories) to 150 meters are identified as high-rises. Structures taller than 150 meters are classified as skyscrapers, while those exceeding 300 meters are termed supertall buildings (Ali and Armstrong, 1995). The Council on Tall Buildings and Urban Habitat (CTBUH) established international standards for defining tall buildings, categorizing them as 'supertalls' and 'mega tall.' A “supertall” refers to a tall building measuring 300 meters (984 feet) or more, while a “mega tall” is one that reaches 600 meters (1,968 feet) or above. As of 2018, there were 149 completed supertall buildings and only 3 mega tall structures worldwide. In India, each city (primarily metropolitan areas and occasionally satellite towns) sets height limits for high-rise buildings as per their building regulations. For example, in Mumbai, high-rise buildings can reach up to 120 meters, or about 40 stories high. The Kolkata Municipal Corporation's building regulations from 2009 do not specifically mention high-rise buildings but emphasize the need for open space in high-rise residential buildings that are 80 meters or taller. There are numerous reasons to invest in high-rise building projects, including rapid urban population growth, which creates constant pressure on limited land areas, high land values, the need to curb uncontrolled expansion near agricultural lands, and the high costs associated with developing infrastructure for new cities, all reflecting progress. During the post-war period from 1950 to 1971, many cities worldwide embraced high-rises as symbols of “a new world,” offering an ideal lifestyle and promoting equitable and healthy housing at higher densities.

Structural Parameters for High Rise Construction

1. Dead Loads
2. Live loads
3. Climatic loads
 - Wind
 - Snow
4. Exceptional Loads
 - Seismic Load
 - Cyclones, hurricanes, tornadoes
5. Dynamic Superimposed Loads
6. Construction Load

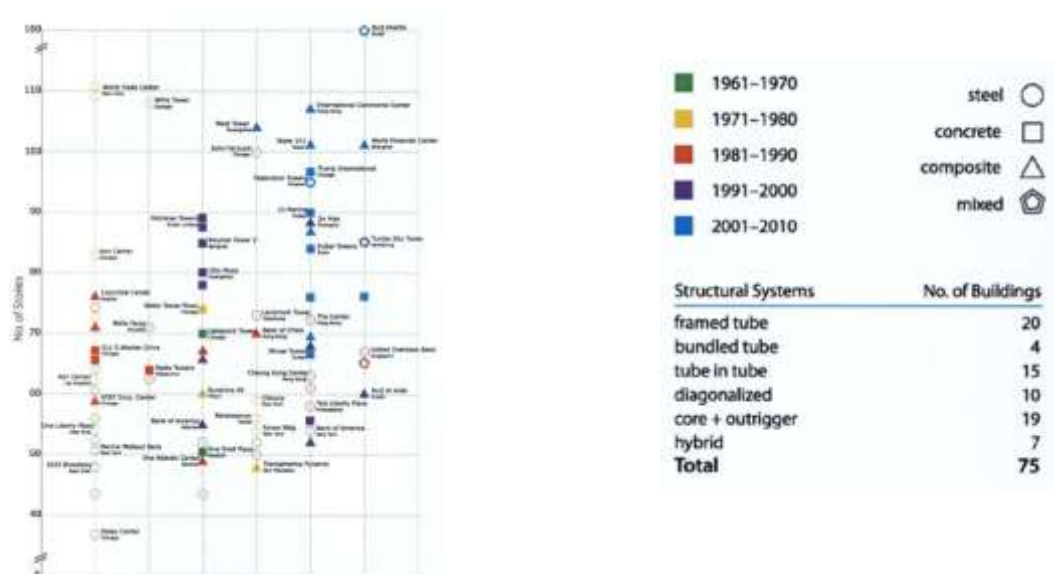


Fig 1: GRAPH SHOWING DIFFERENT BUILDINGS IN DIFFERENT STRUCTURAL SYSTEMS USING DIFFERENT MATERIAL

Same cannot be said for high rise construction in Indian context due to various socio- environmental impacts which are generated by the lack of efficient building material, structural systems and adoption of LGSF as a structural material.

