DEPARTMENT OF BUILDING

UNIVERSITI TEKNOLOGI MARA

(PERAK)

TEMPORARY WORK SYSTEMS USED FOR CONCRETE FRAME CONSTRUCTION

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It is recommended that the report of this practical training provided

By

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entitled

TEMPORARY WORK SYSTEMS USED FOR CONCRETE FRAME CONSTRUCTION

accepted in partial fulfillment of requirement has for obtaining Diploma In Building.

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STUDENT'S DECLARATION

I hereby declare that this report is my own work, except for extract and summaries for which the original references stated herein, prepared during a practical training session that I underwent at Sun Ridge Sdn Bhd for duration of 20 weeks starting from 5 August 2019 and ended on 20 December 2019. It is submitted as one of the prerequisite requirements of BGN310 and accepted as a partial fulfillment of the requirements for obtaining the Diploma in Building.

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Date : 13 DECEMBER 2019

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Alhamdulillah, praise to Allah, the Most Grateful and the Most Merciful,

I would like to express my gratitude and appreciation to Sun Ridge Sdn Bhd for granting me this golden opportunity to complete my industrial training and it was a wonderful experience for me to obtain different sorts of knowledge and development. First and foremost, I would like to express my special recognition to Mr Mohd Yusoff, Project Manager for accepting the application of my industrial training and Mr Koay Woong Keong, who was in charge to guide my training and always keep me updated by making sure that I get sufficient amount of information for my report progress. This professional team includes Mr Tan Kah Heng, Mr Low Tiong San, Mr Lan It Fong, Mr Michelle Tan, Ms Siti Nurzehan, Mr.Zulkiflee Ibrahim, have helped me in learning and develop my professional information, knowledge and have guided me to the exposure of working at construction site. The theory i have learned involved an analysis of structure, building and civil works. They are responsible in evaluating the performance of my work. Also, thanks a bunch to the site personnel Uptown Jelawat, Bachok, Kelantan, they cooperate and blend with me well by helping me to enhance my working experience and skill at construction site especially by practicing effective method to spread site safety awareness and offering various exposure about site administration. I am totally indebted for being able to work with all of them with contented environment.

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Nobody has been more important to me in the pursuit of this report than the members of my family, especially both of my parents, whose love and guidance are always with me in whatever I pursue. Ultimately, I perceive as this opportunity as a big milestone in my career development. I will strive to use gained knowledge and skill in the best possible way.

ABSTRACT

The main feature of temporary work is a major contributor to profitability on largest and mostly complex concrete jobs. In consequence, selecting temporary work and planning its field operation must consider the effects of the system on the overall project because it may affect in significant difficulties in meeting the project requirements. Overall in this report, the sizes and specification of the formwork and scaffolding are referred fully on the detail drawing that is provided by the engineer. Also, the methodology that is used in this report is made by interview, observation and document reviews during the internship at site. To conclude, temporary work systems used for concrete frame construction have continued to develop significantly since the early 1990s. The major innovations have focused on on-site efficiency of production, health and safety, and environmental issues, driving the concrete construction industry towards ever-increasing efficiency.

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CHAPTER 1.0 : INTRODUCTION

1.1 BACKGROUND AND SCOPE OF STUDY

Temporary works have a primary influence on the quality, safety, speed and profitability of all construction projects. They provide access, support and protection of a facility under construction. Most construction disasters occur as the result of the failure of temporary structures. Building codes and standards are largely silent on the subject and the technical literature is scant. The thirteen papers in this volume deal with an overview of the present practices, legal aspects, codes and standards, design philosophies, contractors' worries, risks, safety and economy in general and problems with certain temporary structures in particular. Temporary earth retaining structures, concrete formwork, shoring and reshoring, scaffolding, construction ramps and platforms and temporary works for asbestos removal are discussed in some detail (Robert T. Ratay, 1987).

What is temporary work in construction industry? How the temporary works are installed and how are they removed? Temporary work also can be defined as any structure that is not attached to a permanent foundation. A structure which is permitted within a land use district without any foundation or footing and which is removed when the designated time period, activity, or use for which the temporary structure was erected has ceased. In addition, Temporary works are used to facilitate the construction of buildings, bridges, tunnels, and other above and below ground facilities by providing access, support, as well as protection for the facility under construction, and assuring the safety of workers and the public.

Examples of temporary works include Earthworks such as trenches, excavations, temporary slopes and stockpiles. Also in Structures, the three most common temporary works are scaffolding and formwork. Other options such as falsework, shoring, underpinning also becoming more common and familiar in temporary works

Firstly, one of the common structures is scaffolding. Scaffolding can be well described as a temporary frame usually constructed from steel or aluminum alloys tubes clipped or coupled together to provide a means of access to high level working areas as well as providing a safe platform from which to work that can be dismantled and moved easily. Principally, there are two forms of scaffolding which is putlog scaffolds and independent scaffolds. Meanwhile,

other types can be classified as mobile scaffold, cantilever scaffold, truss-out scaffold and gantries.

