

# **Risk Analysis of Upper Structure Formwork in Building Construction Projects (Case Study of Projects for High-rise Buildings in Tangerang)**

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**ABSTRACT:**This study discusses the risk analysis on the work of upper structure formwork in building projects to improve quality performance. The work of formwork that was analyzed covers the preparation of column & shearwall formwork, the installation of column & shearwall formwork, the removal of column & shearwall formwork, the preparation of slab & beam formwork, the installation of slab & beam formwork, and the removal of slab & beam formwork. This study has 3 factors and 50 variables about the risk of upper structure formwork in building construction. The risk factors used for analysis in this study consist of non-technical aspects, technical aspects, and legal aspects. Non-technical aspects have variables that discuss about labor, equipments, and materials. Technical aspects have variables that related to the execution and method of formwork. The last factor is the legal aspects that discuss about construction regulations and environmental regulations. The result of this study have found three variables that does not affect the risk of quality performance, those are the difficulty of column/shearwall formwork removal in heights and outside the perimeter (X27), missing column/shearwall material (X28), and missing table form material (X48).

**KEYWORDS:**Risk Analysis, Upper Structure Formwork, Building Construction Projects.

## **I. INTRODUCTION**

In the implementation of high-rise building projects, quality discrepancies are often found especially in the upper structure work. At the stage of formwork work has a high risk of quality discrepancies. To determine the risk of formwork work, it is necessary to know how the process of formwork work in buildings. The process of installing formwork must be in accordance with the method so that the targeted quality can be achieved.

To conduct a risk analysis of structural formwork work on building projects, risk factors and risk variables of structural formwork work are needed. Factors and variables risk are obtained through literature studies and construction field reviews. So that these factors and variables are analyzed further.

Factors and variables are analyzed with surveys to know the risks involved in the construction work of the structure of buildings. Surveys are filled by experts to know factors and variables risk of upper structure formwork work have the impact on quality performance.

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## II. RESEARCH INSTRUMENS

Research instruments include data and data collection. Data is raw material that needs to be processed to produce information that shows the facts. The research data must be relevant, meaning that the data must be related with the research problem. Furthermore, the data has to be fresh and interesting to be discussed. The data is divided into two categories, which are qualitative data and quantitative data. The qualitative data can be referred to as data that is not a number. While the quantitative data can be referred to as a real number, so that various mathematical operations can be carried out. Data is also grouped in primary data and secondary data. Primary data is data obtained from the first source that can be obtained from construction field studies by surveying the person related to the problem. While secondary data is data obtained from literature studies, such as books, journals, papers, and related final assignments. Secondary data can also be called processed data. [2] [3]

According to Moh. Nazir in his book entitled "Metode Penelitian", research variables are concepts that have various values. Research variables can be obtained from the results of literature studies, such as books, journals, previous researches, et cetera. Based on the type, variables can be divided into five types, which are independent variables, dependent variables, moderator variables, intervening variables, control variables. [4]

In this study, the used research variables are dependent variables and independent variables. These variables can be assumed as variables Y and variable X. If variable Y is caused by variable X, then variable Y is called dependent variable and variable X is independent. The following relationships X & Y in this research can be expressed in mathematical model functions:

