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Sustainability in Construction Work: A Perspective on Accidents and Building Failure Mitigation in Indonesia

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Abstract. Sustainability in construction sector implementation depends to a wide range of level at national, regional, and local level. Also, it depends on the social and cultural aspect. Construction site safety is an essential aspect of sustainable construction. This paper proposes to identify the causes of accidents and building failure; to mitigate construction safety and building failure, and to describe the development and implementation of safety construction in order to improve safety culture according to the Law of Indonesia Republic No. 2/2017 of Construction Service and Decree of Minister of Public Works and Housing No. 21/PRT/M/2019 of Implementation Guideline of Construction Safety Management. Furthermore, the awareness of d from considering the underlying causes of accidents. This paper suggested, for the prevention of COVID-19 control and the accordance of construction safety; the optimization of digital services in coordination, supervision, control, and administrative governance is urgently needed. Moreover, the development of information technology and legal basis are required to achieve zero construction accidents and high quality infrastructure for both the service providers and users.

1. Introduction

Sustainable development has promote prosperity, economic opportunity and protection to environment. The sustainability issue in the construction sector, as this construction causes large impacts on the environment[1], yet it also give great contributions in a socioeconomic growth[2]. However, the construction sector is one of the highest risk [3], for example, Korea has the highest percentage of workplace accidents of 25.3% [4], US[5]and Australia [6] are the third and fourth-highest. In Indonesia, number of construction accidents and building failures is slightly increased according to the report data from the construction safety committee [7]. As in Indonesia, it is reported that from 2017 until 2020 (September), construction accidents and building failures are increasing from 8 to 15 cases, and 1 to 4 cases, respectively. In response to this condition, the



committee charged with several tasks that imply to put forth a number of policy recommendations thoroughly. For instance, conducting monitoring and evaluation within the major construction risk, conducting construction accident investigations, providing advice, considerations, and recommendations as risk mitigation to achieve construction safety first. The objective of this study is: 1) to identify the underlying causes of construction accidents and building failure occurrences; 2) to mitigate construction safety and building failure, and 3) to describe the development and implementation of safety construction in order to improve safety culture in Indonesia. The study was conducted through an extensively literature review of accidents, safety and building failure-related articles. Also, expert interviews were conducted to validate the regulations application for safety management policy in Indonesia. The approach of this study was mostly interpretive, with addition supporting element of the references.

2. Infrastructure Program in Response to COVID-19 in Indonesia

Indonesia's development program, *NawaCita* program, has 5 (five) main directives including the development of human resources and infrastructure development as a driver of local, regional, and national economic growth [8]. However, the COVID-19 disease was a great worldwide concussion and resulted in a global pandemic. Taking that on a serious note that COVID-19 is a non-natural disaster and requires breakthrough steps from altogether parties [9].

To encounter this global pandemic, the state expenditure budget (APBN) is an instrument that is highly expected in 2020 to revive national economic recovery during the COVID-19 pandemic conditions. Ministry of Public Works and Housing as a governmental institution embeds the greatest budget devises several breakthrough responding intending to improve the continuity of logistics, supporting economic recovery, supporting food security, and reducing unemployment. Several programs to achieve those goals during pandemic include: 1) Construction of road and bridge facilities, 2) Construction of COVID-19 handling facilities, 3) Rehabilitation of facilities for education, worship, economy, and tourism. 4) Construction of dams and irrigation networks; 5) Labour-intensive program as we called *Program PadatKarya* in 34 provinces in Indonesia, which estimated to engage more than 28000 local-labours within 3 months [10] in repairing and increasing the capacity of infrastructure, housing, and environment, 6) Infrastructure development in the National Tourism Strategic Area which including the arrangement infrastructure and amenities, and 7) Provide more opportunities for small and midscale industries (*UMKM*) and small scale contractors to developed required quality infrastructure.

The result of the construction service delivery standard should be viewed from both object and subject's perspectives. The process and output of construction services is fundamentally interconnected in a series of each stage from the work of assessment, planning, design, development, operation and maintenance, demolition, and reconstruction. It is mandatory to follow engineering principles and regulations as a form of guarantee and control of construction service implementation. In addition to taking particular attention to work integration considering the aspect from business entities, labour, and supply chains to pursue a strong, competitive business structure and guarantee the quality of construction service results. From the subject's view, it is necessary to consider the capacities and capabilities of manpower, labour productivity, equipment productivity, business entity productivity, construction service productivity, professional value, and ethical value to establish human resource excellence.

