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Reducing Construction Logistics Costs through Reverse Logistics

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Abstract

The profitability of construction materials delivery and construction and demolition (C&D) waste removal are usually considered to be separate entities – indeed separate issues entirely. However, fundamentally they have at their heart the same core values, i.e. profitability is given by subtracting costs from revenues. In both cases revenue will be dependent on the number of load-carrying journeys undertaken by the contractor. Conversely, not carrying a load on any vehicle is a non-value added activity – rather it is a cost adding activity. Transportation cost pressures on both materials delivery and waste removal are identical, made up of fuel price, direct taxation, maintenance and overheads. The pressure on all these factors is universally upwards and increases with inflation. Conversely, the pressure on revenues is always down, since both activities are subject to extreme competition as a result of the large numbers of small businesses vying for trade. In the future it will be necessary to increase the utility of transportation fixed assets, reduce unit costs, reduce total vehicle movements and hydrocarbon use. There is apparent scope to integrate the two separate functions of materials delivery and waste removal. The logic appears clear since each type of vehicle, 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 utilize some of the concepts of reverse logistics pioneered in the fast moving consumer goods (FMCG) industries. This paper discusses some of the possibilities for using reverse logistics in a construction context in order to improve general construction sustainability.

Keywords

Logistics, Profitability, Materials delivery, C&D Waste, Sustainability

1. Introduction

Commodities used in construction are generally low value and high volume. Therefore construction traffic must constitute a significant proportion of all goods vehicle transits in any urban area. Even relatively modest levels of construction require substantial numbers of goods vehicle transits through an urban area. Thus the costs associated with logistics are a substantial, although largely hidden, cost in the construction process. The construction industry utilises huge quantities of materials and generates very large quantities of waste. A recent UK government report (DETR, 2000) notes that over 90% of non-energy minerals extracted in the UK are used to supply the construction industry, an industry which in turn generates 70 million tonnes of construction and demolition (C&D) waste arisings annually, of which some 13 million tonnes are materials delivered to site and then discarded unused. 70 million tonnes of C&D waste alone equates to some 3.5 million loaded vehicle transits, assuming that the vehicles transporting waste are loaded to their maximum capacity. When the volume of materials being transported onto sites is taken into account - figures vary but the volume is approximately 10 times that of the C&D waste (Koskela, 1999) - the scale of the problem is manifest.

Research has shown that transportation constitutes between 39 to 58% of total logistics costs depending on the nature of a product. Similarly logistics also constitutes between 4 and 10% of the selling price for any product, again depending on the size and value of manufactured products (Coyle *et al.*, 1996; Bowersox and Closs, 1996). Given the cost/volume ratio of construction materials, a similar or greater level of costs associated with construction materials purchases must be in the form of transportation, likely to be in excess 50% or more of the cost of basic raw materials such as sand. Therefore, understanding the dynamic of its transportation requirement must be a key competency as a means of cost control and reduction. Presently, 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 logistics as the pre-eminent subset of SCM. The main reason for this emphasis has been cited as the complexity and organisational structure of the industry making the adoption of logistics management concepts extremely difficult. In Voordijk (1999) it was found that the organisational structure of the construction industry prohibited development of efficient logistical systems.

The authors contend that transportation decisions directly affect logistics costs. Improved understanding of the transportation problem could help determine how cost, pollution and attributed energy reductions can be made. Given the propensity for governments to legislate against road traffic and the need to reduce both construction costs and environment, resolving the problems of organisational structure and complexity to facilitate effective logistics management will become an increasingly attractive proposition for the construction industry.

2. Construction Logistics Costs

The method most commonly used to deliver materials to construction sites is that of dedicated, single use (e.g. cement lorries) vehicles from manufacturer to point of consumption on site. Typically such materials as wooden frames, plasterboard and brick are delivered in this way. This approach offers utility to the manufacturer in that they can load a vehicle with a single material type at the point of production. However at the point of consumption there are significant disadvantages in this approach, in that there will tend to be multiple deliveries that need to be unloaded from multiple vehicles from multiple companies. Very often the traffic problem into and out of sites will be substantially aggravated by the fact that often a vehicle is also only delivering small amounts of materials. This latter case is disproportionately disruptive since a vehicle that is partly loaded will take up the same space, manpower and time to move in and out of a site as that of a fully loaded vehicle.

