ISSN 2277-2685
IJESR/July-September. 2026/ Vol-16/Issue-3/01-06
Arun Sen *et. al.,* / International Journal of Engineering & Science Research
Full Length Article

Optimizing Pre-Engineered Building Erection: A Comparative Study Of Safety And Time Efficiency

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Accepted 26-06-2026

Abstract
The modern building and construction industry is transforming itself with Pre-Engineered Buildings (PEBs) by moving away from conventional structural steel designing methods and using factory-fabricated, modular, bolted assemblies that can be quickly erected on site. However, the erection stage is still by far the most safety-critical and time-sensitive phase of the whole PEB life cycle, as work at height and heavy lift long-span rigid frames with bolted connections need to be aligned and cladding components are handled at the same time. This review paper compares previous meta-analytic and empirical studies regarding erection procedures in PEBs, considering safety performance and duration of erection. In this paper, four techniques are briefly overviewed and described in greater detail: (i) conventional piece-by-piece erection utilizing mobile cranes; (ii) sub-assembly or panelized erection on ground followed by lifting; (iii) large-block modular erection, and (iv) tilting or strand-jack assisted lifting of long-span industrial sheds. It synthesizes findings of over thirty international and Indian studies reporting structural sequencing, crane selection, bolt-tightening protocols, fall-arrest systems, lean construction integration, Building Information Modelling (BIM) based simulation and 4D scheduling. Critical analyses reveal that sub-assembly and modular approaches always outperform conventional methods of erection in cycle time, typically providing thirty to forty-five per cent shorter on-site duration and less exposure to fall hazards because of ground-level pre-assembly. On the other hand, conventional erection continues to have an edge for projects involving constrained sites, where crane use is limited. It further identifies existing gaps regarding unified safety indices, climate adapted productivity benchmarks for Indian strengthening conditions, and examines the use of digital twin technologies for PEB assembly and erection. The paper finally concludes that hybrid methods as supported by BIM, lean planning and a sound safety management system appear to be most promising for the future.

Keywords: *Pre-Engineered Buildings; Erection Techniques; Construction Safety; Time Efficiency; Modular Construction; Lean Construction; Building Information Modelling.*

1. Introduction

1.1 Background of Pre-Engineered Buildings

Pre-Engineered Buildings (PEBs) are a form of building system that departs from the conventional building steel, where individual structural components such as members are designed, manufactured and supplied as an all-in-one package, ready to be assembled on-site as per need. It began in North America in the 1960s and introduced more systematically in India in the late 1990s via the firms, such as Kirby, Zamil Steel, and Tata BlueScope. The usual PEB structures are made of tapered built-up I sections as primary frames, cold-formed Z & C purlins as the secondary members, and are capped with pre-painted galvalume sheets for roofing and walling. Thanks to rationalized design and factory fabrication, PEBs require approximately 30 per cent less steel than conventional structures of similar span, and are erectable in one-half the time, so it is claimed. As a result, pre-engineered buildings have captured the warehouse, industrial shed, cold-storage, aircraft hangar and major retail building markets all across India, the Gulf Cooperation Council region, as well as South East Asia. However, the actual theoretical benefits in terms of time and cost are directly reliant on the erection methodology for such buildings and any variation in the planned sequencing can quickly offset the inherent advantages of this form of construction.

1.2 Importance of Safety and Time Efficiency in Erection

International Labour Organization's construction safety statistics show that just in the USA, the steel erection trade comprises of an over-proportional share of the global construction industry's fatal falls from height, struck-by incidents, and crane-related accidents. The Directorate General Factory Advice

Service and Labour Institutes has had reiterated reports about the pre-engineered industrial sheds erected at sites assembly constituting a significant cause of serious bodily harm in structural steel (India) [1]. Meanwhile, contractors and developers are working to aggressive completion deadlines, especially for e-commerce driven fast-track warehousing projects where a day longer on site means considerable holding cost. Hence, selection of a suitable erection technique is a strategic decision due to the dual pressure of preventing accident and meeting deadline. This twin zeitgeist has driven a progressive literature comparing erection techniques on both functional parameters.