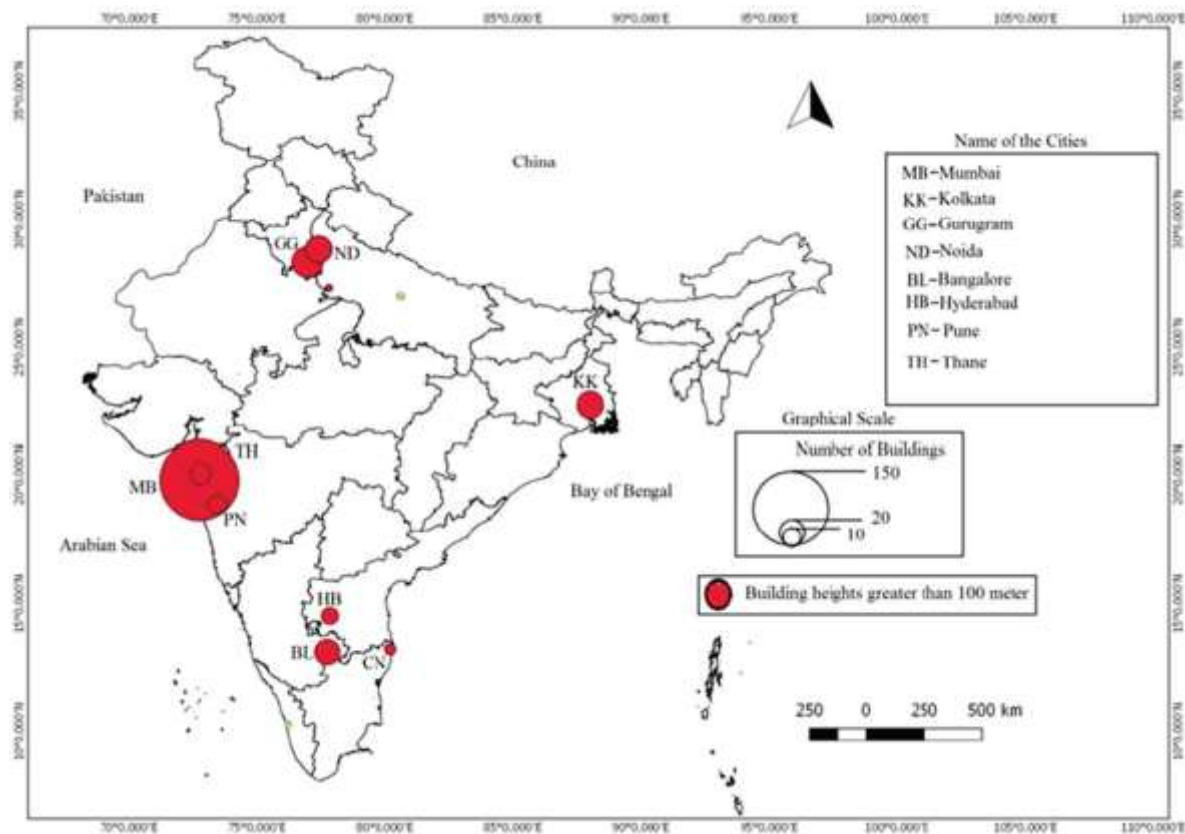


Fig 2: MAP OF INDIA SHOWING BUILDING WITH HEIGHTS MORE THAN 100 FLOORS IN METRO CITIES

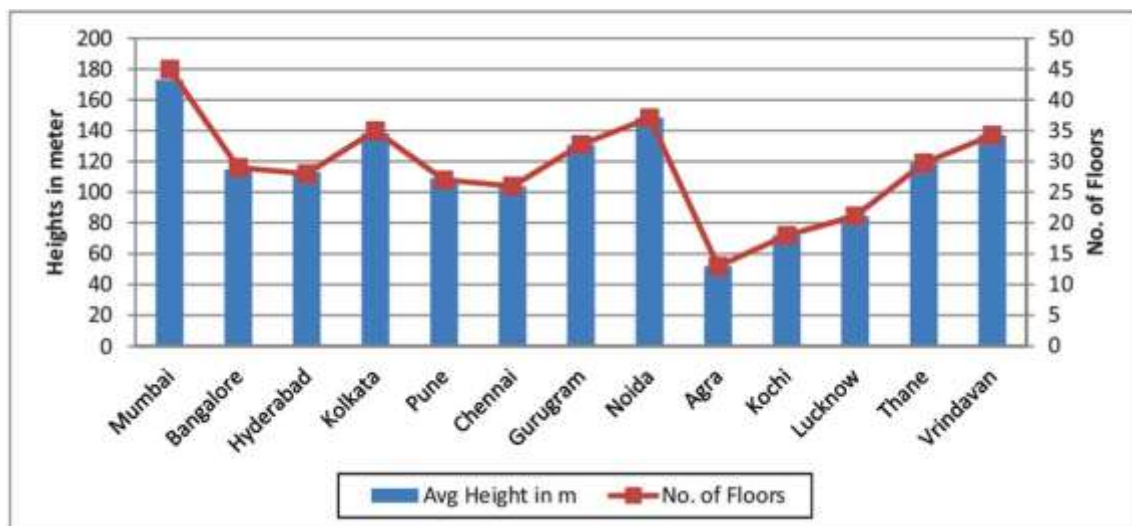


Fig 3: GRAPH SHOWING AVERAGE HEIGHT AND NO. OF FLOORS

LIGHT GAUGE STEEL FRAMING

Over the years, various improved systems have been developed for use in landed properties. An economical light gauge steel frame system is increasingly being used in America, Europe, Australia and New Zealand. This light gauge steel frame is developed through a cold-formed process without the use of heat. This process enables steel manufacturers to produce light-weight but high tensile steel sheets. The sheet surface is coated with a zinc alloy that completely covers the steel surface and seals it from the corrosive action of its environment. This results in buildings

that are more solid, rigid, stronger, durable and easier to build. As such, the light gauge steel frame system is an attractive alternative for use in landed properties.

Fig 4: THE TRUMP TOWER HOTEL



Fig 5: BURJ KHALIFA



Fig 6: BANK OF AMERICA TOWER



Fig 8: LINKED HYBRID



Fig 8: MARIANA BAY SANDS

ADVANTAGES

LGSF systems offer a wide range of advantages that align with the demands of modern construction, particularly in the context of efficiency, resilience, and sustainability.

