



## Risk Analysis of Material Management that Causes Cost and Time Deviations in High-Story Building Projects



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### Article history:

Submitted: 27 August 2023

Revised: 18 September 2023

Accepted: 09 October 2023

### Keywords:

*AHP (analytical hierarchy process);  
material management;  
mitigation actions;  
risk analysis;*

### Abstract

Construction Work Project for Maternal and Child Health Services Building of RSUP Prof. Dr. IGN. Ngoerah Denpasar Bali is a multi-storey building project that has an area of 18,226 m<sup>2</sup> which is targeted for completion on November 27, 2023. To get the time to complete the work on time, it is necessary to anticipate various risks that occur, one of which is the risk of material management during project construction. From the research to be carried out, material management risks that affect time delays and cost deviations in the project will be identified using the AHP (Analytic Hierarchy Process) method. This study will identify the level of risk or risk index that most dominantly affects time delays and cost deviations. The most dominant material management risks that have been identified will then be mitigated to reduce the identified dominant risks. Based on the results of the analysis, 30 risk variables were identified for cost performance, and 34 risk variables were identified for time performance. From the calculation results using the AHP method, it is known that the most dominant risk variable causing cost deviations is "material quality" (RI = 3,220) and time deviations are "very many vendors/suppliers want to enter" (RI = 5,466). The most dominant risk variable is then carried out mitigation actions in the form of preventive and corrective actions.

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## 1 Introduction

The development of construction projects in urban areas now focuses on the construction of high-rise buildings which are certainly dynamic and contain elements of risk (Sugiharto, 2020). In the construction of multi-storey buildings, there are several problems that cause a decline in project performance and company profits due to a lack of risk control. Problems that often occur in multi-storey building construction projects are time delays and cost overruns.

According to research conducted previously (Trisnayanti et al., 2023), the most dominant risks that influence time performance are "Changes in specifications that affect manufacturing" and "Unavailability of materials" with an impact on project time delays of around 5-7%, while for cost performance they are "Planning and cost estimates were not carried out correctly" and "Changes in equipment and material specifications" with a project cost overrun impact of 2.5%- to 3.5%. Implementing materials management is one strategy to avoid problems with time delays and deviations in project implementation costs by detecting as early as possible the risks that may occur at the material management implementation stage.

Based on the results of this research, as a follow-up research, a risk analysis will be carried out on material management which causes cost and time deviations in the Construction Work Project for the Maternal and Child Health Services Building at Prof. Hospital. Dr. IGN. Ngoerah Denpasar Bali is a multi-storey building project which has an area of 18,226 m<sup>2</sup> with a total of 6 floors consisting of B1 (basement 1), floors 1 – 4, and finally the roof. The construction of the project has an implementation time of 396 calendar days starting on October 28 2022 and is targeted for completion on the 27<sup>th</sup> November 2023. To get work completed on time, it is necessary to anticipate various risks that occur, one of which is material management risk during project construction. The research, will be done by identifying material management risks that influence time delays and cost deviations in the project using the AHP (Analytic Hierarchy Process) method (Ardi, 2016; Siswanto & Salim, 2019; Widiarso, 2010; Mufty, 2018; Sugiyono, 2020). This research will identify the level of risk or risk index that most dominantly influences time delays and cost deviations. The most dominant material management risks that have been identified will then be carried out with mitigation actions to reduce the dominant risks that have been identified.

Based on the background described above, the problems raised by researchers are:

- a) What is the most dominant influence of material management risks on cost and time deviations in the Prof. Hospital Maternal and Child Health Services Building Construction Work project? Dr. IGN. Looking for Denpasar, Bali?
- b) What controls are in place for the dominant risks in materials management that cause deviations in project costs and time delays?

