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MINIMISING LOGISTIC COST OF CONSTRUCTION MATERIALS IN THE CONSTRUCTION INDUSTRY: CONTRACTOR'S PERSPECTIVE

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ABSTRACT

Construction projects involve major resource consumption, particularly in materials which can account for up to 60% of the total construction cost. Construction logistics is the integration and collaboration of several activities to plan, execute, and control the flow of physical objects from their point of origin to their point of consumption. While logistics plays a significant role in minimising material costs, the construction industry tends to pay less attention to logistic cost minimisation. This paper aims to identify construction logistic cost components and propose strategies to minimise these components on construction material cost from a contractor's perspective. Accordingly, the literature review highlighted the significance of construction materials as a resource for construction projects and the importance of material costs in total construction costs. Moreover, semi-structured expert interviews were conducted with twelve (12) experts involved in construction logistics to gather data. Both on-site and off-site experts were included in the sample. Manual content analysis was used to analyse the collected data due to its flexibility and adaptability for small sample sizes. Thirteen (13) strategies were proposed to minimise construction logistic costs on material costs, including proper knowledge of the logistic process and its cost components and implementing proper logistic cost minimisation strategies through coordination and collaboration between the head office and the site. The findings of this study are expected to contribute to the construction industry's better understanding of the importance of logistic cost minimisation strategies and their potential benefits.

Keywords: *Construction Logistics; Construction Materials; Logistic Cost (LC); Logistic Cost Minimisation.*

1. INTRODUCTION

Construction is the second highest industry after agriculture, with colossal resource consumption (Raja & Murali, 2020). Construction projects consume significant resources such as labour, material, machinery, and equipment in permanent and temporary works. However, materials around 50-60% take a high percentage, and their impact will be 80%

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of the project budget (Caldas et al., 2015). In some underdeveloped nations, material expenditures might account for 60-65% of the total construction cost (Tserng et al., 2006). Furthermore, a loss of 30% of labour productivity could result from a lack of materials at the time they are required (Caldas et al., 2015). Material management is a necessary process that needs to be controlled conscientiously. When it explores the contractors' perspective, it is essential to manage construction materials well to prevent cost overruns. Therefore, it is likely that the cost of materials would be increased excessively if careful planning, management, and controlling of the utilisation of construction materials were not exercised (Fang & Ng, 2011). As a definition, a flow of physical objects from their point of origin to their point of consumption can be planned, executed, and controlled through the integration and collaboration of several activities known as logistics (Benotmane et al., 2018). Construction logistics support acquiring, storing, and transporting materials, labourers, and other resources needed throughout the construction process (Miashkova, 2022). It involves more than just controlling the flow of information and materials; it also entails providing quality, ensuring safety, and creating an environment that makes construction activities easier (Guffond & Leconte, 2000).

The significance of logistic construction cost is 20-30% of the material cost (Fang & Ng, 2011). Inadequate logistic process planning may cause material shortages that delay the project schedule simultaneously, and it will drive indirect costs such as material price fluctuations, penalty costs, loss of discounts, and so on (Tserng et al., 2006). Fang and Ng (2011) mentioned that transportation, storage, and procurement are major logistic cost components, which acquire a significant proportion of the material cost. Aljohani (2017) identified material cost overrun as a critical factor directly impacting project cost overruns. Nevertheless, the construction industry pays less attention to logistic cost minimisation even though it is a significant component of material cost (Raja & Murali, 2020). Since the material acquisition process involves both supplier and the contractor, there are suppliers' and contractors' side logistic activities. However, this study focuses on logistic cost minimisation from the contractors' perspective because the contractors bear most of the logistic cost components of the material logistic process (Fang & Ng, 2011). As a result, this paper aims to identify the construction logistic cost components and propose strategies to minimise those logistics cost components on construction material cost. Consequently, this study presents an adopted logistic planning model for cost minimisation.

2. RESEARCH METHODOLOGY

According to Chalakkal (2021), the research approach is an action to examine a research problem and justify using methods or strategies. Borrego et al. (2009) have stated that there are three research approaches which are quantitative, qualitative, and mixed methods. In qualitative research, textual data is gathered and analysed via surveys, interviews, focus groups, conversational analysis, observation, and ethnographies (Olds et al., 2005). Qualitative research allows for the development of details through deep involvement in experience, and the qualitative approach enables the researcher to be highly involved in the scenario to collect data (Creswell, 2014). For this study, it is required to collect data regarding the material logistic process at a typical construction site, logistics in the construction industry, logistic cost calculation, and logistic cost minimisation, which are subjective.