- **Buildability:** The use of prefabricated and pre assembled steel components reduces site works, reduces material waste and improves quality.
- **Speed:** This system requires a shorter construction period compared to that for a conventional system.
- **Strong but Lightweight:** Steel has one of the highest strength-to-weight ratios of any construction material. This results in savings in the foundation required and the lightness also makes for easier on-site handling.
- **Safety:** Steel's inherent strength and non-combustible qualities enable light steel frame houses to resist such devastating events as fires, earthquakes, and hurricanes. Homes can be designed to meet the highest seismic and wind load specifications in any part of the country.
- **Quality:** A better-quality finished house that is durable and low in maintenance.
- **Easy to Remodel:** Remodelling can be easily accomplished. Non-load bearing walls can be readily relocated, removed or altered.
- **Design Flexibility:** Because of its strength, steel can span longer lengths, offering larger open spaces and

increased design flexibility without requiring intermediate columns or load bearing walls.

- **Recyclable:** All steel products are recyclable.

Technical Components

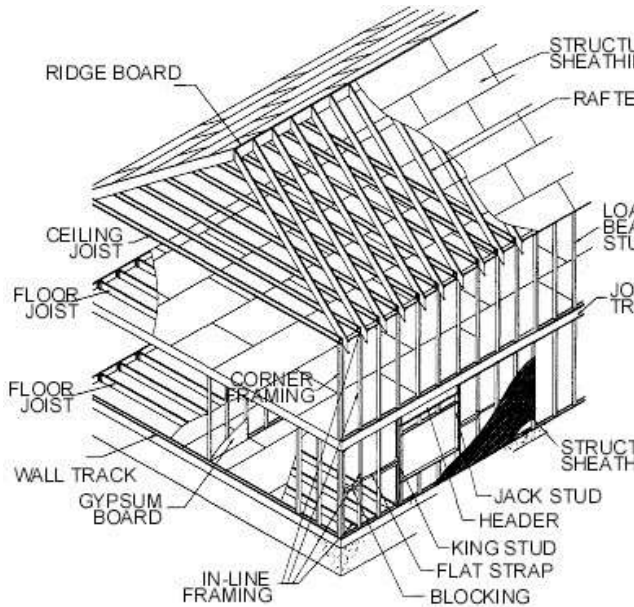


Fig 9: TECHNICAL COMPONENTS

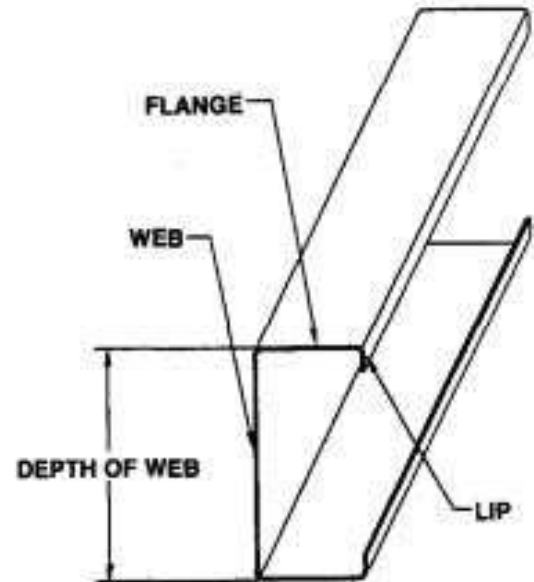


Fig 10: C SECTION

- **Bottom Plate:** A plate that contains the bottom end of a wall stud. The top plate has a web and flanges, but no lips.
- **Ceiling Joist:** A horizontal structural framing member that supports a ceiling and/or attic loads
- **C-section:** Used for structural framing members such as studs, joists, beams, girders, and rafters.
- **Clip Angle:** An L-shaped short piece of metal (normally with a 90-degree bend) typically used for connections.
- **Flange:** The part of a C-section or track that is perpendicular to the web
- **Flat Strap:** Sheet steel cut to a specified width without any bends, typically used for bracing and other flat applications
- **Floor Joist:** A horizontal structural framing member that supports floor loads
- **Gauge:** A unit of measurement traditionally used to describe the nominal thickness of steel. The lower the gauge, the greater the thickness.
- **Header:** A horizontal built-up structural framing member used over wall or roof openings to carry loads across the opening
- **Lip:** The part of a C-section that extends from the flange at the open end. The lip increases the strength characteristics of the member and acts as a stiffener to the flange
- **Multiple Span:** The span made by a continuous member having intermediate supports

- **Shear Wall:** A wall assembly capable of resisting lateral forces to prevent racking from wind or seismic loads acting parallel to the plane of the wall.
- **Single Span:** The span made by one continuous structural member without any intermediate supports.
- **Span:** The clear horizontal distance between bearing supports.
- **Structural Sheathing:** The covering (e.g. steel sheets) used directly over structural members (e.g. studs or joists) to distribute loads, brace walls, and strengthen the assembly
- **Stud:** Vertical structural element of a wall assembly that supports vertical loads and/or transfers lateral loads
- **Top Plate:** A plate used to carry truss loads from the roof to the studs, where the studs are not located directly under the truss load points. The top plate has a web and flanges but no lips.
- **Track:** Used for applications such as top and bottom plate for walls and band joists for flooring systems. The track has a web and flanges, but no lips. Track web depth measurements are taken to the inside of the flanges
- **Web:** The part of a C-section or track that connects the two flanges
- **Web Stiffener:** Additional material that is attached to the web to strengthen the member against web crippling. Also called bearing stiffener.
- **Yield Strength:** A characteristic of the basic strength of the steel material. It is the highest unit stress that the material can endure before permanent deformation occurs.

