UNIVERSITI TEKNOLOGI MARA

DEPARTMENT OF BUILDING

FACULTY OF ARCHITECTURE, PLANNING AND SURVEYING

UNIVERSITI TEKNOLOGI MARA

(PERAK)

SEPTEMBER 2014

It is recommended that the report of this practical training provided

By

KHAIRUNNISA BINTI AHMAD ZAKUAN

2012608262

Entitled

POST-TENSIONED FLAT SLAB

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 UEM Sunrise Berhad for duration of 5 months starting from 12 May 2014 and ended 29 September 2014. It is submitted as one of the prerequisite requirements of DBN307 and accepted as a partial fulfillment of the requirements for obtaining the Diploma in Building.

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Date : 30 September 2014

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ABSTRACT

This report was conducted to identify the post-tensioned systems which use to resist load for a building structure. A building load is simply a force that a building structure needs to resist. The frame must be designed to withstand these loads without produce stress on the structure. One of the initiatives to control the stress and load in the structure is by designing the structure using the post-tensioned system. Post-tensioned system has high fatigue strength since the amplitude of the stress changes in the pre-stressing steel under alternating loads are quite small. For this reason, the post-tensioned construction has become to be used in many situations in buildings. The objective of the present for this report is to summarize the experience available today in the field of post-tensioning system for building construction and in particular. This report discusses the construction method for constructing post-tensioned flat slab, machinery and tools used for constructing post-tensioned flat slab and rectification works of post-tensioned flat slabs. Several methods are used to complete this report which includes observation, supervision, interview people and referring books. The uses of post-tensioned system in construction industry nowadays give positive impacts to the builders committee as it can develop a high strength structure and reduce risk related to building load.

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UEM United Engineers Malaysia

UiTM Universiti Teknologi MARA

CHAPTER 1

PREFACE

1.1 Introduction

Post-tensioned concrete is formed by pouring concrete into mould and allowing concrete to harden before tension force is applied. In many cases, post-tensioning allows construction that would otherwise be impossible due to either site constraints or architectural requirements. Post-tensioning is the method usually employed where stressing is to be carried out on site, curved tendons are required, the complete member is to be formed by joining together a series of precast concrete units and where negative bending moments are encountered (Aalami, 2014).

This method of reinforcing concrete enables a designer to take advantage of the considerable benefits provided by pre-stressed concrete while retaining the flexibility afforded by the cast-in-place method of building concrete structures (Rogers, 2008). Post-tensioned is one of the types of pre-stressed concrete. Pre-stressed concrete can be defined as pre-compressed concrete.

Pre-stressed is a method in constructing structural member by applying force to both ends of the structural member through tensioned reinforcement. This method may produce stronger structure, can carry higher load and also reduces bending. Compression is applied at areas where tensile stress develops when load is applied which will resist or balance out the tensile stress (William & Khan, 2005).

The other type of pre-stressed concrete is pre-tensioned concrete. Pre-tensioned concrete is made by pouring concrete into the mould after the tendons are stresses between the two abutments (Edward, 2009). When concrete has achieved it characteristic strength, tendon are released from the abutment and cut according to length of concrete.

1.2 Objective

i. To study the equipment and plant used of constructing the post-tensioned flat slabs.

ii. To identify the method of constructing the post-tensioned flat slabs.

iii. To determine the rectification works for post-tensioned flat slabs.

1.3 Scope of study

The scope of this study is limited to identifying the construction method of post-tensioned flat slabs. The study had been conducted at MK20 site project which it is a commercial development located at Mont Kiara, Kuala Lumpur. This study reviews the understanding of post-tensioning construction method from the beginning phase until the rectification works. This study also includes the knowledge about the equipment and plant used to construct the post-tensioned flat slabs.

1.4 Method of study

1.4.1 Observation

Observation is a fundamental way of finding out about the construction process of post-tensioned flat slabs. By the observation, the understanding about the method of constructing the post-tensioned flat slabs may be improved as it is the way of collecting and researching the information.

1.4.2 Supervision

Supervision method is the effective way to review clearly all the works at the construction site. By this method, the process of construction can be done smoothly and the problem involved in constructing the post-tensioned flat slabs can be determined by relating the problems with the process of the works involved which had been supervised.

1.4.3 Interview

Interview is the method of collecting data from the specific person who involved in the process of construction. Interview was conducted to obtain more detailed information which involve in construction process. It can be done by interviewing the general manager, site supervisor and any people who had an experience in the construction process of post-tensioned flat slab.

1.4.4 Books

Collecting data from the books is one of the effective methods because the information collected can be trusted. There are several books which are used to collecting data for this study. This method can be done by researching the books at the library and later comparing the information collected from the books with the other methods.

CHAPTER 2

COMPANY BACKGROUND

2.1 Introduction

UEM Sunrise Berhad is a public-listed company and one of Malaysia's leading property developers. Incorporated on 20 August 2008, the Company was formerly known as UEM Land Holdings Berhad. UEM Sunrise has core competencies in macro township development, high-rise residential, commercial, retail and integrated developments.

The Company is currently undertaking the development of Nusajaya, one of the five flagship zones and key driver of Iskandar Malaysia into a regional city like no other. Upon completion, Nusajaya will become the largest fully integrated urban development in Southeast Asia that will provide significant investment, financial and business opportunities to the economic growth and development of the region.

In the Central Region, UEM Sunrise is responsible for numerous residential, commercial and integrated developments largely within Kuala Lumpur's affluent Mont Kiara enclave as well as in Shah Alam, Selangor and Seremban, Negeri Sembilan.

UEM Sunrise is the flagship company for township and property development businesses of UEM Group Berhad and Khazanah Nasional Berhad. UEM Group is wholly-owned by Khazanah, an investment holding company of the Government of Malaysia.

2.2 Company profile

The company operates in three business segments which are property development segment, investment segment and others segment. Property development segment is engaged in constructing and developing residential and commercial properties. Property investment segment is engaged in investing in land and buildings for investment potential and rental income in future. Meanwhile, others segment is engaged in property management and interior design and consultancy services.

The company's subsidiaries include Ascot Assets Sdn Bhd, Aston Star Sdn Bhd, Cekap Kawal Sdn Bhd, Interior Design One Sdn Bhd, Laser Tower Sdn Bhd, Lembah Suria Sdn Bhd, Lucky Bright Star Sdn Bhd, Milik Harta Sdn Bhd, New Planet Trading Sdn Bhd, Prinsip Eramaju Sdn Bhd and SCM Property Services Sdn Bhd.

For MK20 construction project, the main contractor involved is Aston Star Sdn Bhd which is one of the company's subsidiaries. The Aston Star's World'Vest Base number is MYS000033340 and the Company Registration number is 270421-U. Meanwhile, the headquarters office is located at Solaris Dutamas, Kuala Lumpur.