Based on the problem formulation above, the objectives of this research are:

- a) To find out the most dominant material management risks that cause deviations in project costs and time on the Maternal and Child Health Services Building Construction Work project, RSUP Prof. Dr. IGN. Goerah Denpasar Bali.
- b) To determine risk mitigation for dominant risks in materials management. This research is also expected to increase knowledge and develop researchers' mindsets, especially in efforts to understand the influence of implementing risk management on materials on company performance.

This research is limited as follows:

- a) The construction project that is the object of research is the Maternal and Child Health Services Building Construction Work project at Prof. Hospital. Dr. IGN. Ngoerah Denpasar Bali which is located on Jl. Diponegoro, Dauh Puri Klod, District. West Denpasar, Denpasar City, Bali.
- b) A review of risk factors is limited to material management risks only which include aspects of planning, implementation, management, and closing starting from the purchasing, receiving, handling, and material warehousing stages.

### *Basic theory Project*

Project A project activity can be defined as a temporary activity that lasts for a limited period of time, with a certain allocation of financial resources, and is intended to carry out tasks whose targets have been clearly outlined. Each project has a specific goal, for example building a house, bridge, or factory installation. In the process of achieving this goal, there are limits that must be met, namely the amount of costs (budget) that must be allocated, the schedule, and the quality that must be met. These three things are important parameters for project implementation which are often allocated as project targets. These three constraints are called triple constraints (triple construction) (Siswanto & Salim, 2019).

A project is defined as a problem scheduled for solution. This definition forces us to recognize that projects are aimed at solving problems and fail to properly define problems. A project is an undertaking that produces a set of deliverables within a specified time, cost, and quality. Projects are different from ordinary business operations, the projects referred to here are (Andani, 2011):

- a) Unique by nature. The project does not involve an iterative process. Each project carried out is different from projects that have already been carried out, where operational activities often involve the same repetitive processes.
- b) Have a time limit. Projects have specific start and end dates. it is clear where deliveries must be made to meet customer needs.
- c) Have an approved budget. A project is an allocated level of financial expenditure at which deliverables have been generated, to meet specific customer needs.
- d) Have limited resources. At the start of an approved work project, equipment and materials are allocated to the project.
- e) Includes risk elements. Projects result in uncertainty and introduce business risks.
- f) Get changes in profits. The goal of the project in general is to develop a company through implementing business changes.

### *Project management*

Management is a science about the art of leading an organization which consists of planning, implementing, and controlling limited resources in an effort to achieve effective and efficient goals and objectives. The aim is to obtain the best method or technical method so that with limited resources, maximum results can be obtained in terms of accuracy, speed, savings, and comprehensive work safety (Widiarso, 2010). Project management is all planning, implementation, control and coordination of a project from the beginning (idea) to the end of the project to ensure project implementation on time, on cost, and on quality (Mukhlis et al., 2019).

### *Cost deviations*

An increase in project costs is an increase in costs resulting from implementation costs not being in accordance with the planned costs that occurred during the project construction stage. Cost overrun is the construction cost of a project that, during the implementation stage, exceeds the project budget (budget) determined at the initial stage (cost estimation), thereby causing significant losses for the contractor. Cost overruns that occur on a construction project can be caused by internal and external factors.

### *Time delay*

A project manager controls various activities on the project site, one of the important aspects supervised is time performance. Time performance is the process of comparing work in the field with the planned schedule. The time period (duration) can be defined as the time required to complete or complete a predetermined activity or task. Project implementation time is the time determined by the owner to use, utilize or rent out the project building.

### *Material management*

Material management is defined as a system needed to plan and control material quality, material quantity, and timely placement of material, good prices and appropriate quantities (Santoso, 2009).

