# THE PROSPECTIVE APPLICATION OF PRE-CAST AND PRE-STRESSED CONCRETE STRUCTURES IN MALAYSIA

By

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FINAL YEAR PROJECT DISSERTATION REPORT

Submitted to the Civil Engineering Programme
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Civil Engineering)

Universiti Teknologi Petronas
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# CERTIFICATION OF APPROVAL

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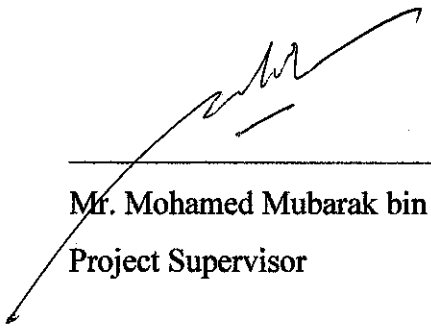
Approved:



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July 2007

# ABSTRACT

This final year project is titled '*The prospective application of pre-cast and pre-stressed concrete structures in Malaysia.* The main objective of this project is to introduce to the Malaysian building industry the advantages and disadvantages of pre-cast and pre-stressed concrete structures in replacing the traditional cast in-situ structures.

This project is basically proposed because of the current problems with the construction industry in Malaysia which consist of delays in schedule, poor quality of end products and labor problems. Pre-cast and pre-stressed concrete structures are proposed because of its usefulness and as an alternative for the execution of construction projects which needed to be done in the shorter period of time and with a high concern for the quality.

# ACKNOWLEDGEMENTS

First and foremost, I would like to thank to God for His guidance and His blessings that I was able to complete this Final Year Project. I would also like to express my heartfelt gratitude to my supervisors, Mr. Mohamed Mubarak Abdul Wahab. He has done a tremendous job in monitoring and guiding me throughout the project, and without his guidance my project will not be as smooth-flowing as it is now.

I also ever grateful to those lecturers who although are not my supervisors, have given me a lot of advices and help in my project. I would like to thank AP Ir. Dr. Arazi Idrus, Miss Koh Moi Ing and all the lecturers from Civil Engineering Department. The list goes on, and it is not possible to include all names, however, I would like to extend my deepest to gratitude to all who have helped me directly and indirectly.

Last but not least, I also would like to say thank you to all of my fellow friends/colleagues who have given assistance to me in this project. Without their help, I would have encountered many obstacles. Their help has greatly improved my success in this project, and helped me to produce better project outcomes.

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# LIST OF ABBREVIATIONS

Perbadanan Kemajuan Negeri Selangor (PKNS)

Pre-cast Pre-stressed concrete structure (PC-PSC)

ACI (American Concrete Institute)

ASTM (American Standard Testing Material)

BS (British Standard)

Construction Industry Development Board of Malaysia (CIDB)

Industrialized Building System (IBS)

Jabatan Kerja Raya (JKR)

Universiti Teknologi Petronas (UTP)

Ministry of Work (MoW)

# CHAPTER 1
# INTRODUCTION

## 1.1 Background of Study

Pre-cast concrete buildings were introduced in Malaysia in 1966 when the government launched two pilot pre-cast house projects. The construction of Tuanku Abdul Rahman Flats in Kuala Lumpur and the Rifle Range Road Flats in Penang was the first time pre-cast concrete elements were used to construct mass houses [4]. Later, Perbadanan Kemajuan Negeri Selangor (PKNS) brought technology from Germany for the construction of numerous housing projects, ranging from low cost houses to high cost bungalows. Since then, numerous construction projects in Malaysia have utilized pre-cast components, especially when the requirement is to build quickly and with high accuracy and quality [4].

Pre-cast and pre-stressed components are used in a number of rapid constructions of, among many others, schools, colleges, quarters, apartments, hospitals as well as roads, rails, ports and drain infrastructures [4]. However, even after four decades introduction, the usage of pre-cast products in the Malaysian construction industry is still relatively very low if compared to other countries such as Japan, United States and Europe [4]. The industry chooses to ignore the benefits of pre-cast construction and still opt for the conventional methods while risking quality, productivity, safety and so on.

Aligned with the development in construction industry, this final year project is proposed to rekindle the awareness among the industry players of the pre-cast and pre-stressed concrete structures as these structures bring more advantages such as

high in quality of end products, shorter construction time, lesser number of foreign labors and reduce overall cost of projects.

## 1.2 Problem Statement

The failure of early pre-cast systems introduced in Malaysia is a contributing factor that forced the industry maintains in-situ construction. Undoubtedly, some of the early Western systems were not suitable to be used in the Malaysian climate. Cracks and leakages were common at the joint area. Shoddy installations had also contributed to these problems. There are also non-standard methods of fabrication used before that made the pre-cast as not fully reliable but different now where the availability of new technology and new software for the design and fabrication of pre-cast and pre-stressed components [4].

The current scenario of cast in-situ concrete structures in Malaysia has several disadvantages. Cast in-situ concrete structures are usually related to messy and unorganized site. The cast in-situ concrete structures involve a variety of complex machineries and material on site. This may also indirectly result in poor safety and health aspect and also increases the safety hazard to the construction workers. Despite being the intensively labored, most of the cast in-situ concrete structures projects have failed to reach completion in the required time and have high tendency of facing project delay problem due to inadequacy of up-to-date construction technology. Malaysian contractors generally are still practicing out-dated conventional technology when the contract duration in Malaysia is getting shorter relatively. In addition, cast in-situ concrete structures comparatively produces low quality finish products result from constructing material such as timber and plywood has the tendency of giving way and human error may involve during the concreting process [4].

## 1.3 Objectives

The objectives of this project are:

1. To introduce the advantages of pre-cast and pre-stressed concrete structures to the industry players.

2. To conduct survey for comparing the pre-cast and pre-stressed concrete structures with the cast in-situ concretes.

3. To gauge the awareness among the industry players about pre-cast and pre-stressed concrete structures.

4. To get industry players opinion on this pre-cast and pre-stressed concrete structures issue.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Pre-cast Pre-stressed concrete structures

Pre-cast and pre-stressed concrete products are cast in molds in a factory setting. These products benefit from superior quality control achievable at a production plant. Cost savings are realized when shapes are duplicated. Pre-cast products range from concrete bricks and paving stones to bridge girders, structural components, and panels for cladding. Pre-stressed products are girder bridges and hollow core structures. Pre-cast and pre-stressed concrete structures widely used for: housing, garage parking, office building, school, hospital, hotel, motel and so on [13].

We are using the pre-cast and pre-stressed concrete because it provides predictable quality and structural characteristics because of the factory controlled condition. Mass production as well as off-site production shortens project timeline and allowing earlier occupancy. For example, the walls of a building can be manufactured while on-site foundations are being built. Pre-cast concrete is capable of higher strength which allows for long clear spans making it especially applicable to structures requiring large open spaces such as parking garages. It is also provides long service for high use applications. Pre-cast concrete also can be used in a way to reduce using so many labors.

Pre-cast and pre-stressed concrete structures have many environmental benefits during construction such as waste minimization, recycled content and less community disturbance. Less material is required because precise mixture proportions and tighter tolerances are achievable. Less concrete waste is created due to tight control of quantities of constituent materials. Waste materials are more readily recycled because

concrete production is in one location. Sand and acids for finishing surfaces are reused. Steel forms and other materials are reused. Residual materials such as fly ash, slag cement, silica fume, and recycled aggregates can be incorporated into concrete, thereby diverting materials from the landfill and reducing use of virgin materials. Less dust and waste is created at construction site because only needed pre-cast concrete elements are delivered; there is no debris from formwork and associated fasteners. Fewer trucks and less time are required for construction because concrete is made offsite; particularly beneficial in urban areas where minimal traffic disruption is critical. Pre-cast concrete units are normally large components, so greater portions of the building are completed with each activity, creating less disruption overall. Less noise at construction sites because concrete is made offsite [12].

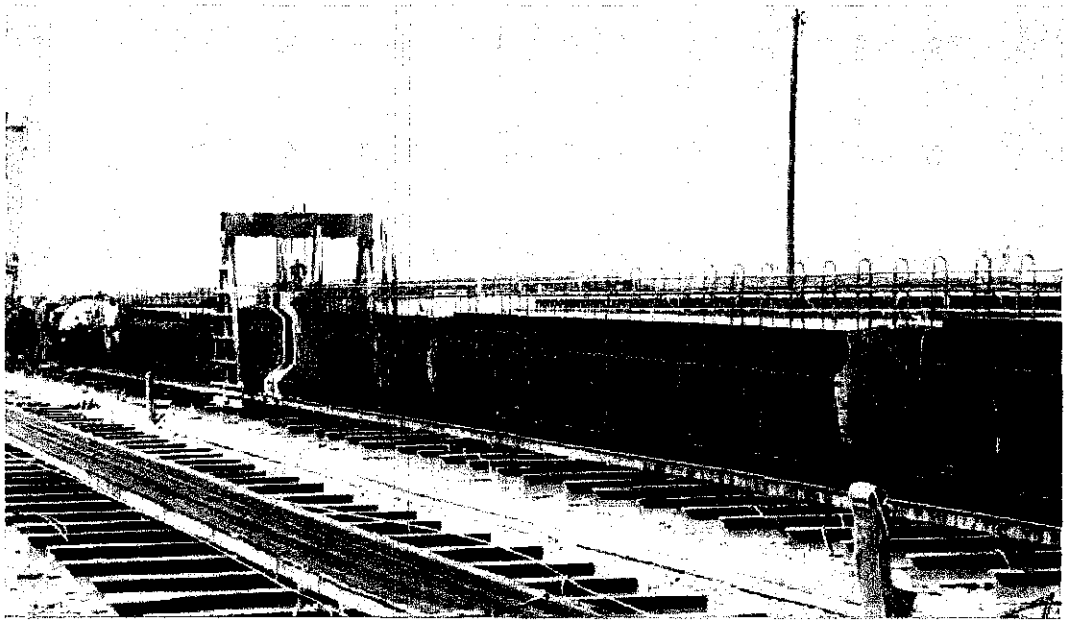


Figure1. Placement of pre-stressing strands and mild steel [8]

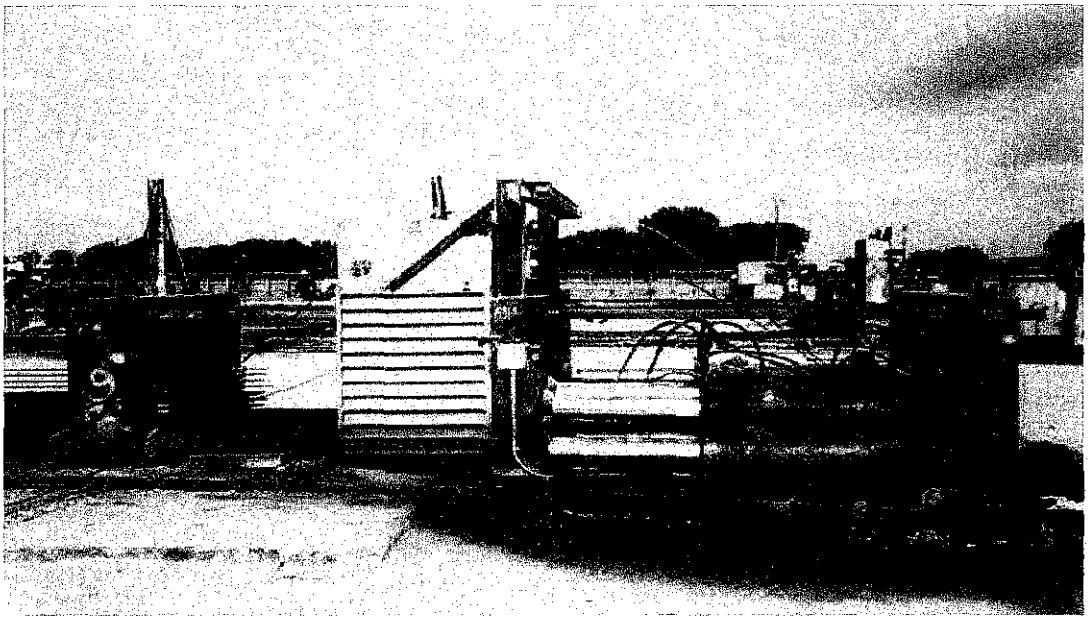


Figure2. Pre-stressing jacks and abutment [8]

## 2.2 Type of pre-cast and pre-stressed concrete structures

### 2.2.1 Hollow Core

Pre-cast and pre-stressed hollow core enjoys wide use in all types of residential structures; particularly multiple units where the repetitive use of standard components manufactured in a factory can be fully utilized. Owners and designers alike recognize the significant benefits of superior fire resistance, sound control, durability and low maintenance, rapid construction and attractive flat ceilings 3].