Moreover, the required data, such as subjective perceptions, opinions, and emotions, is difficult to quantify. Therefore, the qualitative approach is more suitable for this study. The semi-structured expert interview was selected as the data collection method since interviews are considered one of the best data collection techniques as it goes up to the depth of opinion of the interviewees (Punch & Oancea, 2014). Gathering data would be more applicable because the required data is highly dependent on professional experience, opinions, and beliefs. Table 1 shows the profile of selected respondents.

Table 1: Experts' profiles

Detail	Profession	Designation	Experience in the industry
Expert 1	Quantity Surveyor	General Manager in Estimate and Contracts	16 years
Expert 2	Quantity Surveyor	General Manager in Estimate and Contracts	15 years
Expert 3	Quantity Surveyor	Head of Procurement Division	11 years
Expert 4	Quantity Surveyor	Procurement Manager	10 years
Expert 5	Quantity Surveyor	Chief Quantity Surveyor	26 years
Expert 6	Quantity Surveyor	Chief Quantity Surveyor	25 years
Expert 7	Quantity Surveyor	Site Quantity Surveyor	5 years
Expert 8	Quantity Surveyor	Site Quantity Surveyor	7 years
Expert 9	Quantity Surveyor	Site Quantity Surveyor	7 years
Expert 10	Engineer	Project Manager	10 years
Expert 11	Engineer	Project Manager	15 years
Expert 12	Engineer	Site Engineer	12 years

Twelve experts with relevant experience in construction logistics and who are involved in the material logistics process were selected. Both head office and site-level experts were included among these experts to address on-site and off-site logistics consequences. On completion of twelve interviews, data saturation was found because no new interpretations were arising for latest three interviews. The interviewees were systematically queried regarding multiple dimensions related to the research objectives, including the significance of LC, the level of awareness among industry professionals regarding logistics, the processes involved in material logistics, the key components contributing to logistics costs, and potential strategies to mitigate these costs. The collected data were analysed using the manual content analysis method, where the researcher carefully goes over and classifies text-based data, such as written documents, interview transcripts, or focus group transcripts (Elo & Kyngäs, 2008). Since manual content analysis is more flexible and adaptable and can be used for analysing small samples of data in depth (Krippendorff,2019), it was selected as the data analysing method.

3. LOGISTICS IN THE CONSTRUCTION INDUSTRY

When it matches the concept of logistics to construction firms, construction logistics can be defined as the process of delivering materials and resources required at a construction site in a productive way (Ghanem et al., 2018). Voigtmann and Bargstadt (2010) mentioned that planning, coordinating, and monitoring the movement of construction materials within the construction site are all parts of construction logistics. According to

previous studies, construction logistics can be divided into off-site and on-site material logistics.

3.1 ON-SITE LOGISTICS

The technique of allocating places for resource delivery, storage, and handling to minimise site congestion and extra material movement so that inefficiencies are kept to a minimum is known as on-site logistics (Thomas et al., 2005). In the construction industry, when materials arrive at the working site, it does not mean materials have reached their destination. Because still, crews at the site need to transport, store at the on-site warehouse, and install in the right place - these steps in site call on-site logistics (Ghanem et al., 2018). Wang et al. (2014) also highlighted that construction logistics present two potential areas for performance improvement, and the first step is to address the logistical issues at the construction site. Moreover, rearranging site logistics can result in significant improvements (Sundquist et al., 2018).

3.2 OFF-SITE LOGISTICS

Off-site construction logistics is a component of supply chain management in which numerous businesses collaborate to create a network of interconnected procedures to move goods, services, cash, and information efficiently to lower overall costs, shorten overall lead times, and increase overall profits while putting the needs of the customer above all other considerations (Hamzeh et al., 2007). Main contractors are supplied goods and services from sub-contractors and suppliers, and then those activities consider off-site logistics. This is also called supply logistics which involves construction material suppliers (Ekeskär & Rudberg, 2016). Fellows and Liu (2012) argued that supply logistics (off-site logistics) is more complex because it involves more construction processes. For efficient resource and material flow management, cooperation and coordination between supply chain participants and the utilisation of off-site logistics are other steps that should be considered (Brusselaers et al., 2022).

4. MATERIAL LOGISTIC PROCESS AT CONSTRUCTION SITE

According to Fang and Ng (2011), a logistic process in a construction site is a sum of all logistic activities involving material acquisition from suppliers to transporting to the construction site. According to Jang et al. (2003), major logistic activities are procurement, transportation, storing, and handling. The material acquisition process involves both supplier and the contractor; there are suppliers' and contractors' side logistic activities. Since this study focuses on logistic cost minimisation from a contractor's perspective, it would only consider contractors' side logistic activities. Accordingly, Figure 1 illustrates how those major logistic activities are ascertained in a construction site.

