ASSESSING REVERSE LOGISTICS IN SOUTH AFRICAN CONSTRUCTION

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ABSTRACT

The purpose of this paper is to advance the benefits of an efficient reverse logistics system in construction. The paper argues that building material and waste removal operations could be optimized by the application of reverse logistics in a construction context.

Though the larger research entails extensive use of a number of qualitative approaches, this particular paper reports on a multi case study investigation conducted in the City of Cape Town.

Present knowledge of logistics in general and transportation in particular, within South African construction is relatively limited. Emphasis is more frequently placed on supply chain management (SCM) without reference to the fundamental need to understand its pre-eminent subsets, such as transportation. For instance, building materials and waste removal transport operators in construction still operate as independent businesses. As a result, these vendors do not synchronize their operations.

The utilization of reverse logistics in a construction context could improve vehicle utilization and reduce vehicular movements while simultaneously improving the service being provided to customers. In other words, there appears to be a major scope for reducing wastes related to unnecessary movement, conveyance and unnecessary motion in the process.

KEYWORDS

Construction, Reverse logistics, Supply Chain Management, South Africa

BACKGROUND

A well functioning logistics system is a set of interacting elements, variables, and parts or objects that are functionally related to one another and form a coherent group (Bowersox *et al. 20*02; Coyle e*t al.* 2003). Past research studies that addressed logistics from the lean construction perspective suggest that the industry can benefit from the role of logistics centres by employing material aggregation on different projects (Hamzeh *et al*. 2007); and the use of standardized processes and solutions (Elfving *et al.* 2010). Transportation as one of the most visible elements of logistics operations forms the basis of this discourse (Bowersox *et al.* 2002). This came about since the transportation system is arguably the physical link that connects customers, raw material suppliers' plants, warehouses and channel members in the logistics

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system. Typically, transportation represents a major cost component of the logistics supply chain. Transportation costs represent approximately 39 to 58% of total logistics costs and up to 4 to 10% of the product selling price for many companies (Coyle *et al.* 2003).

To improve vehicle transits, logistics managers can use supply chain optimization tools such as reverse or back-haul logistics management (Bowersox *et al*. 2002; Coyle *et al.* 2003). Reverse logistics uses various methods to give scope for back-loading of finished products, components, waste and reusable packaging from consumers to manufacturers or suppliers (Vaidyanathan 2005). Back-loads or logistics against the forward flow, allow manufacturers to reduce costs by using distribution vehicles' return journeys to create income or value. In the simplest sense, reverse logistics happens by a distribution vehicle picking up pallets previously deposited at the warehouse where it makes its deliveries. This concept is now being developed to create novel solutions to the reduction of pollution, costs and vehicular movements, while maintaining high customer service levels. In essence it would introduce the concept of 'lean' in the system (Court *et al*. 2005; Isatto and Formoso 2006). This paper begins with an explanation of logistics and how the coordination of transportation can be improved in construction. It then proposed the use of the concept of reverse logistics in construction. From the conceptualisation of reverse logistics in construction, a case study that examined the phenomenon is presented. Based on the findings of the case study, a model that support the argument for the use of reverse logistics is thereafter discussed.

CONSTRUCTION LOGISTICS

Understanding the dynamics of transportation requirements is a key competency required for cost control and reduction. However, current knowledge of logistics in general and transportation in particular within construction is relatively limited. Emphasis is more frequently placed on supply chain management (SCM) without real reference to the fundamental need to understand its pre-eminent subsets, such as transportation. The main reason for this emphasis has been cited as the organisational structure of the construction industry that is deemed to be prohibitive to the development of efficient logistical systems (Van Herk *et al. 20*06).

