Development of Risk-Based Standard Operating Procedure for the Design and Engineering Phase of ATC Tower and Supporting Facilities Construction Project to Enhance Effectivity and Efficiency

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Abstract

Problems in the design and engineering phase of state buildings, especially the ATC Tower construction project and supporting facilities, are recurring phenomena that need more attention in the project development phase. Some of the problems are flaws in the Detailed Engineering Design (DED) documents, discrepancies between DED documents (Drawings, Engineer's Estimate, BOQ, and Work Plan & Terms), and late completion of design and engineering works. These problems can have an impact on the implementation of construction, such as rework which results in additional time and costs. Several problems in the design and engineering of the ATC Tower Building and supporting facilities indicate that the design and engineering phase is not running effectively and efficiently. To realize an efficient and effective design and engineering stage, it is necessary to standardize operational procedures or an efficient and effective design and engineering work system. This research aims to develop a standard operating procedure regarding the design and engineering works of the ATC Tower Building and supporting facilities.

The product of this study is a Risk-Based SOP for the design and engineering phase of the ATC Tower and supporting facilities construction project which can improve efficiency and effectiveness in the related works. The Risk-Based Standard Operational Procedure (SOP) is developed by adding risk response activities that are obtained from the risk analysis stage in this research. Methods used in this research are archive analysis/literature study, questionnaire survey, and Delphi's method. The results of this study indicate that there are 4 business processes in the design and engineering phase of the ATC Tower and supporting facilities construction project, namely the Conceptual Stage, Pre-Engineering Plan Stage, Design Development Stage, and Detailed Design Stage. There are also a total of 93 potential risks that may occur in the design and engineering phase of the ATC Tower and supporting facilities construction project with 29 risk factors categorized as high risk.

Keywords
Standard Operating Procedure, ATC Tower, Design and Engineering, Risk-Based, Construction Project.

1. Introduction
The construction of the ATC Tower and its supporting facilities is part of supporting the flight traffic service activities which are the responsibility of the Public Company, The Indonesian Aviation Navigation Service Provider also known as AirNav Indonesia. The ATC Tower and its Supporting Facilities Development Program consist of the stages of design and engineering, construction work, and technical supervision. In the design and engineering phase of ATC Tower and its supporting facilities, it is hoped that the design and engineering consultant and construction management

consultant can carry out their duties and responsibilities properly and coordinate with each other effectively to produce good detailed engineering design documents. However, in fact, in some design and engineering works of the ATC Tower Building and its supporting facilities, various problems are often found. Some of the problems are flaws in the Detailed Engineering Design (DED) documents, discrepancies between DED documents (Drawings, Engineer's Estimate, BOQ, and Work Plan & Terms), and late completion of design and engineering works. Furthermore, According to Andi (2005), based on his surveys of 41 respondents who worked in construction industry in Surabaya, Indonesia, the problems of design engineering documents quality are unclear specifications, design delays for finishing works, and design changes.

Based on the above phenomena, it can be concluded that the design and engineering work of the ATC Tower Building and its supporting facilities does not run effectively and efficiently because according to the Big Indonesian Dictionary, efficient is appropriate or appropriate for doing something (without wasting time, effort, and money). While effective means that there is an effect or in other words, that is right on target (Pratama H. Febri 2019). The impact of problems in DED documents is a rework on construction projects (Hendarlim and Winata 2004). Santoso (2004) also states that errors or deficiencies in design documents are risks that have a high level of importance that cause many changes or rework on construction projects. In addition, according to Chandra, G., and Agus, B. (2015), the impact of poor quality design documents is a delay in the execution of work and the rise in construction costs.

Information or owner requests that arrive late, change easily, and are inadequate are some of the causes of design engineering problems (Andi and Minato 2003). On the other hand, the lack of experience of design and engineering consultants on similar projects, lack of coordination between design disciplines, and lack of effective communication between parties are also the causes of these problems (Peter Agbaxode et al. 2007). Based on the causes of the problems above, it can be concluded that a standard work system or standardization of operational procedures in design and engineering activities is needed which can be a guideline to minimize these problems.

To realize an efficient and effective design and engineering stage, it is necessary to standardize operational procedures or an efficient and effective design and engineering work system where this is by the principle of preparing Standard Operating Procedures for Government Administration based on Regulation of the Ministry of State Apparatus Utilization and Bureaucratic Reform of the Republic of Indonesia No.35 of 2012, namely standardized procedures must be procedures that most efficient and effective in carrying out their duties. Therefore, in this study, the development of SOPs is carried out at the design and engineering phase of the ATC Tower construction project and its supporting facilities to improve efficiency and effectiveness using a risk-based approach.

