Risk factors analysis affecting project time delay in construction projects using CATWOE analysis

Wahyu Rachmayanti*, Putri Arumsari
Civil Engineering Department, Faculty of Engineering, Bina Nusantara University, Jakarta, Indonesia 11480

Corresponding author: wahyu.rachmayanti@binus.ac.id

Abstract. Project delays is one of the disadvantages in project development. Risk factors are risk that are identified as a factor that causes a certain event. Risk factors consist of various kinds factors that can affect of project delays. The purpose of this research is to identify risk factors and determine conceptual model that explain the dominant factors using CATWOE analysis. The dominant factors of this research is design changes and conceptual model that chosen are the second conceptual model.

Keyword: CATWOE, conceptual model, construction project, delay, dominant factors

1. Introduction

Project risks can affect the productivity, performance, time, quality, cost limits of the project. The construction process on project usually takes a long time and complex which can causes uncertainty and shows the various kinds of risks.[1]

Every construction project is always faced with the possibility of various kinds of risks. The higher level of complexity project, the greater level of risk that may occur in the project[2]. In the world of construction, there’s may be various kinds of risks that can affect the implementation of multi-storey building construction projects that the implementation of project works has been effect on project delays where the building construction has the correct implementation of procedure and accordance with the rules [3].

Factors that can causes of project delays is because construction works is not completed in accordance with the specified target. The problems can arise if there’s a mismatch between planned and the reality. Those problem is caused by various factors as a construction project risks. These risks will be greatly affect project performance and causes in terms of cost, quality, time, business profits, customer satisfaction, and other factors that affects the success of project [4].
2. Delay in Construction Project

2.1. Definition of Risk Project

There are several risk factors that occur in every job of implementation construction. Risk is an event or condition that is uncertain and has an impact on project objectives which include scope, schedule, cost, and quality (PMBOK, 2008). There are three main elements of risk:

a. Events, event or situations that occur at a certain place during certain intervals;

b. Probability (Likelihood) is qualitative descriptions of the probability or frequency;

c. Impact (Consequences), is the result of an event which is disadvantages of project.

From some of the above definitions, risk is a condition that arises because of uncertainty with the chance of certain events that will cause loss of consequences for the achievement of project objectives, one of which is the project time performance [3].

2.2. Risk Management

Risk management is all a series of activities related to risk, there are several explanations that can be arranged in the form of risk management is planning, assessment, identification of risks, analysis of risks, handling and monitoring of risks. There are the stages of risk management: [5].

a. Planning

The process of developing and documenting strategies and methods that are used to organize, comprehensive and interactive for the purposes of identifying risk issues, developing risk management plans and risk assessments;

b. Assessment

The assessment consists of the process of identifying and analyzing technical areas and processes that have risks to increase the likelihood of achieving cost, performance, and time completion of activities;

c. Handling

Handling is a process of identifications, evaluations, selections, and implementations of risk management with the objectives and constraints of each program, which consists of holding risk, avoiding of risks, preventing of risks, and transferring of risks;

d. Monitoring

Monitoring is a process of evaluating systematically the results of the works of the risk management process that have been determined and used as the basis for a better developing of risk management strategies.

2.3. Risk Identification

There are several tools and techniques to carry out the risk identifications process: [6]

a. Brainstorming
Brainstorming is by inviting several people in a room to discuss the risks of the project with the help and leadership of a facilitator;
b. Delphi Technique
   Delphi Technique is the way to get an idea of dominant project risks by a questionnaire;
c. Interview
   Interview is a technique for collecting data about project risk carried out on team members who have experience in project risk;
d. Roast cause identification
   Is technique to determine the essential causes of risks by a group that have a experience in a risk project;
e. Strength, Weakness, Opportunities, Threats (SWOT) analysis
   This analysis is to enhances a broader understanding of risk.

2.4. CATWOE Analysis
   The CATWOE method is made with several questions as a material from the root definitions which provides an overview of the transformation process. There is the definition of CATWOE:[7]. CATWOE definitions can be seen in table 1.

