WASTE IN TURKISH CONSTRUCTION: NEED FOR LEAN CONSTRUCTION TECHNIQUES

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ABSTRACT

Waste has been considered to be a major problem in the construction industry. Not only does waste have an impact on the efficiency of the construction industry but also on the overall state of the economy of the country. Contractor firms have begun to seek ways of increasing their competitive advantage in global markets by removing all kinds of waste inherent in the construction process by means of implementation of lean construction techniques. The Turkish construction industry also encounters severe problems resulting from huge amounts of waste. This paper aims to identify the main waste causes in the Turkish construction industry in order to establish an initial framework for future studies to develop methods for prevention and elimination of waste causes inherent in the construction process. For this purpose, a survey of 116 contractors, 30 of which are also project consultants, was conducted. The survey revealed the types and frequencies of waste in the Turkish construction industry. Once the main waste causes are identified, a set of recommendations are proposed for eliminating waste inherent in the Turkish construction industry.

KEY WORDS

Materials waste, time waste, waste causes, lean construction techniques

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INTRODUCTION

In the past two decades, great performance improvements have been obtained in the manufacturing industry by means of increasing productivity. A major factor in this achievement was the implementation of the new production philosophy, a.k.a. "Lean Production", which provides a continuous improvement in the production process by removing various types of waste (Lee et al., 1999). While manufacturing attained great results, the construction industry still encounters severe problems resulting from huge amounts of waste.

It is commonly acknowledged that a very high level of waste exists in construction. Since construction has a major and direct influence on many other industries by means of both purchasing the inputs from other industries and providing the products to almost all other industries, eliminating or reducing waste could yield great cost savings to society (Arditi et al., 1985).

The Turkish construction industry also experiences severe problems resulting from huge amounts of waste. As construction is a locomotive sector of the Turkish national economy, waste is not therefore confined only to the construction industry but also affects the state of the overall economy of the country.

This paper aims to identify the main material and time waste causes in the Turkish construction industry, and to establish an initial framework for future endeavors associated with prevention and elimination of waste inherent in construction. For this purpose, a survey of 116 Turkish contractor companies, 30 of which are also project consultants, was conducted. The survey revealed that there are a significant number of waste causes in the Turkish construction industry resulting from lack of lean thinking philosophy.

An overview on waste in construction is presented, followed by a report on the survey and its findings, and concluding with recommendations for action on the part of researchers, individual contractors, the Turkish Contractors' Association, buyers of construction services, and the national government.

WASTE IN CONSTRUCTION

DEFINITIONS OF WASTE

The basic idea of lean production is eliminating all kinds of waste for fulfillment of customer requirements in a better way (Womack, 1999). Koskela (1992) 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 production of a building". A simple way to define waste is "that which can be eliminated without reducing customer value". It can be activities, resources, rules, etc.

Taiichi Ohno (1988) determined the seven basic types of waste in production, and Womack and Jones (1996) added one more waste type to them. Eight basic types of waste are classified as follows:

1) defects that must be corrected,
2) overproduction (producing more or doing more than is needed),

3) inventory,
4) unnecessary processing steps,
5) transportation of materials with no purpose,
6) motion of employees with no purpose,
7) waiting by employees for process equipment to finish its work or for an upstream activity to complete,
8) goods & services that do not meet customer needs (Womack and Jones, 1996).

According to Formoso et al. (1999), waste can be classified as *unavoidable waste* (or natural waste), in which the investment necessary to its reduction is higher than the economy produced, and *avoidable waste*, in which the cost of waste is higher than the cost to prevent it. The percentage of unavoidable waste depends on the technological development level of the company (Womack and Jones, 1996; Formoso et al., 1999).

Formoso et al. (1999) stated that waste can also be categorized according to its source; namely the stage in which the root causes of waste occurs. Waste may result from the processes preceding construction, such as materials manufacturing, design, materials supply, and planning, as well as the construction stage (Formoso et al, 1999). Bossink and Brouwers (1996) classified the main waste causes in construction in 6 sources, which are;

1) Design
2) Procurement
3) Materials Handling
4) Operation
5) Residual
6) Other.

