Knowledge Base Development of Knowledge Management Audit Process for High-Rise Building Projects with Design and Build Contracts to Improve Construction Safety Performance

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Abstract- Indonesian Government is actively pursuing the transfer of nation's capital city or 'Ibu Kota Negara' (IKN) to East Borneo Province. The transfer process demands high rise building constructions for executing governance. The constructions themselves would mostly use design and build scheme to merge the design stage and construction stage parallelly for acceleration purpose. However, throughout the recent years, accident level in construction sector in Indonesia experiences inclining trendline which is concerned to cause project delay, cost increase, project discontinuation, and disreputable company's image. Accordingly, construction work safety needs to be audited through evaluating the policy in Minister Regulation of General Residency ("Permen PU") No. 10 Year 2021 about Guidelines for Construction Safety Management System. To date, the audit process has not been a learning point and established as a knowledge. In this research, there will be study of knowledge base to develop knowledge management of auditing process for further learning and to be established as knowledge especially for high rise building construction with design and build scheme. Research method used includes literature study and expert validation.

Index Terms- knowledge base, design-and-build, high-rise buildings, construction safety performance

I. INTRODUCTION

On 26th August 2019 the President of the Republic of Indonesia announced that he would move the Nation's Capital ("IKN") to East Kalimantan Province (Bappenas, 2020). The Nation's Capital will be the place for central government activities, as well as the seat of representatives of foreign countries and representatives of international organizations/institutions (Indonesian Law Number 3 of 2022). In order for the plan to transfer the IKN to be implemented, it is necessary to carry out massive infrastructure development needed to support the administration of government such as the construction of high-rise buildings that will be used as office buildings for the legislature, executive and judiciary, TNI headquarters, police headquarters, educational facility buildings, health facility buildings, and others (Silalahi, 2019).

The construction of high-rise buildings to support the IKN will be built using the design and build method (Ridwan, 2022), this is done with the consideration that the project has high risk and complexity, and therefore has considerable uncertainty. But on the other hand, work accidents in the construction sector in Indonesia are also experiencing an increasing trend. Based on data obtained from BPJS Employment (Indonesia's Worker Insurance), the increase in the number of work accidents in Indonesia from 2017 to 2021 has an increasing trend from year to year. In 2017 there were 123,040 work accidents that occurred and in 2021 there were 234,270 accidents. Based on data obtained by BPJS Employment, the majority of accidents occur at work sites.

Work accidents that occur at work sites in high-rise buildings have a greater risk than low rise buildings. The most fatal or frequent accident in a high-rise building construction project is a fall from a height which can result in fatal injuries ranging from minor injuries to death (Goh, Goh, Omar, & Toh, 2016). Work accidents in construction projects are generally divided into two main factors, namely unsafe actions and unsafe conditions. Unsafe action is any human action that can allow accidents to occur to oneself or others, while unsafe conditions are conditions in which the work environment can allow accidents to occur (Primadianto, 2018). The main causes of work accidents in construction projects are related to the unique characteristics of construction projects, different work locations, and affected by the weather, limited execution time, dynamic and demanding high physical endurance, and using a lot of skilled manpower untrained (Simanjuntak, 2012).

The impacts that will arise from accidents on construction projects not only affect project activities and progress, but also cause cost losses such as late claims, compensation claims from victims, and overtime claims from workers due to additional work carried out by contractors (Ying, 2017). The project can also be stopped at an unspecified time in the event of a work accident. In addition, the delays that occur will have a negative impact on the company's image and the trust of users of construction services (Fassa, 2021).

Therefore, it is necessary to carry out an audit on construction safety so that construction safety performance can be as expected. The safety audit process is the basis for appropriate corrective and preventive actions for work safety performance that does not meet the criteria. OHS audit results can be developed by companies to become standard checklists, recommendations for improvement, improve environmental, health and safety performance and reduce the number of accidents (Siddiqui., 2014).

In addition, so far the results of the audit process have not been processed into well-documented knowledge. In fact, this is a valuable thing to be used as lesson learnt for construction service providers for future projects because the risks involved in projects are diverse and different (Hallowell., 2012). With limited manpower and time in the knowledge management audit process, a solution can be offered so that these limitations can be overcome (Hon, 2014)

Knowledge is valuable experiences, contextual information, expert insights and underlying intuitions that provide an environment and framework for evaluating and incorporating new experiences with information (Davenport, 1998). Knowledge Management is a systematic process for finding, selecting, organizing, and presenting information in a certain way that can increase the mastery of knowledge in a specific field of study (Ellitan, 2009). Knowledge Management is able to describe the centrality of knowledge as a guiding principle in the use of big data / analytics in organizations (Pauleen & Wang, 2017).

