

Research on Resource Management and Cost Control in Hotel Renovation Projects Based on a Personnel-Equipment Aggregation System

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Abstract: With the transformation and development of the construction industry, the efficient management of key resources (labour, materials, and machinery) in construction projects has become central to ensuring smooth project progression. Traditional resource management approaches often face challenges such as data lag, inaccurate information, and inefficient resource allocation, particularly in large-scale, complex projects. To address these issues, information-based management has increasingly been applied to construction projects. Among these, the labour-material-machinery aggregation management system, as an advanced resource management method, has gained widespread adoption in projects. This study examines the application effectiveness of the labour-equipment-materials aggregation management system through the case of the North Garden Renovation and Upgrade Project for Hefei's DXL Hotel. By statistically analysing the utilisation of labour, machinery, and materials, it details resource usage data and cost distribution. Findings indicate that implementing this system enables project teams to monitor resource deployment in real time, optimise resource scheduling, reduce waste, and achieve dual improvements in cost control and schedule management. Specifically, real-time data collection and analysis of labour, machinery, and materials substantially enhanced the precision and timeliness of resource management. The system enabled the project team to adjust staffing levels more effectively, optimise equipment utilisation, and procure materials rationally, thereby significantly reducing resource wastage and improving overall project management efficiency and economic viability. The study also analysed cost fluctuations, illustrating the cost distribution of different resources within the

project, providing a basis for optimising resource management and cost control in subsequent projects.

Keywords: Labour-Capital-Equipment Aggregation; Refurbishment Projects; Data Analysis; Cost Control.

1. Introduction

With the transformation and development of the construction industry, efficiently managing diverse project resources—particularly labour, machinery, and materials—has become central to ensuring smooth project progression. The rational allocation and management of these key resources (collectively termed labour, machinery, and materials) directly impacts project cost, schedule, and quality^{[1][2]}. However, traditional resource management models often encounter issues such as data lag, imprecise information, and inefficient resource scheduling. These problems become particularly pronounced in large-scale, complex projects, leading to schedule delays, cost overruns, and low management efficiency. To effectively address these challenges, project management is progressively transitioning towards information-based management. The aggregation of labour, equipment, and materials has emerged as a widely adopted resource management approach within construction projects. Through precise data collection and analysis, this methodology enables real-time monitoring and scheduling of manpower, machinery, and materials. It optimises resource allocation, minimises waste, and provides data-driven support for project schedule and cost control. Consequently, project teams gain enhanced control over resources, facilitating refined management^[3].

Taking the North Garden Renovation and Upgrade Project of Hefei DXL Hotel as a case study, this paper first outlines the project overview and the implementation process of

manpower, machinery and materials aggregation. It then delves into the application outcomes of this methodology within the project. Specifically, the study employs quantitative and cost statistical analyses to detail the utilisation patterns and cost distributions of labour, machinery and materials. This provides a scientific basis for project resource management and offers reference points for resource optimisation and cost control in future similar projects^[4].

2. Project Overview and Implementation Framework for Labour-Equipment-Material Aggregation

2.1 Project Overview

This paper examines the renovation and enhancement project of the North Courtyard at Hefei DXL Hotel. The building has a total floor area of 10,520.26 square metres, comprising three above-ground storeys with a height of 20.3 metres and an above-ground floor area of 6,509.51 square metres; plus one basement level with a height of 6 metres and a basement floor area of 4,010.75 square metres. As the project progressed, efficient resource management became critical, particularly concerning the allocation and scheduling of labour, machinery, and materials. Traditional resource management approaches frequently encounter issues such as data lag, imprecise information, and inefficient resource allocation when confronting such complex large-scale projects. These problems not only impact project progress and quality but also generate additional cost pressures. Therefore, to ensure smooth project advancement and efficient resource management, the project team decided to implement a Labour-Equipment-Material Aggregation Management System.

As an information-based management model, the Manpower-Equipment-Materials Aggregation Management System enables real-time monitoring and optimised scheduling of labour, machinery, and materials through precise data collection and analysis. This enhances the accuracy and efficiency of project resource management. The system's implementation not only addresses the shortcomings of traditional management approaches but also provides the project team with more flexible and efficient means for resource scheduling and cost control.

