NON VALUE-ADDING ACTIVITIES: A COMPARATIVE STUDY OF INDONESIAN AND AUSTRALIAN CONSTRUCTION PROJECTS

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ABSTRACT

Construction managers have for a long time focused their attention on conversion processes, with little attention given to flow activities, leading to uncertain flow processes, expansion of non value-adding activities, and reduction of output value. This paper investigates the incidence of non value-adding activities in construction projects in Indonesia and Australia, focusing on non-residential building and infrastructure projects.

Data was collected via questionnaires and personal interviews targeting 99 respondents from Indonesia and 50 respondents from Australia. A quantitative approach was adopted for this research utilising the results of a questionnaire survey involving 53 variables that relate to non value-adding activities. The variables were then separated into two classifications: *waste categories* that contribute to a reduction in the value of construction productivity and *waste cause variables* that could be defined as factors producing waste. Statistical analysis was performed to identify the different perceptions amongst the respondents and to determine the key variables of non value-adding activities.

The paper illustrates the key waste categories, the key waste cause variables and leads the contractors to focus their attentions on these issues in order to reduce the incidence of non value-adding activities during the construction process.

KEY WORDS

Non value-adding activities, construction-contracting companies, Indonesia, Australia.

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INTRODUCTION

Over the past 2 decades, many construction industry sectors have been experiencing chronic problems such as low productivity, poor safety, inferior working conditions and insufficient quality. These problems have been identified as factors that affect construction's performance. Hampson (1997) believed that construction performance affects productivity across all sectors of the economy. Evaluation of performance in the construction process has been a challenge for the construction industry (Alwi et al. 2002). Several models and procedures have been proposed for the evaluation and measurement of project performance. However, most of these procedures limit their analysis only to a number of measures such as cost, schedule, or labour productivity (Alarcon 1994). Numerous reports and studies have investigated the Australian construction industry's performance and identified various problems including: the fragmented nature of the industry, the phasing and sequencing of functions, lack of coordination between participants and trades, excessive subcontracting and unsatisfactory competitive tendering (Love 1995).

Productivity in the construction industry in Indonesia is not only influenced by labour, but also by other factors such as equipment, materials, construction methods, and site management. Some concepts such as Total Quality Management (TQM) and Total Quality Control (TQC) have been implemented in the Indonesian construction industry to achieve better productivity. The adoption of ISO 9000 in the construction industry in Indonesia was slower than in manufacturing, and even now many small and medium size organisations have voiced their concerns over the difficulty and cost of introducing an ISO quality system. Thus, the construction industry preferred to adopt their own in-house quality systems to increase productivity.

Other problems identified in the report included equipment shortages, inefficiencies in using materials, imbalances in organisational structure, unfair competition, limited funds, planning uncertainties and a lack of human resource development. Many of these problems are endemic within the Indonesian construction industry (Royat 1994). In Indonesia, research to date has primarily concentrated on waste materials on site (Alwi 1995). However, based on preliminary investigations, there is now concern over the high level of non value-adding activities within the Indonesian construction industry (Alwi 2001). At present, no accurate method has been developed to identify factors of non value-adding activities and to quantify the extent of the negative impact of non value-adding activities. Prevention of waste must start at project inception. No practical and acceptable method has been agreed upon by all parties involved in construction projects to reduce waste levels. On some construction projects in Indonesia, the extent of non value-adding activities is significant throughout the entire construction process – its participants, processes and the facilities constructed.

The objective of this paper is to identify the incidence of non value-adding activities within the Indonesian and Australian construction industry and to determine the different perceptions of respondents towards any factor of non value-adding activities.

