DYNAMISM AND SUSTAINABILITY THROUGH IBS

A STUDY ON COST COMPARISON BETWEEN IBS AND CONVENTIONAL CONSTRUCTION

CIDB TECHNICAL REPORT
PUBLICATION NO: 182

CIDB MALAYSIA

CREAM

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DYNAMISM AND SUSTAINABILITY THROUGH IBS
A Study on Cost Comparison between IBS and Conventional Construction
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FOREWORD

THE construction sector has been known as a traditional sector that can be characterised as reluctant and even resistant to change. Common perennial problems besieging traditional construction methods are often (i) time delay, (ii) cost overrun, and (iii) waste generation. In this regard, the Government has looked upon the Industrialised Building System (IBS) to catapult the sector into one which is vibrant and cost-effective.

At CIDB, we define IBS as a construction technique whereby building components are manufactured in factories (off-site), prior to be transported and assembled into a structure with limited on-site work.

All-in-all, we deem IBS as possessing six characteristics, all of which are equally important to achieve maximum benefits, notably:

- Industrial production of components though pre-fabrication;
- Highly mechanised in-situ processes, i.e. slip-forms, post-tensioning and tunnel shutters;
- Reduced labour during prefabrication of components and site works;
- Modern design and manufacturing methods, i.e. involvement of computer-aided design (CAD) and computer-aided manufacturing (CAM);
- Systematic Quality Control, i.e. ISO 9000 principles, and
- Open Building Concept, i.e. permitting hybrid applications, adaptable to standardisation and modular coordination (MC).

The benefits of IBS are eminent as it allows for building to be constructed in a shorter time span and with greatly reduced activities at the construction site which in turn provides tremendous cost savings to the builders.

Nonetheless, it has to be acknowledged that there are several barriers in the implementation of IBS in private sector. The challenges include (i) payment method on IBS components, (ii) lack of knowledge, (iii) high investment cost, (iv) concerns on achieving breakeven point, (v) weak level of integration, (vi) design process which is still based on conventional practice, (vii) shortages of skilled worker, and (viii) lack of design standardisation.

Although it has been four decades since the introduction of IBS in Malaysia, the application and adoption of this method in the local construction industry is still low compared to developed countries in the likes of Australia, the US, the UK, and Japan.

In terms of technology, while Malaysia is still using mechanical machines, Japan has advanced to robotics in the production of the components. Despite some setbacks, our reckoning is that those barriers are not insurmountable. Hence the prospects of IBS construction method in Malaysia remains bright and enormous.

Most profoundly, its positive implications on the economy cannot be underestimated. For example, likely savings stemming from IBS implementation in the context of government-mooted projects to help house under-privileged Malaysians would surely reduce development expenditures.

Elsewhere, IBS is also capable of reducing Malaysia's dependency on unskilled foreign workforce in the construction sector, thus improving the industry's image as well as create awareness among local workforce on the benefits of joining the industry.

On the longer term, technical expertise gained from IBS implementation can become a trading platform to strengthen the country's comparative advantages while reinforcing its economic stature in promoting exports of high value-added products and services.

Given that multiple advantages can be gained through the pursuit of IBS, CIDB is proud to unveil ***A STUDY ON COST COMPARISON BETWEEN IBS AND CONVENTIONAL CONSTRUCTION*** which strives to differentiate the IBS and conventional construction method across six categories, namely preliminaries, substructure, superstructure, finishes, sanitary fittings, and mechanical & electrical services.

It is my utmost hope that this publication will serve as a valuable guide in our quest to further spur the adoption of IBS across both the construction and property development sectors in Malaysia. Undeniably, the IBS construction method will contribute towards the improvement of design, components and building quality. Similarly, it will improve the net profit margin of companies through reduction in excessive labour and wastage costs.

Combined with better project delivery in terms of time, earnings will therefore be less volatile and more visible.

Happy reading.

Dato' Ir. Ahmad 'Asri Abdul Hamid
Chief Executive
CIDB Malaysia

PREFACE

THE construction industry has been acknowledged as one of Malaysia's fastest-growing economic sector as the country strives to become a high-income nation. In line with such goal, the Industrialised Building System (IBS) has been earmarked as a key enabler to further spur the productivity of the construction industry by accelerating the adoption of mechanisation and modern construction practices.

The implementation of IBS by CIDB has led to a productive transformation for the construction industry and one which is growing rapidly. Essentially, IBS and the conventional construction method are totally different in various aspects, be it the idealism, processes, construction method, management, or even their respetive skill sets.

Overall, IBS requires a different strategy for the supply chain, planning, scheduling, handling, as well as purchasing of materials which lent the adopter to serious rethinking about how construction projects are planned and executed.

In the broadest sense, IBS entails a new business approach, investment outlook, and financial planning which encompasses an effective combination of cost control and selection of projects to create sufficient volume to justify the investment in a particular construction project.

With this in mind, ***A STUDY ON COST COMPARISON BETWEEN IBS AND CONVENTIONAL CONSTRUCTION*** serves as an effective reference point for the differentation of IBS and conventional construction across six categories, namely preliminaries, substructure, superstructure, finishes, sanitary fittings and mechanical & electrical services.

Shifting from common construction practice to full IBS can contribute to a saving of 0.83% of the total building cost while the construction period can be reduced to 18 months from 24 months. Similarly, IBS can contribute to intangible benefits in terms of the cost of preliminaries, in which there is a saving of 34.7% by shifting from common construction practice to full IBS construction.

In closing, CIDB wishes to express its gratitude to all IBS consultants, manufacturers and the various industry players who are involved in the development of this study. It is hoped that this study will be a beneficial reference for industry players, thereby further speed up the adoption of IBS.

This is consistent with the government's vision to enhance the productivity and economic growth of the Malaysian construction industry.

Datuk Ir. Elias Ismail
Senior General Manager Technology Development Sector
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CHAPTER 1
INTRODUCTION

1.1 Malaysian Construction Industry in General

THE construction sector is often touted as one of the few important and productive sectors that play a major role in Malaysia's economic growth. As a developing country, this sector not only spurs the nation's economic growth, but also contributes in terms of upgrading the quality of life and living standard of Malaysians (Khan, 2014).

In 2006, the expenditure incurred in the funding of building construction and infrastructure upgrading such as schools, hospitals, and government living quarters by the Federal Government was RM35.8 billion compared to RM 40.6 billion in 2007 (CIDB, 2008). What is obvious is that the construction process is going through a transitional change to a more systematic and mechanised system as well as in terms of prefabrication technology and higher workers' skill which reflects a trend towards business sustenance amid global competition (Haron, 2005; Chan, 2011).

Rahim et al. (2013) explained four major parts of the construction method that are typically used in the industry, namely the (i) conventional method; (ii) full fabrication method; (iii) cast *in-situ* method (formwork system), and (iv) composite construction method.

The Construction Industry Transformation Programme (CITP) 2016-2020 has earmarked there are four strategic thrusts such as (i) quality; (ii) safety & professionalism; (iii) environmental sustainability, and (iv) productivity and internalisation. Productivity is the primary engine of growth towards Malaysia achieving its target of becoming a high-income nation. As a vital sector in the nation's economical advancement, the construction industry will lead with high productivity levels through efficient adoption of new technologies and modern practices coupled with high-skilled and highly paid workforce.

As part of the industrialisation process, prefabricated construction has stormed into the 21st century as a plausible solution to improve current construction performance and image (Kamar et al. 2009) which has long been characterised as labour-intensive and surrounded by significant risks associated with market, site, weather conditions, and low productivity relative to other industries.

Prefabrication has the potential to provide – if properly delivered – more client choice and involvement, particularly in the case of housing where a variety of different features and systems can be realised from the manufacturers. The government's vision for Malaysia to be a developed nation by 2020 has pushed forward the use of innovative technologies in most sectors and industries.

With the implementation of various government projects under the Entry Point Projects (EPPs) through the Economic Transformation Programme (ETP), a platform has been established whereby the increasing use of mechanised and enhanced automation in the construction industry is highly encouraged. One of the few construction technologies that is much favoured by the Malaysian government is the use of Industrialised Building System (IBS).

1.2 Industrialised Building System (IBS)

IBS is a construction method which involves the elements of building structure produced in a controlled environment – whether at the factory or at a built-up site – and thereafter installed into a building structure using less labour in the built-up site.

IBS was introduced to replace conventional construction methods. It involves the use of prefabricated components (that are manufactured at factory or on-site) and mechanisation to reduce manpower requirements and material wastage. In Malaysia, the implementation of IBS by using precast concrete elements were introduced in 1966. Back then, the Government launched two pilot projects, namely the Apartmen Tunku Abdul Rahman in Kuala Lumpur and Rifle Range Road Flats in Penang.

The construction industry in Malaysia has been growing rapidly – particularly in the housing sub-sector – with gross domestic product (GDP) spiking to 11.6% in 2014 compared to 10.9% recorded in 2013 (MITI, 2014). However, the industry is plagued with various issues pertaining to quality and abandoned projects. The impact of the presence of foreign labour has had a negative impact mainly on the flow of the Malaysian ringgit and rising social ills in the country (Azman, 2014).

Despite the country having encountered headwinds from a global economic slowdown during the 11th Malaysia Plan (2016-2020) period, its economy has performed extremely well by posting GDP growth which is among the fastest in the region. The life quality of its citizens has also improved as reflected by an increase in both the per capita income and average household income, thanks to the numerous reforms put in place by the Government.

Key among them were the Government Transformation Programme and the Economic Transformation Programme which were underpinned by the 10th Malaysia Plan. Under the 11th Malaysia Plan, there are 2.7 million Bottom 40% (B40) households with mean monthly household income of RM2,537.

As Malaysia continues to grow, the B40 households should not miss out on opportunities that come with national prosperity. Allowing the B40 households to remain in their current socio-economic status will create social costs for all Malaysians as this reduces the number of skilled workers needed to grow national output, perpetuates urban inequality, and limits the growth potential of rural and suburban areas.

Job opportunities, access to healthcare services and education, and a reliable social safety net will ensure that B40 households have the opportunity for a better life. The Government will implement strategies to raise the income and wealth ownership of the B40 households, address the increasing cost of living, and strengthen delivery mechanisms for supporting B40 households.

The Government will also introduce the Multi-Dimensional Poverty Index (MPI) to ensure that vulnerability and quality of life is measured in addition to income. All B40 households regardless of ethnicity will be given greater focus, in particular the urban and rural poor, low income households as well as the vulnerable and aspirational households.

Meanwhile, it is anticipated that the size and composition of the middle-class society will grow to 45% by 2020. The mean income of the B40 households will double to RM5,270 in 2020 from RM2,537 in 2014. More B40 households will have family members with tertiary education – from 9% in 2014 to 20% in 2020. The income share of the B40 households to national household income is poised to increase from 16.5% in 2014 to 20% in 2020.

Nevertheless, the achievements are somewhat disappointing with only 20% completed houses for the B40 category despite numerous incentives and promotions to encourage housing developers to invest in such housing category (Ismail, 2001). Since the Eighth Malaysia Plan, the country has continued to embark on the development of affordable and sustainable low- and medium-cost housing. However, it is facing an uphill task to accomplish the target of 600,000-800,000 houses during this period given the conventional building system that is currently being implemented by the construction industry is unable to cope with such huge demand.

Therefore, the industry must find an alternative solution such as the industrialised building system (IBS) which is deemed to provide immense inherent advantages in term of productivity, indoor quality, durability and cost (Institute of Engineer Malaysia, 2001).

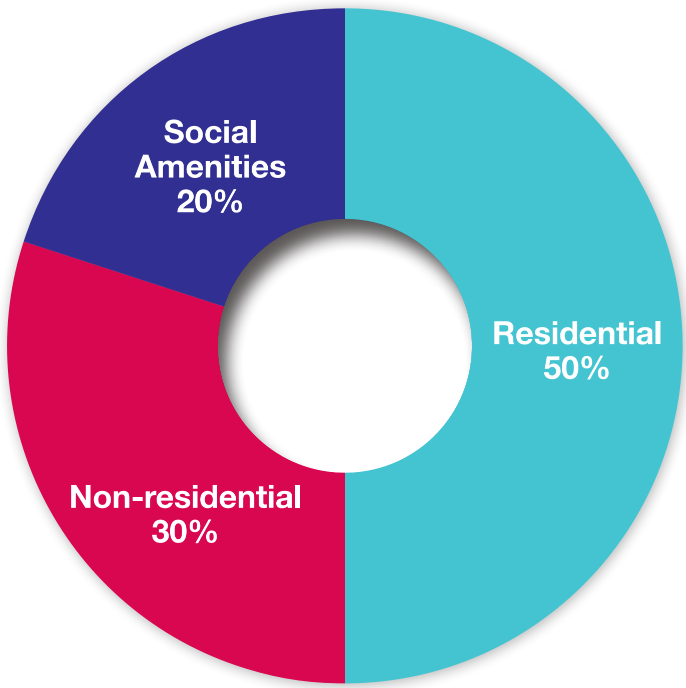
1.3 IBS Uptake in Malaysia

The potential of adopting IBS for the construction of residential housing in Malaysia was well-reflected in a study conducted by Foo et al. (2015). The findings indicated that among new building projects (both government and private) which implemented IBS in 2013, as high as 50% were under the category of residential, followed by 30% non-residential and 20%) social amenities (*see* Figure 1).

However, the same study also pointed out a low IBS uptake in the country with the overall IBS adoption in 2013 stood at a mere 15.3% with 61% and 14% in both the government and private sector projects, respectively (*see* Figure 2). With such low adoption rate, the ability of IBS in reducing foreign workers in the construction industry cannot be readily ascertained unless more buy-ins are received from the private sector.

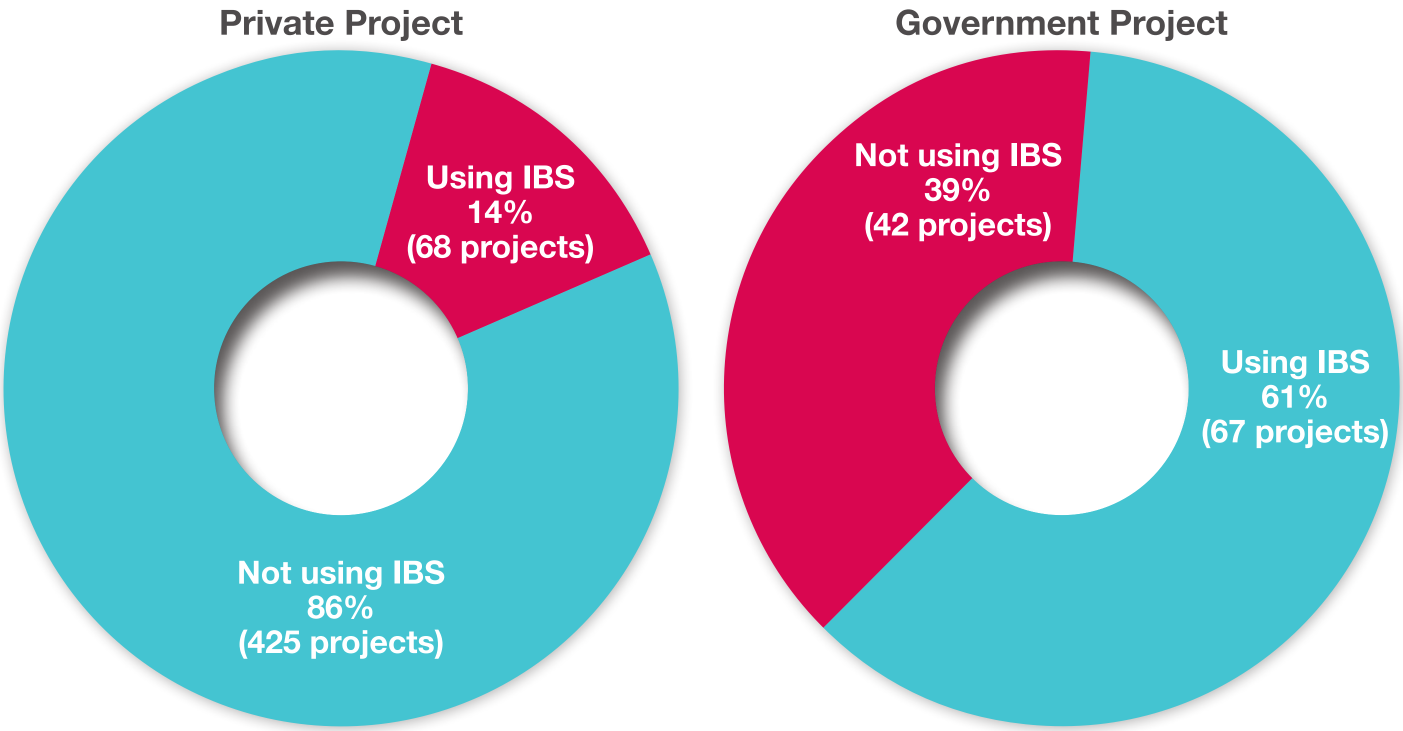
To date, labour usage is still paramount in the Malaysian construction industry with high

Figure 1: Breakdown of IBS Projects by Construction Work Category



Source: Foo et al., 2015

Figure 2: IBS Uptake in Private and Government Project



Source: Foo et al., 2015

dependency on foreign labour force to fill the shortage of their local counterparts. According to Hamid et al. (2017), foreign workers in the construction sector in 2013 accounted for 2.3% of total employment. While these figures may seem less compared to the manufacturing and agriculture sectors, the induced impact cannot be overlooked as their number could be more because the statistic did not capture illegal foreign workers.

It is estimated that there could be some 600,000 foreign workers on construction sites (CREAM, 2011). In 2010, the biggest block of foreign workers in the construction sector originated from Indonesia (80.6%), followed by Myanmar (6.5%), Pakistan (3.3%), the Philippines (1.8%), Nepal (1.6%) and Bangladesh (1.6%) (Hamid et al., 2017).

Previous researches on IBS show that the limited adoption of IBS is due mainly to the vague definition of components qualifying as IBS, notably:

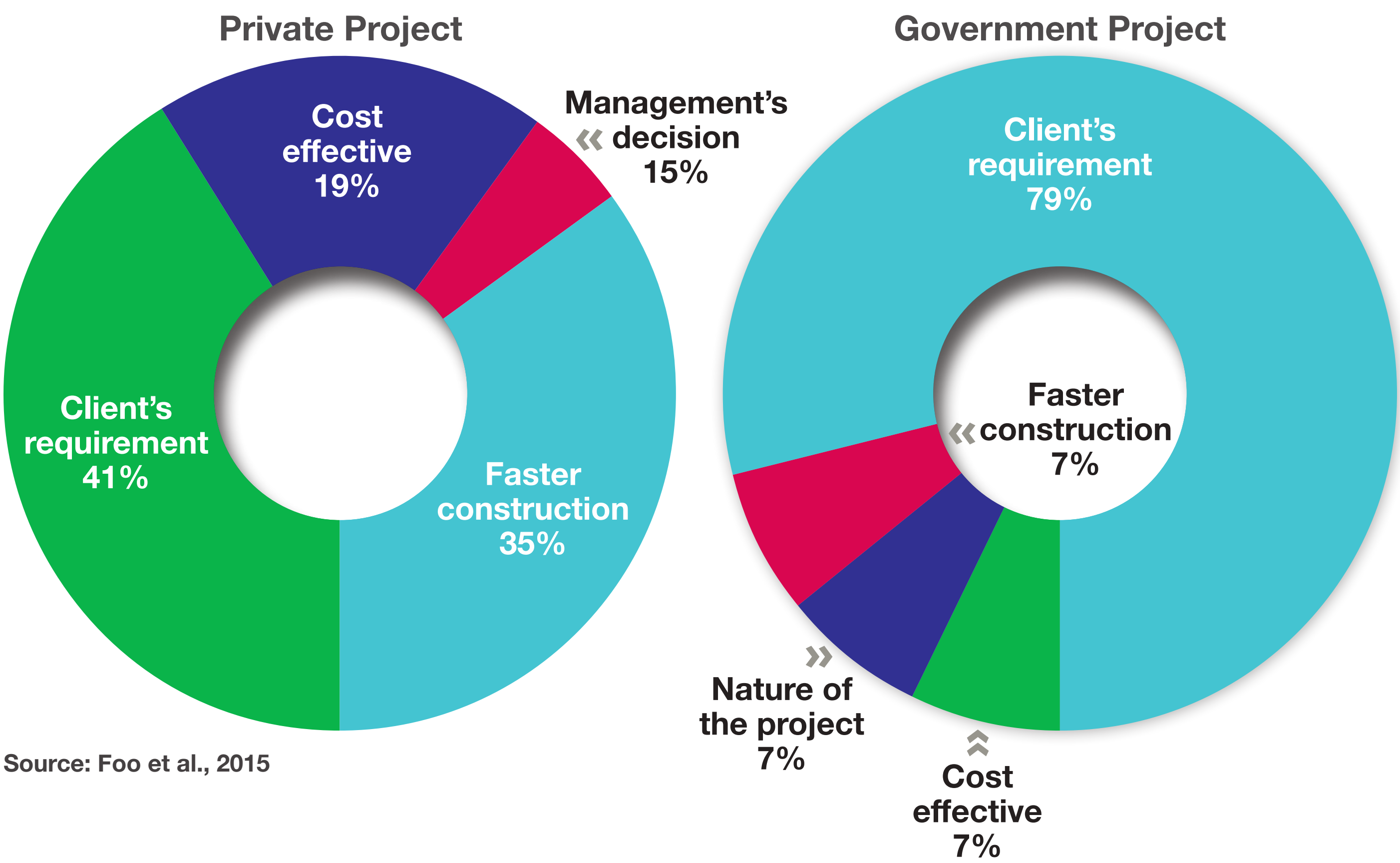
- Lack of standards;
- Lack of training for design consultants on ways to incorporate IBS into their designs, hence the hassle to re-design manufacturing and assembly facilities that led to delays in project implementation;
- Cash flow issues for contractors who are awarded IBS contracts during procurement of IBS components;
- The requirement of large upfront deposits before component delivery as well as delayed client payments,
- The imposition of high import duties on IBS manufacturing equipment and machinery installation.

Developers, among the wide range of industry players, hold a very important position to ensure the success of IBS adoption. This is because the adoption of IBS is hugely dependent on readiness and maturity of developers to move from existing contracting role into the IBS system integrator. Based on Foo et al. (2015) findings, the "client's requirement to use IBS" has been the main driving factor for IBS adoption in both private and government sectors (Figure 3). If more developers, especially from the private sector, can be convinced to adopt IBS, an overall higher level of industrialised construction industry can be achieved.

Private developers were found to be aware of the importance of IBS as an implication for business in future construction project. However, conventional *in-situ* construction is still preferred over IBS mainly due to the sheer cost of investment and the inadequacy of market size.

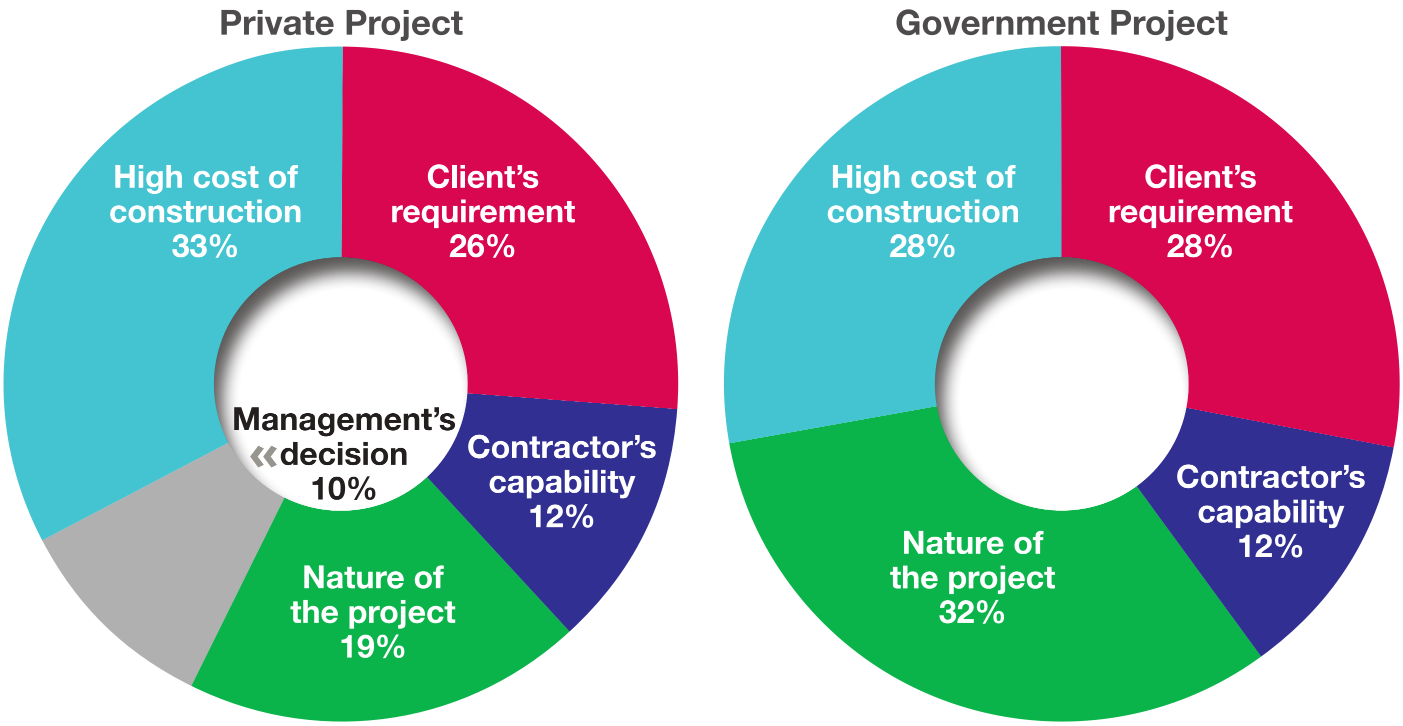
As shown in the questionnaire survey conducted by Foo et al. (2015), 33% of private project respondents were not using IBS mainly given the high cost of construction resulted from IBS construction (Figure 4). IBS is still not viewed as cost-effective because of the existing closed system in IBS supply chain that may cause an increase in the price of components and tender pricing.