Certainly pre-cast concrete hollow core slabs have become the solution of choice for flooring and ceiling units in a variety of housing options. The plank typically comes in 8-inch thicknesses, although they can range up to 12 inches if desired. As the name suggests, they feature hollow cores running the length of the pieces that reduce their weight while retaining their structural stability and durability. These cores also provide access for mechanical and electrical systems, providing flexibility in design. Serving as both floor and ceiling elements, the units eliminate the need for installing suspended ceilings and can cut the total height of the building by as much as 10 inches per floor. This helps meet maximum-height zoning restrictions on buildings and also cuts the amount of building material required for each floor without eliminating any head room. Used with pre-cast concrete structural systems, hollow

core meets its full potential for resisting fire and maintaining durability for many years. And their ability to span as much as 30 feet helps to eliminate supporting columns [3].

Structurally, there is no comparison in a wood frame to what hollow core slabs can provide. They can be finished with a nice texture for ceilings, and a leveling coat can be poured to provide a finished floor. This offers a better look than a suspended ceiling and cuts long-term maintenance costs. But other pre-cast products offer strong benefits too. The possibilities include columns and beams, balcony supports, stair and elevator systems, interior wall panels and architectural panels for exteriors. Exterior panels can provide a range of aesthetic finishes that match many types of surrounding neighborhoods, including brick and stucco. Pre-cast components in a wide range of permutations are providing owners and designers with more options and better solutions to the challenges they face in designing for the growing housing demand.

### 2.2.2 Double tees

Pre-cast or pre-stressed double tees offer beauty and flexibility in design. Double tees are ideal for floor and roof systems requiring medium to long, uninterrupted spans and heavy load carrying capabilities. Double tees come in a variety of widths and depths to suit different spans and loading conditions [3].

The remarkable strength of a double tee is the result of a design and manufacturing system that uses the best attributes of steel and concrete. Consider double tees for spans and loads that exceed the capacity of hollow core slabs (parking garages, swimming pools, food processing, large industrial buildings, etc.) [3].

### 2.2.3 Pre-cast framing

Pre-cast concrete beams, columns, walls, frames and stairs are often the ideal solution for builders who want to achieve wide open spans, fire resistance, energy savings and attractive appearance with one structural system. These components are suited for both low and high-rise structures. The quality of the finishes has allowed many

designers to expose the pre-cast framing in the finished structure. Highly durable, pre-cast concrete support units can be quickly installed in all weather conditions. In addition to the main structure, ancillary recreation, parking and convention facilities are commonly constructed using pre-cast concrete framing with long span roof and floor members [3].

### 2.2.4 Bridge Girder.

Owners and designers are often surprised to learn that pre-cast or pre-stressed concrete bridges and structures are usually lower in first cost than others bridges and structures. Coupled with long-term savings in maintenance, pre-cast girders offer maximum economies. Pre-cast girders can be fabricated and transported in lengths up to 40 to 50 m (130 to 165 ft) and weights up to 75 to 90 tonnes. The spliced girder method of construction has extended the practical use of pre-cast beams to span lengths of 75 m (250 ft) or more by erecting girder sections on scaffolding and joining and post-tensioning girder segments at the site. Standard sections include I-girders, bulb tee girders, trapezoidal girders, solid slab girders, hollow slab girders, rectangular box girders, channel girders, single tee girders and double tee girders [3].

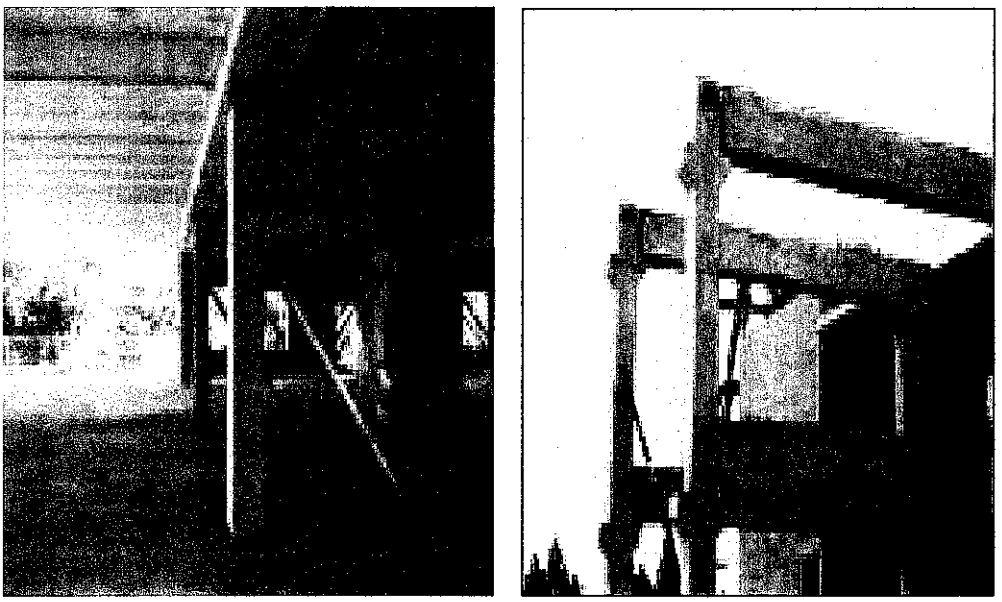


Figure3. Pre-cast concrete column and beam [8]

Figure4. Pre-cast wall panels [8]

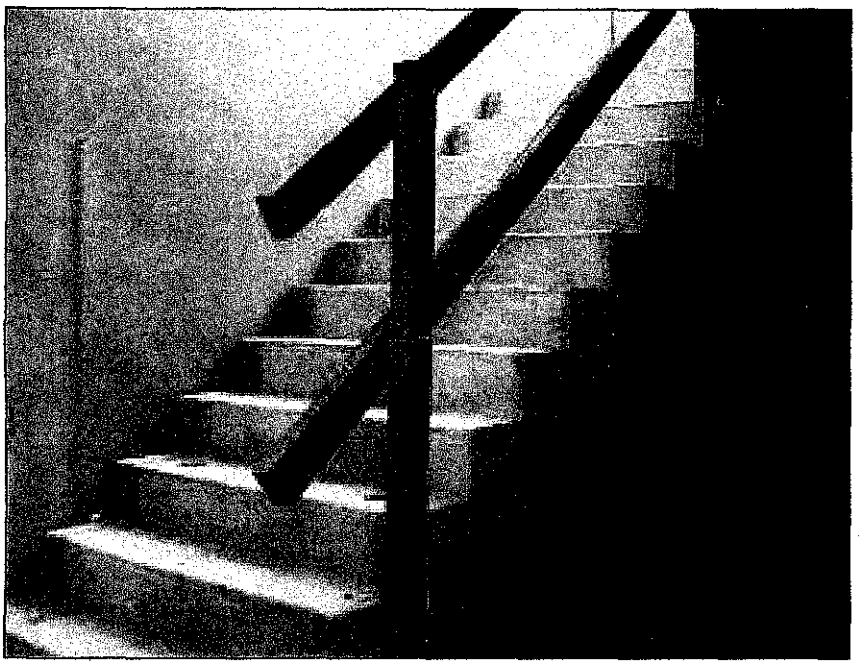


Figure5. Pre-cast concrete stairs [8]

**II. Cyclical Contraction**

1. Environmental Differences (Humidity, Moisture Content and Temperature)

2. Application Loads (Expansion or Contraction)

**III. Abnormal Volume Changes**

1. Permanent Expansion

a. Sulfate Attack

b. Alkali Reaction (between cement and certain aggregate)

The results of these changes are movement (permanent and/or transient) of the concrete elements.

Type of joints and functions [1]

**Control:** When contraction forces associated with curing shrinkage and movement associated with thermal actions or mechanical loads are restrained, then cracking will occur within concrete when the tensile stresses exceed the strength of the concrete. Joints and cracks will open up and become wider as the concrete contracts (shrinks). Concrete is cut during the placement process to help "control" where these cracks will occur.

**Expansion:** If expansion movement is restrained, it may result in distortion and cracking within the unit or crushing of its ends and transmission of unanticipated forces to the abutting elements. Joints and cracks will be closed and the forces will cause spalling if objects preclude the closing. Expansion joints are placed throughout the structure to accommodate this planned and continuous dimensional change.

**Deflection:** When deflection (torsion, flexural, etc.) movement stress is anticipated that may exceed the materials structural design strength limitations, isolation joints are employed.

I. CONTROL (RELIEF) JOINTS

## 2.5 Industrialized Building Systems - An Overview

"The Industrialized Building Systems (IBS) promises elevated levels of expertise throughout the industry, from manufacturers, installers, engineers, planners, designers, and developers. The benefits of IBS are numerous and far reaching. Reduced construction time, better site management, reduced wastage are but a few of these benefits, that will ultimately produce better products for the population." YBhg. Dato' Seri S. Samy Vellu Minister of Works, Malaysia [5]

Industrialized Building System is an alternative approach of construction that will definitely change the scenario of the current local construction industry towards a systematically approach of mass production of construction materials. Prefabricated components of buildings which are conceived, planned, fabricated from factories will be transported and erected on site. With this method, the process would involve planning; management and sustained improvement of the production process to eliminate waste and ensure the right components are produced and delivered at the right time, in the right order and without defect. In this respect, the construction industry has a great deal to learn from the manufacturing sectors that have long been emphasizing on quality and minimizing defects. IBS will definitely among others reduce unskilled workers in the country, less wastage, less volume of building materials, increased site cleanliness and better quality control [5].