The results of the existing work safety audit process have not become lessons learned or compiled into knowledge management in the form of a data base that is updated regularly. Thus, it is necessary to develop a knowledge base for the development of knowledge management in the audit process to become learning and a learning science base can be arranged, especially for high-rise buildings with design and build contracts.

The case study in this study will conduct research on knowledge base development of audit process of high-rise buildings building projects with design and build contracts to improve construction safety performance.

II.   THEORITICAL STUDY

1.   High-Rise Building with Design and Build Contract Project

High rise buildings are the buildings with more than 8 floors or more than 45 meters based on the Government of the Republic of Indonesia Number 36 of 2005. Based on PUPR Government Regulation No. 25 Year 2020, design and build is all work related to the construction of a building, where the provider has a single unitary responsibility for design and construction implementation. Design-build is widely used by project owners considering that this method is the most efficient compared to Design-Bid-Build and CM at Risk because the design process and construction phases can run in parallel (S. Z. Syed Zuber, 2018) so that the project can be started without a detailed design document. (Culp, 2011).

The main factors for the success of design and build project according to Songer & Molenaar (1997) are influenced by the availability of human resources, adequate budget, construction technology used, understanding of the same scope of work between the owner and contractor, and a well-defined scope of work. In addition, DBIA (2020) argues that the success of design and build projects in practice can be developed for the better by starting the project team early, developing a relational project culture, communicating expectations between stakeholders, and all stakeholders being involved in planning.

2.   Audit Process on High Rise Buildings with Design and Build Contractors

Audit is a systematic process to objectively obtain and evaluate evidence regarding statements about economic activities and events, with the aim of determining the degree of conformity between these statements and predetermined criteria, as well as conveying the results to interested users (Mulyadi, 2002). In addition, the definition of audit activity is the process of obtaining and evaluating evidence regarding assertions about economic actions and events in order to determine how well they comply with predetermined criteria (Romney, Marshall, & Steinbart, 2015).

Audits are conducted to measure the effectiveness of the implementation of the management system, through formal observations and field audits conducted by the internal company. Audits are carried out periodically by at least a certified auditor who understands the audit process. Audit findings must be reported to service users and documented and followed up.

In practice, the implementation of the audit program must be monitored and measured on an ongoing basis to ensure that its objectives have been achieved. The audit program should be reviewed to identify needs for change and possible opportunities for improvement (ISO 19011: Guidelines for auditing management systems, 2018). The audit process is an important element of the OSH management

system because audit activities are carried out to review and evaluate how the performance and effectiveness of the applicable OSH management system are (Robson, 2010).

The stages of audit activities based on ISO 19011: 2018 can be seen in Figure below this. The application of this stage depends on the purpose and scope of the audit activities to be carried out.
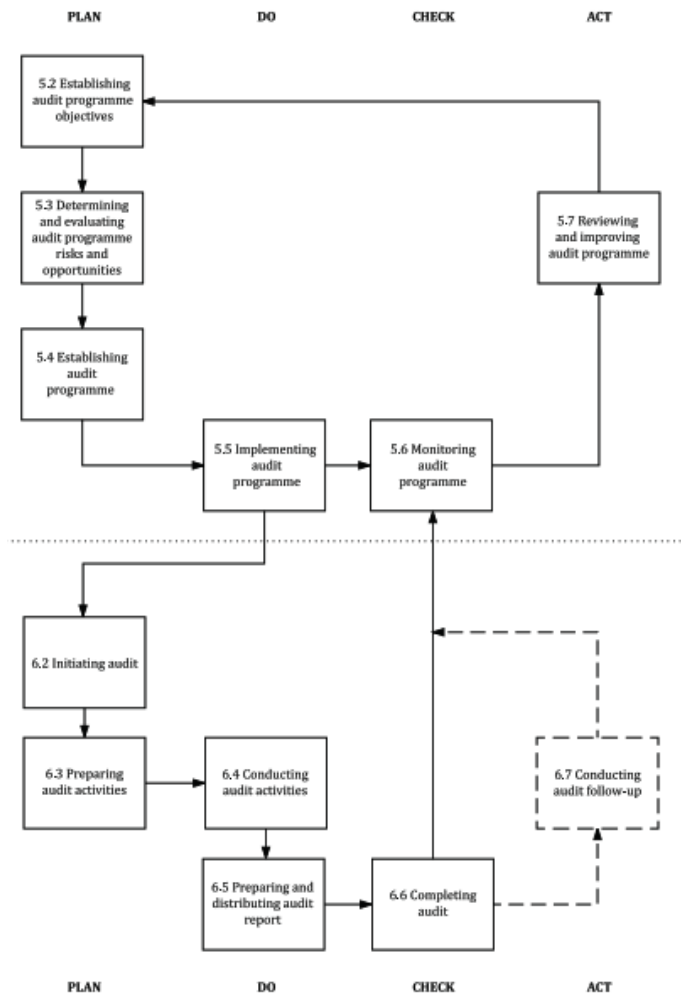

