Journal of Applied Science, Engineering, Technology, and Education *ISSN: 2685-0591 (online)*
Vol. 5 No. 2 (2023)
https://doi.org/10.35877/454RI.asci2337

Implementation of the Hiradc Method in Risk Analysis of Diaphragm Wall Work Projects

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Abstract

The decreasing land area in big cities makes construction progress develop not only vertically upwards, but also downwards. This is done to optimize the land use. One of the things is the construction of a basement as a parking lot, storage space, and other functions to be neatly organized and safe. There are numerous employment risks in basement work that can result in building failures that hinder other construction activity. This research was conducted at a company that focuses on the business of guitar manufacturing, retaining walls, and soil improvement in three high-rise building construction projects that are currently building, and experiencing difficulties in identifying the main risks in diaphragm wall work. The soil conditions are different at each project site, which is not the same as the superstructure work. It is more typical and the quite large project value reaching more than 100 billion than can be classified as a major construction project. The risks that will be encountered in its implementation will also be large. The steps involved in the research were risk identification, risk qualitative analysis, and extreme risk response planning by experts. There were sixty-four (64) identified risks relevant to the project construction phase, classified into eleven categories. The risk was then simulated to obtain high risk and control risk plans that would be carried out when the high risk occurs. There are four high risks, namely the damaged or non-compliant construction materials, inaccurate specifications, delays in the execution of constructor work, and slope failure during excavation.

Keywords: risk, diaphragm wall, HIRADIC

Received: 15 Maret 2021 Revised: 29 November 2021 Accepted: 2 December 2021

1. Introduction

The decreasing amount of land area in big cities means that building construction is increasingly developing in a vertical direction (Bashabsheh et al., 2019; Cao et al., 2022; Moradi et al., 2022; Rani et al., 2022). Not only upwards, the development of human knowledge also causes development to be carried out downwards (Abouhamad et al., 2021; Berlak et al., 2021; Chathuranga et al., 2023; Li et al., 2022; Terzioglu et al., 2022). In its process, downwards construction utilizes the deep excavation method (Wadino et al., 2018). This was done to optimize the land use. Thus, one solution for every construction is to build a basement as a parking area, storage space, and many other functions to remain neatly organized and safe (Lim et al., 2022; Nguyen et al., 2023; Seyman Guray et al., 2023; Suchithra et al., 2022; Zou et al., 2020). In basement work, it is necessary to know the soil condition used to construct a building (Yuniasari et al., 2021).

The main problem that is often faced is the presence of tall buildings nearby. Therefore, when carrying out underground excavation work on a project, it is necessary to maintain the stability of the soil, so a stable retaining wall structure and supporting columns are needed (Bahrami et al., 2021; Gharbia et al., 2020; Kolozvari et al., 2022). This is to minimize the possibility of unexpected movement and deformation in surrounding buildings, which can cause cracks, damage and even building collapse. To overcome the above problems, reinforced concrete walls are used which are called diaphragm walls. These walls are usually cast continuously on site along the edge of the planned excavated hole after the stripped hole is prepared first, and excavation is carried out according to plan. Depth and provision of reinforcement, generally in the form of a cage, are also required (Blount et al., 2020; Kolozvari et al., 2021; Tabrizikahou et al., 2023).

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Considering the different soil conditions at each project location, this type of work is different with the more typical upper structure work (Chen et al., 2021; González et al., 2021; Oluleye et al., 2022; Wang et al., 2020; Zhang et al., 2019). A project value that is large enough to reach more than 100 billion can be categorized as a large-scale project so that the risks that will be encountered in its implementation will also be great. The ongoing high rise building projects, two in DKI Jakarta and one in South Tangerang with a total contract value of more than 100 billion, are experiencing obstacles, among others, in identifying and analyzing risks in foundation work, especially diaphragm walls. The designation of this project as an apartment with mixed used, including offices and malls. The significant need for a large and spacious basement is one of the important points in the characteristics of this project. This research aims to find out what risks are in the high category so that they can be well-controlled.

