



اَبُو سَافِيْقَ بِنِ زَافِيْقَ مَافِيْقَ
UNIVERSITI
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MARA

DEPARTMENT OF BUILDING

FACULTY OF ARCHITECTURE, PLANNING AND SURVEYING

UNIVERSITI TEKNOLOGI MARA

(PERAK)

APRIL 2015

It is recommended that the report of this practical training provided

By

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CAISSON 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 JKP Sdn. Bhd for duration of 5 months starting from 16 December and ended 4 April 2015. It is submitted as one of the prerequisite requirements of DBN307 and accepted as a partial fulfilment of the requirements for obtaining the Diploma in Building.

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ABSTRACT

Excavated caisson is among the conventional method which slightly use machinery and more on labor. Excavated caisson is familiar foundation used in this country and there was many types of caisson use in this world depending on the soil factor to be considered. This report explained the process during the construction of excavated caisson and other test involved in order to ensure the granite is pass the engineering requirements before start to install the reinforcement and concrete. This report will show the process and method to construct the excavated caisson. So the construction of excavated caisson is the most crucial part of the structure because to receive such massive load from live and dead load of the structure to give strength to the foundation to support the loads.

CHAPTER 1.0

PREFACE

1.1 Introduction

The report clarified the construction of caisson for the building on site, supervision and safety for Caisson foundation and advantages and disadvantages of excavated caisson work. This project located on lot 1028, 1041- 1043, Jalan Kampung Bukit, Mukim 11, Daerah Barat Daya, Bayan Lepas, Penang. Excavated caisson is a cylinder and spiral that is construct by excavate from ground level into to a specified depth. The cylinder using steel formwork then filled with concrete, thus creating the foundation. This foundation widely use on type of soil contain mostly granite and rocky.

In every construction, there was many different types of foundation depending on their engineering structural and the requirements to support massive loads from the building Construction of Caisson foundation are mostly suitable for high-rise building besides the factor of the soil condition must be considered before doing soil investigation test to choose a compatible foundation. Excavated caisson is friendly to residential area which mostly use hand tools besides give the strong foundation to the building structure.

1.2 Objective

The objective of this report is to clarify the Caisson foundation in construction that practically involved during my practical training semester. During the practical training period, I have experienced the process of caisson foundation construction works. The content of this report prepared:

- 1) To study the method of construction of Caisson foundation.
- 2) To study the factors affecting selection of foundation.
- 3) To study the advantages and disadvantages of Caisson.

1.3 Scope of Study

In relation with the objective of the study, the scopes of study are:

- a) Study will be conducted at lot 1028, 1041- 1043, Jalan Kampung Bukit, Mukim 11, Daerah Barat Daya, Bayan Lepas, Penang.
- b) Study the proper method to be carried out of supervision and safety for Caisson foundation.
- c) The features and construction drawing of Caisson prepared to clarify deeply regarding the engineering detail of Caisson.

1.4 Methods of Study

In this practical research, I have identified a several methods which can be applied to my practical report so. There are many outcome have been collected and gathered the data from several method to ensure the practical report completed. One of the method are:

1.4.1 Interview

The consultant for foundation work and substructure is Geoscience Engineering Sdn Bhd in this project. I have interviewed the supervisor orally to gain the input. Besides, I also have interviewed the SSJ Consulting Engineers Sdn. Bhd to collect additional info of this project.

1.4.2 Literature review

The JKP Sdn. Bhd monthly report, Geoscience Engineering Sdn. Bhd and AEC Project Management Sdn Bhd, all their monthly report have been one of my main sources to collect the data regarding this project and my research.

1.4.3 Architectural Drawing Review

Architectural drawing review is one of my main references to obtain the information regarding the detail structure to find the information more accurate and gain the better understanding theoretically and practically.

CHAPTER 2.0

COMPANY BACKGROUND

2.1 Introduction



Figure 2.1: Official logo of JKP Sdn. Bhd

Source: Company Profile of JKP Sdn. Bhd, 2014.

JKP Sdn. Bhd. (JKPSB) established on July 12, 1995 is the implementing agency to Penang Bumiputera Development Council (MPBPP), formerly known as the Penang Bumiputera Participation Committee (CMC).

JKPSB establishment is to assist the Federal Government to enhance Bumiputera participation in business and the ownership of property in Penang. Accordingly, the company directly involved in the development of residential and commercial units affordable for a large number of natives.

2.1.1 JKPSB role includes:

1) Property Developers

As a real estate developer, JKPSB develop all of its properties in person, partnership or privatization by other parties. JKPSB also designate certain companies as a project manager responsible for managing the project. JKPSB role as developers need to operate on a full-time and thus it should serve as a private developer to obtain certain approvals from the Local Authority (LA) or related.

2) Property Manager

Real estate management involves completion, including shopping complexes and flats or apartments. This responsibility is carried out through the appointment of representatives and property management agent.

3) Property Holding Company

Role as the holding company to meet the objectives of the establishment of property in accordance with JKPSB existence in 1995, where JKPSB acquired and hold property JKP.

4) Company Having Various Business Interests

The company's interests in other business activities, including collaboration / partnership smart and synergistically to provide business opportunities for Bumiputera businessmen, especially in Penang.

