

# Site Layout Design That Ensures the Efficiency at Construction Site

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**Abstract.** Every construction site needs facilities as well as heavy machinery for construction activities. Therefore, the construction site must be carefully organized so that construction activity is in full swing. However, some of the parties involved, especially the contractors do not seem to get the attention and not considered important to this matter. Lack of management of construction sites will give a bad impression not only during the construction process but also leave a negative issue for the overall project. The purpose of this study is to produce efficient construction site layout design. In order to achieve the aim of this study, three objectives have been set, namely, identify the problems that often occur at construction sites due to the poor site layout, identify the effect of the weakness of the site layout and the improvement elements that increase the efficiency of site layout design. The main approaches in collecting information are through questionnaires and interview sessions. Then, the data were extracted to SPSS v19 to be analyzed using mean index (MI). While, data from interviews were analyzed by using context diagram. Result reveal that eight problems are frequently happening at construction sites. The top three problems are: 1) Insufficient space in construction sites, 2) Material stacks wrongly located, 3) Machinery and equipment wrongly located. Whilst, there are seven effects of poor site layout design. The result found that double handling material to be the most significant effect of improper site layout design, then followed by accident occur at site and vandalism and material lost. Besides, there are six ways to improve the efficiency of site layout design. The most recommended element by the respondents is good and systematic early planning. However, even the site layout design is depending on site condition and the of the project itself, but the initial planning with knowledge and experience about site layout are the most important aspect of producing a good site layout.

## Introduction

The construction industry is in full swing around the world nowadays. Malaysia also among of the country that practices rapid development that has a lot of construction projects. Effective construction management plays a key role in construction projects due to the high complexity involved in administration and construction progress itself. In fact, it is important to anticipate and manage risks that have a probability on harming construction projects. One of the risks that need to be considered along the project cycle is the construction activity at the site.

Site layout planning has significant impacts on productivity, cost, and duration of construction (Haytham M. Sanad, 2008). However, the emphasis on the importance of design and layout of the construction site is still less attention by the site management. An improper site layout planning eventually results in loss of productivity due to excessive travel time for laborers and equipment, or inefficiencies due to safety concern (Chao et al., 2002). Therefore, it is essential to study the construction site layout design in order to make an improvement that can increase the efficiency of the site layout design.

In general, to achieve the aim of this study, three objectives have been set, namely:

- a) To identify the problems that often occur as a result of the weakness of site layout.
- b) To identify the impact of the weakness of site layout to the construction activities on the site.
- c) To identify the improvement elements that increase the efficiency of site layout design.

To ensure that the objectives are achieved, the scope of the studies selected must meet the requirements of the study. This study focuses on construction sites in the limited area such as in urban area. Johor Bharu, Putrajaya, and a few cities are chosen to conduct the research. Projects and construction sites were chosen focused on the high-risk area.

### Previous Studies

Several studies about site layout have been done before. Elements and facilities needed at the construction site were discussed in [1]. The problems that occur on construction sites is also have been described in [1].

Next, the effect of unplanned site layout to the construction project can be found in [2] and [3]. In addition, a study on the causes of the accident at the construction site has been done in [4], but these studies are only made in the northern Peninsular Malaysia only. There are three main causes of accidents on construction sites, namely the weakness of the management, the weakness of the workers, and the condition of the construction site. Based on the study [4], it is clear that the condition of the site and the site layout can be the cause of the accident to a worker at a construction site.

Another topic that has been studied is the optimal site layout that considers the safety and environmental aspects [5]. This research has produced a model layout of the site and uses algorithms to model the optimal site layout. Based on the study [5], a case study has been made to do a comparison between the model generated site layout and a real construction site. However, the case studies conducted in the country of Egypt.

Productivity issues during site planning can be found in [6]. This article presents a layout planning approach that considers both safety and productivity. Consideration for restricted sites also is explained in [6]. While the characteristics of the facilities at the construction site and appropriate position for each facility in construction sites are described in [7].

From the study in [1], among the problems that frequently occur at the construction sites are material stacks wrongly located, plant and equipment wrongly located, and inadequate space allowed. Besides, based on [2] and [3], some of the effects due to poor site layout are accidents, increase the cost of the project, and increase traveling time in a construction site.

