DEPARTMENT OF BUILDING
UNIVERSITI TEKNOLOGI MARA
(PERAK)

THE PRODUCTION OF ON SITE PRECAST CONCRETE COMPONENTS FOR INDUSTRIALISED BUILDING SYSTEM

Prepared by:

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DECEMBER 2018

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Entitled

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be accepted in partial fulfillment of the requirement for obtaining the 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 Sinar MEC Holdings Sdn. Bhd for duration of 14 weeks starting from 3 September 2018 and ended on 7 December 2018. It is submitted as one of the prequisite requirements of DBG307 and accepted as a partial fulfilment of the requirements for obtaining the Diploma in Building.

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DATE : 7 DECEMBER 2018

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Last but not least, my special thanks to my beloved parents for their sacrifices over the years.

Thank you so much.

ABSTRACT

Industrialised Building System (IBS) is a system which has been adopted for many years now. Therefore, this report will discuss about the production of on-site precast concrete components for IBS based on code of practice on BS8110-1:1997. The main objective of this report is to determine the production of concrete components for IBS, which is literally related to the report title itself. Thus, it will focus on the production of precast concrete beams and columns using steel moulds on site, starting from design and shop drawings until the last process which is the quality control. Other than that, this report also includes the introduction to IBS system itself and will identify the problems faced using IBS on site and ways to overcome them. This report was conducted within three months of practical training located at sebahagian lot 7159, Mukim 6, in the province of Bertam. The method of research are interviews, document reviews, observation and references. This report will also look into the problems and solutions to overcome the problem as we look to uphold and enhance the implementation of IBS for future purposes.

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CHAPTER 1.0

INTRODUCTION

Industrialised Building System (IBS) is the term defined by the industry and the government of Malaysia to represent the implementation of construction industrialisation and the use of prefabricated components in building construction. IBS construction consists of precast component systems, fabricated steel structures, innovative mould systems, modular block systems and prefabricated timber structures as construction components. Construction personnel have started to embrace IBS for grasping better construction quality and productivity, reducing risks in regard to occupational safety and health, controlling issues of skilled workers and dependency on manual foreign labour, and achieving the sole purpose of reducing the overall cost of construction. (Warszawski, 1999).

According to Badir Razali building system classification (Badir et al. 1998), IBS and conventional construction are different in various aspects. The IBS adoption requires pivotal structural change to the industry. IBS change how the people in the building industry work, in terms of process and product. IBS made itself to serious consideration of how the construction projects are planned and executed. It needs a new business approach, investment, and financial planning, including effective combination of cost control and selection of project that give enough volume to balance out the investment. In the design stage, the design engineers have to assert input from the production and construction processes and it should not be used as a late solution to minimising construction time, but rather as an pivotal part of the design from the earliest possible stage of the project. Project management in IBS focuses on coordinating and managing the elements, system and organization. It requires a various strategies on supply chain, planning, scheduling and handling.

The IBS building procurement is slightly different from conventional construction which includes purchasing of materials at the first place before the actual site progresses. Nevertheless, there is an inadequency of systematic and rigorous studies on the aspects of IBS and lack of identification of the factors that lead to the success of IBS adoption. (Peng, 1986).

1.1 Background and scope of study

The client for this school project is none other than the Kementerian Pendidikan Malaysia itself (KPM). They have been building a diversified range of alma maters, both primary and secondary schools and educational facilities all over Malaysia since the beginning of time since the ministry was established.

The main contractor for this project is Sinar MEC Holdings Sdn. Bhd. The study is mainly done during the duration of practical training, from 3 September 2018 till 7 December 2018. The construction site is located at Sebahagian Lot 7159, Mukim 6, in the province of Bertam.

The focus of the study is of course, the IBS installation on site. The component that is studied is the type of IBS system used here on this construction site, which is the pin and wedge system including the materials and machineries. To further clarify, the component that is not studied are the quantity of labours, the delivery of IBS structure such as precast hollow core slab from factory to site and the finishes used after the structures are erected.

The project started as early in June 2017 and is expected to be completed in June 2019. This site is proposed to build a four-storey workshop and classroom block, three-storey administration block, elevated water pump, a garbage depot and two bus stands.

1.2 Objectives

The objectives laid out below help to provide basis for data and information collection for my study. Some of the objectives are:

1. To identify the benefits of implementing IBS on site.
2. To determine the production of on-site precast IBS elements on site.
3. To identify the problems faced using IBS system on site and solutions to overcome them.

1.3 Research methods

In obtaining the information and data required, we have set some methods to ease them, namely interviews, document reviews, observation and references.

1.3.1 Interviews

The project manager himself, has helped me in explaining regarding the method used, the process involved and how the construction started. The interviews are rather casual, where i was the one asking questions such as "how is the mechanism of the IBS using this pin and wedge method? What is the weight of each individual hollow core?" These unstructured-interviews are done throughout the length of my practical training on site. The informations obtained are both video recorded and jotted down on a note book.

1.3.2 Document Reviews

We had given the company profile to give me a better insight on the construction team. Monthly progress report is also shown to compare the expected progress and the actual progress of the project. Some borrowed layout plan of the building is used for reference. Evidently, reading an unfinished plan is not as simple as I thought. Those architectural symbols and so much more really need an expert to read them. Otherwise, the project will be awfully constructed.

1.3.3 Observation

From my observation, workplace inspection is compulsory to any of the ongoing construction site in order to maintain safety and prevent any unwanted tragedy and accident. There are 3 most important steps and aid method: (a) informal inspection (b) general inspection (c) critical part inspection. While doing the inspection, it is advisable to prepare a checklist. It will ensure the inspection run smoothly and would not leave any important part before preventing from doing redundant work. The informations obtained are both video recorded and jotted down on a note book.

1.3.4 References

Some of the information is obtained through the searching of books at Penang Public Library and UiTM past lecture notes. The books and lecture notes could provide authentic and valid information as well as to help gain knowledge as the information contained in them are much deeper.

CHAPTER 2.0

COMPANY BACKGROUND

2.1 Introduction of company

Sinar MEC Holdings Sdn. Bhd. is established in the year 2005 and is one of the renowned company in many industrial sectors. Sinar Mec Holdings Sdn. Bhd has many subsidiaries, namely Sinar MEC Plantation Sdn. Bhd., Sinar MEC Printing Sdn. Bhd, and Sinar MEC Entrepreneur Sdn. Bhd.

Mainly focusing on construction industry, Sinar MEC Holdings Sdn. Bhd. has been awarded G7 and 3 Gold Star award by Construction Industry Development Board (CIDB) Malaysia as Sinar MEC thrives to be the leading construction company in Malaysia.

Sinar MEC Holdings Sdn. Bhd. has, up until now remained active in the construction industry, having awarded with multiple construction projects at various scales as their reputation keeps on striving higher than ever.

Currently, the on-going projects that are in construction are housing schemes, factory construction and many other renovation projects as listed in table below.