2.2 Company Profile

The company profile of JKP Sdn Bhd as shown in Table 2.1

Table 2.1: JKP Sdn. Bhd Company Profile

Owner	The Finance Ministry Incorporated (MKD)
Stakeholder	Finance Ministry Majlis Pembangunan Bumiputera Pulau Pinang (MPBPP)
Date Established	12 July 1995
Paid- up Capital	RM10,250,002.00
Authorized Capital	RM15 millions
Asset (2013)	RM240.98 millions
Office Address	114-F, Bangunan JKP Jalan Sungai Pinang, 10150 Pulau Pinang Tel: Laman Web: www.jkpsb.com.my
The Main Bank	Bank Islam Malaysia Berhad Ground Floor, Wisma Great Eastern Lebuh Light, 10200 Pulau Pinang
Auditors	MNZWAJ Associates No. 49, Tingkat 2, Jalan Todak 4, Pusat Bandar Seberang Jaya 13700 Seberang Jaya, Pulau Pinang
Subsidiaries	Mutiara.Com. Sdn. Bhd. Mutiara Smart Computing Sdn. Bhd. Mutiara JKP Properties Sdn. Bhd. JKP Trading Sdn. Bhd.

(Source: JKP Sdn. Bhd, 2014.)

2.3 Organization Chart

The organization chart of site project as shown in figure 2.3

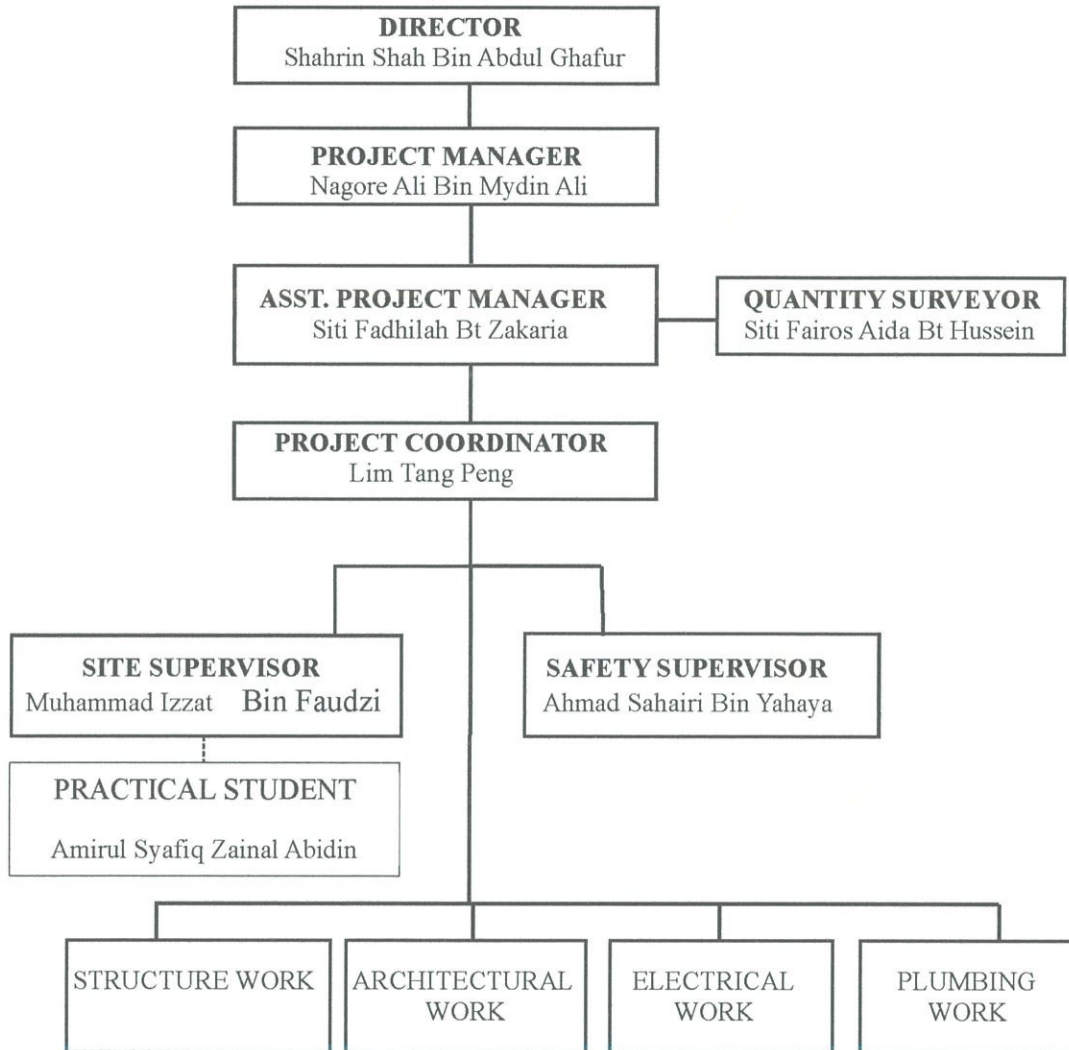


Figure 2.3: Organization Chart on Site Project

(Source: JKP Sdn. Bhd, 2014.)