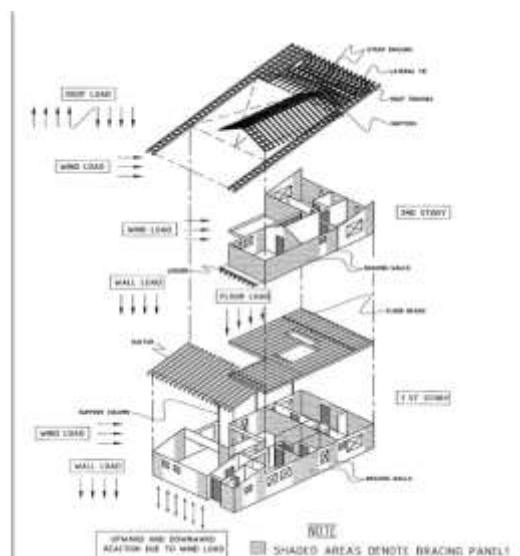


Fig 11: Loading Path Diagram Details recommended by BHP Steel Lysaght

CASE STUDIES FOR COMPARISON IN LOW RISE BUILDINGS

The study focuses on the Shri Amarnath Shrine Board dormitory project situated in Chander Kote, Jammu, with a construction area of 180 square meters. The research examines key aspects of the project, including the

interdependence of time and cost, labour productivity, and the criteria guiding material selection. Comparative analysis of different materials, alternative construction methods are the main factors considered as the research area of this study.

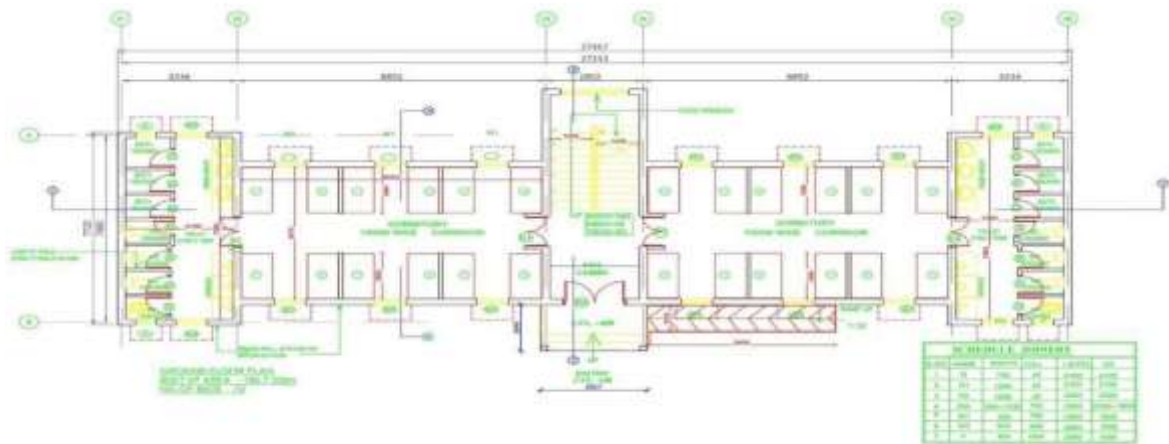


Fig 12: floor plan of LGSF structure

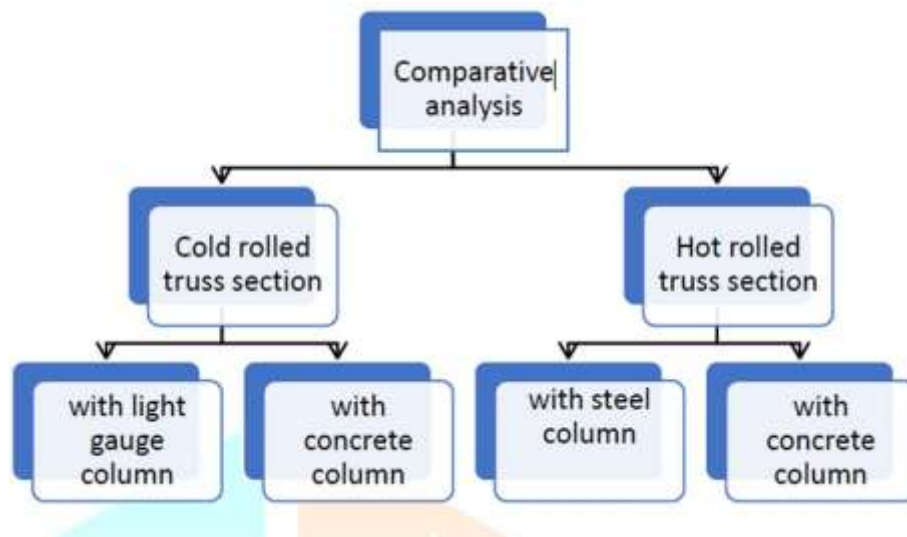


Fig 13: possible models under consideration

Table 1: Cost Comparison for Wall coverings

No	Model	Total cost (Rs)
1	Clay bricks	726900
2	AAC blocks	429931
3	Steel sheet	288862
4	LGSF steel	833940

