Time Waste And Delays In Construction Projects : A State Of The Art Report

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Abstract : ***Delays in construction sites occur due to systematic additions of time waste in various activities that are part of the construction process. Time waste of a particular activity is the waste in productive time that could have been made productive. Different activities have different reasons that contribute to time wastes of that particular activity.***

Time management for construction activities is not activity oriented, but process oriented. Scheduling of projects using bar charts, milestone charts, Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT) or even Critical Chain Project Management (CCPM) is done to maximize the project value by finishing the project at the earliest by managing various activities most judiciously depending on the sophistication of the method employed. However, these techniques are less activity oriented, if the work is not discretized to minute level.

Studies indicating activity oriented time wastes for reduction in delay are not many. Very few authors have studied certain activities in construction in detail, while the detailed study on time waste generation, its reasons and techniques for its reduction are almost nonexistent.

This paper gives a good insight into all presently available studies pertaining to activity oriented as well as non-activity oriented time waste generation. It is seen that the lean technique implementation has reduced wastages in construction, reducing time wastes in the process. Further, studies explaining delay analysis, ways to reduction of delay and betterment of process are reported by a number of scholars. But time waste studies are nominal and a lot of effort is required to be put into this area of study. In case of delay in construction, which is chronic in today's sites delays are to be eradicated or at least reduced substantially.

Keywords : ***Time Wastes, Time Management, Lean Construction, Construction Activities.***

INTRODUCTION

Time wastes in construction mean activity oriented wastages in time, caused by unproductive work or due to idling. A systematic addition of time wastes in various stages of a project finally ends up causing significant delay to the project. Various studies were carried out to analyze the reasons for the delay and its quantification. However, the study on time waste in construction activities is comparatively less. A study on the Saudi Arabian construction industry by Sadi *et. al* (2005) indicated that 70% of the projects in Saudi Arabia have been

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delayed. However, inspite of large amount of resource investment made for carrying out the study for reduction of time waste, the implementation of the time waste reduction techniques has found fewer acceptances in construction industry.

It is observed that most of the project managers used the terms 'Delays' and 'Time Waste' as synonyms. Various methods have been formulated to reduce delays/time overruns which have been confined to academic interest. Moreover studies on the effect of time waste on delay reduction have been nominal or have been limited to specific areas of construction sector.

The key to reduce delay is to reduce time waste. Studies on delay are available in plenty. But studies carried out on time wastes are comparatively limited to specific activities or processes, in the construction projects. The key to reduce delay lies in reducing time waste involved in each and every activity.

COMPLEXITY OF CONSTRUCTION AND TIME WASTES

Construction, unlike manufacturing or other fields in management or engineering, is highly complex and unique with inherent problems and complexities. Most of the Construction Project Management tools and techniques developed are process oriented rather than activity oriented. Thorough knowledge and details of process involved will help in predicting the risk inherent to that activity. Time wastes occur within activities. Hence a thorough knowledge of each and every activity is required beforehand in case time waste is to be minimized or eradicated. Scheduling of projects with the aid of bar charts, milestone charts, Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT) or even Critical Chain Project Management (CCPM) maximize the project value by planning the project to finish at the optimal duration by managing various activities most judiciously, depending on the sophistication of the method employed. However, these methods still are not activity oriented and do not deal with all types of activities, or the amount of complexity involved.

DELAYS IN CONSTRUCTION

A large number of studies relating to delay of construction projects have been conducted all around the world in various types of economies and varying project scenarios. Studies were conducted in last two decades to identify and analyze the delay in construction projects. Studies carried out in various countries have brought out different primary causes of delay. Aibinu *et. al* (2002) studied effects of delay in Nigerian construction sector and concluded time and cost overruns to be the most frequent causes of delay.

One of the primary causes of delay has been attributed to contractors. Abd El-Razek *et. al* (2008) in his study on the construction sector in Egypt found that the delays are primarily caused by the delays in contractors' payments by the owner, design changes by the owner or his agent during construction, partial payments during construction, non utilization of professional and contractual labour used in construction management.