2. Method

The techniques used exploratory quantitative and qualitative techniques, starting from the identification of hazards, risk analysis, and risk control (determining control). The instrument used in this research was through a questionnaire using a scale to determine probability and severity.

Table 1. Probability Level Values

Likelihood/Probability	Value Scale	Criteria
Frequent	5	Very Often/Very High
Probable	4	Frequent/High
Occasional	3	Medium/Fair
Unlikely	2	Rare/Low
Improbable	1	Very Rare/Very Low

Table 2. Severity Level Values

Likelihood/Probability	Value Scale	Criteria
Catastrophic	5	Death, permanent/serious disability, severe environmental damage, B3 leak, huge financial loss, medical costs > 50 million.
Major	4	Lost working days, permanent/partial disability, moderate environmental damage, large financial losses, medical costs < 50 million.
Moderate/Serious	3	Requires medical treatment, disruption of work, significant financial losses, requires external assistance, medical costs < 10 million.
Minor	2	Handling first aid, does not really require outside help, financial costs are moderate, medical costs < 1 million.
Negligible	1	Does not interfere with the work process, no injuries, small financial losses, medical costs < 100 thousand.

It was then analyzed using the Severity Index (SI) method with the following formula:

$$\frac{\sum_{i=0}^{4} ai.xi}{4\sum_{i=0}^{4} xi} \ (100\%)$$

where:

ai = scoring constant
xi = respondent frequency
i = 0, 1, 2, 3, 4,…, n

This method aims to obtain combined results from assessing risk probability and risk impact. For population size, the Slovin technique was used with an error rate of 5%. Staff and workers were involved in foundation work projects. The number of Diaphragm Wall included 46 people, so the number of samples used was 41 people.

3. Results and Discussion

The profiles of respondents who filled out the questionnaire were classified into three, based on education, work experience, and position.

