# Factors influencing contractors' performance in Indonesia: A study of non value-adding activities

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# FACTORS INFLUENCING CONTRACTOR PERFORMANCE IN INDONESIA: A STUDY OF NON VALUE-ADDING ACTIVITIES

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## ABSTRACT

Non value-adding activities can be defined as activities that consume time, resources or space but do not add project value. This term is classified as waste in the language of Lean Production. Waste can significantly affect the business performance and productivity of contracting organisations. This paper aims to investigate the incidence of non value-adding activities within contracting organisations in Indonesia, focusing on non-residential building and infrastructure projects. Data was collected through questionnaires and personal interviews targeting 99 respondents from 46 different contracting organisations. Statistical analyses were performed to rank the importance of waste variables and waste causes variables for different categories of organisations. The findings from both literature and survey conducted suggest that *repair on finishing works, delays to schedule* and *waiting for materials* were identified as the key variables, whereas *design changes, lack of labourers' skill* and *slowness in making decisions* were identified as the key waste causing variables of non value-adding activities. The paper recommends that to minimise the negative impact of non value-adding activities, contractors maintain detailed records of all events which occur on-site in relation to the incidence of waste.

## KEYWORDS

Non value-adding activities, Contractors, Indonesia, Lean Production

## INTRODUCTION

The term "non value-adding activity" has been widely used by researchers in literature pertaining to lean production. 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. Non value-adding activities known as waste, detrimentally affect the performance of construction projects. Hampson (1997) believed that construction performance affects productivity across all sectors of the economy. This paper aims to identify the factor influencing contractor performance in Indonesia, through a study of non value-adding activities during the construction process. Evaluation of performance has been a challenge for the construction industry for decades. Several models and procedures have been proposed for the evaluation and measurement of project performance. However, most of these procedures limit their analysis to selected measures such as cost, schedule, or labour productivity (Alarcon, 1994).

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 to achieve better productivity. Since the publication of the ISO 9000 series of standards in 1987 by the International Organisation for Standardisation (ISO) 9000, quality management has received attention around the world on an unprecedented scale. Initially, 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.

## BACKGROUND

Construction projects are an important priority in Indonesia's national plans. Local contractors participate in the construction of public development projects including large scale infrastructure such as: ports/harbours, terminals, highways, telecommunications, irrigations, waste disposal and treatment; properties; public housing; and industrial buildings. The World Bank's Report (1984) in the book "The Construction Industry" concluded that due to the limited skills and resources on developing countries, a large amount of projects were won by foreign contractors. 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, 1995). 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 begin the moment the client first decides to go ahead with the project. 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, activities and the facilities constructed. In fact, non value-adding activities or waste occurs right across the construction industry irrespective of:

- The size of the building organisations,
- The value and duration of the contract,
- The building type, or
- The nature of the building (new building or buildings being refurbished and maintenanced).

Measuring performance for construction projects is a complex problem. Every project is unique in terms of design specifications, delivery methods, administration, and participants. If the most important influencing factors in any contracting organisation are identified, measures can then be taken to apply them in order to upgrade the contractors' performance (Ofori and Chan, 2001).

## NON VALUE-ADDING ACTIVITIES

This research applies the concept of Lean Production to the Indonesian construction industry in order to assist managers identify the incidence of non value-adding activities. The original concept of Lean

Production came from the manufacturing industry and was made popular by the book “The Machine That Changed The World: The Story of Lean Production” (Womack et al., 1991), which investigated ways to attain technological and competitive benefits in the automobile manufacturing industry.

Over the past two decades, the manufacturing industry has achieved great improvement in productivity, while the construction industry’s productivity has remained stagnant (Lee et al., 1999). An important factor in this achievement has been the manufacturing industry’s adoption new production philosophy of lean Production (Koskela, 1994). According to Koskela (1994), the core of the new production philosophy is in the observation that there are two aspects in all production systems: *Conversions* and *Flows.* Conversions were identified as value-adding activities, whereas flows were identified as non value-adding activities. Koskela (1994) described a value-adding activity as one that converts material and/or information towards that which is required by the customer. A non value-adding activity however, is one that takes time, resources or space but does not add value to the final output. In most cases, a non value-adding activity is known as waste (Koskela, 1994; Love, 1997c; Green, 1999).