Figure 2.1 The Stages of Audit Activities
source: ISO 19011:2018

Factors that help in the successful implementation of OHS based on ISO 45001 are as follows (Dewi, 2020):

1) Good management leadership, commitment, responsibility and accountability;
2) Develop, lead, and promote a culture within the organization that supports the expected results of OHS;
3) Communication;
4) Consultation and participation of workers, can represent workers where they are;
5) Allocation of resources needed to maintain it;
6) OSH policies that are compatible with the overall strategic goals and direction of the organization;
7) Effective processes to control hazards, OSH risks, and take advantage of OSH opportunities;
8) Continuous performance evaluation and monitoring of the OSH management system to improve OSH performance;
9) Integration of OHS into the organization's business processes;
10) Goals aligned with OSH policies and taking into account OSH hazards, OSH risks and OSH opportunities.

3. Construction Safety Performance

Regulation of the Minister of Public Works and Public Housing No. 10 of 2021 explains that construction safety is all engineering activities to support construction work in realizing the fulfillment of Security, Safety, Health and Sustainability Standards that guarantee construction engineering safety, workforce safety and health, public safety and environmental safety.

Construction Safety Risk Assessment is a calculation of the amount of potential based on the possibility of an event having an impact on construction, human lives, public safety, and the environment that may arise from certain sources of hazard, occurring in the Construction Work (Permen PUPR No. 10 of 2021). Safety performance can be measured by safety compliance and safety participation (Neal & Griffin, 2004). Safety Performance reflects the achievement of occupational health and safety aspects which can be seen from three aspects, namely the level/number of work accidents, safety participation, and the level of safety compliance.

The results of measuring safety performance are important to companies and organizations. High hazard activity should be done under certain types of licenses and permits. Based on the results of safety performance measurements, their activities can be continued or stopped. According to Jazayeri & Dadi (2017), work safety indicators are divided into two, namely:

1) Leading Indicators, can be categorized into passive indicators or active indicators. Passive indicators are indicators that cannot be changed in a short time (Hinze et al, 2013).
2) Lagging indicators, the failure as "after the fact". Because the likelihood of a recordable injury or death occurring is low, this indicator cannot identify changes in the safety management system (Lingard et al, 2013).

4. Knowledge Base Concept in the Audit Process

Knowledge base is a collection of information, data or anything related to a topic problem, which is collected to make a decision later and will be managed (Sudarto, 2007). There are several methods that can be used to compile a knowledge base, namely (Sudarto, 2007):

1) Pattern Recognition, is a combination/association of an experience or knowledge that has passed a statistical approach through pattern similarities, pattern differences, pattern classification, and derived characteristics.
   a. Input: observation encoding;
   b. Output: the name (label) given to the observation.
2) The fuzzy approach uses classification and pattern recognition to clarify data. Relevant for dealing with the classification and diagnosis of problems in ambiguous situations. This uses the "if-then" rule.
3) Coding system, the formulation of an object so that the resulting code implies a certain meaning for the data-information-knowledge communication process. The code is arranged based on a classification with a certain hierarchy to make it easier for users to search for literature and to share information between shared databases.

The knowledge base management system has the characteristics of an approach to solving decision making using an if-then approach. It can address specific problems and its scope is highly structured. This management process will be called the knowledge management process which contains activities to implement knowledge management. (Sudarto, 2007).

In this study, a review of previous study to understand audit process for safety and how it's risk management relations.

III. METHOD

This research was conducted with literature studies and expert validation. A literature study was conducted by collecting data from ISO 2015 and ISO 2018 to understand the audit process. For audit activities, objectives, targets, risks, causes, impacts, preventive actions, corrective actions were obtained based on previous research by Afifah Dewi (2019) and Retno Apriyani (2020). Then validation was carried out to 5 experts with the criteria of being a member of the Construction Safety Committee ('Komite Keselamatan Konstruksi' or K2K) or a construction safety auditor who has at least 10 years experience and has worked in the field of engineering construction in high-rise buildings. Minimum last education is S1/D4.

The selection of respondents involving the construction safety committee (K2K) was carried out with consideration in accordance with PUPR Ministerial Decree No.33/KPTS/M/2021, one of the duties and authorities of K2K apart from carrying out accident investigations is to carry out monitoring and evaluation of construction implementation which is estimated to have a high risk in construction safety. The construction safety auditor was selected with the consideration of understanding the current audit process.

Validation is done by giving 2 questions to the expert, namely:
1. Are the audit processes, activities, objectives, targets, risks, causes, preventive actions, impacts, and corrective actions in the construction safety audit process appropriate?
2. In your opinion, the risk factors and its control can affect the construction safety performance in high-rise buildings with design and build contracts?

