RISK OF BROWNFIELD DURING CONSTRUCTION STAGE: CASE STUDY OF PLTGU PROJECT IN INDONESIA

by Ferry Hermawan

INTERNATIONAL JOURNAL OF SOCIAL SERVICE AND RESEARCH

RISK OF BROWNFIELD DURING CONSTRUCTION STAGE: CASE STUDY OF PLTGU PROJECT IN INDONESIA

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Abstract

Projects at the brownfield location cannot be separated from potential hazards related to geotechnical conditions and the existing project site. The construction phase is carried out at a location in the middle of an already operating factory. Lack of understanding of site characteristics and minimal use of the technology used can result in the project not meeting what was expected. This study aims to identify brownfield risk events during the construction phase of the PLTGU project development in Indonesia. This research uses quantitative and qualitative methods with a case study approach. Primary data were collected using documentation, field observations, survey questionnaires and structured interviews. The results of the study identified 23 (twenty three) and 6 (six) main risks based on the rankings, namely: 1) Groundwater level risk, 2) Location infrastructure damage, 3) Flood risk, 4) Structural damage and structural settlement, 5) Land subsidence, 6) Leakage of existing underground pipes. risks affecting project performance during the construction phase. The results of the study reveal that these risk events are risks that must be managed by project management during the construction phase.

Keywords: Brownfield risk; construction phase; land

Received 29 November 2022, Revised 10 December 2022, Accepted 20 December 2022

INTRODUCTION

Brownfield is a term used by experts to define land or buildings that have been previously used or developed and are not fully used, even though they are partially occupied or utilized, may also be vacant, abandoned or contaminated Alker *et al.*, (2000). A brownfield project is defined as a project carried out within existing operating facilities as opposed to a greenfield project which was built from scratch Malik, (2021). The use of brownfield land is used to avoid obstacles in the licensing process and land acquisition.

Project development at the brownfield location has many uncertainties, such as the geotechnical location and the existence of the existing De Sousa, (2000). These projects tend to require large amounts of money to manage the contamination in them before they are used for construction. Luo, Catney and Lerner, (2009) found that there are many obstacles in the brownfield construction, including those related to geotechnical hazards caused by the density and strength of the residual soil material Štefaňák, (2019), heterogeneous materials mixed with the original soil during various stages of expansion over a long period of time, causing geotechnical site characterization to play an important role, because contamination stored in it Štefaňák, (2019).

The Brownfield project is implemented in an environment with existing facilities and ongoing operations Farrance and Taylor, (2012), the project is more complex due to the complex network of interdependencies and conflicting relationships between operations at the location of Brahm and Tarziján, (2015). A number of challenges and constraints on the project often result in cost overruns and schedule delays if not addressed adequately. The implementation of brownfield projects is often affected by a lack of definition resulting in scope growth, low efficiency of brownfield work due to permits, limited layout or simply poor access to facilities Hassan *et al.*, (2016). The need for careful planning and scheduling to determine the potential for criticality and uncertainty of field conditions, using resources effectively to optimize space constraints, and developing strategic responses to reduce risks by taking into account safety, convenience, and implementation time De and Rout, (2022).

In this study, brownfield risk is defined as an event or occurrence that involves hazards related to soil conditions that affect the project objectives. The construction stage is a critical stage during project implementation, risk events during the construction stage can be positive and negative. Positive risks can have a positive impact on the project, such as budget savings, time acceleration and so on. Negative risk is something that is not wanted to happen or can have a negative impact on the project, for example an increase in the budget, potential delays. This study aims to investigate brownfield risk events that occur during the construction phase of a PLTGU construction project in Indonesia.

METHOD

The research method used in this study is a mixed approach, combining quantitative and qualitative approaches. The purpose of integrating quantitative and qualitative data is to ensure completeness, as qualitative evidence can support survey data to explain unidentified relationships. Meanwhile, to answer this research, descriptive qualitative and explanatory methods are used, which aim to analyze, describe, and summarize various conditions, situations from various data collected in the form of interviews or observations of the researched problems that occur in the field with a case study approach on the project. This study chose a case study of the PLTGU project development in Indonesia. Primary data were collected using documentation, field surveys and structured interviews with related information. Other related data in this study are supporting documents for the literature on brownfield hazards and risks.

Purposive sampling method was used in this study to avoid bias from the results of the study, respondents were selected based on criteria that were in accordance with the objectives of this study, namely: experienced in working on PLTGU development projects by sharing brownfield and greenfield characteristics.