2.2 Company profile

COMPANY NAME	: SINAR MEC HOLDINGS SDN. BHD.
COMPANY REGISTRATION NO.	: 1149833W
DATE OF REGISTRATION	: 26 JUNE 2015
COMPANY ADDRESS	: GF-3A, SEJATI SUPERBOWL, JALAN INDAH DUA, TAMAN SEJATI INDAH, 08000 SUNGAI PETANI, KEDAH DARUL AMAN
TEL / FAX NO.	:
STATUS OF COMPANY	: ACTIVE / OWNERSHIP
CIDB REGISTRATION NO.	: 0120151216-KD168630

Director & Key Management

EXECUTIVE CHAIRMAN

Dato' Abd. Rahim bin Kasim

Msc. Civil Engineering

(UTM Skudai, Johor)

MANAGING DIRECTOR

Nurfitriyana binti Abd. Rahim

Bachelor of Civil Engineering

(UTM Skudai, Johor)

PROJECT COORDINATOR

Manivel a/l Asiah

Msc. Civil Engineering

(Open University Malaysia)

SENIOR QUANTITY SURVEYOR

Khairul Haqime bin Mohd. Yusof

Bachelor of Quantity Surveying

(Universiti Sains Malaysia, Pulau Pinang)

2.3 Organization chart

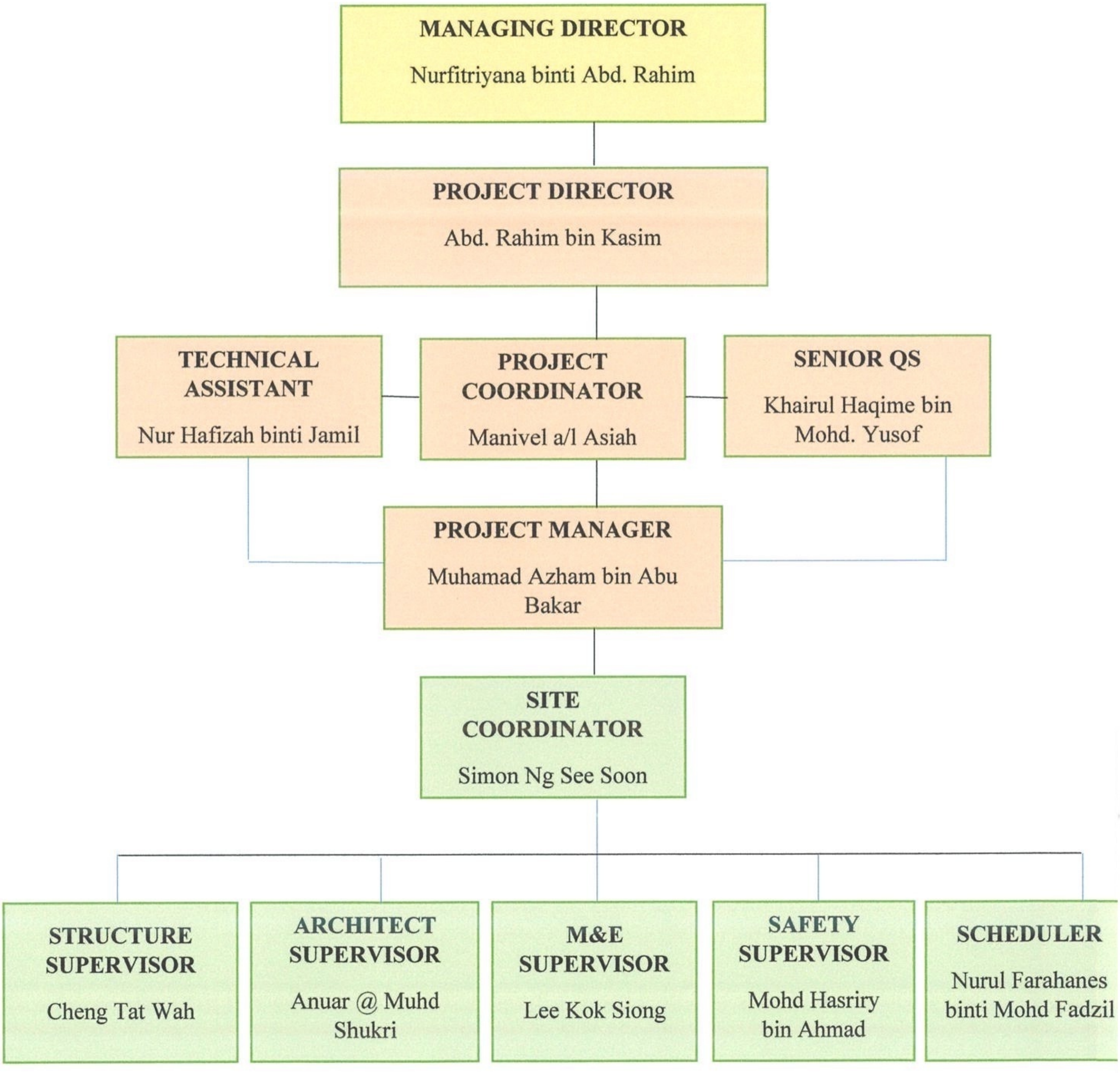

Figure 2.1: Organisation Chart

Source: Sinar MEC Holdings Sdn. Bhd

2.4 List of projects

2.4.1 Completed projects

Table 2.1: List of Completed Projects

NO.	DEVELOPER / OWNER	PROJECT TITLE	COMPLETED DATE
1.	Hanshin Marketing (M) Sdn. Bhd.	Cadangan Membina sebuah gudang 1 tingkat dengan pejabat 3 tingkat di atas lot 15727, Solok, Bayan Lepas, Mukim 12, Daerah Barat Daya, Pulau Pinang	25 November 2016
2.	Torto Food Industries Sdn. Bhd.	Cadangan pindaan dan tambahan kilang-kilang tkt dan 1 unit pejabat 4 tingkat kepada kilang dan pejabat sediada no. 1588 di atas lot 6160, Lorong Perusahaan Utama 1, Mukim 11, Seberang Perai Tengah, Pulau Pinang	8 Feb 2017
3.	Zip-In Solutions Sdn. Bhd.	Cadangan Pembinaan Sebuah gudang setingkat dengan pejabat 3 tingkat di atas Pt. 2946, Prai Industrial Estate, Mukim 11, Seberang Perai Tengah, Pulau Pinang	28 Feb 2017
4.	Eligan Base Avenue Sdn. Bhd	Cadangan Membangunkan 4 unit kilang berkembar 2 tingkat di atas lot 287 dan 31268 (sebahagian lot lama 1475), IKS Bkt. Minyak, Mukim 14, Seberang Perai Tengah, Pulau Pinang	3 Mac 2017
5.	Sime Darby Auto Performance Sdn. Bhd.	Cadangan meroboh binaan struktur sementara sediada dan membina 2 tingkat pusat pameran, jualan dan servis kereta di atas lot 6985 dan sebahagian lot 4547, Jalan Baru, Mukim 1, Seberang Perai Tengah, Pulau Pinang	6 April 2017
6.	Vigilenz Medical Devices Sdn. Bhd.	Cadangan Mendirikan sebuah pejabat 2 tingkat dengan kilang 1 tingkat di atas plot 308B, Jalan Perindustrian Bukit Minyak 18, Penang Science Park, Bukit Minyak, Mukim 13, Seberang Perai Tengah, Pulau Pinang	27 Mei 2018