### *Material Construction*

Material is one of the important elements in implementing a construction project, so a management process is needed to manage materials to achieve the objectives of implementing the construction project. According to the process, materials in construction projects are divided into 4 (four categories):

- a) Raw Materials  
Raw Materials (raw materials) are materials imported to the project location, still in the form of raw materials for processing. Raw materials include stone, sand, cement, rebar, and wood.
- b) Finished Material  
Finished materials are materials that are brought to the project location to be installed directly. Finished materials include tiles, roof tiles, glass, ceramics, and lamps.
- c) Mixed Materials  
Mixed materials are materials that are imported to the project site already in mixed form. Mixed materials include: ready mix concrete and hot-mix asphalt.
- d) Prefabricated Material  
Prefabricated material is material that is printed or assembled outside the project location by another party, when arriving at the project location the activity is only to install the material. prefabricated materials include precast concrete, steel frames, and frames along with doors and windows.

### *Risk management*

Risk management can be intended as a process of measuring and controlling risks that are very likely to occur to assets or income from a business. Project risk management aims to identify and manage risks that are not addressed by other project management processes. Risk management (Santoso, 2009), means identifying and measuring risks and developing, selecting, and managing options to deal with these risks. There are several tools for managing risk, understanding red flags that could indicate problems on the project in question, and prioritizing the most appropriate corrective actions to take.

The aim of risk management is to recognize risks in a project and develop strategies to reduce or even avoid them, on the other hand we must also look for ways to maximize existing opportunities (Labombang, 2011). To make decisions regarding risks, the management stages consist of 6 stages, namely determining the context, hazard identification, risk assessment consisting of risk analysis and risk evaluation, risk control, consultation and monitoring and review.

### *AHP Method (Analytic Hierarchy Process)*

The AHP (Analytical Hierarchy Process) method is a decision-making method in searching for an answer. AHP is used to solve complex problems where there is very little data and statistical information on the problem at hand. AHP (Analytical Hierarchy Process) is a decision-making model developed by Thomas L. Saaty that describes multi-factor or multi-criteria problems into a hierarchy

## **2 Materials and Methods**

### *Research design*

Research design is the process of collecting and analyzing research data to identify problems before the final planning of data collection is used to define the structure of the research being carried out. This research design uses quantitative descriptive analysis methods

### *Variable of research*

A research variable is an attribute or trait or value of a person, object, organization, or activity that has certain variations determined by the researcher to be studied and then draw conclusions.

### *Sample and population*

#### a) Population

Population is the total area of a generalized area consisting of objects or subjects that have certain quantity, quality and characteristics as determined by researchers which are used to compile interpretations and research data which ends with conclusion drawing activities. The population in this study are stakeholders who play a role in the material management system in the Maternal and Child Health Services Building Construction Project at Prof. Hospital. Dr. IGN. Goerah Denpasar Bali.

#### b) Sample

A sample is a portion of objects taken from all the objects studied and is considered capable of representing or being representative of the entire population. The sample is a portion or representative of the population studied which is determined by true and valid.

### *Determining data source*

Determining the data in this research is data collection carried out by the author to obtain results from this research related to the topic of discussion. This data is primary data. Primary data is data that directly provides data to data collectors. against dominant risks.

### *Data collection*

Data collection Data collection is carried out to obtain the information needed to achieve research objectives. The objectives expressed in the form of hypotheses are temporary answers to research questions, so the answers still need to be tested empirically, and for this purpose data collection is needed. Data collection in this research is in the form of questionnaire data collection.

### *Instrument of research*

The research was conducted using questionnaires and interviews as research instruments. Research instruments are tools used to obtain the data needed in research.

### *Research stages*

The research stages include: In the problem identification stage, an initial survey was carried out regarding project problems that often occur in the construction sector in Indonesia. The next stage is to formulate the problem from the background obtained from the initial survey and literature study. Determination of research methods. Data Collection, Testing the validity and reliability of the measuring instruments distributed, if the measuring instruments are not valid then they must be repaired and redistributed. Data analysis method. The results and discussion were obtained in the form of material management risk factors which have a dominant influence on cost and time performance in multi-storey building projects, then discussions were carried out (Akintoye & MacLeod, 1997; Öztaş & Ökmen, 2005; Santiana et al., 2022). Decisions are taken from the results and discussion, and then validation of the findings is carried out by compiling literature.

