# Waste Reduction at Mechanical Electrical Plumbing (MEP) Works Based On Lean Construction in High Rise Building

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**ABSTRACT**
The Mechanical Electrical and Plumbing (MEP) work is part of the implementation of high-rise construction work that often has problems in its completion due to factors or variables that influence each other. So it is necessary to apply the Lean Construction method as an alternative to solving existing problems.
The application of Lean Construction is able to reduce waste material in construction work including the work of MEP, which is able to minimize activities that do not produce value on the final results of construction work and reduce the residual material used. In this study, data was collected from the Statistical Package for the Social Sciences (SPSS) questionnaire which obtained the most influential factor in MEP work in high-rise buildings. The identification results gathered as many as 48 key success factors from 12 sub-factors.
This study uses a simple descriptive method. To determine the significance level of CSF a questionnaire survey was used to respondents working in consulting companies, contractors and owners in Jakarta. The results of the descriptive analysis conclude 5 of the most influential or dominant key success factors. Namely: Planning, Field Conditions, Weather, Design Changes, Delay in Material Delivery and Lack of Labor.

***Keywords** - Lean Construction, Mechanical Electrical and Plumbing, SPSS, Critical Success Factor, Highrise Buildings*

## I. INTRODUCTION

T The Indonesian construction industry, and also in general, is still struggling with inefficiency issues in the implementation of its construction process. There is still too much waste in the form of activities that use resources but do not produce the expected value (value).
Based on research, some waste in the construction process such as' quality mismatch 'reaches 12% of the total project cost,' weak material management 'adds costs around 10-12% of total costs to workers,' the amount of time spent on non-productive activities value 'is 2/3 of the total project implementation time, and' low safety 'causes additional costs of 6% of the total project cost. This proves that in producing value there is a clear barrier that is waste during the construction process [1].
An innovation in the basic theory and paradigm in the world of construction is believed to have a comprehensive and significant impact. As is usually done, the construction industry adopts and learns from the manufacturing industry, so one of the fundamental innovations is the adoption of a production theory called Lean Production in the construction process, hereinafter referred to as Lean Construction.
Based on data presented by the Lean Construction Institute, waste in the construction industry is around 57% while activities that provide added value are only 10% [2].

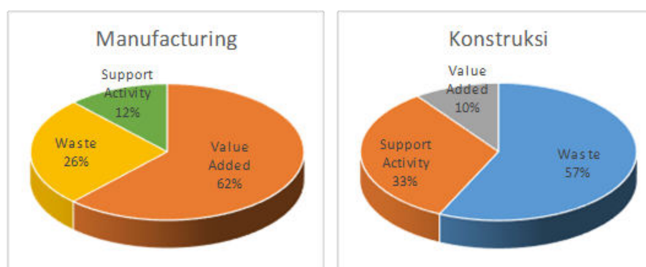



Figure 1. Portions Waste Cost Comparison on Industrial Manufacturing and Construction

While the percentage of MEP Employment Costs from the total construction work cost is 14.1% consisting of 4% mechanical work, 4.8% electrical and 5.3% plumbing work, as shown in figure 2.
Some parties in a construction work, which has an important role in connection with waste material in construction work. The Implementing Contractor has the most important role with the occurrence of construction material waste of 79.17%, Planning Consultant, 16.67% and Owner 4.17% [3]. In addition, based on data from research in the Netherlands, it indicates that 9% of total

material purchases end up as waste, and 1% - 10% of purchases for each material [4].

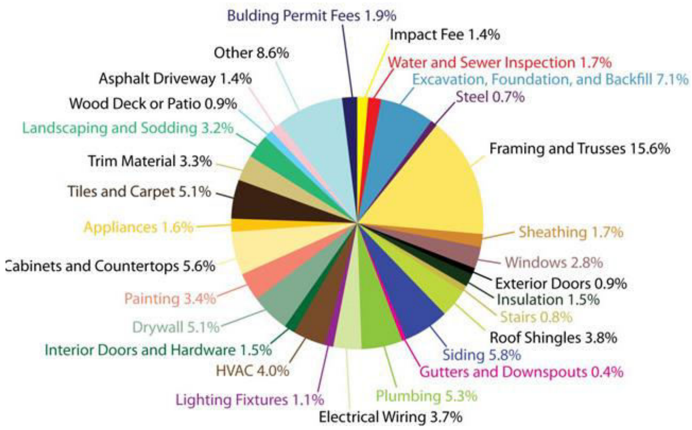



Figure 2. Construction Cost Building on Industrial Sources: Construction Data 2009

The scope of this study is that the data used are perceptions collected through questionnaires originating from contractors and consultant planners and contractors/consultants who are respondents to this study operating in DKI Jakarta with the qualifications of large, medium and small companies.

The objective to be achieved in this study is to identify the key factors for successful LC implementation in building construction projects in Indonesia and determine the key factors of success that are very influential or dominant (CSF) for LC implementation in high-rise construction projects in Indonesia.

Understanding the key success factors are expected to be able to identify the dominant factors in the application of the LC method to the implementation of MEP work in high-rise building construction projects.

## II. REVIEW OF RESEARCH

Lean Construction (LC) is a way to design a production system that can minimize waste from material use, time (time) and effort in order to produce a maximum number of values [5].

LC is a philosophy of project management based on a set of approaches developed in production management and adapted to project management. LC targets the LC system's goal of maximizing value and minimizing waste (LCI, 2007). LC has five principles in lean production, namely value, flow value, flow, attraction, and perfection and applies it to the construction industry to minimize waste [6].

The lean goal that is applied in construction is the elimination of waste, increasing reliability, creating a continuous flow in the pull system, meeting customer needs, the involvement of workers at each level, involvement of suppliers and liens in the project process, building quality projects, making improvements and sharing knowledge [6].

Mechanical, Electrical and Plumbing (MEP) is a core segment of the architectural engineering industry, resembling the blood, nerves and digestive systems of the human body. This core task plays an important role in the overall architecture or construction business with the aim of providing a safe and comfortable place for the environment. The MEP system consists of several work categories and activities that support complex pipeline management in all units, which are often encountered when there is no interface integration which results in delays in the project and reduces the quality of the product itself [7].

The function of MEP in buildings is building support systems that require mechanical systems or machine tools and require electric power. Support systems are applied in buildings for the convenience and safety of its users. Mechanical installation is an installation that deals with piping and installations that use machines, while electrical installations are installations related to electricity supply and components that require an electricity supply. In general, a building's MEP system consists of :

1. Mechanical Systems:
   a. Fire Fighting System (Fire Protection)
   b. System air conditioning (AC / Air Conditioning)
   c. Vertical Transportation Systems (elevator)
2. Electrical & Electronic Systems.
   a. Strong Flow System
   b. System Generator
   c. Lightning Protection Systems
   d. Phone systems
   e. Sound System
   f. Fire Alarm Systems (Fire Alarm)
      -ROR (Rate of Rise) Heat Detector
      -Smoke detector
   g. System MATV (Master Television)
   h. Systems CCTV (Closed Circuit Television)
3. Plumbing system.
   a. Clean Water Systems
   b. Dirty Water Systems
   c. Kitchen Water Systems
   d. Rain Water System
   e. System STP (Sewage Treatment Plan).