### Methodology

There are several methods used to carry out this study. The flow chart in Figure 1 below shows the methodologies used to accumulate data and information.

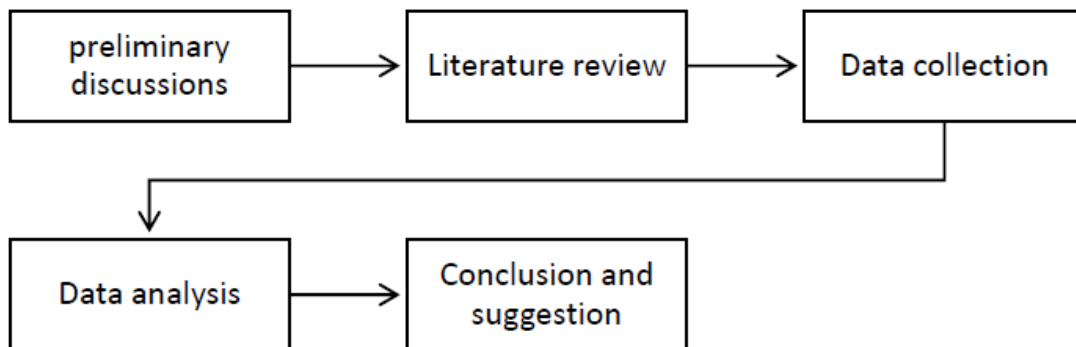


Figure 1: Flow chart of methodology

**Preliminary Discussion** Preliminary discussion is very important to get an initial overview of the research to be undertaken. This step needs to be done to get the relevant information. Preliminary

discussions with PM Ir Dr. Rosli bin Mohamad Zin, as a supervisor, was carried out to obtain suggestions and advice about the study. Selection of research topic, objectives, and type of methodology are the things that been discussed with him.

**Literature Review** A literature review is a review of information obtained from reading the journals, books, proceedings and previous studies (thesis) for the latest research. Literature is the process of gathering information about an ongoing research problem. This literature study is important because it is the basis for ideas and direction of research to be conducted.

**Data Collection** In summary, the information that was obtained been categorized into two parts:

- Primary data
- Secondary data

*Primary data: Questionnaire.* This study uses survey method and then provide a few sets of the questionnaires. Then the form was distributed at construction sites in some area as mentioned in the scope of the study. The survey was targeting the respondents and parties who involved in the management and safety of construction sites such as site supervisors, project managers, site security officer. The questionnaire was divided into two parts, namely part A for the respondent's background information and part B for the questions related to the site layout. Questions were also classified into two, namely qualitative and quantitative. The quantitative questions used the 'Likert Scale' which requires respondents to evaluate each response and the things that have been specified whether they agree with the statement submitted or otherwise. Whereas qualitative questions also asked respondents to give their opinions and suggestions on the questions provided based on their experience and knowledge in construction.

*Primary data: Interviews.* Interviews with several individuals involved in project management have been made to obtain more detailed information about the opinions and experiences of professional persons who involved in construction such as project managers, site supervisors, and other professional individuals. Individuals who were interviewed:

- I. Mr. Bachan Singh, Lecturer, Universiti Teknologi Malaysia
- II. Prof. Nazir bin Ramli, Lecturer, Universiti Teknologi Malaysia
- III. En. Arman dan En. Zuhlilmi, Site Engineers, Sanubari Cekal Sdn. Bhd.

*Secondary Data.* Secondary data is information come from through reading and literature review of articles, magazines, books, reports, and so on. Information from the internet also can be reference data for this study.

## Data Analysis

*Mean Index.* Mean Index is a statistical approach to analyze the data from the questionnaires. It is done to calculate the average index value from the total respondents and it will be used as an average response of the total respondents. The calculation will be made using SSPS v19 software. This software is also used to evaluate the figure for easier understanding of the results. The manual calculation also is made to check the value from the software. The equation used to calculate the average index value is shown below:

$$\text{Mean Index} = \frac{\sum a_i x_i}{\sum x_i}$$

Where,

i = constant which represent of i;

$x_i$  = variable represent the respondent frequency for i;

i = 1, 2 3, 4, 5

Five scale categories are used to show the priority of adoption and occurrence, as below:

1 = “Least important” or “Least agree”	$0.00 < \text{Mean Index} < 1.50$
2 = “Not important” or “Not agree”	$1.50 \leq \text{Mean Index} \leq 2.50$
3 = “Average”	$2.50 \leq \text{Mean Index} \leq 3.50$
4 = “Important” or “Agree”	$3.50 \leq \text{Mean Index} \leq 4.50$
5 = “Very Important” or “Very agree”	$4.50 \leq \text{Mean Index} \leq 5.00$

## Data Analysis

**Demographic Data** (a) Respondents Occupation/Position: Table 1 shows the distribution of respondents according to their occupation or position at their company. The highest percentage of respondents positions is as site supervisors with 36.67%, followed by engineers by 33.33%. Only 3.33% of respondents work as lecturer that represent academic person.

Table 1: Statistic percentage respondent’s occupations

No	Occupation	Frequency	Percentage
1	Site supervisor	11	36.67%
2	Engineer	10	33.33%
3	Site/project manager	3	10.0%
4	Executive staff	3	10.0%
5	Internship	2	6.67%
6	Lecturer	1	3.33%
	Total	30	100%

(b) Respondents Work experience: Table 2 explained the distribution number of respondents based on their work experience in construction. Results from the analysis showed more than half of the respondents who have experience of less than 5 years (70%). They can also be considered as a group of less experienced or new people involved in the construction. While the rest are classified as a group of experienced and only 10% of respondents with more than 15 years’ experience in construction.

Table 2: Statistic of Respondents Based Work Experience

No	Work experience	Frequency	Percentage
1	0 – 5 years	21	70.0%
2	6 – 10 years	4	13.33%
3	11 – 15 years	2	6.67%
4	More than 15 years	3	10.0%
	Total	30	100.0%

(c) Type of Project Conducted by Respondent: Respondents were from different backgrounds and projects that they were managed. However, almost half of them have managed the project construction of high-rise buildings such as apartments and condominiums. While the rest are conducting residential projects, bridges and so on. Table 3 shows the number of respondents according to the type of projects managed by them.

Table 3: Number of respondents by type of project

No	Type of projects	Frequency	Percentage
1	Bridges	2	7.14%
2	High rise building (Apartment)	14	46.67%
3	Residential housing	7	25%
4	Highway, plant, etc.	5	17.86%
	Total	28	100.0%

**Problems That Occur Due to Poor Site Layout** Figure 2 below explained the mean index for the problems that frequently occur at the construction site due to poor site planning. Insufficient space in construction sites problem is that the most critical matter often occurs with mean index value is 4.50. Followed by material stacks wrongly located problems by 4:43. Hoarding does not fully cover the site area become the rarest case happen on any construction site. Value index mean for this problem is just 3:30. Full details about the index value of the mean for each problem at the construction site is shown in the figure below.