In this study, the Likert scale was used to quantify brownfield risk. Likert scale is a scale that can be used to measure the opinion of a population of events that occur. The questionnaire survey was chosen to collect data from service users and service providers. The author has distributed questionnaires to 30 personnel who are experienced in working on PLTGU projects. This study uncovers risk events that occur during the construction phase.

A. Case Study

Gas and Steam Power Plant (PLTGU) is a combination of PLTG and PLTU, where the heat from the exhaust gas from the PLTG is used to produce steam which is used as the working fluid in the PLTU. PLTGU consists of two parts of the building, the main building is the turbine generator building and Heat Recovery Steam Generator (HRSG), and the Balance of plant (BOP) building consists of the Condensate Pump, Forced, draft fan, Induced draft fan, Circulating Water Pump building. Stations. The construction of PLTGU unit 3 (three) is an expansion of the block 2 generator unit. Several buildings such as the Balance of

Plant (BOP) which is a supporting building in a series of Power plant work processes, one of which is the Circulation Water Pump Station building which has the main function of pumping seawater which flows through concrete pipes to the condenser tubes. Then the water in the condenser tube is used to condense the low pressure (LP) output stream in the HRSG to drive a steam turbine. After the evaporation process is complete, the evaporating wastewater is processed at the Wastewater Treatment Plant and then discharged back into the sea through the Outfall network.

Figure 1. Case study location

One of the buildings that became the object was the Circulation Water Pump Station construction, which was built on contaminated land and was built at a depth of -9.2 m from the original ground level and -12.7 m from the face of the landfill. The original soil condition is peat soil and the ground water level is -0.5 m from the original ground water level.

B. Descriptive Analysis of Research Respondents

Characteristics of respondents include work experience in the construction industry and the respondent's position in construction companies. The description of working experience in the construction industry in this study is divided into 4 categories, namely having worked in the construction industry for between 5-10 years, 10-15 years, 15-20 years and more than 20 years. Figure 2. shows the results of the identification of respondents' experiences in the construction sector.

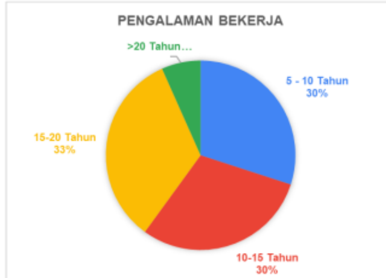

Figure 2. Description of the respondents' work experience.

Identification results show that 30% of respondents have 5-10 years of experience, 30% have 10-15 years of experience, 33% have 15-20 years of experience and 20% have more than 20 years of experience. This shows that most of the respondents already have sufficient experience in handling construction projects. The work experience of research respondents is very influential on the results of this study and is important to review. This is used because it can see the extent to which respondents can understand and assess risk events that occur in projects that they have or are currently working on and see their effect on project completion time performance.

Job descriptions of respondents in this study were divided into 5 categories, namely as senior site engineering, construction manager, engineering manager, project manager, implementer and other positions. Figure 3. shows the results of the identification of research respondents' positions.

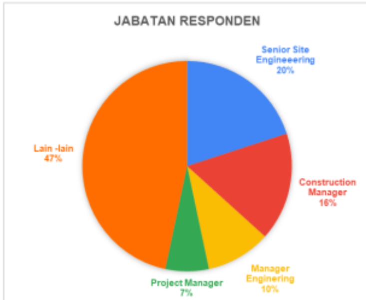

Figure 3. Job description of research respondents

From the identification results obtained, 20% of respondents have a position as a senior site engineer, 16% have a position as a construction manager, 10% have a position as an engineering manager, 7% have a position as a project manager, and 47% others such as quality control inspector, project control. The position of the respondent is very important to review, because the respondents needed in this study are devoted only to those who work in the field during project implementation. From these results, it can be seen that some of the research respondents understand the risk events on the project being worked on and their effect on the performance of the project completion time.

RESULTS AND DISCUSSION

Based on the results of observations and analysis, this study identified brownfield risks during the construction phase. The results of identification and analysis using RII (relative Importance index) consist of 23 risks that affect during the construction phase of the PLTGU Project, which are shown in Table 1.

