IDENTIFYING CAUSES OF MATERIAL WASTAGE ON CONSTRUCTION SITES IN VIETNAM

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ABSTRACT

The wastage of materials on construction sites caused unnecessary losses to contractors. Curbing material waste is important to save costs for contractors and then to improve their competitive advantages in the construction market. Identifying causes plays a key role in mitigation of material waste on building sites. This study is part of an ongoing research aiming to identify major causes of material waste and to reckon the percentage of material waste on building sites in Vietnam. Literature reviews and a pilot survey provided thirty-five preliminary factors. Thirteen factors resulted from statistical techniques (i.e., mean scores and one sample t-test) were considered as major causes of material waste at site through a questionnaire survey of construction professionals, who worked for medium or large construction firms. The top-five main causes are: (1) incapable workers and site engineers; (2) changes to design; (3) late information about types and sizes of products to the contractor; (4) incapable storekeepers; and (5) waste from inappropriate construction processes. It is concluded that there is a need for enhancing the capability of workers and site engineers for mitigating the material wastage at site related to operation problems. The findings of this research can be used as a guideline to overcome material waste in the VCI as well as in other developing countries. The results of this study may expect to be useful not only to practitioners and researchers in Vietnam but also to participants in other developing countries.

Keywords: Construction project, factor analysis, material waste, productivity, Vietnam.

1. Introduction

The wastage of materials on construction sites caused unnecessary losses to contractors. Curbing material waste is important to save costs for contractors and then to improve their competitive advantages in the construction market.

Many people appraise Vietnam as a promising economy, and admire the growth of competitiveness and investment opportunities coming from economic integration of the country (Tri, 2006). However, the construction environment is still risky because of poor infrastructure, backward management mechanisms, a bureaucratic local government, and less competition between stated-own and private enterprises (Luu et al., 2008). In this context, using effective waste-reduction strategies to save costs is vital for contractors. Identifying causes and sources of material waste is an effective way step to mitigate negative impacts of material waste on building sites. The main objective of this paper is to identify causes of material waste on construction sites in Vietnam.

2. Literature Review

2.1. Concept of Waste

Many researchers (Koskela, 1992; Alarcon, 1994; Formoso et al, 1999) pointed out that waste includes all activities, which produce additional cost and take time but do not add value to the product. Ohno (1988) used waste and work

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to classify operations of workers. Waste concerns operations that do not add value and do not need whereas work includes non-value-adding and value-adding work. Womack and Jones (1996) argued that human activity that absorbs resources but creaets no value can be called waste. In this paper, the definition of waste suggested by Formoso et al. (2002) is adapted. As described by Formoso et al. (2002), the loss of any kind of resources (i.e., materials, time, and capital) produced by activities that create direct or indirect costs but do not add any value to the product from the point of view of the client can be called material waste.

There are many different ways to classify waste in the construction industry. Skoyles (1976) divided material waste into direct and indirect material waste. There are seven categories of waste in the Toyota system (Ohno, 1998). They are waiting by employees for process equipment to finish its work, unneccessary movement of workers, defects in products, overproduction of goods not needed, inventories of goods awaiting further processing or consumption, unneccessary processing, and unneccessary tranport of goods. Based on Brazilian conditions, there are nine categories of waste (Formoso et al., 1999): (1) overproduction; (2) substitution; (3) waiting time; (4) transportation; (5) processing; (6) inventories; (7) movement; (8) production of defective products; and (9) others. Consolidating the classification from authors (Gavillan and Bernold, 1994; Bossink and Brouwers, 1996; Graham and Smithers, 1996), waste during the construction process may result from different project phases: (1) design; (2) procurement; (3) material handling; (4) operation; (5) residual; and (6) others.

2.2. *Wastage of Materials at Site*

Continuous research efforts in construction waste can be found in different journal and technical reports. Skoyles (1976) monitored 114 buidling sites and then concluded that most of the problems concerning waste on building sites resulted from flaws in the management system.

In Brazil, Pinto (1989) cited in Formoso et al. (2002) reported that "the percentage of wasted materials ranged from 1 to 102% in weight, in relation to the amount of material defined by design. The total waste was 18% of the weight of all materials purchased, representing an additional cost of 6%". Picchi (1993) cited in Formoso et al. (2002) presented that "the percentage of waste was eliminated to be between 11 and 17% of the expected weight of the building. This represents a waste or between 0.095 and 0.145 t/m^2". In Dutch, Bossink and Brouwers (1996) confirmed that the percentage of wasted materials ranged from 1 to 10% in weight of the purchased construction materials.