2.4 List of Project

2.4.1 Completed project

I. Seri Akasia-Penang.



Figure 2.4 (i): Seri Akasia

Source: JKP Sdn. Bhd, 2014.

Table 2.2: Seri Akasia Description.

No	Client	Project Description	Year Completed	Amount RM
1.	JKP Sdn Bhd	This project is Single Storey Phase Two Detached House named Seri Akasia which located at Penanti, Seberang Perai Tengah	2014	230,000.00

(Source: JKP Sdn. Bhd ,2014)

II. Seri Anggun, Penang.



Figure 2.4 (ii): Seri Anggun.

Source: JKP Sdn. Bhd

Table 2.3: Seri Anggun Description.

No	Client	Project Description	Year Completed	Amount RM
2.	JKP Sdn Bhd	This project is 3 Storey Commercial Building Of Phase One named Seri Anggun which located at Sungai Nibong, Daerah Barat Daya.	2014	176,000.00

(Source: JKP Sdn. Bhd ,2014)

2.4.2 Current Project

I. Sri Bayu, Penang



Figure 2.4 (iii): Sri Bayu

Source: JKP Sdn. Bhd, 2014.

Table 2.4: Sri Bayu Description.

No	Client	Project Description	Date Start	Expected Complete	Amount RM
1.	JKP Sdn Bhd	This project is a medium cost apartment block 18 levels type B (800 sq.) (192 unit) and a podium block of 4 levels of car park. The location of the project is at Daerah Barat Daya.	March 2012	December 2015	262,800.00

(Source: JKP Sdn. Bhd ,2014)

II. Seri Akasia, Penang



Figure 2.4 (iv): Sri Akasia

Source: JKP Sdn. Bhd, 2014.

Table 2.5 : Seri Akasia Description.

No	Client	Project Description	Date Start	Expected Complete	Amount RM
2.	JKP Sdn Bhd	This project is Double Storey Terrace House of Phase 10 which located at Penanti, Seberang Perai Tengah.	January 2014	Feb 2016	350,000.00

(Source: JKP Sdn. Bhd, 2014)

CHAPTER 3.0

CAISSON

3.1 Introduction Of Project

Caisson are commonly used in Malaysia as foundation to support massive loaded structures such as high- rise building and bridges in consideration of reducing vibration ,slightly less noise and minimize involment of machineries. This foundation system and the soils underground avoid the structure from collapse. As the project is built in urban areas where the surrounding is residential house this type of foundation is an optional in order to reduce and minimize the noise while it is also more economical in term of machineries used.

This report presents a summary of excavated caisson construction commonly adopted in Malaysia geographical and the types of caisson which commonly used in this country. Besides, the factors affecting selection of foundation also explained in this report. The excavated caisson are mostly construct and excavate by labour and less machineries involvement. Besides this report also explained regarding the supervision and safety for excavated caisson and their benefits and weakness.

3.2 Project Background



Photo 3.1: The project signboard.

This project consist of 156 point of caissons and 39 micro piles to complete a medium cost apartment block 17 levels type A (900 sq.) (220 unit), a medium cost apartment block 18 levels type B (800 sq.) (192 unit) and a podium block of 4 levels of car park. The location of the project is at lot 1028, 1041-1043, Jalan Kampung Bukit, Mukim 11, Daerah Barat Daya, Bayan Lepas, Pulau Pinang.

3.2.1 Project Location

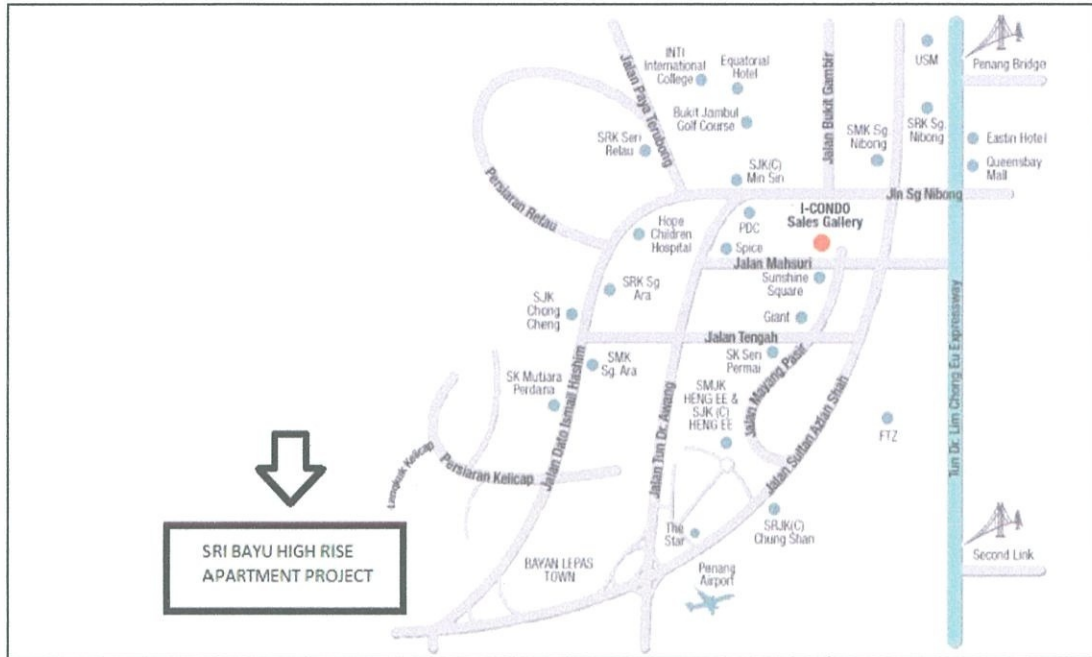


Figure 3.2: The maps location of the projects.

