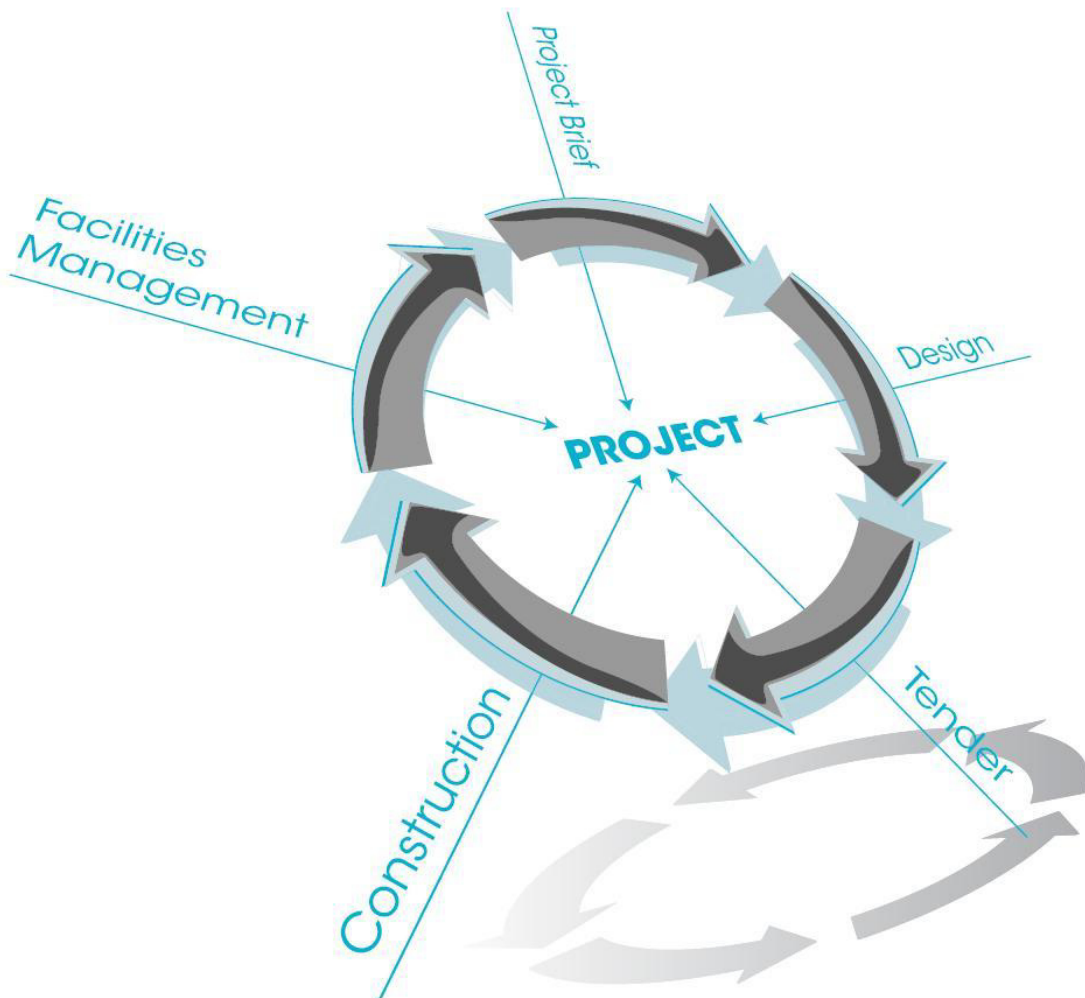


# Malaysian Construction Research Journal





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# Editorial

## Welcome from the Editor

The Editorial welcomes all readers to this fourth issue of Malaysian Construction Research Journal (MCRJ). Special thanks to all contributing authors for their technical papers. The Editorial would also like to express their acknowledgement to all reviewers for their invaluable comment and suggestion.

In this issue, *Kamaluddin*, highlights the current state of Public Works Department (JKR) taking its role as the main engineering agency of the Government of Malaysia to persuade the construction industry to migrate from the existing labour intensive, inefficient and non-sustainable to a more technology intensive, efficient and sustainable construction operations. This paper has been published in the International Seminar Proceedings on IBS at MiIE '09 Malaysia IBS International Exhibition, 21<sup>st</sup>.-23<sup>rd</sup>. January, 2009, Kuala Lumpur.

*Nuzul Azam, et. al.* review the advantages and barriers of IBS implementation in construction industry. It is an attempt to fulfill the Government's call for the adoption of IBS in Malaysian construction industry.

*Sakata, et. al.* proposed a design method for building structures in which damage is controlled during a large earthquake. The authors proposed a frame using PC Mild-Press-Joint method that allows a rocking between the column and beam press-binding interfaces during a large earthquake. Method and application examples of PC Mild-Press-Joint are described in this paper. The mechanical behavior of the damage controlled precast-prestressed concrete structure with P/C Mild-Press-Joint is also explained. This paper has been published in the International Seminar Proceedings on IBS at MiIE '09 Malaysia IBS International Exhibition, 21<sup>st</sup>.-23<sup>rd</sup>. January, 2009, Kuala Lumpur.

*Che Sobry, et. al.* reported the poor adoption on the load-bearing system from industry players. The study reveals that the main factor that contributes to the poor usage of the system in this country is due to the cognitive aspects. Although the industry acknowledges the benefits of using such a system, the lack of knowledge on the design and construction has hindered the proper usage of the technology.

*Hafez, et. al.* present the documentation of three prominent buildings in Klang Valley, Malaysia on intelligent building implementation. The 'Best-Practices Guide for Evaluating Intelligent Building Technologies' provided by the Continental Automated Buildings Association (CABA) was used as the evaluation tools. This paper will provide an insight on initial indication and guidelines on how intelligent is being implemented in Malaysia.

*Rosli, et. al.* discuss the capability of contractors to deliver a desirable quality in construction works. The primary aim of this study is to explore the areas of benefits from experienced contractors after being certified to ISO 9001:2000. Through implementing ISO Quality Management System (QMS) in their organisation, the contractors were generally able to improve their project productivity and enhance their company competitiveness. In the context of project performance perspective most contractors agreed by having the certification enable them to improve their ability to complete the project in time as well as to reduce wastage of construction material.

Finally, *Rawshan, et. al.* investigate the response willingness to pay (WTP) from the contractors for improved construction waste management. Interviews conducted at Klang Valley revealed that 68% of the contractors reported a positive WTP and are willing to pay an average maximum amount of RM 69.88 per tonne for the improved services.

## Editorial Committee





# INDUSTRIALISED BUILDING SYSTEMS: THE JKR PERSPECTIVES

**Kamaluddin Abdul Rashid**

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## **Abstract**

Public Works Department (JKR) as the main engineering agency of the Government of Malaysia has been at the fore front to persuade the construction industry to migrate from the existing labour intensive, inefficient and non-sustainable to more technology intensive, efficient and sustainable construction operations. To do all this, it is envisaged that the relevant production operations of the manufacturing industry could be assimilated into the construction process, thus improving the industry's effectiveness. As a start, the components of the buildings or structures could then be produced using specialised machines in the factory and then assembled rather than produced in-situ on sites. In this country, this approach is referred to as the utilisation of the Industrialised Building Systems (IBS) in the construction works. Nevertheless, there are still issues to be addressed pertaining to the existing design and construction practices as a result of the new approach. The intention of this paper is to highlight from JKR perspectives, such issues and to impress upon the industry on the need to make appropriate adjustments to accommodate these issues.

**Keywords:** *Structural systems, value engineering, off site casting, simple joints, labour reduction*

## **INTRODUCTION**

In November 2008 the Treasury Malaysia issued a Treasury Circular Letter, now referred to as the SPP 7/2008, to all Malaysian Government agencies directing them to increase the IBS content of their building development projects to a level not less than 70 point IBS Score. The circular letter took effect immediately and the Implementation and Co-ordination Unit at the Prime Minister's Department has been given the task to monitor the level of compliance to these directives by the respective agencies.

JKR as an engineering arm of the government is not exempted from this directive and as such, has produced an action plan to kick start the implementation process. Nonetheless, close examination of the existing local design and construction practice is needed to allow for orderly migration from the conventional on-site method of construction to the proposed off-site construction that utilises high content of IBS components. The examination is suggested with the goal of implementing the directive with the least disruptions or upheavals to the local construction industry. It is also an attempt to look at the possible mis-match between the design capabilities of the local engineering consultants and the manufacturing capabilities of the local building product manufacturers.

The outcome of the examination seems to suggest that there are still more rooms for collaborations between the design consultants and the manufacturers to support the implementation drive. These collaborations promise the optimisation of the local manufacturing capabilities resulting in more competitive cost of IBS components compared to conventional construction. Furthermore, it is also quite apparent that there is an urgent need for the construction industry, which has been doing things that they do best in the conventional ways for so long, to align themselves constructively with the government

initiatives to ensure that both parties complementing each other in their effort to achieve the desired objectives.

## **COLLABORATIONS AT THE DESIGN STAGES**

Without having to quote the statistics, it is quite evident that concrete is the material of choice for building construction works in this country by a significant margin. As such, when industrialised building systems are discussed in the industry, the comparison is always between the conventional cast in-situ concrete construction and the off-site factory casting of precast concrete construction. Fully aware that IBS covers more than just deploying the concepts of precast construction in the building works, the approach of this paper is to follow the local trend and to limit the discussion on the issues of IBS implementation to those related to concrete structures. The intention of this approach is to stay as relevant as possible to the local construction environment and hopefully by so doing, able to exert the full impact through the publication of this paper.

### **Choice of structural systems**

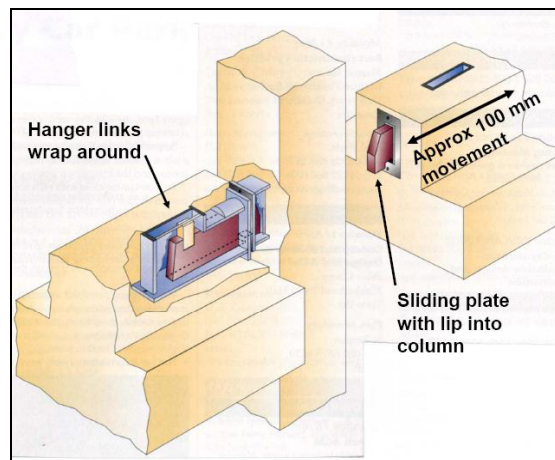
In the conventional cast in-situ concrete construction, the stability of the structures is obtained through frame action of the building skeleton. To allow this to happen, the column-beam joints within the building skeleton will have to be rigid, enabling the joints to resist bending moment developed as a result of lateral loads. Constructing rigid joints at site, the beams and columns will have to be cast monolithically together and this is relatively easy to achieve when cast in-situ concrete construction is employed. Due to the absence of any bracing elements in the building skeleton, the columns are now classified as unbraced and the respective design requirements applicable for unbraced columns, according to the British Standard (BS 8110-1:1997) will now have to be satisfied.

In contrast, when precast concrete construction is deployed in the works, the beams and columns are cast separately off-site and only are assembled on site. In the absence of any special joint adjustments at the ends of the beams or at the appropriate locations in the columns, the joints will be of simple joints, quite unable to develop sufficient rigidity required for the purpose of resisting the induced bending moment. In this condition, the building skeleton is not able to generate the required frame action and the whole building is now unstable.



**Figure 1.** Steel reinforcement bars are left exposed during casting work at the factory to allow for site casting. (Courtesy of Elliott, K. S. University of Nottingham, UK.)

Faced with this problem, the design engineers in this country often opted for the provision of special adjustments at the joints to enable them to develop the required rigidity. The most common approach is to expose the steel reinforcement bars at the ends of the beams and at the appropriate locations in the column to allow for the joints to be cast monolithically at site. Figure 1 above illustrates the use of this approach. Major drawback of this approach is the need to prop up the columns and beams until joints are completely cast together and the cast in-situ concrete in the joint has sufficiently hardened. With the casting of the joints reverted to cast in-situ construction, the problems commonly associated with cast in-situ construction are still be there even though IBS construction method is now implemented.

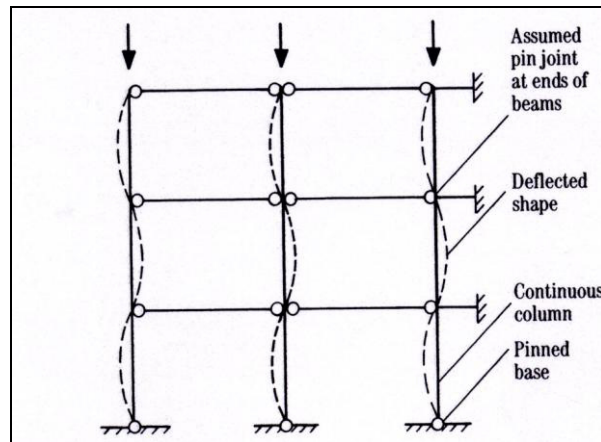


**Figure 2.** Proprietary jointing systems developed by BSF Norway to cater for the need of mechanised joints. (Courtesy of Elliott, K. S. University of Nottingham, UK.)

Another approach that is also popular in this country is to use proprietary ready made rigid jointing systems that are available on the market. These jointing systems are produced by local established precast manufacturer to be used with their precast concrete products. Often the system were developed outside the country by reputable international precast manufacturer and produced here under some kind of licensing agreement. Being proprietary systems, they can not be used freely by everyone in the local industry without having to obtained proper permission from the proprietor. They are also not marketed as an independent jointing system but rather as part of the precast concrete product produced by the particular precast concrete manufacturer. Figure 2 above shows an example of proprietary jointing system. Thus, if a specific jointing system is required by the design engineer, then he has to specify the jointing system together with the accompanying precast concrete beams and columns produced by the joint proprietor. At the moment the number of local precast concrete manufacturer capable of providing such services is still small due to the current low demand of precast concrete building components. As such, it is rather doubtful that the existing manufacturers will be able to cope with the expected increase in the demand once the Treasury directives are fully implemented.

One possible solution to this problem is to encourage design engineers to shift away from the unbraced to braced structural systems. In this approach, instead of relying on the frame action of the building skeleton, the lateral stability of the building is realised through

the utilisation of braced frames or shear walls. Figure 3 below illustrates the deflected shapes of the columns when this structural system is utilised. The lateral loads acting on the skeleton of the building are transferred to the moment resisting structures (braced frames, shear walls or a mixture of both) through the diaphragm action of the concrete floor slabs. In the case of precast concrete hollow core floor slabs, laboratory works have been carried out in Europe as early as 1990 to determine the suitability of the slab to generate diaphragm action. The result of these tests (Omar, 1990) have put it beyond doubt that concrete floors made up of precast concrete hollow core slabs are able to generate the diaphragm action and transfer lateral loads safely to resisting structure.

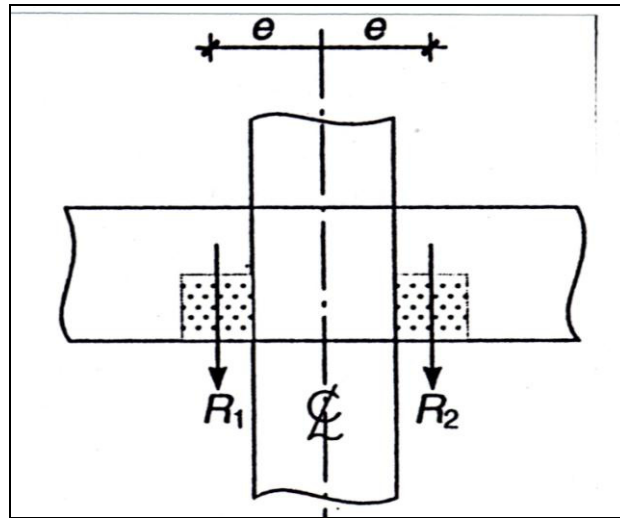


**Figure 3.** Deflected shapes of columns when braced structural system is utilised. (Courtesy of Elliott, K. S. University of Nottingham, UK.)

By allowing the lateral forces to be transferred to the resisting elements through the diaphragm action of the slabs, the need for rigidity at the column and beam joints is now eliminated. The joints can now be constructed as simple joints with no bending moment expected to be resisted. Thus, no special provision for rigid joint is required or very little cast in-situ concreting is required to be done on site.

