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Application of Risk Management Science in Construction Project Learning: Cost Contingency Study in Malang Raya Housing

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Abstract: Housing projects are classified as complex and therefore require risk management analysis for economic and business sustainability for developers. Objective: To apply the risk management science approach to understand the dynamics of contingency costs in real housing construction projects and relate it to strengthening student competencies in construction project-based learning. Method: This research is descriptive because it aims to provide an overview of the facts in the field and the observed phenomena regarding the analysis of dominant contingency cost factors in housing development projects in Malang Raya. Data analysis: Data was obtained through interviews and questionnaires, then analyzed on several factors that influence cost contingencies in housing projects. Results: The dominant factors influencing contingency costs in housing development projects in Malang Raya consist of four main factors: Design, financial, human resources, and engineering. The contingency costs in housing development projects in Malang Raya generally range from 5% to 7.5% of the total project value. Contingency costs are higher in type 36 and 45 housing projects, especially with DP below 20%. Solutions that can be implemented to address risks that cause contingency costs to arise include preventive and corrective actions tailored to each risk factor.

Keywords: Construction; Cost contingency; Project learning; Risk management science; Malang Raya Housing

Introduction

Risk management provides the project team with a formal process for systematically identifying and analyzing risks throughout the project life cycle (El-Sayegh, 2015). This includes developing strategies to mitigate potential losses and monitoring risk events from the conceptual phase through project completion (Yoon et al., 2015). Implementing preventive measures is at the heart of risk management, which aims to minimize the likelihood and impact of risks on project outcomes. This involves evaluating the cost, time, complexity, and probability of success of various preventive strategies (Schieg, 2006).

A risk-based approach includes proactive and reactive controls, allowing flexibility and adaptability in addressing risks as they arise (Burkov et al., 2018). Measuring the performance of the risk management process is critical to ensuring its effectiveness. This involves evaluating the adequacy of responses to mitigate risks and using the results to drive continuous improvement. By combining good practices and lessons from previous projects, construction companies can improve their risk management processes and enhance overall project performance (JaiSai et al., 2025).

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Developing specific skills within the project management team, such as self-awareness, vision, and relationship management, is essential to effective risk management. These skills assist in implementing safety tasks and developing a favorable safety climate. Effective training programs are prioritized to ensure personnel are well-equipped to handle a variety of risks, integrate safety with environmental and quality objectives, and maintain a positive safety attitude.

Housing development is a vital sector contributing significantly to economic growth and fulfilling basic community needs. Along with increasing urbanization and population growth, the need for decent and affordable housing continues to grow, especially in large and developing cities such as Malang Raya. Malang Raya, which consists of Malang City, Malang Regency, and Batu City, is one of the largest metropolitan areas in East Java. This area has experienced significant growth in recent years, especially in the property and housing sectors. According to data from the East Java Central Statistics Agency, the number of housing units built in Malang Raya increased by 15% from 2020 to 2023, indicating rapid development in the housing industry in this region. However, like other construction projects, housing development is not free from various risks and uncertainties that can affect project performance, especially in terms of costs (Siraj & Fayek, 2019).

Cost is one of the essential components in the implementation of housing development projects, in addition to material resources, workers, and time. Every developer will want their project to be completed on time and at a cost that is according to their estimates to obtain the expected profit without reducing the quality of the building (Chen et al., 2022). According to Soemardi & Kusumawardani (2010), developers consider direct and indirect cost components in planning a housing project budget. Direct costs are all related to the project, such as equipment costs, labor wages, and material procurement. Indirect costs are cost elements that are not directly related to the volume of physical components of the final project results but have a contribution to the completion of activities or projects, which are included in the category of indirect costs, including overhead costs, taxes, marketing costs, and risk costs. Risk costs contain and/or are influenced by relatively high uncertainty, such as unexpected costs (contingency) and profits (Eilers et al., 2020).

A project always has different challenges or problems. Even though it has been planned as well as possible, a project will have uncertainty. Developers need to know and manage the possible uncertainty factors so the project can run well (JaiSai et al., 2025). One way to overcome this is to prepare a reserve fund. The reserve fund can be included in the contingency cost. Contingency costs are used as a buffer for risks and mitigation in a project. An estimate of the cost calculation is not entirely accurate with field conditions during the project. For this reason, developers need to know the importance of including contingency costs in the cost estimate (Chen et al., 2022)

In estimating a housing project's price, it is impossible to know the costs incurred during the construction process. This is closely related to variables that cannot be estimated with certainty. To anticipate losses that will occur as a result of variables that cannot be estimated with certainty, it is necessary to allocate several costs that are charged to indirect expenses, namely costs against risk, which in this case are positioned as contingency costs (Eilers et al., 2020). In general, contingency costs in housing project cost estimates are determined based on intuition and previous project experience, considering the complexity and uniqueness of each housing project, so it is often difficult to systematically analyze existing risks and evaluate potential impacts related to risk and uncertainty. Contingency costs have become essential to project management in estimating project cost budgets (Yoon et al., 2015).

