# Industrialized Building System (IBS): Applicability of Industrialized Floor Systems in Malaysia

by

Nurhidayah Abd Rahman
5567

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**Universiti Teknologi PETRONAS**
**Bandar Seri Iskandar**
**31750 Tronoh**
**Perak Darul Ridzuan**

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Civil Engineering Programme
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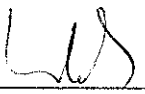
Approved by,



(AP IR DR. Arazi bin Idrus)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2008

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## CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NURHIDAYAH ABD RAHMAN

## ABSTRACT

This report basically discusses the preliminary research done on Industrialized Building System (IBS): Applicability of Industrialized Floor Systems in Malaysia. Industrialized Building System (IBS) may be defined as building systems in which structural components are manufactured in a factory, or on site, transported and assembled into a structure with minimal additional site works. The factors which contribute to the low of usage of IBS are lack of market share, lack of knowledge and lack of marketing. The objective of the project is to study IBS, explore IBS and to develop a chart which will summarize the applicability of different types of floor systems with respect to the span. To accomplish the objectives above, structured and well-planed methodology has been done. This is accomplished by referring to books, articles, journals and previous publications. Surveys and interviews have been conducted to know the level of application of IBS in the building construction industry in Malaysia. There are 7 types of precast floor systems currently available in Malaysia which are Hollow Core Slabs, Prestressed Solid Planks, M-Beam Floors, Double Tee Slabs, Composite Planks, Beam and Block Floors and Bubble Floors. Based on the data retrieved, 5 of these floor systems have been applied in Malaysia's construction industry. The floor systems that has never been applied are Beam and Block Floors and Bubble Floors. An applicability chart of floor system with regard to span was produced as the outcome of this study.

Malaysia is not far behind in the IBS industry and with more exposure in the future IBS components would be used more in developments.

**ACKNOWLEDGEMENT**

First and foremost, I would like to express my deepest gratitude to my supervisor, A.P. I.R. Dr. Arazi bin Idrus, for his continuous support, guidance, encouragement and concern throughout the whole process of making this thesis possible.

Heartfelt gratitude is also dedicated to my tutor, Mr. Christiono and all of my course mates, who never hesitated to help when I needed them. Without their guidance and valuable information, this thesis would not be completed in time.

Last but not least, thanks to all the companies involved in the survey process. Thanks also to persons interviewed for useful feedbacks. Without their reponds, there would be no data for me to analysis in order to produce results. Therefore, I would like to thank whoever that was involved in this project.

**NURHIDAYAH ABD RAHMAN**
**BACHELOR IN CIVIL ENGINEERING**
**UNIVERSITY OF TECHNOLOGY PETRONAS**

**JANUARY 2008**

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# CHAPTER 1
# INTRODUCTION

## 1.1 Background of Study

The Industrialized Building Systems (IBS) is a construction process that utilizes techniques, products, components, or building systems which involve prefabricated components and on-site installation. The most crucial part of a building is the floors. There are seven IBS floor systems identified which are being used in Malaysia, which are as follows:

i. Hollow Core Slabs
ii. Prestressed Solid Planks
iii. M-Beams Floors
iv. Double Tee Slabs
v. Half Slabs / Composite Planks
vi. Bubble Floors / Bubble Deck
vii. Beam and Block Floors

The use of IBS assures valuable advantages such as the reduction of unskilled workers, less wastage, less volume of building materials, increased environmental and construction site cleanliness and better quality control, among others. These advantages also promote a safer and more organized construction site, and reduce the completion time of construction.

Unfortunately, the usage of IBS in Malaysia is still quite low. Only world-class Malaysian developers have chosen IBS over the conventional methods for important projects such as the Kuala Lumpur City Centre (KLCC), Putrajaya, Kuala Lumpur Sentral Railway Station, Kuala Lumpur International Airport (KLIA), Mid Valley

Megamall, Lumut Port Jetty, Bukit Jalil Hockey Stadium and Hospital Universiti Kebangsaan Malaysia (*HUKM*).

Among the components of constructing a building, floor is the most tedious component to construct as well as time consuming and expensive if it is to be constructed in situ. If the floor construction can be made more efficient by IBS, the overall building time of construction and cost can be reduced. The outcome of this research is a chart on applicability of types of floor systems with regard to their applications.

## 1.2 Problem Statements

There are a few factors which contribute to the lack of usage of IBS, which are as follows:

a. Low market share

   Despite being developed for many years, the market share for Industrialized Building Systems (IBS) particularly the floor systems is still small, approximately 15% of the total market share in Malaysia.

b. Lack of knowledge on the structural mechanics of precast construction

   There are not many publications or guidelines on IBS available so the idea of constructing a building using precast components are unfamiliar to the developers.

c. Lack of manufacturing capacity

   Prefabrication factories are not cheap to run. In some instances, it is certainly economical to establish a prefabrication facility on site, or in adjacent field, and work from there.

It is important how to get better understanding about the industrialized floor systems available in Malaysia, to know how much the IBS has been implemented in Malaysia and the suitability of different floor system for different application, and develops the chart that would be produced based on the survey and interview result.

With the comparison of different types of floor system with regard to the application in the form of a chart, it is hoped that engineers and developers would be encourage to use more IBS components in their developments.

## 1.3 Objectives

Mainly there are three objectives to be achieved at the end of this project, which are as follows:

1. To study the awareness of the construction industry on IBS in Malaysia.
2. To study the types of floor systems available in Malaysia.
3. To develop an applicability chart based on the survey and interviews

## 1.4 Scope of Study

This research would be aimed at building projects in Malaysia, mainly focusing on floor systems. Floor construction is the most critical part of constructing a building. Therefore, the usage of IBS would really reduce the time frame needed to construct floors and furthermore reduce the cost of the construction. Using the IBS would also produce better quality of floors.

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 General Theory

The construction and housing industry is often regarded as the least efficient and productive sector compared to the other sectors in the country. Its image is one of labor-intensive, delays and an overhang in projects. Nevertheless, the construction sector remains a significant contributor to the sustainable growth of the national economy. The construction industry transcends all industries and serves to provide the vital infrastructure support for mining, manufacturing, agriculture, transport and support utilities and services such as health, education and tourism. Though the industry is as old as the country, there has been little by way of improvements particularly in terms of technology application and in the quality of construction.

Recently, the industry received a major blow due to the repatriation of illegal foreign workers imposed by the government. The current situation shows that the construction industry depends heavily on foreign workers and therefore the industry players must move away from the conventional labor intensive method to a more technology based mode of construction. The way forward for the construction industry would be towards industrialization, that is, by implementing the Industrialized Building System (IBS). With industrialization, components of a building shall be made off-site and manufactured in a factory and brought into site to be assembled.

Industrialized Building System (IBS) 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.

## 2.2 Advantages and Disadvantages of Industrialized Building Systems (IBS)

The quality, speed of construction, and cost saving are the main emphases given in the building construction industry in Malaysia. These factors are very important ones from the points of view of the Seventh Malaysia Plan in terms of the very large number of buildings envisaged. The savings in labor cost and the savings in material cost are also the major advantages of the Malaysian's IBS. The control in using materials, such as steel, sand, and timber, will result in substantial savings on the overall cost of the project.

The IBS construction activities are highly capital intensive. This is the main disadvantage of the IBS. The heavily mechanized approach has displeased a substantial number of the labor force from the building construction industry. In some IBS there is a tremendous need for expert labor at the construction site. Therefore, extra costs are needed to train the semiskilled labor force for highly skilled jobs.

The main reasons for delay in early completion of projects in IBS construction industry are supply delay, bad weather, and shortage of raw material. In some cases, the main reason for the delay was the lack of labor experience. This is because certain types of IBS construction are still new in Malaysia and the labor force is still not familiar with the special erection procedure required by those systems.

Almost all the IBS in Malaysia are suitable for all number of stories, especially for three to five-storey buildings. At the same time, all the IBS in Malaysia are very much suitable for all classes of construction from the unit cost point of view, which are arranged from low-cost house class to high-cost house class.

