Sustainable Materials Selection and Life-Cycle Cost Management in Construction

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Abstract

This integrative evidence review examines sustainable materials selection and life-cycle cost management in construction by asking how sustainable materials selection is connected to life-cycle cost management and which conditions determine whether that connection becomes operationally meaningful. The article synthesizes peer-reviewed and institutional literature relevant to industrial assets, production systems, infrastructure, and built environments, emphasizing mechanisms, boundary conditions, and measurement choices rather than a universal average effect. The synthesis identifies complementary roles for predictive analytics and maintenance planning, legacy-system compatibility, and governance or coordination routines. No survey, interview, experiment, proprietary dataset, or regression estimate is represented as having been collected for this conceptual review.

Keywords: sustainable, materials, selection, life-cycle, cost, management, construction, engineering, integrative review

Sustainable Materials Selection and Life-Cycle Cost Management in Construction addresses a contemporary question in industrial assets, production systems, infrastructure, and built environments. The title implies a relationship between sustainable materials selection and life-cycle cost management, but the direction and magnitude of that relationship cannot be assumed from terminology alone. This review identifies mechanisms that plausibly connect the two, conditions that make those mechanisms stronger or weaker, and measurements needed to evaluate them without overstating evidence. Context, timing, implementation quality, and decision rights are therefore treated as analytical variables.

1. Introduction

The introduction defines the decision problem and explains why a conditional interpretation is preferable to a deterministic one.

Observed performance becomes interpretable only when implementation quality is separated from nominal adoption. In Sustainable Materials Selection and Life-Cycle Cost Management in Construction, sustainable materials selection can influence life-cycle cost management through lifecycle costing and asset prioritization. The pathway is conditional on legacy-system compatibility and operating

environment; these factors determine whether information becomes an operational response or remains a formal feature with limited practical effect. For engineering managers, asset owners, operations teams, and technical decision makers, measurement should capture both the intervention and the intermediate process expected to produce resource productivity.

The synthesis treats sustainable materials selection as an input into a wider system, not as an automatic cause of life-cycle cost management. In industrial assets, production systems, infrastructure, and built environments, resource-loop design and waste prevention changes what actors can observe, prioritize, or correct, while maintenance capability shapes how consistently that change is translated into practice. The practical implication is to specify the expected sequence of change before choosing metrics.

A mechanism-based reading avoids assuming that identical labels produce identical outcomes. In Sustainable Materials Selection and Life-Cycle Cost Management in Construction, sustainable materials selection can

influence life-cycle cost management through risk identification and resilience engineering. The pathway is conditional on capital constraints and maintenance capability; these factors determine whether information becomes an operational response or remains a formal feature with limited practical effect. For engineering managers, asset owners, operations teams, and technical decision makers, measurement should capture both the intervention and the intermediate process expected to produce operational continuity.

The synthesis treats sustainable materials selection as an input into a wider system, not as an automatic cause of life-cycle cost management. In industrial assets, production systems, infrastructure, and built environments, sensing and condition monitoring changes what actors can observe, prioritize, or correct, while operating environment shapes how consistently that change is translated into practice. The practical implication is to specify the expected sequence of change before choosing metrics.

From a governance perspective, Sustainable Materials Selection and Life-Cycle Cost Management in Construction requires clarity about who owns the intervention, who validates the information it generates, and who can act when performance deviates from expectation. Predictive analytics and maintenance planning is most credible when supported by technical standards and sensor quality. The article therefore emphasizes traceable assumptions, explicit decision rights, and periodic review.

2. Conceptual and Literature Review

The literature review organizes evidence around mechanisms, complementary capabilities, and boundary conditions.

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A recurring issue in research on Sustainable Materials Selection and Life-Cycle Cost Management in Construction is the danger of reading correlation as a universal performance rule. Sustainable Materials Selection may be associated with life-cycle cost management, yet the relationship can be delayed, mediated, or offset when maintenance capability is weak. The mechanism examined here is risk identification and resilience engineering, which connects the focal practice to changes in operational continuity.

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From a governance perspective, Sustainable Materials Selection and Life-Cycle Cost Management in Construction requires clarity about who owns the intervention, who validates the information it generates, and who can act when performance deviates from expectation. Predictive analytics and maintenance planning is most credible when supported by operating environment and technical standards. The reviewed literature (Kraus et al., 2022; Tao et al., 2018) indicates that these complements often explain why apparently similar settings report different outcomes. The article therefore emphasizes traceable assumptions, explicit decision rights, and periodic review.

From a governance perspective, Sustainable Materials Selection and Life-Cycle Cost Management in Construction requires clarity about who owns the intervention, who validates the information it generates, and who can act when performance deviates from expectation. Systems integration and interoperability is most credible when supported by technical standards and legacy-system compatibility. The article therefore emphasizes traceable assumptions, explicit decision rights, and periodic review.

3. Research Method

This manuscript is a conceptual narrative draft revised through a chronological source filter. Bibliography entries dated after 31 December 2023 and sentences explicitly invoking those years have been excluded.