Contingency costs are defined as cost reserves or estimates to anticipate uncertainty conditions allocated to work items based on experience and implementation of previous projects. According to Mak & Picken (Mak & Picken, 2000), contingency costs are the funds provided as a reserve to deal with uncertainty and risks associated with a construction project. The purpose of allocating contingency costs is to ensure that the estimated project budget is proportional, realistic, and sufficient to cover costs incurred by risks due to uncertainty caused by lack of information and errors in interpreting project information/data obtained (PMBOK, 2017).

Analysis of dominant factors of contingency costs in housing development projects is essential to understand and identify the main factors that cause contingency costs. However, research that analyzes the dominant factors that influence contingency costs in housing development projects is still minimal. Most research on infrastructure projects, including housing projects, uses computer simulations with Monte Carlo methods to design projects that can optimize costs and provide engineering input for controlling and managing risks (Hu et al., 2022; Peleskei et al., 2015). Although Monte Carlo simulations provide accurate data related to risk management, including direct and indirect cost risks, the data from Monte Carlo simulations is more appropriate for use before the project begins and may differ from the actual results due to the influence of several factors occurring in the field. Therefore, this study aims to fill this gap by identifying the dominant factors that influence contingency costs, measuring the amount of contingency costs required for housing

projects, and solutions that can be applied to reduce the risks that cause contingency costs.

Method

Types of research

The research conducted is included in the descriptive research type because it aims to provide an overview of the facts in the field and the observed phenomena regarding the analysis of dominant contingency cost factors in housing development projects in Malang Raya.

This research is in the form of a survey conducted to collect respondents' opinions, perceptions, experiences, and attitudes regarding the factors causing contingency costs and responses to the amount of contingency costs in housing development projects in Malang Raya.

Population and Sample

Respondents in this study are parties with direct knowledge and experience related to housing development projects, especially those about contingency cost management. The respondents are owners, site managers, and estimators domiciled in Malang Raya. Respondents will be asked to complete a questionnaire and answer questions about housing development projects.

The population in this study consists of 368 medium-class housing units in 2020-2024 in Malang Raya. A population is a generalization area consisting of objects or subjects that have certain qualities and characteristics determined by researchers to be studied and then conclusions drawn.

Data collection technique

In this study, data collection is the most critical factor in the study's success. The data used in this study are divided into two, namely:

a. Primary Data

Primary data is obtained by conducting direct reviews or field surveys to find out the real conditions in the field. Primary data in this study are:

- Interview: Interviews were conducted with respondents with experience or direct involvement in housing development projects in Malang Raya. This interview aimed to obtain in-depth information on risk factors that affect contingency costs,
- Questionnaire: The questionnaire was designed to collect quantitative data from respondents regarding the dominant factors causing costs and the amount of contingency costs in housing development projects. It covers six main risk categories: design risk, human resource risk, financial risk, engineering risk, environmental risk, and natural risk.

b. Secondary Data

Secondary data is obtained from literature studies or contacting agencies related to the project. Secondary data in this study were obtained from the Public Works, Spatial Planning, Housing and Settlement Areas Agency (DPUPRKP) of Malang City, the Housing, Settlement Areas and Public Works Agency (DPKPCK) of Malang Regency, and the Housing and Settlement Areas Agency (DISPERKIM) of Batu City, in the form of a list of middle-type housing in 2020-2024 in Malang Raya.

Result and Discussion

Results

1. Solutions to Overcome Contingency Cost Risks

Based on the research results above, dominant factors caused contingency costs. For this reason, control over the risks was analysed and planned, which are divided into two controls: preventive actions and corrective actions.

Preventive Action is an action taken to prevent a problem, error, or undesirable situation from occurring. The goal is to anticipate risks before they arise, reducing the likelihood of loss, accident, or failure. Corrective Action is one taken to correct a problem or error that has already occurred. The goal is to address the cause of the problem so that it does not recur in the future.