Table 2.1: Main Features of Manufacturing vs. Construction Method.

| Manufacturing | Conventional |
|---|---|
| • All the work performed at one permanent location. | • Work dispersed among many temporary location |
| • Short to medium service life span of a typical product. | • Long service life of a particular product. |
| • High degree of repetition and standardization. | • Small extent of standardization; each project has distinctive features. |
| • Small number of simplified task necessary to produce a typical product. | • Large number of task requiring a high degree of manual skill necessary to complete a typical construction project |
| • All tasks performed at static workstations | • Each task performed over a large work area with workers moving one place to another |
| • Workplace carefully adjusted to human needs | • Rugged and harsh work environment |
| • Comparatively stable workforce | • High turnover workers |
| • Unified decision-making authority for deign, production and marketing | • Authority divided among sponsor, designers, local government, contractor and subcontractor. |

Figure 2.1: Condition of Conventional Method Construction Site

Figure 2.2: Condition of Precast Construction Site

## 2.3 IBS in Malaysia

IBS Modular (2007) highlighted that 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.

Figure 2.3: Pekeliling Flats Kuala Lumpur


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. IBS Modular (2007) listed these mega projects as projects that used IBS in their construction:

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. In a study conducted by IBS Modular it was reported that 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. The government also needs to put forward regulatory requirements and incentives. An example is the mandatory requirement of 50% usage of IBS in government building projects to qualify them for the CIDB levy exemption. By using a superior construction technology that requires highly skilled workers, the dependence on foreign workers would significantly.

## 2.4 Industrialized Floor Systems in Malaysia

### 2.4.1 Current and Established Systems

According to a catalogue of precast concrete components by CIDB (CIDB Malaysia, 2004) they identified that there are seven generic types of floor systems currently available in Malaysia namely, the hollowcore, lattice girder permanent formwork, ribbed, solid planks, waffle, Autoclaved Aerated Concrete (AAC) and steel decking floors. Currently, there are at least 10 manufacturers producing structural floor systems in Malaysia (CIDB, 2004).

In Malaysia, hollowcore slabs have trade names depending on the product origin such as 'Variax' or 'Acotec'(Finnish), 'Spiroll', 'Humes' or 'Quickflor'(Australian). Among the companies that produce these floors are Eastern Pretech (M) Sdn Bhd, Humes Industries (M) Sdn Bhd and Sunway Precast (M) Sdn Bhd. Lattice girder floors are mainly produced by Associated Concrete Products (M) Bhd under the trade name "Z series half-slab", Humes Industries (M) Bhd (trade-named "half-slab") and Eastern Pretech Sdn

Bhd. As for ribbed floors, the double tees are manufactured by ACPi, Sunway Precast and Eastern Pretech (M) Sdn Bhd while Humes Industries (M) Bhd produces M-Beam floors (Figure 2.5). As for solid planks, ACPi has their version which is PCF Slab "X" Series (Figure 2.6), Setia Precast Sdn Bhd "PC Slab" (Figure 2.7) and "Pretech" Variax Precast Plank (Figure 2.8) by Eastern Pretech Sdn Bhd. AAC and steel decking is respectively produced by CSR Sdn Bhd and Lysaght (M) Sdn Bhd.

### 2.4.2 New and Emerging Systems

In Malaysia, there were not many new and emerging floor systems entering the market or being developed locally in the last fifteen years or so. In fact, the revival towards industrialized construction has only begun recently with the formulation of the IBS Road Map 2003-2010 by the (CIDB, 2003) and the promotional campaigns and incentives that follow. Nevertheless, this study has identified at least three home-grown, new and emerging, floor systems as follows:

1. JKR lattice girder sandwich panel floor

The development of the Public Service Department (JKR) lattice girder sandwish panel floor in 1996 was one of the earliest attempts by the Malaysian government to introduce and promote an open and industrialized system in construction (Arazi, 1995). The floor system is made up of two lattice girder slabs sandwiched together face to face on site in conjunction with a double-wall system utilizing the same configuration (Figure 2.9). The system had been used in a pilot project involving the construction of walk-up apartments for school teachers in the state of Melaka.

2. AAC semi-precast ferrocement composite floor

The AAC lightweight semi-precast ferrocement composite floor (Thanoon et. al, 2007) developed by researchers at the Universiti Putra Malaysia and Petronas University of Technology is a very promising floor system. It comprises of a 3000mm x 1000mm x 130mm precast inverted ribbed ferrocement formwork plank and AAC blocks (Figure

2.10) slotted into position in between the ribs. The top of the ribs are then topped with in-situ concrete to interlock the AAC blocks. Tests conducted on the prototype slab shows comparable structural performance with normal ferrocement formwork.

3. OPS light-weight precast solid plank

In another on-going research University of Malaysia, Sabah, a new light-weight precast solid plank system is being developed utilizing broken oil palm shells (OPS) as partial replacement for normal aggregates to reduce weight (Ng CH, 2007). A series of experiments conducted on 3100mm x 1000mm x 135mm specimen indicated the floor system showed comparable performance with normal precast concrete including at handling, while providing some 20% in weight reduction.

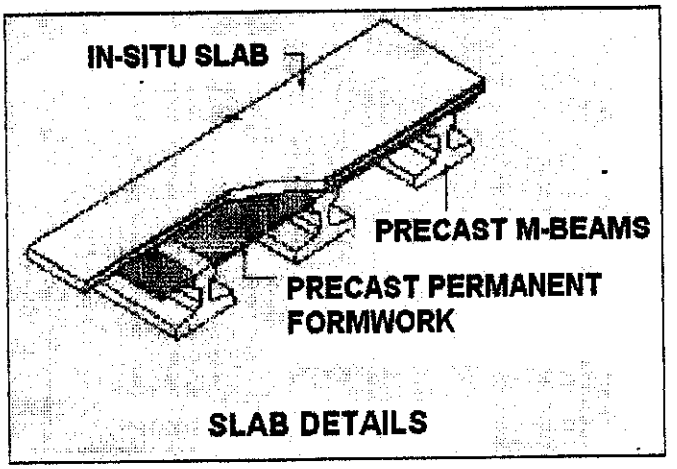



Figure 2.4: M-Beam floor system by Humes (Category: Currently Available)

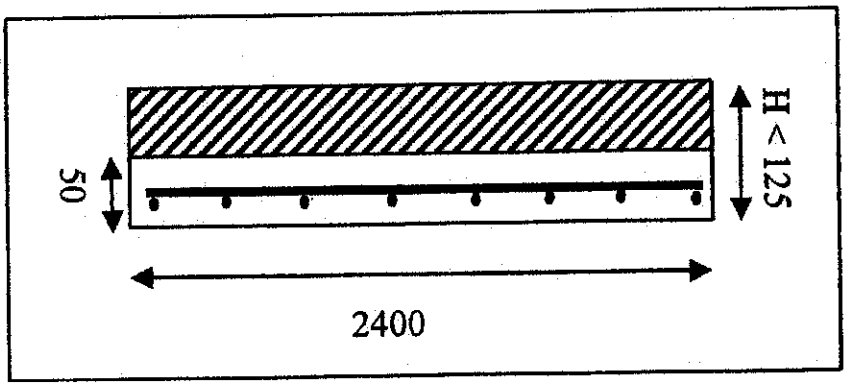



Figure 2.5: PCF Half Slab by ACPi (Category: Currently Available)

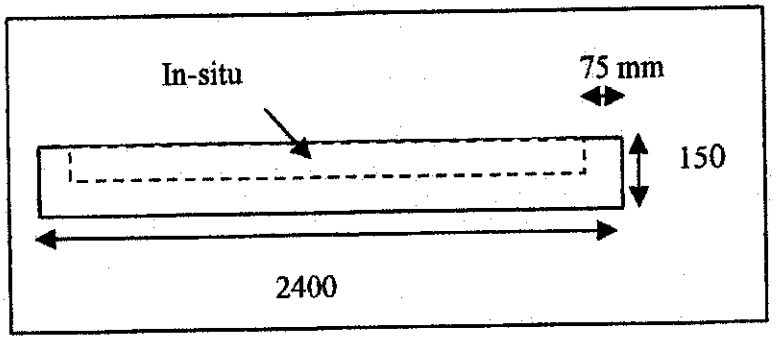



Figure 2.6: Slab Floor by Setia Precast (Category: Currently Available)