1.1 Objectives

This research aims to develop a standard operating procedure regarding the design and engineering works of the ATC Tower Building and supporting facilities. Therefore, this research has 8 research objectives, as follows: Identify the existing state of the organization which handles the design and engineering works of the ATC Tower Building and supporting facilities (RQ1), Identify tasks, responsibilities, and roles of the organization's resources (RQ2), Determine business processes and activities related to the design and engineering works of ATC Tower Building and supporting facilities (RQ3), Determine the inputs and outputs that must be achieved in each activity (RQ4), Determine the required duration from each activity (RQ5), Determine the communication flow in the process of carrying out the design and engineering works of ATC Tower Building and supporting facilities (RQ6), Identify the risks that may occur from each activity (RQ7), and Develop Risk-Based Standard Operating Procedure for the design and engineering phase of ATC Tower Building and supporting facilities construction project (RQ8).

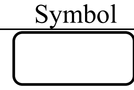
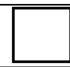
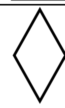
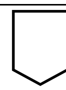
2. Literature Review

According to Regulation of the Ministry of State Apparatus Utilization and Bureaucratic Reform of the Republic of Indonesia No.35 of 2012, Standard Operating Procedures are a series of standardized written instructions regarding various processes of organizing organizational activities, how and when they should be carried out, where and by whom they are carried out. Isenhour J. (2017) states that Standard Operating Procedure is a step-by-step guide on how a task or job should be performed.

The format used in the Standard Operating Procedures for Government Administration is a branched flow chart format and no other format is used. It is assumed that the procedures for carrying out the duties and functions of government agencies including Ministries/Agencies and Local Governments contain many activities (more than ten) and require a lot of decision making. Therefore, to equate the format, all procedures for carrying out the duties and functions of government administration are made in the form of a branched flow chart, including short procedures (a few, less than ten) with/or without decision making.

The symbols used in the SOP for Government Administration only consist of 5 (five) symbols, namely: 4 (four) basic flowchart symbols and 1 (one) Off-Page Connector. The five symbols used are as follows in table 1.

Table 1. Symbols used in SOP

No.	Name	Symbol	Function
1	Terminator		Describe starting and ending activity
2	Process		Describe the process or activity of execution
3	Decision		Describe decision-making activity
4	Arrow		Describe the direction of the activity (direction of activity process)
5	Off-page		Describe the relationship between symbols on different pages

A business process is a collection of activities or processes that are structured and interconnected within the organization to manage resources to achieve a goal that creates added value for the organization (Soemohadiwidjojo 2017). In the design and engineering work of the ATC Tower and its supporting facilities construction project, the business process refers to the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia No.22/PRT/M/2018 concerning the Construction of State Buildings. There are four stages in the design engineering stage for the construction of state buildings, namely as follows Conceptual Stage, Pre-Engineering Plan Stage, Design Development Stage, and Detailed Design Stage.

According to Project Management Body of Knowledge 6th Edition (2017), the risk is an uncertain future event or condition, and if it occurs will have a positive or negative impact on one or more project objectives including scope, schedule, cost, and quality. Risk management is a systematic process of identifying, analyzing, and solving risk problems that will occur in the project, including maximizing the probability of positive opportunities and minimizing the probability of negative risks on the project.

3. Methods

The stages of the research process will be explained through a flow chart. These stages are made to answer the research questions with the measurable procedure.