Waste in construction is defined as "the difference between the value of those materials delivered and accepted on site and those used properly as specified and accurately measured in the work, after the deducting cost saving of substituted materials and those transferred elsewhere" (Pheng and Tan, 1998). Lee et al. (1999) classified construction waste in 8 groups, which are; delay times, quality costs, lack of safety, rework, unnecessary transportation trips, long distances, improper choice or management of methods or equipment, and poor constructability. Garas et al. (2001) grouped construction waste into two principal components: 1) time wastes including waiting periods, stoppages, clarifications, variation in information, rework, ineffective work, interaction between various specialists, delays in plan activities, and abnormal wear of equipment, and 2) material wastes comprising overordering, overproduction, wrong handling, wrong storage, manufacturing defects, and theft or vandalism.

MAGNITUDE OF WASTE IN CONSTRUCTION

Bossink and Brouwers (1996) indicated that 9% of total purchased materials end up as waste (by weight) and from 1% to 10% of every single purchased construction material leaves the site as solid waste (by weight) in the Dutch construction industry. They also stated that in the

Brazilian construction industry, 20 – 30% of the purchased materials are not used and end up as waste. Since materials account for 50 – 60% of a construction project cost, any improvement avoiding material waste results in major cost savings (Akintoye, 1995; Wong and Norman, 1997; Ibn-Homaid, 2002). The second type is time wastes. The duration of construction tasks consists of process (and reprocess or rework) time, inspection time, move time, and wait time (Koskela, 1992). Only process time is considered to be value adding activity. The remainders are non-value adding activities (Koskela, 1992). However, even though all value adding time belongs to process time, not all process time is value adding. Processes are also subject to wastes resulting from overproduction, wrong construction method, defects, and poor optimization in performing tasks (Pheng and Tan, 1998). Koskela (1992) defined value adding activity as "activity that converts material and/or information towards that which is required by the customer".

Apparently, waste is a major problem in the construction industry. The focus therefore should be on both identification and elimination of material and time waste with an aim of improving project performance, namely increasing value for the customer, and reducing consumption of resources in society.

Following Garas et al, this study is limited to two types of waste: material waste and time waste.

SURVEY DESIGN AND DATA COLLECTION

This survey attempts to identify the main causes of material and time waste in the Turkish construction industry, and to identify actions taken in the case of loss. Commonly, five different types of survey techniques are used, which are; 1) direct observations, 2) diaries, 3) interviews (face-to-face), 4) mail surveys, and 5) telephone surveys (http://www.deakin.edu.au/~agoodman/sci101).

Of the 300 questionnaires delivered to the contractors, a total of 116 forms were fully completed and returned. Of these 116 contractors, 30 were also project consultants. The survey was carried out through a combination of means; namely, face-to-face interviews (54 firms), and via e-mail (34 firms) and fax (28 firms).

The major problem with conducting a survey is maximizing the response rate. It is commonly acknowledged that the less a survey uses face-to-face questioning; the lower the response rate. Thus, interviews were the appropriate means for administering the survey in order to get a high response rate.

There are two types of questions used in surveys, which are 1) open-ended, and 2) closed. If most of the possible answers and which data is needed are exactly known, it is better to use nothing but closed questions (http://www.deakin.edu.au/~agoodman/sci101). Since this was the first study regarding waste in the Turkish construction study, it was very hard to predict the possible answers and give the respondents a finite number of choices from which they could select the most appropriate answers. Therefore, open-ended questions were preferred in order not to limit or guide the thinking of the practitioners, and to establish the skeleton around which the closed questions can be placed in future studies.

Since open-ended questions were preferred in this survey, the similar answers of the respondents were grouped and frequency of each answer was calculated when analyzing the survey results.

The questionnaire consisted of 2 sections. The first section inquired about the context of the respondent company. The second section comprised three questions about the main root causes of waste for both material and time, and the actions taken in case of loss.

86% of the respondents were civil engineers and 14% of them were architects. 47% of the respondents were project managers, 31% of them were site managers and 22% of them were technical personnel. More than 75% of the respondents have managed at least one construction project and have personally experienced the problems resulted from the client's attributes. 64% of the respondents have been in business more than 6 years and the remainder has at least 3 years' experience.

The professional background and qualifications of the respondents are sufficient for the validation of the survey results.