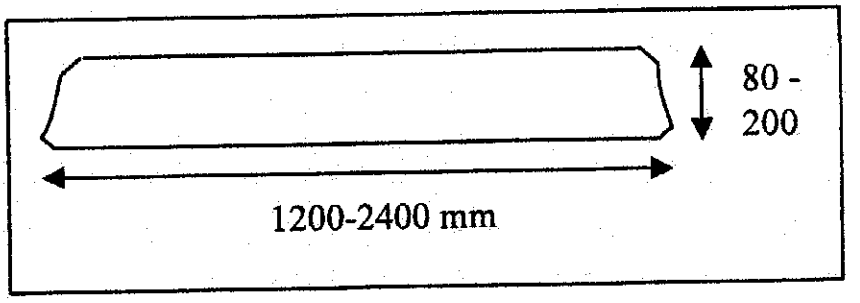



Figure 2.7: Variax Solid Plank by Eastern Pretech (Category: Currently Available)

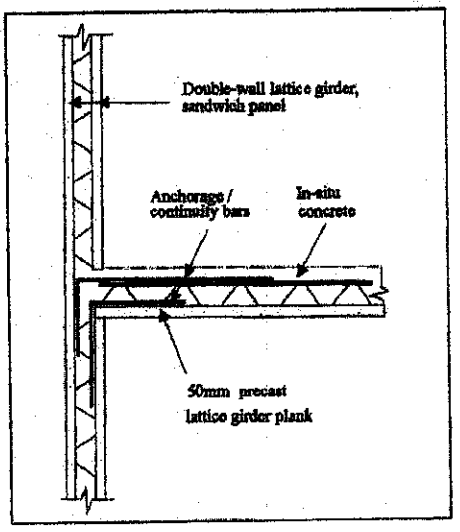



Figure 2.8: JKR Lattice Girder Sandwich Panel (Category: New and emerging)

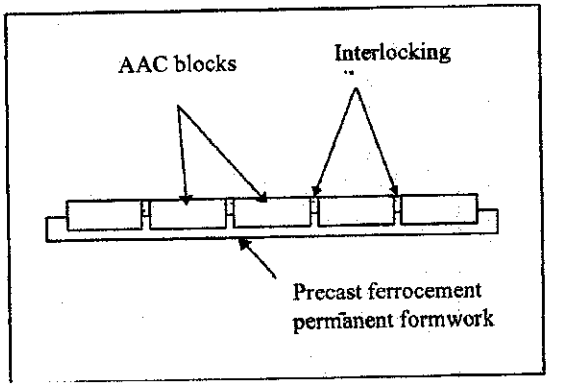



Figure 2.9: AAC Semi Precast Ferrocement Composite Floor (Category: New and emerging)

# CHAPTER 3
# METHODOLOGY

## 3.1 Research Methodology

This study is conducted using the survey-based methodology by which the information is collected directly from the people who are considered specialized in the subject of study.

The major processes included identifying problems, establish aim and objectives, literature review, pilot survey, data collection and sampling, data analysis, result interpretation and conclusion as shown in Figure 3.2 (page 19). The survey method was simple to manage and data is reliable. Besides, the analysis and interpretation of data are relatively simple.

### 3.1.1 Survey Design

The survey had been designed based on the population sampling, sampling method and the respondents using non-probability sampling. The population sampling was mainly IBS contractor and IBS manufacturer as well as consultancy companies in peninsular Malaysia.

50 of the respondents was selected from the List of Registered IBS Contractor/Manufaturer (CIDB, 2007). The respondents designation was focused to the Project Manager, Construction Manager and others.

After the survey questionnaire undergo several refinements on its questions and its ability to reveal the objective of this research, a pilot survey will be carried out first before the questionnaire is posted to the respondents. The reasons for carrying out pilot survey are as follows:

- To ensure that the questions asked are enough to reveal the objective of the research.
- To ensure that the questions asked are relevant to the research.
- To ensure that questions are clear enough to understand.

The pilot survey was carried out and several comments regarding the questionnaire were received. They were as follows:

i. Simplify the questions as some of the questions are hard to interpret.

ii. Need to put more description.

iii. To insert questions on the applicability of types floor systems with regard to their span.

### 3.2 Research Tools

The main tools used in this study consist of:

- Questionnaire for data collection
- Statistical tools for data analyzing

### 3.3 Data Collection

The data collection is divided into two types, primary and secondary data collection. Primary data collection focuses on the survey process and secondary data collection focuses on the study of published literature.

### 3.3.1 Primary Data Collection

The primary data collection uses two methods, which are discussed as follows:

a. Questionnaire

The questionnaires were designed to determine the awareness, the perception and the level of implementation of Floor Systems (IBS) within the construction industry in peninsular Malaysia. The questionnaires were sent through mail with return envelopes and were directly distributed to the selected companies.

Generally, there are two types of questions that could be used in designing survey questionnaire; open-ended and close-ended question. The open-ended question will be particularly used as the ice breaking question and when respondents' own words are important or there are no definite answers for the question. In contrast to open-ended questions, closed-ended questions require respondent to choose from a limited number of responses predetermined by the researcher. The questions provide primarily quantitative data, and are frequently used in confirmatory research.

In designing the questionnaire, both types of question are used. But in determining the objective of this research, close-ended question is widely used as it could provide the answer in a scale format. It is also easier to carry out analysis of the outcome from close-ended question rather than open-ended question.

The survey questionnaire for this research is designed to reveal the objective of this research. It is divided into 4 sections; Section A, B, C and D.

Table 3.1 Sections of Questionnaires

| Section of Questionnaire | Description |
|---|---|
| A. General / Background Information | Contains open-ended questions on company and respondent's background such as name, designation, type of company and years of involvement in the construction industry. |
| B. Level of Awareness and Implementation of Industrialized Building System (IBS) | 7 questions asking respondent's familiarity and awareness with IBS. |
| C. Applicability of Floor Systems | Close-ended questions regarding the application of floor systems in Malaysia. There is also a section asking the respondent's to determine the span of each floor system mentioned. |
| D. Other Information | A section where respondents could add further information or comments regarding the subject matter. |
| E. Feedback | A question whether the respondent is willing to be contacted for further information or not. |

*(Please refer to Appendix B for sample of Survey Questionnaire)*

b. Interview

Face to face interview session was also conducted with respective companies, most of the developers. The objective of the interview is the same is the survey, which is to determine the awareness, the perception and the level of implementation of Floor Systems (IBS) within the construction industry in peninsular Malaysia.

The purpose of the interview is to check the validity of the questionnaires.

### 3.3.2 Secondary Data Collection

Secondary data collection was done by using literature review. The main sources are journals, books, and other relevant sources. The data provides an overview of the related research which has been done before and gives information in designing better questionnaires.

## 3.4 Data Analysis

Statistical analysis was used to analyze data extracted from the completed questionnaires and interviews. The purpose of data analysis was to summarize data gathered from the survey and to compare the outcomes which suit the objectives and scope of study. The result will be presented in tables, graphs and charts for simple understanding.

### 3.4.1 Applicability Chart

An applicability chart will be produced as an outcome of this survey. This chart will act as a rough guide for engineers in designing good structure, economical and practical floor systems for their buildings.

An example of an Applicability Chart (Idrus A.B, 2001) is shown below. From the chart, it can be observed that opinions as to range of span applicability for each floor system differ in the literature, and that even for a given span, there exist a wide range of suitable candidate floor systems.