As far as the local construction industry is concerned, the adoption of the above approach will bring about at least two benefits. Firstly, it will allow greater generation of fresh new local precast manufacturers into the industry because the work involved now is less complicated, limited to just producing precast beams and columns without having to solve the rigid joint problems. The manufacturing technology required to produce these elements is also readily available in the country with little dependency on foreign technological input. The level of capital investment to start production is also relatively low, all within the financial capacity of small and medium local entrepreneurs.

Secondly, the adoption of braced structural elements in the design will result in the optimisation of the load resisting capacity of the columns. In this instance, for the same amount of steel reinforcement in a column, the axial load permitted on the column is higher in the case of braced structures compared with the unbraced structures.



**Figure 4.** Simple column-beam joint resulted in lower moment transferred to the column due to small eccentricity between the support reaction and the centre line of column. (Courtesy of Elliott, K. S. University of Nottingham, UK.)

The reason for this improvement in the axial load capacity is apparent when the analysis of structures is carried out. Due to the rigid connection at the joint, a significant proportion of the bending moment generated in the beams is transferred to the columns. Whereas, in the case of simple connection, as shown in Figure 4 above, bending moment generated in the column is due to the eccentricity between the support reaction and centre line of the column. Since the support reaction and the centre line of column are in close proximity, the magnitude of bending moment in simple connections is often significantly lower than the bending moment in rigid connections. With smaller bending moment to resist, the columns in braced structures are able to take higher axial load safely, resulting in greater economy for the precast concrete construction.

### Input for mechanical and electrical services

It has been a practice in the local industry that design input given by the mechanical and electrical engineers are only sought after the structural engineers have finished with their design work. This makes perfect sense when casting works are carried out in-situ at site. The mechanical and electrical engineers still have enough time to complete their part of the design even after the structural engineers have finalised their work because of the long waiting period between the calling of tender and the actual time the appointed contractor starting the casting work. Moreover, even in cases where mechanical and electrical designs are severely delayed, the flexibility inherent in the cast in-situ construction is huge enough to tolerate the occasional hacking of the concrete elements after the casting has taken place.

Unfortunately the same cannot be said about precast concrete construction. In order to increase productivity, rapid turn around in the factory is essential. Thus, building components are often designed in such a way that they can be transferred out of their moulds within 7 days or even less. The strength of concrete used in this operation is considerably higher than cast in-situ construction because of the need to have sufficient strength in a very short time to allow the elements to be lifted safely to the stock yard for storage. As such, it is

rather typical for manufacturers in Europe to use concrete grade of C60 (Elliott, 2002) for their products. In fact, from author's own research experience, the strength of concrete reaching 80 N/mm<sup>2</sup> has been recorded for concrete used in precast concrete hollow core floor slabs produced in Birmingham, United Kingdom.

**Table 1.** Compression test results performed on concrete used in precast concrete hollow core slab.

Specimen Number	Testing at age of (days)				
	28	60	135	181	196
M1	81.5	-	-	-	-
M2	78.5	-	-	-	-
M3	77.6	-	-	-	-
M4	75.1	-	-	-	-
U1	-	83.5	-	-	-
U2	-	-	79.5	-	-
U3	-	-	60.8	-	-
U4	-	-	92.0	-	-
U5	-	-	89.0	-	-
U6	-	-	-	-	77.0
U7	-	-	-	-	93.0
U8	-	-	-	-	58.5
U9	-	-	-	-	79.0
U11	-	-	-	-	95.0
U12	-	-	-	-	95.0
U13	-	-	-	75.0	-
U14	-	-	-	77.5	-
U15	-	-	-	89.0	-
U16	-	-	-	61.0	-
U17	-	-	-	86.5	-
U19	-	-	-	86.0	-
U21	-	-	-	84.0	-
U22	-	-	-	88.0	-
U23	-	-	-	84.5	-
U24	-	-	-	89.0	-
<b>Mean</b>	78.2	83.5	80.3	82.1	82.9

When dealing with such high strength of concrete, it is just too difficult to do any cutting or hacking work to facilitate the installation of any mechanical or electrical equipments after the concrete have reached the 28-day strength. Any required adjustments to be made on the precast components or equipments to be embedded inside the body of the components will have to be finalised and carried out before the commencing of the casting work in the factory. Figure 5 above shows the installation of electrical ducting prior to casting of concrete.





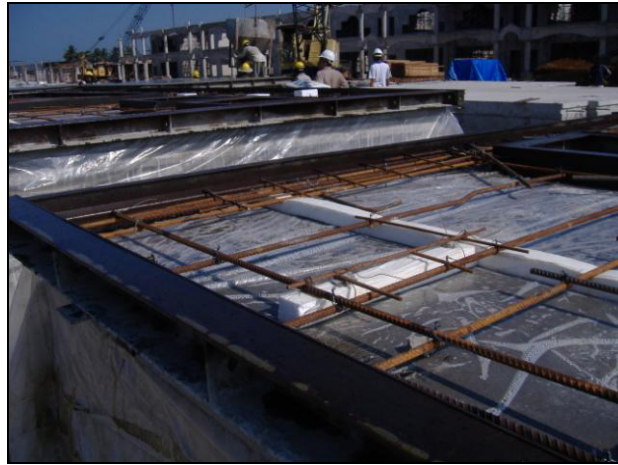
**Figure 5.** Electrical ducting, if required is to be installed in the precast building component prior to the casting of concrete.

It seems imperative now that the timing of the design production for the mechanical and electrical services will have to be significantly brought forward in tandem with the production of structural designs. The mechanical and electrical design engineers may have to review their normal practice of producing up to schematic drawings only at the tender stage with producing actual shop drawings at that stage. The change in the timing is vital to ensure the installation of the required building services at the factory during manufacturing of precast concrete components can be carried out correctly and efficiently.

## **ALIGNMENT OF INDUSTRY AND GOVERNMENT OBJECTIVES**

It is already an open secret that the reason behind the push to persuade the construction industry to adopt industrialised building systems in their work is to modernise the industry, making it more efficient and sustainable. The Government realised that the local industry is very dependent on easy and cheap supply of foreign unskilled labour coming from the neighbouring countries. The influx of these foreign labours has definitely put a lot of strain on the existing social facilities, creating doubts on ability of such facilities to cope with the growing demand for services, especially in specific sectors. This is certainly of serious concern in the important sectors such as housing, public health, transportation, education and security.

The Government reasoned out that this dependency could be lessened if the industry is willing to invest in the mechanisation of selected construction processes through the adoption of industrialised building systems. The Government further envisaged that through this adoption, buildings shall no longer be constructed exclusively on site, rather produced through off-site casting of appropriate building components and then assembled on site. These components are produced in factories that utilise state of the art manufacturing technology allowing substantial labour reduction to be made. In the end, the industry will be able to produce and deliver high quality products, value for money and at the same time stay competitive in the open world market.



**Figure 6.** Producing components on site when they can be more effectively produced off-site in the factory will not help the country to improve the efficiency and reduce labour requirements in the construction industry.

Nevertheless, all these lofty objectives will not be realised if the industry itself is not willing to pull their socks together and work in unison with the Government initiatives. In fact, in order to reduce the demand on unskilled labour, the industry must be willing to invest on machineries and use them in their construction work rather than employing more labours to do the work that machines can do. The fact that, even in the Manual for IBS Content Scoring System, score points are still being allocated for on-site casting of building elements that can actually be produced off-site in the factory seems to support the argument that the industry is unwilling to change.

In addition, there are also persistent calls from the local contractors to allow them to cast the precast concrete components on site, for the reason being the cost of transportation in delivering the factory-made building components is too high. It has to be realised that it is neither cost effective nor practical to set up a precasting yard equipped with the state-of-the art labour reducing technology on a temporary basis. If the request to allow site casting of precast concrete components is to be allowed, chances are the components will be produced using the same cast in-situ technology that the Government is trying to move away from. This will defeat the whole objectives of using IBS in the first place.

## **SUMMARY**

In the effort to migrate from the conventional cast in-situ construction to the off-site factory based construction, engineering issues such as the provision of moment resisting joints and the need to have mechanical and electrical services embedded in the precast concrete elements have been discovered.

However, some of these problems could be solved by changing the approach towards the selection of the structural systems employed in the design of the building, making the need for moment resisting joints no longer relevant. Further more, a re-scheduling of the mechanical and electrical design work should be able to alleviate the difficulty in installation of services on hardened precast components.



Finally, the alignment objectives of both involved parties, the industry and the Government is one of the critical success factors in ensuring smooth and successful implementation of the migration to IBS in the construction works.

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# A LITERATURE REVIEW OF THE ADVANTAGES AND BARRIERS TO THE IMPLEMENTATION OF INDUSTRIALISED BUILDING SYSTEM (IBS) IN CONSTRUCTION INDUSTRY

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## Abstract

The construction industry cannot do today's job with yesterday's methods and be in business tomorrow. IBS is most commonly recognized as a preferred construction method in this day and age. Studies indicate that the IBS promotes labor reduction, cleaner and neater sites, easy installation, fast completion, enhancement of quality finished products and flexibility (Syarul and Nor, 2003). This paper aims to review the advantages and barriers of IBS implementation in construction industry. It is an attempt to fulfill the Government's call for the adoption of IBS in Malaysian construction industry. Hence, it is important to determine the advantages and barrier factors of IBS implementation. The factors are based on the literature review conducted by the author on the subject matters.

**Keywords:** *Industrialised Building System (IBS), Advantages, Barriers Factors, Implementation in Malaysian Construction Industry*

## INTRODUCTION

The concept of mass production of quality building is termed as "Industrialised building system (IBS)". Among the benefits of using IBS are: speed, quality and economics, all of which are required so as to meet the large demand for housing. In order to develop techniques for mass produced houses, Malaysia needs to access itself to the world's most modern building system, building materials and housing products (Waleed et. al., 2003).

The IBS, which enables on-site prefabricated or pre-cast building components manufactured at factories, will enable cost saving and quality improvement through the reduction of labour intensity and construction standardization. Apart from this, it offers minimal wastage, less site materials, cleaner and neater environment, controlled quality, and lower total construction cost (CIDB, 2003).

One fact which seems to have the common consensus of all the stakeholders of IBS in Malaysia is that, the implementation of IBS in Malaysian building construction industry is still very low compared to the conventional methods. It is most intriguing to find out why: which set the author to this paper.

The purpose of this paper is to conduct a critical review on the IBS implementation in construction industry as a whole. The review focused on the advantages and barriers factors on the IBS implementation.

## **METHODOLOGY**

The factors determined are based on the literature review compilation from international and national journal papers, conference papers, proceedings, government's reports and bulletins. The literature review references cover the time frame from 1999 to 2009.

The review comprises all types of IBS construction in Malaysia inclusive of residential and commercial construction building.

The author used both the exploratory and refines review. At the initial exploratory review the author used the terminology or keyword searches for the review. Upon obtaining sufficient literatures on the subject matter the author proceeded with refine review. At this stage the review involves more focused observations, analysis, specific paper references and more importantly the bibliography.

## **SCENARIO OF IBS IN MALAYSIA**

Since 1998, the Construction Industry Development Board (CIDB) has been actively promoting the use of IBS in the Malaysian construction industry. The Malaysian Structural Steel Association (MSSA) president Tan Sri Zaini Omar said the Roadmap 2003-2010 was formulated to effectively coordinate the industry towards industrialization, concentrating on the usage of IBS in the building industry. The usage of IBS, which started in 2003, has been implemented stage by stage in the building industry. The Government, he added, aimed to achieve 100 percent usage of IBS by the year 2010. With the usage of IBS, the government is looking at reducing 15 percent or 50,000 of foreign workers in the construction industry by 2010. "At the moment, we have about 227,000 foreign workers who are registered with the Immigration Department", he said. The Government would be able to reduce remittances by foreign workers with the full implementation of IBS. At the moment, the remittances of foreign workers amounted to about 7.5 billion each year, he concluded (Bernama, 2006).

"CIDB has planned the IBS programme as the Government's agenda, albeit an agenda that calls for the support, participation and commitment of the private sector. From the Government's perspective the IBS programme was necessary to address the salient issues; the large scale dependency of the construction industry on foreign migrant labour was producing a leak in the economy as a result of the repatriation of the large amount of funds outside Malaysia and the large presence of foreign migrant workers of different nationalities have created numerous social and health problems to the local populace" said the General Manager of CIDB, Ir. Elias Ismail (Bernama, 2006).

The benefits of IBS besides requiring minimal labour, offers better quality, increased productivity, faster completion, less wastage with safer and cleaner construction sites. Through IBS, components are prefabricated off-site, leaving the construction sites tidier and cleaner compared to the conventional method (CIDB, 2005).

The experiences in some developed countries such as Japan, Germany and the U.K. indicate that there is a great potential for IBS to progress as evidenced by their growing market share. Indeed, the success of IBS in those countries is prompted by concern of home buyers about long term energy saving, indoor air quality, and other health and comfort related issues, commitment and cooperation between the public and the private sectors

toward greater technological advancement and innovation. Clearly if Malaysia wishes to imitate the success of those countries, a long term comprehensive policy towards the industrialization of building and construction sector should be pursued (Waleed *et al.*, 2003)

IBS systems can only be acceptable to practitioners if its major advantages are valuable compared to the conventional system. However, there is a lack of corroborative scientific evidence to substantiate the benefits of IBS system up to date. It is therefore, arguable that the implementation of IBS is particularly hindered by lack of scientific information (Badir *et al.*, 2002).

## THE ADVANTAGES FOR IBS ADOPTION IN CONSTRUCTION INDUSTRY

The author conducted extensive literature review of journal and conference papers, articles, newspapers and technical reports. Based on overall review on the IBS implementation, the author is able to generalize the following benefits compared to the conventional construction system:

1. **Reduce Remittances by foreign worker:** The Government aimed to achieve 100 percent usage of IBS and to reduce to 15 percent or approximately 50,000 of foreign workers in the construction industry by 2010. With the current foreign workers totalling 227,000, the remittances of the foreign workers amounted to about 7.5 billion. It is expected that the Government would be able to reduce the remittances with the full implementation of IBS. (Bernama.com, 2006)
2. **Enhance Efficiency of Construction Process and Higher Productivity:** IBS is a methodology whereby a local construction industry is driven towards the adoption of an integrated and encouraging key players in the construction industry to produce and utilize pre-fabricated and mass production of the building at their work sites. This will help to enhance the efficiency of construction process, allowing a higher productivity, quality, time and cost saving. (CIDB, 2004)
3. **Produce Better Product:** IBS promises elevated levels of expertise throughout the industry, from manufacturers, installers, engineers, planners, designers, and developers. The benefits of IBS will ultimately produce better products for the population (CIDB, 2003)
4. **Reduce Wastage, Less Site Materials, Costs, Cleaner and Neater Environment:** The IBS, which enables on-site prefabricated or pre-cast building components manufactured at factories offers minimal wastage, less site materials, cleaner and neater environment, controlled quality, and lower total construction cost (CIDB, 2003). For example, the repetitive use of system formwork made up of steel, aluminium, etc and scaffolding provides considerable cost savings (Bing *et al.* 2001).

5. **Higher Quality of Component:** An industrialised building system component produces higher quality of components attainable through careful selection of materials, use of advanced technology and strict quality assurance control (Din,1984)
6. **Reduce Labour at Site:** Prefabrication takes place at a centralised factory, thus reducing labour requirement at site. This is true especially when high degree of mechanisation is involved (Warszawski, 1999)
7. **Faster Completion:** An industrialised building system allows for faster construction time because casting of precast element at factory and foundation work at site can occur simultaneously. This provides earlier occupation of the building, thus reducing interest payment or capital outlays (Waleed *et al.*, 2003)
8. **Not Affected by Adverse Weather Condition:** Construction operation is not affected by adverse weather condition because prefabricated component is done in a factory controlled environment (Waleed *et al.*, 2003)
9. **Flexible Design:** An industrialised building system allows flexibility in architectural design in order to minimise the monotony of repetitive facades (Warszawski, 1999). An industrialised building system provides flexibility in the design of precast element as well as in construction so that different systems may produce their own unique prefabrication construction methods (Zaini, 2000)

## **BARRIERS TO THE ADOPTION OF IBS IN MALAYSIA**

According to Waleed *et. al.* (2003), the common consensus of all the stakeholders of construction in Malaysia is that, the IBS implementation in Malaysian building construction industry is still very low compared to the conventional methods. This is due to several reasons:

- 1) **Costs and Return Investment:** Wide swings in houses demand, high interest rate and cheap labour cost, make it difficult to justify large capital investment. At present there is an abundance of cheap foreign workers in Malaysia and contractors prefer to use labour intensive conventional building system because it is far easier to lay off workers during slack period. The economic benefits of IBS are not well documented in Malaysia and the past experiences indicated IBS is more expensive due to fierce competition from conventional building system.
- 2) **Lack of skilled and knowledgeable manpower:** Fully prefabricated construction system requires high construction precision. Malaysian labour force still lack of skilled workers in IBS implementation.
- 3) **The Practices:** The construction industry is very fragmented, diverse and involves many parties. Consensus is required in the use of IBS during planning stage.