WASTE IN CONSTRUCTION

The term "non value-adding activity" has been widely used by researchers in literature pertaining to lean production (Koskela 1992). The term non value-adding activity is used to differentiate between physical construction waste found on-site, and other waste which occurs during the construction process. A number of definitions of waste are available. In general, Alarcon (1994), Koskela (1992) and Love et al. (1997) argued that all those activities that produce costs, direct or indirect, and take time, resources or require storage but do not add value or progress to the product can be called non value-adding activities or waste. Waste in the construction industry has been the subject of several research projects around the world in recent years (Formoso et al. 1999). To date, no attempt has been made to systematically observe all forms of waste in the construction process (Koskela 1994). However, some researches have investigated specific areas of waste and the root causes. Serpell et al. (1995) argued that in most cases, Construction Managers do not know of, or recognise, the factors that produce waste, nor do they have measurements of their own performance. Most of the factors are not observable. The identification of these factors, their causes, and a measurement of their level of importance, would provide useful information that would allow management to actively reduce their negative effects in advance.

Waste in construction is not only focused on the quantity of waste of materials on-site, but also related to several activities such as overproduction, waiting time, material handling, processing, inventories and movement of workers (Formoso et al. 1999; Alarcon 1994). Consolidating research from authors (Alarcon 1995; Alwi 1995; Koskela 1993; Robinson 1991; Lee et al. 1999; Pheng and Hui 1999), the main categories of waste during the construction process can be described as: reworks/repairs, defects, material waste, delays, waiting, poor material allocation, unnecessary material handling and material waste.

Chilean building construction projects experience waste variables such as waiting time, idle time and travelling time (Serpell et al. 1995). *Waiting time* was caused by overmanning, lack of progress, lack of equipment and lack of materials. During the construction process, they normally have more labourers than needed, especially unqualified labourers. The problem related to unskilled labourers was also identified in the Sri Lanka construction industry. Jayawardane and Gunawardena (1998) indicated in their study that the work force consisted of 51% unskilled workers. The construction industry in Nigeria has similar productivity problems as Indonesia (Kaming et al. 1997). Kaming et al. (1997) identified lack of material, rework/repair, lack of equipment and supervision delays as factors influencing productivity in the construction industry. The study of material management in Malaysia (Abdul-Rahman and Alidrisyi 1994) identified the nature of problems such as delay in the delivery of materials, lack of planning and material variances.

Another investigation showed that 25 per cent time savings is achievable in a typical construction work package without increasing allocated resources (Mohamed and Tucker, 1996). These findings are mainly concerned with time waste on construction sites.

METHODOLOGY

DATA COLLECTION METHOD

All data collection instruments used in this research was questionnaire surveys and followed by interviews. The major part of the primary data collected for this research was the expression of respondents' opinions or perceptions. It is expected that the data collected will be mainly subjective. Three hundred questionnaires were sent to 125 contractor firms in Indonesia, and 90 questionnaires to 45 contractors in Australia, requesting responses based on projects they were undertaking or projects that have completed within the last 5 years. A total of 99 completed questionnaires were returned from 46 different Indonesian companies and 50 from 27 different Australian companies respectively.

Fifty-three (53) variables that related to non value-adding activities were derived from an extensive literature review and pilot studies. The variables were then separated into two classifications: *waste categories* that contributed to a reduction in the value of construction productivity and *waste causes variables* that could be defined as factors producing waste. The survey was designed into three sections questioning the characteristics of non value-adding activities during the construction process. Respondents, projects and company profile were detailed. The first section contained questions relating to the frequency of non value-adding activities and the level of effect of non value-adding activity on construction projects. Respondents were able to identify how frequently the waste occurred using five scales: (1) Never; (2) Rarely; (3) Occasionally; (4) Often; and (5) Always. In order to score the level of effect of waste categories on construction, respondents were provided with five different scales from 1 (no significant effect variable) to 5 as (high detrimental effect variable). Section 2 dealt with the causes of non value-adding activities. The questionnaire gave each respondent an opportunity to rate variables perceived as likely to contribute to construction performances on a scale from 1 (not at all or not relevant) to 5 (most relevant). For the last section, respondents were asked to provide comments on responses provided.

The interviewer conducted two forms of interviews: open-ended interviews and focused interviews. In the open-ended interviews, the respondents were asked for facts, in addition to their opinions about the important variables. In some situations the interviewer asked the interviewee to propose their own insights into certain occurrences. The interviewees ranged from management level to operational level.