Construction transportation costs are made up of fuel price, taxation (vehicle tax, road tax, licences etc), maintenance and overhead costs (labour, administration, buildings, obsolescence, depreciation, warehousing (Brook, 2001; Ashworth and Hogg, 2002; Fellows *et al.*, 2002). In addition, infrastructure and environmental costs are increasingly being passed on to the motorists (Banister and Button, 1996; Christopher, 1998; Banister *et al.,* 2000; Vigar, 2002). Currently, the movements of construction materials from the point of production to the point of consumption are uncoordinated and inefficient. The majority of construction materials suppliers have their own dedicated vehicles and delivery schedules, delivering *'ad hoc'* to various locations. More often than not, adjacent sites in areas of rapid development fail to synchronize their activities and substantially add to their inherent problems by creating 'bottlenecks' in the road transport system (Shakantu *et al.*, 2002). Moreover, the construction industry manifestly fails to make significant use of the 'back-haul' of waste materials from site out to the points of disposal. This situation results in double handling and an associated increase in vehicular traffic, as additional vehicles need to be made available to remove physical waste from site. The problem of inefficiency therefore magnifies the detrimental effects of significant numbers of construction vehicles transiting through urban areas whilst sub-optimally loaded (McKinnon, 1996; Harrison and van Hoek, 2002). This is a significant problem that needs to be addressed if the industry is to don a mantel of true sustainability as it moves in to the 21^{st} Century.

3. Construction Logistics Revenues

Revenue in any business is the total number of 'units' of business conducted multiplied by the unit price. The unit price that can be charged by a company will be dependent on the competition in the market place, the perceived value added of the activity, customer communications, market coverage, sourcing decisions, pricing decisions, location of processing/manufacturing and customer service decisions (Gattorna and Walters, 1996; Christopher, 1998). In total this can be thought of as the sum price that can be charged for the 'basket of utilities' that a supplier provides to the consumer. However, historically it can be seen that consumers will 'shop around' and thus force down market prices if possible. This results in haulage costs being forced down over time; an ideal situation for customers, but leading to an extremely tenuous existence for haulage contractors seeking to achieve a modicum of economic sustainability for their business.

4. Profitability of Construction Transportation

The profitability of construction materials delivery and C&D waste removal are currently separate entities – indeed separate issues. However, both of these businesses have the same core values i.e.

Profitability = Revenue – Costs.

In both cases revenue will be dependent on the number of load carrying journeys that the contractor is undertaking. Carrying a load on a vehicle is the primary 'value-adding' activity that a haulage contractor can undertake and receive revenue for, whilst not carrying a load on any vehicle is a 'non-value-adding' activity – indeed it is a 'cost-adding' activity. Profitability is synonymous with business sustainability, which in turn is synonymous with service sustainability. Therefore, in order to continue to sustainably provide all of the services that society requires, materials delivery and C&D waste removal, both need to reduce costs and increase revenues. Paradoxically, macro economic pressures force costs up and revenue down. In order to create a paradigm shift within the economic model used by haulers, the most logical approach is to use 'unloaded transits' to generate additional revenue.

5. Reverse Logistics

To improve vehicle transits construction logistics managers can use supply chain optimisation tools such as efficient fuel utilization, load smoothing, consolidation of freight, efficiently selecting carriers, route and vehicle optimisation and reverse logistics - back-haul management. Reverse logistics uses various methods to give scope for a 'back-load' of finished products, components, waste, reusable packing, etc. from consumer to manufacturer or supplier. Back-loads – 'logistics against the flow' - allow manufacturers to reduce costs by using the distribution vehicle's return journey to create income or added value. Often this is very simple – a distribution vehicle picks up pallets previously deposited at the warehouse where it makes its deliveries. The return trip adds value to the process by returning those pallets back to a useful condition (i.e. back at their point of origin) (Stock, 1998). This basic concept is now being developed to create novel solutions to the problems of reducing pollution, costs and vehicle movements, whilst maintaining high customer service levels.

The solution may, therefore, lie in utilisation of the spare capacity of construction traffic and the attendant need to reduce vehicle transits. The concept of utilizing the spare capacity of either delivery vehicles departing construction sites, or waste management vehicles arriving at sites, seems elegant in its simplicity. The use of the spare capacity would immediately increase the utility of fixed assets such as vehicles and roads, reduce unit costs, reduce the total number of vehicles movements, reduce hydrocarbon fuel usage and reduce the social costs associated with vehicular transport. Construction could learn this from operational strategies of fast moving consumer goods (FMCG) industries. Operational strategies in the fast moving FMCG industries include Quick response (QR) developed specifically for the textile industry in order to manage wide product ranges with short product life cycles, high seasonality and high complexity (Lowson, 1999), and Efficient Customer Response (ECR) developed especially for the grocery sector. ECR uses components such as electronic point of sale (EPOS) data, EDI, fast re-estimation and re-orders to drive supply to meet demand. It uses Universal Product Codes (UPC's) to generate and efficiently pass on data into the supply chain (Lowson *et al.*, 1999; Burgess *et al.*, 2001). EDI facilitates data transmission throughout the supply pipeline, allowing the store to link supply with real time demand. EDI technology improves order management and invoice issue throughout the supply chain members. This system integrates firms in order to optimise each stage of the procurement - production - distribution process. Marien (1998) provides a detailed look at the use of QR, ECR and EDI in the FMCG industry.