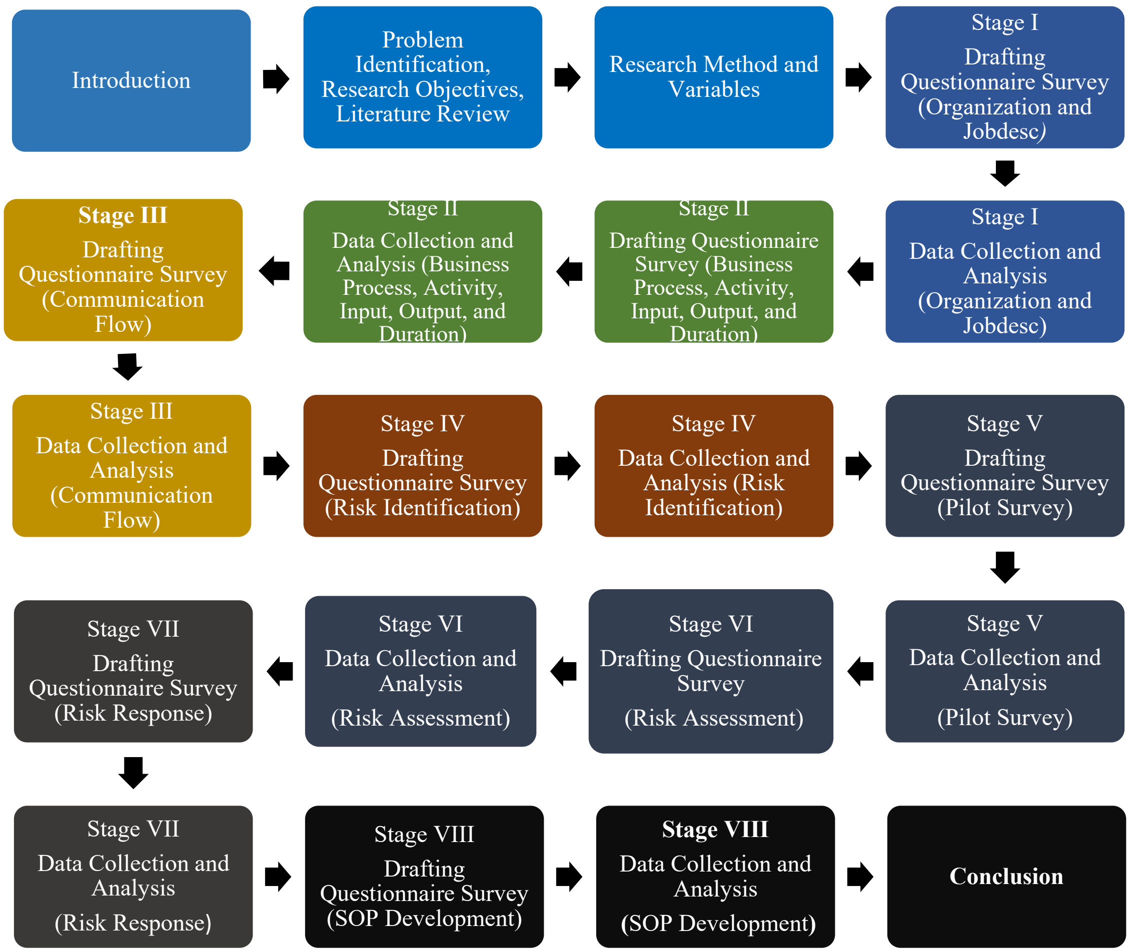


Figure 1. Research Stages Flowchart

This study uses two types of variables, namely the dependent variable and the independent variable (Figure 1) where the independent variable will be referred to as the X variable and the dependent variable will be referred to as the Y variable. The variables in this study are:

- X1: Organizational Structure (RQ1)
- X2: Job Description (RQ2)
- X3: Business Processes and Activities (RQ3)
- X4: Activity Input and Output (RQ4)
- X5: Activity Duration (RQ5)
- X6: Communication Flow (RQ6)
- X7: Risk of Activity (RQ7)
- X8: Development of SOP (RQ8)
- Y: SOP Performance (Effective and Efficient)

Methods used in this research are archive analysis, survey, and case study. The archive analysis is carried out to understand and observe the existing state of the research object. The survey for data collection consists of interviews and questionnaires with experts that have work experience and responsibility in the design and engineering work of the ATC Tower and its supporting facilities construction project. The case study is used to determine the communication flow and development of SOP for the design and engineering phase of the ATC tower and supporting facilities construction project.

4. Data Collection

4.1 Stage I (Organization and Job descriptions)

The data collection at this stage aims to determine whether the existing organizational structure and job descriptions on the object of research are by existing needs. The method used at this stage is the Delphi Method with 5 experts with a minimum of 10 years of experience in the design and engineering of ATC Towe and its supporting facilities construction project.

4.2 Stage II (Business Process, Activity, Input, Output, and Duration)

The data collection at this stage aims to validate content and constructs related to business processes, activities, inputs, outputs, and the duration of each activity based on the needs of the related research object. The method used at this stage is the Delphi Method with 5 experts with a minimum of 10 years of experience in the design and engineering of ATC Tower and its supporting facilities construction project.

4.3 Stage III (Communication Flow)

The data collection at this stage aims to determine the position of a person whether he/she is responsible or accountable in each activity in the design and engineering phase of the ATC Tower and its supporting facilities construction project. The communication flow questionnaire is prepared based on the RACI assignment matrix for each stakeholder related to design and engineering work. The method used at this stage is the Delphi Method with 5 experts with a minimum of 10 years of experience in the design and engineering of ATC Tower and its supporting facilities construction project.

4.4 Stage IV (Risk Identification)

The data collection at this stage aims to validate content and constructs related to risk events that may occur in related activities. The method used at this stage is the Delphi Method with 5 experts with a minimum of 10 years of experience in the design and engineering work of the construction of ATC Tower and its supporting facilities or state buildings.

