NON VALUE-ADDING ACTIVITIES IN AUSTRALIAN CONSTRUCTION PROJECTS

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ABSTRACT

Construction managers attention has long been focused on conversion processes, however little attention has been directed at flow activities, leading to uncertain flow processes, expansion of non value-adding activities, and reduction of output value. In the production process, non value-adding activities are known as waste. This study is part of an on-going research project aiming to determine the incidence of non value-adding activities occurring within contracting organisations in Australia. A quantitative approach was adopted for this research utilising the results of a questionnaire survey involving 53 variables that related to non value-adding activities. The variables were then separated into 2 classifications: *waste variables* (22 variables) that contributed to a reduction in the value of construction productivity and *waste causes variables* (31 variables) that could be defined as factors producing waste. Results showed that there was no significant difference between respondents' perceptions towards waste. In addition, *waiting for instruction* was found to be the most important variable and *poor quality site documentation, weather, unclear drawings, poor design, design changes, slow drawing revision and distribution* and *unclear specifications* were identified as key waste cause variables of non value-adding activities. This paper recommends further suggest that investigation into the incidence of non value-adding activities was needed during construction to improve performance and enhance customers satisfaction.

KEYWORDS

Non value-adding activities, Constructing companies, Australia, Lean construction.

INTRODUCTION

Industry researchers and practitioners acknowledge that there are many wasteful activities during the design and construction process with the majority of these consuming time and effort without adding value for the client (Love, 1996). From the beginning of a construction project, Construction Managers have to deal with many factors that may negatively affect the construction process, producing different types of waste (Serpell et al., 1995). This condition may affect the performance of the companies.

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

BACKGROUND

Construction is characterised by complex communication and coordination environments involving a large number of individuals and interacting functions (Hampson, 1997). Moreover, Hampson said that a major challenge facing today's construction project managers is to encourage innovation throughout the project process to ensure that all problems are easy to identify. Apart from this, construction environments are characterised by problems related to production, general quality of work, design changes, material quality and availability and capacity utilisation (Akintoye, 1995). Koskela (1993, 2000), Alarcon (1993) and Chan et al., (1997) identified low productivity, poor safety, inferior working conditions and insufficient quality as chronic problems of construction. Performance problems in construction have been discussed throughout the 20th century and they are equally relevant today (Koskela, 2000). 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).

The Business Roundtable (1982a) identified the lack of adequate planning, scheduling, materials management, quality control and quality assurance as critical problems during the construction process. Major failures in project performance include cost overruns, delays in the planned schedule, quality problems and an increase in the number of disputes and resultant litigations. According to Oglesby et al. (1989), the word "performance", includes all aspects of construction processes that relate to on-site activities. Performance consists of four elements, namely, productivity, safety, timeliness, and quality. In Hong Kong, the Performance Assessment Scoring Scheme (PASS) has been administered by the Housing Authority of Hong Kong to monitor the performance quality of contractors in order to achieve a desired quality standard (Tam and Leung, 2001). However, the study found that the general level of quality has not significantly improved and continuous improvement in construction quality has not been realised as expected over a specific time period.

The more ill-defined the project, the greater the waste. During site work, waste is mostly in the form of materials that are lost or damaged. Other considerable waste identified is inefficient use of resources by the contractors and their subcontractors. Without complete or adequate design information available before commencement of the construction work, the waste of resources is significant. Studied have indicated that building waste generation has common causes. Graham and Smithers (1996) believed that potential sources of construction waste could be defined from several activities: *design, procurement, materials handling, operation, residual and other (theft* and *vandals.).*

WASTE DEFINITION

The term non value-adding activities used in this paper was derived from the lean production philosophy described by Koskela (1992). Koskela coined the phrase the *new production philosophy* to differentiate lean production thinking from conventional thinking which he termed the conventional production philosophy. The difference between the conventional production philosophy and lean production philosophy lies in how to manage the production process. Conventional production philosophy seeks to manage the production process by managing the conversion of an input to an output. The philosophy of lean production seeks to manage the production process by managing the conversion of the input to output, how the input flows through conversion to output, and maximising

the value of the output in the most efficient way possible (Horman et al., 1997). In lean production, non value-adding activities are explicitly addressed.