The findings reported demonstrate that the standardization of scaffolding equipment had a direct and positive impact on work safety conditions at construction sites. Consequently, fomenting standardization of scaffolding equipment in the construction industry can contribute to improving work safety conditions (J. C. Rubio-Romero, 2011).

Moreover, formwork is perhaps the most prominent temporary work which is for in-situ concrete may be described as mould or box into which wet concrete will be poured and compacted to build based on desired shape and size. Technically, the concrete will finally set according to the inner profile of the mould. There are two types of timber formwork, which are timber formwork and industrialized formwork systems. Throughout the book the term "formwork" is used in its broadest sense to include the total system of support for the freshly placed concrete (Hurd, 1995)

All types of temporary works have their advantages and disadvantages. For instance, scaffolding can be accessed to difficult places when buildings are constructed, workers need to reach certain areas where they cannot get access to easily. A scaffolding would enable them to get to those areas that are out of arm's length. Meanwhile, shoring can cause the method fail to be done is the soil conditions must be fairly soft for the systems to be effectively utilized. Some of the reasons why formwork could be my preferred choice is because it is widely used, easy to dismantle, and it will not require more labour.

Hence, the aim of this study is to ascertain and discover more about temporary works especially formwork at an on-going project and hopefully the structure will perform satisfactory during designing and the concrete will set successfully.

1.2 OBJECTIVES

Objectives are more specific and easier to measure than goals. Objectives are basic tools that provide essential practical tasks emphasized and provide opportunities to apply acquired skills. For this purpose, 3 main objectives are selected for undertaking this case study and will be the guideline for producing this report.

i. To investigate the methods of installing the temporary works

ii. To determine the specific time of formwork removal

iii. To determine the causes of formwork failures and preventions

1.3 SCOPE OF STUDY

The case study is carried out at Uptown Jelawat which is located in Bachok, Kelantan. The study is more likely to focus on temporary works called formwork and scaffolding methods only. As the project covers a large number of building and unit, it is important to ensure that the temporary works are applied according to the assigned standard to prevent failures and damages to the structures. During calculation and finding defects, a lot of problem occur and a few method was identified to apply for construction work. Other elements such as, number of workers, tools and machineries used are not within the scope of study.

1.4 RESEARCH METHOD

Research method is a specific technique that is adopted in research process to collect, assemble and evaluate data in a specific research study. There are various of research method that used defined information instrument. The research method used are:

i. Observation

Observations had been done by conversing and discussing between supervisor, sub-contractor and practical student, supervised on how to identify the durability of the temporary works, the methods of installation and the problem occurred during construction for five consecutive months. The observation is done for half an hour. A few videos and pictures are taken by an

IPhone 6 camera and jotted down some useful notes on B4 sized daily journal for further references and evidences.

ii. Interviews

Based on the observations, any questions that are related to the temporary works used at the site usually were conducted to the site supervisor, sub-contractor and labor during the site visit. The interviews session had been done for half an hour and all the information and explanation is recorded using voice notes on IPhone 6 and jotted down additional information in B4 sized daily journal.

iii. Document Reviews

The documents had been checked at Sun Ridge's site office is about the construction, project progressing schedule, detail drawing of the site plan, and method statement of the assigned works. The supervisor had approved to check the certain documents. The pictures of the construction site had been snapped using the IPhone 6 camera for the case study.

CHAPTER 2.0 : COMPANY BACKGROUND

Sun Ridge Sdn Bhd was established since December 2007 as an investment company. The business centre is located at No.4-2, Jalan Puteri 2/4, Bandar Puteri, 47100 Puchong, Selangor Darul Ehsan. The Sun Ridge Sdn Bhd was formed up by joint ventured of the director from Baxtium Construction Sdn Bhd, Eternal Prominent Sdn Bhd and Low Tiong San. The company also tends to aim to develop long-term relationships that are both beneficial and convenient to all our clients.

The setting up of the company is in conjunction with the rapid growth of the construction project of Pantai Timur, especially government project and residential property. Sun Ridge Sdn Bhd also support any project from small scale building to large project with excellent leadership and commitment, building upon its reputation as one of the most creative and versatile building contractor.

As a Construction company with its wide work experience of the director and the management staff, Sun Ridge Sdn Bhd is well known as the company that offers professional proficiency on servicing the building, infrastructure and civil engineering sectors. Throughout these year, Sun Ridge Sdn Bhd is aggressively and steadily expansion in construction project in Terengganu and Kelantan and delivered the project in quality and on time.

