A conceptual framework for the process protocol of integration quality, safety, health and sustainable construction management systems for infrastructure projects in Indonesia

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Abstract. Construction accidents on infrastructure projects in Indonesia from 2017-2021 have increased by 5.65% from previous years. Construction accidents that result in property damage, death or injury to both workers and the public, pollution and environmental damage cause sustainable development goals not to be achieved. Construction accidents are not only focused on the impacts, but it is necessary to explore how the incident occurred. This is the basis for the need to integrate quality, safety, health and sustainability in construction. The current construction safety management system is not yet integrated with other management systems. This paper aims to develop a conceptual framework in the process of integrating construction quality, safety, health and sustainability management systems. Development of a conceptual framework based on literature review, ISO standards and existing construction safety planning guidelines. The development of this conceptual framework is part of a research proposal that is being formulated to develop a process protocol for integrating process of construction quality, safety, health and sustainability management systems in infrastructure projects. This process protocol can simplify the complexity and overlapping of the processes of each management system so that it is easier to understand and to implement by all project stakeholders.

1 Introduction

1.1 Backgrounds

According BPJSTK (2021), construction accidents in Indonesia as of 2021 have reached 234,270 cases and this number has increased by 5.65% from the previous year of 221,740 cases. Several cases of infrastructure project accidents such as girder collapses, crane overturns, formwork collapses and recent material landslides cannot be separated from technical, human resource and organizational failures in managing projects.

Accidents need to be analysed from how the incident occurred, not only from the results of the incident. In the opinion of [1, 2], structural failure occurs due to the development of deformation and structural fracture because the structure is not designed properly or is not built according to design, apart from that it is also indicated by other failures such as the use of inappropriate materials. Structural failures often occur due to human errors made during the design process. Errors in the design process could be viewed from personnel factors are caused by the level of ability, experience, accountability, or personality type of the design consultant. Meanwhile, if we look at organizational factors, it is caused by lack of education or training, lack of competent resources, professionalism, and use of technology. If we view from project-related factors, human error can be caused by inaccuracies in determining the scope of work and there is no integration between design and other consideration factors [3]. Lack of workmanship in a construction can result in defects resulting in changes in appearance and other examples because lack of attention to foundation design can cause ground movement, which is characterized by cracking of brick walls, changes in construction and possibly also by sagging roofs and changes in the shape of the building. Work that results in a defect can be described as work that does not meet the description or requirements of the contract, in particular the drawings or specifications, with all that implies, quality, workmanship, performance, or design [4].

Failure can also occur during the expected service life of a structure, for example the collapse of bridges and other structures due to lack of maintenance after years of construction [5]. Whittington et al (1992) stated that accidents are initiated by a series of failures from accident events which combine individual and organizational factors as causes of construction accidents. This theory also assumes that accidents in construction projects result from failures initiated by workers, management in the field, project management and organizational policies. Reason (1991) also stated that failures in the system can trigger unsafe conditions and behaviour in operational areas, for example operators commit negligence and

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violations in dangerous areas which allows incidents and accidents to occur [6].

Construction accidents result in increased direct and indirect costs. Direct costs include insurance costs, workers' medical costs, and costs of loss or damage to property, while indirect costs include increased transportation costs and fines for late completion [7-10]. Work accidents have an impact not only on workers but also on their future and their families. Efforts to prevent construction accidents can be mitigated by planning an effective construction safety management system [11]. Construction accidents in the form of property damage, death or injury to workers and the public, pollution and environmental damage cause sustainable construction goals not to be achieved. The concept of sustainable construction is still a global issue to be discussed in the construction sector.

In addition to having to meet reliability, safety and health standards, construction projects must also meet sustainability standard. Some previous researchers [12-15] incorporated construction sustainable indicators into construction management practices to achieve project success. Construction sustainability assessments need to be reviewed throughout the project life cycle starting from the pre-construction, construction, operation, maintenance and demolition phases [16]. Factors related to occupational safety and health [17-19], factors related to construction quality [20, 21], socio-technical considerations [22] and lean construction principles [23] can be taken into account as factors that influence project success to create sustainable construction.