### 2.1. Research methods

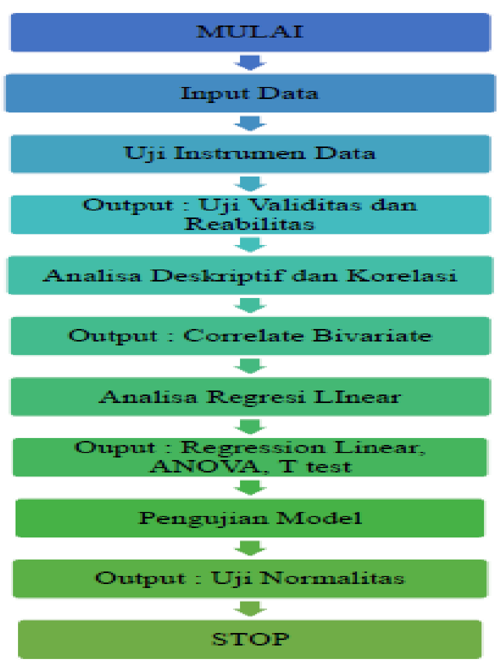
The study was conducted to analyze understanding and assess barriers and examine the effect of applying LC methods on high-rise building projects on project quality and time. Research begins with formulating problems and research titles that are supported by a literature review. After that, the concept and hypothesis of the study were determined which became the basis for choosing the right research method. To find out understanding and identify barriers in LC quality in high-rise building projects, the preparation of research instruments was carried out in the form of variables formulated in the form of questionnaires [8].

The dominant obstacle is then discussed on these findings to draw conclusions about the understanding and dominant factors that cause obstacles in implementing the implementation of lean construction on the work of MEP on high-rise building projects, followed by discussions with experts, where conclusions will be obtained and advice.

This research is descriptive quantitative research, which is used to analyze data by describing collected data as they are without intending to make conclusions that apply to the public or generalizations [9].

### 2.2. Implementation of the integration of lean methods construction

The application of lean integration in the implementation of the MEP work building high-rise buildings can be seen in figure 3.




Secondary data collection is based on literature studies of books, journals, proceedings, internet, and internal company data that are relevant to the research activities carried out. Next is the expert validation stage, pilot survey, and distribution of questionnaires. Sampling is done at the Anandamaya Residences Project in Jakarta, which is considered to represent the contracting company Mechanical, Electrical, and Plumbing (MEP). Respondents selected as samples in the questionnaire survey consisted of 50-60 individuals involved in the project

Then make a tabulation of data to enter the test results, namely the validity test to get the results of a study can be trusted, the reliability test using Alpha Cronbach's method. Next is the frequency distribution analysis to get the mean value of each sub-variable.

Descriptive analysis to provide a general description of the data that has been obtained while correlation analysis to measure the closeness of the relationship between observations, measure the correlation of data intervals and ratios. Regression Analysis Using SPSS, 2004, states that testing must be done by testing hypotheses for conclusions. Regression analysis to estimate the average value (population) of the dependent variable Y based on the value of the independent variables X, which are known or determined.

Model testing consisting of Linearity Test, Normality Test, Homoscedasticity Test (similarity variance), Non-Autocorrelation Test

The research approach uses a survey method based on a questionnaire filled out by respondents. Research with this survey method was carried out by following the research flow as shown in figure 4.

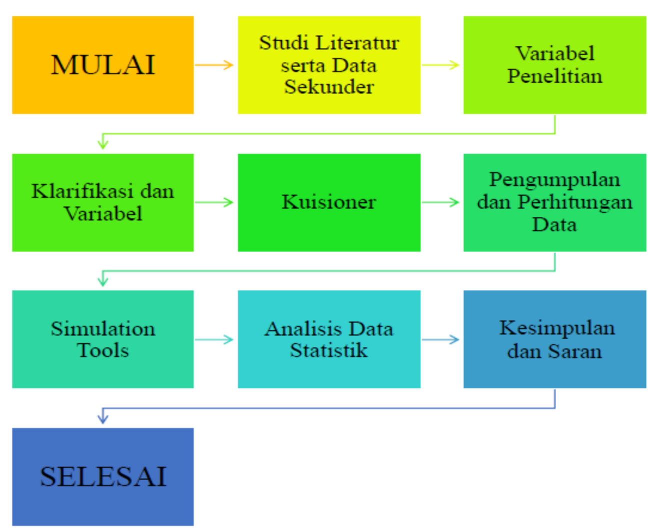



Figure 3. Flowchart of Statistical Analysis with SPSS

## 2.3 Research Variables

The application of lean integration in the implementation of Figure 4. Flowchart of Statistical Analysis with SPSS he following flow chart image:

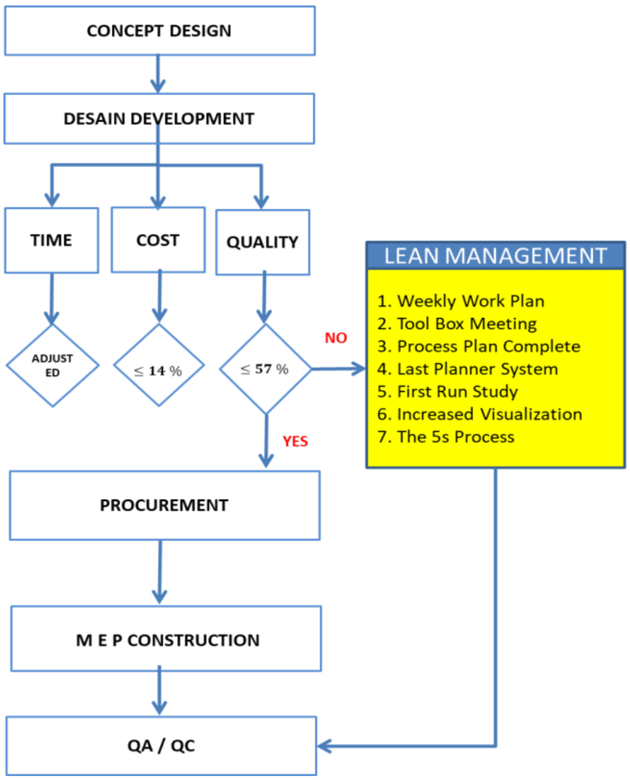



Figure 4. Flow Chart application of Lean Construction

## 2.4 Research Variables

For research using the survey method, based on the data obtained, analysis and preparation of mathematical models were conducted which showed the relationship between identifying the causes of time inefficiency in the production process and the effect of LC applications.

Variables which are research instruments are formulated by describing them as indicators and sub-indicators, which are then transformed into questions or statements.

1. Free Variables

The independent variable (X) consists of several variables which are the results of detailed research factors, indicators and sub-indicators, with the main variables being:

a. Identify the causes of cost and time inefficiencies.

b. Lean construction application

2. Bound Variables

The dependent variable (Y) of the research is cost and time performance.

## 2.5 Identification of the key factors of success

There are many supporting factors so that the implementation of the MEP work on High-rise Building buildings has been successfully carried out including, among others, comparison of measurements and predictions, Adequacy of plans and specifications, Improving Instrument schedules and plans monitoring performance. For more details, the factors that influence the success of the application of the method according to some previous studies can be seen in Table 1.

