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Analyzing the Effectiveness of Material Management in Construction Projects: A Case Study of the Lusaka–Ndola Dual Carriageway

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Abstract: Infrastructure development is a critical catalyst for economic growth in Sub-Saharan Africa. However, road construction projects in Zambia frequently encounter delays and cost overruns attributed to suboptimal resource management. This study evaluates the effectiveness of material management strategies implemented during the construction of the Lusaka-Ndola Dual Carriageway. Utilizing a descriptive case study design, data was gathered from 79 stakeholders using structured questionnaires and interviews. The findings indicate that while 71% of the project team recognizes a formal management framework, the practical application is hampered by technical skill gaps and inconsistent monitoring. Specifically, only 51% of respondents viewed current strategies as "moderately effective." The study concludes that the integration of Total Quality Management (TQM) and digital inventory tracking is essential for improving project performance.

Keywords: *Material Management, Total Quality Management (TQM), Infrastructure Development, Zambia, Lusaka-Ndola Road, Construction Performance.*

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I. INTRODUCTION

In the global construction industry, materials typically represent between 50% and 60% of total project costs. In developing economies like Zambia, where logistics and supply chain volatility are high, the management of these materials becomes the primary determinant of project success. The Lusaka-Ndola Dual Carriageway represents a multi-million dollar investment aimed at facilitating regional trade. Given the scale of this project, even a 5% inefficiency in material handling can result in millions of Kwacha in losses. Zambia has embarked on ambitious road projects such as the "Link Zambia 8000." However, the industry has been criticized for poor quality. In 2008, the Road Development Agency (RDA) blacklisted numerous contractors for substandard work. These failures are often not due to a lack of engineering knowledge, but rather a breakdown in the material management lifecycle, from procurement and testing to on-site storage and application.

II. LITERATURE REVIEW

Modern material management is rooted in the "Just-in-Time" (JIT) and "Lean Construction" philosophies. According to Chileshe and Kikwasi (2016), material management in developing countries is often reactive rather than proactive. The goal of a robust system is to ensure the "Five Rs": the Right material, in the Right quantity, at the Right time, in the Right place, at the Right price. TQM is a management approach centered on quality, based on the participation of all members of an organization. In road construction, this involves:

- Supplier Quality Assurance: Ensuring bitumen and aggregate meet international ISO standards before arrival.
- Employee Involvement: Training site workers to identify material defects immediately.
- Continuous Improvement (Kaizen): Using feedback loops from completed road sections to improve the next phase.

Research identifies common barriers such as currency fluctuations affecting imported material costs, lack of localized technical expertise, and corruption in the procurement process. These factors often lead to the use of "shoddy" materials to maintain profit margins.

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III. METHODOLOGY

The study employed a descriptive case study approach, which allowed for an in-depth exploration of the Lusaka-Ndola project. This design is appropriate for investigating "how" and "why" management systems succeed or fail in a real-world context.

➢ *Target Population*

The target population consisted of 160 professionals, including project managers, civil engineers, quantity surveyors, and site supervisors. Using the Yamane Formula ($n = N / [1 + N(e)^2]$) with a 95% confidence level, a sample of 79 participants was derived.

➢ *Data Collection Instruments*

Questionnaires: Distributed electronically and in person, featuring 5-point Likert scales ranging from "Strongly Disagree" to "Strongly Agree." *Interviews*: Semi-structured sessions with senior engineers to gather qualitative insights into the limitations of the current system.

➢ *Data Analysis*

Quantitative data was processed using STATA, providing descriptive statistics (means, frequencies) and inferential analysis to determine the relationship between management techniques and project outcomes.

IV. RESULTS AND DISCUSSION

➢ *Identification of Techniques*

The study found that the project utilized several standard management tools:

- Work Breakdown Structure (WBS): Used by 68% of respondents to categorize material needs.
- Earned Value Management (EVM): Used primarily by management to monitor budget vs. actual spend.
- Variance Analysis: Conducted monthly to identify discrepancies in material consumption.

➢ *Effectiveness of Strategies*

The data revealed a "Performance Gap":

- Awareness: 71% were aware of the strategies.
- Consistency: Only 63% felt the strategies were applied consistently across all phases.
- Effectiveness: 51% rated the techniques as "moderately effective," while only 10% viewed them as "extremely effective."
- Safety Correlation: 41% of respondents identified a direct link between poor material storage and on-site safety incidents.

➢ *Technical Competence*

A critical finding was the lack of confidence in the technical team. Only 58% of respondents felt the project team possessed the necessary skills to utilize modern material management software effectively.

➢ *Discussion*

- *The Disconnect between Policy and Practice:* The results suggest that while the "books" (frameworks) exist, the "boots" (site execution) are lagging. A 51% moderate effectiveness rating indicates that the project is likely experiencing "hidden waste"—materials that are lost to weather damage, theft, or over-ordering that goes unrecorded.
- *The Importance of Training:* The confidence level of 58% in team skills is a red flag for a project of this magnitude. Without formal, ongoing training, sophisticated tools like EVM become mere "paper exercises" rather than active management tools. This aligns with Covin (2021), who argues that project monitoring systems are only as good as the people interpreting the data.
- *Impact on Performance:* The inconsistency in strategy application (37% noting inconsistency) explains why certain sections of the dual carriageway may exhibit higher quality than others. Inconsistent management leads to inconsistent road durability.

V. CONCLUSION

The study confirms that material management is established on the Lusaka-Ndola project but is operating at a sub-optimal level. The primary inhibitors are a lack of technical training, inconsistent application of TQM principles, and a lack of real-time monitoring.

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