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Optimal Site Layout Selection For Placement Of Facilities and Material In The Construction Project Of Kubu Raya District Education And Training Building

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Abstract

Construction project work has several essential components: construction workers, tools, materials, and other needed facilities. The placement of tools, materials, and facilities in construction projects affects the efficiency of movement (traveling distance) and the level of worker safety (safety index). It is the background of this research aims to analyse the placement of tools, materials, and other facilities in the construction project of the Kubu Raya Regency Education and Training building. In this study, indicators to point out the placement of tools, materials, and other facilities have been optimized by using some indicators such as movement efficiency (traveling distance) and the level of worker safety (safety index). Four alternative placements were drawn up (including the existing placement in the current project), analysed, and assessed which alternative is the most optimal. The other options are selected by analysing those four alternatives using the Analytical Hierarchy Process method and evaluated by weighting ranking. The analysis results show that alternative 3 is the optimal alternative to the traveling distance and safety index indicators. Alternative 3 represents that the placement of tools, materials, and facilities on the project is carried out by conditioning the access space between facilities, which is made capacious to reduce the barriers of workers in moving from one facility to another.

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1. Introduction

Managing the continuity of a project requires expertise in controlling every process carried out within the project itself, from the planning, implementation, to monitoring stages (Ervianto, 2005). Placement of the suitable facilities and materials can optimize the series of activities carried out by workers (Pradana & Nurcahyo, 2014). Placement management is needed, such as adjusting the distance close to the work item work location, moving worker activities, and maximizing spatial planning at the project site, which can later make a series of project activities more efficient (Wulansyky, et al., 2021).

In the Kubu Raya Regency Education and Training Building Construction Project, which is implemented in the Kubu Raya Education and Culture Office Complex, several other buildings are actively doing some work around the project. The placement of facilities and materials endeavours not to disturb the space for workers' activities and other nearby communities. It is also related to the security of the construction process, such as the security of storing project materials and the safety of the community around the project regarding building construction activities (Ramli & Suharni, 2023).

In determining the optimum site layout, it is necessary to decide on alternative placement of facilities and materials by considering the existing conditions and work methods (Yeh, 1995; Mawdesley, et al., 2002; Effendi, et al., 2012; Setyobudi & Supani, 2017). Four alternatives are designed to maximize the placement of tools, materials, and facilities at the existing location. Alternatives will be analysed based on the traveling distance and safety index values to determine the best alternative. In selecting the best alternative, the

analytical hierarchy process (AHP) method was used and assessed by weighting ranking (Saaty , 2008; Akafi, et al., 2023).

2. Materials and Methods

2.1 Theoretical Frame Work

This research aims to arrange the placement of facilities and materials by determining the optimum site layout from various alternatives to implement the project efficiently.

Data collection includes:

- Project site layouts.
- Detailed structural drawings.
- Work sequences.
- Details of goods and heavy equipment used on the project.

The existing site layout or alternative is called 0 from the existing conditions. After field observations, various problems or conditions for placing facilities and materials that could still be optimized were found. Therefore, three new alternatives were created for further analysis, which was the most effective based on each alternative's TD and SI values. The alternative with the smallest TD and SI values is the best. As for the selection of the best alternative based on the combination of the two parameters, the AHP method was selected.

This study observed two main conditions: the 1st-floor casting work and the 2nd-floor beam work. This is because each condition has different tools, materials, and facilities criteria. For example, on the casting of the 1st floor, there is a ready mix truck that is not used in the 2nd-floor beam work, and in the 2nd-floor beam work, there is a location for placing a scaffold as a scaffold, which is not used in the 1st-floor casting.

2.2 Research Location

The object research is the Project of Kubu Raya District Education and Training Building Construction located in the area of the Kubu Raya District Office of Education and Culture building, Jalan Adi Sucipto, Sungai Raya sub-district, Kubu Raya District, West Kalimantan. The Kubu Raya District Education and Training Building Construction Project was done in 180 working days.