Figure 3: Reasons for Using IBS



Source: Foo et al., 2015

Figure 4: Reasons for Not Using IBS



Source: Foo et al., 2015

1.4 IBS vs. Conventional Construction

In essence, both the IBS and conventional construction are totally different in various aspects, be it the idealism, processes, construction method, management or even the required skill sets.

1.4.1 Conventional Construction

Conventional building method is defined as components of the building that are prefabricated on site through the processes or via timber or plywood formwork installation, steel reinforcement and cast *in-situ*. Conventional buildings are mostly built of reinforced concrete frames. Traditional construction method tends to use wooden formwork. It is much costlier for construction from the perspective of labour usage, raw material, transportation and low speed of construction time.

However, the traditional or conventional procurement method has been a standard practice in the construction industry for 150 years following the emergence of general contracting firms and independent client consultants. There are two main features synonymous with the traditional method:

i. The design process is separate from the construction (although contracts by the joint contracts tribunal provide for design of specific parts of the works to be carried out by the contractor).
ii. Full documentation (i.e. drawings, work schedules or bills of quantities) must be supplied by the client before the contractor can be invited to tender or to carry out the work.

The traditional system has evolved and developed over the centuries. The role of the architect was established in more or less its present form during end of the 18th century by which time such individual was recognised as an independent designer of buildings and manager of the construction process.

In the early 19th century, bills of quantities of the building work to be carried out for a particular building project were frequently used as the means to provide the number of different contractors with a common basis for tendering of a project. By middle of the 19th century, the quantity surveyor had established himself as an independent compiler of bills of quantities and an expert in building accounts and cost matters.

There is considerable evidence extending back over several centuries of building craftsmen acting as contractors for complete building projects while embracing the work of all crafts. Nevertheless, the general contractor in his present form is frequently regarded as coming into his own at the beginning of the 19th century. The present traditional system which involves the parties mentioned above is enshrined in the Standard of Building Contract (with quantities). Among the characteristics of the traditional system are:

i. The system has operated in Britain, the Commonwealth and other parts of the world reasonably satisfactorily. It has stood the test of time.
ii. It is understood by most clients who would know their financial commitment when they accept the builder's tender if the design has been fully developed at time of going to tender.
iii. The architect has considerable freedom to conceive and develop the design without excessive time or economic pressures, provided the cost ceiling is not exceeded and the client's requirements are generally satisfied.
iv. The project cost can be estimated, planned and controlled by the quantity surveyor from the inception stage through to completion of the project.
v. The system makes it possible for the architect to introduce consulting engineers, landscape architects and other experts to advise on or design 'sub-systems' of the project.
vi. The architect is able to consult specialist contractors and suppliers who are deemed to be appropriate for the project or who manufacture and/or install components for sub-systems which would be compatible with the system as a whole at the design stage with a view of nominating them subsequently as sub-contractors or supplier for the project.
vii. The sub-contractors may be invited to submit competitive tenders to the architect for the sub-system in which they specialise, thus ensuring that the most economic price is obtained.
viii. Drawings and bills of quantities provide a common basis for competitive tenders from selected main contractors.
ix. In the event of a client requiring the project to be varied during the course of construction, the bills of quantities contain prices for items of work which may be used to adjust the contract sum to take into account the variations.
x. The design should be fully developed before the preparation of bills of quantities and, subsequently, tenders. If not, excessive variations and work disruption is likely to occur.
xi. The need for the design to be fully developed before tenders are prepared leads to an 'end-on' design/build arrangement. Such an arrangement frequently requires a longer overall project

period than is necessary if both design and construction are able to proceed concurrently.

xii. As the length of the project period increases, so does the project cost because the client usually incurs financing charges on the sum which he has invented in land purchase, interim payments to the contractor and other members of the building item.

xiii. The fees of the architect and other consultants are usually on 'recommended scales' and there is little or no competition between them on fees.

xiv. Some contractors are of the opinion that their ability to organise and control the work of nominated sub-contractors is undermined by the nomination process because such sub-contractors have less loyalty to the contractor than to the architect who nominated them.

xv. The separation of design and construction processes tend to foster a 'them and us' attitude between the designers and contractors, thus reducing the team spirit that experience has shown to be vital for the satisfactorily conclusion of a building project.

xvi. Lines of communication between the parties tend to be tenuous and the interests of all may suffer as a consequence.

xvii. The traditional system has been proven to be unsatisfactory for some large and complex projects which require advanced management systems, structure and skills.

1.4.2 IBS Construction

Since 2003, the Malaysian Government together with CIDB has aggressively encouraged the construction industry to leverage the IBS method of construction. Such lobbying is part of an integrated effort to further enhance the capacity, capability, efficiency, and competitiveness of the industry, thus reducing the industry's reliance on foreign workers. Above all else, this is also an effort to promote a cleaner, safer, simpler, and more efficient method of construction.

In line with the objectives of the IBS Roadmap 2003-2010, Budget 2005 declared that all new government building projects are required to comprise at least 50% of IBS content. To attract private clients, the second announcement levied exemption on housing projects with a minimum IBS Score of 50%. Since then, boosted by the Construction Industry Master Plan 2006-2015 and the Ninth Malaysia Plan 2006-2010, numerous activities have been spearheaded by the Government.

Two of the major initiatives are the release of the Treasury Circular Letter No. 7, Year 2008 *(Surat Pekeliling Perbendaharaan Bil. 7, Tahun 2008)* and the announcement of the Action Plan for IBS Implementation in Government Projects *(Pelan Tindakan Pelaksanaan IBS dalam Projek-Projek Kerajaan).* These initiatives have replaced the earlier instruction released by the Treasury on July 6, 2005 for the usage of 50% IBS content in all government projects. Released on October 31, 2008, the Treasury Circular Letter was issued to all Secretary- Generals, Heads of Federal Department, State Secretaries, Heads of Federal Statutory Bodies as well as all local authorities.

The essence of the instruction is the usage of Open Building, Modular Coordination (MC) design and 70% IBS Score for all projects. Agencies are required to submit periodical reports of IBS project implementation to the Implementation Coordination Unit which acts as the central monitoring agency. Exemptions are offered for certain classes of projects while the IBS Centre functions as the main technical reference centre.

According to CIDB (2007), the IBS system can be divided into six categories (*see* Table 1).

Table 1: Categories of IBS System

SYSTEM	COMPONENT	DESCRIPTION
Precast Concrete	Column Beam Wall Slab	The common IBS used includes precast concrete elements, lightweight precast concrete and permanent concrete formwork.
Formwork	Column Beam Wall Slab	The common IBS used includes precast concrete elements, lightweight precast concrete and permanent concrete formwork.
Steel Framing	Column Beam Roof truss	Commonly used with precast concrete slab, the steel framing system has always been a popular choice and used extensively to fast-track construction of skyscrapers. The recent development of this IBS includes the usage of light steel trusses consisting of cost efficient profiled cold formed channel and steel portal frame system. These are the alternatives to the heavier traditional hot rolled section.
Pre-fabricated Timber Framing	Column Beam Roof truss	This system consists of timber building frames and timber roof trusses. The timber building frame system also has their market and demand, offering attractive designs from simple dwelling units to buildings that required high aesthetical values such as resorts and chalets.
Block Work	Column Beam Wall	The construction method of using traditional bricks has been revolutionised by the developments of interlocking concrete masonry units and lightweight concrete blocks. The tedious and time-consuming traditional bricklaying tasks are vastly simplified by the usage of these practical solutions.
Innovative	Wall	In order to classify the new systems introduced in the Malaysian construction industry that do not belong to the five main IBS in the CIDB's IBS classifications (2003), CIDB has introduced an innovative system to classify both the new and innovative systems in approaching IBS.

According to CIDB (2007), the advantages of relying on IBS as compared to the conventional construction method are as follows:

i. Fewer site workers due to simplified construction methods.
ii. Quality controlled end product through controlled prefabrication process and simplified installations.
iii. Reduction of construction materials at site through the usage of prefabricated components.
iv. Reduction of construction waste at site with the usage of standardised component and less on-site materials.
v. Safer construction site due to reduction of site workers, material and construction waste.
vi. Faster completion of the construction process due to usage of standardised prefabricated components and simplified installation process.
vii. Much lower total construction cost.

1.5 IBS vs. Conventional Construction in Housing Development

Figure 5 compares the housing construction process flow between conventional and IBS approaches. While the two processes are almost similar, the IBS approach requires high level of collaboration among project parties to account for major constraints in the design with respect to transportation of components, installation logistics, permits and inspection schedules.

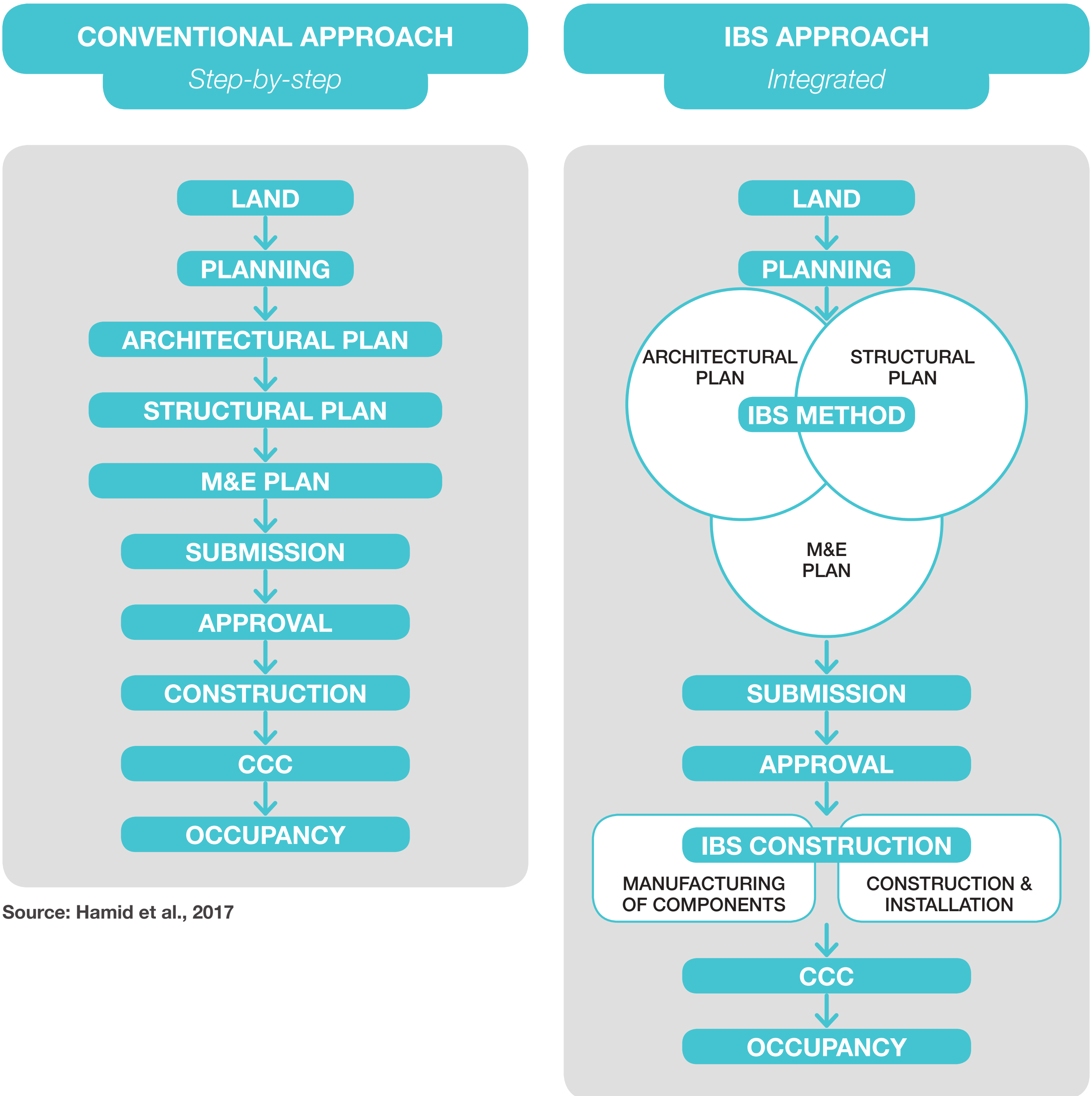
In short, it requires fundamental structural change to the industry, both in the design and construction stage. During the design stage, the IBS approach requires the integration of the architectural plan, civil and structural (C&S), mechanical and electrical (M&E) and workshop drawings to ensure the effectiveness of design coordination, while during the construction stage, IBS components are manufactured in a factory and then delivered on-site for assembly and erection.

Overall, IBS requires a different strategy for the supply chain, planning, scheduling, handling, as well as purchasing of materials, thus requiring the adopter to seriously re-think how construction projects are planned and executed. As such, a new business approach as well as investment and financial planning that includes the effective combination of cost control and selection of projects that provide enough volume to justify the investment is compulsory in an IBS construction.

However, it has to be borne in mind that from the developer's point of view, the costs of material, labour and machinery within the IBS system are not deemed as a good business investment compared with the conventional system. In current practice, the client pays between 10% and 25% of the total amount of the contract value as an initial payment before a construction begins. However, in an IBS project, initial spending has to be made to the manufacturers before any progress in the payment is made.

IBS manufacturers are normally required to advance approximately 75% of the capital to manufacture the IBS components before delivering these components to construction sites. Without sufficient financial backup, the developers are hardly convinced to use IBS in their projects. In addition, the adoption of IBS mainly depends on the readiness and

Figure 5: Process Flow Using Conventional and IBS Approach for Housing Construction



Source: Hamid et al., 2017

maturity of the developers or contractors in terms of know-how and expertise.

In several cases, the use of IBS by the developers or contractors has not only led to total satisfaction but actually has been less productive, lacking in quality, and overall more costly than the conventional method. There were even cases where certain building projects were awarded and constructed using the IBS system but suffered in terms of delay and poor quality. This condition has left the industry with noticeable difficulties when using IBS. Consequently, the industry has become reluctant in accepting IBS except when it is required by the clients.

1.6 Objectives

The main objective of this study is to provide a comparative study between the conventional construction and the IBS construction approach from the perspectives of cost and productivity.

1.7 Significant of Study

The definition of Stakeholders in an IBS Construction is as follows:

a) **Construction Industry Development Board (CIDB):** Based on the amendments to the Construction Industry Development Board Act (Act 520), namely the principal Act, one of the functions of the Board is to regulate the implementation of the IBS construction industry.

b) **Local Authorities:** Local Authorities (i.e. city council or municipal council) are state government agencies responsible for administration, approval, project monitoring and the issuance of Certificate of Completion and Compliance (CCC).

c) **Developer:** As the project owner, the developer is responsible for ensuring that contractors and consultants comply with the requirements set by CIDB on IBS.

d) **Producer or Distributor of IBS:** This can be a manufacturer or distributor of IBS components who are registered under the IBS Producers List certified by CIDB. There are three categories of accreditation/certification under CIDB:

   i. Manufacturer of IBS Status (IBS Status Manufacturer);
   ii. Distributor/Supplier IBS Status (IBS Status Distributor/Supplier), and
   iii. Manufacturer of IBS Status Site (IBS Status on Site Manufacturer).

   The certification/recognition is further classified according to six major groups as follows:

   i. Precast Concrete System;
   ii. The Steel Frame System;
   iii. Repeated Reference System (Formwork);
   iv. Wood Framework System;
   v. Block System, and
   vi. Innovative System.

e) **Contractor:** An IBS construction contractor who will conduct IBS construction based on specifications set by CIDB. The contractor will ensure that IBS components are used in construction and installed by recognised IBS installers.

f) **Consultant:** Consultants, Engineers, Materials Surveyors and Architects involved in the construction of IBS will assist in ensuring that an IBS construction process is carried out in accordance with the specifications set by CIDB.

g) **IBS installer:** This is referred to as an IBS component installer recognised by CIDB for an IBS-related construction. The IBS installer is also trained by CIDB's recognised IBS producer or distributor.

h) **Transporter:** The transporter is an IBS component transportation service provider.

CHAPTER 2
METHODOLOGY

THIS chapter presents the method of the present study on comparison of IBS construction with conventional construction. Two types of approaches are used to achieve the objective of the study: (i) Case Study, and (ii) Hypothetical Study.

2.1 Case Study

Data collection is helpful to find out cost of the project for both construction methods. Based on the review presented in Chapter 4, the case for promoting precast technology in a developing country is obvious and has been proven in many instances to bring about immediate gains in productivity, shorter construction periods, improved quality and safety performance, as well as cost reduction in numerous cases.

There is clear evidence to indicate that the concept of a greater productivity with large-scale precast buildings can be achieved in Malaysia (Lai, 2005). Five case studies conducted by local scholars to examine the input costs for precast building projects in Malaysia are included in this present study. The projects were selected based on availability of suitable projects at the time of the study, hence should not be interpreted as representative of the cost of precast construction at the respective locations.

2.2 Hypothetical Study

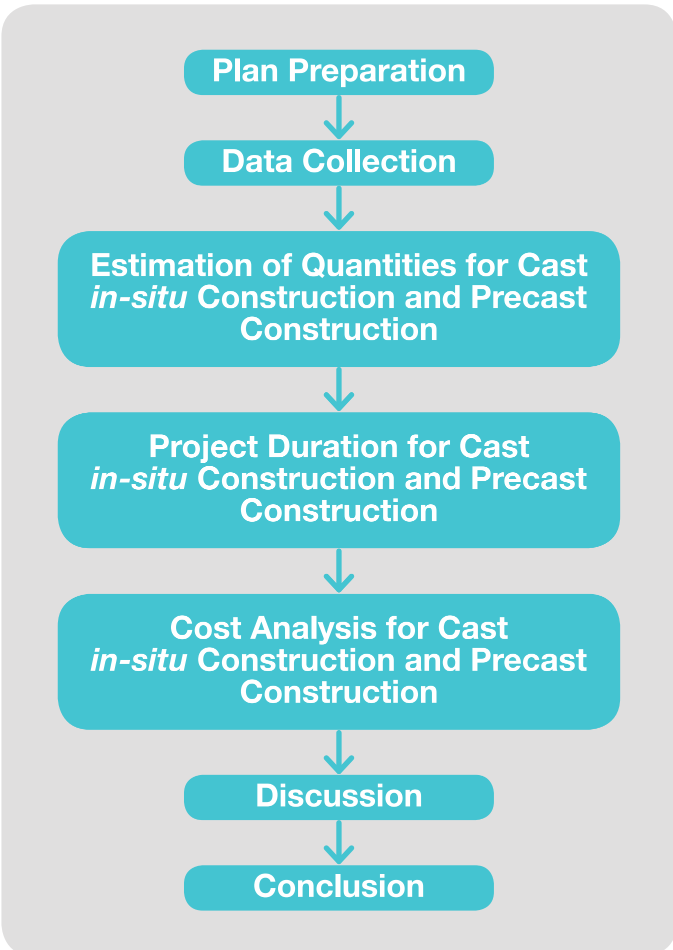
A residential building is taken for comparing and it includes the preparation of plan, data collection from precast industry, estimation of quantities, and determination of project duration. The work flow of the hypothetical study is as shown in Figure 6.

Plan preparation is done for residential building to estimate the quantities of conventional and precast constructions. A double-storey building is taken to estimate the quantities.

Estimation is used to find out the requirement of the materials for both the constructions. Details of the materials which are used in the construction from the companies were collected. By getting these details, we can estimate the quantities of the materials. Project duration of each construction process was collected and compared to the completion period by using the Critical Path method with Primavera P6.

Finally, this is followed by cost analysis.

Figure 6: Work Flow for Hypothetical Study



CHAPTER 3
IBS SCORE

3.1 Prefabrication and Standardisation

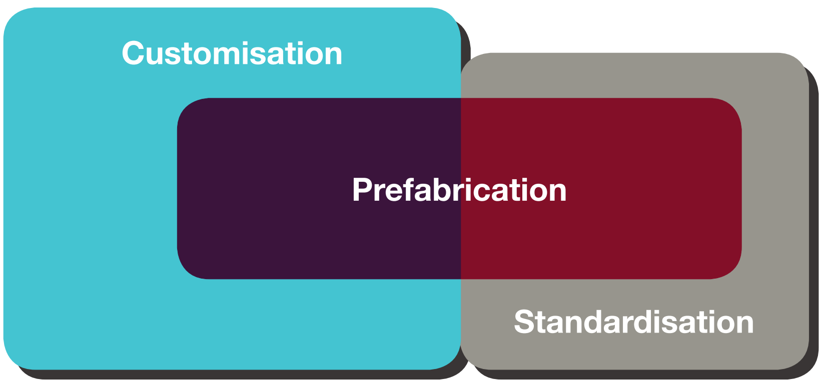
PREFABRICATION and standardisation (P&S) are both generally thought to have benefitted the building construction industry, but quantifying such benefits has proven to be difficult. The initial cost when using P&S will not necessarily be lower from traditional construction methods. Instead, benefits such as quicker construction, savings in the use of standardised panels and modules, and better product quality are seen as the main potential benefits.

A method for combining these hard to quantify savings with costs is discussed. The potential for further use of prefabrication and standardisation is analysed by building type and component. To differentiate between standardiastion and prefabrication, it is helpful to introduce a third term – customisation (Figure 7). This helps to explain that estimation of the potential for prefabrication and standardisation presented in this report is not additive. Some form of standardisation may be done off-site (prefabrication), but others such as the same floorplan used for side-by-side townhouses may be achieved on-site.

Standardisation is the repeated production of standard sizes and/or layouts of components or complete structures. Examples include modular bathrooms, standard kitchen cabinet sizes, standard prison cell or classroom designs, standard window sizes or wall panel sizes and finishes. This repeated production of identical components or structures may occur on-site (in which case, it is simply a form of standardisation), or it may occur off-site (in which case, it is also a form of prefabrication).

Prefabrication, on the other hand, is the off-site production of standardised or customised components or complete structures. Examples may include pre-cutting and pre-nailing of wall framing and roof trusses, or off-site construction of wall panels or bathrooms, whether they are standardised or customised. Prefabrication may be for bespoke (customised) components and structures (in which case, it is simply off-site production) or standardised components and structures (in which case, it is also standardisation).

Figure 7: The Relationship between Customisation, Prefabrication and Standardisation



3.2 IBS Scoring System in Malaysia

Prosperity and high economic growth in Malaysia has created a high demand for construction activities. The IBS scoring system was published in January 2005 with first revision in April 2010. The objective of this scoring is to provide a systematic and structured assessment system to measure the usage of IBS in a consistent way.

As a consequence, this has attracted a huge number of foreign workers into this country to take up employment on-site as unskilled labour doing manual jobs. Despite their contribution, the country is in a quagmire with a host of problems such as low quality works, delays, wastages, social problems and diseases, to name a few issues. (CIDB, 2004). Attributes emphasised by the IBS Scoring System are shown in Figure 8.

A higher IBS score is a reflection of a reduction of site labour, lower wastage, less site materials, a cleaner environment, better quality, a neater and safer construction site, faster project completion, as well as lower total construction costs. The method of determining the IBS Score is designed to be a simple but effective process.

Points are awarded based on the IBS Factors of the structural and wall elements used. The presence of high repetitiveness in the design as well as other simplified construction solutions shall also contribute to the total score. The points are summed up to give the IBS Score of the entire building. The IBS score for a whole development project that consists of a group of buildings can also be calculated.

3.2.1 Components of IBS Score

The maximum IBS Score for a building is 100 points. The IBS Score is made up of various components which can be divided into three parts:

- **Part 1:** Structural Systems where the maximum score is 50 points. Points are awarded for various types of structural systems used, e.g. precast concrete beams and columns, steel, prefabricated timber, among others.
- **Part 2:** Wall Systems where the maximum score is 30 points. Points are awarded based on various types of wall systems used, e.g. precast concrete panel, glass, dry partition and block work, among others.
- **Part 3:** Other Simplified Construction Solutions where the maximum score is 20 points. Points are awarded based on usage of other simplified construction solutions, e.g. standard components based on MS 1064, standardised grids, other 3D prefabricated components such as prefabricated toilets and staircases, among others.

