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# Safety Practices and Labour Productivity in Construction Projects

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***Abstract:*** Safety and productivity issues are become a vital concern in the construction industry nowadays. Low labor productivity and unsafe working environment have often been claimed to relate each other. Base on that reason, the aim of this study was to identify the most influencing safety practices on construction labor productivity. Questionnaire survey form with the Likert scale questions gave to the respondents to achieve research objectives. Then, the average index method, Kruskal Wallis test, and factor analysis technique were used to analyzed data. The result showed that the using of basic personal protective equipment (PPE) and the existence of safe guard device are the most influencing safety practices on labor productivity. The contractor result is the highest score compare to the client and consultant. This result can be useful to all the stake-holders in construction projects, from the initial to the end of project stages. The most important contribution of this study is the identification of the safety practices factors that give positive influence to the labour productivity. If these factors have been identified, it is easier to prepare the construction process. Construction projects expected to be more productive and also safer.

***Keywords***: Safety practices, Labor productivity, Construction projects, Personal protective equipment (PPE).

## 1.0 Introduction

Labor productivity is an important subject and dominant in a construction management process. It is influenced by the use of resources in order to be efficient and economically use, which will eventually affect all stages of the construction process. Labor productivity in construction industry is influenced by a lot of factors. Myers (2004), categorized the factors that influencing the productivity into four groups, namely: the quantity and quality of natural and man-made

resources, the quality and extent of the education and training of the labor force, the levels of expectation, motivation, and wellbeing, and the commitment to research and development. Tucker (1986) also explained the factors that causing productivity loss, are as follows : relative influence of labor costs, more sophisticated labor demands, more complex and larger projects, more participants and communication, centralization and specialization, accelerated schedules, increased paper work, and lack of research. Other factors defined are containing congestion, sequencing, weather, supervision, plant status, information, equipment, tools, materials, and rework Thomas and Sakarcan. (1994).

Safety is one of the influencing factors on labor productivity in construction industry based on previous research by (Dai, Goodrum and Maloney 2009; Herbsman and Ellis 1990 and Liberda Ruwanpura and Jergeas 2003). Safety can included in the labor factor, in management factor, in supervision factor, and others. The National Audit Office report (2001) also identified the root cause of the inefficiency in construction industry. One of the problems is the industry demonstrates a poor safety record and an inability to recruit good staff. Construction industry has been experiencing chronic problems such as poor safety, inferior working conditions, and insufficient quality. This industry has earned the reputation of being dangerous or highly hazardous industry because of the disproportionately high frequency of accidents and fatalities that occur on construction sites (The Business Roundtable 1983; Churcher and Alwani-Starr 1996 and Smallwood and Haupt 2000). Being dangerous refers to being risky, hazardous, or unsafe.

This study will identify safety practices that give most positive influences to labour productivity. If the factors have been identified, the stake-holders in construction projects will be easy to prepare construction works to reach the optimum labour productivity.

## 2.0 Literature Review

In safety management, there are two terms related to safety practices, namely unsafe actions and unsafe conditions. Injuries are the result of a combination of unsafe actions and unsafe conditions. Unsafe actions may be the outgrowth of a number of causes, including lack of proper training, lack of the attention to the work, carelessness, macho behavior, and inadequate instructions. Unsafe actions may include actions taken by managers or the failure of managers in doing action to make the job safe. The mental environment prompts many unsafe actions. Unsafe actions by workers may also be influenced by management. It should be noted that unsafe actions can occur even though workers would prefer not to sustain any injuries Hinze (1997). According to Abdelhamid and Everett (2000), an unsafe condition is a condition where the physical layout of the workplace or work location as well as the status of tools, equipment, and/or materials are in violation of contemporary safety standards. Examples of unsafe conditions include open sided floors,

defective ladders, improperly constructed scaffolds, protruding ends of reinforcing rods, protruding nails and wire ties, un-shored trenches, defective equipment, overloaded tools or equipment, unprotected explosive materials, ungrounded electrical tools, flying materials, etc.

Safety and productivity issues have gained vital importance in the competitive global environment (Choudhry, Fang and Hinze 2008). Low labor productivity and unsafe working environment have often been claimed to relate to each other. It has been said that the improvement of the working environment lays the foundations for the improvement of labor productivity (Kemppilä, Laitinen and Mettänen 2004). In line with the increasing awareness of all parties involved in the construction industry about the importance of occupational safety to improve labour productivity, this study try to identify the safety practices factors that influence the labour productivity. It needs to identify the safety practices that give a positive influence to increase labor productivity. Indonesia as one of developing countries in Asia facing the both of safety and productivity problems in their construction industry. Therefore, this research aim is to determine the most influencing safety practices on labour productivity in construction industry in one of province in Indonesia. With respect to so many safety practices from various resources, this paper has been summarized the safety practices to be asked to the respondents in the questionnaire survey.