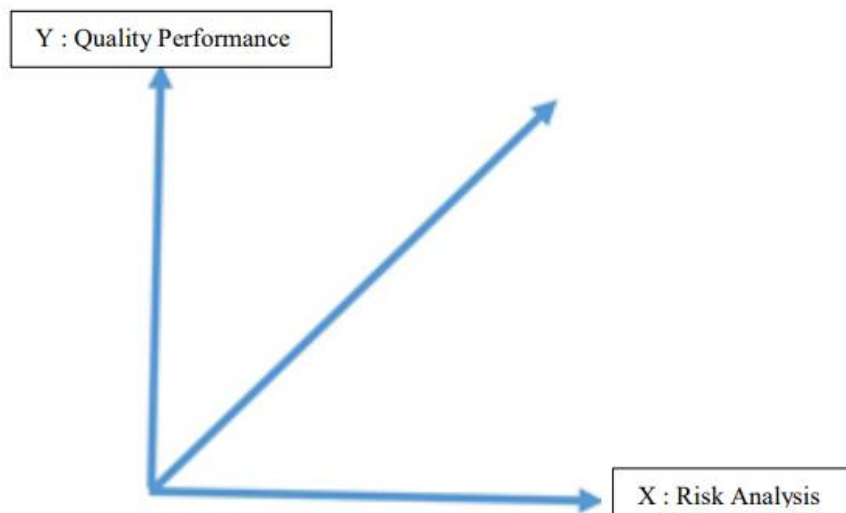


Fig. 1. Research Model Function

In this study, quality performance is the dependent variable (Y) because it is an object that will be affected. Whereas the influence variable is the independent variable (X), which is the variable form of the events that might occur the risk of the structure formwork work on a high-rise building project. The Data collection methods used in this study are questionnaires and interviews. Both methods were used because they are systematic and easy. The collected data have to be correct, because the data is the basis for answering the formulation of the problem, Questionnaire is a series of questions logically related to research problems, and each questions have the answers to test the hypothesis. According to Moh. Nazir, questionnaire was divided into two, namely open questionnaire and closed questionnaire. Open questionnaire is a questionnaire that have various answers. Respondents have the freedom to answer the questionnaire. While the closed questionnaire is a questionnaire that instruct the respondent to give limited answers with some or only one alternative.

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## III.METHODOLOGY

The research strategy used in this study is survey. Survey is an investigation conducted to obtain facts from the existing indications. The survey methods used in this study are questionnaires and interviews with people related in the construction sector [5]. Questionnaires were distributed to samples from a population to obtain primary data. The population in this study is the main contractor who is carrying out structural construction of a high-rise building in Tangerang. This study also interviews experts so that the data to be tested is truly valid.

Every data collected needs to be analyzed. It was done to review if the collected variables are valid or not. Data analysis from the questionnaire was assumed by the researcher in two assessments. The first assessment of variables is the acceptable, namely the variables that have a number of experts who agree more than the experts who disagree. The second assessment is the reduced, namely the variables that have a number of experts who disagree more than experts who agree.

## IV.ANALYSIS RESULTS

### Upper Structure Formwork

The development of technology in the construction world today is marked by the development of innovations carried out during construction. The technology used in the work process is carried out to make construction projects easy. One of the functions of technology in the construction process is the formwork technology.

According to Hanna in her book entitled "concrete formwork system", a formwork construction must have the requirements of strength, rigidity, and stability. These requirements must be fulfilled considering the formwork is a job carried out repeatedly in multi-storey buildings and requires a large cost. The cost for formwork ranges from 40% - 60% of the cost of concrete work or about 10% of the total cost of building construction. [7]

According to F. Wigbout in his book entitled "Formwork", there are currently 3 types of formwork; namely conventional formwork, semi-system formwork and system formwork. The selection of formwork type is an important decision in high rise building project because it affects the cost, the time of work and the quality of construction. [8]

The first formwork is conventional formwork. It is a formwork which every time after being removed and dismantled into basic parts, can be rearranged into another form. In general, conventional formwork consists of various woods. This conventional formwork can be formed as desired and needed. The advantages of conventional formwork are the material is easy to find and cheap, it also does not require skilled workers. While the disadvantages of conventional formwork are wood materials cannot be used for repeated process, installation and removal of the formwork becomes longer, produce woods and nails waste, and the shape is not precise. [9]

From the various disadvantages in conventional formwork methods, semi-system formwork was developed with steel plate or hollow iron. The material in semi-system formwork is much more durable and long-lasting than conventional formwork. The semi-system formwork can be much cheaper if the execution of formwork is good. The advantages of semi-formwork system are durable and cheaper. Whereas the disadvantage of semi-system formwork is that the formwork demands an area for formwork manufacturing.

The last formwork method is system formwork method. According to Abdul Muis in his research entitled "AnalisisBekistingMetode Semi SistemdanSistemPadaBangunanGedung", the formwork system or also called full formwork system is a formwork that experiences further development of a universal formwork with all its possibilities can be used in various types of buildings. The implementation of system formwork is faster than conventional formwork and semi-system forwork because the system formwork components have a standard size. System formwork can be expensive at first, but with relatively short implementation and repeated usage, the cost does not take too much effect. [10].

The type of formwork used in this study is system formwork. For column and shearwall formwork work, this study discusses peri girder system formwork. For beam and plate formwork work, this study discusses table form system.