Source: Sinar MEC Holdings Sdn. Bhd

2.4.2 Project in progress

Table 2.2: List of Project in Progress

NO.	DEVELOPER / OWNER	PROJECT TITLE	Name of Architect / Engineer
1.	GF Harmoni Sdn. Bhd.	Cadangan Mendirikan 16 unit kedai pejabat teres 2 tingkat di atas pt. 157 (Lot lama 331) Mukim 15, Seberang Perai Selatan, Pulau Pinang	Atelier Alan The Architect
2.	Hup Tatt Development Sdn. Bhd.	Cadangan mendirikan 7 unit rumah banglo 2 tingkat di atas lot-lot 934-940, Mukim 17, Taman Sentosa, Bukit Mertajam, Seberang Perai Tengah, Pulau Pinang	Jurutera Perunding Cahaya Sdn. Bhd.
3.	Pemaju Sungai Lokan Sdn. Bhd.	Cadangan Pembinaan 68 unit kilang berkembar 2 tingkat dan 3 unit kilang sesebuah 2 tingkat di atas lot 10085, Jalan Perindustrian Sungai Lokan 3, Mukim 16, Seberang Perai Utara, Pulau Pinang	NWS Cost Engineering Consult
4.	Daema Marketing Sdn. Bhd.	Cadangan Membangunkan 1 unit kilang dan pejabat 1 tingkat denagn bilik qc 2 tingkat di atas plot 1207, Mukim 13, Lorong Perindustrian Bukit Minyak 21, Penang Science Park, Bukit Minyak, Seberang Perai Tengah, Pulau Pinang	THW & Associates Sdn. Bhd.
5.	Eligan Base Homes	Cadangan Skim Perumahan untuk 68 unit rumah teres 2 tingkat di atas lot 3726-3793, Mukim 7, Taman Jawi Jaya, Seberang Perai Selatan, Pulau Pinang	K.H. Tan Architects

Source: Sinar MEC Holdings Sdn. Bhd

CHAPTER 3.0

CASE STUDY

3.1 Introduction of Project

Figure 3.1: The project signage

To start things off, the construction site is located at sebahagian lot 7159, Mukim 6, in the province of Bertam. The project is to propose to build and complete Sekolah Kebangsaan Bertam Putra consisting of 18 classrooms and other related facilities. The client for this school project is Kementerian Pendidikan Malaysia (KPM) and is valued at RM 18,799,983.14 (exclusive of 6% GST). The duration of project completion is for 2 years, which is from 7 June 2017 to 7 June 2019.

Roughly, the site is strategically located, whereby it is situated nearby a cluster housing scheme and is located as near as a 2-minute drive away from a terrace housing scheme, which is taman bertam putra indah. It is also situated quite near from a shophouse district and it takes only 5-minute drive away from Mydin Supermarket.

Interestingly, the construction site implemented a rather unique style of construction, whereby the use of conventional style of construction and IBS are in synergy, whereby the percentage used for both are 30% and 70% respectively. To clarify, the use of IBS is mainly implemented on two blocks, which are the administration block and classroom block, on the main structures of the building, which is the column, beam and the floor slab. The floor slab make use of a precast hollow core slab, which only means that within the floor slab, there are 5 hollow holes throughout the length of the slab.

However, the use of conventional method of construction which comprises of 30% on site is not to be forgotten. The use of this method is done for the staircases of the entire building, the preschool building, guardhouse and bus stand.

3.1.2 Summary of the project:

Client	:	Kementerian Pendidikan Malaysia
Main contractor	:	Sinar MEC Holdings Sdn. Bhd.
Project handled by main contractor	:	Propose to build and complete Sekolah Kebangsaan Bertam Putra consisting of 18 classrooms and other related facilities
Year start-completed	:	June 2017- June 2019 (2years)
Location	:	Lot 7159, Mukim 6, Bertam, Seberang Perai Utara, Pulau Pinang
Other consultants	:	Perunding ANR (Civil Engineer and Structure) S.A.A Consultant Sdn. Bhd (M&E Engineering) NB Architects (Consultant Architect) Triple Consult & Resources Sdn. Bhd. (IBS Supplier)

