Review of Engineer Professionalism in Construction Project Failure: A Case Toll Road Project in Indonesia

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Abstract

The leading causes of work accidents on construction projects are related to the unique characteristics of the construction project, different work locations, openness, and weather conditions. The professionalism of the parties involved in implementing a construction project significantly affects a construction project's safety and success. A review of engineers' professionalism on the failure and accidents of construction projects took a case study on the Pier Head PCB 34 Toll Road Bekasi Cawang Kampung Melayu, which was carried out fast track. The method chosen was to carry out a literature study and a simple analysis of these incidents. A simple analysis shows that the failure and accidents of the construction project are caused by the deterioration of the already plastic steel material, which has a direct impact on the bracket's ability to withstand loads during casting. Such deterioration does not need to occur if the entire project cycle is carried out properly with the parties' professional handling.

Keywords: Construction Failure, Deterioration, Pier-head, Toll road.

1. Introduction

A construction project's success, apart from being measured by the achievement of time, cost, and quality targets. It is also determined by safety in its implementation with zero accidents, and in the end, it can be used reliably by the wider community. The characteristics of construction work do have a high risk of danger, so they require comprehensive and well-systemized handling to reduce accidents' potential. Currently, zero accidents must be the leading and most important goal in the construction process. It is a "goal" in a step towards zero accidents and the final form of a "journey" to a "process" when composing a safe work sequence Zwetsloot et al. (2013).

The leading causes of work accidents on construction projects are related to the unique characteristics of the construction project, different work locations, openness, and weather conditions. The implementation time is limited, dynamic and demands high physical endurance, and uses much-untrained labor, coupled with fragile safety management, resulting from which workers work with high-risk construction implementation methods. The causes of construction accidents can also occur due to improper construction implementation methods and weak supervision, resulting in the structural system collapsing and killing many victims. In several instances, the construction implementation method is one-factor causing construction accidents Zhang et al. (2019). Other causes are the lack of discipline of workers in complying with occupational safety and health (K3) regulations and insufficient quantity and quality of personal protective equipment in construction projects.

One of the construction accidents that attracted enough attention was constructing the Bekasi Cawang Kampung Melayu Toll Road, better known as the Becakayu Toll Road. The design of the Becakayu Toll Road was started in 1995. The Becakayu Toll Road project is one of the toll elevated (not built directly on the ground, but on the ground with other infrastructure underneath). Construction of this toll road began in 1997 and was stopped in the very little construction progress. The city's development is speedy, resulting in very rapid changes in city planning, drainage, land use, and others. Changes to these changes led to a redesign in 2006. However, the implementation of the 2006 design stopped again. After being proclaimed by President Joko Widodo as one of the National Strategic Projects, then in late 2014, the implementation began, of course; in 8 years, there will be significant changes in land use, both for settlement, drainage, and utilities. If traced from 2006 to the resumption of the Becakayu Toll Road construction in 2015 (9 years), there has been a significant change from the initial design, due to changes in land use, buildings, infrastructure, and others, and because the nature of the project is National Strategic Project. So the owner decided to implement the fast track project management method (contemporary road design and execution).

The construction accident on the Becakayu Toll Road Project is an exciting thing to analyze from a professional engineer's point of view. This professionalism is closely related to the implementation of work that strictly implements safety rules, whether this safety factor hinders or even causes the acceleration of project implementation. Acceleration of work as part of a fast track project still considers the rules of cost requirements and professional and safe construction methods.

2. Literature Review

2.1 Issue of Construction Failures and Accidents in Indonesia)

Construction failures and accidents can occur when the construction project does not reach or exceed specific performance values (minimum requirements and tolerances) as determined by the prevailing regulations, standards, and specifications. Construction failure is a condition where the results of construction work are not by the work specifications as agreed in the construction work contract, either in part or in whole, as a result of errors from the service user or service provider. Construction failure is a failure of a technical and non-technical nature Gamil, Y., & Abdul Rahman, I. (2020). This failure can be caused due to failure in procuring goods/services or failure during the construction process.

Limited time for preparation and execution of work can be one of the causes of construction failures and accidents. The construction implementation is known as the past track, which is a construction method policy taken in accelerating the implementation of the project completion schedule. However, of course, this step will create a little uncertainty in maintaining the rhythm of the construction project's performance that is being implemented Laryea & Watermeyer (2020). The acceleration of project implementation due to the infrastructure project's rapid development requires attention in the high-risk construction area.