2.3 Data

The data collection in this journal is used as material for research analysis, where the data acquisition can be classified into two they are:

- Primary data is the leading data obtained directly in the form of data obtained from direct observation or through interviews with the Kubu Raya Regency Education and Training Building Development project. The results of the interviews that have been received are processed into data in the form of values for the level of worker safety in the work being reviewed;
- Secondary data is supporting data obtained from various literature related to the issues discussed in the study, as well as data from the project, such as general project data, lists of types of work, lists of material requirements, and work schedules of the Kubu Raya District Education and Training Building Development project.

2.4 Analysis Method

In the research process, to facilitate a series of directed and measurable activities, the authors designed a research flowchart in Figure 1.

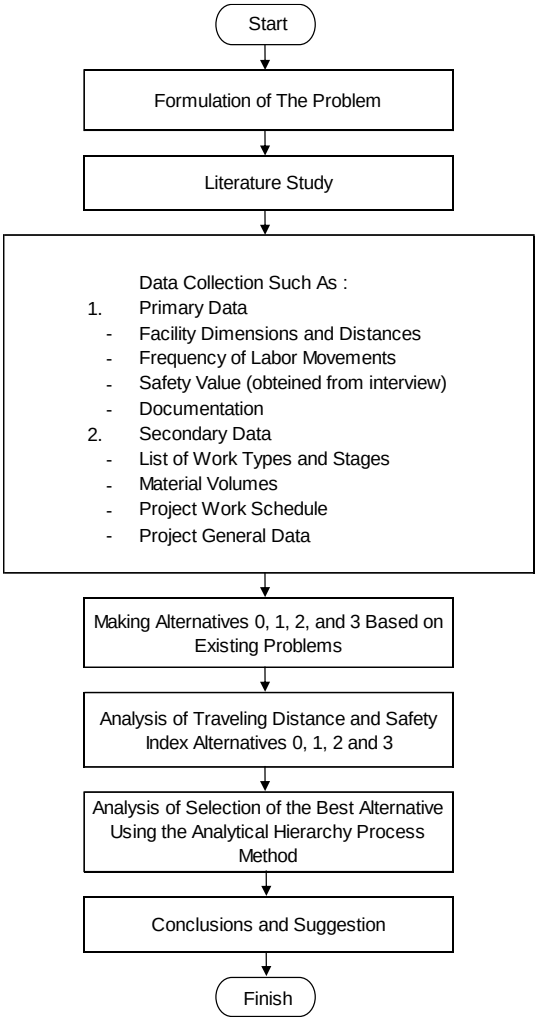

Fig. 1 Flow Chart

Referring to the book Construction Project Management compiled by Ervianto (2005) states that there are several things that must be considered in the placement of facilities on the project, namely:

- Driveway
- Material Storage
- Temporary Facility
- Equipment
- Office

Problems can be happened during site layout planning, which are consisted of identifying the facilities required to support the project, determining the size and shape of the facilities and the placement of facilities constrained by space on the project. The examples include offices, parking lots, warehouses, batching plant, maintenance area, fabrication, staging area and lay-down area (Yeh, 1995).

2.4.1 Traveling Distance

Traveling distance is the distance reached during the movement of materials, workers, and equipment between many facilities (Bazaati, 2017; Benjaoran & Peansupap, 2020). In this research, the method used for measuring traveling distance was Manhattan Distance method (Larson & Sadiq, 1983). It is used, because that method considers obstacles in determining the distance between facilities, Manhattan Movements in the form of blocks, which can also be though various routes with the same distance as illustrated in Figure 2 (Misaki & Tanaka, 2020). Figure 2 describes the movement from P1 to P2 where the movement goes through three different routes with the same distance.

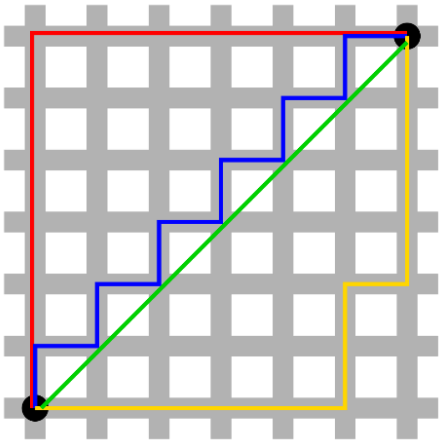

Fig. 2 Manhattan Distance
(Source: Wikipedia, 2023)

Traveling distance is formulated by Equation 1 (Effendi, et al., 2012).

$$\text{TD} = \sum_{i,j=1}^{n} d_{ij} \; x \; F_{ij} \quad \text{.....(1)}$$

TD is traveling distance (m). n is the number of facilities (non-fixed facilities and fixed facilities). d_{ij} is the distance between i and j. F_{ij} is the frequency of facility movement between i and j.