The business of Sun Ridge Sdn Bhd is growing tremendously through it conceited effort and spirit of each dedicated employees. One of the foremost, with the maintaining of a close business relationship and support from the client and suppliers. Sun Ridge Sdn Bhd always emphasize the spirit of "Work as One Family" to all employees. The company also believes that its future success based on philosophy of mutually benefits as a guidance towards a brighter future.

2.1 COMPLETED PROJECT

Sun Ridge Sdn Bhd completed project as shown in the Table 2.1:

Table 2.1 Completed Project

No.	Project Name/Description	Project Valued	Date of Award	Completion Period
1	ASPIRASI VIANA, WAKAF CHE YEH, KB Proposed Development of 1 14-storey Serviced Apartment Block (161 Units) including 1 basement and resident facilities as well as 1 level parking and 1 guard cottage unit	Rm18.75 Million	20 April 2015	8 February 2017

Sun Ridge Sdn Bhd currently have 1 ongoing project as shown in Table 2.2:

2.2 ONGOING PROJECT

Table 1.2 Ongoing Project

No.	Project Name/Description	Project Valued	Date Of Award	Completion Period
1	UPTOWN JELAWAT, BACHOK Proposed Development of Bandar Baru Jelawat (Uptown Jelawat) Paid-Partnership with Majlis Daerah Bachok on 22.72 Acres Lot Consisted of 207 Units of Shop Office, Wet and Dry Market, Supermarket, Shop Lots, Bus Terminal, Surau, Toilet and Other Ammenities at Mukim Rusa, Daerah Melawi, Jajahan Bachok, Kelantan Darul Naim.	Rm80 Million	15 March 2016	22 September 2022