(Source: Google maps, 2014).

The location for the report been conducted is very strategic area in term of geographical and near to the Bayan Lepas International Airport. There was massive development and good for the investment or make an asset in this urban area.

3.2.2 Major Scope of Works In This Project.

Piling Works.

Piling works for caisson and micro pile for apartment type A, type B and a car park podium four levels. The coordinate of caisson according to construction drawing have been pointed by surveyor to proceed the piling works by referring construction drawing.

Building Works

Super structure and sub structure works for apartment block type A, B and car parks podium block four level. The super structure for these apartment is starting from floor slab until roof. The sub structure is involving the piling, pile cap until stump.

External and Side Works

Site preparation, earthworks and retaining wall considering our site location very near to the hillside. The roads work and parking for the residences to enter and exit the housing area. The drains, ditches, sewage pipes, reticulated water supply and hydrants work for the plumbing system of these apartments. It also including fence and grass planting.

Installation of Mechanical and Electrical Control Equipment.

Installation of fire control equipment, elevator, telephone and electrical equipment. For the facilities of the building, the installation of street lighting and area lighting, SMATV system and building security system.

Provisional sum works.

Landscape and swimming pool equipment with system and related works. Installation of equipment for children's playground and signboard. Rock or hard material excavation, smart home system, micropile and upgrading existing traffic lights and related works.

3.3 Case Study

The beginning before structural construction, the process of foundation work is the crucial part which the point to receive massive load from structural above so the foundation must be construct precisely and very influence towards the strength and verticality stabilization of the structure. So this report are focusing excavated caisson and the related works.



Photo 3.2: The process to erect the spiral link of Caisson.

3.3.1 Types of Caisson

i) Box Caisson



Photo 3.3 (i): Box Caisson

(Source: <http://www.thereeftank.com>)

It is open at the top and closed at the bottom which is usually constructed on land, then launched, floated to position, sink onto a previously prepared foundation while leaving its upper edge above water level. It serves as a suitable shell for a pier, seawall, breakwater, jetty or similar work and remaining permanently in place on the sea bottom.

ii) Pneumatic Caisson



Photo 3.3 (ii): Pneumatic Caisson

Source: <http://chestofbook.com>

Pneumatic Caissons have a similarities with an Open Caisson in term of their feature except they are provided with airtight bulkheads above the cutting edge. The space between the bulkhead and cutting edge, called the working chamber is pressurized to the extent necessary which able to control the inflow of water and soil, so the excavating could be performed by workmen operating in the working chamber at the bottom of the caisson.

iii) Open Caisson



Photo 3.3 (iii): Open Caisson

Source: <http://www.mancinicompanies.com>

It is open at both the bottom and the top is fitted with a cutting bottom edge which facilitates sinking through soft material while excavation is carried out inside through a honeycomb of large pipes or dredging wells. During the excavating and the caisson is sink, additional section are added to the shaft above. This process is continued until the caisson has sunk to required depth. A floor, usually of concrete is laid to provide a bottom seal. The dredging wells can then be filled with concrete to complete the structure.

iv) Excavated Caisson



Photo 3.3 (iv): Excavated Caisson

Construct manually from ground level using hand tools continually until reach the bedrock then performing penetration test to get the accurate strength which is enough the limit before inserting reinforcement and casting then construct a pile cap on cut of level.

3.3.2 Advantages and Disadvantages of Caisson Foundation.

In construction industries nowadays was very progressive in term of technology so many foundations and pilings have been made so the contrast of the benefit might be seen depending on the features of them. While the method to construct are also different because of soil types factor and the features of the purpose caisson.

Advantages of Caisson Foundation

There are several advantages towards construction of caisson which is it could minimize the noise and vibration. In term of machineries used, caisson is a method that can cut cost of machineries which could benefit the client and contractor.

Disadvantages of Caisson Foundation

The disadvantages for caisson it is extremely sensitive to construction procedures which is mean it influenced by water level activity, the water level is unpredictable and also the nature. The contaminated sites also will affected by caisson excavation. Then, lack of construction expertise and qualified inspectors contribute a major problem for caisson construction.

3.3.3 Factors Affecting Selection of Foundation

1) Loads from Buildings

The first factor considered is loads from building on the foundation. This load is a combination of dead load and imposed load on the buildings. Other loads such as wind loads, earthquake loads, snow loads and others are also considered based on location. The quantity of loads depends on the types of structure, number of floors and material of construction . As the number of floors increases, the dead load and imposed loads also increase. Choice of material for construction such as reinforced concrete or steel construction also has impacts on foundation according to Rushdi, N. (2011) *GeoScience Engineering Sdn. Bhd*, Penang : JKP Sdn. Bhd.