Beyond contractors, it is seen that the delay is primarily due to errors arising from planning stages. Towhid *et. al* (2011) studied causes of delay in Iranian construction sector and identified 10 most important causes of delay from a list of 6 different effects of delays and 27 causes of delay. They were: poor contract management by consultants, poor site management, delay in progress payment by clients, delay in reviewing and approving design documents by clients, ineffective planning and scheduling of a project by the contractor, slow decision making by the client, delay in producing design documents, problems with subcontractors, change orders by the client during construction

and financial difficulties faced by the contractor. Other primary causes have been attributed to the design phase. Saleh al Hadi *et. al* (2009) studied causes of delay in Libyan construction industry and found 43 factors responsible for the delay. The top three factors responsible were; improper planning, lack of effective communication and design errors. Further, the study identified the following factors as the impact of these delays: loss of interest on stakeholders' part, blacklisting by authorities, wastage of time and money and decline of reputation.

Studies have also shown that in some cases, site conditions are primary factors of delay. Chan *et. al* (1997) in his study surveyed and evaluated the relative importance of 83 potential delay factors in Hong Kong construction projects and found five principal factors: poor risk management and supervision, unforeseen site conditions, slow decision making, client-initiated variations, and work variations.

External factors such as inflation have also been seen to cause delays. Kaming *et. al* (1997) studied influencing factors on 31 high-rise projects in Indonesia and found that cost overruns occur more frequently and are perceived as more severe problems than time overruns. The study pointed out that the major factors influencing cost overruns are material cost increase due to inflation, inaccurate material estimation and degree of complexity. For time overrun, the most important factors that cause delays are design changes, poor labor productivity, inadequate planning, and resource shortages.

Noulmanee *et. al* (1999) investigated causes of delays in highway construction in Thailand and concluded that delays can be caused by all parties involved in projects; however, main causes come from inadequacy of sub-contractors, organization that lacks sufficient resources, incomplete and unclear drawings and problems between consultants and contractors. The study suggested that delay can be minimized by discussions that lead to better understanding. Al-Momani (2000) investigated causes of delay in 130 public projects in Jordan. The main causes of delay were related to designers, user changes, weather, site conditions, late deliveries, economic conditions and increase in quantity. The study suggested that special attention to these factors will help industry practitioners in minimizing contract disputes. Delays have strong relationship with failure and ineffective performance of contractors. Ubaid (1991) discussed the performance of contractors as one of the major causes of delay. Thirteen major measures were considered. These measures are related to contractor resources and capabilities.

At times, political reasons also tend to influence construction process and lead to delays. Ibrahim Mahamid *et.al* (2011) conducted detailed study on delay of road projects in West Bank, Palestine. It identified 52 causes. The study further concluded five severe delay causes of the political situation in West Bank, awarding project to lowest bid price, shortage of equipment, progress payment delay by owner, the segmentation of West Bank and limited movement between areas. Comparative study by Long *et. al* (2008) showed varying causes depending on the area of study (*Refer Table 1*).

WASTES IN CONSTRUCTION

Construction industry produces huge amounts of waste annually that tends to wear down the economy of any nation. A study carried out by Formoso *et. al* (2002) has confirmed that wastes in construction industry represent a relatively large percentage of production cost. Horman et. al (2005) found that on an average, about 49.6% of time in construction is devoted to wasteful activity. Study

