

Supervision Indicator of Formwork on Reinforced Concrete

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Abstract. This research aims to investigate formwork supervision that will be used as a model of reinforced concrete supervision. The research was conducted in Medan by using the survey method. The research sample consist of 20 construction projects which were under construction in Medan in 2016 with the purposive random sampling method. A research instrument was used as a guidance for supervisors, the interview was developed by researchers. Data obtained was analyzed by using descriptive analysis. The result of the study is that there are five categories of supervision indicator which may impact the quality of formwork, they are: 1) precision e.g: elevation, dimension and distance, perpendicular, flatness and elbow of building shaft, 2) stabilizing and stiffness of formwork, 3) leakage indicated by sealed connection, casting disconnection, neatness of pipe sparing 4) formwork material indicated by wood quality and smooth potted surfaces, 5) work verification indicated by installation date, usage date, work volume, signature and supervisor's name approved by quality control.

1. Introduction

Generally, all construction will be begun from structure phase. It is a crucial phase because it becomes a determinant so that a building can long last to retain both own load and external load. Structure design is developed and it begins from column, beam and floor plate. To construct column, beam and floor plate needs support construction named formwork as a tentative support to mould concrete relating to size and dimension as a plan alignment. Formwork functionates to mold related to size and dimension in concrete construction that can support own load and other load impacted by foundry. Formwork also functionates as a tentative construction which has to support own load, wet concrete, motion load and work equipment. According to Nemati [1] tentative construction is a connector between design and construction work, the construction cannot be built without a tentative support. Formwork includes structure design process, it begins from column frame, beam and floor plate which conform to the plan and finally mould concrete and open the scaffold.

Normally scaffold work has the highest cost in concrete construction, that is why it is carried out carefully in order to prevent over budget. The study of Cho, et al [2] implies that material structure composition of reinforced concrete of 46 floors building in South Korea consist of 28.4 % concrete work, 30.4 % steel reinforcement and 41.2 % formwork. While 53 floors building 25.8 % concrete work, 32.8 % steel reinforcement and 41.4 % formwork. The formwork is the highest cost in concrete work with 40 - 60 % or 10 % of construction total cost, Hanna [3]. Considering a big amount of formwork cost, it needs a correct method, system and supervision in formwork work in construction. Supervision is a crucial thing in quality control of project. In the other words, quality control is one of evaluation in order to improve the quality of work. Normally statistical measures and checklist are applied as evaluation to ensure in fulfilling the planned criteria and specification. Owner, contractor, consultant are involved in effort to attain the



quality of project. The quality work will be impacted by the intensity of supervision in construction site. According to Tumilar [4] many collapse of buildings relate to open the formwork. Formwork removal is too early because of time limitation and lack of supervision on formwork work. The lack of supervision on scaffold work may impact a porous concrete because of formwork is not clean, old concrete is still stuck on that can minimize the strength of structure. In addition, when moulding is going on, there is a leak on formwork that impact water or cement paste comes out. The fault of formwork removal will impact a defect on concrete. Saputra AG, et al [5] find the concrete defect is impacted by high concrete fall when moulding, fault of formwork removal, fault of cast iron, vibrator, curing, dilatation of casting, incorrect design, and extra load. A failure of construction on formwork is accumulated by various factors. Oyfer [6] implies that construction defect in USA is caused by human being (54%), design (17%), maintenance (15%), material (12%), and unexpected thing (2%). Vickynason [7] states that 80 % total project risk in construction by human. The construction failure in human factor is impacted by lack of supervision, on the other hand the successful of construction project is depend on supervisor who significant impact the quality of project. To strengthen the function of supervision needs manual and guidance to ensure the step of work based on planned procedures.

The formwork work needs a good plan because formwork installment need to be strong to restrain horizontal force arising. A good plan to create the quality as designed needs supervision on each step of work. A consultant supervisor is one of crucial aspect in a project. Supervisor consultant has responsibility to supervise in all processes of the project including quality control. The failure occurred is always caused by lack of supervision that incorrect formwork removal, not enough strong, and shifted support impacted by vibration. Therefore, supervisor consultant needs manual and form as a standard to ensure the quality work as planned. The manual is very important for formwork construction supervision, so it needs to identify the indicators that may impact the performance of formwork. The indicators for formwork work will be a patron for supervisor to do checklist as an evaluation of outcome work.