Figure 2.1 Logo of UEM Sunrise Berhad

2.2.1 Board of directors

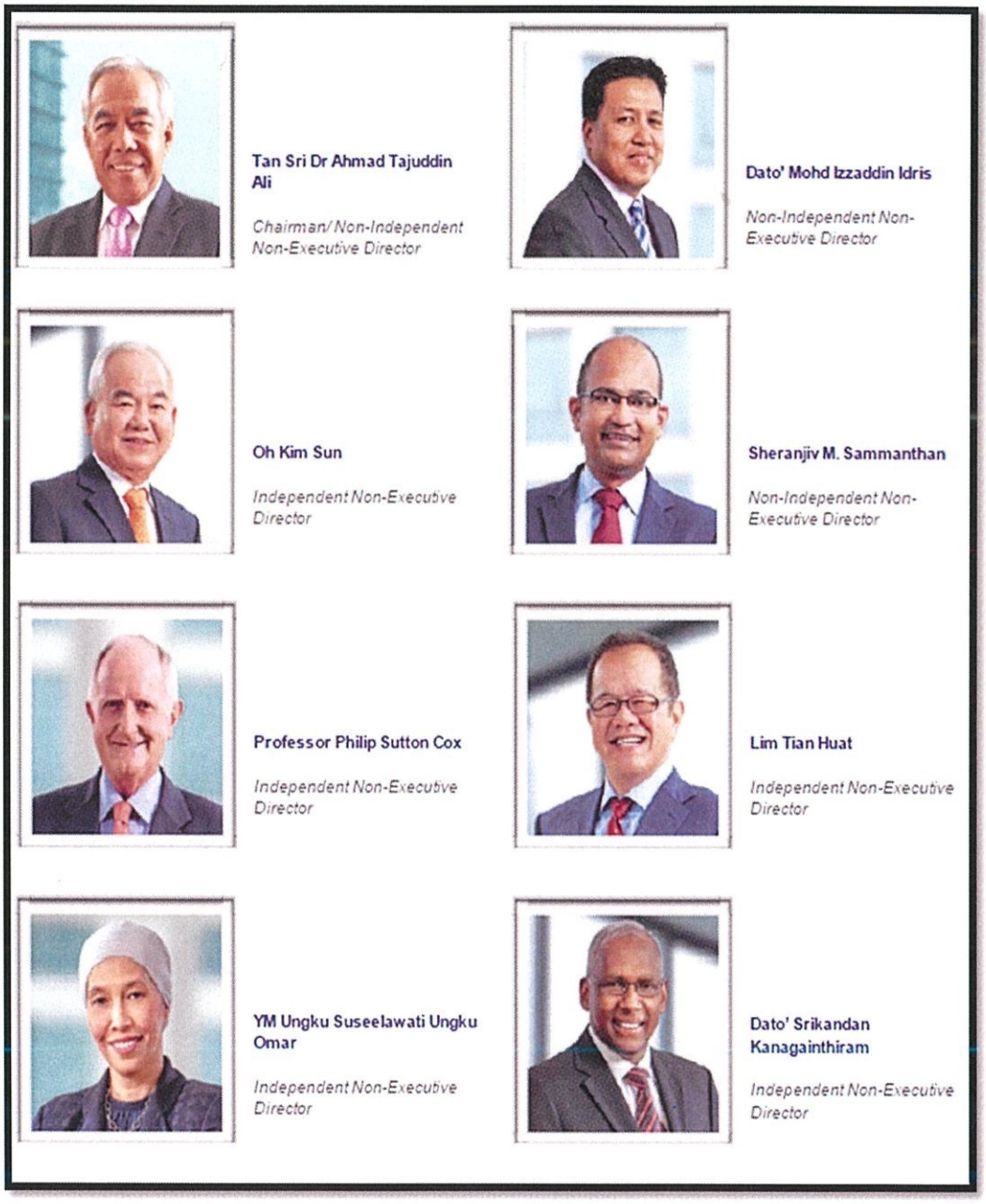


Figure 2.2 Board of directors of UEM Land Berhad

Source: UEM Sunrise Annual Report (2013)

2.2.2 Senior management

Figure 2.3 Senior management of UEM Land Berhad

Source: UEM Sunrise Annual Report (2013)

2.2.3 Vision

Building communities of the future with you and for you.

2.2.4 Mission

UEM Sunrise brings together the talented and skilled, the imaginative and the courageous. We create sustainable environments loved by home owners, acclaimed by investors and recognised by industry. We believe in thinking big and acting quickly to unlock potential; to thrive in a changing world.

2.2.5 Values

Our core values have stood the test of time. Acronym as TIPS, these values play a vital part in defining who we are as a diverse group of people with skills, expertise and knowledge that allow us to deliver innovative products and service excellence to our customers. T stands for Teamwork which is cooperative effort by the members of a group or team to achieve a common goal. I stands for Integrity which is the state of having steadfast adherence to a strict moral or ethical code. P stands for Passion for success which is a relentless drive to achieve excellence; commitment to meet and exceed targets. Lastly, S stands for Sincerity of intent which is something that is intended to be taken into action with consideration of the quality or condition of being sincere.