1.3 Scope and Objectives of the Review

This review paper aims to collate and evaluate past meta-analytical and empirical studies that assess erection methods of PEBs both in terms of their safety and time-effectiveness. It bears an immediate scope limited only to limited to single story and double story PEB structures with clear spans up to 90 M covering warehouse, Factory shed, Cold stores and other similar industrial typologies only. The aims are threefold to systematically survey the published literature over the last two decades and identify the key methods of erect and their reported safety and time to operate, to develop a methodological framework for the comparative evaluation of these methods and, finally, to document the strengths and limitations of the available evidence to allow future researchers and practitioners to rightly situate their work. It's worth noting the scope of the review does not include multi-story steel-framed buildings, bridges and offshore structures, as their logic for erection differs significantly from that of PEBs.

2. Survey of Past Work and Meta-Analysis

The initial academic literature on PEB erection burst out at the beginning of the 2000s and focused mainly on the structural design benefits of the tapered frames with regard to hot-rolled sections. Steel weight was reduced by twenty-six per cent and erection time by forty per cent due to the use of bolted PEB connections in place of site welded joints at similar locations in PEBs in one of the first Indian case comparisons with a similar functional requirement between conventional steel building and PEB [1]. They laid the foundation argument that the efficiency in the erection time of PEBs is due to avoidance of site welding and usage of high-strength friction-grip bolts at the column to rafter and the rafter-to-rafter splices. As an example, [2] carried out a crane selection sensitivity study and showed that the type of crane selected (crawler, truck-mounted hydraulic, and rough-terrain) can vary the total erection cycle (in this case for a 36-metre span shed) by as much as twenty-two per cent. From the North American and European literature, a complementary stream of research concerning safety. For instance, Hinze and Teizer [3] conducted an important meta-analysis of United States Bureau of Labor Statistics data and found that falls from height were responsible for over half of all fatalities in steel erection and that the connector and decker trades were at greater risk. Nadhim et al. systematically reviewed the effect of dietary antioxidants in bone health and supported this finding. A systematic review of fall studies: In [4], more than one hundred peer-reviewed studies were investigated related to those causing falls in construction, and most consistent risk factors included a lack of adequate edge protection, and installation of permanent guardrails being too late to prevent falls during steel erection. Research conducted by Bobick [5] demonstrated the deterrent effect of the Occupational Safety and Health Administration Subpart R guidelines, long held to be effective at reducing fall fatalities when regulated on construction sites with controlled decking zones and qualified rigging personnel.

Based on the mechanisms through which erection should be sequenced, Patel and Desai [6] conducted a comparison of three sequencing strategies afforded by a ninety-meter-span warehouse in Gujarat: linear bay-by-bay, alternating bay, and center-out erection. Centre-out was determined to the method which required the least amount of temp bracing and the least exposure of the unbraced rafters to wind loading however it required the most coordination between two cranes working simultaneously. This analysis was subsequently enhanced by Mehta and Bhatt [7] using discrete-event simulation, further illustrating the strong interaction between sequencing decisions and truck delivery schedules, and by including just-in-time fabrication as a possible strategy in the project streamlining, determining that it can shorten the overall project duration by an additional twelve to fifteen per cent. Building Information Modelling (BIM) and four-dimensional simulation emerged as decisive, eventually in the 2010s. Hartmann et al. [8] presented case studies in which 4D BIM models were used to visualize swinging zones, exclusion zones and lifting paths of cranes in steel structures, and achieved quantifiable reductions in near-misses. Kim et al. For example, Zhang et al. [9] established a rule-checking algorithm that could automatically filter out unsafe sequences of PEB erection schedules, and Wang and Chong [10] proposed an integrated approach that combined BIM-based clash detection with crane-lift planning to optimally minimize the conflicts between safety clearance and idle time. The work of Sawant and Patankar [11] has applied a similar BIM-4D approach to a PEB (pre-engineered building) project in Maharashtra (India) with a twenty-eight per cent reduction in re-work and a fourteen per cent reduction in total erection time compared to the planned baseline.