3.1.3 Location Plan and Site Plan

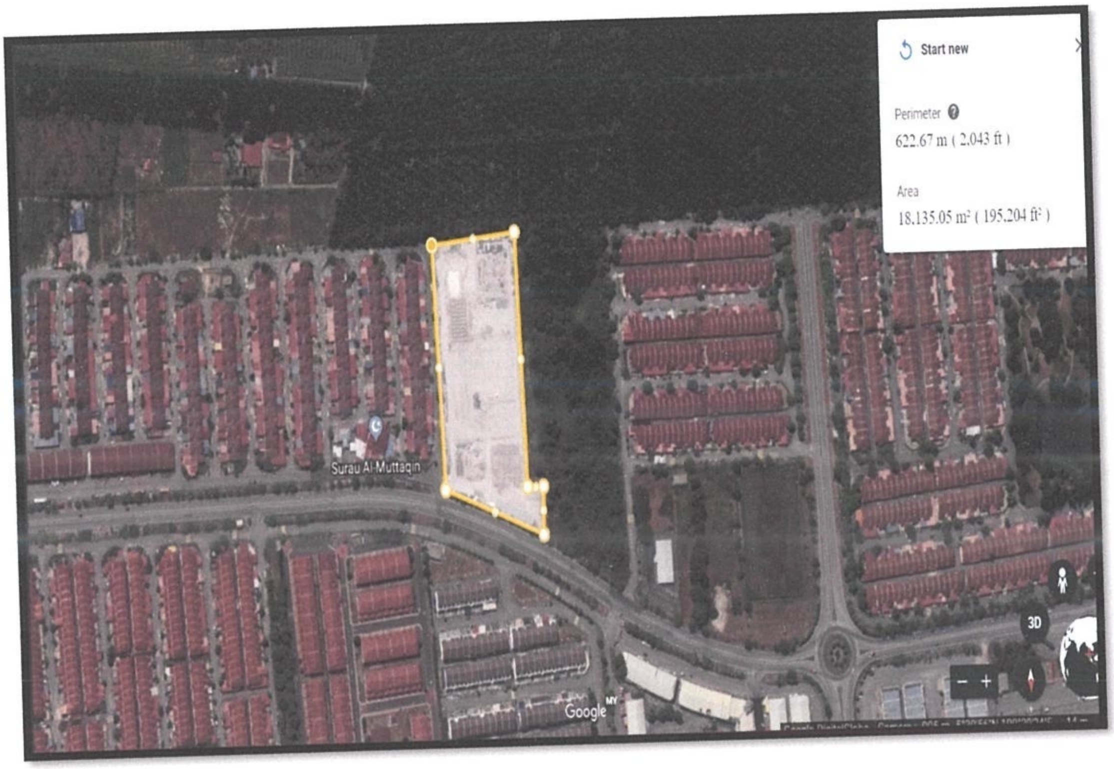

Figure 3.2: Location Plan of Site Project

Source: Google Earth

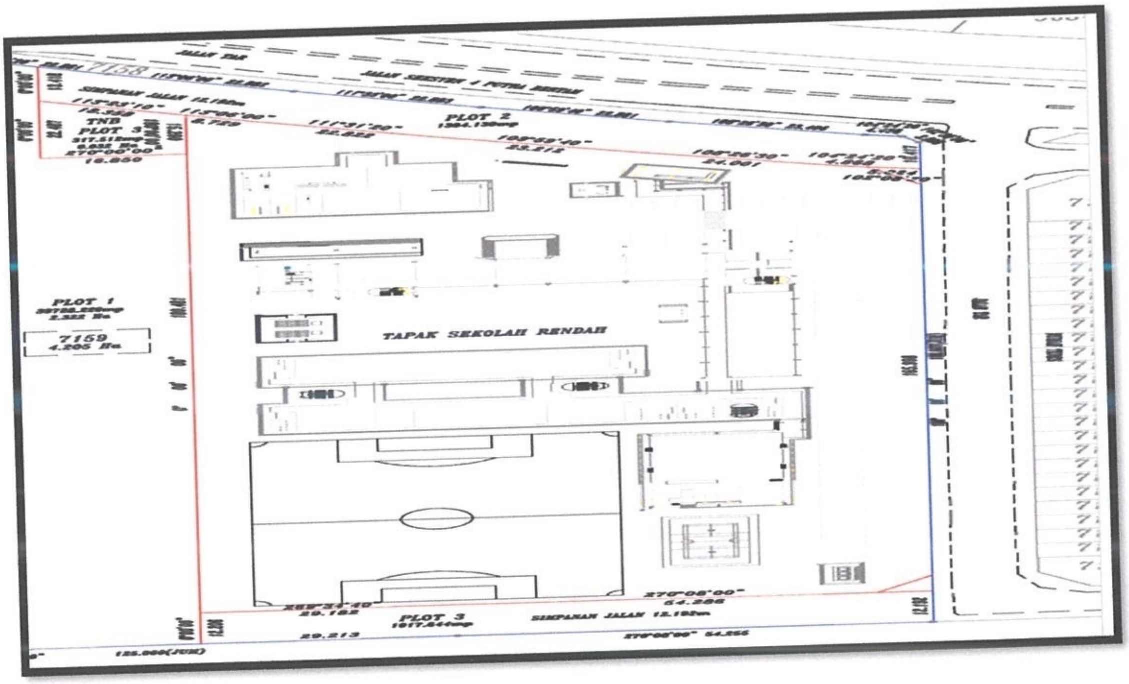

Figure 3.3: Site Plan

Source: Monthly Progress Report of Project, Sinar Mec Holdings Sdn. Bhd

3.2 Introduction to industrialised building system

The definition of an industrialised building system (IBS) is building components. For example, beam, column, staircase, wall and floor slab which are produced in abundance either factory-fabricated or cast on-site under rigid quality control and on-site activities which are kept at a minimum level. (Trikha, 1999).

IBS utilises workers on a holistic sector of construction to a system that practice the use of production manufacturing to minimise the wastage of resource and increasing value for end users.

Industrialisation process, as explained by Warswaski (1999) is a long-run investment in technology, equipment, and facilities to make sure the output of production is maximised and to keep labour resource at a minimal level. Meanwhile the definition of a building system is a set of elements that are interconnected or joined together to ensure the utmost peak performance of a building.

All in all, the most accurate definition of IBS was explained clearly by Junid (1986). He implied that using IBS in the industry includes the process of industrialisation whereby the components of a building are fabricated, conceived, planned, transported and erected on site. The system includes a fusion that is balanced between the software and hardware components. The elements that are included in the software components are system design, in which it is a complex process of studying the market analysis, necessity of the end user, development of standardised components, establishment of manufacturing and assembly layout and process, resources allocation and materials and definition of a building designer's conceptual framework. The software elements provide a prerequisite to build a conducive environment for said industry to expand.

On the other hand, the hardware elements are distinguished into three alpha groups. These include box system, frame or post and beam system, and panel system. The box systems include those system that employ three-dimensional modules (or boxes) for fabrication of habitable units are capable of withstand load from various directions due to their internal stability. Meanwhile, The framed structures are defined as those structure that carry the loads through their beams and girders to columns and to the ground whilst in panel system load are distributed through large floor and wall panels.

3.2.1 Classification of IBS

Generally, according to Badir Razali building system classification (Badir et al. 1998), currently there are four types of building systems that are available in Malaysia. There are named conventional building system, cast in-situ building system, prefabricated building system and composite building systems as shown in Figure 3.3. The representation of each building system is distinguished by their respective construction method which is further characterised by its functional and geometrical configuration and construction technology.

Warszawski (1999) explained that the building system could be narrowed down and classified in many different ways, depending on the specific interest of their end users or producers. Such classification make use of construction technology as a basis for classifying different building systems. In this manner, four major groups can be discriminated namely, system which uses timber, steel, cast in-situ concrete, and precast concrete as their main structural and space-enclosing materials. These said systems can be further assorted according to the geometrical configuration of their main components of frame as follows; linear or skeleton (beams and columns) system, planar or panel systems, and three-dimensional (3D) or box systems.

Majzub (1977) clarified that the relative weight of components should be used as a basis for building classification is presented in Table 1.0. The factor of weight has significant impact on the transportability of the components and also has influence on the production method of the components and their erection method on site. The classification by weight also has the advantage of distinguishing between the various basic materials used in the production of component which by itself could determine the characteristic of the system under study. However, Majzub's classification method is found to be inadequate to incorporate other building system flourish recently.

One of the distinct example is the interlocking load bearing blocks which was the brainchild of a group of researchers in Universiti Putra Malaysia. This new building system cannot be categorised according to frame, panel or even box system. On the other hand, the composite system that combines two or more construction method cannot also be categorised under the Majzub's classification. Hence, the classification needs to be updated to reflect the current technological advancement.

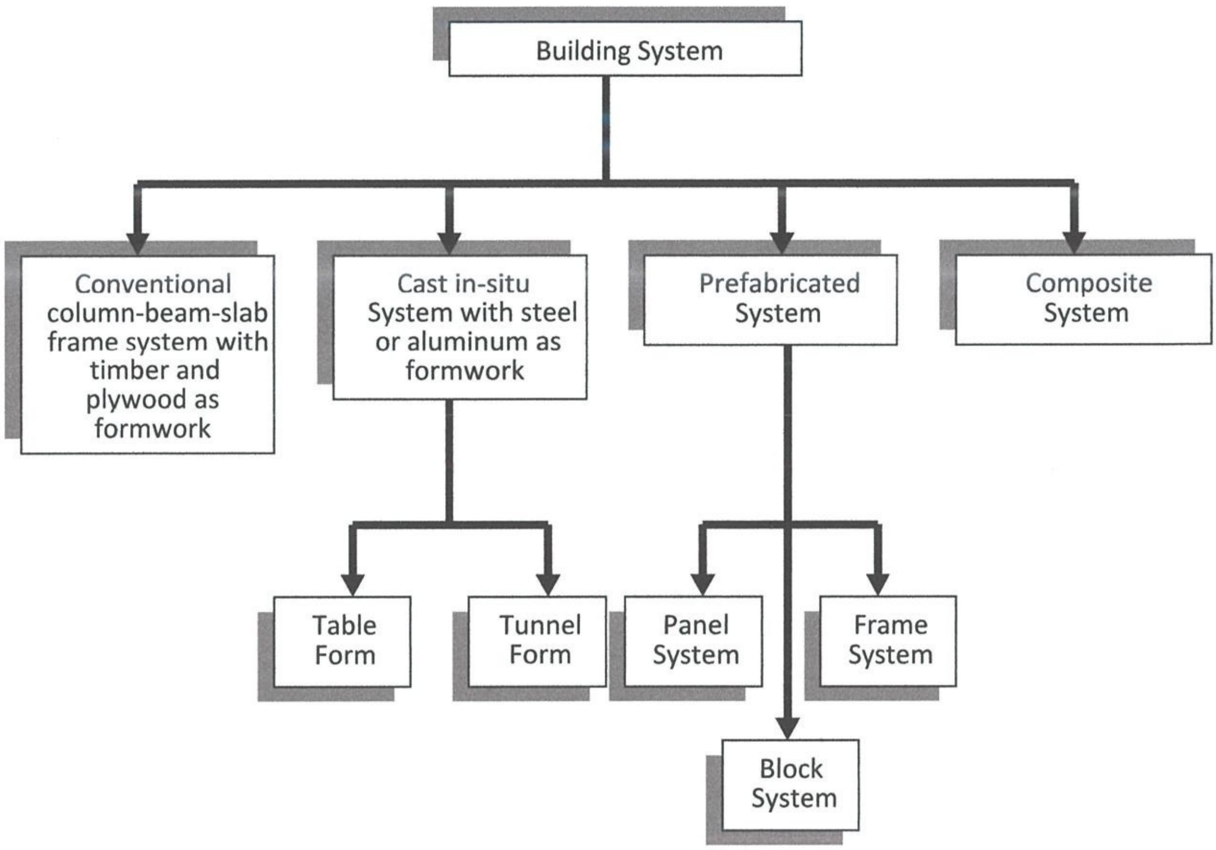

Figure 3.4: Types of building system in Malaysia

Source: *Modular housing systems used around the world.* (Majzub, 1977)