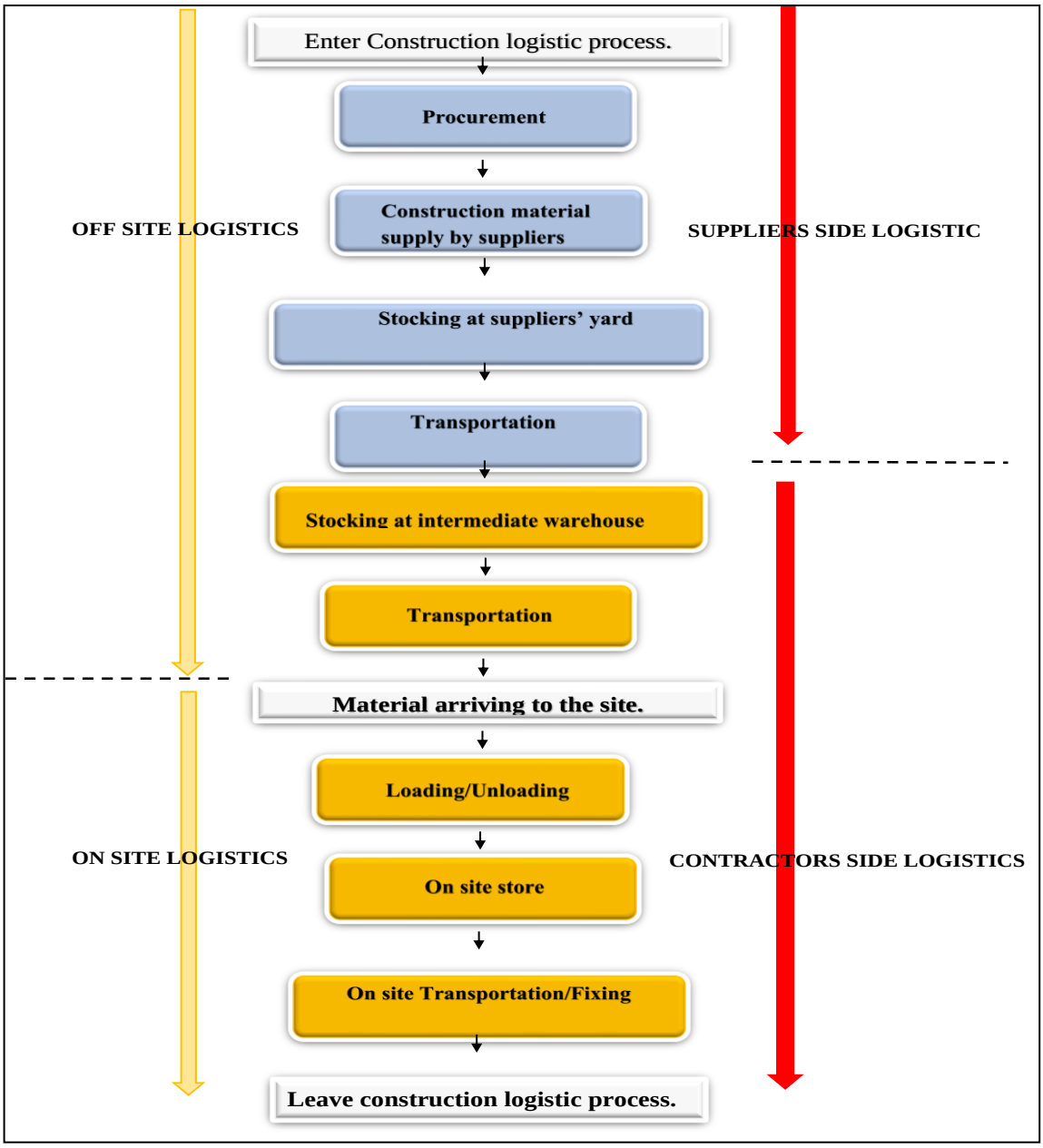

Figure 1: Material logistic process at a typical construction site

5. BASIC CONSTRUCTION LOGISTIC COST ELEMENT

Fang and Ng (2011) proposed Activity Based Cost (ABC) method to quantify the total logistic cost, which is a method for identifying cost components, determining the costs associated with each activity, and assigning those costs to cost objects, such as labour, materials, equipment, facilities, property, and capital. According to Fang and Ng (2011), the cost of each logistic activity is identified as a logistic cost element. Sobotka and Czarnowski (2005) presented a similar concept. Generally, the supplier bears the storage costs at the supplier's yard and transportation costs to the intermediate warehouse. The contractor absorbs the storage cost on site and intermediate warehouse, material handling (loading/unloading), other transport costs between the construction site, on-site transportation, and procurement cost (Fang & Ng, 2011).