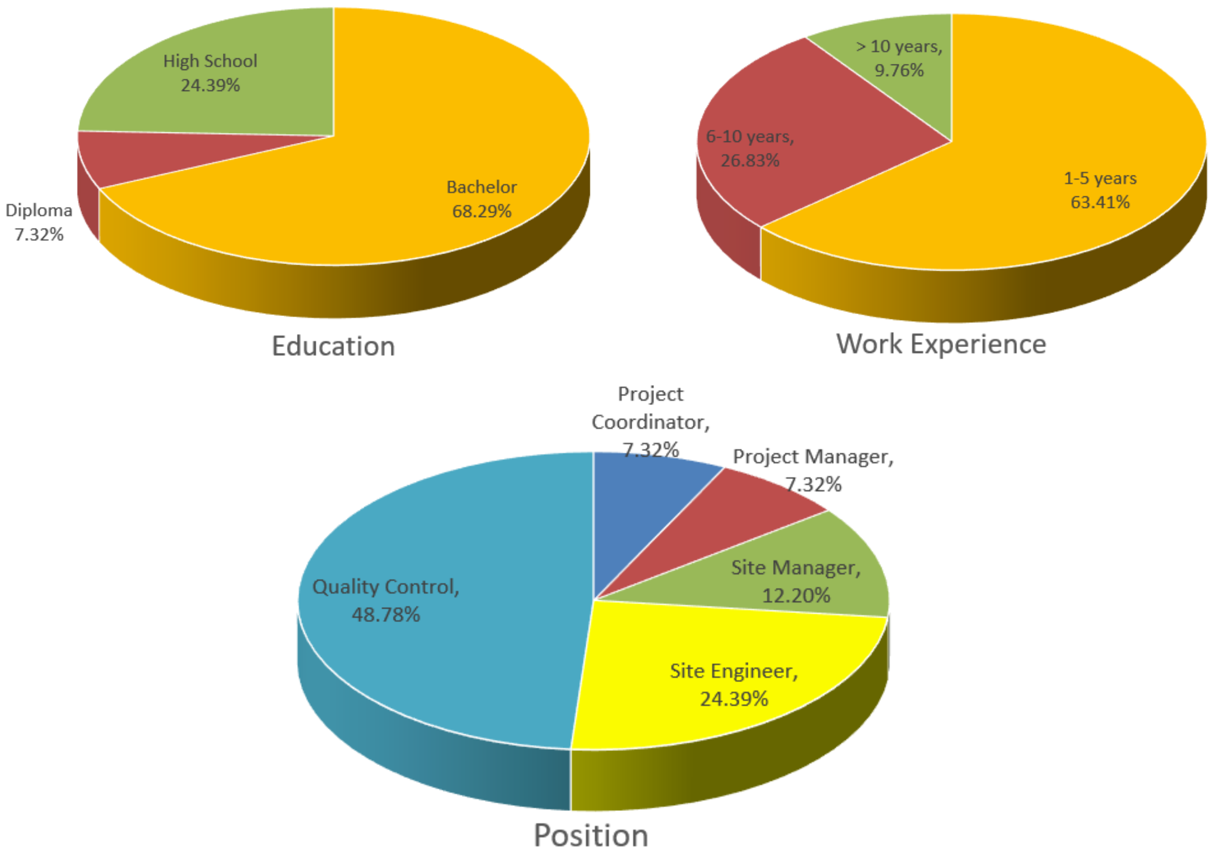

Figure 1. Profile of Research Respondents

Based on the data on Figure 1, more than half of the respondents are bachelor (68,29%) and have experience of up to 5 years (63,41%). In the quality control position category, almost half of the population (48,78%) is followed by site engineer at 24,39%. Respondents were then asked to fill out a questionnaire with 64 variables that had been previously identified and through expert validation regarding risks in foundation work diaphragm walls in high rise building projects, which have a significant impact. After that, the data was analyzed using the Severity Index method. This method aims to obtain combined results from assessing risk probability and risk impact. Risk analysis of the probability of occurrence and impact was carried out by multiplying the results of the probability assessment (P) with the results of the impact assessment (Impact = I) of each risk variable. The table 3 show the results of multiplying probability and impact (PxI).

The Risk Map contains information on risk positions that have been analyzed by assigning risk categories to Probability and Impact measurements using Severity Index calculations (Figure 2).