4.5 Stage V (Pilot Survey)

The data collection in stage V aims to ensure that the questionnaires that have been made are easy to understand by respondents. If the respondent has understood, it can be continued for the questionnaire data collection process, but if not, the questionnaire will be corrected to make it easier to understand. The pilot survey is validated by 5 respondents with a minimum education level of a Bachelor’s Degree and a minimum of 5 years of work experience in the design and engineering work of the construction of ATC Tower and its supporting facilities or state buildings.

4.6 Stage VI (Risk Assessment)

The data collection at this stage aims to conduct a risk assessment based on the probability and impact of the risk. At this stage, the respondent will determine each risk factor's probability and impact scale. The scale used at this stage is the Likert scale. The method used at this stage is the Delphi Method with various respondents in the internal organization, Design and Engineering Consultants, and Construction Management Consultants. Respondents at this stage amount to 35 respondents who have a minimum of 3 years of work experience in the field of design and engineering work for the construction of ATC Tower and its supporting facilities or state buildings.

4.7 Stage VII (Risk Response)

The data collection at this stage aims to determine the risk response of each activity that has a high-risk value related to causes, impacts, preventive actions, and corrective actions. The method used at this stage is the Delphi Method with 5 experts with a minimum of 10 years of work experience in the design and engineering work of the construction of ATC Tower and its supporting facilities or state buildings.

4.8 Stage VIII (Development of SOP)

The data collection at this stage aims to validate the development of SOP and whether the SOP has complied with the SOP principles. Validation is carried out by the internal organization in the Design and Engineering Division that will be the user of SOP for the design and engineering phase of the ATC Tower and its supporting facilities construction project. The method used at this stage is the Delphi Method with 5 experts with a minimum of 10 years of experience in the design and engineering of ATC Towe and its supporting facilities construction project.

5. Results and Discussion

5.1 Answering RQ1 (Organization) and RQ2 (Job Description)

Based on the results of expert validation, it can be concluded that the existing organizational structure is by the needs in the design and engineering work of the ATC Tower construction project and its supporting facilities. The Head of the Design and Engineering Division remains in charge of 4 sections led by each Manager. Regarding the design engineering work of the ATC Tower building, the Head of the Design and Engineering Division is assisted by a Manager who handles electrical and mechanical facilities, and a Manager who handles building facilities and security. Each Manager has 2 Junior Managers where the first Junior Manager is in charge of design work and the second is in charge of engineering work.

5.2 Answering RQ3 (Business Process and Activity), RQ4 (Input and Output), and RQ5 (Duration)

Based on the results of data collection and analysis in phase II, there are 4 business processes in the design and engineering work of the ATC Tower construction project and its supporting facilities, which are as follows:

• X1 - Conceptual Stage: 19 activities
• X2 - Pre-Engineering Plan Stage: 27 activities
• X3 - Stages of Design Development: 10 activities
• X4 - Detailed Design Stages: 24 activities

The business process, activity, input, and output are determined by referring to the Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia No.22/PRT/M/2018 and existing contract documents of design and engineering work. Then they are validated by the experts. The duration of each activity is determined by the experts using lesson learned documents from existing projects (Table 2).

Table 2. Business process, activity, input, output, and duration

Code	Business Process	Code	Activity	Input	Output	Duration (Day)
X4.1	Detailed Design Stages	X4.1	Make detailed drawings of architecture, structure, MEP, IT & electronics and environmental/landscape planning	Design development documents	Detailed engineering drawings (Architecture, Structure, MEP, IT	14
		X4.2	Make work plans and requirements in the scope of architecture, structure, MEP, IT & electronics	Detailed engineering drawings	Work Plan & Terms Document	14
		X4.3	Make details of the volume of construction work and budget plans	Detailed engineering drawings	Bill of Quantity (BOQ) dan Engineer's Estimate (EE)	14
		X4.4	Make reports on structural calculations, MEP, IT & electronics	Detailed engineering drawings	Calculation reports of structure, MEP, IT & Electronics	14
		X4.5	Make a list of material specifications	Detailed engineering drawings, Work Plan & Terms Document, BOQ and	Material Specification	5

Table 2 is an example of business process, activity, input, output, and duration in this research which is the result of expert validation at stage II.

5.3 Answering RQ6 (Communication Flow)

The communication flow that has been obtained as a finding is the result of expert validation to determine the role of each working group using the RACI method. This communication flow itself is a component to integrate each activity with the work unit so that the work process can run coherently. The communication flow is an important part of the SOP and is outlined in a flow chart format refers to Regulation of the Ministry of State Apparatus Utilization and Bureaucratic Reform of the Republic of Indonesia No.35 of 2012 (Table 3).