- 4) **Knowledge based:** Lack of R&D in the area of novel building system that uses local materials. Majorities of IBS in Malaysia are imported from developed countries, thus driving up the construction cost. Engineering degrees in local universities seldom teach about the design and construction of IBS.
- 5) **Low Quality:** The use of IBS in Japan and Sweden are so successful due to high quality and high productivity but it is the opposite in Malaysia. Previous projects constructed with IBS concept were of low quality and high construction cost.
- 6) **Lack of Incentive and Awareness:** Due to the lack of incentive and promotion from government in the use of IBS, many many architects and engineers are still unaware of the basic elements of IBS such as modular co-ordination.
- 7) **Lack of Scientific Information:** An IBS system can only be acceptable to practitioners if its major advantages are valuable compared to the conventional system. However, up to date, there is inadequate corroborative evidence to substantiate the benefits of IBS system. It is therefore, arguable that the implementation of IBS is particularly hindered by lack of scientific information (Badir *et al.*, 2002)
- 8) **Wastage of Material:** Standardization of building elements faces resistance from the construction industry due to aesthetic reservation and economic reason. One good example of this is when a 300mm thick modular standardized floor slab has to be used although a 260mm thick floor slab can achieve the similar structural performance. This results wastage of material (Waleed *et al.*, 2003)

## CONCLUSIONS

Based on the literature review, there are nine (9) potential success factors and eight (8) barriers that had been found for the success of IBS implementation in Malaysia.

With these factors identified the author attempted to weigh the benefits of IBS and the reasons for not fully realizing the benefits in the Malaysian IBS context. This brings the author to conclude that there is insufficient research work being done to highlight the benefits and the reasons for IBS lack of implementation in Malaysian construction industry.

These advantages and the barriers must be used to conduct a survey among Malaysian construction industry players to select the most important advantages and the most important barriers that reflect the level of IBS implementation in Malaysia construction industry. It is very important to determine the advantages for IBS adoption in Malaysia in order to fulfill the Government target in adopting hundred percent (100%) of IBS implementation by the year 2010.

The author proposes that more studies are conducted not only to identify the benefits and advantages of the IBS implementation in Malaysia but also to identify the dormant reasons for the stakeholders for not fully capitalizing on the IBS implementation in Malaysian construction industry.

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# DAMAGE CONTROLLED PRECAST - PRESTRESSED CONCRETE STRUCTURE WITH P/C MILD-PRESS-JOINT

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## **Abstract**

The seismic design of some buildings has been based on new methods aimed at protecting human lives from even large earthquakes by utilizing the structure's plastic deformation capacity. In the Hyogo-ken Nanbu Earthquake, many of these buildings escaped the worst damage including collapse. It was thus considered that they had achieved their safety objective of protecting human lives. However, they suffered cracking and residual deformation, and some that had suffered large damage had to be demolished. In addition, depleting natural resources, global environmental issues, etc., make it desirable to extend building life. Accordingly, it is regarded as important to sustain post-earthquake building usage and to quickly restore building functions. Although security of human lives is of paramount importance, it is also desirable to minimize damage to building structures to enable continued use of buildings and to sustain property values even after the largest level earthquake. It is therefore necessary to establish a design method for building structures in which damage is controlled during a large earthquake. The authors and others have thus proposed a frame using a PC Mild-Press-Joint method. With this method, members are press-bound by prestressing strands in columns and beams of PCa with an initial tension set to  $0.5 P_y$  / strand ( $P_y$ : nominal yield strength) that is lower than in a conventional PC structure. This method allows a rocking between the column and beam press-binding interfaces during a large earthquake. This is aimed at controlling damage to members and minimizing residual deformations. In this paper, outline the PC Mild-Press-Joint method and application examples are described. The mechanical behavior of the damage controlled precast-prestressed concrete structure with P/C Mild-Press-Joint is also explained.

**Keywords:** *P/C MILD-PRESS-JOINT structure, damage control, corbels, elastic rotation,  $\perp$ -shaped frame,  $\vdash$ -shaped frame, beam-column joint, damage control, shear strength of joint panel*

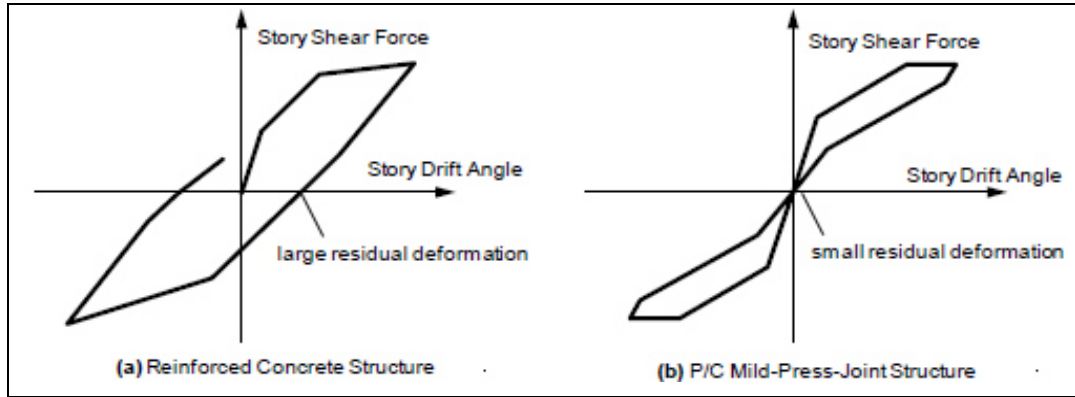
## **DAMAGE CONTROLLED CONCRETE-BASE STRUCTURES**

In conventional RC structures, earthquake energy is absorbed by all structural members, resulting in a lot of cracks. Furthermore, reinforcing bars yield under large earthquake load. This results in spindle-shaped hysteresis characteristics, as shown in Fig. 1(a), and large residual deformations. In PC structures, cracking is suppressed by the compressive stress introduced into the concrete. Even large deformations are restored after an earthquake by the internally introduced prestress force. Therefore, origin-oriented hysteresis characteristics, as shown in Fig. 1(b), are indicated. The authors have utilized these characteristics of PC structures to develop a P/C Mild-Press-Joint method that realizes damage control. Precast-concrete frames using unbounded post-tension are being studied in the U.S.A. in the area of concrete-based structures utilizing the characteristics of crack-resistance, origin-oriented hysteresis, and so on. These studies are typically found in the PRESS research program (El-Sheikh, 1999 and Priestley, 1996).



## OVERVIEW OF P/C MILD-PRESS-JOINT SYSTEM

Principal features of the proposed new structural system are as follows.



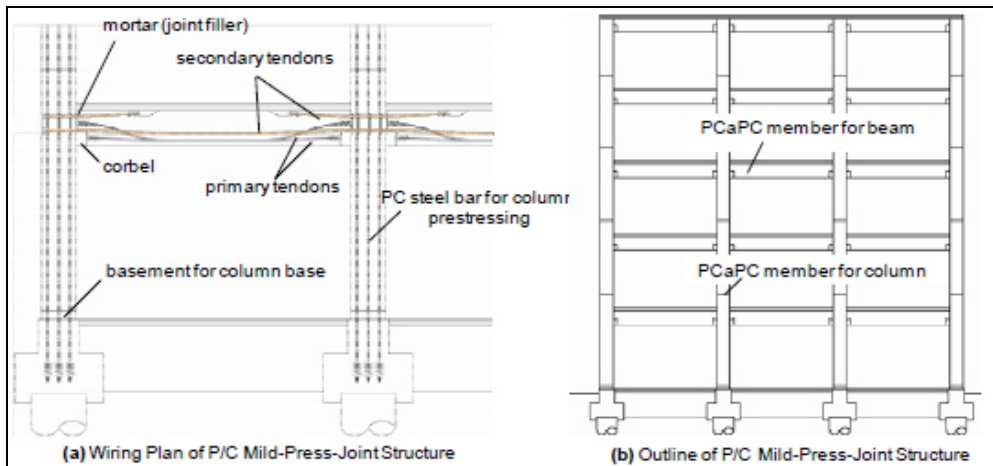
**Figure 1.** Compare Reinforced Concrete Structure with P/C Mild-Press-Joint Structure

- 1) Structural members, beams and columns are precast-prestressed components. Structural frames are realized by connecting the beam and the column using prestressing tendons. Table 1 shows structure design criteria for P/C Mild-Press-Joint system. The frames behave as full-prestressing structures under design vertical load and under Level 1 earthquake load provided for by the Japanese Building Code. Level 1 earthquake corresponds to moderate earthquakes, which are being expected to occur in Japan approximately every 50 years. Under Level 1 earthquake load, connections among beams and columns behave as rigid joints and interfaces among them remain in compressive state. Under Level 2 earthquake load (recurrent period of 500 years) and Level 3 earthquake load (recurrent period of 1000 years), the connections rotate elastically to prevent damage to beams and columns. Seismic energy dissipation devices, such as damper and damping wall, are installed as needed.

**Table 1.** Structural Design Criteria

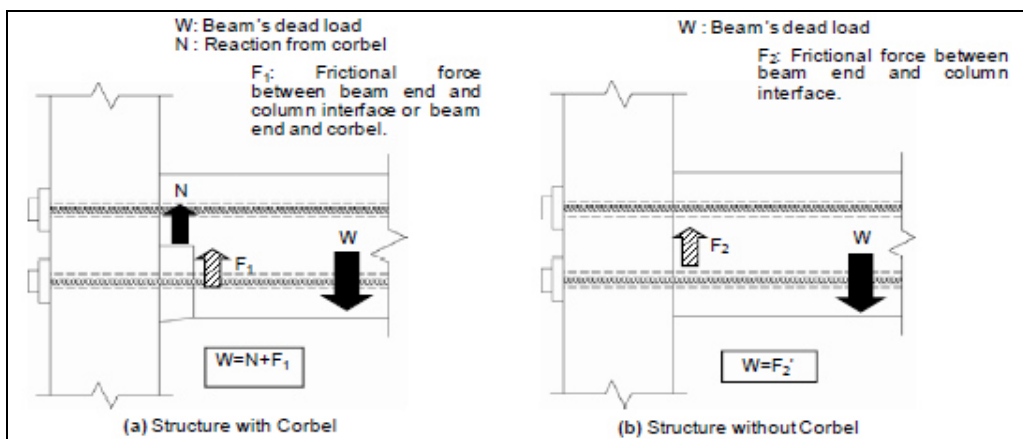
	Behavior of beam-column interface	Rotation angle of member	Storey drift angle (residual story drift angle)	Damage of general member of framework	Damage of beam-column interface
Vertical loading	Compressive stress remains at beam-column interface	Rigid	-	None	None
Level 1 (moderate earthquake)	Compressive stress remains at beam-column interface	Rigid	-	None	None
Level 2 (severe earthquake)	<ul style="list-style-type: none"> <li>Member of framework rotate elastically</li> <li>Secondary EC strands does not yield</li> </ul>	$<1/50$	$<1/75$ ( $<1/500$ )	None	Beam end concrete & mortar (joint filler)
Level 3 (very severe earthquake)	<ul style="list-style-type: none"> <li>Member of framework rotate elastically.</li> <li>Secondary EC strands does not yield</li> </ul>	$<1/33$	$<1/50$ ( $<1/400$ )	None	Beam end concrete & mortar (joint filler)

- 2) Fig.2 shows example of P/C Mild-Press-Joint structure prestressing tendons are classified into primary tendons and secondary tendons. The primary tendons are stretched up to 85% of nominal yielding strength, and then are anchored at the end surface of each component. They never are placed through adjacent components. The secondary tendons are playing the role to connect beams and columns or columns and foundations. The effective prestressing force of the secondary tendons is limited to 50% of nominal yielding strength. It is because the secondary tendons should not be entered in plastic range under Level 2 or Level 3 design earthquake loads that initial stretching force is controlled to low level.



**Figure 2.** Example of P/C Mild-Press-Joint Structure

- 3) Frictional force produced between beam end and column interface by prestressing strand has to transmit shearing stress to column in traditional P/C anchoring method. The problem which it can't resist beam's dead load, if prestress forces introduced into the PC steel members strand are not set some level. But, in P/C Mild-Press-Joint system, column has corbel shown in Fig.3. This makes corbel transmit beam's dead load. So, it is easy to construct stable structure, even if prestress forces introduced into the PC steel members strand are set at 50% of the nominal yield strength of the prestressing strands.



**Figure 3.** Difference between with Corbel and without Corbel

## Characteristics of P/C Mild-Press-Joint Method

### 1) High durability

Damage conditions of the joint used in the PC Mild-Press-Joint method are shown in Figure 4. Using the high quality industrial products (concrete strength  $F_c$ : 50N/mm<sup>2</sup>) for main members, column and beam members are press-bound by the tensile forces of the prestressing strands. Prestress prevents cracks from occurring. Elastic rotation is generated at the joints in a secondary design level earthquake and above, and closes after the earthquake. Therefore, if the joints are inspected and repaired after the earthquake, the structure's life is maintained.

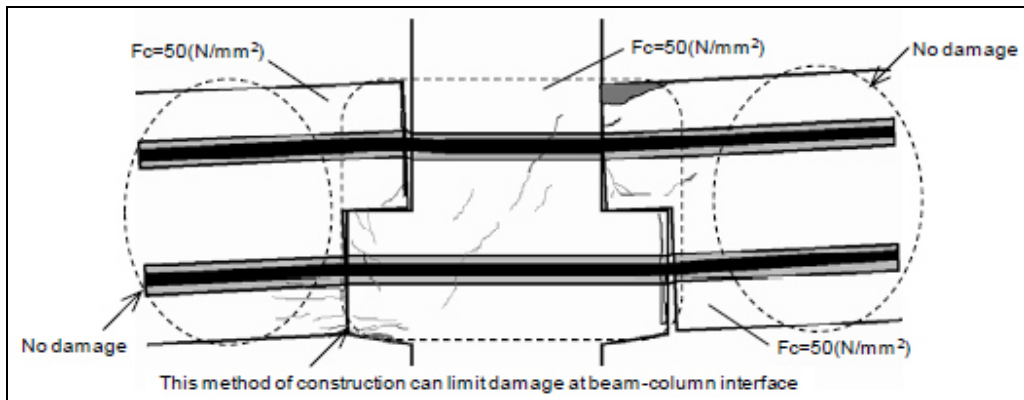


Figure 4. Ultimate State (P/C Mild-Press-Joint)

### 2) High seismic energy adsorption capacity

The mechanism in which the P/C Mild-Press-Joint structure absorbs seismic energy is shown in Figure 5. Capacity to absorb an earthquake's input energy is lower in prestressed concrete structures than in reinforced concrete structures and steel structures. This method allows joint rotation during the earthquake and thus improves this capacity. It can also efficiently absorb energy by co-using damping members.

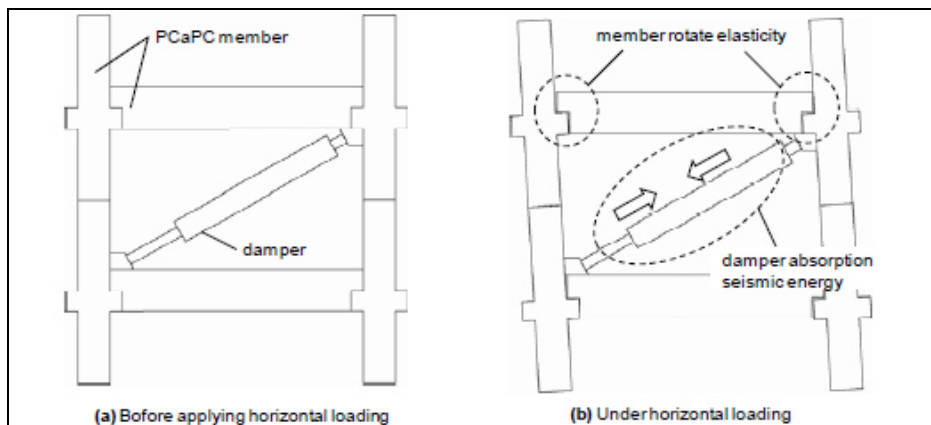


Figure 5. Example of Energy Absorption in P/C Mild-Press-Joint Structure

### 3) Small residual deformation

Cracks do not occur in general parts of members even under an earthquake force of secondary design level. Furthermore, primary PC steel members and secondary PC steel members do not yield. Therefore, deformation is restored after the earthquake and the prestress minimizes residual deformation. Local damage due to concrete collapse occurs at beam-column joints. This is caused by joint rotation. However, the influence on residual story deformation angle is small. The typical hysteresis loop of the Mild-Press-Joint system is shown in Fig. 6(a). The relationship between the peak story deformation angle and the residual deformation angle is shown in Fig. 6(b). It is found that neither primary nor secondary PC members yield even when they suffer a secondary design level seismic force and above. Thus, deformation is restored by the prestress effects after the earthquake finishes, while showing hysteresis where residual deformation is very small.