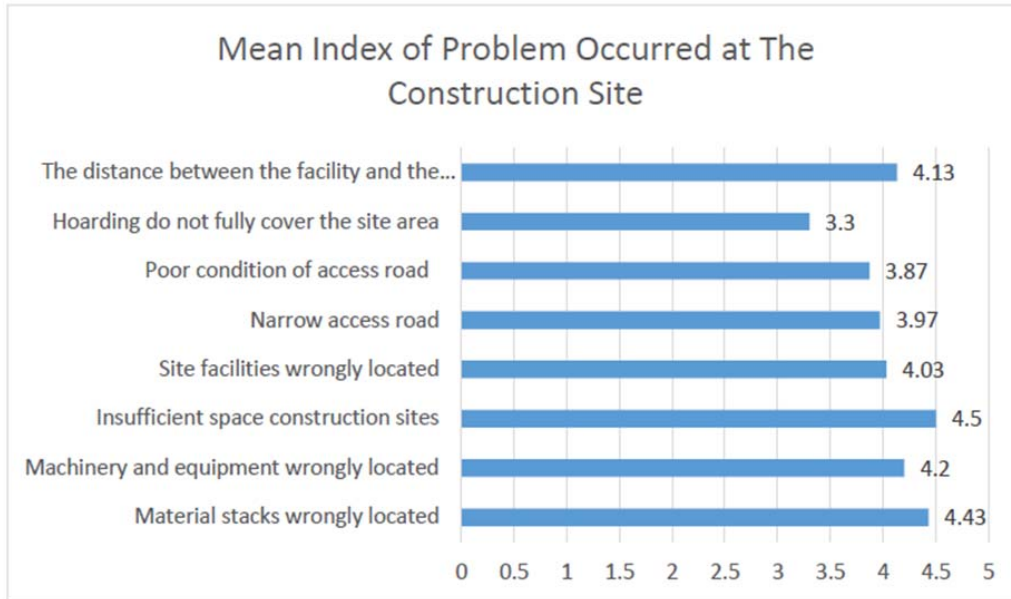


Figure 2: Index mean problems that occurred at the construction site

**Problems That Occur Due to Poor Site Layout According to Respondent's Experiences.** Based on Figure 3 below, the bar graph explained about mean index of the problem at construction site according to respondent's experiences. Respondents who work more than 6 years can be categorized as experienced people and respondents who work in construction 5 years and less categorized as a less experienced person.

According to the figure, the experienced group said that insufficient space in a construction site is the biggest problem with mean index 4.67. Then, followed by machinery and equipment wrongly located problem become second highest mean index with 4.33.

While, for the less experienced group, the highest index for a problem that occurs at a construction site is material stacks wrongly located with 4.57. The second highest index value is insufficient space in a construction site with 4.43.

But, all respondents said that hoarding not fully covered all site area is not a common problem happen at a construction site.

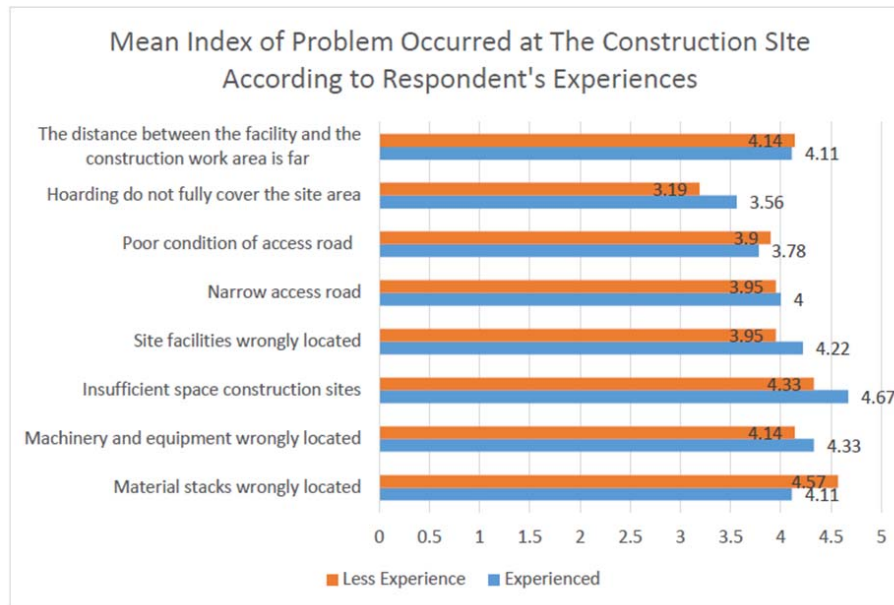


Figure 3: Index mean problems that occurred at the construction site according to respondent's experiences

*Problems That Occur Due to Poor Site Layout According to Type of Projects.* The figure 4 below shows index value for problems at construction site according to the type of project. For housing projects, the problem that often happen at the site is material stacks wrongly located with index value 4.71. Next is the distance between the facility and the construction work area is far, poor condition of access road, and narrow access road has the same value of mean index with 4.43. The lowest mean index value is hoarding not fully covered all site area problem that gets mean index value 4.00. While for high-rise project, the biggest problem frequently happens at the site is insufficient space construction sites that has mean index value 4.43. The second highest mean index value is material stacks wrongly located, 4.14. Hoarding not fully covered all site area problem has the lowest index value with 2.57. The value shows that every high rise project will have a fully hoarding that cover all perimeter of the site.