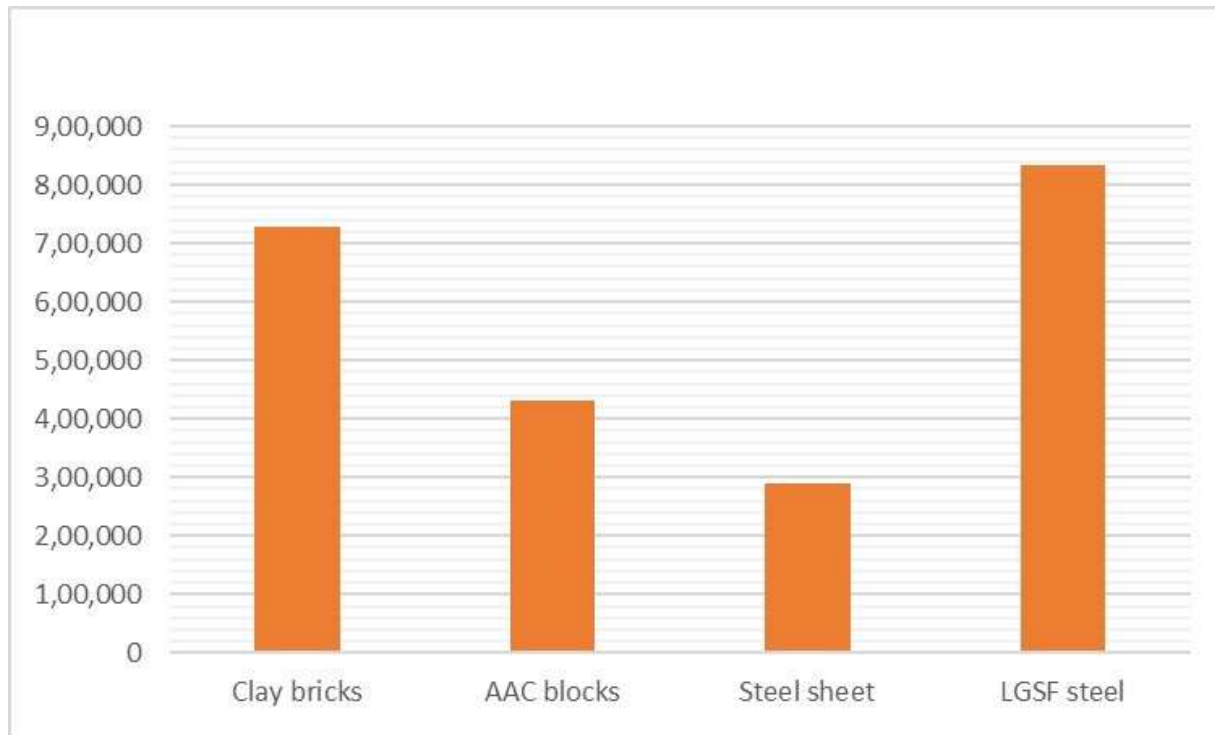


Fig 14: Graph Showing Comparison of Cost for All Four End Wall Coverings

Table 2: Cost Components in Steel Structure

Component	Weight (Kg)	Rate (Rs/Kg)	Total cost (Rs)
Steel structure	8286	72	5,96,592

Table 3: Cost Components in LGSF Steel Structure

Component	Weight (Kg)	Rate (Rs/Kg)	Total cost (Rs)
LGSF steel structure	4277	115	4,91,855

Table 4: Cost Components in Steel truss and concrete

Component	Weight (Kg)	Rate (Rs/Kg)	Total cost (Rs)
Steel truss	5745	72	4,13,640
Concrete	23625	7	1,65,375
Total	29370	-	5,79,015

Table 5: Cost Components in LGSF truss and concrete

Component	Weight (Kg)	Rate (Rs/Kg)	Total cost (Rs)
LGSF truss	2954	115	3,39,710
Concrete	23625	7	1,65,375
Total	26579	-	5,05,085

