

TECHNICAL NOTE

**RISK FACTOR IDENTIFICATION IN THE
MANUFACTURING PROCESS OF HOLLOW CORE SLAB**

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Abstract: Risk management is an effort that needs to be done by a company to manage potential opportunities and adverse impact. Risk management activities are designed to assist the practitioner in identifying significant risks and implement follow-up and risk management process. The purpose of this research is to identify the risk factors related to the activities in the manufacturing process of Hollow Core Slab (HCS) by utilizing interview method and field observation method. This is then followed by grouping those factors based on the related aspects in Project Management Book of Knowledge (PMBok). Based on the research analysis, there are twenty nine risk factors in the manufacturing process of HCS, which then grouped on the project management aspects of PMBoK, which three risk factors to the aspects of time, five risk factors to the aspects of procurement, seven risk factors to the aspects of quality, six risk factors to the aspects of equipment resources, and eight risk factors to the aspects of human resources.

Keywords: *Risk Identification, Hollow Core Slab.*

1.0 Introduction

In the construction materials manufacturing industry of precast concrete, there are various challenges in every activity of the process that produce the difference and uncertainty. In terms of difference, each plant has an accomplishment target and success indicator of any results of the production. Meanwhile, the uncertainty is a condition that can result risks on the performance of the plant. Therefore, it takes a management to overcome the risks that may appear so that the benefit and objective of the plant can be achieved.

“Risk management is a culture, process, and structure that lead to the management of potential opportunities and impact that appear. Management of risk is related to the implications of the events and changes in various aspects of the work environment or organization” (Staveren, 2006). Risk management activities are designed to assist the executive in identifying significant risk, allocating resources, and implementing follow-

up and risk mitigation process. Meanwhile, risk is an event or a number of conditions that is uncertain, and if this condition occurred it will give impact to the target of achieving a project (Meredith *et al.*, 2010).

From the explanation above there is an interesting matter to be analyzed further which is the application of risk management to the order of activities related to the fabrication process of hollow core slab in a precast concrete plant in Bandung Regency. As for the purpose of this research is to identify the risk factors contained in the fabrication process of hollow core slab.

2.0 Literature Study

2.1 Precast Concrete

Sheppard *et al.* (1989) and Elliot (2002) defined precast concrete as a concrete that have compressive strength between 250-450 kg/cm². Selection of a higher power is more advisable to ensure durability and speed of rotation of the production in the plant. Types of precast concrete for building structures and constructions that commonly used are piling, sheet pile, hollow core slab and half slab, precast concrete beams and prestressed precast concrete beams, one floor or multi-floor precast column, the wall panels that are composed of solid components, such as facade and eco panels, another precast components such as ladder, fence panels, kansteen and U-ditch. The advantages of using precast concrete and prestressed precast concrete are high load capacity, high durability, long economic life, low maintenance, attractive appearance, ready availability, good quality control, speed of construction.

2.2 Project Management Book of Knowledge (PMBok)

The profession of project management includes nine areas of Project Management Body of Knowledge (PMBok) or 'Body of Project Management' which are scope management, time management, cost management, quality management, resource management, communication management, risk management, procurement management, that centralized to the integration which is a start point. Things that should always be kept in mind is Project Management prioritizes integrated activities.

3.0 Research Methodology

The first step in risk management is planning. This is useful for ensuring the level, type, and visibility of a risk management that is commensurate with the risk and the level of importance of the project for the company, as well as to provide resources and time for

risk management activities. In this research, detail analysis was conducted in each stage of the fabrication process to identify risk factors in each stage. Afterward those factors were grouped based on related aspects in Project Management Book of Knowledge (PMBok).

4.0 The Analysis by Research Case-Study

4.1 Fabrication Process of HCS

Hollow Core Slab (HCS) is a building material in the form of precast hollow floor plate, in the width of 1.2 m and the length based on consumer request. The path length of HCS in this research is 150 m. The fabrication process of HCS can be seen in Figure 1 below. From each activity of the fabrication process in Figure 1, identification and analysis are conducted so it can produce risk factors that are related to the stages of the process. Identification is conducted by using expert opinion method by an interview to every head of division that involved and direct observation method.

