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DEVELOPMENT OF FRAMEWORK FOR BUILDING MATERIALS-RELATED DECISIONS: A CASE STUDY

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Building materials occupy a large proportion of construction costs, comprising of nearly 50%, although the exact percentage varies from project to project. Given how important building materials are, due attention must be given to the strategies for procuring them. This study investigates building material purchasing practices and examines significant factors that could impact the optimum building materials for a specific project selection. This paper is an outcome of a PhD study conducted to improve supply chain practices relating to building materials for residential buildings in New Zealand in such a way that delivers the highest possible value to all stakeholders. The broader PhD study employed both qualitative (subject matter expert interviews) and quantitative (questionnaire survey) methods to gather information from those who supply and manufacture building materials, architects, builders, and homeowners. It found that the facilitation of effective materials management processes is reliant on the collaborative efforts of the entire supply chain in any construction project. When determining "best buy" decisions for key material inputs, the roles of the contractor, clients, and suppliers cannot be disconnected. Decisions relating to building materials were categorized into demand-side or supply-side choices, and a framework was developed to support supply chain stakeholder decisions in selecting appropriate materials for residential construction projects.

Keywords: Building materials management, Construction supply chain management, Collaboration, Procurement, Decision-making framework.

1 INTRODUCTION

Every building facility incorporates a variety of material items, which must be understood in terms of their availability, the mode of fabrication, the energy taken to produce them, energy consumption throughout their lifetime, any of the essential maintenance they require, end-of-life considerations, and, especially, cost of purchase (Domone and Illston 2010). The process to source, obtain, and incorporate these building materials can be key to a project's success. Materials represent a significant construction expense, and there are opportunities to significantly reduce overall construction costs by minimizing the cost of materials. Wise management practices are essential when it comes to ordering and paying for these materials and to ensure construction success at the best possible price (Abdul-Malak *et al.* 2000, Zavadskas *et al.* 2008, Hadikusumo *et al.* 2005). Attention should be given to selecting the right building material procurement strategies, given how important these key resources are (Ruparathna and Hewage 2015). There appear to be opportunities to minimize costs at the purchasing stage, notably the

purchase prices (Watermeyer 2012). Therefore, maintaining a suitable management plan for materials procurement dynamics could deliver opportunities for project cost minimizations. The ensuring of timely acquisition of construction materials and equipment, from the design phase right to the construction site, is recognized as construction procurement (Naief Turki 2002, Ruparathna and Hewage 2015), which includes the purchasing, transporting, storing, and moving of goods as the production process progresses. In past literature, there has been a considerable focus on the purchasing function, largely as a result of its effect on profitability, business performance, and, ultimately, the firms' survival (Bayazit *et al.* 2006, Carr and Pearson 1999). Gadde and Hakansson (2001) found that purchasing is an integral function in the operation of a company and not a separate function. Within the construction industry, this function can occur at all stages of a project. It is usual to purchase building materials using traditional or electronic systems through builders' merchants, consumer clubs, and direct purchases, but which of these methods (or combination of methods) provide the best value to a project?

This paper reviews the literature on construction materials management focusing on the procurement function and associated issues. It will then link to the wider PhD study to identify the significance of collaborative decision-making criteria focused on New Zealand's residential materials supply chain.

2 CONSTRUCTION MATERIALS MANAGEMENT

The first major construction industry materials management research determination was undertaken by Business Roundtable (1982). It defined materials management not as the organization required to perform the task but, rather, as a system. Materials management can basically be summarized as maintaining the integrity of a vendor's purchase, expedition, and control systems. Effective materials management processes could reduce surpluses of bulk materials in the range of 5-10% of bulk materials purchased to about 1-3%. Productivity could potentially improve 8% with such a system (Akintoye 1995).

In a traditional contractual environment, construction material purchases are initiated at the time of tender, during design approval (Kong 2001, London 2007). On receipt of the tender document, contractors persistently begin to estimate and liaise with their suppliers. Thereafter, they consider and choose from the best quotes from which they finalise the tender documentation. If the contract is secured, a supplier's original quote is very often validated and reconfirmed by the contractor. On occasion, it may be necessary to negotiate an amended price for materials. Having a defined and unified project team ensures that an entity can deliver proper and effective materials management according to a hierarchical model of distribution. Additionally, well-functioning relationships among staff at every hierarchy level result in more effective materials management. For the project team, this pathway extends from the project manager to the materials manager before it finally reaches expediters, buyers, subcontractors, and administrators at the third hierarchy level. When correct decisions are made by these personnel, this will ultimately result in a successful finished project (Kini 1999, Forgues and Koskela 2009). It is not only the building contractors' role to select building materials—this task is also influenced by the choices of architects and homeowners early on in a construction project (Samarasinghe *et al.* 2012). Also, the supply of the right materials is the responsibility of materials manufacturers and suppliers. As such, it is important to ensure the right decisions are made in the selection, purchase, and supply of materials. This ensures that when all the choices of the aforementioned are factored in, the appropriate building materials can be obtained (Eriksson and Westerberg 2011).