2.4.2 Safety Index (SI)

Irregularity in site layout arrangement can give significant impact to site safety for workers in project. The level of risk appeared is not same for every facility in project location. Therefore, safety index (SI) is calculated to measure safety level with respect of movement frequency between facility (Effendi, 2012).

$$\text{SI} = \sum_{i,j=1}^{n} s_{ij} \; x \; F_{ij} \quad \text{.....(2)}$$

SI is safety index. S_{ij} is the level of safety and security between facility of i and j.

2.4.3 Analytical Hierarchy Process (AHP)

AHP is a method for determining the best alternatives decision based on the scale of priority with some criteria. This method develops the numeric value to rank every alternative based on how far every alternative fulfil the criteria of decision maker (Darko, et al., 2019; Akafi, et al., 2023). There are three main principles that have to implement in AHP Method.

- Principle Hierarchy Preparation
- Principle of Determination Priority
- Principle of Logic Consistency

3. Result and Discussion

Before doing the analysis, first we do the identification of tools and materials needs that was carried out to determine the facilities and storage required during the 1st floor casting work process and 2nd floor beam work in Table 1 and Table 2.

Table 1. List of Reviewed Material Storage

Materials	Placement Storage
Sand	Project Open Space
Block Wood	Project Open Space
Mal Board	Project Open Space
Reinforcing Steel Ø16	Project Open Space
Reinforcing Steel Ø8	Project Open Space
Wire	Site Office / Warehouse
Nail	Site Office / Warehouse
Ready mix	Just In Time
Wood Pile	Project Open Space

Table 2. List of Reviewed Tool Storage

Tools	Placement Storage
Hammer	Site Office / Warehouse
Sledge Hammer	Site Office / Warehouse
Shovel	Site Office / Warehouse
Hoe	Site Office / Warehouse
Barrow	Site Office / Warehouse
Saw	Site Office / Warehouse
Misuring Tape	Site Office / Warehouse
Cement Spoon	Site Office / Warehouse
Margin	Site Office / Warehouse
Ready Mix Trucks	Just In Time
Water Pump	Site Office / Warehouse
Vibrators	Site Office / Warehouse
Ropes	Site Office / Warehouse

After detailing the needs for tools and materials, details of facilities and their category of facilities will be obtained, including the following.

Table 3. Category of Reviewed Facilities

Facilities	Facilities Category			Explanation
	Fixed	Temporary	Obstacle	
Gedung Plan Building	√			Building to be constructed area
Site Office & Warehouse		√		Temporary office and storage of project tools and materials
Steel storage		√		Steel storage area
Wood storage		√		Wood storage area
Formwork Workshop		√		Formwork assembly area
Steel Workshop 1		√		Clamp cutting and shaping area
Steel Workshop 2		√		Firts sloof assembly area a
Steel Workshop 3		√		Second sloof assembly area
Roadway	√			Office roadway
Sand		√		Sand storage area
Disposan Area		√		Waste material storage area
Ready Mix		√		Ready mix truck placement area
Shallow Storage		√		Shallow storage area for scaffolding
Office Building for Cooperatives, Trade and Industry Micro Enterprises			√	The building is to the right of the project site
Community and Village Empowerment Service Building			√	The building is to the left of the project site

Then each facility is also measured the distance of movement or path distance from one facility to another as shown in the following table.