In the Malaysian context, five common types of fully developed IBS have been identified as shown [5]:

1) Pre-cast Concrete Framing, Panel and Box systems
2) Steel Formwork Systems
3) Steel Framing Systems
4) Prefabricated Timber Framing Systems
5) Block Work Systems

**IBS Projects in Malaysia [5]**

IBS is not new in Malaysia and have been around since the early sixties. The first pilot project was initiated by the Government and it was along Jalan Pekeliling which

compressive forces that develop during expansion, under applied loads or differential settlement. Isolation joints are used primarily to isolate walls from floors or roofs, columns from floors or cladding, and pavement slabs and decks from bridge abutments - thus the name "isolation joint". Where greater continuity is desired from one structural unit to the next (floor slab to floor slab or floor slab to stem wall) reinforcing bars or dowels, stepped or keyed joints may be employed. To protect and fluid proof the joints (prevent egress of fluids in or out of the structure) when movement will occur require the use of a flexible joint filler (sealant or assemblage). This material must be capable of accommodating the anticipated movement between the structural units. High elongation, Elastomeric urethane, silicone or polyurea materials are frequently used for this application.

NOTE: Elastomeric (urethane, silicone, etc) joint sealants should comply with ACI 302.1R-15 and ACI 504.

## III. CONSTRUCTION (INTERRUPTION) JOINTS

Construction joints may be planned or unplanned. Planned construction joints are incorporated into the structural units for several reasons, such as pre-cast elements, length restriction or during a concrete pour due to configuration or "trick" form placement requirements. Planned construction joints can be called upon to function as expansion joints to accommodate the normal or even radical movement of a structure. Planned construction joints are treated in a similar fashion to expansion joints listed above. Unplanned construction joints usually occur due to unforeseen concrete placement difficulties or forming restrictions. In the case of unplanned and unwanted construction joints due to unforeseen interruption of concrete placement, an epoxy injection adhesive can be used to bond the units together,, providing a monolithic structural unit as originally designed, by permanently welding the unit together at the construction joint.

NOTE: Epoxy injection adhesive should comply with ACI 503 and ASTM C 881-87 Type IV.

## 2.4 Construction Industry Development Board of Malaysia (CIDB) and Industrialized Building System (IBS)

The Malaysian Government is also currently very active in promoting the usage of prefabricated materials, particularly pre-cast components. The Public Works Department (JKR), Construction Industry Development Board (CIDB) as well as the Ministry of Housing and Local Government are among the leaders in championing its usage in the construction industry. JKR have also produced a new set of drawings utilizing pre-cast components for its standard quarters. More hostels, schools, colleges and low cost houses are also now being designed and constructed using pre-cast elements. It is hoped that more clients, designers and contractors in the local construction industry heed to government's call for the industrialization of the construction sector and opt for pre-cast construction as an alternative to the in-situ method. The commitment and cooperation between the government and private sector are crucial in ensuring the success of the program. In order to survive in the era of globalization, it is important for local players to change their perception and begin to use new techniques to produce better quality, productivity and safety in construction [4].

### 2.4.1 Tunnel Form Solutions [4]

Tunnel Form is a formwork system that allows the contractor to cast walls and slabs in one operation on a daily cycle. It can be reused more than 500 times which results in higher productivity, efficiency, economy and quality. The usage of Tunnel Form System has now become a trend in the Malaysian construction industry, especially for high rise buildings. Recognized as one of the Industrialized Building Systems (IBS), Tunnel Form simplifies the whole construction process by enabling a smooth and fast operation that can result in cost effectiveness, productivity and high quality finished. Tunnel Form projects have proven that impressive results can be achieved in terms of productivity, efficiency, economy and quality. It can usually be reused for 500 to 1,000 times, and is an effective way to construct buildings that have repetitive elements or layouts. The system is now one of the most preferred methods of cellular construction by the contractors in Malaysia whilst clients appreciate Tunnel Form's ability to deliver projects to budget and on time. Costs value engineering starts with the early involvement of the formwork supplier. The formwork is available to the

contractor for purchase or rent and can be reused on other projects [4].

During the construction process, Tunnel Form allows the contractor to cast walls and slabs in one operation on a daily cycle. Each 24 hours, the formwork is moved so that another tunnel can be formed. The walls and slabs are cast in a single operation using specially designed half tunnel steel forms (upside down U shape) that maintains a certain size. This cuts down the construction time significantly. The wall and the slab form a monolithic joint. The following construction sequence is implemented:-

1) The Tunnel Forms are first cleaned and coated with form oil. They are then placed in their positions by using the kicker as the guide.

2) The wall reinforcement leads the tunnel formwork. Reinforcement steel and electric conduits are positioned on the tunnel form.

3) Walls, slabs and kickers are cast together. In accordance with the design, steel block outs may be installed on the formwork panels to form the plumbing openings.

This process is repeated on the next floor. A strong, monolithic structure is thus constructed that can reach 20 or more storey in height. Tunnel Form creates cells which are 2.4 to 6.6m wide. These can be easily subdivided to create smaller rooms. Where longer spans (up to 11m) are required, the Tunnel Form can be extended using a mid span section. The result is a cellular reinforced concrete structure, the surfaces of which are of sufficiently high quality to require only minimal finishing for direct decoration, while the end walls and façades are easily completed with thermally insulated units that can be claded as required. The system creates an efficient load bearing structure for use in a wide variety of applications. It is particularly effective in projects suited to repetitive cellular construction such as residential blocks, hotels, hostels and prisons. The techniques used for Tunnel Form only need a team of nine site operatives plus a crane operator; can strike and fix some 300m2 of formwork each day, including placing 35m3 of ready-mixed concrete: typically 2.5 cells. In addition to speed of construction, the technique provides further inherent benefits of concrete: high levels of thermal mass, sound insulation and fire resistance. The schedule provided by the 24-hour cycle means each operative knows exactly what to

do and when, and works to a precisely detailed plan. The smaller work teams and predictable, measurable daily production rates simplify and enhance overall control of the project. Known completion times make scheduling of material deliveries and follow-on trades more accurate and optimize cash flow by facilitating 'just in time' principles. By quickly providing protection, the system allows the following trades to commence work on completed rooms while work proceeds on upper floors [4].

Tunnel Form has integral working platforms and edge protection systems. In addition, the repetitive, predictable nature of the tasks involved encourages familiarity with operations and, once training is complete, productivity improves as construction progresses. The minimal requirement for tools and equipment when moving the Tunnel Form further reduces the risk of accidents on site. Comprehensive method statements from the formwork suppliers and a full safety risk assessment enhance safety in Tunnel Form's application. Normally, the Tunnel Form suppliers provide design and technical support to ensure that engineers, architects and contractors are all familiar with the system and its application as the project starts; enabling time and cost savings to be achieved. If the contractor is inexperienced with Tunnel Form System, the supplier's site training would quickly help bring them up to speed. Tunnel Form provides a winning combination of the speed, quality and accuracy of factory production with the flexibility and economy of in-situ construction [4].

Tunnel Form construction can provide:

- Substantial savings in costs
- Substantial savings in labor
- Much faster construction
- Enhanced safety
- Better management control
- Predictable work flow
- Quicker return on investment
- Precise, high quality structures
- Design flexibility

### 2.4.2 CIDB specification for pre-cast pre-stressed concrete structures

Table 1: CIDB Quality Standard for Construction [7]

| Item | Element | Standards | Tolerance | Assessment Tool |
|---|---|---|---|---|
| **2.** | **REINFORCEMENT (CAST IN-SITU & PRECAST)** | | | |
| **2a.** | **Main & Secondary rebars** | 1) According to structural drawings (numbers/sizes) | | Visual and calliper |
| | | 2) Spacing of bars not more than that specified | ±10 mm | Steel measuring tape |
| **2b.** | **Achorages & lap lengths** | 1) Required lap length not less than that specified | | Steel measuring tape |
| **2c.** | **Cover provision** | 1) According to specification | +5 mm | Measurement Tape |
| **2d.** | **Links, stirrups and trimming bars** | 1) According to structural drawings (numbers/sizes) | | Visual |
| | | 2) Spacing of links not more than specified | ±10 mm | Measurement Tape |
| **2e.** | **Rebar Condition** | 1) Rebars must be securely and properly tied in place | | Visual |
| | | 2) Rebars must be free from concrete dropping, corrosion etc. | | Visual |

Table 2: CIDB Quality Standard for Construction (cont') [7]

| Item | Element | Standards | Tolerance | Assessment Tool |
|---|---|---|---|---|
| 3. | FINISHED CONCRETE (CAST IN-SITU & PRECAST) | | | |
| 3a. | **Dimension for elements/opening for services** | 1) Tolerance for cross-sectional dimension of cast in-situ and precast elements | :+10 mm/-5 mm | Steel measuring tape |
| | | 2) Tolerance for opening | :+10 mm for size and ± 25 mm for location | Steel measuring tape |
| | | 3) Tolerance for length of precast members (major dimension of unit): | | Steel measuring tape |
| | | • Up to 3 m | ±6 mm | Steel measuring tape |
| | | • 3 m to 4.5 m | ± 9 mm | Steel measuring tape |
| | | • 4.5 m to 6 m | ± 12 mm | Steel measuring tape |
| | | • Additional deviation for every subsequent 6 m | ±6 mm | Steel measuring tape |
| | | 4) Straightness or bow (deviation from intended line) of precast member: | | Steel measuring tape, sprit level and L-square |
| | | • Up to 3 m | ±6 mm | |
| | | • 3 m to 6 m | ±9 mm | |
| | | • 4.5 m to 6 m | ±12 mm | |
| | | • Additional deviation for every subsequent 6 m | ±6 mm | |
| | | 5) Squareness of precast member-Difference between the greatest and shortest dimensions should not exceed the following: | | Steel measuring tape |
| | | Length of shorter sides | | |
| | | • Up to and including 1.2 m | ±6 mm | |

Table 3: CIDB Quality Standard for Construction (cont') [7]

| | Element | Standards | Tolerance | Assessment Tool |
|---|---|---|---|---|
| | | • Over 1.2 m but less than 1.8 m | ±9 mm | Steel measuring tape |
| | | • 1.8 m and over | ±12 mm | Steel measuring tape |
| | | 6) Twist of precast member - Any corner should not be more than the deviation stated from the plane containing the other 3 corners: | | Steel rule, L-square & spirit level |
| | | • Up to 600 mm wide and 6 m in length | ±6 mm | |
| | | • Over 600 mm wide and for any length | ±12 mm | |
| | | 7) Flatness | ≤6 mm per 1.2 m | Steel rule and spirit level |
| 3b. | **Alignment, plumb and level** | 1) Tolerance for departure of any point from its position | ±10 mm | Steel measuring tape |
| | | 2) Tolerance for plumb:, maximum 20 mm for floor to floor height and 40 mm for the entire building height | 3 mm/1m | Plum bob and Steel measuring tape |
| | | 3) Maximum deviation of mean level | ±10 mm | Precise levels |
| | | 4) For cast in-situ elements, the maximum deviation of levels within the elements | ±10 mm | Steel measuring tape |
| | | 5) Chamber at mind-span: according to specifications | | Steel measuring tape and L-square |
| 3c. | **Exposed surface** | 1) Should not have visual exposure of groups of coarse aggregates resulting from grout leakage | | Visual |
| | | 2) Cold joint & formwork joint must be smooth | | Visual |