Concerning with time waste on construction sites, Serpell et al. (1995) argued that waiting time, idle time and traveling time explained 87% of the total value of waste.

Based on previous studies related to waste measurement, Formoso et al. (1999) proposed a classification for waste in construction industry and conclued that there is the need to integrate waste control into the production planning. Forsythe and Marsden (1999) proposed a model for analyzing the impact of waste in the cost of the project. Using statistical technique, Ekanayake and Ofori (2000) found that design changes while construction works are in progress is the most significant cause of waste generation at site and then concluded that there is a need to minimize design changes in Singapore construction industry. Based on results of a research project in Australia, Alwi et al. (2002) found that poor quality site documentation, weather, unclear drawings, poor design,

design changes, slow drawing revision and distribution and unclear specifications were key waste cause variables of non value-adding activities.

3. Research Method

A set of factors causing material waste on site was uncovered from the rigorous literature review of previous studies on construction waste. Unstructured interviews were selected to add or remove factors during the preliminary questionnaire design. In order to facilitate for respondents, the preliminary questionnaire was tested. An expert group of four practitioners and three researchers was involved in the pilot test. Participants in the expert group were asked to revise the final survey questionnaire. This provided 35 preliminary factors (Table 1). In this study, the classification of material waste during the construction process proposed by many researchers (Gavillan and Bernold, 1994; Bossink and Brouwers, 1996; Graham and Smithers, 1996) is adapted. As proposed by these researchers, six categories of sources of material waste are design, procurement, material handling, operation, residual, and others.

Table 1: Preliminary factors and factor categories

Source	Code	Factors
Design	DES1	Selection of products that do not comply with specifications
	DES2	Unclear stipulations for materials in contract documents
	DES3	Changes to design
	DES4	Selection of low quality products
	DES5	Designer is not familiar with possibilities of available products at the market.
	DES6	Designer is lack of knowledge about construction during design activities
Procurement	PRO1	Ordering materials that do not comply with contract documents
	PRO2	Over-ordering
	PRO3	Under-ordering
	PRO4	Lack of possibilities to order small quantities
	PRO5	Materials supplied do not comply with contract documents
	PRO6	Late delivering materials by suppliers
	PRO7	Cooperation with dishonest suppliers.
Material handling	MAT1	Damaged during transportation to site
	MAT2	Damaged during transportation on site
	MAT3	Disordering materials on site
	MAT4	Improper storage of materials leading to damage or deterioration
	MAT5	Incapable storekeepers
	MAT6	Do not gather residuals to reuse
Operation	OPE1	Equipment malfunction
	OPE2	Inclement weather
	OPE3	Accidents

	OPE4	Use of incorrect materials, requiring rework
	OPE5	Required quantity of products unknown due to imperfect planning
	OPE6	Late information about types and sizes of products to the contractor
	OPE7	Incapable workers and site engineers leading to rework
	OPE8	Damage caused by subsequent trades
	OPE9	Poor awareness of workers to use materials in the right way
	OPE10	Project plan is inconformity with construction schedule
Residuals	RES1	Conservation waste from uneconomical cutting shapes
	RES2	No scientific methods to cut materials at site
	RES3	Waste from inappropriate construction processes
Others	OTH1	Material waste due to vandal
	OTH2	Criminal waste due to theft
	OTH3	Lack of scientific site material management

The formal questionnaire was designed and distributed to a random sample of site engineers, site supervisors and site managers, who worked for medium or large construction firms in Ho Chi Minh city, Vietnam. The respondents were asked to rate factors using five-point Likert-scale rating (from 1='no influence' to 5='Extreme influence'). The authors received 72 responses showing a response rate of 36.73%. Responses to the questionnaire were then collected and analyzed. The reliability analysis resulted in Cronbach's alpha coefficient to be 0.897. This coefficient is large enough to confirm the reliability of the measure scale used in the formal questionnaire.

4. Analysis and Discussion

The collected data were statistically analyzed with the software 'SPSS 13.0 for Windows'. Preliminary factors were ranked based on the average score. Moreover, a one sample t-test was performed to determine whether the mean rated by all respondents significantly differs from a hypothetical value. Since the study used the five-point Likert scale, a hypothetical value of 3 is assigned because above the test value 3 corresponds to "high influence". The factors, which have a high influence on the wastage of materials at site, are those that showed significant differences at 95% confidence level.