## WASTE IN CONSTRUCTION

The potential impact of applying lean production philosophies on construction effectiveness is well-documented (Koskela, 1992; 2000). However, Construction Managers often fail to identify or address waste in the construction process. One reason why waste is not properly recognised, is the absence of appropriate tools for measuring waste (Lee et al., 1999).

To date, no attempt has been made to systematically observe all form 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 act to reduce their negative effects in advance. Koskela (1992) argued that if the flow aspects in the construction process have been ignored by the project participants, the construction project will encounter a significant amount of waste, non value-adding activities, and ultimately loss of value. These strong evidence of factors leading to waste and lost value in the construction industry of several countries (Koskela, 2000).

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., 1997b). Kaming et al. (1997b) 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.

## METHODOLOGY

The initial objective of this research was to conduct a questionnaire survey followed-up by interviews with the people who work both at management and operational levels in construction. The interviewees included: Project Managers, Site Managers, Supervisors, Foremen and Labourers.

The survey was divided into three separate sections of questions on the characteristics of non value-adding activities during the construction process. The first section contained questions referring to the frequency and the level of effect of non value-adding activities on construction projects. Section 2 dealt with the causes of non value-adding activities, while the last section, respondents are asked to provide comments on any answers they had given. By using the member listing catalogues from Indonesian contractor associations, 300 questionnaires were sent to 125 different contractor firms within 5 large cities in Indonesia, in December 1999, and responses were requested based on projects they were currently undertaking or projects that had completed within the last 5 years. Ninety-nine of questionnaires from 46 different contractors in Indonesia were returned which represented an average response rate of nearly 40%.

## RESEARCH FINDINGS

### *Respondents' Characteristics*

The respondents comprised of government companies, privately companies, joint venture, and others with the percentages of 32%, 56%, 10% and 2%, respectively. Of the respondents, approximately 56% were involved in the construction of multistorey buildings with an average of 13 levels, 3% in Housing, 19% in infrastructure including fly-overs, highways, oil and gas plants, water treatment plants, bridges, and 21% in other types of construction including factories, supermarkets, and sport clubs.

52% respondents were from companies which had obtained ISO 9000 accreditation (ISO 9000 companies) compared with nearly 37% of respondents that had not yet applied for ISO 9000 accreditation (Non-ISO 9000 companies). Approximately, 5% of the respondents were in the process of obtaining the ISO 9000 and the rest (7%) had their own In-house Quality System. The length of time that the companies had been ISO 9000 accredited ranged between 2 and 6 years with an average of 4 years, whereas the experience of the companies that had been using their own In-house Quality System ranged anywhere between 3 to 10 years. The qualifications of the respondents were classified into seven categories: Director, Manager, Project Manager, Site Manager, Construction Manager, General Manager and Other. The Other category includes Contract Administration, Plan Manager, Marketing Manager, Construction Design, Estimator, Supervisor and Architect. Most of the respondents (approximately 60%) were actively involved on site, working as Project Managers, Site Managers, Construction Managers and Managers.

### *Waste Variables*

The collected data was analysed using an Importance Index. The Importance Index was computed according to frequency and effect of variables, using the following formula:

$$I = \frac{\sum_{i=1}^{5} a_i x_i}{W.100}$$

Where $I$ = importance index; $a_i$ = constant expresses the weight of the $i^{th}$ response, where $i$ = 1,2,3,4,5; $x_i$ = frequency of the response given as a percentage of the total responses for each variable; $i$ = response category index where $i$ = 1,2,3,4,5; $W$ = the highest weight (5). To assist respondents in identifying how frequently the waste occurred, frequency was divided into five categories: (1) Never;

(2) Rarely; (3) Occasionally; (4) Often; and (5) Always. In order to score the level of effect that a waste category has on construction, respondents were provided a scale of 1 (no significant effect variable) to 5 (high detrimental effect variable). By using the frequency and effect index, ranking can be used to identify the important variables. Weighted indexes were computed by multiplying the Frequency Index by the Effect Index. The results are summarised in Table 1.