6. Reverse Logistics in a Construction Context

There are several methods that can be used to apply the reverse logistics concept to the construction context. Three of these are: use of consolidation centres, resource reduction and extended producer responsibility.

6.1 Consolidation Centres (CC)

This method of maintaining levels of material flow to sites whilst reducing total vehicle transits is currently under investigation on large contracts. The concept is to make up mixed vehicle loads at a CC (Brooks, 2003). The CC functions as a warehouse breaking down bulk deliveries into mixed loads for subsequent local distribution. The principle is straightforward in that, manufacturers deliver to a receiving CC rather than to individual sites. Just sufficient materials for a day's work are 'picked' into a mixed load for dispatch. This means that for any one site in operation, it will only normally receive one or two deliveries per day. Also, significant amounts of 'stock on hand' at the site can be eliminated by an approximation to a JIT (Just in Time) delivery process. The traditional delivery regime compared to the revised regime is demonstrated in Figure 1. Brooks (2003) notes that, although there is (of necessity) an increase in handling costs associated with double handling, this is more than offset by the reduction of loss and damage at the point of use. Another substantial benefit comes from the utilisation of the delivery vehicles return trip to collect waste materials for disposal off site. This approach to delivery, inventory management, and waste management the authors contend, holds significant potential for the future process sustainability of construction logistics management in urban environments.

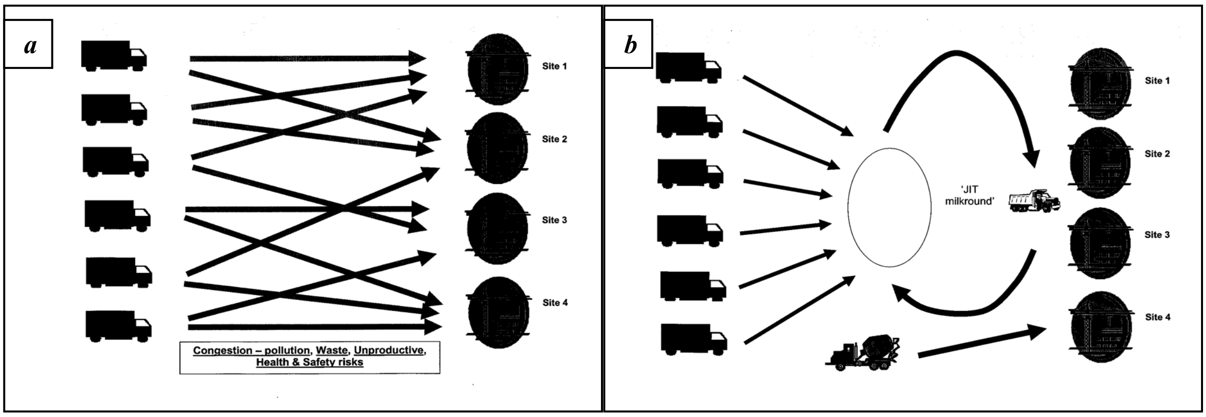

Figure 1: Traditional delivery (a) vs. Consolidation Centre (b) system (in Brooks, 2003)

6.2 Resource Reduction

Construction and demolition (C&D) waste constitutes the waste generated during construction, renovation and demolition. C&D waste commonly includes building materials and products such as concrete, wood, glass, bricks, metal roofing etc. Such a large and complex waste stream presents many opportunities for reducing waste and costs associated with construction activities. Reducing C&D waste can reduce overall project cost by avoiding disposal costs and purchase of new materials and by generating revenue from sale of recycled materials (www.epa.gov/wastewise). To minimise the environmental impact of construction, steps can be taken to re-use and recycle used materials and prevent waste. From incorporating used or environmentally preferable materials into construction or renovation to disassembling structures for re-use and recycling of their components, each phase of the construction life cycle offers opportunities to reduce waste (www.epa.gov/wastewise). Within this evolving environment, a number of organisations are capitalising on reverse logistics systems combined with resource reduction processes to reduce the amount of waste fed into the supply chain and landfills. The reverse logistics process, here, is thought of as 'investment recovery' as opposed to simply minimising the cost of waste management (Marien, 1998).