Table 1
Brownfield risk during the construction phase

Code	Risk	RII	Rank
R1	Placement of materials and equipment at the project site	0.780	15
R2	Mobilization of project resources	0.760	19
R3	Limited work locations	0.787	14
R4	Existence of underground service networks such as existing pipelines	0.840	7
R5	Flooding due to high tides and puddles for days at the project site	0.873	3
R6	Risk of claims due to non-compliance with the work agreement is in the contract	0.807	12
R7	Risk of subcontractor price bidding	0.780	16
R8	Risk of swelling of project budget	0.833	9
R9	Payment of project owner	0.780	17
R10	Resource planning and scheduling	0.833	10
R11	Availability of materials according to contract specifications	0.707	23
R12	Delay in completion of work by subcontractors	0.793	13
R13	Risk of clarity of working drawings	0.720	22
R14	Risk of design changes during the construction phase	0.740	21
R15	Construction methods are not in accordance with field conditions	0.837	8
R16	Risk of bill of quantity of work	0.747	20
R17	Difficulty in installing heavy machinery and equipment	0.767	18
R18	Work error (rework)	0.833	11
R19	Structural damage	0.867	4
R20	Structural drop	0.867	5
R21	Damage to infrastructure around the project site	0.880	2
R22	Presence and high ground water level	0.887	1
R23	Land consolidation	0.867	6

Of the 23 (twenty three) identified risks, there are 6 risks that are very serious. influence during the construction phase, based on the analysis results as follows:

A. Risk of Existence of ground water level

Groundwater generation and its effects are often a major consideration in the design of construction project work. Changes in groundwater levels outside of normal seasonal variations are not considered while major changes can occur, such as a lack of groundwater pumping capacity which will cause the water level to rise, pooling in the lower construction area and tunnels, and can change the soil load Brassington, (1986).

Figure 4. Existence of groundwater level

The accumulation of groundwater can increase the movement of groundwater contaminants to adjacent work sites, have an impact on work activities and can damage building materials as shown in Figure 4. Some work activities are still carried out in the presence of groundwater.

B. Damage to Location Infrastructure

The availability of infrastructure utilities is an advantage of the brownfield project and infrastructure damage is the responsibility of the contractor, as shown in Figure 5. Damage to drainage channels can cause water logging around the project site. Meanwhile, road damage causes discomfort for road users in industrial complex environments.

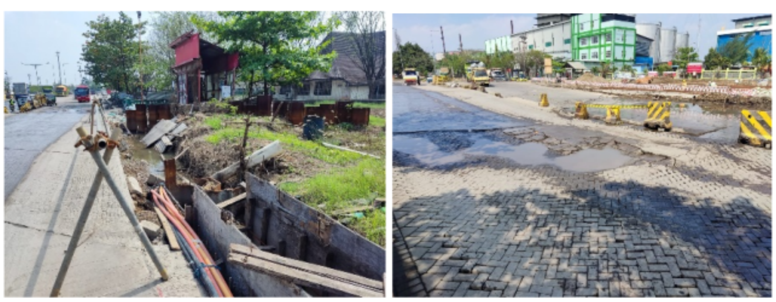

Figure 5. Damage to Infrastructure around the Site

During the construction phase the unstable soil condition of the site due to contamination caused some soil damage to the infrastructure which was difficult to repair. This event resulted in additional work during the construction phase such as sewer damage which could pose a risk of flooding.

C. Flood Risk

Surface water flooding can be caused due to the interaction of complex factors, such as inappropriate hydrology of the location, intensity and duration of rainfall, soil surface characteristics and the design of surface drainage and sewer systems.

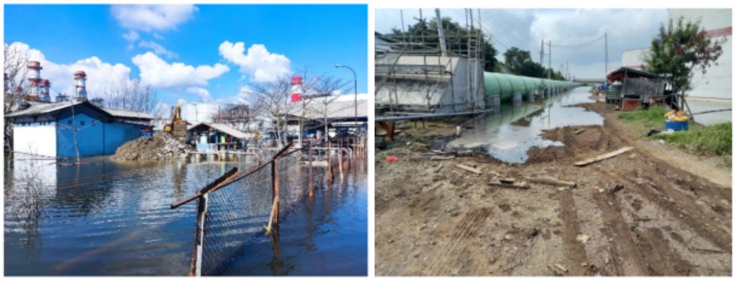

Figure 6. Surface water and tidal flooding

Surface water flooding can be severe during high-intensity rains. Exclusively convective rainfall events can infiltrate into the soil, but in areas with contaminated soil it causes impermeable soil surface Jenkins et al., (2018). During the construction phase the events in Figure 6. Several times these events occurred which hampered the implementation and damaged the material and accelerated corrosion.

D. Structural damage and structural settlement

Events of structural damage and structural settlement are shown in Figure 7. It is the impact of the condition of soil movement during the construction phase. According to Castaldo et al., (2013) in their research damage to reinforced concrete structures can be affected by land subsidence due to excavations around the work site.