An additional problem is that the movement of construction materials from the point of production to the point of consumption could be uncoordinated and inflexible (Vogt *et al*. 2002). The majority of construction materials suppliers have their own dedicated vehicles and delivery schedules, delivering *'ad hoc'* to various locations. As a result, the method most commonly used to deliver materials to construction sites is that of dedicated, single use vehicles such as cement and concrete-carrying trucks from manufacturers to points of consumption on sites. Materials such as wooden frames, plasterboard and bricks are also delivered in the same way. Concerns regarding gridlock and pollution on public roads have led to increasing analysis of approaches to controlling the flow of traffic in large cities. The reduction of waste materials and increased recycling has also received more attention recently (Bowersox *et al*. 2002; Coyle *et al*. 2003). The benefits of this concept are still largely not being felt in the construction industry. This paper develops the concept of reverse logistics in a construction context in order to improve materials availability while simultaneously improving the management of construction and demolition (C&D)

wastes. Reducing vehicle movements could eliminate non-value adding activities related to conveyance, movement and motion (Forbes and Ahmed 2011).

SCOPE FOR REVERSE LOGISTICS IN CONSTRUCTION

Construction materials delivery and C&D waste removal are usually considered to be separate businesses and activities. A consequence of this separation is that each vehicle type, when moving to or leaving a construction site, moves full in one direction and empty in the opposite direction.

There is, therefore, a significant opportunity to utilise the concept of reverse logistics to achieve process optimisation or 'leanness' (Bowersox *et al*. 2002; Coyle *et al.* 2003, Roper 2006; Kalsaas and Sacks 2011; Azambuja and Formoso 2003). The concept of reverse logistics, operationalised through utilization of spare capacity of either delivery vehicles departing from construction sites or waste management vehicles arriving at sites is elegant in its simplicity. The use of the spare capacity would immediately increase the utility of assets such as vehicles and roads to reduce unit costs, the total number of vehicular movements, hydrocarbon fuel usage and the social costs associated with vehicular transport. Reverse logistics can therefore be seen as a means to improve vehicle utilisation and reduce vehicular movements while simultaneously improving the service being provided to customers.

CONCEPTUALISATION OF REVERSE LOGISTICS IN CONSTRUCTION

There are four approaches for analysing logistics systems: materials management versus physical distribution; cost centres; logistics channels and nodes versus links (Coyle *et al.* 2003). Given that the nature of construction is input versus output from sites, the node versus links approach is by far the most appropriate concept by which to view the logistics system in a construction context. This approach was therefore adopted as the methodological framework for the analysis of the dynamics between construction materials supply and C&D waste removal. The nodes are spatial points where goods stop for storage or processing. The links represent the transportation network connecting the nodes in the logistics system. Figure 1 illustrates the concept. A node versus link approach allows analysis of a logistics system's two basic elements, transportation and the processing of materials. This approach also represents a convenient basis for assessing and analysing the logistics of building materials and building waste transportation to and from sites respectively.

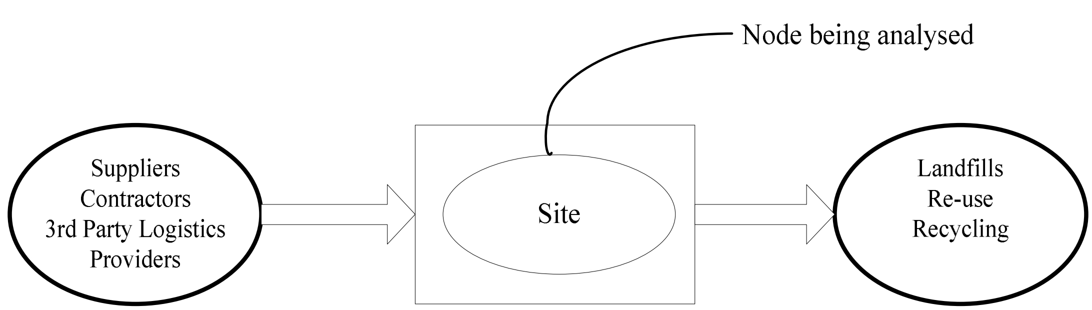

Figure 1: The node versus link in a logistical system
(Adapted from Coyle *et al*. 2003)

