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A Comprehensive Review on Estimation and Costing of Multistorey Buildings

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ABSTRACT

Estimation and costing form the backbone of successful construction project management, directly influencing financial viability, resource allocation, and overall project success. This paper presents a comprehensive review of estimation and costing methodologies for multistorey buildings, synthesizing findings from various research studies conducted across different geographical contexts including Bangladesh, India, Pakistan, Egypt, and Slovakia. The review examines traditional manual estimation methods, software-based approaches using tools like Microsoft Excel, AutoCAD, STAAD Pro, and ETABS, as well as advanced Building Information Modeling (BIM) techniques. Key factors affecting estimation accuracy are identified, including market conditions, estimator experience, site conditions, and labour availability. Comparative analysis reveals that BIM assisted estimates achieve accuracy within 0.5 0.8% variance, significantly outperforming traditional manual methods which typically show 5 15% variance. The integration of digital tools, proper work breakdown structures, and consideration of critical success factors significantly enhances estimation accuracy. This review provides valuable insights for civil engineers, project managers, and researchers seeking to improve cost estimation practices in residential construction projects.

KEYWORDS: *Estimation, Costing, Multistorey Building, Building Information Modeling (BIM), Quantity Surveying, Construction Management.*

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1. INTRODUCTION

Estimation and costing represent fundamental processes in civil engineering that determine the probable cost of construction projects before execution. As noted by Ali and Rahman (2019), accurate estimation is crucial because the success and quality of any construction project depend on it. The construction industry, being one of the largest contributors to national economies worldwide, requires precise cost forecasting to ensure project viability and stakeholder confidence.

In the context of multistorey buildings, estimation complexity increases exponentially due to the multitude of structural elements, varied material requirements, labour considerations, and the intricate interplay between architectural, structural, electrical, and plumbing components. The loss and profit of a construction project are strictly dependent on proper estimating and costing, with slight variations potentially hampering the overall success of real estate enterprises (Ali & Rahman, 2019).

The evolution of estimation practices has witnessed a remarkable journey from rudimentary manual calculations to sophisticated digital methodologies. Initially, estimation techniques were basic, relying on practical rules of thumb and manual calculations. The industrial revolution introduced standardized measurement systems and the bill of quantities concept. The mid-20th century brought computing technology integration, while the 21st century has seen the emergence of Building Information Modeling (BIM) and integrated digital platforms that enable real-time data fusion and collaborative project management (Subhakesavulu et al., 2025).

This review synthesizes knowledge from multiple research studies conducted across diverse geographical contexts, including Bangladesh, India, Pakistan, Egypt, and Slovakia, providing a holistic understanding of estimation practices globally. The findings aim to guide practitioners toward more accurate, efficient, and reliable cost estimation approaches for multistorey residential buildings.

In the context of multistorey buildings, estimation complexity increases significantly due to the presence of numerous structural components, diverse material requirements, labor dependencies, and the coordination of architectural, structural, electrical, and plumbing systems. Even minor inaccuracies in estimation can lead to cost overruns, delays, or compromised quality. Thus, proper estimation and costing play a decisive role in determining the profitability and feasibility of construction projects.

Furthermore, modern estimation approaches increasingly incorporate data-driven techniques, including statistical analysis, simulation methods, and emerging machine learning models, to enhance prediction accuracy and adaptability to market fluctuations. These advancements not only improve cost reliability but also support sustainable construction practices through lifecycle cost analysis and resource optimization.

2. OBJECTIVES

The primary objectives of this comprehensive review are:

1. **To analyse** the various estimation and costing methodologies employed in multistorey residential building construction, including manual, software-based, and BIM approaches.
2. **To identify** and categorize the critical factors influencing the accuracy of cost estimates in residential building projects.
3. **To evaluate** the comparative effectiveness of different estimation methods through quantitative analysis of cost variance percentages reported in existing literature.
4. **To examine** the technological evolution from traditional manual estimation to modern digital and BIM-integrated approaches.
5. **To synthesize** best practices and recommendations for improving estimation accuracy in multistorey residential construction projects.

