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Comparative Analysis of Linear Scheduling Method and Critical Path Method for High-Rise Building Construction

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Abstract—High-rise building projects contain several repetitive activities that move vertically from one floor to another. Conventional Critical Path Method (CPM) schedules can identify activity dependencies and overall project duration, but they often do not show floor-wise work continuity, crew movement, or location-based interference with sufficient clarity. This paper presents a case-study-based comparative analysis of the Linear Scheduling Method (LSM) and CPM for a 31-storey reinforced concrete residential tower in Pune, India. Project schedule data, activity durations, Microsoft Project outputs, and the updated presentation results were interpreted through a time-location planning framework. The updated PPT-based comparison indicates that the selected repetitive work package required 645 days under the CPM-based schedule and 543 days under the revised LSM planning scenario. This represents a time saving of 102 days, corresponding to a 15.81% duration reduction. The results further show that LSM improves visualization of floor-wise progress, supports production-rate-based interpretation, highlights trade overlap, and assists in managing crew continuity. However, the study emphasizes that schedule savings depend on realistic productivity assumptions, continuous work fronts, resource availability, and regular progress updates. LSM is therefore recommended as a complementary planning and monitoring tool for repetitive high-rise construction rather than as a replacement for baseline CPM control.

Index Terms—Critical Path Method, high-rise building, Linear Scheduling Method, location-based scheduling, repetitive construction, schedule optimization, time-location planning.

I. INTRODUCTION

Construction scheduling is a major control function in high-rise projects because structural, service, and finishing operations are repeated floor after floor. A schedule that only represents time and dependency may not adequately show how crews move vertically, how multiple trades occupy different floors, or how a delay on one level propagates through subsequent floors. These issues become more important when cranes, hoists, material supply, inspection clearances, and crew availability must be synchronized with repetitive construction cycles.

The Critical Path Method (CPM) remains a widely used method for baseline scheduling because it provides activity dependency logic, float, and the overall critical path. Nevertheless, for repetitive high-rise construction, CPM and Gantt-based formats can become visually complex and may hide the location dimension of work. The Linear Scheduling Method (LSM), also described within the broader family of location-based scheduling methods, directly connects time and location by plotting activities as production lines across floors or work zones. The method is therefore suitable for analyzing floor-wise continuity, activity interference, and production rate.

This updated paper incorporates the results from the project presentation and aligns the analytical discussion with the revised CPM–LSM comparison. The study focuses on repetitive high-rise activities such as RCC structural work, brickwork, plumbing, drainage, electrical conduiting, flooring, skirting, painting, final finishing, and handover.

II. LITERATURE REVIEW

Previous studies have shown that repetitive construction requires planning approaches that can represent continuity, rate of production, and spatial progress. Linear and location-based scheduling approaches have been used for roads, pipelines, railways, tunnels, multi-storey buildings, and modular construction because such projects contain repeated production units. Optimization studies have also integrated genetic algorithms, particle swarm optimization, constraint programming, fuzzy logic, BIM, and probabilistic reliability models to improve schedule performance under uncertainty.

Abdelbasset et al. developed multi-objective optimization models for repetitive construction projects with multiple crews and work-continuity constraints [1]. Ammar formulated resource optimization under line-of-balance scheduling to improve continuity and duration decisions [2]. García-Nieves et al. proposed mathematical programming and multimode resource-constrained models for repetitive activities [4], [5]. Katsuragawa et al. advanced fuzzy repetitive scheduling for uncertainty in activity durations [8]. Lee et al. demonstrated that enhanced TACT planning can reduce high-rise finish work duration by coordinating repetitive activities [10]. Recent studies further extend location-based and LSM concepts through Linear4D systems, BIM-linked line-of-balance scheduling, and data-driven optimization [11], [16].

Despite this progress, direct case-based comparisons of CPM and LSM for high-rise residential towers remain limited. The reviewed literature supports the need for a practical study that compares schedule duration, floor-wise visibility, production rate, and workflow interpretation for a repetitive RCC building. This paper addresses that gap using a 31-storey high-rise residential case study.

III. RESEARCH METHODOLOGY

A case-study-based comparative design was adopted. The selected project was VTP Bellissimo in the Codename Blue Waters township, located in the Mahalunge-Hinjawadi corridor of Pune, Maharashtra. The case represents a high-rise residential development where repetitive work fronts progress vertically through a 31-storey RCC tower. The study used project observations, schedule information, Microsoft Project outputs, Excel-based calculations, presentation results, and document analysis.