Table 3. Communication Flow at the Detailed Design Stage

Code	Activity	Executor					Input	Output	Duration (Day)
		Head of Design and Engineering Division	PPP/PPIK	Design and Engineering Consultant	Construction Management Consultant	PHP			
X4.1	Make detailed drawings of architecture, structure, MEP, IT & electronics and environmental/landscape						Design development documents	Detailed engineering drawings (Architecture, Structure, MEP, IT & Electronics, and Environmental/landscape	14
X4.2	Make work plans and requirements in the scope of architecture, structure, MEP, IT & electronics						Detailed engineering drawings	Work Plan & Terms Document	14
X4.3	Make details of the volume of construction work and budget plans						Detailed engineering drawings	Bill of Quantity (BOQ) dan Engineer's Estimate (EE)	14
X4.4	Make reports on structural calculations, MEP, IT & electronics						Detailed engineering drawings	Calculation reports of structure, MEP, IT & Electronics	14
X4.5	Make a list of material specifications						Detailed engineering drawings, Work Plan & Terms Document, BOQ and EE	Material Specification	5

Table 3 is an example of a communication flowchart of a detailed design stage as part of the design and engineering works of ATC Tower and its facilities project.

5.4 Answering RQ7 (Risk of Activity)

There are 4 stages needed to answer Research Question 7 as follows: risk identification, pilot survey, risk assessment, and risk response. Based on the validation experts at the risk identification and pilot survey stage, there are 93 potential risk variables in the overall business process of the design and engineering work of the ATC Tower and its supporting facilities construction project. In carrying out the risk assessment stage, the qualitative risk analysis process contained in the PMBOK Guide 6th Edition is used. The method used in the analysis is to use a probability and impact matrix.

Table 4. Probability and Impact Matrix

Probability	Threats					Opportunities					Probability
Very High 0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05	Very High 0.90
High 0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04	High 0.70
Medium 0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03	Medium 0.50
Low 0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02	Low 0.30
Very Low 0.10	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01	Very Low 0.10
	Very Low 0.05	Low 0.10	Moderate 0.20	High 0.40	Very High 0.80	Very High 0.80	High 0.40	Moderate 0.20	Low 0.10	Very Low 0.05	
	Negative Impact					Positive Impact					

The risk factor value is then obtained by multiplying the average frequency value by the average impact value on each risk factor which will later obtain a risk rating. In this calculation, the probability and impact matrix guidelines are used as shown in Table 4. Based on the results of the qualitative risk analysis, 29 variables from 93 risk variables are obtained as the highest risk variables as shown in Table 5.