2.3 ORGANISATION CHART

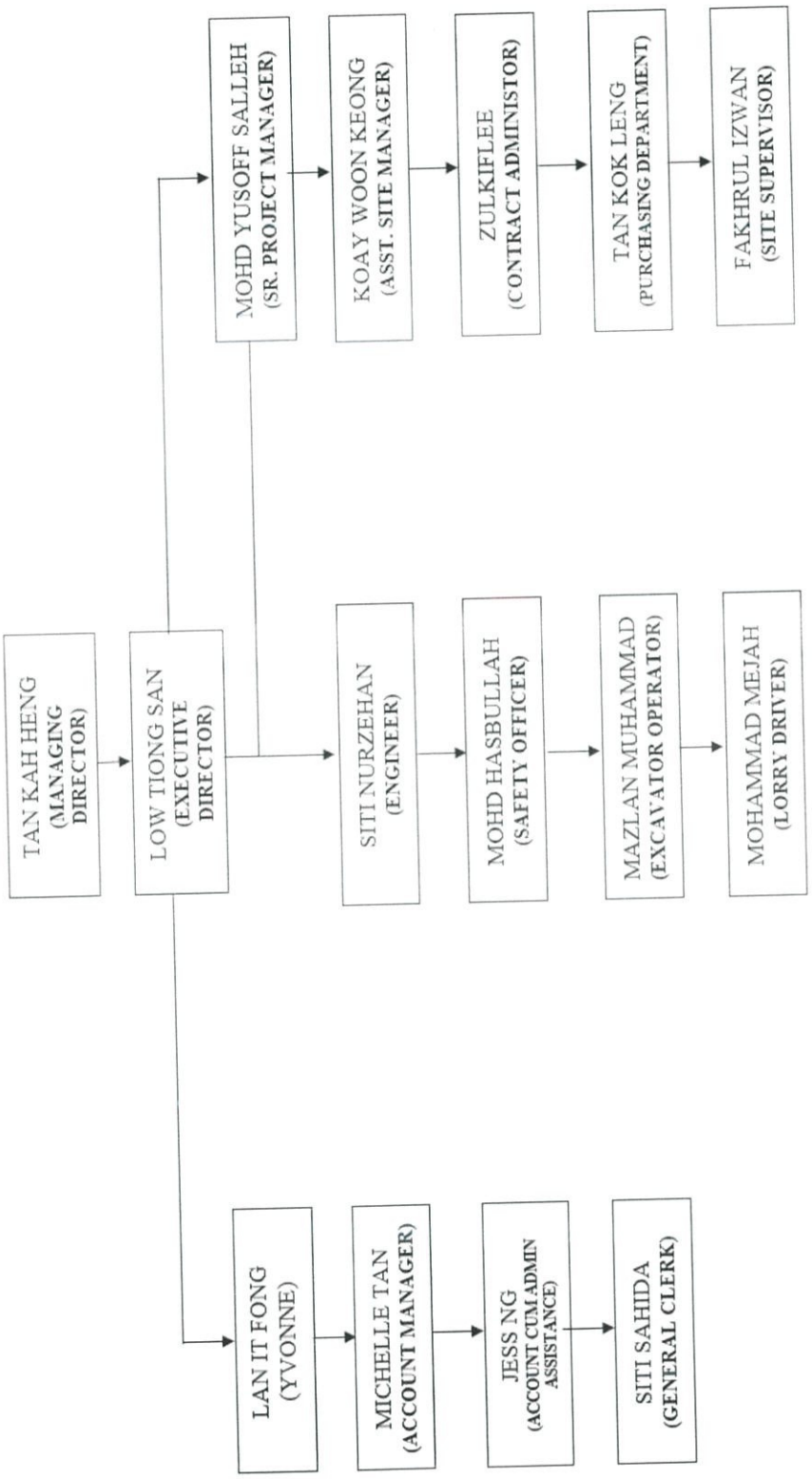


Figure 2.1 Organisation Chart of Sun Ridge Sdn Bhd

CHAPTER 3.0 : CASE STUDY

3.0 INTRODUCTION TO CASE STUDY

This study is about temporary works which are the parts of construction project that are needed to enable the permanent works to be built. Temporary Works are also used in Uptown Jelawat and is carried out by Sun Ridge Sdn Bhd. Induk Setia has offered contractors of Sun ridge Sdn Bhd to build their building with the project titled as Proposed Development of Bandar Baru Jelawat (Uptown Jelawat) Paid-Partnership with Majlis Daerah Bachok on 22.72 Acres Lot Comprised of 207 Units of Shop Office, Wet and Dry Market, Supermarket, Shop Lots, Bus Terminal, Surau, Toilet and Other Ammenity at Mukim Rusa, Daerah Melawi, Jajahan Bachok, Kelantan Darul Naim. The site value is subjected to be RM80 million ringgits.

Sun Ridge Sdn Bhd has successfully completed 44% of the project which are Block K, L, M, N, O and J, leaving the other blocks, supermarket, market, surau, toilet and bus terminal on progress. Hence, this study focused on Supermarket with project titled as Proposed Development of 1 Unit of Double Story Supermarket at Lot PT 4536, with 8791 sqft (2.17 Acres) in The Development of Bandar Baru Jelawat (Uptown Jelawat) at Mukim Rusa, Daerah Melawi, Jajahan Bachok, Kelantan Darul Naim as shown in the Figure 3.1.

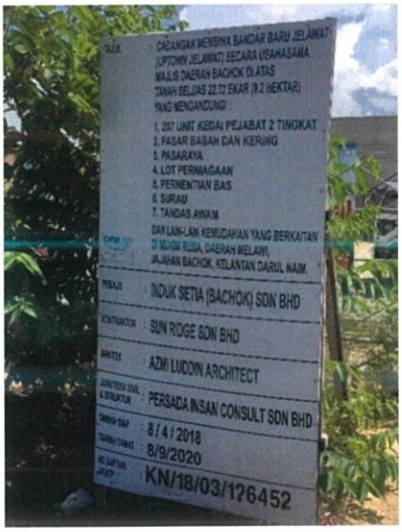
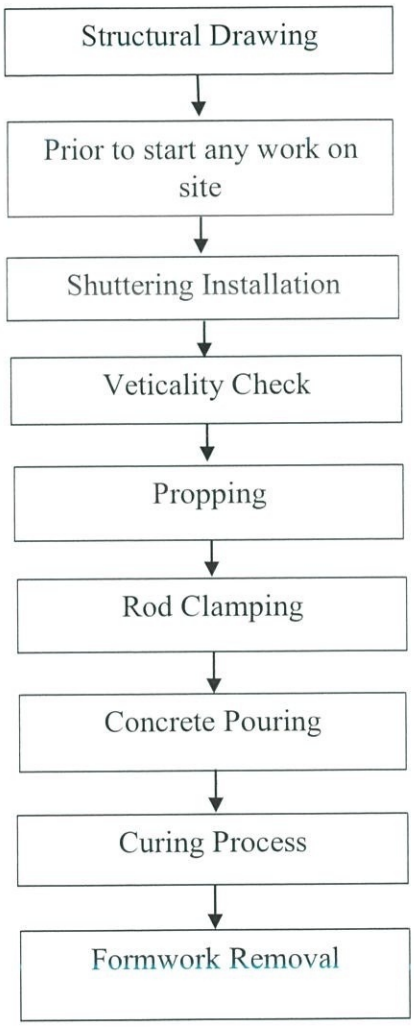


Figure 3.1 Signboard of Company

3.1 METHOD OF INSTALLATION AND REMOVAL OF FORMWORK (SHUTTERING)

Method of installation and removal of formwork as shown in Table 3.1 below:

Table 2.1 Method of installation and removal of formwork



3.1.1 EQUIPMENT THAT IS USED TO CONSTRUCT A FORMWORK (SHUTTERING)

To construct a good formwork or temporary mold, it is initial to use suitable equipment before proceeding with formwork installation process. Before the formwork is constructed, it is a necessity for the person in charge, especially site supervisor or project manager at the site to make sure that workers wearing the suitable personal protection equipment such as gloves, safety shoes, safety goggles and other required safety equipment.

