IMPROVING H&S BY LIMITING TRANSPORT EXTERNALITIES IN SOUTH AFRICA

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ABSTRACT

The paper reviews construction transport externalities and their effect on construction workers and public health and safety (H&S) and the contribution of reverse logistics to the reduction of these externalities.

Qualitative approach in the form of "content analysis" led to the primary data that were generated through the study.

The findings suggest that H&S issues relating to construction transport externalities have largely been ignored. This represents a huge omission as the effects of transport externality are a major cause of H&S concerns, which apart from affecting construction workers, also affect the general public. It can be argued that these findings, which may lead to injuries and accidents, work against lean construction philosophy.

The safeguarding of H&S and welfare of construction workers has been a central theme for most H&S research. In particular, much of the literature and guidance on construction H&S has been directed towards reducing the number of accidents on the job and job related physical ailments.

KEYWORDS

Construction, Health and Safety (H&S), Construction Traffic, Transport Externalities, South Africa

BACKGROUND

The construction industry utilises an enormous quantity of materials and generates a very large quantity of waste. The UK and South African construction industries utilize 1000 million and 400 million tonnes of materials and generate 100 million and about 10 million tonnes of waste annually (DETR 2000, Lazarus 2002, Shakantu 2004).

Given the above figures for material consumption and waste generation, the requirement for transportation of materials to and waste from construction sites is clearly significant. For instance, transporting 100 million tonnes of construction and demolition (C&D) waste materials from sites around the UK alone equates to 5 million loaded vehicle transits (assuming that vehicles transporting waste were fully loaded to their maximum capacity). When the volume of materials being transported onto sites, which is approximately 10 times that of C&D waste, is taken into account,

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the shear scale of the transportation problem is manifest (Koskela 1999; DETR 2000).

However, unlike other industries, the construction industry is unable to elect where it should conduct its productive activities. The industry is peripatetic and therefore has to move to where the work is. This inevitably means into the heart of the city and large built up areas. Therefore, in addition to transporting millions of tonnes of materials, the industry also has to transport very large quantities of waste and equipment necessary to work with such waste in cities and built up areas. Moreover, at the end of projects, the industry again has to transport large pieces of equipment and machinery back to the operating bases. In addition, it also has to transport workmen to and from sites on a daily basis leading to motor vehicle accidents (MVAs).

As a result, despite the benefits that construction transport provides the industry, there is also inevitable opportunity cost for construction workers and the general public (Construction Industry Development Board (CIDB) 2009). However, transportation is a significant source of environmental hazards. Smog in urban areas, caused by traffic creates severe health problems for construction workers and the general public. Clearly, these transport externalities are serious environmental problems affecting the quality of life. Increased traffic externalities roll back past environmental gains. Typically, current traffic trends are not sustainable.

Although, IGLC (International Group for Lean Construction) papers have investigated managing safety through production planning and control; developing new approaches to construction safety; using performance measures to improve safety on AEC projects; and forecasting risk levels for workers as a function of time (Alves and Tsao 2007); they have not addressed transport externalises to a major extent. Therefore, this paper argues that by utilising the spare capacity of, either delivery vehicles departing construction sites or waste management vehicles arriving at sites, construction related vehicle movement would be reduced substantially which in turn would reduce the level of environmental hazards and increase the quality of life of workers and the general public and also contribute to a reduction in vehicular accidents.

CONSTRUCTION TRAFFIC

The movement of construction materials transport and those of waste removal transport are totally independent and uncoordinated in South Africa (Shakantu 2009). This is so because the majority of construction materials suppliers and waste management operators have their own vehicles and delivery schedules, delivering ‘ad hoc’ to various locations locally and nationally. As a result, often, the material delivery and waste vehicle operators do not synchronize their activities and substantially add to inherent traffic problems by creating ‘bottlenecks’ in the road transport system.

A further dimension of this problem comes from the fact that construction traffic fails to ‘back haul’ materials from site to points of disposal. This results in an immediate increase in vehicular traffic, as additional vehicles need to be made available to remove physical waste from site. Transporting workers to and from sites also contributes to hazard in the system and to workers.

CONSTRUCTION TRANSPORT EXTERNALITIES

The issue of transport and the environment is paradoxical in nature (Rodrigue 2003). While transport supports mobility, it also results in growing levels of motorization, congestion and environmental hazards such as accidents.

The transport sector is increasingly being linked to environmental externalities, such as, air, noise and water pollution, congestion and accidents (Rodrigue 2003). These problems affect the construction fraternity and the general public alike in the form of construction related injuries, accidents and in worse cases, fatalities.