Table 4: CIDB Quality Standard for Construction (cont') [7]

| | Element | Standards | Tolerance | Assessment Tool |
|---|---|---|---|---|
| | | 3) No bulging of structural element | | Visual |
| | | 4) All formwork, nails, zinc strips, etc must be removed | | Visual |
| | | 5) No cracks or damages | | Visual |
| | | 6) No exposed rebar | | Visual |
| **4.** | **PRECAST SPECIFIC REQUIREMENTS** | | | |
| **4a.** | **Lifting points/inserts** | 1) Tolerance for position | ±20 mm from centre line location in drawing | Steel measuring tape |
| | | 2) Lifting devices and inserts free from damages | | Visual |
| **4b.** | **Sleeve system/connections** | 1) Tolerance for position | ±6 mm from centre line location in drawings | Steel measuring tape |
| | | 2) Bar protrusion length according to requirements. No bending, cranking or damages to bars | | Visual |
| | | 3) Bars free from concrete droppings or corrosion | | Visual |
| | | 4) Sleeves, grout holes, grout tubes not congested with debris | | Visual |
| **4c.** | **Interface/joint requirement** | 1) Joint taper: | | Steel measuring tape |
| | | * Over 3 m length | ±6 mm | |
| | | * Maximum for entire length: | ±9 mm | |
| | | 2) Aligment of horizontal and vertical joint | ±6 mm | Steel measuring tape |
| | | 3) Jog in aligment of matching edges: | ±6 mm | Steel measuring tape |

Table 5: CIDB Quality Standard for Construction (cont') [7]

| | Element | Standards | Tolerance | Assessment Tool |
|---|---|---|---|---|
| | | 4) Sitting of element | according to specifications | Visual |
| | | 5) Installation of sealant and waterproofing | according to specifications | Visual |
| **4d.** | **Cast-in steel items/welded & bolted connection** | 1) Tolerance for position of cast-in steel items | ±6 mm from centre line location in drawings | Steel measuring tape |
| | | 2) Tolerance for position of openings for bolt connections | ±3 mm from centre line location in drawings | Steel measuring tape |

Table 6: CIDB Quality Standard for pre-stressed concrete [7]

**PRE-STRESSED CONCRETE**

| | Element | Standards | Tolerance | Assessment Tool |
|---|---|---|---|---|
| **1** | **Condition of tendons & anchorges** | 1) All pre-stressing strands amd wires should comply with the specified standards and requirements and be free from loose rust, oil, tar, paint and any foreign objects | | Steel measuring tape |
| | | 2) All tendon anchorge are to comply with the specified standards and protected from corrosion | | Visual |
| | | Thread parts to be greased wrapped and tapped holes protected until use | | Visual |
| **2** | **Installation of sheathing** | 1) Sheating properly secured and protected and free from damage or puncture | | Visual |
| | | 2) Sheating profile according to drawings throught out the length with position tolerance | ±5 mm | Steel measuring tape |
| | | 3) Splice to sheathing shall be mortar tight | | Visual |
| | | 4) Air vents grout tubes provided according to the drawing | | Visual |
| **3** | **Stressing & grouting process** | 1) Tendon ducts clean and free from foreign objects and tendon free moving in the duct | | Visual |
| | | 2) All grouting operations of the tendons must be smooth and achieved without need to flush out in the first grouting | | Visual |
| **4** | **Debonding** | 1) Open ends of debond tubes over the debond length of strands sealed | | Visual |
| | | 2) Debond lengths according to the drawings | | Steel measuring tape |
| | | 3) Debonding materials not punctured or damaged | | Visual |

## 2.5 Industrialized Building Systems - An Overview

"The Industrialized Building Systems (IBS) promises elevated levels of expertise throughout the industry, from manufacturers, installers, engineers, planners, designers, and developers. The benefits of IBS are numerous and far reaching. Reduced construction time, better site management, reduced wastage are but a few of these benefits, that will ultimately produce better products for the population." YBhg. Dato' Seri S. Samy Vellu Minister of Works, Malaysia [5]

Industrialized Building System is an alternative approach of construction that will definitely change the scenario of the current local construction industry towards a systematically approach of mass production of construction materials. Prefabricated components of buildings which are conceived, planned, fabricated from factories will be transported and erected on site. With this method, the process would involve planning; management and sustained improvement of the production process to eliminate waste and ensure the right components are produced and delivered at the right time, in the right order and without defect. In this respect, the construction industry has a great deal to learn from the manufacturing sectors that have long been emphasizing on quality and minimizing defects. IBS will definitely among others reduce unskilled workers in the country, less wastage, less volume of building materials, increased site cleanliness and better quality control [5].

In the Malaysian context, five common types of fully developed IBS have been identified as shown [5]:

1) Pre-cast Concrete Framing, Panel and Box systems
2) Steel Formwork Systems
3) Steel Framing Systems
4) Prefabricated Timber Framing Systems
5) Block Work Systems

**IBS Projects in Malaysia [5]**

IBS is not new in Malaysia and have been around since the early sixties. The first pilot project was initiated by the Government and it was along Jalan Pekeliling which

involved 3,000 units of low cost flats and 40 shop lots. However, developments in IBS after that failed to gain support from the industry and consumers. From a survey done by CIDB on 2003, it was found that the percentage usage of IBS in the local construction industry is only at a mere 15%. However, several major world class developers in Malaysia have used some percentage of IBS in their projects. Several projects that use IBS can be seen as follows.

i) KLIA
ii) Government Quarters in Putrajaya
iii) Petronas Twin Towers
iv) KL Sentral

Among the reasons that have made IBS not very popular with the developers would be the abundance of cheap foreign labors in the country. Currently there are about 250,000 workers in the construction industry. The Government's effort to reduce the foreign workers to not more than 15 percent of the country's labor force in the next five years would be an impetus for the local developers to use IBS. By using a superior construction technology that requires highly skilled workers, the dependence on foreign workers would significantly be reduced.

**IBS Roadmap 2003 – 2010 [5]**

On October 2003, an IBS Roadmap 2003 – 2010 has been tabled by the Ministry of Works to the Cabinet and subsequently has been endorsed by the Cabinet to be the blueprint document for the industrialization of the Malaysian construction sector. The blueprint that have been produced by the IBS steering committee and working groups, organized by CIDB will be a reference point for all parties to implement all the programs towards industrializing the Malaysian construction sector. The program's that will be implemented is hoped to meet the objective of total industrialization of Malaysia's construction sector by 2010.

Under this roadmap, MIGHT through the Office of the Science Advisor have been tasked to develop an IBS vendor program for the nation together with the Ministry of Finance and Ministry of Entrepreneur and Co-operative Development. The IBS

vendor development program will consist of existing and new industry players and covering a wide spectrum of activities, from preliminary design to the assembly and installation of housing projects. Towards this end, MIGHT is constantly in consultation with other stakeholders such as the Ministry of Housing and Local Government, Construction Industry Development Board, Ministry of Entrepreneur and Co-operative Development, SIRIM and other related agencies to develop a comprehensive vendor development program.

Several ingredients will need to be in place for the development of the vendor program. Among them are identifying the vetting agencies that will provide a control uniformity of design and quality of the components produced by the vendor. The vetting agencies will also maintain standards and ease the legislative problems. The investment requirements for setting up a factory to manufacture components by the vendor are estimated to be about RM1.25 million (excluding land) and dependable on the type of components to be produced. This level of investment is within the reach of small and medium contractors.

With Budget 2005 announced recently, the Government is committed in ensuring IBS implementation by providing an additional of 100,000 units of affordable homes to be implemented using IBS. Budget 2005 also reveals Government intention in increasing the IBS usage in Government building projects from 30 percent currently to 50 percent starting from 2005.

On achieving a wider scale implementation of IBS scale for Malaysia, the Government will also give full exemption on levy imposed by CIDB for developers who utilize IBS components exceeding 50 percent. These wise decisions made by the Government will definitely create a lot of interest from the industry to use IBS as an alternative approach of construction. The next stage of IBS would be to explore the 'export' of the system to overseas market. The success of these efforts will enable the local construction industry to be competitive and penetrate the global market

# CHAPTER 3
# METHODOLOGY/PROJECT WORK

## 3.1 Methodology

This project will be conducted for two semesters. For the first semester, the focus is on the literature review to get basic ideas about the pre-cast and pre-stressed concrete structures. Information from Construction Industry Development Board of Malaysia (CIDB) and Industrialized Building System (IBS) has been searched especially regarding the development of pre-cast pre-stressed concrete structures and their specification.

For the second semester, questionnaires have been prepared and dispersed out to the industry to conduct survey. The purpose of this survey is to gauge the understanding, awareness and acceptance towards the pre-cast and pre-stressed concrete structures. Through this survey a statistical analysis about the Malaysian building industry on the problems and obstacles it is facing which prevent it from using pre-cast and pre-stressed concrete structures in Malaysia will be obtained.

It should be noted that one does not start by writing questions. The first step is to decide 'what are the things one needs to know from the respondent in order to meet the survey's objectives?'. At the outset, the researcher must define the population about which he/she wishes to generalize from the sample data to be collected. Secondly, researchers have to draw up a sampling frame. Thirdly, in designing the questionnaire we must take into account factors such as the age, education, etc. of the target respondents [9]. The main methods available in survey research are:

· Personal interviews

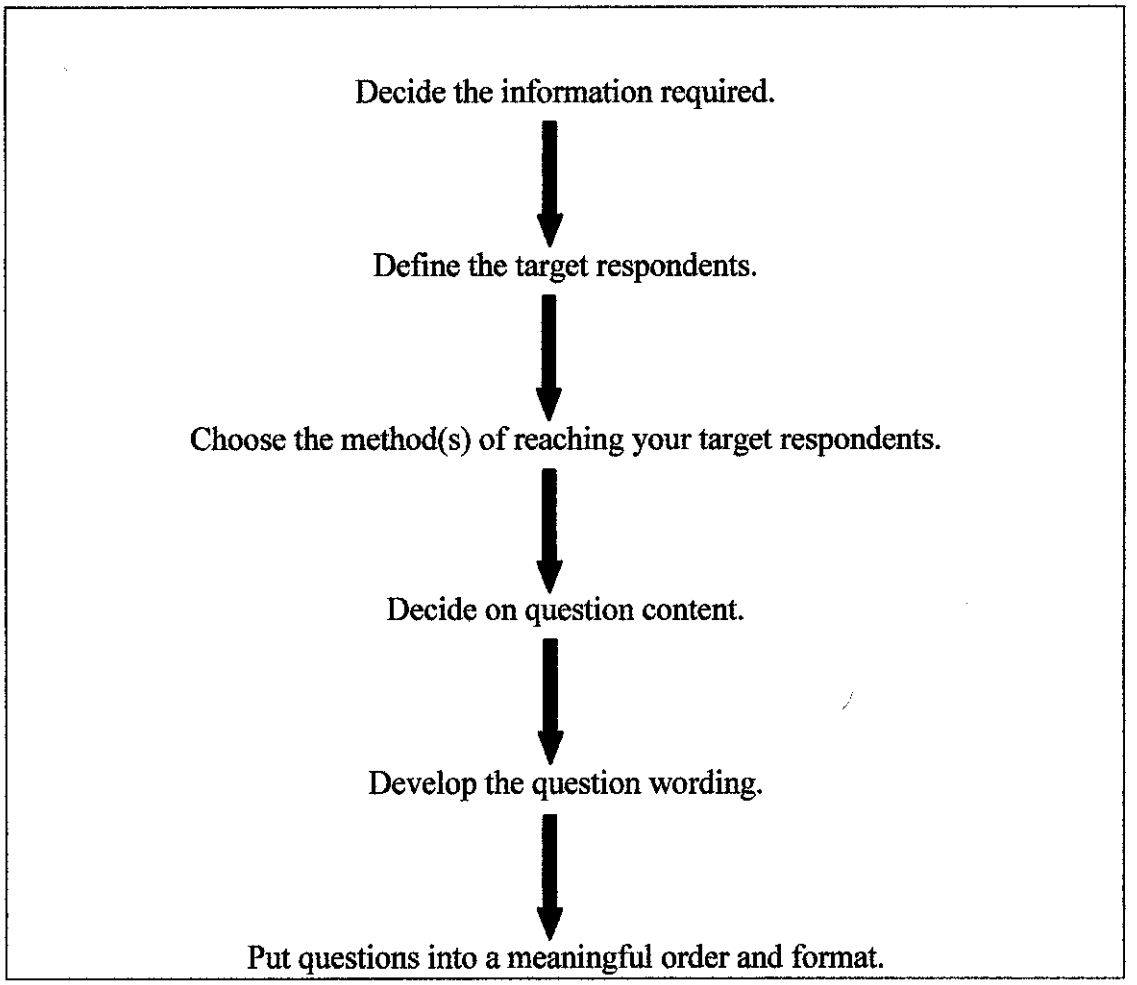
· Group or focus interviews

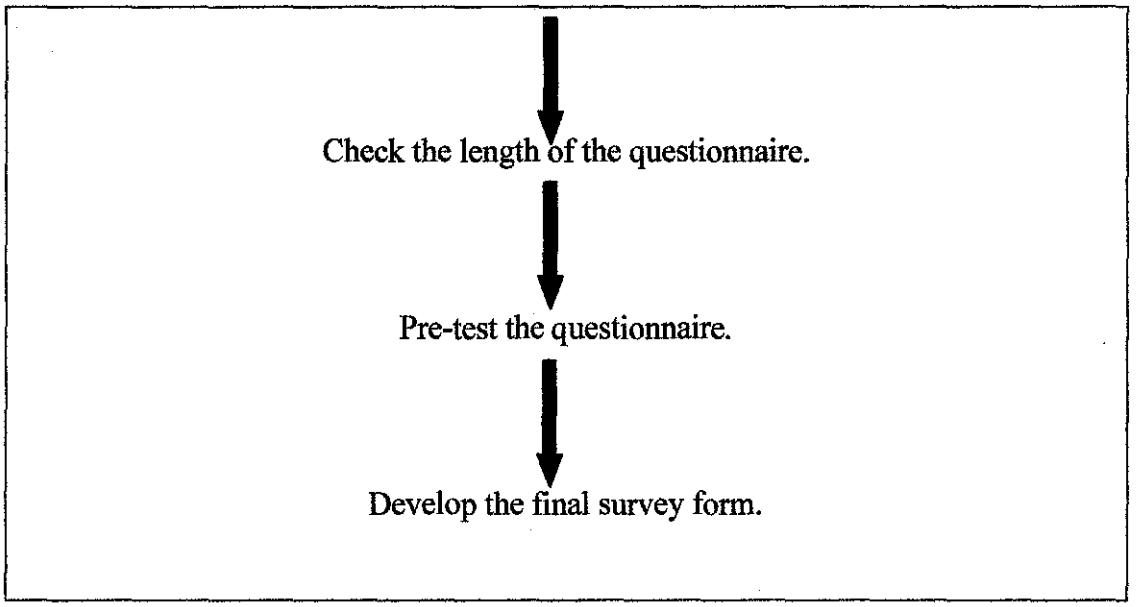
· Mailed questionnaires

· Telephone interviews.

For my project, mailed questionnaire method has been selected. One must always be prepared to ask, "Is this question really needed?" The temptation to include questions without critically evaluating their contribution towards the achievement of the research objectives, as they are specified in the research proposal, is surprisingly strong. No question should be included unless the data it gives rise to is directly of use in testing one or more of the hypotheses established during the research design. Survey questions can be classified into three forms, i.e. closed, open-ended and open response-option questions. In my case, an open response-option question has been considered. The questions are put in the proper wording and format and the length of the questionnaire is checked in order to avoid any redundant question or too many questions. The questions were tested before the final survey form is drafted.

Here are the nine steps involved in the development of the questionnaire:






The questionnaire consist of background of the respondent, current situation in the local construction industry, benefits of using pre-cast and pre-stressed concrete structures and the implementation (**The sample of questionnaire form is attached in the appendix**). Survey form dispersed to the construction industry players such as consultants, contractors, developers, government organizations and pre-cast and pre-stressed concrete manufacturers. The feedbacks that had been received from the respondents need to be analyzed statistically to gauge the problems or obstacles of not using pre-cast and pre-stressed concrete structures in their structures or even by the industry as overall. Conclusion can be made in term of the understanding, awareness and acceptance of industry players towards the usage of pre-cast and pre-stressed concrete structures in Malaysia.

# CHAPTER 4
# RESULT/DISCUSSION

After 1year of doing this final year project, I have done the literature review which is focusing on basic ideas about the precast and pre-stressed concrete structures, its current status and development in Malaysia and also on its application in the construction industry in Malaysia. I have searched for informations regarding the pre-cast and pre-stressed concrete elements, its problems, CIDB and IBS development on pre-cast pre-stressed concrete structures and its specification.

## 4.1 Survey analysis and results

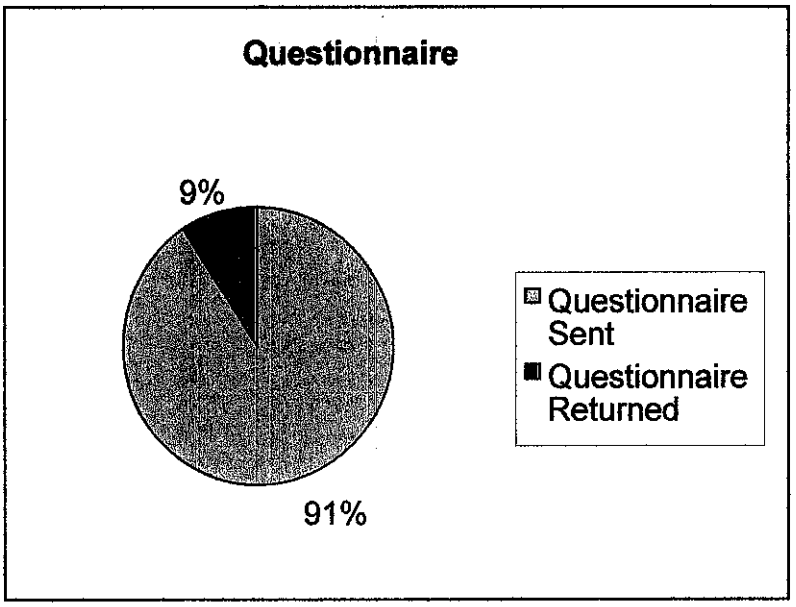



Chart 1: Feedback chart

The respondents were given the option of returning the questionnaire forms by mail or fax. A total 15 respondents out of 150 returned the questionnaire. Though only 9% of the respondents replied, this low percentage had been expected for a mailed and questionnaire-based survey research.

Table 7: Respondents' Category

| Type of Company | No. |
|---|---|
| Consultant | 3 |
| Construction | 9 |
| Development | 2 |
| Government | 1 |
| Pre-cast and Pre-stressed Manufacturer | 0 |

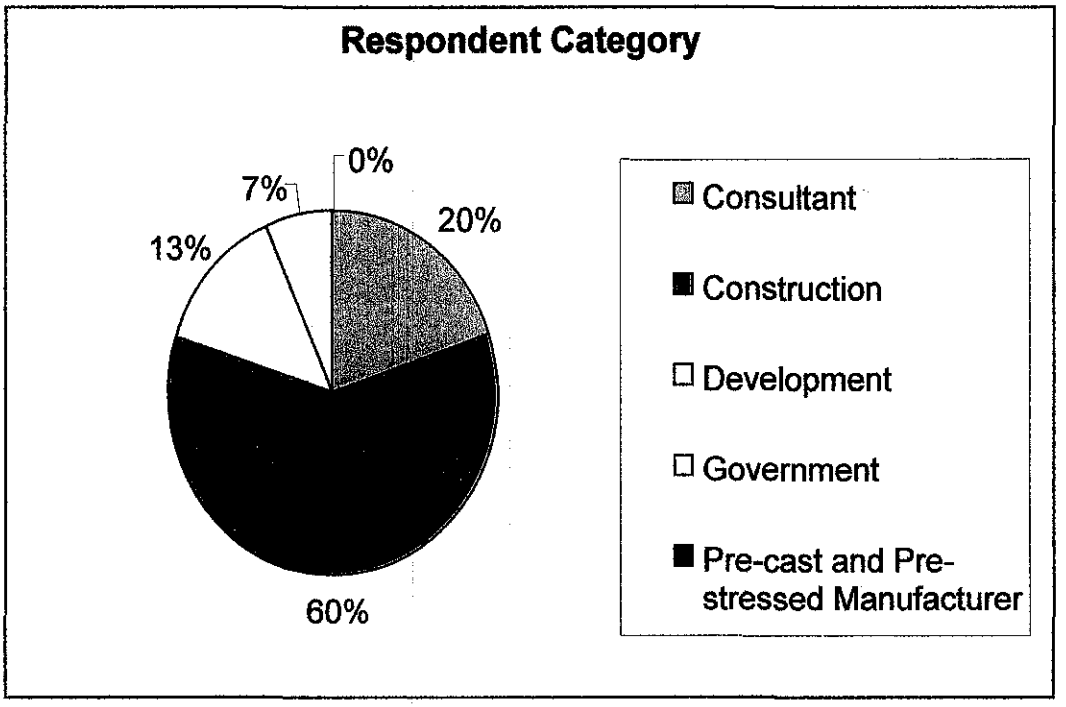



Chart 2: Respondent category

Of the 15 completed forms, construction company registered as the highest number of respondents at 9companies (60%), followed by 3consultant firms (20%) and 2developers (13%) and lastly 1government (7%) and no feedback receive from pre-cast and pre-stressed concrete structures manufacturer probably they do not have time to respond this feedback or they might be worry if this survey is from their competitors (other concrete manufactures).