For the most part, the construction industry in New Zealand follows traditional procurement practices in which design and construction are separate (Liu and Wilkinson 2011, Ruparathna and

Hewage 2015). Because of this, different parties in the supply chain make distinct decisions around building materials. It is essential that the industry in New Zealand distances itself from these traditional procurement methods and adopts more supply chain management (SCM) concepts (Masood *et al.* 2016, Samarasinghe 2014, Samarasinghe *et al.* 2013). This will require the integration of a number of behaviors relating to materials procurement. This study aims to create a framework for improving these practices in such a way that every stakeholder receives the best possible value for materials used in New Zealand's residential buildings.

3 RESEARCH METHODS ADOPTED

As discussed before, this paper is based on a wider research undertaken for a PhD degree (Samarasinghe 2014) in the field of construction management. The PhD study used a mixed-method research approach in three phases, collecting both quantitative and qualitative data. Phase one involved a literature review of the research problem investigated (*i.e., existing procurement and use practices relating to building materials do not deliver optimum benefits to end users. Taking on board stakeholder views on the subject matter, how can this practice be improved? Could an understanding of stakeholder behaviors help to improve practice?*) and semi-structured interviews. The interviews were undertaken with those involved in the creation, supply, or use of building materials—suppliers, construction contractors, manufacturers, residential contractors, homeowners, and architects from the Auckland region. In total, 30 participants (six from each group) were interviewed, representing companies of all sizes from small to large. In the second phase of the PhD study, the qualitative information gathering was followed up with a nationwide survey questionnaire (with an overall response rate of 23.4%), which was administered across the residential construction supply chain. The questionnaire allowed further insight into the variables identified through the semi-structured interviews. The last data collection phase was aimed at verifying and expanding on the findings from the questionnaire survey. This exercise in research validation was conducted using five subject matter experts (SMEs) in the form of semi-structured interviews.

4 PRESENTATION OF THE RESULTS

The responses received from suppliers, manufacturers, contractors, architects, and homeowners were analyzed using the NVivo tool. The main themes drawn were then presented to a wider population across the supply chain using a questionnaire survey. The questionnaire findings were statistically analyzed using the SPSS tool. Lastly, the key decision-making criteria determined by the questionnaire were validated through SME interviews. These key considerations are presented in Table 1 according to their statistical significance.

Table 1. The key building materials related decision-making criteria.

	Suppliers/manufacturers	Builders	Architects	Homeowners
1	The need for strong customer relationships (M = 4.70, SD = 0.446)	Quality of materials (M = 4.7, SD = 0.532)	The material is fit for purpose (M = 4.86, SD = 0.345)	Quality and satisfactory performance of materials (M = 4.78, SD = 0.422)
2	Delivery service (M = 4.58, SD = 0.536)	Price of materials (M = 4.52, SD = 0.569)	Accurate information about materials (M = 4.75, SD = 0.544)	Functionality, properties, specifications, and the feel of materials (M = 4.55, SD = 0.582)
3	Offering and supplying a wide range of materials to service the wide variety of bespoke houses (M = 4.48, SD = 0.638)	Contractors' own level of efficiency (M = 4.46, SD = 0.679)	The performance and quality of materials and warranties (M = 4.69, SD = 0.500)	Aesthetic values (M = 4.39, SD = 0.583)

Table 1. The key building materials related decision-making criteria (contd).

	Suppliers/manufacturers	Builders	Architects	Homeowners
4	Understanding customer needs (M = 4.44, SD = 0.595)	Materials specifications (M = 4.37, SD = 0.554)	Materials specifications (M = 4.32, SD = 0.819)	The level of maintenance affordability of a house (M = 4.30, SD = 0.703)
5	Providing a competitive price to enable business viability long-term (M = 4.44, SD = 0.684)	Degree of negotiation (M = 4.23, SD = 0.830)	Homeowner's brief (M = 4.32, SD = 0.819)	Homeowner's requirements (M = 4.30, SD = 0.703)
6	Product quality requirements (M = 4.39, SD = 0.715)	Repetitive business (long-term relationships) (M = 4.23, SD = 0.736)	Architect's knowledge and experience (M = 4.17, SD = 0.722)	Materials supplier's reputation in the industry (M = 4.00, SD = 0.739)
7	Having a good logistics system (M = 4.2, SD = 0.707)	Supplier's service (M = 4.22, SD = 0.737)	Good communication with suppliers (M = 3.98, SD = 0.820)	Homeowner's relationship with contractor (M = 3.91, SD = 1.083)
8	Having sophisticated software systems (M = 4.06, SD = 0.826)	Past experience and knowledge (M = 4.19, SD = 0.722)	Site conditions (M = 3.81, SD = 0.860)	Homeowner's relationship with architect (M = 3.50, SD = 1.340)
9	Adopting waste minimization strategies such as appropriate logistics processes, JIT, SCM and collaboration (M = 3.79, SD = 0.979)	Degree of collaboration and information sharing (M = 3.81, SD = 1.075)		Quality and satisfactory performance of materials (M = 4.78, SD = 0.422)
10		Supplier's credit period (M = 3.74, SD = 1.075)		The properties and specifications of materials, and their functionality and feel (M = 4.55, SD = 0.582)

5 DISCUSSION

The study identified the behaviors of both demand- and supply-side stakeholders in the materials supply chain and created a framework (see Figure 1) for supply-chain stakeholders' building material-related decisions.