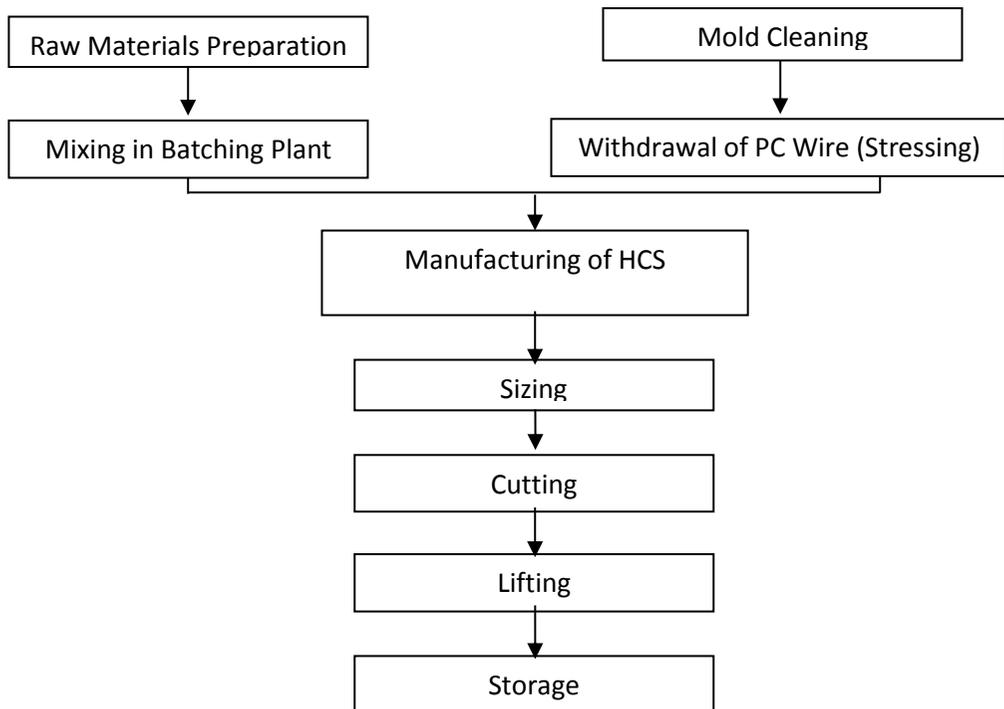


Figure 1: Fabrication process scheme of HCS

4.2 *Process of Raw Materials Preparation*

HCS is a pre-order product. The normal time span from the order date to delivery date is at least one week. There is a possibility that construction projects run faster than the planning that have been defined by the consumers, so there will be a need for HCS in the near future. The delay in starting the production process may result in a delay in the delivery process. By the presence of a work order for the near future and in a large amount, it will give influence on the arrival of raw materials. This thing can lead to delay in starting the production process.

The amount of raw materials that is not appropriate to the order can be caused by inaccuracy of the operator when making an order of raw materials. Based on the interview with the Production Manager, the ordering of raw materials always in large amount so that at least there are enough raw materials to start the production process within a few days. From the analysis above, risk factors in the process of raw materials preparation are:

1. Work order for the near future
2. Delay in arrival of raw materials order
3. Amount of raw materials does not match the order

4.3 *Process of Mixing in Batching Plant*

The process of weighing and mixing the concrete materials is using a machine in batching plant. Failure in the mix design and cylinder test can occur if the operator did the weighing process of raw materials inaccurately. This thing caused by concrete that did not meet the plan quality which is K-450. If the quality of the concrete has reached K-450 so the value of $f_c' \geq 37.35$ MPa. This value of f_c' is obtained from the conversion value for the cylinder specimen, which is 0.83 by using formula (1) below.

$$\frac{K \times 0,83}{\text{conversion of MPa to kg/cm}^2(10)} \quad (1)$$

If the mixture of raw materials holds for too long in the mixing process, it can lead to the failure of concrete setting. Although this thing scarcely happened, the impact that may appear is the concrete cannot be used so the process has to be repeated from the beginning and this requires a lot of raw materials. Based on the field observation, the work process of batching plant machine always runs smoothly. It is supported by the regular maintenance on a weekly basis and inspection when operating the machine by the operator and technicians from maintenance division. If there is a failure of batching plant machine, then it cannot be in operation and it will obstruct the production process.

From the analysis above, risk factors in the process of mixing in batching plant are:

1. Failure of mix design and cylinder test
2. Failure of concrete setting
3. Failure of batching plant machine

4.4 Process of Mould Cleaning

Mould cleaning process is done twice, before and after manufacturing:

Before manufacturing

Based on the field observation, the operator did not use gloves when using putty knife, where there is a possibility that the operator's hand wounded when using putty knife or while taking the remnants of concrete piece (Figure 2). If this thing happened there are first-aid boxes around the site work that can be used to treat wounds in hand.