DATA ANALYSIS

Weighted score model was used to achieve greater degree of certainty to determine key waste variables. This model assigns a weighting to each criterion depending on the product of its frequency and its level of effect. The most important criterion is awarded the highest weighting. The weighted score was calculated by multiplying frequency and effect scores. Two main statistical analyses were carried out using SPSS package program. Multiple linear regression (MLR) was used to identify the different perceptions of respondents towards waste and *t*-tests were conducted to rank the important variables. Detail of the statistical analysis procedures are provided in the following sections.

RESEARCH FINDINGS

CHARACTERISTICS OF RESPONDENTS

The characteristics of respondents involved in the survey were tabulated in Table 1 and were indicated by percentages, except for "experience in construction industry" by years. Respondents were grouped into two categories: *construction respondents* and *non-construction respondents. Construction respondents* represented people who actively worked or were involved in on-site activities. The respondents that were categorised as *non-construction respondents* represented those who did not actively work daily on the construction site. However, they support the construction team in order to carry out the project. They included Estimator, Contract Administrator, Architect and other designers.

Table 1: Characteristics of Respondents

No	Characteristics of respondents	INDONESIA	Australia
1	Construction respondent	84%	86%
2	Non-construction respondent	15%	14%
3	Experience in construction industry (average)	13 years	19 years
4	Government company	32%	2%
5	Private company	56%	64%
6	Publicly listed	-	32%
7	ISO 9000 compliant company	52%	72%
8	Non-ISO 9000 compliant company	37%	2%
9	In-House quality system	7%	16%
10	Multistorey building	56%	20%
11	Infrastructure	19%	32%
12	Other project types	21%	46%

Respondents' Perceptions

Multiple linear regression (MLR) was used as a tool to establish the relationship between dependent variables and independent variables and to test the null hypothesis of no evidence of an independent variable to be a significant predictor of a dependent variable, at a 95% confidence interval. The analysis was conducted towards the weighted scores (as a combination of frequency and effect scores). Waste categories and the causes of waste variables were defined as the dependent variables. Whereas the independent variables were identified as the characteristics of the respondents such as experience in the construction industry; ownership of companies; quality system of companies; and types of project undertaken.

Probability values are used to assess the significance of the relationship between the dependent variables and the independent variables. An independent variable can be viewed as a significant predictor of a dependent variable if the "Sig T" (The probability values) is less than the alpha level designated for the analysis (the criterion alpha level is $\rho < 0.05$). Within the study, MLR was conducted to identify the sensitivity of waste categories and waste causes to different characteristics of respondents. These include:

- Between non-construction and construction respondents,
- Between respondents who had experience more than and less than the average years in the construction industry,
- Between private companies and publicly listed companies/government companies,
- Between companies which have obtained ISO 9000 accreditation and those who used In-House quality system/non-ISO 9000 companies, and
- Between different types of project undertaken (building, infrastructure and other projects).

The summary of the results regarding the respondents' perceptions towards waste categories and waste causes variables were tabulated in Table 2. In order to simplify the table, only significant values that are less than 0.05 are listed in the table. The results indicated that no difference in perceptions existed amongst the respondents in Australia towards waste categories compared to the respondents in Indonesia. However, the results from the Australian construction industry show that companies that have obtained ISO 9000 accreditation highlighted that *weather* (F2) was a significant factor causing waste during the construction process than companies with In-House quality system. This is because almost 50% of the ISO 9000 companies in Australia were involved in infrastructure projects such as roads, highways, fly-over and bridge, where weather could be one of the most influential factors causing delays.