The analysis followed five stages: selection of the case project, identification of repetitive work packages, review of the CPM/MSP schedule, conversion of relevant activities into LSM time-location logic, and comparison of duration, production rate, and managerial visibility. The same core activities were interpreted under both scheduling approaches so that differences in output could be traced to the planning logic rather than to changes in the activity scope.

Fig. 1. Research workflow adopted for CPM–LSM comparison.

TABLE I. CASE STUDY AND DATA BASIS

Parameter	Description
Project type	31-storey RCC residential high-rise tower
Location	Mahalunge-Hinjawadi corridor, Pune, Maharashtra
Scheduling comparison	Microsoft Project/CPM output versus LSM time-location interpretation
Activities considered	RCC work, brickwork, plumbing, drainage, electrical conduiting, flooring, skirting, painting, final cleaning, and handover
Analysis focus	Duration, floor-wise movement, production rate, trade overlap, crew continuity, and delay visibility
Study limitation	Cost estimation and procurement planning were not included; LSM values represent a planning scenario based on optimized productivity rates

IV. LSM MODEL DEVELOPMENT

The LSM model was developed by interpreting repetitive activities as activity lines in a time-location plane. Time was represented along the horizontal axis, while the vertical axis represented floors. The slope of each activity line indicates production rate. A steep line indicates a faster activity or higher floor-per-day rate, while a gentle line indicates slower movement and potential influence on the overall completion trend.

The productivity assumptions were derived from the project schedule and PPT result charts. RCC monolithic wall-slab casting was treated as a controlling activity for the start of downstream work. Brickwork, plastering, services, flooring, skirting, painting, and final finishing were then interpreted as follow-on trades that move vertically after their predecessor activities. The activity sequence was checked so that obvious trade clashes and unrealistic floor-level overlaps could be avoided.

TABLE II. PRODUCTIVITY RATE SUMMARY FROM PPT RESULTS

Activity	Productivity rate (floor/day)	Scheduling implication
RCC structural / monolithic wall-slab casting	0.143	Slowest repetitive activity; controls work-front release
Brickwork / masonry	0.250	Requires continuous access after RCC work
Internal plastering	0.333	Moderate rate; dependent on masonry completion
External plastering	0.250	Slower external finishing package
Plumbing	0.500	Faster service activity requiring coordination
Drainage	0.500	Follows plumbing sequence and floor availability
Electrical conduiting	1.000	Fastest service activity; needs clash control
Flooring	0.500	Moderate finishing productivity
Skirting	1.000	Fast finishing activity
Painting	0.333	Extended finishing package despite moderate floor rate
Final finishing	0.500	Late-stage completion and handover support

V. RESULTS AND DISCUSSION

A. Microsoft Project/CPM Schedule Interpretation

The CPM/Gantt results presented in the project presentation show the activity sequence from initial construction to final handover. Mobilization, site setup, survey, excavation, PCC, footing, substructure, parking floors, typical floors, upper floors, masonry, plumbing, drainage, electrical conduiting, flooring, skirting, painting, carpentry, railing, lift installation, cleaning, and handover were arranged with logical dependencies and controlled overlaps.

For the superstructure and services, the Gantt charts show the repetitive nature of floor-wise execution. Parking floor and typical floor structural activities follow short 1–2 day cycles for column, beam, and slab tasks. Brickwork is generally planned in 3-day cycles, while plumbing and drainage use 2-day cycles. Electrical conduiting and some finishing packages have shorter 1-day to 2-day cycles. Painting and final finishing extend the overall completion period and become important for handover control.

B. Productivity Rate Comparison

The productivity rate chart indicates that electrical conduiting and skirting have the highest productivity at 1.000 floor/day. RCC monolithic wall-slab casting has the lowest productivity at 0.143 floor/day, making it the slowest repetitive activity and a controlling factor for downstream work-front release. Plumbing, drainage, flooring, and final finishing each show 0.500 floor/day, while internal plastering and painting show 0.333 floor/day. This output supports production-rate-based LSM planning because crew movement can be evaluated using floor/day values rather than only task durations.

