



A REVIEW OF CONSTRUCTION TECHNIQUES FOR HIGH-RISE BUILDINGS

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Abstract

The rapid growth of urbanisation and increasing demand for residential, commercial, and institutional spaces have led to the widespread construction of high-rise buildings. The construction of these buildings involves several challenges related to structural stability, construction time, cost, quality control, material handling, worker safety, and environmental sustainability. Various construction techniques, including conventional cast-in-situ reinforced concrete construction, advanced formwork systems, structural steel construction, precast concrete construction, modular construction, and top-down construction, are adopted depending on project requirements and site conditions. Recent technological developments, such as Building Information Modelling (BIM), automation, robotics, and digital monitoring, have further improved the planning and execution of high-rise construction projects. This paper reviews the major construction techniques used in high-rise buildings and examines their advantages, limitations, and suitability for different construction conditions. The review also discusses the influence of construction techniques on productivity, quality, safety, cost, and sustainability. The findings indicate that conventional construction remains suitable for buildings requiring flexibility in geometry, whereas advanced formwork, prefabrication, and modular construction offer potential benefits in repetitive and time-sensitive projects. Digital technologies can improve coordination and resource management when integrated effectively into construction planning. However, the selection of an appropriate technique depends on building height, structural system, site accessibility, labour availability,

equipment requirements, transportation constraints, and project economics. The review highlights the need for integrated construction planning and further research into hybrid construction systems, lifecycle environmental performance, and digital construction management.

Keywords: High-rise buildings, construction techniques, reinforced concrete, formwork systems, precast construction, modular construction, BIM, sustainability.

1. Introduction

High-rise buildings have become an essential component of modern urban development because they enable efficient land utilisation and accommodate large numbers of occupants within limited urban areas. The increasing demand for housing, offices, commercial centres, hospitals, and institutional facilities has encouraged the development of taller and more complex structures. However, the construction of high-rise buildings requires careful planning and coordination because of the challenges associated with structural stability, foundation design, vertical transportation, construction sequencing, material handling, and occupational safety.

The selection of an appropriate construction technique plays a significant role in determining the overall performance of a high-rise construction project. Traditional cast-in-situ reinforced concrete construction is widely used because it provides flexibility in structural design and utilises locally available materials and labour. However, conventional methods may require considerable time for formwork installation, reinforcement placement, concrete casting, curing, and formwork removal. These activities can influence the construction schedule, particularly when repetitive floor layouts are involved.

To address these challenges, several advanced construction techniques have been developed and adopted. These include climbing formwork, slipform construction, precast concrete systems, modular construction, structural steel framing, composite construction, and top-down construction. Such techniques can improve construction efficiency when appropriately matched to project requirements. Prefabrication and modular construction, in particular, enable some construction activities to be performed in controlled factory environments while site preparation proceeds simultaneously.

The development of digital technologies has further influenced high-rise construction practices. Building Information Modelling supports coordination among architectural, structural, and building-services disciplines, while construction simulation and digital monitoring can assist in scheduling, quality management, and progress tracking. Automation and robotics also offer opportunities to reduce repetitive manual operations and improve productivity.

Despite these developments, no single construction technique is suitable for every high-rise building. Factors such as building geometry, floor repetition, structural system, foundation conditions, site constraints, workforce skills, equipment availability, and financial resources influence the selection process.

Therefore, this paper reviews the major construction techniques used in high-rise buildings, evaluates their advantages and limitations, and identifies opportunities for improving construction productivity, safety, quality, and sustainability.

The main objectives of this paper are:

1. To review conventional and advanced construction techniques used in high-rise buildings.
2. To examine the advantages and limitations of different construction methods.
3. To discuss the influence of construction techniques on project cost, time, quality, and safety.
4. To investigate the role of digital technologies in modern high-rise construction.
5. To identify research gaps and future opportunities for efficient and sustainable construction.

2. Literature Review

2.1 Conventional Cast-in-Situ Construction

Conventional cast-in-situ reinforced concrete construction is one of the most widely used methods for high-rise buildings. The method involves erecting formwork, placing reinforcement, pouring concrete, curing the concrete, and removing the formwork after sufficient strength has developed. The process is repeated floor by floor until the required building height is achieved.

The major advantages of this method are flexibility in architectural design, continuity between structural members, and the availability of established construction practices. It is suitable for buildings with irregular layouts or varying structural configurations. Nevertheless, the method requires substantial site labour and careful coordination of reinforcement, formwork, concrete supply, and curing operations. Repeated formwork installation and removal may increase construction time and labour costs.

2.2 Advanced Formwork Systems

Advanced formwork systems have been developed to improve the speed, consistency, and safety of concrete construction. Common systems include table formwork, flying formwork, jump formwork, slipform, and self-climbing formwork.