Table 1. Key Success Factors for applying LC

| No. | Factors | Reference |
|---|---|---|
| 1 | Poor Control Management | Serpell et al., 1995 |
| 2 | Poor Planning | Serpell et al., 1995, Alwi et al., 2002 |
| 3 | Poor Coordination of Employees | Alwi et al., 2002 |
| 4 | The slow pace of decision-making | Alwi et al., 2002 |
| 5 | Design Changes | Alwi et al., 2002 |
| 6 | Image Work Unclear | Alwi et al., 2002 |
| 7 | Specifications Unclear | Alwi et al., 2002 |
| 8 | Information Unclear | Alarcon, 1995 |
| 9 | Late information | Alarcon, 1995 |
| 10 | Poor Quality Material | Alwi et al., 2002 |
| 11 | Lack of material | Alarcon, 1995 |
| 12 | Material delivery Late | Alwi et al., 2002 |
| 13 | The recent Material Handling | Alwi et al., 2002 |
| 14 | shorthanded | Alarcon, 1995 |
| 15 | Worker Skills Less | Alwi et al., 2002 |
| 16 | Poor distribution of workers | Alwi et al., 2002 |
| 17 | Supervisory Came Too Late | Alwi et al., 2002 |
| 18 | Inspektor Not Experienced | Alwi et al., 2002 |
| 19 | Error Working Methods | Serpell et al., 1995, Alwi et al., 2002 |
| 20 | Not Following Procedure | Alwi et al., 2002 |
| 21 | Equipment Not Available Capacity | Alwi et al., 2002 |
| 22 | Poor Layout Tool | Alwi et al., 2002 |
| 23 | Tools Of Date | Alwi et al., 2002 |
| 24 | Setup Tool Lama | Gaspersz and Fontana, 2011 |
| 25 | Poor Maintenance | Gaspersz and Fontana, 2011 |
| 26 | Environment | Serpell et al., 1995, Alwi et al., 2002 |
| 27 | Weather | Alwi et al., 2002 |
| 28 | Damage By Others | Alwi et al., 2002 |
| 29 | Master Schedule Preparation of project schedule thoroughly and determination milestone | Ballard, 2000 |
| 30 | Reverse Phase Scheduling (RPS): Manufacture scheduling plan starts from a target completion backward (the technique of "pull") | Ballard and Howell, 2003 |
| 31 | Six-Week Lookahead : 6 weekly work plan | Ballard, 2000 |
| 32 | Weekly Work Plan (WWP): Work plan weekly | Ballard, 2000 |
| 33 | Percent Plan Complete (PPC): A tool achieving the target of weekly working | Ballard, 2000 |
| 34 | Working diagram | Moser and Dos Santos, 2003 |
| 35 | Performance Target | Moser and Dos Santos, 2003 |
| 36 | Work schedule | Moser and Dos Santos, 2003 |
| 37 | Safety signs | Moser and Dos Santos, 2003 |
| 38 | Job evaluation | Schwaber, 1995 |
| 39 | Work plan | Schwaber, 1995 |
| 40 | Plan : Plan a job | Ballard and Howell, 1977 |
| 41 | do : Do what is already planned | Ballard and Howell, 1977 |
| 42 | check : Define and measure what happens | Ballard and Howell, 1977 |
| 43 | Act : Discuss the development of methods and performance to be used as a standard | Ballard and Howell, 1977 |
| 44 | Sort : Separate the items needed and waste unused material | Kobayashi, 1995 and Hirano, 1996 |
| 45 | Stabilize : Storing items necessary in a place easily retrieved if used | Kobayashi, 1995 and Hirano, 1996 |
| 46 | Shine : Clean and trim work area | Kobayashi, 1995 and Hirano, 1996 |
| 47 | Standardize : Doing standardizing 3s | Kobayashi, 1995 and Hirano, 1996 |
| 48 | Sustain : Getting discipline becomes a habit | Kobayashi, 1995 and Hirano, 1996 |

## III. RESULTS AND DISCUSSION

Research variables will be used as the basis for obtaining the results of primary data (questionnaire) Data processing for survey results of questionnaires was analyzed using Microsoft Excel 2007 software and SPPS Statistics 24.0 for Windows. The results will be displayed in the form of tables, pie charts, bar charts, and other diagrams, based on the variables and types of analysis used.

### 3.1. Data collection and analysis results :

Of the 60 questionnaires distributed offline return rate reaches 66%. With the background of the respondents as shown in Table 2.

Table 2. Background of Respondents Construction

| Respondents Work place | | respondents | percentage |
|---|---|---|---|
| X1 | developer | 5 | 16% |
| X2 | Consultant | 4 | 13% |
| X3 | Construction management | 6 | 20% |
| X4 | Main Contractor | 4 | 13% |
| X5 | MEP contractor | 9 | 30% |
| X6 | Supplier | 1 | 4% |
| X7 | Etc | 1 | 4% |
| **Total Number of Respondents, X** | | **30** | **100%** |

With an education level of 63% at the level of Bachelor (S1) 30% Diploma (D3) and 7% of high school / vocational education. While the position and work experience of respondents can be seen in tables 3 and 4:

Table 3. The Position of Respondents R Construction

| Position respondents | | responses | percentage |
|---|---|---|---|
| X11 | Project Manager | 9 | 31% |
| X12 | site Manager | 4 | 13% |
| X13 | Head Engineering | 3 | 10% |
| X14 | Engineering | 4 | 13% |
| X15 | supervisor | 10 | 33% |
| **Total Number of Responses, X** | | **30** | **100** |
| | | | |

Table 4. Respondents Work Experiences

| Work Experience respondents | | responses | percentage |
|---|---|---|---|
| x19 | 1-10 years | 21 | 70% |
| X20 | 11-20 years | 6 | 20% |
| X21 | ≥20 years | 2 | 10% |
| **Total Number of Respondents, X** | | **30** | **100%** |

Furthermore, from the existing variables testing the validity, reliability, with results that can be seen in tables 5 and 6.