2.3 Organization chart

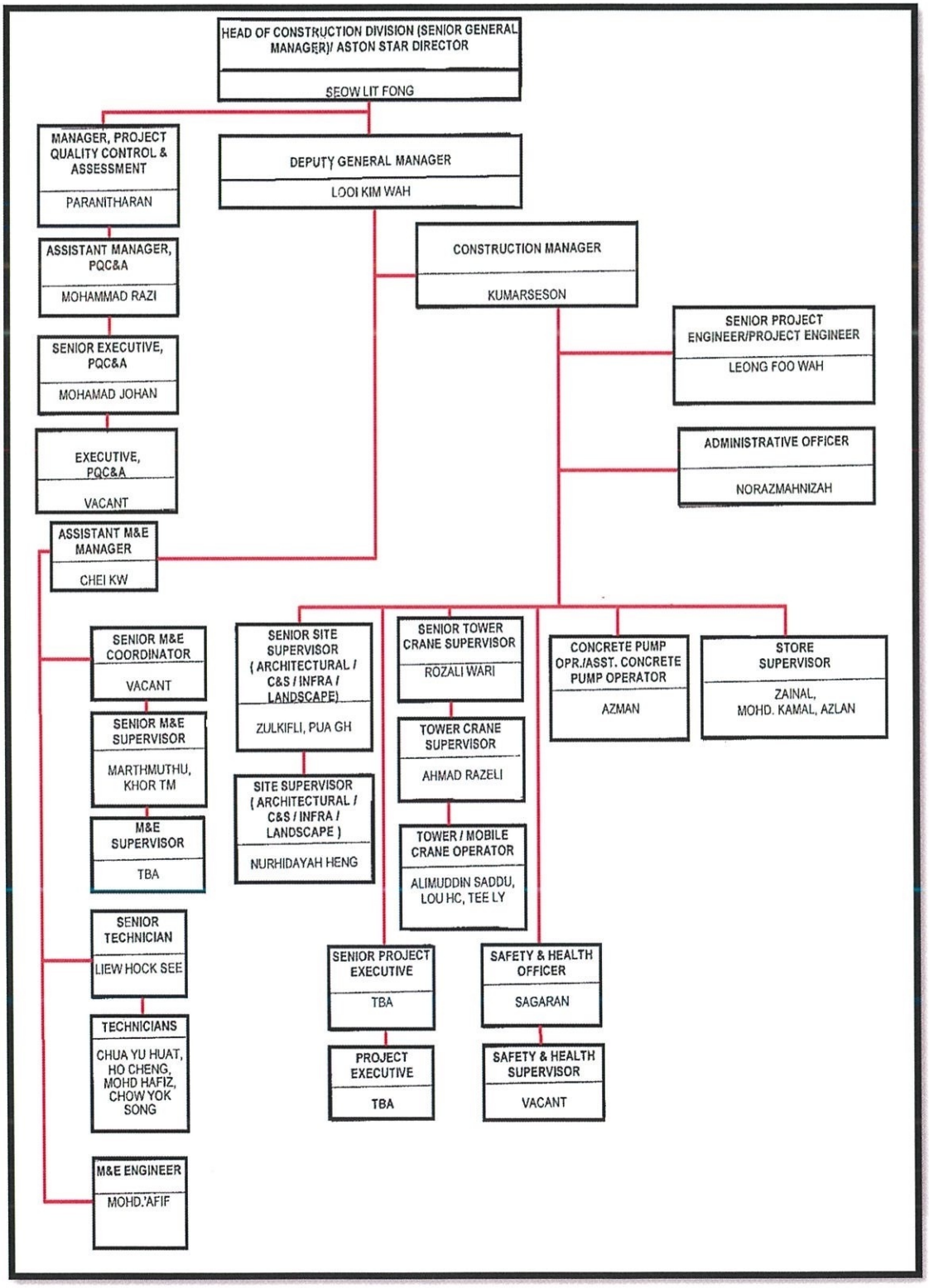


Figure 2.4 Organization chart of Aston Star Sdn Bhd for MK20 construction project

2.4 List of project

Most of the projects involved by UEM Sunrise Berhad are focused at southern region and central region of Malaysia and also includes for international projects. UEM Sunrise will always ensure the quality of construction and the design of the building.

Table 2.1 List of projects from UEM Sunrise Berhad

No.	Region	Project	Location	Description
1.	International	Quintet, Vancouver, Richmond	Singapore	This contemporary Asian-inspired mixed-use development is built on a 4.8 acres freehold land right in the heart of the bustling, vibrant city of Richmond, Canada. Majority of the 615 units within the five tower blocks are one and two bedrooms with sizes ranging from plus 500 square feet for a one- bedroom to over 1,500 square feet for penthouses and townhouses.
2.	International	DUO Singapore	Singapore	DUO is located within Bugis, an established art, educational, heritage and cultural district. It is home to more than 20 historical site and national monuments, and plays host to an exciting variety of events such as the monthly Bugis Arts Flea Market and the annual Singapore Night Festival. Located near the Singapore Art Museum, La Salle College of the Arts and the Waterloo Street Arts Belt.

3.	Central	Summer Suites	Kuala Lumpur	Summer Suites combines 34 storeys of premier office spaces, excellent work-conducive surroundings and unmatched location in Kuala Lumpur's Golden Triangle with innovative business infrastructure.
4.	Central	Residensi 22	Kuala Lumpur	Residensi 22 offers cosmopolitan and sophisticated interior, designed for gracious eco-living and luxury lifestyle. This majestic twin-tower condominium is located at a prime area of Mont Kiara with dual access to several major highways in Kuala Lumpur. The interior design will have a high level of personalisation for its residents with over 75% are corner units that come with wide balconies and excellent views that make for a pleasant place to unwind.
5.	Central	Verdi eco-dominium	Kuala Lumpur	Verdi eco-dominium is a development situated on 9.16 acres of freehold land that boasts an eco-friendly concept within a gated and guarded smart community conceived with convenience, comfort and security in mind. Each unit of Verdi eco-dominium comes equipped with the smart home features such as Unified Home Network, interactive Community Services Portal, web access home control, automated lighting control and a panic button.

6.	Central	Symphony Hills	Kuala Lumpur	Situated on a 98-acre freehold land in Cyberjaya's central business district, Symphony Hills is a mixed-strata urban residential development and the countries first Connected Intelligent Community offering smart-home features and community connectivity.
7.	Southern	Kota Iskandar	Johor	Kota Iskandar is the administrative centre of the Johor State Government developed by turnkey contractor Cahaya Jauhar Sdn Bhd. It comprises Dewan Negeri Johor, Chief Minister and State Secretary Office Complex as well as state and federal government office buildings, mosque and government staff housing.
8.	Southern	Puteri Harbour	Johor	Dubbed as the Jewel of Nusajaya, Puteri Harbour is a 688 acre urban integrated waterfront development offering the experience of exceptional waterfront living over the picturesque Straits of Johor. Featuring 10.8 km of waterfront properties comprising of canal homes and many more.
9.	Southern	Horizon Hills	Johor	Horizon Hills is an up-market mixed golf residential development that features a variety of landscapes that are a joy to the senses. Top notch 24 hour security completes this residential haven in Nusajaya.

10.	Southern	East Ledang	Johor	East Ledang UEM Sunrise's most prestigious offering with contemporary and spacious luxury resort homes nestled within seven parks featuring 31 esoteric, intimate and lush gardens. The lake, forest, wetland and canal themes here are melded together with tropical landscaping celebrating nature and where space means much than mere dimensions, both in the residences and in the overall 275-acre secured, guarded and patrolled.
11.	Southern	Nusa Bayu	Johor	Nusa Bayu is a medium-cost mixed development situated on a 260 acre footprint. It was conceptualised to cater to young families and first time homebuyers and planned with essential amenities such as primary and secondary schools, a mosque, a community centre, shopping and recreational facilities that include a 3.7 acre football field, 550-metre jogging path and a 7.5 acre lake.

CHAPTER 3

CASE STUDY

3.1 Introduction

This case study describes the construction method for post-tensioned flat slabs from the beginning phase until the rectification works. Post-tensioning is the method of concrete being cast around ducts in which the stressing tendons can be housed and the stressing is carried out after the concrete has hardened. The tendons are stressed from one or both ends.

When a concrete slab is stressed by the post-tensioning method, it means the steel is being tensioned and the concrete is being compressed (Dickens, 2008). Compression is a force that squeezes or crushes, and tension is a force that pulls something apart. Adding post-tensioned reinforcement instead of rebar alone combines the action of reinforcing the tension zones with the advantages of compressing the concrete slab.

The use of post-tensioned reinforcement to construct floor slabs can result in thinner concrete sections or longer spans between supports (Hurst, 1998). Designers commonly take advantage of this method to produce buildings and structures with clear open spaces which allowing more architectural freedom.

3.2 Project background

This case study is carried out at Mont Kiara, Kuala Lumpur for UEM Sunrise construction project. The project is to propose commercial development consists of Block A and Block B with 5 stories car park and one level of basement for shops and public amenities. Block A includes one block of 37 stories of hotel with 585 rooms and SOHO with 436 units. Meanwhile, Block B includes one block of 19 stories of services apartment with 334 units. The official name of this building is Arcoris Mont Kiara. The rough cost for this project is RM 47 300 000.00 which includes preliminaries cost, earth works cost, retaining structure cost, piling and pile cap cost, basement slab cost, mechanical and electrical services cost and others cost.