2) Types of Soil

Soil is a mixture of solid particles, moisture and air. Soil can be of many types such as clayey soil or expansive soil, sandy soil or loose soils etc. The soil near surface is called as top soil and below a depth of 300mm is called as sub soil. Generally subsoil is used as base for foundation for small buildings.

3) Types of Structure in Neighbourhood

According to Chew, M. (2009). *Construction Technology for Tall Buildings*, Singapore: World Scientific Publishing Co. Pte. Ltd. The selection of foundation for building construction can also be done based on the type of foundation selected for the buildings in the neighbouring building for the same types. Based on the success or failure of foundation for such buildings, decision can be taken for the selection of foundation.

3.3.4 Supervision and Safety for Caisson Foundation



Photo 3.3 (v): Safety requirements.

During the construction of caisson there is ‘Dos’ and ‘Don’t’ is aim at providing site operatives and contractors supervisory staff with guidance on safety precautions covering the day-to-day working of Hand Dug caisson.



Photo 3.3 (vi): Caisson workers wear safety attire.

Caisson workers should wear a safety helmet, particularly whilst inside caisson excavation. Keep working platforms around the top of caissons clear of all debris. Cover caissons when they are not being worked in such a manner that the cover cannot be accidentally dislodged. Then the safety officer must ensure the worker not enter a caisson excavation while concreting is proceeding or has only recently been completed in an immediately adjacent caisson, nor when the water level in an adjacent excavation is significantly higher. Besides, wear breathing masks and ear protection when drilling into rock inside caisson. When ascending or descending on a drum skip, observe the following precautions such as ensure locking clips are securely fixed to prevent tilting of the skip and wear a belt and line harness clipped to the skip chain and use a secure board on the skip to stand on.



Photo 3.3 (vii): Inspection for safety ensure.

Supervisors should ensure that lifting gear and supporting beams and frames regularly inspected and properly maintained. Ensure that concrete apron is provided around the top of all caisson and the apron top is at least 200mm above ground surface. Then make sure that all electrical equipment is of the proper type, properly sealed and insulated, and effectively earthed. Besides, supervisor should ensure that a rope is provided down the full height of each excavation as an emergency escape aid. Safety supervisor also should check that air-supply to bottom of excavation is uncontaminated and adequate, and that unworked caissons are thoroughly ventilated before work recommences. Ensure that a lifting harness and line are maintained on site for emergency use, together with a simple reliable oxygen breathing set and caisson workers are not left unattended in excavations. Carry out frequent inspections of caissons under construction and maintain accurate construction records.





Photo 3.3 (viii): Briefing of supervision and safety on site.

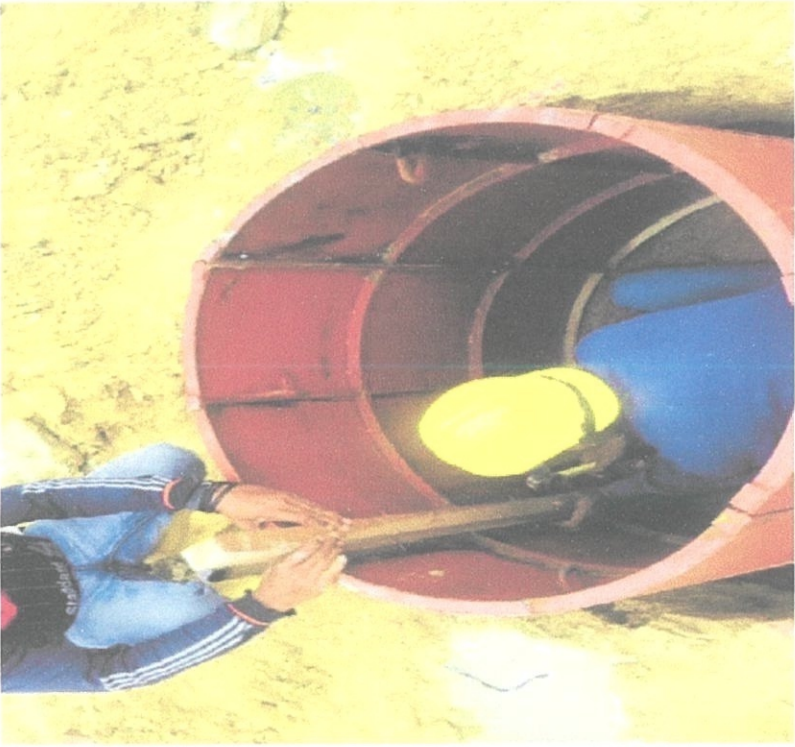
Safety can only be ensured if all involved in caisson construction are aware of the dangers and take them into consideration at the proper time. Concern for safety must start at the design stage and must continue until successful completion of work. Professional and technical personnel on consultants and contractors staffs must be involved in addition to site operatives and supervisors.

3.4: Method Statement for Construction of Caisson.