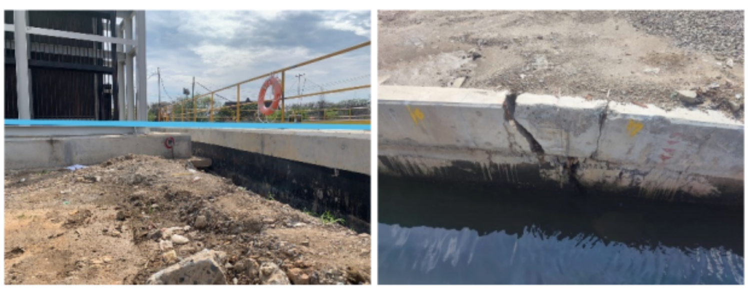

Figure 7. Structural damage and structural settlement

Based on the results of interviews with project workers during the structural work in Figure 7. At the construction, there are several works such as the installation of a bona pipe weighing 10 tons per segment below ground level and excavation. The events in Figure 3 such as observations and research conducted by Castaldo et al.,(2013).

E. Land subsidence

The movement of land subsidence in Figure 8. is an event that occurred during the construction phase, the results of observations found several cases of land subsidence in cavities with varied depths. According to Hills, (1994) stated that the mechanism of creeping soil settlement, otherwise known as secondary consolidation, is one of gradual rearrangement of material particles, which results in a decrease in the void ratio and an increase in the density of the material. This behavior occurs over a long period of time under constant stress of environmental conditions, Charles, (2008); Brink and Tinto, (2021)

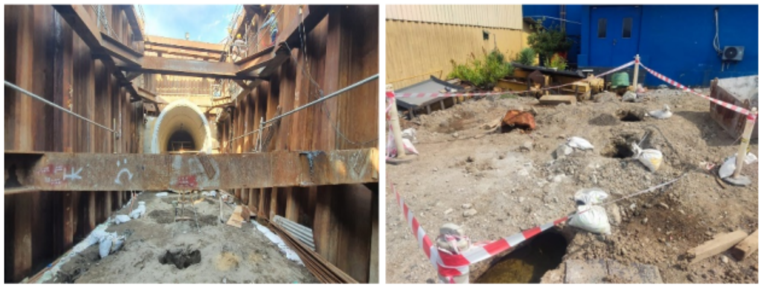

Figure 8. Creeping decrease in soil

According to Day, (2013) in Brink and Tinto, (2021) revealed that standing water is the main trigger for the decrease in collapse of the embankment. This is due to an increase in water content in the embankment due to infiltration of surface water downwards, through walls, utility lines, leakage of infiltration channels, and rising groundwater levels after the dewatering operation stops.

F. Leakage of existing underground pipeline

Leakage of existing pipelines containing fuel close to construction works can endanger the health of workers at the work site and can cause explosions and fires. Basically the brownfield project is carried out with the condition of the factory location still operating. It does not rule out the possibility of finding some underground services such as gas pipelines, fuel pipes and power lines. Field observations found risk events as shown in Figure 9.

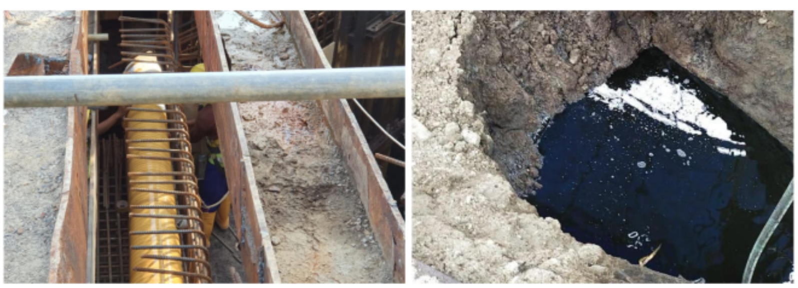

Figure 9. Existing pipe leakage

Observations in Figure 9. found damage to the fuel pipe network which is still active and has leaks. The results of the interview revealed that before the leak occurred, the outer physical condition of the pipe experienced a severe level of corrosion. Construction activities with limited locations cause pipes to crack and leak.

Construction work is a critical stage, the occurrence of risk events during the construction stage causes losses and schedule swelling. The results of interviews with the project team revealed that the contractor's lack of understanding and experience working on projects with brownfield characteristics, neglecting the dangers that should have been mitigated at the beginning of the project, because the lack of familiarity with technology, and the large repair budget, were the main factors. The condition of environmental uncertainty during the construction phase exacerbates the hazard. Construction at the brownfield site requires geotechnical test planning, data collection, analysis and interpretation of field and laboratory results in a timely and cost-effective manner.