Table 5. Risk variables categorized as high risk

Rank	Risk	Business Process	Activity	Rank	Risk	Business Process	Activity
1	X72 Discrepancies between DED documents (Drawings, Engineer's Estimate, BOQ, and Work Plan & Terms)	X4 Detailed Engineering Stage	X4.3 Make details of the volume of construction work and budget plans	16	X55 Mistakes in project estimation	X3 Design Development Stage	X3.4 Make construction cost estimates
2	X67 Discrepancies between DED documents (Drawings, Engineer's Estimate, BOQ, and Work Plan & Terms)	X4 Detailed Engineering Stage	X4.2 Make work plans and requirements of architecture, structure, MEP, IT, electronics & landscape	17	X44 Document revision time is too long	X2 Pre-Engineering Plan Stage	X2.20 Revision and submission of Pre-engineering plan documents and permission drawings to the construction management consultant
3	X66 Discrepancies between DED documents (Drawings, Engineer's Estimate, BOQ, and Work Plan & Terms)	X4 Detailed Engineering Stage	X4.1 Make detailed drawings of architecture, structure, MEP, IT, Electronics and landscape	18	X65 Lack of standard detail on documents	X4 Detailed Engineering Stage	X4.1 Make detailed drawings of architecture, structure, MEP, IT, Electronics and landscape
4	X70 Mistakes in calculating volume and budget plan	X4 Detailed Engineering Stage	X4.3 Make details of the volume of construction work and budget plans	19	X45 Examination or evaluation is not done properly	X2 Pre-Engineering Plan Stage	X2.21 Pre-engineering plan documents second evaluation by construction management consultant
5	X63 Incomplete part of drawings	X4 Detailed Engineering Stage	X4.1 Make detailed drawings of architecture, structure, MEP, IT, Electronics and landscape	20	X56 Material specifications that are less detailed and accurate	X3 Design Development Stage	X3.5 Make outline specifications
6	X62 Mistakes in detailed design (architecture, structurer, MEP, IT and landscape)	X4 Detailed Engineering Stage	X4.1 Make detailed drawings of architecture, structure, MEP, IT, Electronics and landscape	21	X82 Document revision time is too long	X4 Detailed Engineering Stage	X4.13 Revision and submission of Detailed design documents to the construction management consultant
7	X74 Material specifications that are less detailed and accurate	X4 Detailed Engineering Stage	X4.5 Make a list of material specifications	22	X58 Document revision time is too long	X3 Design Development Stage	X3.7 Revision and submission of Design development documents to the construction management consultant
8	X53 Mistakes in calculating structural loads and anticipating earthquakes load	X3 Design Development Stage	X3.2 Make a development of structure system	23	X69 Information on design documents is inaccurate and incorrect	X4 Design Development Stage	X4.2 Make work plans and requirements of architecture, structure, MEP, IT, electronics & landscape
9	X64 Lack of clear details or dimensions in the design document	X4 Detailed Engineering Stage	X4.1 Make detailed drawings of architecture, structure, MEP, IT, Electronics and landscape	24	X42 Incomplete part of drawings	X2 Pre-Engineering Plan Stage	X2.18 Make permission drawings
10	X43 Examination or evaluation is not done properly	X2 Pre-Engineering Plan Stage	X2.19 Pre-Engineering Plan documents evaluation by construction management consultant	25	X33 Document revision time is too long	X2 Pre-Engineering Plan Stage	X2.10 Revising and finishing pre-engineering plan drawings
11	X81 Examination or evaluation is not done properly	X4 Detailed Engineering Stage	X4.12 Pre-Engineering Plan documents evaluation by construction management consultant	26	X83 Examination or evaluation is not done properly	X4 Detailed Engineering Stage	X4.14 Detailed engineering documents second evaluation by construction management consultant
12	X73 The calculation report does not match the detailed drawings	X4 Detailed Engineering Stage	X4.4 Make calculation reports of Structure, MEP, IT & electronics	27	X68 Documents use outdated standards and specifications	X4 Detailed Engineering Stage	X4.2 Make work plans and requirements of architecture, structure, MEP, IT, electronics & landscape
13	X57 Examination or evaluation is not done properly	X3 Design Development Stage	X3.6 Design development documents evaluation by construction management consultant	28	X31 Changes desired by the owner are very frequent	X2 Pre-Engineering Plan Stage	X2.9 Conducting discussions related to the pre-engineering plan concept
14	X71 Inaccurate Bill of Quantity estimates	X4 Detailed Engineering Stage	X4.3 Make details of the volume of construction work and budget plans	29	X18 Mistakes in soil test results	X1 Conceptual Stage	X1.16 Carry out soil test investigation
15	X59 Examination or evaluation is not done properly	X3 Design Development Stage	X3.8 Design development documents second evaluation by construction management consultant				

Table 5 is a list of risk variables in a high-risk category. After obtaining the highest risk variable, an analysis is carried out to obtain a risk response by identifying the causes, impacts, preventive and corrective actions of these risk variables. The results of expert validation obtain 24 preventive actions and 13 corrective actions as shown in Table 6 below.

Table 6. Risk response

Risk Response	
Kode	**Preventive Action**
TP1	Creating a collaborative work system between people who make drawings, engineer's estimate, and work plan and terms documents.
TP2	Provide direction to design consultant's personils to do better and more in designing
TP3	Checking the compatibility and consistency between drawings, engineer's estimate, and work plan and terms documents.
TP4	Provide direction to CM consultant's personils to do better and more in supervising
TP5	Re-check the bill of quanitity and engineer's estimate that have been made regarding the compatibility of the volume with the drawings, arithmetic calculations, unit price analysis and unit price list
TP6	Using the latest unit price list and according to the project location area
TP7	Checking the completeness of the drawings according to the scope of work
TP8	Checking the compatibility of the DED drawing so that the fields are consistent with each other and conformity with the calculation/concept report
TP9	Choose a design alternative that does not complicate the construction process
TP10	Checking material specifications to match the designs and work items listed in the drawings, engineer's estimate, and work plan and terms documents.
TP11	Adjusting material specifications with items on the market or affordable purchases at the project site
TP12	Checking the calculation of earthquake loads to follow the latest Indonesian National Standards for Calculation of Earthquake Loads (SNI 1726 - 2019)
TP13	Checking the compatibility of dimensions on the drawings and engineer's estimate
TP14	Make a CM consultant evaluation report containing the results of a detailed and thorough examination or evaluation
TP15	Checking the compatibility of the structural & MEP calculation report with detailed engineering drawings
TP16	Provide direction to design consultant's personils to make revision faster
TP17	Checking the standards on the drawings regarding the compatibility of the information with the design drawings and the accuracy of the drawings
TP18	Checking work plan and terms documents' content to use the latest standards
TP19	Making design standards for the ATC Tower building and its supporting facilities as a reference for the Design and Engineering Consultant
TP20	Provide direction to the user to make an agreement internally so that the input given is uniform
TP21	Ensuring that the standards for carrying out soil tests related to procedures and test samples are in accordance with SNI Geotechnical Design Requirements (SNI 8460:2017)
TP22	Require and ensure Geotechnical Experts to be in the field when carrying out soil tests
TP23	Ensure that the test samples taken are from stable soil conditions
TP24	Provide direction to personils to monitor and evaluate the implementation of soil tests and their results
Code	**Corrective Action**
TK1	Revising drawings, engineer's estimate, and work plan and terms documents so that there is no conflicting information
TK2	Revising bill of quantity and engineer's estimate
TK3	Revising and finishing detailed engineering drawings
TK4	Revising material specification document
TK5	Revising structural calculation repprt regarding earthquake loads calculation
TK6	Carry out a more detailed and thorough examination or re-evaluation
TK7	Revising calculation reports and detailed engineering drawings to sync with each other
TK8	Correcting documents immediately and according to the set target time
TK9	Revising standard drawing on DED drawing documents
TK10	Revising work plan and terms documents
TK11	Revising permission drawings
TK12	Limiting the design input received so that only a few important inputs need to be followed up
TK13	Conducting soil investigation again