Table 2: Major causes of material waste on building sites

Rank	Code	Major causes of material waste on building sites	Mean	SD	t-test
1	OPE7	Incapable workers and site engineers leading to rework	3.81	1.10	0.000*
2	DES3	Changes to design	3.72	1.10	0.000*
3	OPE6	Late information about types and sizes of products to the contractor	3.65	1.10	0.000*
4	MAT5	Incapable storekeepers	3.65	1.06	0.000*
5	RES3	Waste from inappropriate construction processes	3.64	1.04	0.000*
6	OTH3	Lack of scientific site material management	3.53	0.89	0.000*

7	RES2	No scientific methods to cut materials at site	3.53	1.01	0.000*
8	OPE1	Equipment malfunction	3.53	1.11	0.000*
9	OPE5	Required quantity of products unknown due to imperfect planning	3.50	1.15	0.000*
10	MAT4	Improper storage of materials leading to damage or deterioration	3.47	0.87	0.000*
11	OPE10	Project plan is inconformity with construction schedule	3.46	1.14	0.001*
12	DES6	Designer is lack of knowledge about construction during design activities	3.46	1.16	0.001*
13	OPE4	Use of incorrect materials, requiring rework	3.42	1.28	0.007*

*Note: * denoted that it was significant at 95% level of confidence*

Table 2 shows that 13 major causes have a large influence on the wastage of materials at site. The highest ranking by all respondents was *incapable workers and site engineers* (mean value = 3.81). Therefore, this cause is an extremely influential cause to the wastage of construction materials at site. *Changes to design* (mean value = 3.72) were ranked as the second most influential cause, while the third ranked cause was *late information about types and sizes of products to the contractor* (mean value = 3.65), the forth ranked cause was *incapable storekeepers* (mean value = 3.65) and the fifth ranked cause was *waste from inappropriate construction processes* (mean value = 3.64). It is interesting to note that all respondents perceived '*Designer is lack of knowledge about construction during design activities*' and '*Use of incorrect materials*', requiring rework as the two least influential factors affecting the wastage of construction materials at site.

There is a boom in construction due to the continual growth of the Vietnamese economy during the past ten years. This leads to higher demand for investment opportunities and capable human resources. However, the available human resources in the VCI did not meet the requirements for construction projects, especially for building and residential construction projects. As a result, respondents highly ranked '*incapable site engineers*' as one of major causes of material waste at site. Moreover, the majority of construction workers are untrained before they do their trade. New workers often look at skilled workers and then learn what skilled workers do. Therefore, *incapable workers and storekeepers* also major causes of material waste at site.

Table 2 implied that curbing changes to design resulting from incapable designers and design firms is the second priority to avoid material waste at site. In Vietnam, only structure design firms may be capable of carrying out structure design services whereas mechanical and electrical design services may be incapable. Therefore, changes to design while construction is in progess are common. For that reason, changes *to design* (mean value = 3.72) were ranked as the second most influential cause of material waste at site.

5. Conclusion

The major objective of this paper was to identify main causes of material waste at site in Vietnam. Thirty-five factors were identified as a result of a comprehensive literature survey. The pilot test provided 30 factors considered as inputs and then analyzed with the software 'SPSS 13.0 for Windows'. Data analysis provided thirteen major causes, which have the mean value higher than 3. A one-sample t-test also confirmed that those causes had a large influence on the wastage of materials at site.

All respondents identified *incapable workers and site engineers*, *changes to design*, *late information about types and sizes of products to the contractor*, *incapable storekeepers* and *waste from inappropriate construction processes* are main causes of material waste at site. The study found that '*incapable workers and site engineers'* were an extremely influential cause to the wastage of construction materials at site. It is concluded that there is a need for enhancing the capability of workers and site engineers to mitigate the material wastage at site related to operation problems. Moreover, enhancing the capability of designers is a second priority to avoid material waste at site.

The findings of this research can be used as a guideline to overcome problems related to material waste in the VCI as well as in other developing countries. The results of this study may expect to be useful not only to practitioners and researchers in Vietnam but also to participants in other developing countries.

Since limitations are unavoidable in any study, several limitations were pointed out. The survey was made on building projects located in Ho Chi Minh city, thus it may seem inappropriate to generalize for the whole of Vietnam on the basis of the data. However, a large proportion of building projects in Vietnam are located Ho Chi Minh city. Further studies should be performed to other kinds of construction projects or located in other provinces so that a full set of factors causing material wastage at site can be identified.

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