Figure 3.1: Applicability Chart of Floor Systems in Europe in 2001

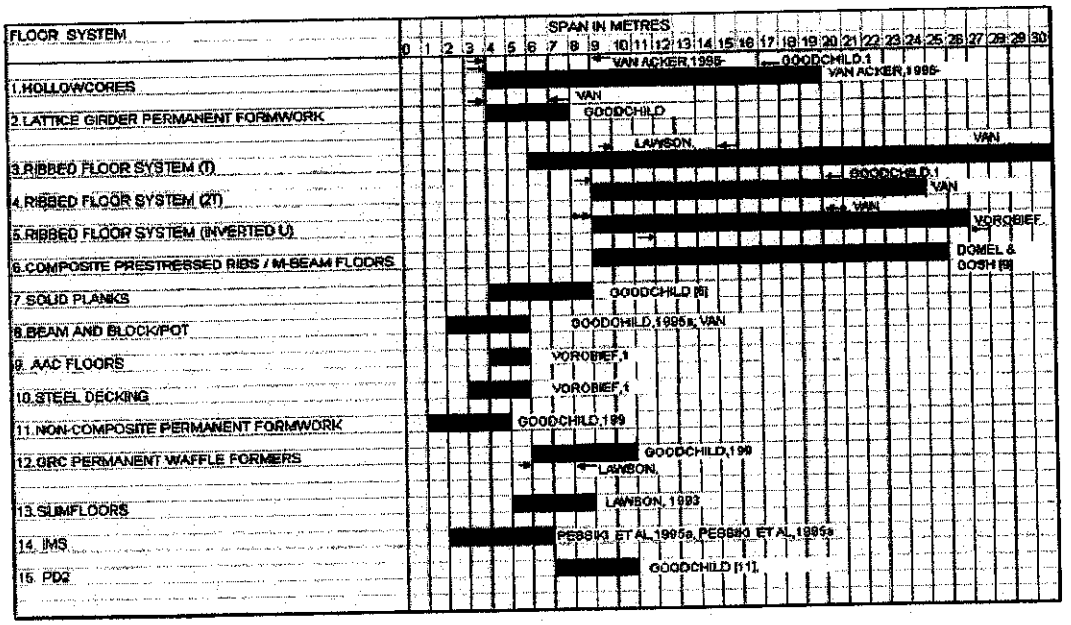
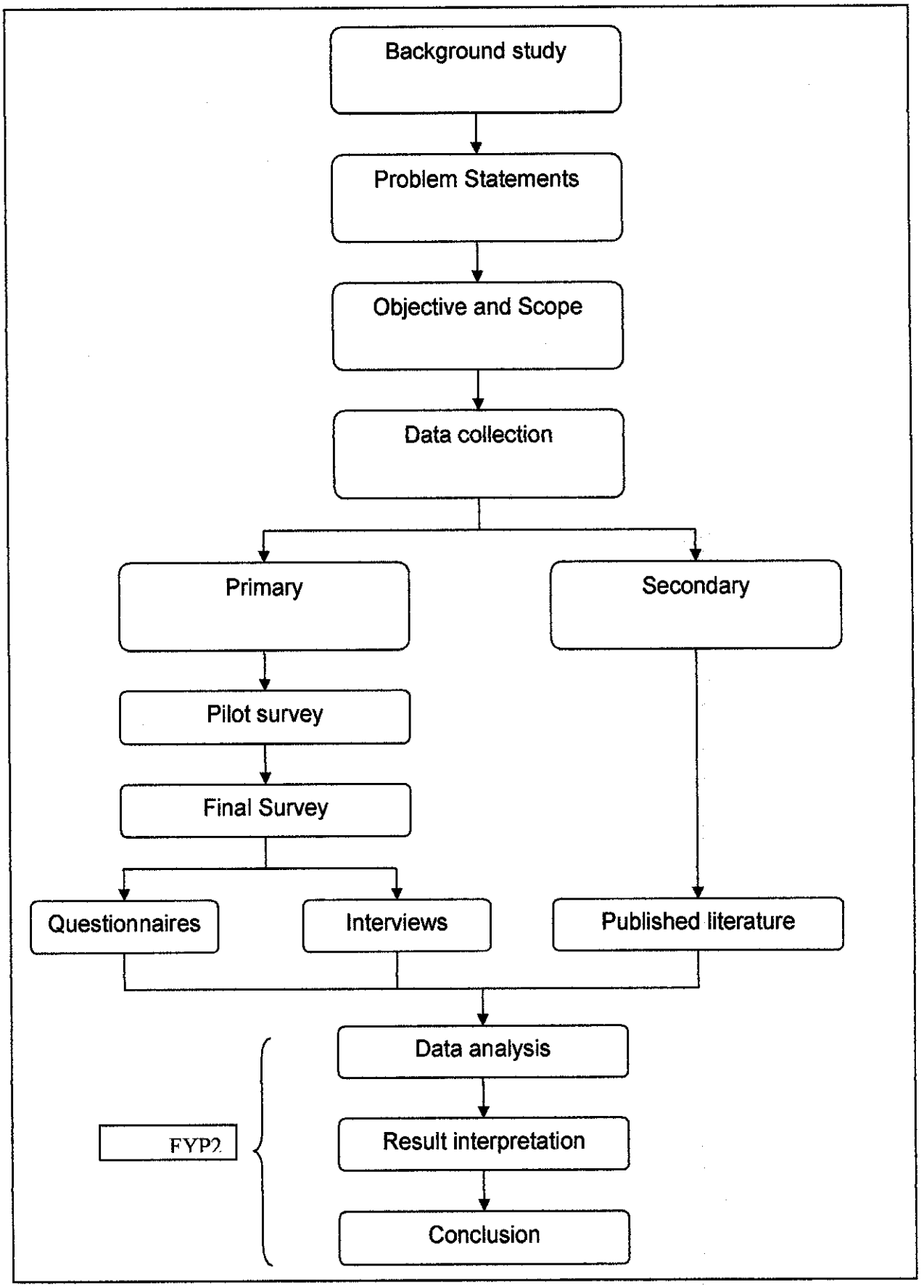



Figure 3.2: Project Flowchart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Pilot survey
Final Survey
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Interviews
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Data analysis
FYP2
Result interpretation
Conclusion

# CHAPTER 4
# RESULT AND DISCUSSION

## 4.1 Method of Analysis

The data obtained were analyzed by using a descriptive statistical analysis, which presents data in tabular and figure form such as tables, charts and graphs. This method was chosen because the analysis is simple and the data will be well presented and easy to understand.

## 4.2 Data Retrieval

As of 26th March 2008, 34 replies have been received out of 100 questionnaires sent. These were obtained through postal questionnaires and interviews. The population is Malaysia, but mainly focusing on Peninsular Malaysia.

There are four parts in the questionnaire, which will be discussed separately in this chapter.

### 4.2.1 Section A: General/Background Information

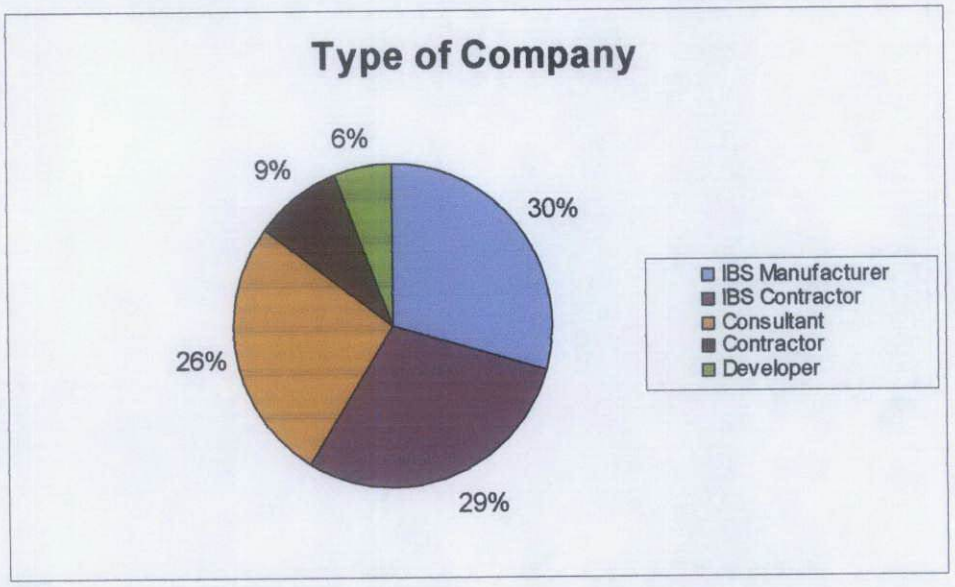
#### 4.2.1.1 Type of Company

The tabulation of the type of company is shown in the Table 4.1 and the percentage of respondents based on type of company is shown in Figure 4.1. The highest number of response was retrieved from IBS manufacturer and IBS contractor, which occurred because they have the most knowledge on IBS compared to the others. Therefore, most of the responses are valid.