In recent years, the Indonesian government has continued to accelerate infrastructure development, some of which have been carried out on a fast track basis. Wu & Chong (2018) stated that Indonesia and Thailand have the same policy in accelerating infrastructure to pursue significant economic improvements, especially in fulfilling transportation infrastructure. However, unfortunately, at the same time, the acceleration of construction work was accompanied by work failures and accidents. During the period 2018 and 2019 alone, many construction accidents were recorded, as shown in table 1.

Table 1. Construction Failures and Accidents in Indonesia 2018-2019

Time of Event	Project	Type of Failure
January 02, 2018	Depok-Antasari Toll Road Project	A total of Six Girder Beams with a length of 30.8 meters at the flyover for the Depok Antasari toll road project rolled, fell, and broke. There were no fatalities in this incident, and the girder fell on the dump truck and excavator underneath when there were no workers. This incident is thought to have occurred due to an error in machine maneuvering that knocked over the girder's end, which caused a domino effect to overthrow the other girder.
January 22, 2018	Pulomas Jakarta LRT project	Girder Box, which was being erected using the gantry launcher, suddenly fell and collapsed. This incident injured 5 (five) workers, and there were no casualties. Until now, the alleged cause of the accident is not known because the SOP has been followed, the equipment is in good condition, and is suitable for operation. This project was carried out by PT Wijaya Karya (Persero) with PT VSL Indonesia always subcontracting precast box girder stressing.
February 04, 2018	The collapse of the Girder Launcher in the Double Track Jatinegara project	The Gantry Launcher is used to lift the precast box girder segment overturning from its support. This incident caused 4 (four) workers to die because they were hit by precast concrete, and 1 (one) worker was injured. This project is carried out by the contractor PT Hutama Karya (Persero). The support launcher gantry slipped from its support allegedly due to an operating error used to lift the box girder.
February 20, 2018	Construction of the Bekasi-Cawang-	Fall Formwork Pier Head PCB 34 Becakayu. The pier head formwork that was being cast was not strong enough to withstand the load, so that it collapsed, and the workers fell and were crushed by the material. This incident caused 7 (seven)

Time of Event	Project	Type of Failure
	Kampung Melayu Toll Road.	workers to be injured because they were hit by casting material. This project was carried out by PT Waskita Karya (Persero).
April 17, 2018	Construction of the Manado Bitung Toll Road	Slab box culvert for a toll road underpass that is being cast collapsed. This incident resulted in 2 (two) workers having died, 1 (one) worker was seriously injured, and 14 (fourteen) workers were slightly injured. This project was carried out by PT Wijaya Karya (Persero).
July 10, 2019	Bogor Highway Outer Ring Road	BORR Toll Road Session 3A in Cibadak Village, Tanah Sareal District, Bogor City collapsed. Some workers started casting concrete walking support beams (formwork / Pier Head mold).

2.2 Type of Construction Projects Failure And Accidents

Various experts identify various types and causes of construction failures and accidents. Most accidents occur at work sites, from falling from a height/danger of falling Orji, Enebe, & Onoh (2016), explosions Hovden, Albrechtsen, & Herrera (2008) falling heavy objects during the appointment. However, HSE (2006) identified the most frequent falls, material falling and collapsing, and tripping. Apart from accidents, HSE also identifies various health conditions experienced by workers, including asbestos, manual handling, noise and vibration, and exposure to chemicals. Furthermore, through the extensive literature, thirteen types (categories) of accidents were identified differently, namely: Accidents related to falls; Contact with objects; Vehicle-related accidents; Lifting and handling accident objects; Explosion; Collapsed accident; Welding accident; Drowning accident; Animal behavior accidents; Slip and Trip Accidents; Victims of human aggression; accident-related equipment/tools; and electric shock accidents.

Furthermore, with exploratory studies conducted by Williams et al. (2017) regarding the types and frequency of accidents, four categories of accidents are most prominent: contact with work tools, accidents related to vehicles, slips, trips, and accidents to falls. However, there are accident subtypes under each category.

2.3 Causes of Construction Projects Failure And Accidents

To uncover the factors associated with construction failures and accidents, many researchers have investigated many of these causes ranging from personal, technical, physical, to environmental factors. For example, Nkurunungi (2005) argues that technical, physical, and environmental factors are the causes of accidents at construction sites. Meanwhile, unsafe equipment, worksite conditions, unique industry properties, unsafe methods, human elements are the identified factors most responsible for construction accidents. Goh et al. (2016) also classified the causes of construction accidents as human-made factors, environmental factors, and equipment factors.