5.5 Answering RQ8 (Development of SOPs)

In this study, the development of risk-based SOPs is carried out based on the addition of risk response activities obtained from the analysis results. The additional activities are derived from the selected Preventive and Corrective Actions. These risk response activities are added to the SOP to prevent or minimize the occurrence of risks in the activity. Table 7 below is the example of the development of SOP in the detailed design stage of the design and engineering work of the ATC Tower and its supporting facilities construction project that is already risk-based (New activities originating from risk response analysis are marked in red) (Table 7).

Table 7. Example of SOP in the detailed design stage of the design

SOP X4. Detailed Design Stage									
		Pelaksana							
Code	Activity	Head of Design and Engineering Division	PPP/PPIK	Design and Engineering Consultan	Construction Management Consultant	PHP	Input	Output	Duration (day)
X4.1	Make detailed drawings of architecture, structure, MEP, IT, Electronics and landscape						Design development documents	Detailed engineering drawings (Architecture, Structure, MEP, IT &Electronics and landscape)	14
X4.2	Conducting evaluation: 1. Drawings completeness based on scope of work 2. Dimensional clarity on the drawings 3. Compatibility of standard drawings with designs 4. The compatibility of DED drawings so that the fields (Architecture, Structure, MEP) are consistent with each other			No Yes			Detailed engineering drawings	Revised detailed engineering drawings	3
X4.3	Make work plans and requirements document of architecture, structure, MEP, IT, electronics & landscape						Design development documents	Work plans and requirements document	14
X4.4	Checking work plan and terms documents' content to use the latest standards and the compatibility with drawings and engineer's estimate			No Yes			Work plans and requirements document	Revised work plans and requirements document	3
X4.5	Make details of the volume of construction work and budget plans						Design development documents	Bill of Quantity (BOQ) dan Engineer's estimate	14
X4.6	Re-check the bill of quantity and engineer's estimate that have been made regarding the compatibility of the volume with the drawings, arithmetic calculations, unit price analysis and unit price list			No Yes			Bill of Quantity (BOQ) dan Engineer's estimate	Bill of Quantity (BOQ) and Engineer's estimate that have been checked and revised	3
X4.7	Checking the compatibility and consistency between drawings, engineer's estimate, and work plan and terms documents.		No	Yes			Drawings, engineer's estimate, and work plan and terms documents	Drawings, engineer's estimate, and work plan and terms documents that have been revised	3

6. Conclusion

The conclusions in this research are reviewed through the answers to the research objectives, namely as follows:

- The form of the existing organizational structure related to the design and engineering work of the ATC Tower and its supporting facilities construction project at Airnav Indonesia led by the Head of the Design and Engineering Division is relevant to the work.
- The roles and responsibilities of each of the existing organizational functions that are reviewed are by the needs of the design and engineering work of the ATC Tower construction project and its supporting facilities.
- There are 4 Business Processes in the design and engineering work of the ATC Tower construction project and its supporting facilities, namely the Conceptual Stage, the Pre-Engineering Plan Stage, the Design Development Stage, and the Detailed Design Stage.
- Activities, Inputs, Outputs, and Durations are developed for each business process and become an important part of the SOP.