5.1 PROCUREMENT COST

The word "procurement cost" refers to the costs related to finding appropriate suppliers for the project, which includes selecting the best suppliers, requesting quotes from them, negotiating the terms of the contracts with them, and ordering the material (Zeng & Rossetti, 2003). The best item must be purchased at the appropriate quality, quantity, time, and cost, according to the objectives of material procurement (Kamalaeaswari & Vedhajanani, 2015). Observing consumed resources which are working staff, office equipment, and capital cost, provide the cost of procurement (Fang & Ng, 2011).

5.2 TRANSPORT COST

Transportation is significant when considering logistic activities in the construction industry (Sobotka & Czarnigowska, 2005). Generally, suppliers are responsible for transport from their store to an intermediate warehouse or on-site storage. Meanwhile, the contractor takes care of himself with on-site and material transportation to the construction site (Fang & Ng, 2011). Rafiq et al. (2021) emphasised that the transportation cost should relate to the distance travelled between the warehouse and the destination, including the driver's salary, equipment expenses, fuel cost, and inventory costs incurred in transit. The cost of the inspector and the rental or depreciation of the vehicles should be included in the transportation cost (Fang & Ng, 2011).

5.3 COST OF SITE STORAGE

Some studies on the manufacturing sector believe that once the materials arrive at the warehouse, the logistics process is complete (Lambert et al., 1998; Ferguson, 2000). However, in the construction industry logistic process will not be ended until materials are fixed to the exact location (Fang & Ng, 2011). Thus, construction materials are often loaded into a temporary storage facility at the construction site before being fixed at the appointed place (Fang & Ng, 2011). The fundamental responsibility of material management is an in charge of the flow of materials from where they are ordered, received, and stored until they are used (Patil & Pataskar, 2013). According to Fang and Ng (2011), the cost of site storage shall include all the cost-related items, which are material costs for racks, stow woods, other relevant materials, and labour costs charged at the store. Moreover, it consists of the capital cost, which means the opportunity cost of frozen material at the site (Fang & Ng, 2011).

5.4 INVENTORY COST

Inventory control is crucial to the timely and successful execution of construction projects. The purpose of the inventory is to have the supplies on hand for when needed by storing them (Zeng & Rossetti, 2003). Inventory also keeps finished goods, spare parts, tools, and supplies needed for construction. Contractors maintain an intermediate warehouse to keep materials and supply construction sites when needed (Kumar & Malik, 2022). The same authors mentioned inventory cost consists of holding cost, storing cost, rent and electricity. The inventory holding cost is the difference between the transfer and buffer stock costs (Zeng & Rossetti, 2003).

5.5 COST OF MATERIAL HANDLING

Effective material handling is a material management objective consisting of loading, unloading, and fixing materials (Ramya & Viswanathan, 2019). Material handling is

performed using machinery, mobile cranes, and other equipment or manually with human resources (Muralitharan & Elangovan, 2015). Equipment used for material handling, such as cranes, forklifts, chain hoists, and slings, should be sufficiently capable and adequately maintained. Material handling costs include labour costs, machinery costs (cranes), and equipment costs (Fang & Ng, 2011).

5.6 CUSTOM DUTY/TAXES

According to Jayasinghe et al. (2016), the tax was identified as a significant cost component of the material. The construction industry development authority in Sri Lanka and the Sri Lankan custom confirms that most of the construction materials in the local industry are imported from foreign countries, and then there are several duties and taxes charged. CESS levy, PAL, and customs duty take a significant amount on material cost (Customs, 2023). The form of the contracts stated that paying tax on materials is a contractor's responsibility.

Based on the ABC method, the Contractors' total LC can be quantified as follows:

Contractors' total LC = Procurement cost + Cost of intermediate warehouse + Cost of transportation + Cost of material handling (loading, fixing) + On site storage cost + Custom duty/taxes

Therefore, if the contractor requires to minimise total LC, they shall identify possible LC cost components to cut unnecessary costs.

6. STRATEGIES TO MINIMISE LOGISTIC COST

This research study focuses on developing strategies to minimise logistic costs from a contractor's perspective. Several researchers have endeavoured to discover suitable strategies for logistic cost minimisation. Further, strategies have been identified through expert interviews. According to expert interviews, LC comes to the arena in two major stages. They are LC estimating at the bidding stage and monitoring and calculating actual LC during construction. Therefore, LC minimisation strategies shall be developed in the bidding stage, and developed strategies will be implemented during the construction stage. It is imperative to monitor the progress after implementing strategies to ascertain the degree to which logistical activities conform to said strategies. Table 2 presents the strategies recognised through the literature review and expert interviews. If at least one expert said that a particular strategy minimises logistic cost, it has been mentioned as an identified strategy through expert interviews. If a specific strategy has been deemed effective in minimising logistic costs by at least one expert, it is considered an identified strategy through expert interviews.