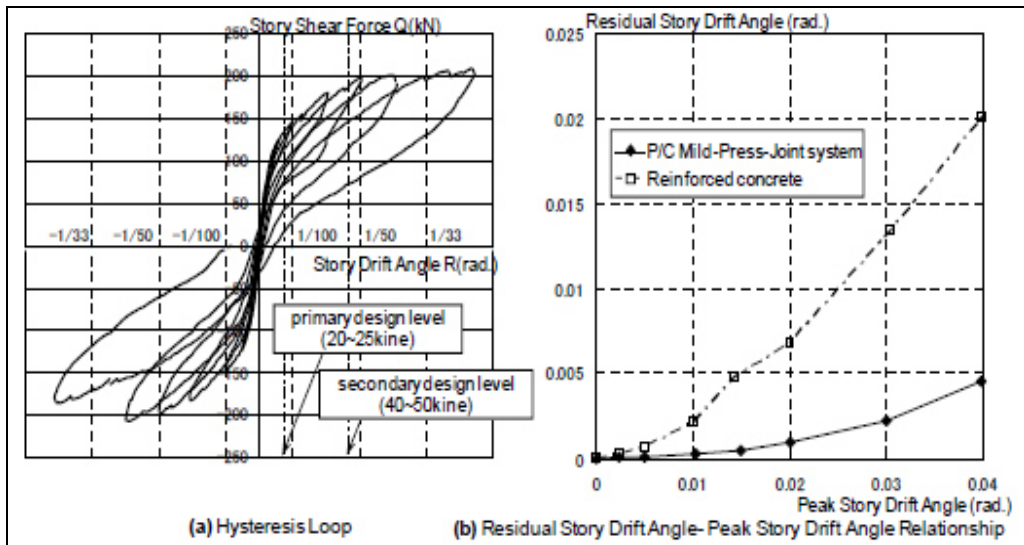
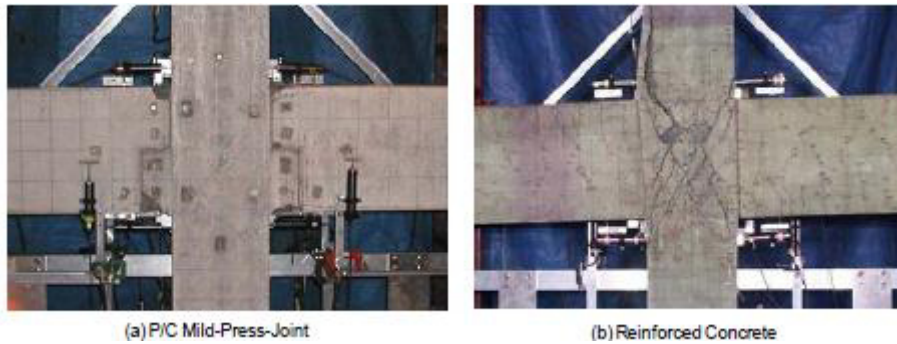


Figure 6. Deformation Property of P/C Mild-Press-Joint

### 4) Easy assessment of post-earthquake damage

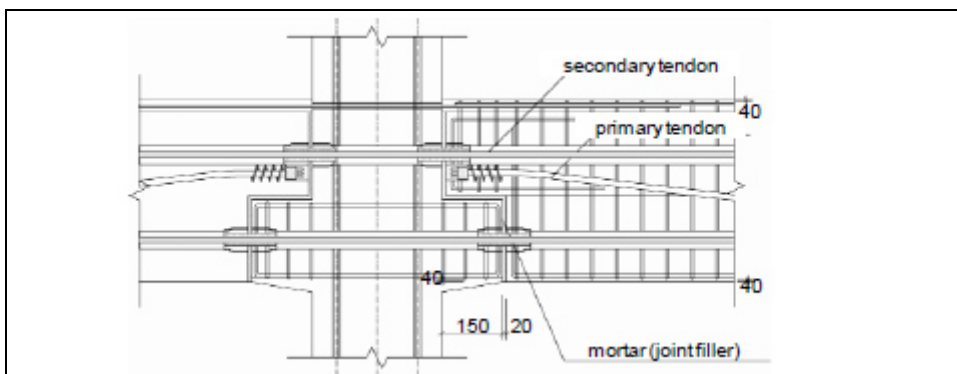
Photos of experiments on frame beam-column joints conducted in 2003 (story deformation angle  $R = 1/25$  rad. at the final stage) are shown in Fig. 7. Earthquake damage was localized to binding parts and damping members. This shows that repair cost and executors can be estimated and located with high accuracy in the design stage.



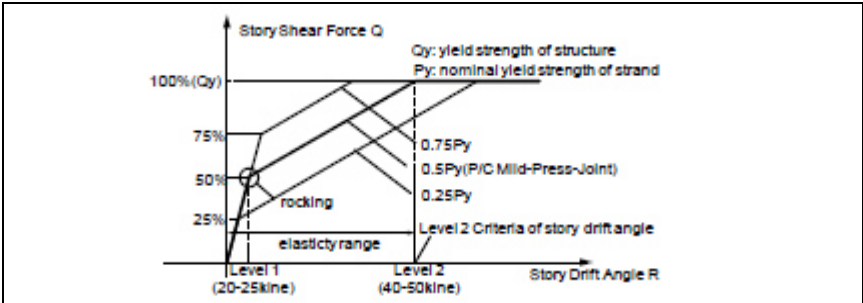
**Figure 7.** Ultimate Stage (story drift angle  $R= 1/25$  rad.)

## DESIGN DETAILS

P/C Mild-Press-Joint detail is shown in Fig. 8. Two kinds of PC steel members, primary and secondary, are employed in this joint method. Both members are placed in a pipe sheath, into which grout is injected to integrate them. Primary tendons, which are stretched to 80 % of nominal yielding strength, are anchored at the end surface of beams. Those members are aimed at making the beam members PC members. The members were designed for full prestress under long-term load. Secondary tendons coated with epoxy resin of suitable adhesion capacity are employed for the beam-column press-binding. The prestressing strands are anchored in the column and beam members. Prestress forces introduced into the PC steel members strand by strand are set at 50% of the nominal yield strength of the prestressing strands. As a result, although the tensile forces in the prestressing strands increase with rotation during the earthquake, the strand will stay within the elastic range. Thus, the frame is restored to its original location after the earthquake and residual deformation becomes very small. To show why the prestress force is set to 50%, conceptual skeleton curves of the frame are presented in Fig. 9 for prestress forces of 25%, 50% and 75%. As shown, for an introduced prestress force of 75%, yield is reached before the target story deformation angle is reached. For an introduced prestress force of 25%, large deformation is needed to utilize the strand's full strength. An introduced prestress force of 50% maintains the prestressing strand within the elastic range over the angle up to the targeted secondary design level ( $R=1/75$ rad.). This does not cause excess deformation at maximum strength and does not to lose prestress force under repeated deformation. Mortar is inserted between column face and beam end. Because it is difficult to undertake construction in the case that clearance that is between clearance of column and beam's span is zero.



**Figure 8.** Detail of Beam-Column Connection



**Figure 9.** Conceptual Skeleton Curve of the Frame for Various Levels of Prestress Forces

**EXAMPLE OF P/C MILD-PRESS-JOINT METHOD APPLICATION**

**Katsura Campus of Kyoto University**

Buildings where the PC Mild-Press-Joint method was actually applied are introduced below. Photos1 (a), (b) and Fig. 10 show the Katsura Campus of Kyoto University, Japan. The building is of four stories, about 20m high and 45m long in the ridge direction, showing a delicate line at the façade.



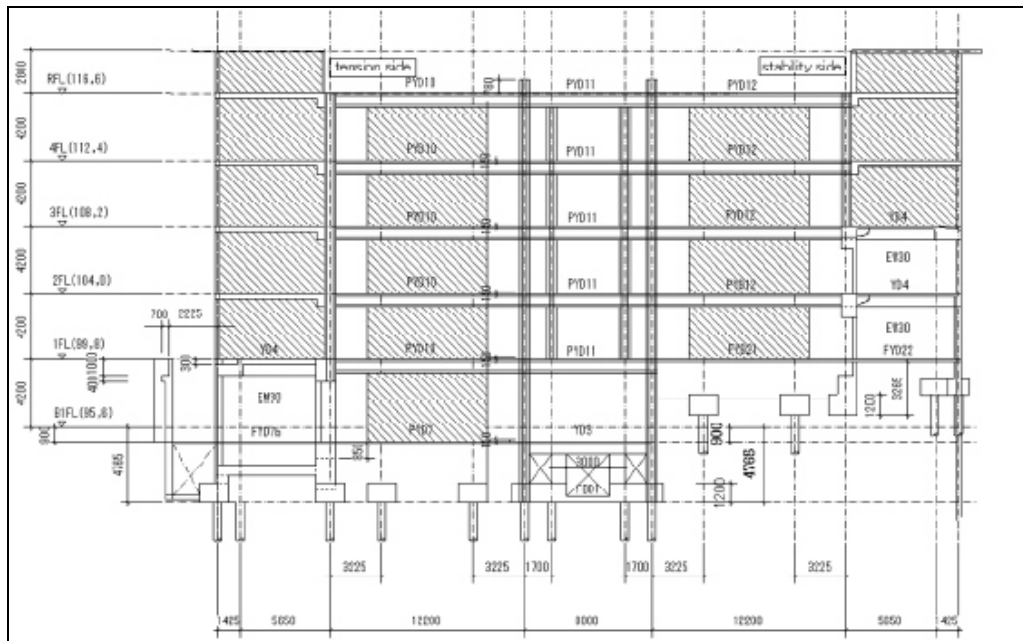
(a) Outside View (1)



(b) Outside View (2)

**Photo 1.** Outside View of Katsura Campus of Kyoto University





**Figure 10. Framing Elevation of Kyoto University**

**LUXIA**

A 22-story high-rise condominium named “LUXIA”, 72.3m high, built in Shinagawa, Tokyo is shown in Fig. 11. To increase its seismic-energy absorption capacity, steel dampers with low-yield steel are employed in each story. Damper layout is showed in Fig.12. This increases earthquake resistant capacity. It is used damper of NK=LY100, NK-LY160, NKLY225, in “LUXIA”. Mechanical properties of damper showed in Table 2.



**Figure 11.** Outside View and Ground Plan of “LUXIA”

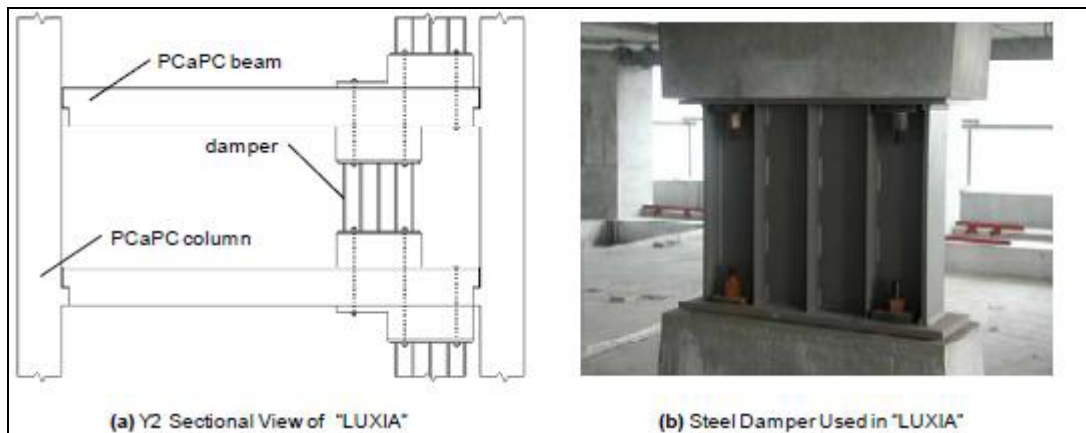


Figure 12. Damper Layout in "LUXIA"

Table 2. Mechanical Properties of Damper

damper	mechanical property					Charpy absorption energy
	yield strength $\sigma_y$	tensile strength $\sigma_{max}$	$\sigma_y / \sigma_{max}$	stretch		
	[N/mm2]	[N/mm2]	[%]	test piece	[%]	
NK-LY100	100±20	200-300	<60	No.5	50<	27<
NK-LY160	160±20	220-320	<80	No.5	45<	
NK-LY225	225±20	300-400	<80	No.5	40<	

## CONCLUSIONS

- 1) It is possible to build a high-tenacity frame by using corbels and by press-binding the beam and column while controlling the introduced prestress force at 50%.
- 2) It is easy to assess post-earthquake damage, since the damaged areas are localized.

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# LOAD-BEARING MASONRY CONSTRUCTION SYSTEM – ITS ADOPTION BY THE CONSTRUCTION INDUSTRY IN MALAYSIA

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## **Abstract**

Load-bearing masonry (LBM) is a construction method used since the early civilisations. Over the past decades the method went through tremendous advancement in the materials, design and construction technology. Modern LBM construction is a widely used system in the Western world, particularly for housing and low-rise buildings. The system offers several advantages in terms of cost, speed of construction, durability, aesthetics and flexibility. Despite these advantages, the system has not been widely used in Malaysia. Though masonry units (i.e. bricks and blocks) are extensively used in the country, the local construction industry prefers the reinforced concrete (RC) frame construction where bricks and blocks only serve as non-load-bearing infill walls. This paper presents a study on the perception of the industry players on the load-bearing system that resulted in the poor adoption of the system. A study was conducted using questionnaires sent to companies involved in the construction industry i.e. builders (developers and contractors) and designers (consulting engineers and architects). The study reveals that the main factor that could be related to the poor usage of the system in this country was due to the cognitive aspects. Although the industry acknowledges the benefits of using such a system, the lack of knowledge on the design and construction has hindered the usage of technology.

**Keywords:** *Structural masonry, load-bearing, brick construction, perception, technology adoption.*

## **INTRODUCTION**

Building materials form the single largest input in construction, accounting for 50-80 percent of the total value of construction and out of that, brick roughly accounts an average of 15 percent of the materials cost (FOA, 1993). For some buildings, the cost of bricks/blocks can be as high as 50 percent of the total building materials cost.

Nearly all modern buildings in Malaysia use brick or block units as the siding or walling materials. However, the units are mostly used only as in-fills for reinforced concrete (RC) or steel framed structures. (i.e. building loads are carried and transferred through columns where brick walls do not carry any structural loads). Bricks and block units possess the strength and durability qualities, it is quite unfortunate and uneconomical that the structural potential of the units are not been fully capitalised in the design and construction of buildings. In countries like America, Europe, and Australia, buildings from load-bearing (LB) masonry system (structural masonry) are widely use. Most of their residential and low-rise office buildings are from load-bearing masonry. The system is becoming more popular for the construction of larger span buildings such as commercial premises, factories, and sports centres.

The load-bearing masonry construction had an excellent record not only overseas but also domestically. The system had been approved and gazetted under the Uniform Building By-Laws in 1984. It also won the prestigious Prime Minister's Award in the low-cost House National Competition in 1994. Despite the recognition, the system has yet to find its place in

the local construction industry. The few existing buildings found using the system are mainly old buildings that were built during the colonial days. These old buildings were designed based on rules-of-thumb rather than using the state-of-art engineering theory and thus looked massive and bulky. Many of those involved in the construction industry have acknowledged the benefits of using the LB system, but they still feel sceptical of the system. As a result, not many industry players have used or attempted to use the system, and thus the system remains unpopular.