2.2 Research Methodology

This study employs a combined quantitative and qualitative analytical approach. Firstly, relevant data concerning human resources, machinery, and materials since project commencement was gathered through the project management system and on-site data collection. Data sources included: an automated attendance system recording worker attendance, job roles, and working hours; an equipment management system logging machinery usage duration and operational status; and a materials management system documenting incoming material quantities, specifications, and consumption rates.

Secondly, during the data organisation phase, Excel was employed for data cleansing and standardisation. Missing and anomalous data were corrected to ensure completeness and accuracy. Finally, the data analysis phase utilised statistical tools such as SPSS and Excel's charting functions to conduct statistical analysis and cost evaluation of labour, machinery, and material usage. By comparing resource consumption patterns across different time periods, project resource allocation was further optimised^[5].

Through this multi-level, multi-dimensional data analysis approach, this study delves into the application effectiveness of labour-material-equipment aggregation within the project, providing empirical data support for similar initiatives. The process flow is illustrated in Figure 1.

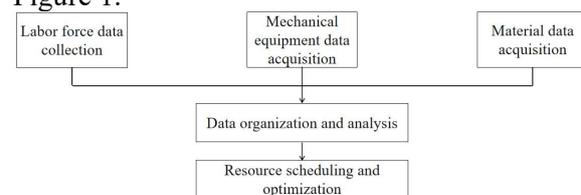


Figure 1. Process Flow Chart for Labour-Machinery-Material Aggregation

3. Labour, Equipment and Material Data Analysis

3.1 Labour-Day Data Statistics

This project compiled all labour man-day data since commencement, presenting workforce utilisation visually through charts. As illustrated in Figure 2, colour-coded bar charts represent employment data for different trades, making labour demand per trade immediately apparent. These data enable the project

management team to clearly understand employment patterns for each trade and adjust staffing promptly. The data reveals that labour demand peaked predominantly between July and September, with a significant increase in manpower requirements during this period. This correlates closely with the project's construction schedule, particularly during critical construction phases where demand was substantial. Specifically, the number of labourers employed in steel fixers, carpenters, bricklayers, and plumbers remained consistently high throughout this period. The peak demand for these trades reflects the workload associated with these key construction processes. To address the labour peak from July to September, the project team deployed a substantial number of temporary workers. This measure ensured timely completion of construction tasks during the peak period, preventing delays caused by labour shortages. Through such statistical analysis, the project management team can rationally allocate resources across different phases, optimise manpower deployment, thereby enhancing construction efficiency and securing both project progress and quality.

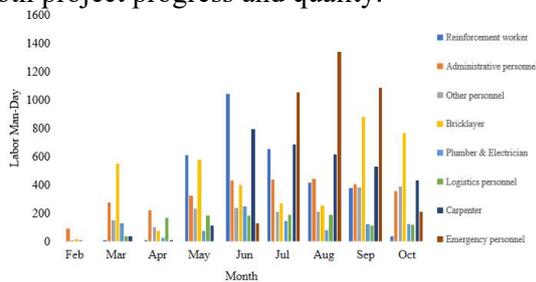


Figure 2. Labour Man-Day Statistics Chart

3.2 Material Data Statistics

This project has compiled statistics on material usage since commencement, categorising materials into five principal groups based on specific project requirements: client-supplied materials, primary civil engineering materials, primary installation materials, ancillary materials, and materials for administrative expenses. This detailed classification enables clearer oversight of material utilisation and expenditure across categories, thereby providing a scientific basis for resource management and cost control within the project. As illustrated in Figure 3, the chart reveals that primary civil engineering materials constitute the largest proportion of material expenditure, representing the project's principal

material cost component. This category primarily encompasses fundamental materials required for civil engineering works, such as concrete, reinforcing steel, and aggregates, which directly impact the smooth progression of civil construction. Given the extensive scale and prolonged construction period of civil engineering works, material consumption in this area is correspondingly high, resulting in the largest expenditure share. Other material categories, such as client-supplied materials and installation main materials, also constitute a certain proportion. However, compared to main civil engineering materials, their expenditure share is markedly smaller. Through this material classification and statistical analysis, the project team can gain a clear understanding of the capital investment for each material category and promptly make adjustments and optimisations to ensure the rational procurement and utilisation of materials. This not only helps improve the efficiency of resource allocation but also provides reliable data support for project cost control, further safeguarding the smooth progress of the project.