Table 1. CATWOE

| CATWOE  | Definitions                                   |
|---------|----------------------------------------------|
| Customer| The parties who gets the loss in the events  |
| Actors  | The parties that facilitate events to customers |
| Transformation| The changes that will be achieved, usually define the intial conditions and the final conditions to be achieved |
| Worldview| General view which provides a statement that the events does not occurs |
| Owners  | The parties that can stop the events         |
| Environment| Factors that can influence events but can not control the system. |

3. Methodology
   This research methodology is using qualitative analysis. Qualitative analysis is a research that produces descriptive data in the form of written words from a journal under studies. The data is used in this study are primary data and secondary data. The primary data is by doing an interview, which is a technique by collecting data or information materials carried out by unilateral oral questions and answers. Respondents in data collections with interviews were 3 respondents conducted with experts or project staffs who had more than 10 years of work experiences. Then the secondary data is used in this research were research papers such as journals related to this research which consisted of 30 journals by exploring informations or ideas then the data is analyzed qualitatively. Qualitative analysis is a research that produces descriptive data in the form of written words from a journal under studies.
   CATWOE analysis is carried out after obtaining the dominant factors which is then analyzed which aims to determine and develops the concept of choices from the dominant risk factors which is carried out by interviewing several respondents, construction experts. The stages in CATWOE analysis are root definitions, CATWOE analysis, conceptual models, comparison of conceptual model with reality, determining the chosen concept. Methodology of this research can be seen in Figure 2.
4. Analysis

4.1. Risk factor analysis

Based on the qualitative and descriptive analysis on 30 journals, there are the 31 factors affecting the delay of building construction project is classified as seen in Table 2.

| Code | Tool and Material Factors                                      | Modus |
|------|----------------------------------------------------------------|-------|
| A1   | The materials used is less than required                       | 12    |
| A2   | Late delivery of materials                                     | 22    |
| A3   | Equipment malfunctions                                         | 10    |
| A4   | The tools not accordance with the specifications               | 15    |
| A5   | Lack of storage space of materials                             | 9     |

| Code | Human Resources Factors                                        | Modus |
|------|----------------------------------------------------------------|-------|
| B1   | Low labor productivity                                        | 22    |
| B2   | The labor required is insufficient                             | 15    |
| B3   | Lack of work experiences                                      | 11    |
| B4   | Lack of labor skills                                          | 18    |

| Code | Scope Factors and Work Documents                              | Modus |
|------|----------------------------------------------------------------|-------|
| C1   | Design changes                                                | 26    |
| C2   | Incomplete planning (drawing or specifications)               | 20    |
| C3   | Design error                                                  | 20    |
| C4   | Scope changes of work at the time of implementation           | 14    |
| C5   | Delay in providing detailed images                            | 8     |

| Code | Planning and Scheduling Factors                               | Modus |
|------|----------------------------------------------------------------|-------|
|      |                                                                  |       |
| D1 | Unfavorable sequence of work activities | 11 |
|----|----------------------------------------|----|
| D2 | Work plan changes                       | 10 |
| D3 | The implementation schedule does not as planned | 18 |

**Communication, Coordination, Organization Factors**

| E1 | Miss communication                       | 19 |
|----|------------------------------------------|----|
| E2 | Lack of coordination between contractors & owners | 10 |
| E3 | Lack of control and coordination between teams | 12 |

**External Factors**

| F1 | Rainfall intensity                        | 21 |

The dominant factors of this research based on Table 2 is design changes because modus values of that factors is the higher than other factors.

### 4.2. CATWOE Analysis

**a. Rich Picture**

Rich picture describes the relationship between the parties is to connected with design changes problems. The scenario of rich picture can be seen at Figure 3.

![Figure 3. Rich Picture](image)

**b. CATWOE**

Based on interview with 2 speakers, CATWOE analysis can be seen at Table 3 and Table 4.

| CATWOE         | Questions                                                                 | Results                                                                                  |
|----------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| **Customer**   | The parties who gets the loss in the events?                              | Quality control, engineering, quantity surveyor, subcon and labour.                       |
| **Actors**     | The parties that facilitate events to customers?                          | Engineering.                                                                             |
| **Transformation** | The changes that will be achieved, usually define the initial conditions and the final conditions to be achieved | There is no changes, because the labor or staffs must be ready to accept the design changes. |
World View

General view which provides a statement that the events does not occurs

Design changes in a project are common and there is adjustments of the design.

Owner

The parties that can stop the events?

Owner.

Environment

Factors that can influence events but can not control the system.

There is a technical problems or requests from the owner regarding additional building facilities.

| CATWOE  | Questions                                      | Results                                      |
|---------|------------------------------------------------|----------------------------------------------|
| Customer| The parties who gets the loss in the events?   | Quality control, engineering, quantity surveyor, subcon and labour. |
| Actors  | The parties that facilitate events to customers? | Engineering.                               |
|         | The changes that will be achieved, usually define the initial conditions and the final conditions to be achieved | There is no changes, because the labor or staffs must be ready to accept the design changes. |
| Transformation| General view which provides a statement that the events does not occurs | Design changes can be occurs anytime if the owner asks for the changes. |
| World View| The parties that can stop the events? | Owner.                                     |
| Owner   | Factors that can influence events but can not control the system. | Owner requests is about spatial planning, structural changes and architectural changes. |