Also, a further in-depth study conducted by Nichols & Edlund (2020) on the causes of accidents that can occur due to carelessness and negligence, failure to follow safety rules, inappropriate use of safety items, reckless actions, poor managerial safety awareness, skilled workforce uncertified, poor equipment and maintenance, lax enforcement of safety regulations, uncertain organizational commitment, ineffective operation of safety regulations, poor labor education, poor labor awareness, lax operating procedures, regulations imperfect safety, overtime work for the workforce, lack of safety management, and poor information flow. From various sources of literature collected, all of these factors are interrelated and influence each other.

3. Writing Method

This paper is written by exploring the types and factors that cause accidents in several construction project sites in Indonesia, many articles related to work failures and accidents are reviewed extensively, including several news sources. Through literature review, identifying various types of accidents at building construction sites is possible, as researched and discovered by previous researchers. Various factors that cause accidents are identified and then analyzed for review from the professional engineer side. This review study considers how factors related to individual engineers contribute to construction failures and accidents. Each personnel (owner, consultant, and contractor) 's characteristics affect the types and types of construction accidents. Likewise, the factors most often responsible for accidents will be discussed.

4. Discussion

4.1 Construction Methods

The pier-head of the Becakayu Toll Road Construction Project is reinforced concrete cast in place. Implementation of casting in place (in situ) requires formwork. Implementing the formwork (supporting) for the pier-head used is the cantilever system formwork/bracket system.

Figure 1. Cantilever system formwork on the pier-head of the Becakayu Toll Road

In essence, the general requirements that must be met by formwork are: it has a stable structure, can be used repeatedly, is easy to assemble and move, is tight (does not leak easily), and has low adhesion with concrete that is easy to clean. According to the Department of Transportation of Engineering Services Offices of Structure Construction in Sandanayake et al. (2017), bridge/flyover scaffolding can be divided into three types, generally namely:

1. Conventional Systems, where the various components (beams, poles, pile heads, bracing, and others) are each installed separately to form a unitary system
2. A shoring system, in which metal components are assembled into modular units that can be assembled on top of each other, forms a series of towers consisting of load-bearing rods with vertical supports. For shoring with large loads, a more robust and more stable foundation is required.
3. Bracket system, scaffolding with a bracket system is very suitable when it is impossible to use a shoring system scaffold at the bridge/flyover location. This bracket system relies on the strength of the tie-rod rods that rest on the pier body. The bracket system's scaffolding is inspired by the manufacturer's particular climbing formwork system because it supports the structure itself. Apart from functioning as formwork, this bracket system also functions as a platform/foundation for workers.

The key to the strength of the bracket/cantilever system formwork in bearing the load is the bracket in the form of tie-rod iron, which is embedded in the pier structure's body. The loads in question are fixed loads (own weight of formwork and cast material), variable loads (equipment, workers, etc.).

4.2 Implementation and Supervision of Work

The implementation and supervision of work include implementing the work implementation methods and K3 that have been designed. Accidents on elevated structures are mainly caused during implementation, particularly in connection with heavy lifting works and installing works. Heavy lifting and installing works are part of construction activities that carry very high risks related to safety aspects. Based on sources compiled via the internet, it is known that the cause of the failure of the pier-head formwork structure began when several brackets were detached during casting. The bracket is a support that is used to carry loads and strengthen the corners. There is usually a thread bar made of steel in brackets that functions to lock the bracket and pier structure.

Indications of the cause of the bracket released when casting are lack of bracket strength, poor installation (not according to the SOP), and a part of the bracket that has not been installed. This indication relates to human error (human error) due to a lack of supervision during implementation. The late implementation time is also thought to cause the increased risk of human error, namely fatigue.

4.3 Material Deterioration

Material deterioration is a deterioration in the quality of a material. In the Becakayu Project, indications of material deterioration are on the bracket and thread bar, made of steel. The use of formwork at the pier head of the Becakayu Toll Road uses a system, namely the type of formwork that can be reused due to the typical structural dimensions so that there is an indication that the steel material is experiencing fatigue. In examining the accident's cause, eight

thread-bars, as shown in Figure 2, are used as evidence, which is considered healthy. The material is then tested regarding the material's existing condition (tensile strength, deformation value, and so on). It is also planned that the material will be simulated with the same load when the failure of the formwork occurs. In essence, the strength of steel material is its tensile strength.