## 3.0 Methodology

In total, 144 questionnaires filled by the respondents. Respondents for this research were people who work as contractors, consultants, and owners in a middle management position. The reasons why choose the middle management staff are: because they have an important responsibilities for the continuity of works and almost every day stay tune at the project. They also have a power to the workers about safety and health matters. In accordance with the scope of the research, the work site was in the Pekanbaru City, Riau Province, Indonesia. The selected respondents were the people who worked at the contractor company with grade 5, 6, and 7 in Indonesian contractor grade system. The location of respondents was in the same city, so it was quite efficient when distributing the questionnaires by means of direct distribution.

For data analysis, there were three types of statistical method used, namely descriptive statistics, inferential statistics, and factor analysis technique. This study also tested the reliability and validity of the research instruments and results from the research questionnaire survey.

From Table 1 the Cronbach's Alpha values are 0.932 and 0.942. If alpha is bigger than 0.90, it means it has perfect reliability. Value of Guttman Split-Half coefficient is 0.930; it is bigger than value of r product moment from product moment table. It was obtained from r table for $\alpha = 0.05$, and degrees of freedom (df = n-1 = 144-1 = 143), the value is 0.164. It can be concluded that all instruments used in

these questionnaires meet the requirements of reliability. If an item is valid, it must be reliable. There are 31 items which will be tested whether they are valid or invalid. To declare that an item is valid must be proved through calculation.

To determine the level of validity, it should be noted the value of rcount compared to rtable. If the value obtained for rcount is greater than the value of rtable from product moment table, it means that each item in this research is considered valid. From the result, the value of rcount for all safety practice items is greater than the value of rtable. The value of r table = 0.164. This indicates that all of the research instruments meet the standards of validity.

Table 1. Reliability test

| | | | |
|---|---|---|---|
| Cronbach's Alpha | Part 1 | Value | 0.932 |
| | | N of Items | 16[a] |
| | Part 2 | Value | 0.942 |
| | | N of Items | 15[b] |
| | | Total N of Items | 31 |
| | | Correlation Between Forms | 0.870 |
| Spearman-Brown Coefficient | | Equal Length | 0.930 |
| | | Unequal Length | 0.930 |
| | | Guttman Split-Half Coefficient | 0.930 |

a. The items are: P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P11, P12, P13, P14, P15, P16.

b. The items are: P16, P17, P18, P19, P20, P21, P22, P23, P24, P25, P26, P27, P28, P29, P30, P31

Data was then analyzed using the statistical computing package SPSS (Statistical Package for Social Science) version.17.0. In descriptive statistic, the average index was obtained from the frequency analysis that was measured to rank each safety practices which is influence to labor productivity. This formulation was used to calculate average index by Al-Hammad and Assaf (1996).

Average Index (AI) = $\sum (a_i.x_i) / \sum x_i$ (1)

where, $a_i$ = constant expressing the weight given to i, and $x_i$ = variable expressing the frequency of response for i = 1,2,3,4,5. In this questionnaire, the choices are : 1 = not influence, 2 = less influence, 3 = moderately influence, 4 = influence, and 5 = very influence.

To specify the level of influence of safety practices on labor productivity as in questionnaire, this study applied the classification of the rating scales proposed by Abd Majid (1997) as the following, and was adjusted to the statements in the questionnaire. This also showed the strength of indices of respondents' options. Not Influence

$0.00 < AI < 1.50$, Less Influence $1.50 \leq AI < 2.50$, Moderately Influence $2.50 \leq AI < 3.50$, Influence $3.50 \leq AI < 4.50$, and Very Influence $4.50 \leq AI < 5.00$.

For inferential statistic, Kruskal-Wallis test was used to compare three or more groups of data samples (*K* populations) and that might have different sample sizes. This technique is commonly used as an alternative if the assumptions in the ANOVA (Analysis of Variance) test cannot be met or data are not a normal distribution. Kruskal-Wallis test is a distribution-free test (Morgan, et al, 2007). The preparation of the Kruskal Wallis test hypothesis and the steps of hypothesis testing are as follows: If $H_0$ : All *K* populations are identical, and If $H_1$ : Not all *K* populations are identical.
This study examined whether the response of the three groups of respondents (owners, contractors and consultants) was significant.