Table 1 : Causes Of Delay In Selected Countries Ranked From 1 To 5

	Major causes				
	1	2	3	4	5
Vietnam (This study, 2007) (1)	Poor site management and supervision	Poor project management assistance	Financial difficulties of owner	Financial difficulties of contractor	Design changes
Malaysia (Sambasivan, 2007) (2)	Improper planning	Site management	Inadequate contractor experience	Finance and payments of completed work	Subcontractors
South Korea (Acharya *et al*., 2006) (2)	Public interruptions	Changed site conditions	Failure to provide site	Unrealistic time estimation	Design errors
Hong Kong (Lo, 2006) (2)	Inadequate resources due to contractor/lack of capital	Unforeseen ground conditions	Exceptionally low bids	Inexperienced contractor	Works in conflict with existing utilities
UAE (Faridi, 2006) (2)	Preparation and approval of drawings	Inadequate early planning of the project	Slowness of the owner's decision-making process	Shortage of manpower	Poor supervision and poor site management
Jordan (Sweis, 2007) (2)	Financial difficulties faced by the contractor	Too many change orders from owner	Poor planning and scheduling of the project by the contractor	Presence of unskilled labor	Shortage of technical professionals in the contractor's organization
Kuwait (Koushki, 2005) (2)	Change orders	Financial constraints	Owner's lack of experience	Materials	Weather
(3)	Contractor	Materials	Financial constraints	Change orders	Weather
Ghana (Frimpong, 2003) (1)	Monthly payment difficulties	Poor contract management	Material procurement	Inflation	Contractor's financial difficulties
Nigeria (Aibinu, 2006) (2)	Contractors' financial difficulties	Clients' cash flow problem	Architects' incomplete drawing	Subcontractor's slow mobilization	Equipment breakdown and maintenance problem

(1): Delay and cost overruns; (2): Delay only; (3): Cost overrun only

Source : Adapted from Long *et. al* (2008)

by Landais (2008) showed that a total of 30,000 tons of construction and demolition waste are created every day in Dubai. It can be avoidable wastes, which occur due to lack of pre-planning and unavoidable wastes, which are part of the construction process itself. Study in this area of construction has been limited.

A number of definitions of waste in construction have been put forward by researchers. Nazech (2008) defined "Waste as any inefficiency that results in the use of equipment, materials, labor, or capital in larger quantities than those considered as necessary in the construction process. Waste includes both the incidence of material losses and the execution of unnecessary work, which generates additional costs but do not add value to the product such as delay times, quality costs, lack of safety, rework, unnecessary transportation trips, long distances, improper choice or management of methods or equipment and poor constructability" Lee *et. al* (1999) recognized one reason that waste is not properly recognized is the absence of appropriate tools for measuring waste. Very few data from previous projects are available within the reach of project managers to avoid the causes of waste generated during construction operations.

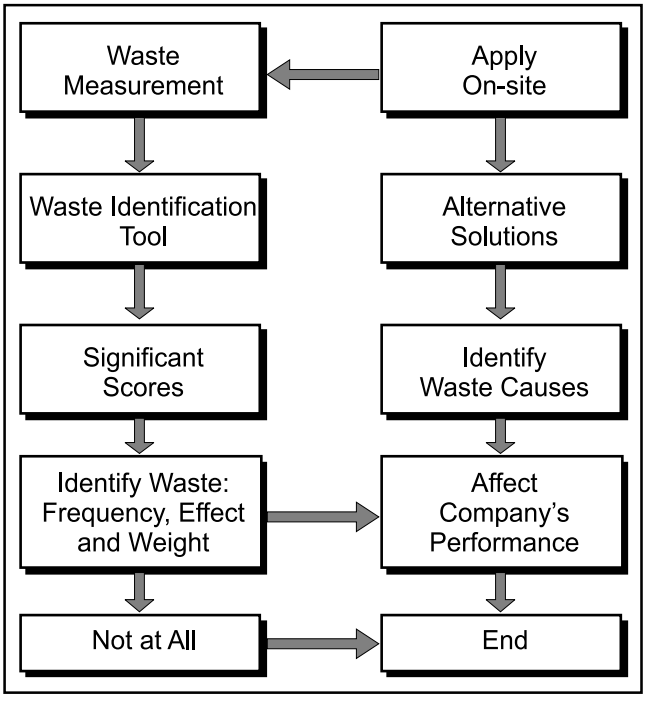
Sources And Identification Of Wastes In Construction

Lack of proper communication leads to waste. Macomber and Howell (2004) identified two reasons for causes of waste, i) Not listening and ii) Not speaking. These causes of wastes are due to poor communication between the client and the contractor. Not asking includes fear of asking top level managers for clarifications on how exactly the work is to be done. The gap that exists between various parties involved in construction is the major problem. Wastes have been quantified as well as

grouped into categories so as to study them in detail. A study by Nazech *et. al* (2008) examines the causes of wastes which divide the entire construction process into three groups of activities: 'Construction processes', 'Structural Works' and 'Materials Management'. Rankings of the causes of the wastes were made for each of the three. It was found that 'Work Execution' ranked the highest among other factors viz. Materials, Manpower, Professional Management, Design and Documentation in all the three group activities.