### 3 Results and Discussions

#### *Project Overview*

RSUP Prof. Dr. IGN. Ngoerah Denpasar Bali is a new name change for the hospital. Sanglah Denpasar Bali, which was founded in 1959, is located on Jl. Diponegoro Denpasar has many superior specialist clinics, as well as being the largest hospital on the Island of the Gods, Bali with a land area of 13.5 Ha<sup>2</sup>. Construction Work Project for Maternal and Child Health Services Building Prof. Hospital. Dr. IGN. Ngoerah, Denpasar Bali is a government project which is an effort by the Ministry of Health to improve the quality of maternal and child health. This project aims to increase the availability, accessibility and quality of maternal and child health services.

In this research, what is identified is the dominant material management risk factor that influences cost and time deviations on ongoing projects. After knowing the dominant risk factors, risk mitigation actions can be taken, namely reducing the dominant risks so that the project implementation can proceed according to the implementation plan. In this research, the respondents in question are stakeholders or people directly involved in the project that is the object of the research. In this case, the author describes the research object as including gender, age, position and work experience (Mahdi & Alreshaid, 2005; Subramanian & Ramanathan, 2012; Dey, 2010).

Data analysis in this research was carried out with the aim of seeing the influence of the most dominant material management risk variables which cause cost and time deviations in multi-storey building projects with statistical analysis methods using SPSS v.24 software. The data obtained in this research will be processed using descriptive analysis methods and AHP (Analytical Hierarchy Process).

#### *Preparation of material management risk variables*

The preparation of material management risk variables was obtained from previous research references (Trisnayanti et al., 2023), which were then conducted with interviews and brainstorming with stakeholders on the project under study. Interviews and brainstorming. This is done by ensuring that the risk variable has the possibility of occurring or has occurred on the project. Material management risk variables identified in the Prof. Hospital Maternal and Child Health Services Building Construction Work project. Dr. IGN. Ngoerah Denpasar Bali can be seen in Table 4.5 to Table 4.8.

In this research, the material management risk variables identified as causing time deviations consist of 4 risk variables/criteria, namely risks at the planning stage which consists of 12 sub-risks, risks at the implementation stage which consist of 8 sub-risks, risks at the management stage which consist of 12 sub risks, and risks at the closing stage which consist of 2 sub risks.

#### *Analytic Hierarchy Process (AHP)*

AHP (Analytic Hierarchy Process) is a measurement method used to find ratio scales from both discrete and continuous pairwise comparisons. In this research, the AHP (Analytical Hierarchy Process) method is used to determine the weight value of a risk. The weight value is the portion of the value of how important one criterion is to another in a hierarchy. This value can be calculated based on an assessment of a person's perception of a criterion using the Saaty Scale. Weight is the value used to find the risk index value (Andani, 2011).

Risk criteria describe the level of risk that exists compared to the company's ability and resilience to face it. Risk criteria are described in the form of a combination of likelihood and severity of consequences. Risk assessment and analysis is carried out to determine the level of risk that exists. Risk is formulated as a function of likelihood(possibility/frequency) and impact (impact/consequence). Risk acceptability risk category = F (likelihood) x I (impact). The results of the questionnaire that had been distributed to 31 respondents were then tabulated. From the tabulation of frequency and consequence data, the average (mean) of each identified material management risk statement is obtained originally (Chan et al., 2001; Aminbakhsh et al., 2013; Eskander, 2018).

#### *Mitigation measures*

After obtaining the most dominant risk variables causing cost and time deviations, the final stage is to determine mitigation actions for the dominant risks obtained from journal references and direct interviews with stakeholders in the project concerned. Risk mitigation is action or response to risks that occur during the project cycle. The

measures taken do not mean eliminating the risks that occur but minimizing the frequency and consequences of the risks that occur. The mitigation actions for the most dominant risk variables cause cost and time deviations (Hwang et al., 2017; Islam et al., 2021; Suasira et al., 2022).

