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Measuring the Parameters of Logistics in Construction

Winston M.W. Shakantu
Doctoral Candidate, Department of Construction Economics and Management
University of Cape Town, Cape Town, South Africa

Dr. John E. Tookey
Lecturer, School of the Built and Natural Environment
Glasgow Caledonian University, UK

Professor Paul A. Bowen
Professor, Department of Construction Economics and Management
University of Cape Town, Cape Town, South Africa

Abstract
Effective planning of the logistics function has for some years been considered to be an integral part of an efficient manufacturing process. The issue and practice of efficient logistics is similarly starting to attract interest in the construction sector. Construction is uniquely placed to benefit from improved logistics since construction components and materials are generally of relatively low value and high volume. At present, research in and understanding of the logistics function is addressed through the current fashion for discussing supply chain management (SCM) in the construction industry. However, in order to discuss SCM and its implications, there is an implicit assumption that the logistics function is well understood. This has to be the case since the concept of SCM is that of fully integrating the activities of both suppliers and consumers with an already known and understood logistics process. At present little work has been conducted to ascertain the workings of the logistics process in the construction industry. The aim of this paper is therefore to examine and identify the key parameters that need to be measured in order to start the process of optimisation. The paper then goes on to discuss a proposed methodological framework and research instrument for the conduct of this research.

Keywords
Logistics, Supply Chain Management, Construction, Planning, Processes.

1. Introduction

The received theories of supply chain management (SCM) have been widely reported. Studies have been undertaken by various authors including Winograd and Flores (1986), Stevens (1989), Dale *et al.,* (1994), Hewit (1995) Wegelius-Lehtonen et al., (1996) Burgess (1998), Lambert *et al*., (1998), Marbet and Vankataraman (1998) Larson and Rogers (1998). These are well known and have more recently been enhanced through the contributions of Koskela (1999), Ofori (2000), Briscoe et al., (2001) and Saad *et al*., (2002). All of these studies were founded at least initially upon the extensive and growing degree of SCM in the manufacturing industry. Research has been driven by the need to improve the efficiency with which the construction industry operates its supply network (Briscoe *et al*., 2001). Because other sectors of the economy such as vehicle manufacturing take a holistic view of supply chain interactions, closer and value-adding relationships between parties have been seen to develop (Lamming and Hampton, 1996).

Following successes in other sectors, a small but increasing number of construction organisations are beginning to adopt SCM principles as a means to improve performance and to address their supply chain relationships. Crucial in the SCM process for the construction industry is the performance of material handling, distribution and information flow in both upstream and downstream linkages (Agapiou *et al.*, 1997; Agapiou *et al.*, 1998; Voordijk *et al.*, 2000; Vrijhoef and Koskela, 2000; Edum-Fotwe 2000; Briscoe *et al.*, 2001). In construction SCM literature considerable focus has been on materials flows and lean production (e.g. Vrijhoef and Koskela, 2000).

However, much construction literature has applied SCM and lean production concepts without the detailed exploration of the logistics function. Where attempts have been made, e.g. in the work of Voordijk (1995) and Voordijk (1999) it was found that the organisational structure of the construction industry prohibited development of efficient logistical systems. However, construction is uniquely placed to benefit from improved logistics because of the nature of materials consumed and the methods and volumes involved. Currently, the movements of construction materials from the point of production to the point of consumption are uncoordinated and inflexible with the majority of construction materials suppliers using own vehicles assigned to dedicated delivery schedules, delivering *ad hoc* to various locations (Agapiou *et al.*, 1997, Agapiou *et al.*, 1998). At present little work has been done to ascertain the workings of the logistics process in the construction industry. This paper examines and identifies the key parameters that need to be measured in order to start the process of optimisation.

2. Construction Site Vehicle Transits

The construction industry utilises millions of tonnes of materials and generates large quantities of waste. Moving these volumes of materials and waste requires millions of loaded vehicle transits. The requirement for transportation is clearly significant. Paradoxically, construction delivery and C&D waste removal are usually considered to be separate businesses and entirely separate issues. Materials delivery vehicles and waste removal vehicles are completely separate issues. A consequence of this scenario 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 some of the concepts of reverse logistics to achieve process optimisation (Coyle *et al.*, 1996). To establish the nature and scope of construction materials and waste logistics it is essential to establish the dynamics of the relationship between materials and waste. It would then be possible to develop methods and systems that can optimise the flow of materials and waste to and from site respectively.

3. Conceptual Framework

There are four approaches for analysing logistics systems: materials management versus physical distribution; cost centres; nodes versus links and logistics channels (Coyle *et al.*, 1996). For problems of such a nature as this paper is investigating, the node versus links approach is most appropriate and has therefore been adopted as the preferred approach for this paper. 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 below illustrates the concept.

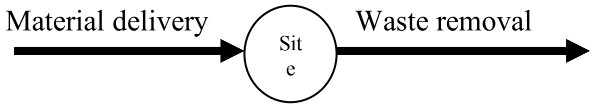

Figure 1: Nodes and Links in a Logistical System
Source: Adapted from Coyle *et al*., (1996: 50)

The node and link perspective in allowing analysis of a logistics system's two basic elements represents a convenient basis for seeking possible system improvements. Coyle *et al*., (1996) notes that the complexity of the logistics system often relates directly to the time and distance relationship between the nodes and the links and to the flow of goods entering, leaving and moving within the system. The node and link perspective gives context to the concept of utilisation of spare capacity of either delivery vehicles departing construction sites or waste removal vehicles arriving at sites. In order to optimise vehicle movements relating to materials delivery and waste removal, it is necessary to establish the parameters associated with such movements.