Table 5. Validity Test Results

| variables | No. Statement | rhitung | Interpretation |
|---|---|---|---|
| Management (X1) | X1.1 | 0.69 | item Valid |
| | X1.2 | 0.70 | item Valid |
| | X1.3 | 0.68 | item Valid |
| | X1.4 | 0.63 | item Valid |
| | X1.5 | 0.64 | item Valid |
| Design (X2) | X2.1 | 0.69 | item Valid |
| | X2.2 | 0.71 | item Valid |
| | X2.3 | 0.68 | item Valid |
| | X2.4 | 0.67 | item Valid |
| | X2.5 | 0.69 | item Valid |
| | X2.6 | 0.69 | item Valid |
| | X2.7 | 0.67 | item Valid |
| | X2.8 | 0.61 | item Valid |
| Materials (X3) | X3.1 | 0.63 | item Valid |
| | X3.2 | 0.63 | item Valid |
| | X3.3 | 0.63 | item Valid |
| | X3.4 | 0.69 | item Valid |
| | X3.5 | 0.63 | item Valid |
| HR (X4) | X4.1 | 0:55 | item Valid |
| | X4.2 | 0:50 | item Valid |
| | X4.3 | 0:49 | item Valid |
| | X4.4 | 0:45 | item Valid |
| | X4.5 | 0.60 | item Valid |
| | X4.6 | 0.63 | item Valid |
| | X4.7 | 0:46 | item Valid |
| | X4.8 | 0:56 | item Valid |
| | X4.9 | 0:54 | item Valid |
| | X4.10 | 0:54 | item Valid |
| | X4.11 | 0:45 | item Valid |
| Tool (X5) | X5.1 | 0.60 | item Valid |
| | X5.2 | 0.73 | item Valid |
| | X5.3 | 0.71 | item Valid |
| | X5.4 | 0.61 | item Valid |
| | X5.5 | 0.66 | item Valid |
| Influence From Outside (X6) | X6.1 | 0.72 | item Valid |
| | X6.2 | 0.75 | item Valid |
| | X6.3 | 0.68 | item Valid |
| | X6.4 | 0.79 | item Valid |
| | X6.5 | 0.70 | item Valid |
| The Effect of In (X7) | X7.1 | 0.65 | item Valid |
| | X7.2 | 0.62 | item Valid |
| | X7.3 | 0.63 | item Valid |
| | X7.4 | 0.70 | item Valid |
| | X7.5 | 0.61 | item Valid |
| Last Planner System (X8) | X8.1 | 0.68 | item Valid |
| | X8.2 | 0.68 | item Valid |
| | X8.3 | 0.72 | item Valid |
| | X8.4 | 0.70 | item Valid |
| | X8.5 | 0.77 | item Valid |
| | X8.6 | 0.78 | item Valid |
| Increased Visualization (X9) | X9.1 | 0.78 | item Valid |
| | X9.2 | 0.78 | item Valid |
| | X9.3 | 0.81 | item Valid |
| Marketing Tool Box (X10) | X10.1 | 0.90 | item Valid |
| | X10.2 | 0.89 | item Valid |
| First Run Studies (X11) | X11.1 | 0.71 | item Valid |
| | X11.2 | 0.75 | item Valid |
| | X11.3 | 0.70 | item Valid |
| | X11.4 | 0.76 | item Valid |
| The 5s Process (X12) | X12.1 | 0.72 | item Valid |
| | X12.2 | 0.75 | item Valid |
| | X12.3 | 0.67 | item Valid |
| | X12.4 | 0.67 | item Valid |
| | X12.5 | 0:42 | item Valid |
| Time and Cost (Y) | Y1 | 0.96 | item Valid |
| | Y2 | 0.93 | item Valid |

Table 6. Reliability Test Results

| variables | Cronbach's alpha | Interpretation |
|---|---|---|
| Management (X1) | .669 | reliable |
| Design (X2) | 0.815 | highly Reliable |
| Materials (X3) | 0.608 | reliable |
| HR (X4) | .713 | reliable |
| Tool (X5) | .673 | reliable |
| Influence From Outside (X6) | .760 | reliable |
| The Effect of In (X7) | .638 | reliable |
| Last Planner System (X8) | .807 | highly Reliable |
| Increased Visualization (X9) | .690 | reliable |
| Marketing Tool Box (X10) | .760 | reliable |
| First Run Studies (X11) | 0,702 | reliable |
| The 5s Process (X12) | .640 | reliable |
| Time and Cost (Y) | .871 | highly Reliable |

### 3.2. Variable Test Results

Based on the validity of the test results shown in Table 7 can be seen the value of Alpha Cronbach's entire variable is greater than 0.6. With the ever thus, the entire item statement further stated to have reliable and can be used to measure the variables studied.

Table 7. Descriptive Management Variables

| Management (X1) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale question | | | | | | | | | | | | |
| No | 1 | | 2 | | 3 | | 4 | | 5 | | Jumlah | Mean |
| | F | % | F | % | F | % | F | % | F | % | | |
| 1 | 1 | 3.33% | 1 | 3.33% | 16 | 53.33% | 10 | 33.33% | 2 | 6.67% | 30 | 3.37 |
| 2 | 0 | 0.00% | 2 | 6.67% | 7 | 23.33% | 16 | 53.33% | 5 | 16.67% | 30 | 3.80 |
| 3 | 0 | 0.00% | 1 | 3.33% | 15 | 50.00% | 9 | 30.00% | 5 | 16.67% | 30 | 3.60 |
| 4 | 1 | 3.33% | 7 | 23.33% | 14 | 46.67% | 8 | 26.67% | 0 | 0.00% | 30 | 2.97 |
| 5 | 5 | 16.67% | 6 | 20.00% | 13 | 43.33% | 6 | 20.00% | 0 | 0.00% | 30 | 2.67 |
| TOTAL MEAN | | | | | | | | | | | | 3.28 |

Based on the results of data processing of respondents to each question item in Management variable (X1), it is known that the average value of the total score is a question of 5 items by 3, 28. This value> 2.5 (mean score on a scale of 1-5). These results show that the variable sub Management is a dominant factor in causing the inefficiency of time in the production process.

The average value of all items question> 2, 5, these results show that all factors involved in the sub-variables of management be the dominant factor in causing the inefficiency of time in the production process. Item number 2 question about the level of achievement of the work against ongoing plans scored the highest average (3.80), while the question item number 5 on the speed in taking decisions at the managerial level obtained the lowest average score (2.67) compared to with questions in other management variables.

Table 8. Descriptive Design Variables

| Design (X2) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale question | | | | | | | | | | | | |
| No | 1 | | 2 | | 3 | | 4 | | 5 | | Jumlah | Mean |
| | F | % | F | % | F | % | F | % | F | % | | |
| 1 | 0 | 0.00% | 1 | 3.33% | 12 | 40.00% | 13 | 43.33% | 4 | 13.33% | 30 | 3.67 |
| 2 | 0 | 0.00% | 1 | 3.33% | 10 | 33.33% | 19 | 63.33% | 0 | 0.00% | 30 | 3.60 |
| 3 | 1 | 3.33% | 1 | 3.33% | 11 | 36.67% | 15 | 50.00% | 2 | 6.67% | 30 | 3.53 |
| 4 | 1 | 3.33% | 4 | 13.33% | 10 | 33.33% | 15 | 50.00% | 0 | 0.00% | 30 | 3.30 |
| 5 | 0 | 0.00% | 13 | 43.33% | 14 | 46.67% | 3 | 10.00% | 0 | 0.00% | 30 | 2.67 |
| 6 | 0 | 0.00% | 2 | 6.67% | 10 | 33.33% | 18 | 60.00% | 0 | 0.00% | 30 | 3.53 |
| 7 | 0 | 0.00% | 6 | 20.00% | 20 | 66.67% | 4 | 13.33% | 0 | 0.00% | 30 | 2.93 |
| 8 | 3 | 10.00% | 3 | 10.00% | 8 | 26.67% | 16 | 53.33% | 0 | 0.00% | 30 | 3.23 |
| TOTAL MEAN | | | | | | | | | | | | 3.31 |

Based on the results of data processing of each item of respondents to the question in the design variable (X2), it is known that the average value of the total score is the question of 8 items by 3, 31. This value> 2.5 (mean score on a scale of 1-5). These results indicate that the sub-variable design is a dominant factor in causing the inefficiency of time in the production process.

The average value of all items question> 2, 5, these results show that all factors involved in the sub-variables Design be the dominant factor in causing the inefficiency of time in the production process. Item number one question on the design changes in work earn the highest average value (3.67), whereas item number 5 questions about the level of information delivery speed field to obtain the lowest average score (2.67) compared to the questions in the variable other designs.