Table 2: The Respondents' Perception Towards Waste

No	INDEPENDENT VARIABLES				
		Waste categories	**Waste causes variables**	**Waste categories**	**Waste causes variables**
1	Non-construction respondents and Construction respondents	B3, B4, E2, E3	-	-	-
2	Experience in construction industry	A1	-	-	-
3	Private companies and Publicly listed/Government companies	C2, C4, E1	E4'	-	-
4	ISO 9000 and In-House quality system/Non-ISO 9000 companies	A1, B5	-	-	F2
5	Multi-storey building, Infrastructure and Other projects	-	-	-	-

Note:
A1 – Repair on structural works
B3 – Waiting for equipment repair
B4 – Waiting for equipment arrive
B5 – Waiting for labour
C2 – Material does not meet specification
C4 – Too much material inventory on-site
E1 – Excessive accidents on-site
E2 – Equipment frequency break downs
E3 – Unreliable equipment
E4' – Poor equipment choice/ineffective equipment
F2 – Weather

In the Indonesian construction industry differences in perceptions towards waste categories occurred almost in every independent variable, except between multistorey and infrastructure projects. Non-construction and construction respondents showed different perceptions for four Variables: B3 (Waiting for equipment repair), B4 (Waiting for equipment to arrive), E2 (Equipment frequently break down), and E3 (Unreliable equipment). Non-construction respondents scored these variables higher than construction respondents. Respondents who have more than 13 years experience in the construction industry scored Variable A1 (Repair on structural works) lower than those who have experience of 13 years and less. Between the government firms and the private firms, the different perceptions occurred towards 3 variables such as C2 (Material does not meet specification), C4 (Too much material inventory on site) and E1 (Excessive accidents on site). The private firms scored those variables higher than the government companies. ISO 9000 companies and non-ISO 9000 companies showed differences for 2 variables: A1 (Repair on structural works) and B5 (Waiting for labour). ISO 9000 companies scored Variable A1 higher than non-ISO companies. However, ISO-9000 companies also scored Variable B5 lower than the non-ISO 9000 companies. The conclusion is therefore that ISO 9000 companies are more concerned about *repairs on structural works* than *waiting for labour*.

The results suggest that non-construction respondents who do not actively work on daily activities scored waste variables higher than respondents who are involved actively on-site. Discussion amongst Project Managers did not reveal the causes clearly. Two reasons, which is still in debate, on why they may have scored those variables higher than other participants are: (1) bias and misinformation by their colleagues (leading to overstating the problems) and (2) waste problems related to equipment are not as large a problem as most respondents thought it was.

Regardless of the respondents' experience in industry, non-construction respondents mostly were engaged in residential projects and infrastructure projects, with only a few involved in non-residential projects for construction up to 6 levels. On the other hand, most construction respondents were involved in high-rise building projects up to 55 levels. Equipment was used more frequently within infrastructure projects with more equipment types than in high-rise building projects. As a result, problems related to equipment more frequently occurred with more detrimental effects within infrastructure projects. Therefore, non-construction respondents scored waste related to equipment higher than construction respondents.

Differences of perceptions between government and private companies were associated with materials management and excessive accidents on-site. These problems were scored higher by private companies. The characteristics of these firms were not significantly different. However, their experience in dealing with ISO 9000 accreditation was found to be the main reason why they scored waste variables differently. More than 60% of private companies involved in this survey had not obtained ISO 9000 accreditation. Only 20% had obtained the accreditation within the past 2 years. Compared to government companies, almost all of them (97%) had obtained ISO 9000 accreditation, having an average of 5 years experience. In Indonesia, ISO 9000 accreditation has become mandatory for all government companies and major private companies. The issue of quality certificates to recognised standards such as ISO 9000 has become a contentious issue within the construction industry (Love and Li 2000). Becoming certified to a recognised standard has become a matter of survival for many private companies. Rothery (1993) considers ISO 9000 to be a tool that can be used as an effective control mechanism which seeks to reduce waste and labour inefficiencies in a process so that quality in the production and delivery process can be ensured. This statement was supported by research undertaken by the Australian Construction Industry Development Agency (CIDA 1995). The research claimed that when a formal quality management system was used by construction organisations, the cost of waste decreased significantly. For example, within 15 months of being certified, a Project Manager reported that the incidence of waste in projects was significantly reduced.

