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Analysis of Cost Control Strategies in Green Building Construction Processes

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Abstract: Green building construction typically incurs higher costs than conventional methods. To facilitate broader adoption by construction entities, cost optimization is essential. Firms must align with technological advancements, judiciously apply emerging technologies, and ensure resource efficiency through context-specific strategies. Proactive and precise scheduling is critical to avert delays from unforeseen events. Additionally, construction units should enhance on-site safety training, promote mastery of innovative techniques, and foster environmental awareness among personnel. Finally, companies ought to capitalize on government incentives for green materials while adopting bulk procurement from local sources to minimize transportation costs and secure lower unit prices.

Keywords: Construction process; Cost control; Strategy analysis

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1. Introduction

The construction industry plays a pivotal role in national economic development, while civil buildings serve as essential necessities for people's livelihoods. With growing public awareness of ecological protection, green building has garnered widespread attention across society [1]. Traditional construction processes often lead to environmental pollution and substantial waste of resources, adversely affecting the environment, economy, and residents' health. Consequently, many advocate for greening the construction process to achieve sustainable societal development [2]. Green building construction must ensure safety, prevent accidents, guarantee structural quality and longevity, while aligning with ecological civilization by minimizing environmental pollution [3]. Compared to conventional methods, green construction incurs additional costs in materials and emerging technologies, imposing financial burdens on enterprises. To enable firms to meet environmental protection requirements with minimal cost increments and alleviate operational pressures. Given the challenges posed by elevated costs in green building construction, exploring effective cost-control strategies is imperative. This paper examines technical, managerial, and market-oriented measures to address cost escalations arising from novel technologies and materials, thereby achieving overall cost containment.

2. Factors affecting the cost of green building construction

2.1. Technical measures

Technological innovation is a pivotal approach to mitigating elevated construction costs. Although novel materials are often pricier than conventional alternatives, their inherent energy-saving characteristics translate into operational cost savings during the building's lifecycle, ultimately yielding greater economic benefits compared to traditional construction.

A common issue during the construction phase is the failure of contractors to adequately assess the site's geological conditions, leading to an oversight and underutilization of inherent natural resources; in essence, failing to maximize the use of available materials. Furthermore, construction firms seldom utilize renewable energy sources, resulting in inefficient energy consumption.

To meet environmental protection standards during construction, units must implement innovative construction technologies. These advanced techniques encompass energy-efficient technologies, water-saving technologies, solid waste utilization technologies, low-carbon technologies, and intelligent monitoring systems. However, the high research and development (R&D) costs associated with these technologies, coupled with their procurement expenses, substantially drive up the overall cost for the construction unit. Moreover, the rapid iteration and replacement cycles of these advanced technologies further contribute to rising corporate expenditures.

In recent years, continuous advancements in science and technology have made it possible to effectively address these cost challenges through technological refinement and optimization.

2.2. Management level

Effective management and training of the workforce constitute a critical issue during the construction process. Construction firms must prioritize the health and safety of their personnel. Concurrently, they are required to embrace ecological civilization principles by adopting green construction methods to minimize pollutant emissions and maximize environmental protection, a requirement that inherently increases management complexity.

Common challenges in green construction include the workforce's unfamiliarity with new techniques and methods, as well as instances of laborers exhibiting a lack of awareness or commitment to environmental protection. These issues necessitate additional training investment from the construction unit. Furthermore, some firms suffer from insufficient detailed pre-planning, failing to anticipate potential risks or execute thorough inspections of construction materials. Such managerial deficiencies can trigger unexpected incidents, resulting in project delays or costly rework. All these management-related problems demand close attention from supervisory personnel to ensure the smooth execution of the construction process and on-schedule completion.

2.3. Market level

The market primarily influences construction costs through material pricing. Novel green materials, due to their superior environmental protection and energy-saving qualities, are generally priced higher than conventional materials, though their prices fluctuate within a certain range based on market demand.

To alleviate the financial burden on construction units, the government often introduces preferential policies aimed at lowering the price of new materials. This serves multiple goals: reducing corporate costs, promoting the adoption of innovative construction techniques, enhancing building quality, increasing market appeal, and boosting purchasing power. However, some construction units fail to recognize or capitalize on these government incentives or miss optimal material procurement timing, leading to avoidable cost escalations. Furthermore, instances of construction firms employing suboptimal procurement strategies can result in paying excessively high prices for raw materials, thereby increasing expenditure.