FINDINGS AND DISCUSSION

The experience levels of the responding companies according to different types of projects are important for validation of the research. Table 1 shows the distribution of project types completed by the surveyed companies.

Table 1: Project types completed by the companies

Project types	Frequency (%)
Residential / mass housing	68
Industrial	53
Infrastructural	47
Institutional	41
Maintenance	20

More than 40% of the companies have undertaken four different types of projects at least one time.

MATERIAL WASTE

The respondents were asked to identify the main causes of material waste. Since the questions were open-ended, the answers were not pre-classified. Table 2 presents the respondents' answers, which were organized in respect of the classification proposed by Bossink and Brouwers (1996), and enumerated from the one having the highest frequency to the one with lowest frequency.

Table 2: Main Causes of Material Waste

Source	Causes of Material Waste	Frequency (%)
Design	Lack of information about types and sizes of materials on design documents	13
	Design changes and revisions	12
	Error in information about types and sizes of materials on design documents	10
	Determination of types and dimensions of materials without considering waste	3
Procurement	Ordering of materials that do not fulfill project requirements defined on design documents	**86**
	Overordering or underordering due to mistakes in quantity surveys	8
	Overordering or underordering due to lack of coordination between warehouse and construction crews	4
Material Handling	Damage of materials due to deficient stockpiling and handling of materials	16
Operation	Imperfect planning of construction	**61**
	Workers' mistakes	**32**
	Damage caused by subsequent trades	3
Residual	Conversion waste from cutting uneconomical shapes	22
Other	Lack of on site materials control	23
	Lack of waste management plans	10

86% of the respondents consider that the ordering of materials that do not fit in terms of quality, type and dimensions brings about material waste. This situation may result from either unreliable information flow or intentional choice of low quality products in order to reduce cost. This result is consistent with the previous study conducted by Bossink and Brouwers (1996), which measured the amount of construction waste at the building sites of five housing construction projects in the Netherlands, and classified the main waste causes in 6 sources. Their study revealed that use of products that do not fit and choice of low quality materials are two of the main waste causes.

61% of the respondents consider that imperfect planning of construction results in material waste. The key components of construction planning are deciding on the most proper site layout, examining documents associated with the construction process, choosing appropriate methods of construction, and determining the sequence and prerequisites of construction activities. Figure 1 shows an example of material waste resulting from imperfect planning of construction, and Figure 2 shows an example of material waste as a result of overordering due to mistake in quantity survey.

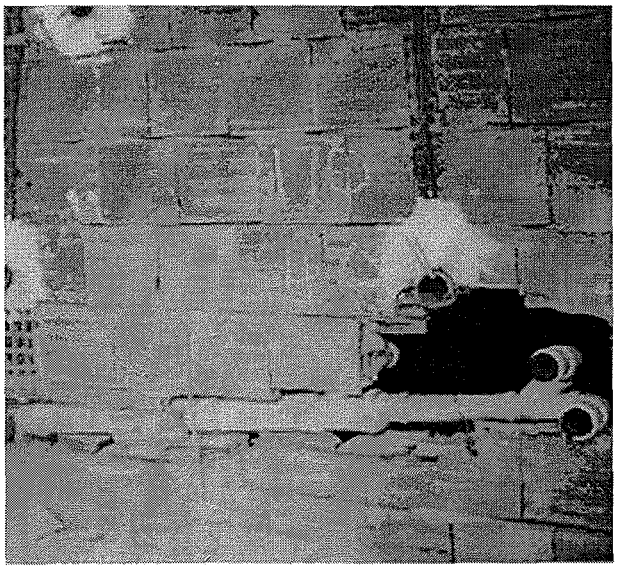

Figure 1: Material waste due to imperfect planning of construction.

Figure 2: Material waste resulting from overordering due to mistake in quantity survey.

32% of the respondents consider that workers' mistakes bring about material waste. There are no construction labor unions in Turkey. This certainly lowers the cost of construction labor, but skills are not satisfactory. In their study of dominant causes of waste generation in the Egyptian construction industry, Garas et al. (2001) found that untrained laborers make mistakes more frequently.

TIME WASTE

The respondents were asked to identify the main causes of time waste. Table 3 presents the respondents' answers.