The factor analysis technique was applied to reduce the large amount of data to a small number of factors (or components), showing the group of safety practices that has the most influence on labor productivity. The factor analysis technique is too complex to be described here, but can be read in most statistical texts. In short, it takes into account the weighting of the various variables (items), scored by the respondents, and combine them together to form a group of factors (group of safety practices).

Each safety practices for the questionnaire purpose named as P1 to P31. All statements given in the questionnaire are positive statements, or the opposite of the statements of "unsafe actions" and "unsafe conditions". It is intended that respondents think the positive influence of safety practices on labor productivity.

## 4.0 Results and Discussion

Discussion of the research findings was based on results of the average index and classification of rating scales and factor analysis technique which are shown in Table 2 to Table 6.

### 4.1. Descriptive Statistic

Table 2 is a summary for overall results from three types of respondents. In this table, P.1 and P.9 are considered as safety practices which are very influential to the labor productivity. The respondents choose that using personal protective equipment (PPE) and providing and installing safe guard devices give a positive impact to improve productivity. The remaining 29 safety practices are categorized as "influence" items.

### 4.2. Test of Differences of Mean Score (Kruskal-Wallis test)

This section will test whether there are differences in average scores between the three types of respondents using the Kruskal-Wallis test for several independent samples. The result is given at Table 2. The assumptions for this test are; Ho : mean value of the three types of respondents is identical, and Ha : mean value of the three types of respondents is not identical. From the test results, it is obtained that $\alpha = 0.05$, Sig = 0.00. Because Sig < $\alpha$ ($0.00 < 0.05$), then Ho is rejected or Ha is accepted. The conclusion is the average value of the three types of

companies is not identical or not significant. There are differences among the three groups. There is a difference in opinions from the respondents in providing an assessment for each safety practice that influences labour productivity.

Table 2 Rank of safety practices from all types of respondents

| de | Safety Practices | Std Deviation | AI (N=144) | Rank | Class of Rating Scales |
|---|---|---|---|---|---|
| P1 | Using basic personal protective equipment and clothing, e.g. safety shoes, helmet, and gloves | 0.117 | 4.61 | 1 | Very Influence |
| P9 | Providing and installing safe guard devices e.g. safety net, guard rail, and safety sign board | 0.1**Co**66 | 4.52 | 2 | |
| P18 | Paying more attention to the dangerous works, like working in the roof, under ground work etc. | 0.157 | 4.49 | 3 | |
| P4 | Supervisor should have safety knowledge, motivate, and push their workers to work safely. | 0.207 | 4.47 | 4 | |
| P22 | Paying more attention to the heavy equipment, e.g. tower crane, bulldozer, scrapper also operator's skill | 0.065 | 4.45 | 5 | |
| P2 | Using any other specialized protective equipment required for a specific task, e.g. respiratory, eye, face, and hearing protection | 0.081 | 4.40 | 6 | |
| P21 | Using appropriate equipment and tools | 0.136 | 4.36 | 7 | |
| P6 | Awareness of workers toward safety | 0.096 | 4.35 | 8 | |
| P7 | Working area is tidy and clean from the rubbish and waste material | 0.244 | 4.34 | 9 | |
| P31 | Strict / firm management toward safety practice on the project | 0.248 | 4.33 | 10 | |
| P23 | Paying more attention to the supporting work devices, such as ladder, scaffolding, platform, and safety harness | 0.124 | 4.31 | 11 | |
| P8 | Providing adequate worker facilities e.g. toilet and barracks | 0.151 | 4.31 | 12 | |
| P14 | Safety orientation for new workers | 0.150 | 4.28 | 13 | Influence |
| P10 | Allocation planning at the site, and providing traffic line of workers and materials | 0.192 | 4.26 | 14 | |
| P30 | Designation of safety officer at the site | 0.275 | 4.26 | 14 | |
| P28 | Developing safety plan for the whole site and for each task | 0.080 | 4.26 | 14 | |
| P3 | Not taking an obvious risk when conducting the job | 0.070 | 4.26 | 14 | |
| P13 | Giving a short training when using new equipment or tools | 0.045 | 4.25 | 15 | |
| P16 | Safety inspection regularly at the site | 0.236 | 4.25 | 15 | |
| P20 | Checking condition of equipment and tools before using | 0.138 | 4.25 | 15 | |
| P19 | Maintenance and repair of equipment and tools | 0.080 | 4.24 | 16 | |
| P29 | Communicating safety target / goal to the workers, such as "zero accident" target, safety first, etc. | 0.136 | 4.24 | 16 | |
| P17 | Safety hazards inspection before starting the works | 0.147 | 4.22 | 17 | |
| P12 | Conducting safety training regularly for the employees | 0.245 | 4.20 | 18 | |
| P15 | Giving a short training about method and procedure | 0.255 | 4.20 | 18 | |