A number of definitions of waste are available. In general, Alarcon (1994), Koskela (1992) and Love et al. (1997a) 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 waste. These waste categories are measured as a function of their costs, including opportunity costs. Furthermore, other types of waste are related to the efficiency of process, equipment or personnel.

WASTE IN CONSTRUCTION

Waste in the construction industry has been the subject of several research projects around the world in recent years (Formoso et al., 1999). The study by Skoyles and Skoyles (1987) in the UK also suggested that all those involved in the construction process contributed to waste. This includes those who design materials, plant and building; those who specify and communicate, for example the Quantity Surveyors and Head Office Staff; and particularly Site Managers and Site Operators. Therefore, the responsibility for minimising waste should be shared by all parties involved in construction projects, including:

- All managers in building organisations, not only Site Managers,
- Those who design, manufacture and supply merchandise and plant used in construction,
- Those who design buildings,
- Those who specify, describe and account for the works, and
- Those who provide briefs, pay for and use buildings.

Graham and Smithers (1996) believed that construction waste could occur during different project phases:

- Design (plan errors, detail errors and design changes),
- Procurement (shipping error and ordering error),
- Materials Handling (improper storage, deterioration and improper handling on and off site),
- Operation (human error, trades person, labour, equipment error, accidents and weather),
- Residual (leftover and unreclaimable non-consumables), and
- Other (theft, vandals and clients actions).

Despite variations in construction projects, potential material waste was caused by similar inefficiencies in design, procurement, material handling, operation or residual on-site waste such as packaging (Formoso et al., 1993 and Gavilan and Bernold, 1993). Research also indicated that clients could be a source of waste through careless inspection procedures and variation orders during the process. Initially, carelessness at the design stage can lead to excessive waste which creates a need to over order to avoid a shortage of materials on site (Graham and Smithers, 1996).

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. In Chile, a research study from 1990 to 1994, focusing upon waste was conducted to identify the most relevant factors that produce waste of productive time in building construction works (Serpell et al., 1995). The study concluded that *waiting time*, *idle time* and *travelling time*, indicated as the main subcategory of non-contributory work (waste), explained 87% of the total value of waste.

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

A quantitative research approach was adopted for this investigation requiring the development and dissemination of a questionnaire survey. 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 variables* (22 variables) that contributed to a reduction in the value of construction productivity and *waste causes variables* (31 variables) that could be defined as factors producing waste. The same categories of variables in each classification were then clustered into the same group. *Waste variables* are grouped into 5 categories – *Repair*, *Waiting Periods*, *Materials*, *Human Resource* and *Operations*. *Waste causes variables* are grouped into 6 categories – *People, Professional Management, Design and Documentation, Materials, Execution* and *External*.

The survey was designed into three sections questioning about 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 categories: (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.

Ninety questionnaires were distributed to 45 contracting companies in May 2000. A total of 50 completed questionnaires were returned from 27 different companies, representing a response rate of nearly 60%. Two main statistical analyses were carried out. Multiple linear regression was used to identify the different perceptions of respondents towards waste and *t*-tests were conducted to rank the importance of waste types and the causes of waste.

RESEARCH FINDINGS AND DISCUSSION

Company Profile and Project Detail

The various types of companies ownership are Government, Private companies, Publicly listed with the percentages as 2%, 64% and 32% respectively. Based on the 50 respondents, 72% were ISO 9000 accredited, 2% were without ISO 9000 accreditation, 4% were in the process of obtaining the ISO 9000 accreditation and remaining16% with an existing In-House quality system. Most of the respondents (84%) acted as the main contractors and were primarily engaged in the construction of multistorey building and infrastructure projects.