AIR POLLUTION

Transportation of construction materials and wastes accounts for a significant proportion of vehicular movements in major cities. In the UK, it accounts for 30% of all road freight (Lazarus 2002). Increased construction traffic aggravates air pollution. For instance, for every 100 tonnes of material transported 10 miles, 91kg of carbon dioxide equivalent emissions are produced (Lazarus 2002; Vigar 2002). In addition, transport is the major source of particulate emissions. Particulate matter may be toxic or may carry trace substances absorbed onto them. Particulates are harmful to lung tissue and worsen respiratory and cardiovascular conditions. For instance, smog that often becomes particularly dense during a thermal inversion impairs visibility and then, results in or worsens respiratory problems (Rodrigue 2003; DEFRA 2003).

Other gaseous emissions of environmental concern include carbon dioxide's possible climatic impacts. Carbon Monoxide emissions affect worker productivity and absorption of oxygen in the red blood cells. It also affects respiration of plants by inhibiting photosynthesis. Nitrogen Oxide emissions lead to respiratory difficulties and associated diseases such as Oedema or Emphysema and also infects and irritates the eyes. Sulphur dioxide can result in bronchitis and contributes to acid rain. Volatile organic compounds resulting from incomplete combustion of fossil fuels produce respiratory problems and eye irritations (Rodrigue 2003; DEFRA 2003).

WATER POLLUTION

Transport affects ground water in two ways. Firstly by transport infrastructure taking up considerable space, drainage patterns and the water table are affected. Then, secondly, particulates directly pollute watercourses. There is also direct pollution by surface runoff. Accidental and nominal run off of pollutants and debris from transport sources contaminate surface and ground water. In total, the transport share of water pollution is 4% (Pouliot and Pierce 2003).

NOISE POLLUTION

Noise is a nuisance in urban areas and on sites. Site noise affects communication, which in turn induces psychological and physiological disorders such as stress, tiredness and other disturbances. Vibrations caused by machinery and vehicles on site exacerbate noise pollution (Rodrigue 2003). Road transport accounts for 70% of the total noise emissions of transportation.

The main sources of noise come from the engine and the friction of the wheels over the road surface. Further, travel speed and the intensity of traffic are linked with the intensity of the noise. For example, a truck moving at 90Km/hr makes as much noise as 28 cars moving at the same speed (Rodrigue 2003). Considering that most construction transport is in the form of trucks, the contribution to noise pollution is significant.

ACCIDENTS

Accidents are an inherent danger associated with transport. On a day-to-day basis there are many fatal and serious accidents. A CIDB report entitled "*Construction Health & Safety in South Africa: Status & Recommendations*" revealed that MVAs among other, cause 47% of construction industry related fatalities (CIDB 2009). This corroborates the contention of Smallwood (2002) in a previous publication.

Smallwood (2002) observed that MVAs contribute substantially to fatalities and injuries in construction because of common unsafe transport / traffic practices. Such practices are not limited to non-wearing of seat belts; workers sitting on the sides and beds of vehicles; workers mounting or dismounting from moving vehicles and the overloading of vehicles; and non-roadworthiness of vehicles.

BUILT ENVIRONMENT

Transportation causes structural damage to infrastructure such as road surfaces and bridges. It also causes damage to property through accidents. In addition, corrosive local pollutants emitted by vehicles damage monuments and property and also affect the respiratory health of construction workers and the general public (Vigar 2002; Rodrigues 2003). Apart from the environmental impact and other externalities discussed above, there are other more direct costs related to transportation.

A CASE EXAMPLE

An exploratory study was conducted in a large construction site in the Cape Town central business district (CBD). The main purpose was to identify the types and classifications of vehicles and their volumetric capacities, as well as the patterns of movements. The study involved both observation of vehicle movement and communication with available site personnel.

The site is a residential development project consisting of a reinforced concrete frame structure with brick in-fills. It has 450 single floor units, ranging from 1 to 3 bedroom units. The site was chosen for investigation because of its size and complexity as well as the construction technology used. In other words, the site lent itself to a study of material delivery and C&D waste removal. In total, 241 vehicle movements were captured using a specially designed observation protocol. The data were collected randomly from Monday to Saturday. A total of 6 vehicle types were observed. In terms of vehicle movements, 31 were made by the open type, 3 by closed, 62 by tippers, 1 by skip, 14 by ready-mix concrete trucks and 130 by dump trucks. And in terms of classifications, 100 were classified as material delivery and 138 as waste removal; while 2 were for employee movement and 1 was for plant movement.