Table 3.1: Building system classification according to relative weight of component

No	General System	System	Production Material
1	Frame system	Light weight frame	Wood, light gage metals
		Medium light weight frame	Metal, reinforced plastics, laminated wood
		Heavy weight frame	Heavy steel, concrete
2	Panel system	Light and medium weight panel	Wood frame, metal frame, and composite materials
		Heavy weight panel (factory produced)	Concrete
		Heavy weight panel (tilt up – produced on site)	Concrete
3	Box system (modules)	Medium weight box (mobile)	Wood frame, light gage metal, composite
		Medium weight box (sectional)	Wood frame, light gage metal, composite
		Heavy weight box (factory produced)	Concrete
		Heavy box (tunnel produced on site)	Concrete

Source: *Modular housing systems used around the world.* (Majzub, 1977*)*

3.2.2 Essential characteristics of IBS

It is indeed possible to review the prerequisite specifications which focuses on the successful implementation of industrialised building system. Each and every one of them is discussed below.

- **Closed System**

This system can be narrowed down into two categories, namely production in which client-based design is used and production based on the design of the precaster. The first category is designed to cater the client's structural requirement, in which it is the spaces required for different functions in the building and also its architectural design. In this context, the client's necessities are the ultimate focus and the precaster is always driven to produce a particular component for a building. Meanwhile, the production based on the design of the precaster includes designing and fabricating a consistent type of building or a group of building variations, which could be fabricated with a common differentiations of component. These said building includes school, gas station, parking garage and low cost housing schemes. Nonetheless, these types of arrangement of buildings can be condoned economically when the following situations are taken into account (Warszawski, 1999).

a) The size of project is massive enough to cater for distribution of design and fabrication costs over the extra cost per component induced due to the particular design.

b) The architectural design sees into large repetitive element and standardisation. In regard to this, a prefabrication system can overcome the requirement of many standardised elements by specifying the design and production process.

c) There is a sufficient supply and demand for a particular type of building such as school so that a large-scale production can be achieved.

d) There is an comprehensive marketing strategy by precaster to persuade the clients and designer regarding the potential benefit of the system in terms of economics and non-economic factors.

- **Open System**

In contrast to the limitations imposed in the closed system, an alternate system; an open system offers greater flexibility of design and maximum coordination between the designer and precaster has been decided beforehand. This system is possible because it allow the production of a limited number of elements with a predetermined range of product and at the same time maintaining their own aesthetic values.

Despite many advantages imposed in an open system, its introduction experiences one ultimate hindrance. For example, joint and connection problem might occur when two elements from different systems are fixed together. This happens because similar connection technology must be observed in order to achieve better structural performance.

- **Mass Production**

Only when large production volume is observed, the costs in terms of equipment investment, human recourses, and facilities associated with an industrialisation can be cut down drastically. This large-scale or mass production provides a distribution of the fixed investment charge over a large number of product units without ultimately inflating their ultimate cost (CIDB Singapore, 1992).

- **Transportation**

In a particular research, it is shown that casting of large-panel system can reduce labour costs up to 30 percent. However, these cost savings are balanced out by the transportation costs. The transportation of large panels is also subject to the country's road department requirement, such as how many hollow core slabs are allowed to be loaded onto the loader trailer. These limitations must be taken into account when implementing a prefabrication system (Peng, 1986).

- **Equipment at Site**

Heavy crane is needed for the purpose of erecting and assembling precast panels into their position, especially for multi-storey building. Thus, it is essential to incorporate this additional cost when implementing a prefabrication system (Warszawski, 1999).

3.2.3 Benefits of IBS

The benefits of implementing Industrialised Building System compared to the conventional construction method are as follows:

a) The repetitive use of system formworks which are made up of steel, aluminium, etc. and scaffolding could really cut down costs in that particular manner (Bing *et al.* 2001).

b) As prefabricated components are done in a factory controlled environment, there is no need to worry regarding the construction operation due to harsh weather. (Peng, 1986).

c) The reduction of labour costs and requirement at site can be seen to be implied as prefabrication takes place at a centralised factory. This is purely beneficial especially when high degree of mechanisation involved. (Warszawski, 1999).

d) An IBS system caters for faster construction time because casting of precast element at factory and foundation work at site can occur simultaneously. This provides earlier completion of the building. Therefore, reducing payment of interest or capital outlays. (Peng, 1986).

e) An IBS system allows for flexibility in architectural design in order to minimise the tedious repetition of building layouts. (Warszawski, 1999).

f) An Industrialised Building System allows for flexibility in the design of precast element as well as in construction to ensure that different systems may produce their own unique prefabrication construction methods (Zaini, 2000).

g) An Industrialised Building System component produces higher quality of components as they make use of through careful selection of materials, advanced technology and strict quality assurance control (Din, 1984).

3.3 Production Process of On-Site Precast Concrete Elements

On-site precast concrete element is a type of method of casting concrete at the construction site.

Firstly, the difference between on-site production process and off-site precast concrete elements can be seen by their respective locations in which the elements are being cast. One is being cast on-site and the other is being cast at a casting yard somewhere away from the site.

The implementation of casting precast elements on-site is of course, to reduce the overall cost of handling and transportation and to cater the beams and columns design according to the project's needs as per construction drawing specifically. If there are any defects on the concrete elements, they can straight away be repaired or rectified on-site without accounting for the need to transport the elements back to the casting yard.

The other significant benefit of using this method is the use of repetitive mould. The moulds that are used are made of steel. These steel moulds differ in shape for beams and columns respectively. The moulds are sufficiently rigid and strong and thus, will not deform. It is also sufficiently tight to prevent loss of grout or mortar from the concrete at all stages and for all methods of placing and compacting. The benefits of using this mould is that it can be used repetitively with a minimum usage of 20 times of use, thus it is way economical compared to the typical use of timber formwork.