TABLE 1

GENERAL RANKING OF WASTE VARIABLES

| No | Waste categories | Frequency | | Effect | | Weighted | |
|---|---|---|---|---|---|---|---|
| | | Index | Rank | Index | Rank | Index | Rank |
| **A** | **Repair:** | 0.54 | | 0.51 | | 0.68 | |
| 1 | On structural works | 0.53 | 11 | 0.55 | 10 | 0.72 | 9 |
| 2 | On foundation works | 0.42 | 21 | 0.42 | 20 | 0.45 | 21 |
| 3 | On finishing works | 0.68 | 1 | 0.57 | 5 | 0.97 | 1 |
| 4 | On formwork/falsework | 0.53 | 10 | 0.49 | 12 | 0.65 | 11 |
| **B** | **Waiting periods:** | 0.52 | | 0.52 | | 0.68 | |
| 1 | Waiting for instructions | 0.56 | 4 | 0.56 | 8 | 0.78 | 7 |
| 2 | Waiting for materials | 0.58 | 3 | 0.60 | 3 | 0.88 | 2 |
| 3 | Waiting for equipment repair | 0.49 | 14 | 0.51 | 15 | 0.63 | 12 |
| 4 | Waiting for equipment to arrive | 0.48 | 16 | 0.48 | 11 | 0.58 | 13 |
| 5 | Waiting for labour | 0.48 | 15 | 0.47 | 16 | 0.57 | 16 |
| **C** | **Material:** | 0.50 | | 0.50 | | 0.63 | |
| 1 | Waste of raw materials on site | 0.54 | 7 | 0.61 | 2 | 0.82 | 5 |
| 2 | Material does not meet specification | 0.43 | 20 | 0.49 | 14 | 0.52 | 17 |
| 3 | Loss of materials on site | 0.55 | 5 | 0.56 | 7 | 0.76 | 8 |
| 4 | Too much material inventory on site | 0.54 | 9 | 0.43 | 19 | 0.57 | 15 |
| 5 | Unnecessary material handling | 0.50 | 12 | 0.41 | 21 | 0.51 | 18 |
| 6 | Damaged materials on site | 0.47 | 17 | 0.49 | 13 | 0.58 | 14 |
| **D** | **Human resource:** | 0.53 | | 0.54 | | 0.70 | |
| 1 | Lack of supervision/poor quality | 0.54 | 8 | 0.59 | 4 | 0.80 | 6 |
| 2 | Tradesmen slow/ineffective | 0.58 | 2 | 0.57 | 6 | 0.83 | 4 |
| 3 | Idle tradesmen | 0.45 | 18 | 0.45 | 18 | 0.51 | 20 |
| **E** | **Operations:** | 0.47 | | 0.51 | | 0.60 | |
| 1 | Excessive accident on site | 0.39 | 22 | 0.39 | 22 | 0.38 | 22 |
| 2 | Equipment frequently break down | 0.49 | 13 | 0.56 | 9 | 0.69 | 10 |
| 3 | Unreliable equipment | 0.44 | 19 | 0.47 | 17 | 0.51 | 19 |
| 4 | Delays to schedule | 0.54 | 6 | 0.63 | 1 | 0.86 | 3 |

Analysis was also carried out according to ISO 9000, Non-ISO 9000, government and private company. The weighted results and the ranking of important within these categories variables were tabulated in Table 2.

TABLE 2

RANKING OF WASTE VARIABLES ACCORDING TO RESPONDENT TYPE (BASED ON THE WEIGHTED INDEX)