For each vehicle movement, the tonnage and cubic capacity of the vehicle was recorded. At the end of the study, all movements made by vehicles of the same tonnage and cubic capacity were collated. In general, it was observed that the categories of vehicle tonnage ranged from 1 to 22 tonnes and from 2 to 32m3 for cubic capacity. It was also observed that the highest number of vehicle movements, totalling 180, was made by the 10m3 vehicles. In addition, 135 movements, the largest number of vehicle movements in terms of tonnage capacity were made by 18 tonne vehicles. It was observed that the 18 tonne 10m3 waste removal vehicle and the 15 tonne 10m3 material delivery vehicles have the highest numbers of vehicle movements. This suggests that these were the most frequently used vehicles on the site. Further consideration of vehicles, especially with regard to selection of the optimum vehicle mix, will have to take the two types of vehicle to consideration. There is equally a coincidence in cubic capacity and proximity in tonnage capacity of the most commonly used material delivery and waste removal vehicles respectively. This significant intersection between the waste removal and material delivery vehicles ideally provides scope for the identification of the vehicle mix for the site.

DISCUSSION OF THE CASE EXAMPLE

Given that transportation waste is one of the eight production wastes (Forbes and Ahmed 2011), limiting of vehicular traffic related to the site is a way forward in terms of the elimination or avoidance of externalities that affect H&S. To achieve this, process visibility must be engendered. The mere fact that some of the vehicles moving into and out of the sites were empty, especially the C&D waste vehicle, shows that transportation constitute an area of non value adding activities that could lead to the manifestation of H&S externalities.

Therefore, invisibility of process in terms of value, flow and the state of key processes must be addressed (Terry and Smith 2011). The goal will be to map the flow of vehicles to and fro the site from end-to-end so that empty vehicular movements can be minimised. Using the lean supply system (Figure 1) proposed by Terry and Smith (2011), wasteful movement / transportation of materials and waste can be reduced if the site manager could:

- Identify high-impact supply chain members and suppliers based on strategic importance, simplicity, resources, capability, willingness, and rationalisation potential;
- Understand the whole supply chain by mapping the current state value stream by focusing on the achievement of goals that are not limited to simplifying the configuration of the supply chain, reducing variability of both supply and demand, and improving visibility;
- Reduce lead times and inventories not required to absorb variability;
- Reduce variability by standardised components;
- Use offsite manufacture and pre-assembly where possible to reduce C&D wastes that are generated on site; and
- Use logistics centres as permanent consolidation points to create kits of parts to be pulled when required for on-site assembly.

In this context, when a climate of collaboration and long-term mutual benefit pervade the material delivery and waste removal logistics system, it should be easy to reduce vehicular movements related to the construction activities that were taking place on the site.

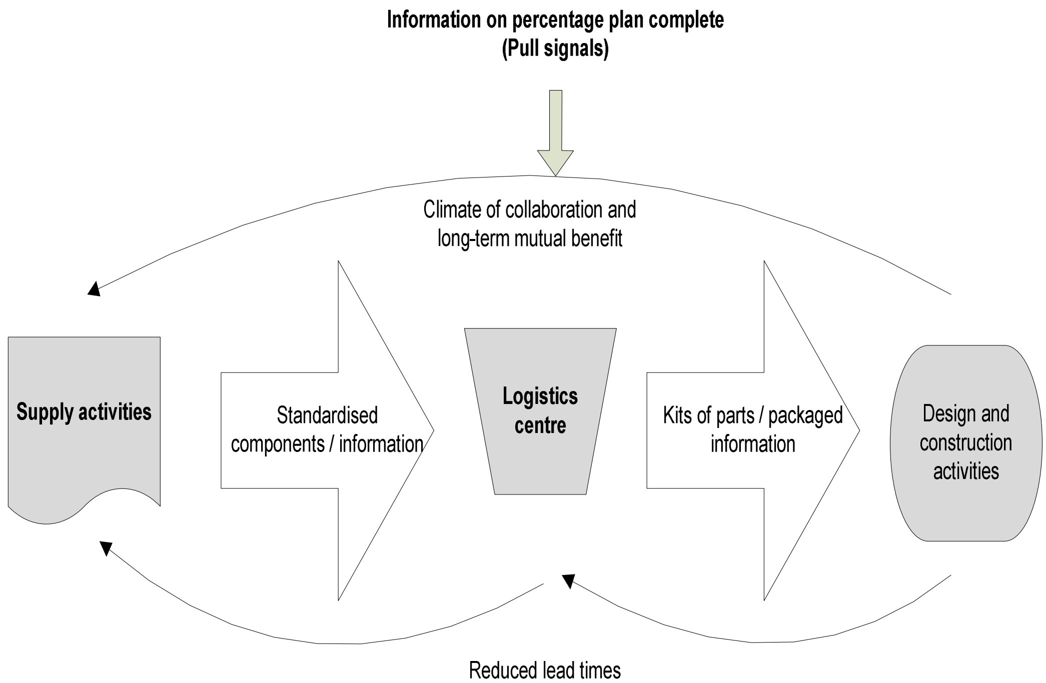

Figure 1: Lean supply system suitable for construction logistics management (source: Terry and Smith 2011: 147).