3. Construction Accidents, Building Failures Occurrence and Safety Culture

During the construction phases, accidents could occurs within its stages. A study on construction safety by Szymberski [11] had determined the best time for consideration of construction safety in the project cycle. He developed a curve of time versus safety influence. Within this curve, he suggested that the most suitable time to consider the construction safety is in the beginning stages of conceptual, feasibility and preliminary design phase (Figure 1). This curve shows that during a construction project lifecycle, the ability of influence on construction safety will gradually decreased concept down to the

start-up phases. The potential for construction accidents may be coming from the planning/conceptual design stage, the design stage (detailed engineering along with technical specifications), the selection (procurement) stage for service providers and supervisory, the construction stage, and the work completion stage before being submitted to the end-user [12]. It is also stated in Government Regulation No. 22/2020 [26] that the output of lifecycle construction project that entails planning, design, implementation, supervision and/or operation and construction management obligated to meet engineering, security, safety and health, and sustainability standard, abbreviated in Bahasa Indonesia language as K4 standard.

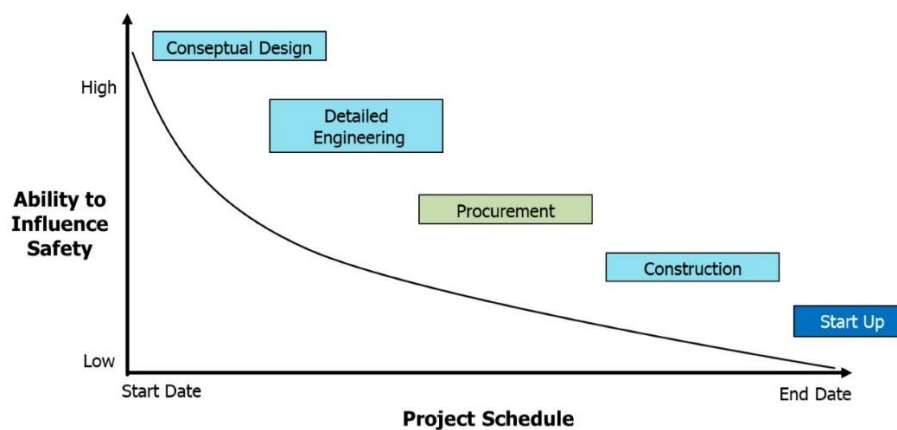


Figure 1. Correlation between project schedule (time) and ability to influence safety[11]

Causes of failures and collapses fall into five general areas, namely design deficiencies, construction deficiencies, material deficiencies, administrative deficiencies and maintenance deficiencies[13]. Failure during planning has the potential to cause construction accidents, especially in projects with a general conceptual design and has been settled long before the construction stage. To prevent the failure occurrence, technical justification from contractors and supervisors at the construction stage is needed. Of course, this technical justification should consider the design and calculation, and conducting consultation with the designer and the job owner.

In responding to the construction accidents and building failures occurrence, the maturity level of the safety culture in Indonesia's construction industry is still at a reactive level which indicated by (a) the system runs in case of a previous work problem or accident; (b) not solution-oriented; (c) off responsibility; (d) accident investigations only focus on the human error; (e) lack of detail analysis due to accident investigations; (f) poor conscious for the context of incident notice; (g) Inadequate to conduct regular job training; (h) the level of quality, health, safety and environment(QHSE) communication has been settled but still need to be improved; (i) poor regulation compliance; (j) the implementation level of hazard identification, risk assessment and control, and work hygiene and worker health is still in reactive level; (k) lack of consciousness in terms of the importance of personal protective equipment (PPE) as preventive tool; and (l) audit conduction occurs due to problem occurrence not as a regular stage to obtain qualified evaluation.

Another concern on infrastructure as stated in the Law of Indonesia Republic No. 2/2017[14] of Construction Service is about building failure. It is stated that building failure as a condition of building collapse and/or malfunctioning of the building after the final delivery of the results of construction services. The responsibility of those building failure incidents can be charged to the service users and/or providers.

The essence of an engineering investigation of building failure is to determine the cause not only the failure mechanism but the procedural causes and contributing factors as well[15]. These findings are in alignment with previous studies[16,17,18]opined that the causes of collapse of

structures in the constructions are as follows: poor materials and workmanship, design and construction errors, absence of professional supervision of site-works, wrong implementation of construction methods, and neglecting of approved design procedures. They asserted that if the right procedures are followed in the design, construction and operation of the structures, construction failures can be prevented.