By reviewing how defects and failures occurred and even causing construction accidents which result in loss of reputation, damage to assets and property, as well as environmental damage, this becomes the basis for considering the need to integrate quality, safety, health, environmental and construction sustainability management systems. It resulted a few research questions which are:

1. What is a more appropriate integration approach in integrating elements in the quality, safety, health and sustainability management system into an integrated management system?
2. How to integrate processes that are fragmented in the quality, occupational safety and health, environmental and sustainability so that it become integrated processes?
3. What are the duties and responsibilities of each organization in implementing an integrated management system at the conceptual, planning, design, selection, implementation, supervision, operational, maintenance and demolition phase?
4. What are the integrated risks that impact buildings, workers, environmental and social factors?
5. How can a more comprehensive risk assessment methodology be developed?
6. How are the integrated documents in the implementation of the integrated management system at the conceptual, planning, design, selection, construction, supervision, operational and maintenance and demolition phases?

So therefore, this study aims to develop a conceptual framework in the implementation of integrating construction quality, safety, health and sustainability management systems.

1.2 Integrated management system

Integrated management system is a system that integrates various management functions needed to support business operations into one comprehensive management system involving organizational structure, resources and procedures including planning, implementation, monitoring, and controlling aimed to be able to improve the company's business performance. The integrated management system must also adopt the Plan-Do-Check-Action concept as an effort to continuously improve as a management system. Seghezzi explained that there are three different ways of system integration, including addition, merger and integration. In “addition”, the partial systems for quality and environmental management are separated and described in separate documents but their content is made comparable. In ‘‘merging’’, work instructions are fully integrated, but not procedures and manuals, an overall management system is created but partial systems are still visible. In "integration", companies can select or develop a basic management system as their general system and include all partial systems in it" [24].

Wilkinson and Dale also describe a four-level model for integrating management systems. The first level of management systems and functions is still separate. The second level is a combination of systems based on the relationships identified between one management system and other management systems. Documentation is combined and integration into each function is still required. The third level involves integrating selected parts of each management system with other certified management systems, but without using the identified relationships. The fourth level is to integrate certified and non-certified systems with the overall management system with policies and objectives aligned and supporting the organization's overall strategy, policies and business objectives. Kirkby stated that there are three possible management system models, including separate, parallel and integrated management system models. The first level is “separate”, where management systems cover their own distinct areas for each set of requirements. The second level is “parallel” where the management system utilizes standard areas and all common elements such as management reviews and internal audits are directed to the same system. The final level is "integrated" which combines all standards into one common management system. Karapetrovic (2002) concluded that there were three types of organizations that were found to only integrate documentation, equalize core processes, objectives and resources, and finally have all parts of the management system integrated in one management system. The process is summarized where two levels can be defined, the first is "partial integration" which ranges from simple collaboration to the alignment and compatibility of objectives, processes and resources of

separate management systems and the second is "full integration" in where management systems lose their unique identity, resulting in incomplete integration into a multifunctional integrated management system. The same opinion from Beckmerhagen et al (2003) suggested system integration at three levels. The first level, "harmonization", namely harmonizing management systems, an organization partially integrates documentation. The second level, ‘‘cooperation’’ denotes joint system improvement using integrated audits and resources. The third level is "integration" meaning that one management system and other management systems are combined into a comprehensive integrated management system [25, 26].

It is possible to integrate quality and safety management systems, which has been done in previous studies. Theoretical studies were carried out by looking at the similarities in the ISO 9001 and OSHA 18000 management standard clauses [27-29] while empirical studies were carried out by investigating the relationship between factors that influence quality and safety. Quality and safety are interconnected with each other and the presence of defects or rework carries a risk of work accidents [30-33]. Some elements that can be integrated are implementation objectives, policies, management commitment, organizational structure and responsibilities, human resources, training, processes, work instructions, investigations, communication, company safety climate and culture, audits and documentation [34]. The benefits of integrating quality with safety are that the implementation of the management system becomes more optimal, there is increased competitiveness, and resource utilization becomes more efficient. To integrate quality and environmental management systems, which has been done in previous studies.

The similarity or suitability of the clauses in the ISO 9000 and ISO 14000 standards is the basis for integrating these two management systems. Based on the similarity or suitability of the clauses, the elements that can be integrated include policies, goals and objectives, processes, work instructions, audits, management reviews, corrective actions, communication and documentation. The reduction in waste from production results is due to the "zero defects" concept with the implemented quality management system which can further improve the company's reputation [35]. The benefits of integrating quality and environmental management systems can improve company performance, increase productivity, reduce costs and waste, increase customer satisfaction, improve company reputation, reduce duplication of procedures, save on resource use [36].