Table and flying formwork systems are particularly useful for repetitive floor slabs because large formwork units can be transferred between floors. Jump formwork is generally employed for vertical structural elements such as shear walls and lift cores. Slipform construction enables continuous upward movement of formwork and is suitable for structures with relatively uniform cross-sections. Self-climbing formwork uses mechanical or hydraulic systems to raise formwork without requiring a crane for every climbing operation.

These techniques can reduce repetitive manual work and improve construction-cycle efficiency. However, their effectiveness depends on building geometry, equipment availability, initial investment, workforce training, and the continuity of construction operations.

2.3 Precast Concrete Construction

Precast concrete construction involves manufacturing structural elements in a factory

or casting yard before transporting them to the construction site for installation. Typical precast components include columns, beams, slabs, staircases, wall panels, and façade elements.

Precast construction offers opportunities for improved dimensional accuracy, controlled curing, reduced site formwork, and better management of material waste. Factory production can also proceed simultaneously with foundation and site preparation activities, potentially reducing the overall construction period.

However, transportation, lifting capacity, storage, installation tolerances, and connection design are important considerations. In high-rise buildings, connections between precast elements must provide the required strength, stiffness, ductility, and structural integrity. Therefore, successful implementation requires coordination between structural design, manufacturing, transportation, and site installation.

2.4 Modular Construction

Modular construction involves manufacturing three-dimensional building units in controlled factory environments and assembling them at the construction site. Modules may include structural framing, floors, walls, building services, and internal finishes.

Thai et al. (2020) reviewed modular construction for high-rise buildings and discussed its potential to improve productivity and construction efficiency. Modular construction allows several activities to be performed simultaneously, reducing dependence on sequential on-site operations. It may also improve quality control and reduce site disturbance.

Despite these advantages, modular construction presents challenges associated with module transportation, lifting, structural connections, fire safety, acoustic performance, and integration of building services. The method is generally more attractive for projects with repetitive layouts and standardised components. Its economic feasibility depends on the number of repeated units, factory capacity, transport distance, and project-specific installation requirements.

2.5 Structural Steel and Composite Construction

Structural steel construction uses prefabricated steel columns, beams, braces, and other members assembled on site. Composite

construction combines steel and concrete to utilise their complementary structural properties.

Steel construction offers a high strength-to-weight ratio, the potential for rapid erection, and flexibility in providing long spans. Factory fabrication enables dimensional checks before components are delivered to the site. Composite systems may improve structural efficiency by combining steel framing with concrete slabs or composite columns.

The principal challenges include fire protection, corrosion control, connection design, erection stability, and the need for specialised fabrication and lifting equipment. The selection of steel or composite construction depends on structural requirements, building geometry, construction schedules, material prices, and the availability of skilled contractors.

2.6 Top-Down Construction

Top-down construction is a technique frequently used for buildings with deep basements and restricted urban sites. In this method, retaining walls and suitable foundation elements are constructed before or during excavation, and basement slabs are progressively constructed as excavation proceeds beneath them.

The method can provide lateral support to retaining walls through completed slabs and may allow superstructure construction to proceed concurrently with basement excavation where the structural design permits. This approach can be advantageous in congested urban areas where conventional open excavation is difficult.

However, top-down construction requires careful planning of temporary and permanent load paths, groundwater control, excavation support, ventilation, spoil removal, and monitoring of neighbouring structures. The method is particularly dependent on geotechnical conditions and the complexity of the basement arrangement.

2.7 Building Information Modelling and Digital Technologies

Building Information Modelling (BIM) has become an important tool for coordinating the design and construction of complex buildings. BIM provides a digital representation of building geometry and associated information, enabling coordination among architectural, structural, and building-services disciplines.

Omran et al. (2023) examined BIM applications in the early design stage of high-rise buildings and highlighted its potential to support design coordination and decision-making. BIM can also be linked to construction schedules and cost information to support four-dimensional scheduling and five-dimensional cost management.

Other digital technologies, including drones, sensors, digital twins, artificial intelligence, and robotics, offer opportunities for monitoring construction progress, identifying defects, managing equipment, and improving safety inspections. Nevertheless, implementation may be constrained by software costs, data interoperability, inadequate training, and the need for reliable project information.

2.8 Sustainability in High-Rise Construction

Sustainability has become an important consideration in the selection of construction techniques. Construction methods influence material consumption, transportation requirements, energy use, construction waste, and the environmental impacts associated with temporary works and equipment.

Prefabrication and modular construction may reduce on-site waste and improve material utilisation. However, additional factory operations, transportation, and lifting activities can affect their overall environmental performance. Consequently, the environmental benefits of alternative construction techniques should be evaluated using lifecycle assessment with consistent functional requirements and clearly defined system boundaries.

The use of recycled materials, supplementary cementitious materials, efficient structural design, and improved construction logistics can also contribute to reducing environmental impacts. Digital technologies may support these objectives by improving quantity estimation, resource allocation, and waste management.