6.3 Extended Producer Responsibility

Construction materials, especially component type materials, have fixed product lives. They require replacement at their end-of-life stage. The concept of 'extended producer responsibility' (EPR) has emerged as a concept to incorporate negative externalities from product use and end-of-life issues. One of the EPR's is producer take-back requirements at end-of-life. Producers are made responsible to collect and recycle end-of-life products (Murphy *et al*., 1995). The EPR thrust places the 'cradle-to-grave' responsibilities on companies for products and processes (Murphy, 1995). According to Murphy *et al*. (1995), the 'cradle-to-grave' responsibilities mean that business must evaluate a product's entire lifecycle from source of raw materials to final disposal. Reverse logistics, noted Murphy *et al*., (1995), is well suited to deal with these 'cradle-to-grave' issues because reverse logistics' focus is on supply chain management which emphasises the control of materials from suppliers through value added processes on to the customer (Coyle *et al*., 1996). These strategies are currently being used to respond to environmental issues in logistics recycling of materials, reduction of consumption and re-using of materials (Murphy *et al*., 1995). This is in line with frequent references in the literature that 'reverse logistics' is 'all the issues relating to logistics activities carried out in source reduction, recycling, substitution, re-use of materials and disposal', Stock, (1992). Thus, the increasing importance of construction environmentalism suggests that less traditional reverse logistics functions such as return goods handling and salvage and scrap disposal should become more prominent in construction (Murphy, 1995; Carter and Ellram, 1998).

7. Conclusions

Construction logistics forms an integral part of the site production system. An important part of construction logistics is transportation. At present, little work exists on logistics' role within construction, in spite of the oft-referenced works purporting to address the issue of SCM. Given that logistics is an essential element of effective SCM, it would seem wise to address the issue from a construction standpoint. Numerous questions of logistics need to be addressed, including: -

- What is the most effective and appropriate mix of vehicles required to fully service the logistics requirement of a major construction project?
- To what degree should multi-functional vehicles be utilised to provide this service?
- What should the logistics performance criteria that contractors, and other procurers of construction services, use to assess the logistical abilities of those who tender for contracts?
- Would it be most effective to utilise the services of professional logistics management 3rd party providers (3PL) in the provision of construction logistics services?

Without doubt, the role of transportation provides contractors with the ability to position resources in the correct location in order to be able to deliver the final product or service. Transport forms a huge and costly part of the logistical system for the construction industry in particular. It must also be bourn in mind that transportation of construction materials has negative social costs associated with it. The authors feel that there is a tremendous scope for the reduction of Construction logistics costs in particular. However any reduction in total number of vehicle movements for construction materials can have nothing but a positive social and environmental effect. Probably the most effective manner in which these cost savings can be culled from the construction process would appear to be through the increased use of reverse logistics as a means to improve vehicle utilisation and reduce vehicle movements. This approach could be used in conjunction with various other approaches pioneered in other industrial sectors, including consolidation centres, source reduction and EPR.

The research highlighted in this paper identifies the initial conceptual findings of a PhD project being undertaken by the lead author. The objective of the research is to explore these issues surrounding construction logistics, in order to be able to model current logistical flows within the construction process. The ultimate outcome of this effort will be to highlight the ‘choke points’ of the logistical systems currently in operation and therefore be able to recommend the most efficient mix of vehicle types and delivery / pick up strategies necessary to maintain operations at current or enhanced levels whilst simultaneously reducing total vehicle movements. The authors accept the difficulties associated with changing attitudes to logistics in construction. Without doubt the use of reverse logistics will present significant challenges to even the most technically advanced construction supply chains, particularly in the context of dedicated vehicle platforms and cross contamination of new materials vs. C&D waste. However, it is contended that the nature of cost vs. environmental controls necessary to create a sustainable construction industry is evolving rapidly. The introduction of SCM concepts is generally accepted as being a worthwhile goal. However, to do so without addressing the core logistics function implicit to SCM appears illogical. Given the scale of the problem and its inherent cost to the industry, even a small improvement will have a significantly measurable result. Thus the benefits of successful research could be highly significant. Field research has been scheduled to being during the latter half of 2003, and will be reported upon thereafter.

8. References

Ashworth, A. and Hogg, K. (2002) *Willis's Practice and Procedure for the Quantity Surveyor*, Eleventh Edition, Blackwell Science, Oxford.