Table 9. Descriptive Material Variables

| Material (X3) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale question | | | | | | | | | | | | |
| No | 1 | | 2 | | 3 | | 4 | | 5 | | Jumlah | Mean |
| | F | % | F | % | F | % | F | % | F | % | | |
| 1 | 2 | 6.67% | 2 | 6.67% | 11 | 36.67% | 14 | 46.67% | 1 | 3.33% | 30 | 3.33 |
| 2 | 0 | 0.00% | 3 | 10.00% | 14 | 46.67% | 13 | 43.33% | 0 | 0.00% | 30 | 3.33 |
| 3 | 0 | 0.00% | 0 | 0.00% | 11 | 36.67% | 18 | 60.00% | 1 | 3.33% | 30 | 3.67 |
| 4 | 4 | 13.33% | 13 | 43.33% | 12 | 40.00% | 1 | 3.33% | 0 | 0.00% | 30 | 2.33 |
| 5 | 0 | 0.00% | 4 | 13.33% | 17 | 56.67% | 9 | 30.00% | 0 | 0.00% | 30 | 3.17 |
| TOTAL MEAN | | | | | | | | | | | | 3.17 |

The average value of the total score of 5 items of questions from sub-variable material is 3, 17. This value> 2.5 (mean score on a scale of 1-5). These results indicate that the sub-variable material is a dominant factor in causing the inefficiency of time in the production process.

The average value of all items questions> 2.5, except for item number 4 of the material in storage and warehouse arrangement which has an average value of 2.33 so it does not become a factor in the dominant material cause inefficiency of time in the production process. Item number 3 questions regarding material delays often occur in the field to be the most dominant factor among other material factors (obtaining the highest average value, ie 3.67).

Table 10. Descriptive Human Resources Variables

| Human Resources (X4) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale question | | | | | | | | | | | | |
| No | 1 | | 2 | | 3 | | 4 | | 5 | | Jumlah | Mean |
| | F | % | F | % | F | % | F | % | F | % | | |
| 1 | 0 | 0.00% | 0 | 0.00% | 14 | 46.67% | 14 | 46.67% | 2 | 6.67% | 30 | 3.60 |
| 2 | 2 | 6.67% | 14 | 46.67% | 11 | 36.67% | 3 | 10.00% | 0 | 0.00% | 30 | 2.50 |
| 3 | 0 | 0.00% | 0 | 0.00% | 13 | 43.33% | 16 | 53.33% | 1 | 3.33% | 30 | 3.60 |
| 4 | 1 | 3.33% | 5 | 16.67% | 16 | 53.33% | 7 | 23.33% | 1 | 3.33% | 30 | 3.07 |
| 5 | 2 | 6.67% | 6 | 20.00% | 11 | 36.67% | 9 | 30.00% | 2 | 6.67% | 30 | 3.10 |
| 6 | 9 | 30.00% | 9 | 30.00% | 10 | 33.33% | 2 | 6.67% | 0 | 0.00% | 30 | 2.17 |
| 7 | 0 | 0.00% | 8 | 26.67% | 11 | 36.67% | 11 | 36.67% | 0 | 0.00% | 30 | 3.10 |
| 8 | 1 | 3.33% | 5 | 16.67% | 15 | 50.00% | 6 | 20.00% | 3 | 10.00% | 30 | 3.17 |
| 9 | 0 | 0.00% | 1 | 3.33% | 20 | 66.67% | 8 | 26.67% | 1 | 3.33% | 30 | 3.30 |
| 10 | 0 | 0.00% | 1 | 3.33% | 10 | 33.33% | 18 | 60.00% | 1 | 3.33% | 30 | 3.63 |
| 11 | 0 | 0.00% | 0 | 0.00% | 13 | 43.33% | 17 | 56.67% | 0 | 0.00% | 30 | 3.57 |
| TOTAL MEAN | | | | | | | | | | | | 3.16 |

The average value of a total score of 11 items of questions from the Human Resources sub-variable is equal to 3.16. This value> 2.5 (mean score on a scale of 1-5), so it shows that the sub-variables of Human Resources are the dominant factor in causing the inefficiency of time in the production process.

The average value of all items questions> 2.5, except for item number 2 on the expertise of workers in carrying out the work which has an average value of 2.5 and item number 6 on the supervisor can give a decision in the field (2.17), so it does not become the dominant factor in human resources cause inefficiency of time in the production process. Item question number 10 on the working methods that run optimally be the most dominant factor among other human factors (obtaining the highest average value, ie 3.63).

Table 11. Descriptive Tool Variables

| Tool (X5) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale question | | | | | | | | | | | | |
| No | 1 | | 2 | | 3 | | 4 | | 5 | | Jumlah | Mean |
| | F | % | F | % | F | % | F | % | F | % | | |
| 1 | 1 | 3.33% | 2 | 6.67% | 10 | 33.33% | 17 | 56.67% | 0 | 0.00% | 30 | 3.43 |
| 2 | 3 | 10.00% | 7 | 23.33% | 8 | 26.67% | 11 | 36.67% | 1 | 3.33% | 30 | 3.00 |
| 3 | 8 | 26.67% | 14 | 46.67% | 5 | 16.67% | 3 | 10.00% | 0 | 0.00% | 30 | 2.10 |
| 4 | 0 | 0.00% | 6 | 20.00% | 11 | 36.67% | 11 | 36.67% | 2 | 6.67% | 30 | 3.30 |
| 5 | 19 | 63.33% | 9 | 30.00% | 2 | 6.67% | 0 | 0.00% | 0 | 0.00% | 30 | 1.43 |
| TOTAL MEAN | | | | | | | | | | | | 2.65 |

The average value of the total score of 5 items of questions from sub-variables are Tools of 2, 65. This value> 2.5 (mean score on a scale of 1-5), so it shows that the sub-variables Tool is a dominant factor in causing the inefficiency of time in the production process.

The average value of all items questions> 2.5, except for item number 3 on the average age of the equipment used which have an average value of 2.1 and item number 5 on the duration of maintenance work tools after use (1.43 ), so it does not become the dominant factor in tool cause inefficiency of time in the production process. Item number one question concerning the number and capacity of working tools and aids that fit the needs of the field become the most dominant factor among factors other equipment (obtaining the highest average value, ie 3.43).

Table 12. Descriptive Influence From Outside Variables

| Influence From Outside (X6) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale question | | | | | | | | | | | | |
| No | 1 | | 2 | | 3 | | 4 | | 5 | | Jumlah | Mean |
| | F | % | F | % | F | % | F | % | F | % | | |
| 1 | 0 | 0.00% | 0 | 0.00% | 14 | 46.67% | 9 | 30.00% | 7 | 23.33% | 30 | 3.77 |
| 2 | 0 | 0.00% | 8 | 26.67% | 3 | 10.00% | 9 | 30.00% | 10 | 33.33% | 30 | 3.70 |
| 3 | 3 | 10.00% | 5 | 16.67% | 5 | 16.67% | 13 | 43.33% | 4 | 13.33% | 30 | 3.33 |
| 4 | 2 | 6.67% | 1 | 3.33% | 12 | 40.00% | 14 | 46.67% | 1 | 3.33% | 30 | 3.37 |
| 5 | 3 | 10.00% | 3 | 10.00% | 11 | 36.67% | 8 | 26.67% | 5 | 16.67% | 30 | 3.30 |
| TOTAL MEAN | | | | | | | | | | | | 3.49 |

The average value of the total score of 5 items of questions in the sub-variables Effect From Outside is 3, 49. This value> 2.5 (mean score on a scale of 1-5). These results show that the sub-variables of Foreign Influence are a dominant factor in causing the inefficiency of time in the production process.