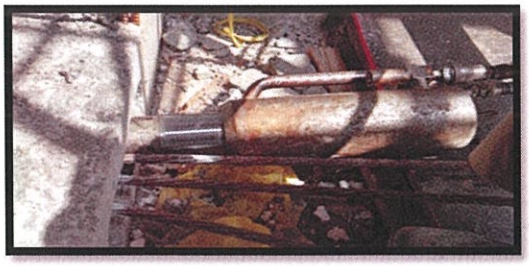
The main contractor for this project is Aston Star Sdn Bhd which it is a subsidiaries company of UEM Sunrise Berhad. The design consultant is Foster and Partners (M) Sdn Bhd which it is the British architectural firm based in London. Architect appointed is GDP Architects Sdn Bhd. Mechanical and electrical consultant is PAC & Rakan-Rakan Sdn Bhd. Meanwhile, the quantity surveyor appointed is Northcroft Lim Perunding Sdn Bhd and lastly WEB Structures (M) Sdn Bhd was appointed for civil, structural and geotechnical engineer. The sub-contractor was appointed from many companies base on their jobs specification. The BBR Construction Systems (M) Sdn Bhd was appointed for post-tensioned works. For this project, post-tensioned flat slab is only constructing at several parts of the building.

Photo 3.1 The scale model of Arcoris Mont Kiara

3.3 Case Study

The sequence of works involve in constructing the post-tensioned flat slab must be done correctly by the skilled workers. The equipment and plant used also must be handled by the skilled workers to avoid any of accidents occur during the works on the site and to avoid any of defects occur on the post-tensioned flat slab. Besides that, some of the plant used must have an approval certificate before it can be used.

Table 3.1 List of equipment and plant used for constructing post-tensioned flat slab

Item	Plant	Purpose
1	Disc cutter  **Photo 3.2** Disc cutter	To cut the pre-stressing strands or cables. An extra length of strands should be cut off after the stressing process.
2	Dead end device  **Photo 3.3** Dead end device	To fabricate the dead ends zone. Each dead end device can accommodate five strands.
3	Mono jack  **Photo 3.4** Mono jack	To stress off single strand or cable. The mono jack can stress only one strand on one time.

4	Hydraulic stressing pump  **Photo 3.5** Hydraulic stressing pump	To operate the mono jack device. The meter on this device will show the pressure exerted on the mono jack to stress the strands.
5	Grout mixer  **Photo 3.6** Grout mixer	To mix the cement grout. The ratio of the mixer materials will calculate by the supervisor.
6	Motorized grout pump  **Photo 3.7** Motorized grout pump	To pump grout into tendons through the PVC hoses.
7	Test cube mould  **Photo 3.8** Test cube	To make test cubes for grout and concrete of slab.

8.	Rebar wire twister  **Photo 3.9** Rebar wire twister	To tie the wire between the reinforcement bars. It is a simple tools and easy to handle by the general workers.
9.	Hammer  **Photo 3.10** Hammer	To tight the floor prop of the formwork. It is also used to nail the formwork.
10.	Concrete vibrator  **Photo 3.11** Concrete vibrator	To ensure that a poured concrete is free of air bubbles so that the concrete will remain strong and have a smooth finish even after the formwork is removed.
11.	Trowelling machine  **Photo 3.12** Trowelling machine	To apply a smooth finish to the surface of concrete slabs.
12.	Plastic mallet  **Photo 3.13** Plastic mallet	To adjust the verticality of floor props of formwork and use only on the bottom of floor props.

The **Figure 3.1** shows the sequence for constructing the post-tensioned flat slab. Before the concrete being cast and the stressing process being implemented, the main works should be constructed are formworks as it is the mould for the slab. Secondly, the reinforcement bars will be installed base on approved shop drawing. Then, tendon will be installed which it was the main elements of post-tensioned system. The concreting process will be carried out after the tendons were installed. After the concreting process and the concrete achieve a specified strength, all cables shall be stressed using hydraulic jack. If any defect was detected, the rectification works will be carried out.

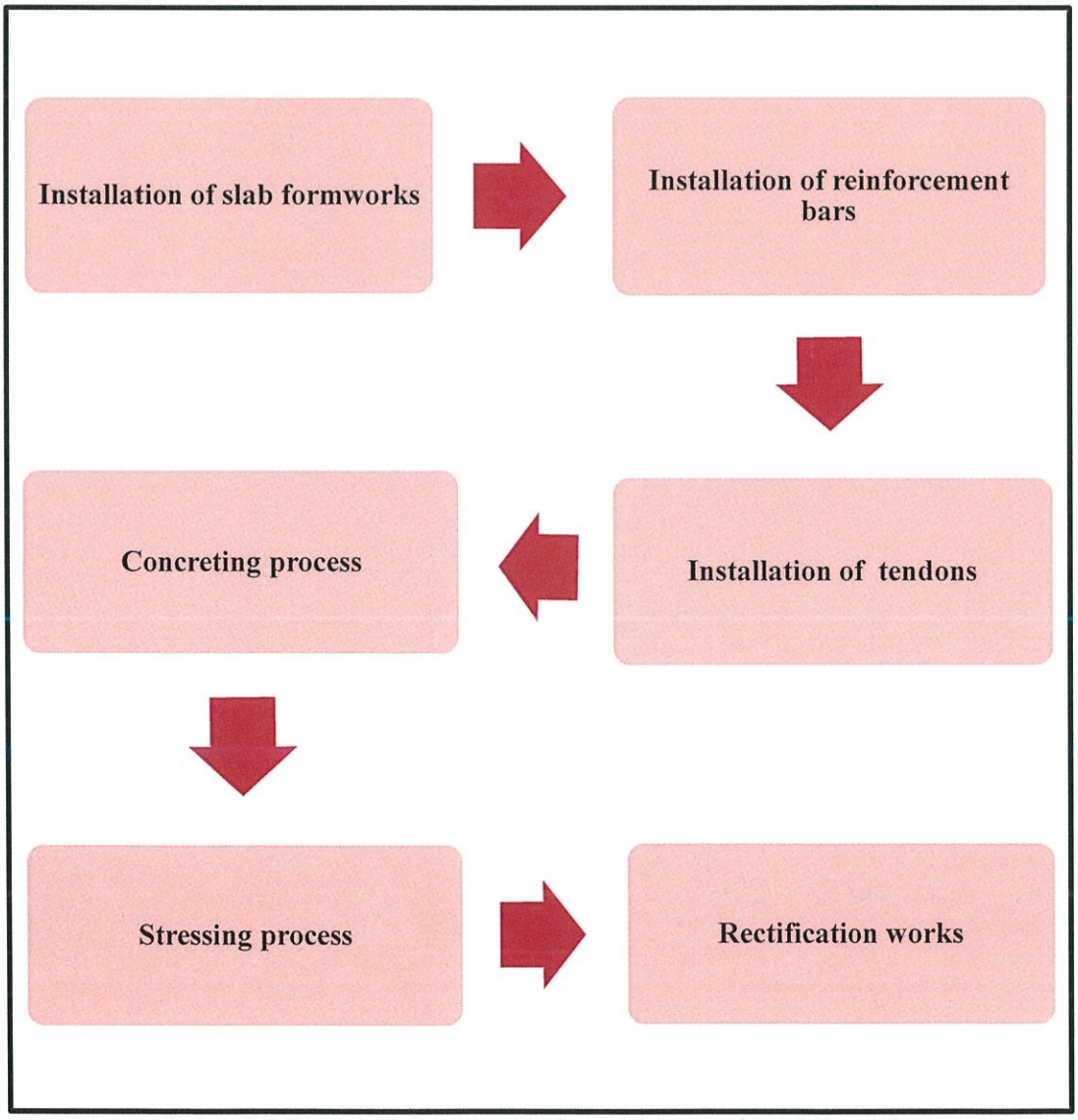


Figure 3.1 Sequence for construction of post-tensioned flat slab

3.3.1 Installation of slab formworks

For this project, the formworks are supplied by Doka Formwork Malaysia Sdn Bhd. With a slogan of "The Formwork Expert", Doka formwork system makes the construction process going smooth and efficient. Doka is an international producer and supplier of prefabricated formwork used in concrete pouring. The company headquarters is located in Amstetten, Austria.