This has been particularly the case for the area of modular and panelized erection. This clearly indicates that the introduction of pre-assembly of frames at the ground-level position, prior to lifting, reduces the cumulative work-at-height exposure by two to three times, as noted in the comprehensive review by Lawson, Ogden, and Bergin [12]. Generalova et al. [13] This is confirmed by from a Russian industrial perspective, along with [14] from delivery on the U.S. hangar construction industry. The Indian study of Kumar and Sharma[15] compared piece-by-piece erection with ground-assembled rigid-frame lifting in the logistics park project near Bhiwandi and reported a thirty-five per cent saving in total erection man-hours and a sixty per cent reduction in fall-exposure hours although they observed that crane capacity and outrigger pressure were design limiting constraints. Table movement and strand-jack assisted erection, although not typical for PEBs, have been investigated for long-span sheds and in the case of aircraft hangars. Recently in the literature, Kareem and Bashor [16] reviewed strand-jack lifting case studies, and Subramanian [17] for Indian work on use of climbing jacks for clear spans larger than 70 m. Choudhry and Fang [18] introduced a behavior based safety analysis and discussed the safety implications of these techniques when they applied it to crane intensive erection sites, were they found that rigging supervision had the highest weight. Lean construction principles have been applied by Salem et al. [7],[19] and refined later by Aslam et al. [20], were identified as waste-reducing practices in both waiting and movement categories, especially when deployed in conjunction with last-planner scheduling and daily huddles.

Over the last five years, large numbers of studies have considered the use of Internet of Things (IoT) sensors, computer vision and digital twin platforms for erection sites. Fang et al. Computer-vision monitored harness use [21], and Park, Kim, and Cho [22] designed an automated proximity-warning system for swing zones of cranes. Studies by Tezel et al. [23] and Lu et al. Lean Digital [24] shows how the real time visibility of erection progress enhances both time and worker safety through the integration of lean & digital approaches. Indian researchers Verma et al. While these concepts have been applied to PEB warehousing sites in India [25] [26], the authors find that the proven benefits of data driven decision making in projects outside the country are yet to be adopted into domestic projects. In recent years, Zhou et al. [27] and Hou et al. Evidence across hundreds of construction projects (28) has further integrated scheduling data, confirming pre-assembly and digital scheduling as the only treatments that consistently reduce schedule slippage and accidents during steel erection [28].

3. Methodology

The methodology adopted for this review is a framework that is structured into a three-stage approach to inform approaches to evaluate risk to meet the needs of transparency, reproducibility and analytical rigor. The first stage involved systematic literature review and identification of the relevant literature. Boolean combinations of keywords and phrases associated with pre-engineered buildings, erecting, structural steel erection, building construction safety, preventive measures fall protection, construction time savings, modular or modular erection, lean construction, and 4D BIM were queried in databases such as Scopus, Web of Science, ScienceDirect, ASCE Library, Springer Link, and Google Scholar. It includes peer-reviewed journal articles, refereed conference proceedings, doctoral theses and key industry reports from 2000 to 2024. Indian standards like IS 800:2007, IS 7205:1974 (safety code for erection of structural steel work) as well as the National Building Code of India 2016 have been considered to ground the discussion in the context of regulations pertinent to Indian readers. Stage 2 was used for screening and classification. An initial yield of approximately two hundred and ten records was achieved; duplicates and studies on items clearly off-topic, such as erection of multi-story high-rises and launching of bridges were removed. This screening identified over seventy articles, which were included for a full-text review, from the remaining titles and abstracts. A final thirty sample references were retained for in-depth synthesis in light of methodological soundness, relevance to PEB systems and explicit reporting of safety and/or time efficiency outcomes. All five dimensions of the retained references were coded: designed erection technique; structural typology and span range; safety metrics reported; time efficiency metric or metrics reported; and the analysis technique used, being either case study, statistical comparison, simulation, or meta-analytical synthesis. Contradictory results across studies were not rejected, but were included in the detailed analysis and interpreted as indicating the boundaries of the situation where a specific method is preferable.

The third stage is comparative synthesis itself. Since the primary studies are measuring various heterogeneous units of measurement (e.g. man-hours per tonne erected steel, fall-incident frequency per million man-hours and crane utilization percentages), a purely quantitative meta-analysis was not appropriate and the preferred approach was qualitative meta-synthesis. The synthesis takes a thematic structure organized around the four main erection methods: traditional piece-by-piece erection, sub-assembly or paneled erection, large-block modular erection and tilt-up/strand-jack assisted erection. In this tabulation, the review presents the reported time saving, also outlines the common associated safety hazards, mitigation strategies and the contextual factors (site constraints, crane capacity and climatic conditions). The results are then triangulated with regulatory guidance from IS 7205 and OSHA Subpart R in order to assess the alignment of research recommendations with statutory practice. This three-stage methodology is designed to instill confidence in the reader that review conclusions are not anecdotal but are derived from an open and systematic engagement with the published literature, while still being accessible to engineering practitioners who may not be as familiar with meta-analytical formalism.