Table 3: Main Causes of Delay

Source	Causes of Time Waste	Frequency (%)
Design	Interaction between various specialists	19
	Rework 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
	Delay in approval of drawings	3
Procurement	Delay in material supply	**72**
	Receiving materials that do not fulfill project requirements defined on design documents, and waiting for replacement	**53**
	Delay in transportation and/or installation of equipment	6
Operation	Scarcity of crews	29
	Unrealistic master schedule	23
	Rework due to workers' mistakes	16
	Scarcity of equipment	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
	Unpredictable local conditions	6
	Acts of God	5

72% of the respondents report delays in material supply. This problem may be caused by either the contractor's purchasing department (sending the purchase requisition to the supplier late) or the supplier (delay in producing and/or delivering the requested goods to the site). This result is consistent with the two previous studies conducted by Arditi et al. (1985), and Zhao and Chua (2003). Arditi et al. (1985) investigated the main reasons for delays in public projects in Turkey. The survey of 44 public organizations and 34 contractors revealed that delay in material supply is the most important reason for delay with average relative weight of 17.46%.

53% of the respondents report that waiting for replacement due to receiving of materials that do not fulfill project requirements defined on design documents brings about time waste. This problem may result from either mistake in purchase requisitions or the supplier's delivery of incorrect materials. This problem also depends on the information flow through the entire supply chain, both the accuracy of the information and the reliability of its flow through the chain.

39% of the respondents report that delays in receiving monthly payments results in time waste. This result is consistent with the study of Arditi et al. (1985), which identified contractor's difficulties in receiving monthly payments as the second most important reason for construction delay with average relative weight of 10.67%. There are more than 50,000 contractors in Turkey and they mostly do not have a chance to select the owner dependent on his financial status. They tend to undertake a project in order to provide the continuity of the company. The major owner is the public sector in Turkey, and most commonly a public agency awards a project without being sure that the funds are available (Polat and Ballard, 2004). Thus, long delays in receiving monthly payments frequently occur. Since most contractors have financial difficulties (Arditi et al., 1985) and manage their business with the monthly payments (progress payments) received from clients (Polat, 1999), delays in getting monthly payments ends or interrupts projects for a long period of time. However, having financial strength allows the contractor to operate with some independence from timely project payments received from the owner.

ACTIONS TAKEN IN THE CASE OF LOSS

The respondents were asked to identify actions taken in the case of loss (Table 4).

Table 4: Actions Taken in the case of Loss

Actions Taken in the case of Loss	Frequency (%)
Procuring required material immediately	73
Increasing the number of crews	44
Increasing working hours	22
Revision of master schedule	16
Nothing	11
Increasing the amount of equipment	10
Procuring required equipment immediately	7
Warning crews	6
Changing actual construction method	2

The answers of the practitioners revealed that the common means preferred in the Turkish construction industry in order to overcome problems associated with loss are procuring required material immediately, increasing the number of crews, and increasing working hours. All of the actions taken in the case of loss, which are presented in Table 4, are reactions to problems; attempts to accommodate loss. This is obviously necessary. However, no mention was made of actions taken to prevent reoccurrence. In hindsight, a specific question to that effect should have been included in the survey. However, interviews also did not reveal such preventive actions. The lean production philosophy advocates identifying the root causes of waste and removing those causes by means of related tools and techniques, and encourages preventing loss rather than relying solely on reactions attempting to overcome negative effects of loss (Womack and Jones, 1996). Accordingly, contractors should attempt to find out the main causes of the waste and eliminate these causes via various tools and techniques proposed by lean construction.

A FRAMEWORK FOR REDUCING WASTE IN THE TURKISH CONSTRUCTION INDUSTRY

The survey of 116 Turkish contractors revealed that material and time wastes are significant problems in the Turkish construction industry. Furthermore, the answers of practitioners showed that lean construction techniques are not applied in order to remove waste.

Table 5 presents main waste sources and some of the related lean construction techniques put forward by the Lean Project Delivery System[3] (LPDS) in order to remove waste.