Table 8: Respondents' Experience in Construction Industry

| Year Range | No. |
|---|---|
| <2 | 0 |
| 2-5 | 0 |
| 5-20 | 12 |
| >20 | 3 |

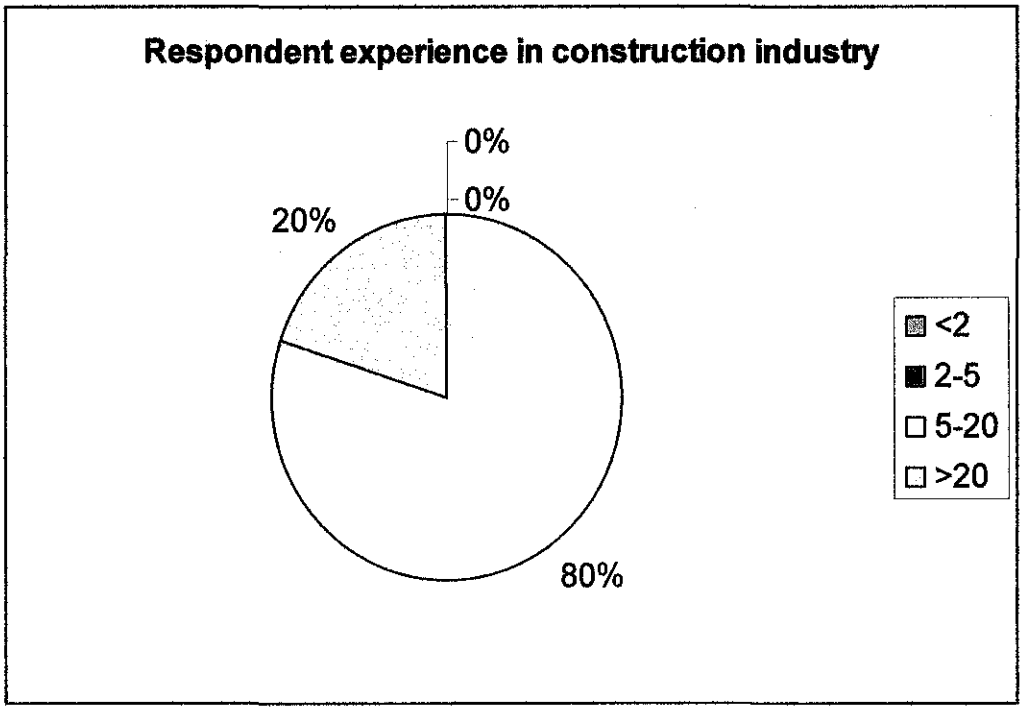



Chart 3: Respondents' Experience in Construction Industry

Based on the result from Table 8 and Chart 3, it is a good indication because most of the feedback responded from the industry players are people who have working experience at least 5 years. They have had sufficient knowledge concerning cast in-situ concrete which has been practiced and they are able to compare the advantages and flaws of both cast in-situ and pre-cast and pre-stressed concrete structures.

Table 9: Current situation in the local construction industry

| Problems \ Option | Percentage (%) | | | | |
|---|---|---|---|---|---|
| | **Strongly disagree** (1) | **Disagree** (2) | **Intermediate** (3) | **Agree** (4) | **Strongly agree** (5) |
| Time | 9.10 | 18.20 | 27.30 | 9.10 | 36.30 |
| Quality | 0.00 | 0.00 | 27.30 | 27.30 | 45.40 |
| Local labor | 4.55 | 4.55 | 40.85 | 27.30 | 22.75 |
| Workmanship | 3.00 | 0.00 | 21.3 | 27.30 | 48.40 |
| Foreign Labor | 0.00 | 0.00 | 27.00 | 28.00 | 45.00 |

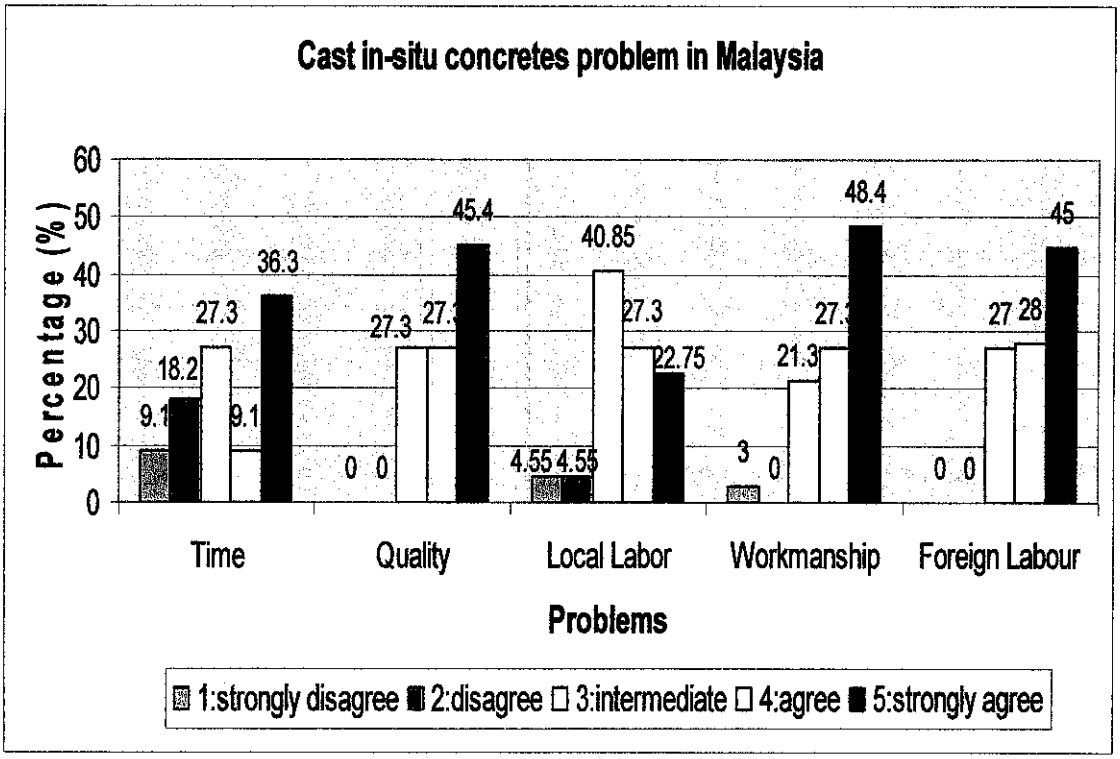



Chart 4: Cast in-situ concrete problems in Malaysia

Table 10: Benefits of using pre-cast and pre-stressed concrete structures

| | Percentage (%) | | | | |
|---|---|---|---|---|---|
| Option / Benefits | **Strongly disagree** (1) | **Disagree** (2) | **Intermediate** (3) | **Agree** (4) | **Strongly agree** (5) |
| Time | 0.00 | 3.10 | 27.30 | 42.40 | 27.20 |
| Cost | 0.00 | 0.00 | 45.40 | 9.10 | 45.40 |
| Quality | 0.00 | 0.00 | 18.20 | 36.30 | 45.50 |
| Labor | 6.10 | 12.10 | 33.30 | 18.20 | 30.30 |

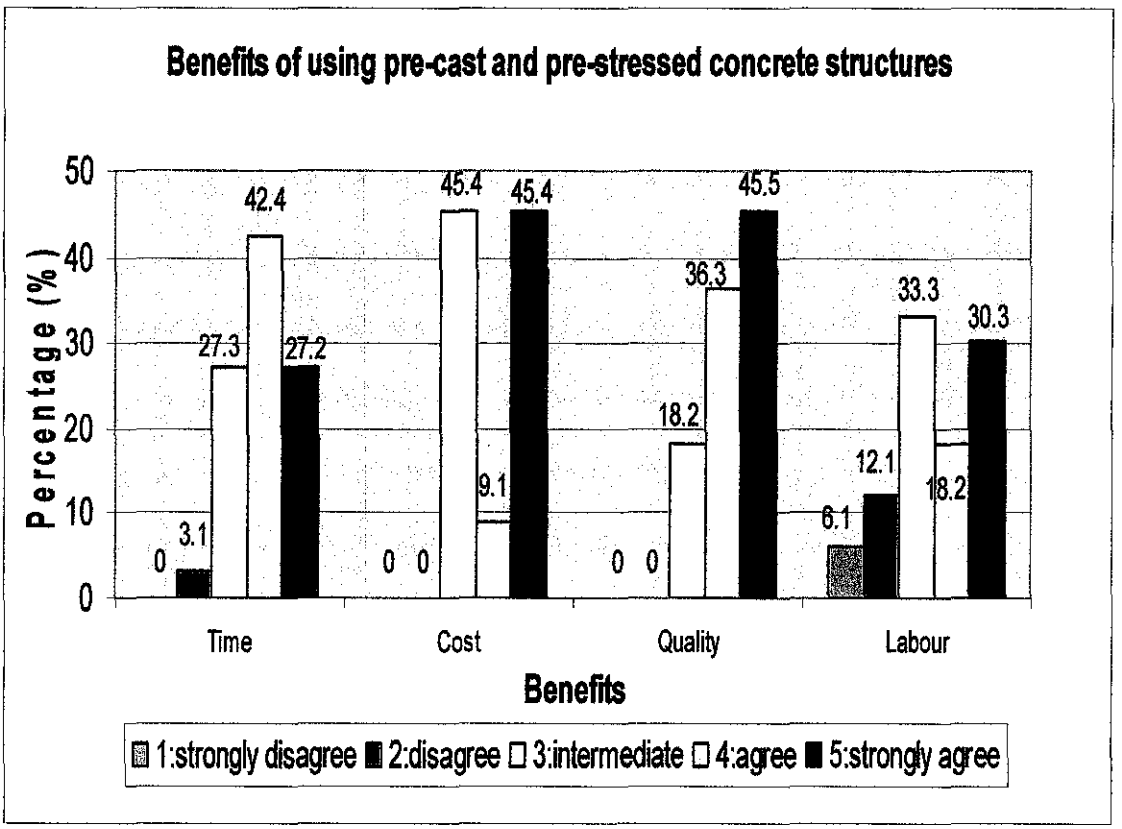



Chart 5: Benefits of using pre-cast and pre-stressed concrete structures

Table 11: Implementation of pre-cast and pre-stressed concrete structures

| Option / Benefits | Percentage (%) | | | | |
|---|---|---|---|---|---|
| | **Strongly disagree** (1) | **Disagree** (2) | **Intermediate** (3) | **Agree** (4) | **Strongly agree** (5) |
| Campaign/Seminar | 0.00 | 9.10 | 45.40 | 18.20 | 27.30 |
| Education | 0.00 | 9.10 | 54.50 | 27.30 | 18.20 |
| Set up policies/codes | 9.10 | 9.10 | 18.20 | 36.30 | 27.30 |
| Allocate budget | 0.00 | 0.00 | 27.30 | 18.20 | 54.50 |