## 4 Conclusion

Based on the results and discussion described in the previous chapter, conclusions can be drawn from this research, namely as follows:

- a) In this study, 10 risk variables were identified that had the highest/most dominant Risk Index values that caused cost and time deviations: In cost performance, namely "material quality" (3.701), "owner's specification requirements" (3.470), "changes in number of equipment and materials by engineering" (3.279), "accuracy of material quantities" (3.220), and "currency and exchange rates" (2.760). In terms of time performance, namely "very many vendors/suppliers who want to enter" (5.466), "specification requirements from the owner" (5.079), "changes in specifications that affect manufacturing" (3.721), "material quality" (3.716), and "changes on the amount of equipment and materials by engineering" (3.544).
- b) Mitigation actions for dominant risks in material management, namely as follows: In cost performance, namely understanding and ensuring that the materials to be purchased are in accordance with the quality/technical specifications; ensuring the design is mature, holding discussions with the owner, strengthening engineering capability; review material planning in accordance with predetermined designs or technical specifications; evaluate the project periodically if necessary addendums to reduce losses due to payment planning that does not work well. On-time performance, namely selecting vendors/suppliers according to the technical specifications of the work required; requesting an extension of the implementation time if the specifications must be met; reviewing designs and rescheduling activities and materials; creating a purchase order (PO); Making a change order request to the owner.

### *Conflict of interest statement*

The authors declared that they have no competing interests.

### *Statement of authorship*

The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

### *Acknowledgments*

We are grateful to two anonymous reviewers for their valuable comments on the earlier version of this paper.