Flow chart for the production of on-site precast concrete components for IBS

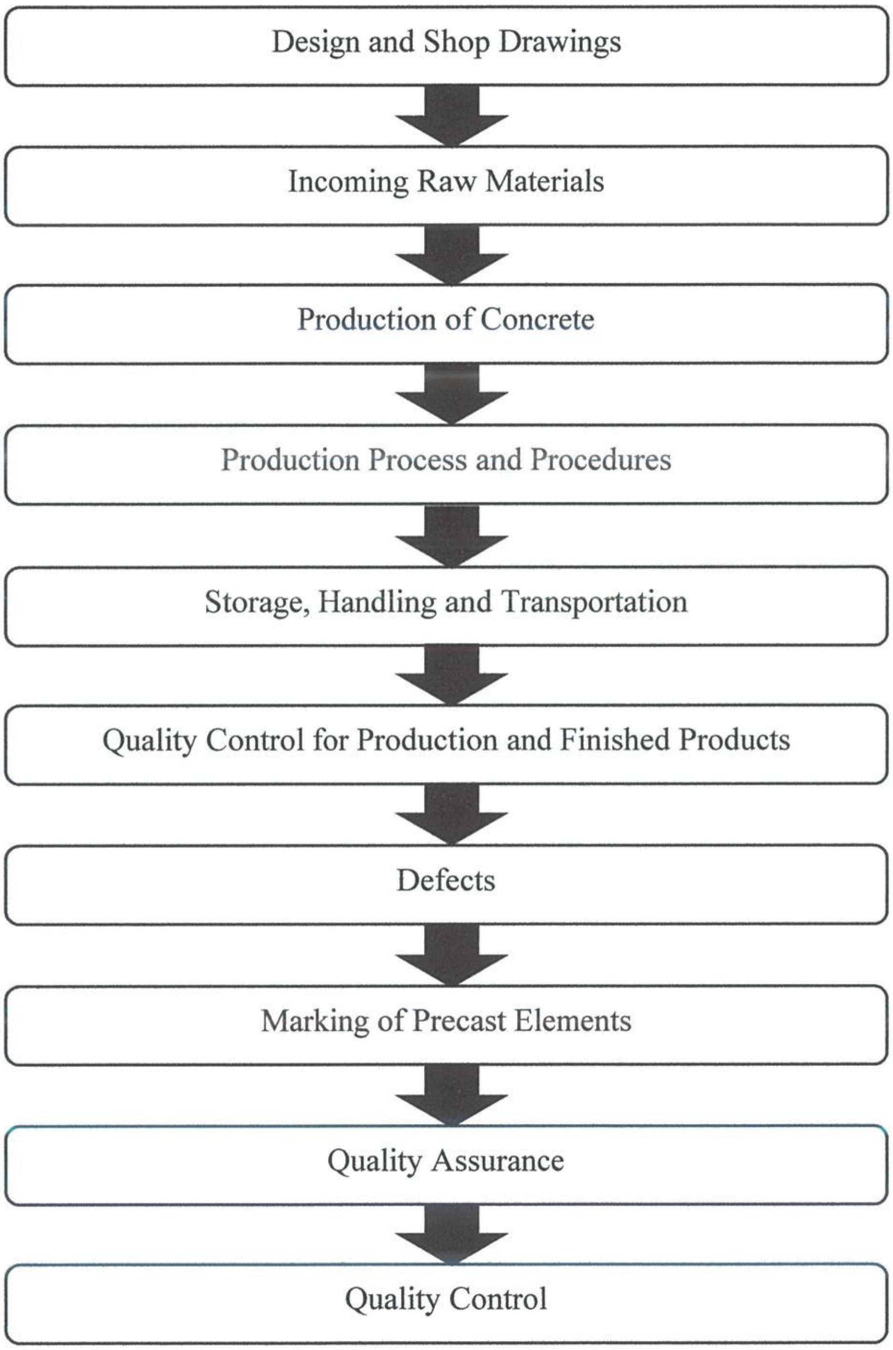

Figure 3.5: Flow chart for the production of on-site precast concrete components for IBS

3.3.1 Design and shop drawings *(refer appendix A,B,C,D)*

An appointed Professional Engineer reporting to the TCR IBS Manufacturing Vice President is responsible to carry out the designs, preparation of the shop drawings, endorse the final and approved design and shop drawings. Design of IBS elements conforms to the relevant codes, specifically the BS 8110.

He is also to address any discrepancies or any changes in the design and detailing. A professional engineer is appointed to endorse the final and approved design and shop drawings.

3.3.2 Incoming raw materials

3.3.2.1 Concrete

For the concrete work, the relevant Codes of Practice are the current I ssue of BS 8110 "The Structural Use of Precast Concrete".

3.3.2.2 Cement

The cement used for concrete shall be ordinary Portland Cement complying with MS 522 unless otherwise specified by the engineer for certain purpose.

3.3.2.3 Fine aggregate

Fine aggregate shall be natural and be free from coagulated lumps. The sand shall not contain more than 8% of clay and silt by volume or (4% by weight) measured according to field settling test Ms 29/30. The grading of the sand shall be within Zone as per Table 2 of MS 29.

3.3.2.4 Coarse aggregate

The coarse aggregate shall be crushed granite. The grading of the coarse aggregate shall be within the limits given in Ms 29/30 for the ¾" graded aggregate.

3.3.2.5 Water

The water shall conform to MS 28 or equivalent. In general, drinking water is fit for concreting.

3.3.2.6 Admixture

The admixture shall conform to MS 922 JIS A 6204 ASTM c494. Admixture containing calcium chloride shall not be used.

3.3.2.7 Reinforcements

Steel reinforcement rolled steel bars shall conform to MS 144.

3.3.2.8 Pre-stressing strand wire reinforcement

Pre-stressing strand wire shall conform to BS 5896/ASTM A416 or equivalent. All steel shall be free from oil, dirt, loose rust or other deleterious matters before placing of concrete.

3.3.3 Production of concrete

3.3.3.1 Batching plant

Batching of concrete is carried out in an automatic batching plant with the facility of generally recording all batch weights.

Measuring of moisture content of aggregates is by moisture probe installed in the storage hopper. The readings from the probe are transmitted to the batching computer for automatic moisture compensation.

3.3.3.2 Strength of concrete for column and beam

The 28-day characteristics of strength in compression (compressive strength) of concrete shall be based on the consultant's approved drawings.

The 28-day characteristics compressive of concrete shall be 40.0 N/mm^2 /50.0 N/mm^2 as per approved drawing specification.

Before placement of concrete, the sampling point must be taken at the point of discharge.

Sampling rate for strength compliance shall be $20mm^2$ of concrete as per sample. Not less than 4 cubes shall be made from each sample. Cubes must be tested at the following ages:-

3 cubes for 7 day

3 cubes for 14 days

3 cubes for 28 days

The sampling point shall be taken at point of discharge from the concrete spreader.

3.3.3.3 Strength of concrete for hollow core slab

The 28-day characteristics compressive of concrete shall be 50.0 N/mm^2 as per consultant's approved drawings.

For every pre-stressing bed comprising 1 line, not less than 6 cubes per batch (10m^3/ batch or less) shall be cast in accordance to MS 26 on each day concrete is placed.

1 batch comprises for every 20m^3

Early age	2 cubes for transfer age
	2 cubes for 7-day age
Later age	2 cubes for 28-day age
Other age	1 cube for 14-day age or other age

3.3.3.4 Consistency of concrete

While concreting takes place, the mix shall be tested on workability for every batch of 20m^3. Slump tests shall be carried out in accordance with BS 1881. The workability shall be within specified value of slump limits.

Furthermore, for every batch of concrete, a visual inspection of the mix shall be carried out.

3.3.4 Production processes and procedures

3.3.4.1 Precast columns and beams

Steel moulds is required for casting to be produced. The steel moulds differ in shape for beams and columns respectively. The moulds are sufficiently rigid and strong and thus, will not deform. It is also sufficiently tight to prevent loss of grout or mortar from the concrete at all stages and for all methods of placing and compacting. In order to ensure that concrete dimension is within permitted tolerances, particular supervision and attention will be taken. The bottom portions of the forms are prevented from adhering to the concrete and the sides are designed to permit striking without affecting the stability of the remaining formwork.