2. Reinforced concrete work

Reinforced concrete is a composite structure which is good to use in building construction. In reinforced concrete structure there are some superiority because of mixture of two materials, such as: concrete (cement and agregate) and steel as frame. Superiority of concrete is high strong while the steel is good to restrain tensile strength and shear forces. The mixture of concrete and steel is to restrain tension forces, tensile strength and shear forces so that building structure becomes strong and safe. Reinforced concrete in a building structure is normally in foundation work (bored pile), sloof, column, beam, concrete slabs, and shear wall. However, besides the superiority of reinforced concrete compared to other materials, it has a weakness to reduce the superiority. There is always cracked on reinforced concrete. The cracked on reinforced concrete might be caused the effect of improperly installation. For instance, when concrete pavement processing, many water comes out, it needs a supervision to prevent a leakage. The water comes out because of an imperfect formwork, there is a leakage when moulding.

Column is an element of compression structure that plays in important role in a building, that is why a collapse of a column in critical area will collapse both floor and all structure (Sudarmoko, [8]). Beam ring is a part of building structure which functionate to tie up bricks to flatten the structure load, like load on proponent. Floor plate is not a floor directly on the ground but floor above. The floor plate is supported by beams which have support on building column. In column work, beam, floor plate consist of three main components have to be planned, because they will impact the perfectness of structure work. The three components are: concrete mix, reinforced concrete and formwork. The three components have own function in work method of building structure.

There are three general requirements to design column work, beam and plate for both permanent structure and formwork, such as: 1. Strength, material of formwork e.g: wood beam will not fracture when it is loaded. 2. Rigid, material of formwork will not be deformation. 3. Stability, formwork beam and pole will not collapse by workload.

Formwork must be strong to restrain both own load and extra load. When it is moulding, formwork must be strong enough and even extra supporter added during work.

2.1. Formwork

Formwork is a temporary construction for moulding of cast concrete and thereafter harden to be a building structure according to design and dimension planned. Formwork is a moulding container for wet concrete to harden based on shape and dimension and after few days can be opened for next usage. According to Stephens [9] formwork is a temporary moulding to restrain concrete during concrete moulding based on design as planned. Daryanto [10] implies that formwork is a helper construction as a moulding of reinforced concrete building.

Formwork in a building has a function to configurate based on design and dimension in a concrete construction and is able restrain own load and all other load. According to Wighhout [11], the cycle of formwork are: a) steel installation, b) formwork fixing, c) casting concrete, d) concrete hardening, e) formwork removing. Basically formwork construction has three functions, they are: 1. determine the shape of concrete construction, 2. restrain own load and other external load, 3. formwork must be easy to install, remove and move. Formwork installation plays important role in concrete moulding because formwork installation may determine the quality of concrete both architecture and structural. According to Nawy, PEG [11] there are three objectives in installing and designing formwork, such as: 1) quality, 2) safety, 3) economic. Formwork quality will impact the configuration and appearance concrete construction, therefore it must be a quality material and it is needed to plan so that is not easy to damage when the concrete is poured (Kole, R.S and Kusuma, G, [12]). This is accordance with the findings of Meidiani, S.K and Pratama, R [13]. The strength of concrete formwork made of sengon wood will decrease 42.45% and the strength of concrete formwork made of balai wood will decrease 29.82%.

The quality of formwork material is categorized good if it is no water leakage and absorb water in concrete mixture. For standardization, according to American Concrete Institute (ACI) on Formwork For Concrete implies that formwork has criteria, such as: strong, stable, rigid. This is accordance with the findings of Antil, J.M and Ryan, P.W [14] that the criteria of formwork is strong, rigid, economic, easy to strengthen and remove without damaging concrete and formwork. If formwork construction is not eligible, the moulding will be failure and formwork construction will collapse. An imperfect formwork will impact the thickness of concrete cover not same. For artistical concrete formwork must have a texture as designed; the strength of formwork must be guarantee; the dimension as planned; accuracy (precision of dimension); clean formwork before moulding; easy to install and remove. After concrete is getting hard, formwork is removed and concrete is cured by curing compound, watering column by means of roll evenly.

Some important thing in mold designing, they are:

1. The quality material of mold should create a good surface of concrete and dimension accuracy of formwork
2. Mold safety, no deformation impacted by load so that it may not harm both the material and workers.