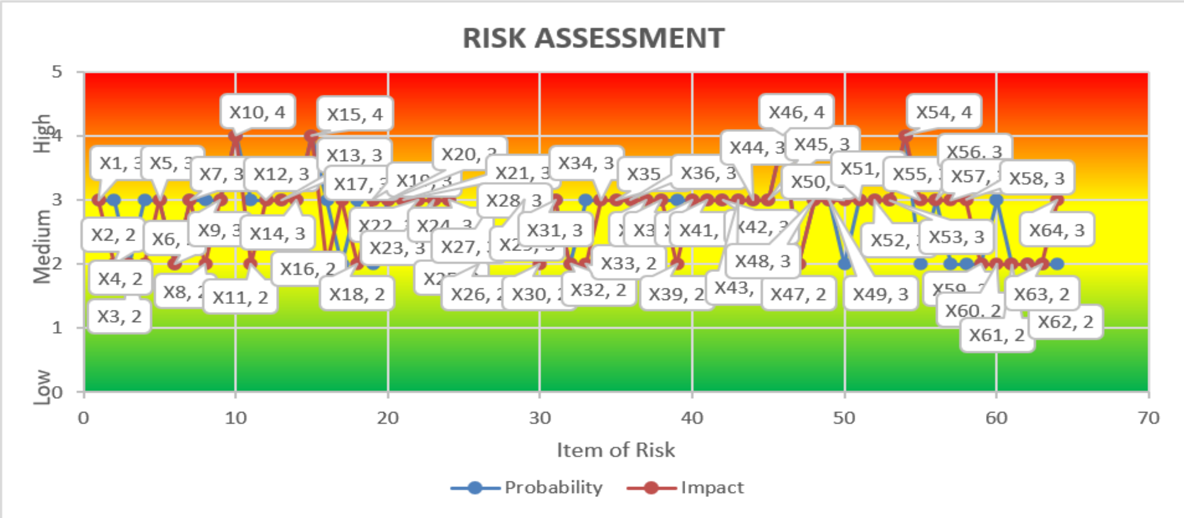

Figure 2. Risk Map

Table 3. Multiplication of Probability vs Impact

Code	Risk Variables	P	I	P x I	Category
X1	Change the sequence in construction activities	3	3	9	Medium
X2	Unavailability of resources	3	2	6	Medium
X3	Change the number of jobs	2	2	4	Low
X4	Work permit to carry out work	3	2	6	Medium
X5	Worker safety	3	3	9	Medium
X6	Termination of work due to medical outbreak	2	2	4	Low
X7	The material used does not meet specifications	3	3	9	Medium
X8	Is there an opportunity for the procurement team to know the client's sales chart?	3	2	6	Medium
X9	Estimated material quantities based on contract drawings and Bill of Quantity	3	3	9	Medium
X10	Materials are damaged or do not comply with construction requirements	4	4	16	High
X11	Material delivery scheduling	3	2	6	Medium
X12	Monitoring delivery schedules	3	3	9	Medium
X13	Late design changes or revisions from the client side	3	3	9	Medium
X14	The project schedule is tight or tight	3	3	9	Medium
X15	Incorrect specifications	4	4	16	High
X16	Inadequate and incomplete design	3	2	6	Medium
X17	Slow to revise and redistribute working drawings	2	3	6	Medium
X18	Document control is not good	3	2	6	Medium
X19	Knowledge of equipment	2	3	6	Medium
X20	Inappropriate implementation method	3	3	9	Medium
X21	The type of equipment used is inappropriate or does not suit its function	3	3	9	Medium
X22	Less amount of equipment used	3	3	9	Medium
X23	Poor site plan or site layout arrangement	3	3	9	Medium

Code	Risk Variables	P	I	P x I	Category
X24	Loss of data or computer software/hardware	3	3	9	Medium
X25	Impact of weather conditions on project completion	2	2	4	Low
X26	Difficult field conditions	2	2	4	Low
X27	Licensing and regulatory issues	3	3	9	Medium
X28	Damage by third parties (surrounding environment and society)	3	3	9	Medium
X29	Pollution caused by construction waste	3	3	9	Medium
X30	Procedures to facilitate the cleanup or disposal of construction waste	3	2	6	Medium
X31	Placement of ex-work waste and rubbish	3	3	9	Medium
X32	Project team discussion of risks	2	2	4	Low
X33	Time for planning	3	2	6	Medium
X34	Documented process for identifying project risks	3	3	9	Medium
X35	Distribution of data/information is not good	3	3	9	Medium
X36	Communication between parties is not good	3	3	9	Medium
X37	Unclear flow of coordination between parties	3	3	9	Medium
X38	Insufficient number of workers	3	3	9	Medium
X39	Insufficient workforce skill level	3	2	6	Medium
X40	How long will staff and workers be needed?	3	3	9	Medium
X41	Losing important staff at crucial points in construction	3	3	9	Medium
X42	The quality of the project engineering team is not good	3	3	9	Medium
X43	Too much overtime (overtime work)	3	3	9	Medium
X44	Unclear division of duties and authority	3	3	9	Medium
X45	Opportunity for sub-contractors to leave the project (resign)	3	3	9	Medium
X46	Delays in implementing subcontractor work	4	4	16	High
X47	Price revision	2	2	4	Low
X48	There are existing excavations in the Diapraghm Wall	3	3	9	Medium
X49	Error creating work sequence	3	3	9	Medium
X50	Error placing CWS position	2	3	6	Medium
X51	The depth of the excavation exceeds the initial plan/design	3	3	9	Medium
X52	Insufficient slurry for excavation work	3	3	9	Medium
X53	Inappropriate base plate arrangement	3	3	9	Medium
X54	failure in during excavation	4	4	16	High
X55	Amount and. The quality of the iron does not meet technical specifications	2	3	6	Medium
X56	The number of Man Power of iron assembly is inadequate	3	3	9	Medium
X57	Errors in assembling reinforcement/reinforcement Diapraghm Wall	2	3	6	Medium
X58	Concrete decking/concrete not installed	2	3	6	Medium
X59	The casting location is not yet ready	2	2	4	Low