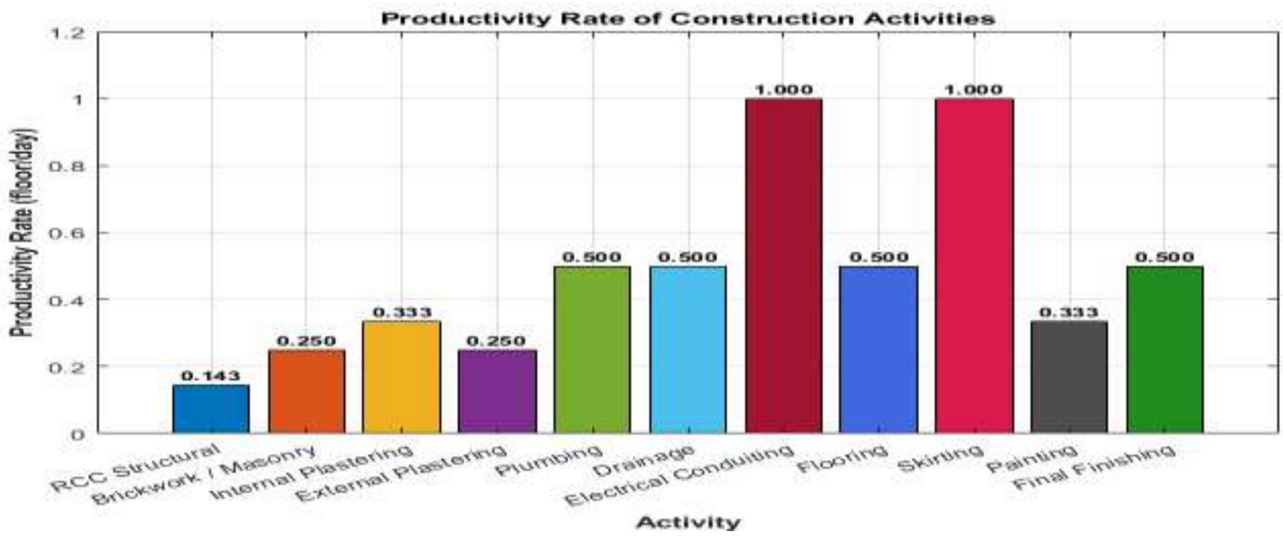

Fig. 2. Productivity rate comparison of repetitive construction activities.

TABLE III. FINISH DAY OF CONSTRUCTION ACTIVITIES

Activity	Finish day
RCC structural	210
Brickwork	162
Plumbing	156
Drainage	165
Electrical	143
Internal plaster	228
External post-pour	285
Flooring	255
Skirting	252
Painting	356
Final finishing	543

C. Finish-Day Pattern of Construction Activities

The finish-day chart highlights variation in the completion of repetitive packages. Electrical work completes at day 143, plumbing at day 156, brickwork at day 162, drainage at day 165, and RCC structural work at day 210. Internal plastering, flooring, skirting, and external post-pour activities extend into the middle portion of the schedule. Painting completes at day 356, while final finishing and handover extend the revised LSM schedule to day 543. Therefore, the late-stage finishing package governs the final completion date in the PPT-based LSM result.