The average value of all items question> 2, 5, these results show that all factors involved in the sub-variables Effect From Outer become the dominant factor in causing the inefficiency of time in the production process. Item number one question about the influence of the terrain on the progress of work in the field gained the highest average score (3.77), whereas item number 5 questions about the frequent delays in the completion of work by a third party obtained the lowest average score (3.30) compared to the question in the variable effect of other Affairs.

Table 13. Descriptive Influence From Inside Variables

| Influence From Inside (X7) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scale question | | | | | | | | | | | | |
| No | 1 | | 2 | | 3 | | 4 | | 5 | | Jumlah | Mean |
| | F | % | F | % | F | % | F | % | F | % | | |
| 1 | 2 | 6.67% | 9 | 30.00% | 12 | 40.00% | 6 | 20.00% | 1 | 3.33% | 30 | 2.83 |
| 2 | 1 | 3.33% | 6 | 20.00% | 16 | 53.33% | 6 | 20.00% | 1 | 3.33% | 30 | 3.00 |
| 3 | 0 | 0.00% | 4 | 13.33% | 18 | 60.00% | 8 | 26.67% | 0 | 0.00% | 30 | 3.13 |
| 4 | 0 | 0.00% | 8 | 26.67% | 12 | 40.00% | 10 | 33.33% | 0 | 0.00% | 30 | 3.07 |
| 5 | 0 | 0.00% | 4 | 13.33% | 17 | 56.67% | 8 | 26.67% | 1 | 3.33% | 30 | 3.20 |
| TOTAL MEAN | | | | | | | | | | | | 3.05 |

The average value of the total score of 5 items of questions in the sub-variables Effect From Within is 305. This value> 2.5 (mean score on a scale of 1-5). These results indicate that the effect of the sub-variable In a dominant factor in causing the inefficiency of time in the production process.

The average value of all items question> 2, 5, these results show that all factors involved in the sub-variables Effect Of In becoming the dominant factor in causing the inefficiency of time in the production process. Item number 5 questions about Lean Construction that can be used in every job MEP obtained the highest average value (3.20), while the number one item on the frequent questions understanding Lean Construction in the construction world scored the lowest average (2.83) than the question in the variable effect of in others.

Based on the results of data processing on the identification of factors - factors that cause inefficiencies in time and costs in the production process, can be arranged the average value of each factor and sub-variables as shown table 13.

Table 13. Overall Average Rating Factor Inefficiency Time and Cost

| No factor | Factor | Average |
|---|---|---|
| X1.4 | Field coordination | 2.97 |
| X2.8 | Shop drawing | 3:23 |
| X2.1 | Design Changes | 3.67 |
| X4.1 | Less Labor | 3.60 |
| X3.3 | Delay Delivery Material | 3.67 |
| X1.2 | plan | 3.80 |
| X2.3 | Specifications Unclear | 3:53 |
| X6.2 | Weather | 3.70 |
| X6.1 | Field conditions | 3.77 |
| X1.1 | Management controls | 3:37 |
| X2.6 | Jobs That Repeats | 3:53 |
| X4.3 | Work Area division | 3.60 |
| X3.2 | Material Missing | 3:33 |
| X2.2 | Picture Unclear | 3.60 |
| X4.10 | Working methods | 3.63 |
| X6.4 | Filing a Work Permit | 2:17 |
| X1.3 | Coordination among Contractors | 3.60 |
| X7.5 | Application of Lean Construction | 3:20 |
| X3.1 | Quality Materials | 3:33 |
| X7.3 | Support From Management | 3:13 |
| X3.5 | installation Materials | 3:17 |
| X4.11 | Not Following Procedure | 3:57 |
| X5.1 | Tools That Are Not Available | 3:43 |
| X6.3 | Damage by Third Parties | 3:33 |
| X4.5 | Supervisor What Not Experienced | 3:10 |
| X4.9 | Reading Figure Work | 3:30 |
| X4.8 | Workers Doing job Back | 3:17 |
| X7.1 | Understanding of Lean Construction | 2.83 |
| X2.8 | Differences Working Pictures | 3:23 |
| X6.5 | Awaiting Completion of Third Parties | 3:30 |
| X2.4 | Information Unclear | 3:30 |
| X7.2 | The purpose of Lean Construction | 3:00 |
| X4.4 | Supervisor Its Too Late | 3:07 |
| X5.3 | age Equipment | 2:10 |
| X4.7 | Workers Who Came Late | 3:10 |
| X2.7 | The Disadvantaged Job | 2.93 |
| X7.4 | readiness Staff | 3:07 |
| X2.5 | Late Submission of Information | 2.67 |
| X5.4 | setting Equipment | 3:30 |
| x1.5 | Decisions Slow | 2.67 |
| X4.6 | Supervisor In Decision Making | 2:17 |
| X4.2 | Expertise Workers | 2:50 |
| X5.5 | Maintenance Tool | 1:43 |
| X5.2 | storage Material | 3:00 |
| X3.4 | placement Tool | 2:33 |

Based on the average score (mean) frequency distribution result earned 40 (forty) factors that dominate the time and cost inefficiencies in the production process and six (6) factors that not be the dominant cause. This refers to the average score of the five factors were below the limit of the minimum average score is equal to 2.5. These six factors are as shown in Table 14

Table 14. Six Factors Not Dominant Still Causes Inefficiency Time and Cost

| No factor | Factor | Average |
|---|---|---|
| X6.4 | Filing a Work Permit | 2:17 |
| X5.3 | age Equipment | 2:10 |
| X4.6 | Supervisor In Decision Making | 2:17 |
| X4.2 | Expertise Workers | 2:50 |
| X5.5 | Maintenance Tool | 1:43 |
| X3.4 | placement Tool | 2:33 |

Table 15. Descriptive Variables Lean Construction

| descriptive Statistics | | | | | |
|---|---|---|---|---|---|
| | N | Minimum | maximum | mean | Std. deviation |
| *Last Planner System* | 30 | 19 | 28 | 23.90 | 2,123 |
| *Increased Visualization* | 30 | 8 | 13 | 10.87 | 1,408 |
| *Tool Box Marketing* | 30 | 5 | 10 | 7.97 | 1,273 |
| *First Run Studies* | 30 | 13 | 19 | 15:40 | 1,545 |
| *The 5s Process* | 30 | 10 | 22 | 17:10 | 3,305 |

The lowest value of the sub-variables *Last Planner System* at 19, while the highest was 28 with an average score of a total of 6 items of questions is 23.9. In sub-variables Increased Visualization, the lowest value is 8 and the top 13 with an average value of 10.87. In the sub-variables Marketing Tool Box, the lowest score of 5 and 10 with the highest average value of 7.97.

The next lowest score on the sub-variables *First Run Studies* highest at 13 and 19, with an average score of 15.4, while the sub-variables The Process 5s, the lowest score of 10, top 22, with an average value of 17.10.