3.3.1.1 Process of formworks installation by Doka Formwork

i. While the tables are still on the stack, attach an edge strip to each table that is going to be placed directly against a wall of the building. The table platforms for edge tables should also be pre-mounted while the tables are still on the stack.

Photo 3.14 Table platforms of Doka Formwork which still on stack before mounted process

ii. Mount the table platforms on the floor props. Fix the floor prop by open the wedge of the Dokamatic swivel-head and insert the prop.

Photo 3.15 The worker tightens the swivel-head by using a hammer

Photo 3.16 The table formwork which prefabricated on the site and ready to set to its using location

iii. Bring the table using a tower crane and set up the table approximately to its location. This process needs the cooperation between the workers to set the table formwork accurately on its position.

Photo 3.17 The tower crane used as a transport to carry the table formworks to its using location

Photo 3.18 The workers fix the table formwork and arrange it to be in straight position

iv. The height adjustment of the formworks may be applied during the step ii. After the table formworks are set up at its using locations, the floor prop may be adjusted to get in vertically position by using a plastic mallet. The mallet has been designed with just the right weight for this job and with plastic material of the right hardness.

Photo 3.19 The workers adjust the verticality of the formwork by using a plastic mallet

After the formworks are in straight position and in correct verticality, the works on it may be started. This system of formwork has many of advantages. By using a tower crane or Doka table lifting, it can be move in one place to another location without dismantle it.

3.3.2 Installation of reinforcement bars

Reinforcement bar is the main structural material and is also used as the connection, link and base plate. Reinforcement bar used in reinforced concrete and also pre-stressed concrete as it has high tensile strength.

3.3.2.1 Process of reinforcement bars installation

i. The installation of reinforcement bars should be started from the bottom part. The spacing between reinforcement bars will be marked on the formwork panels.

Photo 3.20 The spacing between reinforcement bars was marked by using a chalk

ii. After the marking process, the reinforcement bars will be installed by tying them using a wire. Rebar wire twister will be used as a tool to tie the reinforcement bars.

Photo 3.21 The general workers tie the bottom reinforcement bars

iii. The spacer block will be put and tied under the reinforcement bars to give spacing between the formworks and reinforcement bars.

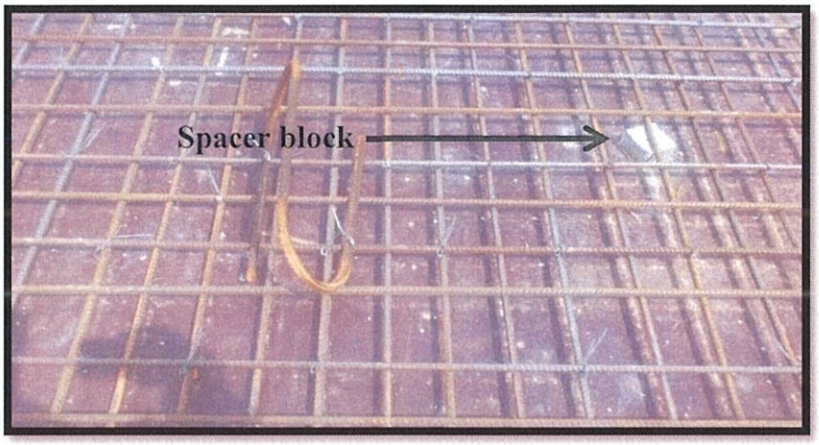


Photo 3.22 Spacer block on the bottom of reinforcement bars

iv. The steel chair will be installed on top of the bottom reinforcement bars as a support before top reinforcement bars being installed. The height of the steel chair is depends on the thickness of the slab.

Photo 3.23 The steel chair was installed to create a support for top reinforcement bars

v. Mechanical and electrical works will be carried out before the tendon was installed and concreting process was implemented. Specific items such as electric conduit, plumbing system and others facility being installed in order to complete the building requirements. This process also was carried out before the top reinforcement bars was installed.

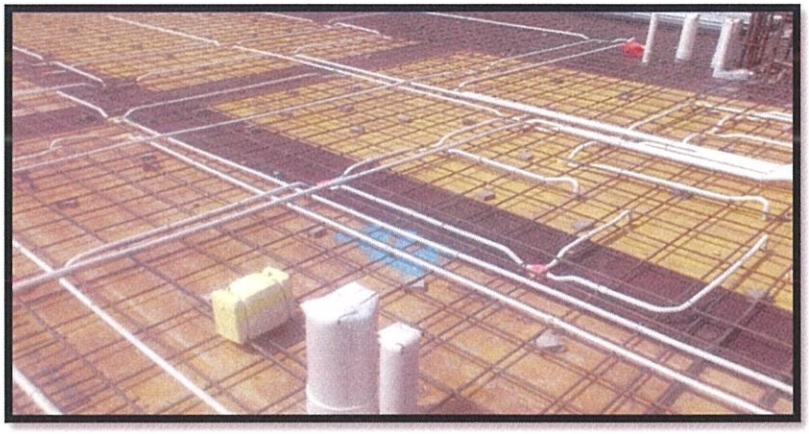


Photo 3.24 The conduit was installed for mechanical and electrical services

After the bottom reinforcement bars and mechanical and electrical conduit was installed, the site supervisor will make sure it was installed properly and was in good condition. The installation of top reinforcement bar will only carried out after the tendon for post-tensioned system was installed. The type of reinforcement bars used in this study is high tensile steel bar with 16 mm of diameter. The reinforcement bars will be tested first at the lab to ensure it is achieve required strength before installations process begin at the site.

3.3.3 Installation of tendons

A post-tensioning tendon is defined as a complete assembly consisting of the anchorages, the pre-stressing strand or bar, the sheathing or duct and any grout or corrosion-inhibiting coating surrounding the pre-stressing steel. The placing sequence and the supporting of the tendons are carried out in accordance with the placing and support drawings. For post-tensioned flat slabs, drawings for the pre-stressing must be prepared in addition to the reinforcement drawings. The sequence in which the tendons are to be placed must be carefully considered, so that the operation can take place smoothly. Normally, sequences of tendons allow it to be placed without any difficulty. To assure the stated tolerances, good coordination is required between all the installation of mechanical works, electrical works, structure works and the organization responsible for the tendon layout.