Also the person in charge must make sure and they have to check the machineries that use to excavate the drains.

The equipment that involve to construct a formwork is:

1. Hand saw
2. Hammer
3. Tie Rods
4. Plumb bob
5. Props
6. Ledgers
7. Yokes
8. Jacks
9. Joints

3.1.2 INSTALLATION METHOD OF COLUMN FORMWORK

STEP 1 : Drawing and Design Plan Study

In order to construct a good and neat formwork, it is crucial to study the drawing or design plans beforehand. By referring to the drawings, all the formworks can be set out accordingly, making it easier for all the workers to fasten the formworks securely according to the drawing. It is also necessary for the plans to include all revisions for the jack layout, shoring equipment details, working decks, scaffolds, and all other important accessories. Once all those details are checked and designed, formwork equipment must be inspected to determine that the equipment meets the requirements specified in the formwork drawings. The contractor is convinced to check on and inspect all the equipment thoroughly and if there is weakened components found, reinforce it promptly as in Figure 3.2.

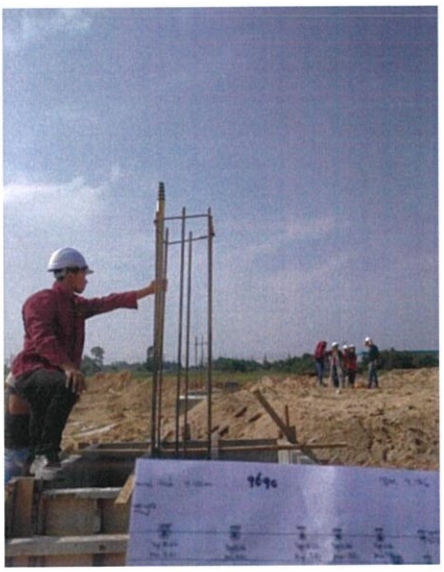


Figure 1.2 Drawing and design plan study

STEP 2 : Column Reinforcement Bar Checking

Check and inspect on the reinforcement bars of the column that has been built if there is any defects or error detected, it needed to be fixed immediately without further ado. The actual purpose of columns as support structures is principally to withstand the compressive forces, but that's not entirely the case. Without proper reinforcement, concrete columns can buckle or burst outward. So, it is important to look over the reinforcement bars of the column first before proceeding to construct the shuttering as in Figure 3.3.

Figure 3.3 Column reinforcement bar checking

STEP 3 : Constructing Formwork

Construct the formwork of the column on each sides to provide a square shaped space for the reinforced concrete to set in. The timber of the formwork should not warp or get distorted when exposed to the weather and other element, be it live loads or dead loads. Timber used for shuttering that is exposed to concrete work should have smooth and even surface on all sides which come in contact with concrete. Also, the formwork is set specifically to the desired line and levels should have planar surface. The joints in the formwork have to be tight in case of any undesired leakage of cement grout as in Figure 3.4.

Figure 3.4 Constructing formwork

STEP 4 : Verticality Check

Conduct the verticality check of the constructed column formwork by using plumb bob. The plumb bob comprises of a weight having pointed tip on the bottom connected with the end of a string. The heavyweight will suspend under gravity and provide a perfectly vertical line that is known as a plumb line. This process is useful for examining or managing vertical line of structural elements specifically indoors like column formwork.

STEP 5 : Propping And Centering

Prop both sides of the column formwork with adjustable timber posts before locking the two components down the floor with the angle of 45°. This method is considered as one of the crucial thing to do during installing the formwork since poor preparation of formwork leading to defective concrete work. The purpose of making the posts adjustable is to ensure that formwork equipment is practical to use and reusable for the future as shown in the Figure 3.5

.

Figure 3.5 Column formwork is propped on both sides

STEP 6 : Column Formwork Clamping

One of the method to lock the timber formwork together is to clamp the panels in position using the tie rods and steel column clamps. After stacking up all the yokes to the timber formwork which happen to be 4cm x 4cm galvanized steel hollow, followed by 16mm high tensile steel rods and clamps. The clamp is secured by hammering the bolts according to the fit size of the formwork to ensure there is no exposure to any tiny opening and sufficiently watertight to avoid leakage at the joints. Then, the formwork is ready for concrete pouring process which takes up to 2 days of striking due to the use of rapid hardening Portland Cement as in Figure 3.6.

Figure 3.6 Column formwork clamping using tie rods and clamps

3.1.3 INSTALLATION METIIOD OF ROOF BEAM FORMWORK

STEP 1 : Studying The Drawing Plan

The size of roof beam formwork is build based on the stated drawing and design plan. Roof beam formwork consists of scaffolding equipment, base plate, u head, timber batten, crosshead, cleat, fixing cleat and all of the equipment needs to be inspected carefully to avoid any error during installation process. By referring to drawing plan, roof beam formwork can be constructed more precisely and efficiently.