Quality, safety, health and environmental (QHSE) management systems make it possible to be integrated due to the suitability of elements in the ISO 9001, ISO 14001 and OHSAS 18001 standards [37-41] and ISO 45001 [42]. Some previous researchers also proposed efforts to QHSE management systems to realize sustainable construction based on ISO 9001, ISO 14001, OHSAS 18001 and ISO 45001 [43, 44]. Elements that have similarities between systems include policies, goals and objectives, organizational structure responsibilities, documentation, planning, records, resources and infrastructure, control and action, workforce, communication, continuous improvement, corrective action, process control, maintenance and calibration, integration management guidelines, training, operational procedures, nonconformities, as well as internal and external audit policies. The benefits of QHSE integration are increasing the effectiveness of the management system, reducing costs, goals can be aligned, eliminating conflict of responsibilities between departments and simplifying management standards increasing work productivity, reducing resources, internal audits can be unified, increasing training, reducing duplication of documentation, reducing bureaucracy, system better communication, the company's competitiveness increases and can increase compliance with regulations and the impact of integration which reduces accident incidents, environmental related issues and improves quality.

Integration also has a significant impact on the sustainability of construction project management, especially reducing economic, social and environmental risks, organizing good, transparent and accountable organizations, optimizing resources, implementing rewards and punishments and developing new technological innovations. Meanwhile, the difficulty in integrating these three management systems is that each management system has different targets and the safety and health management system is "forced" to conform to the other two management systems. The success of integration is influenced by the company's internal will, ability to make improvements and external factors that influence the process. Leadership commitment and awareness are the most important factors within a company to achieve increased sustainability. Policy and planning are the most important factors in the success of implementing the integration process.

Two integration models were proposed by [44], namely clause-based and process-based integration models. However, the process-based integration model in his paper is not explained for the reason that it is considered not much different from the clause-based integration model and process integration also depends on the management system implemented by the organization. This means that the integration process is not described and explained by him and is a matter for future research in developing an integration process that can be standardized.

Some previous researchers adopted the risk management framework into the implementation of management system integration. Zeng developed a quality, safety, occupational health and environmental risk assessment methodology for contractors in implementing an integrated management system based on the Plan-Do-Check-Action concept. This integrated risk assessment was carried out using the Failure Mode Effect and Analysis (FMEA) method. Williams and Bertsch integrated risk management systems with quality and concluded that factors that influence quality simply can be assessed as identified risks such as risks that exist at the operational stage. Quality does not play a role in managing unidentified risks. The risk management

system can also be integrated with other management systems. Sánchez and Lopez identified, classified and assessed construction sustainability risks. Sustainability aspects include environmental aspects (land, water, air, biodiversity, resources, energy), social aspects (culture, accessibility, participation, security, public facilities and social integration) and economic aspects (costs, technical requirements, bureaucracy, economics). social, and heritage/historical heritage) [45]. However, not many discuss the adoption of the risk management process into an integrated management system starting from conceptual, planning, implementation, operations, maintenance to the demolition stage. It is important to examine how risk management is implemented throughout the project life cycle.

1.3 A review of construction safety management system guidelines in Indonesia

The current construction safety management system guidelines still separate a few management systems such as quality, safety and health, environmental and sustainability management systems where the processes, tasks and responsibilities of the organization and documents are still fragmented so that these elements become complex and overlapping. By referring to the management system integration theory according to Seghezzi, it can be assessed that Indonesia's construction safety management system is currently not yet an integrated management system among its partial management systems. The construction safety management system only "adding" or "merging" of its partial management systems. It is necessary to integrate and to simplify processes, organizational responsibilities and documents in implementing an integrated construction safety management system.

This also requires a comprehensive safety risk assessment methodology starting by including design safety risks at the pre-construction stage, work safety risks at the implementation stage, safety risks at the operational and maintenance stages and safety risks at the demolition stage. By considering sustainability standard which are one of the construction safety standards, it is necessary to identify construction sustainability risks as well by examining failure risks in economic, social and environmental sustainability as hazards or residual safety risks that need to be identified and evaluated so that the construction safety risk assessment is more comprehensive and integrated.