Figure 8: IBS Scoring System Attributes

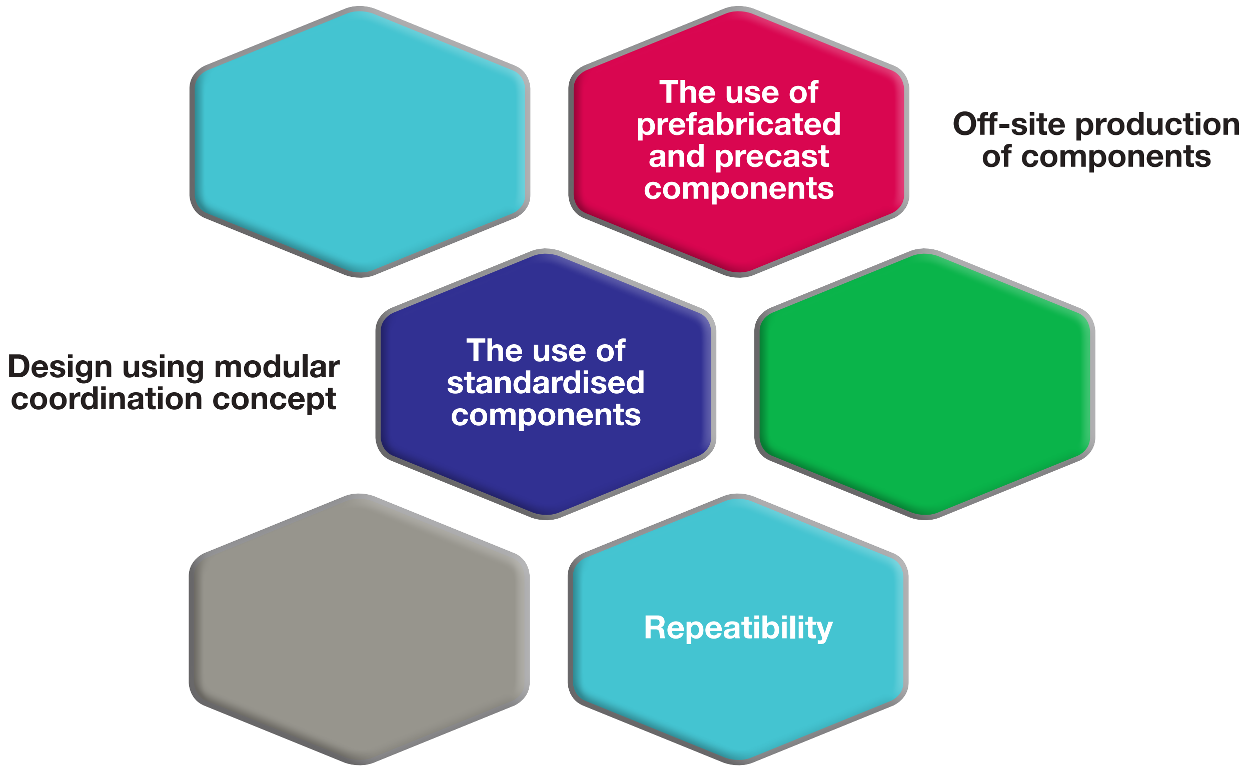


Table 2: Components of IBS Score

	PART 1		PART 2	PART 3
	Structural Systems (50 IBS Points)	Roof	Wall Systems (20 IBS Points)	Other Simplified Construction Solutions (30 IBS Points)
Full IBS Factors	Precast Concrete Columns, Beams & Slabs, Prefabricated Steel Structures and Timber Framed System	Precast Concrete Columns, Beams & Slabs, Prefabricated Steel Structures and Timber Framed System.	Precast Concrete Panel Wall Cladding, Prefabricated Timber Panel, Full Height Glass Panel, Dry Wall System and Pre-Assemble Blockwall	
Partial IBS Factors	Reusable System Formworks for *in-situ* concrete structures	Reusable System Formworks for *in-situ* concrete structures	*In-situ* Concrete with Reusable System Formwork (Blockwork System)	
Nil IBS Factor	Timber Formwork	Timber Formwork	Common Brickwall	
Emphasis on				Utilisation of MS1064 Guidelines • Horizontal & Vertical Repetition • Buildability

3.2.2 The IBS Score formula

The IBS Score formula is as follows:

Figure 9: IBS Score Formula

IBS SCORE = SCORE FOR STRUCTURAL SYSTEMS
+
SCORE FOR WALL SYSTEMS
+
SCORE FOR OTHER SIMPLIFIED CONSTRUCTION SOLUTIONS

Or in detail:

$$50 \sum \left[\frac{Q_S}{Q_{ST}}\right] F_S + 30 \sum \left[\frac{Q_W}{Q_{WT}}\right] F_W + S$$

Where:

Q_S	–	Floor area of a structural system
Q_{ST}	–	Total construction area of building
F_S	–	IBS Factor for structural system
Q_W	–	Length of a wall system (external or internal wall)
Q_{WT}	–	Total wall length (external and internal wall)
F_W	–	IBS Factor for wall system
S	–	IBS Score for other simplified customer solutions

- The tables for FS, FW and S can be found in the IBS Score manual.

- In the case that there is a group of buildings in one project, the IBS Score of the project shall be calculated by summing the weighted IBS Score of each individual building, i.e. the IBS Score of each building is multiplied by the percentage of area of the respective building (out of the total area of the project):

Figure 10: IBS Score Formula for One Project

$$\sum \left[\text{IBS SCORE FOR BUILDING} \times \frac{Q_{ST\ (building)}}{Q_{ST\ (project)}}\right]$$

3.2.3 How to Target the Higher IBS scoring

As part of the push for the utilisation of IBS, a number of incentives and regulatory requirements have been put forward. An example of a regulatory requirement is the minimum percentage of utilisation of IBS in government building projects. The way to target higher IBS scoring is illustrated on Figure 11.

Figure 11: Method on How to Target Higher IBS Scoring

- Contractors should always be looking at more efficient construction methods
- Design shall be modular coordinated with compliance to MS1064 (Utilisation of Standardise Components)
- Developers & Contractors to plan for the use of IBS from the beginning (including any simplified construction method)
- Prefabrications wherever possible
- Minimise labour intensive works wherever possible, e.g. brickwork & plastering
- Developers should have a preference for IBS construction so that the project sites are cleaner, less labour-intensive and reflect better site quality

CHAPTER 4
CASE STUDY

THE construction industry in Malaysia is undergoing transitional change from a project-based industry to embracing a more systematic and mechanised product-based technology which is IBS.

The IBS construction method can increase both productivity and work quality through the use of systematic machinery, equipment, materials and extensive pre-project planning.

However, cost impact appears to be major hindrance in preventing contractors to leverage IBS. Against such backdrop, good cost comparison data and a holistic and thorough valued-based comparative system is required by the industry to ascertain the true benefits of IBS for the particular project settings to support decision making in opting IBS over the conventional system.

Therefore, the objective of this study is to propose a comparative cost study of IBS vs. the conventional system in the construction of a residential building project. This is followed by a study on the effectiveness of IBS residential building projects in term of cost, time, and improvement in construction productivity. The data required for these case studies was generated through interviews.

From results of the case studies, it can be concluded that even though the construction cost of an IBS building project is higher than the conventional method, IBS offers better quality in terms of improving productivity and quality, faster rate of completion and occupation as well as able to complete within the project budget.

4.1 Literature Review on Construction Productivity

The construction cost of a building leveraging IBS should be assessed in its overall product utilisation context. Aside from time-saving, if properly designed and executed, the precast method can lead to much better work quality. The overall cost impact of IBS construction, therefore, has to take in consideration all these factors.

In retrospect, IBS has been introduced in Malaysia since the 1960s through the application of precast concrete in beam-column elements. Since the demand of building construction has increased rapidly, it is necessary to innovate the construction method to speed up the building construction process.

Demand for construction labour usage varies as a project progresses from structural work (including basement construction) to architectural and finishing work to mechanical and electrical (M&E) work. Furthermore, the proportion of foreign to local workers also differs considerably through these stages given the different skills required to accomplish a specific tasks.

Table 3 shows the differentiation of local labour and foreign labour with the distribution of total local labour in structural works at 50% and foreign workers at 80-85%. The same goes to finishing work and mechanical and electrical (M&E) work with higher proportion of foreign labour usage at 50-60% and 30%, respectively.

The table also shows the distribution of total labour and the proportion of foreign labour in these stages of building work. The statistics

Table 3: Usage of Workers and Potential for Productivity Improvement in Building Work

WORK TYPE	USAGE OF WORKERS (%)	USAGE OF FOREIGN WORKERS (%)	POTENTIAL FOR PRODUCTIVITY IMPROVEMENT	SKILLS REPLACEABLE	
Structural	50	80-85	High	Craft	Assembly
Finishing	30-35	50-60	Medium	More craft and less assembly	Less craft and more assembly
Mechanical and electrical	15-20	30	Low	Assembly	Assembly

Source: CIDB Singapore Manpower Survey

presented in Table 3 are cited from Singapore's construction industry, the paradigm of which is similar to Malaysia given the locals in both countries are shying away from the construction industry.

As of end-1991, Singapore had a construction workforce of about 120,000, of which over 80,000 were foreign workers. The biggest block of foreign workers were Malaysian who constituted 34% of the total number of construction workers, followed by Thais (25%), Bangladeshis (10%), Indians, Sri Lankans, Myanmarese, and those from North Asian countries such as South Korea, China and Taiwan (Lim and Alum, 1995). On the other hand, the number of legal foreign workers in Malaysia's construction sector stood at 19.8% out of a total of 1.36 million in July 2004 (The Star, 2004). Out of this figure, 66.5% were from Indonesia, followed by Nepal (9.2%), Bangladesh (8%), India (4.5%) and Myanmar (4.2%).

According to Junid (1986), the implementation of IBS in the construction industry encompasses the industrialised process by which components of a building are conceived, planned, fabricated, transported and erected on site. This entails the combination of software and hardware components.

The software elements include system design which is a complex process of studying the requirement of the end-user, market analysis, development of standardised components, establishment of manufacturing and assembly layout and process, allocation of resources and materials, and definition of a building designer conceptual framework. Moreover, they further provide a pre-requisite to create the conducive environment for industrialisation to expand.

On the other hand, the hardware elements are categorised into three major groups as below (Figure 12):

Figure 12: IBS Elements

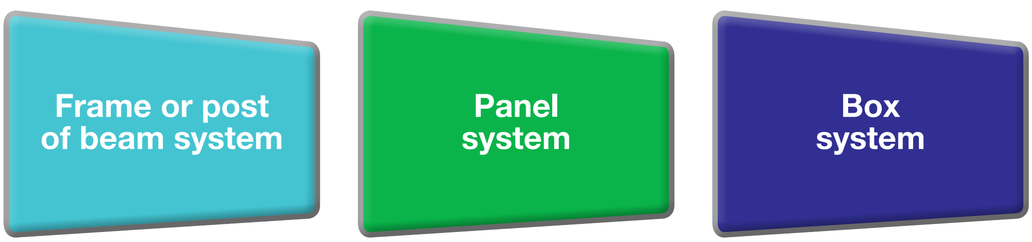
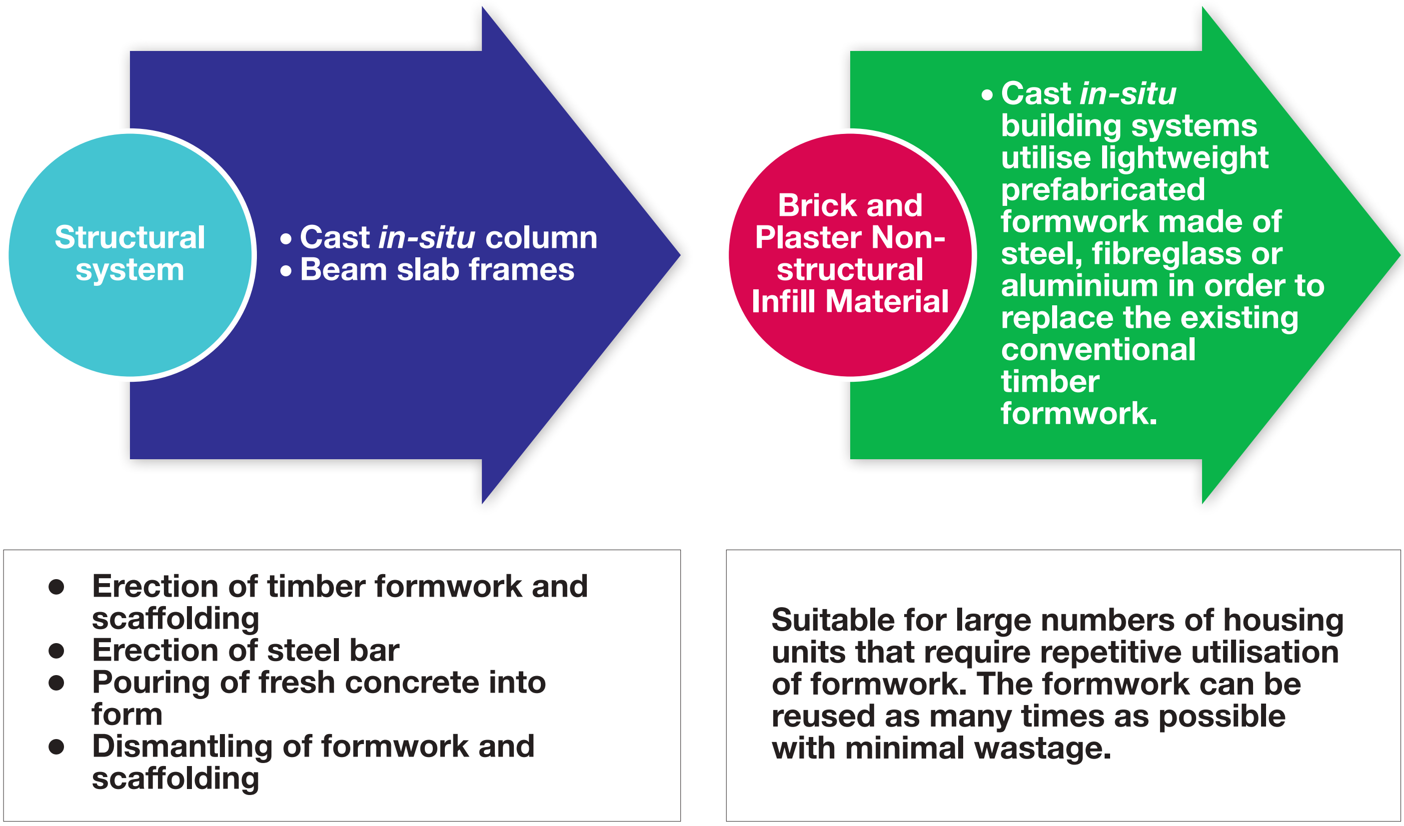


Figure 13: Conventional System Components



The conventional building system is divided into two major components as above (Figure 13). In essence, careful planning of cast *in-situ* work can improve productivity, speed, and total cost (Ismail, 2001). There are two fully prefabricated building systems available, namely on-site prefabricated and off-site prefabricated (factory produced). On-site prefabricated method involves casting structural building elements within site before erecting to actual location. On-site precasting provides several advantages over cast *in-situ* construction. These include mass production of units, cost and time reduction and improved quality of work (CIDB, 1992).

The off-site prefabricated method involves transferring building operations from site to factory. Prefabrication entails on-time delivery with relevant components can be built on any suitable ground. The composite construction method involves casting some elements in the factory while others are cast on site. The floor slabs, infilled wall, bathrooms and staircase are types of precast elements. These elements are placed for incorporation into main units, column and beams which are usually cast *in-situ*. Studies of comparison between the IBS and conventional methods have been widely conducted in Malaysia.

Table 4 shows the various studies on comparison between the IBS method and conventional method in Malaysia. There are different methods and different outcomes from the various case studies from 2002 until 2015.

Table 4: Study on Cost Comparison between Conventional and IBS Method

Researchers	Year	Method	Results
Haron N.A, Hassim. S, Razali A.K & Jaafar M.A	2006	• Comparative study on labour usage represents one of the critical elements in the Malaysian construction industry due to severe shortage of local workers. • More skewed towards construction performance comparison between the conventional building systems and IBS. • Data were obtained from 100 residential projects through a questionnaire survey in 2005. A total of 100 respondents participated in this study. The analysis of variance (ANOVA) results indicated that the actual labour productivity comparison between conventional building system and IBS was significantly different.	• The comparison of crew size indicated that the conventional building system of 22 workers was significantly different from 18 workers for IBS. • The time cycle of 17 days per house for conventional building system was found to be significantly different from four days for IBS.
Aziz. Z	2012	• Comparative cost study of IBS vs. conventional system of school building construction projects by using Elemental Cost Analysis technique. • Using case study and interview.	Even though the building cost of IBS school project is higher than the conventional system, IBS offers better quality in term of productivity and quality, faster completion and occupation time as well as ability to complete within the project's budget.

Continue on next page >>

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Haron N.A	2002	• The data was collected through questionnaire survey and case studies which consisted of residential and institutional buildings. • The analytical methodology was chosen for case study. • Consist IBS A, IBS B and IBS C (including advantages of IBS, building cost information and cost comparison). • The study is limited to client or developer, consultant, contractor and supplier.	The use of t-test showed significant difference in terms of cost saving for the conventional system as compared to IBS.
Mohamed N.F	2014	• Case study on a double-storey and 3-storey house. • Differentiation on conventional method and Interlocking Block System.	• The study shows that the cost to build a single-storey house based on the interlock block system is 23% less than the conventional method. For a double-storey and 3-storey house, it is less 16% and 22% compared to conventional method. • It is more efficient to use the IBS method rather than conventional method. More economical in term of price. • It also requires less time to construct the house and need fewer workers.
Rahim M.A and Haron N.A	2014	• Case study condominium (260 units) • Interview with consultant company • Comparison made on material costs, labour costs, equipment cost, overhead costs and profit	• The construction cost by using conventional system method is much more expensive than using the IBS. The cost differential is RM200,000. • The IBS method can be deemed as the most appropriate system for a high-rise building since it could provide a cheaper overall construction cost.

4.2 Case Study on Productivity Comparison

The following are some case studies on productivity comparison between IBS and conventional construction conducted by Malaysian researchers.

4.2.1 3-Storey Cluster House at Indah Heights, Skudai, Johor

This case study for performance comparison between IBS and conventional construction is provided by Kimlun Group. The building is a 3-storey cluster house (Figure 14) located at Indah Heights – a new residential housing development in Skudai, Johor (Figure 15).

Figure 14: Building for Comparison Study

Skudai is located 8 km, 4 km and 16 km from Kulai, Senai, and Johor Bahru city, respectively. It is a rapidly expanding suburb of Johor Bahru where part of it is located in the newly growth

Figure 15: Location of Indah Heights, Skudai, Johor

Figure 16: Site Plan of Indah Heights

corridor of southwest Johor, including the Senai International Airport, Tanjung Pelepas Port and the proposed new administrative capital of Johor, Bandar Nusajaya. The population of Skudai ranges between 160,000 and 210,000. It is also the headquarters of the Johor Bahru Central Municipal Council and home to the Universiti Teknologi Malaysia (UTM) campus.

Indah Heights consists of 45 acres of prime land and is host to a collection of 3-storey Semi-D, cluster, and bungalow homes (Figure 16). The cluster house used as case study came from Phase 2B which boasts 60 units of 3-storey cluster house with the standard land size and built-up area of 38' x 70' and 3,280 sq ft, respectively.

The specifications of the 3-storey cluster house are as shown in Table 5. As shown in Figure 17, 12 units – including four show units and eight *in-situ* units (denoted as 2B) – were first built with conventional approach as the developer had no idea about the actual unit to be built nor the buyers' responses. At the later stage – once the market was confirmed – 48 units (denoted as B-01 to B-12) were constructed by IBS means. The *in-situ* units consist of C1, C2, and C3 are Semi-D. It is believed that the case study can provide a good comparison between conventional and IBS construction given all the units were located in the same area, subject to the same environmental factor, as well as come under the same company administration and management.

Figure 17: Detailed Site Plan of Indah Heights Phase 2B

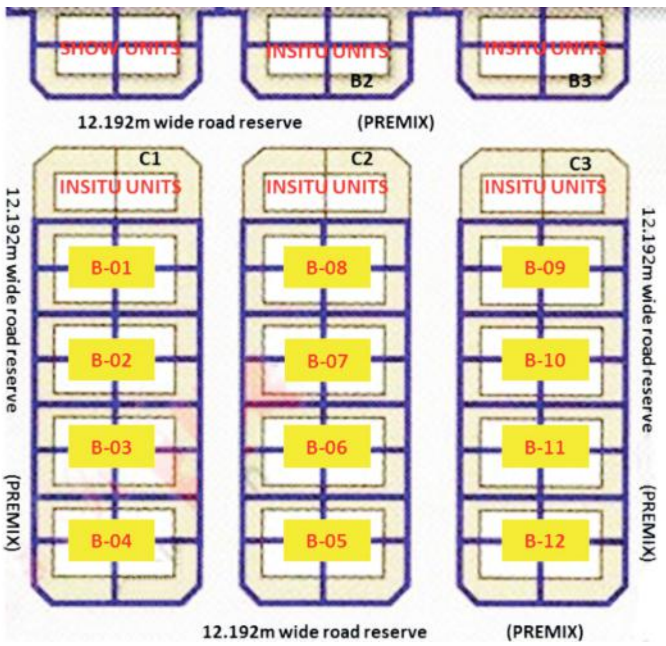


Table 5: Specifications of the 3-Storey Cluster House, Indah Heights Phase 2B

Structure	Reinforced concrete frame	
Walls	Concrete wall/Brick wall with skim coat and cement plaster finished	
Roofing Tile	Concrete roof tiles	
Roofing Structure	Galvanised steel structure/Reinforcement concrete roof	
Ceiling	Gypsum plaster board/Skim coat finished	
Windows	Aluminium framed glass windows	
Doors	Solid timber door/Timber flush door/Aluminium framed sliding glass door	
Lock	Selected quality locksets	
Sanitary fittings	Selected quality sanitary wares	
Staircase	R.C. Staircase with ceramic tiles finished	
Ironmongery	Quality Locksets	
Floor Finishes	Foyer/Living/Dining/Meals/Bedroom 5/Utility/Kitchen/car Porch/Balcony/Driveway /Patio/Lifestyle Deck	Homogeneous tiles
	Bedrooms 1, 2, 3, 4/Family area/Study room	Timber Finished
	Close	Tiles finish
	All bathrooms	Porcelain tiles
Wall Finishes	All Bathroom – Wall tiles to ceiling height Kitchen – Wall tiles to ceiling height.	
	Other Areas – Skim coat/Cement plaster & paint	
Electrical Installation	13 Amp Power Point	34
	Lighting Point	39
	Telephone Outlet Point	3
	TV Outlet Point	3
	Ceiling Fan Point	9
	Air conditioner Point	6
	Heater Point	3
	Bell Point	1
	Auto Gate Point	1
	Gate Light Point	2
Gate	M.S. gate with brick pier c/w letter box	
	1,650mm high mild steel/brick fence	

Table 6: Comparison between Conventional and IBS Construction

DESCRIPTION	CONVENTIONAL	IBS
Gross Floor Area (GFA) for one unit of 3-storey cluster house	304.86 m^2 (3,281 ft2)	304.86 m^2 (3,281 ft2)
Construction period		
• Structure (superstructure) • Architecture (i.e. brickwork, plastering, skim coat, door/ window installation, tiling, painting)	8 weeks 19 weeks	6 weeks 12 weeks
Number of labour		
• Carpenter • Barbender • Concretor • Installer • Labour for architectural work	15 7 10 - 47	10 5 10 5 26
Machinery	Mobile crane for concreting	Mobile crane and crawler crane for concreting and the installation of precast panel
Quality (QA/QC Assessment)	80%	80%
Material wastage	11%	3%
Feedback from purchasers	• Wall finishing got hair line crack • Painting off white • Easy renovation • Got water seepage	• Smooth wall finishing • Wall tile hollow • Limited tile hollow • Got water seepage

Table 6 summarises differences between conventional and IBS construction of the 3-storey cluster house at Indah Heights Phase 2B in terms of (i) construction period; (ii) number of labour; (iii) machinery; (iv) quality; (v) material wastage, and (vi) feedback from purchasers. To note, the comparison only focuses on on-site construction work, while works done in the factory is excluded.

One of the obvious drivers to use IBS is a reduction of construction build time. It has been proven that IBS project can be completed faster than a conventional construction project due to the use of standardised components and simplified construction process. The application of large structural panels is able to speed up the structural works, thus other work areas such as painting, electrical wiring and plumbing can commence sooner.

As shown in Table 6, structural work for constructing one block or four units of the 3-storey cluster houses took eight weeks in a conventional construction; while a period of six weeks was suffice in an IBS construction by leveraging precast panel and slab system. Bear in mind that barbender and concretor were still needed in an IBS construction given the cluster house in the study was not fully IBS-constructed.

Certain parts of the house such as staircase and topping were constructed using the conventional approach. One may also notice that there was tremendous time saving in the architectural work because in an IBS construction, joint section is the only part to be grouted, thus eliminating the requirement of plastering. Additionally, less brick work was required for IBS-constructed house as internal partitions were mostly precast panel whereby only skim coat was necessary for finishing.