Respondents' Profile

The average work experience of the respondents involved in the construction industry is 19 years. This indicates a reasonably high work experience profile within the Australian construction industry. Approximately 70% of the respondents were involved in the daily activities as they worked either as

Project Managers, Site Managers or Construction Managers. They were then identified as *construction respondents*. Another 30% of the respondents were categorised as *non-construction respondents* that 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 and Architect Design.

Respondents' Perceptions

Multiple linear regression (MLR) was used as a tool to establish the relationship between dependent variables and independent variables. Waste variables 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 qualifications; experience in the construction industry; ownership of companies; quality system of companies; and types of project undertaken. Within the study, MLR was conducted to identify the sensitivity of waste variables and waste causes to different characteristics of respondents. These include:

- Between non-construction and construction respondents,
- Between respondents who had experience more than 19 years and less than 19 years in the construction industry,
- Between private held and publicly listed companies,
- Between companies which have obtained ISO 9000 accreditation and those who used In-House quality system, and
- Between different types of project undertaken (building, infrastructure and other projects).

The summary of the results regarding the waste variables and waste causes variables were tabulated in Table 1.

TABLE 1
THE RESPONDENTS' PERCEPTION TOWARDS WASTE

No	Independent variables	Types of variables	
		Waste variables	Waste causes variables
1	Non-construction respondents and Construction respondents	-	-
2	Experience in construction industry	-	-
3	Private held and Publicly listed	-	-
4	ISO 9000 and In-House quality system	-	(+)F2
5	Multi-storey building, Infrastructure and Other projects	-	-

Note: F2 = Weather

The results indicated that no difference in perceptions existed amongst the respondents towards waste variables. However, the results show that companies that have obtained ISO 9000 accreditation highlighted that the variable *weather* 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 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.

Significant Variables

To identify the significant variables of waste, firstly mean and standard deviation scores were calculated and listed in descending order. 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. As a result, the waste variables and the waste causes variables could be grouped based on their importance. The results were tabulated in Appendices 1 to 4.

Table 2 summarises the most significant waste variables classified into different groups: frequency (F), effect (E) and weighted (W). The Symbol " ● " indicates where the variables are being grouped.

TABLE 2
KEY WASTE VARIABLES

Waste variables	F	E	W
Repair on foundation works		●	
Delays to schedule		●	
Waiting for instruction	●	●	●
Waiting for equipment repair		●	
Lack of supervision/poor quality		●	

Waiting for instructions was found to be the most significant waste variable as indicated by the frequency, effect and weighted results. This means that the variable *waiting for instructions* occurs the most frequently and has the highest detrimental effect on construction projects.

Referring to Appendix 4, the findings give clear evidence that the most significant variables in causing the incidence of waste during the construction process to be :

- Poor quality site documentation,
- Weather,
- Unclear site drawing supplied,
- Poor design,
- Design changes,
- Slow drawing revision and distribution, and
- Unclear specifications.

As shown in Appendix 4, the results reduce 32 ranked variables into six distinct groups, in which each group contains waste causes variables that are not significantly different from each other even if their observed sample mean is different. Of the 7 waste causes variables, 6 variables – *poor quality site documentation, unclear specifications, unclear site drawing supplied, slow drawing revision and distribution, design changes,* and *poor design* – were identified as lack of design and documentation.

CONCLUSION

This on-going research has assisted construction managers to identify the incidence of non value-adding activities within Australian constructing companies. 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 variables and waste causes variables were analysed clearly by separating them into different categories groups. The results indicated that infrastructure projects were mostly affected by weather.

Waiting time, especially for instructions, has been shown to contribute to non value-adding activities during the construction process, representing a lack of human resources skills especially on large projects. On the other hand, there was almost universal agreement amongst respondents that a lack of design and documentation was the most significant cause of waste.

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.