Based on the research results above, the increase in contingency costs comes from Design, Financial, Human Resources, and Engineering factors. The following are solutions that can be done to overcome the risks that cause contingency costs, which have been further consulted with experts to obtain validation and refinement.

2. Design Risk

Design changes that occur during project implementation can result in increased contingency costs. To minimize the impact of this risk, preventive and corrective actions can be taken as follows:

a. Preventive Actions:
   - Conduct a thorough design review at the early stages of the project (pre-construction review) to ensure no errors or deficiencies could lead to revisions later.
   - Involve all relevant parties in the design finalization process so that all needs and input are considered from the start.
   - Ensure all client requirements and specifications are complete and final before the project is implemented.

b. Corrective Action:
   - Handle design changes quickly and systematically through the change request

assessment process so that changes do not hinder the project implementation process.
- Calculate the impact of design changes on cost, time, and other technical aspects, then formally approve the changes through a Change Order.
- Adjust project schedules and budgets to stay in line with current conditions.
- Provide official communication and prompt coordination to all relevant parties, such as suppliers and implementation teams, to ensure all parties understand and follow the changes that occur.

Implementing these preventive and corrective measures is hoped to minimize the risks resulting from design changes, allowing the project to run according to plan and contingency costs to not experience a significant spike.

3. Human Resources (HR) Risk

One of the risks in project implementation is poor coordination and communication between the parties involved, which can result in delays, implementation errors, and increased contingency costs. To overcome this risk, preventive and corrective actions are needed as follows:

a. Preventive Actions:
- Establish a clear project organizational structure, including the division of responsibilities of each party, so that communication and coordination can run smoothly.
- Hold regular coordination meetings, both weekly and monthly, involving all parties involved in the project.
- Clear meeting minutes and activity *timelines, then share them with all stakeholders so that each party has the same references and guidelines.*

b. Corrective Action:
- Evaluate the current communication patterns to identify the causes of communication problems.
- Establish a more orderly communication reporting and documentation system, such as using email.
- Providing reprimands or formal approaches to parties who are obstacles in the coordination process.
- Replace personnel if coordination problems continue to recur and are caused by certain individual factors.
- Holding clarification or mediation meetings if there is conflict or miscommunication between parties in the project.

Implementing these steps is hoped to minimize communication and coordination barriers in project implementation, making the work process more efficient and avoiding the risk of additional costs.

4. Financial Risk

Inaccuracy in preparing cost estimates is one of the financial risks that can cause a spike in contingency costs in construction projects. To overcome this risk, preventive and corrective actions are needed as follows:

a. Preventive Actions:

Before calculating the tender (price offer), the developer must have conducted a survey and investigation of the location (environment), including existing conditions, to determine the most appropriate and efficient working method. This is important to ensure the accuracy of the cost estimate and the accounting for the estimation results.

Provide cubist application training (BIM software used to calculate work volume and construction costs automatically from design drawings). Cost estimates must be realistic and based on existing capabilities, especially related to labor and tool productivity. Calculating accurate productivity based on experience and field data will reduce the risk of inaccuracy. Involve an experienced estimator or cost planning team to ensure the estimation process is carried out professionally and thoroughly. Using the latest and valid unit price data from national standards (SNI) and actual vendors or providers of goods and services to avoid significant price deviations. In making estimates, you must refer to similar projects already underway.

b. Corrective Action:
- Identifying the work items that contribute most to the cost variance. Once identified, alternative searches or efficiency strategies are conducted without sacrificing the quality of the work.
- Implementing a *value engineering approach* by looking for alternative materials, work methods, or other technologies that are more efficient but still meet the established quality standards.

5. Technical Risk

Implementation errors or deviations from work procedures are among the technical risks that often occur in construction projects. This risk not only affects the quality of the work results but can also cause delays and increase contingency costs. Therefore, planned preventive and corrective steps are needed to prevent and overcome this risk.

a. Preventive Actions:
- Prepare and disseminate Standard Operating Procedures (SOP) that are clear, detailed, and easy to understand for all parties involved in the project.

- Provide regular training to workers, supervisors, and related parties to help them understand the correct work procedures and quality standards that must be met.
- Conduct daily or weekly briefings in the field to convey work plans, technical procedures, and potential obstacles that must be anticipated.
- Form an active and competent field supervisory team to monitor work implementation and ensure compliance with established procedures.

b. Corrective Action:

- Specifically, deviations or violations of procedures should be identified through routine inspections or reports from the supervisory team.
- Conduct technical evaluations and correct work that does not meet standards so it does not have a broader impact on work quality or safety.
- Providing reprimands, sanctions, or coaching to parties has proven to be negligent in carrying out procedures as a form of learning and preventing repeated errors.
- Update SOPs or work instructions if weaknesses or inconsistencies are found in old procedures to increase their effectiveness and relevance in the field.