CONCLUSION

The construction phase of the brownfield project has complex challenges, because it has to run side by side with a factory site that is still operating. Uncertainty about the dangers caused such as geotechnical conditions and the existence of an existing site, can cause delays in work time. Lack of technological familiarity and experience in running the project will have an impact on cost loss. The results of observation and analysis of case studies during the implementation of the PLTGU construction project have identified 23 (twenty three) risks and 6 (six) main risks based on ratings, namely: 1) Risk of Existence of Groundwater, 2) Damage to Location Infrastructure, 3) Flood Risk, 4) Structural damage and structural deterioration, 5) Land subsidence, 6) Leakage of existing underground pipe. The results of the interview reveal that the event is a risk that the project management must face during construction. This event is the risk that will affect the most in terms of performance, cost and time during the PLTGU construction phase.

REFERENCES

Alker, S., Joy, V., Roberts, P., & Smith, N. (2000). The definition of brownfield. *Journal of Environmental Planning and Management*, *43*(1), 49–69. https://doi.org/10.1080/09640560010766 Google Scholar

Brahm, F., & Tarziján, J. (2015). Does complexity and prior interactions affect project procurement? Evidence from mining mega-projects. *International Journal of Project Management*, *33*(8), 1851–1862. https://doi.org/10.1016/j.ijproman.2015.08.005 Elsevier

Brassington, F. C. (1986). The inter-relationship between changes in groundwater conditions and engineering construction. *Geological Society, London, Engineering Geology Special Publications*, *3*(1), 47–50. Google Scholar

Brink, G., & Tinto, R. (2021). *A settlement hazard risk management framework for the development of backfilled open-cut quarries backfilled open-cut quarries. August*. Elsevier

Castaldo, P., Calvello, M., & Palazzo, B. (2013). Probabilistic analysis of excavation-induced damages to existing structures. *Computers and Geotechnics*, *53*, 17–30. https://doi.org/10.1016/j.compgeo.2013.04.008 Elsevier

Charles, J. A. (2008). The engineering behaviour of fill materials: the use, misuse and disuse of case histories. *Géotechnique*, *58*(7), 541–570. Google Scholar

Day, P. W. (2013). *A contribution to the advancement of geotechnical engineering in South Africa*. Stellenbosch: Stellenbosch University. Google Scholar

De, M., & Rout, S. K. (2022). An {Approach} for {Geotechnical} {Site} {Characterization} of {Brown} {Field}

{Site} of a {Steel} {Plant}. In *Ground {Characterization} and {Foundations}* (pp. 73–88). Springer. Google Scholar

De Sousa, C. (2000). Brownfield redevelopment versus greenfield development: A private sector perspective on the costs and risks associated with Brownfield redevelopment in the Greater Toronto Area. *Journal of Environmental Planning and Management*, *43*(6), 831–853. https://doi.org/10.1080/09640560020001719 Google Scholar

Farrance, S., & Taylor, K. (2012). *Corinda to {Darra} rail upgrade project: the challenges of brownfield construction and integration while maintaining network operations*. Google Scholar

Hassan, K., Wasnik, R. V., Singh, H., Kamal, F. R., & Takeiddine, O. (2016). Overcoming the design challenges of brownfield projects. *Society of Petroleum Engineers - Abu Dhabi International Petroleum Exhibition and Conference 2016*, *2016-Janua*(November), 7–10. https://doi.org/10.2118/183081-ms Google Scholar

Hills, C. W. W. (1994). *The University Of Nottingham*. Google Scholar

Jenkins, K., Hall, J., Glenis, V., & Kilsby, C. (2018). A Probabilistic Analysis of Surface Water Flood Risk in London. *Risk Analysis*, *38*(6), 1169–1182. https://doi.org/10.1111/risa.12930 Google Scholar

Luo, Q., Catney, P., & Lerner, D. (2009). Risk-based management of contaminated land in the UK: Lessons for China? *Journal of Environmental Management*, *90*(2), 1123–1134. https://doi.org/10.1016/j.jenvman.2008.05.001 Elsevier

Malik, M. S. (2021). Delivering Brown-Field Projects in the Petrochemical Industry: Challenges and Recommended Solutions. *International Journal of Risk and Contingency Management (IJRCM)*, *10*(4), 39–45. Google Scholar

Štefaňák, J. (2019). Revitalization of Brownfield Sites–Example of the Solution of the Geotechnical Issues. *International Conference on Critical Thinking in Sustainable Rehabilitation and Risk Management of the Built Environment*, 519–526. Google Scholar

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