Table 2: Strategies

Strategy	Literature findings	Expert interviews
Better construction site plan	X	X
Better logistic plan	X	
Identifying the most suitable material delivery schedule in line with the construction schedule	X	
Identifying the quickest route (lowest distance) with less disruptions	X	X

Strategy	Literature findings	Expert interviews
Better labour supervision and optimising construction site with less interruption	X	X
Better material management	X	
Centralised material supply centre to supply materials for each ongoing site		X
Local vendors		X
Identifying ideal storage capacity	X	X
Keeping own material plants to integrate the supply chain		X
Alternative transportation methods		X
Technological advancement		X
Ensure the quality of material		X

6.1 BETTER CONSTRUCTION SITE PLAN

According to Gustafsson and Schultz (2010), a construction site plan includes many logistic cost-related aspects such as transportation routes, lifts, cranes, crane placements and ranges, gates, passages, unloading areas, and storage areas. Experts emphasised that a better construction site plan will minimise on-site transportation and storage costs and save material handling by optimising the site space. Moreover, optimising construction site space will minimise material handling costs since it saves working hours on loading and unloading materials.

6.2 BETTER LOGISTIC PLAN

Said and El-Rayes (2011) developed a logistic planning model to assist contractors in reducing material logistics costs by utilising an integrated approach that optimises the critical planning decisions of material procurement and layout on construction sites. Figure 2 shows that the existing model in a specific construction site cannot integrate material procurement plans and storage layouts on construction sites. With that number of drawbacks which increase logistic cost more, are arising. By utilising an integrated strategy that simultaneously optimises two categories of decisions, the new model is intended to assist contractors in reducing the costs associated with material logistics: (1) material procurement decisions, which affect material inventory levels and storage requirements; and (2) dynamic layout decisions, which identify various locations of material storage areas and other temporary facilities over the course of a project. Both types of decisions directly impact the objective function created to minimise the construction logistics (Said & El-Rayes, 2011).