The Decree of Minister of Public Works and Housing No. 21/PRT/M/2019 [19] is clearly stated that this construction safety management system is applied in all stages of cradle to grave implementation of construction services, beginning from the recognition, planning, design, procurement stages, construction preparation stages, construction stages, first handover job (PHO) stage, maintenance and final handover of work (FHO). Application of construction safety management system in The minister's Decree [19] and supported by Decree of Minister of Public Works and Housing No. 14/PRT/M/2020 of Standard and Guideline for Service Procurement through Service Providers [20] regarding the standard of service goods procurement documents, the cost of implementing safety management system in construction work is outlined in 9 cost components and must be included in the list of quantities and prices with the appropriate amount by necessity. Considering the impact of project delay, construction accidents can result in critical contracts. Both Decrees [20] and sub-attachment c of Decree [19] are stated that service users must provide a written warning or enforce critical contract provisions for providers who causing work delayed and conducting a show cause meeting to deliver physical achievement targets. For critical contracts, compensation can be bestowed by the provider through work completion opportunity with the setup conditions in the addendum contract.

Then the impact of cost overrun is caused by a quality defect and procurement process defect. It indicates a loss to the state that implies criminal charges. In terms of construction accidents due to a quality defect, the provider is obliged to repair the quality defect during the contract period at the request of the service user or job supervisor. By looking at the responsibilities and authorities of service users and providers, construction accidents and building failures have the potential to cause disputes between users, supervisors, and service providers. As an effort to resolve the disputes, all the parties are obliged to take into account to resolve the disputes with the deliberation principle to reach consensus. In the case of building failures, as stated in Law of Indonesia Republic [14] of Construction Service and strengthened in Decree of Minister [20] that the provider is responsible for no more than 10 years in the coverage period for building failure, unless the losses incurred are the result of mistakes or negligence of the service user.

4. Mitigation of Construction Accidents and Building Failure

The construction accident and building failure is a series of failure management systems and engineering failures. Considering those indications, to increase the safety culture, requires improvements in its safety management system, accident investigation [21], communication, and commitment. Some problems found in the incident investigations are property damage and poor design to construct [22]. To overcome the design problem, it is necessary to evaluate design engineering and to convey the reliability design by proper and sufficient investigation, to supervise the selection of construction methods according to the various factors in the field, and maintain the coordination and communication to deliver instruction and information. Those are the component of systemic management which involves all project's manpower to handle during the pre-construction and construction period. Several things consider to be causes problems in building failure in Indonesia as reported in investigation by the safety construction committee including:

- Planning fallacy, bad design, error calculation, and improper material or material selection, that imply miscalculating of load-bearing and misplacement of columns;
- Construction fallacy may be caused by structural failures such as non-bonding reinforcement structure and imperfect welding works;
- Foundation failure, not consider the conformity between the foundation and soil type;

- Operational and maintenance guidelines have not been settled. The documents should help to recognize the safety implementation based on the design built;
- Negligence in infrastructure utilization, not tackling live load capacity in the building into account and inaction in utilizing roads;
- Negligence building maintenance, not providing fire hydrant, not maintaining building piping and electrical system and/or road preservation.

Factors that would help to checkmate the incidence of structural failure at pre-construction and post-implementation phases of construction development:

- Strict adherence to code of practice;
- Determination of bearing capacity of soil before design;
- Getting approval before commencing construction on site;
- Project Control Officials should ensure compliance with approved project plans;
- Adequate supervision;
- Carrying out proper site investigation;
- Strict conformance to working drawings;
- Prohibiting the use of quacks and adherence to specification.

5. Safety Culture and Sustainable Infrastructure Principles

Sustainable infrastructure as stated in Decree of Minister of public work and housing[8] is an approach to create a broad process/mechanism for the realization of physical facilities that supports development that considers sustainable principle including economic, social, and environmental aspect. This applied for component material and natural resources (land, energy, water, material, and ecosystem), methodology in every stage of the construction project cycle.

The sustainable principle as referred in the Decree[8] provides a more comprehensive framework as follows:

- Settle the common goals, understanding, and action plans that views as fundamentally interconnected;
- reduce the usage of natural resources;
- reduction of waste generation, both physical and non-physical;
- utilize resources component by reusing previous material;
- use of recycled resources;
- preserve the environment by applying holistic thinking as regards construction and management of the built environment, taking a lifecycle perspective;
- mitigate the safety, health, climate change and disaster risks;
- apply the life cycle orientation;
- pursue the development in order to achieve the desired quality;
- perform innovative and appropriate technology; and
- Implement the nexus approach of institutional support, leadership and management, e.g. [23,24,25].