To these two questions, the expert gave the answer "yes" if it was appropriate and "no" if it was not appropriate and provided improvements to things that were not appropriate. Then the results obtained from experts will be processed using the nominal method so that audit processes, activities, objectives, targets, risks, causes, preventive actions, impacts, and corrective actions will be obtained in the construction safety audit process in high-rise buildings with design and build contracts that have been approved and validated.

Each series of activities and risk management is coded and then compiled into a strategic mapping of the audit process along with its risk management to be used as a knowledge base in developing the knowledge management. This mapping is called pattern recognition which is arranged from left to right with the sequence of activities (X), objectives (T), targets (S), preventive actions (TP), causes (P), risks (R), impacts (D), and corrective action (TK).

IV. RESULT & DISCUSSION

The results of the literature study and expert validation that have been carried out on audit processes, activities, objectives, targets, risks, causes, preventive actions, impacts, and corrective actions in the construction safety audit process for high-rise buildings with design and build contracts, are obtained the result is that the data has been received with several notes and additional recommendations from experts on several audit activities.

Based on the results of expert validation, there are 6 audit process clauses, 26 audit activity clauses, 25 audit process objective clauses, 25 target audit activity, 26 preventive action clauses, 25 cause clauses, 32 risk clauses, 20 impact clauses, 22 corrective action clauses. The following is a recapitulation of the audit process and its validated risk management.

Tabel 1. Audit Process snd Risk Management Strategy for High-Rise Buildings With Design And Build Contract

No	Audit Process	Audit Activity	Objective	Target	Risk	Cause	Preventive Action	Impact	Corrective Action	Refference
1	Establishing audit program objective	The organization establishes consistent audit program objectives and supports the organization's policies and objectives	To get one goal that is agreed upon by all parties in the organization and in accordance with organizational policies and objectives	Define the scope of the audit process by considering external and internal issues, interested parties and the organization's products and services	There are many views and opinions about the purpose of an audit program in an organization so it is difficult to unify them	The objectives of the audit program are not well defined	Define clear boundaries and scope of the audit program	the objectives of the audit program are inconsistent and inconsistent with organizational goals	Conducts related reviews	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		Organisasi memastikan bahwa tujuan program audit ditetapkan untuk perencanaan dan pelaksanaan audit dan harus memastikan bahwa program audit dilaksanakan secara efektif	determine that audit program objectives are aligned with audit planning and execution and effective audit program implementation	Determine inputs, outputs, as well as the expected outcome of the process, criteria, methods, including measurement and related performance indicators required for effective operation	The objectives of the audit program are not aligned with the planning and implementation of the audit so that the implementation of the audit program is not effective	The objectives of the audit program are not well defined	Determine inputs, outputs, and expected outcomes of processes, criteria, methods, including related performance measurements and indicators required for effective operations	The audit program runs ineffectively	Conducts related reviews	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
2	Determining and evaluating audit program risks and opportunity	The organization identifies audit program risks	To minimize the possibility of risk occurring	Define the risks that need to be addressed to provide assurance that the system can achieve its desired results.	The occurrence of risks that have not been identified	Lack of competence and experience in human resources in risk based thinking	Identify risks with future-oriented details (new risks) and historical data.	Organizations are not ready to control risk	Carry out control quickly and responsively and can be assisted by asking for input from experienced parties,	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization identifies audit program opportunities	To maximize the opportunities in the audit program	Define opportunities that need to be addressed to provide assurance that the system can achieve its desired results.	There are unidentified opportunities	There are opportunities that have not been identified	Identify opportunities with details oriented to the future as well as historical data.	Organizations are not ready to maximize the benefits of opportunities in audit programs	Carry out control quickly and responsively and can be assisted by asking for input from experienced parties,	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization evaluates the risks of the audit program	To be able to measure and control possible risks that may occur	Plan actions to address risks and integrate them into system processes.	There are uncontrollable risks to the audit program	There is no improvement to the risks that will occur in the audit process	Conduct a detailed risk evaluation that is oriented to the future (new risks) and historical data.	Organizations are not ready to control risk	Carry out control quickly and responsively and can be assisted by asking for input from experienced parties,	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization evaluates opportunities in the audit program	To identify and plan improvements to opportunities in the audit program	Plan actions to address opportunities and integrate them into system processes.	There is no improvement to the opportunities that will occur in the audit process	There was no evaluation of the previous audit process	Evaluate opportunities in detail oriented to the future as well as historical data.	Organizations are not ready to maximize the benefits of opportunities in audit programs	Carry out control quickly and responsively and can be assisted by asking for input from experienced parties,	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018