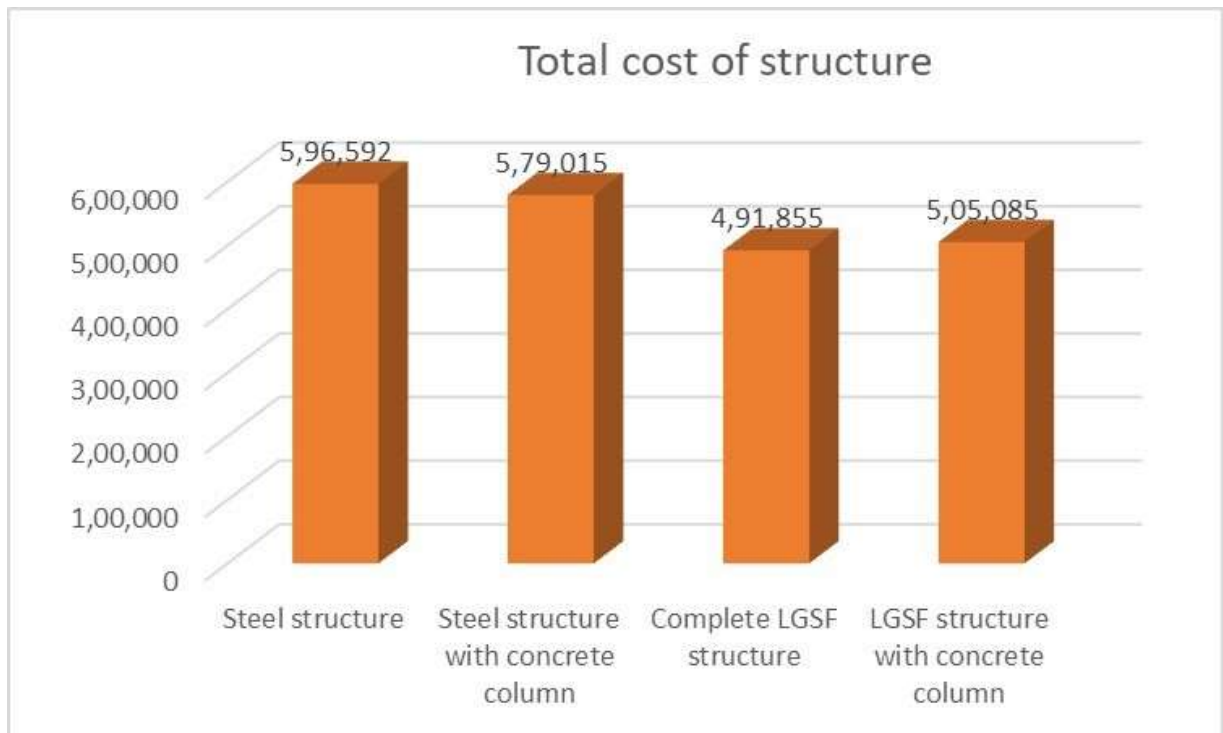


Fig 15: bar chart showing variation in total cost of different structure.

Table 6: Final Cost Comparison

S.No.	Model	Total cost (Rs)
1	Steel structure	5,96,592
2	Steel structure with concrete columns	5,79,015
3	Complete LGSF structure	4,91,855
4	LGSF structure with concrete column	5,05,085

CASE STUDIES FOR COMPARISON IN MID RISE BUILDINGS

Light gauge steel structures are thin sheets, shaped into desired profiles. As the thickness is less the major criterion for failure is buckling of the studs. The general buckling modes for the cold formed profiles are local buckling, distortional buckling and lateral torsional buckling.

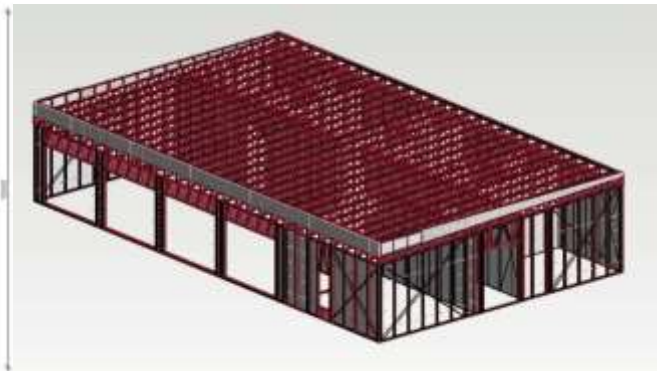
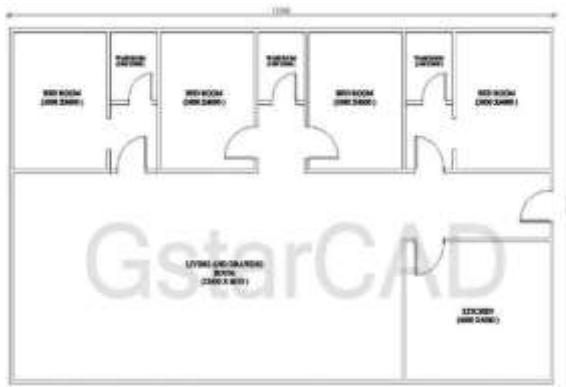


Fig16: Plan view of the Resort Building.

Fig 17: Modelling of Resort Building using Cold form sections.

The structure chosen for analysis is formed with walls of 110 mm thick which includes 10 mm thick fibre cement boards on each side of 89 mm wide stud. The height of the structure is

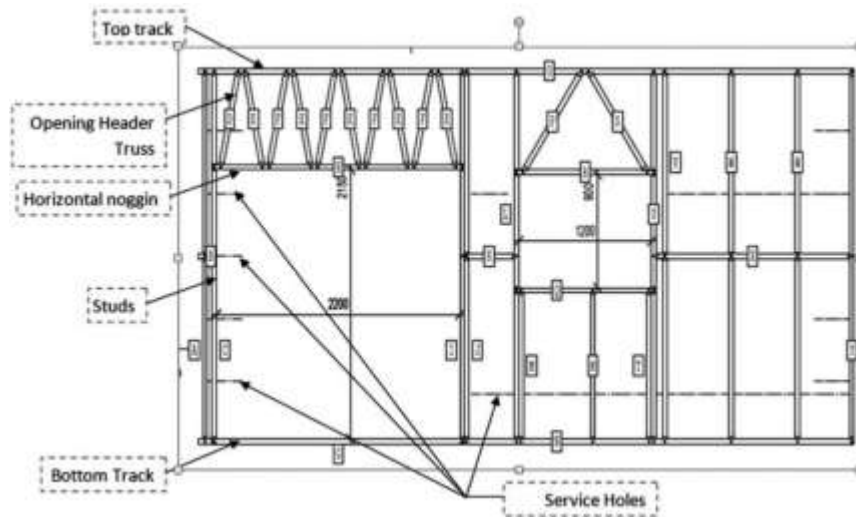


Fig 18: Light Gauge Steel (LGS) system

maintained at 3000 mm at one end and an inclined roof is placed on the walls at a slope of 2 Degrees. The studs in the wall panel are placed at a spacing of 600 mm. Wind braces are placed at the corner wall panels to restrict the deflection of the structure for wind forces. The floor joist trusses are 300mm deep and are spaced at 600 mm c/c. Web spacing of 450 mm is provided for the floor joist and lintel trusses above the large windows.