Therefore, it is crucial for construction units to consistently monitor and strategically utilize the available

government preferential policies, while simultaneously adopting appropriate and cost-effective raw material purchasing methods. Nevertheless, a current issue is the relatively limited scope of government incentive policies and the insufficient penalty enforcement against firms engaging in severely polluting practices, which collectively contributes to the reluctance of construction units to fully adopt green building materials.

3. Strategies for cost control in green building construction

3.1. Technology-level strategies

Technological refinement for cost control primarily involves three key approaches: adopting Passive Building Energy-Saving Technologies, utilizing Renewable Energy Sources, and effectively employing Building Information Modeling (BIM) technology.

Passive Building Energy-Saving Technologies involve leveraging natural resources based on specific regional climates and geological conditions to maintain optimal indoor temperature, humidity, and ventilation [4,5]. This approach allows construction to be site-specific and maximize resource utilization. It provides construction units with various methods for exploiting natural resources, such as natural ventilation, daylighting, and the reuse of construction waste [1]. These methods contribute to more streamlined construction and lower costs.

The use of renewable energy sources is an essential tool for cost control. Systems like solar water heaters and air-source heat pumps provide hot water by harnessing solar or natural energy (air heat storage), respectively. Utilizing these abundant and easily accessible renewable natural resources meets the requirements for both cost reduction and environmental sustainability [4]. Furthermore, instead of direct disposal, construction waste should be considered for recycling and reuse, with surplus materials being reserved for subsequent projects.

BIM technology is a common technique used in green building construction. BIM enables precise modeling, accurate calculation of required material quantities and costs, pre-assessment of potential issues during the actual construction process, and the development of optimized construction plans [6]. This allows construction units to identify problems proactively, find rational solutions, mitigate risks, and minimize losses. Additionally, BIM can analyze multiple scenarios to identify the most cost-effective construction plan, thereby achieving the goal of cost savings.

Based on the perspective of adopting advanced scientific and technological methods, this paper introduces the application of energy-saving elevators in practical scenarios, focusing on two examples: the Permanent Magnet Gearless (PMG) elevator and the Electro-Hydraulic Hybrid Drive Traction Elevator with a variable displacement pump/motor.

For typical elevators, a significant amount of power is consumed during motor rotation, with a portion of this energy dissipating as both electrical and thermal energy. A common feature of both these advanced elevator types is their ability to recover substantial amounts of clean electrical energy. This recovered energy can account for 30% to 70% of the total energy consumed during the elevator's operation. Furthermore, the energy recovery efficiency, especially through the pump/motor recovery method, can exceed 90% [4,7]. This regenerated energy can be fed back into the building's power grid via an accumulator, allowing the electricity to be reused by the elevator. This approach not only reduces energy waste but also lowers the temperature inside the elevator cabin, enhancing user comfort and experience [4].

The fundamental objective of employing energy regeneration technology is ultimately cost saving. From a unit price perspective, the cost of a new energy-regenerating elevator is comparable to that of a traditional elevator, both being around 6,000 RMB per unit. However, in terms of power consumption, the new energy-regenerating elevator offers a distinct advantage, reducing consumption from the original 1872 kW/h to approximately 1 kW/h. This dramatically increases energy utilization efficiency, conserving energy and lowering operational costs [4].

In a separate study, experiments conducted on the Electro-Hydraulic Hybrid Drive Traction Elevator with a variable displacement pump/motor (as shown in **Table 1**) demonstrated its excellent energy-saving performance. Moreover, the energy-saving effect was observed to initially decrease and then increase as the load increased. This indicates that the energy-saving benefits of these elevators are greatest when carrying either very few or very many passengers.

Table 1. Relationship between load and energy-saving effect for the electro-hydraulic hybrid drive traction elevator with variable displacement pump/motor

Load / kg	Energy-saving effect / %
100	36.9
300	8.4
700	10.6
900	39.2

3.2. Management-level strategies

The most critical subjects of management during the construction process are the site personnel. Construction units must prioritize the safety of the workforce, emphasize the selection of experienced workers, and strengthen their safety training. Concurrently, site security must be ensured to prevent accidents.

It is necessary to intensify skills training for personnel, ensuring they learn to operate novel equipment and can apply it proficiently during construction. Workers must also be educated against the arbitrary disposal of construction waste to raise their environmental protection awareness. Furthermore, dust and exhaust fumes generated during construction must be handled appropriately to prevent environmental contamination.