The LB system had won first prize in a low-cost house system organised by Jabatan Perumahan Negara (JPN) in 1994. That company that won was awarded a small project near Chembong using the LB system and that seems to be all, very few low cost housing projects using the LB system was built since then. The system fails to convince the general public and the construction industry.

Various factors have been argued to affect the LB system being is less popular than the RC system. (Abdullah, 1994). However, there has been no proper study to confirm these factors. This paper reports on a study to look into the perception and the adoption on the technology by the industry players.

## LITERATURE REVIEW

### Load-bearing (LB) Masonry System

The load-bearing or structural masonry is a method of construction where the elements of a structure are built using masonry units. For load-bearing wall system, the masonry walls are used to support building loads imposed by the roof, upper walls, and floor slabs as well as lateral loads such as wind and soil pressure. For framed structures, the beams and columns can be built from masonry. In addition, the stairs and foundations can also be built using masonry. Generally, there are three types of structural masonry construction:

- 1) *Plain or unreinforced masonry* is the simplest to construct as they contain no steel reinforcements. They rely on the strength of the masonry alone to bear the building loads. This load-bearing construction is commonly used in low and medium rise buildings in areas of low seismic activity.
- 2) *Reinforced masonry* has steel reinforcement embedded in the masonry to provide tensile and bending strength, and improves compressive strength. This enables building elements such as beams and stairs to be built using masonry. As for reinforced brickwork, steel reinforcements are normally sandwiched or encased between two layers of units and bonded compositely using grout. For blockwork, the reinforcements are mainly laid inside the cores that are then filled with grout.
- 3) *Prestressed masonry* involves pre-imposition of compressive force on the masonry. Early prestressed masonry was constructed by placing a weighty statue on top of a column to increase its resistance to lateral thrust. Today's prestressing is carried out by tensioning high strength steel rods or tendons embedded within the masonry structure. Steel rods or tendons are inserted at appropriate locations in an

unreinforced masonry element and then tightened down against end plates so as to compress the element. In almost all masonry applications, the steel is centrally located in the element so the induced compressive stresses are uniform over its cross-section. Typical applications include the construction of diaphragm walls for sports complexes, and earth and water retaining structures.

### **Advantages of the LB Masonry System**

The LB masonry wall system offer several advantages as compared to the conventional RC frame system. The overall construction cost using LB masonry is much cheaper mainly due to the elimination of formwork for columns and beams as well as from the savings for using raft foundation instead of piled foundations. The raft foundation can also serve as the ground floor. The LB system was claimed to has saved 20 to 30 percent of the project cost as compared to the RC framed system (ZNA, 1993).

Majid (1997) commended that LB system can provide 10-20 percent cheaper building costs compared to the conventional RC building. Haseltine and Thomas (1971) emphatically agreed that even buildings of more than four storeys, the LB system is more economical than many other systems. The cost can be further be reduced by as much as 20 percent when using blocks instead of bricks.

Theoretically, block-laying per square metre is cheaper than brick-laying because of its size and shorter laying time. Many studies supported this statement, for example, Clamp (1970) showed that the cost of materials in blockwork was about 15 percent less than the cost of equivalent brickwork. Madekor et al. (1987) reported that the interlocking blockwork system that was developed for low cost housing can achieve about 25 percent savings as compared to the use of the conventional method. Ting (1991) reported that an average cost saving of RM2500-RM3500 per unit of single storey link house can be achieved when using concrete masonry compared with RC frame, which constituted to only 10-15 percent cost saving. Ahmad et al. (1989) reported that the cost of RC beam was about 20 percent more than that of reinforced brickwork beam design for the same working load.

The speed of construction using loadbearing wall system is faster than the R.C. system. In their project, Perunding ZNA (1993) claimed that the construction time for the load-bearing building is 30 to 50 percent faster compared to RC building. This is achieved by eliminating or minimising the use of concrete framework, very quick start-up of wall construction, and continuous construction due to the rapid strength gained from the brickwork. For RC buildings, the proceeding construction task would have to wait until the casted concrete gains enough strength before the formwork or falsework can be dismantled. An early study by Kinniburgh (1968) on 18 houses showed very significant reductions in construction time for laying common concrete blocks as compared to bricks – a reduction from 210 hours required for normal cavity brickwork to only 84 hours to build the same house with cavity blockwork. The use of hollow blocks had reduced the cost of materials and foundations, particularly in tall buildings.

When compared to other building systems such as the prefabricated precast building system which require '*economies of scale*', load-bearing brickwork can be used even for one

single construction unit at any location, whether in the urban or isolated rural areas. In addition, it also has the flexibility of construction to any layout required.

In terms of quality control, brickwork does not require the tedious site cube and slump tests as for concrete, since the quality of bricks are pre-tested at the factory during production. Furthermore, a construction site using the system looks less messy than the RC construction site. It is well known that brickwork is very durable. Plain masonry does not pose any problem if used for coastal and marine structures. Modern brickwork is strong. Thin walls can replace the thick walls that were formerly required to prevent ingress of moisture. The appearance of brickwork does not deteriorate with age. It derives from the colour texture and size of brick, bond, and joint width. However, cracked brickwork greatly detracts from appearance (Henry et al., 1987).

### **Masonry vs. Reinforced Concrete**

Early construction was mainly of structural masonry, until about a century ago, the development of structural steel and reinforced concrete led to a general decline in of the construction. Burgeoning knowledge about the elastic behaviour of structures was put to use in the development of design theories for the newer materials. Steel and reinforced concrete, being able to resist both tension and compression (and consequently bending) was seen as being more versatile and led to lighter and taller structures than was possible with masonry, which could only resist compression and relied upon its mass for stability. In general, rather than keeping pace with developments in structural steel and reinforced concrete, the use of masonry declined and, to a greater extent took the form of infill walls and veneers. Furthermore, while rational design methods and building codes were developing for other construction materials, masonry was being designed based on *rules-of-thumb*. Masonry construction was massy and bulky. Only when the concept of reinforcing with steel rods to resist tension was applied could masonry be re-established as a competitive construction material. Although sporadic attempts were made to reinforce brick masonry from 1825 onwards, it was not until about one hundred years later, when engineers in India and Japan realised that steel reinforcing would enhance the resistance of masonry structures to earthquake forces, that masonry entered the modern era (Drysdale *et al.*, 1994). Design codes were drafted which allows its use with as much confidence as the more familiar modern materials of steel and concrete. Since that time, through the use of reinforcement and pre-stressing, the number of storeys and longer width in masonry buildings has increased substantially while bearing wall thickness have decreased similarly, and masonry is also being used for beams, columns, stairs and arches.

Basically, there were not many studies found comparing the LB systems with the other building construction systems neither in terms of technology nor economy. Abdullah (1993, 1994) listed the possible reasons why LB system is not popular. Among these reasons were that the contractors and housing developers were complacent with using RC construction and procurements. The LB system was thought to be difficult to renovate. Many felt that most architects, engineers, as well as the local authorities lack the knowledge and are not really familiar with the system. Many thought that load-bearing wall construction would require skilled workmanship in which our brick layers have not acquired.

In his study, Medallah (1989) stated that 74 percent and 84 percent of the builders in the United Arab Emirates (UAE) prefer RC frame structure over the LBM structures for residential bungalows and low-rise apartments, respectively. The majority of the designers chose the framed structure believing it would be more advantageous in many aspects apart from its economy and speed. Only about 25 percent of them indicated that they 'intend' to use the LBM system despite not being entirely impressed by its characteristics other than speedy construction. On the other hand, the reasons given by those who chose LB were not unanimous. Some of them felt that the system was not popular among their clients. Medallah (1989) also commented that the behavioural reasons that builders prefer RC over LB system are rooted in the convention of over-design in RC structures, a lack of technical knowledge on LB, unexplained bias or prejudiced against change, and unexplained insistence on the part of clients.

Haseltine and Thomas (1971) acknowledged that even with the issue of the Fifth Amendment of the Building Regulation (HMSO, 1970) following the Ronan Point incident in May 1968, LBM still retained as the most economical structural material for housing and other residential types of buildings. A survey conducted by Suter et al. (1980) showed that blocks were more widely used in Canada for load-bearing walls. About 25 percent of the firms in Canada were involved in LB construction for buildings from 4 to 21 storeys high comprising 75 percent of the total residential buildings.

## **PROSPECT OF LB MASONRY CONSTRUCTION IN MALAYSIA**

In Malaysia, there has always been a need to construct houses cheaper and faster to meet the growing demand, especially affordable housing prices for the lower income groups. This strategy is considered one of the most impertinent agenda in the socio-economic development of the country. On the other hand, land and building materials especially steel and concrete are becoming more expensive and often short of supply. Therefore, building houses using the load-bearing wall system can provide an excellent alternative. As most modern houses in the developed countries are using this system without many problems, there should be no reason why a similar system cannot perform here as well. Our bricks and blocks are manufactured using modern kilns as those in other developed countries, and they are of equally high quality. Further, in some under-developed countries, load-bearing wall houses are still being built from the low technology adobe and mud-straw bricks. It should be pointed out that depending on the type of buildings, LBM can be unreinforced, reinforced or prestressed. Thus there is no reason as to why this system cannot be applied and used in this country.

## **RESEARCH METHODOLOGY**

This study was carried out through a survey using questionnaires. The method is useful for identifying incidents, distributions, and associations between sociological variables and psychological variables such as opinions and perceptions (Kerlinger, 1973). The survey also provides a feeling of anonymity to the respondents who may then give more genuine responses, thus providing a more accurate picture.

## Sampling Procedure and Data Collection Strategy

The target population of this study is geographically bounded to the local and multinational companies directly involved with the construction industry in the whole of Malaysia. A pilot study was carried out prior to the main survey to gather information, perform analysis, and make improvements and necessary modifications to the main study.

The unit of analysis of this study is the organisation that is directly involved in the construction industry namely, the developers, consulting architects, engineering consultants and contractors of various categories. The respondents of this survey were representatives from each of the organisations surveyed, for example the managing director, project manager, or any other person who knows exactly the day-to-day operation of the company's businesses.

The list of contacts from the different categories was acquired and the names of these companies were stratified according to the company type, followed by a random sampling method. A total of 500 questionnaires were mailed to various companies throughout Malaysia. Each questionnaire set was accompanied with a short cover letter, an introduction, and an article to explain the purpose of the survey as well as to inform the respondent about the load-bearing technique. To help increase the response rate, a stamped self-addressed envelope was also included in the questionnaire bundle.

## The Measurement and Instrumentation

The purpose of this research was to examine the perception of companies in the construction industry on the load-bearing masonry method. The structured questionnaire was divided into three sections and administered to the target respondents:

- 1) Section one was designed to obtain the demographic characteristics of the company and the respondent. This section includes questions regarding the company nationality status, company type, the number of workers, percentage of skilled workers, and the respondent's designated position.
- 2) Section two of the questionnaire was intended to examine the respondent's awareness of the load-bearing technique, as well as the details of their projects.
- 3) Section three consists of 24 items relating to the respondent's perception. For the purpose of this research, the possible responses were arranged on a five-point Likert scale, comprising of *strongly disagree* (1), *disagree* (2), *neutral* (3), *agree* (4), and *strongly agree* (5). The section was again divided into three sub-sections with each sub-section being mutually exclusive of one another. The respondents were expected to respond to only one of the three sections presented according to the questionnaire pathway into these sub-sections.

The preparation and development of the questionnaire design was based on the frequently asked questions (FAQs) through prior interaction with the companies directly involved in the construction industry.

## Data Analysis

Descriptive analyses were used to extract and present demographic information in the form of tables and figures for a general overview of the respondents that were being surveyed. Information about the companies, types of bricks used in projects, and other information were also extracted.

As suggested by Mogey (1999), following the descriptive section of analyses, several inferential techniques can be used to analyse the data to formulate some conclusions from the observation of the results.

## RESULTS AND DISCUSSION

### Characteristics of Respondents

During the pilot test, 30 companies from the Alor Star and Sungai Petani area were selected which comprised of twelve Contractors, six Developers, six Engineering Consultants, and six Consulting Architect. 27 (90 percent) questionnaires were returned.

For the survey, out of the 500 questionnaires that were sent, 131 were returned within the given time-frame and only 126 numbers were usable delivered response (Table 1)

**Table 1.** Returned questionnaires classified into company type.

Company Type	Frequency	Percentage (%)
Developer	25	19.8
Contractor	39	31.0
Engineering Consultant	43	34.1
Consulting Architect	19	15.1
<b>Total</b>	<b>126</b>	<b>100.0</b>

It was observed that the majority of respondents were from the engineering consultants and contractors. Almost all companies were locally based with only two multinational companies (1.6 percent) that responded in this survey. Both these multinational companies were engineering consultant firms. Most of these companies were small to medium sized companies, with 59.5 percent of them employing 25 workers or less. The larger companies that supported 101 workers or more only made up for 12.7 percent of the questionnaires received.



## Usage and Knowledge on the LB System

The usage and knowledge of LB is presented in Table 2. The adoption of the technology is still very low although the awareness of the technology is high. Only 26.8 percent of the respondents have used the load-bearing system, 66.7 percent claimed to have knowledge but have never used the system, whereas 9.5 percent have no knowledge at all on the system.

**Table 2.** Type of Respondents

Type	Frequency	Percentage (%)
User	30	26.8
Non-User with Knowledge	84	66.7
Non-User with NO Knowledge	12	9.5
<b>Total</b>	<b>126</b>	<b>100.0</b>

The place where the respondents had learned or had been exposed to the load-bearing masonry methodology is given in Table 3.

**Table 3.** Place and Method Acquired LBM Knowledge

Place/Method	Number of Respondents	Percentage (%)
University	72	63.2
Workplace	25	21.9
Self study	13	11.4
Seminars and Workshops	4	3.5
<b>Total</b>	<b>114</b>	<b>100</b>

In a separate interview with the Deans and lecturers of several universities, it was found that not even one university in this country has given emphasis on teaching the LBM design subject in their undergraduate civil engineering curriculum (Table 4). The universities that taught the subject allocated only allocated a few hours and not comparable to the time allocated for RC and steel structural design subjects.

**Table 4.** LBM Design Subjects Offered by Local Universities

University	Teaching of LB Design Subject
Universiti Malaysia Sabah	not taught
Universiti Teknologi Malaysia	as an optional subject – many years not offered
Universiti Sains Malaysia	as part of the structural design subject – allocation only 3-4 hours total
Universiti Putra Malaysia	not taught
Universiti Malaya	not taught
Universiti Teknologi Mara	not taught
Universiti Malaysia Sarawak	not taught



## Application of the LBM System

A summary of the respondents that had developed projects using LB and the type of projects is presented in Table 5.

**Table 5.** Respondents' Usage of the LB System

Item Description	Number of Respondents	Percentage (%)
Used LB system in projects	30*	26.3
Housing projects	(23)	-
Office/Hospital projects	(4)	-
Wall/Retaining wall projects	(9)	-
Other projects	(6)	-
Have not used LB system	84	73.7

\*Respondents were allowed to select more than one choice.

Only 26.3 percent of the respondents have ever been involved in LB related projects and of these, mostly are in housing. The actual percentage would expected be much lower since through earlier interactions with prospective respondents, it was observed that those who have not used nor have little knowledge on the system seemed not to show much interest in responding to this study. However, the majority of respondents (86.8 percent) agreed with the estimate that less than 1 percent of building projects (either in terms of volume or cost) in the country were from LB (Table 6). Although there is no reliable data to support this fact, this perception would hold true since LB buildings could hardly be found in the surrounding locality.

**Table 6.** Estimation on Buildings Using LB System in Malaysia

Percentage (by Volume or Cost)	Number of Respondents	Percentage (%)
< 1%	99	86.8
1% - 5%	13	11.4
5% - 10%	2	1.8

The number of LB related projects that each respondent had completed is summarised in Table 7. This table shows that most of the respondents were involved in one or two projects only, which made up a total of more than 65 percent of all the companies.

**Table 7.** Number of Completed LB Projects

Number of Projects Completed	Number of Respondents	Percentage (%)
1	11	36.7
2	9	30.0
4	2	6.7
5	3	10.0
8	1	3.3
9	2	6.7
10	1	3.3
12	1	3.3

From these projects, the respondents gave the estimated costs of their projects. It could be observed that the companies were evenly distributed across the categories previously defined, but none had exceeded RM 50 million mark. The estimated cost of LB projects is summarised in Table 8.