Table 4. Distance Between Facilities On 1st Floor Casting Work

Type of Facility	Building	Site Officet & Warehouse	Steel storage	Wood storage	Formwork Workshop	Steel Workstation 1	Steel Workstation 2	Steel Workstation 3	Roadway	Sand	Disposal Area	Ready Mix
Building	0.0	44.0	2.4	31.5	39.5	29.6	34.4	34.4	2.5	2.3	59.3	15.9
Site Officet & Warehouse	44.0	0.0	35.1	1.3	0.9	15.3	2.8	2.7	16.5	46.1	50.9	18.4
Steel storage	2.4	35.1	0.0	23.8	33.8	0.8	26.7	3.6	0.7	2.5	50.9	18.4
Wood storage	31.5	1.3	23.8	0.0	2.6	2.9	0.4	2.4	3.0	34.5	40.7	5.9
Formwork Workshop	39.5	0.9	33.8	2.6	0.0	8.1	3.4	0.3	10.5	38.8	50.8	10.8
Steel Workstation 1	29.6	15.3	0.8	2.9	8.1	0.0	5.8	0.5	3.0	32.1	40.6	1.2
Steel Workstation 2	34.4	2.8	26.7	0.4	3.4	5.8	0.0	5.5	2.9	39.7	35.7	8.3
Steel Workstation 3	34.4	2.7	3.6	2.4	0.3	0.5	5.5	0.0	5.5	35.7	44.2	7.1
Roadway	2.5	16.5	0.7	3.0	10.5	3.0	2.9	5.5	0.0	0.8	24.1	0.0
Sand	2.3	46.1	2.5	34.5	38.8	32.1	39.7	35.7	0.8	0.0	62.6	18.0
Disposal Area	59.3	50.9	51.6	40.7	50.8	40.6	35.7	44.2	24.1	62.6	0.0	33.6
Ready Mix	15.9	18.4	7.0	5.9	10.8	1.2	8.3	7.1	0.0	18.0	33.6	0.0

Table 5. Distance Between Facilities On 2nd Floor Beam Work

Type of Facility	Building	Site Office & Warehouse	Steel storage	Wood storage	Formwork Workshop	Steel Workstation 1	Steel Workstation 2	Steel Workstation 3	Roadway	Shallow Storage	Disposal Area
Building	0.0	44.0	2.4	31.5	39.5	29.6	34.4	34.4	2.5	2.3	59.3
Site Office & Warehouse	44.0	0.0	35.1	1.3	0.9	15.3	2.8	2.7	16.5	46.1	50.9
Steel storage	5.4	8.9	0.0	23.8	33.8	0.8	26.7	3.6	0.7	2.5	50.9
Wood storage	21.5	5.3	0.2	0.0	2.6	2.9	0.4	2.4	3.0	34.5	40.7
Formwork Workshop	22.9	7.7	1.4	0.5	0.0	8.1	3.4	0.3	10.5	38.8	50.8
Steel Workstation 1	33.4	4.2	12.0	6.5	11.8	0.0	5.8	0.5	3.0	32.1	40.6
Steel Workstation 2	25.3	5.3	0.7	0.2	6.9	1.5	0.0	5.5	2.9	39.8	35.7
Steel Workstation 3	26.7	4.0	2.6	4.5	6.5	0.3	0.3	0.0	5.5	35.7	44.2
Roadway	4.5	9.1	0.5	2.4	0.6	13.0	4.3	7.7	0.0	0.8	24.1
Shallow Storage	3.8	28.2	3.4	20.6	23.4	32.4	22.3	25.4	0.8	0.0	62.6
Disposal Area	44.6	34.6	27.7	28.9	23.3	38.7	30.1	33.1	19.7	43.6	0.0

Besides that, the frequency of movement between each facility is also calculated as in the following table.

Table 6. Frequency of Worker Movement in 1 Day on 1st Floor Casting Work

Type of Facility	Building	Site Office & Warehouse	Steel storage	Wood storage	Formwork Workshop	Steel Workstation 1	Steel Workstation 2	Steel Workstation 3	Roadway	Sand	Disposal Area	Ready Mix
Building	0	26	8	6	0	6	0	0	71	0	0	630
Site Office & Warehouse	26	0	2	3	0	5	7	0	45	0	0	0
Steel storage	8	2	0	0	0	0	6	0	9	0	0	0
Wood storage	6	3	0	0	0	0	0	0	8	0	0	5
Formwork Workshop	0	0	0	0	0	0	0	0	6	0	0	0
Steel Workstation 1	6	5	0	0	0	0	0	0	22	0	0	0
Steel Workstation 2	0	7	6	0	0	0	0	2	6	0	2	0
Steel Workstation 3	0	0	0	0	0	0	2	0	5	0	0	0
Roadway	71	45	9	8	6	22	6	5	0	0	0	23
Sand	0	0	0	0	0	0	0	0	0	0	0	0
Disposal Area	0	0	0	0	0	0	2	0	0	0	0	0
Ready Mix	630	0	0	5	0	0	0	0	23	0	0	0