After manufacturing

After the manufacturing process of HCS, the operator cleaned again the mold by removing 50-cm concrete remnants from the end of the lane by using a hoist. This process is also assisted by an operator who directed the concrete remnants to the disposal site. Based on the field observation the operator did not use safety devices such as helmet and gloves to protect his body from the wire that comes from the concrete (Figure 3). If this thing happened, this can cause injury to the hand, head and other body parts.



Figure 2: Operator cleaned the mould without using gloves



Figure 3: Operator directed the concrete remnants without using safety devices

From the analysis above, risk factors in the process of mould cleaning are:

1. Work accident (injury to the fingers)
2. Work accident (injury to the hand, head and another body parts)

4.5 *Process of Withdrawal of PC Wire (Stressing)*

Wire that will be pulled by the stressing machine comes from wire roll, so when the wire is pulled by the stressing machine withdrawal also assisted by operator. The operator helped organize the wire that twisted when pulled by the stressing machine. Based on the field observation, it takes about 20 minutes to fix the twisted wire until the end of the lane. And from the interview with the Production Manager, the possibility of wire twisted often occurs in the process of withdrawal the wire. This thing caused delay in starting the manufacturing process.

Based on the field observation, the work process of stressing machine always runs smoothly. It is supported by the maintenance every week and inspection when operating the machine by the operator and technicians from maintenance division. If there is a failure of stressing machine, then it cannot be used and it will obstruct the production process. When the operator fixed the wire roll, he did not use gloves. In fact, PC wire is made from steel without coating. However, this thing is ignored by the operator, while this can cause work accident like injury to the fingers. If in the process of withdrawal the PC Wire and it turns out that concrete quality has not reached the minimum power to hold the stressing, then there will be defect in the concrete that commonly referred as slip. Slip is a condition of defect in which the PC Wire is too embedded into the concrete. Slip can cause defect in a concrete piece but can also occur along a single lane of concrete, so that the concrete cannot be used as the function of HCS. If there is slip in

concrete, so the HCS cannot be used as its intended function. From the analysis above, risk factors in the process of withdrawal of PC wire are:

1. Wire twisted
2. Failure of stressing machine
3. Work accident (injury to the fingers)
4. Slip defect in concrete

4.5 Process of Manufacturing of HCS by Using Slide Former Machine

During the manufacturing process of HCS with the slide former machine, operators and officers who work on that machine did not use helmet and in the meantime there is a hoist that works on top of them. This situation may cause an accident which is disorder of the central nervous inside the head that can eventually cause a brain concussion or other nervous disorders.

Tearing defect occur if at the time of manufacturing process of HCS, the concrete dragged down by slide former machine that caused the concrete ripped (Figure 4). If there is a small size of tearing, then the concrete can be repaired by patching. Patching is a repairing method for concrete by embedding bonding agent and cement in the concrete. However, the tearing is too big, then the concrete cannot be used as HCS.

Pore defect is a concrete defect in the shape of small holes in the pores of the concrete (Figure 5). This pore defect has no effect on the structure of HCS, only affecting the aesthetic factor. This pore defect can be repaired by patching.



Figure 4: Tearing defect



Figure 5: Pore defect

Based on the field observation, the work process of slide former machine always runs smoothly. It is supported by the regular maintenance on a weekly basis and inspection when operating the machine by the operator and technicians from maintenance division. If there is a failure of slide former machine, then it cannot be in operation and it will obstruct the production process.

From the analysis above, risk factors in the process of manufacturing of HCS by using slide former machine are:

1. Work accident (hit by hoist)
2. Defect in concrete (tearing)
3. Defect in concrete (pore)
4. Failure of slide former machine

4.6 *Sizing Process*

As the concrete hardened, the operator did the sizing process by recording the project code, length of HCS, and the placement code number. The coding was conducted by using handwriting with a black marker. This thing can cause mistakes when writing and reading the code project that is very influential in the process of storage and distribution of HCS later. This can cause mistake in distributing the HCS to the projects. From the analysis above, risk factor in the sizing process is mistakes in writing and reading the project code.