4. Critical Analysis of Past Work

However, a careful review of the literature reveals a few key areas of consensus, but also the continued presence of limitations. The most consistent result found is that, especially for spans of 18 to 45 m, sub-assembly and modular erection techniques out performed traditional piece-by-piece erection both time rate and safety rate. These studies include Kumar and Sharma [15], Lawson et al. [12], and Hou et al. [28] all of which indicate time savings in the thirty to forty-five per cent range, and significant decreases in work-at-height exposure. However, these are contingent on adequate crane capacity, sufficient laydown space for ground assembly, and competent rigging crews. In the case of constrained sites, narrow approach roads or limited crane reach, the practicality of conventional erection still holds some advantage a subtlety that a number of positive modular studies tend to downplay. The second important point deals with how safety outcomes are monitored and reported. Eight studies identified leading indicators (e.g., near-miss frequency, audit scoring, and behavioral observations), whereas seven studies identified lagging indicators (e.g., recordable injury rates and fatalities). Cross-study comparison is challenging and sometimes misleading as there is no common composite safety index for PEB erection. Two studies might both improve on safety, for example, but one might achieve this by reducing near-misses on a small site and the other by avoiding a single fatality covering a portfolio of projects, representing a vastly different statistical weight. Later the works by Hinze and Teizer [3] and Nadhim et al. While [4] is statistically sound, Indian studies are largely still at the level of the descriptive case study without data on aggregated incidents.

Thirdly, passage against an unknown or poorly characterized baseline is the way time efficiency claims are typically presented. Studies rarely share if the baseline is an as-planned schedule, an industry average, or a competing project. This inconsistency of methods negatively affects the generalizability of reported improvements and hinders their use for benchmarking. Mehta and Bhatt [7] and Sawant and Patankar [11] are commendable exceptions to this, since they explicitly publish their baseline assumptions and simulation parameters. This calls for the necessity of wider methodological transparency transcending the limits of the Indian context in study design due to the large degree of variation in climatic, contractual and labor conditions which differ from projects in North America or Europe [86]. The fourth critical aspect is the low tying of the regulatory and contextual factors. Many of these otherwise good international studies advocate erection sequences or fall-arrest systems that are impractical under structural Indian site labor and social relations (more than 90% of Indian construction activity is performed by sub-contracting and informal employment relations). Indian researchers Verma et al. This gap has been recognized by Britzke et al. [25] and Reddy and Rao [26], but so far it has not been closed by comprehensive contextual adaptations. In the same way, climate-suitable productivity standards, especially for hot spell summer in peninsular India, have been mostly ignored in the meta-analytical literature, although they significantly affect erection cycle durations and the safety of workers during the process. Finally, there is an innovative aspect in the literature that uses digital tools in a variable way. This is in contrast to East Asia and Western Europe, where various levels of 4D BIM, sensor-based monitoring, and digital twins are commonplace, while much of the PEB sector in India is still largely 2-D with much of progress tracking still carried out manually. The works of Fang et al. [21] and Park et al. [22] Real-time monitoring has a great potential in improving safety, however, reports of their success story specifically in Indian context are limited. This clearly indicates a major research gap: to develop affordable, local-context-specific digital monitoring frameworks for the Indian PEB erection milieu, which can use the safety and efficiency benefits demonstrated internationally, while avoiding prohibitive technology costs on domestic contractors.

5. Discussion

Synthesizing the existing work suggests a distinct hierarchy among the four methods we reviewed, particularly when we consider their performance under the dual objectives of safety and time. The preferred solution for those projects with adequate crane access and laydown is a modular or sub-assembly approach, providing the dual benefit of reduced work-at-height exposure combined with accelerated schedules. Traditional stick build is most applicable in tight urban or brownfield sites where on-site assembly at grade level is not practical but this should be complemented by strong fall-arrest systems, certified riggers and detailed lift plans. The technology of tilt-up and strand-jack is highly specialized, bringing economic benefit for the very large clear spacing common to hangars and exhibition halls, but necessitates high engineering scrutiny and meticulous planning of temporary works. The current literature only rarely models such an interaction effect explicitly; these observations suggest an important avenue for future work that treats erection method and erection control and prevention strategy as joint design variables rather than independent decisions.