- The communication flow is determined using the RACI method with the work units involved including the Head of Design and Engineering Division, PPIK/PPP, PHP, Design and Engineering Consultant, and Construction Management Consultant.
- Risk factors are identified for all work activities. Based on the results of data collection and expert validation, there are a total of 93 potential risks that can occur in the design and engineering work of the ATC Tower and its supporting facilities construction project. Furthermore, from the risk assessment stage, 29 risk factors are categorized as high risk. After obtaining the highest risk variable, risk response analysis is carried out by identifying the causes, impacts, preventive and corrective actions of these risk variables. The results of expert validation obtained 30 causes, 15 impacts, 24 preventive actions, and 13 corrective actions.
- Development of risk-based SOPs is carried out by adding additional risk response activities derived from the selected Preventive and Corrective Actions. These risk response activities are added to the SOP to prevent or minimize the occurrence of risks in the activity.

References

Agbaxode, Peter. et al, Design Documentation Quality Influential Variables in the Construction Sector. *IOP Conference Series: Earth and Environmental Science*, 2007.

Andi, Masalah-Masalah Pada Dokumen Desain dan Dampaknya pada Proyek Konstruksi. *Jurnal Teknik Sipil, Universitas Tarumanagara*, XI(1), pp. 19-33, 2005.

Andi, Faktor-Faktor yang Mempengaruhi Kualitas Dokumen Desain. *Jurnal Teknik Sipil, Universitas Tarumanagara*, X(1), pp. 161-174, 2004.

Andi, and Minato, T., Design Document Quality in the Japanese Construction Industry: Factors Influencing and Impacts on Construction Process, *International Journal of Project Management,* 21, pp. 537-546, 2003.

Cokronegoro, I., Berawi, M. A., and Ivara, W., Pengembangan SOP untuk Pengawasan Pembangunan Gedung Sekolah Terhadap Mutu Konstruksi, *Depok: LibUI*, 2010.

Chandra, G., and Agus, B., Pandangan Kontraktor Mengenai Kualitas Dokumen Desain dan Dampaknya pada Proses Konstruksi, *Universitas Petra, Surabaya*, 2015.

Firdauzi, A.P., Latief, Y., & Sagita Riantini, L, Evaluasi Sistem Manajemen Mutu Berbasis Risk pada Proses Perencanaan Jembatan di Lingkungan Direktorat Jembatan Kementerian PUPR, *Depok: LibUI*, 2016

Framilia, T., Latief, Y., Pengembangan Sistem Manajemen Mutu Proses Perencanaan dan Pembangunan Jalan Layang Non Tol dengan Kontrak Rancang Bangun Berbasis Risiko, *Depok: LibUI*, 2017

Handayaniputri, A., Berawi, M. A., Subiyanto, E., Pengembangan Konsep Standar Operasional Prosedur pada Proses Manajemen Pemeliharaan dan Perawatan Bangunan Gedung, *Depok: LibUI*, 2009.

Idawati, L., Simanjuntak, M.A., and Paulus Kurniawan, Identifikasi Lingkup Kerja Konsultan MK pada Dokumen Kontrak untuk mengurangi Risiko Keterlambatan pada Proyek Konstruksi Bangunan Gedung Bertingkat Tinggi di DKI Jakarta, *Simposium Nasional RAPI XV*, 2016.

Nasution, N,R,, Latief, Y., Pengembangan Standar Operasional Prosedur (SOP) Tanggap Darurat Kebakaran Berbasis Risiko pada Gedung Pemerintah, *Depok: LibUI*, 2017.

Nur Z., Mahirudin M., Studi Kualitas Dokumen Desain dan Faktor-Faktor yang Mempengaruhinya Menurut Konsultan Perencana pada Proyek Konstruksi di Surakarta, *Universitas Sebelas Maret, Surakarta*, 2010.

Peraturan Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia Nomor 22 Tahun 2018 Tentang Pembangunan Bangunan Gedung Negara.

Peraturan Menteri Pendayagunaan Aparatur Negara dan Reformasi Birokrasi Republik Indonesia Nomor 25 Tahun 2012

Putri, P.A., Latief, Y., Pengembangan Standar Operasional Prosedur Pemeliharaan dan Perencanaan, Pelaksanaan, Pengawasan Pekerjaan Perawatan Gedung Pemerintah Berbasis Risiko, *Depok: LibUI*, 2017.

Pratama, F.H., Latief, Y., & Armyn R., Pengembangan Standar Operasional Prosedur Pekerjaan Pemeliharaan dan Perawatan Komponen Struktur Bangunan Gedung Pemerintah Untuk Meningkatkan Efisiensi dan Efektifitas Berbasis Risiko, *Depok: LibUI*, 2019.

Tilley, P.A., and Barton, R., Design and Documentation Deficiency – Causes and Effects, *Proceedings of The First International Conference on Construction Process Reengineering, Gold Coast, Australia*, 1997.

Winata, S., Hendarlim, Y., Andi, Faktor – Faktor Penyebab Rework pada Pekerjaan Konstruksi, *Universitas Kristen Petra, Indonesia*, 2004.

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