Table 7. Frequency of Worker Movement in 1 Day on 2nd Floor Beam Work

Type of Facility	Building	Site Office & Warehouse	Steel storage	Wood storage	Formwork Workshop	Steel Workstation	Steel Workstation	Steel Workstation	Roadway	Shallow Storage	Disposal Area
Building	0	41	0	48	4	0	0	0	32	23	0
Site Office & Warehouse	41	0	8	2	0	0	7	29	38	0	0
Steel storage	0	8	0	0	0	0	0	4	12	0	0
Wood storage	48	2	0	0	0	0	0	6	5	0	0
Formwork Workshop	4	0	0	0	0	0	0	0	3	0	0
Steel Workstation 1	0	0	0	0	0	0	0	14	16	0	0
Steel Workstation 2	0	7	0	0	0	0	0	0	2	0	3
Steel Workstation 3	0	29	4	6	0	14	0	0	3	0	0
Roadway	32	38	12	5	3	16	2	3	0	0	0
Shallow Storage	23	0	0	0	0	0	0	0	0	0	0
Disposal Area	0	0	0	0	0	0	3	0	0	0	0

Furthermore, identification of the value of security at each existing facility. The security weight values can be divided as shown in the following table.

Table 8. Level of Security Value

Security Level	Value	Explanation
Very safe	1	It is impossible for work accidents to occur so no need for security.
Safe	2	It is rare that there is a possibility of a work accident that has an impact on the surroundings, so it requires security.
Neutral	3	Sometimes accidents happen, so you need safety because there may be minor accidents, but they can still be avoided.
Not safe	4	There is often the possibility of work accidents that must be anticipated, thus requiring safety to minimize the possibility of injury or injury.
Very not safe	5	Accidents always happen, so the location should not be passed.

Meanwhile, based on the results of discussions and interviews, the value of the possible hazard level between facilities is in Table 9.

Table 9. Level of Possible Hazards Between Facilities at Work on the 1st Floor

Facility	Security Level					Value
	Very Safe	Safe	Neutral	Not Safe	Very Not Safe	
Building			√			3
Site Office & Warehouse		√				2
Steel Storage		√				2
Wood Storage		√				2
Formwork Workshop		√				2
Steel Workstation 1		√				2
Steel Workstation 2			√			3
Steel Workstation 3			√			3
Roadway	√					1
Sand		√				2
Disposal Area		√				2
Ready Mix		√				2

Table 10. Level of Possible Hazards Between Facilities at Work on the 2nd Floor Beam Work

Facilities	Security Level					Value
	Very Safe	Safe	Neutral	Not Safe	Very Not Safe	
Building			√			3
Site Office & Warehouse		√				2
Steel storage		√				2
Wood storage		√				2
Formwork Workshop		√				2
Steel Workstation 1		√				2
Steel Workstation 2			√			3
Steel Workstation 3			√			3
Roadway	√					1
Shallow Storage		√				2
Disposal Area		√				2

After obtaining these data, so now we can analyse the value of traveling distance and safety index from the existing site layout.

Table 11. Traveling distance at 1st Floor Casting Work (Analysis, 2023)