| No | Waste categories | ISO 9000 | | Non-ISO | | Government | | Private | |
|---|---|---|---|---|---|---|---|---|---|
| | | Index | Rank | Index | Rank | Index | Rank | Index | Rank |
| **A** | **Repair:** | 0.69 | | 0.64 | | 0.62 | | 0.70 | |
| 1 | On structural works | 0.82 | 3 | 0.55 | 18 | 0.72 | 5 | 0.68 | 12 |
| 2 | On foundation works | 0.42 | 21 | 0.42 | 21 | 0.36 | 20 | 0.45 | 21 |
| 3 | On finishing works | 0.96 | 1 | 0.95 | 4 | 0.92 | 1 | 1.03 | 1 |
| 4 | On formwork/falsework | 0.60 | 12 | 0.68 | 11 | 0.55 | 12 | 0.70 | 9 |
| **B** | **Waiting periods:** | 0.63 | | 0.72 | | 0.63 | | 0.72 | |
| 1 | Waiting for instructions | 0.75 | 5 | 0.81 | 8 | 0.84 | 2 | 0.82 | 7 |
| 2 | Waiting for materials | 0.76 | 4 | 0.98 | 3 | 0.74 | 4 | 0.96 | 3 |
| 3 | Waiting for equipment repair | 0.64 | 11 | 0.58 | 15 | 0.67 | 9 | 0.62 | 13 |
| 4 | Waiting for equipment to arrive | 0.57 | 13 | 0.57 | 16 | 0.52 | 13 | 0.60 | 17 |
| 5 | Waiting for labour | 0.44 | 19 | 0.70 | 10 | 0.42 | 19 | 0.62 | 15 |
| **C** | **Material:** | 0.53 | | 0.73 | | 0.48 | | 0.70 | |
| 1 | Waste of raw materials on site | 0.65 | 10 | 1.01 | 1 | 0.56 | 11 | 0.99 | 2 |
| 2 | Material does not meet specification | 0.44 | 20 | 0.60 | 14 | 0.35 | 21 | 0.62 | 14 |
| 3 | Loss of materials on site | 0.66 | 9 | 0.86 | 5 | 0.62 | 10 | 0.78 | 8 |
| 4 | Too much material inventory on site | 0.46 | 18 | 0.73 | 9 | 0.42 | 18 | 0.70 | 10 |
| 5 | Unnecessary material handling | 0.47 | 17 | 0.56 | 17 | 0.43 | 17 | 0.54 | 19 |
| 6 | Damaged materials on site | 0.52 | 14 | 0.66 | 13 | 0.50 | 14 | 0.61 | 16 |
| **D** | **Human resource:** | 0.64 | | 0.77 | | 0.61 | | 0.77 | |
| 1 | Lack of supervision/poor quality | 0.75 | 6 | 0.85 | 7 | 0.70 | 6 | 0.84 | 6 |
| 2 | Tradesmen slow/ineffective | 0.70 | 8 | 1.00 | 2 | 0.67 | 8 | 0.93 | 4 |
| 3 | Idle tradesmen | 0.48 | 16 | 0.51 | 19 | 0.48 | 16 | 0.55 | 18 |
| **E** | **Operations:** | 0.59 | | 0.59 | | 0.56 | | 0.61 | |
| 1 | Excessive accident on site | 0.35 | 22 | 0.40 | 22 | 0.35 | 22 | 0.43 | 22 |
| 2 | Equipment frequently break down | 0.72 | 7 | 0.68 | 12 | 0.68 | 7 | 0.70 | 11 |
| 3 | Unreliable equipment | 0.51 | 15 | 0.50 | 20 | 0.49 | 15 | 0.49 | 20 |
| 4 | Delays to schedule | 0.85 | 2 | 0.85 | 6 | 0.77 | 3 | 0.88 | 5 |

### *Waste Causes Variables*

The waste causing variables were grouped into the six categories: People, Professional Management, Design and Documentation, Material, Execution and External. The questionnaire gave each respondent an opportunity to rate a variable contributed to construction performance on a scale from 1 (not at all or not relevant) to 5 (most relevant).

A summary of waste causes identified by respondents, is presented in Table 3. Using these percentages, the Level Index (LI) had been computed in order to determine the importance of each causes.