Besides that, the implementation of the construction safety management system in Ministerial of Public Works and Housing Regulation No. 10 of 2021 is explained only at the conceptual and planning, design, selection, implementation and supervision phases. It is necessary to transform into an integrated phases from the pre-construction, construction, operation, maintenance to demolition stages that can be implemented and complied with by all project stakeholders, including clients, contractors, sub-contractor, feasibility study and planning consultants, design consultants, supervisory consultants, suppliers and the community.

2 Research methodology

This study is qualitative research with deductive reasoning. It was begun by identifying problem statements by analysing regulation and reviewing literatures of previous studies related to integrated management system.

To develop a conceptual framework was conducted by analysing Ministerial of Public Works and Housing Regulation No. 10 of 2021 concerning Construction Safety Management System Guideline. The next step is to analysis the conformity of the clauses among ISO 9001:2015, ISO 45001:2018, ISO 14001:2015, ISO 31000:2018, ISO 37101:2016 and ISO 55001:2014. ISO 9001:2015 focuses on increasing customer satisfaction, ISO 45001:2018 focuses on eliminating hazards and minimizing the risk of work accidents, ISO 14001:2018 focuses on achieving environmental values for stakeholders and society, ISO 31000:2018 provides a risk management framework for any industrial sector. ISO 37101:2016 focuses on achieving sustainable development targets, meanwhile ISO 55001:2014 focuses on achieving asset management targets.

To identify the duties and responsibilities of organizations in the study using the 2015 Construction Design and Management (CDM) regulations which are regulation-based operational guidelines that help project stakeholders including clients, design consultants, principal design consultants, sub-contractor and principal contractor in carrying out the construction process starting from the pre-construction until the project is completed and equipped with rules that determine the duties and obligations of stakeholders in implementing occupational safety and health management.

Meanwhile, to identify safety risks at the pre-construction, construction, operational, maintenance and demolition phases in this study, the Construction Hazard Assessment Implication Review (CHAIR) method is used. CHAIR is a method that facilitates discussion with the aim of inviting the project stakeholders involved to jointly identify integrated risks that have the potential to occur during pre-construction, construction, maintenance, renovation and demolition in developing a safer design.

3 Results and discussion

Developing a conceptual framework is an important first step in conducting research. By seeing at the current guideline of implementing construction safety management systems in Indonesia, where construction safety management system is not yet integrated. The construction safety management system is part of the construction work implementation management system to ensure construction safety. Construction safety standards include construction security, safety, health and sustainability standards. This means that the construction safety management system combines quality, safety, health, environmental and construction sustainability management systems. However, implementation is still fragmented.

Furthermore, the construction safety management system is transformed into an integrated management system. Ministerial of Public Works and Housing Regulation No. 10 of 2021 concerns construction safety system guideline, describes the implementation of a fragmented construction safety management system with other management systems combined and of course some elements of this system are duplicated and overlap with each other. The duties and responsibilities of each organization as well as implementation documents are also not clearly defined. Therefore, it requires a process protocol that is lean, clearly defined throughout the project cycle and easy to implement and understand by all project stakeholders.

Protocols can be considered as references or guidelines that must be adhered to by parties involved in organizing these activities. By using process modeling, some complex processes can be easily broken down into processes that are easy to identify and easy to understand. A process protocol is a modeling tool that is capable of representing stakeholder interests in a process, providing flexibility and clarity that allows activities to be formulated into a framework called standardization. This framework encourages users to understand processes more easily, problems can be identified, improvements can be made in communication and coordination, control and management of resources in order to adopt a shared vision.

The development of construction quality, safety, health and sustainability management system integration process protocols is based on an analysis of regulations, guidelines and ISO standards. the conformity of the clauses in ISO 9001:2015, ISO 45001:2018, ISO 14001:2015, ISO 31000:2018, ISO 37101:2016 and ISO 55001:2014. Some of the compatibility clauses among ISO are as follows goals and objectives, leadership, organizational responsibility and authority, risk management planning, resources, communication, documentation, operational procedures, control, audit and continuous improvement. Besides that, the state of the art management system elements that allow for integration are as follows goals and objectives, leadership, organizational structure, planning, procedures, use of resources, audits, documentation and management reviews.

The duties and responsibilities of organizations in this study using the 2015 Construction Design and Management (CDM) regulation which are regulation-based operational guidelines that help project stakeholders including clients, design consultants, principal design consultants, sub-contractor and principal contractor in carrying out the construction process starting from the pre-construction until the project is completed and equipped with rules that determine the duties and obligations of stakeholders in implementing occupational safety and health management. Meanwhile, safety risks at the pre-construction, construction, operational, maintenance and demolition stages in this study, the Construction Hazard Assessment Implication Review (CHAIR) method is used. It could be facilitated by discussion with the aim of inviting the project stakeholders involved to jointly identify integrated risks that have the potential to occur during construction, maintenance, renovation and demolition in developing a design.