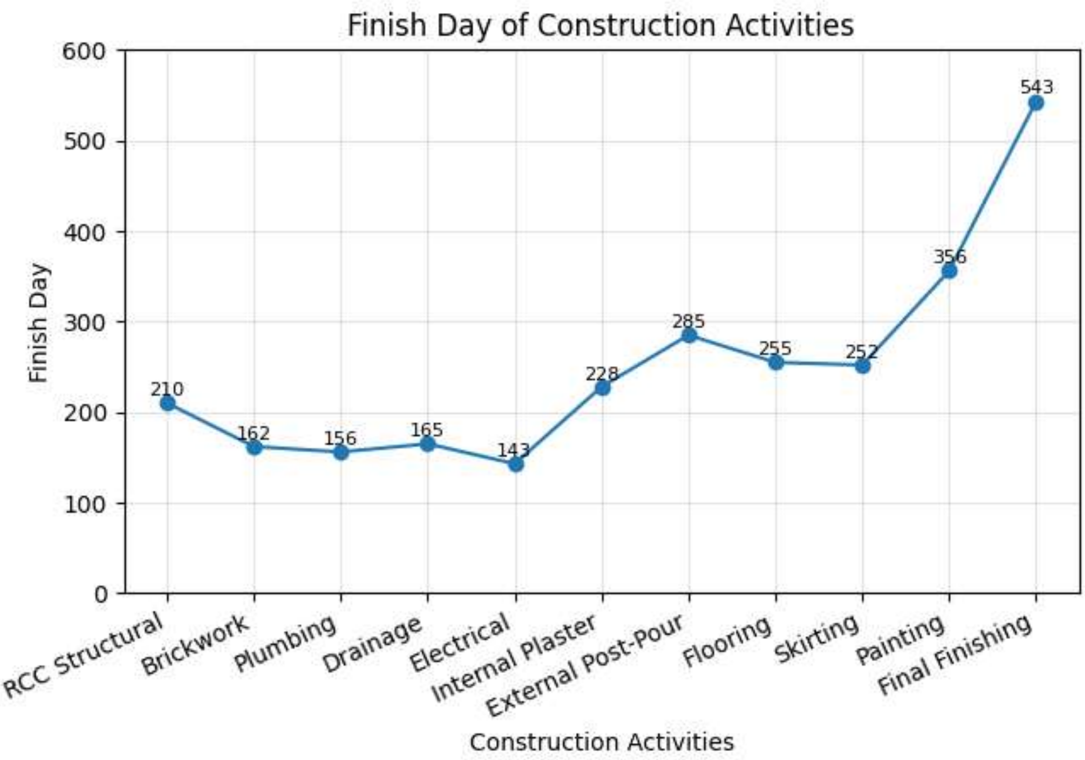

Fig. 3. Finish day of construction activities based on the updated PPT result chart.

D. Time-Location Interpretation

The time-location chart maps activity movement across floors against time. Steeper lines represent faster activities, while flatter lines indicate slower activities or activities with lower production rates. The chart provides visual evidence of how RCC, masonry, services, plastering, flooring, skirting, painting, and final handover move vertically through the 31-storey tower. Close or intersecting activity lines indicate potential work-front congestion, trade overlap, and the need for buffers.

The main advantage of this representation is that delays can be detected spatially. If the actual progress line of a trade becomes flatter than the planned line, the crew is losing productivity. If two activity lines approach the same floor at the same time, the planner can revise buffers, crew allocation, or floor release sequence before the conflict becomes a site delay.

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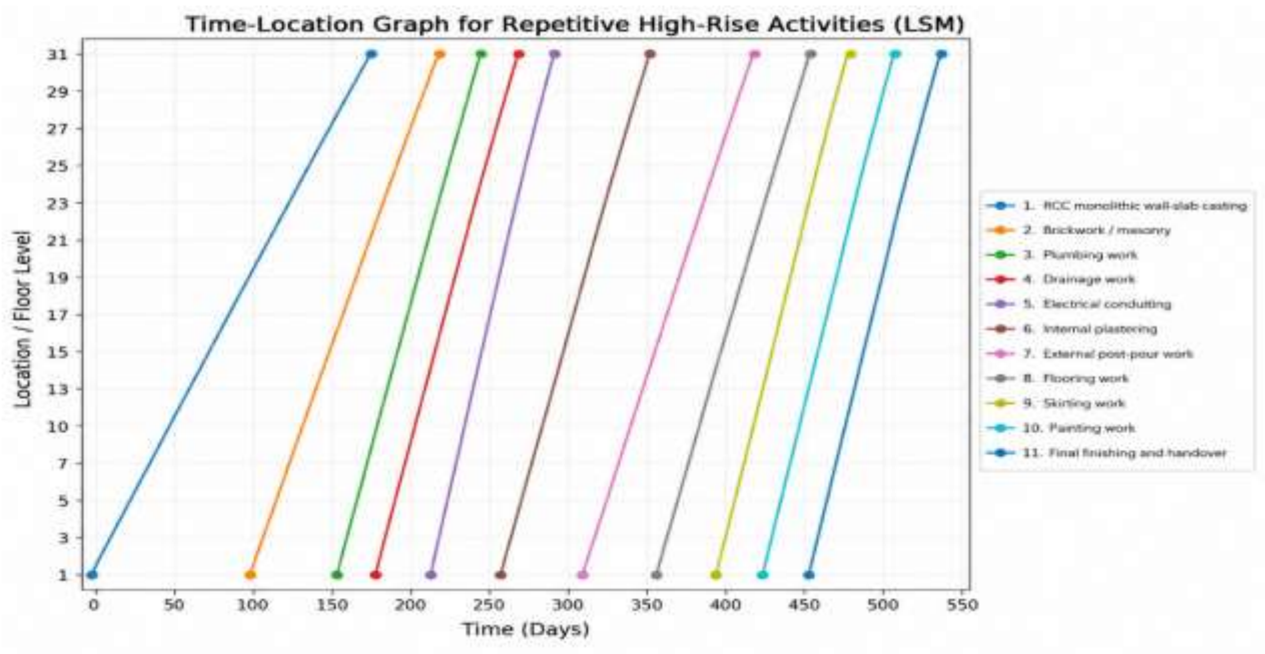