[3] LPDS was developed by the Lean Construction Institute (LCI) to design and build capital facilities in a better way, and it can be considered as the modification of lean production techniques and tools to the

Table 5: Main Waste Sources and Related Lean Construction Techniques

Source	Lean Construction Techniques
Design	Project definition, design structure matrix, 3D modeling/shared geometry, cross functional teams, concurrent design, set based design, sharing incomplete information, reduced batch sizes, collaborative design, design for buildability
Procurement	Work structuring, pull scheduling, supplier training, partnership, kanban, work packaging, supplier managed inventories
Material Handling	5S, reduced batch sizes, elimination of packaging, just-in-time deliveries
Operation	First Run Studies, multiskilled craftworkers, Last Planner[4]

Apparently, most of the waste causes can be removed by means of implementation of lean construction techniques. Only time waste resulting from irregular cash flows cannot be removed by the techniques presented in Table 5. It depends on both the financial status of the contractor and regularity of the cash flow received from the owner.

But principles and habits of thought and action come before techniques, however powerful. A saw is useless to someone who is not trying to cut wood. The ability to recognize waste and the commitment to its elimination are aspects of a management philosophy very different from the received wisdom in the Turkish construction industry. As the surveys reveal, contractors react to material and time waste by attempting to accommodate or work around the problems. The more powerful alternative is to attack and eliminate problems. One reason for this reactive management practice is the relative impotence of an individual contractor.

There are more than 50,000 contractors in the Turkish construction industry (Polat, 1999). Although there is an organization named "Turkish Contractors Association" (TCA), an independent and non-profit organization founded in 1952, only 142 of 50,000 contractors are members of this organization (www.tmb.org.tr). This association not only has a small number of members, but also is not effective in identifying and introducing solutions for the major problems in the construction industry, educating and training the member companies, and conciliating between various participants of the construction industry. TCA should act on behalf of their members through promoting awareness of the problems and potential solutions, allying with owner and supplier organizations in mutually beneficial process improvement initiatives, and supporting their member companies through education and

specific circumstances of the construction industry. For detailed information see (Ballard, 2000a,b; Ballard and Zabelle, 2000; Ballard et al., 2001) available at www.leanconstruction.org

[4] Last Planner is the name of the production control system of the LPDS. For further information see (Ballard, 2000c)

training. Although the members of this association are large-scale companies in Turkey and may play a significant role individually in future improvement initiatives, it is apparent that TCA can be more authoritative only if their membership increases.

A contractor should also do his part and employ lean construction techniques via adopting lean thinking philosophy, and concentrating on eliminating waste causes rather than only reacting to problems. The survey revealed that waste can arise from activities performed by design team, supplier, and operation crew. The focus of the contractor should therefore be on not only the operation activities but also the other activities making up the entire supply chain. Two of the key steps for changing the traditional construction management perception of the Turkish contractors are ensuring reliable information and material flow among the project participants via establishing close relationship based on mutual benefits, and inculcating lean thinking principles in managers and workers through education and training.

CONCLUSIONS

The construction industry has a major impact on many other industries by both purchasing the inputs from other industries, and providing products to other industries. Waste in construction is a problem not only for the construction industry, but also influences the state of the overall economy of the country. Eliminating waste in both material and time would improve project performance, namely enhancing value for individual customers, and would also have a positive impact on the national economy.

The survey revealed that material and time wastes are significant problems in the Turkish construction industry, and lean construction techniques are not applied in order to remove waste.

This study is useful in two ways. First, it provides an identification of the main waste causes in the Turkish construction industry. Secondly, it establishes an initial framework for a model associated with developing methods for prevention and elimination of waste causes inherent in the construction process. In future studies, the preliminary model can be developed based on the findings of this study by applying lean construction techniques and measuring their effectiveness in reducing waste.

Universities and researchers can carry the flag of advancing knowledge, but industry action is also needed. Individual contractors can help themselves by learning and applying lean construction thinking and tools. Construction industry clients can encourage their suppliers of design and construction services to develop their management capabilities. TCA can provide training and education in lean construction for its members.

All of these things can be done and all will help. However, the best solution may be a national initiative led by the government. Improving construction industry performance is a matter of national importance and both deserves and requires government leadership in the formation of a government/university/industry initiative. The Movement for Innovation in the UK (Egan, 1998) is one example of such an initiative.

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