In the case of conventional construction, longer build time was needed for architectural work as it involved brickwork, plastering, skim coat, door/window installation, tiling, and painting. Therefore, IBS construction is able to save valuable time aside from helping to reduce the risk of project delay and possible monetary losses.

Past researches have shown that the number of workforce required in an IBS construction is far lower than those required in a conventional construction. This is because conventional construction requires many wet trades on site (i.e. skill carpenters, plasterers, and brick layers) in order to cast the reinforced concrete frame and brick, beam, column, wall, and roof.

As for the case of IBS construction, the use of carpentry work, brick-laying, bar bending and manual job at site is greatly reduced since most of the carpentry works are completed in the factory. Those parts of building that are repetitive but difficult, time consuming and labour-intensive to cost at site are designed and detailed as standardised components at factory.

As shown in Table 6, 79 workers were required in a conventional construction as compared to 56 to undertake IBS construction. While installers were needed in the IBS construction, relatively fewer carpenters and workers for architectural work were required as compared to conventional construction. With less workers involved in the IBS construction and shorter construction period, contractors are able to save on the overhead cost involved in the construction process.

The quality of the final IBS products is normally better than its conventional counterpart given the former are produced under rigorously controlled condition, while the latter depends very much on the workmanship factor. However, as shown in Table 6, both the conventional and IBS construction achieved an average quality score of 80% through the internal QA/QC assessment. This is because conventional approach was only used for the construction of three blocks or 12 units of houses for showcase purpose, while IBS was used to construct remainder of the houses (12 blocks or 48 units) upon confirmation of their buyers.

It can be assumed that in the process of mass production, IBS is able to reduce the possibility of poor workmanship and lack of quality control, thus ensuring an improvement in quality, productivity and efficiency from the use of factory-made products. The quality of houses built with both conventional and IBS approaches can also be observed from customers' feedback whereby houses leveraging the IBS method are said to provide higher quality surface finishes as compared to hair line crack at wall finishing found on houses constructed under the conventional approach.

Although findings from other studies claimed that IBS houses were inflexible for renovation with hollow sounding tile being a common feature, we beg to differ. For IBS houses in our study, incidences of hollow sounding tile only occurred in limited areas, and were mostly due to poor workmanship whereby the adhesive did not provide a good bond between the tiles and the substrate, or that there were hollow voids of missing adhesive under the tiles.

If tiles are laid correctly with 100% adhesive coverage – and the bond is sound – then the tiles will effectively become one with the substrate. While water seepage is often perceived to be the common problem in IBS houses, the present case study points to the fact that houses constructed with both the conventional and IBS approaches were facing a similar problem, indicating that it was rather a workmanship issue than a design problem. And more often than not, water seepage happened at the floor trap.

In addition, 11% of the materials used for construction became waste in the conventional construction, but the figure can be further reduced to 3% in IBS construction. This is because IBS eliminates or greatly reduces conventional timber formwork and props. Such reduction will eventually minimise the use of timber, thus saving forests from destruction. Furthermore, most elements produced at the plant are designed to be repetitive, thus ensuring minimal wastage at the factory and construction site.

In the present case study, the labour productivity is calculated by applying Equation 1 (Abdul Kadir et al., 2006). In fact, there are myriad of studies focusing on labour productivity for single operation such as concrete productivity, rebar productivity, and formwork productivity although little effort is devoted towards the combined labour productivity for all the single operation that join together to form the structural element of one-unit house (Abdul Kadir et al., 2005).

In the present case study, labour productivity is measured in terms of structural works done by the carpenter, barbender, concretor, and installer in erecting structural elements for one block or four units of 3-storey cluster houses.

According to the data source, the construction of one block of four units of 3-storey cluster house with GFA of 1,219.44 m² was implemented six days per week (from Monday to Saturday) on the basis of eight hours per day. In the case of conventional construction, all the labours were semi-skilled foreign workers supervised by a semi-skilled local supervisor, while in IBS construction, only the carpenters, barbenders, and concretors were semi-skilled foreign workers (both the supervisor and the installers were skilled local worker).

Equation 1: Labour Productivity for Structural Element of One-Unit House

$$\text{Labour productivity} = \frac{\text{Crew size X Working time (days)}}{\text{Building floor area (m}^2\text{)}}$$

By applying Equation 1, the labour productivity for structural element of one block for both conventional and IBS are 10.08 man-hours/m² and 6.38 man-hours/m², respectively as shown in Table 7. The result is in line with past studies which suggested that IBS construction contributes to higher productivity than conventional construction. The assumption is

Table 7: Actual Labour Productivity Comparison (Conventional Method vs. IBS)

DESCRIPTION	CONVENTIONAL	IBS
Building floor area (m^2)	1,219.44	1,219.44
Crew size	32	27
Working time (hours)	384	288
Labour productivity (man-hours/m^2)	10.08	6.38

that labour productivity in IBS construction may improve as the number of unit house increases. This is because as workers carried out repetitive work, their skill and experience would improve.

4.2.2 SMK Idris Shah, Kinta, Perak & SMK Tinggi Klang, Selangor

A joint research among University Tenaga National, University Tun Hussein Onn, and Limkokwing University was conducted to obtain more understanding on the construction costs of a school project using IBS. Both projects took place at (i) SMK Idris Shah, Kinta, Perak (Figure 18); and (ii) SMK Tinggi Klang, Selangor (Figure 19).

The technical data such as bill of quantities, construction drawing, and the work programme of the selected school projects was collected and evaluated. For the construction of the slab by using IBS material which is half slab, few elements were considered in the calculation of the cost per area or per volume of the slab, namely (i) concrete for topping; (ii) half slab panel; (iii) formwork for topping; (iv) fabricated reinforcement bar, and (v) grouting.

Figure 18: SMK Idris Shah, Kinta, Perak

Figure 19: SMK Tinggi Klang, Selangor

As for the conventional method, only three elements were taken into the calculation of construction cost, namely (i) slab concrete; (ii) reinforcement bar, and (iii) formwork. The cost evaluation for both methods are based on materials used to complete the one floor slab of the ground floor (based on conventional method) and the first floor (based on IBS method) on each school. Details of the area and the price factor are made available in the technical data such as bill of quantities, construction drawings, and work programme of the school construction project.

Table 8: Summary of Cost Calculation for Conventional Method

CONVENTIONAL			
ITEM	**QUANTITY UNIT**	**PRICE**	**TOTAL**
Slab concrete	137.7m³	RM220/m³	RM30,294.00
		RM20/m³	RM2,754.00
BRC (A8)	58 pieces	RM90/piece	RM5,220.00
	810m²	RM1.40/m²	RM1,134.00
Formwork	446.82m²	RM28,60/m²	RM12,779.50
		RM8.70/m²	RM3,887.34
		Total	**RM56,068.39**

Table 8 shows the distribution of the construction materials used for conventional construction method and the summary of cost calculation. The materials used as stated in the bill of quantities for this project are concrete slab grade 30, prefabricated reinforcement bar (A8 type), and conventional formwork (wood). The total cost to complete one floor using conventional method is RM56,068.39.

A similar method was used to collect details of construction information for the IBS method. Table 9 shows the summary of calculation and breakdown of materials used for the IBS method that leveraged the half slab precast concrete slab panel. The total cost to complete one floor using IBS precast concrete slab is RM49,398.10 or a 11.9% cost reduction incurred by shifting conventional construction to IBS construction.

4.2.3 Residential condominium (260 units) at Shah Alam, Selangor

The selected project for this case study is a 260-unit condominium development located in Shah Alam, Selangor (Figure 20). Basically, the project is made up of three condominium blocks, namely Block 5, Block 6, and Block 7. These three blocks boast 11-storey height with 88 residential units each, a ground level car park area and two levels for mechanical and electrical equipment. However, there are only

Table 9: Summary of Cost Calculation for IBS Method

IBS			
ITEM	**QUANTITY UNIT**	**PRICE**	**TOTAL**
Half Slab	405m³	RM94.20/m³	RM30,294.00
BRC (A7)	29 pieces	RM80/piece	RM2,320.00
	405m²	RM1.40/m²	RM567.00
Concrete (G30)	30.375m³	RM220/m³	RM6,682.50
		RM20/m³	RM607.50
		RM8.70/m²	RM1,070.10
Grouting	123m	**Total**	**RM49,398.10**

Figure 20: Condominium Project in Shah Alam, Selangor

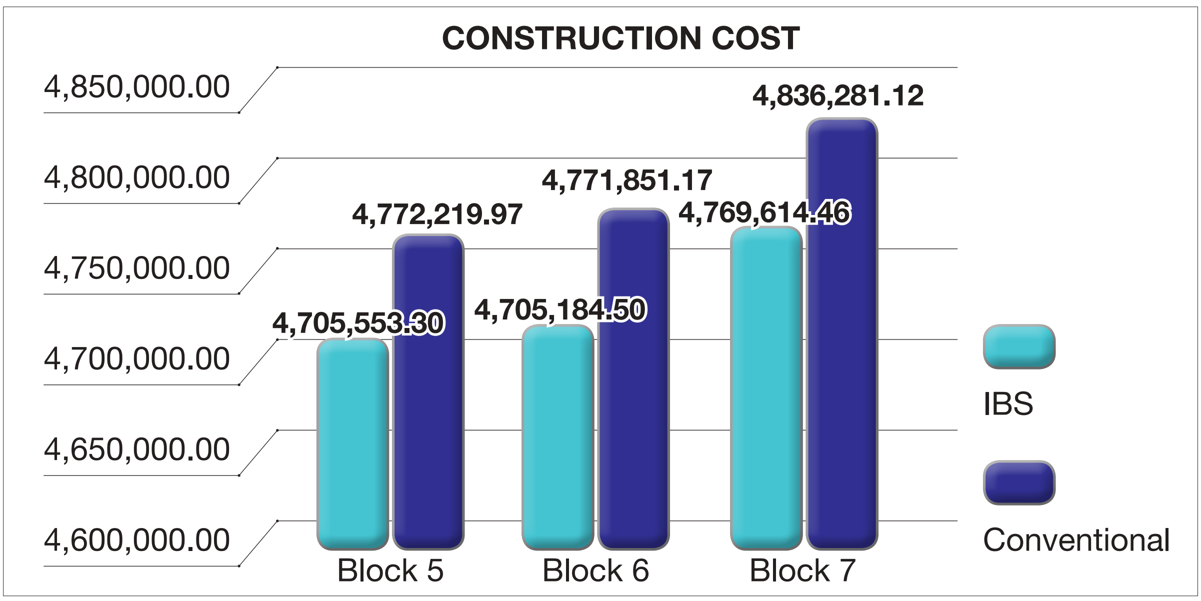
84 residential units for Block 7. Other facilities to be constructed include a unit of *surau,* a unit of guard post, two playing courts, playground and a unit of disposal area.

Based on its document contract, the project would initially pursue the traditional/conventional construction method. The total cost tendered by the contractor for this particular project was estimated at about RM25,301,911.54. However, in view of increases in certain construction materials such as steel bars and BRC, reinforcement concrete as well as sand (for plastering, rendering and concreting), the tender was revised upward by 3% to RM25,999,709.02.

Given the exorbitant tender cost, the client had requested the project contractor to lower the tendered sum. In tandem with the costing revision, the contractor then submitted a more economical pricing of RM25,799,709.02. For this new revised tender price, the scope of works was demarcated in terms of building works (dwelling unit), i.e. constructed using the formwork system method (IBS) while other construction work is still based on the conventional method.

And as in the new tender document, the contract would be treated as lump sum in relation to the proposed IBS drawings while the type of contract is changed to design and build concept. Additionally, the client accepted this new amount, hence an official contract document was made to explain the revised contract cost.

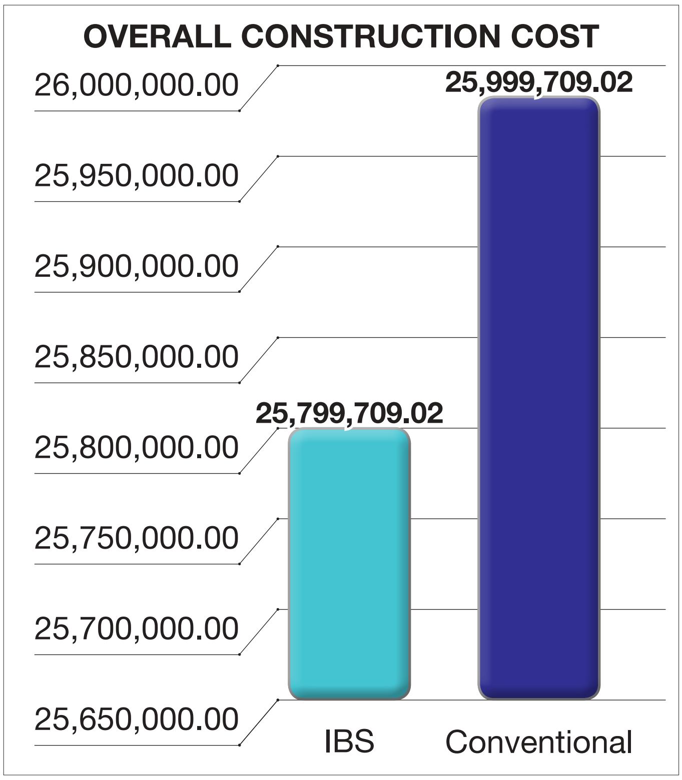
Figure 21: Cost Comparison for Each Block between Conventional System and IBS (Dwelling Unit)



As illustrated in Figure 21, the IBS-based construction cost for Block 5 (dwelling unit) was RM4,705,553.30 (conventional system: RM4,772,219.97); Block 6 was RM4,705,184.50 (conventional system: RM4,771,851.17), while that for Block 7 was RM4,769,614.46 (conventional system: RM4,836,281.12). As a whole, construction cost for the dwelling units of each of the three blocks was cheaper using the IBS method as opposed to the conventional system. The cost difference for both systems stood at RM66,666.67.

On a bigger picture, Figure 22 shows that the overall construction cost using the conventional system was RM25,999,709.02 while that leveraging IBS was RM25,799,709.02. Hence, it can be concluded that construction cost using the conventional system was higher than that using IBS. The cost differential was approximately RM200,000.00.

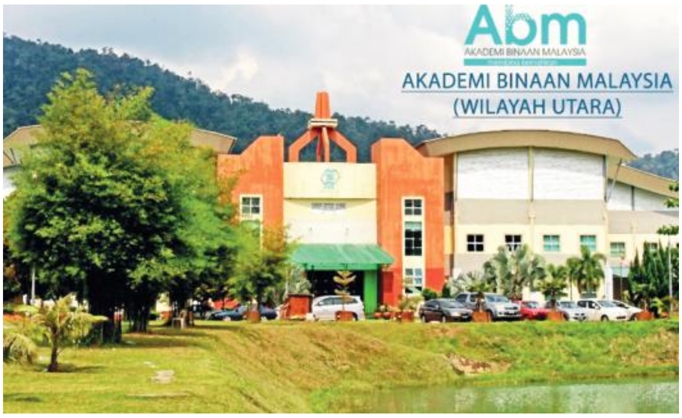
Figure 22: The Construction Cost Difference between the Two Systems



4.2.4 Akademi Binaan Malaysia (ABM), Sintok; Akademi Audit Negara (AAN), Nilai, and Pusat Automasi Industri, Bukit Jalil

Data collection for this research was carried out at the construction sites for the precast and cast-in-site (CIS) construction method as well as in the precast concrete factory. In this study, a number of sample data is collected from three construction sites located at Sintok, Kedah; Nilai, Negeri Sembilan, and Bukit Jalil, Selangor.

Figure 23: Akademi Binaan Malaysia (ABM) at Sintok, Kedah



Among these three sites, the first two were constructed using precast technology while the last one relied on the conventional cast-*in-situ* method.

The project at Sintok, Kedah – Akademi Binaan Malaysia – is an academic project under CIDB. At time of writing, the building is being constructed using both the precast and cast *in-situ* construction method. Five workshops of nearly the same size have been built using precast technology. The precast structural components used are beam, column, half slab, fast wall and staircase. Thus, data collection for this project places emphasis on the five workshops.

Figure 24: Akademi Audit Negara at Nilai, Negeri Sembilan

The project at Nilai, Negeri Sembilan – Akademi Audit Negara – is a training centre project under the National Audit Department. It was also built using two types of construction methods. A five-storey hostel was constructed using precast technology. The precast structural elements were beam, column, wall, slab, staircase and balcony.

For the cast *in-situ* project, data is collected at the project site at Pusat Automasi Industri in Bukit Jalil which is meant to house a laboratory building under SIRIM. The two-storey building was to be constructed using the conventional method.

Data collection would focus only on the four structural components that will be studied in this research, notably beam, column, wall, and slab. Comparison between labour productivity of these two constructions method is made according to the measurement factors. Results on the productivity performance of these three projects are as shown in Table 10.

As one can observe, comparisons are made in terms of man-hour per volume of concrete. This is given the unit of man-hour per volume of concrete is more suitable for comparison rather than work hours per volume of concrete. Man-hour takes into account the number of workers involved in each sub-task and their working hour. On the other hand, work-hour only considers the working hour of the day without looking into the number of workers involved. Thus, such comparison may not be suitable.

Under the cast *in-situ* construction method, productivity is mainly contributed by on-site construction. This is because the structures are constructed from the activity of formwork fabrication until such formwork activity ceases. These activities are mainly carried out at the construction site. On the hindsight, the material transportation or delivery of materials may not affect the productivity of cast *in-situ* method that much.

Table 10: Productivity Comparison between Cast *in-situ* and Precast Construction Method

ITEM	CONVENTIONAL	IBS	
Study site	**Pusat Automasi Industri**	**Akademi Binaan Malaysia**	**Akademi Audit Negara**
Construction productivity (man-hour/m³)	42.2	11.6	11.2
Number of workers	52	31	25
Machinery expenses at site (RM/month)	42,000	8,500	33,000

As shown in Table 10, the productivity factor can be compared in two ways: to include or exclude the cast *in-situ* transportation period. Initial findings revealed that productivity for both the precast constructed projects are better than the cast *in-situ* project. Between these two projects, Akademi Audit Negara (AAN) enjoyed a better productivity rate than Akademi Binaan Malaysia (ABM).

Yet, it is predicted that the ABM project will have a slightly higher productivity value than 24.1007 man-hour per m^3 as it is still an on-going project when the analysis and the report is prepared. Moreover, the topping productivity for the half slab has not been taken into account given the workers have not conducted such task at this project stage.

There is a big difference in terms of workforce requirement between cast *in-situ* and precast construction projects. As a rule of thumb, cast *in-situ* projects may require more workers compared to precast projects. Our site monitoring during this research further confirmed that cast *in-situ* does indeed require more workers. This is clearly demonstrated in Table 10 with Pusat Automasi Industri (constructed based on cast *in-situ* construction method) needing more workers compared to Akademi Binaan Malaysia and Akademi Audit Negara (constructed based on precast method).

Skilled workers such as bar benders, carpenters and operators are in great demand during a cast *in-situ* project undertaking. As for a precast project, the workers engaged in precast factories are mostly semi-skilled or unskilled (except for the installer who are either skilled or semi-skilled). Apparently, monthly expenses in terms of labour wages for cast *in-situ* tend to be double that of precast project.

Nevertheless, it is difficult to compare the cost of machinery for cast *in-situ* and precast projects. This is because most of the machinery involved in the production of precast components in a precast factory are owned by the factory as an initial investment. Thus, a comparison of machinery cost can only be based on the equipment found at construction sites.

Apparently, the cast *in-situ* machinery cost at site is much higher than those two precast sites. This is because it involves lots of machinery such as excavators, cranes, backholes and breakers in addition to labour and machinery costs as well as expenses incurred from delivery of precast components to the construction site. Based on information gathered from the ABM project, the transportation cost of one lorry (one-trip-to-and-from-site) for the delivery of nearly 20 tonnes of precast component is around RM400.

4.2.5 Two Apartment Units (1,000 sq ft/unit)

The case study for productivity comparison between IBS and conventional construction

Figure 25: Two Apartment Units (1,000 sq ft/unit) – A project by Setia Precast

is provided by Setia Precast. The case study featured two apartment units of 1,000 sq ft which were constructed using precast column, beam and panel (Figure 25). A comparison of the construction process (using both conventional and IBS method) is shown on Table 11. As one can observe, there is a 40% reduction in terms of labour intensity – from 108 man-day needed for cast *in-situ* construction to 65 man-day in precast construction.

Table 11: Productivity Comparison between Cast *in-situ* and Precast Construction Method

CONVENTIONAL			
Column (23 units)	Carpenters	9p x 1 day	9MD
	Bar Benders	7p x 1 day	7MD
	Concretors	5p x 0.5 day	2.5MD
Beam/Slab (174MR/185m²)	Carpenters	9p x 3 days	27MD
	Bar Benders	7p x 2 days	14MD
	Concretors	5p x 0.5 day	2.5MD
Brickwalls/ Plastering (223m²/4,4446m²)	Brickwall	6p x 3 days	18MD
	Plasters (Ext & Int)	8p x 3 days	24MD
	Electrician	4p x 1 day	4MD
M&E Works		**Total**	**108MD**

IBS			
Production (52 m³ – 2units/day)	Mould setting, rebar setting, concreting, touch-up, panel dispatch	30p x 1 day	30MD
Panel transportation (65pcs – 2 units/day)	Trailer operators	3p x 1.5 day	4.5MD
Panel erection (65pcs – 2 units/day)	Foreman, rigger, installers, welders, mortar setting	8p x 1.5 day	12MD
Typical floor slab (185 m² – 3 days)	Carpenters	5p x 1.5 days	7.5MD
	Rebar	4p x 1 day	4MD
	Concretors	6p x 0.5 day	3MD
Sealant (2 units/day)	Sealant applicators	2p x 1 day	2MD
Electrician (at PC Yard)	Semi skill workers	2p x 1 day	2MD
		Total	**65MD**

P= Person; MD= Man-day

CHAPTER 5
HYPOTHETICAL STUDY

WHILE previous case studies have provided substantial inputs on comparison between IBS and the conventional construction method, limitation abounds. First and foremost, these case studies do not provide comprehensive comparison between both construction methods. In view of limited information, these studies present only certain scopes of comparison – be it on labour productivity, period of construction, or cost of building materials.

None of them is able to provide a complete cost comparison between IBS and conventional construction. Besides, some of these case studies are not conducted on an "apple-to-apple" basis, i.e. they tend to compare different projects with different construction methods. As such, a hypothetical study is proposed and undertaken in this chapter.

In fact, only a hypothetical study is able to provide alternative insight into what is deemed as cost-effectiveness. This is made possible by looking into a building which is designed with the construction cost estimated by several scenarios based on (i) fully conventional method; (ii) partial IBS construction, and (iii) fully IBS construction. The whole process of this exercise is treated as the actual construction practice – be it during the design and cost estimation stage – with the only difference being the building is never built.