Lee *et al.*, (1999) studied the identification of waste forms, and the techniques to reduce waste. Lean Construction is a form of waste reduction technique. An important aspect challenging lean construction advocates is the systematic identification and quantification of wastes, improvement verification and development of lean operation. Alwi *et. al* (2002a) developed a flow chart presented in *Fig. 1*. Researchers have been able to carry out regular measurement of waste and obtain benefits including: Providing comprehensive documentation of waste during the process; increasing understanding of waste variables; measuring the contractors' performance; and providing alternative solutions to be applied on-site. This indicates a methodology used by contractors and researchers worldwide for proper measurement of waste. The benefits of this methodology are better understanding of waste variables, measuring the contractors' performance, providing alternative solutions to be applied on-site and providing comprehensive documentation of waste during the process.

Another method of identifying wastes is by using Construction Process Analysis or CPA. It implements process charts and top-view flow diagrams common among process analysis techniques. Lee *et al.* (1999) used Construction Process Analysis technique (CPA) for identifying and quantifying waste in construction operations which revealed the benefits as well as drawbacks of the project. As a communication tool, CPA was used graphically to denote progress of various processes on site. Major wastes at sites identified by this technique were Defects, Over-production, Unnecessary planning, Unnecessary people moves, Unnecessary Movement of Materials, Waiting, Inventories and Designing something that does not meet client's needs. Alwi *et. al* (2002a) investigated the incidence of waste within contracting companies in Indonesia, focusing on nonresidential building and infrastructure projects and found six key factors as major variables responsible for waste namely repair on finishing work, waiting for materials, delays in schedule, slow tradesmen, waste of raw materials on site and lack of supervision. Similar study was conducted by Alwi *et. al* (2002b) on the Australian construction sites and they found fifty-three non value-adding activities. These were further classified into 22 waste variables and 31 waste causing variables. Waste



Source : Adapted from Alwi, S. *et. al* (2002a)

Figure 1 : Method Of Waste Identification

variables were grouped in 5 categories - Repair, Waiting Periods, Materials, Human Resource and Operations. Waste Causing variables were grouped in 6 categories - People, Professional Management, Materials, Execution, Design & Documentation and External factors.

Classification Of Wastes In Construction

Formoso *et. al*, (2002, 1999) formulated a methodology based on the ratio of prevention investment cost of prevention over the cost of waste itself. Wastes have been classified into two general groups namely: natural or unavoidable wastes and avoidable wastes. Natural waste (or unavoidable waste) is the one in which the investment necessary to reduce it is more than the economic benefit it will produce. The amount of unavoidable waste depends on the company and the particular site taken into consideration. Avoidable wastes are those in which the cost of waste is significantly higher than the cost to prevent it. Material wastes and time wastes are important wastes that involve good percentage of avoidable wastes.

TIME WASTES

Alwi (2002b) in his study stated that construction industry researchers and practitioners acknowledge that there are many wasteful activities during the design and construction process. The majority of these activities consume time and effort without adding value for the client. However Koskela (1992) emphasized that construction tasks consist of process time, inspection time, move time and wait time other than process time; all others are non-value adding (or waste). All value adding time belongs to process time, but not all process time is value adding Process time incorporates all value adding activities, but the vice versa is not true. Further study made by Polat *et. al* (2004) found that processes are also subject to wastes resulting from overproduction, wrong construction methods, defects, and poor optimization in performance tasks.

Time waste occurs as a result of a number of factors. Serpell *et. al* (1995) carried out an extensive research on the relevant factors that caused waste in production time for construction in Chile during 1990 to 1994. The study focused on the waste, identified the most relevant factors responsible for waste of productive time i.e. waiting time, idle time and travelling time, indicated as the main subcategory of non-contributory work (waste) which, explained 87% of the total value of the waste.