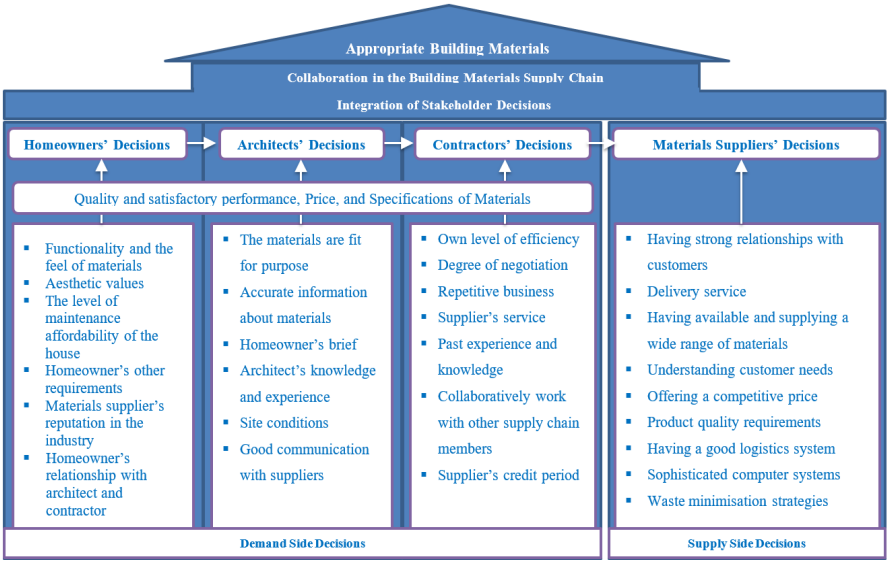

Figure 1. A framework for building materials supply and demand-related decisions.

Demand-side decisions involve the choices made by architects, homeowners, and contractors. Supply-side decisions are the choices made by building materials manufacturers and suppliers. The study ascertained that the common criteria for all stakeholders on the demand-side (homeowners, architects, and contractors) are satisfactory performance, quality, specification, and price. Because homeowners and stakeholders generally work together, there are many commonalities in their decision-making. Architects base their decisions largely on the requirements of homeowners, while homeowners' choices are significantly influenced by architects. Contractors and suppliers also impact the homeowners' decisions in regard to building materials. Architects appear to collaborate with homeowners and materials suppliers when making decisions about materials. However, the study determined that their decisions are, in fact, quite separate from those of the contractors. When it comes to building contractors, their decisions relating to building materials seem to be influenced by the three other stakeholders. In the main, it is the contractors who connect the supply-side of the supply chain to the demand-side, and they appear to maintain a set of favored suppliers as a result of their own business histories. When it comes to the demand-side, customer relationships are the primary consideration for materials suppliers when making materials-related decisions, followed by delivery service and the availability of a wide range of materials for supply. As a result, these demand-side choices, as generated by architects, homeowners, and contractors, are passed on to the supply-side primarily through contractors. Thereafter, the suppliers of materials make their supply decisions to meet customer requirements. This study emphasizes that the integration of supply-side and demand-side decisions would be advantageous in determining the most appropriate building materials. Stakeholders on each side would benefit from understanding the criteria considered by those on the opposite side. In short, the current study recommends that increased collaboration is required across the supply chain.

6 CONCLUSION

This paper has provided a review of literature around materials management and materials purchasing decisions in construction projects. In addition, it has given an account in support of the use of construction materials management systems and outlined why they are a key factor in successful project delivery. The paper shows that opportunities for improving materials management exist at the procurement stage of construction projects when decisions concerning the "best buy" for key materials could determine project success. In New Zealand, the construction industry primarily uses the traditional procurement system with a highly fragmented supply chain, which has a number of issues in regard to building materials. The development of a framework for the supply chain parties' decisions ensures each party can gain insight into the others' thinking and materials-related decision-making. Good materials management processes rely on the collaborative efforts of the entire project implementation team in any construction project. The roles of the contractor, clients and suppliers cannot be disconnected when it comes to the "best buy" decision-making for key material inputs. Presently, supply chain decisions tend to be made by individuals and are less collaborative. Despite this, the industry has started distancing itself from the traditional procurement system in favor of SCM, which will benefit the whole supply chain in many ways, including in terms of sourcing the most appropriate materials and improving teamwork. Consequently, this will result in an increase in residential sector performance and that of the construction industry as a whole. Adopting an integrated approach to making supply chain-related decisions about materials should elevate overall supply chain performance and enable those in the industry to find building materials that are right for houses in New Zealand.

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