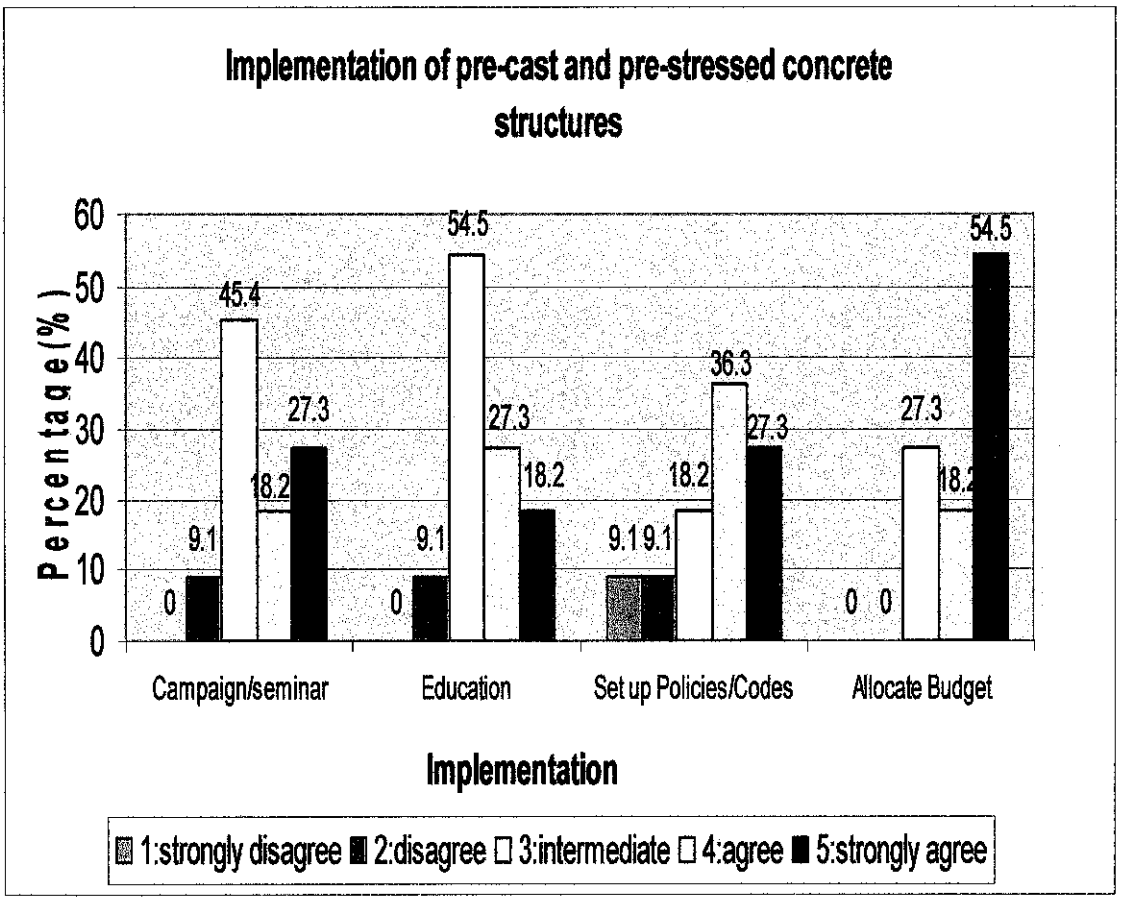



Chart 6: Implementations of pre-cast and pre-stressed concrete structures

## 4.2 Discussion

After the survey has been done, beneficial information about the problems or obstacles of not using apre-cast and pre-stressed concrete structures as an alternative to the typical cast in-situ construction by the industry in general, has been gathered. It was learned that the main reason the consultants, contractors, developers and especially the client prioritize to choose traditionally cast in-situ construction is because of the relatively cheap and abundant supply of foreign labors from neighboring Indonesia, Bangladesh, Pakistan and so on, mainly from the third world Asian countries.

Further more, the failure of the technology transfer also resulted in the low reception of the pre-cast and pre-stressed concrete structures in Malaysian. Besides, before the proper guidelines set up by the CIDB, there was no standard for the contractors or consultants to follow and to abide. Thus, these are the reason for the industry players did not choose the pre-cast and pre-stressed concrete structures. Most of the contractors are still practicing traditional cast in-situ construction because they have been used to/using the system since the beginning. They could not accept and adopt themselves to this new technology as they do not possess any/proper knowledge on that.

Assistant director of Jabatan Kerja Raya (JKR) Perak commented that IBS is not favorable for the current industry because of the high technology implied. Contractors inclusive of engineers and technical personnel do not possess adequate knowledge of this technology, especially at the critical jointing area between of the pre-cast where leakages often occur if not installed with the right method, especially at the bathroom area whereby the joint must be sealed and waterproofed.

Data analysis of the questionnaire was done after the feedback from the respondents have been received. Descriptive data collection is being implemented whereby each question answered by the respondents is being summed up through cumulative method. However, there were certain questions that does not sum up to the total

number as the respondents were having a conservative stand and choose not to answer them. After data compilation was done, the analysis was commenced.

Limitations to the survey

As the survey was using research method, this study has its own limitations that have affected the results of the findings:

i) The respondents

The 15 respondents only represented 10% of the target sample of 150 selected participants. The low response might be caused by the questionnaires failing to reach the participants.

ii) Non-stated answers

There is a minor percentage of the respondents did not answer the questionnaire in full. This might have slightly affected the results and the actual scenario of the construction market.

iii) Population sample

Due to time constraint, small sample size of 150 samples from a possible approximate 20,000 industry players around Malaysia were being selected for this questionnaire research. Thus, the result might not portray the accurate situation in the market.

# CHAPTER 5
# CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

Generally, the result shows that the pre-cast and pre-stressed concrete structures are better than the traditional cast in-situ construction. Most of the respondents agreed with the benefits of pre-cast and pre-stressed concrete structures which can overcome the disadvantages of the traditional cast in-situ structures.

The respondents who agreed with the current situation in the local construction industry scored the highest percentage, i.e. 36.3% of the respondents strongly agreed that cast in-situ concretes causes delays in construction works and the delays can cause the overall project cost to increase. 45.4% of the respondents strongly agreed that the low quality of cast in-situ concrete works in Malaysia is mainly because of the unskilled foreign labors and the lack of supervision on the process of cast in-situ concretes. 40.85% of the respondent partially agreed that local labors face difficulties in competing for the jobs with foreign labors who accepts a meager salary for heavy work loads. Heavy work loads and hot weather prevents local labors from getting a job in the construction industry. 48.4% of the respondents strongly agreed that too many unskilled labors in a workplace can cause healthy and safety issues and would make the monitoring, control and supervision more difficult. 45% of respondents strongly agreed that the hiring of foreign workers can cause flow of Malaysian currency to foreign countries which will affect the local currency market. High number of foreign workers can also cause social problems whereby there were cases in Malaysia where foreign workers were involved in criminal activities such as robberies, rapes, gang fights and so on.

The pre-cast and pre-stressed concrete structures provide so many benefits in the construction industry in terms of quicker time for completion, lesser overall cost of projects, higher quality end products, and lesser number of labors. 42.4% of the respondents agreed that speed of construction is high with the pre-cast and pre-stressed concretes as they are factory produced, while site preparations can proceeded at the same time. 45.4% of respondent partially and strongly agreed that establishment of the pre-cast and pre-stressed construction facilities would incur high cost initially relatively but in the long run the overall cost would be significantly lesser than the conventional construction method. 45.5% of the respondents strongly agreed that the pre-cast and pre-stressed construction produces better quality of end product because of the factory controlled fabrication processes and easier monitoring and control at the site due to lesser number of workers involved and mainly involving skilled workers. 33.3% of respondents partially agreed and 30.3% of respondent strongly agreed that the pre-cast and pre-stressed construction would enable local labors are been fully utilized with fewer number of unskilled foreign labors. It also would benefit local labors by getting the necessary skills and technology of modern day construction method. Higher numbers of local labors are expected to anticipate in the construction industry because of the conducive work environment, lesser exposure to hot weather, not strenuous physical works, better pay and better technological advancement and so on.

45.4% of the respondents partially agreed that the way to commercialize pre-cast and pre-stressed construction method in Malaysia is through advertisement by means of campaign, seminar and so on. 54.5% of the respondents partially agreed that through education by means of providing curriculum and courses at tertiary levels, it could help to commercialize the pre-cast and pre-stressed concrete structures. 36.3% of the respondents agreed that by setting up of government policies and provision of proper codes of practice to encourage participation from the industry would enable the pre-cast and pre-stressed construction methods to be commercialized. 54.5% of the respondents strongly agreed that the government through the Ministry of Work (MoW) should allocate budgets for the research and development of the pre-cast and pre-stressed construction methods.

From the feedback, about 10 out of 15 questionnaires returned suggested that the government is the most important party to play the role in encouraging the usage of pre-cast and pre-stressed concrete structures in Malaysia. The other 5 questionnaires suggested that the consultants and manufacturers should promote and introduce the pre-cast and pre-stressed concrete structures to the construction industry so that the industry players are exposed to the benefits of choosing pre-cast and pre-stressed concrete structures in their construction works. As agreed by most of the respondents, that because of the pre-cast and pre-stressed elements are manufactured in a casting area where critical factors including temperature, mix design and stripping time can be closely checked and controlled; and this will ensure that the quality of the products are better than cast-in-situ concretes. Also due to the factory-controlled prefabrication environment, many combinations of colors and textures can be applied easily to the architectural or structural pieces. A vast range of sizes and shapes of pre-cast and pre-stressed components can be produced, providing a great deal of flexibility and offer fresher looks to the structures. Pre-cast and pre-stressed concrete construction will save valuable time and helps to reduce the risk of project delays and possible monetary losses. Pre-cast and pre-stressed design and production of elements can be started while the construction site is under survey or earthworks. Also, the usage of large pre-cast panels will reduce the time taken to complete the structural works. Therefore, other trades such as painting and electrical wiring can begin work sooner.

## 5.2 Recommendation

During the first semester, students are focused on the literature review for obtaining basic ideas about pre-cast and pre-stressed concrete structures. The methodology that has been used is to conduct survey in order to gauge the understanding, awareness and perspective of the industry players towards the pre-cast and pre-stressed concrete structures. However the method of survey which is dispersing the questionnaire is not really helping because only a small percentage of the questionnaire will be returned by the respondents. So if this project is to be continued in the future, it is suggested that the person responsible has to choose other method of survey.

Also it is recommended that the results from the survey will be used to propose to the highest authority such as government so that the implementation of pre-cast and pre-

stressed concrete construction could be done in Malaysia. Consultants and manufacturers also are advised to introduce the pre-cast and pre-stressed concrete structures to the industry players so that able to increase the usage of the pre-cast and pre-stressed concrete structures in the construction industry.

For any future survey on the pre-cast and pre-stressed concrete structures, it is recommended that the person who will be doing the survey will prepare and disperse more number of questionnaires so that they could obtain more reliable feedbacks. It is also suggested to call the participants to remind them about the questionnaire that has been sent to them so that they will reply to it as soon as possible and take the survey seriously.

# REFERENCES


[1] http://www.generalpolymers.com/tech_lib/concrete103.pdf (20th March 2007)

[2] http://www.ibsmodular.com/highlights.php?id=9 (10th May 2007)

[3] http://www.precastsearch.com/?id=s&ex=2 (9th March 2007)

[4] IBS DIGEST January-March 2005, pp1-20.