5.1 Background of Study

The undertaken hypothetical study is a high-rise residential building (condominium) located

Figure 26: 240 Units of Residential Building at Jalan Chan Sow Lin, Kuala Lumpur

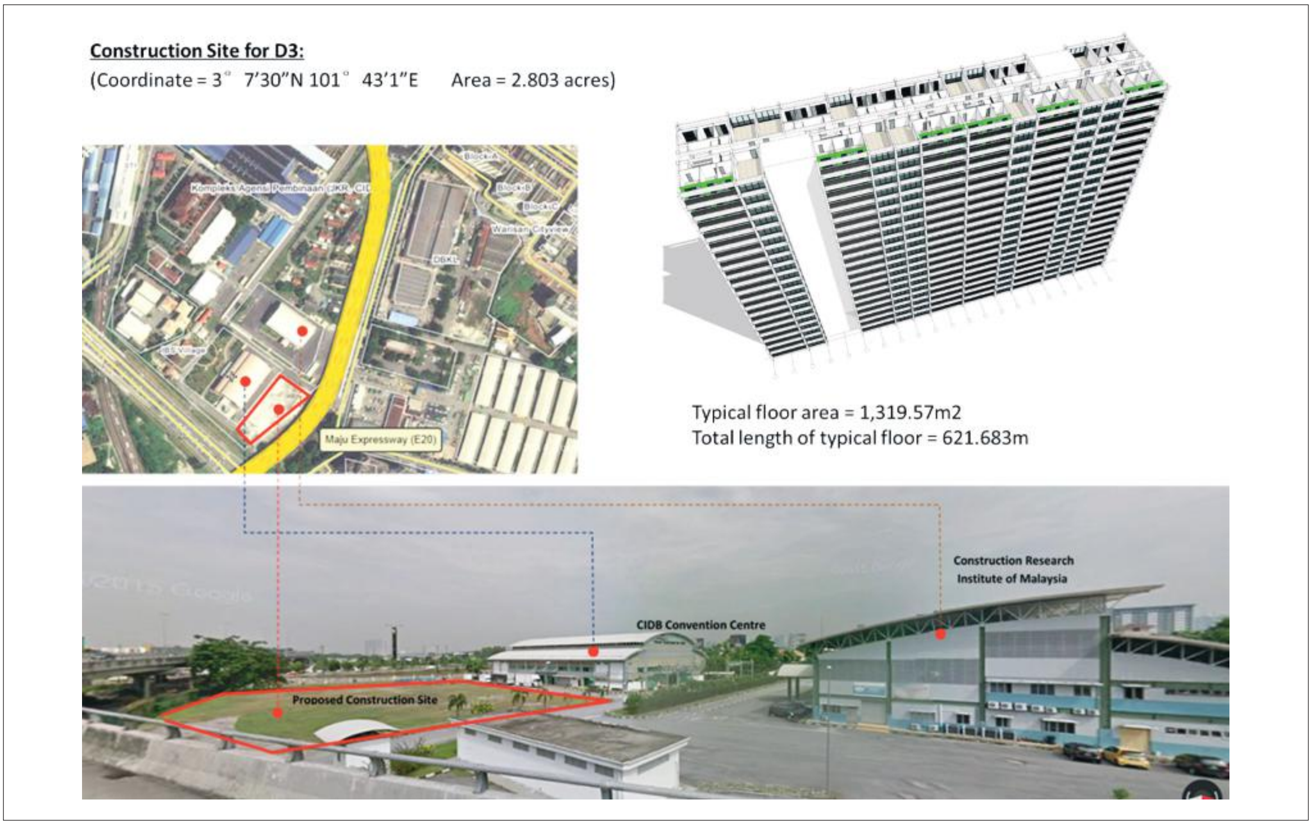
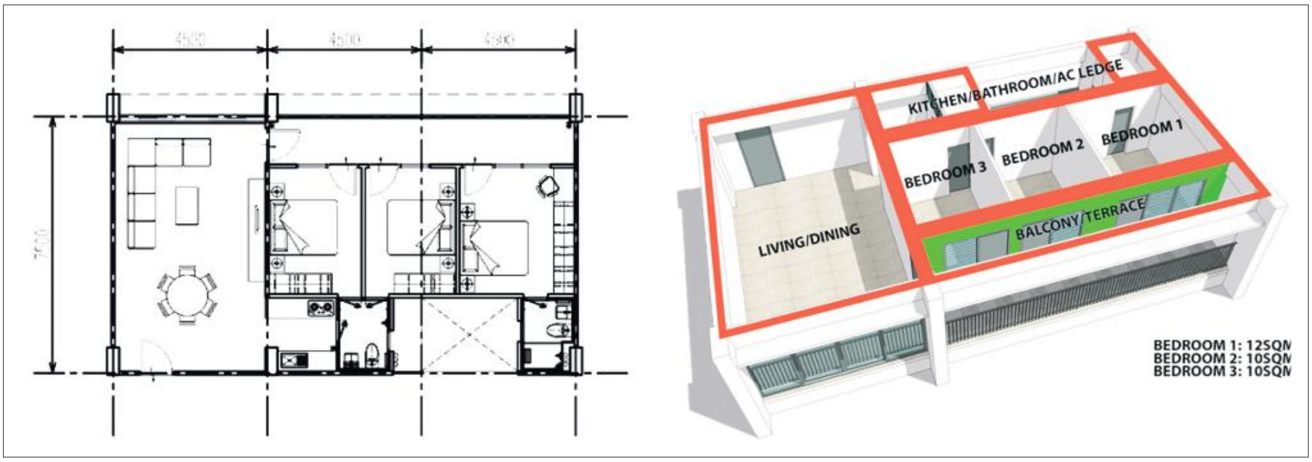


Figure 27: Layout of Typical Unit



at Jalan Chan Sow Lin, Kuala Lumpur, with a typical floor area 1,319.57m² (Figure 26). Details of the condominium project are as shown below:

- Unit size = 1,000 sq ft
- No of units/floor = 12 units
- Total number of floor = 20 floors
- Total number of units = 240 units
- Floor-to-floor height = 3,150mm

The layouts of the typical unit and typical floor are provided in Figure 27 and Figure 28, respectively.

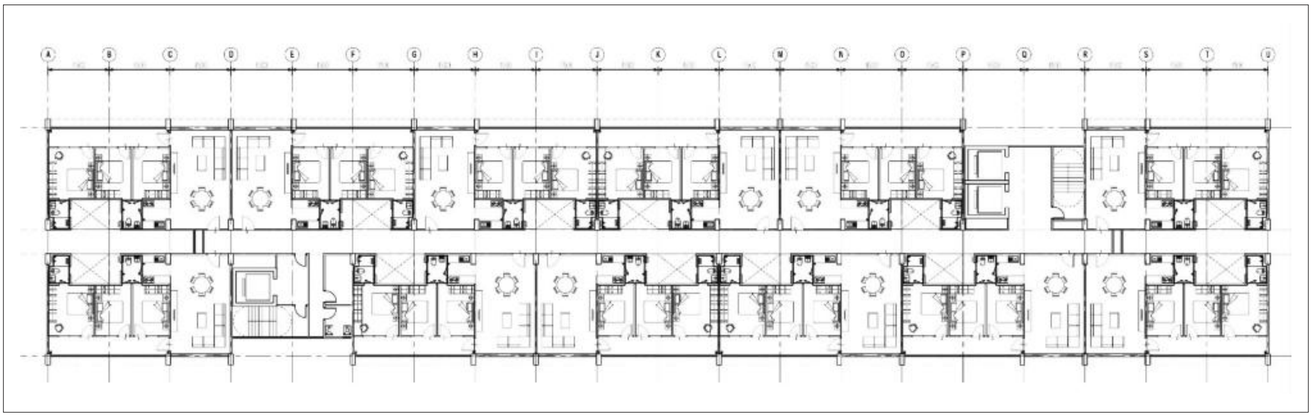
5.1.1 Conception of Design

Flexibility – a design approach which has been widely assimilated in the vernacular architecture – is adopted as an inherent design strategy for this hypothetical study.

Flexibility refers to the idea of accommodating changes over time (Siddharth and Ashok, 2012). It is an innovative approach to architectural design that enables facilities to be retrofitted quickly, economically and repeatedly. The concept of flexibility has long been a hallmark of office and commercial spaces design.

In line with the new trend of residential housing design, the concept of flexibility is further intensified in the design of housing given the concept of housing in the present day does not longer entail housing one family or group of occupants over their lifecycle, but also allowing new residents to adapt the dwelling to their needs, or to allow a suitable mix of dwelling exists in an ever-changing environment.

Figure 28: Layout of Typical Floor



Flexibility in the context of housing is represented by comprehensive research on cases in the European context beginning from the early 20th century (Siddharth and Ashok, 2012). According to Schneider and Till (2007) who introduce “flexible housing” by providing a criticism on the current condition of housing in the UK, housing flexibility addresses a number of issues related to the current and future needs of the users as it (i) offers variety in the architectural layout of the units; (ii) includes adjustability and adaptability of housing units over time, and (iii) allows buildings to accommodate new functions.

To ensure the designed housing is an attractive option for the average family, the provision of architectural flexibility is essential (Singh et al., 1999). Since each dwelling unit is a primary structure that would contribute to the quality of life through its flexible organisation – and the root causes leading to housing quality problem are identified as issues related to housing layout and design, surrounding environment, maintenance, location, amenities and building material – flexibility should be reflected as much as possible within all aspects of the housing type (Živković and Jovanović, 2012).

According to Friedman and Krawitz (1998), elements to be considered for a flexible housing should include (i) the composition of the varied households within the single structure; (ii) the choice of components that are available, and (iii) the ability to make future modifications with minimal inconvenience. In other words, each dwelling unit should be designed in such a way that it is economically and easily adjustable, while adheres to the context of contemporary technology, tropical adaptation, and cultural responses.

The key design element is the realisation that lifestyle – as one of the defining characteristics of peoples’ lives as citizens, consumers and householders – is a feature that shifts in accordance with a dynamic lifecycle process. A home that can be altered with minimum effort and expense at a time of change in the lives of its owners, whether through such a minor intervention as the re-arrangement of furniture in a non-restrictive space or through more vigorous modification such as the relocation of living or storage spaces, is a home that evolves with the lifecycles of its household rather than becoming rigidly obsolete in the conventional manner (Friedman and Krawitz, 1998).

Figure 29: Design Approach for Hypothetical Study

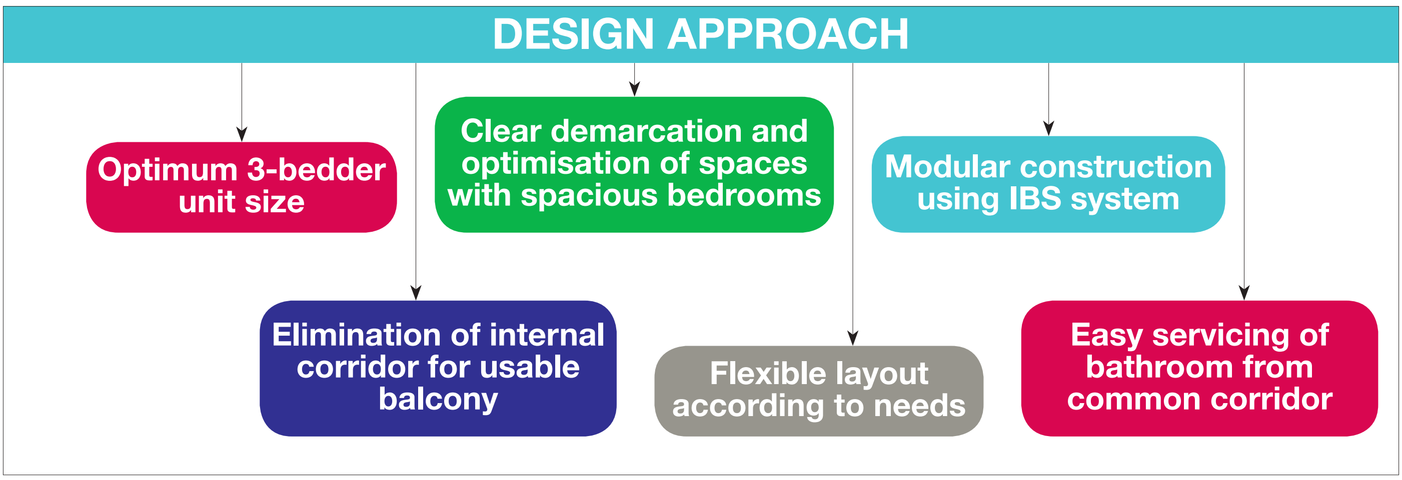
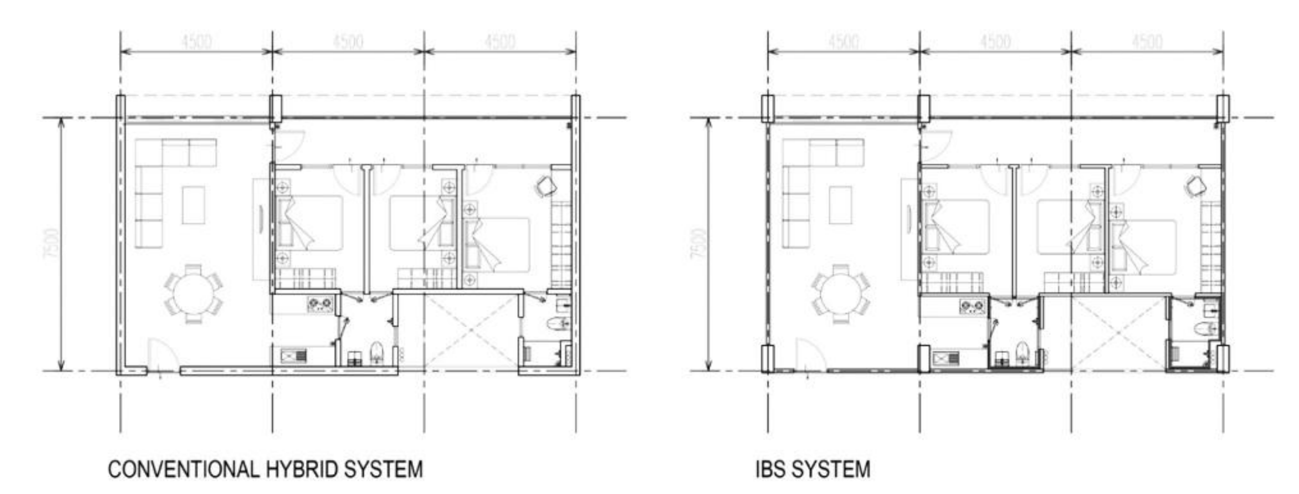


Figure 30: Layout Adjusted to IBS and Conventional Construction



In our case, the six design strategies adopted in this hypothetical study are highlighted as follow:

5.1.2 Scenario for Comparative Study

In order to provide a comprehensive study on construction cost estimation, the layout on Figure 30 is adjusted to suit both the IBS and conventional construction. The proposed materials for both construction approaches are listed in Table 12. Moreover, three scenarios are created to examine how the construction cost varies with different degree of prefabrication level. Table 13 summarises the three scenarios for the comparative study.

5.2 Calculation of IBS Score

For each scenario determined in the previous section, the respective IBS scores are calculated based on the formula discussed in Chapter 3. Scenario 1 is representative of the common construction practice currently adopted by most of the contractors in Malaysia when

Table 12: Proposed Materials Used for IBS and Conventional Construction

ITEM	CONVENTIONAL HYBRID SYSTEM	IBS SYSTEM
Structural System	Shear wall, column and beam	Modular precast column and beam
Floor System	150mm cast *in-situ*	150mm thk 600mm wide hollow core slab
Wall System	150mm brick wall with two-sided plastering	100mm thick 1,200mm wide precast concrete panel with 2mm skim coat
Bathroom	On-site wet construction	Prefabricated bathroom pod completed with finishes and appliances
Window & Door	Non-standard sizing	Standardised modular sizing
Other Features	On-site staircase casting	Precast staircase and shaft

Table 13: Three Scenarios for Comparative Study

NO	ITEM	SCENARIO 1 (CONVENTIONAL HYBRID SYSTEM)	SCENARIO 2 (PARTIAL IBS SYSTEM)	SCENARIO 3 (FULL IBS SYSTEM)
1	**Structural System**	Metal formwork shear wall, *in-situ* column and beam	Metal formwork shear wall, *in-situ* column and precast beam	Modular precast column and beam
2	**Floor System**	150mm thk cast *in-situ* (metal formwork)	150mm thk cast *in-situ* (metal formwork)	150mm thk 600mm wide hollow core slab
3	**Wall System**	150mm brickwall with two-sided plastering	100mm thk 1,200mm wide precast concrete panel with 2mm skim coat	100mm thk 1200mm wide precast concrete panel with 2mm skim coat
4	**Bathroom**	On-site wet construction	On-site wet construction	Prefabricated bathroom pod completed with finishes and appliances
5	**Window & Door**	Non-standard sizing	Standardised modular sizing	Standardised modular sizing
6	**Other Features**	On-site staircase casting	On-site staircase casting	Precast staircase and shaft

Table 14: IBS Score Calculation for Scenario 1

Scope	Element	IBS Score
Structural system	*In-situ* concrete column & beam with reusable formwork	25
Wall system	*In-situ* concrete slab with reusable formwork	5.1
	In-situ concrete wall with reusable formwork	
	Common brick wall	
Other simplified construction solution	Standardised components based on MS1064	10
	Repetition of structural layout	
	TOTAL	**40.1**

constructing high-rise residential building. The resulting IBS score for this scenario is 40.1 (Table 14). As for Scenario 2, the purpose is to show how IBS score can be increased by adding more components that fulfill the requirement of MS1064 as well as changing the wall system from cast *in-situ* shear wall to precast concrete panel.

As a whole, the bathroom areas are still constructed using cast *in-situ* approach. As one can observe, the IBS score for Scenario 2 has

Table 15: IBS Score Calculation for Scenario 2

SCOPE	ELEMENT	IBS SCORE
Structural system	*In-situ* concrete column & beam with reusable formwork	30
Wall system	*In-situ* concrete slab with reusable formwork	14.9
	In-situ concrete wall with reusable formwork	
	Common brick wall	
Other simplified construction solution	Standardised components based on MS1064	16
	Repetition of structural layout	
	TOTAL	**60.9**

Table 16: IBS Score Calculation for Scenario 3

SCOPE	ELEMENT	IBS SCORE
Structural system	*In-situ* concrete column & beam with reusable formwork	50
Wall system	*In-situ* concrete slab with reusable formwork	20
	In-situ concrete wall with reusable formwork	
	Common brick wall	
Other simplified construction solution	Standardised components based on MS1064	30
	Repetition of structural layout	
	TOTAL	**100**

risen to 60.9 (Table 15). Meanwhile, Scenario 3 is hypothesised as a full IBS construction in which all the structural and wall systems are precast. The modular bathroom is proposed in this scenario. Since Scenario 3 is an extreme case with full prefabrication construction, its IBS score is 100 (Table 16).

5.3 Results and Findings

With the establishment of building design, material uses, and construction methods, the estimation of cost structure for each scenario is conducted. For reference, the quotation for precast column, beam, and slab is obtained from Alloy Mtd Sdn Bhd while that for the Acotect Wall Panel is obtained from Acotect Sdn Bhd. The quotation for toilet pod is obtained from Bronte Attic (M) Sdn Bhd.

The duration of both IBS and conventional construction was estimated through interviews with the contractor and project manager by determining the most accurate duration of sub-structure construction, super structural erection, and finishing work. The duration of sub-structure was the same as conventional construction because the same method is used in prefabrication construction.

However, the super structure in IBS construction is due for completion earlier when compared to conventional construction as the project duration of super structure has a huge variation and is an advantage to IBS construction. The wall and slab, as well as beam and column are manufactured in factory and installed on site, thus reducing the duration of super structure construction. IBS construction requires less time duration in finishing works when compared to conventional construction primarily because the electrical piping works were already fitted in precast walls and slabs.

The fact that plastering work is no longer needed for precast elements also help save some time and construction cost during the finishing stage. As a whole, the duration of construction for Scenarios 1, 2, and 3 are expected to take 24 months, 20 months and 18 months, respectively. Details of cost structure estimation are given in Appendix 1, while summary of cost comparison for the three scenarios is presented in Table 17. Based on the present study on 240 units of dwellings, the construction cost leveraging full IBS system is the cheapest. Partial IBS system, as reflected in Scenario 2, costs the highest. Additionally, obvious declining trends are observed for Preliminaries, Finishes, and

Table 17: Building Cost Comparison

ITEM	SCENARIO 1	SCENARIO 2	SCENARIO 3
IBS Score	40.1	60.9	100
Construction Period	24 months	20 months	18 months
COST BREAKDOWN	**(RM)**	**(RM)**	**(RM)**
PRELIMINARIES	**1,296,388**	**1,125,107**	**1,009,914**
SUBSTRUCTURE	**5,950,232**	**5,950,232**	**5,950,232**
• Piling works	4,223,000	4,223,000	4,223,000
• Work Below Lowest Floor Level (WBLFL)	1,727,232	1,727,232	1,727,232
SUPERSTRUCTURE	**17,162,385**	**18,380,941**	**16,769,364**
• Frame	3,219,306	3,802,030	4,970,418
• Upper floor	3,905,221	3,905,221	4,832,755
• Roof	687,500	687,500	687,500
• Stair & Ramps	360,000	360,000	360,000
• External wall	5,158,005	5,446,141	2,887,236
• Windows & external door	1,377,996	1,277,420	1,277,420
• Internal walls & partitions	2,084,204	2,558,629	1,506,035
• Internal doors	370,152	344,000	248,000
FINISHES	**5,766,688**	**4,978,039**	**3,269,757**
• Internal floor finishes	1,539,210	1,539,210	1,407,630
• Internal wall finishes	2,307,408	1,886,460	553,760
• Internal ceiling finishes	389,826	389,826	361,962
• External finishes	1,530,244	1,162,543	946,405
SANITARY FITTINGS	**816,000**	**816,000**	**3,880,800**
Mechanical & Electrical Services	**6,198,338**	**6,150,000**	**6,000,000**
TOTAL BUILDING COST	**37,190,030**	**37,400,318**	**36,880,066**
Cost per sq ft	**129.00**	**130.00**	**128.00**

Table 18: Decreasing Cost with Increasing IBS Score

SCOPE OF WORK	AMOUNT (RM)		
ITEM	SCENARIO 1	SCENARIO 2	SCENARIO 3
Performance Bond	10,000.00	12,000.00	14,000.00
Contractor's All Risk	29,888.00	30,181.00	30,171.00
Workmen's Compensation	56,040.00	46,700.00	42,030.00
CIDB Levy	46,700.00	-	-
Samples	25,000.00	20,000.00	15,000.00
Testing	25,000.00	15,000.00	10,000.00
Contractor's Office, Storage, Welfare and Site Accommodation	250,000.00	200,000.00	150,000.00
Watching and Lighting	36,000.00	30,000.00	24,000.00
Light and Power	31,200.00	26,000.00	20,800.00
Water for Works	31,200.00	26,000.00	20,800.00
Plant and Machinery	150,000.00	130,000.00	110,000.00
Mosquito Prevention	8,400.00	7,000.00	5,600.00
Safety of Site	36,000.00	30,000.00	24,000.00
Progress Report	4,800.00	4,000.00	3,600.00
Progress Photograph	6,000.00	5,000.00	4,000.00
Site Meetings	4,800.00	4,000.00	3,200.00
Shop Drawing	10,000.00	8,000.00	6,000.00
Dust Prevention	10,000.00	8,000.00	6,000.00
Removing of Rubbish	8,000.00	7,000.00	6,000.00
Stamping of Main Contract Documents	37,360.00	37,726.00	37,713.00
Leave Works Perfect	10,000.00	8,500.00	7,000.00
TOTAL	**826,388.00**	**655,107.00**	**539,914.00**

Mechanical & Electrical Services with increasing IBS score (intangible benefits of using IBS are reflected in Preliminaries).

Previous studies could not capture the intangible benefits contributed by IBS construction because the costs of some of the activities under the scope of preliminaries were not adjusted according to the reduction of construction period. By reducing construction period through the adoption of IBS, intangible benefits are realised, thus can be monetised. Intangible benefits of using IBS include:

- Site cleanliness
- Low wastage
- Less labour intensive

In fact, activities under the scope of preliminaries can be divided into two categories based on their nature of consistency. For example, activities where costs are consistent regardless of the construction method include:

- Soil investigation
- Work programme
- Temporary scaffolding

- Temporary sign board
- Hoarding
- Keeping site dry
- Safety helmet and boots
- First aid kit
- Preservation of earth slopes and adjoining property
- Contract documentation charges
- Built drawing

Meanwhile, there are certain activities whereby the cost varies with the period of construction or influenced greatly by the adopted construction approach (be it IBS or conventional construction). Table 18 shows the list of these activates with the varying cost under each scenario. As one can observe, there is a cost saving of 34.7% or an equivalent value of RM286,474 from Scenario 1 to Scenario 3 by shifting from conventional construction practice to full IBS construction.

A detailed illustration on the cost structure is given in Figure 31. The total cost is divided into six categories:

- Preliminaries
- Substructure
- Superstructure
- Finishes
- Sanitary fittings
- Mechanical & electrical services

As one can observe, three main categories are driving down the construction cost, namely

Figure 31: Building Cost Analysis

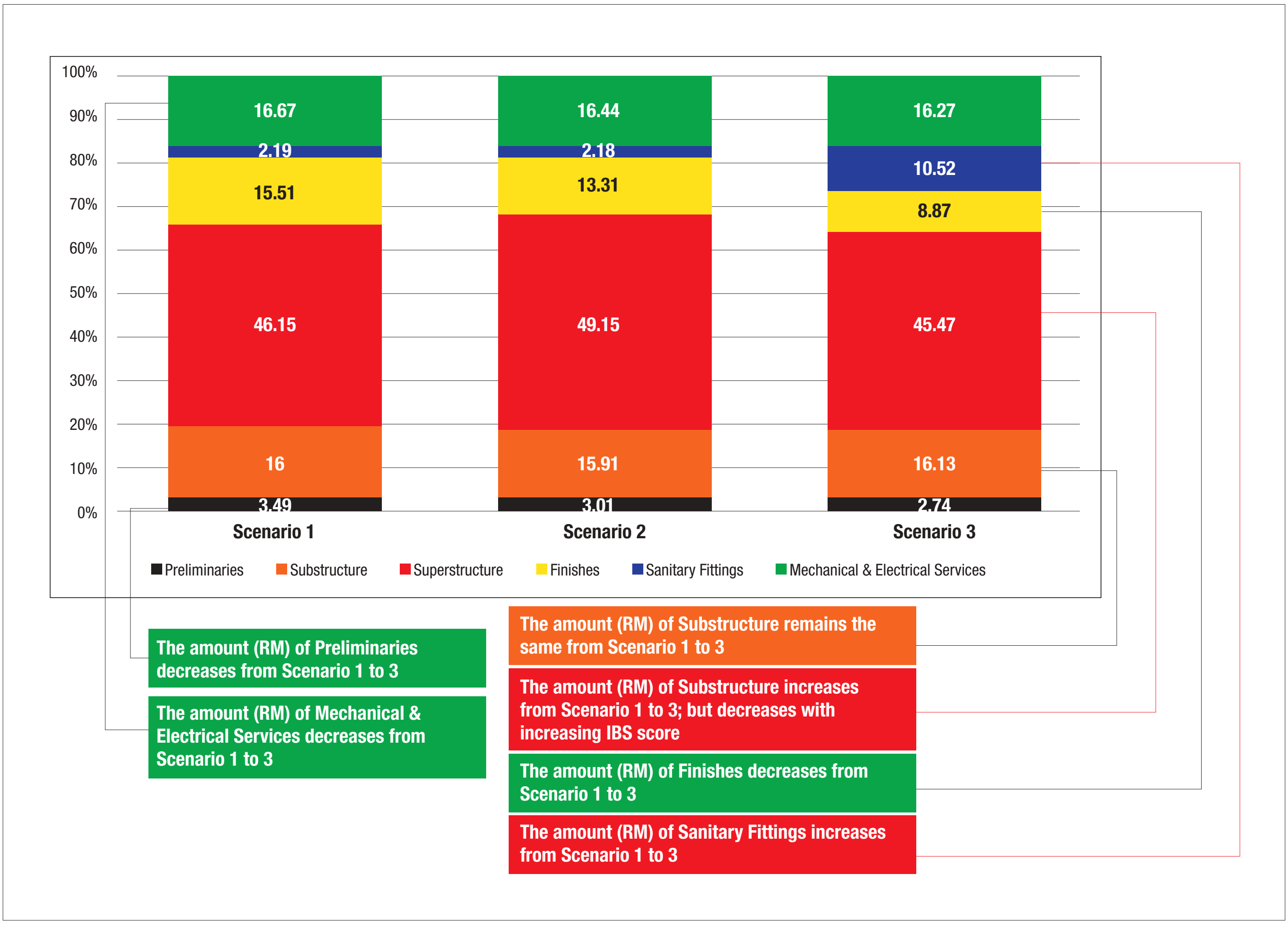


Table 19: Cost Structure for Sanitary Fittings

ELEMENT	CONVENTIONAL BATHROOM		BATHROOM POD	
Wall Finishes	RM	1,576.80	RM	-
Floor Finishes	RM	274.13	RM	-
Celling Finishes	RM	58.05	RM	-
Door and window	RM	877.20	RM	-
Sanitary fittings	RM	1,515.20	RM	-
All-in bathroom pod	RM	-	RM	7,900.00
TOTAL COST PER UNIT	**RM**	**4,301.18**	**RM**	**7,900.00**

preliminaries; mechanical & electrical services, and finishes. The cost for finishes are declining substantially from Scenario 1 to Scenario 3 due mainly to advantages offered by the IBS construction method. Better cost efficiencies and less wastage are achieved given most of the required components are built in factories under stricter norms using cutting edge technology.