Table 3.4.1: Method Statement for Construction of Caisson

No	Operation	Method	Labor	Tools / Machineries
1.	<p>Setting out</p>  <p>Photo 3.4.1(i): Pointing a Caisson Coordinate</p>	<ul style="list-style-type: none"> - The surveyor is pointed the caisson position according to construction drawing before start the excavation of the caisson. - The surveyor use theodolite to get the reading and record the data. 	-1 Surveyor	<ul style="list-style-type: none"> - Tripod - Prism - Pole - Theodolite

2.	<p>Excavation of Soil</p>  <p>Photo 3.4.1(ii): Excavation of Caisson</p>	<ul style="list-style-type: none"> - The method of this process is to excavate to depth of 500mm from the ground level, excavation shall be carried out manually using hand tools. - The duration for this process took almost 1 day depending on underground water activity. - There are no machineries involved only hand tools being used by labor. The diagrams below will show further steps of the process. 	<ul style="list-style-type: none"> - 10 Labors 	<ul style="list-style-type: none"> - Hoe
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No.	Operation	Method	Labor	Equipment
3.	<p data-bbox="327 1433 359 1836">Construct Unreinforced Lining</p>  <p data-bbox="1220 1265 1252 1836">Photo 3.4.1(iii): Lock the Mould Casing Set</p>	<p data-bbox="327 683 805 1052">- Construct 150mm thick concrete annular (unreinforced lining). Place mould 1000mm into pit. Fix formwork around the top of the mould formwork size 200mm height. Each stage of excavation is only 1meter depth.</p> <p data-bbox="853 683 933 1052">- There are only using hand tools such as hoe and drill.</p>	- 2 Labors	- Hammer

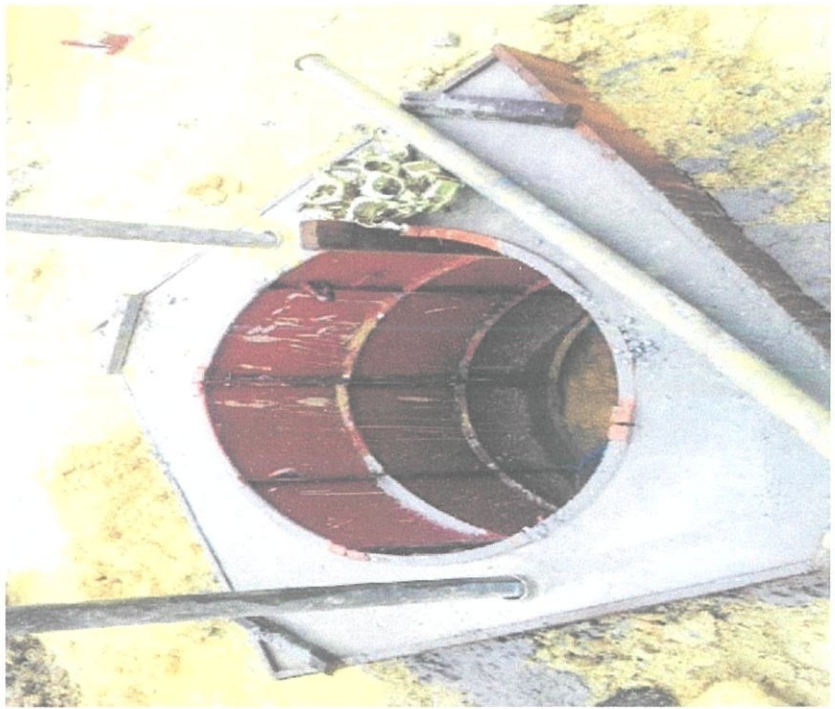
4.	Setup an Apron.		<p>- The apron is setup at initial excavation and act as a pulley base. This to ease the labors to collect and removed the excavated soil using a pulley frame.</p> <p>- The duration to cast the apron only 5minutes while to open up the formwork is 24 hours.</p> <p>- The apron have been poured concrete grade 35. The apron is important as a medium of removed the excavated soil.</p>	<p>- 2 Labor</p> <p>- Pulley stand</p>
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Photo 3.4.1(iv): Casting an Apron




5.	Repeat Operation (2)		<p>- Repeat operation '2' and continued until we reach the required base level or required bearing stratum. Penetration drill to a depth of 4.5m as required.</p>	-10 Labors	- Hoe
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Photo 3.4.1(v): Excavation of Cassion Continued