NEED OF STUDY

The construction industry faces persistent challenges in cost estimation accuracy, with significant implications for project success. Several factors necessitate this comprehensive review:

1. Economic Significance

The construction sector contributes substantially to national GDP, with Egypt reporting approximately 8% contribution in 2019 (Sayed et al., 2020). In India, the residential real estate sector experienced unprecedented growth in 2023, reaching levels unseen in the past 15 years (Ramakrishna et al., 2025). Accurate estimation directly impacts investment decisions and financial stability.

2. Persistent Accuracy Issues

Despite technological advancements, cost overruns remain common. Studies indicate that manual estimation methods typically show cost variance between 5-15%, while more sophisticated approaches can reduce this to under 1% (Haider et al., 2020; Sayed et al., 2020).

3. Gap in Standardized Methodologies

There is no consensus among researchers regarding the most important factors influencing cost estimate accuracy. Sayed et al. (2020) identified 29 potential factors, while others have proposed varying sets, highlighting the need for synthesized knowledge.

4. Technological Transition Challenges

The construction industry in developing countries lags in adopting digital estimation tools. In Bangladesh, manual estimation remains prevalent, leading to errors and improper forecasting (Ali & Rahman, 2019).

5. Complexity of Multistorey Structures

Modern residential buildings incorporate complex designs, varied materials, and integrated systems requiring sophisticated estimation approaches that traditional methods cannot adequately address (Subhakesavulu et al., 2025).

3. METHODOLOGY

This review was conducted through systematic analysis of published research papers, case studies, and review articles spanning the period 2000-2025. The methodology involved:

1. Literature Collection

A total of 14 primary research papers and review articles were analyzed, including:

- ➢ Primary research papers (manual methods) covering studies from Bangladesh, India, and Pakistan
- ➢ Review and research papers (software based methods) covering international perspectives including BIM comparison, cost estimation factors, and software applications

2. Thematic Analysis

The collected literature was categorized into thematic areas:

- Manual estimation methodologies
- Software-based estimation approaches
- Building Information Modeling (BIM) applications
- Factors affecting estimation accuracy
- Comparative studies across methods

3. Quantitative Synthesis

Cost variance percentages and comparative metrics were extracted and analyzed to provide quantitative insights into method effectiveness.

4. Methodological Framework Analysis

The research methodologies employed in reviewed studies were analyzed, including:

- Questionnaire surveys and Pareto analysis
- Case study validation
- Comparative analysis between manual and software methods
- Monte Carlo simulation applications

4. RESULT AND DISCUSSION

4.1. Classification of Estimation Methods

The reviewed literature reveals three primary categories of estimation methods:

4.1.1. Manual Estimation Methods

Manual estimation encompasses traditional approaches where quantities are calculated using physical measurements, formulas, and manual calculations. The two predominant manual methods identified are:

Long Wall – Short Wall Method:

This method determines external lengths of long walls (out-to-out) running longitudinally and internal lengths of short or cross walls transversely. As noted by Manoj et al. (2022), this method is considered more accurate than the centre line method for buildings where cross walls are not provided. Aradhana Rao et al. (2019) applied this method for G+5 apartment building estimation.

Centre Line Method:

This method involves finding the total length of walls and multiplying by width and height to obtain volume. It is particularly suitable for buildings with similar cross-section walls and fewer junctions (John & Warrier, 2018). Pawar et al. (2021) successfully applied this method for G+1 residential building estimation, while Khan et al. (n.d.) used it for G+1 school building estimation.