Other major factor causing time waste is 'waiting time'. Nazech *et. al* (2008) stated that waiting time is related to the idle time caused by lack of synchronization and leveling of material flows, and pace of work by different work groups or equipment. One example is the "idle time caused by the lack of material or lack of work place available for a group". Further studies by Garas *et.al* (2001) identified similar 9 primary areas of time wastes. They were Idle time (Waiting Periods), Stoppages, Clarifications, Variation in information, Re-work, Ineffective work (errors), Interaction between various specialties, Delays in plan activities and Abnormal wear of equipment. Findings of studies on time wastes conducted by Polat and Ballard (2004) on 116 contractors in Turkey are shown in *Table 2*.

Time wastes in most cases remain hidden unlike material losses. Moreover time wastes are considered as secondary loss, which depends on some other losses. Ramaswamy *et. al* (2009) divided waste in construction into four categories namely, material, quality, labour and equipment (*Refer Fig. 2*). Lack of quality of work leads to rework which is indirectly a time waste. Further, labour and equipment cause wastages of waiting, idle time, transportation,

unwanted processing and excess movements. All these cause wastage of time and hence lead to lag in the project itself. Except for material wastes, all other waste factors identified by Ramaswamy and Kalindindi have some connection with wastage of time also.

Al-Moghny (2006) highlighted time wastes in his study, 'Wastes in Construction in Gaza Strip, Palestine'. He found out 92 factors responsible for time waste. These factors were distributed into 5 groups, mainly: Design and documentation, Material, Operation, Site management and Practices. The study revealed that the site supervision group was the major cause of time waste and the materials group the least. Study conducted by Faridi & El-Sayegh (2006) on delays for construction projects in Dubai showed that the delays in preparation of drawings and designs as the most frequent cause of the delays in Dubai. Inadequate early planning, slowness of the owner's decision making process, shortage of man power, poor supervision and poor site management, productivity of manpower, skill of manpower, non-availability of materials on time and obtaining approval from authorities, financing by contractors during construction were identified as other major causes.

Quantification Of Time Wastes

Terge Kalsas (2010) developed a method to quantify work waste time of activities, based on a study

Table 2 : Causes Of Time Waste

Source	Causes of Time Waste	Frequency (%)
Design	Interaction between various specialist	19
	Re work due to design changes and revisions	13
	Lack of information about types and sizes of materials on design documents	10
	Error in information about types and sizes of materials on design documents	6
	Contradictions in design documents	3
	Delays in approval of drawings	3
Procurement	Delays in material supply	72
	Receiving materials that do not fulfill project requirements defined on design documents and waiting for replacement	53
	Delays in transportation and/or installation of equipment	6
Operation	Scarcity of crews	29
	Unrealistic master schedule	23
	Re work due to worker's mistake	16
	Scarcity of equipments	13
	Waiting for design documents and drawings	9
	Lack of coordination among crews	8
	Choice of wrong construction method	5
	Accidents due to lack of safety	4
Other	Irregular cash flow	39
	Severe weather conditions	35
	Bureaucracy and red tape	6
	Unpredicted local conditions	6
	Acts of God	5