As in the case of superstructure and sanitary fittings, cost tends to increase with rising IBS score. Costs for sanitary fittings (bathroom) is the highest in Scenario 3 due to the relatively higher build-up rate of a unit of modular bathroom

Table 20: Build-up Rate for Wall System

METHOD OF CONSTRUCTION	ACOTECT WALL PANEL		CEMENT BRICKWALL	
MATERIAL COST				
Acotec Panel	RM	63.50	RM	-
Cement brick	RM	-	RM	35.33
Cement san (1:6) plastering	RM	-	RM	2.84
Weathershield Paint	RM	2.82	RM	2.82
	RM	66.32	RM	40.99
LABOUR COST				
Installation/laying bricks	RM	12.00	RM	14.09
Plastering	RM	-	RM	7.75
Painting	RM	0.85	RM	0.85
	RM	12.85	RM	22.69
15% overhead and profit	RM	11.88	RM	9.55
COST PER M²	**RM**	**91.05**	**RM**	**73.24**

as compared to cast *in-situ* bathroom. However, the cost of modular bathroom is believed to be at par or substantially reduced if there is a mass volume such as 1,000 units and above. Table 19 shows the breakdown of cost structure for sanitary fittings.

In the case of superstructure, the cost can be analysed by a breakdown into wall, slab and beam & column. Based on the build-up rate calculation for 1m² of wall, the cost for precast concrete panel is higher than the common brick wall due to higher material cost as indicated in Table 20. Nevertheless, the labour cost for precast concrete panel is lower than the common brick wall. For reference, the cost for internal wall & partition, and external wall for Scenario 2 are the highest among the three scenarios. But such costs are substantially reduced when IBS is fully adopted.

Based on the build-up rate shown in Table 21, the cost for cast *in-situ* column is cheaper than precast column due to the relatively higher material cost. However, the labour cost for precast column is relatively lower than the cast *in-situ* column. A similar circumstance happens to the slab as shown in Table 22 whereby the build-up cost rate which takes into account the cost for cast *in-situ* slab is cheaper than its precast counterpart due to the latter's relatively higher material cost. Nevertheless, the labour cost for precast slab is relatively lower than the cast *in-situ* slab.

Table 21: Build-up Rate for Beam and Column

METHOD OF CONSTRUCTION	PRECAST COLUMN		PRECAST BEAM		CAST *IN-SITU* COLUMN/BEAM	
MATERIAL COST						
Concrete	RM	-	RM	-	RM	306.67
Reinforcement	RM	-	RM	-	RM	367.50
Formwork	RM	-	RM	-	RM	522.42
Percast	RM	1,473.92	RM	1,657.85	RM	-
	RM	1,473.92	RM	1,657.85	RM	1,196.59
LABOUR COST						
Laying concrete	RM	-	RM	-	RM	23.75
Bending/laying reinforcement	RM	-	RM	-	RM	53.20
Installation of formwork	RM	-	RM	-	RM	-
To install the precast	RM	35.15	RM	31.07	RM	
	RM	35.15	RM	31.07	RM	76.95
15% overhead and profit	RM	9.55	RM	253.34	RM	191.03
COST PER M³	**RM**	**1,735.43**	**RM**	**1,942.26**	**RM**	**1,464.57**

Table 22: Build-up Rate for Slab

METHOD OF CONSTRUCTION	PRECAST SLAB		CAST *IN-SITU* SLAB	
MATERIAL COST				
Concrete	RM	-	RM	62.93
Reinforcement	RM	-	RM	24.15
Formwork	RM	-	RM	47.00
Percast	RM	155.00	RM	-
	RM	155.00	RM	134.08
LABOUR COST				
Laying concrete	RM	-	RM	7.10
Bending/laying reinforcement	RM	-	RM	2.00
Installation of formwork	RM	-	RM	17.34
To install the precast	RM	14.00	RM	-
	RM	14.00	RM	26.44
15% overhead and profit	RM	25.35	RM	24.08
COST PER M²	**RM**	**194.35**	**RM**	**184.61**

CHAPTER 6
CONCLUSION

In essence, shifting from common construction practice to full IBS can contribute to a saving of 0.83% of the total building cost. On the same note, construction period can be reduced from 24 months to 18 months. Intangible benefits from applying IBS can be reflected in the cost of Preliminaries whereby there is a saving of 34.7% by shifting from common construction practice to full IBS construction.

Figure 32: Plot of Unit Construction Cost vs. IBS Score

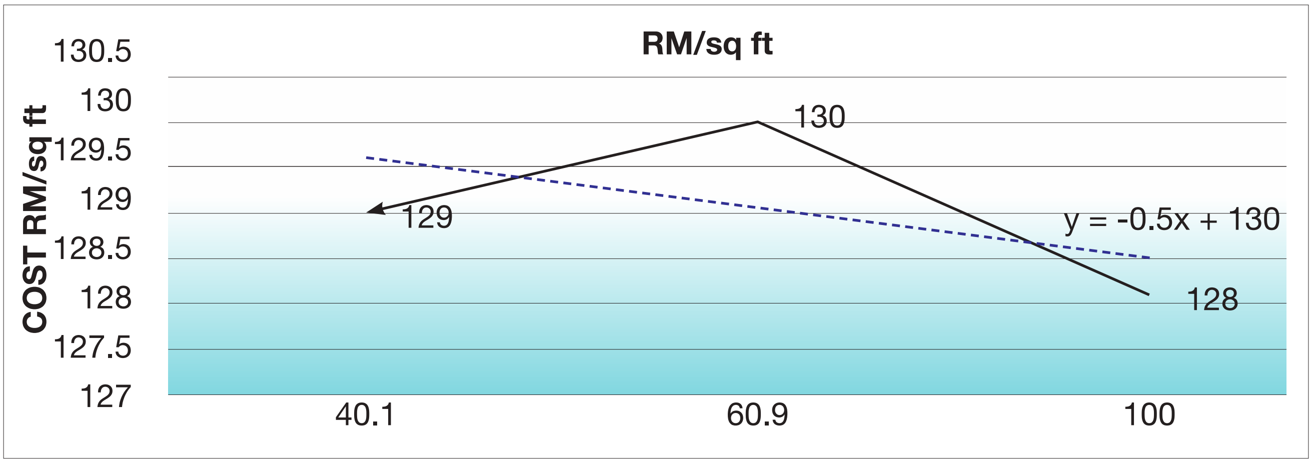


Table 23: Summary of Key Findings

ELEMENT	SCENARIO 1	SCENARIO 2	SCENARIO 3
IBS Score	40.1	60.9	100
TOTAL BUILDING COST (RM)	37,190,030	37,400,318	36,880,066
Cost per sq ft	129	130	128
Construction period	24 months	20 months	18 months

REFERENCES

Abdul Kadir, M.R., Lee, W.P., Jaafar, M.S., Sapuan, S.M. and Ali, A.A.A. (2005). “Performance Comparison between Structural Elements of Building Systems in Malaysia”. In *American Journal of Applied Sciences*, 2(5): 1014-1024.

Abdul Kadir, M.R., Lee, W.P., Jaafar, M.S., Sapuan, S.M. and Ali, A.A.A. (2006). “Construction Performance Comparison between Conventional and Industrialised Building in Malaysia”. In *Structural Survey*, 24(5): 412-424.

Azman, M.A, Nawi, M.N, Kamar, K.A, Hamid Z.A (2013). “Kajian Terhadap Penggunaan IBS dalam Projek Swasta di Kawasan Lembah Klang”*. Jurnal Teknologi*. 65:1 (2013) 9-15 www.jurnalteknologi.utm.my | eISSN 2180–3722 | ISSN 0127–9696.

Azman (2014). “Increasing Construction Value Added: A Malaysian Case study”. Faculty of Architecture Building and Planning, The University of Melbourne.

Badir, Y.F., Kadir, M.R.A. and Ali, A.A. (2006), “Construction Performance Comparison between Conventional and Industrialised Building Systems in Malaysia”. In *Bulletin of Institution of Engineers, Malaysia*, Vol. 24 No. 5, pp. 412-424.

Chan. T (2011). *Comparison of Precast Construction Costs-Case Studies in Australia and Malaysia*. In 27th Annual ARCOM Conference, pp. 5-7, September 2011.

CIDB (2004). *Industrialised Building Systems (IBS) Roadmap 2003-2010*. Kuala Lumpur, Malaysia.

CIDB (2007). *Construction Industry Master Plan 2006-2015*. Kuala Lumpur.

CIDB (2008). *Malaysia Report*, Construction Industry Development Board (CIDB), Asia Construct Conference.

CIDB Singapore (1992). “Raising Singapore’s Construction Productivity”. In *CIDB Construction Productivity Taskforce Report*, CIDB Singapore.

Construction Research Institute of Malaysia (CREAM) (2011). *Report on the Current State of Local and Foreign Workforce in Malaysian Construction Site: Building Projects*.

Foo, C.H., Hamid, Z.A., Din, M.I. and Norman, M.R. (2015). “Study on Industrialised Building System (IBS): Adoption Level and Contractors’ Readiness in Malaysia 2013”. In *Malaysian Construction Research Journal (MCRJ)*, 17(2), 1-19.

Friedman, A. and Krawitz, D. (1998). “The Next Home: Affordability through Flexibility and Choice. In *Housing and Society*, 25(1 & 2), 103-116.

Hamid, Z.A., Foo, C.H. and Ahmad Hazim, A.R. (2017). “Retrospective View and Future Initiatives in Industrialised Building Systems (IBS) and Modernisation, Mechanisation and Industrialisation (MMI). In K.S. Elliott & Z.A. Hamid (Eds.), *Modernisation, Mechanisation & Industrialisation of Concrete Structures* (pp 424 – 452). Wiley Blackwell.

Haron, N.A. (2005). *Building Cost Comparison between Conventional and Formwork System: A Case Study of Four-Storey School Buildings in Malaysia*. American Journal of Applied Sciences, vol. 2(4), pp.819-823.

Ismail, E. (2001). “*Industrialised Building System for Housing in Malaysia*”, paper presented at The Sixth Asia-Pacific Science and Technology Management Seminar, Tokyo, November 2001.

Institute of Engineer Malaysia (IEM) (2001). “A Need for New Building Technologies”. In *Bulletin of Institution of Engineers, Malaysia*, February, pp. 7-8.

Junid, S.M.S. (1986). *Industrialised Building System*. Proceedings of a UNESCO/FEISEAP Regional Workshop. Serdang: Universiti Putra Malaysia.

Lim, E. C.; Alum, J. (1995). *Construction Productivity: Issues Encountered by Contractors in Singapore*. International Journal of Project Management, 13(1), p. 51-58.

Kamar, K. A. M., Alshawi, M. and Hamid, Z. A. (2009*). Barriers to Industrialized Building Systems: The Case of Malaysia*. Paper proceedings in BuHu 9th International Postgraduate Research Conference (IPGRC 2009), The University of Salford, 29-30 January 2009, Salford, United Kingdom.

Khan, R.A. (2014). “*Malaysian Construction Sector and Malaysia Vision 2020: Developed Nation Status*”. Second World Conference on Business, Economics and Management (WCBEM 2013). Procedia – Social and Behavioural Sciences 109 (2014). 507-513. Elsevier.

Lai, K. W. (2005). *Construction Labour Productivity Study for Conventional Cast In-Situ and Precast Construction Methods,* Master of Science thesis, Malaysia University of Science and Technology, Malaysia.

Ministry of International Trade and Industry (MITI) (2014). *Malaysian Economy First Quarter 2014.* http://www.treasury.gov.my/pdf/ekonomi/suku_tahunan/sukutahun1_2014.pdf

M. Rahim, M. Syazwan, and N. A. Haron (2013). “Construction Cost Comparison between Conventional and Formwork System for Condominium Project”. In *International Journal of Advanced Studies in Computer Science and Engineering*, vol. 2(5), pp. 19-25.

M. Z. Ramli, H. M. Mahayudin, G. Hayder, Z. M. Hafiz, M. Daud, and A. M. Salleh (2014). “The Importance of Lightweight Concrete Technology Development for IBS Industry in Malaysia Based on Cost Comparison between Concrete Slab and Hollow Core Slab: A Case Study of LRT Car Park Project”. In *Applied Mechanics and Materials* vol. 567, pp. 637-641, June 2014.

Rahim. M, M. Syazwan, and N. A. Haron (2013). “Construction Cost Comparison between Conventional and Formwork System for Condominium Project”. In *International Journal of Advanced Studies in Computer Science and Engineering*, vol. 2(5), pp. 19-25.

Schneider, T., & Till, J. (2007). *Flexible Housing*. Oxford, United Kingdom: Architectural Press.

Siddharth, I. and Ashok, K. (2012). *Flexibility Concept in Design and Construction for Domestic Transformation*. Seventh International Conference on Innovation in Architecture, Engineering & Construction, 15-17 August 2012, Sao Paulo, Brazil.

Singh, A., Barnes, R. and Yousefpour, A. (1999). *High-Turnaround and Flexibility in Design and Construction of Mass Housing*. Proceedings IGLC-7, 26-28 July 1999, University of California, Berkeley, CA, USA.

The Star (2004). *Foreign Labour Dilemma*.

Y. F. Badir, M. R. A. Kadir, and A. H. Hashim (2002). “Industrialised Building System Construction in Malaysia.” In *Journal of Architectural Engineering*, vol. 8, No.1 (March 2002), pp. 19-23.

Yong, T. N. (2010). "Feasibility of Precast Concrete Construction System in Malaysia: A Comparative Study between Australia and Malaysia". In *Research Project Report,* The University of Melbourne, Australia.

Živković, M. and Jovanović, G. (2012). “A Method for Evaluating the Degree Of Housing Unit Flexibility in Multi-Family Housing.” In *Architecture and Civil Engineering*, 10 (1), 17-32.

APPENDIX 1

COMPARISON COST SUMMARY

GROSS FLOOR AREA : 26,391 m² 284,074 ft²

ELEMENT	CONVENTIONAL HYBRID SYSTEM				PARTIAL IBS SYSTEM				FULL IBS SYSTEM			
	RM	RATE/M² FLOOR AREA	RATE/SQ FT FLOOR AREA	% OF TOTAL COST	RM	RATE/M² FLOOR AREA	RATE/SQ FT FLOOR AREA	% OF TOTAL COST	RM	RATE/M² FLOOR AREA	RATE/SQ FT FLOOR AREA	% OF TOTAL COST
1 PRELIMINARIES	1,296,388	49.12	5.00	3.49	1,125,107	42.63	4.00	3.01	1,009,914	38.27	4.00	2.74
Group Elemental Total	**1,296,388**	**49.12**	**5.00**	**3.49**	**1,125,107**	**42.63**	**4.00**	**3.01**	**1,009,914**	**38.27**	**4.00**	**2.74**
2 SUBSTRUCTURE												
2.1 Piling Works	4,223,000	160.01	15.00	11.36	4,223,000	160.01	15.00	11.29	4,223,000	160.01	15.00	11.45
2.2 Work Below Lowest Floor Level	1,727,232	65.45	6.00	4.64	1,727,232	65.45	6.00	4.62	1,727,232	65.45	6.00	4.68
Group Elemental Total	**5,950,232**	**225.46**	**21.00**	**16.00**	**5,950,232**	**225.46**	**21.00**	**15.91**	**5,950,232**	**225.46**	**21.00**	**16.13**
3 SUPERSTRUCTURE												
3.1 Frame	3,219,306	121.98	11.00	8.66	3,802,030	144.06	13.00	10.17	4,970,418	188.33	17.00	13.48
3.2 Upper Floor	3,905,221	147.97	14.00	10.50	3,905,221	147.97	14.00	10.44	4,832,755	183.12	17.00	13.10
3.3 Roof	687,500	26.05	2.00	1.85	687,500	26.05	2.00	1.84	687,500	26.05	2.00	1.86
3.4 Stairs & Ramps	360,000	13.64	1.00	0.97	360,000	13.64	1.00	0.96	360,000	13.64	1.00	0.98
3.5 External Wall	5,158,005	195.44	18.00	13.87	5,446,141	206.36	19.00	14.56	2,887,236	109.40	10.00	7.83
3.6 Windows & External Door	1,377,996	52.21	5.00	3.71	1,277,420	48.40	4.00	3.42	1,277,420	48.40	4.00	3.46
3.7 Internal Walls & Partitions	2,084,204	78.97	7.00	5.60	2,558,629	96.95	9.00	6.84	1,506,035	57.07	5.00	4.08
3.8 Internal Doors	370,152	14.03	1.00	1.00	344,000	13.03	1.00	0.92	248,000	9.40	1.00	0.67
Group Elemental Total	**17,162,385**	**650.30**	**59.00**	**46.15**	**18,380,941**	**696.47**	**63.00**	**49.15**	**16,769,364**	**635.41**	**57.00**	**45.47**
4 FINISHES												
4.1 Internal Floor Finishes	1,539,210	58.32	5.00	4.14	1,539,210	58.32	5.00	4.12	1,407,630	53.34	5.00	3.82
4.2 Internal Wall Finishes	2,307,408	87.43	8.00	6.20	1,886,460	71.48	7.00	5.04	553,760	20.98	2.00	1.50
4.3 Internal Ceiling Finishes	389,826	14.77	1.00	1.05	389,826	14.77	1.00	1.04	361,962	13.72	1.00	0.98
4.4 External Finishes	1,530,244	57.98	5.00	4.11	1,162,543	44.05	4.00	3.11	946,405	35.86	3.00	2.57
Group Elemental Total	**5,766,688**	**218.51**	**19.00**	**15.51**	**4,978,039**	**188.62**	**17.00**	**13.31**	**3,269,757**	**123.89**	**11.00**	**8.87**
5 FITTINGS & FURNITURES												
5.1 Sanitary Fittings	816,000	30.92	3.00	2.19	816,000	30.92	3.00	2.18	3,880,800	147.05	14.00	10.52
Group Elemental Total	**816,000**	**30.92**	**3.00**	**2.19**	**816,000**	**30.92**	**3.00**	**2.18**	**3,880,800**	**147.05**	**14.00**	**10.52**
6 SERVICES												
6.1 Mechanical & Electrical Services	6,198,338	234.86	22.00	16.67	6,150,000	233.03	22.00	16.44	6,000,000	227.35	21.00	16.27
Group Elemental Total	**6,198,338**	**234.86**	**22.00**	**16.67**	**6,150,000**	**233.03**	**22.00**	**16.44**	**6,000,000**	**227.35**	**21.00**	**16.27**
TOTAL BUILDING COST	**37,190,030**	**1,409**	**129.00**	**100.00**	**37,400,318**	**1,417**	**130.00**	**100.00**	**36,880,066**	**1,397**	**128.00**	**100.00**
		129.00	Cost/ft²			**130.00**	Cost/ft²			**128.00**	Cost/ft²	

COMPARISON COST SUMMARY

PRELIMINARIES

	DESCRIPTION	UNIT	AMOUNT CONVENTIONAL SYSTEM	PARTIAL IBS SYSTEM	FULL IBS SYSTEM
A	Soil Investigation	Item	60,000.00	60,000.00	60,000.00
B	Performance Bond	Item	10,000.00	12,000.00	14,000.00
C	Contractor's all risk	Item	29,888.00	30,181.00	30,171.00
D	Workmen's Compensation	Item	56,040.00	46,700.00	42,030.00
E	CIDB Levy	Item	46,700.00	-	-
F	Work Programme	Item	20,000.00	20,000.00	20,000.00
G	Samples	Item	25,000.00	20,000.00	15,000.00
H	Testing	Item	25,000.00	15,000.00	10,000.00
J	Contractor's Office, Storage, Welfare and Site Accomodation	Item	250,000.00	200,000.00	150,000.00
K	Temporary Scaffolding	Item	250,000.00	250,000.00	250,000.00
L	Watching and Lighting	Item	36,000.00	30,000.00	24,000.00
M	Light and Power	Item	31,200.00	26,000.00	20,800.00
N	Water for the Works	Item	31,200.00	26,000.00	20,800.00
P	Plant and Machinery	Item	150,000.00	130,000.00	110,000.00
Q	Temporary Sign Board	Item	8,000.00	8,000.00	8,000.00
R	Hoarding	Item	60,000.00	60,000.00	60,000.00
S	Keeping Site Dry	Item	10,000.00	10,000.00	10,000.00
T	Mosquito Prevention	Item	8,400.00	7,000.00	5,600.00
U	Safety of Site	Item	36,000.00	30,000.00	24,000.00
V	Safety Helmet and Boots	Item	5,000.00	5,000.00	5,000.00
W	First Aid Kit	Item	2,000.00	2,000.00	2,000.00
X	Progress Report	Item	4,800.00	4,000.00	3,600.00
Y	Progress Photograph	Item	6,000.00	5,000.00	4,000.00
Z	Site Meetings	Item	4,800.00	4,000.00	3,200.00
AB	Shop Drawing	Item	10,000.00	8,000.00	6,000.00
AC	Dust Prevention	Item	10,000.00	8,000.00	6,000.00
AD	Removing of Rubbish	Item	8,000.00	7,000.00	6,000.00
AE	Preservation of Earth Slopes and Adjoining Property	Item	25,000.00	25,000.00	25,000.00
AF	Stamping of Main Contract Documents	Item	37,360.00	37,726.00	37,713.00
AG	Contract Documentation Charges	Item	5,000.00	5,000.00	5,000.00
AH	As Built Drawing	Item	25,000.00	25,000.00	25,000.00
AI	Leave Works Perfect.	Item	10,000.00	8,500.00	7,000.00
		TOTAL	**1,296,388.00**	**1,125,107.00**	**1,009,914.00**

ELEMENTAL COMPARISON

METHOD OF CONSTRUCTION	ACOTECT WALL PANEL		CEMENT BRICKWALL	
MATERIAL COST				
Acotec Panel	RM	63.50	-	
Cement brick		-	RM	2.84
Cement sand (1:6) plastering		-	RM	2.84
Weathershield Paint	RM	2.82	RM	2.82
	RM	66.32	RM	40.99
LABOUR COST				
Installation/laying bricks	RM	12.00	RM	14.09
Plastering		-	RM	7.75
Painting	RM	0.85	RM	0.85
	RM	12.85	RM	22.69
15% overhead and profit	RM	11.88	RM	9.55
COST PER M²	**RM**	**91.05**	**RM**	**73.24**