Figure 2. Thread-bar on the pier-head formwork bracket for the Becakayu Toll Road Project

When the steel is given a load, the steel will tend to experience stress by :

$$\sigma = \frac{P}{A}$$

Where :

s = stress (N / mm2)

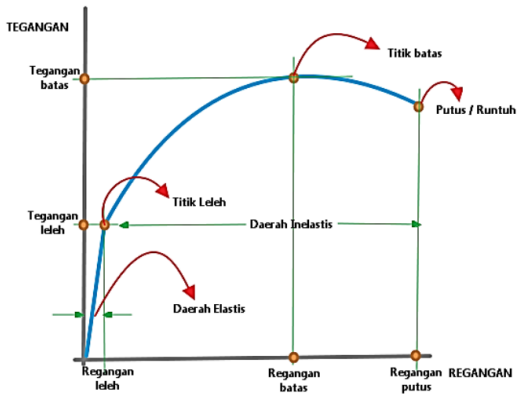
P = Force / load (N)

A = Cross-sectional Area (mm2)

This change in shape results in the strain/strain equal to the deformation of the initial length. If an object is given a tensile or compressive force, then the object will stretch (deform to lengthen or shorten). However, if the force is removed one day, an object will return to its original state. This condition is called an elastic state, which is a condition where the object returns from its deformation when the load/force acting on the object is removed. However, there is a situation where if the force or load acting on the object is increased in magnitude, the object cannot return to its original shape or return to how it was before the object deformed. This state is known as the plastic or in-elastic state.

In the initial conditions where the load is applied, elongation (deformation) is lost if the load is removed. However, if the load continues to increase so that the stress continues to increase, then the extension cannot be completely lost at a certain point or limit, aka permanent strain occurs. The point at which permanent elongation (deformation) begins is the melting point, while the strain that occurs at this point is known as the yield strain, and the resulting stress is called the yield stress.

When this melting point is reached, the stress-strain relationship is no longer linear, the elongation (deformation) of the object is no longer elastic, but is already plastic or in-elastic, so just a little increase stress, the elongation (deformation) will be multiple. Fold when compared to when the deformation is still elastic. If the stress continues to increase, then at some point, the elongation (deformation) will reach its limit. The point at which the deformation reaches the limit is called the limit point or ultimate point. When this point is reached, the object's deformation has reached its peak (just waiting for the moment to break/collapse), there is no significant increase in stress, but the deformation (strain) that occurs continues to increase. The point where the strain has reached collapse is called the break/collapse point, and the strain that occurs is known as the break/collapse strain.



Steel stress and strain

In connection with the deterioration of steel material in the Becakayu Toll Road Project, the effect of plastic steel material directly impacts the bracket's ability to withstand loads when casting. Repeated use of brackets without any supervision/checking before each use can increase the risk of brackets and thread bars that are approaching increasingly high plastic properties.

4.4 Professionalism and Supervisory Code of Conduct

The supervisory factor plays a significant role. This is indicated by the fact that almost all of the incidents above were caused by weak supervision. The quality of work is very dependent on external supervision, meaning that if external supervision is weak, good quality of work will never be achieved. Internal supervision plays a decisive role for external supervision, meaning that if the organization's condition in a job is weak, external control of supervision cannot be achieved. In other words, the quality will be difficult to control.

Based on the above phenomena, HR is an essential factor that becomes the primary stakeholder. Thus, human resources management is essential, considering that humans are the leading player in the construction industry. Human resources here also include all human resources (workforce) who are actively involved in fulfilling the success of achieving company performance. The company organizes and manages work and tasks to achieve company goals to anticipate changes according to business needs by targeting and planning existing HR development strategies. In preparing the human resource development plan, including determining the organization's needs and requirements, increasing efforts to achieve work plans, establishing rules for rewards and punishments, identifying educational needs & expertise, measuring the work plan implementation's effectiveness, and the process of continuous improvement and improvement. HR's focus system is divided into two main criteria: an integrated work system (workforce engagement) and employee involvement in the work environment (workforce environment).

The reality in the field, the role of supervisors, both internal (field management-Contractor) and external (Supervisory Consultants and Technical Agencies), has not been maximal in carrying out the duties and functions quality of work is not maintained which results in failure and construction accidents. Management's lack of seriousness in maintaining and developing a focus on human resources has resulted in a decline in professionalism and professional ethics. It is necessary to improve professionalism and a professional code of ethics for supervisors.

4.5 Construction Safety Management System

The Ministry of Public Works and Public Housing as a national construction service supervisor continues to be committed to increasing the capacity and capacity of the national construction service business, increasing the competence, professionalism, and productivity of the construction workforce, and the implementation of construction services by security, safety, health standards. Furthermore, sustainability, as regulated in Law no. 02 of 2017 concerning Construction Services.