Table 4.1: Number of Respondents Based on Type of Company

| No. | Type of Company | Number of Respondents |
|---|---|---|
| 1 | IBS Manufacturer | 10 |
| 2 | IBS Contractor | 10 |
| 3 | Consultant | 9 |
| 4 | Contractor | 3 |
| 5 | Developer | 2 |
| | Total | 34 |

Figure 4.1: Percentage of Respondents Based on Type of Company



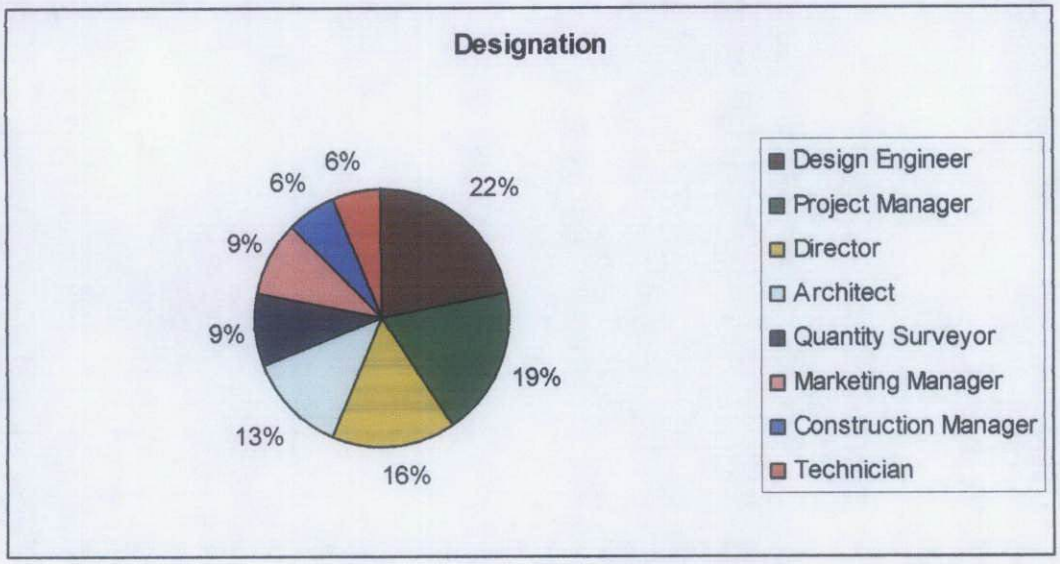

#### 4.2.1.2 Designation of Respondents

There are a variety of designations of the respondents; ranging from the Director to Technician. T he highest number of respondents came from the Design Engineer category. This makes the survey results valid as design engineers probably has the most knowledge on the subject matter compared to the other designations.

Table 4.2: Number of Respondents Based on Designation

| No. | Designation | Number of Respondents |
|---|---|---|
| 1 | Design Engineer | 7 |
| 2 | Project Manager | 6 |
| 3 | Director | 5 |
| 4 | Architect | 4 |
| 5 | Quantity Surveyor | 3 |
| 6 | Marketing Manager | 3 |
| 7 | Construction Manager | 2 |
| 8 | Contract Manager | 2 |
| 9 | Technician | 2 |
| | Total | 34 |

Figure 4.2: Percentage of Respondents Based on Designation



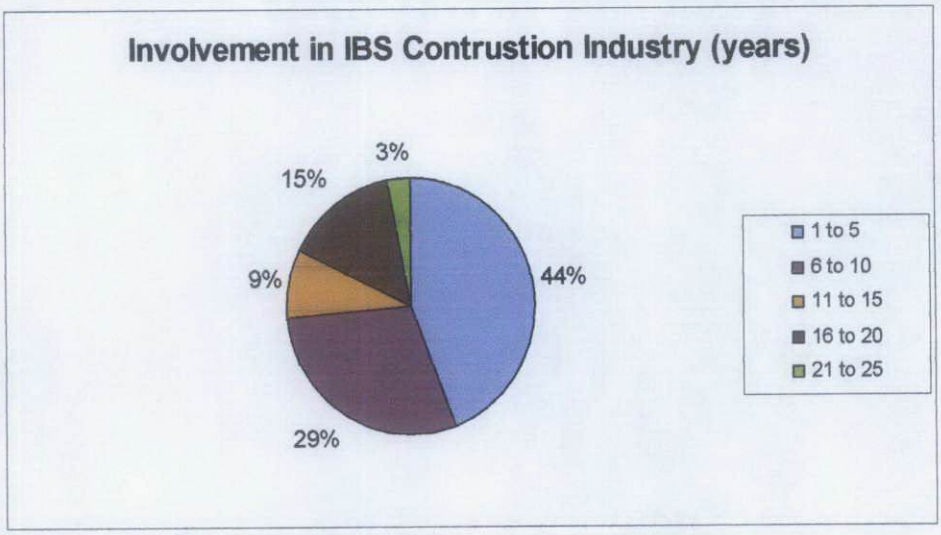

#### 4.2.1.3 Involvement of Respondents in IBS Construction Industry

Majority of the respondents have 1 to 5 years involvement in IBS construction industry. However, 73% of the respondents have at least one to ten years of experience in the IBS construction industry. This shows that IBS are not new in Malaysia.

Table 4.3: Involvement of Respondents in IBS Construction Industry

| No. | Involvement in IBS Construction Industry (years) | Number of Respondents |
|---|---|---|
| 1 | 1 to 5 | 15 |
| 2 | 6 to 10 | 10 |
| 3 | 11 to 15 | 3 |
| 4 | 16 to 20 | 5 |
| 5 | 21 to 25 | 1 |
| | Total | 34 |

Figure 4.3: Percentage of Involvement of Respondents in IBS Construction Industry




### 4.2.2 Section B: Level of Knowledge and Awareness of Industrialized Building (Floor) System

This section of the survey was calculated using Severity Index (Al-Hammad, 2000) to neglect the level of the severity effect of applicability of floor systems (IBS). The index formula is as follows:

$$\text{Severity Index (I)} = [\,(\sum_{i=0}^{4} \mathbf{ai} \,.\, \mathbf{xi}\,) / (\,4 \sum \mathbf{xi}\,)\,] \times 100\%$$

where:

**ai** = constant expressing the weight given to i

**xi** = the variable expressing the frequency of i, the response for i = 0, 1, 2, 3, 4 and illustrated as follows:

**x**0 = frequency of "very low" response and correspondence to **a**4 = 0

**x**1 = frequency of "low" response and correspondence to **a**3 = 1

**x**2 = frequency of "average" response and correspondence to **a**2 = 2

**x**3 = frequency of "high" response and correspondence to **a**1 = 3

**x**4 = frequency of "very high" response and correspondence to **a**0 = 4

The Severity Index of 0 to 20% is categorized as "non-severe", 20% - 40% "somewhat non-severe", 40% - 60% "moderately severe", 60% - 80% "severe" and 80% to 100% "most severe" to reflect the scale of the answer of the respondents to the questionnaire.

A bar chart showing the Severity Index is shown in Figure 4.4 and the ranking based on the index is shown in Table 4.5. Majority of the respondents agreed that IBS reduces the number of manpower at site as only the process of installation of precast components would be implemented at site.