3.3.3.1 Process of tendons installation

i. Pre-stressed slab stressing anchorage devices at the stressing end will be fixed to the polystyrene or wooden box-out. The device at the stretching end consists of an anchor block and wedges.

Photo 3.25 Anchorage device at stretching end

ii. Install flat duct sheathing from the stretching end anchorage devices on top of the bottom reinforcement bar. Sheathing shall be joined using duct coupler and sealed with adhesive tape. The pre-stressing strands shall be threaded into the sheathing as shown in approved shop drawing.

Photo 3.26 Installation of flat duct sheathings and strands

iii. The strands will be supported by profile concrete chairs or steel bar chairs and securely tie to the ducts using wire. The tendon support chairs could be tied to the bottom reinforcement bar or any adjacent steel bars.

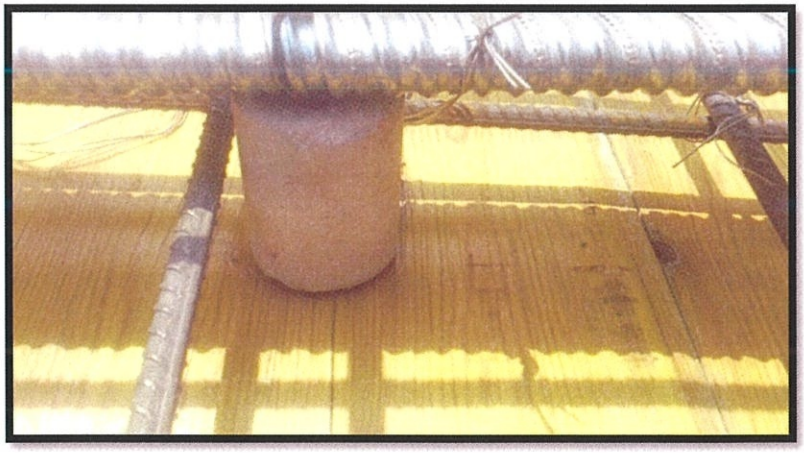


Photo 3.27 Concrete chair used to support the tendons

iv. At the dead end, the wires are looped to provide the anchorage. It transfers the force from the stressed tendon by a combination of bond and mechanical anchorage.

Photo 3.28 Anchorage device at dead end zone

v. Grout ventilation with PVC hoses shall be fixed at the stressing end and dead end. The joints and connections shall be sealed with adhesive tape to avoid ingress of cement grout or any concrete materials.

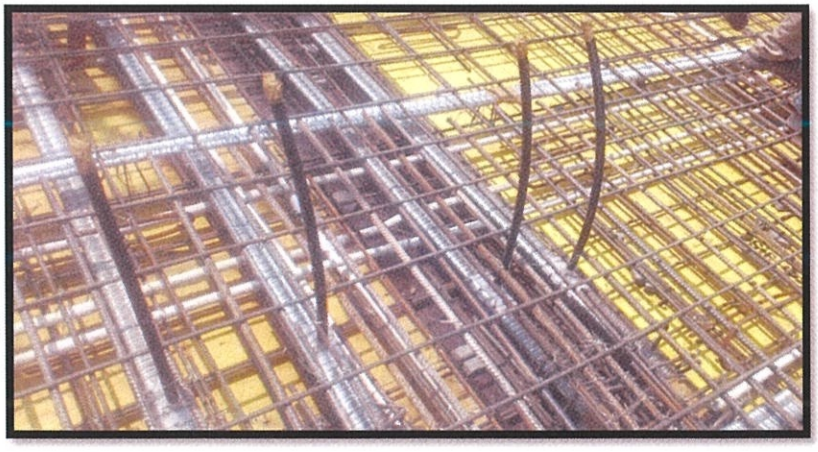


Photo 3.29 PVC hoses installed at end zones as grout ventilation

vi. After the PVC hoses fixed to the tendons, the supervisor will make an inspection works to ensure the installation of tendons are done correctly base on the approved shop drawings.

Photo 3.30 The supervisor measure the height of tendon from the surface of formwork

After all the tendons installations are done, the installation of top reinforcement bar will be carried out. The clerk of work will do the inspection works before approve and allow concreting process to be carried out.

3.3.4 Concreting process

For this case study area, the grade of concrete used for the slab is Grade 35. The concreting process will only be carried out after get an approval from the clerk of work. Before the concreting process, the site supervisor will do the slump test for the fresh concrete from the concrete truck mixer. After the required strength of the concrete pass the slump test, the concreting process may begin for constructing the post-tensioned flat slab. Cube test also will be carried out along this process.

3.3.4.1 Steps for concreting process

i. Begin the concrete placement at a corner and continuing placing the concrete along screed lines as have established. Do not let concrete free-fall more than one metre from a chute, pipe or bucket when it is being placed.

Photo 3.31 The workers concreting the slab from the corner area

ii. Concrete vibrator machine will be used along the concrete pouring process. Concrete vibrators consolidate freshly poured concrete so that trapped air and excess water are released and the concrete settles firmly in place in the formwork.

Photo 3.32 Concrete vibrator machine used to compact concrete

iii. Continue pouring the concrete until the forms are filled to the finished grade of the slab. Once the concrete completely filled, use the troweling machine to get a good finish on slab. Make one worker pass with the machine over the whole slab starting where the concrete was first placed. Then go back and make a second worker pass over the whole slab working up and down the length of the slab instead of across it.

Photo 3.33 Troweling machine used to get good finish for slab

iv. After the concrete have achieve around 70% of harden percentage, the concrete must be protected against loss of moisture as soon as the surface is sufficiently hard to resist spoilage. The method used is spray onto the slab with a special chemical called a curing compound which stops water drying out of the concrete too fast.

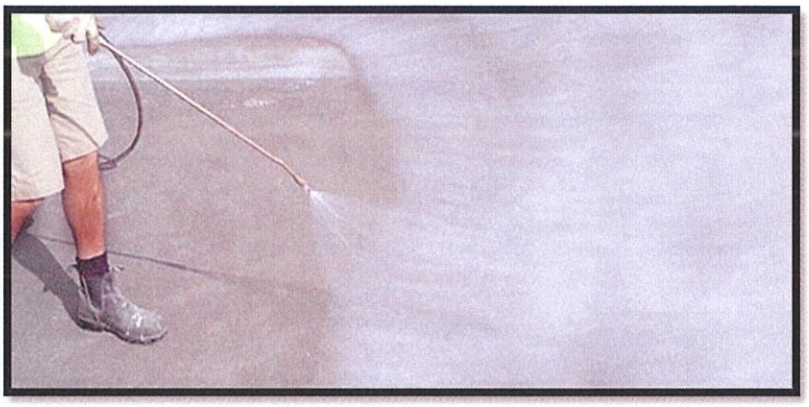


Photo 3.34 Curing compound was sprayed onto the slab surface

Once the concreting process is done, the site supervisor must observe any of defects occur on the slab. If any defect detected, the site supervisor may discuss with the clerk of work and the resident engineer to determine the correct and best way to solve the problems.