Construction accident and building failure is a series of failure management systems and engineering failures. In response to the need for mitigation of safety, health, climate for the sustainability of construction service to encounter COVID-19 pandemic issue, the public work and housing Minister publish Circulation Letter No. 18/2020[9] to arrange the implementation of new habit adaptations in construction services that regulates several things: 1) workplace and health protocols during the construction consultancy and construction work period, 2) online system to conduction procurement process and the mechanism of rebuttal submission, 3) contract adjustments protocols due to the implementation of the COVID-19 protocol. It is stated in the contract adjustment protocol should attach a construction safety plan document that entails the recommendations for construction safety needs. In terms of the material/equipment and technical specification alteration, it requires to attach technical specification adjustment and term of reference (TOR) that implies method adjustment. A

price adjustment may be implied, it is necessary to adjust the contract price by referring to the effective efficiency principle. And 4) furthermore, if necessary, contract period adjustments can also be made, either to terminating due to force majeure or adjusting the contract performance period. Regarding the K4 standard compliance, risk mitigation is required and should be applicable in the field, which included in the hazard identification, risk assessment and opportunity (HIRAO), preparation of work methods/work procedures, preparation of work implementation plans or commonly known as work method statements and jobs safety analysis for high risk works. The documents must be compiled by a design consultant, construction management consultant, supervisory consultant, and the contractor as an executor of construction work. The compliance of K4 standard is manifested to pursuit the implementation of construction safety for the development of a sustainable infrastructure (Figure 2).

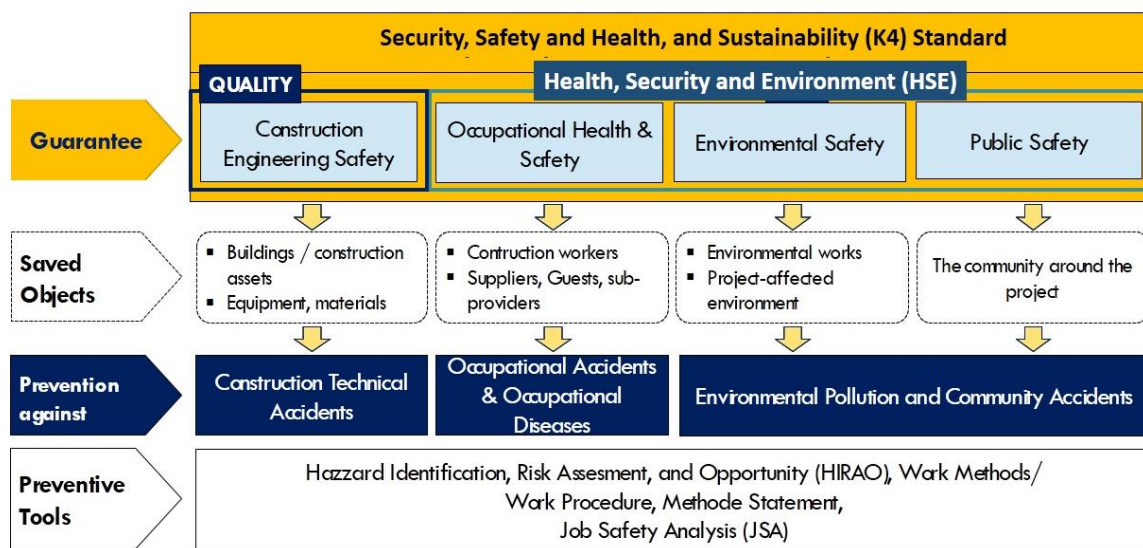


Figure 2. Diagram of K4 standard in the implementation of construction safety for the development of a sustainable infrastructure. Source:[14,19]

Sustainable infrastructure as stated in Decree of Minister of Public Work and Housing [8] that consist of 12 (twelve) points of sustainable principles which covers economic, social, and environmental aspect to accelerate the development in Indonesia (Table 1). Fulfillment of K4 standard (no.12) within the principles of construction sustainability in Table 1.