Indoor air quality and pollutants generated by building materials and the construction process must also be monitored. The presence of residual pollutants, such as formaldehyde, in the finished structure could negatively impact the occupants' health, thereby failing to meet green building standards. During nighttime operations, construction units should avoid using excessively bright lighting and control construction noise by minimizing the use of large-scale mechanical equipment. This approach reduces light and noise pollution, achieving the environmental benefits of green construction [3]. Such practices minimize negative impacts on nearby residents while safeguarding the health of the construction workers.

To further ensure worker health, construction units should monitor weather forecasts to prevent heatstroke during high-temperature periods. Relevant authorities have also mandated specific working hours based on temperature conditions to reduce the risk of on-site accidents.

Construction units must also proactively plan the construction schedule to account for potential delays caused by environmental factors such as high temperatures or heavy rainfall, which could halt normal operations and jeopardize the timely completion of the project. This requires construction management to motivate workers to maintain an efficient and diligent pace, while simultaneously preparing for unforeseen circumstances by allocating both buffer time and contingency funds.

Furthermore, construction units must ensure the quality of construction materials by strictly inspecting every component to confirm it meets project specifications and pre-defined quality standards. This is essential to prevent safety incidents arising from material failure or the need for costly rework due to substandard quality, which would undermine the on-time delivery of the project [2]. Finally, the construction unit should closely monitor the project budget, regularly reviewing expenditure against the cost plan, and making timely adjustments to construction strategies as needed.

3.3. Market-based approaches

This section primarily analyzes the market's influence on costs from the perspective of raw material procurement.

It is essential to conduct a thorough evaluation of potential material suppliers to secure a stable, reliable source that complies with green building requirements. The selected supplier must offer materials that are quality-assured, reasonably priced, and highly regarded within the industry, ensuring the durability of materials put into use and eliminating safety risks [6]. Construction units must also develop the discernment necessary to assess the quality of materials and equipment, emphasizing a refined selection process.

To achieve cost efficiency, firms should implement centralized, bulk procurement of common equipment and materials. By establishing long-term partnerships with fixed suppliers, construction units can secure volume discounts and subsequently reduce the unit price of materials [6]. Furthermore, sourcing raw materials from regions near the construction site is critical to minimize transportation costs and time [6]. Firms should also evaluate market supply and demand dynamics to purchase materials when prices are at a low point, thereby maximizing cost savings.

Construction units must pay close attention to government-issued preferential policies and leverage these incentives to achieve cost savings. To encourage the use of green building materials in construction, the government has introduced various supportive policies, such as reductions in Value-Added Tax (VAT) and Consumption Tax. For instance, taxpayers selling self-produced new wall materials listed in the Catalogue of New Wall Materials Eligible for VAT Refund-upon-Collection Policy are entitled to a 50% immediate refund of VAT collected. Additionally, the Consumption Tax is waived for the production, commissioned processing, or import of coatings with a volatile organic compound (VOC) content below 420 g/L in their application state. These policies can effectively reduce the operational costs for construction units.

The government also needs to expand the scope of tax reductions and exemptions for construction units that implement green construction practices, introducing a greater variety of preferential policies. Furthermore, it is essential to fully implement the specific guidelines within green construction regulations, making the construction standards clearer and more detailed. Severe penalties should be enforced against firms that cause significant environmental pollution. By establishing a clear system of rewards and punishments, more construction units will be incentivized to adopt green building construction methods [1].

4. Conclusion

Technical improvements in green building construction processes are diverse. Construction entities should prioritize keeping pace with technological advancements, selectively adopting novel methods tailored to their specific needs. This approach enables the practical implementation of green building construction, while simultaneously enhancing residents' living environments, reducing construction costs, and conserving energy. Emphasis must also be placed on construction management, including elevating workers' technical skills and environmental awareness. Advance planning is essential to ensure material quality, complemented by rigorous on-site inspections to prevent rework.

Construction entities should leverage government incentive policies effectively, formulate procurement plans aligned with market prices, and proactively incorporate green building materials to achieve cost savings.

With ongoing advancements in science and technology, cost-control methods for green building construction processes will proliferate. In the future, construction entities will be able to identify optimal strategies from this expanding array to minimize project expenses and generate additional exemplary cases of cost efficiency in green building practices, yielding greater benefits for both entities and residents. Governments should establish clear reward-and-penalty mechanisms to promote green construction and penalize environmentally damaging practices.

Disclosure statement

The author declares no conflict of interest.

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