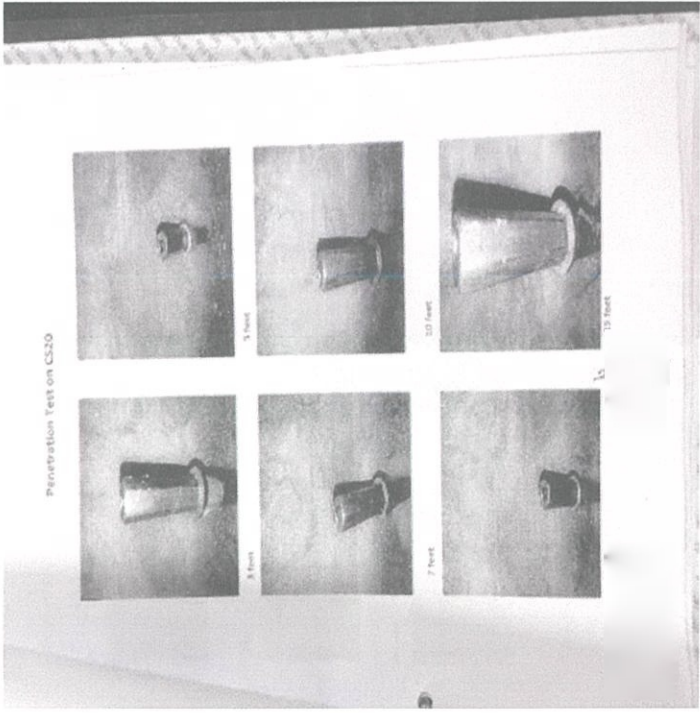
6.	Pneumatic Drilling	<p>- When rock is encountered during excavation, rock which cannot be break by manual tools, pneumatic drilling shall be used and blasting to be carry out or other devices approved by engineers.</p>	- 1 Labor	- Pneumatic Driller
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7.	<p>Drilling and Blasting</p>  <p>Photo 3.4.1(vi): Grenade used for Blasting.</p>	<p>- Drilling and blasting per stage shall be maximum 300mm depths. During drilling of rock, ventilator shall be used to suck out the dust inside the Caisson.</p>	<p>- 1 Engineer - 4 Labors</p>	<p>- Grenade</p>
8.	<p>Excavation to Bedrock</p>	<p>- Excavation shall be carried down to the required or to the specified bedrock level to the satisfaction of the engineers.(refer method statement for Penetration Test)</p>	<p>- 1 Labor</p>	<p>- Hoe</p>

9.	Casting Work	<p>- In dry or nearly dry Caisson shaft, concrete shall be placed through hopper and pipes with a free fall not exceeding 3meter.</p>	- 3 Labors	- Tremie Pipe
10.	Casting Work	<p>- In wet Caisson shaft concreting shall be carried out using tremie mix and method. The bottom of the tremie pipe shall always be immersed at least 1meter below the concrete surface.</p>	- 4 Labors	<p>- Tremie pipe - Concrete hopper</p>

11.	<p>Erection of Spiral Link</p>  <p>Photo 3.4.1 (viii): Erection of Spiral Link</p>	<p>- The reinforcement are fabricated on site and lifted by crane lower into the Caisson vertically. The duration to install the reinforcement took about 20minutes. 5-6 labors are needed in this process.</p>	<p>- 5 to 6 Labors</p>	<p>- Mobile crane</p>
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3.5 Method Statement for Penetration Test (from method Construction of Caisson)

No	Operation	Method	Labor	Equipments
1.	<p>Drill the Bedrock</p>  <p>Photo 3.5.1(i): Time Stopper And Penetration Set Are Being Used For This Test.</p>	<p>The penetration set consist of 6 different type of length which are 2, 5, 7, 10, 13, 15 feet. The worker will start using the 2 feet drill steel to do the test. Then continue another type of length continuously and the data to be recorded. The size of drill rod remains the same but different length for the penetration test. When the driller started to drill the rock, the time watcher which holding the time stopper will start the counting.</p>	<p>- 1 Engineer - 1 Labor</p>	<p>- Time Stopper - Driller</p>


3.	Drilling Work	<ul style="list-style-type: none"> - When the driller drills until 2 feet, he will change the drill steel from 2 feet to 5 feet in order to continue the drilling. 	- 1 Labor	- Driller
4.	Drilling Work (repeat step 3)	<ul style="list-style-type: none"> - Step 3 is repeated until we reach the target depth of 15 feet. 	- 1 Labor	- Driller
5.	Blasting Work	<ul style="list-style-type: none"> - Blasting work done before make a socket and bell out diameter. 	- 4 Labors	- Grenade

Photo 3.5.1(iii): Blasting Process.

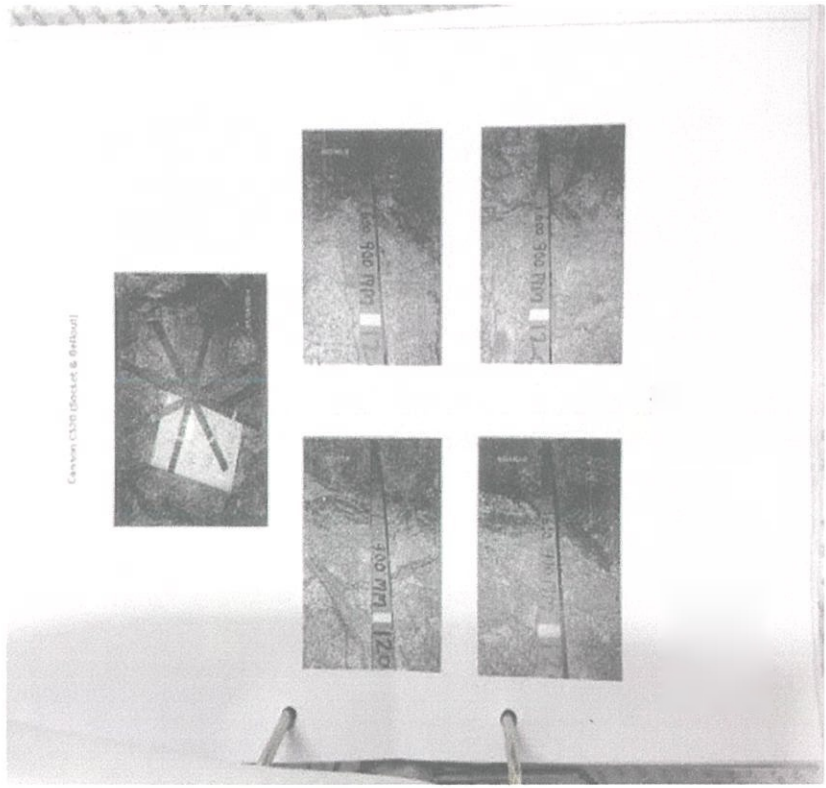
<p>6. Make a socket and bell out.</p>		<p>- The actual photo has been taken shown that the socket length was measure by wood that has been marked with measurement act as indicator. It is because the bell out was to deep for the engineer to measure manually. The photo shown the bell out diameter is 1200mm and the socket length is 900mm (refer detailed drawing).</p>	<p>- Measuring Tape</p>