MATERIAL ANALYSIS

The estimates show that the concrete required for the foundation of light gauge structures is 7% less than conventional structures. Strip or raft foundations are the most preferred types for LGS, the excavation volume for LGS is 16% less than conventional footings. Comparing the weight ratio of HRS to CFS System in terms of superstructure weight the value is 2.0 which indicates the weight of LGS system is twice lower than HRS system. Reinforcement usage percentage in LGS foundation is 2.5% less when compared to HRS and concrete structures. The carpet area obtained using LGS is 10% more than HRS and concrete as the wall thickness is less in LGS. The volume of plastering for LGS is almost zero as fibre cement boards have sufficient finishing on the surface. LGS being thin and lighter requires a greater number of members and joints, than conventional structures

COST ANALYSIS

Cost for foundation of LGS system is reduced by 18% when compared to HRS and Concrete systems as light foundations are sufficient. As fabrication is automated the fabrication cost for LGS is reduced to 33% than HRS and 24% than Concrete system. Material handling costs for LGS is 38% less than Concrete and 56% less than HRS. Erection cost is 62% less than HRS as there is no need of heavy crane equipment for lifting and 26% less than Concrete as there is no need for shuttering. Structural skeletal frame cost of LGS system is 24% less than HRS. Cost for roofing is found similar in both HRS and LGS systems and is 18% less than Concrete systems as generally decking sheets are used for roofing in LGS and HRS. Connection cost for HRS is found 10% higher as HRS connections involve welding and HSFG Bolts, Concrete systems do not have any connection cost. The cost for partitions of LGS System is 12% less than HRS and 28% less than Concrete system. Upon comparing all the factors, the overall structural cost of the LGS system is found 1.5 to 2% less when compared to concrete systems and 4.5% cheaper to HRS.

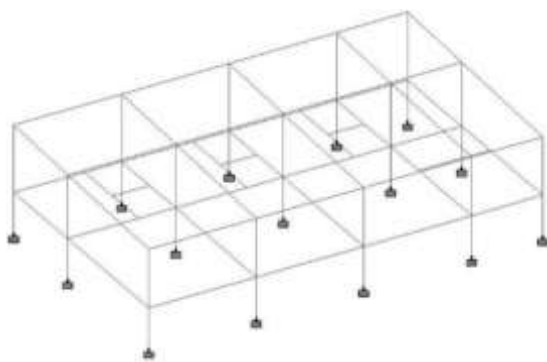


Fig 19: Hot Rolled Steel Frame Model in STAAD.

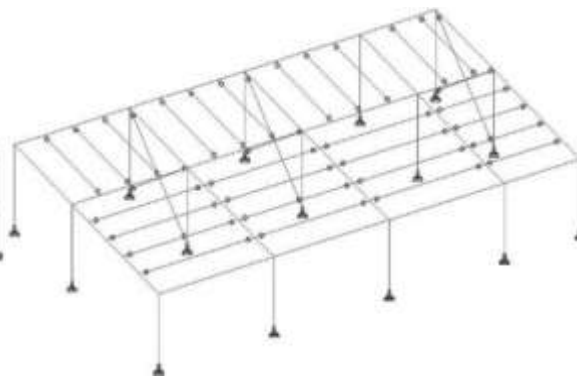


Fig 20: Concrete Frame Model in STAAD.

TIME ANALYSIS

Time for sub structure erection generally depends on the soil condition, but when compared the study shows there is negligible time difference between all the three systems, however having lighter foundations excavation time can be reduced by 16% using LGS systems. In concrete structures, it is generally a 15–17-day cycle for each slab erection.

(Includes erection of columns, beams, and slab concreting) and from study it is found that for a slab area of 1000 square feet, it takes 5 days for brick work and 4–6 days for plastering. But when it comes to LGS this cycle time can be reduced to 7–9 days and for fixing sheathing boards, infilling it takes 3–4 days which concludes a 58% of time efficiency for using LGS system over Concrete. For HRS system the cycle time remains the same for midrise level, but lags during the partition wall erections and hence takes 15–18% more time than LGS system. In conventional systems like concrete most of the time is exhausted in curing and setting of concrete and in hot rolled systems it is the fabrication time, which can be significantly reduced by 60% using LGS system and the level of accuracy is much higher to conventional systems. From the study it is seen that time taken for substructure erection is similar in both the LGS and conventional systems and further from super structure the pace of work progress increases rapidly by 75% in LGS system that other two systems.