No	Audit Process	Audit Activity	Objective	Target	Risk	Cause	Preventive Action	Impact	Corrective Action	Refference
3	Establishing audit program	The organization defines the roles and responsibilities of the person who will manage the audit program and the audit team/auditors	To streamline work because everyone who works in the audit/auditor team already knows their respective roles and responsibilities	Ensure all personnel working for, or on behalf of, the organization are aware of their responsibilities to others who may be affected by their standardized activities.	Roles and responsibilities do not match the competence and passion of the person	lack of communication from the organization regarding the targets or achievements to be targeted by the organization	Conduct selection of people involved in the audit program as well as the audit/auditor team	The objectives of the audit program were not achieved and the process was not running efficiently	Perform related reviews	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization determines the competence of the person managing the audit program as well as the audit/auditor team	To improve the standard and performance of the audit program because there is a minimum competency threshold	Ensure that people who can affect system performance are competent by virtue of education, training or experience or appropriate action.	a. It is difficult to find workers/people who are in accordance with the competencies desired by the organization	human resources lack training and certification	Improvement of training and certification programs for human resources in determining competency and competency criteria	the company's performance is not as planned	Improvement of training and certification programs for human resources in determining competency and competency criteria	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
			To improve the standard and performance of the audit program because there is a minimum competency threshold	Ensure all personnel working for, or on behalf of, the organization are aware of their responsibilities to others who may be affected by their standardized activities.	b. Determination of competence that is not in accordance with the intended target	lack of resource program planning	develop long-term programs that are efficient and in accordance with existing funds	the company's performance is not as planned	create a competent human resource fulfillment program in the short term	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization selects the person who manages and is responsible for the audit program	To maintain the quality of the audit program and the people selected are believed to be accountable for their work	Ensure all personnel working for, or on behalf of, the organization are aware of their respective responsibilities, respective authorities, and links between functions/departments	The selected person cannot properly manage and be responsible for the audit program	lack of resource program planning and non-detailed description of the scope of work	Determine the ideal criteria, and provide training related to responsibility and audit programs for the candidates to be selected.	Can reduce the performance of the organization / company	Provide suggestions to improve performance, or replace the person with someone who meets the criteria / experience	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization determines the level of the audit program	To classify the audit program according to the existing situation	Define the level of the audit system taking into account external and internal issues, interested parties and the organization's products and services	The level of the audit program does not match the existing conditions	Understanding of audit levels that differ from existing conditions	make relevant audit levels in accordance with existing conditions and accurately	The objectives of the audit program were not achieved and the process was not running efficiently	Periodic evaluation and correction of nonconformities	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization Establish procedures for audit programs	To assist in running the audit program	Determine the expected inputs, outputs and outcomes of the processes, criteria, methods, including related performance measurements and indicators required for effective operations	a. The established procedures are too complicated and not in accordance with the existing conditions, making it difficult to implement	The procedural planning is not ready yet	Develop related SOPs	organizational performance goals are not achieved	agree on a simple risk identification flowchart before carrying out procedure creation	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
			To assist in running the audit program	Establish measurable processes in accordance with requirements, relevant and consistent with and communicate the	b. The socialization of the program was not carried out properly	There is no planning of scheduled outreach activities	Increasing socialization related to the audit program	the audit system process is running ineffectively	Re-socialize	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018

No	Audit Process	Audit Activity	Objective	Target	Risk	Cause	Preventive Action	Impact	Corrective Action	Refference
				audit process to parties involved in the audit program						
			To assist in running the audit program	Determine the expected inputs, outputs, and outcomes from the processes, criteria, methods, including related performance measurements and indicators needed for an effective audit process	c. The audit is not running according to the system	The audit system is difficult to understand and multiple interpretations	Develop related SOPs	the audit system process is running ineffectively	setting up appropriate methods for reviewing and monitoring the audit process	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization identifies audit program resources	To be able to determine the resources needed in the audit program	Determine the resources needed to ensure correct and reliable monitoring and measurement of results.	The required resources are not available	lack of resource program planning	develop long-term programs that are efficient and in accordance with existing funds	organizational performance goals are not achieved	create a competent human resource fulfillment program in the short term	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
4	Implementing Audit Program	The organization defines the audit objectives, scope, schedule and criteria including the competence of the auditor	To be able to know and carry out audit programs in accordance with audit objectives, scope, schedule and criteria including auditor competence and auditor evaluation process	Defining the scope of the system taking into account external and internal issues, interested parties and the organization's products and services	The organization failed to define the objectives, scope, schedule and audit criteria including the competence of the auditor and the auditor's evaluation process so that the implementation of the audit program did not run smoothly	lack of company competency in defining audit objectives, scope and criteria	study and try to formulate an audit framework	The audit process that causes the process to be too long	improve the competence of the company in implementing the audit program	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization selects an audit method	To determine the appropriate audit method and use	Establish methods to maintain regular audit processes by ensuring discipline as a work culture	The method chosen is not in accordance with the goals and circumstances of the organization	Lack of corporate management commitment	Increase outreach and related training	Irregular maintenance of system processes	Set up appropriate methods to maintain system processes on a regular basis	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization selects audit team members	To determine people who are in accordance with the competence to work in an audit team	Ensure all personnel working for, or on behalf of, the organization are aware of their respective responsibilities, respective authorities, and links between functions/departments	The people who have been selected in an audit team cannot adapt and communicate well with one another	lack of communication from the organization regarding Targets or Achievements to be targeted by the organization	Improving teamwork training programs and communication between teams	Organizational performance goals are not achieved	Conducting audits by combining senior auditors and junior auditors	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization assigns responsibility for the audit to the audit lead	To submit and ensure that the implementation of the audit can be in accordance with procedures and can be accounted for	Assign top management roles in support of other relevant management roles to demonstrate their leadership as applicable to their areas of responsibility	a. The audit leader was unable to carry out his responsibilities properly so that the audit program was neglected	lack of top management sensitivity and contribution to the audit process	top management understands and seeks information related to the audit process in the organization and studies it in detail and clearly	Lack of employee trust in top management	Top management immediately learns and seeks maximum information regarding the ongoing audit process to achieve the results of the audit process	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018