Table 8. Cost of the LB Projects

Cost of LB projects	Number of Respondents	Percentage (%)
Less than RM100,000	5	17.2
RM100,001 – RM500,000	6	20.7
RM500,001 – RM 1 mill	4	13.8
RM 1 mill - RM 5 mill	5	17.2
RM 5 mill - RM 10 mill	6	20.7
RM 10 mill – RM 50 mill	3	10.3

Type of Masonry Units Used

Figure 1 clearly shows that the most popular type of masonry unit used by the local construction industry is fired clay bricks, followed by cement bricks and concrete blocks which are 78.1 percent, 66.7 percent and 36.8 percent, respectively. Non-baked earth bricks are also widely used, while calcium silicate bricks produced by only one active manufacturer seem to be quite popular as well. It seems that there is no up-to-date statistics regarding the amount of bricks consumed. However, it is estimated that for housing alone, a total of 4.5 billion bricks (all types) would be needed for the 9<sup>th</sup> Malaysia Plan, as summarised in Table 9. A leading brick manufacturing company give an estimate that approximately 4 billion clay bricks are produced in Peninsular Malaysia each year with Johor and Selangor contributing more that 65 percent. Calcium silicate bricks produced amount to about 60 million units per year.

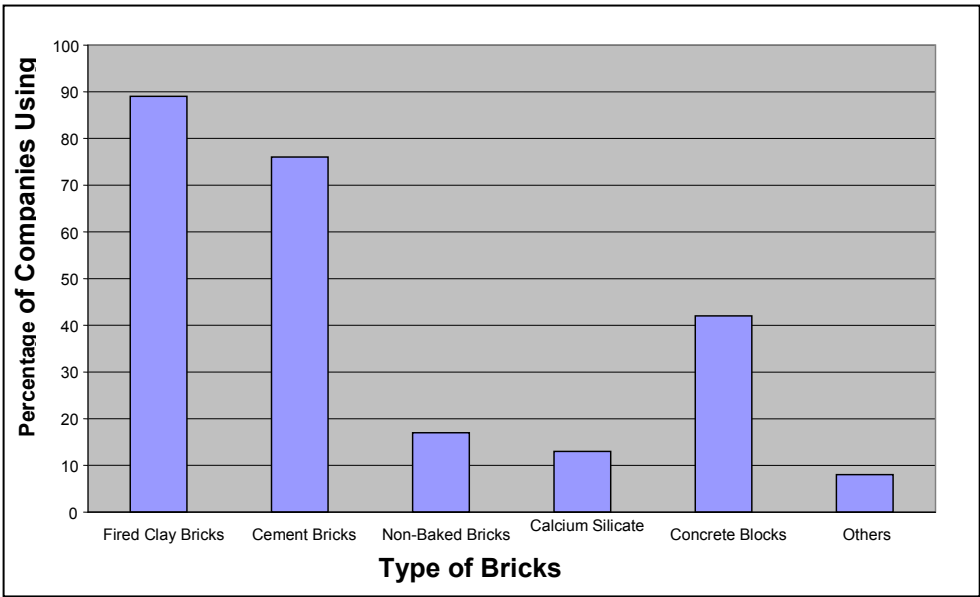


Figure 1. Types of bricks used in construction projects

**Table 9.** Estimated Bricks Needed for Housing Projects in the 9th Malaysia Plan

Programme	Total	Types of Housing				
		Housing for Poor	Low Cost	Low-Medium Cost	Medium Cost	High Cost
Public Sector*	197,805	20,000	85,000	37,005	27,100	28,700
Private Sector*	511,595	0	80,400	48,500	183,600	199,095
<b>Total</b>	<b>709,400</b>	<b>20,000</b>	<b>165,400</b>	<b>85,505</b>	<b>210,700</b>	<b>227,795</b>
Est. Number of Bricks/House		3,500	4,500	5,000	6,000	9,000
Est. Number of Bricks (million)	<b>4,556.1</b>	70.0	744.3	427.5	1264.2	2050.1

\*Source: *Public and private sector housing target 2006-2010 (JPN, 2008)*

Most of the most of the masonry units used were local made. The majority of companies obtained from suppliers within their locality (82.5 percent) to fulfil their needs, and some even outsourced nationwide (16.7 percent), while the rest used imported bricks.

### Perceptions on the LB System by Non-Users

Majority of the respondents are those that have not used but have knowledge on the system (66.7%). For further evaluation of the results, the respondents were divided into two main groups, the Designers (i.e. engineers and architects – 40 responding companies) and the Builders (i.e. developers and contractors – 44 responding companies). The Designers were those who provide the design services and who have expert knowledge in the design of buildings. While the builders were those who were directly involved in construction projects and in most cases design knowledge is not important for them. No companies were found to be involved with the same project thus the data obtained were exclusively independent.

Table 10 shows the descriptive statistic of the responses given by the non-users of LB system to the constructs regarding the respondents' perception. The study indicated that the most dominant reason for LB system not being widely used was because most industry players were more familiar and complacent with the conventional RC techniques. They felt that the techniques were sufficient in meeting the demands of their business undertakings. This was due to the fact that, most of them were mainly being trained and exposed to the use of RC techniques – the technology that not only dominates the local construction industry, but also throughout the world. The reason behind the poor reception amongst industry players on the LB system was due to the obvious lack of knowledge on the design and construction aspect of the LB system.

**Table 10.** Descriptive Statistics on the Perceptions of Non-Users Towards LB System (according to frequency ranking)

Ranking	Items	Mean Score (Std. Dev.)	Frequency of Score (%)		
			Disagree (score 1 and 2)	Neutral/ Not Sure (score 3)	Agree (score 4 and 5)
1	RC system is sufficient	3.86 (0.946)	11.9	9.5	78.6
2	RC building is easier to build and maintain	3.77 (1.057)	13.1	8.3	78.6
3	No demand by the clients	3.82 (0.959)	10.7	13.1	76.2
4	LB building is difficult to renovate	3.77 (1.101)	16.7	13.1	70.2
5	Lack of skilled worker	3.56 (1.134)	21.4	13.1	65.5
6	Lack of knowledge on the design	3.43 (1.185)	26.2	14.3	59.5
7	Lack of experience on the system	3.33 (1.216)	29.8	14.2	56.0
8	Not encouraged by others	3.45 (1.046)	15.5	32.1	52.4
9	Local bricks are low quality	3.43 (1.215)	26.2	25.0	48.8
10	RC buildings are better technologically	3.30 (0.902)	19.1	35.7	45.2
11	Difficult to get approval	2.86 (0.894)	26.2	54.8	19.0
12	No confidence in LB system	2.48 (1.000)	52.4	30.9	16.7

The belief that the LB buildings are *difficult to renovate* was still salient amongst those who had never use the system. In seminars and workshops that have been conducted on LB construction, this was the most frequent question posed by the participants. Again this issue relates to the level of knowledge on the subject – where in fact, as for any other construction technique, the LB buildings can undergo renovation but it must be done through proper planning and design.

The limited projects that used the LB system would lead to the lack of skilled workers and designers. Generally, all of our builders are familiar with brick-laying as it is one of the most widely used techniques. Most of the skill training centers whether they are either under the jurisdiction of MLVK, such as GIATMARA, IKM, IKBN, ILP, and ABM, or under the Ministry of Higher Education, such as Community College do provide training in brick-laying, however, they do not cover much on load-bearing brick/block construction.

Since not many of the industry players have had the experience of working with the system, they are unsure of the approval procedures and by-laws regarding the LB system. It should be pointed out that the system had been gazetted and stipulated under the Uniform Building By-Laws 1984.

The respondents, however, disagreed that the factor of *no confidence* in the LB system was the reason that hinders its usage. This is supported by the results given in Table 8 where the majority of the respondents (52.4 percent) did not agree with the item statement.

## Perceptions on the LB System by Users

The LBM users which comprise of 26.8 percent of the respondents gave very encouraging response. Table 9 gives the mean score arranged according to rank. Except for the statement that *Malaysian bricks are of low quality* (mean score of 2.80) and *LB technique is perceived better than RC* (mean score of 2.73), for the other item statements, the mean scores were generally more than 3.00.

The highest score is for the statement *LB technique needs promotion*. It can be seen that none of the respondents indicated that they did not agree with this statement. This means that many industry players are expecting that more effort should be made to promote the use of the system.

**Table 11.** The Scoring by Respondents That Have Used LB System

Ranking	Question Description	Score	Score Frequency (%)		
		Mean (Std. Dev.)	Disagree (score 1 and 2)	Neutral (score 3)	Agree (score 4 and 5)
1	LB needs promotion	4.33 (0.758)	0.0	16.7	83.3
2	LB building is more beautiful than RC	3.53 (0.730)	7.0	40.0	53.0
3	LB technique is faster than RC	3.43 (0.935)	13.3	36.7	50.0
4	Will use LB in future projects	3.30 (0.596)	6.7	56.7	36.6
5	Will recommend LB to others	3.27 (0.640)	10.0	53.3	36.7
6	LB technique is cheaper than RC	3.20 (0.997)	20.0	50.0	30.0
7	LB is suitable for Malaysia	3.13 (1.008)	33.3	30.0	36.7
8	Malaysian bricks are low quality	2.80 (0.997)	43.3	30.0	26.7
9	LB technique is better than RC	2.73 (0.828)	40.0	46.7	13.3

Although the majority of those who had used the LB system acknowledged that the technique was cheaper, faster and more beautiful than RC, only 13.3 percent of them indicated that LB technique as a whole is more superior to the RC technique. It is interesting to note that the misconception regarding local bricks being low quality was not prevalent.

It is however interesting to observe that the non-LB users perceived that our bricks are of low quality (Table 10). On the other hand, the users who had the experience and knowledge on the materials thought otherwise. This had been one of the most prevailing misconceptions that had been in the mind of many industry players. They perceived that local bricks were of low quality compared to those from the western countries. They also perceived that local bricks were not strong enough for use in the LB construction. Tests carried out at Universiti Teknologi Malaysia on clay bricks from 26 factories from over Johore, Negri Sembilan and Melaka found that not a single brick from those factories had compression strength of less than 5.2 N/mm<sup>2</sup> and some had strength as high as 70 N/mm<sup>2</sup> as shown in Figure 2 (Abdullah, 1994). Result in a more recent study (Table 12) at Universiti Utara Malaysia supported the earlier findings (Abdullah et al, 2003). Though most of these bricks were common bricks that would normally be plastered after laying, they acquired nice

texture and attained the strength requirement for LB use. The British Standard stipulates that brick for LB unreinforced masonry should have a minimum strength of 5.2 N/mm<sup>2</sup>.

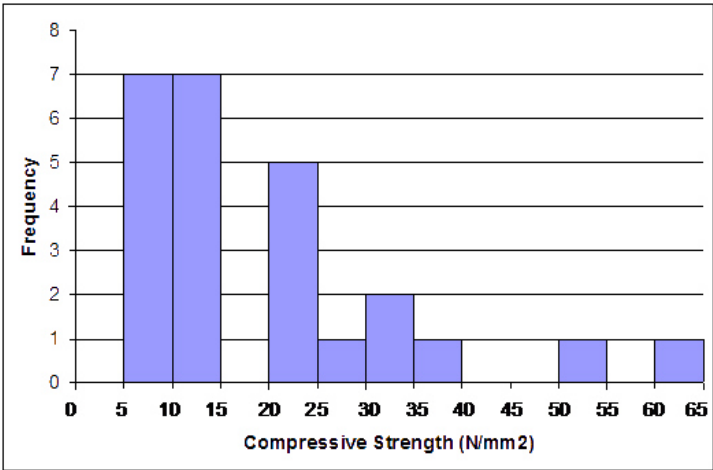


Figure 2. Strength of Malaysian Bricks (Abdullah, 1994)

Table 12. The compressive strength of fired clay bricks produced by factories (Abdullah et al, 2003)

Compressive Strength (N/mm <sup>2</sup> )	No. of factories	%
5 – 10	4	8.3
11 – 30	25	52.1
31 – 50	17	35.4
> 50	2	5.2
Total	48	100.0

Perceptions from Those with No Knowledge of LB System

The response of those that have no knowledge on the LB system (9.5%) is given in Table 13.

Table 13. Response by Those Without Knowledge of LB System

Question Description	Mean (Std. Dev.)	Frequency of score (%)		
		Disagree (score 1 and 2)	Neutral (score 3)	Agree (score 4 and 5)
Would like to know more about LB	4.25 (1.215)	8.3	8.3	83.3
Would like to learn LB in depth	4.08 (1.311)	16.7	16.7	66.6
RC system is sufficient	3.25 (0.622)	0.0	83.3	16.7

It would be obvious that those who do not have knowledge on the LB system could not provide their opinion on the system. Majority would like to know and learn more about the LB system. As highly indicated by the LB users as shown in Table 13, the system needs more promotion.

## **CONCLUSION AND RECOMMENDATIONS**

This study has revealed that the application of LB masonry for construction in this country is still at a very low level. The factors that caused the low adoption of LB system are mainly due to the reasons related to lack of knowledge and experience on the system. In addition, the dominance of the long rooted RC system within the construction industry has made it difficult for the LB system to penetrate into the construction industry. The study implies that the level of knowledge and experience acquired by the industry players is still low, particularly in the aspects of design and construction.

Those who have used the system acknowledged that the LB system offers several advantages such as being cheaper, faster to build, and looks better. Public awareness about the LB system is very low due to the low usage amongst the industry players. As it is now, none of the local universities really taught this subject in their curriculum. This is rather unfortunate to know that several prominent local universities have been embarking extensive research works on masonry materials and construction, and yet no specific subject on the design and construction of LB structural masonry have been offered in their civil engineering and architectural courses. At the skill training centres, although brick-laying courses have been conducted, they do not extensively cover LB techniques.

Malaysia is also known as a technologically friendly country, i.e. technology can easily penetrate and gain usage at a very fast rate, particularly those related to electronics, computers, and communications. Unfortunately, not so for the construction, where it seems to be very conservative and less receptive towards adopting new technologies. In order to promote the usage of the LB systems, efforts have to be made by universities to offer subjects on design and detailing of LB masonry structures. The related professional bodies such as Institution of Engineers (IEM) and Construction Industry Development Board (CIDB) should also conduct intensive courses and programmes in this area. The skill training centres should extend the training courses to cover the construction of LB masonry. Government agencies, such as Jabatan Perumahan Negara (JPN) and State Economic Development Corporations (SEDCs) should provide opportunities by awarding suitable projects to housing developers and contractors who are interested in using the LB system.



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# A CASE STUDIES OF INTELLIGENT BUILDINGS IN MALAYSIA

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## **Abstract**

Nowadays, the rapid changes of information and communication technology (ICT) has dominant the way we conduct our business and has also influenced our daily life styles such as attitudes, expectations and behaviours. The demand on ICT facilities in buildings has also increased dramatically to accommodate such lifestyles. Observing this phenomenon, the brand of 'intelligent building' (IB) or 'smart building' has become a popular trend as building owners attempt to accommodate their building design with modern life style characteristics. In Malaysia, numerous intelligent buildings have been built over the years since the Multimedia Super Corridor (MSC) was introduced by the government in 1996. To date, there is lack of documenting intelligent building implementation in Malaysia. Therefore, this paper aims to presents the documentation of intelligent building implementation in Malaysia that focus on three prominent buildings in Klang Valley, Malaysia. The 'Best-Practices Guide for Evaluating Intelligent Building Technologies' provided by the Continental Automated Buildings Association (CABA) was used as an evaluation tools. It is anticipated that this paper will provide an initial indication and guidelines on how intelligent is being implemented in Malaysia.

**Keywords:** *Intelligent building, building automation system, Best-Practices Guide*

## **INTRODUCTION**

ICT plays a vital role in influencing our daily life either at work or at home. The advanced ICT are becoming common and fast, than previous time. The ICT and its rapid changes have affected our expectations, lifestyles, attitudes and behaviours (Sherbini & Krawczyk, 2004). Thus, ICT has been viewed at various stages of civilisation as leading to future progress (Clements-Croome, 2004). Gann (2000) stated that, the building owners and designers need to transform the way they design the building. Developments of climate control, environmental systems, access, security and fire detection should be taken into consideration. Intelligent Building Institute (IBI) define IB as one which provides a productive and cost effective environment through the optimization of its four basic elements- systems, structure, services, management and the inter-relationship between them (Coggan, 2007).