| | | | | |
|---|---|---|---|---|
| | of the work | | | |
| P25 | Clear and written safety policy and regulation at the site | 0.195 | 4.19 | 19 |
| P24 | Conducting field safety meeting / toolbox meeting regularly | 0.135 | 4.17 | 20 |
| P5 | Executing hazard analysis and work analysis before working toward safety | 0.246 | 4.17 | 20 |
| P27 | Investigation of an accident to know the causes of the accident as a preventive and corrective action for the future | 0.172 | 4.14 | 21 |
| P11 | No adverse environment, such as noise, light, dust, and heat | 0.075 | 4.13 | 22 |
| P26 | Safety evaluation/monitoring program regularly | 0.227 | 4.07 | 23 |

Based on 'mean rank (for all companies)' at the Table 3, the high mean rank scores indicate that the respondents at that company have the high mean rank. In this case, the contractors have a mean rank 70.73 as the highest value, followed by consultants with 37.35, and client with 32.92. This also means that respondents who work in the contractor company assess safety practices as more influencing than the other two companies. This is accordance with the statement that contractor hold a very important role in the implementation of safety and health management system in their project (Hughes and Ferrett 2007). For consultant, unfortunately, a survey about designers revealed that "less than one-third of the design firms address construction worker safety in their design (Hinze and Wiegand 1992), and it is proven in this research, consultant got the score below the contractor. As well as the client, obtain a lower score below the value of the contractor. Although the owners involvement in construction safety can pay real dividends through reduced injuries. Before any construction contract is contemplated, owners should assess their commitment to safety

### 4.3. Factor Analysis Technique

The average index is used to identify the items that will be clustered into a number of factors that have the closest or similar characteristics. Mean score from each item is less than two (4.61 to 4.07), and almost close to each other; it means that respondents consider most items are in "influence category" on the labor productivity. This result shows that it is significant to analyze the finding using factor analysis

From Table 4, the value of KMO MSA test was 0.919, certainly and substantially exceeding the recommended value of 0.70. Meanwhile, the value of Bartlett's Test of Sphericity was 3278.997 and significant at 0.00. It means that the variables are correlated highly enough to provide a reasonable basis for factor analysis.

Table 3. Kruskal-Wallis test result

| Ranks | | | | Test Statistics[a,b] | |
|---|---|---|---|---|---|
| **Company** | | **N** | **Mean Rank** | | **Mean** |
| Mean | 1 - client | 31 | 32.92 | Chi-Square | 36.401 |
| | 2 - contractor | 31 | 70.73 | df | 2 |
| | 3 - consultant | 31 | 37.35 | Asymp. Sig. | 0.000 |
| | Total | 93 | | Std Deviation | 0.185 |

a. Kruskal Wallis Test
b. Grouping Variable: company

Table 4: KMO and Bartlett's test

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.919 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 3278.997 |
| | Df | 465 |
| | Sig. | 0.000 |

The factor analysis technique was utilized to help identifying the underlying cluster of factors that dominate safety performance. The research has applied the factor analysis on the 31 safety practices.. Test of factorability was performed using Kasier-Meyer-Olkin's measure of sampling adequacy. In order to give meaning to the results of the factor analysis, it is necessary to assign an identifiable name to the group of factors of high correlation coefficient. Table 5 shows that there are five factors obtained from the rotated factor matrix. The bold and italic value indicated that the item is included into the above component/factor. Example item P24 is in component 1; it has the greatest value contained in component 1.

**Table 5. :** Rotated factor matrix

| | Component | | | | |
|---|---|---|---|---|---|
| **Item** | **1** | **2** | **3** | **4** | **5** |
| P24 | ***0.662*** | 0.281 | 0.190 | 0.228 | 0.196 |
| P5 | ***0.599*** | 0.482 | 0.060 | 0.096 | 0.158 |
| P11 | ***0.616*** | 0.168 | 0.160 | 0.168 | 0.443 |
| P1 | ***0.564*** | -0.079 | 0.212 | 0.343 | 0.361 |
| P13 | ***0.576*** | 0.281 | 0.261 | 0.249 | 0.268 |
| P12 | ***0.546*** | 0.211 | 0.214 | 0.544 | 0.169 |