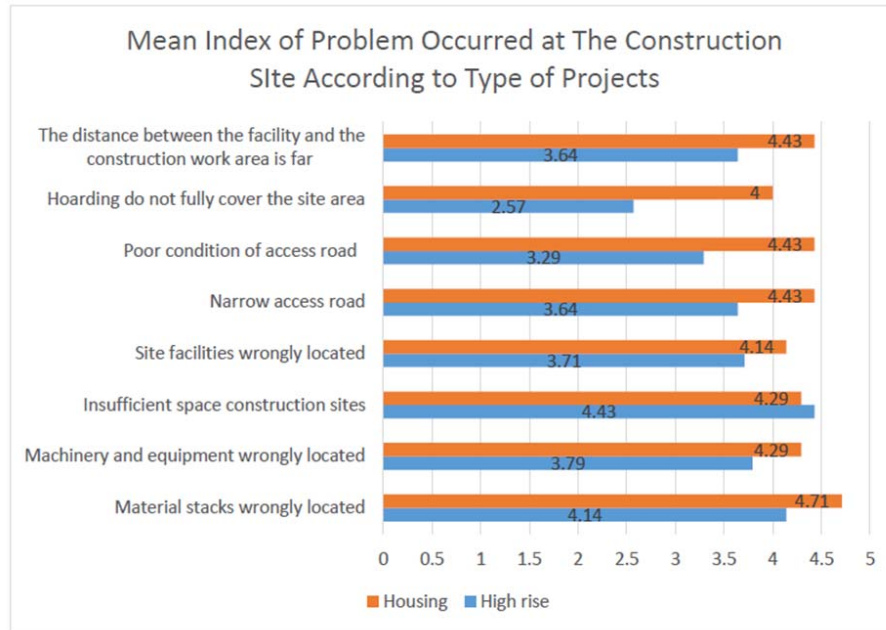


Figure 4: Index mean problems that occurred at the construction site according to the type of projects

*The Effect of Poor Site Layout Design.* Figure 5 is a bar graph of the effects of poor site layout design. It was found that the accident at the construction site and double handling material is the most significant effect on the construction site due to the poor layout of the construction site. Both of these things have the highest mean index of 4.37. Followed by vandalism and loss of construction materials with indices mean value of 4.20. Whereas the effect of reducing the quality of work have the lowest index min with only 3:53. It is clear that the layout of the construction site will not has a significant impact on the quality of construction work, otherwise, it will affect the construction activities for the project.

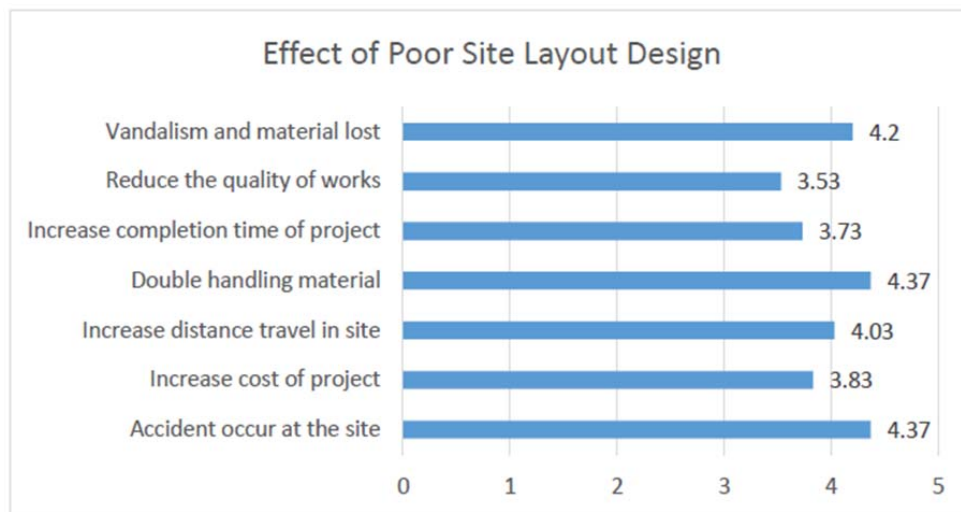


Figure 5: The effect of poor site layout design

*The Effect of Poor Site Layout Design According to Respondent's experienced.* Figure 6 below explained the different opinion from experienced respondents and less experienced respondents about the effect of poor site layout. For less experienced respondents, they said that the most

significant effect of poor site layout is accident occur at the site with index value 4.48. Next, the second higher effect is double handling material, the mean index is 4.38.