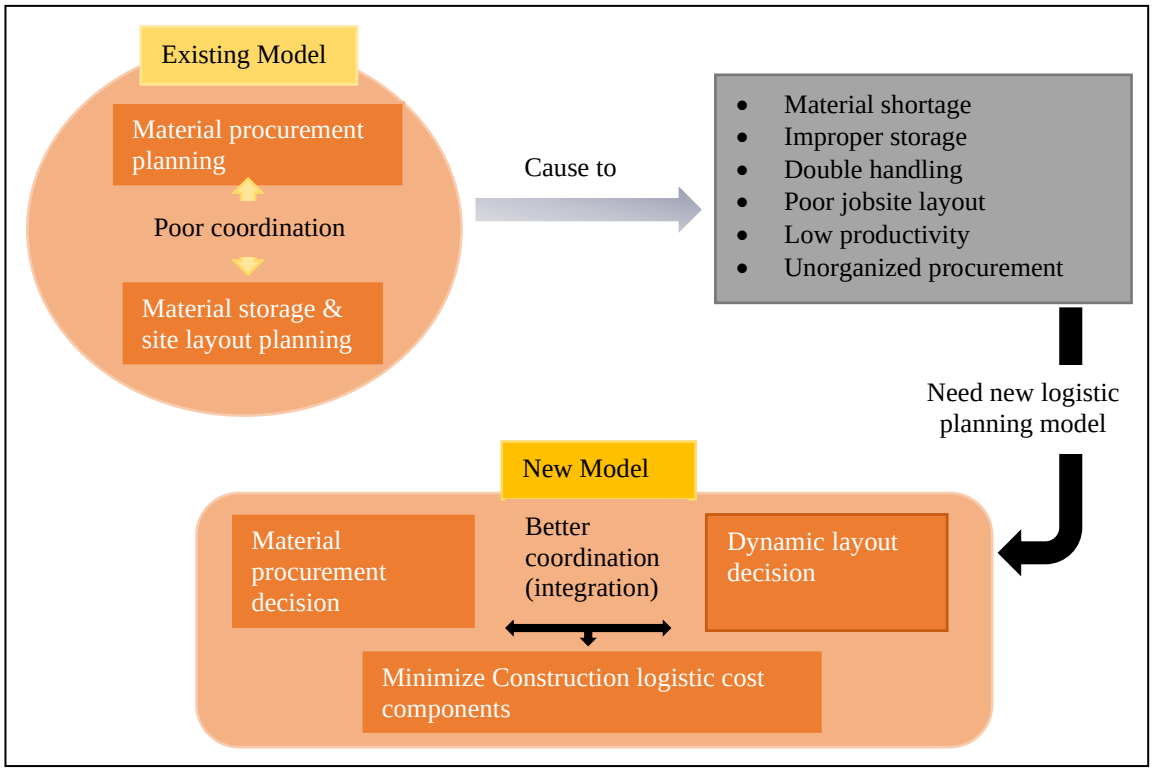

Figure 2: Construction logistic planning model (Adopted from Said & El-Rayes, 2011)

6.3 IDENTIFYING THE MOST SUITABLE MATERIAL DELIVERY SCHEDULE IN LINE WITH THE CONSTRUCTION SCHEDULE

A material delivery schedule minimises the number of orders and delivery times. According to Expert 2, the most suitable material delivery schedule can be easily implemented if a proper construction schedule is available. The construction schedule mentions resource requirements for relevant activity in line with time. This strategy can minimise procurement and transportation costs due to few material orders (Fang & Ng, 2011).

6.4 IDENTIFYING THE QUICKEST ROUTE

Identifying the quickest route with the lowest distance and fewer disruptions is crucial to minimise material transport costs (Shah et al., 2019). Expert interviews further elaborated on the quickest route strategy will be caused to minimise project delays, which saves unnecessary costs for Contractors

6.5 BETTER MATERIAL MANAGEMENT

Shah et al. (2019) have mentioned that better material management which consists of material procurement, material quality, and transportation of suitable material on-site at the right time, is another strategy for logistic cost minimisation. If the material management in construction projects is not managed correctly, it will create a significant project cost variance (Gulghane & Khandve, 2015).

6.6 CENTRALISED MATERIAL SUPPLY CENTRE TO SUPPLY MATERIALS FOR EACH ONGOING SITE

Most of the experts stated that a centralised material supply centre allows bulk purchasing, which causes a reduction in the number of orders. On the other hand, each ongoing construction site can decline logistic costs because all the materials can be delivered from one place.

6.7 LOCAL VENDORS

According to Sri Lanka customs, the construction industry spends high costs on customs duties and port/airport levies depending on imported materials and experts confirmed it is better to deal with local vendors to minimise duties, levies, and taxes as a logistic cost component (Jayasinghe et al., 2016). Experts believe the Contractors should explore alternative materials for imported materials.

6.8 IDENTIFYING IDEAL STORAGE CAPACITY

Ideal storage capacity cuts down the high initial cost of the store and maintenance costs (Fang & Ng, 2011). On the other hand, experts confirmed that ideal storage capacity minimises the number of material orders.

6.9 KEEPING OWN MATERIAL PLANTS TO INTEGRATE THE SUPPLY CHAIN

Another suggestion of the experts was keeping their material plants to integrate the supply chain that, allows the contractor not to be concerned about material transportation from suppliers' yards, taxations and material shortages.

6.10 ALTERNATIVE TRANSPORTATION METHODS

Contractors should find alternative transportation methods which spend the least transportation cost to minimise the logistic cost. Experts recommended that material transportation from railways is a cheap alternative transportation method.

6.11 TECHNOLOGICAL ADVANCEMENT & ENSURING QUALITY OF MATERIALS

Furthermore, ensuring excellent quality material and using new technologies were identified as effective strategies to minimise the logistic cost component. Poor quality materials increase material rejections, which repeat the logistic process. As suggested by Experts 1, 2, 3, 4, 8, 10 and 12, adopting new technologies improves the efficiency of the material acquisition process and minimises the logistic cost as they have practically experienced using Enterprise Resource Planning (ERP) system.

7. CONCLUSIONS

Examining logistical expenses is paramount for contractors as it facilitates the successful execution of projects within budgetary constraints while attaining anticipated profitability. The primary objective of this research endeavour was to formulate strategies that mitigate logistical costs on material expenses, achieved through a comprehensive review of existing literature and semi-structured interviews conducted with industry experts. The literature review in this study centred on elucidating the fundamental principles underlying the minimisation of logistical costs associated with construction

materials, thereby underscoring the influential role construction materials play as a critical resource in construction projects. Prior scholarly investigations have unequivocally substantiated the significance of material costs within the overall framework of construction expenditure. Consequently, this study adopted a contractor-centric perspective in its examination of logistical costs, identifying a substantial portion of such costs attributable to construction material expenses. Minimising unnecessary logistic costs and observing the logistic cost component to reduce material costs is crucial. The study presented the material logistic process and identified major logistic activities that could be categorised as significant cost components. These costs related to the logistics of construction materials were delineated based on the ABC approach.

