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Oleksandr Ignatenko
Kyiv National University of Construction and Architecture, Kyiv, Ukraine
ORCID iD: 0009-0009-7691-884X
Serhii Storozhev
Kyiv National University of Construction and Architecture, Kyiv, Ukraine
ORCID iD: 0009-0006-9436-1764

DEVELOPMENT OF CONSTRUCTION TECHNOLOGY FOR LIFT-COMMUNICATION BLOCKS OF HIGH-RISE MONOLITHIC BUILDINGS

Abstract. Traditional methods for erecting lift-communication blocks (LCBs) in high-rise buildings are heavily constrained by tower crane availability, complex high-altitude labor, and strict weather dependencies. This paper presents an innovative, crane-free technological solution for LCB construction using the tier-by-tier jacking-up-underneath method. The proposed approach relocates complex reinforcement cage prefabrication and formwork assembly to the safe environment of the ground level. The assembled tiers are incrementally hoisted using a synchronized hydraulic jacking system anchored to the foundation. Structural integration is finalized through continuous bottom-up concreting with self-compacting concrete pumped directly from the ground. Analyzed through the lens of ongoing high-rise projects in Kyiv, this method ensures the parallelization of construction workflows and eliminates high-altitude occupational hazards. The study proves that the jacking-up-underneath paradigm offers structural height independence, meaning that technological complexity and financial costs do not scale exponentially with the building's height, making it highly efficient for skyscraper erection.
Keywords: high-rise construction; lift-communication blocks; shear cores; jacking-up-underneath method; crane-free technology; self-compacting concrete; bottom-up concreting; construction logistics; vertical scalability.

Introduction

Modern global urbanization trends are characterized by a massive influx of population into large metropolitan areas, driving a rapid and irreversible increase in the volume of high-rise construction. As land resources in urban centers become increasingly scarce and costly, the vertical development of city infrastructure turns into a strategic necessity. The primary structural and engineering feature of modern high-rise monolithic reinforced concrete buildings is the integration of rigid vertical shear cores, which are designed to bear the main lateral wind, aerodynamic, and seismic loads, ensuring the overall spatial stability and geometric immutability of the high-rise frame.

The structural and spatial basis of these shear cores typically consists of complex lift-communication blocks (LCBs). Inside these blocks, vital infrastructure elements -

such as elevator shafts, stairwells, ventilation ducts, and vertical utility networks - are centralized. From a technological perspective, the construction of LCBs represents a critical path in the calendar schedule of the project. The pace of their erection directly determines the overall duration, labor intensity, and budget of the entire building superstructure. Consequently, from a scientific standpoint, developing new, highly efficient, and innovative approaches to forming such dense vertical structures contributes significantly to the theory and practice of construction technology, opening up new horizons for the radical intensification and automation of modern construction processes.

Analysis of Recent Studies and Publications

Traditionally, the erection of LCBs in high-rise monolithic construction relies on tier-by-tier upward extension methods using climbing, self-climbing, or heavy slipform formwork systems. A comprehensive analysis of current technological solutions and recent publications indicates that, despite a high level of modern mechanization, the processes of forming complex vertical and horizontal LCB structures remain the most logistically complicated, labor-intensive, and time-consuming operations in the entire structural frame cycle [1, pp. 39 – 52]. [2].

Current scientific literature highlights several critical technological and organizational limitations inherent in conventional methods:

– **Tower Crane Dependency:** Most traditional methods depend critically on the operational cycles of high-capacity tower cranes for moving formwork panels, reinforcing steel, and large components. This creates severe technological bottlenecks, as crane time is shared among multiple processes, ultimately limiting the overall speed of the structural frame erection.

– **Technological Desynchronization:** A distinct operational gap exists between the rapid lifting of the vertical core walls and the slower installation of horizontal structural elements, such as internal landings, stairs, and floor slabs. This desynchronization disrupts the continuity of concrete pouring and increases the overall technological cycle time.

– **Labor Intensity at High Altitudes:** The reinforcement and assembly of dense structural components inside confined LCB spaces require significant manual labor under high-altitude conditions. This not only lowers productivity but also increases occupational safety risks for the workers.

– **Curing and Cycle Boundaries:** Conventional systems are tightly constrained by the concrete curing time required before formwork stripping and lifting can occur. This lock-step dependency prevents overlapping phases and hinders the application of concurrent engineering principles.