Photo 3.5.1(iv): Caisson CS20 (Socket & Bell out)

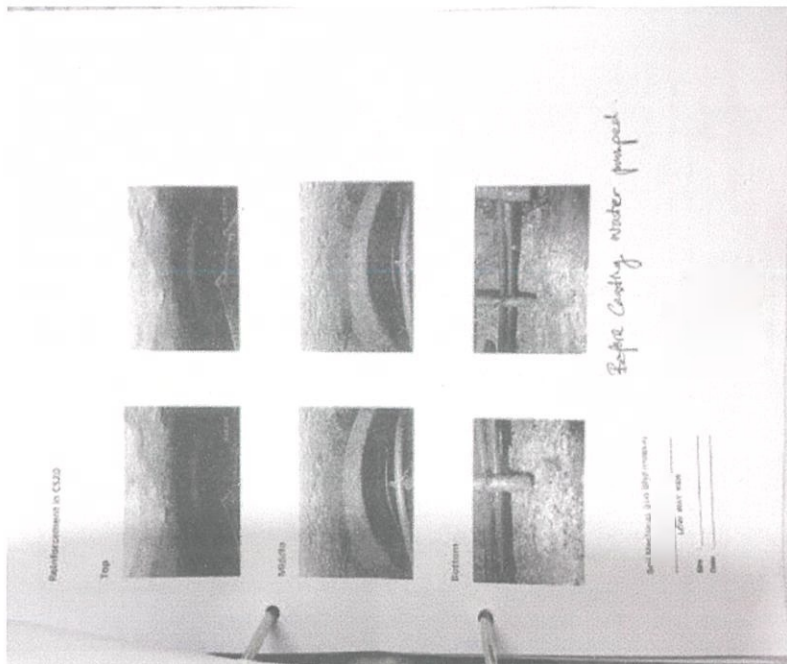
8.	<p>Installation of Reinforcement.</p>  <p>Reinforcement in Caisson</p> <p>Top</p> <p>Middle</p> <p>Bottom</p> <p>Before Casting water pumped.</p> <p>Date: _____</p> <p>Time: _____</p>	
- After the verticality is approved by engineer, the installation of spiral link reinforcement required before casting water pumped. The reinforcement must be not touch the floor of Caisson at least 20mm while the top and middle reinforcement must not touch the wall also minimum 20mm.	- 1 Labor	- Measuring Tape

Photo 3.5.1(vi): Reinforcement at Bottom of Caisson.

CHAPTER 4

CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Based on the observation for 3 main objectives for five months of internship training, a lot of things have been learnt and gain experience practically at the construction site of medium cost apartment block 17 levels type A (900 sq.) (220 unit), a medium cost apartment block 18 levels type B (800 sq.) (192 unit) and a podium block of 4 levels of car park such as the process of installation of acotec panel, construction of swimming pool and attending site project meeting experienced. The concreting and inspection of engineering structure also is valuable experienced to gain in this site. However, the scope of study is focusing on construction of caisson and its supervision for the case study that been conducted.

There are some minor problems occurred during the construction of excavated caisson such as water level underground activity and workers ventilation when in deep excavation. The water level underground activity is unpredictable and water can rise suddenly when it is very active. In order to overcome this problems, the contractor will provide water pump and summer sewer pump to sucking the water and remove from the caisson hole. The workers ventilation is one of the problems usually happened, so the safety supervisor will provide the ventilator duct for worker safety and good ventilation to excavate the caisson.

4.1 Recommendation

The excavation of caisson on site is very crucial and risky to all workers and possibility of negligence fall to the hollow of caisson is high. So it is recommended for safety supervisor to increase the security on site in every aspect to implement such control and inspect frequently each of caisson excavation progress in order for securities on site.

Safety supervisor also must ensure security after working hours to prevent theft of equipment for excavation such provide extra guard security staff when the site project is in wide scale and provide security patrols schedule for efficient security rotation system.

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