Fig. 4. Time-location graph for repetitive high-rise activities under LSM.

E. Duration Comparison Between CPM and LSM

The updated duration comparison from the PPT replaces the earlier inconsistent values in the research paper. The CPM-based duration for the selected repetitive work package is 645 days, whereas the revised LSM-based duration is 543 days. Therefore, the total time saving is 102 days. The percentage duration reduction is calculated as follows:

$$\textbf{Duration reduction (\%)} = [(645 - 543) / 645] \times 100 = 15.81\%$$

TABLE IV. UPDATED CPM–LSM DURATION COMPARISON

Parameter	CPM result	LSM result	Interpretation
Total duration	645 days	543 days	LSM reduces the repetitive work-package duration
Time saving	—	102 days	Difference between CPM and revised LSM durations
Duration reduction	—	15.81%	Percentage saving with respect to CPM duration
Planning meaning	Baseline dependency control	Location-based workflow control	Combined CPM–LSM use gives stronger planning visibility

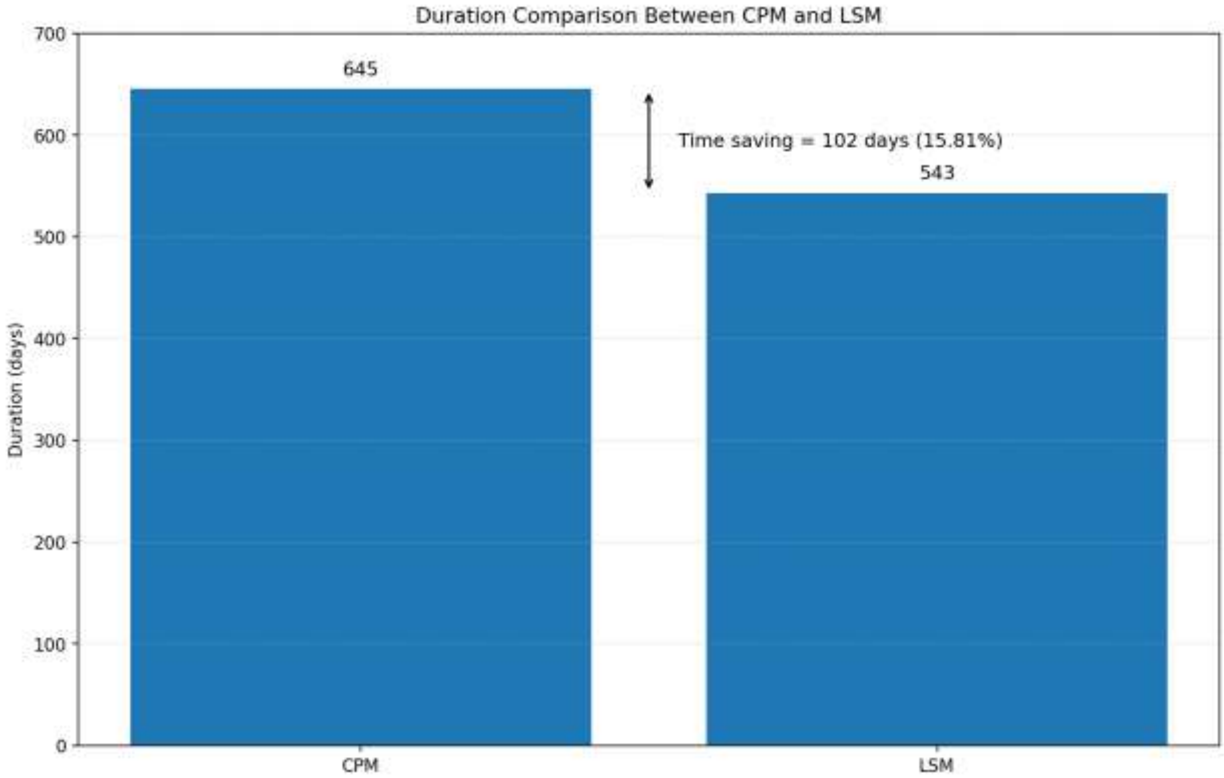

Fig. 5. Duration comparison between CPM and LSM based on updated PPT results.

F. Overall Comparative Evaluation

TABLE V. OVERALL COMPARISON SUMMARY: CPM VS LSM

Parameter	CPM	LSM
Visualization	Moderate	Excellent
Repetitive work handling	Limited	Strong
Resource continuity	Difficult	Better
Floor-wise tracking	Limited	Easy
Delay identification	Moderate	Fast
Suitable for high-rise	Partial	Highly suitable

The comparative results show that CPM is valuable for formal baseline scheduling, dependency logic, and contractual control. However, LSM provides stronger floor-wise visualization and better interpretation of crew continuity. It is especially suitable when activities are repetitive and progress through known floors or locations. The PPT-based summary confirms that LSM improved schedule performance from 645 days to 543 days while also improving visibility of workflow, delay propagation, and trade coordination.

VI. KEY FINDINGS

- LSM provides stronger floor-wise visualization than CPM because it combines time and location in a single planning view.
- Controlled overlapping and continuous crew movement reduced the schedule duration from 645 days to 543 days.
- The 102-day saving corresponds to a 15.81% improvement over the CPM-based schedule.
- Electrical conduiting and skirting achieved the highest productivity of 1.000 floor/day, while RCC monolithic wall-slab casting was the slowest at 0.143 floor/day.
- Painting and final finishing extend the completion period, with final finishing reaching day 543 in the revised LSM schedule.
- LSM supports early identification of trade overlap, resource clashes, and delay propagation in repetitive high-rise work fronts.