Thus, the resolution of these fundamental contradictions—specifically between the need for high-speed high-rise assembly and the technological limitations of modern

crane-dependent formwork systems—remains an open and highly relevant scientific problem that requires the development of alternative technological paradigms.

Problem Statement

Existing conventional technologies for erecting lift-communication blocks (LCBs) at high elevations suffer from several interrelated structural and technological drawbacks that critically reduce construction efficiency.

First, the geometric configuration of LCBs frequently undergoes structural modifications along the vertical axis of the building (e.g., changes in wall thickness, reduction of shaft cross-sections, or variation in door opening dimensions). Under traditional top-down or tier-by-tier upward extension methods, these alterations require the constant adaptation of formwork systems, involving the development of customized templates and complex, waste-heavy cutting plans for formwork sheets directly on-site.

Second, the structural interfaces between LCB vertical tiers and adjacent elements of the monolithic frame (such as floor slabs and shear walls) feature highly congested reinforcement cages. Ensuring supreme execution accuracy for these connections under high-altitude conditions is extremely difficult. Examples of such intricate structural configurations, compiled from actual facilities currently under construction in Kyiv, are illustrated in Fig. 1.

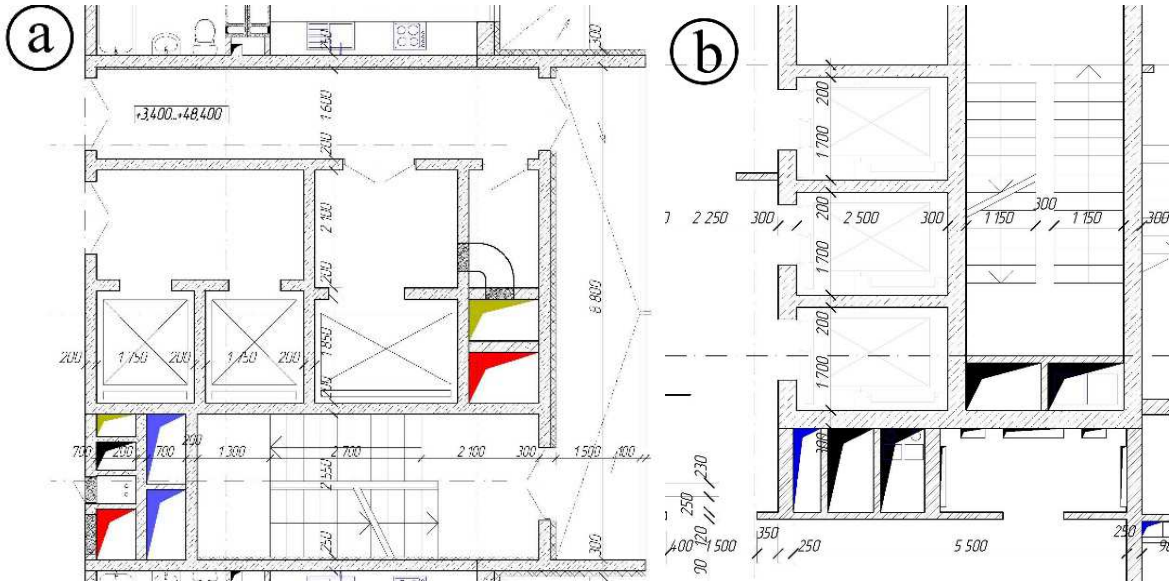


Fig. 1. Structural design variations of lift-communication blocks in monolithic high-rise buildings (exemplified by projects in Kyiv)

Finally, executing the complete scope of steel fixing, formwork assembly, and concrete pouring operations at extreme elevations (especially exceeding 75 meters) introduces cumulative negative factors. These include severe hazards for personnel, extended technological cycles due to wind velocity limits on crane operations, and a strict dependence on weather conditions. Ultimately, these factors substantially inflate the total cost of the structural frame.

Main Body

To resolve these interconnected challenges, a fundamentally new technological paradigm for erecting LCBs using the tier-by-tier jacking-up-underneath method is proposed. The conceptual schematic of this approach is shown in Fig. 2. This methodology serves as a logical extension and evolutionary development of the scientific subdiscipline "Crane-Free Methods for LCB Erection" within the broader framework of modern construction technology theory [3].

The core philosophy of this technological process lies in the complete spatial relocation of the most labor-intensive, precise, and hazardous manufacturing operations from high altitudes down to the controlled, safe environment of the ground or foundation level.