No	Audit Process	Audit Activity	Objective	Target	Risk	Cause	Preventive Action	Impact	Corrective Action	Refference
			To submit and ensure that the implementation of the audit can be in accordance with procedures and can be accounted for	Ensuring top management's commitment to the sustainability of the system which is the starting point for whether the commitments conveyed by top management are consistent with the actual situation	b. Leaders do not clearly know the objectives and audit procedures	Leaders never receive an understanding of the goals and procedures that apply	Provide understanding regarding overall audit objectives and procedures to management	Goals and procedures not achieved	Identifying matters that result in leaders not understanding objectives and procedures and seeking solutions, and providing re-understanding regarding audit objectives and procedures.	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization manages the results of the audit program	To get the final results and conclusions from the audit program that has been implemented	Ensure the results of the audit program are in accordance with actual conditions and existing procedures	The results of the audit program are incomplete making it difficult to draw conclusions	The audit process was not carried out according to procedures	Details the things that need to be audited in detail	Invalid audit program results	Collect data related to the auditee that can be used to assist in drawing conclusions about conducting a re-audit.	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization manages and maintains records of the audit program	To maintain audit program records so that they can be stored and used when needed	Define the documented information system required by the standard and necessary for the effective implementation and operation of the system.	Audit program records are not well maintained (damaged/lost)	negligent in keeping information/records	Keep audit program records in a safe and secure place and have a person responsible for keeping and maintaining the audit program records.	Information/records not available when needed	Conducting analysis on the data obtained to a minimum, conducting interviews with parties related to the records and the audit program	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
5	Monitoring Audit Program	The organization monitors compliance with the audit program, schedule and audit objectives	To ensure that the audit program runs according to plan	Establish a detailed audit program plan	Implementation of the audit program is late, not according to schedule and audit objectives	Lack of commitment from the parties involved	Make a realistic audit schedule and define clear objectives, identify things that can hinder the audit program and prepare a back up plan if this happens	The work is not completed according to schedule so that it can affect the audit program at a later stage.	The implementation of the audit program is carried out immediately, giving a late deadline so that the delay rate is not too high, improving the existing schedule according to the conditions at that time.	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization monitors the performance of audit team members	To ensure that the audit team works optimally	Ensure that the people performing work under the control of the organization are aware of its policies, objectives, contribution to system effectiveness including the benefits of improving the quality of performance, the implications of non-	a. The performance of the audit team is not as expected	human resources lack training and certification	Improvement of training and certification programs for human resources in determining competency and competency criteria	the company's performance is not as planned	Create a competent human resource fulfillment program in the short term	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018