The work of formwork that was analyzed includes the preparation of column &shearwall formwork, the installation of column &shearwall formwork, the removal of column &shearwallformwork, the preparation of slab & beam formwork, the installation of slab & beam formwork, and the removal of slab & beam formwork

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## Factor & Variable

The risk factors used in this study consist of non-technical aspects, technical aspects, and legal aspects. Non-technical aspects have variables discussing about labor, equipments, and materials. Technical aspects have variables that are related to the execution and method of formwork. The last factor is the legal aspects that discuss about construction regulations and environmental regulations.

Variables on non-technical aspects consist of man power productivity (X.1), an unexpected increase in labor prices (X.2), a lack of labor (X.3), low productivity of the tool (X.4), delays in ordering equipment ( X.5), improper age of equipment (X.6), lack of equipment security (X.7), delays in ordering materials (X.8), delays in material delivery (X.9), incompatible quality of materials for specifications ( X.10), lack of material security in storage (X.11), and unavailable materials on the market (X.12)

Variables on the technical aspect involve working on columns, shearwalls, slabs and beams. Variable in column formwork & shearwall preparation work consists of; marking of the column/shearwall position with shop drawing (X.13), clear and not tilted marking line of column/shearwall position (X.14), uneven oil in column/shearwall formwork (X.15), and feasibility of column/shearwall formwork after use (X.16). Furthermore, the variable of column installation & shearwall formwork consists of; suitability of column/shearwall formwork installation with method (X.17), surface flatness of column/shearwall formwork (X.18), joint tightness of column/shearwall formwork (X.19), cleanliness of column/shearwall formwork (X.20), column/shearwall formwork verticality (X.21), and strength of column/shearwall formwork against concrete (X.22). For variable of column & shearwall formwork removal consists of; improper time release column/shearwall (X.23), fault of column/shearwall formwork removal method (X.24), lack of concentration which causes column/shearwall formwork material damaged (X.25), placement of formwork material after use (X.26), difficulty in dismantling column/shearwall formwork at height in the outer perimeter (X.27), and missing column/shearwall formwork material (X.28).

Furthermore for plate & beam formwork preparation work includes variable marking suitability of the position of the plate & beam formwork with shop drawing (X.29), clear and not tilted marking line of the plate & beam formwork (X.30), basic elevation suitability form table (X.31), suitability of material fabrication table form with shop drawing (X.32), feasibility table form after used (X.33), and security of material table form at the time of fabrication (X.34). In the installation of slab & beam formwork, the suitability installation of the table form with the method (X.35), the flatness of the surface of the plate & beam formwork (X.36), the joint tightness of the plate & beam formwork (X.37), the cleanliness of the plate & beam formwork (X.38), difficulty installation of slab & beam formwork at height (X.39), straightness of beam wall formwork (X.40), column head neatness (X.41), and suitability of MEP sparing with shop drawing (X.42). For the removal of slab & beam formwork includes improper time release table form (X.43), lack of concentration which causes the material table form to be damaged (X.44), difficulty in reducing table form (X.45), the amount of remaining formwork plates & beams attached in concrete (X.46), transfer of table form collides with concrete (X.47), and table form material is lost (X.48)

For variables of legal aspect factors consist of project violating legal aspects (X.49) and the project violating environmental aspects (X.50).

## Analysis

The preliminary analysis of this research is a validation test carried out to experts who master the work of structural formwork on building projects. Here is the following data of the experts involved in this questionnaire:

Tab. 1. Expert Personal Data

Expert	Education	Experience (years)	Position
P1	S1	11	Project Manager
P2	S1	14	Project Manager
P3	S1	18	Project Manager

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all experts who gave assessments to the questionnaire of this research were a project manager from the main contractor. furthermore, all experts who gave assessments to the questionnaire of this research have undergraduate education. The difference between experts is on work experience. the first expert has 11 years of experience, the second expert has 14 years of experience. and the last expert has 18 years of experience.

The result of this study have found three variables that does not affect the risk of quality performance, those are the difficulty of column/shearwall formwork removal in heights and outside the perimeter (X27), missing column/shearwall material (X28), and missing table form material (X48). Other than those variables, the rest will have risks that can make impacts on quality performance.

## V. CONCLUSION

The work of formwork that was analyzed includes the preparation of column & shearwall formwork, the installation of column & shearwall formwork, the removal of column & shearwall formwork, the preparation of slab & beam formwork, the installation of slab & beam formwork, and the removal of slab & beam formwork.

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