In respect to the causes of waste variables, the majority of the respondents do not have differences of perceptions, apart from between the government and the private companies. Government companies scored the Variable E4' (Poor equipment choice/ineffective equipment) higher than private companies.

Significant Variables

To identify the significant variables of waste, firstly mean and standard deviation, scored by all respondents, were calculated and listed in descending order. The calculation was based on the frequency, the effect and the weighted results. The determination of the most significant variables was based on the ranking of the variables using independent-samples *t*-test, at a 95% confidence interval. This test was focused on testing the difference between means of two variables. In descending order of the waste variables, independent-samples *t*-test was carried out towards frequency, effect and weighted variables. In addition, the same procedures were conducted on the waste causes variables.

The *t*-test was carried out towards the top variable and the second variable, the third and so on. The procedures are used to test the null hypothesis of no difference in the means of two variables. The null hypothesis is rejected if the *r*-value obtained is less than the 0.05 level of significant. Statistically, the waste categories and the waste causes variables that have no different mean one another were listed into the same group. When the *t*-test was performed for the top variable and the "certain variable" and the *r*-value obtained is less than the designated *r*-value, it indicates that there is a significant difference between these two variables. Consequently, the "certain variable" belongs to the next group of waste variables. The results reduce the all waste categories ranking order to between 4 and 6 grouping order, in which each group contains variables that are not significantly different from each other even if their observed sample mean is different. Variables that are listed in the first group indicate as the significant variables.

Table 3 summarises the significant waste categories and classified into different group: frequency (F), effect (E) and weighting (W). The Symbol "●" indicates where the variables are being grouped according to the results from statistical analysis. For example, *repair on finishing works* is one of the significant variables for Indonesia based on the frequency result, and *repair on foundation works* is one of the significant variables for Australia based on the effect result. These variables are listed in the first group of variables.

Table 3: Significant Waste Categories

Waste categories	**Indonesia**			**Australia**		
	F	**E**	**W**	**F**	**E**	**W**
Delays to schedule	●	●	●		●	
Repair on finishing works	●					
Repair on foundation works					●	
Damaged materials on site	●		●			
Waiting for instructions				●	●	●
Waiting for equipment repair	●	●			●	
Waiting for equipment to arrive	●					
Equipment frequently breaks down	●					
Material does not meet specifications		●	●			
Lack of supervision/poor quality					●	
Loss of materials on site		●	●			

The most significant variables in causing waste during the construction process are summarised in Table 4.

Table 4: Key Waste Causes Variables

Waste causes variables

Indonesia	Australia
Design changes	Design changes
Lack of trades' skill	Poor design
Slow in making decisions	Poor quality site documentation
Poor coordination among project participants	Slow drawing revision and distribution
Poor planning and scheduling	Unclear site drawing supplied
Delay of material delivery to site	Unclear specifications
Inappropriate construction methods	Weather

KEY WASTE CATEGORIES

Of five key waste categories in Australian construction projects, *waiting for instructions* was found to be the most significant variable as indicated by the frequency, effect and weighting results. Interviews confirmed that *waiting for instructions* could be happened either within the contractors' personnel themselves or amongst project participants (between contractors and clients). The major cause of *waiting for instructions* relates to poor quality of site documentation. This also means that the variable *waiting for instructions* occurs most frequently and has the highest detrimental effect on construction projects.

On the other hand, in Indonesia, *delays to schedule* was found to be the most significant variable amongst the eight key waste categories. Even though *delays to schedule* was not the key for Australian projects, the effect was significant during the construction process. Projects can be delayed for a large number of reasons, usually impacting project cost and schedule. Interviews from construction personnel in Indonesia identified the important variables causing delays such as inclement weather, lack of trade skill, poor planning and scheduling, delay of material delivery to site, design changes, and slow decision making. The interviewees also agreed that *delays to schedule* was one of the most important variables affecting construction projects, contributing to non value-adding activities. This evidence is supported by Al-Khalil and Al-Ghafly (1999) in their study in Saudi Arabia. They stated that delays in project completion are a major problem leading to costly disputes and acrimonious relationships between the parties involved. In Nigeria, project delays were identified as the principal factors leading to the high cost of construction (Okpala and Aniekwu 1988).