Code	Risk Variables	P	I	P x I	Category
X60	The occurrence of high deposits or beyond tolerance limits	3	2	6	Medium
X61	Treami pipe is clogged or there is leftover concrete from previous casting	2	2	4	Low
X62	Necking and Bulging occur when concrete is poured into the Diapraghm Wall hole	2	2	4	Low
X63	Slump test does not meet technical requirements and specifications	2	2	4	Low
X64	Treami pipe cannot be removed or taken after the casting process is complete	2	3	6	Medium

From the multiplication results that have been obtained and are outlined in Table 3, it can be found that there are 4 risk variables that have a greater value than other risks, namely the high category regarding the probability of occurrence and impact. The following are the types of risks resulting from risk analysis based on the probability and impact matrix table, which has a high category in tabular form, where these risks will then be given a risk response.

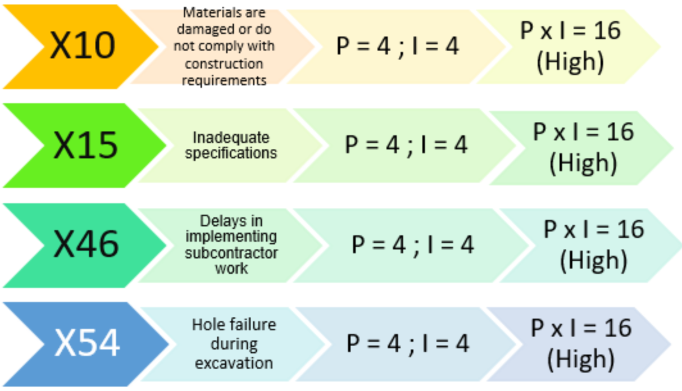

Figure 3. High Risk Category

After all risk elements were identified and measured, the next stage in risk analysis was to carry out risk control in the "High" risk category through interviews with the authorities in the project development process. Risk control data can be seen in Figure 4.

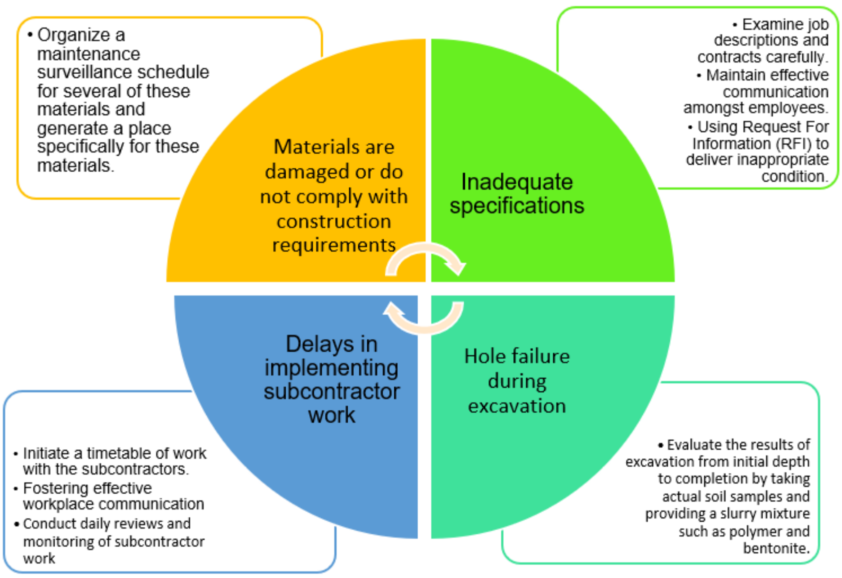

Figure 4. High Risk Control

4. Conclusion

Based on the research results, there are four dominant risks in this diaphragm wall work project, each with a score of 16, namely damaged materials or not complying with construction requirements, inaccurate specifications, delays in implementing subcontractor work, slope failures during excavation. Strategies for controlling the risks of diaphragm wall work include making a material maintenance monitoring schedule, being careful in reading contracts, building communication, submitting RFIs, making timeline schedules with subcontractors, as well as conducting reviews and monitoring related to earthworks.

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