No	Audit Process	Audit Activity	Objective	Target	Risk	Cause	Preventive Action	Impact	Corrective Action	Refference
				compliance with system requirements.						
			To ensure that the audit team works optimally	Establish audit process monitoring procedures	b. The monitoring process is not in accordance with the procedure	Procedures are not detailed, clear, and firm	Setting up a special team for monitoring the audit program, providing training to the audit program monitoring team, carrying out strict selection when recruiting the audit program monitoring team	There are things left to monitor that could cause problems.	Improve the monitoring system urgently.	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization monitors the ability of the audit team to carry out the audit plan	To ensure that the audit team can handle and carry out the audit plan properly	Ensure all personnel working for, or on behalf of, the organization are aware of the implications and consequences of non-conformance with requirements.	a. The audit team had difficulties in dealing with problems that occurred during the implementation of the audit program	human resources lack training and certification	Improve related training and certification programs	The audit process is not going well	Conducting audits by combining senior auditors and junior auditors	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
			To ensure that the audit team can handle and carry out the audit plan properly	Establish audit process monitoring procedures	b. The monitoring process is not running according to the procedure	The personnel involved do not receive an understanding of the monitoring process in place	Setting up a special team for monitoring the audit program, providing training to the audit program monitoring team, carrying out strict selection when recruiting the audit program monitoring team	There are things left to monitor that could cause problems.	Improve the monitoring system urgently.	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization monitors feedback from top management, auditees, auditors and other interested parties	To ensure that every interested party in the audit program is satisfied with the implementation of the audit program	Determine the resources needed to ensure correct and reliable monitoring and measurement of results.	a. There are parties that do not work properly or are not optimal so that it affects the implementation of the audit program	lack of communication from the organization regarding Targets or Achievements to be targeted by the organization	Conduct outreach to resources	Organizational performance goals are not achieved	Implement Award & Reward.	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
			To ensure that every interested party in the audit program is satisfied with the implementation of the audit program	Establish audit process monitoring procedures	b. The monitoring process is not in accordance with the procedure	Procedures are not detailed, clear, and firm	Setting up a special team for monitoring the audit program, providing training to the audit program monitoring team,	There are things left to monitor that could cause problems.	Improve the monitoring system urgently.	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018

No	Audit Process	Audit Activity	Objective	Target	Risk	Cause	Preventive Action	Impact	Corrective Action	Refference
							carrying out strict selection when recruiting the audit program monitoring team			
		The organization assigns responsibility for the audit to the audit monitoring lead	To submit and ensure that the implementation of the audit can be in accordance with procedures and can be accounted for	Assign top management roles in support of other relevant management roles to demonstrate their leadership as applicable to their areas of responsibility	a. The audit monitoring leader was unable to carry out his responsibilities properly so that the audit program was neglected	lack of top management sensitivity and contribution to the audit process	top management understands and seeks information related to the audit process in the organization and studies it in detail and clearly	Lack of employee trust in top management	Top management immediately learns and seeks maximum information regarding the ongoing audit process to achieve the results of the audit process	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
			To submit and ensure that the implementation of the audit can be in accordance with procedures and can be accounted for	Ensuring top management's commitment to the sustainability of the system which is the starting point for whether the commitments conveyed by top management are consistent with the actual situation	b. The audit monitoring leader lacks understanding of audit procedures and objectives	Lack of leadership enthusiasm for understanding the audit process	Provide understanding regarding overall audit objectives and procedures to management	Goals and procedures not achieved	Identifying matters that result in leaders not understanding objectives and procedures and seeking solutions, and providing re-understanding regarding audit objectives and procedures.	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
6	Reviewing and Improving Audit Program	The organization reviews the audit program to assess whether its objectives have been achieved	To ensure that the implemented audit program has achieved its objectives or not	Ensure the results of the review identify decisions and actions relevant to changes to performance, policies and objectives.	The audit program did not achieve its objectives	lack of understanding regarding the audit process and key success factors	Identify the audit process established and adapted to the management review material	The audit results are not right on target	Make improvements to the results of the review	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018
		The organization reviews the overall implementation of the audit program, identifies areas of improvement, changes the program if necessary, reviews the auditor's continuing professional development and reports the results of the review of the audit program to top management	To find out the overall results of the audit program whether it requires improvement, program changes, the level of professionalism of the auditors and ensure that top management gets information related to audit program reviews	Have appropriate processes for managing non-conformances and corrective actions related to quality, safety, occupational health and the environment.	The overall results of the audit program are incomplete making it difficult to identify whether program improvements or changes are needed and unable to report the results of the review to top management due to incomplete results of the audit program	discussion on management review has not yet become a priority scale	Make the main agenda in management review according to management system standards	The results of the management review are not on target	Perform management review improvements	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018

No	Audit Process	Audit Activity	Objective	Target	Risk	Cause	Preventive Action	Impact	Corrective Action	Refference
		The organization uses the results of the review of the audit program as input for the program's continuous improvement process	To improve audit programs in the future by taking lessons or knowledge from the results of previous audit programs	Have appropriate processes for managing non-conformances and corrective actions related to quality, safety, occupational health and the environment.	The results of the audit program review are missing/damaged	negligent in keeping information/records	Keep audit program records in a safe and secure place and have a person responsible for keeping and maintaining the audit program records.	Information/records not available when needed	Look for data that can help to get information on audit results	Retno, 2019; Dewi 2019; ISO 2015; ISO 2018