2.2. Quality Control

The supervision aims to ensure the process and outcome resulted by contractor based on specification, provide technical administration document for monitoring the progress during the work (Ikatan Arsitek Indonesia, 1991).

Project supervision plays an important role to ensure for successful of construction project. The role of supervisor both internal and external will significantly impact on project quality (the failure of construction and building) (Wiyana, YE, [15]). One of the objectives of supervision is to improve the quality of work. Supervision is supervised by supervisor consultant. Supervisor consultant has a responsibility to ensure the work based on design and other contract document and supervise according to his/her authority. Supervisor consultant also supervises dimension, quality and quantity of building material, equipments using in work. One of responsibilities of supervisor is to do quality checklist. Quality

checklist is a tool which is used to verify the steps in a project so that the project will be documented. There are many kinds of documentation, one of them is report. The report made by consultant is not only a responsibility to the project owner but also for a documentation which contains an important information to prevent the failure of construction work. 20 - 40 % construction failure is in implementation process and the failure is caused by employees (54 %) and material quality (12 %) (Akinci dkk., [16]). The failure is accumulation of various factors. Oyfer [6]) states that construction defect in USA is impacted by human being (54 %), design (17 %), maintenance (15 %), material (12 %) and unexpected thing (2 %). Meanwhile, Carper [17] implies that the potential impact of construction failure is site selection and site development.

Many factors of the building and construction failure technically, such as: the construction process is not based on specification approved in project contract and also the fault on process of bidding, unqualified company, employee, management is not professional and poor supervision (Wiyana, [15]). The successful of construction project depends on supervisor, this is accordance with Simanjuntak, et. al [18]) that supervision plays role to support for quality construction process. Formwork construction begins from installation to removal needs supervision to get a quality formwork.

The problem occurred in formwork installation is always caused by four things, such as: supervision limitation, employee careless, inappropriate work sequence and difficulty to apply the design drawing

3. Methodology

This research aims to investigate the supervision indicator in formwork construction and thereafter to be a model of supervision for reinforced concrete. Methodology used is survey method. Based on Medan statistical data report 2015 there are 363 general contractor. But the only 120 contractors get involve in construction project and only 20 contractors have supervision manual and do the supervision well in formwork construction. Purposive randomize sampling is used in this research. The sample of this study is 20 construction projects. Data collection is by means of supervisor manual and interview. The instrument validity of the research is based on content validity. Descriptive statistic is used to analyze in this study.

4. Results and Discussion

Based on the result of manual collected and the interview of project supervisor can be concluded that there are five categories of supervision indicators that impact the quality of formwork, they are: 1) precision indicated by height and elevation, dimension and distance, straight, flatness and elbow on building axis. 2) stability and stiffness of formwork indicated by the strength of formwork, formwork joint, formwork site. 3) leakage indicated by impermeable of joint, discontinuance of moulding, tidiness sparing pipe. 4) formwork material indicated by wood quality, no crack wood, smooth plywood surface. 5) work item examine indicated by date of installation, date of use, volume of work, signature and name of supervisor and approve by quality control. The result will be compiled to be a manual for formwork construction supervision and thereafter to be a directory for consultant and contractor.

4.1. Precision

Making formwork, the height must accord with plan elevation, bottom elevation and upper elevation. Dimension and design must accord with its height and width. Angle of joint must be flat, it may not be a gap so that it is not squeezed by concrete to prevent a deformation or defect when it is removed.

Constructing formwork on a high level, like column or wall must pay attention to: vertical axis on under and above construction to prevent a slope when formwork installation. Checking the verticality is by means of lot pendulum from upper to the bottom or use the equipment as shown in Figure 1. Construction formwork of column must prepare column shoe: 1) to keep the consistency of the wall, 2) to keep consistency of the width of wall, 3) to place the overlapping of formwork to the vertical.