The study found that logistic costs can be controlled in both the bidding and construction stages. Accordingly, thirteen strategies were proposed to minimise logistic construction costs on material costs. It was confirmed that estimators, planners, project managers, and other industry professionals must properly know the logistic process and its cost components. Logistic costs take a considerable proportion of material costs, and a lack of planning and controlling of logistics can cause material cost overruns. Therefore, this study's outcome is beneficial for contractors to have a clear picture of logistic costs and develop a proper logistic plan to address logistic cost minimisation strategies. As both the head office and construction site are involved in the logistic process, implementing proper logistic cost minimisation strategies requires proper coordination and collaboration between the head office and the site. The introduction of technological advancements can enhance the implementation of these strategies.

Finally, in-depth investigation, proper training for staff, and identifying barriers will provide continuous development for contractors in establishing logistic cost minimisation strategies. The findings of this study are expected to contribute to the construction industry's better understanding of the importance of logistic cost minimisation strategies and their potential benefits.

8. REFERENCES

Aljohani, A. (2017). Construction projects cost overrun: What does the literature tell us?. *International Journal of Innovation, Management and Technology, 8*(2), pp.137-143.

Benotmane, Z., Belalem, G., & Neki, A. (2018). A cost measurement system of logistics process. *International Journal of Information Engineering and Electronic Business, 10*(5), pp.23-29.

Borrego, M., Douglas, E., & Amelink, C. (2009). Quantitative, qualitative, and mixed research methods in engineering education. *Journal of Engineering Education, 98*(1), pp.53-66.

Brusselaers, N., Fufa, S. M., & Mommens, K. (2022). A Sustainability assessment framework for on-site and off-Site construction logistics, *Sustainability*, *5*(1), 8573.

Caldas, C. H., Menches, C. L., Reyes, P. M., Navarro, L., & Vargas, D. M. (2015). Materials management practices in the construction industry. *Practice Periodical on Structural Design and Construction, 20*(3), 04014039.

Chalakkal, K. (2021). *Introduction to research methodology*. https://doi.org/10.13140/RG.2.2.21389.97764

Creswell, J. (2014). *The selection of a research design:Research design* (4th ed.). Sage publications.

Sri Lanka Customs (2023, January 01). Import tariff: Sri Lanka Customs. https://www.customs.gov.lk/customs-tariff/import-tariff/

Creswell, J. (2014). *Research design* (4th ed.). SAGE publications.

Ekeskär, A., & Rudberg, M. (2016). Third-party logistics in construction: The case of a large hospital project. *Construction Management and Economics, 34*(3), pp.174-191.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing, 62*(1), pp.107-115.

Fang, Y., & Ng, S. T. (2011). Applying activity-based costing approach for construction logistics cost analysis. *Construction Innovation, 11*(3), pp.259-281.

Fellows, R. & Liu, A. (2012). Managing organisational interfaces in engineering construction projects: Addressing fragmentation and boundary issues across multiple interfaces. *Construction Management and Economics, 30* (8), pp.653-671.

Ferguson, B.R. (2000). Implementing supply chain management. *Production & Inventory Management Journal, 41*(2), pp.64-7.

Hamzeh, F. R., Tommelein, I. D., Ballard, G., and Kaminsky, P. (2007). *Improving construction work flow–The connective role of look ahead planning.* 16th Annual Conference of the International Group for Lean Construction, Manchester, UK. 10.13140/RG.2.1.3804.3685.

Ghanem, M., Hamzeh, F., Seppänen, O., & Zankoul, E. (2018). A new perspective of construction logistics and production control: An exploratory study. In VA González. (ed.), *IGLC 2018 - Proceedings of the 26th annual conference of the international group for lean construction: Evolving lean construction towards mature production management across cultures and frontiers*, pp.992-1001.

Guffond, J.L., & Leconte, G. (2000). Developing construction logistics management: The french experience. *Construction Management and Economics, 18*(6), pp.679-687.

Gulghane, A. A., & Khandve, P. V. (2015). Management for construction materials and control of construction waste in construction industry: A Review. *In Journal of Engineering Research and Applications, 15*(2), pp.167-174.

Gustafsson, F., & Schultz, M. (2010). *Construction site plan to increase awareness of logistics. English abstract of degree project at the division of logistics, LTH*. Lunds Universitete, Sweden. https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=1714863&fileOId=1714866

Jang, H., Russell, J. S., & Yi, J. S. (2003). A project manager's level of satisfaction in construction logistics. *Canadian Journal of Civil Engineering, 30*(6), pp.1133–1142.