As indicated in Figure 2, lean thinking principles could engender a culture that will seek to minimise wasteful movement of vehicles related to the construction activities that were taking on the site. The adoption of lean thinking principles should involved site management and suppliers so that construction traffic related to the site will be minimal. And when that is minimal, then transport externalities in the form of air pollution, water pollution, noise pollution and accidents can be reduced.

The idea proposed and represented in Figure 2 is not without challenges. The use of spare capacity for movement of materials and wastes may encounter hiccups among some of the suppliers that are not used to working collaboratively. Although the optimisation of the material and waste transport process should, among others, reduce lead times, improve H&S, and ensure project delivery within allowable cost; a change in the mind set of the project stakeholders is required.

Suppliers should be able to share delivery information on time and they should be flexible about vehicular movement of their materials. Even waste that must depart from site is a huge area of improvement. Most waste removal vehicles come to the site empty and depart the site almost with spare capacity all the time. Looking into out this spare capacity can be used optimally should be considered by all project parties.

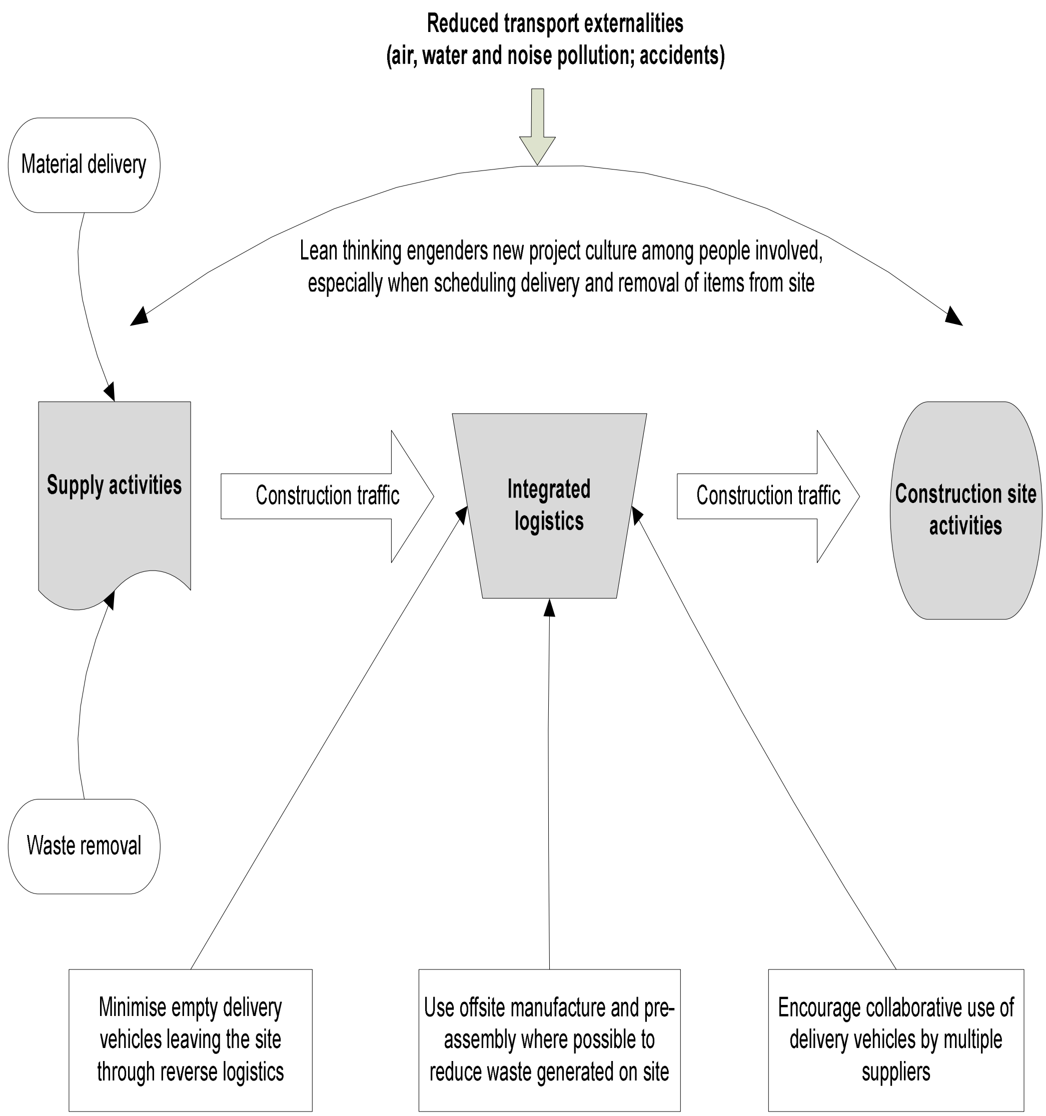

Figure 2 Reducing transport H&S related externalities through lean thinking

THE WAY FORWARD

It is clear from the foregoing that there is an inevitable paradox in the way the construction industry currently operates. On one hand, the industry employs a large number of people and contributes significantly to gross domestic fixed capital formation and creates buildings and structures, which improve the appearance of towns and countryside. The economic activity associated with the construction industry supports other industries that supply it with inputs.

On the other hand, the industry consumes large amounts of energy and resources and also generates large quantities of waste. The generation of physical waste is a manifestation of the inefficient use of resources and the root cause of pollution and associated environmental degradation (Arendse and Godfrey 2001). This results in increased air pollution, noise, accident risk, gridlock, increasing fuel costs and other side effects leading to a reduction in the quality of urban life (Vigar 2002).

Paradoxically, it seems the relationship between construction economic activity and the resulting urban environment tends to be mutually detrimental. Therefore, it is necessary to find a way of carrying out construction activities without increasing the factors that could reduce the quality of life. To achieve this, construction must conduct its activities sustainably. To achieve sustainability, it is necessary to find a method of maintaining the same level of material flow into sites whilst reducing the total number of vehicle transits. In effect, there is a need to introduce elements of 'leanness' in terms of resource usage and construction method (Koskenvesa and Koskela 2011).