4.1.2. Software-based Estimation Methods

Microsoft Excel:

Excel serves as a widely accessible tool for systematic estimation. Pawar et al. (2021) utilized Excel for approximate quantity method estimation, calculating excavation (58.3 m^3), PCC for foundation (18.543 m^2), and brickwork (324.94 m^2) quantities. Excel enables real-time recalculation and sensitivity analysis, reducing estimation time by up to 30% (Subhakesavulu et al., 2025).

STAAD Pro and ETABS:

These structural analysis and design software packages enable integrated modeling and estimation. Ramakrishna et al. (2025) conducted comparative analysis between STAAD Pro, ETABS, and manual calculations for a G+3 building, finding that ETABS provided greater accuracy compared to manual Kani's method. Krishna Chaitanya et al. (2021) similarly employed both platforms for G+3 residential building analysis.

AutoCAD and Revit:

AutoCAD facilitates 2D and 3D planning, while Revit enables BIM-based 3D modeling with integrated quantity take-off capabilities. Khan et al. (n.d.) used Revit for 3D perspective design and elevation of a G+1 school building, enabling cross-sectional analysis at any point.

4.1.3. Building Information Modeling (BIM)

BIM represents the most advanced estimation methodology, enabling automated quantity take-off and cost estimation from 3D models. Haider et al. (2020) conducted a comprehensive comparison between manual and BIM-based estimation for a building project, finding:

- Percentage differences between methods:
  - Brick Work: 4.57%
  - RCC Slab: 2.61%
  - Plaster Work: 7.58%
  - PCC Flooring: 3.27%
  - Floor Tile Work: 1.87%
  - Skirting: 6.73%
  - Paint Work: 8.03%
  - False Ceiling: 1.87%
  - Doors and Aluminum Work: 0.00%

The total cost difference between manual and BIM-based estimation was 4.8%, with BIM demonstrating superior accuracy.

4.2. Critical Factors Affecting Estimation Accuracy

Sayed et al. (2020) conducted a comprehensive study identifying factors influencing cost estimation accuracy. Using a questionnaire distributed to 280 participants and applying Pareto analysis, they identified nine critical factors from an initial list of 29:

Table 1: Critical Factors Affecting Cost Estimation Accuracy

Rank	Factor	Cumulative Frequency (%)
1	State of Market	8%
2	Experience of Estimating Team	16%
3	Site Conditions	24%
4	Labor and Equipment Required	32%
5	Transportation Problems	39%
6	Periodical Payments	47%
7	Availability of Productivity Standards	54%
8	Availability of Power & Water in Site	61%
9	Availability of Management and Finance Plans	68%

Other researchers have identified complementary factors:

- **Project characteristics**: Weather conditions, transportation problems, site conditions, project schedule (Odusami & Onukwube, 2008)
- **Financial issues**: Currency exchange fluctuation, uncertainty of taxes, inflation (Avinash et al., 2018)
- **Estimation process**: Availability of cost indexes, estimating team experience (Akintoye, 2000)

4.3. Comparative Analysis of Estimation Methods

4.3.1. Accuracy Comparison

The reviewed studies provide quantitative evidence of method effectiveness:

Table 2: Cost Variance by Estimation Method

Method	Cost Variance Range	Study References
Traditional Manual	5-15%	Sayed et al. (2020)
Manual with Excel	2-8%	Pawar et al. (2021); Subhakesavulu et al. (2025)
STAAD Pro/ETABS	1-4%	Ramakrishna et al. (2025); Krishna Chaitanya et al. (2021)
BIM (Revit)	0.5-0.8%	Haider et al. (2020); Sayed et al. (2020)

Sayed et al. (2020) validated their analytical model on 14 finished construction projects, demonstrating that the model reduced cost variance from 1-15% to 0.5-0.8%.

4.3.2. Time Efficiency

Haider et al. (2020) noted that manual estimation is “hectic, time taking” with significant error potential, while BIM software estimation is “fast, easy, efficient, automatic.” Subhakesavulu et al. (2025) reported that MS Excel application reduced overall estimation time by up to 30%.