Implementation of the Construction Safety Management System (CSMS) is part of the implementation management system to guarantee Construction Safety realization. Construction safety means all activities engineering to support construction work in realizing fulfillment security, safety, health, and sustainability standards that guarantee workforce safety and health public safety, property, material, equipment, construction, and the environment. This CSMS adopts ISO 45001: 2018 with several adjustments, particularly in Indonesia's post-publication construction services sector Law No. 2 of 2017 concerning Construction Services. Law No. 2 of 2017 concerning Construction Services mandates article 3, whereas the objectives of providing construction services include providing direction growth and development of Construction Services to realize a strong, reliable, highly competitive business structure and the results of quality Construction Services.

The Ministry of Public Works and Public Housing officially established the Construction Safety Committee (CSC). This committee's formation is a follow-up to the rampant cases of construction accidents that have occurred in recent times. This committee consists of three sub-committees, namely the Roads and Bridges Subcommittee, the Water Resources Subcommittee, and the Buildings Subcommittee. The formation of the CSC is a mandate from Law No. 02 of 2017 concerning Construction Services in which the government is responsible for providing construction services by security, safety, health, and sustainability standards. This committee, consisting of experts, is tasked with monitoring and evaluating the implementation of high hazard potential construction, investigating construction accidents, and providing recommendations to the Minister of Public Works and Public Housing.

It is hoped that the Construction Safety Management System and the Construction Safety Committee will reduce the number of construction accidents that occur in Indonesia, where the data shows that the construction sector in Indonesia is the largest contributor to work accidents. It is 33% above other sectors. With the uniqueness and specificity of the construction sector, it is found that the construction sector in Indonesia can not only rely on the Occupational Safety and Health Management System to prevent potential construction accidents but requires a more specific and technical system for managing potential hazards. The construction sector, namely through the Construction Safety Management System.

5. CONCLUSION

Based on the results of the analysis of the construction failure on the pier-head work of the Becakayu Toll Road above so that it does not recur in similar work in the future, the following are things that need attention both for the implementing contractor and the supervisory consultant, namely :

1. Improved implementation supervision
   The enhanced supervision includes supervision when the implementation and supervision of materials used. Implementation supervision can be applied by tightening SOPs (Standard Operational Procedures) and implementing more risk management.
2. Improved material supervision
   Material control can be improved by conducting periodic checklists with a series of tests. The material contained in the pier head bracket formwork is steel material. Tests commonly carried out on steel materials include tensile strength, deformation, and corrosion tests. The effect of corrosion on steel materials can reduce the strength of steel materials.
3. Improved human resource management
   In this case, improving the quality of human resources, workers and masons who carry out construction can be done by improving human resource management. This HR management includes scheduling workers, counseling on SOPs, and counseling on the importance of K3 in construction. In the Becakayu Toll Road project, there are indications of poor human resource management, including a busy work schedule but inadequate shift/work change arrangements. As a result, the risk of workers experiencing fatigue and making mistakes is getting bigger. Improving HR management in work scheduling can be done by re-analyzing the needs and scheduling of worker shifts according to the time/target the contractor is trying to achieve.
4. Re-analyze the strength of the pier-head formwork
   The pier-head formwork used in the Becakayu Toll Road Project is a cantilever/bracket system. The load on the formwork is entirely transferred to the pier body through the brackets. To reduce stress on the bracket, it can be done by installing reinforcing scaffolding/shoring. Shoring is a component made of metal assembled into a modular unit, which is usually used to strengthen freshly cast concrete (compressive strength is not optimal). In the case of the Becakayu Toll Road pier head, the shoring system can be used to carry the burden during and after casting. This reduces the stress on each bracket connected to the pier head body.

This shoring requirement can be analyzed by recalculating the pier head formwork ability that has been used. Existing loads on the pier head work are the concrete's weight, the load the possibility of piling the concrete at one point (centered), the live load of workers, tools (vibrators), and other equipment. There are also shock loads, such as the height and speed of casting, which generally cause additional loads on the formwork. After the load has been calculated, the next step is to calculate the formwork ability. The bracket system essentially transfers all the load during casting to the pier body. In the Becakayu Toll Road Project case, structural failure was not found in the pier but the bracket. Thus, the bracket's ability to withstand stress needs to be recalculated by the existing condition of the test results. Shoring can reduce stress on the bracket because shoring transfers most of the load to the ground.

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