TABLE 3

GENERAL RANKING OF WASTE CAUSES VARIABLES

| No | Waste causes | Level of Effect | | | | | Level Index | Rank |
|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | | |
| **A** | **People:** | | | | | | **0.635** | |
| 1 | Lack of trades' skill | 8.2 | 10.2 | 20.4 | 38.8 | 22.4 | 0.714 | 3 |
| 2 | Poor distribution of labour | 13.1 | 27.3 | 38.4 | 19.2 | 2.0 | 0.539 | 30 |
| 3 | Supervision too late | 14.1 | 22.2 | 24.2 | 30.3 | 9.1 | 0.596 | 28 |
| 4 | Too few supervisors/foremen | 10.1 | 16.2 | 35.4 | 30.3 | 8.1 | 0.621 | 21 |
| 5 | Lack of subcontractor's skill | 9.1 | 19.2 | 20.2 | 34.3 | 17.2 | 0.663 | 15 |
| 6 | 6. Inexperienced inspectors | 9.1 | 14.1 | 25.3 | 33.3 | 18.2 | 0.675 | 9 |
| **B** | **Professional Management:** | | | | | | **0.690** | |
| 1 | Poor planning and scheduling | 10.1 | 14.1 | 23.2 | 24.2 | 28.3 | 0.692 | 7 |
| 2 | Poor provision of information to project participants | 8.1 | 23.2 | 19.2 | 31.3 | 18.2 | 0.657 | 18 |
| 3 | Poor coordination among project participants | 6.1 | 15.2 | 24.2 | 34.3 | 20.2 | 0.695 | 6 |
| 4 | Slow in making decisions | 8.1 | 10.1 | 19.2 | 40.4 | 22.2 | 0.717 | 2 |
| **C** | **Design and Documentation:** | | | | | | **0.662** | |
| 1 | Poor quality site documentation | 13.1 | 22.2 | 35.4 | 22.2 | 7.1 | 0.576 | 29 |
| 2 | Unclear specifications | 14.1 | 15.2 | 20.2 | 27.3 | 23.2 | 0.661 | 17 |
| 3 | Unclear site drawings supplied | 14.1 | 9.1 | 24.2 | 33.3 | 19.2 | 0.668 | 10 |
| 4 | Slow drawing revision and distribution | 12.1 | 10.1 | 26.3 | 29.3 | 22.2 | 0.679 | 8 |
| 5 | Design changes | 4.0 | 17.2 | 20.2 | 30.3 | 28.3 | 0.723 | 1 |
| 6 | Poor Design | 14.1 | 10.1 | 27.3 | 25.3 | 23.2 | 0.667 | 12 |
| **D** | **Material:** | | | | | | **0.652** | |
| 1 | Poor quality of materials | 12.1 | 14.1 | 25.3 | 25.3 | 23.2 | 0.667 | 13 |
| 2 | Delay of material delivery to site | 6.1 | 13.1 | 29.3 | 30.3 | 21.2 | 0.695 | 5 |
| 3 | Poor material handling on site | 9.1 | 26.3 | 28.3 | 25.3 | 11.1 | 0.607 | 26 |
| 4 | Poorly scheduled delivery of material to site | 6.1 | 16.2 | 34.3 | 24.2 | 19.2 | 0.668 | 11 |
| 5 | Inappropriate/misuse of material | 14.1 | 12.1 | 22.2 | 30.0 | 21.2 | 0.662 | 14 |
| 6 | Poor storage of material | 13.3 | 17.3 | 30.6 | 25.5 | 13.3 | 0.616 | 22 |
| **E** | **Execution:** | | | | | | **0.633** | |
| 1 | Too much overtime for labour | 9.2 | 22.4 | 31.6 | 28.6 | 8.2 | 0.608 | 25 |
| 2 | Inappropriate construction methods | 10.1 | 13.1 | 19.2 | 30.0 | 27.3 | 0.701 | 4 |
| 3 | Equipment shortage | 10.2 | 19.4 | 30.6 | 25.5 | 14.3 | 0.629 | 20 |
| 4 | Poor equipment choice/ineffective equipment | 16.2 | 14.1 | 28.3 | 30.0 | 11.1 | 0.610 | 24 |
| 5 | Outdated equipment | 13.3 | 17.3 | 20.4 | 29.6 | 19.4 | 0.649 | 19 |
| 6 | Poor site layout | 15.2 | 19.2 | 29.3 | 22.2 | 14.1 | 0.602 | 27 |
| **F** | **External:** | | | | | | **0.594** | |
| 1 | Site condition | 10.1 | 23.2 | 25.3 | 31.3 | 10.1 | 0.616 | 23 |
| 2 | Weather | 7.1 | 14.3 | 30.6 | 35.7 | 12.2 | 0.663 | 16 |
| 3 | Damage by other participants | 21.2 | 34.3 | 22.2 | 16.2 | 6.1 | 0.503 | 31 |

The results shown that different companies may have different perceptions of what causes waste during the construction process. Table 4 summarises the ranking of waste causing variables perceived by four different categories of companies: ISO 9000, Non-ISO 9000, Government and Private companies.