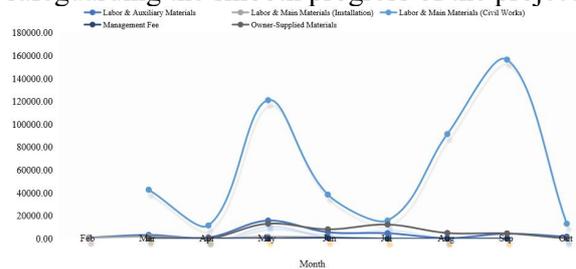


Figure 3. Material Quantity Statistics Chart

3.3 Mechanical Equipment Data Statistics

Regarding machinery quantity statistics, we categorise commonly used equipment into four main types based on project requirements: earthmoving machinery, lifting machinery, industrial vehicles, and other machinery. Usage volumes and billing methods vary across each category to ensure precise management and cost control of mechanical resources. Earthmoving machinery, primarily excavators, constitutes a significant proportion of the total machinery inventory. Due to the extensive earthworks required during the civil construction phase, excavators see high utilisation rates, resulting in a prominent share in machinery statistics. This category typically employs shift-based pricing, charging according to operational duration, thereby ensuring precise accounting and cost control for

equipment usage. Lifting machinery is chiefly represented by truck-mounted cranes, primarily employed for hoisting, lifting, and transport tasks. Their usage correlates closely with project construction phases, particularly during high-rise building construction and heavy equipment installation where demand is substantial. Similarly, lifting machinery is priced per shift, with charges based on the number of shifts completed for hoisting operations. Industrial vehicles are predominantly forklifts, extensively used for routine material handling and equipment transport. Forklifts are typically charged per operation, meaning fees are levied based on the workload per transport or handling task. This approach enables more granular and precise management of forklift usage costs. Beyond these three categories, other machinery includes trucks, water sprinklers, and similar equipment. Their deployment centres on material transportation, site clearance, and construction environmental protection. Such machinery also adopts a per-operation pricing model, charged per task to facilitate better resource management and cost control. As illustrated in Figure 4, the proportion of each machinery category within the total fleet is clearly depicted. The chart reveals that earthmoving and lifting machinery constitute a significant proportion, reflecting the project's substantial reliance on these equipment types. The rational allocation and optimised utilisation of machinery resources not only enhance construction efficiency but also provide robust support for project cost control and resource scheduling.

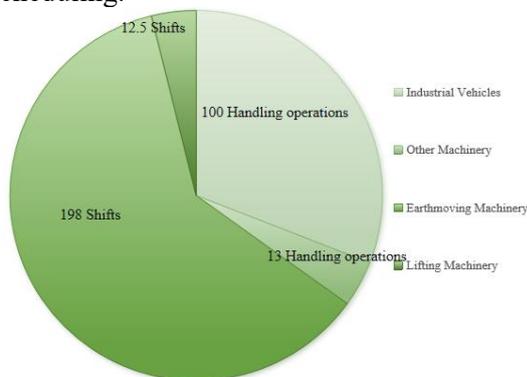


Figure 4. Machinery Quantity Statistics Chart

3.4 Data Analysis and Advantages

The implementation of the labour-material-equipment aggregation system has demonstrated significant advantages in data