Source : Adapted from Polat, G. and Ballard, G, 2004

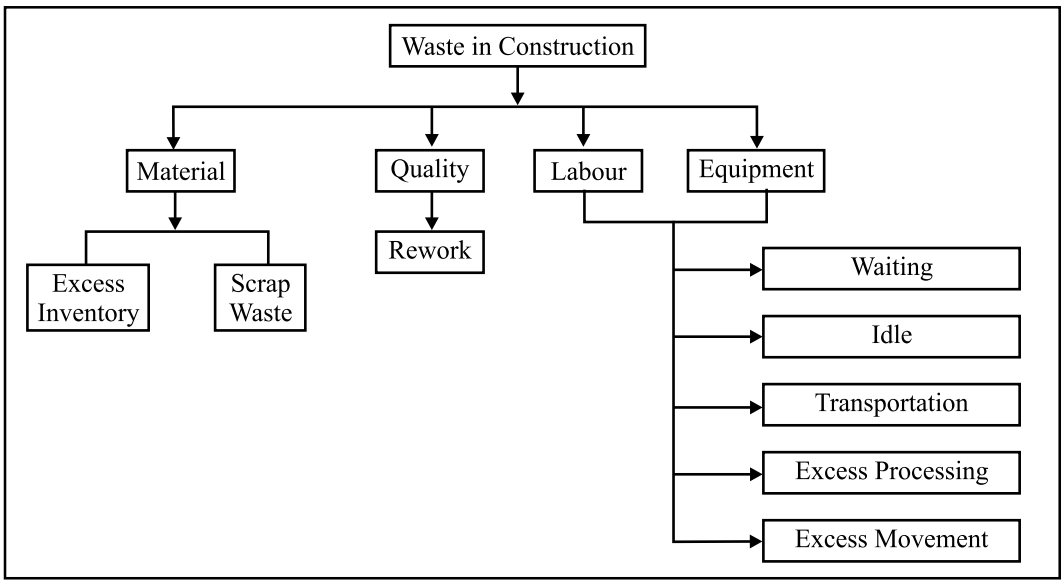
of reports of time wastes carried out by the heads of a selected group of activities such as Plumbing, Electrification etc. It was seen that the more the subdivided the data, the more was the uncovered waste. The finding proved that 17% of working time constitutes pure waste.

A study by Horman *et. al* (2005) used statistical meta-analysis of a number of construction activities whose time waste was found by numerous other studies. This analysis revealed that 49.6% of all activities are time wastes.

TIME WASTE REDUCTION & LEAN TECHNIQUES

With the birth of Lean Construction in 1992, the 'lean techniques' in manufacturing sector were adopted in construction industry. Lean techniques involve techniques to reduce non value adding activities. Any reduction of non-value adding activities reduce waste, which eventually reduces time waste of the project. Lean techniques are not fully activity oriented, but do tend to influence activities using 'lean tools'. For example, 'Daily huddle meetings' is a type of a lean technique that has been implemented successfully. It by itself is a small activity that is incorporated in the project process, which helps to reduce waste by improving co-ordination and control within the teams.

Lean techniques are totally focused on reducing non-value adding activities and hence waste. There are a few evidences of reduction of time wastes using lean techniques. Pilot studies made by AlSehaimi *et.al* (2009) on the implementation of Last Planner System (a lean technique) in Middle East construction projects showed an early completion of various activities involved. The process involved identifying waste causes in the first phase of the study and further implementation of Last Planner System(LPS) in the second phase. Based on the experiment, the project productivity was seen to increase. The Percentage Plan Complete (PPC) was seen to range from 16.67% to 100%, with an average of 55.84%. It was eventually observed that wastes have been reduced in the process, but not well quantified or documented.The lean techniques in waste reduction were applied in construction of certain buildings India.



Source : Adapted from Ramaswamy, K. P. and Kalindindi, S. N, 2009.

Figure 2 : Wastes In Construction

CONCLUSIONS

Time wastes are activity oriented wastes that occur due to unproductive work and it leads to project delays. The main findings of this study are :

- Delay analysis of projects has been conducted extensively worldwide.
- Very little study has been carried out in detail on the entire construction process regarding time waste although partial studies pertaining to certain activities have been carried out.
- The units of time waste; for the purpose of quantification, have not been identified by any scholarly work.
- Extensive research is required into activity oriented time wastes in construction. Study needs to be carried out on reason, causes and remedies for reduction in time waste.
- Lean techniques adopted from manufacturing may help in reduction of time waste; but extensive study needs to be carried out to adopt the lean practices in reduction of time waste in construction process.
- There is a need to conduct a study to identify causes of time waste in building construction projects and further identification of factors that are internal and external to the project. The influence of these factors on each activities obtained by discretizing the construction project into manageable units need to be studied along with its relative importance and its interrelationship. This interrelationship between activities and between time waste factors needs to be studied.
- A model to analyze the time waste, needs be developed to analyze the time waste and reduce conflicts in construction projects.
- The data on time wastes for a project is expected to depend widely on type of construction, methodology/techniques adopted, man power available, socio-economic situations in the region, climatic conditions etc. Hence a probabilistic model or a fuzzy model will be more appropriate to model it. This model can be utilized to predict the time waste & reduce the conflicts inside.

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