[5] Industrialized Building Systems (IBS) Roadmap 2003 – 2010

[6] Standard Construction Industry "Quality Assessment System for Building Construction Work", CIS XX: 2006, October 2006, pp 55-67.

[7] http://images.search.yahoo.com/search/images?p=precast+and+prestressed&fr=yfp-t-501&toggle=1&cop=mss&ei=UTF-8&vc=&fp_ip=MY

[8] 2. Sudman, S. and Bradburn, N. M. (1973), Asking Questions, pp. 208 - 28.

[9]Cheok, G. S., and Lew, H. S., "Performance of 1/3-Scale Model Pre-cast Concrete Beam-Column Connections Subjected to Cyclic Inelastic Loads," NIST 4433, National Institute of Standards and Technology, Gaithersburg, MD, October 1990.

[10]Waleed A.M. Thanoon, Lee Wah Peng, Mohd Razali Abdul Kadir, Mohd Saleh Jaafar and Mohd Sapuan Salit. September 2003. The Experience of Malaysia and other countries in Industrialised Building System Universiti Putra Malaysia

[11]Yee, Alfred A., "Social and Environmental Benefits of Pre-cast Concrete Technology," PCI Journal, V. 46, No. 3, May-June 2001, pp. 14-19.

[12]PCI Design Handbook, 5th Edition, Pre-cast/Pre-stressed Concrete Institute, Chicago, IL, 1999, pp 690

[13]Pre-stressed Concrete Institute, 1977. PCI Manual for Structural Design of Architectural Pre-cast Concrete, Chicago. pp440.

[14] Englekirk R. E., "The Development and Testing of a Ductile Connector for Assembling Pre-cast Concrete Beams and Columns," PCI JOURNAL, V. 40, No. 2, March-April 1995, pp. 36-51.

# APPENDIXES

UNIVERSITI
TEKNOLOGI
PETRONAS

Zahara Yaakop
Civil Engineering Department,
Universiti Teknologi Petronas,
Bandar Sri Iskandar,
31750, Tronoh,
Perak.

30th October 2007

Dear Sir/Madam,

Survey on Application of Pre-cast and Pre-stressed concrete structures in Malaysia

Referring to the above matter, I am Zahara Yaakop, a final year student taking Civil Engineering Program at **Universiti Teknologi Petronas** undergoing my Final Year Project on "Application of the Pre-cast and Pre-stressed concrete structures in Malaysia".

2. Part of my project requires me to undertake a survey on the application of pre-cast and pre-stressed concrete structures in Malaysia.

3. On behalf of the Universiti, kindly I am inviting your organization/company to participate in this survey. Your response is very important to enable me to complete my project. I personally value your feedback. Please complete and return the survey in the enclosed stamped self addressed envelope provided **OR** fax it to the number provided **before 11th November 2007.**

All your effort and co-operation are highly appreciated and thanked most.

Yours sincerely,

(ZAHARA YAAKOP)
Civil Engineering Student,
Universiti Teknologi Petronas.

Endorsed by Final Year Project Supervisor

(Mr. Mohamed Mubarak Abdul Wahab)
Lecturer,
Civil Engineering Department,
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**Survey on application of pre-cast and pre-stressed concrete structures in Malaysia**

Currently, construction industry in Malaysia which highly depends on cast in-situ concrete structures faces many problems, such as poor workmanship and low quality of end product, delays in completion of works, difficulty in getting workers within the country, abundant numbers of foreign labors whom related to many social issues and so on. Therefore, pre-cast and pre-stressed concrete structures are considered as the better alternatives to help to mitigate these problems.

Pre-cast and pre-stressed products are concrete cast in molds under factory setting. These products benefited from superior quality control achievable at production plants. Pre-cast and pre-stressed products range from floor slab, beam, column to bridge girder, structural components, and panels for cladding and so on. They could be widely used for houses, office buildings, schools, hospitals, hotels, bridges, railway slippers and so on. Pre-cast and pre-stressed concrete structures are expected to be economical when the shapes are duplicated several times and are more durable compared to the conventional type.

The purpose of this questionnaire is to collect data from the players of the industry about the current status of pre-cast and pre-stressed concrete structures in Malaysia and to identify the 'industry endorsed obstacles' which prevents the wider usage of pre-cast and pre-stressed concrete structures in Malaysia.

**Part A. Background of the Respondent**

1. What is the name of the organization/company that you are currently working for?

_____

2. What is the age of the organization/company?

☐ < 2 years ☐ 2-5 years ☐ 5-20 years ☐ >20 years

3. What is your position in the organization/company?

_____

4. How long have you been working for the organization/company?

_____

5. What are the main activity/ nature of work of the organization/company?

☐ Consultancy ☐ Government Agency/Regulating Body

☐ Construction ☐ Development

☐ Manufacturing ☐ Others (please specify :.....)

**Part B.** (Please **circle** your answers)

| | Strongly Disagree ← | | | | → Strongly Agree |
|---|---|---|---|---|---|
| **Current situation in the local construction industry** | | | | | |
| 1. Cast in-situ concretes cause delays in construction works due to nature of the works which highly affected by weather conditions since it has been done at outdoors. | 1 | 2 | 3 | 4 | 5 |
| 2. Delays in works would increase the project cost and create disputes among the parties involved. | 1 | 2 | 3 | 4 | 5 |
| 3. Low quality of cast in-situ concrete works in Malaysia is mainly because of the unskilled foreign labors. | 1 | 2 | 3 | 4 | 5 |
| 4. Too many unskilled labors in a workplace cause health and safety issues. | 1 | 2 | 3 | 4 | 5 |
| 5. Too many unskilled labors would make the monitoring, control and supervision more difficult. | 1 | 2 | 3 | 4 | 5 |
| 6. Greater dependency on foreign labors is risky due to the fact that one day they might leave the country and that can cause chaos and insufficiency in labors source therefore increase the manpower cost due to lack of supply. | 1 | 2 | 3 | 4 | 5 |
| 7. Abundant foreign labors can cause social and cultural problems within the country. | 1 | 2 | 3 | 4 | 5 |
| 8. Lack of supervision and the use of unskilled labors can result significant defects to cast in-situ concretes due to excessive vibration, improper handling and implementation of the works. | 1 | 2 | 3 | 4 | 5 |
| 9. Local labors face difficulties in competing for jobs with foreign labors who accepts a meager salary for heavy work loads. | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| 10. Heavy work load, hot weather, stiff competition with foreign labors and meager pay prevents local labors from getting a job in the industry. | 1 | 2 | 3 | 4 | 5 |
| 11. Hiring of foreign workers cause flow of Malaysian currency to foreign countries which will affect the local currency market. | 1 | 2 | 3 | 4 | 5 |
| 12. High number of unskilled foreign workers in Malaysia can cause social problems. | 1 | 2 | 3 | 4 | 5 |
| 13. High number of unskilled foreign workers in Malaysia could cause health problems to the locals due to fact that the countries these workers are coming from are still lack of good hygiene and proper sanitation. | 1 | 2 | 3 | 4 | 5 |
| 14. There are cases in Malaysia where foreign workers were involved in criminal activities such as robberies, rapes, gang fights and so on. | 1 | 2 | 3 | 4 | 5 |
| **Benefits of using pre-cast and pre-stressed concrete structures** | | | | | |
| 1. Pre-cast and pre-stressed construction requires fewer workforces than typical cast in-situ. | 1 | 2 | 3 | 4 | 5 |
| 2. Pre-cast and pre-stressed construction produces better quality end products because of the factory controlled prefabrication processes and easier monitoring and control at site due to lesser number of workers involved and done by skilled workers, mostly. | 1 | 2 | 3 | 4 | 5 |
| 3. Pre-cast and pre-stressed construction works are not much affected by the weather conditions due to the fact that it only involves assembling at site. | 1 | 2 | 3 | 4 | 5 |
| 4. There would be relatively lesser issues of delays due to weather conditions in pre-cast and pre-stressed construction works. | 1 | 2 | 3 | 4 | 5 |
| 5. Construction is fast with pre-cast and pre-stressed concretes as they are factory produced, while site preparations can proceed | 1 | 2 | 3 | 4 | 5 |
| 6. Higher number of local labors is expected to anticipate because of the good conducive work environment, lesser exposure to hot weather, not strenuous physical works, better pay and better technological advancement. | 1 | 2 | 3 | 4 | 5 |
| 7. Pre-cast and pre-stressed construction would enable local labors are fully utilized with fewer number of unskilled foreign labors. | 1 | 2 | 3 | 4 | 5 |
| 8. Pre-cast and pre-stressed construction would benefit local labors by getting the necessary skills and technology of modern day construction method. | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| 9. Establishment of pre-cast and pre-stressed construction facilities would incur high cost initially relatively but in the long run the overall cost would be significantly lesser than the conventional construction method. | 1 | 2 | 3 | 4 | 5 |
| 10. The huge upfront investment made in the pre-cast and pre-stressed industry would be benefited later in term of cheaper overall cost, faster construction works, better quality products and technological advancement achieved by the country. | 1 | 2 | 3 | 4 | 5 |
| **Implementation of pre-cast and pre-stressed construction method** | | | | | |
| 1. Among the ways to commercialize pre-cast and pre-stressed construction method in Malaysia is through advertisement by means of campaign, seminar and so on. | 1 | 2 | 3 | 4 | 5 |
| 2. Other way to commercialize pre-cast and pre-stressed construction method in Malaysia is through education by means of introducing curriculum and courses at tertiary levels. | 1 | 2 | 3 | 4 | 5 |
| 3. Setting up of government policies and provision of proper codes of practice to encourage participation from the industry would enable the pre-cast and pre-stressed construction methods to be commercialized. | 1 | 2 | 3 | 4 | 5 |
| 4. Government through the ministry of work should allocate budget for the research and development of pre-cast and pre-stressed construction methods. | 1 | 2 | 3 | 4 | 5 |

5. In your opinion, who should play the main role in introducing and increasing the expertise and usage of pre-cast and pre-stressed construction methods in Malaysia?

- ☐ The government
- ☐ Consulting Engineers
- ☐ Architects
- ☐ Developers
- ☐ Contractors
- ☐ Others (please specify :_____)
- ☐ Pre-cast and Pre-stressed Product manufacturers

6. Based on your answer in question 5, why do you think should they?

_____

_____

_____

7. Have your company ever/been involved in any form of pre-cast or pre-stressed constructions or designs or structures?

☐ Yes (if you tick this, please proceed to the question no 8 & 9)

☐ No

8. Based on your answer in question 7, what was the motivation/reason(s) for your organization/company to do so?

_____

_____

_____

9. Based on your answer in question 7, what was/is the outcome from that involvement?

_____

_____

_____

**Thank you for completing this questionnaire.**

Kindly please **return this questionnaire by** 11th November **2007 by mail via the provided stamped and self addressed envelope OR fax it to 05-365 6716 (Attn: Mr. Mohamed Mubarak Abdul Wahab** [final year project supervisor] **)**

Yours sincerely,

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(ZAHARA YAAKOP)
Civil Engineering Student.
Universiti Teknologi Petronas.

Endorsed by Final Year Project Supervisor

.....

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