Table 16. Descriptive Variables Time and Cost

| No. | scale Answers | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | 2 | | 3 | | 4 | | 5 | |
| | F | % | F | % | F | % | F | % | F | % |
| 1 | 0 | 0.00% | 1 | 3:33% | 1 | 3:33% | 22 | 73.33% | 6 | 20.0% |
| 2 | 0 | 0.00% | 0 | 0.00% | 1 | 3:33% | 23 | 76.67% | 6 | 20.0% |

Based on the results of data processing at Table 16 can be seen that the majority (73.33%) of respondents stated

that the application of Lean Construction may affect the time of the execution of the work in the field, while 76.67% of respondents stated that the application of Lean Construction may affect the fee to the implementation of the work in field.
Correlation test using Pearson Correlation method. The relationship between variables was significant if it has a significance value <0.05.

Table 17. Correlation Test Results

| Independent variables | Correlation coefficient | significance | Interpretation |
|---|---|---|---|
| Management (X1) | 0,622 | 0,000 | significant relationship |
| Design (X2) | 0.341 | 0.065 | The relationship was not significant |
| Materials (X3) | 0,496 | 0,005 | significant relationship |
| HR (X4) | 0.527 | 0,003 | significant relationship |
| Tool (X5) | 0,046 | .810 | The relationship was not significant |
| Influence From Outside (X6) | 0.162 | .393 | The relationship was not significant |
| The Effect of In (X7) | .551 | 0,002 | significant relationship |
| Last Planner System (X8) | 0,397 | 0,030 | significant relationship |
| Increased Visualization (X9) | 0.605 | 0,000 | significant relationship |
| Marketing Tool Box (X10) | 0.114 | .549 | The relationship was not significant |
| First Run Studies (X11) | .326 | 0.079 | The relationship was not significant |
| The 5s Process (X12) | 0.095 | .619 | The relationship was not significant |

Based on the results of correlation, sub-variables that had a significant association (significance <0.05) with the time and cost of implementation is the job of Management, Materials, Human Resources, The Effect of In, *Last Planner System* and Increased Visualization.

Table 18. Regression Coefficients Values

| Coefficientsa | | | |
|---|---|---|---|
| | | Coefficients unstandardized | |
| Model | | B | Std. Error |
| 1 | (Constant) | -7545 | 1,621 |
| | management | .235 | .050 |
| | design | .112 | .027 |
| | Material | -.040 | .065 |
| | SDM | -.020 | .042 |
| | Tool | -.008 | .033 |
| | Influence From Outside | .010 | .025 |
| | Influence From Within | .279 | .054 |
| | *Last Planner System* | .115 | .068 |
| | *Increased Visualization* | .279 | .080 |
| | *Tool Box Marketing* | .082 | .069 |
| | *First Run Studies* | -.004 | .070 |
| | *The 5s Process* | -.023 | .029 |
| a. Dependent Variable: Time and Cost | | | |

Based on the results of data processing are shown in Table 4.13 can be structured as a regression model following:

Y = -7.545 + 0.112 + 0,235X1 X2 - X3 0,040 - 0,020 X4 - X5 0.008 - 0.01 + 0.279 X6 X7 X8 + 0.279 + 0.115 + 0.082 X9 X10 - X11 0,004 - 0,023 X12.

Table 19. Coefficient Determination Value

| Model Summary | | | | | |
|---|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. The Error of the Estimate | Durbin-Watson |
| 1 | .956[a] | .915 | .855 | .387 | 1.309 |

a. Predictors: (Constant), The 5s Process, In creased Visualization, Design, Pengaruh Dari Dalam, Pengaruh Dari Luar, Manajemen, Tool Box Marketing, First Run Studies, Alat, Material, SDM, Last Planner System
b. Dependent Variable: Waktu dan Biaya

Based on the results of data processing are shown in Table 4:14, it is known that the coefficient of determination (Rsquare) of 0.915 which means that the variable Management, Design, Materials, Human Resources, Tools, The Effect Of Affairs, The Effect Of In, Last Planner System, Increased Visualization, tool Box Marketing, First Run Studies and The 5s Process variability can be explained by 91.5% of the variable Y (time and Cost Efficiency), while the variability of 8.5% is explained by variables other than X1 and X2.

hypothesis:
H0: $\beta 1..\beta 12 = 0$ No significant effect on the dependent variables simultaneously to the Time and Cost of Production.
H1: $\beta 1..\beta 12 \neq 0$ There is a significant effect on the dependent variables simultaneously to the Time and Cost of Production.
The results of $F_{arithmetic}$ compared with F table with criteria:

a. Reject Ho if F count> F table at alpha 5% for a positive coefficient.
b. Reject Ho if F count <F table at alpha 5% to a negative coefficient.
c. Reject Ho if F-sign < $\alpha$ (0.05).

Based on the results of processing using *SPSS software version* 24 obtained Anova table for simultaneous testing, which can be seen in the following table:

Table 20. Simultaneous Hypothesis Test Results

| ANOVA | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | mean Square | F | Sig. |
| 1 | Regression | 27 320 | 12 | 2,277 | 15,200 | .000b |
| | residual | 2,546 | 17 | .150 | | |
| | Total | 29 867 | 29 | | | |

a. Dependent Variable: Time and Cost
b. Predictors: (Constant), The 5s Process, Increased Visualization, Design, Effect From Within, The Effect Of Affairs, Management, Marketing Tool Box, First Run Studies, Equipment, Materials, Human Resources, Last Planner System

Based on test results data shown in Table 4:15, demonstrates the value of F with DF1 and DF2 = 12 = 17 is = 15,200 with sig = 0,000. Testing by comparing sig = 0,000 <α= 0.05, then Ho is rejected. When testing by comparing the F count = 15,200> F table = 2.381, so Ho rejected.

Based on test results and interpretations, it can be concluded from this test that together (simultaneously) there is a significant effect of the variable Management, Design, Materials, Human Resources, Tools, The Effect Of Affairs, The Effect Of In, Last Planner System, Increased Visualization , Tool Box Marketing, First Run Studies and The 5s Process of the time and Cost of Production. These results also indicate that the regression model was fit (fit) to be able to explain the variable Time and Cost of Production.

To determine the partial hypothesis can be formulated as follows:

H0: $\beta 1 = 0$, no significant effect partially.

H1: $\beta 1 \neq 0$, no significant effect partially.

Then testing the hypothesis using the t-test, significance level used 5%. For a 5% error test two tiled and dk = n - k - 1 = 30 - 12-1 = 17, the obtained table = 2,11 with the following conditions:

a. If t table then H0 rejected and H1 accepted meaning there is a significant influence.
b. If t calculate > t table then H0 rejected and H1 accepted meaning no significant effect.

Table 21. Partial Test Results

| Coefficientsa | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Coefficients unstandardized | | standardized Coefficients | | |
| | | B | Std. Error | beta | t | Sig. |
| 1 | (Constant) | -7545 | 1,621 | | -4654 | .000 |
| | management | .235 | .050 | .415 | 4693 | .000 |
| | design | .112 | .027 | .334 | 4112 | .001 |
| | Material | -.040 | .065 | -.064 | -.619 | .544 |
| | SDM | -.020 | .042 | -.050 | -.479 | .638 |
| | Tool | -.008 | .033 | -.022 | -.240 | .814 |
| | Influence From Outside | .010 | .025 | .039 | .416 | .682 |
| | Influence From Within | .279 | .054 | .478 | 5,134 | .000 |
| | Last Planner System | .115 | .068 | .240 | 1,682 | .111 |
| | Increased Visualization | .279 | .080 | .387 | 3,481 | .003 |
| | Tool Box Marketing | .082 | .069 | .103 | 1,194 | .249 |
| | First Run Studies | -.004 | .070 | -.006 | -.058 | .955 |
| | The 5s Process | -.023 | .029 | -.073 | -.787 | .442 |
| **a. Dependent Variable: Time and Cost** | | | | | | |

The results of data processing at 4:16 table known to ntuk partial hypothesis testing, management variable (X1), Design (X2), The effect of the (X7) and Increased Visualization (X9) has a value of t> t table and significance <0.05. Thus, these variables have a positive and significant impact on the time and cost of production, while eight other independent variables do not have a significant effect.