Jayasinghe, S. A. Y. B., Alahakoon, C. S., & Wijewardena, L. S. S. (2016). Sensitivity of the ICTAD price fluctuation formula procedure for the true material price fluctuations in construction industry. *Journal of Engineering and Technology, 3*(1), pp.19-40.

Kamalaeaswari, A. S., & Vedhajanani, A. B. (2015). Process analysis of material procurement in commercial buildings and recommendation. *International Journal of Engineering Research & Technology (IJERT), 4*(3), pp.15-27.

Krippendorff, K. (2019). *Content analysis: An introduction to its methodology* (4th ed.). Sage Publications.

Kumar, S. P., & Malik, H. (2022). Inventory Management in Construction Industry. *IOSR Journal of Engineering (IOSRJEN), 12*(1), pp.26-33.

Lambert, D.M., Stock, J.R. & Ellram, L.M. (1998). *Fundamentals of Logistics Management*. Irwin, Boston, MA.

Muralitharan, T., & Elangovan, T. (2015). Safety and analysis in material handling of construction industry. *Middle-East Journal of Scientific Research, 23*(3), pp.523-528.

Miashkova, Y. (2022, October 6). Construction Logistics: Track-Pod. https://www.track-pod.com/blog/construction-logistics/

Olds, B. M., Moskal, B. M., & Miller, R. L. (2005). Assessment in engineering education: Evolution, approaches and future collaborations. *Journal of Engineering Education, 94*(1), pp.13-25.

Patil, A. R., & Pataskar, S. V. (2013). Analysing material management techniques on construction project. *International Journal of Engineering and Innovative Technology, 3*(4), pp.96-100.

Punch, K. F., & Oancea, A. (2014). *Introduction to research methods in education.* Sage publication.

Rafiq, W., Musarat, M. A., Altaf, M., Napiah, M., Sutanto, M. H., Alaloul, W. S., Javed, M. F., & Mosavi, A. (2021). Life cycle cost analysis comparison of hot mix asphalt and reclaimed asphalt pavement: A case study. *Sustainability, 13*(8), pp.15-25.

Raja, K. A. K., & Murali, Dr. K. (2020). Resource management in construction project. *International Journal of Scientific and Research Publications (IJSRP), 10*(5), pp.252-259.

Ramya, R., & Viswanathan, K. E. (2019). A study report on material management in construction industry. *International Journal of Intellectual Advancements and Research in Engineering Computations*, *7*(2), pp.48-52.

Said, H., & El-Rayes, K. (2011). Optimising material procurement and storage on construction sites. *Journal of Construction Engineering and Management, 137*(6), pp.421-431.

Shah, K., Abbasi, S. S., Zia, M. M., Khan, I. S., & Shah, S. A. A. (2019). Logistics optimisation in road construction projects of Pakistan. *International E-Journal of Advances in Social Sciences, 5*(15), pp.1470-1473.

Sobotka, A., & Czarnigowska, A. (2005). Analysis of supply system models for planning construction project logistics. *Journal Of Civil Engineering and Management. 6* (1), pp.73-82.

Sundquist, V., Gadde, L. E., & Hulthén, K. (2018). Reorganising construction logistics for improved performance. *Construction Management and Economics, 36*(1), pp.49-65.

Thomas, H., Hornman, M., Lemes de Souza, U. and Zavrski, I. (2005). Reducing variability to improve performance as a lean construction principle. *Journal of Construction Engineering and Management, 128*(2), pp.144-54.

Tserng, H. P., Yin, S. Y. L., & Li, S. (2006). Developing a resource supply chain planning system for construction projects. *Journal of Construction Engineering and Management, 132*(4), pp.393-407.

Voigtmann, J., & Bargstadt, H. (2010). Construction logistics planning by simulation. In B. Johansson, S. Jain & J. Montoya-Torres (Eds.), *Proceedings of the 2010 Winter Simulation Conference*, *Baltimore Maryland*, 5-8 December 2010. pp.3201-3211. Winter Simulation Conference.

Wang, Y., Caron, F., Vanthienen, J., Huang, L., & Guo, Y. (2014). Acquiring logistics process intelligence: Methodology and an application for a Chinese bulk port. *Expert Systems with Applications, 41*(1), pp.195–209.

Zeng, A. Z., & Rossetti, C. (2003). Developing a framework for evaluating the logistics costs in global sourcing processes: An implementation and insights. *International Journal of Physical Distribution & Logistics Management, 37*(3), pp.1235-1248.