4. Establishing the Parameters

It has been established elsewhere in this paper that construction delivery vehicles, when moving to or leaving construction sites move full in one and empty in the opposite direction. There is therefore a significant amount of spare capacity, which could be usefully utilised. Utilisation of spare capacity offers a unique opportunity to optimise the process. To start the process of optimisation it is necessary to analyse the logistics of vehicle movements relating to the delivery of construction materials to site and the removal of waste from site. To achieve optimisation it also necessary to establish:

- volume of material being brought to site over the project work package
- number of vehicles delivering these materials over the project work package
- volume of waste generated on site over the project work package
- number of vehicles removing waste over the project work package

For the average site utilising traditional construction technology methods and technology it would be expected that there would be a gradual build up of movements to and from site which would peak around substructure and structure plus fabric and slow down during finishing work, tailing off at completion (Figure 2). Consequently the material supply curve would be skewed as shown in figure 2. The waste removal curve would be expected to be normal as there would be a gradual build up of waste with increasing site activity peaking around end of substructure and middle of structure plus fabric.

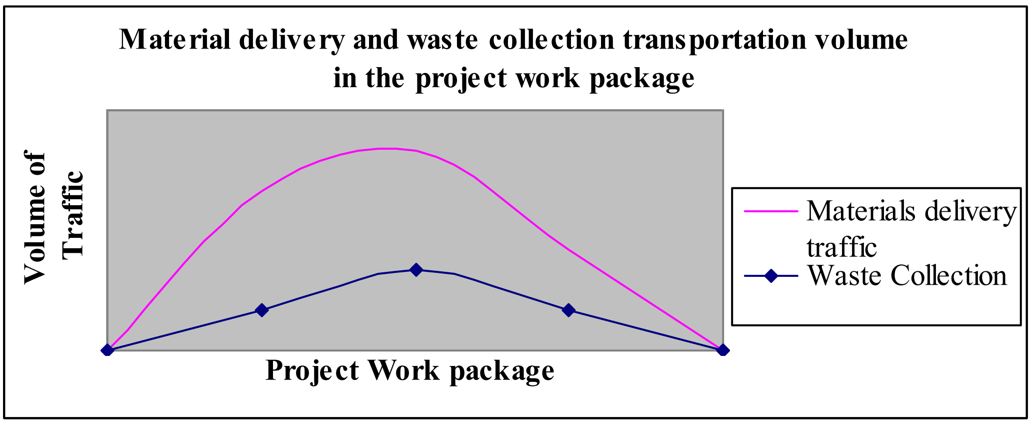

Figure 2: Materials delivery and waste collection transportation volume in the project work package

The parameters required in the first instance would therefore be volumes of material and waste and numbers of vehicles. The parameters will differ with size of site but will show a similar trend when taken over 10 case study sites. On average the parameters will be per unit size of site but measured over the work packages. The variables will be work packages forming the life cycle of each individual project and the types of vehicles used. In order to model the process, additional primary data would be required. This would be for such items as:

- Time of arrival/departure
- Classification of vehicle (material delivery/waste removal)
- Nature of delivery
- Type of consumables
- Location of previous delivery/pick up
- State of vehicle on arrival by volume (Full/Half full/empty
- State of vehicle on departure (full/half full/empty)
- Identification of total vehicle tonnage/cubic capacity
- Identification of the vehicle manifest loading

5. Methodology

The methodological framework envisaged for this research sees the logistics system for construction materials and waste arisings from sites to consist of two main domains:

- The operations and processes associated with delivery of materials to site
- The operations and processes associated with the removal of waste from site to the point of either reclamation, recycling or disposal.

These domains may be described as subsystems within the overall project process and communication occurs within each subsystem and between each subsystem. For each of these domains the dynamics of materials flows and communication patterns need to be established. This will necessitate the use of a multi-case study format. It will involve the analysis of some 10 case studies in Cape Town using a standard observation protocol. More specifically this will entail the examination of:

- Nature of building materials and waste arisings being transported in the city.
- Location and distance of supplier to point of use
- Sorting processes adopted in the streamlining of C&D waste
- The location and distance of point of use to point of reclamation, recycling or disposal.
- Identification of the proportion of transport capacity in use.
- Identification of the nature of packaging system being used.
- Characterisation of the ordering process adopted (i.e. replenishment stocking, co-managed or vendor managed inventory etc)
- Disposal processes being adopted (i.e. private / self / public removal etc)
- Communication modes adopted between supplier, transporters, construction and disposal sites

The data collected will be used for development of conceptual and computer based simulation models using specially selected simulation software (**Simul8**). The objective will be to identify the critical performance characteristics of the construction delivery vehicle fleet. The expected results will be an optimised model of the flow of construction materials and waste from and from site respectively. The resultant model would be validated by testing it on pilot projects in Cape Town. An analysis of the economic and environmental benefits associated with such optimisation will be conducted.

6. Conclusion

The aim of this paper has been to examine and identify the key parameters that need to be measured in order to start the process of optimisation of construction materials delivery and waste removal fleet. It discussed the nature of logistics of construction and the sampling strategy that would be used to establish the rate of loading. The study is timely in that it is pertinent to the industry at a time when business is facing increasing pressure to expand its environmental awareness, improve its environmental performance and provide tangible measures of environmental safeguards. There is spiralling demand for more environmentally empathetic and sustainable construction.

The novelty of the research is in the exploration of the social economic context of sustainability and implementation of the debate by assessing the logistics of materials delivery and waste removal so that optimisation models could be developed. The analysis of transport scheduling, sorting and consolidation of construction materials and waste and assessment of potential benefits of improved logistics and e-commerce as tools for optimising building waste management efficiency would assist with minimisation of environmental impact of construction transport, construction and demolition waste and save money.

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