After the audit and risk management processes for high-rise buildings with design and build contracts have been validated and acceptable, the data can be used for the preparation of pattern recognition which is arranged from left to right with the sequence of activities (X), objectives (T) , targets (S), preventive actions (TP), causes (P), risks (R), impacts (D), and corrective actions (TK).
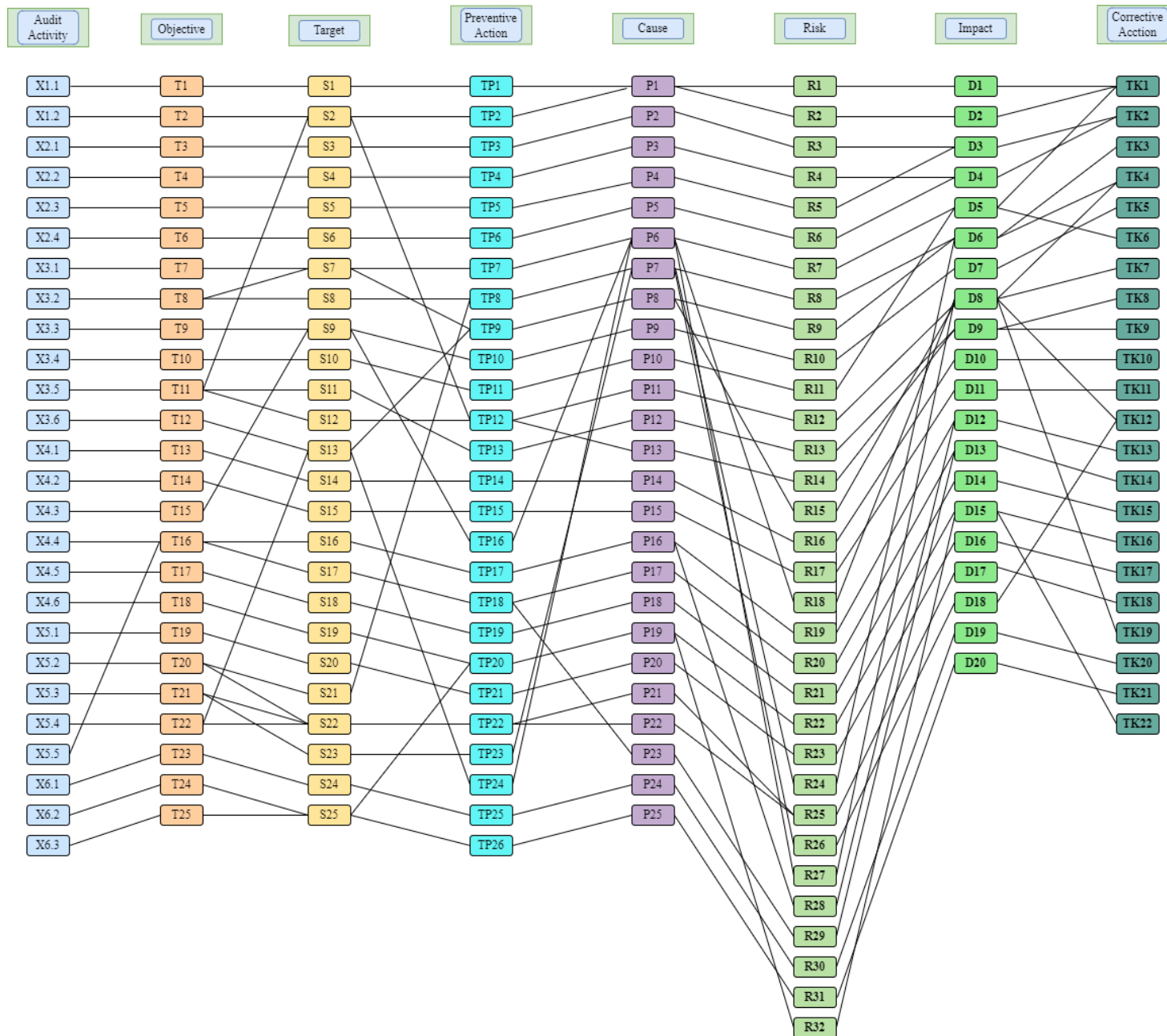
Figure 2. Pattern Recogintion Audit Process for High-Rise Buildings with Design and Build Contracts

V.   CONCLUSION AND SUGGESTION

Based on the results of the research that has been done, there are 6 safety audit processes, namely establishing an objective audit program, determining and evaluating audit program risks and opportunities, establishing audit program, implementing audit program, monitoring audit program, reviewing and improving audit program. From each of these processes there are activities, objectives and targets for the work safety audit process in high-rise buildings with design and build contracts. In addition, risk management strategies for each of these activities (impact, causes, preventive actions, corrective actions) can be used to improve construction safety in high rise buildings with design and build contracts. Pattern recognition audit process for high-rise buildings with design and build contracts has been compiled to become a knowledge base on the audit process.

For further research, this knowledge base can be used to develop knowledge management in the audit process for high rise buildings with design and build contracts. The development of knowledge management can be done by developing an information system for sharing knowledge and applying knowledge. The information system used can be in the form of a website that can be used by auditors to improve construction safety performance in high rise buildings with design and build contracts.

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