It also represents a convenient basis for seeking possible system improvements as it allows analysis of the supplier-site and site–disposal links. The complexity of the logistics system relates directly to the time and distance relationship between nodes and links, as well as to the flow of goods entering, leaving and moving within the system (Kay and Jain 2002; Coyle *et al*. 2003). In this case, only two links needed to be thoroughly investigated because they gave a detailed picture of construction materials delivery to, and C&D waste removal from, sites or within the unit of analysis. By using the node versus link, volumes of both delivery vehicles entering and departing construction sites or waste removal vehicles arriving at or departing sites could be measured. To illustrate the utility of reverse logistics in a construction context, the following case study was conducted on seven (7) sites in Cape Town, South Africa.

THE CAPE TOWN CASE STUDY

A sample of sites that would provide sufficient vehicular movements for analysis within a reasonable time period was identified. Consequently, the selected sites were logistically, rather than statistically significant. The primary selection criterion was physical size of the development. The secondary consideration was that of construction technology. A total of 7 sites were selected for observation, all of which were high rise, mixed use though predominantly residential developments. The contract sum of the projects were above R130m ($16.5m); the contract period ranged from 18 months to 30 months; and the number of housing (flat) units of the projects ranged from 200 to 450 units. Reinforced concrete shell was used mostly on the projects. This represented about 80% of all such developments in the Cape Town metropolitan area at the time of the study. The data from the 7 sites were collected in random order for a period of 5 months. The observations were made until there was enough density of data from each site (up to a minimum of 100 observations). The data were then captured through Microsoft Excel for the purpose of analysis.

A two phase pilot study was conducted during the observation period. The first phase was an exploratory study conducted on a large construction site in the Cape Town Central Business District (CBD). The main purpose of this phase was to identify the types and classifications of vehicles and their cubic and tonnage capacities, as well as the patterns of their movements. It involved both observation of vehicle movements and talking to some drivers and site personnel about vehicular movements to and from the sites that were visited.

The results obtained were used in the design of a template used for data collection during the field study. In the second phase of the pilot study, the template was pre-tested on another large construction project in the Milnerton area of Cape Town to determine the practicality of using the instrument on site and the ease with which data could be captured. Specifically, the aim of the second phase of the pilot study was to test the instrument on a trial run before full use and to examine how it would work in practice. At this stage data capture problems such as the actual loading levels of vehicles were resolved by utilising visual identification of vehicle fill. Depending on the body type, fill was measured by deducting the area of the body length and height that was not taken up by the materials being transported. The observation protocol adopted was full, ¾ full, ½ full, ¼ full and empty. The quarter scale system was more appropriate as it was easy for the researchers to obtain a higher and consistent accuracy. The parameters that came out of the pilot study for establishing the logistics of building materials and C&D waste and for identifying potential improvements were summarised as follows:

- classification of vehicle (material delivery/waste removal);
- number of vehicle movements delivering building materials:
- number of vehicle movements for C&D waste removal;
- state of vehicle on arrival by volume (Full/ ¾ / ½ /¼ / empty), and
- state of vehicle on departure (Full/ ¾ / ½ /¼ / empty).

RESEARCH FINDINGS AND MODEL

Of the 911 vehicular movements to and from the 7 construction sites, 570 were for materials delivery while 240 involved waste removal. There were also vehicle movements related to employees, equipment and 'other' transport, such as for consultants, inspectors and visitors. Figure 2 provides a classification of vehicles that transited the construction sites during the study period.