2.9 Research Gap

The literature demonstrates that several construction techniques can improve high-rise construction performance under suitable conditions. However, many studies focus on individual methods, such as modular construction, formwork systems, or digital technologies, rather than evaluating their combined influence on overall project performance.

Further research is required to compare construction methods using consistent

indicators of construction time, whole-life cost, quality, safety, and environmental impact. Additional investigation is also needed into hybrid systems that combine cast-in-situ cores, precast floors, steel framing, modular service units, and digital construction management.

Project-based studies in developing construction markets, including India, would be valuable for understanding the influence of labour availability, transportation constraints, equipment costs, contractor capabilities, and local regulations on the selection of construction techniques.

3. Methods

3.1 Review Approach

This study adopts a narrative literature review approach to examine construction techniques used in high-rise buildings. The review focuses on conventional construction, advanced formwork, precast and modular construction, steel and composite systems, top-down construction, digital technologies, and sustainability.

The literature is organised thematically to identify the principles, applications, benefits, and limitations of each construction technique. A comparative assessment is then developed to examine their suitability for different high-rise construction conditions.

3.2 Literature Identification

Relevant literature should be identified from scholarly databases such as Scopus, Web of Science, ScienceDirect, SpringerLink, and Google Scholar. Search terms may include combinations of the following keywords:

- “High-rise building construction techniques”
- “Advanced formwork systems”
- “Precast concrete high-rise buildings”
- “Modular construction”
- “Top-down construction”
- “Steel and composite construction”
- “Building Information Modelling in high-rise construction”
- “Sustainable construction methods”
- “Construction productivity and safety”

Peer-reviewed journal articles, review papers, and relevant technical publications should be prioritised. Foundational studies may be included where they provide important information on established construction methods.

3.3 Inclusion and Exclusion Criteria

The review should include publications that directly address construction methods, construction sequencing, productivity, safety, quality, digital technologies, or sustainability in high-rise buildings. Research on modular and prefabricated systems may also be included when its findings are relevant to multi-storey or high-rise construction.

Studies that focus exclusively on unrelated building types or topics without meaningful implications for high-rise construction should be excluded. Publications with insufficient methodological detail or unverifiable bibliographic information should not be relied upon as primary evidence.

3.4 Comparative Evaluation

The construction techniques are evaluated using qualitative performance indicators, including:

1. Construction speed and productivity.
2. Initial investment and overall project cost.
3. Quality control and dimensional accuracy.
4. Labour and equipment requirements.
5. Safety and construction risks.
6. Flexibility in architectural and structural design.
7. Site accessibility and logistical requirements.
8. Material efficiency and environmental sustainability.

The qualitative comparison is intended to identify general advantages and constraints rather than establish universal numerical rankings. Actual performance varies according to project conditions, building geometry, construction scale, local labour costs, material availability, and contractor experience.

3.5 Limitations of the Method

The present review is a narrative synthesis and does not constitute a fully systematic review or meta-analysis. A systematic journal submission would require a documented search period, complete search strings, database-specific results, duplicate removal, screening records, and a transparent account of the studies included. Quantitative conclusions should be developed only when sufficiently comparable and verifiable project data are available.

4. Conclusions

This review examined major construction techniques used in high-rise buildings,

including conventional cast-in-situ reinforced concrete construction, advanced formwork systems, precast and modular construction, structural steel and composite systems, and top-down construction. The review also considered the role of BIM, digital technologies, construction safety, and sustainability in improving project performance.

Conventional cast-in-situ construction remains an important option because of its flexibility, established practices, and adaptability to different structural configurations. Advanced formwork systems can improve repetitive concrete construction, particularly in buildings with regular floor layouts and continuous vertical cores. Precast and modular construction offer opportunities for factory-based quality control and parallel production, although their success depends on transportation, lifting arrangements, structural connections, and supply-chain coordination.

Steel and composite construction can support rapid erection and flexible structural arrangements, provided that fire protection, connection design, corrosion control, and erection stability are appropriately addressed. Top-down construction can be effective for deep basements and constrained urban sites but requires detailed geotechnical and construction-sequence planning.

The review further indicates that BIM and digital monitoring can improve design coordination, construction planning, and progress management. However, their effectiveness depends on data accuracy, interoperability, trained personnel, and integration into actual site operations. Similarly, sustainability benefits should be assessed through lifecycle-based comparisons rather than assumed from the adoption of prefabrication or other advanced techniques alone.

The principal conclusion is that **the selection of a high-rise construction technique should be based on an integrated evaluation of structural requirements, construction duration, cost, quality, safety, site conditions, and environmental performance.** Future research should focus on comparative project data, hybrid construction systems, digital construction management, and lifecycle assessment to support more reliable and sustainable decisions.

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