I. Workability and consistency

A test on workability of the mix is carried out randomly before processing to work on concreting whenever any materials or the proportions of the mix have changed or when directed by the engineer. Moreover, by using speedy moisture tester (calcium carbide method), moisture content can be determined once daily.

II. Mixing concrete

The mixing is carried out in mechanical batch mixer of adequate capacity. Mixing shall continue until there is uniform distribution of materials and the mass is uniform in colour and consistency.

Figure 3.6: Precast reinforced concrete products cast in steel moulds

III. Compacting concrete

A power-driven immersion type vibrators/ external form vibrator is used to fully compact all of the reinforced concrete.

Figure 3.7: The process of mixing concrete poured into the steel moulds

IV. Bending and fixing reinforcement

All reinforcement bars is cold bent by a bending machine. Reinforcements will be accurately fixed by approved means and maintained in the position as described on the drawings or elsewhere. Bars intended to be in contact at passing points will be securely wired together at all such points using G.I. tying wires.

The reinforcements will be examined in order to maximise the accuracy of placing and cleanliness and corrected if necessary immediately before concreting takes place.

The concrete cover to the reinforcement is to be as per specified in established drawing and is to be maintained during concreting by means of spacer block of comparable strength to the surrounding concrete.

Figure 3.8: The bending of reinforcement bars by barbender

Figure 3.9: The fixing of reinforcements inside mould

V. Curing

Generally, there are three options for concrete curing as described below:

i. **Water curing**

After concrete has initially set, water curing ought to be carried out. The method called hosing, done occasionally is used to keep the surface damp; the frequency of this depends on the prevailing weather condition.

ii. **Steam curing**

Another method of curing is called steam curing, whereby the concrete is cured at atmospheric pressure and the duration is dependent on the production cycle intended and the minimum strength of transfer required. However, the total cycle must be ensured to be at no more than 18 hours and maximum temperature must never exceed 70° Celsius.

Once the concreting is completed, a cover, also known as canvas should enclose the members and steam is blown to the mould from leading to a distributed temperature throughout the concrete. Further curing is not necessary once steam curing is done.

iii. **Curing compound**

Once the concrete has finally set, the unformed surface (known as the trowelled face) of the product ought to be sprayed with curing compound and enclosed with a plastic sheet or gunny sacks. After the stripping of mould side panels, formed surface shall also be applied with the said compound.

Figure 3.10: The precast elements in steel moulds are cured and enclosed with gunny sacks

VI. De-moulding

Unless stated otherwise, the strength of concrete at transfer shall be preferably at 16.0 N/mm², and de-moulding works shall begin at least 12 hours from completion of concreting works. This guideline is solely for quality assurance i.e. control purposes only.

Figure 3.11: The de-moulding of precast column from steel mould

3.3.5 Storage, handling and transportation

3.3.5.1 Precast columns and beams.

I. Handling and transportation

After de-moulding process, all precast columns and beams are transported by means of lifting using a crawler crane on site. The beams are lifted by clamping the chains from the hook of crawler crane's arm around the bent reinforcement bars on the left and right side of the beam, while the columns are also lifted using crawler crane by clamping the chains from the hook of crawler crane's arm around the starter bar and the U-head that is inserted at the foot of the column, as shown in the pictures below.

Figure 3.12: The lifting of beam and column using a crawler crane

II. Storage

The lifted beams and columns are then placed on a designated space on site and arranged accordingly for ease of lifting during installation of the said precast elements later on.

Figure 3.13: The precast elements are placed and stored at a designated space on site

Table 3.2: Ground floor column specifications (administration block)

MARKING	DIMENSION (mm)			QUANTITY
	Length	Width	Height	
TCR-GC001	3350	400	400	7
TCR-GC002	3350	400	400	1
TCR-GC003	3050	400	400	1
TCR-GC004	3350	400	400	1
TCR-GC005	3350	400	400	1
TCR-GC006	3350	400	400	1
TCR-GC007	3350	400	400	1
TCR-GC008	3350	400	400	1
TCR-GC009	3050	400	400	1
TCR-GC010	3350	400	400	1
TCR-GC011	3050	400	400	1
TCR-GC012	2850	400	400	1
TCR-GC013	3050	400	400	1
TCR-GC014	3050	400	400	1
TCR-GC101	3450	400	400	8
TCR-GC102	3450	400	400	1
TCR-GC103	3150	400	400	1
TCR-GC104	3150	400	400	1
TCR-GC105	3050	400	400	1
TCR-GC106	3150	400	400	1
TCR-GC107	3150	400	400	1
TCR-GC108	3150	400	400	1
TCR-GC109	3450	400	400	1
TCR-GC110	3150	400	400	1
TCR-GC201	3400	400	400	1
TCR-GC202	3400	400	400	1
TCR-GC203	3165	400	400	1
TCR-GC204	3400	400	400	1

Source: Triple Consult & Resources Sdn. Bhd.

Table 3.3: First floor column specifications (administration block)

MARKING	DIMENSION (mm)			QUANTITY
	Length	Width	Height	
TCR-1C001	3350	400	400	2
TCR-1C003	3250	400	400	1
TCR-1C005	3050	400	400	1
TCR-1C007	3350	400	400	1
TCR-1C010	3350	400	400	1
TCR-1C011	3350	400	400	1
TCR-1C012	3050	400	400	1
TCR-1C014	3050	400	400	1
TCR-1C101	3400	400	400	3
TCR-1C103	3400	400	400	1
TCR-1C104	3100	400	400	1
TCR-1C105	3000	400	400	1
TCR-1C106	3100	400	400	1
TCR-1C107	3100	400	400	1
TCR-1C108	3100	400	400	8
TCR-1C109	3400	400	400	1
TCR-1C110	3100	400	400	1
TCR-1C301	3550	400	400	5
TCR-1C302	3550	400	400	5
TCR-1C303	3250	400	400	1
TCR-1C304	3550	400	400	2
TCR-1C401	3600	400	400	5
TCR-1C402	3300	400	400	1

Source: Triple Consult & Resources Sdn. Bhd.

Table 3.4: Second floor precast column specifications (administration block)

MARKING	DIMENSION (mm)			QUANTITY
	Length	Width	Height	
TCR-2C301	3550	400	400	5
TCR-2C302	3550	400	400	2
TCR-2C303	3550	400	400	1
TCR-2C401	3600	400	400	3
TCR-2C402	3600	400	400	1
TCR-2C403	3450	400	400	2
TCR-2C404	3450	400	400	1
TCR-2C405	3450	400	400	1
TCR-2C406	3450	400	400	2
TCR-2C412	3600	400	400	2

Source: Triple Consult & Resources Sdn. Bhd.