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APPENDIX 1: RANKING FREQUENCY RESULTS

NO.	WASTE VARIABLES	n	Mean	SD	z	Group
B1	Waiting for instructions	47	3.55	0.80	0.00	1
A3	Repair on finishing works	46	3.20	0.78	0.00	2
C1	Waste of raw materials on site	47	3.11	0.70	0.59	2
C5	Unnecessary material handling	47	2.91	0.80	0.00	3
D2	Tradesmen slow/ineffective	47	2.91	0.71	0.00	3
C6	Damaged materials on site	46	2.89	0.80	0.12	3
E4	Delays to schedule	47	2.85	0.72	0.38	3
B2	Waiting for materials	47	2.74	0.71	1.09	3
B4	Waiting for equipment to arrive	47	2.70	0.69	1.36	3
B3	Waiting for equipment repair (Publicly listed)	16	2.69	0.48	1.31	3
D1	Lack of supervision/poor quality	47	2.68	1.09	1.17	3
C3	Loss of materials on site	47	2.66	0.73	1.58	3
B5	Waiting for labour	47	2.62	0.85	0.00	4
A1	Repair on structural works	46	2.59	0.78	0.18	4
D3	Idle tradesmen	47	2.55	0.77	0.42	4
A4	Repair on formwork/falsework	46	2.44	0.75	1.08	4
A2	Repair on foundation works	46	2.35	0.90	1.49	4
C2	Material does not meet specification	47	2.32	0.56	0.00	5
C4	Too much material inventory on site	47	2.28	0.65	0.32	5
E2	Equipment frequently break down	47	2.11	0.60	1.75	5
E3	Unreliable equipment	47	2.04	0.51	0.00	6
B3	Waiting for equipment repair (Private held)	29	2.00	0.60	0.30	6
E1	Excessive accident on site	47	1.81	0.50	0.00	7

APPENDIX 2: RANKING EFFECT RESULTS

NO.	WASTE VARIABLES	n	Mean	SD	z or t	Group
A2	Repair on foundation works (Publicly listed)	16	3.88	0.96	0.00	1
E4	Delays to schedule	46	3.74	1.22	0.42	1
B1	Waiting for instructions	46	3.63	1.16	0.77	1
B3	Waiting for equipment repair (Publicly listed)	16	3.56	0.89	0.98	1
D1	Lack of supervision/poor quality	46	3.30	1.52	1.43	1
C2	Material does not meet specification	46	3.30	1.19	0.00	2
D2	Tradesmen slow/ineffective	46	3.28	1.20	0.08	2
B2	Waiting for materials	46	3.24	1.18	0.24	2
E2	Equipment frequently break down (ISO 9000)	32	3.16	1.17	0.52	2
B4	Waiting for equipment to arrive	46	3.00	1.17	1.22	2
C3	Loss of materials on site	45	2.89	0.96	0.00	3
C6	Damaged materials on site	46	2.89	1.04	0.00	3
B5	Waiting for labour	46	2.78	1.38	0.44	3
A1	Repair on structural works	46	2.76	1.42	0.51	3
D3	Idle tradesmen	45	2.71	1.24	0.77	3
E3	Unreliable equipment	45	2.71	1.39	0.71	3
A3	Repair on finishing works	46	2.70	0.99	0.93	3
E1	Excessive accident on site	44	2.66	1.94	0.71	3
C5	Unnecessary material handling	46	2.50	0.98	0.00	4
C1	Waste of raw materials on site	46	2.26	0.93	1.20	4
A4	Repair on formwork/falsework	46	2.24	1.20	1.14	4
B3	Waiting for equipment repair (Private held)	28	2.07	1.30	1.51	4
A2	Repair on foundation works (Private held)	28	1.93	1.46	0.00	5
C4	Too much material inventory on site	45	1.80	0.94	0.46	5
E2	Equipment frequently break down (In-house quality system)	9	1.44	1.59	0.86	5