BUILD-UP RATE

1 Constructing 1m² of external wall using ACOTEC wall panel complete with painting finishes

ITEM	DESCRIPTIONS				AMOUNT (RM)	
	TO INSTALL 100MM THICK ACOTEC WALL PANEL					
1	**Material cost directly supply from factory:** Acotect Wall Panel c/w Acofix finished with cement render on the external side 15mm thick	RM	63.50/m²	=	RM	63.50
2	**Labour cost:** Labour rate Productivity of 16m²/day for a labour.	RM	12.00/m²	=	RM	12.00
				=	**RM**	**75.50**
	PAINTING OF BRICKWALL WITH 2 COATS OF WEATHERSHIELD PAINT					
1	**Material cost:**					
	Weathershield paint	RM	16.80/litre			
	16 litres of paint are needed for every 100m² of wall	RM	268.80/100m²			
	Hence, for 1m² of brickwall			=	RM	2.69
	Allow 5% for wastage 5%			=	RM	0.13
	Weathershield paint of 1m² of wall			**=**	**RM**	**2.82**
2	**Labour cost:**					
	Painter (production of 100m² of wall per day)	RM	85.00/day			
	Hence, for 1m² wall	RM	0.85	=	RM	0.85
				=	**RM**	**3.67**
	Total cost for 1m² of half brickwork in external wall finished with weathershield paint					79.17
	Add 15% for overhead and profit		15%	=	RM	11.88
	Hence, cost for constructing a 1m² of external wall using 100mm thick Acotec Panel finished to weathershield painting			**=**	**RM**	**91.05**

2 Constructing 1m^2 of external wall using normal brickwall complete with weathershield paint finishes.

ITEM	DESCRIPTIONS						AMOUNT (RM)
	HALF BRICKWORK IN CEMENT BRICKS						
1	Material cost:						
A	Cement brick	RM	0.20/No				
	No of bricks per m^2; cost per m^2	1000mm x 1000mm / 225mm x 75mm	= 60	nos	=	RM	12.00
B	Mortar; cement and sand (1:3)						
	Cement	RM	18.3/pack (50kg)				
	28 pack of cement needed for every 1m^3	RM	18.3 x 28	packs	=	RM	512.40
	Sand					RM	52.5/m^3
	3m^3 of sand	52.5	x 3	m^3	=	RM	157.50
	Allow 1/3 for shrinkage and wastage	1/3				RM	223.30
	Cost for 4m^3 of mortar					RM	893.20
	Every 1m^2 of brickwork need 0.025m^3 of mortar	0.025	m^3 RM 22.33				
C	DPC	RM	1 /m^2		=	RM	1.00
2	Labour cost:						
	Bricklayer (production of 1m^2 every 1 hour)		1 hour	RM 90.00 / 8 hours	=	RM	11.25
	General Worker (production of 1m^2 every 0.35 hour)		0.35 hour =	RM 65.00 / 8 hours	=	RM	2.84
						RM	49.42

ITEM	DESCRIPTIONS						AMOUNT (RM)
	CEMENT AND SAND (1:6) PLASTER TO WALL						
1	Material cost:						
A	Mortar; cement and sand (1:6)						
	Cement	RM	18.3/pack (50kg)				
	28 pack of cement needed for every 1m^3	RM	18.3 x 28	packs	=	RM	512.40
	Sand	RM	52.5 /m^3				
	6m^3 of sand		52.5 x 6	m^3	=	RM	315.00
	Allow 1/3 for shrinkage and wastage		1/3		=	RM	275.80
	Cost for 7m^3 of mortar				=	RM	1,103.20
	Cost for 1m^3 of cement and sand plaster		1	m^3	=	RM	157.60
B	Cost of concrete mixer per 1m^3				=	RM	20.00
	Cost for 1m^3 of mortar				=	RM	177.60
	Cost per m^2 of 16mm thick of plastering		0.016 m		=	RM	2.84
2	Labour cost:						
	Concreter (production of 1m^2 every 0.4 hour)		1 hour	RM 90.00 / 8 hours	=	RM	4.50
	General Worker (production of 1m^2 every 0.4 hour) 0.35 hour		= RM 65.00	=	RM 3.25		
						RM	10.59

ITEM	DESCRIPTIONS						AMOUNT (RM)
	PAINTING OF BRICKWALL WITH 2 COATS OF WEATHERSHIELD PAINT						
1	Material cost:						
	Weathershield paint	RM	16.80/litre				
	16 litres of paint are needed for every 100m^2 of wall	RM	268.80/100m^2				
	Hence, for 1m^2 of brickwall				=	RM	2.69
	Allow 5% for wastage	5%			=	RM	0.13
	Weathershield paint of 1m^2 of wall				=	RM	2.82
2							
	Labour cost:						
	Painter (production of 100m^2 of wall per day)	RM	85.00/ day				
	Hence, for 1m^2 wall RM	0.85		=	RM 0.85		
					=	RM	3.67
	Total cost for 1m^2 of half brickwork in external wall finished with weathershield paint						63.69
	Add 15% for overhead and profit	15%			=	RM	9.55
	Hence, cost for constructing a 1m^2 of external wall using half brickwork finished to weathershield painting				**=**	**RM**	**73.24**

ELEMENTAL COMPARISON

ELEMENTAL COMPARISON	METHOD OF CONSTRUCTION		PRECAST COLUMN		PRECAST BEAM	
MATERIAL COST						
Concrete	RM	-	RM	-	RM	306.67
Reinforcement	RM	-	RM	-	RM	367.50
Formwork	RM	-	RM	-	RM	522.42
Precast	RM	907.03	RM	1,798.94	RM	-
	RM	907.03	RM	1,798.94	RM	1,196.59
LABOUR COST						
Laying concrete	RM	-	RM	-	RM	23.75
Bending/laying reinforcement	RM	-	RM	-	RM	53.20
Installation of formwork	RM	-	RM	-	RM	-
To install the precast	RM	239.23	RM	158.19	RM	
	RM	239.23	RM	158.19	RM	76.95
15% overhead and profit	RM	171.94		293.57	RM	191.03
COST PER M²	**RM**	**1,318.20**	**RM**	**2,250.70**	**RM**	**1,464.57**

BUILD-UP RATE

1 Constructing 1m³ of Precast Concrete Column

ITEM	DESCRIPTIONS						AMOUNT (RM)
	TO INSTALL PRECAST COLUMN						
1	**Material cost directly supply from factory:**						
	800mm x 350mm x 3150mm high Precast Columnt	RM	800.00	/No	=	RM	800.00
	Cost of 800mm x 350mm x 3150mm column/nos					RM	800.00
	Hence, cost per m³					RM	907.03
2	**Labour cost :**						
	To install column ; production output of 5nos/day = 4.41m³				=		
	Specialist	RM	90.00	/day			
	General Labour	RM	65.00	/day			
	Mobile Crane	RM	780.00	/day			
	Plant Operator	RM	120.00	/day			
	Cost of 800mm x 350mm x 3150mm column/4.41m³		1,055.00	/day		RM	1,055.00
	Hence, cost per m³					RM	239.23
	Therefore, cost of 1m³ precast column is					RM	1,146.26
	Add 15% for overhead and profit	15%			=	RM	171.94
	Hence, cost for constructing a 1m³ of precast column is				=	**RM**	**1,318.20**

2 Constructing 1m³ of Precast Concrete Beam

ITEM	DESCRIPTIONS						AMOUNT (RM)
TO INSTALL PRECAST BEAM							
1	**Material cost directly supply from factory:**						
	9000mm x 350mm x 450mm high Precast Beam	RM	2,500.00	/No	=	RM	2,500.00
	Transport and handlling	RM	50.00	/No		RM	50.00
	Cost of 9000mm x 350mm x 450mm Precast Beam/nos					RM	2,550.00
	Hence, cost per m³					RM	1,798.94
2	Labour cost :						
	To install column ; production output of 5nos/day = 7.08m³				=		
	Specialist	RM	90.00	/day			
	General Labour, 2nos	RM	130.00	/day			
		RM	780.00	/day			
	Plant Operator	RM	120.00	/day			
	Cost of 900mmx350mmx450mm/7.08m³	RM	1,120.00	/day		RM	1,120.00
	Hence, cost per m³					RM	158.19
	Therefore, cost of precast beam for 1m³ is						1,957.13
	Add 15% for overhead and profit	15%			=	RM	293.57
	Hence, cost for constructing a 1m³ of precast beam is				=	**RM**	**2,250.70**

3 Constructing 1m³ of Reinforced In-Situ Grade 25 Column/Beam

ITEM	DESCRIPTIONS						AMOUNT (RM)
	REINFORCED IN-SITU CONCRETE GRADE 35						
1	**Material cost:**						
	Ready Mix Concrete Grade 35 (1:1/1/2:3)	RM	230.00	/m³	=	RM	230.00
	Allow 1/3 for shrinkage and wastage		1/3		=	RM	76.67
	Cost for 1m³ of ready mix concrete Grade 25				=	RM	306.67
2	**Labour cost:**						
	Labour to place / mix the concrete	RM	5.00	/m³	=	RM	5.00
	Rental of Concrete mixer (all-in)	RM	150.00	/day			
	Output of 1m³/hour = 8m³/day	8.00	m³	per day			
	Cost for 1m³ of rental of concrete mixer				=	RM	18.75
	Cost for 1m³ of ready mix concrete Grade 25				=	RM	23.75
	Therefore, cost of producing 1m³ of ready mix concrete Grade 25				=	RM	330.42
	REINFROCEMENT ; VARIES SIZE						
1	**Material cost:**						
	Supply of reinforcement (including loading)	RM	2,500.00	/tonne			
	Allow 5% of wastage	RM	125.00	/tonne			
		RM	2,625.00	/tonne			
	Weightage of 0.140tonne/m³ of column		0.140		=	RM	367.50
2	**Labour cost:**						
	Labour to load/unload the reinforcement	RM	80.00	/tonne			
	Labour to cut and bend the reinforcement	RM	150.00	/tonne			
	Labour to place the reinforcement	RM	150.00	/tonne			
	Weightage of 0.140tonne/m³ of column		0.140	tonne	=	RM	53.20
	Therefore, cost of reinforcement for every 1m³ of concrete is				=	RM	420.70
	METAL FORMWORK ; ASSUME SIZE OF 2.4M X 1.20M X 0.012M THICK						
1	**Material cost:**						
	Metal formwork directly supply from factory	RM	30.00	/m²	=	RM	30.00
	Handling and transport chargers	RM	1.00	/m²	=	RM	1.00
	Material cost/m²				=	RM	31.00
	Hence, material cost/m³				=		
2	**Labour cost:**						
	To prepare and install;						
	Specialist with production output of 1hour/m²	RM	90.00/day	x 1 hour	=	RM	11.25
	General labour with production output of 0.40 hour/m²	RM	65.00/day	x 0.40 hour	=	RM	3.25
	Labour cost per m²				=	RM	14.50
	Total cost /m²				=		45.50
	Formwork for beam of 8.1m² (**assume), with volume of 1.4175m³				=	RM	368.55
	Therefore, cost of metal formwork for every 1m³ of concrete is				=	RM	522.42
	Total cost for 1m³ in-situ Column / Beam				=	RM	1,273.54
	Add 15% for overhead and profit	15%			=	RM	191.03
	Hence, cost for constructing a 1m³ of *in-situ* column				=	**RM**	**1,464.57**

METHOD OF CONSTRUCTION	PRECAST SLAB CAST		*IN-SITU* SLAB	
MATERIAL COST				
Concrete	RM	-	RM	62.93
Reinforcement	RM	-	RM	24.15
Formwork	RM	-	RM	47.00
Precast	RM	155.00	RM	-
	RM	155.00	RM	134.08
LABOUR COST				
Laying concrete	RM	-	RM	7.10
Bending/laying reinforcement	RM	-	RM	2.00
Installation of formwork	RM	-	RM	17.34
To install the precast	RM	14.00	RM	17.34
	RM	14.00	RM	26.44
15% overhead and profit	RM	25.35	RM	24.08
COST PER M²	**RM**	**194.35**	**RM**	**184.61**

BUILD-UP RATE

1 Constructing 1m² of Precast Concrete Slab

ITEM	DESCRIPTIONS					AMOUNT (RM)	
	TO INSTALL PRECAST SLAB						
1	Material cost directly supply from factory:						
	200mm thick hollow core slab	RM	145.00	/m²	=	RM	145.00
	Transport and handlling	RM	10.00	/m²	=	RM	10.00
	Hence, cost per m²					RM	155.00
2	Labour cost :						
	Specialist to install and laying the filling and grouting material	RM	14.00	/m²	=	RM	14.00
	Hence, cost per m²					RM	14.00
	Therefore, cost of 1m² precast slab is					RM	169.00
	Add 15% for overhead and profit	15%			=	RM	25.35
	Hence, cost for constructing a 1m² of precast slab is				=	**RM**	**194.35**

2 Constructing 1m² of Reinforced In-Situ Grade 25 Slab

ITEM	DESCRIPTIONS					AMOUNT (RM)	
	REINFORCED IN-SITU CONCRETE GRADE 35						
1	**Material cost:**						
	Ready Mix Concrete Grade 35 (1:1/1/2:3)	RM	236.00	/m³	=	RM	236.00
	Allow 1/3 for shrinkage and wastage		1/3		=	RM	78.67
	Cost for 1m³ of ready mix concrete Grade 25				=	RM	314.67
	Cost for 1m² of ready mix concrete Grade 25				=	RM	62.93
2	**Labour cost:**						
	Labour to place / mix the concrete	RM	15.00	/m³	=	RM	15.00
	Rental of Concrete mixer (all-in)	RM	205.00	/day			
	Output of 1.25m³/hour = 10m³/day		10.00 m³	per day			
	Cost for 1m³ of rental of concrete mixer				=	RM	20.50
	Cost for 1m³ of ready mix concrete Grade 25				=	RM	35.50
	Cost 1m² of concrete for slab				=	RM	7.10
	Therefore, cost of producing 1m² of ready mix concrete Grade 25				=	RM	70.03
	REINFROCEMENT ; VARIES SIZE						
1	**Material cost:**						
	Supply of reinforcement (including loading)	RM	23.00	/m²	=	RM	23.00
	Allow 5% of wastage	RM	1.15	/m²	=	RM	1.15
					=	RM	24.15
2	**Labour cost:**						
	Labour to place the reinforcement	RM	2.00	/m²	=	RM	2.00
						RM	2.00
	Therefore, cost of reinforcement for every 1m² of concrete slab is				=	RM	26.15
METAL FORMWORK ; ASSUME SIZE OF 2.4M X 1.20M X 0.012M THICK							
1	**Material cost:**						
	Metal formwork directly supply from factory	RM	45.00	/m²	=	RM	45.00
	Handling and transport chargers	RM	2.00	/m²	=	RM	2.00
	Material cost/m²					RM	47.00
2	**Labour cost:**						
	To prepare and install;						
	Specialist with production output of 1hour/m²	RM	90.00 / day x 1 hour		=	RM	11.25
	General labour with production output of 0.75 hour/m²	RM	65.00 / day x 0.75 hour		=	RM	6.09
	Labour cost/m²				=	RM	17.34
	Therefore, cost of metal formwork for every 1m³ of concrete is				=	RM	64.34
	Total cost for 1m³ in-situ Column				=	RM	160.53
	Add 15% for overhead and profit	15%			=	RM	24.08
	Hence, cost for constructing a 1m³ of *in-situ* column				=	**RM**	**184.61**

CIDB CREAM (HIGH RISE RESIDENTIAL TYPOLOGY STUDY)
SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

APPROXIMATE BILL OF QUANTITIES
(BUILDING WORKS)

REVISION NO. 1

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

SUMMARY OF ELEMENTAL COSTS

GROSS FLOOR AREA: 26,391 m² 284,074 ft²

	ELEMENT	% OF TOTAL COST	RATE/M² FLOOR AREA	RATE/SQ FT FLOOR AREA	TOTAL RM
1	PRELIMINARIES	3.49	49.12	5.00	1,296,388
	Group Elemental Total	**3.49**	**49.12**	**5.00**	**1,296,388**
2	SUBSTRUCTURE				
2.1	Piling Works	11.36	160.01	15.00	4,223,000
2.2	Work Below Lowest Floor Level	4.64	65.45	6.00	1,727,232
	Group Elemental Total	**16.00**	**225.46**	**21.00**	**5,950,232**
3	SUPERSTRUCTURE				
3.1	Frame	8.66	121.98	11.00	3,219,306
3.2	Upper Floor	10.50	147.97	14.00	3,905,221
3.3	Roof	1.85	26.05	2.00	687,500
3.4	Stairs & Ramps	0.97	13.64	1.00	360,000
3.5	External Wall	13.87	195.44	18.00	5,158,005
3.6	Windows & External Door	3.71	52.21	5.00	1,377,996
3.7	Internal Walls & Partitions	5.60	78.97	7.00	2,084,204
3.8	Internal Doors	1.00	14.03	1.00	370,152
	Group Elemental Total	**46.15**	**650.30**	**59.00**	**17,162,385**
4	FINISHES				
4.1	Internal Floor Finishes	4.14	58.32	5.00	1,539,210
4.2	Internal Wall Finishes	6.20	87.43	8.00	2,307,408
4.3	Internal Ceiling Finishes	1.05	14.77	1.00	389,826
4.4	External Finishes	4.11	57.98	5.00	1,530,244
	Group Elemental Total	**15.51**	**218.51**	**19.00**	**5,766,688**
5	FITTINGS & FURNITURES				
5.1	Sanitary Fittings	2.19	30.92	3.00	816,000
	Group Elemental Total	**2.19**	**30.92**	**3.00**	**816,000**
6	SERVICES				
6.1	Mechanical & Electrical Services	16.67	234.86	22.00	6,198,338
	Group Elemental Total	**16.67**	**234.86**	**22.00**	**6,198,338**
	TOTAL BUILDING COST	**100**	**1,409**	**129**	**37,190,030**

129.00 Cost/ft²

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

WORK BELOW LOWEST FLOOR LEVEL (WBLFL)

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	EXCAVATION				
A	Oversite (400mm thick)	m²	1,375	5.00	6,875.00
B	To pile caps n.e 2.00m depth	m³	1,409	11.00	15,499.00
C	To ground beam n.e 1.00m depth	m³	66	11.00	726.00
	HARDCORE				
D	Under ground slab (300mm thick)	m²	1,375	8.00	11,000.00
WATER PROOFING					
E	Under ground slab	m²	1,375	45.00	61,875.00
	ANTI-TERMITE				
F	Under ground slab	m²	1,375	5.00	6,875.00
	CONCRETE BLINDING GRADE 20				
G	Under ground slab (50mm thick)	m³	69	280.00	19,250.00
H	Ditto pile caps (ditto)	m³	70	280.00	19,726.00
J	Ditto ground beam (ditto)	m³	3	280.00	924.00
	PILE CAPS				
K	Concrete Grade 35	m³	1,380	330.00	455,400.00
L	Formwork	m²	1,655	60.00	99,300.00
M	Rebar (Allow poundage @ 140kg/m³)	Kg.	193,252	3.90	753,682.80
	COLUMN STUMP				
N	Concrete Grade 35	m³	24	330.00	7,920.00
P	Formwork	m²	193	60.00	11,580.00
Q	Rebar (Allow poundage @ 140kg/m³)	Kg.	3,360	3.90	13,104.00
	GROUND BEAM				
R	Concrete Grade 35	m³	90	330.00	29,700.00
S	Formwork	m²	513	60.00	30,780.00
T	Rebar (Allow poundage @120kg/m³)	Kg.	10,800	3.90	42,120.00
	GROUND SLAB (150MM THICK SLAB)				
U	Concrete Grade 35	m³	206	330.00	67,980.00
V	Formwork; 150mm Height	m	551	7.00	3,857.00
W	BRC A8 (Top and Bottom)	m²	2 ,750	20.00	55,000.00
	LIFT PIT FOUNDATION				
X	Concrete Grade 35 (250mm thick)	m³	11	330.00	3,630.00
Y	Formwork	m²	88	60.00	5,280.00
Z	Rebar (Allow poundage @ 120kg/m³)	Kg.	1,320	3.90	5,148.00
				TOTAL	**1,727,231.80**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

FRAME

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	COLUMN (GF TO ROOF)				
A	Concrete Grade 35 q	m³	212	330.00	69,960.00
B	Reusable Metal Formwork	m²	1,852	60.00	111,120.00
C	Rebar (Allow poundage @ 140kg/m³)	Kg.	29,680	3.90	115,752.00
	FLOOR BEAM (1ST FLOOR TO 20TH FLOOR)				
D	Concrete Grade 35	m³	1,706	330.00	562,980.00
E	Reusable Metal Formwork	m²	12,141	60.00	728,460.00
F	Rebar (Allow poundage @ 140kg/m³)	Kg.	238,840	3.90	931,476.00
	ROOF BEAM				
G	Concrete Grade 35	m³	90	330.00	29,700.00
H	Reusable Metal Formwork	m²	639	60.00	38,340.00
J	Rebar (Allow poundage @ 120kg/m³)	Kg.	10,800	3.90	42,120.00
	LIFT CORE WALL				
K	Concrete Grade 35 (250mm thick)	m³	461	330.00	152,130.00
L	Reusable Metal Formwork	m²	3,692	60.00	221,520.00
M	Rebar (Allow poundage @ 120kg/m³)	Kg.	55,320	3.90	215,748.00
				TOTAL	**3,219,306.00**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

UPPER FLOOR CONSTRUCTION

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	UPPER FLOOR (1ST FLOOR TO 20TH FLOOR)				
A	Concrete Grade 35	m^3	3,918	330.00	1,292,940.00
B	Reusable Metal Formwork	m^2	26,123	60.00	1,567,380.00
C	BRC A8 (Top and Bottom)	m^2	52,245	20.00	1,044,901.20
				TOTAL	**3,905,221.20**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

ROOF

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	RC FLAT ROOF				
A	Construct of flat roof including concrete, formwork, reinforcement, gutter and all necessary works as per specification and drawing.	m^2	1,375	500.00	687,500.00
				TOTAL	**687,500.00**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

STAIRCASE & RAMPS

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	REINFORCED CONCRETE STAIRCASE				
A	Construct of reinforced concrete staircase from the ground floor to the 20th floor (including concrete, reinforcement, formwork, plastering, painting work, 600mm x 600mm ceramic tiles, mild steel handrailing and all necessary works as per specification and drawing).	Flight	80	4,500.00	360,000.00
				TOTAL	**360,000.00**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

EXTERNAL WALL

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
BRICKWALL					
A	115mm Thick cement and sand brickwall	m^2	16,540	47.00	777,380.00
B	Damp proof coursing (DPC)	m^2	443	1.00	443.00
C	Bonding tie	No.	3,240	1.00	3,240.00
SHEAR WALL					
D	Concrete Grade 35 (250mm thick)	m^3	3,002	330.00	990,660.00
E	Reusable Metal Formwork	m^2	24,016	60.00	1,440,960.00
F	Rebar (Allow poundage @ 96kg/m^3)	Kg.	288,192	3.90	1,123,948.80
LEDGE					
D	Concrete Grade 35 (100mm thick)	m^3	194 3	30.00	64,020.00
E	Reusable Metal Formwork	m^2	5,472	60.00	328,320.00
F	Rebar (Allow poundage @ 96kg/m^3)	Kg.	18,624	3.90	72,633.60
HANDRAIL					
G	1,200mm High handrail with M.S hollow handrail and M.S hollow ballustrade	m	3,240	110.00	356,400.00
				TOTAL	**5,158,005.40**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

WINDOWS AND EXTERNAL DOORS

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	WINDOWS				
A	Lintel beam reinforced	m	1,368	28.00	38,304.00
B	900mm x 1,600mm high natural anodised louvers window.	No.	480	300.00	144,000.00
C	1,700mm x 1,600mm high natural anodised louvers window.	No.	240	600.00	144,000.00
D	600mm x 600mm high natural anodised louvers window.	No.	480	80.00	38,400.00
E	6mm Thick clear float glass panels	m^2	1,517	60.00	91,020.00
	EXTERNAL DOORS				
F	Lintel beam reinforced	m	2,224	28.00	62,272.00
G	900mm x 2,100mm high decorative solid core door.	No.	240	650.00	156,000.00
H	900mm x 2,100mm high timber flush door.	No.	1,040	400.00	416,000.00
J	4,200mm x 2,400mm high sliding door.	No.	240	1,200.00	288,000.00
				TOTAL	**1,377,996.00**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

INTERNAL WALL

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	BRICKWALL				
A	115mm Thick cement and sand brickwall	m^2	13,205	47.00	620,635.00
B	Damp proof coursing (DPC)	m^2	235	1.00	235.00
C	Bonding tie	m^2	720	1.00	720.00
	SHEAR WALL				
D	Concrete Grade 35 (250mm thick)	m^3	1,235	3 30.00	407,550.00
E	Metal Reusable Formwork	m^2	9,878	60.00	592,680.00
F	Rebar (Allow poundage @ 96kg/m^3)	Kg.	118,560	3.90	462,384.00
				TOTAL	**2,084,204.00**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

INTERNAL DOORS

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	INTERNAL DOORS				
A	Lintel beam reinforced	m	934	28.00	26,152.00
B	900mm x 2,100mm high timber flush door.	No.	20	400.00	8,000.00
C	750mm x 2,100mm high timber flush door.	No.	960	350.00	336,000.00
				TOTAL	**370,152.00**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

INTERNAL FLOOR FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Ceramic tiles	m²	20,109	70.00	1,407,630.00
B	Non-slip homogenous tiles	m²	1,548	85.00	131,580.00
				TOTAL	**1,539,210.00**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