Original pre-cutoff references have been retained, with a limited historical source context added separately. This revision does not constitute a new systematic search, a meta-analysis, or a reproducible coding exercise. The historical source cutoff is stated here so that the scope of the discussion is explicit.

The remaining discussion proposes mechanisms and research questions. It does not supply new observations, estimated coefficients, or verified causal effects. Earlier reference entries retained from the source draft are retained as supplied and should be assessed against the original publications when interpreting specific claims. Sources added during this revision support only the historical context described in the dedicated source-context section.

4. Evidence Synthesis: Mechanisms

The first synthesis layer asks how the proposed relationship works in practice and which intermediate processes can be observed before the final outcome changes.

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A mechanism-based reading avoids assuming that identical labels produce identical outcomes. In Sustainable Materials Selection and Life-Cycle Cost Management in Construction, sustainable materials selection can influence life-cycle cost management through predictive analytics and maintenance planning. The pathway is conditional on maintenance capability and capital constraints; these factors determine whether information becomes an operational response or remains a formal feature with limited practical effect. For engineering managers, asset owners, operations teams, and technical decision makers, measurement should capture both the intervention and the intermediate process expected to produce energy efficiency.

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A useful starting point is to distinguish formal adoption from effective use. In Sustainable Materials Selection and Life-Cycle Cost Management in Construction, sustainable materials selection can influence

life-cycle cost management through lifecycle costing and asset prioritization. The pathway is conditional on operating environment and legacy-system compatibility; these factors determine whether information becomes an operational response or remains a formal feature with limited practical effect. For engineering managers, asset owners, operations teams, and technical decision makers, measurement should capture both the intervention and the intermediate process expected to produce resource productivity.

The topic is best understood as a sequence of decisions rather than as a single intervention. In Sustainable Materials Selection and Life-Cycle Cost Management in Construction, sustainable materials selection can influence life-cycle cost management through resource-loop design and waste prevention. The pathway is conditional on technical standards and capital constraints; these factors determine whether information becomes an operational response or remains a formal feature with limited practical effect. For engineering managers, asset owners, operations teams, and technical decision makers, measurement should capture both the intervention and the intermediate process expected to produce safety.

5. Evidence Synthesis: Boundary Conditions

The second synthesis layer examines why results may differ across settings even when the focal intervention appears similar.

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6. Integrated Discussion

The integrated discussion reconciles different findings by distinguishing mechanism, context, timing, and measurement.

A recurring issue in research on Sustainable Materials Selection and Life-Cycle Cost Management in Construction is the danger of reading correlation as a universal performance rule. Sustainable Materials Selection may be associated with life-cycle cost management, yet the relationship can be delayed, mediated, or offset when legacy-system compatibility is weak. The mechanism examined here is systems integration and interoperability, which connects the focal practice to changes in lifecycle value.

The most decision-relevant question concerns the conditions under which the proposed relationship strengthens, weakens, or reverses. In Sustainable Materials Selection and Life-Cycle Cost Management in Construction, sustainable materials selection can influence life-cycle cost management through lifecycle costing and asset prioritization. The pathway is conditional on maintenance capability and technical standards; these factors determine whether information becomes an operational response or remains a formal feature with limited practical effect. For engineering managers, asset owners, operations teams, and technical decision makers, measurement should capture both the intervention and the intermediate process expected to produce resource productivity.

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A useful starting point is to distinguish formal adoption from effective use. In Sustainable Materials Selection and Life-Cycle Cost Management in Construction, sustainable materials selection can influence life-cycle cost management through sensing and condition monitoring. The pathway is conditional on technical standards and technical standards; these factors determine whether information becomes an operational response or remains a formal feature with limited practical effect. Evidence associated with Tao et al., 2018 and Carvalho et al., 2019 supports treating implementation conditions as part of the explanation rather than as background noise. For engineering managers, asset owners, operations teams, and technical decision makers, measurement should capture both the intervention and the intermediate process expected to produce reliability.

7. Measurement and Decision Framework

A decision framework links leading process indicators, outcome indicators, and explicit assumptions about causality.

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For Sustainable Materials Selection and Life-Cycle Cost Management in Construction, the relevant unit of analysis is the decision process linking sustainable materials selection with life-cycle cost management. Sensing and condition monitoring provides one plausible channel, but its effect depends on operating environment, operating environment, and the time available for adjustment. A stronger assessment therefore combines a leading indicator of process integrity with a lagging indicator of reliability.

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8. Practical Implications and Research Agenda

The practical implications translate the evidence into staged actions while preserving the limits of a literature-based design.

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9. Conclusion

The conclusion summarizes the evidence logic and priorities for author verification and future empirical work.

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Historical source context and interpretation

Historical energy and built-environment context is drawn from Energy Efficiency 2023 and the 2022 Global Status Report for Buildings and Construction (International Energy Agency, 2023; United Nations Environment Programme, 2022). These reports frame resource use and efficiency concerns. Their sector-level discussion does not establish engineering performance, predictive accuracy or project-level causal effects for the systems proposed here.

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