- The most practical approach is to use CPM for baseline logic and LSM for repetitive activity control and location-based monitoring.

VII. LIMITATIONS

The study is limited to a single 31-storey RCC residential building case study. Some LSM duration and productivity values are based on planning assumptions and optimized sequencing from the presentation results. Actual site constraints such as labour fluctuation, weather, material delays, equipment breakdowns, inspection holds, and design changes were not fully validated using live daily productivity records. Detailed cost optimization, procurement planning, contractual claims, and real-time field monitoring were outside the scope of the present study.

Therefore, the 15.81% time saving should be interpreted as a potential planning improvement under controlled overlap and continuity rather than a guaranteed construction outcome. For practical implementation, LSM must be updated regularly with actual site progress and resource availability.

VIII. FUTURE SCOPE

- Integrate LSM with live site progress updates to support real-time project control.
- Combine time-location scheduling with BIM/4D planning, Primavera P6, Microsoft Project, and quantity databases.
- Extend the analysis to cost, labour, equipment, material flow, tower crane movement, hoist utilization, and vertical transportation constraints.
- Compare LSM with Line of Balance, TACT Planning, and Location-Based Management Systems on multiple residential and commercial projects.
- Validate the approach using actual site execution data, daily progress reports, and measured crew productivity.

IX. CONCLUSION

This updated paper presented a comparative study of CPM/MSP and LSM for a 31-storey RCC residential high-rise building. The PPT-based results show that LSM provides stronger floor-wise visualization, clearer crew-flow interpretation, and better identification of repetitive activity overlap than CPM alone. The updated schedule comparison showed a CPM duration of 645 days and a revised LSM duration of 543 days for the selected repetitive work package. This indicates a total saving of 102 days, or approximately 15.81%, under the LSM planning scenario.

The study concludes that LSM is a useful planning and monitoring tool for high-rise buildings where typical floors and repetitive trade sequences dominate the construction process. It should be adopted as a complementary method with CPM, particularly for production-rate monitoring, location-based clash identification, and delay propagation analysis. Future work should integrate LSM with Primavera P6, BIM/4D simulation, cost data, labour allocation, and live site progress records to improve schedule reliability and decision-making.

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