Type of Facility	Building	Site Officet & Warehouse	Steel storage	Wood storage	Formwork Workshop	Steel Workstation 1	Steel Workstation 2	Steel Workstation 3	Roadway	Sand	Disposal Area	Ready Mix	Accumulation
Building	0.0	1144.3	19.1	189.2	0.0	177.6	0.0	0.0	177.5	0.0	0.0	10017.6	11725.2
Site Officet & Warehouse	1144.3	0.0	70.2	4.0	0.0	76.7	19.4	0.0	742.5	0.0	0.0	0.0	2057.0
Steel storage	19.1	70.2	0.0	0.0	0.0	0.0	160.4	0.0	5.9	0.0	0.0	0.0	255.5
Wood storage	189.2	4.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1	0.0	0.0	29.4	246.7
Formwork Workshop	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.8	0.0	0.0	0.0	62.8
Steel Workstation 1	177.6	76.7	0.0	0.0	0.0	0.0	0.0	0.0	66.4	0.0	0.0	0.0	320.7
Steel Workstation 2	0.0	19.4	160.4	0.0	0.0	0.0	0.0	11.0	17.4	0.0	71.4	0.0	279.5
Steel Workstation 3	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0	27.3	0.0	0.0	0.0	38.2
Roadway	177.5	742.5	5.9	24.1	62.8	66.4	17.4	27.3	0.0	0.0	0.0	0.0	1124.0
Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Disposal Area	0.0	0.0	0.0	0.0	0.0	0.0	71.4	0.0	0.0	0.0	0.0	0.0	71.4
Ready Mix	10017.6	0.0	0.0	29.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10046.9
									Total				**26227.9**

Table 12. Traveling distance at 2nd Floor Beam Work

Type of Facility	Building	Site Officet & Warehouse	Steel storage	Wood storage	Formwork Workshop	Steel Workstation 1	Steel Workstation 2	Steel Workstation 3	Roadway	Shallow Storage	Disposal Area	Accumulation
Building	0.0	1804.4	0.0	1032.1	91.8	0.0	0.0	0.0	143.9	87.5	0.0	3159.7
Site Officet & Warehouse	1804.4	0.0	70.8	10.7	0.0	0.0	37.3	114.4	346.7	0.0	0.0	2384.2
Steel storage	0.0	70.8	0.0	0.0	0.0	0.0	0.0	10.3	5.6	0.0	0.0	86.7
Wood storage	1032.1	10.7	0.0	0.0	0.0	0.0	0.0	26.9	11.9	0.0	0.0	1081.6
Formwork Workshop	91.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	93.6
Steel Workstation 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	207.4	0.0	0.0	210.8
Steel Workstation 2	0.0	37.3	0.0	0.0	0.0	0.0	0.0	0.0	8.6	0.0	90.2	136.1
Steel Workstation 3	0.0	114.4	10.3	26.9	0.0	3.4	0.0	0.0	23.1	0.0	0.0	178.1
Roadway	143.9	346.7	5.6	11.9	1.8	207.4	8.6	23.1	0.0	0.0	0.0	749.0
Shallow Storage	87.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	87.5
Disposal Area	0.0	0.0	0.0	0.0	0.0	0.0	90.2	0.0	0.0	0.0	0.0	90.2
									Total			**8257.5**

Table 13. Safety Index at 1st Floor Casting Work

Type of Facility	Building	Site Officet & Warehouse	Steel storage	Wood storage	Formwork Workshop	Steel Workstation 1	Steel Workstation 2	Steel Workstation 3	Roadway	Sand	Disposal Area	Ready Mix	Accumulation
Building	0.0	3.0	16.8	1.0	0.0	1.0	0.0	0.0	56.8	0.0	0.0	198.1	276.6
Site Officet & Warehouse	3.0	0.0	0.3	11.2	0.0	1.6	25.3	0.0	5.5	0.0	0.0	0.0	46.8
Steel storage	16.8	0.3	0.0	0.0	0.0	0.0	2.2	0.0	27.4	0.0	0.0	0.0	46.7
Wood storage	1.0	11.2	0.0	0.0	0.0	0.0	0.0	0.0	5.3	0.0	0.0	4.3	21.8
Formwork Workshop	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.1
Steel Workstation 1	1.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	14.6	0.0	0.0	0.0	17.2
Steel Workstation 2	0.0	25.3	2.2	0.0	0.0	0.0	0.0	3.6	4.1	0.0	0.3	0.0	35.6
Steel Workstation 3	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	1.8	0.0	0.0	0.0	5.5
Roadway	56.8	5.5	27.4	5.3	1.1	14.6	4.1	1.8	0.0	0.0	0.0	0.0	116.6
Sand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Disposal Area	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3
Ready Mix	198.1	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	202.4
									Total				**770.5**