Table 3.5: First floor precast beam specifications (administration block)

MARKING	DIMENSION (mm)			QUANTITY
	Length	Width	Height	
TCR-MB001	8550	400	600	4
TCR-MB002	5550	400	600	10
TCR-MB003	5675	400	600	2
TCR-MB004	5425	400	600	2
TCR-MB005	8425	400	600	1
TCR-MB023	9550	400	600	1
TCR-MB101	8550	400	535	1
TCR-MB102	9550	400	535	1
TCR-MB103	2675	400	600	1
TCR-MB104	5550	400	600	1
TCR-MB105	8675	400	535	1
TCR-MB106	8425	400	535	1
TCR-MB201	8425	400	600	2
TCR-MB202	9550	400	600	1
TCR-PB001	7050	300	600	2
TCR-PB002	2050	300	600	1
TCR-PB003	2675	300	600	1
TCR-PB004	2550	300	600	2
TCR-PB005	5050	300	600	2
TCR-PB006	3050	300	600	2
TCR-PB007	5550	300	600	1
TCR-PB008	7050	300	600	1
TCR-PB009	9550	300	600	1
TCR-PB101	9550	300	600	1

Source: Triple Consult & Resources Sdn. Bhd.

Table 3.6: Second floor precast beam specifications (administration block)

MARKING	DIMENSION (mm)			QUANTITY
	Length	Width	Height	
TCR-MB001	8550	400	600	5
TCR-MB002	5550	400	600	2
TCR-MB005	8425	400	600	2
TCR-MB011	2675	400	600	2
TCR-MB023	9550	400	600	1
TCR-PB004	2550	300	600	2
TCR-PB006	9550	300	535	2
TCR-PB010	5550	300	535	2
TCR-RB001	8550	300	600	1
TCR-RB002	5550	300	600	8
TCR-RB003	5675	300	535	2
TCR-RB004	5425	300	535	2
TCR-RB005	8425	300	600	1
TCR-RB006	8675	300	600	1
TCR-RB008	9550	300	600	5
TCR-RB010	9550	300	600	1
TCR-RB012	5725	300	600	1
TCR-RB013	5650	300	600	4
TCR-RB014	5475	300	600	1
TCR-RB101	7050	300	600	1
TCR-RB102	2050	300	600	1
TCR-RB105	5050	300	600	2
TCR-RB107	3050	300	600	2

Source: Triple Consult & Resources Sdn. Bhd.

Table 3.7: Precast roof beam specifications (administration block)

TCR-PB004	2550	300	600	2
TCR-PB006	9550	300	600	2
TCR-RB001	8550	300	600	7
TCR-RB002	5550	300	600	2
TCR-RB005	8425	300	600	2
TCR-RB008	9550	300	600	6
TCR-RB010	9550	300	600	1
TCR-RB011	2675	300	600	2
TCR-RB013	5650	300	600	1
TCR-RB015	8650	300	600	3
TCR-RB016	2775	300	600	1
TCR-RB017	8575	300	600	1
TCR-RB018	9550	300	600	1
TCR-RB104	2550	300	600	2
TCR-RB106	9550	300	600	1
TCR-RB108	9550	300	600	1

Source: Triple Consult & Resources Sdn. Bhd.

3.3.6 Quality control for production and finished products.

3.3.6.1 Quality check for production

As described in the method statement, quality control shall be carried out at every stage of operation.

A QC Assistant/ Foreman carries out the pre-concreting check, before the casting of each elements. Areas to be checked are:

i. Dimensions : -Measurements of the side forms and positions of all openings.

ii. Steel bars : -Diameter, quality and spacing of steel bars.
-Cover to reinforcements

iii. Lattice Girder Bars: -Size, height spacing and cover.

iv. M&E opening : -Box, hook, floor trap etc.

After checking all these areas, the QC Assistant/ Foreman will sign on the pre-concreting checklist column in the shop drawing.

3.3.6.2 Finished product acceptance criteria

The criteria for acceptance shall be based on:

I. Dimension measurement

All dimensional tolerance shall comply with Clause 6.11.3 of BS 8110; Part 1: 1985 equivalent.

II. Surface finish

Surface finish shall be type B finished to BS8110 and free from excessive air voids (not more than 10mm diameter).

Visible surface crack shall not exceed 0.3mm width, unless it impairs the performance of the structure, then with the approval of Engineer, it shall be repaired with suitable material for acceptance.

III. Cube strength

Cube strength shall comply with the specified characteristic strength of concrete.

3.3.6.3 Q.C. documentation

All Q.C. documents shall be verified by the plant Engineer/ Manager, and kept in proper filing.

The list of Q.C. documents are as listed below:

a. Concrete batching records
b. Shop drawings and pre-concreting checklists.
c. Cubes sampling sheet and test results.
d. Aggregate sieve analysis.
e. Particle size distribution graphs

3.3.7 Defects

All repairs shall be carried out subjected to engineer's evaluation and approval. Separate method statements shall be submitted for the said engineer's approval based on any execution of rectifying works.

3.3.8 Marking of precast members

The marking will be marked on the body of the final products, by stating the date and orientation for traceability purposes.

Figure 3.14: The precast column that has been marked.

3.3.9 Quality assurance

Quality assurance in the manufacturing of Precast Reinforced Concrete Product is provided via established MS ISO 9001:2000 Quality Management System.

3.3.10 Quality control

This includes routine inspections at various levels of the manufacturing process such as inspection in process and final inspection.

3.4 Problems and solutions faced on-site

i) Narrow working space

Any site adopting IBS faces the same problem, which is narrow working space. Generally, projects implementing IBS require a large working area especially for storage and handling the precast elements during installation process. The precast element such as beams take up a lot of space, let alone operating a crawler crane to lift and install them.

Therefore, extra care must be considered when handling these components. Furthermore, several workers must be placed at various angles of the narrow space to ensure that the components are installed correctly.

ii) Lack in component standardisation

There is, somehow a lack in precast component standardisation, whereby the size and specification is not accurate as per the construction drawing. This is due to the misunderstanding between supplier and main contractor.

To solve this, the main contractor or the supervisor must ensure that the ordered size and specifications must be exactly the same as per construction drawing to ensure that all the size standards and quality assurance will be in one piece.

iii) Honeycomb on IBS beam

In some cases, there might be honeycomb present on IBS beams due to the improper vibration during the casting process of the beams. This will cause the strength of the beams to deteriorate drastically.

The solution to this problem is rather easy, whereby the areas where honeycomb is present is grouted or pasted using Grade 50 non-shrink grout. The reason behind this is simply because the said grout can achieve strength up to 70N/mm^2. Thus, this will substitute the strength of the beam that is lost due to honeycomb.

CHAPTER 4

CONCLUSION

Overall, the objectives of this practical training is achieved. The first objective for this report is to study the benefits of of implementing IBS on-site. The benefits are sustainability of formworks which could be used repetitively, the ease of mind knowing that there is no halt in construction operation due to harsh weather, the reduction of labour costs, faster construction time and completion of project, flexibility in architectural design, flexibility in design of the precast elements and the production of higher quality precast elements.

On the other hand, the second objective, which is the production of on-site precast elements are thoroughly explained. Starting from the organisation management responsibilities, design and shop drawings, incoming raw materials, production of concrete, production processes and procedures, storage, handling and transportation, quality control for production and finished products, defects, marking of precast elements, quality assurance and lastly, quality control.

Last but not least, the problems and solutions as stated in the third objective are specifically explained. The first problem is narrow working space, which could be overcomed by placing several workers to ensure correct installation of pecast elements and to avoid any infringements and to be extra careful in handling them. Next is the lack in component standardisation, whereby there are misunderstandings regarding the size and specifications of the supplied beams or columns. This problem is basically just a misunderstanding between the contractor and supplier and could be solved by double checking the ordered precast elements as per the construction drawing. Lastly, there is honeycomb on the precast beams, which could easily be fixed by pasting or grouting the honeycomb area using Grade 50 non-shrink grout.

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