STEP 2 : Assemble The Beam Scaffold

Position the base plate and assemble the scaffolding as support elements for the soffit and its sides, followed by the U Head, timber batten and crosshead. For timber this is done by the use of a crosshead across the top of a vertical member. It is also consequential step to prefabricate form sections on the ground first rather than on scaffolding. By ensuring the base plate is in the good place and the scaffolding is stable enough to withstand the pressure or the weight of the fresh concrete plus any constructional live loads, the formwork is ready to be installed.

STEP 3 : Installing The Side Walls And Beam Soffits

Construct the roof beam formwork by fixing and erecting the side walls and beam soffit. Apparently beam formwork consists of open through section and because it is not closed at the top requires more supporting framework to restrain the sides. Besides, the supports need to be maintained to the soffit and also provide lateral support to the sides which is using cleats to ensure that the sides remain motionless. Then, the formwork is ready for concrete pouring process, the standard sides of beam striking time is 2 days and the props of beams is equivalent to 8 days by using the rapid hardening Portland Cement as shown in Figure 3.7.

Figure 3.7 Side walls and beam soffits have been installed

3.1.4 INSTALLATION METHOD OF SCAFFOLDING

STEP 1 : Fixing The Base Plate

Place the base plates on a plane surface to ensure that the scaffolding is constructed on a firm and levelled base. The base plate is a foot plate for scaffold systems and is mainly used to spread the load onto the sole plates. The base plate happens to be 24 inches galvanized steel.

STEP 2 : Scaffold frame installation

Fix the H scaffold frames with 1700mm in height onto the base plates after the reusable frames are confirmed to be in good shape. Fabricated frame scaffolds are the most common type of scaffold because they are versatile, economical, and easy to use. Also, their modular frames can also be stacked several stories high for use on large-scale construction jobs as shown in the Figure 3.8.

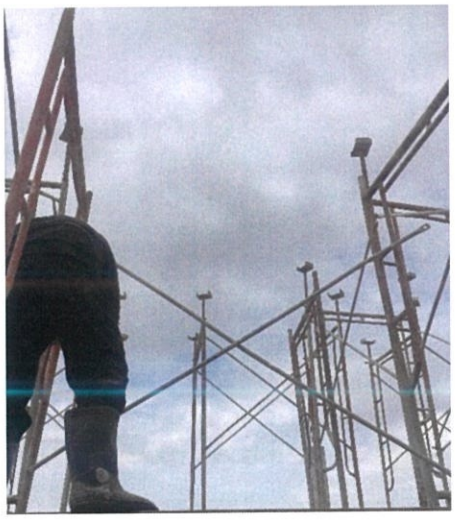


Figure 3.8 Scaffold frame installation

STEP 3 : Cross bracing locking

Attach the cross brace onto the scaffold frames and secure it with locks on both sides. Supposedly, the 'X' bracing placed diagonally with respect to the vertical and horizontal members of a scaffold and fixed to them to give the scaffold stability as in Figure 3.9.

Figure 3.9 Cross bracing locking

STEP 4 : Fixing the joint pin into the scaffold frame

Insert the joint pin into the scaffolding frames tube to stack another storey above it. The main purpose of joint pin is in use is to connect scaffold tubes end to end a joint pin. The joint pin is inserted into the end of the scaffold tubes and a centre bolt is tightened. This tightening causes the two parts of the joint pin to expand gripping the ends of the scaffold tubes. It is necessary not to use this fitting in situations where it will be subject to tension or bending as shown in Figure 3.10 .

Figure 3.10 Fixing the joint pin into the scaffold frame

STEP 5 : Installing Walking Board

The walking board is used to provide space and platform for workers and materials. In the absence of walking board, there will be no means of access to the upper floors for material. Usually, the walking board is fixed on the top of scaffold system as in Figure 3.11.

Figure 3.11 Walking board

3.2 FORMWORK REMOVAL TIME PERIOD

The rate of hardening of concrete or the concrete strength depends on temperature and affects the formwork removal time. For instance, time required to remove the formwork of the reinforced concrete in rainy season or wet monsoon tend to be more than the time required during summer.

Constant observation is needed for formwork removal of flexural members such as beams and slabs. As these members are subjected to self-load as well as live load even during construction, they may deflect if the strength gained is not adequate enough to handle to loads.

Figure 3.12 Column formwork dismantling process

To estimate the strength of concrete before formwork removal, the tests on concrete cubes should be carried out. The concrete cubes test should be prepared from the same mix as that of the structural members and cured under same circumstances of temperature and moisture as that of structural member.

When it is ensured that the concrete in the structural members has gained sufficient strength to withstand the design load, only then formworks shall be removed. If possible, the formworks shall be left for curing a little longer as it really requires more time.