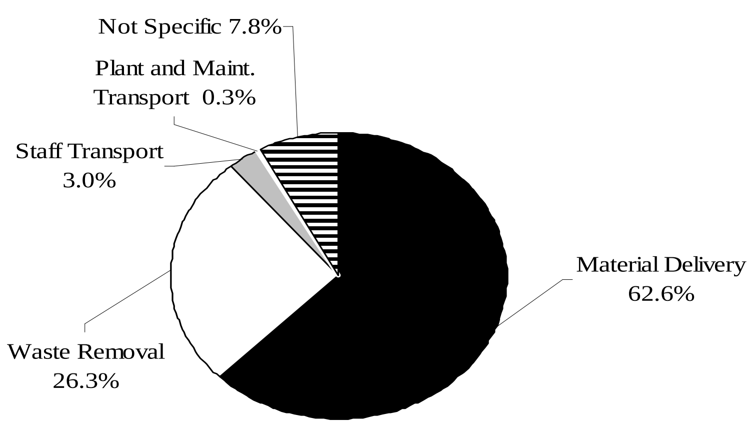

Figure 2: Classification of vehicles arriving on sites

The ratio of 570:240, which was 62.6% to 26.3%, worked out to be 2.4:1. Establishing the ratio was essential as it formed the basic tenet in the modelling process. Figure 3 depicts the volumes of vehicle movements related to the delivery of materials to and removal of waste from sites. The size of the arrows represented the volume of vehicular movements. There was a heavy movement of fully loaded vehicles to and a heavy flow of empty vehicles departing sites. The figure also shows light flows of ¼ full and lighter flows of ¾ and ½ full loaded vehicles. Figure 3 models the state of the logistics of construction materials focusing on vehicle movements related to the delivery of construction materials to and removal of waste from sites. The Figure 3 models the combined state of site logistics results from the field study and highlights the fact that there was a substantial amount of empty runs in the logistical system.