While for experienced respondents, the highest mean index for unplanned site layout effect is double handling material, 4.33. Then, followed by increase distance travel in site, 4.22. Accident occurs at site become third highest effect with mean index 4.11.

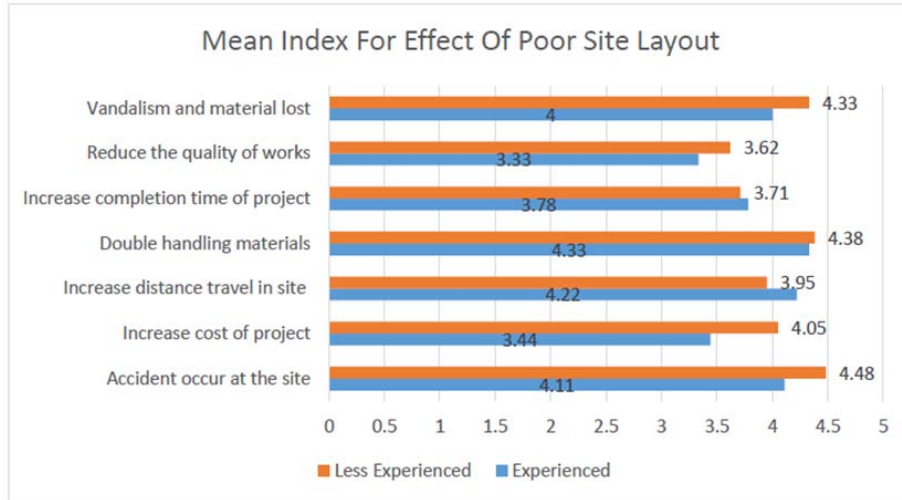


Figure 6: Index mean for effect of poor site layout according to respondent’s experiences

*The Effect of Poor Site Layout Design According to Type of Projects.* The mean index for the effect of poor site layout according to the type of project is shown in Figure 7 below. For housing projects, the effect that has highest mean index value is vandalism and material lost with 4.57. This value same for the effect of accident occurs at the site. Effect of double handling material is a second highest effect with 4.43 mean index value.

But for high-rise projects, accident occur at site become the highest effect with mean index 4.43. Next, double handling material is a second highest effect, 4.21.

Reducing the quality of works is the minimum effect happen at both sites. This result explained that site layout does not affect the quality of projects.