collection, analysis, and application for project management. Firstly, the system enables real-time updates on the utilisation status of labour, machinery, and materials, substantially improving data accuracy and timeliness. This real-time collection and updating allows the project team to access critical resource usage information at any moment, eliminating the data lag inherent in traditional management approaches. For instance, real-time monitoring of labour man-day statistics enables precise recording of workforce deployment across all trades. Project management teams can flexibly adjust staffing levels based on live data, thereby preventing both labour underutilisation and shortages. Equipment utilisation efficiency has also markedly improved: real-time monitoring ensures rational scheduling, avoiding both idle time and overuse, thus enhancing overall equipment utilisation rates. Real-time material consumption data enables project teams to manage procurement and usage with greater precision, reducing unnecessary waste and optimising inventory management. Overall, the labour-material-equipment aggregation system delivers more accurate project resource management, substantially improving the timeliness and accuracy of data updates. This resolves the issues of information lag and inaccuracy inherent in traditional resource management models, providing more reliable data support for smooth project progression.

4. Cost Analysis of Labour, Materials and Equipment Aggregation

4.1 Labour Cost Statistics

Labour cost statistics since project commencement, as illustrated in Figure 5, visually present the utilisation costs of different trades through graphical representation. The chart clearly reveals cost trends across trades, with a notable surge in temporary labour costs between July and September. This phenomenon primarily resulted from the urgent deployment of additional temporary workers during this period to meet construction schedule requirements and ensure timely completion of critical project milestones. Whilst this measure effectively accelerated construction progress, it also led to increased labour costs. Particularly during the peak period from July to September, the monthly labour cost rose significantly due to the increased workforce and intensified

workloads. This chart enables the project team to clearly visualise fluctuations in labour costs and make more rational adjustments in subsequent resource scheduling.

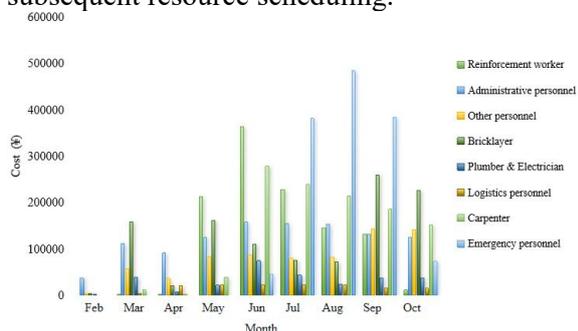


Figure 5. Labour Cost Statistics Chart

4.2 Material Cost Analysis

The material cost data statistics for this project since commencement are presented in Figure 6. This line chart provides a visual representation of the usage costs for different materials. The chart clearly indicates that the cost of owner-supplied materials is significantly higher than other materials. Owner-supplied materials primarily include core civil engineering materials such as concrete and reinforcing steel, which are consumed in large quantities and with high frequency throughout the project, directly impacting the project's cost structure. Concrete and reinforcing steel, in particular, serve not only as foundational materials for civil construction but also account for a substantial proportion of resource investment throughout the project's construction. Consequently, the cost of Owner-supplied materials constitutes the largest share among all materials, forming the primary component of material expenditure. In contrast, the costs of other materials — such as primary civil construction materials, primary installation materials, ancillary labour materials, and management fee materials — are comparatively lower. Although these materials play equally vital roles in project construction, their unit prices and consumption volumes are smaller than those of client-supplied materials, resulting in a comparatively lower proportion of overall costs. Through in-depth analysis of various material costs, the project team can more clearly identify cost peaks and troughs. This enables reasonable adjustments in subsequent resource procurement and scheduling, ensuring the economy and efficiency of material usage. In subsequent project phases, particularly at

critical milestones of civil engineering works, the procurement and utilisation of client-supplied materials will become a focal point for cost control. By optimising procurement schedules, refining material management practices, and forecasting demand in advance, the project team can further reduce wastage and over-procurement of client-supplied materials, thereby controlling material costs and providing robust support for the project's smooth progression [6].