There are three descriptions that falls under the "Average" category, which are:

- IBS reduces speed of construction
- IBS application in respondent's projects
- IBS has been implemented widely in Malaysia's construction industry

The Malaysia's construction industry definitely has to improve in these three areas in order to increase the level of application of IBS. From the interviews conducted, most respondents mentioned that the major problems are storage and transportation utilities.

Precast components especially floor systems need a large amount of space for storage as they could span out up to 30 meters long. And this will make transportation for these components difficult, as faced by Bena Block Sdn. Bhd. which resides in a remote area in Sarawak.

These two setbacks will have an addition to the cost of the project. An excellent project is one that is completed on time with the best quality using the most economical cost. In Malaysia, the storage, transportation, factories and many other utilities are still at minimum. Therefore, small number of implementation of IBS, especially floor systems is relatively low.

Table 4.4: Calculation of Severity Index

| No. | Description | Very Low | Low | Average | High | Very High | Total | Mean | Category (Based on Abd Madjid and McCaffer, 1996) | Severity index for ranking (%) based on Abdulmohsen al hammad and sadi assaf, 1996 | Ranking |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Knowledge on IBS | 1 | 2 | 14 | 16 | 1 | 34 | 2.41176 | High | 60.29411765 | 3 |
| 2 | IBS produce better quality of buildings | 0 | 0 | 8 | 19 | 7 | 34 | 2.97059 | High | 74.26470588 | 2 |
| 3 | IBS reduces speed of construction | 9 | 5 | 5 | 8 | 7 | 34 | 1.97059 | Average | 49.26470588 | 5 |
| 4 | IBS reduces the number of manpower at site | 0 | 1 | 2 | 19 | 12 | 34 | 3.23529 | Very high | 80.88235294 | 1 |
| 5 | Clients can achieve better value for money if IBS is implemented | 0 | 4 | 15 | 13 | 2 | 34 | 2.38235 | High | 59.55882353 | 4 |
| 6 | IBS has been implemented widely in Malaysia's construction industry | 6 | 16 | 12 | 0 | 0 | 34 | 1.17647 | Average | 29.41176471 | 7 |
| 7 | IBS application in your projects | 7 | 8 | 8 | 6 | 5 | 34 | 1.82353 | Average | 45.58823529 | 6 |
| | Total | 23 | 36 | 64 | 81 | 34 | | | | | |
| | | 0 | 1 | 2 | 3 | 4 | | | | | |
| | Mean | 3.28571 | 5.14286 | 9.14286 | 11.5714 | 4.85714 | | | | | |
| | Variance | 15.2381 | 30.1429 | 22.8095 | 51.619 | 17.8095 | | | | | |

Figure 4.4: Level of Awareness of IBS (Floor) System

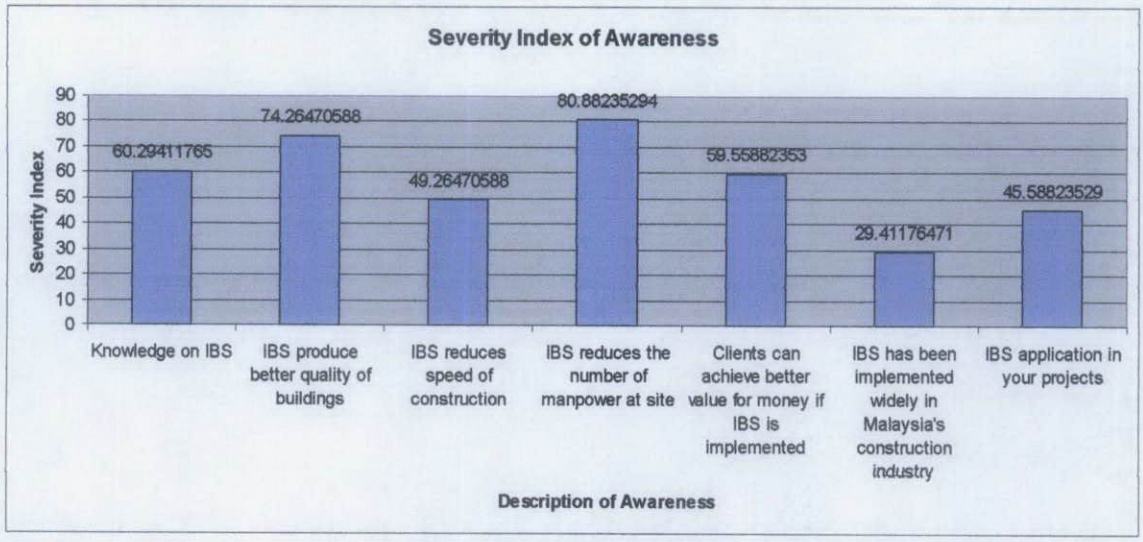



Table 4.5: Ranking on Level of Awareness based on Severity Index

| Ranking based on Severity Index | Description on Awareness | Category (Based on Abd Madjid and McCaffer, 1996) |
|---|---|---|
| 1 | IBS reduces the number of manpower at site | Very High |
| 2 | IBS produce better quality of buildings | High |
| 3 | Knowledge on IBS | High |
| 4 | Clients can achieve better value for money if IBS is implemented | High |
| 5 | IBS reduces speed of construction | Average |
| 6 | IBS applications in respondent's projects | Average |
| 7 | IBS has been implemented widely in Malaysia's construction industry | Average |

### 4.2.3 Section C: Applicability of Floor System

#### 4.2.3.1 Level of Application of Floor Systems

The data retrieved was tabulated in the Table 4.6 which shows the mean and variance values of each floor system, which are:

1. Hollow core slabs
2. Prestressed precast solid planks
3. Half slabs / composite planks
4. M-Beam floors
5. Precast double tee slabs
6. Beam and block floors
7. Bubble floors / bubble deck

From the survey, it was shown that five out of the seven floor systems has been applied in Malaysia's construction industry. The two systems which have not been applied and less knowledgeable are beam and block floors and bubble floors / bubble deck.

The floor systems are calculated using scores to determine whether the respondents have no idea of the floor system, have never applied or have applied the floor system in their previous projects. The score was determined by the mean value of each floor system and was categorized as shown in Table 4.7.

A graph showing the ranking of application of floor system in shown in Figure 4.5. the graph shows the score and remarks of each of the floor system.

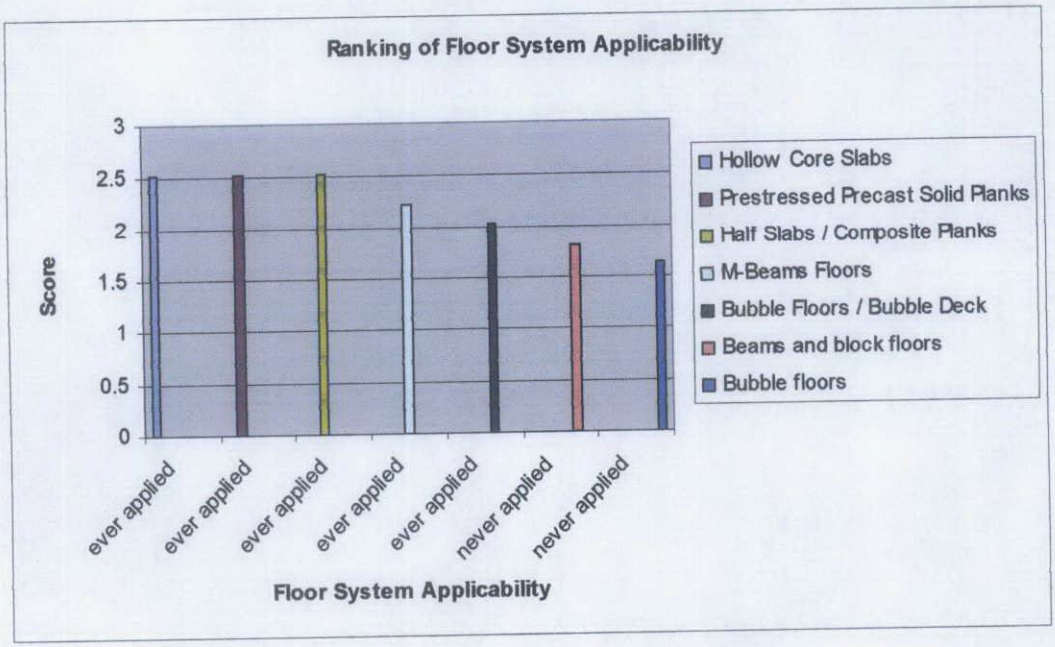
Table 4.6: Data Tabulation of Application of Floor Systems