Banister, D. & Button, K. (1996) “Environmental Policy and Transport: An Overview”, in Banister, D & Button, K (eds.) *Transport, the Environment & Sustainable Development,* E&FN Spon London.

Banister, D., Stead, D., Steen, P., Akerman, J., Dreborg, K., Nijkamp, P. and Scheicher-Tappeser R. (2000) *European Transport Policy and Sustainable Mobility*, E & FN Spon, London.

Bowersox, D. J. and Closs, D. J. (1996) *Logistical Management: The integrated Supply Chain Process*, McGraw Hill, Singapore.

Brook, M (2001). *Estimating and Tendering for Construction Work*, Second edition, Butterworth_Heinemann, Oxford.

Brooks, J. (2003), “Towards a sustainable environment”, unpublished proceedings of *Construction Logistics Forum*, BRE, Scotland.

Carter, C. R. and Ellram, L. M. (1998) “Reverse Logistics: A Review of the Literature and Framework for Future Investigation”, *Journal of Business Logistics*, Vol.19, No.1, pp. 85-102.

Christopher, M., (1998). *Logistics and Supply Chain Management*, 2nd Ed., Financial Times Publishing, London.

Council of Logistics Management (1991) *Logistics Management*, Ork Brook, Illinois.

Coyle, J. J., Bardi, E.J., Langley, C.J. Jr. (1996) *The Management of Business Logistics*, Sixth Edition, West Publishing Co., Minneapolis.

De Burgos Jimenez, J. and Cespedes Lorente, J.J. (2001) “Environmental Performance as an Operations Objective”, *International Journal of Operations and Production Management*, Vol.21, No. 12, pp. 1553-1572.

Department of the Environment Trade and the Regions (2000) *Building a better quality of life: a* strategy for more sustainable construction: HMSO, London.

Fellows, R., Langford, D., Newcombe, R., and Urry, S. (2002) *Construction Management in Practice*, Blackwell Science, Oxford.

Gattorna, J.L. and Walters D.W. (1996) *Managing the Supply Chain: A Strategic Perspective*, MacMillan Press, London.

Harrison, A. and van Hoek, R. (2002) *Logistics Management and Strategy,* Prentice Hall, London.

Hesse, M. (1995) Urban space and logistics: on the road to sustainability? *World Transport Policy and Practice*, Vol. 1 No. 4, pp. 39-45.

Lambert, D.M. and Stock, J.R. (1993) *Strategic Logistics Management*, 3rd Ed., Homewood, Illinois.
Lowson, R.H., King, R and Hunter, A. (1999) "Quick Response: Managing the Supply Chain to meet Customer Demand", John Wiley & Sons, Chichester.
Marien, E.J. (1998) "Reverse Logistics as Competitive Strategy", *Supply Chain Management Review*, Spring, pp. 1-14.
McKinnon, A. C. (1996) "The Empty Running and Return Loading of Road Goods Vehicles", *Transport Logistics,* Vol, 1, No. 1, pp. 1-19.
Murphy, P.R., Poist, R.F. and Braunschweig, C.D. (1995) "Role and Relevance of Logistics to Corporate Environmentalism: An Empirical Assessment", *IJPDL*, Vol. 25, No. 2, pp. 5-19.
Shakantu, W., Tookey, J.E. and Bowen, P.A. (2002) "Defining the role of reverse logistics in attaining sustainable integration of materials delivery with construction and demolition waste management". *Proceedings of 1st International Conference of CIB W107 Creating a Sustainable Construction Industry in Developing Countries,* 11-13 Nov 2002, RSA, pp 97-103.
Stock, J.R. (1992) "Reverse Logistics", Ork Brook Illinois, *Council for Logistics Management*.
Stock, R. J. (1998) "Development and Implementation of Reverse Logistics Programs", Ork Brook Illinois, *Council for Logistics Management.*
U.S. Environmental Protection Agency, on URL: http://www.epa.gov, 27th May 2003.
URL: www.transportenergy.org.uk, 10th June 2003.
Voordijk, H. (1999) "Preconditions and dynamics of logistics networks in the Dutch building Industry", *Supply Chain Management: An International Journal* Vol.3 No. 4, pp.145-154.
Vigar, G. (2002) *The Politics of Mobility: Transport, the Environment and Public Policy*, Spon, London.
Wastewise Update on URL: http://www.epa.gov/epaoswer/non-hw/debris/reduce.htm, 27thMay 2003.
Wu, H. and Dunn, S.T. (1995) "Environmentally Responsible Logistics Systems", *International Journal of Physical Distribution and Logistics Management*, Vol. 25, No. 2, pp. 20-38.