LIGHT GAUGE STRUCTURAL FRAMING IN HIGH RISE BUILDINGS

A few examples like the SFIA Matsen Tower, Wisconsin, USA, theorised a 48-storey tower using only LGSF but was not realised. Another example is a housing project in Atlanta of 12 storey of pure LGSF construction. Whereas in India significant development has only been seen in low and mid-rise using LGSF construction in metropolitan cities such as New Delhi and Mumbai. But a significant development in this area is seen in a housing project of 13 storeys done by Stratus Steel using hot rolled steel as structural members and LGSF as periphery wall systems. This clearly shows lack of research on sustainability in terms of efficiency in cost and urban environment when pure LGSF construction is considered in high-rise construction. This calls for more study on the influencing factors in pure LGSF high-rise construction to develop efficient and sustainable construction techniques in the domain of high-rise construction.

CONCLUSION

The exploration of Light Gauge Steel Frame (LGSF) systems in high-rise construction reveals its substantial potential as a more efficient alternative to conventional materials, especially within the Indian context. The advantages of LGSF, such as its lightweight nature and the reduced time required for construction, translate into tangible benefits—faster build times and cost reductions in both materials and labour. The ability to streamline the process through prefabrication not only makes construction more efficient but also minimizes the environmental impact, particularly by reducing waste. When compared with Hot Rolled Steel (HRS) and reinforced concrete, LGSF stands out in areas like foundation costs, structural weight, and construction speed.

Despite these merits, the material's application in larger structures still presents challenges, notably regarding stability under lateral loads and the behaviour of slender steel profiles. These limitations, while not insurmountable, highlight the need for further research to refine its capabilities, particularly for high-rise buildings. For a country like India, where urban growth is accelerating, adopting LGSF could significantly contribute to addressing the twin challenges of resource efficiency and rapid urbanization. However, its broader adoption will hinge on continued innovation and overcoming the technical barriers that remain.

References

- [1] Yawar Hussain, 2. (2024). *REVIEW PAPER ON COMPARATIVE STUDY BETWEEN LGSF BUILDING AND CONVENTIONAL BUILDING*. Gobingarh,punjab :
www.ijert.org.
- [2] Aditi Sonavane, N. D. (2022). A case study on Light gauge framed steel structure. *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, 31-36.
- [3] BUILDING HIGH WITH STEEL FRAME. (1961). In *Official Architecture and Planning* (pp. 374-377). Alexandrine Press.
- [4] DAVE, S. (2010). High Urban Densities in Developing Countries: A Sustainable Solution? *Alexandrine Press*, 27.
- [5] E Yandzio, R. M. (2015). The Journal of Preservation Technology. *SCI Publication P402*, 127.
- [6] FRIEDMAN, D. (2012). Hidden Intricacies: The Development of Modern Building Skeletons. *The Journal of Preservation Technology*, 13-21.
- [7] Harshavardhan Palvai a, ft. T. (2021). Modelling and design analysis of light gauge steel systems against. *Materials Today: Proceedings*, 5164-5172.
- Journal, C. (2010). Tall Buildings in Numbers. *CTBUH*, pp 40-41.
- [8] Karmakar, J. (2020). Dynamics of High-Rise Buildings in Indian Cities: Case of Mumbai. *The Urban World* , pp 11-23.
- [9] Mir M. Ali 1 and Kheir Al-Kodmany 2, *. (2021). Tall Buildings and Urban Habitat of the 21st Century:.. *buildings*, 384-424.
- [10] Mona Abouhamad, M. A.-H. (2020). Life Cycle Environmental Assessment of Light Steel Framed Buildings with Cement-Based Walls and Floors. *sustainability*, 17.

- [11] Oluwaseun S Dosumu, W. D. (2024). Awareness and Adoption of Light Gauge Steel (LGS) Technique in the. <https://www.researchgate.net/publication/380513882>, 8.
- [12] Perampalam Gatheeshgara, K. P. (2020). Optimal design of cold-formed steel lipped channel beams: Combined. www.elsevier.com/locate/structures, 825-836.
- [13] Saeed Erfania, V. A.-n. (2020). Lateral load resisting behavior of steel moment frames with reduced web. *Elsevier*, 252-265.
- [14] *STRUCTURAL CONCEPT FOR LIGHT GAUGE*. (n.d.).
- Yang, H. (2020). Performance analysis of semi-rigid connections in prefabricated high-rise. www.elsevier.com/locate/structures, 837-846.
- [15] Yogendra Pratap Singh, G. S. (2022). Review on Finite Elemental Analysis of Industrial Mid Rise Building Using Cold Formed Steel. *International Research Journal of Engineering and Technology (IRJET)*, 683-685.
- [16] , M. R., Nikhade, A. R., & Ruprai, B. S. (2023). Comparative study of hot rolled steel sections and cold. *AIP Conf. Proc.* 2753, 020001 (2023).
- [17] Indian Standard IS 801: 1975 Code of Practices for use of cold formed and welded section and light gauge steel structural members in general building construction.
- [18] Indian Standard IS 875: 1987 Code of Practice for design loads
Part 1 - Dead Loads - Unit Weights of Building Material and Stored Materials Part 2 - Imposed Loads
Part 3 - Wind Loads
- [19] IS 1893 (Part 1):2002 Criteria for Earthquake Resistant Design of Structures –
Part 1: General Provisions and Buildings
- [20] <https://stratus-steel.com/the-adoption-of-lgsf-technology-in-india/>
- [21] <https://www.allaboutlgsf.com/post/40-storeyed-building-built-with-cold-formed->