| No. | Floor Systems | | | | | Total | Mean | Variance | Ranking based on Mean | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 31 | 32 | | | | | |
| 1 | Hollow Core Slabs | 3 | 2 | 2 | 3 | 81 | 2.53125 | 0.386089 | 1 | Ever applied |
| 2 | Prestressed Precast Solid Planks | 3 | 3 | 2 | 3 | 81 | 2.53125 | 0.257056 | 2 | Ever applied |
| 3 | Half Slabs / Composite Planks | 3 | 3 | 3 | 2 | 81 | 2.53125 | 0.386089 | 3 | Ever applied |
| 4 | M-Beams Floors | 3 | 2 | 2 | 2 | 71 | 2.21875 | 0.36996 | 4 | Ever applied |
| 5 | Precast Double Tee Slabs | 3 | 2 | 2 | 1 | 65 | 2.03125 | 0.482863 | 5 | Ever applied |
| 6 | Beams and Block Floors | 2 | 2 | 2 | 1 | 58 | 1.8125 | 0.350806 | 6 | Never applied |
| 7 | Bubble Floors / Bubble Deck | 2 | 1 | 1 | 1 | 52 | 1.625 | 0.370968 | 7 | Never applied |
| | | | | | | 437 | 13.65625 | | | |

Table 4.7: Scoring of Floor System Applicability

| Score | Remarks |
|---|---|
| 0-1 | No Idea |
| 1-2 | Never Applied |
| 2-3 | Ever Applied |

Figure 4.5: Ranking of Floor System Applicability



### 4.2.3.2 Applicability of Floor Systems with Regard to Span

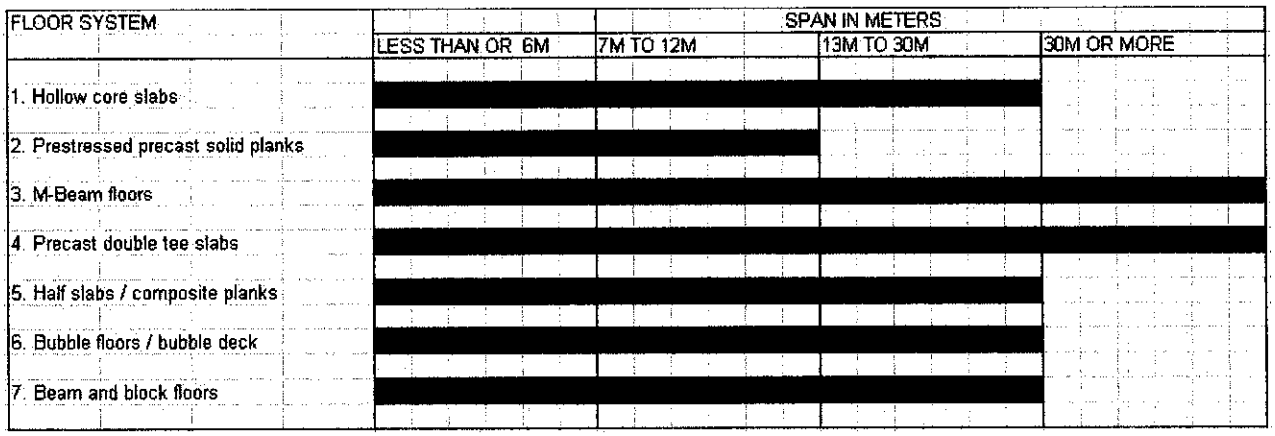
The table below shows the data retrieved on applicability of the floor system with regard to the span (Meter). The popularity of the span is designated by the number of respondents.

Table 4.8: Popularity of Floor System

| NO. | FLOOR SYSTEMS | Span (meter) | | | |
|---|---|---|---|---|---|
| | | <6 | 6 to 12 | 13 to 30 | 30< |
| 1 | Hollow Core Slabs | 6 | 20 | 3 | 0 |
| 2 | Prestressed Precast Solid Planks | 11 | 22 | 0 | 0 |
| 3 | M-Beams Floors | 3 | 7 | 16 | 1 |
| 4 | Precast Double Tee Slabs | 4 | 10 | 6 | 4 |
| 5 | Half Slabs / Composite Planks | 23 | 5 | 2 | 0 |
| 6 | Bubble Floors / Bubble Deck | 5 | 4 | 4 | 0 |
| 7 | Beams and Block Floors | 11 | 5 | 3 | 0 |

The applicability or currently available industrialized floor systems in Europe and Malaysia is summarized in a span "applicability chart" in Figure 4.6 which can help designers in making the choice of floor systems for their building. The chart indicated the range of span for which the floors can be structurally and practically used. It acts as a rough guide only and by no means meant to replace sound judgment of the engineer. There are other affecting factors such as the cost should be incorporated in the study in order to make this chart more accurate.

Figure 4.6: Applicability Chart of Floor System with Regard to Span



### 4.2.4 Section D: Further Information/Comments

Below are some of the further information or comments received from the questionnaires:

1. Although IBS enhances the speed of construction, but the construction cost could be higher due to additional transportation cost, higher due to additional transportation cost, higher capacity of crainage, and more skillful workers. Also, safety can be an issue due to the heavy usage or cranes.

2. He-Con Sdn. Bhd. is specialized in precast wall panel system and in precast component such as staircase. We suggest that the government should enforce the use of IBS system in the building industry. IBS will help to reduce social problems and improve our country cash outflow.

3. The awareness by contractors on the use of IBS floor system needs to be enhanced. Transportation of IBS component to site is a major factor with regards to cost. Most cases in Sarawak in particular, rural projects cannot be excused by crane to carry out IBS installation.

4. In order to materialize IBS, manufacturers must be able to make certain profit from projects. Steel moulds are one of the most costly items; hence moulds must be about to revise it's certain projects (repeat). Secondly, authority must enforce consultant to use IBS in their design.

5. Precast floor system is yet to make an impact to the residential sector and only favorable to commercial building and car park (due to wide span). The residential purchasers', architects' and developers' acceptance of the visual joints between the sectional modular of each components is the negative, hindering the usage of IBS floor system in the residential sector which is a bigger market.

It is obvious that these respondents support the usage of IBS but their vision is hindered by the lack of awareness and knowledge of IBS in Malaysia as well as precast utilities.

# CHAPTER 5
# CONCLUSION AND RECOMMENDATION

It is shown in Figure 4.4: Level of Awareness of IBS (Floor) System that the Malaysia's construction industry is aware of the usage of Industrialized Building System; Floor System in particular. About 81% of the respondents agreed that the IBS reduces the number of man power at site. 60% of the respondents have 'high' knowledge on the subject matter but only 45% of their projects applied IBS. (Table 4.4: Calculation of Severity Index)

Hence, the usage of the Industrialized Floor System is still minimal compared to the United States, European and other Asian countries. This could be due to low market share, lack of knowledge on the structural mechanics of precast construction, lack of manufacturing capacity and many others. It is agreed that IBS components need more technical specialization which the country is lacking of.

This study has been conducted to acquire information with regard to the availability, characteristics, advantages, disadvantages and applicability of industrialized concrete floor systems in Malaysia. Based on the study, the following conclusion can be made:

1. The Malaysia's construction industry is aware of the Industrialized Building System.
2. In Malaysia, at least seven generic types of floor systems are currently available, while at least there are three more emerging.
3. The applicability chart can only act as a rough guideline for design engineers. Further studies on other affecting factors such as the cost and structural components has to be made in order to make the chart more precise.