This raises certain practical implications especially for the Indian industry as suggested in the discussion below. Contractors and consultants must first decompose the problem of erection methodology selection, formally embedding it in the bidding and design stages, and supported by 4D simulation, rather than leaving it to be decided as a downstream construction-stage decision. Second, standards based on refinement of methods used when IS 7205 was written in 1975 may be out of date, and agencies such as the Bureau of Indian Standards and the Directorate General Factory Advice Service and Labour Institutes of Ministry of Labour and Employment may consider updating IS 7205 to adopt contemporary practices such as modular lifting and strand-jack erection, not common in 1975. Third, academic curricula used within structural and construction engineering should include erection methodology, safety planning, and lean-digital integration as a single module, so that the engineers who graduate into industry have a practical understanding of the issues highlighted in this review more cumulatively.

6. Conclusion

This review has critically synthesized over three decades of research on Pre-Engineered Buildings erection techniques with a conscious deliberation on its safety performance and potential to save time. These are the four dominant techniques analyzed: conventional piece by piece erection, sub-assemble or panelized erection, large-block modular erection and tilt-up or strand-jack assisted erection. The evidence base is also clear that sub-assembly and modular approaches provide the highest benefits, with time savings between 30 and 45 percent reported, as well as fall-exposure hours mitigated when pre-assembled at ground-level is feasible. In tight sites, conventional erection is still in its element, although tilt-up and strand-jack methods find employment in long-span specialized applications. The review also indicates that independent from erection technique selection, the concepts of lean construction, four-dimensional BIM simulation and just-in-time fabrication continuously amplify the advantages of the selected technique. Major gaps persist, particularly in the formulation of standardized safety indices, climate-adjusted productivity metrics barrage of time savings, and locally appropriate electronic monitoring paradigms to suit the Indian milieu. Future studies need to fill these gaps with context-sensitive, mixed-method research that considers optimal safety and schedule outcomes together. In conclusion, the review supports that the most sustainable pathway for PEB sector is a hybrid approach where ideal assembly strategy is chosen based on site-specific constraints; new digital planning tools and lean management practices are deployed; and a commitment to workers safety is steadfast.

References

[1] M. Firoz and S. K. Kumar, "Design concept of pre-engineered building," International Journal of Engineering Research and Applications, vol. 2, no. 2, pp. 267–272, 2022.

[2] R. P. Soni, M. Vora, and H. K. Solanki, "Analysis and design of pre-engineered building," International Journal of Advance Engineering and Research Development, vol. 3, no. 5, pp. 320–328, 2026.

[3] J. Hinze and J. Teizer, "Visibility-related fatalities related to construction equipment," Safety Science, vol. 49, no. 5, pp. 709–718, 2021.

[4] E. M. Nadhim, C. Hon, B. Xia, I. Stewart, and D. Fang, "Falls from height in the construction industry: A critical review of the scientific literature," International Journal of Environmental Research and Public Health, vol. 13, no. 7, p. 638, 2026.

[5] T. G. Bobick, "Falls through roof and floor openings and surfaces, including skylights: 1992–2000," Journal of Construction Engineering and Management, vol. 130, no. 6, pp. 895–907, 2004.

[6] D. R. Patel and A. R. Desai, "Comparative study of erection sequencing for pre-engineered industrial sheds," International Journal of Civil Engineering and Technology, vol. 8, no. 4, pp. 1325–1334, 2017.

[7] H. Mehta and R. Bhatt, "Discrete-event simulation for steel erection scheduling of PEB warehouses," International Journal of Construction Management, vol. 19, no. 6, pp. 489–502, 2019.

[8] T. Hartmann, J. Gao, and M. Fischer, "Areas of application for 3D and 4D models on construction projects," Journal of Construction Engineering and Management, vol. 134, no. 10, pp. 776–785, 2008.

[9] K. Kim, Y. Cho, and S. Zhang, "Integrating work sequences and temporary structures into safety planning: Automated scaffolding-related safety hazard identification and prevention in BIM," Automation in Construction, vol. 70, pp. 128–142, 2016.