Table 14. Safety Index at 2nd Floor Beam Work

Type of Facility	Building	Site Officet & Warehouse	Steel storage	Wood storage	Formwork Workshop	Steel Workstation 1	Steel Workstation 2	Steel Workstation 3	Roadway	Shallow Storage	Disposal Area	Accumulation
Building	0.0	2.8	0.0	6.7	0.5	0.0	0.0	0.0	14.2	18.1	0.0	42.4
Site Officet & Warehouse	2.8	0.0	2.7	1.1	0.0	0.0	5.3	29.4	8.3	0.0	0.0	49.6
Steel storage	0.0	2.7	0.0	0.0	0.0	0.0	0.0	6.2	51.1	0.0	0.0	60.1
Wood storage	6.7	1.1	0.0	0.0	0.0	0.0	0.0	5.3	4.2	0.0	0.0	17.4
Formwork Workshop	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.8	0.0	0.0	10.3
Steel Workstation 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	228.4	2.5	0.0	0.0	230.9
Steel Workstation 2	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.3	6.5
Steel Workstation 3	0.0	29.4	6.2	5.3	0.0	228.4	0.0	0.0	0.8	0.0	0.0	270.1
Roadway	14.2	8.3	51.1	4.2	9.8	2.5	0.9	0.8	0.0	0.0	0.0	91.9
Shallow Storage	18.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.1
Disposal Area	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.3
									Total			**797.6**

The next step is to determine three new alternatives based on the existing problems in the existing conditions. On those three alternatives, an analysis of the traveling

distance and safety index values of each alternative was performed, and then the best alternative will be selected compared to one another by using the analytical hierarchy process (AHP) method.

3.1 1ST Floor Casting Work

On the 1st floor casting work, the difference in traveling distance and safety index values can be seen as follows.

Table 15. TD and SI Values of the Three Alternatives at 1st Floor Casting Work

Alternative	Traveling Distance (TD)		Safety Index (SI)	
	Value (m)	Change	Value (m)	Change
0	26227.9	0%	770.5	0%
1	22353.0	-15%	1246.3	62%
2	22211.5	-15%	1215.4	58%
3	17580.7	-33%	934.2	21%

As for the following diagram, it can be seen also the difference between alternative tials in the 1st floor casting work as follows.

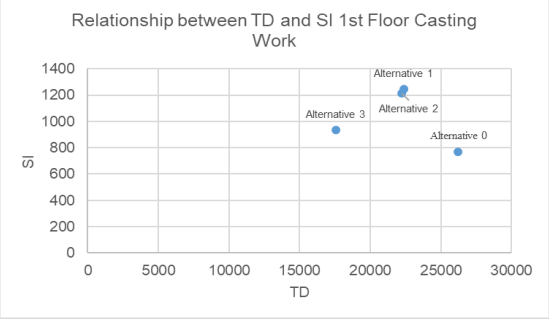

Fig. 2 Graph of Relationship between TD and SI Values of 1st Floor Casting Work (Analysis, 2023)

The description of the problem hierarchy in the 1st floor casting work can be seen as follows.

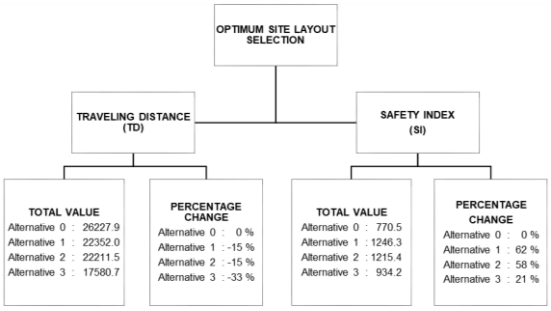

Fig. 3 Problems Hierarchy of 1st Floor Casting Work

In order to maximize the selection of alternatives that have the optimum criteria, an assessment of the weight of the criteria is carried out according to the comparison of the parameters of each alternative.