Table 22. Linearitv Test Results

| **Regression** | **Deviation From Linearity** | |
|---|---|---|
| | **Fhitung** | **significance** |
| **X1-Y** | 1,910 | .124 |
| **X2-Y** | 1,490 | 0.222 |
| **X3-Y** | 1,895 | 0.127 |
| **X4-Y** | 1,725 | 0.152 |
| **X5-Y** | 1,035 | .449 |
| **X6-Y** | 0,939 | .516 |
| **X7-Y** | 1,134 | 0.364 |
| **X8-Y** | 0.931 | 0.503 |
| **X9-Y** | 1.173 | 0,348 |
| **X10-Y** | 0.148 | 0,962 |
| **X11-Y** | 1,630 | 0.192 |
| **X12-Y** | 0.697 | 0.715 |

Linearity test results are shown in Table 4:17 shows the significance of the entire regression model <0.05. These results indicate that the assumption of linearity in the regression model has been fulfilled.

Table 23. Normality Test Results

| One-Sample Kolmogorov-Smirnov Test | | |
|---|---|---|
| | | **standardized Residual** |
| **N** | | 30 |
| **Normal Parametersa, b** | mean | .0000000 |
| | Std. deviation | .76564149 |
| **Most Extreme Differences** | Absolute | .124 |
| | positive | .087 |
| | negative | -.124 |
| **Test Statistic** | | .124 |
| **Asymp. Sig. (2-tailed)** | | .200c, |

a. Test distribution is Normal.
b. Calculated from data.
c. Significance Lilliefors Correction.
d. This is a lower bound of the true significance.

The test results show the value of significance (P value) of 0.200 > 0.05. This result means that residual data on the regression model has a normal distribution.

Table 24. Test Results Homokedasticity

| Coefficientsa | | | | | | |
|---|---|---|---|---|---|---|
| | | Coefficients unstandardized | | standardized Coefficients | | |
| Model | | B | Std. Error | beta | t | Sig. |
| 1 | (Constant) | -2147 | 18 053 | | -.119 | .907 |
| | LnX1 | .480 | 2,745 | .040 | .175 | .863 |
| | LnX2 | .818 | 2,377 | .073 | .344 | .735 |
| | LnX3 | -5130 | 3,193 | -.485 | -1607 | .127 |
| | LnX4 | 4829 | 5,393 | .264 | .895 | .383 |
| | LnX5 | -1090 | 1,331 | -.200 | -.819 | .424 |
| | LnX6 | .167 | 1,462 | .029 | .114 | .910 |
| | LnX7 | -1384 | 2827 | -.118 | -.490 | .631 |
| | LnX8 | -3199 | 5,446 | -.219 | -.587 | .565 |
| | LnX9 | -.163 | 3,245 | -.017 | -.050 | .961 |
| | LnX10 | 2,375 | 1737 | .317 | 1,367 | .189 |
| | LnX11 | 2,131 | 3636 | .161 | .586 | .566 |
| | LnX12 | -.768 | 1,500 | -.122 | -.512 | .615 |
| a. Dependent Variable: Lnei2 | | | | | | |

The test results are shown in Table 4:17 shows the significance of the entire regression model < 0.05. These results show the data in the regression model occurred.

Table 25. Autocorrelation Durbin Watson Test Results

| Model Summary | | | | | |
|---|---|---|---|---|---|
| **Model** | **R** | **R Square** | **Adjusted R Square** | **Std. The Error of the Estimate** | **Durbin-Watson** |
| 1 | .956a | .915 | .855 | .387 | 1,309 |

a. Predictors: (Constant), The 5s Process, Increased Visualization, Design, Effect From Within, The Effect Of Affairs, Management, Marketing Tool Box, First Run Studies, Equipment, Materials, Human Resources, Last Planner System

b. Dependent Variable: Time and Cost

The results obtained showed that the value of Durbin Watson is equal to 1.309, where the value is between 1, 21 <DW <1.65, so it can not be concluded whether or not there is autocorrelation. To take a decision, another test is performed as follows Test Run

| Runs Test | |
|---|---|
| | Residual unstandardized |
| Test Valuea | -.00918 |
| Cases <Test Value | 15 |
| Cases> = Test Value | 15 |
| total Cases | 30 |
| Number of Runs | 12 |
| Z | -1301 |
| Asymp. Sig. (2-tailed) | .193 |
| a. median | |

Based on the results of Run Test, the known value of P-Value (Asymp.Sig (2-tailed)) amounted to 0.193> 0.05. Thus the decision could be made that model has been free from problems of autocorrelation.

Table 26. Test Results Multicollinearity

| Coefficientsa | | | |
|---|---|---|---|
| | | collinearity Statistics | |
| Model | | tolerance | VIF |
| 1 | (Constant) | | |
| | management | .640 | 1,562 |
| | design | .760 | 1,315 |
| | Material | .476 | 2,099 |
| | SDM | .457 | 2,188 |
| | Tool | .588 | 1,700 |
| | Influence From Outside | .566 | 1,766 |
| | Influence From Within | .580 | 1,726 |
| | Last Planner System | .246 | 4,057 |
| | Increased Visualization | .406 | 2,462 |
| | Tool Box Marketing | .671 | 1,491 |
| | First Run Studies | .445 | 2247 |
| | The 5s Process | .577 | 1,733 |
| a. Dependent Variable: Time and Cost | | | |

Based on the test results Multicollinearity at 4:22 table, it can be seen VIF all variables no more than 5, so it can not happen multicollinearity concluded between the independent variables in the regression model

## IV. CONCLUSION

Based on this research, a number of conclusions as follows:

1. The application of Lean Construction is very influential and can be used as an alternative method

of increasing cost efficiency in MEP work. To support this implementation, it is necessary to carry out every step in the lean construction method in an effort to reduce waste and add value to achieve a level of satisfaction and continuous improvement.

2. The most important factor that causes cost inefficiency in MEP work is 39 factors where the mean score is above the minimum average of 2.5.
3. While the non-dominant factors that cause cost inefficiencies in mechanical, Electrical, Plumbing (MEP) work on high-rise projects are 6 factors.
4. Simultaneously, there are significant influences from Management, Design, Material, HR, Tools, External Effects, Internal Influence, Last Planner System, Increased Visualization, Box Marketing Tool, First Run Studies and The 5s Process of Time and Production cost. The magnitude of the simultaneous effect of these variables is 91.5% while the remaining 8.5% is influenced by other variables not examined.
5. Partially, the Management variable (X1), Design (X2), Internal Influence (X7) and Increased Visualization (X9) proved to have a positive and significant influence on production time and costs, while the other 8 independent variables did not have a significant effect.
6. The hypothesis of this study by applying Lean Construction on MEP work can improve the performance of time and project costs

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