There are a few improvements should be made for IBS especially floor systems to be applied widely throughout Malaysia, which are:

1. More publications and guidelines on implementation of IBS.
2. Increase the market share in the precast construction industry.

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**APPENDIX A: COVER LETTER**

UNIVERSITI
TEKNOLOGI
PETRONAS

Dear Sir/Madam,

**Research on Industrialized Building System (IBS) in Malaysia: Industrialized Floor Systems.**

We seek your help in a university research survey on the applicability of Industrialized Building (Floor) Systems in Malaysia especially around of Malaysia.

Industrialized Building Systems (IBS) is not new in Malaysia and have been around since the early sixties. However, developments in IBS 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%. There has always been a preference to conventional method of construction because of the cheap foreign labors in our country.

Industrialized Building Systems (IBS) is an alternative approach of construction intended to reduce or eliminate the dependency on labor workers, reduce the volume of building materials, promote cleanliness on-site, and also to achieve better quality in the construction. Industrialized Building Systems (IBS) is the way forward for construction in Malaysia. Therefore, the objectives of this survey are to study the awareness, knowledge and examine the applicability of Industrialized Building System (IBS) focusing on Floor Systems in the local construction industry.

To address the above issues, we have devised a questionnaire which we would like you to complete and return and which will only take no more than 15 minutes of your time. With your cooperation, we should be able to collect as many data as possible regarding the applicability of Industrialized Building System (IBS): Industrialized Floor Systems in Malaysia.

Please contact Ms. Nurhidayah Abd. Rahman, (0196146289 or email hidayahrahman @hotmail.com) if you have any question regarding the survey.

Thank you.

Yours Sincerely,

_____

(Nurhidayah Abd Rahman)
Civil Engineering Department,
Universiti Teknologi PETRONAS

Cc: Assoc. Prof. Ir. Dr. Arazi Idrus

## APPENDIX B: SURVEY QUESTIONNAIRE

# SURVEY QUESTIONNAIRE ON IMPLEMENTATION OF INDUSTRIALIZED BUILDING (FLOOR) SYSTEMS IN MALAYSIA'S CONSTRUCTION INDUSTRY

Building (floor) systems can either be constructed *in-situ* or by industrialized construction. Industrialized building (floor) system have all or some of their components produced at the factory and then transported to site for erection. In order to improve the construction efficiency of such a system, this survey is being conducted firstly to identify the knowledge and awareness on Industrialized Floor System, the existing types of floor systems in Malaysia as well as the span applicability for each of the floor systems.

The questionnaire is divided into 5 sections; Section A, B, C, D and E. Please answer the questionnaire by referring to the instructions given in each section.

**Section A: General / Background Information**
Please answer all the questions and tick [ X ] for your answer.

**I. Company**

i. Name of Company: _____

ii. Type of company:
1. [ ] Consultant
2. [ ] Industrialized Building System (IBS) Manufacturer
3. [ ] Industrialized Building System Contractor
4. [ ] Others (please specify): _____

iii. Company's involvement in IBS construction industry: _____years

**II. Respondent**

i. Your name: _____

ii. Designation:
1. [ ] Project Manager
2. [ ] Construction Manager
3. [ ] Others (please specify): _____

iii. Your involvement in IBS construction industry: _____ years.

**Section B: Level of Knowledge and Awareness of Industrialized Building (Floor) System**

This section is about knowledge and awareness on Industrialized Building (Floor) System. Please indicate your selected answer by circling a number from 1 – 5.

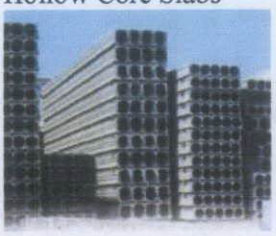
**1 = Very Low  2 = Low  3 = Average  4 = High  5 = Very High**

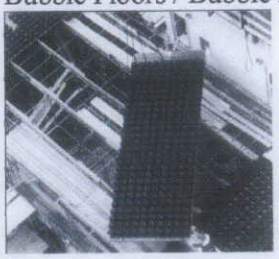
| NO | DESCRIPTION | ASSESSMENT | | | | |
|---|---|---|---|---|---|---|
| 1. | **Knowledge on IBS.**<br>State your satisfactory level to the statement. | 1 | 2 | 3 | 4 | 5 |
| 2. | **IBS produce better quality of buildings.**<br>State your satisfactory level to the statement. | 1 | 2 | 3 | 4 | 5 |
| 3. | **IBS reduces speed of construction.**<br>State your satisfactory level to the statement. | 1 | 2 | 3 | 4 | 5 |
| 4. | **IBS reduces the number of manpower at site.**<br>State your satisfactory level to the statement. | 1 | 2 | 3 | 4 | 5 |
| 5. | **Clients can achieve better value for money if IBS is implemented.**<br>State your satisfactory level to the statement. | 1 | 2 | 3 | 4 | 5 |
| 6. | **IBS has been implemented widely in Malaysia's construction industry.**<br>State your satisfactory level to the statement. | 1 | 2 | 3 | 4 | 5 |
| 7. | **IBS application in your projects.**<br>State your application level to the statement. | 1 | 2 | 3 | 4 | 5 |

**Section C: Applicability of Floor Systems**

1. In this section please indicate level of application of each floor system on your project by circling a number from 1-3

**1 = have no idea about this floor system (NO IDEA)**
**2 = as an alternative system but never applied (NEVER APPLIED)**
**3 = ever applied this floor system (EVER APPLIED)**

| LEVEL OF APPLICATION | | | | |
|---|---|---|---|---|
| NO. | FLOOR SYSTEM | NO IDEA | NEVER APPLIED | EVER APPLIED |
| 1. | Hollow Core Slabs  | 1 | 2 | 3 |
| 2. | Prestressed Precast Solid Planks  | 1 | 2 | 3 |
| 3. | M-Beams Floors  | 1 | 2 | 3 |
| 4. | Precast Double Tee Slabs  | 1 | 2 | 3 |
| 5. | Half Slabs / Composite Planks  | 1 | 2 | 3 |

| | | | | |
|---|---|---|---|---|
| 6. | Bubble Floors / Bubble Deck  | 1 | 2 | 3 |
| 7. | Beam and Block Floors  | 1 | 2 | 3 |
| OTHERS (Please specify) | | 1 | 2 | 3 |
| | | 1 | 2 | 3 |
| | | 1 | 2 | 3 |

2. If you answered NEVER APPLIED or EVER APPLIED for Question 1, please indicate the span applicability for each floor system (beam to beam).

| No. | FLOOR SYSTEM | SPAN (meter) | | | |
|---|---|---|---|---|---|
| 1 | Hollow Core Slabs | <6 | 6-12 | 12-30 | >30 |
| 2 | Prestressed Precast Solid Planks | <6 | 6-12 | 12-30 | >30 |
| 3 | M-Beams Floors | <6 | 6-12 | 12-30 | >30 |
| 4 | Precast Double Tee Slabs | <6 | 6-12 | 12-30 | >30 |
| 5 | Half Slabs / Composite Planks | <6 | 6-12 | 12-30 | >30 |
| 6 | Bubble Floors / Bubble Deck | <6 | 6-12 | 12-30 | >30 |
| 7 | Beam and Block Floors | <6 | 6-12 | 12-30 | >30 |
| 8 | Other | <6 | 6-12 | 12-30 | >30 |
| 9 | Other | <6 | 6-12 | 12-30 | >30 |
| 10 | Other | <6 | 6-12 | 12-30 | >30 |

**Section D: Other Information**

1. Please feel free to add further information regarding the use of industrialized building system, floor systems in particular.

_____

_____

_____

_____

_____

**Section E: Feedback**

1. Would you be willing to be contacted to provide additional information to support this research?
   [ ] Yes, my contact no. is _____.
   [ ] No.

Thank you for your time and cooperation in completing the questionnaire. All responses will be used for research purpose only.

Please find a self-addressed and stamped envelope to return the questionnaire. Or simply fax to 05-3656716.

Thank you.