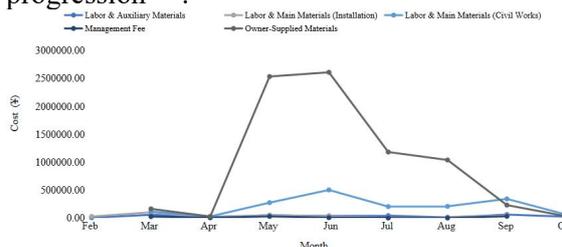


Figure 6. Material Cost Statistics Chart

4.3 Mechanical Equipment Cost Analysis

The statistical data on machinery and equipment costs since project commencement, as illustrated in Figure 7, visually presents the usage costs of different machinery through a pie chart. The chart clearly indicates that earthmoving machinery accounts for a substantial 74% of costs, representing the largest component of machinery expenditure. This phenomenon primarily stems from the significant demand for earthworks during the civil construction phase, particularly the extensive use of excavators. Given the substantial workload and extended construction period of earthmoving operations, earthmoving machinery exhibits high utilisation rates, consequently driving its significant cost proportion. The usage costs for lifting machinery and industrial vehicles account for relatively smaller shares, reflecting their concentrated deployment during specific construction phases. Lifting machinery is particularly required during heavy equipment installation and high-rise construction, while industrial vehicles are primarily employed for material handling and equipment transportation. Through precise statistical analysis of machinery costs, project teams gain clear insight into the cost distribution across different equipment types, providing crucial basis for subsequent machinery resource scheduling and cost control. Particularly when earthmoving machinery constitutes a significant proportion, teams can further optimise usage

plans to avoid over-reliance on any single category, thereby achieving more refined resource management and cost control [7].

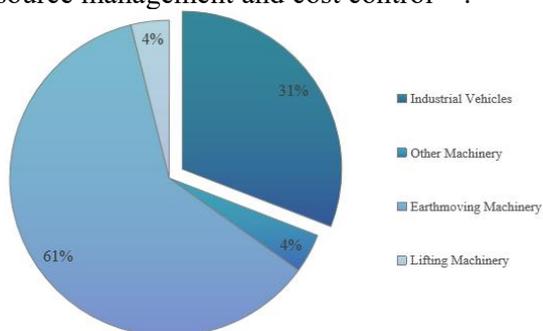


Figure 7. Mechanical Equipment Cost Statistics Chart

4.4 Cost Comparative Analysis

The implementation of the labour-material-equipment aggregation system has significantly enhanced project cost control. By capturing real-time usage data for labour, machinery, and materials, the project team can allocate resources with greater precision, eliminating waste inherent in traditional management approaches^[8]. Labour costs have been optimised, with the system facilitating real-time adjustments to staffing levels to reduce overstaffing or understaffing. Machinery utilisation efficiency has improved, minimising idle time and overuse, thereby lowering equipment rental and maintenance expenses. Regarding material costs, precise demand forecasting and real-time prevented over-procurement and waste, thereby controlling inventory pressure. Overall, the system's implementation enabled effective project cost control, eliminating waste and unnecessary expenditure inherent in traditional management while enhancing the precision of overall cost management^{[9][10]}.

5 Conclusions and Outlook

This study demonstrates the effectiveness of the labour-material-equipment aggregation management system in construction projects through a case analysis of the North Garden renovation and enhancement project at Hefei's DXL Hotel. Findings indicate that by adopting an information-based management approach, project teams can more efficiently schedule and optimise labour, machinery, and material resources, achieving simultaneous improvements in cost control and project progress. Specifically, the system demonstrated

significant advantages in ensuring data accuracy and real-time availability, effectively reducing resource wastage and providing precise data support for project decision-making. However, current implementation still faces challenges such as data accuracy, information-sharing efficiency, and system integration issues. Future advancements in information technology, particularly big data and artificial intelligence, hold promise for further enhancing the system's management precision and application scope. Future research may explore integrating machine learning algorithms to conduct predictive analysis of project resource usage data, thereby achieving more precise resource scheduling and cost control.

In summary, as the construction industry continues to evolve, the manpower-material-equipment aggregation approach, being an efficient resource management method, will see wider adoption in large-scale construction projects. Through continuous optimisation of management processes, enhanced data analysis capabilities, and improved system intelligence, the efficiency and quality of construction project management will be further elevated.

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