TABLE 4

RANKING OF WASTE CAUSING VARIABLES ACCORDING TO CATEGORIES OF RESPONDENTS

| No | Waste causes | ISO 9000 | | Non-ISO 9000 | | Government | | Private | |
|---|---|---|---|---|---|---|---|---|---|
| | | Index | Rank | Index | Rank | Index | Rank | Index | Rank |
| **A** | **People:** | **0.62** | | **0.64** | | **0.61** | | **0.63** | |
| 1 | Lack of trades' skill | 0.70 | 5 | 0.71 | 3 | 0.70 | 10 | 0.71 | 3 |
| 2 | Poor distribution of labour | 0.53 | 30 | 0.55 | 30 | 0.54 | 31 | 0.54 | 30 |
| 3 | Supervision too late | 0.60 | 26 | 0.59 | 25 | 0.59 | 28 | 0.60 | 28 |
| 4 | Too few supervisors/foremen | 0.60 | 27 | 0.62 | 19 | 0.59 | 29 | 0.62 | 21 |
| 5 | Lack of subcontractor's skill | 0.63 | 21 | 0.70 | 6 | 0.62 | 25 | 0.66 | 15 |
| 6 | Inexperienced inspectors | 0.65 | 18 | 0.69 | 7 | 0.61 | 27 | 0.67 | 9 |
| **B** | **Professional Management:** | **0.71** | | **0.68** | | **0.73** | | **0.69** | |
| 1 | Poor planning and scheduling | 0.71 | 4 | 0.69 | 8 | 0.75 | 2 | 0.69 | 7 |
| 2 | Poor provision of information to project participants | 0.69 | 9 | 0.63 | 18 | 0.68 | 16 | 0.66 | 18 |
| 3 | Poor coordination among project participants | 0.72 | 3 | 0.67 | 11 | 0.72 | 6 | 0.69 | 6 |
| 4 | Slow in making decisions | 0.73 | 2 | 0.72 | 2 | 0.77 | 1 | 0.72 | 2 |
| **C** | **Design and Documentation:** | **0.66** | | **0.68** | | **0.69** | | **0.66** | |
| 1 | Poor quality site documentation | 0.59 | 29 | 0.56 | 29 | 0.62 | 22 | 0.58 | 29 |
| 2 | Unclear specifications | 0.67 | 15 | 0.68 | 10 | 0.72 | 5 | 0.66 | 17 |
| 3 | Unclear site drawings supplied | 0.65 | 17 | 0.71 | 5 | 0.71 | 9 | 0.67 | 10 |
| 4 | Slow drawing revision and distribution | 0.66 | 16 | 0.68 | 9 | 0.67 | 17 | 0.68 | 8 |
| 5 | Design changes | 0.70 | 6 | 0.76 | 1 | 0.73 | 3 | 0.72 | 1 |
| 6 | Poor Design | 0.67 | 13 | 0.67 | 12 | 0.70 | 11 | 0.67 | 12 |
| **D** | **Material:** | **0.67** | | **0.64** | | **0.65** | | **0.65** | |
| 1 | Poor quality of materials | 0.68 | 11 | 0.66 | 14 | 0.62 | 26 | 0.67 | 13 |
| 2 | Delay of material delivery to site | 0.70 | 8 | 0.71 | 4 | 0.68 | 14 | 0.69 | 5 |
| 3 | Poor material handling on site | 0.63 | 22 | 0.59 | 26 | 0.63 | 21 | 0.61 | 26 |
| 4 | Poorly scheduled delivery of material to site | 0.67 | 14 | 0.67 | 13 | 0.68 | 15 | 0.67 | 11 |
| 5 | Inappropriate/misuse of material | 0.70 | 7 | 0.61 | 22 | 0.69 | 12 | 0.66 | 16 |
| 6 | Poor storage of material | 0.62 | 23 | 0.59 | 23 | 0.63 | 20 | 0.62 | 22 |
| **E** | **Execution:** | **0.66** | | **0.60** | | **0.67** | | **0.63** | |
| 1 | Too much overtime for labour | 0.62 | 24 | 0.62 | 20 | 0.63 | 19 | 0.61 | 25 |
| 2 | Inappropriate construction methods | 0.75 | 1 | 0.63 | 16 | 0.73 | 4 | 0.70 | 4 |
| 3 | Equipment shortage | 0.64 | 19 | 0.63 | 17 | 0.65 | 18 | 0.63 | 20 |
| 4 | Poor equipment choice/ineffective equipment | 0.64 | 20 | 0.57 | 27 | 0.69 | 13 | 0.61 | 24 |
| 5 | Outdated equipment | 0.69 | 10 | 0.59 | 24 | 0.71 | 8 | 0.65 | 19 |
| 6 | Poor site layout | 0.62 | 25 | 0.57 | 28 | 0.62 | 23 | 0.60 | 27 |
| **F** | **External:** | **0.59** | | **0.58** | | **0.63** | | **0.59** | |
| 1 | Site condition | 0.60 | 28 | 0.62 | 21 | 0.62 | 24 | 0.62 | 23 |
| 2 | Weather | 0.67 | 12 | 0.64 | 15 | 0.72 | 7 | 0.66 | 14 |
| 3 | Damage by other participants | 0.51 | 31 | 0.47 | 31 | 0.55 | 30 | 0.50 | 31 |