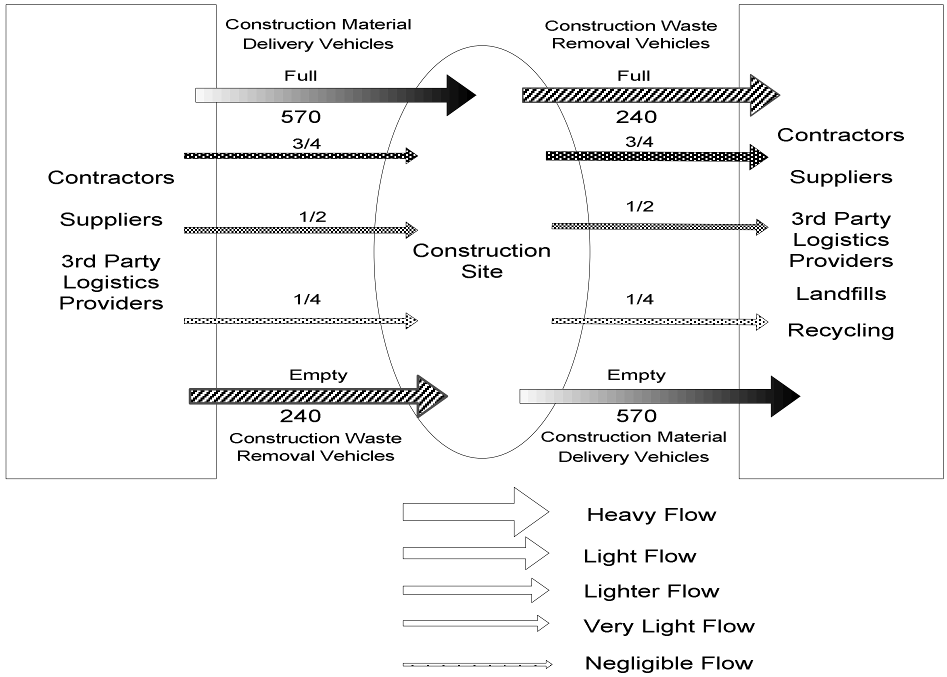

Figure 3: Integrated materials delivery and waste removal logistics

In particular, there was a heavy flow of fully loaded construction material delivery and empty waste removal vehicles on the inbound leg and a heavy flow of fully loaded waste removal and empty materials delivery vehicles on the outbound leg. Using the ratio of 2.4:1 and assuming that the system started with 2.4 fully loaded material delivery vehicle movements delivering materials to sites, there would be 2.4 empty material vehicle movements after offloading. If one of the empty material vehicle movements was fully loaded with waste on its outbound journey then only 1.4 (2.4 - 1=1.4) vehicle movements would travel back empty. If the one waste removal vehicle movement was made to carry material on its way to site then the volume of material being delivered would increase without increasing the total number of vehicles travelling to sites, hence introducing leanness in the process. This scenario is illustrated in Figure 4. In Figure 4, the result of improvement or the utilisation of lean principles shows that the empty vehicles travelling to sites to collect waste could be eliminated because material delivery vehicles could be used to carry waste out to points of re-use, disposal or reclamation. By removing the forward movement of waste removal vehicles, 26.3% of vehicle movements would be eliminated.

To be succinct, the case study in this research showed that in terms of transport distribution, of all vehicle movements observed, 62.6% were classified as materials delivery and 26.3% as C&D waste removal. These percentages translate into a ratio of approximately 2.4 materials delivery journeys to one (1) waste removal journey**.** The significance of this finding is that it generates for the first time in literature a relationship between materials delivery and waste removal vehicle movements expressed in terms of a ratio. In effect, adopting a lean construction approach in terms of the reduction of unnecessary conveyance and / or movement provides a platform for performance improvement.

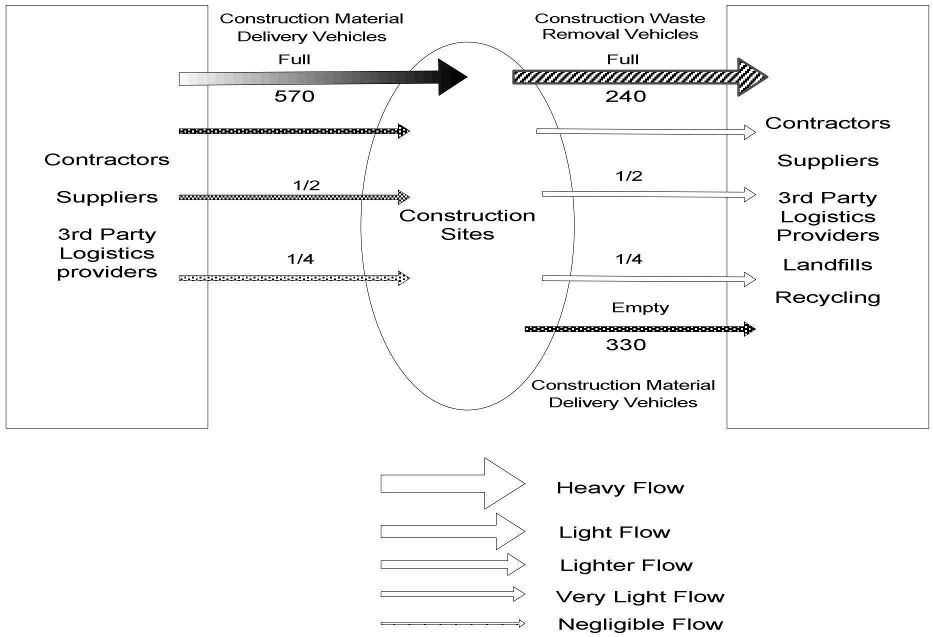

Figure 4: Improved site logistics with the empty waste removal fleet

DISCUSSION

Another issue that emerged from the field study was that the logistics of building materials delivery and C&D waste removal were not integrated and that the vehicle movements for both activities were sub-optimal. This was the case because the field study found that 570 of materials delivery vehicle movements were empty runs on their return journey and 240 C&D waste vehicle movements were empty runs on their forward journey. This was largely due to a failure by the construction industry to back-haul and / or operates in a lean manner. This necessitates the need to implement concepts related to supply chain management (SCM) from the lean construction perspective. Granted that SCM in the lean construction context has being examined to some extent by describing how actors in a specific supply chain interact, how the supply chain operates and what its main problems are, opportunities for improvement, and good practices that can be replicated to other supply chains in construction (Alves and Tsao 2007), however the use of reverse logistics concepts was observed to be limited.