Figure 3.13 Conducting the cube test

3.2.1 FACTORS AFFECTING FORMWORK REMOVAL TIME

Time of formwork removal or also known as de-shuttering depends on several factors:

- **Type of cement**

  Rapid hardening Portland Cement require short period of time compared to Ordinary Portland Cement (OPC) since rapid hardening cement have higher strength gain in lesser period of time than the Ordinary Portland Cement. Besides, Low heat cement takes more time to gain sufficient strength than OPC.

- **Weather condition**

  Hydration process accelerates better in hot weather conditions as compared to cold and humid conditions. The higher temperature of concrete during placement can cause rapid curing of concrete and formwork can be struck in shorter time than low temperature weather. Especially during rainy days or wet monsoon season, the concrete strength gain time gets prolonged. Besides, formwork helps the concrete to insulate it from surrounding, so longer the concrete sits in the formwork, the less is the loss of heat of hydration and rate of strength gain is high.

- **Ratio of concrete mix**

  Rich ratio of concrete mix gain strength more effectively and faster as compared to weak ratio concrete. Also, higher grade of concrete leading the rate of development of strength is higher and thus concrete will set in shorter time.

- **Accelerated curing**

  Accelerated curing also helps in boosting the concrete curing process. It is also a method to increase the strength gain rate with the application of heat.

- **Size and type of the concrete member**

  Size of the concrete member definitely affects the formwork striking time. Larger concrete section members cure in shorter time than smaller sections. Furthermore, soffit of beams and slabs or sides of beams or columns require different time.

3.2.2 STANDARD FORMWORK STRIKING TIME

Turkish standard formwork striking time as shown in Table 3.2:

Table 3.2 Turkish standard formwork striking time

CEMENT TYPE	SIDES OF BEAMS, WALLS, AND COLUMNS	SLABS	PROPS OF BEAMS AND LARGE OPENING SLABS FORMS
ORDINARY PORTLAND CEMENT	3 DAYS	8 DAYS	21 DAYS
RAPID HARDENING PORTLAND CEMENT	2 DAYS	8 DAYS	8 DAYS

3.2.3 CONCRETE FORMWORK REMOVAL IMPORTANT CONSIDERATIONS AND SPECIFICATIONS

During striking of concrete formwork, there are several important things that needs to be considered:

- Formwork should not be dismantled until the concrete has developed sufficiently strength to support all loads placed upon it. The time required for formwork removal depends on the structural function of the member and time period for the concrete takes to set. The type of cement, weather condition, ratio of concrete mix etc. influence the striking time for concrete formwork.

- The formwork removal procedure should be supervised by the contractor or engineer to ensure that quality of hardened concrete in structural member. For example, it should be free from or has minimum casting defects such as honeycombing, size and shape defects. These defects in concrete influence the strength and stability of structure. In consequence, immediate repair works shall be done or the members can be dismissed.

- Joist forms should be designed properly and removed so that the shores may be removed temporarily to permit removal of joist forms but must be replaced at once. The joists and shores will be dismantled beginning from the middle of the member's span, continuing symmetrically up the supports.

- The approval from the engineer should be obtained for the sequence and pattern of formwork removal.

- The formwork parts and connections should be arranged in a way that makes formwork removal easy and simple, prevents damage to concrete and formwork panels so that it can be reused without extensive repair

3.3 CAUSES OF FORMWORK FAILURES AND PREVENTIONS

Failure of formwork in general results from various causes which are excessive loads, premature removal of forms or shores, inadequacies related to formwork, and human error on the job, whether due to indifference, haste, or lack of knowledge.

There are various formwork failures are reported every year. In almost every single one of them, a pattern is outright uniform, failures are a consequence of fast rate of placing the concrete and happen during the stage of construction when the forms had been used multiple times and work is still carry on. Some few failures are reported at the beginning of a construction project and usually failures rarely occur in small operations.

Also, formwork failure can result in serious structural damage. Evidently, a building is only as strong as its foundation. If it's well-built and sturdy enough, you can be assured that the building's structure will stay erect for a long time to come, even it happens to face of nature's elements. But if it's weak, however, you can't rely on it to stand the test of time without having some sort of structural damage or even worse, collapsing. One prominent aspect of foundations that can lead to a devastating situation when it falls apart is the formwork.

The issue with foundation failure is that you don't always see it out in the open even though sometimes it's quite clear to a certain extent. As a matter of fact, a total collapse will have occurred for you to finally realise that something was wrong in the first place. Problems like roof leaks will bring about brown patches to form on ceiling tiles, and they certainly will fly out at you. However, with formwork failures, you often have to take a real closer look at what's happening. If it's left undetected, the impaired structure could result in a slew of exterior and interior signs.