## DISCUSSION

Based on the Weighted Index in Table 1, the results indicated that the waste variables *repairs on finishing works, waiting for materials* and *delays to schedule* were ranked as first, second, and third by contracting companies in Indonesia. As seen in table 3, the contracting companies believed that *design changes, slow in making decisions* and *lack of trades' skill* were identified as the first three most important variables causing waste during the construction process. Each of the variables are discussed in detail below.

### *Repair on Finishing Works*

According to Table 2, *repairs on finishing works* was found to be the most important variable for ISO 9000, government and private companies, as they ranked this variable as number one. However, it was ranked fourth by Non-ISO 9000 companies. Repair is defined as an activity that must be redone or altered (Alwi, 1995). Repair includes variations and it can occur any time and within any activity during construction. In this case, *repairs on finishing works* include tiles works, ceiling works, painting, brick-works and plastering. Four of the Project Managers interviewed believed that this variable is a common cause of waste. They stated that certain construction requires specific tools that need a higher skilled labour force in order to fulfil the clients' finishing requirements. A Site Manager working in the construction industry for 25 years stated that the incidence of repair on finishing works is not only due to a lack of labour skill and the poor quality of materials used, but also due to the failure of other construction works such as structural works and mechanical-electrical works. For example, in the case of structural failures (beam or column), floors, tiles-works may need to be redone.

***Waiting for Materials***

Most of the interviewees argued that materials represent a large proportion of construction costs and will continue to represent a large portion in future. However, few materials management systems are presently effective in the construction industry. Generic procedures for material acquisition in construction include material inspection, delivery, handling, and storage before installation (Akintoye 1995; Illingworth and Thain, 1988; Magad and Amos, 1995).

For the general construction industry, a lack of material management could cause *waiting for material* on-site. *Waiting for materials* consist not only of waiting for material deliveries to site by external deliveries, but also waiting for material deliveries from storage on site to certain areas of the construction site (internal delivery). Data in Table 2 shows that this variable was of more concern both Non-ISO 9000 and Private companies than by the others. From the Project Managers' point of view, in order to minimise the waiting time of materials during the construction process (internal and external), two main issues should be considered. Firstly, site layout needs to be designed appropriately to ensure that the material flows could proceed smoothly without any interruptions. Secondly, efficient communication links must be established with suppliers. The suppliers must know and monitor each stage of work-in-progress. This can be achieved with ease by contractors giving authority to their site management to communicate directly with their suppliers on site material requirements.

***Delays to Schedule***

Projects can be delayed for a large number of reasons, usually impacting project cost and schedule. Interviews 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.

*Delays to schedule* was a concern of ISO 9000 and Government companies, ranking second and third respectively. Respondents from Private companies 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). Therefore, this research supports the ideas from previous studies, particularly within developing countries, that *delay* was identified to be one of the key factors affecting contractor performance, leading to reduced productivity levels.

***Design Changes***

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.

The survey confirmed that this variable was ranked first by Non-ISO 9000 and Private companies (see Table 3). 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.

***Slow in Making Decisions***

Most managers, including Construction Managers, regard decision-making as a key aspect of their work. Studies have shown that while managers may not always spend a lot of time on decisions, a good decision is often the result of much careful information gathering and analysis, involving discussions with a wide range of people, scrutiny of recorded information, and for some, decisions and manipulation of data using computer programs.

A decision involves choosing between several courses of action. If the choices are well-defined, the decision problem can be come routine. If the choices are unclear, the problem is non-routine and the managers may spend large amount of time looking at options before reaching a final decision. The decision will be more difficult if the number of choices are large or the outcomes are hard to compare. If managers lack information about the problem, or about the options available, the decision can become very difficult. Slow decision-making may be caused by contractor's personnel, clients, or consultants. From the contractors' point of view, the slow decision making of clients leads to delays in schedule. A company Vice-President noted that slow decision-making is common for government projects. However, other group of companies such as ISO 9000, Non-ISO 9000 and Private companies also experienced similar problems, ranking this variable second (see Table 3). Therefore, to avoid delays in the construction process, contractors need to be extremely proactive when communicating with owner representatives.