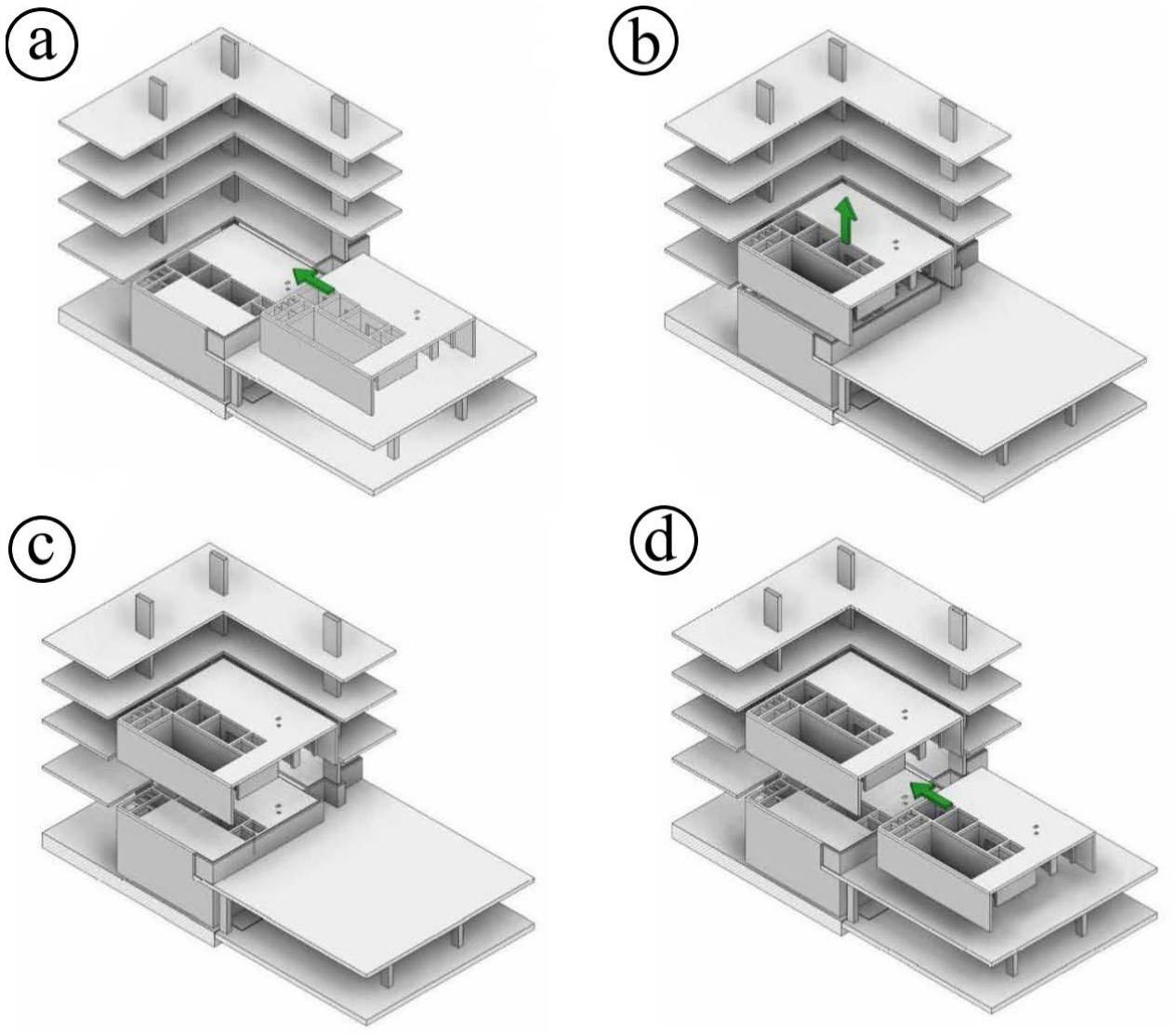


Fig. 2. Conceptual technological schematic of the tier-by-tier jacking-up-underneath process for lift-communication blocks: *a* - assembly of the first LCB tier at the first-floor level; *b* - displacement of the first LCB tier to the second-floor level using hydraulic jacks; c - securing the first LCB tier in the intermediate position at the second-floor level; *d* - assembly of the second LCB tier at the first-floor level.