Table 16. Alternative Ranking Assessment Weighting On 1st Floor Casting Work

Alternative	Traveling Distance (TD)		Safety Index (SI)		Total Weight
	Value	Weight	Value	Weight	
0	26227.9	1	770.5	4	5
1	22353.0	2	1246.3	1	3
2	22211.5	3	1215.4	2	5
3	17580.7	4	934.2	3	7

From the results of the analysis, on the 1st floor casting work, the selected site layout based on the results obtained is alternative 3, with a minimum TD and SI value of 17580.7 m for the TD value (decreased in the TD value of -33%) and 934.2 for the SI value (subject to a decrease in the SI value of 21%).

3.2 2nd Floor Beam Work

For work on the 2nd floor beams, the difference in traveling distance and safety index values can be seen in the following.

Table 17. TD and SI Values of the Three Alternatives at 2nd Floor Beam Work

Alternative	Traveling Distance (TD)		Safety Index (SI)	
	Value (m)	Change	Value (m)	Change
0	8257.5	0%	797.6	0%
1	8402.3	2%	496.4	-38%
2	9670.8	17%	441.7	-45%
3	8655.2	5%	405.8	-49%

As for the following diagram, you can also see the differences in each alternative in the 2nd floor beam work as follows.

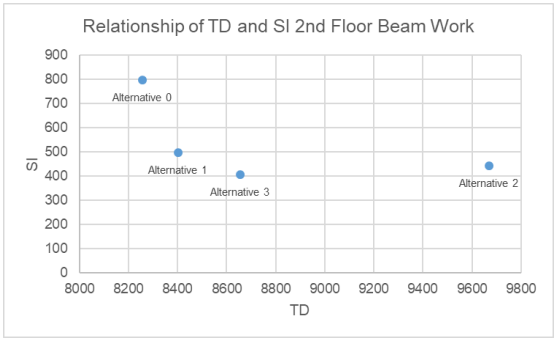

Fig. 4 Graph of Relationship between TD and SI Values of 2nd Floor Beam Work

The description of the problem hierarchy in the first floor casting work can be seen in Figure 5.

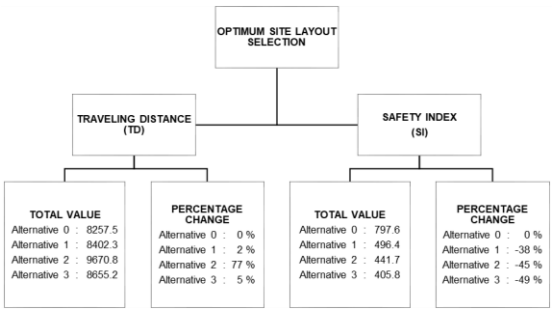

Fig. 5 Problems Hierarchy of 2nd Floor Beam Work (Analysis, 2023)

In order to maximize the selection of alternatives that have the optimum criteria, an assessment of the weight of the criteria is carried out according to the comparison of the parameters of each alternative.

Table 18. Alternative Ranking Assessment Weighting On 2nd Floor Beam Work

Alternative	Traveling Distance (TD)		Safety Index (SI)		Total Weight
	Value (m)	Change	Value (m)	Change	
0	8257.5	4	797.6	1	5
1	8402.3	3	496.4	2	5
2	9670.8	1	441.7	3	4
3	8655.2	2	405.8	4	6

From the results of this analysis, for the 2nd Floor Beam Work, the selected site layout based on the results obtained is alternative 3, with a TD value of 8655.2 (experiencing an increase in TD value of 5%) and an SI value of 405.8 (decreasing value SI of 49%).

4. Conclusion

There are several things can be concluded from this research:

- Site Layout for the placement of facilities and materials on the project can still be optimized.
- Based on AHP analysis, using traveling distance and safety index indicators, alternative 3 is the most optimal alternative for both 1st floor casting work and 2nd floor beam work.
- The existing site layout can become more efficient, through efforts to maximize the effectiveness of facility placement and material storage by minimizing the distance between facilities and reducing barriers for worker movement, especially at facility that have a high level of risk and have the highest frequency of worker movement.

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6. Author's Note

The contents of making this journal are written based on research results with the help of Mrs. Lusiana and Mr. Syahrudin as the advisor lecturer and has completed his undergraduate thesis for the Civil Engineering Study Program at Tanjungpura University.

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