| | | | | | |
|---|---|---|---|---|---|
| P16 | ***0.555*** | 0.296 | 0.248 | 0.485 | 0.115 |
| P17 | ***0.548*** | 0.302 | 0.400 | 0.204 | 0.212 |
| P3 | ***0.476*** | 0.044 | 0.359 | 0.058 | 0.312 |
| P29 | 0.194 | ***0.717*** | 0.179 | 0.404 | 0.164 |
| P28 | 0.225 | ***0.679*** | 0.262 | 0.135 | 0.185 |
| P26 | 0.431 | ***0.621*** | 0.261 | 0.236 | 0.265 |
| P27 | 0.120 | ***0.607*** | 0.429 | 0.252 | 0.226 |
| P25 | 0.220 | ***0.526*** | 0.250 | 0.389 | 0.435 |
| P20 | 0.296 | 0.320 | ***0.725*** | 0.097 | 0.196 |
| P19 | 0.255 | 0.293 | ***0.666*** | 0.061 | 0.371 |
| P21 | 0.246 | 0.205 | ***0.666*** | 0.324 | 0.044 |
| P22 | 0.097 | 0.084 | ***0.667*** | 0.457 | 0.239 |
| P23 | 0.196 | 0.455 | ***0.610*** | 0.112 | 0.194 |
| P30 | 0.206 | 0.502 | 0.201 | ***0.520*** | 0.115 |
| P4 | 0.288 | 0.305 | -0.033 | ***0.464*** | 0.480 |
| P31 | 0.065 | 0.407 | 0.057 | ***0.704*** | 0.326 |
| P18 | 0.211 | 0.036 | 0.367 | ***0.559*** | 0.363 |
| P15 | 0.441 | 0.280 | 0.282 | ***0.614*** | -0.014 |
| P14 | 0.407 | 0.245 | 0.251 | ***0.550*** | 0.129 |
| P9 | 0.300 | 0.140 | 0.104 | 0.176 | ***0.689*** |
| P10 | 0.266 | 0.382 | 0.242 | 0.045 | ***0.586*** |
| P8 | 0.106 | 0.309 | 0.308 | 0.210 | ***0.558*** |
| P2 | 0.501 | 0.192 | 0.114 | 0.116 | ***0.540*** |
| P6 | 0.256 | 0.390 | 0.324 | 0.058 | ***0.510*** |
| P7 | 0.145 | 0.016 | 0.365 | 0.381 | ***0.557*** |

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
Rotation converged in 25 iterations

Table 6 is a result of factor analysis for questionnaire about safety practices that influence labor productivity in construction. These are five factors that have been formed and have similar characteristics. The factors can be identified by delivering the group name based on their similar characteristics, such as in the column (3) of Table 5.

**Table 6 Result of extracted of factor analysis**

| Factor | Safety Practices | Name of the Group |
|---|---|---|
| **(1)** | **(2)** | **(3)** |
| 1 | P1, P3, P5, P11, P12, P13, P16, P17 and P 24 | Standard and Procedure |
| 2 | P25, P26, P27, P28, and P29 | Management |
| 3 | P19, P20, P21, P22, and P23 | Equipment and Tools |
| 4 | P4, P14, P15, P18,P30, and P31 | Personnel |
| 5 | P2,P6,P7,P8,P9, and P10 | Environmental |

## 5.0. Conclusions

Based on the analysis, some conclusions can be drawn as follows:

a. The aim of the research was to identify the most influencing safety practices on construction labor productivity has been achieved. All safety practices have been sorted by the highest value to lowest. “Using basic personal protective equipment and clothing, e.g. safety shoes, helmet, and gloves’ and ‘providing and installing safe guard devices e.g. safety net, guard rail, and safety sign board’
b. All respondents agreed that safety practices have a positive influence on labour productivity, it can be seen from the results, the answer given just two types, namely “very influence” and “influence”
c. Safety practices P1 (using basic personal protective equipment and clothing, e.g. safety shoes, helmet, and gloves) and P9 (providing and installing safe guard devices e.g. safety net, guard rail, and safety sign board, installing safe guard devices e.g. safety net, guard rail, and safety sign board) obtaining the highest average index (AI) score, so fall into the category of "very influence", the others (29 safety practices) fall into the category “influence”.
d. Based on the results of the questionnaire, it was found that respondents from the contractors have a mean or average index higher than clients and consultants. It can also be interpreted that they are more aware and understanding of the influence of safety practices on labor productivity in construction field. The reason is the contractor is the direct executor of the construction work, so they should know the safety management.
e. There are 5 factors or groups that are formed from the results of the factor analysis technique, namely: standard and procedure, management, equipment and tools, personnel, and environmental. All the safety practices in the questionnaire survey form, which amounted to 31 items have been get into the groups that have similar characteristics.

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