INTERNAL WALL FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Plastering	m²	55,376	18.00	996,768.00
B	Painting	m²	55,376	10.00	553,760.00
C	Ceramic wall tiles including screeding	m²	9,461	80.00	756,880.00
				TOTAL	**2,307,408.00**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

INTERNAL CEILING FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Skim Coat	m^2	21,657	8.00	173,256.00
B	Painting to skim coat	m^2	21,657	10.00	216,570.00
				TOTAL	**389,826.00**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

EXTERNAL FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	EXTERNAL FLOOR FINISHES				
A	Ceramic tiles	m²	6,191	70.00	433,352.50
	EXTERNAL WALL FINISHES				
B	Plastering	m²	32,436	18.00	583,842.60
C	Painting	m²	32,436	12.00	389,228.40
	EXTERNAL CEILING FINISHES				
D	Skim coat	m²	6,191	8.00	49,528.00
E	Painting to skim coat	m²	6,191	12.00	74,292.00
				TOTAL	**1,530,243.50**

SCENARIO I (CONVENTIONAL HYBRID SYSTEM)

SANITARY FITTING

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Pedestal water closet	No.	480	600.00	288,000.00
B	Wash basin	No.	480	250.00	120,000.00
C	Wash basin tap	No.	480	75.00	36,000.00
D	Shower	No.	480	80.00	38,400.00
E	Soap holder	No.	480	35.00	16,800.00
F	Towel holder	No.	480	75.00	36,000.00
G	Hose tap	No.	480	65.00	31,200.00
H	UPVC floor trap	No.	1,200	15.00	18,000.00
J	Single bowl single drainer kitchen sink	No.	240	250.00	60,000.00
K	Kitchen tap	No.	240	75.00	18,000.00
L	Mirror	No.	480	250.00	120,000.00
M	Rail divider tt	No.	480	70.00	33,600.00
				TOTAL	**816,000.00**

CIDB CREAM (HIGH RISE RESIDENTIAL TYPOLOGY STUDY)
SCENARIO II (PARTIAL IBS SYSTEM)

APPROXIMATE BILL OF QUANTITIES

(BUILDING WORKS)

REVISION NO. 1

SCENARIO II (PARTIAL IBS SYSTEM)

SUMMARY OF ELEMENTAL COSTS

GROSS FLOOR AREA : 26,391 m² 284,074 ft²

	ELEMENT	% OF TOTAL COST	RATE/M² FLOOR AREA	RATE/SQ FT FLOOR AREA	TOTAL RM
1	PRELIMINARIES	3.01	42.63	4.00	1,125,107
	Group Elemental Total	**3.01**	**42.63**	**4.00**	**1,125,107**
2	SUBSTRUCTURE				
2.1	Piling Works	11.29	160.01	15.00	4,223,000
2.2	Work Below Lowest Floor Level	4.62	65.45	6.00	1,727,232
	Group Elemental Total	**15.91**	**225.46**	**21.00**	**5,950,232**
3	SUPERSTRUCTURE				
3.1	Frame	10.17	144.06	13.00	3,802,030
3.2	Upper Floor	10.44	147.97	14.00	3,905,221
3.3	Roof	1.84	26.05	2.00	687,500
3.4	Stairs & Ramps	0.96	13.64	1.00	360,000
3.5	External Wall	14.56	206.36	19.00	5,446,141
3.6	Windows & External Door	3.42	48.40	4.00	1,277,420
3.7	Internal Walls & Partitions	6.84	96.95	9.00	2,558,629
3.8	Internal Doors	0.92	13.03	1.00	344,000
	Group Elemental Total	**49.15**	**696.47**	**63.00**	**18,380,941**
4	FINISHES				
4.1	Internal Floor Finishes	4.12	58.32	5.00	1,539,210
4.2	Internal Wall Finishes	5.04	71.48	7.00	1,886,460
4.3	Internal Ceiling Finishes	1.04	14.77	1.00	389,826
4.4	External Finishes	3.11	44.05	4.00	1,162,543
	Group Elemental Total	**13.31**	**188.62**	**17.00**	**4,978,039**
5	FITTINGS & FURNITURES				
5.1	Sanitary Fittings	2.18	30.92	3.00	816,000
	Group Elemental Total	**2.18**	**30.92**	**3.00**	**816,000**
6	SERVICES				
6.1	Mechanical & Electrical Services	16.44	233.03	22.00	6,150,000
	Group Elemental Total	**16.44**	**233.03**	**22.00**	**6,150,000**
	TOTAL BUILDING COST	**100**	**1,417**	**130**	**37,400,318**

130.00 Cost/ft²

SCENARIO II (PARTIAL IBS SYSTEM)

WORK BELOW LOWEST FLOOR LEVEL (WBLFL)

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	EXCAVATION				
A	Oversite (400mm thick)	m^2	1,375	5.00	6,875.00
B	To pile caps n.e 2.00m depth	m^3	1,409	11.00	15,499.00
C	To ground beam n.e 1.00m depth	m^3	66	11.00	726.00
	HARDCORE				
D	Under ground slab (300mm thick)	m^2	1,375	8.00	11,000.00
	WATER PROOFING				
E	Under ground slab	m^2	1,375	45.00	61,875.00
	ANTI-TERMITE				
F	Under ground slab	m^2	1,375	5.00	6,875.00
	CONCRETE BLINDING GRADE 20				
G	Under ground slab (50mm thick)	m^3	69	280.00	19,250.00
H	Ditto pile caps (ditto)	m^3	70	280.00	19,726.00
J	Ditto ground beam (ditto)	m^3	3	280.00	924.00
	PILE CAPS				
K	Concrete Grade 35	m^3	1,380	330.00	455,400.00
L	Formwork	m^2	1,655	60.00	99,300.00
M	Rebar (Allow poundage @ 140kg/m^3)	Kg.	193,252	3.90	753,682.80
	COLUMN STUMP				
N	Concrete Grade 35	m^3	24	330.00	7,920.00
P	Formwork	m^2	193	60.00	11,580.00
Q	Rebar (Allow poundage @ 140kg/m^3)	Kg.	3,360	3.90	13,104.00
	GROUND BEAM				
R	Concrete Grade 35	m^3	90	330.00	29,700.00
S	Formwork	m^2	513	60.00	30,780.00
T	Rebar (Allow poundage @120kg/m^3)	Kg.	10,800	3.90	42,120.00
	GROUND SLAB (150MM THICK SLAB)				
U	Concrete Grade 35	m^3	206	330.00	67,980.00
V	Formwork; 150mm Height	m	551	7.00	3,857.00
W	BRC A8 (Top and Bottom)	m^2	2,750	20.00	55,000.00
	LIFT PIT FOUNDATION				
X	Concrete Grade 35 (250mm thick)	m^3	11	330.00	3,630.00
Y	Formwork	m^2	88	60.00	5,280.00
Z	Rebar (Allow poundage @ 120kg/m^3)	Kg.	1,320	3.90	5,148.00
				TOTAL	**1,727,231.80**

SCENARIO II (PARTIAL IBS SYSTEM)

FRAME

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	COLUMN (GF TO ROOF)				
A	Concrete Grade 35	m^3	212	330.00	69,960.00
B	Reusable Metal Formwork	m^2	1,852	60.00	111,120.00
C	Rebar (Allow poundage @ 140kg/m^3)	Kg.	29,680	3.90	115,752.00
	PRECAST CONCRETE FLOOR BEAM (LEVEL 1-LEVEL 19)				
D	9,000mm x 350mm x 450mm High	No.	532	2,300.00	1,223,600.00
E	4,500mm x 350mm x 450mm High	No.	456	1,200.00	547,200.00
F	7,500mm x 350mm x 450mm High	No.	532	1,900.00	1,010,800.00
	PRECAST CONCRETE ROOF BEAM				
G	9,000mm x 350mm x 450mm High	No.	28	2,100.00	58,800.00
H	4,500mm x 350mm x 450mm High	No.	24	1,100.00	26,400.00
J	7,500mm x 350mm x 450mm High	No.	28	1,750.00	49,000.00
	LIFT CORE WALL				
K	Concrete Grade35 (250mm thick)	m^3	461	330.00	152,130.00
L	Reusable Metal Formwork	m^2	3 ,692	60.00	221,520.00
M	Rebar (Allow poundage @ 120kg/m^3)	Kg.	55,320	3.90	215,748.00
				TOTAL	**3,802,030.00**

SCENARIO II (PARTIAL IBS SYSTEM)

UPPER FLOOR CONSTRUCTION

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	SUSPENDED FLOOR SLAB (LEVEL 1-LEVEL 20)				
A	Concrete Grade 35	m^3	3,918	330.00	1,292,940.00
B	Reusable Metal Formwork	m^2	26,123	60.00	1,567,380.00
C	BRC A8 (Top and Bottom)	m^2	52,245	20.00	1,044,901.20
				TOTAL	**3,905,221.20**

SCENARIO II (PARTIAL IBS SYSTEM)

ROOF

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	RC FLAT ROOF				
A	Construct of flat roof including concrete, formwork, reinforcement, gutter and all necessary works as per specification and drawing.	m²	1,375	500.00	687,500.00
				TOTAL	**687,500.00**

SCENARIO II (PARTIAL IBS SYSTEM)

STAIRCASE & RAMPS

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	REINFORCED CONCRETE STAIRCASE				
A	Construct of reinforced concrete staircase from the ground floor to the 20th floor (including concrete, reinforcement, formwork, plastering, painting work, 600mm x 600mm ceramic tiles, mild steel handrailing and all necessary works as per specification and drawing).	Flight	80	4,500.00	3 60,000.00
				TOTAL	**360,000.00**

SCENARIO II (PARTIAL IBS SYSTEM)

EXTERNAL WALL

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	WALL PANEL SYSTEM				
A	100mm Thick ACOTEC wall panel	m^2	18,484	83.00	1,534,172.00
	SHEAR WALL				
B	Concrete Grade 35 (250mm thick)	m^3	3,002	330.00	990,660.00
C	Reusable Formwork	m^2	24,016	60.00	1,440,960.00
D	Rebar (Allow poundage @ 96kg/m^3)	Kg.	288,192	3.90	1,123,948.80
	HANDRAIL				
E	1,200mm High handrail with M.S hollow handrail and M.S hollow ballustrade	m	3,240	110.00	356,400.00
				TOTAL	**5,446,140.80**

SCENARIO II (PARTIAL IBS SYSTEM)

WINDOWS AND EXTERNAL DOORS

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	WINDOWS				
A	900mm x 1,600mm high natural anodised louvers window with fixed glass.	No.	480	300.00	144,000.00
B	1,700mm x 1,600mm high natural anodised louvers window with fixed glass.	No.	240	600.00	144,000.00
C	600mm x 600mm high natural anodised louvers window with fixed glass.	No.	480	80.00	38,400.00
D	6mm Thick clear float glass panels	m²	1,517	60.00	91,020.00
	EXTERNAL DOORS				
E	900mm x 2,100mm high decorative solid core door.	No.	240	650.00	156,000.00
F	900mm x 2,100mm high timber flush door.	No.	1,040	400.00 4	16,000.00
G	4200mm x 2,400mm high sliding door.	No.	240	1,200.00	288,000.00
				TOTAL	**1,277,420.00**

SCENARIO II (PARTIAL IBS SYSTEM)

INTERNAL WALL

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	WALL PANEL SYSTEM				
A	100mm Thick ACOTEC wall panel	m²	13,205	83.00	1,096,015.00
	SHEAR WALL				
B	Concrete Grade 35 (250mm thick)	m³	1,235	330.00	407,550.00
C	Reusable Formwork	m²	9,878	60.00	592,680.00
D	Rebar (Allow poundage @ 96kg/m³)	Kg.	118,560	3.90	462,384.00
				TOTAL	**2,558,629.00**

SCENARIO II (PARTIAL IBS SYSTEM)

INTERNAL DOORS

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	INTERNAL DOORS				
A	900mm x 2,100mm high timber flush door.	No.	20	400.00	8,000.00
B	750mm x 2,100mm high timber flush door (exc door frame).	No.	960	350.00	336,000.00
				TOTAL	**344,000.00**

SCENARIO II (PARTIAL IBS SYSTEM)

INTERNAL FLOOR FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Ceramic tiles	m²	20,109	70.00	1,407,630.00
B	Non-slip homogenous tiles	m²	1,548	85.00	131,580.00
				TOTAL	**1,539,210.00**

SCENARIO II (PARTIAL IBS SYSTEM)

INTERNAL WALL FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Plastering	m²	30,910	18.00	556,380.00
B	Painting to plastered wall	m²	30,910	10.00	309,100.00
C	Painting to skim coat	m²	26,410	10.00	264,100.00
D	Ceramic wall tiles including screeding	m²	9,461	80.00	756,880.00
				TOTAL	**1,886,460.00**

SCENARIO II (PARTIAL IBS SYSTEM)

INTERNAL CEILING FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Skim coat	m^2	21,657	8.00	173,256.00
B	Painting to skim coat	m^2	21,657	10.00	216,570.00
				TOTAL	**389,826.00**

SCENARIO II (PARTIAL IBS SYSTEM)

EXTERNAL FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	EXTERNAL FLOOR FINISHES				
A	Ceramic tiles	m²	6,191	70.00	433,352.50
	EXTERNAL WALL FINISHES				
B	Plastering	m²	12,008	18.00	216,140.40
C	Painting to plastered wall	m²	12,008	12.00	144,093.60
D	Painting to skim coat	m²	20,428	12.00	245,136.00
	EXTERNAL CEILING FINISHES				
E	Skim Coat	m²	6,191	8.00	49,528.00
F	Painting to skim coat	m²	6,191	12.00	74,292.00
				TOTAL	**1,162,542.50**

SCENARIO II (PARTIAL IBS SYSTEM)

SANITARY FITTING

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Pedestal water closet	No.	480	600.00	288,000.00
B	Wash basin	No.	480	250.00	120,000.00
C	Wash basin tap	No.	480	75.00	36,000.00
D	Shower	No.	480	80.00	38,400.00
E	Soap holder	No.	480	35.00	16,800.00
F	Towel holder	No.	480	75.00	36,000.00
G	Hose tap	No.	480	65.00	31,200.00
H	UPVC floor trap	No.	1,200	15.00	18,000.00
J	Single bowl single drainer kitchen sink	No.	240	250.00	60,000.00
K	Kitchen tap	No.	240	75.00	18,000.00
L	Mirror	No.	480	250.00	120,000.00
M	Rail divider	No.	480	70.00	33,600.00
				TOTAL	**816,000.00**

CIDB CREAM (HIGH RISE RESIDENTIAL TYPOLOGY STUDY)
SCENARIO III (FULL IBS SYSTEM)

APPROXIMATE BILL OF QUANTITIES
(BUILDING WORKS)

REVISION NO. 1

SCENARIO III (FULL IBS SYSTEM)

SUMMARY OF ELEMENTAL COSTS

GROSS FLOOR AREA : 26,391 m² 284,074 ft²

	ELEMENT	% OF TOTAL COST	RATE/M² FLOOR AREA	RATE/SQ FT FLOOR AREA	TOTAL RM
1	PRELIMINARIES	2.74	38.27	4.00	1,009,914
	Group Elemental Total	**2.74**	**38.27**	**4.00**	**1,009,914**
2	SUBSTRUCTURE				
2.1	Piling Works	11.45	160.01	15.00	4,223,000
2.2	Work Below Lowest Floor Finish	4.68	65.45	6.00	1,727,231.80
	Group Elemental Total	**16.13**	**225.46**	**21.00**	**5,950,232**
3	SUPERSTRUCTURE				
3.1	Frame	13.48	188.33	17.00	4,970,418
3.2	Upper Floor	13.10	183.12	17.00	4,832,755
3.3	Roof	1.86	26.05	2.00	687,500
3.4	Stairs & Ramps	0.98	13.64	1.00	360,000
3.5	External Wall	7.83	109.40	10.00	2,887,236
3.6	Windows & External Door	3.46	48.40	4.00	1,277,420
3.7	Internal Walls & Partitions	4.08	57.07	5.00	1,506,035
3.8	Internal Doors	0.67	9.40	1.00	248,000
	Group Elemental Total	**45.47**	**635.41**	**57.00**	**16,769,364**
4	FINISHES				
4.1	Internal Floor Finishes	3.82	53.34	5.00	1,407,630
4.2	Internal Wall Finishes	1.50	20.98	2.00	553,760
4.3	Internal Ceiling Finishes	0.98	13.72	1.00	361,962
4.4	External Finishes	2.57	35.86	3.00	946,405
	Group Elemental Total	**8.87**	**123.89**	**11.00**	**3,269,757**
5	FITTINGS & FURNITURES				
5.1	Sanitary Fittings	10.52	147.05	14.00	3,880,800
	Group Elemental Total	**10.52**	**147.05**	**14.00**	**3,880,800**
6	SERVICES				
6.1	Mechanical & Electrical Services	16.27	227.35	21.00	6,000,000
	Group Elemental Total	**16.27**	**227.35**	**21.00**	**6,000,000**
	TOTAL BUILDING COST	**100**	**1,397**	**128**	**36,880,066**
			128.00 Cost/ft²		

SCENARIO III (FULL IBS SYSTEM)

WORK BELOW LOWEST FLOOR LEVEL (WBLFL)

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	EXCAVATION				
A	Oversite (400mm thick)	m^2	1,375	5.00	6,875.00
B	To pile caps n.e 2.00m depth	m^3	1,409	11.00	15,499.00
C	To ground beam n.e 1.00m depth	m^3	66	11.00	726.00
	HARDCORE				
D	Under ground slab (300mm thick)	m^2	1,375	8.00	11,000.00
	WATER PROOFING				
E	Under ground slab	m^2	1,375	45.00	61,875.00
	ANTI-TERMITE				
F	Under ground slab	m^2	1,375	5.00	6,875.00
	CONCRETE BLINDING GRADE 20				
G	Under ground slab (50mm thick)	m^3	69	280.00	19,250.00
H	Ditto pile caps (ditto)	m^3	70	280.00	19,726.00
J	Ditto ground beam (ditto)	m^3	3	280.00	924.00
	PILE CAPS				
K	Concrete Grade 35	m^3	1,380	330.00	455,400.00
L	Formwork	m^2	1,655	60.00	99,300.00
M	Rebar (Allow poundage @ 140kg/m^3)	Kg.	193,252	3.90	753,682.80
	COLUMN STUMP				
N	Concrete Grade 35	m^3	24	330.00	7,920.00
P	Formwork	m^2	193	60.00	11,580.00
Q	Rebar (Allow poundage @ 140kg/m^3)	Kg.	3,360	3.90	13,104.00
	GROUND BEAM				
R	Concrete Grade 35	m^3	90	330.00	29,700.00
S	Formwork	m^2	513	60.00	30,780.00
T	Rebar (Allow poundage @120kg/m^3)	Kg.	10,800	3.90	42,120.00
	GROUND SLAB (150MM THICK SLAB)				
U	Concrete Grade 35	m^3	206	330.00	67,980.00
V	Formwork; 150mm Height	m	551	7.00	3,857.00
W	BRC A8 (Top and Bottom)	m^2	2,750	20.00	55,000.00
	LIFT PIT FOUNDATION				
X	Concrete Grade 35 (250mm thick)	m^3	11	330.00	3,630.00
Y	Formwork	m^2	88	60.00	5,280.00
Z	Rebar (Allow poundage @ 120kg/m^3)	Kg.	1,320	3.90	5,148.00
				TOTAL	**1,727,231.80**

SCENARIO III (FULL IBS SYSTEM)

FRAME

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	PRECAST CONCRETE COLUMN (GROUND FLOOR - LEVEL 20)				
A	800mm x 350mm x 3,150mm High precast reinforced concrete Grade 35 including formwork.	No.	1,120	1,300.00	1,456,000.00
	PRECAST CONCRETE FLOOR BEAM (LEVEL 1-LEVEL 19)				
B	9,000mm x 350mm x 450mm High	No.	532	2,300.00	1,223,600.00
C	4,500mm x 350mm x 450mm High	No.	456	1,200.00	547,200.00
D	7,500mm x 350mm x 450mm High	No.	532	1,900.00	1,010,800.00
	PRECAST CONCRETE ROOF BEAM				
E	9,000mm x 350mm x 450mm High	No.	28	2,100.00	58,800.00
F	4,500mm x 350mm x 450mm High	No.	24	1,100.00	26,400.00
G	7,500mm x 350mm x 450mm High	No.	28	1,750.00	49,000.00
	LIFT CORE WALL				
H	Concrete Grade 35 (250mm thick)	m^3	461	350.00	161,350.00
J	Reusable Metal Formwork	m^2	3,692	60.00	221,520.00
K	Rebar (Allow poundage @ 120kg/m^3)	Kg.	55,320	3.90	215,748.00
				TOTAL	**4,970,418.00**

SCENARIO III (FULL IBS SYSTEM)

UPPER FLOOR CONSTRUCTION

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	PRECAST CONCRETE HALF SLAB PANEL (LEVEL 1-LEVEL 20)				
A	200mm Thick hollow core slab	m²	26,123	185.00	4,832,755.00
				TOTAL	**4,832,755.00**

SCENARIO III (FULL IBS SYSTEM)

ROOF

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	RC FLAT ROOF				
A	Construct of flat roof including concrete, formwork, reinforcement, gutter and all necessary works as per specification and drawing.	m²	1,375	500.00	687,500.00
				TOTAL	**687,500.00**

SCENARIO III (FULL IBS SYSTEM)

STAIRCASE & RAMPS

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	REINFORCED CONCRETE STAIRCASE				
A	Construct of reinforced concrete staircase from the ground floor to the 20th floor (including concrete, reinforcement, formwork, plastering, painting work, 600mm x 600mm ceramic tiles, mild steel handrailing and all necessary works as per specification and drawing).	Flight	80	4,500.00	360,000.00
				TOTAL	**360,000.00**

SCENARIO III (FULL IBS SYSTEM)

EXTERNAL WALL

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	WALL PANEL SYSTEM				
A	100mm Thick ACOTEC wall panel	m^2	30,492	83.00	2,530,836.00
	HANDRAIL				
B	1,200mm High handrail with M.S hollow handrail and M.S hollow ballustrade	m	3,240	110.00	356,400.00
				TOTAL	**2,887,236.00**

SCENARIO III (FULL IBS SYSTEM)

WINDOWS AND EXTERNAL DOORS

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	WINDOWS				
A	900mm x 1,600mm high natural anodised louvers window with fixed glass.	No.	480	300.00	144,000.00
B	1,700mm x 1,600mm high natural anodised louvers window with fixed glass.	No.	240	600.00	144,000.00
C	600mm x 600mm high natural anodised louvers window with fixed glass.	No.	480	80.00	38,400.00
D	6mm Thick clear float glass panels	m^2	1,517	60.00	91,020.00
	EXTERNAL DOORS				
E	900mm x 2,100mm high decorative solid core door.	No.	240	650.00	156,000.00
F	900mm x 2,100mm high timber flush door.	No.	1,040	400.00	416,000.00
G	4,300mm x 2,100mm high sliding door.	No.	240	1,200.00	288,000.00
				TOTAL	**1,277,420.00**

SCENARIO III (FULL IBS SYSTEM)

INTERNAL WALL

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	WALL PANEL SYSTEM				
A	100mm Thick ACOTEC wall panel	m^2	18,145	83.00	1,506,035.00
				TOTAL	**1,506,035.00**

SCENARIO III (FULL IBS SYSTEM)

INTERNAL DOORS

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	INTERNAL DOORS				
A	900mm x 2,100mm high timber flush door.	No.	20	400.00	8,000.00
B	750mm x 2,100mm high timber flush door (exc door frame)	No.	960	250.00	240,000.00
				TOTAL	**248,000.00**

SCENARIO III (FULL IBS SYSTEM)

INTERNAL FLOOR FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Ceramic tiles	m²	20,109	70.00	1,407,630.00
				TOTAL	**1,407,630.00**

SCENARIO III (FULL IBS SYSTEM)

INTERNAL WALL FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Painting to skim coat	m²	55,376	10.00	553,760.00
				TOTAL	**553,760.00**

SCENARIO III (FULL IBS SYSTEM)

INTERNAL CEILING FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Skim coat	m²	20,109	8.00	160,872.00
B	Painting to skim coat	m²	20,109	10.00	201,090.00
				TOTAL	**361,962.00**

SCENARIO III (FULL IBS SYSTEM)

EXTERNAL FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
	EXTERNAL FLOOR FINISHES				
A	Ceramic tiles	m²	6,191	70.00	433,352.50
	EXTERNAL WALL FINISHES				
B	Painting to skim coat	m²	32,436	12.00	389,232.00
	EXTERNAL CEILING FINISHES				
C	Skim Coat	m²	6,191	8.00	49,528.00
D	Painting to skim coat	m²	6,191	12.00	74,292.00
				TOTAL	**946,404.50**

SCENARIO III (FULL IBS SYSTEM)

INTERNAL CEILING FINISHES

UNIT	DESCRIPTION	UNIT	QUANTITY	RATE	TOTAL
A	Bathroom pod	No.	480	7,900.00	3,792,000.00
B	UPVC Floor trap	No.	720	15.00	10,800.00
C	Single bowl drainer kitchen sink	No.	240	250.00	60,000.00
D	Kitchen tap	No.	240	75.00	18,000.00
				TOTAL	**3,880,800.00**

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CIDB MALAYSIA

CREAM