Although, handling of operations in construction in terms of logistics have being addressed from the lean construction perspective in the past (Jacobs 2011), this study highlighted the potential for integration of logistics of building materials delivery and C&D waste removal. Integration would in the end improve the logistics of the construction industry. As the research demonstrated, there is scope for utilization of reverse logistics through utilisation of the available spare capacity. The utilisation of spare capacity would increase the effectiveness of vehicles; reduce unit costs and the number of empty vehicular movements. While integration would improve the process, the study conducted by Briscoe and Dainty (2005) suggests that supply chain integration in construction as espoused within the Egan report has proved rather elusive in practice. Despite the identification of a number of impediments to improved integration, the study provides some evidence of informal, but closer co-operative working between clients, main contractors and subcontractors in several aspects of the construction supply chain. Where collaborative relationships appear to have evolved, the various teams in the construction project have often developed effective systems of communication and information exchange and they have succeeded in aligning their management systems to the benefit of the project (Briscoe and Dainty 2005). This indicates that despite the perception that adversarial culture seems to be ingrained within the industry's operating practices as evident in the mistrust within small and medium enterprise (SME) organisations (Dainty, Briscoe and Millet 2001), innovate ways of improving performance (such as reverse logistics) could be enacted when collaborative relationships exist in the supply chain.

MANAGERIAL IMPLICATION

Although several methods that could improve building and C&D waste logistics were identified in the literature, the use of a consolidated centre and reverse logistics demonstrated the greatest potential for integrating the logistics of transportation related to site construction activities. The findings thus show how the logistics of building material and C&D waste in Cape Town could be improved and the techniques that could be identified to achieve this.

In this context, site managers or agents should work towards reducing wastes related to transportation and motion or rather unnecessary material and people movement related non-value adding activities (Alarcon, 1997) through the use of reverse logistics. Moreso, given the importance of the detrimental effects of wastes in terms of project performance, the supply chain members have to take measurable steps to reduce, and if possible, eliminate them in the construction process (Emuze and Smallwood 2011).

CONCLUSIONS

SCM in construction is a way of working in a structured, organised and collaborative manner shared by all participants in a supply chain. SCM from the lean construction perspective emphasises delivering customer value without compromising the ability of each member of the supply chain to maintain a viable business. Given construction clients' propensity to demand reduction in construction costs, facilitating effective and improved SCM and logistical performance would be an increasingly attractive position for the construction industry. Improved SCM and logistical performance would invariably result in reduced cost, reduced risk and economic sustainability of the construction process.

Primary points of interest to logistics should be the interfaces between parties, exchange of data and development across organizational boundaries. The primary focus of the logistics function in construction, should therefore, be to improve coordination and communication between project participants during the design and construction phases. It should provide accurate scheduling of materials, coordination of supplies and organizational planning and control of the supply chain. It should seek to minimize non-value adding activities related to motion / movement and drive operating and investment costs and time in the supply chain down.

In brief, there appears to be a significant need for an enhanced understanding of logistics in a construction context in order to deliver the full benefits of SCM. This calls for advancing the role of reverse logistics in a construction context and therefore being lean. For example, building materials and waste removal transport operators in construction still operate as independent businesses as indicated in the case study. As a result, these vendors do not synchronize their operations so the concept of reverse logistics was explored and applied in a construction context by modelling the key findings of the field study. The graphical flow model highlighted the potential for reduction in the total number of vehicle movements and reduction in the number of empty runs.

The utilization of reverse logistics in a construction context could improve vehicle utilization and reduce vehicular movements while simultaneously improving the service being provided to customers. In other words, there appears to be a major scope for reducing wastes related to unnecessary movement, conveyance and unnecessary motion in the process. However, the sampling strategy, which was purposive in nature, reduces the generalizability of the findings since the sample is non-random and did not obtain the minimum data set required for statistical analysis. Therefore, the inability to generalise the findings widely could be construed as a limitation of the study.

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