4.7 *Cutting Process*

Based on the field observation, it can be seen that the length of HCS that has been cut are often different with the length that has already planned. However, the difference in length of which often occur still in the tolerance limit that has been defined by Precast Concrete Institute (PCI), which is 0.5 inch or equal to 12.7 mm. The standard that has been defined by PCI is listed in Appendix 1. If the length of HCS that has been cut is shorter than 12.7 mm, then the HCS cannot be used for the project and must be stored in the stockyard. However, if the length of the HCS that has been cut is more than 12.7 mm, further trimming is required.

Based on the field observation, the work process of cutting machine is run with low risk of interruption supported by regular maintenance process. From the analysis above, risk factors in the cutting process are:

1. The length of the concrete that has been cut does not match with the plan
2. Failure of Cutting Machine

4.8 *Lifting Process*

During the lifting process of HCS, the operator operates the lifter in a standing position without using a helmet as shown in Figure 6 where there are lifter components around

him which can be dangerous if the operator's head hit by those components. In fact it is dangerous because it can cause a mild impact like bumps to disorders of the central nervous inside the head that can eventually cause a brain concussion or other nervous disorders.

The operator also did not use safety shoes, but a sandal made of rubber (Figure 6). This is quite dangerous because the operator can just slip or hit by the machine components when operating the lifter. Based on the interview with the Chief of the General Division, work accident due to fall off from lifter can seriously harm the operator and may cause fatality.



Figure 6: Lifter operator did not use helmet and safety shoes

The lifter operator in lifting the HCS is assisted by at least two officers who directed the HCS to its position just above the wood that put in two places on top of a pile of other HCS. From the field observation, there is only one officer who directed the placement. Based on the interview with the Chief of the General Division, it can injure officer's hands when putting down the wood.

Every HCS that has been lifted by lifter immediately inspected by a Quality Control officer. The inspection and measurements results are written in a form. Based on the field observation and interview with the Quality Control Manager, there is only one officer who inspect and measure the HCS, hence higher chances of possibility of inaccuracy in concrete inspection because of the officer's mistake. This can affect the customer trust to the company.

Crack in HCS may occur in the lifting process if the HCS released from the lifter (Figure 7). If there is a crack that is long enough then the HCS cannot be used. If the crack is not long then HCS will be cut and stored in stockyard for other projects that require the length of the HCS that has been cut.



Figure 7: Crack in HCS



Figure 8: Porous Defect

In the lifting process of HCS, there may be porous defect in concrete if it hit by machine (Figure 8). Non severe porous defect can be repaired by patching.

From the analysis above, risk factors in the lifting process are:

1. Work accident in the lifter operator (injury to the head)
2. Work accident in the lifter operator (fall off from lifter)
3. Work accident in the concrete placement referrer (injury to the hand)
4. Inaccuracy in the inspection of the concrete
5. Failure of the lifter
6. Defect in concrete (crack)
7. Defect in concrete (porous)

4.9 Storage Process

During storage process, there is only one forklift utilised to transport all HCS in each pile. This contributes to the time consuming to transport all HCS. Nevertheless, it is not that influential in the production process because the storage process is the final process in the manufacturing flow of HCS. Based on the interview with the Chief of Maintenance Division, if there is a failure of forklift, then another forklift can be used. The study also notices malpractice in the operation of forklift whereby a forklift which is designed as a one man operation machine has been used to carry a passenger.

From the analysis above, risk factors in the storage process are:

1. Delay in the storage process
2. Failure of the forklift
3. Work accident (fall off from forklift)

5.0 Conclusions

Based on the observation and analysis, there are twenty nine risk factors in the manufacturing process of hollow core slab. All of the risk factors are grouped as project management aspects of PMBoK as follows:

- a. Three risk factors in the aspects of time are summarized as follows: delay in arrival of raw materials order, PC wire often twisted, and delay in storage process.
- b. Five risk factors in the aspects of procurement are summarized as follows: work order that is too close to the installation time in the field, amount of raw materials does not match the order, mistakes in writing and reading the project code, the length of the concrete that does not match with the plan.
- c. Seven risk factors in the aspects of quality are summarized as follows: mix design that did not meet the quality standard, failure of concrete setting, concrete defect.
- d. Six risk factors in the aspects of equipment resources are summarized as follows: failure of tools and machine in each stage of the process.
- e. Eight risk factors in the aspects of human resources are summarized as follows: work safety that is work accident.

The results of this research requires further analysis using quantitative methods to improve risk management in hopes of contributing positively to precast concrete producer.

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