APPENDIX 3: RANKING WEIGHTED VARIABLES

NO.	WASTE VARIABLES	n	Mean	SD	z	Group
B1	Waiting for instructions	47	11.32	6.42	0.00	1
E4	Delays to schedule	46	9.17	5.43	0.00	2
D2	Tradesmen slow/ineffective	46	8.67	4.88	0.46	2
D1	Lack of supervision/poor quality	46	8.50	6.39	0.54	2
B2	Waiting for materials	47	8.26	4.37	0.89	2
A3	Repair on finishing works	45	7.71	4.58	1.39	2
C6	Damaged materials on site	44	7.57	4.50	1.52	2
B4	Waiting for equipment to arrive	47	7.21	4.09	0.00	3
C2	Material does not meet specification	46	6.85	4.13	0.42	3
D3	Idle tradesmen	46	6.74	4.87	0.50	3
A1	Repair on structural works	45	6.71	4.54	0.55	3
B5	Waiting for labour	47	6.64	4.92	0.61	3
C3	Loss of materials on site	46	6.57	3.69	0.79	3
C5	Unnecessary material handling	46	6.35	4.42	0.97	3
A2	Repair on foundation works	45	6.18	4.24	1.19	3
C1	Waste of raw materials on site	46	6.17	3.27	1.36	3
B3	Waiting for equipment repair	47	5.96	3.87	1.52	3
A4	Repair on formwork/falsework	45	5.27	3.64	0.00	4
E2	Equipment frequently break down	46	5.26	3.50	0.01	4
E3	Unreliable equipment	46	5.13	3.36	0.19	4
E1	Excessive accident on site	46	4.48	4.03	0.98	4
C4	Too much material inventory on site	46	4.00	3.26	0.00	5

APPENDIX 4: RANKING WASTE CAUSES

NO.	WASTE CAUSES VARIABLES	n	Mean	SD	z	Group
C1	Poor quality site documentation	50	4.24	0.90	0.00	1
F2	Weather (ISO 9000)	36	4.17	0.91	0.35	1
C3	Unclear site drawings supplied	50	4.14	0.88	0.56	1
C6	Poor Design	50	4.14	1.09	0.50	1
C5	Design changes	50	4.10	0.93	0.76	1
C4	Slow drawing revision and distribution	50	4.08	0.99	0.85	1
C2	Unclear specifications	50	4.00	0.93	1.31	1
B2	Poor provision of information to project participants	50	3.88	1.04	0.00	2
B3	Poor coordination among project participants	50	3.80	1.01	0.39	2
B1	Poor planning and scheduling	50	3.78	1.30	0.42	2
B4	Slow in making decisions	50	3.72	1.20	0.71	2
A5	Lack of subcontractor's skill	50	3.58	0.95	1.51	2
A3	Supervision too late	50	3.52	0.84	0.00	3
F1	Site condition	50	3.40	1.01	0.65	3
A1	Lack of trades' skill	50	3.32	1.08	1.03	3
D2	Delay of material delivery to site	50	3.28	0.88	1.39	3
A4	Too few supervisors/foremen	50	3.26	1.08	1.34	3
D4	Poorly scheduled delivery of material to site	50	3.16	1.11	0.00	4
A2	Poor distribution of labour	49	3.10	0.80	0.31	4
E2	Inappropriate construction methods	50	3.10	1.05	0.28	4
F2	Weather (In-house quality system)	10	3.10	0.88	0.19	4
D1	Poor quality of materials	50	3.06	1.06	0.46	4
D3	Poor material handling on site	50	2.92	0.94	1.17	4
D5	Inappropriate/misuse of material	49	2.90	1.08	1.18	4
E4	Poor equipment choice/ineffective equipment	50	2.90	1.05	1.20	4
F3	Damage by other participants	50	2.90	1.18	1.13	4
A6	Inexperienced inspectors	50	2.82	1.08	1.55	4
E1	Too much overtime for labour	50	2.76	1.04	0.00	5
E6	Poor site layout	49	2.71	1.06	0.24	5
E3	Equipment shortage	50	2.68	1.00	0.39	5
D6	Poor storage of material	50	2.60	0.93	0.81	5
E5	Outdated equipment	50	2.40	1.05	1.72	6