3.3.1 MAJOR CAUSES OF FAILURES OF FORMWORK

There are several factors that may lead to the failure of formwork during and after concrete placement especially during my investigation time period at Uptown Jelawat:

1. Improper vibration or consolidation of concrete
2. Improper or inadequate connections
3. Improper or inadequate bearing details
4. Premature stripping of formwork
5. Errors in placement of reshoring
6. Improper, or lack of, design of formwork
7. Inadequate strength of concrete material
8. Failure to follow codes and standards
9. Notifications of vendor-supplied equipment
10. Negligence of workers or supervisors

1. **Improper vibration or consolidation of concrete**

   Vibration and impact due to passing traffic, movement of workers and equipment on formwork, and vibration because of concrete consolidation can displace supporting shores or jacks of formwork system and cause total failure of the forms. Technically, the more air bubbles you have in your concrete, the weaker its structural integrity when it hardens. A concrete vibrator produces stronger concrete by vigorously shaking the concrete right after you pour it into the formwork to eliminate the air bubbles.

2. **Improper or inadequate bearing details**

   Improper or insufficient cross bracing and horizontal bracing of shores are common causes of formwork failure. This is because of poor bracing effectuate lateral force and hence create lateral deformation of supporting members. When a failure occurs at one point, inadequate bracing may cause the collapse to extend to a large portion of the structure and multiply the damage.

3. **Premature stripping of formwork**

Early striping of forms and careless practices in reshoring can lead to failure of formworks and total failure of specifically in multistory building in which progressive collapse is highly likely. Sometimes, premature striping causes sagging of partially cured concrete. This leads to crack development on the concrete and spontaneously create maintenance issues. Inadequate spacing and size of re-shores may lead to a formwork collapse during construction as well as damage of the concrete structure.

4. **Improper, or lack of, design of formwork**

Assemblage errors such as incorrect design, insufficient nailing, failure to tighten the locking devices on metal shores, inadequate provisions to prevent rotation of beam forms where slab forms frame into them on one side, inadequate anchorage against uplift for sloping form faces, and lack of bracing or tying at corners can cause failure of formworks even if its design is completed in the best possible way. So, skilled and trained labour shall assemble the formwork system under great supervision.

5. **Inadequate strength of concrete material**

It is another factor that has been reported to be the cause of concrete formwork system. Concrete strength is affected by many factors, such as quality of raw materials, water and cement ratio, coarse and fine aggregate ratio, age of concrete, compaction of concrete, temperature, relative humidity and curing of concrete. Inadequate concrete strength leading failures to the formwork striking system.

6. **Negligence of workers or supervisors**

There are cases in which the failure of the formwork system during building construction is not related to formwork faults. Factors such as incorrect assumption regarding types of soil in design stage, inadequate shear reinforcement placement, and placement of ducts at high stress region in slabs are reported to be the causes of failures conducted by supervisors and workers.

3.3.2 PREVENTIONS OF FORMWORK FAILURES

The safety of workers is a concern to all parties especially owners, contractors and designers. Safety is everyone's responsibility, including workers in the field, supervisors and top management. Following is the list of rules that can be utilized to reduce the potential of formwork failures and provide a better and safe working environment during formwork construction and striking process:

- Prepare a formwork plan that includes detailed drawings and written specifications for erecting, fabricating and dismantling of the formwork. The plan shall be prepared by a person who is competent in the design of formwork
- Ensure compliance of all OSHA rules and regulations
- Follow all of the procedures, recommendations and instructions from manufacturers of formwork components used in the formwork
- Follow all state, local and federal codes, ordinances and regulations pertaining to formwork, shoring and scaffolding
- Inspect all shoring and scaffolding before using it. Make a thorough check of the formwork systems after it is erected and immediately before a pour
- Post guidelines for shoring and scaffolding in a conspicuous place and ensure that all persons who erect dismantle, or use shoring are aware of them
- Survey the jobsite for hazards, such as loose earth fills, ditches, debris, overhead wires and unguarded openings
- Ensure adequate fall protection for workers during erection of formwork, pouring of concrete, and dismantling of formwork

CHAPTER 4.0 : CONCLUSION

To recapitulate, temporary work is considered as one of the most essential thing in conducting construction work to ensure that the concrete pouring process will be able to run smoothly without having to face any sort of complications. Perhaps, without proper plan and design of the temporary work itself, there will be no well-built and sturdy beam, slab, column or even wall. Also, precise way and flow started from the beginning can guarantee that the project can finish on the period of time that had been provided. When compared in detail, certain types of temporary are reusable, so apparently they are cost effective and economical.

Apart from that, the most common temporary work in construction industry happen to be formwork, scaffolding, shoring etc. For quality wise, the formwork can be built to exceed 60 years design life and eventually damaged parts can be replaced with the new one. Also, the scaffolding puts the worker in a position from where they can comfortably do the construction work and increases overall productivity. In content with this, formwork and scaffolding are applied in this site not only for its structural benefits but also for time efficiency and its cost effectiveness.

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