Safety plan on feasibility study and planning, safety plan on design, construction safety plan, supervision safety plan, quality program for supervising, construction work quality plan, environmental control and monitoring plan as well as work traffic management plan also needs to be analyzed to formulate an integration process starting from pre-construction to demotion phase. The following is the conceptual framework of the research shown in Fig. 1.

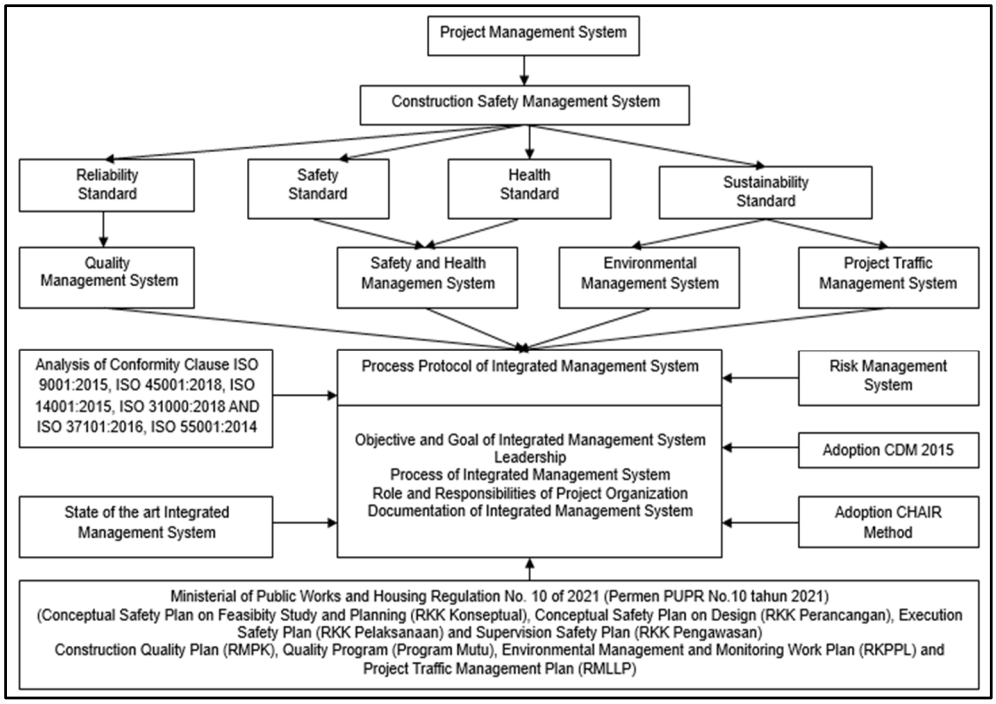

Fig. 1. Research conceptual framework

4 Conclusion

The current construction safety management system cannot be said to be an integrated management system in terms of goals and objectives, leadership, organizational duties and responsibilities, processes and documentation which are still fragmented between partial management systems, giving rise to overlapping and duplication. The construction safety management system only "adding or combining" partial management systems such as quality, occupational safety and health, environmental and construction sustainability management systems. Implementation of the construction safety management system is carried out throughout the project life cycle, starting from the pre-construction, construction, operational and maintenance stages to demolition. Meanwhile, the implementation of the construction safety management in the guidelines is only at the conceptual and planning, design, selection, implementation and supervision stages. The need to review the implementation of the construction safety management system at the operational, maintenance and demolition stages. Opportunities and impacts of risks in construction safety planning in safety management guidelines require a more comprehensive methodology and need to include safety risks in design components, risks at the maintenance and demolition/demolition stages. In addition, considering that sustainability standards are part of construction safety standards, it is necessary to include economic, social and environmental sustainability indicators as residual risks that need to be identified. Existing studies related to integrated management systems have not been able to provide solutions to research problems, so they require a novelty to integrate quality, safety, health and construction sustainability management systems with different framework. A conceptual framework as rationale thinking for developing a lean process protocol to integrate quality, safety, health, and construction sustainability management systems in the future research

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