3.3.5 Stressing process

Stressing process is the important process for post-tensioned system. It must be done properly by skilled workers. Tendons have to be stressed at a specific time during the curing stage. Stressing them too late allows the slab to advance significantly through the curing stage. At this point, the slab is too strong to allow the stressing operation to close any plastic cracks that opened up during curing. To prevent this problem, the stressing operation should start as soon as the concrete attains the proper strength. This strength is typically reached during the first 4 to 10 days of the curing stage (Dickens, 2008).

3.3.5.1 Steps for stressing process

i. After concreting, the carpenter shall remove the vertical side formwork and wooden boxes or polystyrene boxes at stretching end anchorage device.

Photo 3.35 Anchorage devices at stretching end is ready to stress

ii. The cable will be connecting to the mono jack machine for stressing process. Mono jack machine only can stressing one strand in one time. The mono jack machine shall have stressing jack certificate as attached in Appendix A before it can be used.

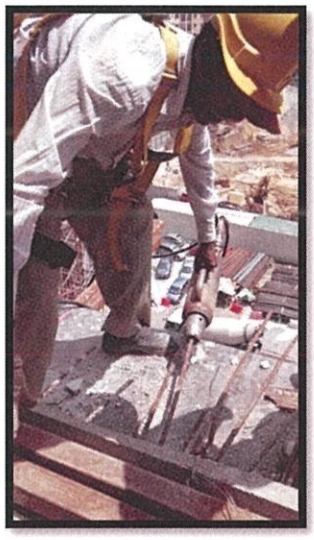


Photo 3.36 Mono jack machine connected to the first cable

iii. Hydraulic stressing pump was used to operate the mono jack machine. Hydraulic stressing pump must have the certificate of calibration as attached in Appendix B before it can be used. During stressing, the supervisor will calculate the actual measured extension on site and compare with the theoretical calculated extension by the engineer.

Photo 3.37 The supervisor records the required data

iv. The step iii. will be done for every cables. Once the strands stressed, the extension measurement will be taken and recorded in the quality checklist form as attached in Appendix C. All stressing length of cables shall be cut after getting an approval of stressing records from the engineer.

Photo 3.38 Extra strands being cut after the stressing process

v. The PVC hoses for grout ventilation will be filled. Grout shall be mixed according to the grout specification as attached in Appendix D. Grout mixer shall be injected into each PVC hoses until clear grout flow out from another outlet PVC hoses on the other end. The grout hose at the outlet hoses shall then be sealed.

Photo 3.39 Surplus grout flow out through PVC hoses

vi. Before grouting works can proceed, the anchor heads in the stressing end zone shall be sealed off with sand and cement grout to ensure no loss of grout from this point. After grouting completed, concrete back all stressing recesses and pour strip.

Photo 3.40 Hole at stressing end zone being sealed off

The stressing process must be handled by experienced personnel as it is the complicated procedures that must be done correctly and smoothly. The equipment used must be in good condition so that any of possibility errors may be avoid. In the nutshell, this procedure is the last steps if there are no any of defects are detected.

3.3.6 Rectification works

The defects occurred of post-tensioned flat slab may be different with some elements. Since it has tendons, post-tensioned system raises a number of problems related to the strands. The problem that related with reinforcement bars and concrete slab can be solve with similar method of reinforce concrete slab. Meanwhile, specific method must be done if the defects or problems are related with the tendons.

If a few strands in the slab tendon had snapped during stressing, stop the stressing works immediately and examine the strands. Report the problems to the design engineer and pre-stressing manager. The force lost in the affected tendon will be calculated and the good strands will remain stress to the required force by using mono jack and hydraulic stressing pump. For the other tendons, stress to higher forces to compensate for the losses.

If a few strands in the tendon had snapped off after lock off, check whether the remaining locked off strands have their wedges evenly sealed on the anchor block. Re-stress the tendon to a force to be determined by design engineer. The adjacent tendons may be required to be stress to higher forces to compensate for the loss in force in the affected tendon.

CHAPTER 4

CONCLUSION AND RECOMMENDATION

The application of post-tensioned system in the building construction gives many of advantages in construction industry. The most important advantages offered by post-tensioning is have high fatigue strength since the amplitude of the stress changes in the pre-stressing steel under alternating loads are quite small (Lin & Burns, 1981). By comparison with reinforced concrete, post-tensioned saving in the uses of concrete and steel due to the possibility of working the entire concrete cross-section with more slender design (Rogers, 2008).

The process includes in constructing post-tensioned flat slabs are the installation of formworks, installation of reinforcement bars, installation of tendons, concreting process, stressing process and lastly rectification works. This process must be done correctly and effectively by all personnel engaged in pre-stressing works. All personnel must know, understand and complying the site safety rules and procedures during the construction of post-tensioned flat slabs. Meanwhile, the plants used must be in good condition and has certificate of approval before it can be used. The equipment and plant used for constructing the post-tensioned flat slab are disc cutter, dead end device, mono jack machine, hydraulic stressing machine and test cube mould.

The maintenance process of post-tensioned flat slabs was different with others type of slab for certain elements. Compare to reinforce concrete slabs, the post-tensioned flat slabs may have an additional problems related to the tendons. For this reason, the post-tensioned flat slabs must be maintained regularly from the construction process until it was completed. In conclusion, the construction of post-tensioned flat slabs is more ideal design for the mega project because it has smaller deflections than reinforced concrete. Its construction should be developed in this country as it is more economical structures and considerable reduction in construction time.