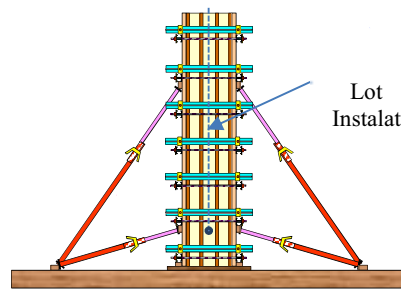


Figure 1. “Lot” Installation

4.2. *Stability and stiffness*

Stability and stiffness are important things for a construction. Formwork should be developed strongly so that it may restrain and support the dead and live load without collapse that may harm the employees and concrete construction. For a stability, formwork should not shaky and sloping when it is moulded, the stiffness of formwork depends on the structure of support which is made from some directions to restrain shaky. Instability formwork can be impacted by moulding method, uncontrol speed moulding will impact stacking of wet concrete and make formwork site cannot restrain load.

Formwork constructed in a high level must be supported by a strong scaffolding so that may restrain the collapse as shown in figure 2.

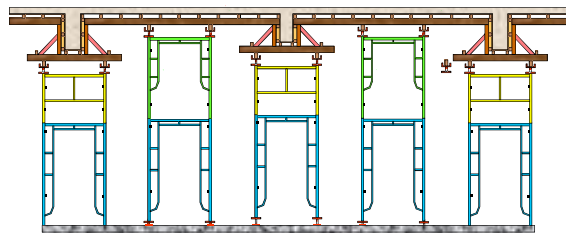


Figure 2. Structure of Support

4.3. *Leakage*

Joint between board and plywood of formwork must have a strong position, not shaky so that water of cement will not come out, that is why a mold must be rigid and stable as shown in Figure 3.

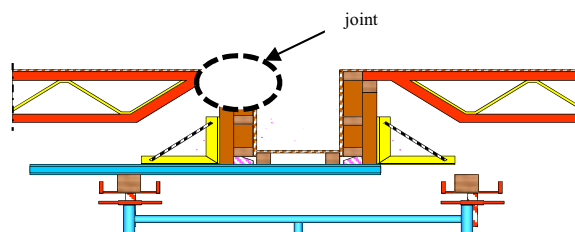


Figure 3. formwork joint spot

Wood with high water content (over 20 %) will cause wet cement shrink which cause the joint will open and thereafter leakage. The surface of formwork must be tight and flat to prevent a leak of cement water that will cause water cement factor decreasing.

Moulding discontinuance must use impermeable and strong divider. A pipe hole on formwork must be impermeable, gap must be closed tightly to prevent leakage, formwork installation on floor plate needs a divider to prevent leakage. Cast breaker process can be seen in Figure 4.