Table 1. Principle of Construction Sustainability

No	Component
1	Having goals, understanding and action plans in common
2	Reducing the use of resources, in the form of land, material, water, natural resources and human resources
3	Reduction of waste generation, both physical and non-physical
4	Reuse of resources that have been used previously
5	Utilization of recycled resources
6	Protection and management of the environment through conservation
7	Mitigation of safety, health, climate change and disaster risks
8	Life-oriented
9	Orientation towards achieving the desired quality

10	Innovative technology for sustainable improvement
11	Institutional support, leadership and management in implementation
12	Fulfillment of security, safety and health, and sustainability (K4) standard

Source: [8]

The Minister of public work and housing has highlighted the importance of relaxing regulations to improve services to the community, without neglecting the quality control of work as part of consumer protection. Construction safety derives thorough engineering activities to support construction work to enhance the K4 standard [19,27]. And also, to ensure construction engineering safety, workforce safety and health, public, and environmental safety [19]. As stated in Government Regulation No. 22/2020 [26] that entails in Decree of Minister of public work and housing No. 21/PRT/M/2019 [19] that the safety standard occupied in building reliability based on design standard; safety and health standard encourage to guarantee and protect occupational safety and health; and sustainability standard to ensure sustainability in economic, environmental, and social aspects.

6. Conclusion and Recommendation

To fulfil the inquiry of safety construction included in K4 standard, it is necessary to consider the following aspect: (1) construction engineering safety requires compliance standard in planning, design, procedure, material quality, equipment feasibility standard, and the quality of the results of the implementation of construction services which include buildings and construction assets. The fulfilment of construction engineering safety is oriented to prevent construction accidents; (2) occupational health and safety (OHS) is the fulfilment of workforce safety and health, including labour service providers, sub-service providers, suppliers, and other parties permitted to be at the project site.

The fulfilment of occupational safety and health is oriented towards preventing occupational accidents and occupational diseases. This reflects that the COVID-19 pandemic in the project has become part of construction safety management; (3) environmental safety, including compliance with the affected environment as an effort to preserve the environment and the comfort of the built environment. The orientation of the fulfilment of environmental safety is as prevention against environmental pollution and the health of workers and communities affected by pollution; and (4) public safety, including the fulfilment of the safety of the community and/or parties in the environment and around the workplace affected by construction work.

The fulfilment of this public safety is to prevent accidents in the community around the construction site. The impact of construction accidents causes the sustainability of the construction service in the internal scope of the project, within the company, and also the global level of the company's competitive index. In the project-scope, the accident will cause the possibility of delayed completion time and additional cost for the project accident itself, the workers who have had the accident and maintain the cost of a polluted-environment. The construction accident will affect the company's performance. A smaller number of accidents imply to company's performance due to time and cost-efficiency. On the greater scale impact, construction accidents reflect a bigger cause of competitiveness index value.

There are 4 (four) clusters of recommendations for enhancing safety culture:

1. Construction safety management system

Construction safety recommendations are the result of suggestions or investigations of construction accidents and building failures by the Construction Safety Committee, they are as follows:

- a) Concerning the recognition, planning, design, and procurement stages, by analysing adequate data from geologist, investigation on-site, local wisdom that affect the design and technical specifications;
- b) Improve process management, through the preparation of standard/procedures, work breakdown structure, and detailing work method statement by incorporating elements of

project components, man, machine material, methods, construction safety including control of vendors and subcontractors;

- c) Compiling risk mitigation in hazard identification, assessment, risk, and control by including aspects of construction safety risks (workers, assets/construction, public, and the environment).

2. Investigation

The accident investigation is a comprehensive investigation of the reliability of man, method, material, machine and safety construction which includes:

- a) Design to construct and its technical specifications;
- b) Adopted established standard as methods and minimal requirement ;
- c) Inspection test and acceptance criteria provided by the sub-service and suppliers;
- d) Equipment that considers calibration and the service life cycle of equipment utilization;
- e) Unconformity report and countermeasure action from contractor and supervisory consultant;
- f) Emergency response report;
- g) Qualified and certified manpower (supervisory consultant, operator, and construction safety expert).

3. Communication

Settling a clear and solid communication is a liability of all parties in the construction project. Arrange the flow of coordination and instructions among the planner, project implementer, supervisors, construction management, Internal Quality Control, and project owners and contained in the organizational structure.

4. Commitment

Commitment is the consistency of all parties to maintain a safety culture

- a) Increase supervision and control of the work, especially in additional shifts to ensure workers are in good condition before conducting work. Supervision applies to the supervisory consultant, service users, and contractors;
- b) Taking worker welfare into account;
- c) Work controlling through work permit approval, especially for high-risk work including during additional work shifts and should be approved by 3 (three) parties (owner, operator, and consultant);
- d) Scheduling inspections and monitoring to the project site by company management.

During the COVID-19 pandemic. In terms of construction sustainability consider something that we should take into account. For instance, emphasizing contract documents, advance and appropriate technology, and supply chain system; maintaining coordination and communication with the stakeholders.

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