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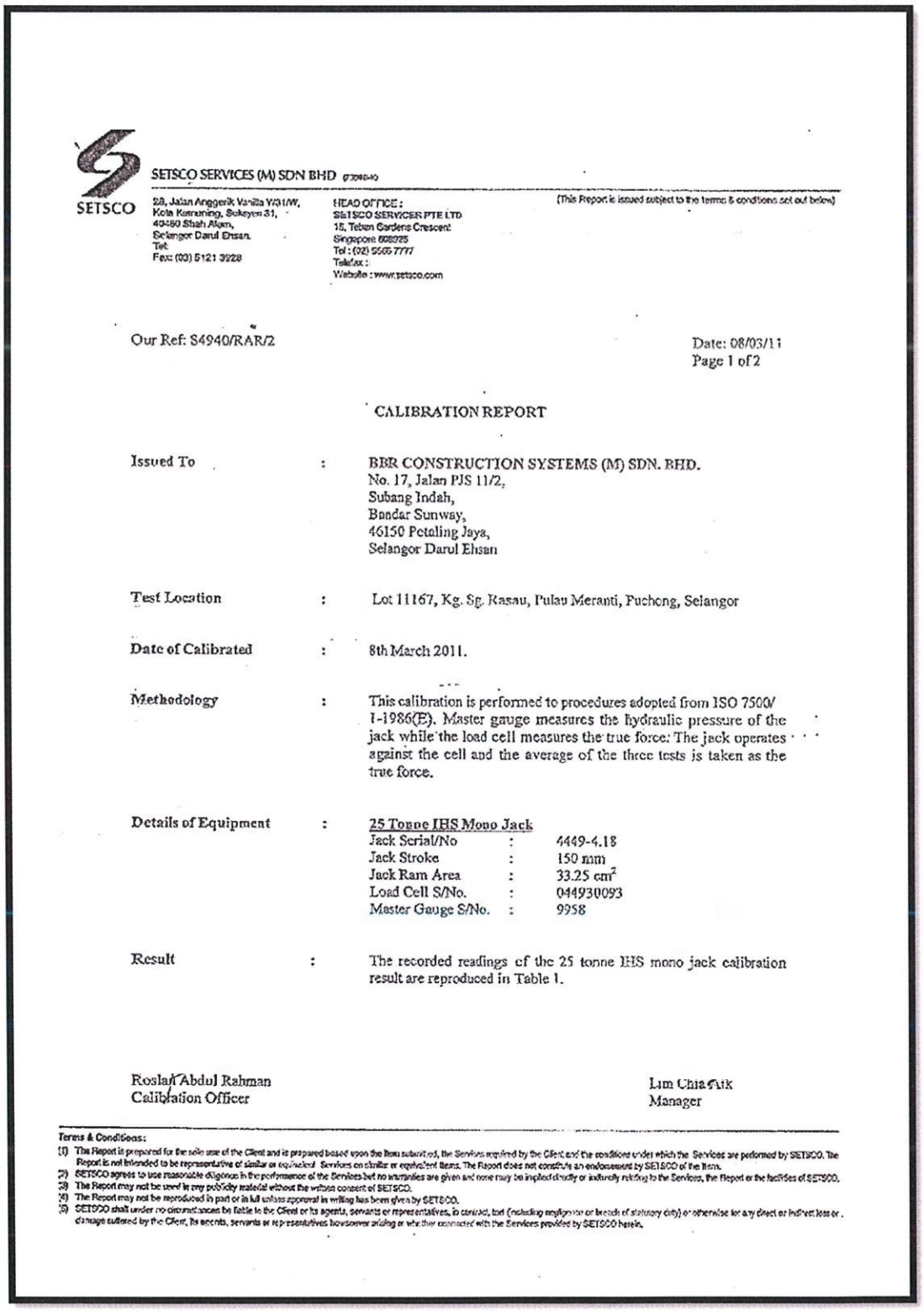
Appendix A: Stressing jack certificate



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Website : www.setsco.com

(This Report is issued subject to the terms & conditions set out below)

Our Ref: S4940/RAR/2

Date: 08/03/11
Page 1 of 2

CALIBRATION REPORT

Issued To	:	BBR CONSTRUCTION SYSTEMS (M) SDN. BHD. No. 17, Jalan PJS 11/2, Subang Indah, Bandar Sunway, 46150 Petaling Jaya, Selangor Darul Ehsan
Test Location	:	Lot 11167, Kg. Sg. Rasau, Pulau Meranti, Puchong, Selangor
Date of Calibrated	:	8th March 2011.
Methodology	:	This calibration is performed to procedures adopted from ISO 7500/ I-1986(E). Master gauge measures the hydraulic pressure of the jack while the load cell measures the true force. The jack operates against the cell and the average of the three tests is taken as the true force.
Details of Equipment	:	25 Tonne IHS Mono Jack Jack Serial/No : 4449-4.18 Jack Stroke : 150 mm Jack Ram Area : 33.25 cm^2 Load Cell S/No. : 044930093 Master Gauge S/No. : 9958
Result	:	The recorded readings of the 25 tonne IHS mono jack calibration result are reproduced in Table 1.

Roslan Abdul Rahman
Calibration Officer

Lim Chia Aik
Manager

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Appendix B: Certificate of calibration

SIME-SIRIM TECHNOLOGIES

CERTIFICATE OF CALIBRATION

DATE OF ISSUE : 12 January 2011 CERTIFICATE NUMBER : SSTS/R/2011A-936

ISSUED BY : Sime-SIRIM Technologies Sdn. Bhd.
(Co No.:292201-P)
Kompleks Sime Darby, Pensiran Kewajipan,
47600 Subang Jaya,
Selangor Darul Ehsan
Tel. : Fax. : 03-56329077

PAGE 1 OF 2 PAGES

APPROVED SIGNATORIES
Hasnah Hassan
Mohd Hashim Effendi

Submitted by : BBR Construction Systems (M) Sdn.Bhd.
No.17, Jalan PJS 11/2,
Subang Indah, Bandar Sunway,
46150 Petaling Jaya, Selangor.
[Attn. : Ng.Si-Peng]

Job No. : SJ2011-124-1
Date Received : 07.01.2011

Instrument : Dial Gauge /Indicator
Manufacturer : Mitutoyo

Model No. : 3058-11
Serial No. : 401285

Instrument Condition When Received:
Physically in good condition

Instrument Condition When Returned:
1. Calibrated and Test Serviceable
2. Calibration Due Date requested by customer
3. The user should be aware that there are a number of factors that may caused this instrument to drift out of calibration before the specified calibration interval has expired.
4. *Denote out of Tolerance

Environmental Condition :-
Average Temperature : 20 ± 1 ° C
Average Relative Humidity : 52 ± 1 % RH
Calibration Date : 12 January 2011
Requested Cal. Due Date : 12 January 2013

Calibration Method :
This instrument was calibrated using the Calibration Procedure No. M3D/0009 Rev. 11.0

Calibration Standard(s) Used:

Instrument Type :	Serial No. :	Cal. Due Date :	Cal. Cert. No.	Traceability :
Sylvac Probe	9125	18.05.2011	SST/I/R/2010-138(S)	SST (SI)/NML(MSIA)

The standard instruments used in this calibration are traceable to either the National Standards maintained at the National Metrology Laboratory, SIRIM Berhad or other recognised International Standard Laboratories

Calibration Sticker No. : S-32-3613

Measurement Uncertainty : ± 7 µm
The uncertainty calculation is based on the ISO Guide to the Expression of Uncertainty in Measurement.
Coverage factor: k =2.18

Approved Signatory

The uncertainties are for a confidence probability of not less than 95%

Appendix C: Quality checklist form

BBR

BBR CONSTRUCTION SYSTEMS (M) SDN BHD (Company No: 295010-X)

Form No: FI-QR-03 Rev. (1)

MATERIAL/CUTTING LIST

Project :

Date :

Beam No : Floor Area :

Tendon Mark	Nos. of Strand	Nett Length [m]	Stressing Length [m]	Cutting Length [m]	Coil No.	Mill Certificate No.

Prepared By :- Checked By :-

Name : Name :

Appendix D: Grout specification

- GROUT SPECIFICATION

1. Proposed Grout Mix

   1.1 Cement one bag (50kg) OPC

   1.2 Water 0.40 x 50Kg = 20.0 kg (20.0 litre) maximum

   1.3 Admixture - Estogrout Admix PE (or equivalent)

   - 325gm (one sachet) for 1 bag of cement (50 kg)

2. Grouting Pressure

   The grout is pumped to a minimum pressure of 25 psi (0.173 N/mm2) and maximum pressure of 60 psi (0.414 N/mm2) before lock-off.

3. Grout Strength

   The required strength of above grout mix is:-
   - 17 N/mm² at 7 days
   - 30 N/mm² at 28 days [BS 8110: Part 1:1997; Clause A.3.4]
     [Test in accordance with BS 1881: Parts 108, 111 and 116]

- No provision to test for 7 days concrete cube strength.