***Lack of Trades' Skill***

People are the most important resource in completing construction projects. The category of "people" relates to the skill of the tradesmen/labourer, its distribution on site, the effectiveness of supervisors/inspectors on site. The performance of field labour is critical to the success of any construction project.

According to the respondents, contractors are still facing a *lack of trade skills* to complete a project satisfactorily. In fact, interviewees stated that "skilled" operators were often not skilful, having gained their experience on the job site, learning construction skills through trial and error. The trend observed with activities on the project was that, labourers do not use their own initiative, and instead rely on both the foremen and the supervisors' ability to check and approve all works. For many activities, labourers are unable to interpret site drawings. Most labourers require instruction from foremen or supervisors.

The main reason identified by most Project Managers to this in fact that lack of skill was the majority of the Indonesian construction labour force are self-employed, often being farmers from rural areas. Typically young workers are often recruited through friends or relatives (often of the foremen). To overcome this problem, Mohamed and Yates (1995) suggested that management should encourage labour to undertake training programs. However, training institutions that may educate construction workers are limited in Indonesia. As a result, contractors have developed their own formal "in-house" training and evaluation progress and generally they do not share their programs with others (Alwi et al., 2001). Labour as a resource has specific characteristics. The production output of labour is a function of skill and motivation. From interviews it is clear that Indonesia has similar problems to other developing countries i.e.: poor labour productivity.

## CONCLUSION

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. A waste causing variable can be described as a variable/factor that produces waste. The variables are more likely to act as poor conditions of something (equipment, materials, environment), a lack of doing something (methods, ineffective, misuse), or poor conditions of human resources (behaviour, skills, qualifications, experience).

This paper presents a methodology which provides a useful tool to introduce the concepts of non value-adding activities in the field using a questionnaire survey. The model in Figure 1 provides opportunities to establish comprehensive cooperation between researchers and industry. This model also considers the following principle, practical implications of this research for the construction industry:

- Method for regular measurement of waste,
- Method for identifying key waste variables,
- Provide comprehensive documentation of waste during the process,
- Identification of contractor's performance, and
- Provide alternative solutions to be applied on-site.

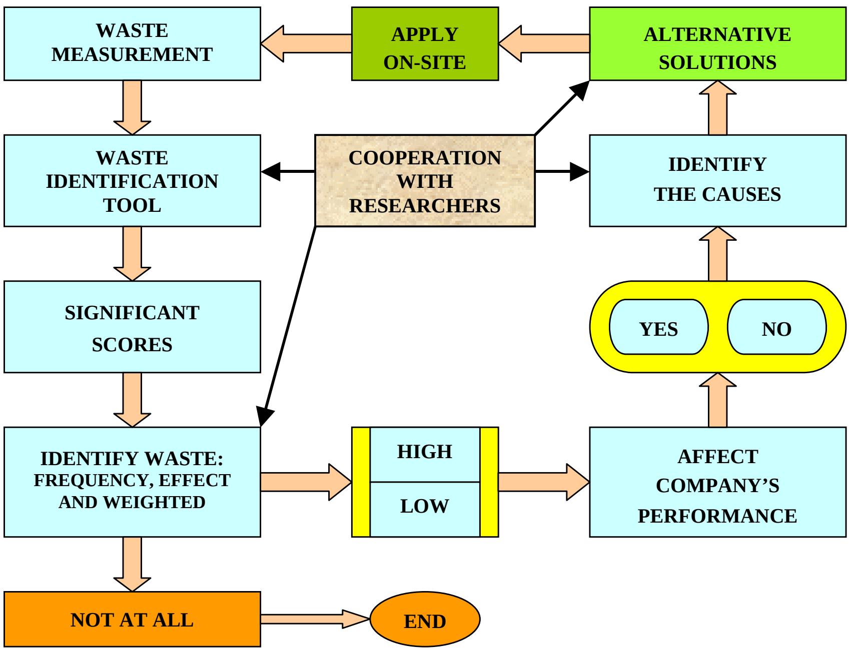


Figure 1: Model of Construction Practice

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