There is also a need to integrate the efforts of sustainability in construction with the efforts to reduce vehicle transits (Vieira and Cachadinha 2011). The solution requires the embracing of the seemingly divergent fields of sustainable construction and logistics when managing the construction supply chain. This would seek to integrate and optimize the efficient supply of production with minimized vehicle transits (Elfving *et al*. 2010). The reduction of vehicular movement and use of spare capacity corroborate the argument that there is a relationship between lean construction and sustainability (Vieira and Cachadinha 2011). Through the application of lean tools (such as value steam mapping, just in time, 5S, kaizen, last planner) in the construction processes of a case study, Vieira and Cachadinha (2011) observed that it was possible to establish a parallelism between sustainability and lean construction.

Therefore, a solution may lie in utilisation of the spare capacity of construction traffic. Moreover, given that over 50% of all goods vehicles travelling on roads are empty or less than full, the concept of utilising spare capacity should become an attractive solution and should assume a significant urgency (Harrison and Hoek 2002). 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 reduce the total number of vehicles movements and the social costs associated with vehicular transport.

The reduction of vehicular movement is in tandem with lean construction principles since safety has a significant impact on construction related non-value adding activities (waste) according to Forbes and Ahmed (2011). Forbes and Ahmed (2011) noted that labour hours lost to illness or job related injuries do not add value to the construction process. In the context of lean construction, injuries and fatalities have impacts that work against lean principles (Leino and Elfving 2011). While lean seeks to reduce or eliminate non-value adding activities and deliver more value to clients, accidents have many negative consequences including lost work hours (Forbes and Ahmed 2011). As an illustration, not only does an injured worker reduce the capacity of the work force, but also fatalities may lead to major work stoppages and low morale among workers. Leino and Elfving (2011) also contend that lean direction and zero accidents goal may be communicated together in construction as both approaches share values. They argued that the implementation of Last Planner (LP) and zero accidents programme in a construction organisation in Finland improved employee satisfaction and H&S performance; and lost time accident rate dropped over 80% between 2004 and 2009.

CONCLUSIONS

Construction H&S research has tended to concentrate on the unfavourable site challenges that workers face while executing construction work. Indeed these challenges have been at the receiving end of the latest flurry of H&S reports and legislation.

What have not been as loudly sounded are the environmental H&S effects of construction traffic on construction workers and the general public. This is a serious omission in that construction traffic contributes significantly to noise, air and water pollution and induces psychological and physiological disorders such as stress, tiredness and other disturbances which reduce the productivity of construction workers. This paper has established that by using the spare capacity of construction vehicles, the number of site inbound and outbound vehicles can be reduced considerably. Such a reduction would also have a corresponding reduction in H&S related ailments directly caused by transport to construction workers and the general public.

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