4.4. Analysis of Building Components Estimation

4.4.1. Structural Elements

The reviewed studies provide detailed estimation data for various structural components:

Slab-Estimation:

Ali and Rahman (2019) provided slab estimation data for a 7-storied building:

- Slab size: 51.42 ft × 32.67 ft × 0.42 ft
- Volume: 7,224 ft^3
- Reinforcement: 11,113 kg
- Cement: 1,342 bags

Beam Estimation:

- Beam size: 20.67 ft × 0.83 ft × 0.83 ft
- Volume: 1,305 ft^3
- Reinforcement: 1,586 kg

Column Estimation:

- Column size: 1.67 ft × 1 ft × 8.5 ft
- Volume: 300 ft^3
- Reinforcement: 1,728 kg

4.4.2. Foundation Systems

Aradhana Rao et al. (2019) detailed foundation estimation for a G+5 building:

- Earthwork excavation: 762.5 m³
- Sand filling: 25.55 m³
- Plain cement concrete: 114.5 m³
- CRS masonry wall: 198 m³
- Foundation excavation: 8,50,000 (cost)
- Ground floor: 26,93,611
- First floor: 28,28,611

4.5. Innovative Methodologies

4.5.1. Knowledge-Based Databases

Smetanková et al. (2021) proposed an innovative knowledge database for cost estimation in building production. The database structure includes:

- **15 functional elements** dividing the building systematically
- **Graphical and non-graphical information** for each element
- **Life cycle cost data** including realization, operation, and liquidation phases
- **Environmental parameters**: PEI (Primary Energy Intensity), GWP (Global Warming Potential), AP (Acidification Potential)

The proposed model enables economic expression of lifetime:

$$L_E = \frac{C_r + C_o + C_d}{DS_l} [€/year]$$

Where:

C_r = Realization costs

C_o = Operation costs

C_d = Disposal costs

DS_l = Declared service life

4.5.2. Monte Carlo Simulation

Sayed et al. (2020) incorporated Monte Carlo simulation in their analytical model to merge market state factors into estimation. The simulation provides:

- Three cost estimates per activity (pessimistic, most likely, optimistic)
- Histograms showing iteration outcomes
- Cumulative probability distributions (S-curves)

4.6. Comparative Study Results

4.6.1. Manual vs. Software Analysis

Ramakrishna et al. (2025) conducted comprehensive comparative analysis between STAAD Pro, ETABS, and manual Kani's method for a G+3 building. Results showed:

Table 3: Comparative Moment Analysis for Ground Storey (kN-m)

Member End	STAAD Pro	Manual (Kani's)	ETABS
MAB	-6.437	-5.24	-7.032
MBA	12.597	10.48	11.122
MBG	29.574	-27.443	-25.448
MGB	35.157	-34.58	-38.652
MGL	41.698	-39.872	-38.99

The study concluded that ETABS provides greater accuracy than STAAD Pro when compared with manual analysis, though STAAD Pro variations remain within 4% for all stories.

4.6.2. Cost Estimation for Different Building Types

Table 4: Comparative Building Costs from Reviewed Studies

Building Type	Location	Total Cost	Reference
G+1 School	India	₹19.68 Crore	Khan et al. (n.d.)
G+3 Residential	India	₹95.40 Lakh	Ramakrishna et al. (2025)
G+5 Apartment	India	₹4.85 Crore	AradhanaRao et al. (2019)
G+16 Apartment	India	₹89.06 Crore	Ramakrishna et al. (2025)

4.7. Software Tool Evaluation

The reviewed literature evaluated various software tools:

Table 5: Software Tool Capabilities

Software	Primary Function	Key Capabilities
AutoCAD	2D/3D Planning	Drawing, elevation, sections, layout
Revit	BIM Modeling	3D modeling, quantity take-off, schedules
STAAD Pro	Structural Analysis	Frame analysis, load calculations, design
ETABS	Structural Analysis	3D modeling, dynamic analysis, design
MS Excel	Estimation	Formulas, sensitivity analysis, reporting
STRUDS	Structural Analysis	Load analysis, design