Table 4. CATWOE according to Speaker II

c. Conceptual Model

Conceptual model is to explains about the problems of the dominant factors that is design changes. The scenario of conceptual model is made according to speakers one and speakers two and can be seen at Figure 4 and Figure 5.
d. Comparison Between Conceptual Model with Reality

The purpose of this comparison is to find out the actual situations that occurred in the project of various kinds activities. The comparison can be seen at Table 5 and Table 6 according to the project. Critical comments are as follows:

**Figure 4. Conceptual Model I**

- **Owner Requests**
  
  - **Why design changes can occur in the project?**
    
    - Design changes can occur in the project as commonplace because there must be adjustments to the design.
  
  - **Causes**
    
    - Technical Changes
      
      Example of technical changes are where there is a change in the function of the building, there will be an additional machine or additional infrastructure that the structure must be changed.
  
  - **Impact**
    
    - Working methods changes can be fast.
  
  - **Solutions**
    
    - The work sequence planning can be structured well.
    - Acceleration programs

**Figure 5. Conceptual Model II**

- **Owner Requests**
  
  - **Why design changes can occur in the project?**
    
    - Design changes occur as request by the owner which means the contractor cannot refuse the changes because it must be done on contractual manners.
  
  - **Causes**
    
    - Structural Changes
      
      One of the structural changes is a design changes from parking areas to a pump room, which means the structure must be considered and especially on the plate with due regard to the ability of the plate and cover in the design. If not then there will be additional reinforcement on the slab.
  
  - **Impact**
    
    - Architect Changes
      
      One of the architect changes is design changes on the slab and becomes an elevator in accordance with the owner’s instructions which means that must be broken and the function well changes.
  
  - **Solutions**
    
    - Participated on the process design.
    - Development of coordination project.
    - Development of human resource skills.
Table 5. Comparison between conceptual model with reality according to Speaker I

| Activities                                      | Reality                                                                                     | Recommendations                                                                 |
|------------------------------------------------|--------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Work methods changes in shop drawing approval  | The owner or supervisory consultant in approving the shop drawing are still slow due to design changes. | Working methods changes can be fast with good coordinations with contractor, for examples is communication and cooperation in the project. |
| Planning the sequences of work construction    | Construction implementation activities are carried out in accordance with the master schedule or plan schedule that has been agreed by the owners | The work sequence planning can be structured well then work completing projects can be formed effectively and efficiently |
| activities [9]                                 | The acceleration programs are carried out in the event of delays in certain items in the project | Additional labor, additional tools and materials                                   |
| Acceleration programs [9]                      |                                                                                             |                                                                                  |

Table 6. Comparison between conceptual model with reality according to Speaker II

| Activities                                      | Reality                                                                                     | Recommendations                                                                 |
|------------------------------------------------|--------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Participated on design process [8]             | In each divisions has work according to the design but for the design process and revising, the consultant and engineering staffs have more teamworks on design changes with the owners | Establish the criteria necessary to determine the successfull of design.          |
| Development of project coordination [8]        | The coordination that has been carried out is quite good, but there is a miss communication that often occurs in conveying information on job implementations | Improving the communication between stakeholder in the project and hold the coordination meetings internally with the owner. |
| Development of human resources (SDM) [10]      | The project does not provide personal or skills development facilities for the labors or human resources. | Provide sufficient facilities to the labors on the project can be develop according to their skills. |

5. Conclusion

Based on the results of risk identifications and CATWOE analysis on delays in construction projects, there are conclusions of this research:

a. Factors that can be affect of project delays includes equipment and material factors, human resources factors, scope and document factors, planning and scheduling factors, coordination and communication factors as well as external factors;

b. The dominant factors in this research is factor design changes that minimize project delays, it can be done by changing the way of works quickly in shop drawing approval, planning the
sequence of construction work activities regularly, accelerating programs, participating in the design process, developing project coordination, development human resource skills;
c. The concept of the problems in this research is to describes the problems of the dominant factors that is the design changes. The concept describes why the design changes can occur that is according to the speakers, design changes can be occur due to owner requests and the causes is usually due to technical errors or the owner’s own request, then the impact for the project is that the work schedules will be delayed.

6. Suggestion
Based on the results of the conclusion, there are suggestions of this research:

a. In the implementations of construction, construction management should be given more attentions because the role of construction management in design changes and other construction activities is very important for construction implementations from the beginning to the end of implementations;
b. The staff can be notice attentions to the design and planning for every project that is currently under construction so that in the future there will be no design changes.

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