The said technological and economic change has begun in the late 1970s (Gann, 2000). In the early and mid- 1980s, the said changes has taken hold throughout the developed countries because of the need to provide a new infrastructure and facilities to support ICT based activities (Gann, 2000) and during then, the concept of IB has initially occurred (Athens, 2004). According to Athens (2004), from 1980 to 1985, IBs are known as buildings automatically controlled according to function. Subsequently, from 1986 to 1991, IBs represent buildings that are capable of responding to the changing needs and From 1992 till present, IBs are more equipped with features that can effectively satisfy the changing needs. Moreover, Gann (2000) has also cited that during the 1990s, successive waves of development in computing, telecommunications have been spurred by technical opportunities on the supply-side to increase speed, and capacity whilst cutting costs of equipment. As seen from both sources. It is important to remember that the advancement of

ICT in an IB are known in various terms such as Building Automation System (BAS), Energy Management System (EMS), Energy Management and Control System (EMCS), Central Control and Monitoring System (CCMS) and Facilities Management System (FMS).

Today, IB is considered as one that incorporates the best available concepts, materials, systems and technologies. By integrating all factors in IB, the performance requirements of the buildings stakeholders could be achieved as well as exceeded on certain area.. Stakeholders include the building's owners, managers and users, as well as the local and global community (Athens, 2004). Clements-Croome (2004) mentioned that IB should be sustainable, healthy, and technologically aware, meets the needs of occupants and business, and should be flexible and adaptable to deal with change. In other words, a host of modern technological changes, which are adaptable to short-term and long-term human needs, signifies the fundamental meaning of IB. So et.al. (1997) has listed some of the systems or services installed in most commercial buildings:

1. HVAC: providing thermal comfort, humidity control and adequate ventilation;
2. Lighting systems: providing overall illumination for all tenants and adequate lightings for public areas;
3. Life safety systems: for smoke and fire detection, control and fighting;
4. Security systems: for controlling access and detecting unauthorized entry;
5. People movers: including elevators, escalators, travellers and automatic doors;
6. Electrical power: supply and distribution of electrical energy.

This paper aims to presents a report on the investigation of IB implementation on three prominent buildings in Klang Valley, Malaysia by using a criteria designed in 'Best Practices Guide for Evaluating Intelligent Building Technologies' provided by the Continental Automated Buildings Association (CABA) as an evaluation tools.

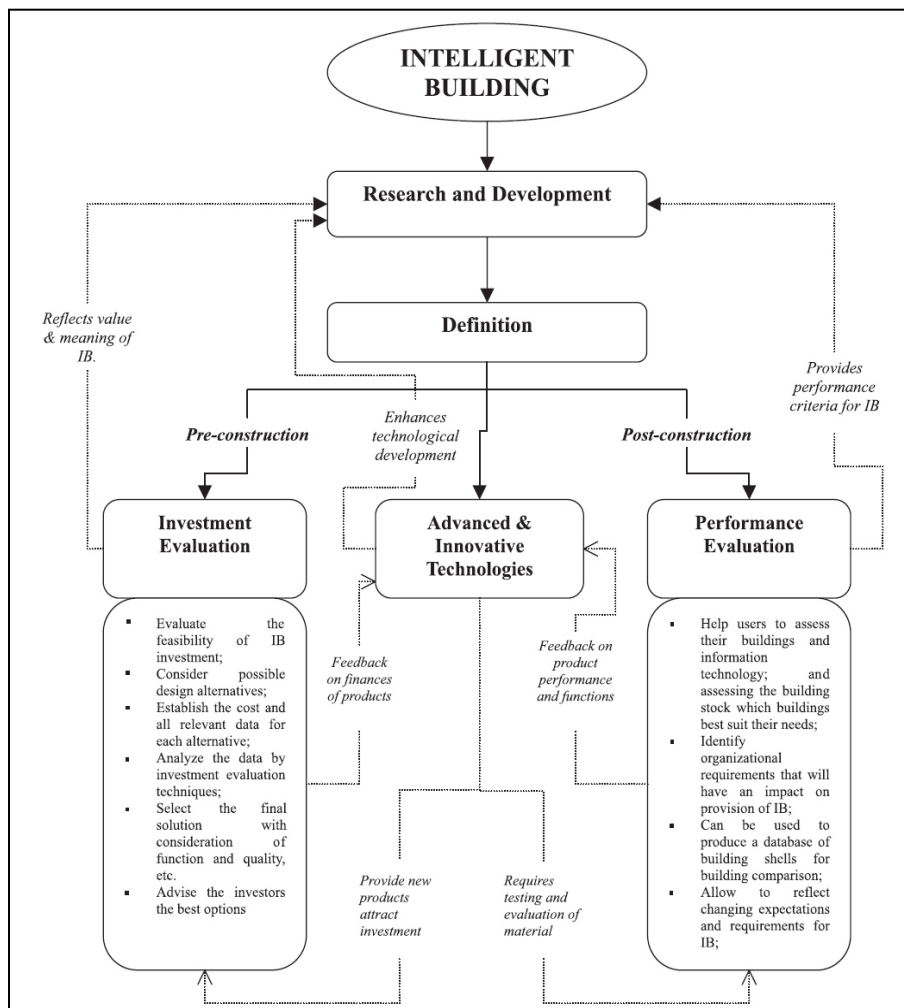
## LITERATURE REVIEW

It was mentioned by Coggan (2007) that in the early 1980s, trade magazines began running stories on 'Intelligent Buildings'. For instance, articles concerning mechanical systems had been published especially issues on automation systems on how it makes buildings more energy-efficient. Furthermore, communications industry magazines have been explained on how advanced telecommunications systems had made buildings more efficient and therefore more intelligent. Consequently, there had been growing pressure on owners and developers to build IB due to extensive press coverage and suppliers advertisement. Therefore, decades from the 1980s, there have been numerous articles regarding IB focusing on the positive impacts such as higher productivity, better office morale, flexibility in accommodating changes in the office environment, etc (Yow, 2002). To further illustrate, there are reports on IB available from Continental Automated Buildings Association (CABA), European Intelligent Buildings Group (EIBG), Smart Home Foundation, City University of Hong Kong and etc. and regularly published magazines. These include the CABA Quarterly publication, the Electronic Home magazine, a Polish Technical magazine 'Inteligentny Budynek' (Intelligent Building) and 'Inteligentny Dom' (Intelligent House) (Himanen, 2003).

The articles often revolve on the IBs of United States, Canada, Japan, United Kingdom, Germany, Singapore and others. These articles highlights about what is IB, its characteristics and the intelligent systems incorporated in the case studies. However, not many studies have been made on the Malaysian IB except for a book entitled, 'IB in South East Asia' by Harrison et al (1998). Most articles published in Malaysia are only discussing ontheir intelligent features. This clearly shows that there is a lack of studies regarding IB in Malaysia. The pertinent questions of the issue should be: What are the indications of IB practices in Malaysia? With the documentation and understanding of the implementation of IB in Malaysia, practitioners and researchers are then able to further improve on the development of IB in Malaysia.

### Research Taxonomy of Intelligent Building Evaluation

Wong *et.al.* (2005) claims that , previous study have focused mainly on three research streams; namely research in advanced and innovative technologies, research in performance evaluation methodologies, and research in investment evaluation analysis



(Source: Wong *et al.*, 2005)

**Figure 1.** Taxonomy of research on intelligent building

In the first stream, research efforts have revolved about the advanced development of system integration, network protocol and building subsystem services, which include HVAC system, lighting system, fire protection system, lift system, security system and communication system.

Whereas in the second stream, there are considerable amount of research on performance evaluation methodologies apart from IB technologies research (Wong *et al.*, 2005). Performance evaluation is carried out as a feedback mechanism to facilitate learning purpose (Serafeimidis & Smithson, 2000). The more precise definition of performance evaluation probably can be found from Remenyi & Smith (1999); *“Evaluation is a series of activities incorporating understanding, measurement, and assessment. It is either a conscious or tacit process which aims to establish the value of or the contribution made by a particular situation. It can also relate to the determination of the worth of an object”*

The third research stream is the investment evaluation analysis which focuses on evaluating economic and financial aspects of IB, in other words, the investment feasibility evaluation of IB projects (Wong *et al.*, 2005). Traditionally, investment justification has been predominantly based on cost savings that directly relate to the tangible benefits to the organisation. To evaluate this tangible benefit, a rigorous accounting method such as net present value (NPV), internal rate of return (IRR), cost-benefit-analysis have been applied to interpret the benefits in monetary terms (McBride & Fidler, 1994). Nevertheless, there are still limited researches related to investment evaluation of IB projects (Wong *et al.*, 2005).

## METHODOLOGY

In this research, the investigation are conducted according to a various phases of building process such as building planning, construction, commissioning, and operations as defined The aim of the research is to document the implementation of IB in prominent buildings in Klang Valley, Malaysia. Case studies are conducted via interviews with experienced persons as well as observing the documentations available. The selection of case study buildings is carefully performed in order to increase the validity of this study. Thus, a few case studies in Klang Valley, Malaysia are selected based on the criteria modified from Harrison *et al.* (1998).

1. Designed or constructed during last 20 years
2. At least 5000m<sup>2</sup> gross floor area (GFA)
3. Predominantly designed for office use
4. Generally perceived to be ‘intelligent’ in some way by building professionals in that location

With that, three case studies were opted in Klang Valley, Malaysia. However due to the confidentiality issue, the real name of the selected building will not be disclosed. First, the IB practices in each selected case study are identified

## RESULTS OF CASE STUDY

*Building 1* was completed in 2001, owned by telecommunication company in Malaysia. Building 1 offer their occupant a conducive working environment that is equipped with the state-of-the-art technologies and facilities and was constructed with the 'organic' nature balanced with technical aspects of construction ease and planning efficiency. *Building 2* was completed in 1992 and is owned by one of Malaysia's leading information and communication technology (ICT) solutions providers. Building 2 received acknowledgement as one of the first IBs in Klang Valley. *Building 3* was completed in 1999, which is owned by the Securities company. This building was constructed with glass structure protected by a traditional Malay architectural design of encircling pillars upholding a sheltering peaked roof. In February 1999, Building 3 appears to be a Malaysian work of art as it incorporates high technology and energy efficient IB. For that reason, the ASEAN Energy Awards (AEA) was bestowed upon it in year 2001.

### The planning phase

*In Building 1*, the designer developed and proposed the features of the subsystems to meet the building's requirements and energy targets. Features' such as resources, funding, planning, control mechanisms, regulatory approvals were clarified. The resources and requirements of the BAS equipment were also determined at this phase. Factors like user interface, interface between device and network, communications media, interconnection among building networks, power supplies for communications, communication tools, and building facilities to accommodate network equipment were contemplated in this phase. The interaction with other subsystems that were taken into account were the BAS functions, legacy systems, network access, interoperable systems, diagnosis and repair and monitoring parameters. The cost and benefit issues was also considered at this phase. The basic costs that were contemplated by the owner and designer were cost for installation of personnel, contractor training, building operators for management and maintenance of subsystems inclusive of training, outsource to facilities operators or contract to suppliers and life cycle. Likewise, the benefits from the implementation of IB were also considered such as the benefit of increased employee satisfaction and comfort, improved overall organizational productivity, higher market rents sustainable by an intelligent building compared to a conventional building.

*In Building 2*, the features of the subsystems were revised as the building façade was altered from the square building proposed by the architect to the current round shape. Therefore, the feature application description was revised where the lighting system and air conditioning system were made more energy efficient. The daylight sensing and lighting control allowed lighting system to be controlled to minimum energy consumption between the hours of 10.00am to 12.30pm with the highest sun impact. The location of lobby facing the sunshine received natural lighting while the brick wall built behind the lobby and against the daylight provide lower temperature for the office environment. Thus, less energy consumed for air conditioning to keep building cool. The interactions among subsystems were further developed in at this phase. Besides the clarification of interactions among subsystems, the BAS equipments used were also defined. User interface, interface between device and network, communications media, interconnection among building networks, power supplies for communications, communication tools, and building facilities to accommodate network equipment were the factors considered in this phase. The cost and



benefit issues were contemplated by the owner before commencing the project in the planning phase. The costs of implementing an IB for Building 2 includes cost for installation personnel required, contractor training, building operators for management and maintenance of subsystems inclusive of training, outsource to facilities operators or contract to suppliers and life cycle. On top of that, benefits generated from implementing an IB were also deliberated. Benefits like increased employee's satisfaction and comfort, improved overall organizational productivity, reduced energy costs, minimal environmental impact, attraction and retention of employees. A significant benefit of IB implementation is higher market rents as compared to traditional building, yet this building is occupied only by own company employees.

*In Building 3*, the designer developed a list of subsystem features for specification proposal. The designer proposed the subsystem features according to the building's requirements and energy targets. The project had a project manager to manage the whole project from inception stage to completion stage. The project manager also managed both the construction and consulting parties. The owner, which is the building management executives were also involved in the early project phases to give input on the subsystems' features and performances which this building required. The factors considered for BAS equipments were for instance user interface, interface between device and network, communications media, interconnection among building networks, power supplies for communications, communication tools, and building facilities to accommodate network equipment. BAS equipments were properly defined to go well with the building's requirements. The cost and benefit issues were not considered in the planning phase. Back then, the Building 3 was implemented because it was the trend to build IB. The push factors of economical trend, social trend, and technological trend induced the implementation of IB. The economical aspect was so much better when the Kuala Lumpur Stock Exchange (KLSE) was generating great revenues. The building owner constructed the building to become the first few organisations that owned high-technology building.

### **The implementation phase**

*In Building 1*, the designers considered the features and performance of the subsystems as conducted in the previous phase. During this phase, the construction of building proceeded together with the installation of services and building systems. The operating environment factors considered in this building were the impact of the usage against environment and operating requirements. Another vital consideration during implementing phase was the failure and emergency operations. The subsystems selected were able to respond to emergency failure like emergency power failure, subsystem failure modes, and network failure mode. The subsystems implemented in this phase were capable to respond and function normally even those situations occurred. The interaction among subsystems and BAS equipment criteria were altered due to the inputs from other parties, for instance modifications in drawings and experiences or knowledge from the experts during the construction period. The BAS features such as network structure, access, control, security, configuration, capacity, bandwidth, performance, and error control were confirmed in this phase. Building 1 utilised the IB system from Johnson Controls. Therefore, the BAS features were conformed to standards. Besides the BAS features, the communication protocol issues were also implemented in this phase. The application layer features and lower layer features (under communication protocol features) were considered and confirmed at this phase before the building operation commenced. The application layer features refers to layer 7 of OSI

Reference Model such as application language, data management, application language extensions, application message transfer, and addressing of devices on the network. The lower layer features refer to the layer 1-6 of the OSI Reference Model for Communications. They are message security (OSI layer 6), session control (OSI layer 5), transport layer functions (OSI layer 4), network layer functions (OSI layer 3), data link layer functions (OSI layer 2), and physical layer (OSI layer 1). In actual fact, the OSI Reference Model for communication was not comprehended by the interviewee in this case study. However, it was deduced that the 7 layers OSI Reference Model for communication were divisions of communication protocol features, thus the 7 layers were positively considered and implemented in the implementing phase. The subsystem manufacturers were properly selected in qualifying them before contracts were awarded. Some of the qualifications of the subsystem manufacturers that were considered: experience in developing subsystems networking, reputation in the business, participation in trade association developing standards and practices for building automation and participation on international standards bodies

*In Building 2*, four criteria were considered, namely subsystems' features, performances, operating environmental factors, and failure and emergency operations. The construction changes had triggered the reconsideration of subsystems' features and performances as per previous phases. The construction hindered certain subsystems feature performances thus amendments took place. Failure and emergency operations considered in this phase responded to emergency failure such as emergency power failure, subsystem failure modes, and network failure mode. To prevent any malfunction of building operations, Building 2 equipped with standby generator, functioned as usual whenever emergency power failure occurred. The emergency power were provided for two lifts, lighting system (50%), working station (100%), fire protection system (100%) and air conditioning system. Both the interaction with other subsystems and BAS equipment criteria continued to be considered as per previous phase. The BAS features specifically network structure, access, control, security, configuration, capacity, bandwidth, performance, and error controls were determined in this phase. Considerations for communication protocol issues were necessities for the normal operation of Building 2. The Building 2's BAS system provider, Johnson Controls covered the communication protocol issues. The application layer features and lower layer features (under communication protocol features) were considered and confirmed during this phase before the building operation commenced. The 7 layers of OSI Reference Model are similar to that explained in Building 1's case study. Since the 7 layers were the subsets of communication protocol issues, thus it was deduced that these layers were considered in this phase. The subsystem manufacturers were selected properly in qualifying them before contracts were awarded. The subsystem manufacturers qualified were those that provide subsystems in accordance with standard such as SIRIM approval, Public Works Department standard, and Fire Department's approval. These were the few qualification criteria mentioned.