With strict implementation of SOPs, ongoing training, and consistent supervision, the risk of implementation or procedural errors can be significantly reduced. Quick and appropriate corrective actions are also essential to maintaining the quality of work and avoiding cost waste. Through these preventive and corrective efforts, projects can run more efficiently and safely and be done by established technical standards.

Discussion

Risk management in construction projects involves a systematic approach consisting of six process steps, including risk identification, analysis, and response planning (Kallow et al., 2023). The integration of risk management systems in construction projects should cover all project areas, functions, and processes, with particular emphasis on risks in the personnel area (Suseelan & Senthil Vadivel, 2024). Risk and uncertainty are inherent in all construction projects, and effective risk management involves systematically identifying, analyzing, and formulating risk management strategies to reduce potential losses and monitor risk events throughout the project life cycle (Arabi et al., 2022). Understanding and selecting risk response strategies is essential in reducing the likelihood and impact of risks, and risk interdependencies play a critical role in deciding risk response strategies. Effective risk management can minimize the influence of external risk factors on project success and enhance the success of construction projects, especially in cases where risk management plays a mediating role (Qabazard, 2019).

Risk management effectively reduces the financial impact of known hazards, improves target achievement, increases efficiency in project management processes, and reduces costs (Tadayon et al., 2012). Project costs consisting of direct costs, namely costs incurred for building materials, construction equipment, project design and development, maintenance of essential services, and labor, indirect costs, and logistics (Polat et al., 2016). The project cost contingencies must be continuously monitored carefully and thoroughly, both before the project is executed using Monte Carlo simulations to identify key items that have a significant impact on the total project cost and making changes mid-project to respond to several factors that occur in the field and avoid project cost overruns (Batselier & Vanhoucke, 2015; Bouayed, 2016),

Risk management practices, such as risk identification, monitoring, and prevention, significantly affect project success, and risk handling capacity mediates the relationship between risk management practices and project success (Siraj & Fayek, 2019). The challenges in operational analysis and management of risks associated with construction are significant, and the literature lacks a sufficient risk management process approach that can capture how risks affect various project objectives (Burkov et al., 2018).

Existing risk assessment methods often do not consider the interdependencies of risks and the role of risk response strategies in reducing project risk exposure (Arabi et al., 2022). The lack of data in construction projects hinders the use of risk assessment methods. An integrated risk management approach enables construction organizations to consistently deliver superior performance while proactively managing risk, and guidelines for applying a consolidated risk management system for building projects can enhance risk management capabilities in building projects (Suseelan & Senthil Vadivel, 2024).

Integrating risk management into the development strategy of construction companies, collecting and accumulating statistical data, interacting between units, and involving key stakeholders are the primary development areas of risk management in construction projects. The implementation of BIM methods opens up new possibilities for automatically linking risk management information with other processes, and a well-executed risk management plan is critical to ensuring the timely and profitable completion of construction projects.

Conclusion

The dominant factors influencing contingency costs in housing development projects in Malang Raya consist of four main factors: Design, Financial, Human Resources, and Engineering. The contingency costs in housing development projects in Malang Raya generally range from 5% to 7.5% of the total project value. Contingency costs are higher in type 36 and 45 housing projects, especially with DP below 20%. Solutions that can be implemented to address risks that cause contingency costs to arise include preventive and corrective actions tailored to each risk factor. By implementing these solutions in a disciplined and comprehensive manner, the risk of contingency costs can be reduced, project efficiency increased, and the quality of construction results maintained. It also ensures the project runs according to the planned time and costs.

Author Contributions

Conceptualization, F.F.Q. and A.Z.; methodology, F.F.Q.; software, F.F.Q.; validation, F.F.Q., A.Z. and R.A.; formal analysis, F.F.Q.; investigation, F.F.Q.; resources, A.Z. and R.A.; data curation, F.F.Q.; writing—original draft preparation, F.F.Q.; writing—review and editing, A.Z. and R.A.; visualization, F.F.Q.; supervision, A.Z. and R.A.; project administration, A.Z.; funding acquisition, A.Z.

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Conflicts of Interest

The authors declare no conflict of interest.

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