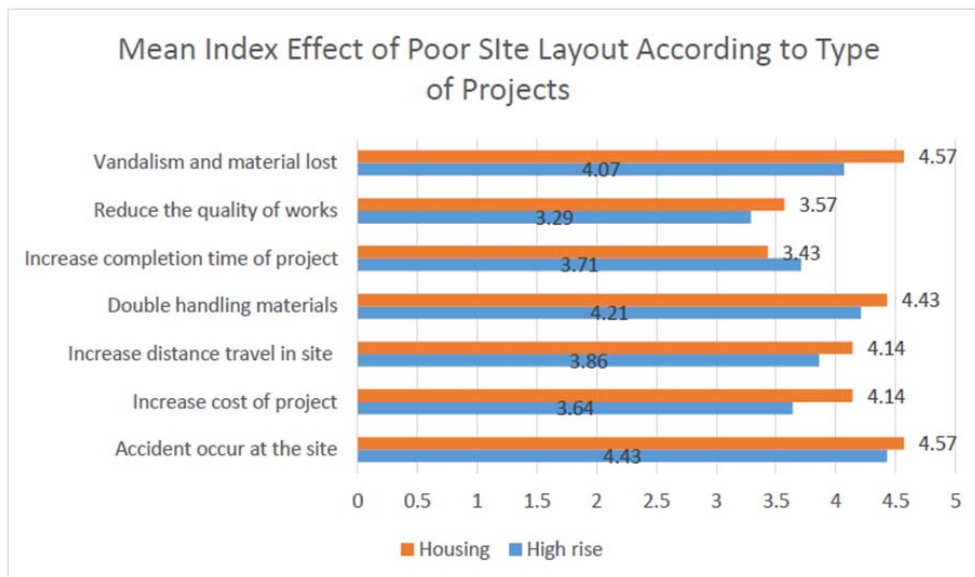


Figure 7: Mean index effect of poor site layout according to type of projects



***The ways to improve the efficiency of the construction site layout*** Table 4 is a list of suggestions provided by respondents to improve the efficiency of the layout of the construction site and the frequency of each idea. Nine respondents indicated that good early planning is necessary to produce a good site layout design. Experience and knowledge of site management are also very important. This matter will ensure that the site layout plan that will be generated will not cause problems when the construction project activities are in progress.

Table 4: Description and recommendations for improving the efficiency of the layout of construction sites

No	Recommendation for Improving Site Layout	Frequency
1	Good and systematic early planning	9
2	Requires knowledge and experience about the site layout	8
3	Good communication among workers in conveying information	2
4	Increase the level of safety at construction site	3
5	Provides design guidelines and examples of good and efficient site layout	3
6	Using software to simulate the course of activities at construction site	2

***Other Elements of the Data Analysis*** There is much information needed to produce a good result for this study. Some other information required to support the main result that related to the objectives. The items below are the other elements that obtained from the respondents.

(a) Guidelines for Site Layout: Based on the feedback received from respondents, 16 respondents (53.33%) said the layout of construction sites have guidelines that must be followed. Among the guidelines used is Master program and Temporary Structure Plan. In addition, respondents said that site layout depends on the construction contract and the requirements from authorities such. However, 14 respondents (46.67%) stated there were no guidelines in the process of preparing the layout.

(b) Factors Influencing the Site Layout: Figure 8 below shows the mean index for each of the factors that affect the site layout design. Factor that has the highest mean index value is the site area by 4.67. This value indicates an area of the construction site is the biggest factor affecting the overall site layout design. The second most important factor is the position of the buildings constructed and machinery and equipment used on construction sites with both index average of 4:47. Factors that have the lowest mean value is amenities and productivity of workers because the factor does not give a significant effect on the layout at a construction site.

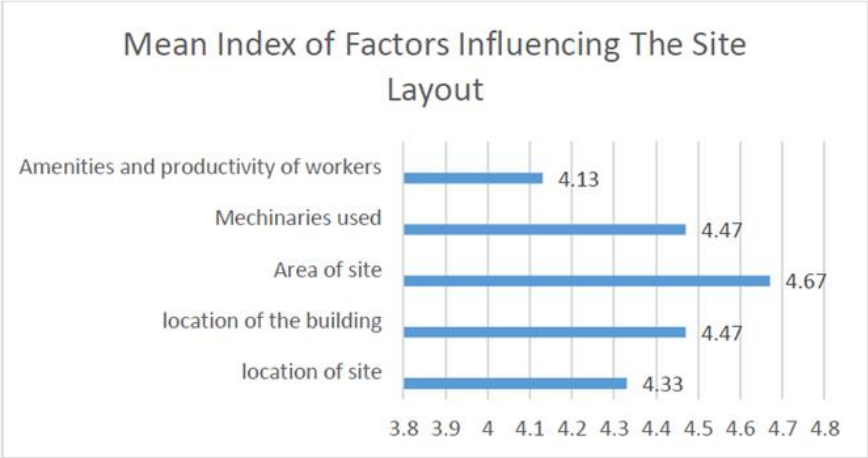


Figure 8: Index min factors affect the layout of the site

(c) Causes of Accidents at Construction Sites: Generally, there are three main causes of accidents on construction sites, namely the unsafe condition of the construction site, the weakness of the workers, and the weakness of the management of the project. Figure 9 shows the weakness of the workers is the main cause of accidents with a mean index value of 4.40. This is because, the workers at the construction site, especially construction workers do not comply with the safety regulations and always careless when working. Followed by the cause of unsafe sites and lastly the weakness of the management of the project.