4.8. Planning Principles and Their Impact

Pawar et al. (2021) and other researchers emphasized key planning principles affecting estimation:

- **Aspect:** Arrangement of doors and windows for natural ventilation and lighting
- **Prospect:** Architectural treatment for aesthetic appeal
- **Privacy:** Spatial arrangement for user privacy
- **Roominess:** Optimization of room dimensions for functionality
- **Grouping:** Functional grouping of rooms by inter-relationship
- **Circulation:** Horizontal and vertical movement pathways
- **Sanitation:** Hygienic provisions and adequate lighting
- **Economy:** Cost optimization within available funds

These principles directly influence material quantities and thus estimation accuracy.

SUMMARY OF FINDINGS

This comprehensive review of estimation and costing methodologies for multistorey buildings yields several significant conclusions:

1. Methodological Evolution

Estimation practices have evolved significantly from manual calculations to sophisticated digital tools. Manual methods, while still prevalent in developing countries, demonstrate 5-15% cost variance. software-based approaches using Excel, STAAD Pro, and ETABS reduce this to 2-8%. BIM-based estimation achieves the highest accuracy with variance as low as 0.5-0.8%.

2. Critical Success Factors

The synthesis of literature identifies nine critical factors affecting estimation accuracy: market state, estimator experience, site conditions, labor and equipment requirements, transportation, periodic payments, productivity standards availability, site utilities availability, and management/finance planning. Attention to these factors significantly improves estimate reliability.

3. Comparative Effectiveness

Quantitative analysis reveals that:

- Manual methods: 5-15% cost variance
- Excel-based methods: 2-8% variance
- STAAD Pro/ETABS: 1-4% variance
- BIM (Revit): 0.5-0.8% variance

4. Technological Integration

The integration of digital tools, particularly BIM, enables:

- Automated quantity take-off
- Real-time design modification response
- Multi-disciplinary collaboration
- Life cycle cost analysis
- Environmental impact assessment

5. Knowledge-Based Approaches

Innovative methodologies incorporating knowledge databases and Monte Carlo simulation offer promising avenues for further accuracy improvement. The economic expression of building element lifetime provides holistic cost assessment across the project life cycle.

6. Practical Implications

For practitioners, the findings suggest:

- Adoption of BIM tools for projects where accuracy is paramount
- Utilization of Excel for rapid, flexible estimation with real-time updates
- Consideration of critical factors during estimation process
- Integration of structural analysis and estimation workflows

7. Research Gaps

Areas requiring further investigation include:

- Machine learning applications in cost prediction
- Standardization of digital estimation protocols
- Long-term validation of BIM cost models
- Integration of real-time market data in estimation tools

The future of construction cost estimation lies in integrated digital platforms that combine design, analysis, and costing with real-time market data and machine learning capabilities. As construction projects become increasingly complex, the adoption of advanced estimation methodologies becomes not merely advantageous but essential for project success.

CONCLUSION

Estimation methods for multistorey buildings have evolved from manual techniques (5–15% variance) to advanced digital tools like Excel, STAAD Pro, and ETABS (1–8%), with BIM providing the highest accuracy (0.5–0.8%). Key factors influencing accuracy include market conditions, estimator expertise, site conditions, resources, and financial planning.

Digital tools, especially BIM, enhance estimation through automation, real-time updates, collaboration, and lifecycle costing. Emerging approaches like knowledge-based systems and simulations show further potential. Future research should focus on machine learning, standardization, and real-time data integration, as digital platforms become essential for accurate and efficient cost estimation.

Comparative analysis confirms that digital tools performing traditional methods, with BIM offering additional benefits such as automated quantity take-offs, real-time design updates, interdisciplinary collaboration, lifecycle cost evaluation, and environmental assessment.

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