## References

- Akintoye, A. S., & MacLeod, M. J. (1997). Risk analysis and management in construction. *International journal of project management*, 15(1), 31-38. [https://doi.org/10.1016/S0263-7863\(96\)00035-X](https://doi.org/10.1016/S0263-7863(96)00035-X)
- Aminbakhsh, S., Gunduz, M., & Sonmez, R. (2013). Safety risk assessment using analytic hierarchy process (AHP) during planning and budgeting of construction projects. *Journal of safety research*, 46, 99-105. <https://doi.org/10.1016/j.jsr.2013.05.003>
- Andani, S. (2011). Analisa resiko manajemen material dominan yang berpengaruh terhadap kinerja waktu pelaksanaan proyek gedung bertingkat BUMN. *Tugas Akhir Departemen Teknik Sipil, Fakultas Teknik, Universitas Indonesia, Depok*.
- Ardi, A. W. (2016). Analisis risiko manajemen material dan pengaruh tindakan koreksi pada proyek gedung bertingkat.
- Chan, F. T. S., Ip, R. W. L., & Lau, H. (2001). Integration of expert system with analytic hierarchy process for the design of material handling equipment selection system. *Journal of Materials Processing Technology*, 116(2-3), 137-145. [https://doi.org/10.1016/S0924-0136\(01\)01038-X](https://doi.org/10.1016/S0924-0136(01)01038-X)
- Dey, P. K. (2010). Managing project risk using combined analytic hierarchy process and risk map. *Applied Soft Computing*, 10(4), 990-1000. <https://doi.org/10.1016/j.asoc.2010.03.010>
- Eskander, R. F. A. (2018). Risk assessment influencing factors for Arabian construction projects using analytic hierarchy process. *Alexandria engineering journal*, 57(4), 4207-4218. <https://doi.org/10.1016/j.aej.2018.10.018>
- Hwang, B. G., Shan, M., & Supa'at, N. N. B. (2017). Green commercial building projects in Singapore: Critical risk factors and mitigation measures. *Sustainable cities and Society*, 30, 237-247. <https://doi.org/10.1016/j.scs.2017.01.020>
- Islam, R., Nazifa, T. H., Mohammed, S. F., Zishan, M. A., Yusof, Z. M., & Mong, S. G. (2021). Impacts of design deficiencies on maintenance cost of high-rise residential buildings and mitigation measures. *Journal of Building Engineering*, 39, 102215. <https://doi.org/10.1016/j.jobbe.2021.102215>
- Labombang, M. (2011). Manajemen risiko dalam proyek konstruksi. *SMARTek*, 9(1).
- Mahdi, I. M., & Alreshaid, K. (2005). Decision support system for selecting the proper project delivery method using analytical hierarchy process (AHP). *International journal of project management*, 23(7), 564-572. <https://doi.org/10.1016/j.ijproman.2005.05.007>
- Mufty, F. (2018). Mitigasi Risiko Pada Penjadwalan Proyek Pekerjaan Network Improvement Quality Equipment (NIQE) FIBER OPTIC (Studi Kasus PT. Indo Com Nusantara).
- Mukhlis, M., Natalia, M., Lusiana, L., Satwarnirat, S., & Yuma, A. R. (2019). Analisa Faktor-Faktor Mempengaruhi Penyimpangan Biaya Material Terhadap Kinerja Biaya Akhir Proyek Gedung di Kota Padang. *Jurnal Ilmiah Rekayasa Sipil*, 16(1), 39-46.
- Öztaş, A., & Ökmen, Ö. (2005). Judgmental risk analysis process development in construction projects. *Building and environment*, 40(9), 1244-1254. <https://doi.org/10.1016/j.buildenv.2004.10.013>
- Santiana, I., Wibawa, I., Yasa, I., Suasira, I. W., & Sutapa, I. K. (2022). Factors Caused for Delays and Alternatives in The Denpasar Living World Mall Building Project. *International research journal of engineering, IT & scientific research*, 8(6), 299-305.
- Santoso, B., & Proyek, M. (2009). Konsep dan Implementasi. *Yogyakarta: Graha Ilmu*.
- Siswanto, A. B., & Salim, M. A. (2019). *Manajemen Proyek*. CV. Pilar Nusantara.
- Suasira, I. W., Intara, I. W., Sutapa, I. K., Santiana, I., Wibawa, I., & Yasa, I. (2022). Structure Analysis of Building Functions Transition on The Earthquake Area five Reviewed from Costs and Time Schedule. *International research journal of engineering, IT & scientific research*, 8(1), 7-16.
- Subramanian, N., & Ramanathan, R. (2012). A review of applications of Analytic Hierarchy Process in operations management. *International Journal of Production Economics*, 138(2), 215-241. <https://doi.org/10.1016/j.ijpe.2012.03.036>
- Sugiharto, R. (2020). Analisis faktor-faktor dominan manajemen risiko terhadap kinerja keuangan proyek tahap konstruksi. *Jurnal Teknik Sipil Dan Lingkungan Universitas Nusa Putra (J-Teslink)*, 1, 1-11.
- Sugiyono, P. D. (2020). Metode Penelitian Kualitatif Untuk Penelitian Yang Bersifat: Eksploitatif, Enterpretif Dan Konstruktif. *Edited By Y. Suryandari. Bandung: ALFABETA*.
- Trisnayanti, N. M. A., Santiana, I., & Triadi, I. (2023). *Analisis Risiko Terhadap Manajemen Material yang Menyebabkan Penyimpangan Biaya dan Waktu pada Proyek Gedung Bertingkat (Studi Kasus: Pekerjaan Konstruksi Gedung Pelayanan Kesehatan Ibu dan Anak RSUP Prof. Dr. IGN. Ngoerah Denpasar Bali)* (Doctoral dissertation, Politeknik Negeri Bali).



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Widiarso, A. (2010). Pengaruh Manajemen Material Terhadap Produktivitas Kerja Proyek Konstruksi Gedung Bertingkat Pada Pekerjaan Struktur (Studi Kasus: Proyek-X). *Fakultas Teknik Universitas Indonesia, Depok*.