From the Australian construction perspective, in addition to variable *delays to schedule*, other variables such as *repair on foundation works*, *waiting for equipment repair* and *lack of supervision/poor quality* were identified as variables that had detrimental effect when they occurred. On the other hand, except for *delays to schedule* and *waiting for equipment repair*, Indonesian construction projects were affected by materials problems (*materials that do not meet specifications* and *loss of materials on-site*). In addition, Table 3 shows that five variables: *repair on finishing works, damaged materials on-site, waiting for equipment repair, waiting for equipment to arrive* and *equipment frequently breaks down* were indicated as the most frequently variables occurring during the construction process.

KEY WASTE CAUSES VARIABLES

In the Indonesian construction projects, the key waste causes variables related to several types of classifications such as *design and documentation* (design changes); *people* (lack of trades' skill); and *professional management roles* (slowness in making decisions, poor planning and scheduling, and poor coordination among project participants). However, in the Australian construction projects, the key waste causes variables were mostly focused on the classification of *design and documentation*. As shown in Table 4, except *weather*, all key variables related to lack of design and documentation. This result was supported by Senior Project Managers who stated that design and documentation was indicated as a major cause of waste during the construction process. A study conducted by Tilley and Barton (1997) indicated that the Australian construction industry perceived major problems with the design and documentation.

Design changes was the only variable that both Indonesian and Australian projects agreed to be a significant variable causing waste during the construction process. *Design changes* can be categorised as variations, and are described by Choy and Sidwell (1991) as any change to the scope of the work as defined by the contract documents following the creation of legal relations between the principal and contractor. Often the changes are no fault of the contractors. *Design changes* may occur in architectural, structural, plumbing and drainage, siteworks or other aspect of construction. Interviewees confirmed that *design changes* were the result of owner demands or client requests for changes to design in order to meet changing requirements and preferences. In certain cases, *design changes* were caused by problems in material acquisition, and unforeseen circumstances such as statutory requirements.

CONCLUSIONS

Concepts such as waste and value are not well understood by construction personnel. They often do not realise that many activities they carry out do not add value to the work. Waste is not only associated with waste of materials in the construction process, but also other activities that do not add value such as repair, waiting time and delays. These issues contribute to a reduction in the value of construction productivity and could reduce company performance. This research has assisted construction managers to identify the incidence of non value-adding activities within Indonesian and Australian constructing companies and may be used for other countries. The evidence gives a clear indication that waste goes beyond the waste of materials on-site, but also includes other activities that do not add value to the construction projects.

The characteristics of the respondents towards waste categories and waste causes variables were analysed clearly by separating them into different groups. The differences in perceptions towards waste were identified amongst construction personnel in Indonesia and Australia. The differences were more prevalent in Indonesian construction personnel than in Australian construction personnel, especially towards waste categories.

Waiting time, especially for site instructions, has been shown to contribute to non value-adding activities in Australian projects, representing unavailability of adequate site documentation, especially on large projects. In addition, there was almost universal agreement amongst respondents that a lack of design and documentation was the most significant cause of waste in Australia. In Indonesian projects, *delays to schedule* was found to be the significant waste variables and contractors needed to focus their attentions on developing processes to increase trades’ skill.

By identifying the incidence of non value-adding activities during the process, construction managers are able to easily identify the best solutions and ways to apply any new technique for reducing the amount of waste, leading to increased project productivity. The research findings gave an idea that there are different concerns of waste between developing and developed country.

The results of the research are based on individual respondents' perceptions. It has perhaps been the case that perceptions are subjective views about an issue which may or may not reflect reality. In other words, while collecting data from respondents who are involved in a project, the personal bias of respondents, influenced by personal qualifications and work experience, may reduce the objectivity of the responses.

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