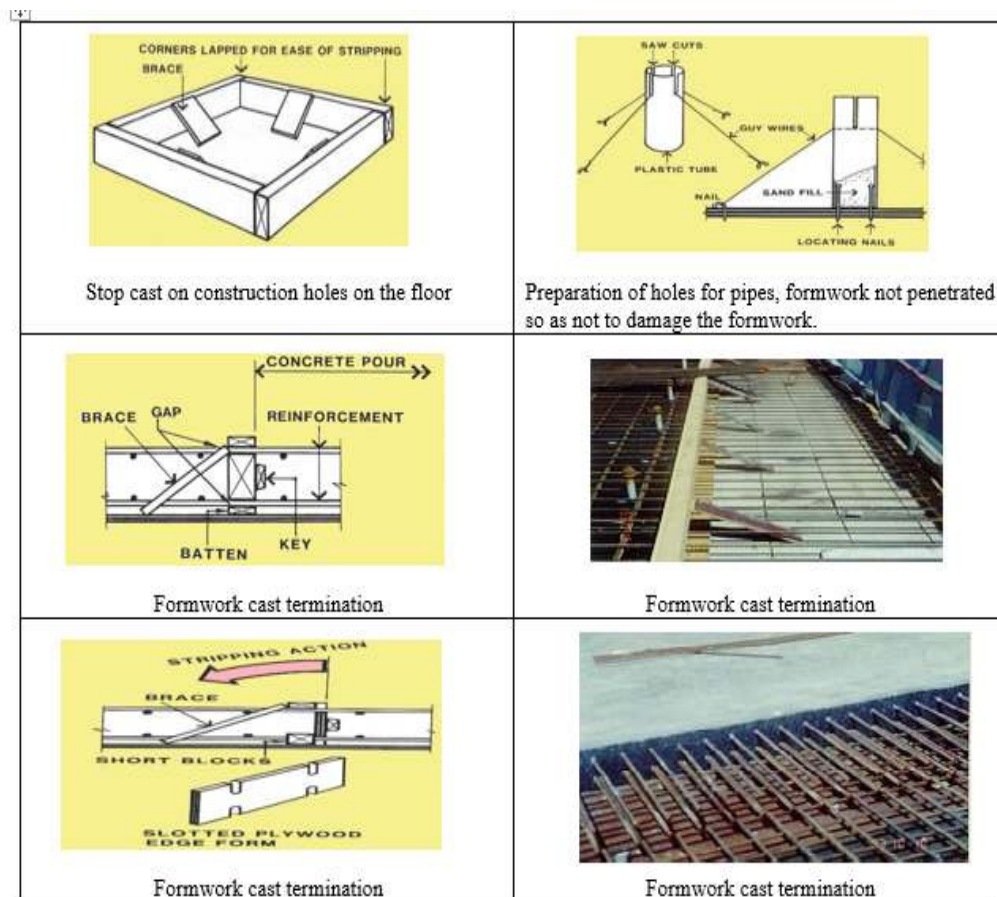


Figure 4. Installation of cast breaker formwork on the floor

4.4. Formwork material

Formwork material should be made of quality material to prevent a damage caused by deflection when concrete is poured. Formwork material should be made of no absorb water material and also no damage concrete. The wood used must be a new wood, wood used will absorb water and the surface wider and create various surface (Triono Budi Astanto, [18]). Dry wood will absorb the humidity of wet concrete that may weaken other part of concrete. Wood beam as a formwork material must not be crack and moldy to prevent broken to restrain the load. Formwork material should not be deformation, so that it will not change the structure. Board or plywood of formwork must be flat, not curved, waved, perforated. Formwork surface must be made of good material, not absorb water hence easy to remove it from the concrete without damage the concrete.

4.5. Work elements inspection

Work element inspection aims to ensure the work done based on plan drawing and contract document, behave based on authority. The work inspection is to evaluate the accuracy of measurement, quality and quantity of building material and equipment during project construction.

After being constructed formwork, the site of formwork have to check the vertical, horizontal site, the position of axis, the position of clamp, leakage and the cleanness of formwork by doing checklist on prepared form. Indicators needed in work element inspection are construction date, volume, signature and supervisor name and approved by quality control. Construction date must be included in work element to know the time of formwork development, it is necessary for the next construction, if it takes too long will influence the quality of formwork, the building volume is necessary to know the amount of concrete needed for moulding. Signature and supervisor name is to know the responsible person for inspection formwork construction. Quality control is to control the quality of formwork construction and thereafter to recommend for moulding work. Based on analysis and discussion, the important indicators to construct formwork which can be a model for supervisor can be seen on table 1.

Table 1. Formwork Implementation Indicator

Indicator	Checked	Requirement/specification
Precision		
height or elevation	Bottom elevation	El.....
	Upper Elevation	El.....
dimension and distance	Dimension	Fondation /Culomn/Beam/Plat /.....
	Width cm
	Height cm
Straightness	Vertical	check with thread to the bottom /measuring instrument
	Horizontal	check with thread horizontally / measuring instrument
Perpendicular on building	Axis position or grid of building	In the midst of Ax.....
Joint of plywood/formwork	Angle joint	Must be flat, no gap, to prevent wedge oleh by concrete
Stability and rigidness of formwork		
Strength of formwork	A support from many direction	Strong frame formwork for horizontal and vertical forces
	Formwork site	The bottom/strong scaffolding and enough
Leakage		
Impermeable joint	Joint must be tight and flat	The connections should be retrofitted so that the flat does not rise and fall, and shake when in the load
Moulding removal	discontinuance of moulding	discontinuance of moulding should have divider on formwork
Neat sparing pipe	Pipe or structure of hole struktur must not have gap	Formwork penetrated by pipe must be tight, construction hole should have a tight divider
Formwork material		
Formwork surface	Wood	No crack on wood, no moldy
	Board or plywood	Board or plywood must not be curved, waved or perforated
Element work inspection		
• construction date		
• usage date		
• volume		
• signature and supervisor name		
• approved by Quality control.		

Based on formwork construction indicator, manual like form/checklist is created as a model for supervision by contractor or consultant on formwork construction as shown in Table 2.

Table 2. Checklist guidance of formwork construction

Pemeriksaan Pekerjaan Bekisting																	
No	Uraian Pekerjaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan	Pemeriksaan
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