The advanced technological sequence for implementing the proposed method involves the following highly synchronized stages:

1. **Ground-Level Assembly and Prefabrication:** The complete structural assembly of an LCB tier—including the dense reinforcement cage, internal utilities, embedded parts, and specialized formwork panels—is executed at the first-floor level. Working at this elevation eliminates high-altitude hazards, ensures maximum geometric tolerance control, and facilitates the use of highly productive automated welding and assembly jigs.

2. **Hydraulic Engagement and Primary Lift:** Utilizing a synchronized system of high-capacity hydraulic jacks anchored to the foundation mat, the fully assembled LCB tier is engaged. The system performs a controlled vertical translation, lifting the entire assembled structure to the height of the subsequent floor level. The synchronization software monitors pressure and displacement variations at each jacking point to prevent any angular distortion or structural racking.

3. **Interim Structural Fixation:** Once the lifted LCB segment reaches its temporary design elevation, its spatial position is securely locked using a specialized system of mechanical locking collars, structural latches, or heavy-duty temporary supports capable of bearing the dead weight of the growing assembly.

4. **Jack Retraction and Resetting:** After verifying the load transfer to the temporary fixation system, the hydraulic jack rams are decompressed and systematically retracted to their initial baseline position at the foundation level, clearing the workspace for the next cycle.

5. **Sub-Tier Alignment and Interface Assembly:** The subsequent LCB tier is assembled at the first-floor level, positioned directly underneath the previously hoisted structure. At this stage, the upper reinforcement starters of the new tier are precisely aligned with the lower structural nodes of the suspended tier.

6. **Cyclic Jacking-Up and Structural Extension:** The newly formed tier is integrated into the hydraulic circuit, lifted underneath the preceding one, and structurally spliced. This cyclical jacking up and anchoring process is repeated sequentially for all subsequent floors, progressively pushing the completed portion of the building core upward.

7. **Continuous Bottom-Up Concreting:** Upon reaching the final design elevation for the entire LCB column, the final phase of structural integration is executed. High-performance, self-compacting concrete (SCC) is pumped under pressure tier-by-tier from the bottom up, utilizing specialized valves integrated into the formwork at the ground level. This continuous upward pouring fills the cavities seamlessly, eliminates internal voids, ensures superior adhesion to the reinforcement, and eliminates the need for high-altitude concrete distribution systems.

Conclusions

The proposed innovative technology for erecting LCBs via the tier-by-tier jacking-up-underneath method transcends purely applied engineering boundaries. It serves as a major theoretical and practical contribution to the advancement of modern

construction technology and high-rise structural engineering. Synthesizing the comprehensive research findings yields the following definitive conclusions:

1. **Theoretical Substantiation of Crane-Free Methods:** The scientific viability and technological feasibility of isolating crane-free LCB erection methods as an independent, high-efficiency direction within the system of construction production technology have been rigorously proven. This paradigm shift enables the complete optimization of job site logistics, eliminates critical technological bottlenecks, and minimizes reliance on the strictly constrained resource of heavy tower crane equipment.

2. **Modernization of Work Organization and Safety:** Shifting the spatial zone for formwork assembly and complex, dense reinforcement cage fabrication to the ground or foundation level establishes optimal conditions for stationary, highly mechanized, and controlled production (creating a "factory-on-site" effect). This modernization significantly reduces specific labor intensity, guarantees maximum geometric precision and tolerance control of complex structural joints, and completely eliminates the occupational hazards associated with executing critical manual operations at extreme heights exceeding 75 meters.

3. **Technical and Economic Efficiency:** The developed cyclic, crane-free jacking-up-underneath algorithm ensures the seamless parallelization and continuous execution of subsequent technological processes. This achieves a stable, predictable reduction in the overall structural frame construction timeline of high-rise buildings and lowers operational costs by neutralizing workflow downtime caused by high-altitude wind velocity constraints and lifting machinery delays.

4. **Vertical Scalability and Height Independence:** The application of the proposed tier-by-tier jacking-up technology establishes a path toward building structural frames of virtually unlimited design heights. Because the core mechanical lifting operations and material assembly remain localized at the ground level, the technological complexity, economic costs, and structural risks do not scale exponentially with the building's height. This opens up new technological horizons for the erection of supertall and ultra-high-rise skyscrapers without requiring specialized super-heavy high-altitude machinery.

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