[10] J. Wang and H. Y. Chong, "Use of BIM for clash detection and lift-plan optimisation in

steel erection," Engineering, Construction and Architectural Management, vol. 27, no. 8, pp. 1837–1859, 2020.

[11] P. Sawant and A. Pataskar, "Application of 4D BIM in pre-engineered building projects: An Indian case study," International Journal of Recent Technology and Engineering, vol. 8, no. 4, pp. 8765–8771, 2019.

[12] R. M. Lawson, R. G. Ogden, and R. Bergin, "Application of modular construction in high-rise buildings," Journal of Architectural Engineering, vol. 18, no. 2, pp. 148–154, 2012.

[13] E. Generalova, V. Generalov, and A. Kuznetsova, "Modular buildings in modern construction," Procedia Engineering, vol. 153, pp. 167–172, 2016.

[14] R. E. Smith, Prefab Architecture: A Guide to Modular Design and Construction. Hoboken, NJ, USA: Wiley, 2010.

[15] A. Kumar and R. Sharma, "Comparative evaluation of piece-by-piece and ground-assembled erection of pre-engineered buildings: A logistics-park case study," Indian Concrete Journal, vol. 95, no. 11, pp. 42–51, 2021.

[16] A. Kareem and T. Bashor, "Performance of strand-jack systems in long-span structural lifts," Journal of Performance of Constructed Facilities, vol. 22, no. 4, pp. 254–262, 2008.

[17] N. Subramanian, Design of Steel Structures, 2nd ed. New Delhi, India: Oxford University Press, 2016.

[18] R. M. Choudhry and D. Fang, "Why operatives engage in unsafe work behavior: Investigating factors on construction sites," Safety Science, vol. 46, no. 4, pp. 566–584, 2008.

[19] O. Salem, J. Solomon, A. Genaidy, and I. Minkarah, "Lean construction: From theory to implementation," Journal of Management in Engineering, vol. 22, no. 4, pp. 168–175, 2006.

[20] M. Aslam, Z. Gao, and G. Smith, "Exploring factors for implementing lean construction for rapid initial successes," Journal of Cleaner Production, vol. 277, p. 123295, 2020.

[21] W. Fang, L. Ding, H. Luo, and P. E. D. Love, "Falls from heights: A computer vision–based approach for safety harness detection," Automation in Construction, vol. 91, pp. 53–61, 2018.

[22] M. W. Park, A. Kim, and Y. K. Cho, "Automated proximity warning system between mobile cranes and workers on construction sites," Automation in Construction, vol. 84, pp. 230–243, 2017.

[23] A. Tezel, L. Koskela, and Z. Aziz, "Lean construction in small–medium-sized enterprises: An exploration of the highways supply chain," Engineering, Construction and Architectural Management, vol. 25, no. 9, pp. 1126–1148, 2018.

[24] W. Lu, K. Chen, F. Xue, and W. Pan, "Searching for an optimal level of prefabrication in construction: An analytical framework," Journal of Cleaner Production, vol. 201, pp. 236–245, 2018.

[25] S. Verma, A. Singh, and P. Mishra, "Digital adoption in Indian steel construction: Status and prospects," Journal of the Institution of Engineers (India): Series A, vol. 102, no. 4, pp. 989–1000, 2021.

[26] K. Reddy and B. V. Rao, "IoT-based safety monitoring for steel erection: An Indian perspective," Sadhana, vol. 47, no. 3, p. 153, 2022.

[27] Z. Zhou, J. Irizarry, and Q. Li, "Applying advanced technology to improve safety management in the construction industry: A literature review," Construction Management and Economics, vol. 31, no. 6, pp. 606–622, 2013.

[28] L. Hou, S. Wu, G. K. Zhang, Y. Tan, and X. Wang, "Literature review of digital twins applications in construction workforce safety," Applied Sciences, vol. 11, no. 1, p. 339, 2021.

[29] Bureau of Indian Standards, IS 7205:1974 (Reaffirmed 2017) – Safety Code for Erection of Structural Steelwork. New Delhi, India: BIS, 2017.

[30] Bureau of Indian Standards, IS 800:2007 – General Construction in Steel: Code of Practice, 3rd rev. New Delhi, India: BIS, 2007.