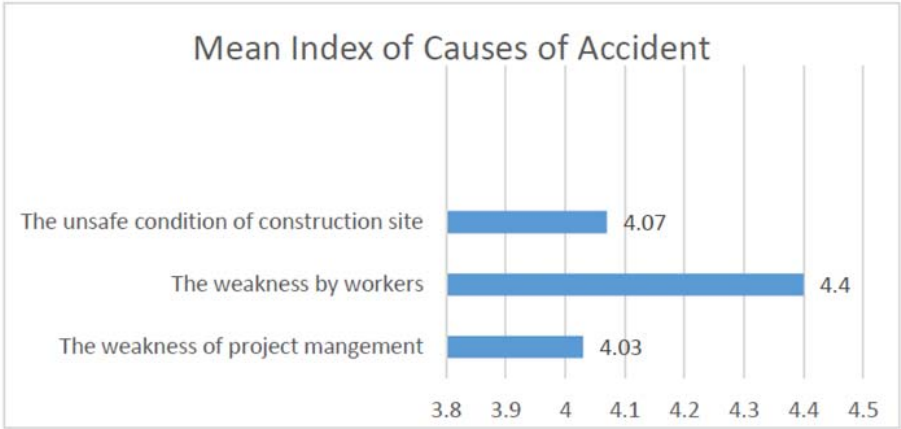


Figure 9: Index min causes of accidents at construction site

(d) Security Elements to Be Considered in Site Layout Design: The Figure 10 below is related to elements that to be considered for the safety of workers at construction sites. Create a safety zone at the construction site is the most important because the majority of respondents agreed with this. The index value for that element is 4.70, a value that indicates the level of the most important element. The minimum distance between the facility received

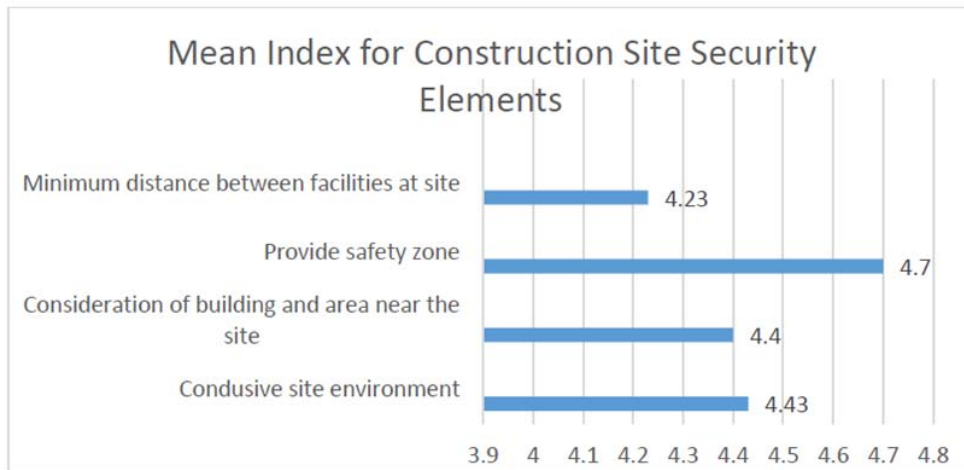


Figure 10: Mean index for construction site security elements

## Conclusion

This study was conducted to achieve the objectives that have been set at the beginning of the study. Generally, this study is managed to fulfill these objectives. The results obtained are as below. The lists according to their priority and level of interest. The first point becomes the most important and highest priority.

### *Problems That Occur Due to Poor Site Layout*

- i. Insufficient space in construction sites
- ii. Material stacks wrongly located
- iii. Plant and equipment wrongly located
- iv. The distance between the facility and the construction work area is far
- v. Site facilities wrongly located
- vi. Narrow access road
- vii. Poor condition of access road
- viii. Hoarding does not fully cover the site area

### *The Effect of Poor Site Layout Design*

- i. Double handling materials
- ii. Accident occurs at the site
- iii. Vandalism and material lost
- iv. Increase distance travels in site
- v. Increase cost of project
- vi. Increase completion time of project
- vii. Reduce the quality of works

### *The ways to improve the efficiency of the construction site layout*

- i. Good and systematic early planning
- ii. Requires knowledge and experience about the site layout
- iii. Increase the level of safety at construction site
- iv. Good communication among workers in conveying information
- v. Provides design guidelines and examples of good and efficient site layout
- vi. Using software to simulate the course of activities at construction site

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