*In Building 3*, initially, the architect of this building proposed a building with environmental interactions. Hence, Building 3 was built with the considerations of building environment effects such as number of occupants, audible noise, heat generated and pollutants. The failure and emergency operations were another consideration in this phase. The subsystems selected were able to respond to emergency failure like emergency power failure, subsystem failure modes, and network failure mode. With the said capabilities, the building subsystems were able to operate at critical emergency period. Considerations and

alterations were executed by the project manager together with the consultants and building executives of the owner of the building. BAS features encompassed the network structure, access, control, security, configuration, capacity, bandwidth, performance, and error control. Communication protocol issues were considered as the BAS system provider, Johnson Controls set up for the building. Evidently, in this case study, the application layer features and lower layer features (divisions of communication protocol issues) were absolutely considered as well. Proper selections were made before qualifying the subsystem manufacturers. The subsystem manufacturers' qualifications were as long they were the best manufacturers producing the best products. The best of all certainly covered the standards, experiences and reputations. Besides that, the building automation provider, Johnson Controls was opted as it was the most established company in the United States in the business. It was told that the Johnson Controls' hardware performed well without problems till today.

### **The commissioning phase**

*In Building 1*, the performances of the subsystems were double confirmed. In this stage of construction to operation, the subsystems of Building 1 were tested and adjusted on the normal operating function. This was the phase in which the construction was completed and handed over to the owner then to the operator of the building. Hence, the operator of this building dealt with the BAS management issues such as network configuration, expansion, reconfiguration, security, and management integration. An example on BAS management issues was the number of subsystem components was decided for operation that linked to other subsystems. As network decided in the previous phases was too limited, expansion of network took place which required additional components and alteration in software used. As for the system management issues, the following were deliberated: the network enabling and disabling, configuration, upgrades, system maintenance, and operator interface conveniences.

*In Building 2*, at the stage of transferring the completed building from construction to operation, the performances of subsystems were again verified. This is an important aspect in the commissioning phase as the future operations depends on a good system start up. The subsystem manufacturers provided services for system start up as well as a warranty on any malfunctions for a year. Since support and maintenance was out sourced to third party, the trainings were mainly for the building operation related personnel. Training was also provided to the building managers operating the networked subsystems. Trainings were provided by the subsystem manufacturers especially during the one year warranty.

*In Building 3*, the subsystem manufacturers were stationed in the building to start up, tested and adjusted the subsystems for normal operations. The subsystem manufacturers were called to do inspection whenever building operators detected any issues on subsystems' performances. The BAS management issues consisting of network configuration, expansion, reconfiguration, security, and management integration were considered and thoroughly executed. Besides, the system management issues were considered in the commissioning phase. Network enabling and disabling, configuration, upgrades, system maintenance, operator interface conveniences, and commissioning for tenants were the considerations under system management issues. The BAS management issues needed to be determined includes network configuration, expansion, reconfiguration, security, and management integration. In the transferring of construction to building operating stage, the total number

and particular of subsystem components required to be linked for operation in a network to other subsystems were considered. As for the system management issues, the network enabling and disabling, configuration, upgrades, system maintenance, operator interface conveniences were the factors for considerations. This case study showed an example on system maintenance. For example, the Maximum Demand Control (MDC) installed in the electricity system that could controlled and monitored the electricity demand at a certain maximum of maybe 150kW. When the electricity demand reached 150kW, response time would be reset to delay the start of each appliance or switch off the unnecessary appliance. The amount of electricity bill could be controlled as well. In this case study, every subsystem manufacturer provided complete documentation such as layout drawings, operating manuals, installation manuals and etc. The documentations were relevant for the building operation and maintenance personnel especially when modifications and reconfigurations were needed. Johnson Controls provided a one year training for the building operator and related staff. Besides trainings from Johnson Controls system, the maintenance team also received trainings from the subsystem manufacturers. The trainings lasted for a year commencing from commissioning phase.

### **The operation phase**

*In Building 1*, the impacts on building environment such as generation of heat and noises by equipments were considered during building operation. Apart from operating environment factors, the failure and emergency operations were also contemplated. During building operation, the subsystems' failure modes, network failure modes, and emergency control were verified to smooth the progress of building operations. The building operations are not affected if any subsystem failure, network failure or emergency occur. The support and maintenance issues were not considered during operating phase as the support and maintenance were contracted to suppliers and third-party vendor. The documentation, training, and industry education were provided to ease the operation phase. The documentation for proper installation and usage of IB control such as 'Operation and Maintenance Manual Air-Conditioning Systems' was also provided. This particular documentation consists of items like schedule of service and maintenance; where there is daily inspection, service check-list (monthly basis), electrical components, trouble-shooting manual, and component list. Besides documentation, there were training available for building managers that operate the networked subsystems and maintenance personnel. The trainings were required for all personnel involved in operations, maintenance and that related to the subsystems to handling electrical system, air conditioning & mechanical ventilation system (ACMV), central vacuuming system (CVS), and document conveying system (DCS). The trainings were also conducted whenever required and are compulsory for the newly recruited building management personnel. Some of the personnel were sent for building automation industry education for new information and update of knowledge.

*In Building 2*, the operating environment factors, failure and emergency operations criteria were reconsidered. During the actual operation of building, there were scheduled inspections held. To minimise the subsystems' negative impacts on building environment and occurrence of failure emergencies, there were daily, weekly, monthly, quarterly, semi-annually and yearly inspections. Then again, the support and maintenance criterion was not considered in this phase because Building 2 out sourced its support and maintenance for subsystems. The third party vendor monitored all the subsystems' performances on a monthly basis. Along the operation period, one problem existed which was the system

obsolete. The BAS was outdated and could not be upgraded and configured for further usage. As a result, the hardware and software of the Direct Digital Control (DDC) were replaced with a significant cost. Therefore, as Hetherington (1999) mentioned, additional considerations must also address the flexibility and modularity as well as state of the art Direct Digital Control (DDC) BAS to minimize future costs associated with installation as well as incorporate centralized control to implement energy optimization routines, scheduling, monitoring and interface with other IB systems.

*In Building 3*, the performances of the subsystems were stable as configured and monitored by the specialised manufacturers in the commissioning stage. Therefore, the operating environment factors, failure and emergency operations, and support and maintenance criteria were considered in this phase. As for the operating environment factors, the subsystems' operations suited the number of occupants in the building and were not emitting any hazards to the building environment like noise pollution, heat generation, and the like. However, there was a flaw in the consideration where the refrigerant used for the chillers was not environmental friendly. As for newly recruited members of the operation department, trainings were essential until they familiarised with the operations. Organisational learning is practiced in the trainings during operating phase, in which internal sharing of knowledge was repeated. With that, operating knowledge of the experienced personnel would never cease but remained in the organisation. Besides documentations, trainings were continuous for newly recruited building operation and maintenance staff. The trainings include tackling problems of BAS failures, understanding the interactions among subsystems, scheduling operations, and etc.

### **The support and maintenance**

*In Building 1*, the support and maintenance were out sourced to the suppliers of the subsystems and part of them to a third-party vendor. This vendor has a team of 50 personnel that are stationed in the building. This vendor handles and maintains the electrical system, air conditioning & mechanical ventilation system (ACMV), central vacuuming system (CVS), and document conveying system (DCS). As for the suppliers or sub-contractors, they responded to service or repair of the building to the Building Operation Maintenance (BIOM) department received any reports of any subsystems' failures in operations from tenants. There are three ways to notify or report dysfunctions to the department; call, email, and automatic signal input from system.

*In Building 2*, building management staffs consist of merely two persons. The building's support and maintenance for subsystems was awarded to the third party vendor. The mechanical and electrical services such as fire protection system, electrical system, and air conditioning system were outsourced to respected maintenance company. As for the lift or vertical transport system, the subsystem manufacturer continued the contract for the maintenance till today.

*In Building 3*, the support and maintenance team consists of 8 persons. The subsystem manufacturers provide one year warranty in the contracts. Within one year period, the support and maintenance team worked together with the experts to gain necessary skills of maintaining and operating. To date, the maintenance team is capable of maintaining all the subsystems except for the specialised elevator subsystems.



## CONCLUSION

The demand for comfort living environment and requirement has increased dramatically, thus, IB has become the future of the building industry. IB systems and their integrated communications are still evolving due to the continual advancement of technologies. This outcome of research can become one of the sources for future researchers focusing on the same issues or related issues. Also, this may denote a beginning or starting point for future researchers to further discuss and study on this issue. As for the contribution to the IB practice and industry, the outcome of this research provides an indication and guidelines on how IB is being implemented in Malaysia. Hence, it informs the type of Malaysian IB practice for the designers, engineers and clients to concentrate on. It is sort of a common vision for the parties involved to work closely together throughout the design, construction and operational stages of the conception, birth and life of the building. It is evident that all three buildings under evaluation are fulfill the requirements and concept of intelligent buildings by planning and integrating ICT features into all aspects of system engineering workflow from planning, definition, implementation, commissioning, operating and evaluation. However, the designer and developer need to work closely and improve communication in order to synchronizing the workflow. For example, during the construction of Building 2, the construction had changes that triggered the reconsideration of subsystems' features and performances. This is due to misinterpretation of design of both parties. Even worst, the construction of Building 3 had experienced a lot of changes to the features and performances of the subsystems due to miscommunication factor. Only Building 1 has shows the smooth of construction flows proceeded together with the installation of services and building systems. In the aspects of support and maintenance, Building 1 and 2 outsourced it to the third-party vendor for electrical system, air-conditioning & mechanical ventilation system and fire protection system. While Building 3 had their own support and maintenance team. Building 1 and 3 acquired the proper documentation on the installation and usage of IB. While Building 2 was lack of adequate manual for the operation of IB system. All of three buildings were not considered training on awareness of IB system during early stage of construction. However, they are more emphasis on training to staff during operation and maintenance. This is probably a reason why there were communication breakdown at the early stage of construction that required a lot of changes to the building design. In conclusion, from the case studies indicates that an attention should be given to educate the industry relating to the awareness and potential of intelligent building. Further studies can be carried out on the other IBs in Malaysia to observe their practices on IB implementation. A better indication can be provided with this study. With such indication of best practice IB in Malaysia, studies can be made to compare with IBs in other countries in regional order. Before commencing on comparison, all the foreign IBs must be evaluated using of the same evaluation guide or tool. The outcome of this further study can be the identification of the IB implementation practices, and an indication or a benchmark in this case for the IB industry.

Another study can be conducted on the 'greening' value of subsystems in IB. In this research, the operating environmental factors of the case study buildings are evaluated in the sense of whether they have taken this issue into consideration in certain project phase. However, this further study will be made on identifying the environmental impact of each subsystem in operation. Comparison of the equipments' or subsystems' environmental

impact can be studied between the IB and conventional building. Summing up, an overall IB performance benchmarking can be researched on either in Malaysia or in a wider region. Also, 'greening' value of the IB subsystem can be studied and in addition, comparison of 'greening' value of the equipments and subsystems between IB and conventional building is also a possible direction of research. These are the directions of further studies on IB that can make further improvements to the industry.

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# AN OBSERVATION OF IMPACT IN IMPLEMENTATION OF QUALITY MANAGEMENT SYSTEM BY CONTRACTORS

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## Abstract

The Ninth Malaysia Plan (RM9) was launched by our Prime Minister in March 2006 is expected to boost the construction sector. However the contemporary issue that prevails in the construction realm is the capability of our contractors to deliver a desirable quality construction works. One way of improving their capability is by implementing ISO Quality Management System (QMS). How far is that true? Do our present fleet of ISO contractors performed well? What are their areas of improvement with regard to project management? Thus the primary aim of this study is to explore the areas of benefits that are experienced by our contractors after having certified to ISO 9001:2000. Based on Construction Industry Development Board (CIDB) data base, the designed questionnaire forms were sent to 190 ISO QMS certified contractors throughout the country. Subsequently 51 (26.8%) completed forms were returned. Data received were analyzed using SPSS software. It was found that by implementing ISO QMS, the contractors were generally able to improve their project productivity and enhance the company competitiveness. In context of project performance most contractors agreed by having ISO QMS enable them to improve their ability to complete the project in time as well as ability to reduce the wastage of material. In terms of managing the project, among the significant areas of improvement after ISO QMS certification were improved in storage and traceability of project records, more organized and systematic in submission of VOs, more organized in inspections, improved overall site management and improved in testing and commissioning activities.

**Keywords:** *Contractors, Construction, Quality Performance, ISO 9001:2000, Quality Management System (QMS)*

## INTRODUCTION

The Ninth Malaysia Plan (9MP) was finally tabled by our honorable Prime Minister on 31<sup>st</sup> March 2006. The public development has been allocated about RM 200 billions which is 18 % higher than the previous five years plan. This significant allocation is necessary to boost the construction sector to meet the targeted construction gross domestic product (GDP) growth of 3 %. Thus 9MP is expected to keep the contractors busy for the next five years. However from previous records, depicted that poor quality of the construction works still prevailed. For instance, townhouse under construction collapses, killing one in Jalan Klang Lama, Kuala Lumpur (The Star, December 15<sup>th</sup>, 2004), concrete floor collapse in Shah Alam (News Straits Times, April 3<sup>rd</sup>, 2005), roof of new school hall collapses due to aluminium supporting structures fall down (News Straits Times, October 8<sup>th</sup>, 2005) and JB hospital 'sick' again- This time it's structural defect (The Star, 20<sup>th</sup> April 2007). Thus the prime concern of public at large is that are our contractors really committed to deliver high quality of construction works. One way to show their commitment is to go for ISO Quality Management System (QMS) certification.

In 1993 SIRIM introduced the MS ISO 9000, a quality standard system recognised throughout the world, to Malaysia construction industry (Wan Yusoff and Norizan Mansor, 1996; Mokhtar Abdullah, 1996). Realising the importance of QMS, some contractors have taken their initiatives to be certified with MS ISO 9000. However, the acceptance of ISO 9000 standards in the construction industries is not as wide as in other industries, such as manufacturing. There are special features in the construction industry that limit the implementation of the ISO 9000 standards (Phenol, 1994). The common perception is that ISO certification would implicate additional financial burden to their operations. They fail to realise the saving or added value whether tangible or intangible that can be generated by implementing the said QMS. Hence having said that, the primary aim of this study is to explore the area of benefits experienced by our local contractors, after having certified to ISO 9000 QMS. Among other objectives of this study are as follows:

- i. To examine the overall quality performance by our ISO 9001:2000 certified contractors
- ii. To ascertain and to rank the significant areas of improvement by our local contractors after having certified with ISO 9001:2000 QMS.

## OVERVIEW OF THE CURRENT ISO 9001:2000

Basically ISO, stands for International Organization for Standardization which is based in Geneva, Switzerland. ISO first published its ISO 9000 series of standards in year 1987, revised them in year 1994 and then republished an updated version in year 2000. It has been widely understood that the ISO 9000 has been reviewed at least once in five years by the International Organization of Standardization (ISO) which the membership is made up of the national standards bodies of more than ninety countries (Yeoh and Lee, 1996). The present series of ISO 9001:2000 which was introduced in the year 2000 is a revised version that was introduced in 1994. This new version seems to be more generic because it is equally applicable to all kinds of organizations in all kinds of sectors (i.e. manufacturing, service, construction, etc). It also can be applicable to all sizes of organizations i.e. small, medium or multinational companies.

For companies that have been certified to version 1994 need to convert their respective certification to version 2000 by the year 2003. There are several significant changes to the current version, obviously the structure of the series of standards. Basically ISO 9000:2000 series comprise of three primary standards as follows:

- *ISO 9000 : Quality Management Systems – Fundamentals and Vocabulary*
- *ISO 9001 : Quality Management Systems – Requirements*
- *ISO 9004 : Quality Management Systems – Guidance for Performance Improvement*

ISO 9001:2000 will be the sole ISO standard for use in third-party certification. The previous 1994 version which comprise of three quality assurance models i.e. ISO 9001:1994, ISO 9002:1994 and ISO 9003:1994 have been consolidated into one single international standard (Table 1)

**Table 1.** Change of Standards from Version 1994 to 2000

Standard	Title	Status
ISO 9001 : 1994	Quality System - Model for quality assurance in design/development	Revised and consolidated into a single ISO 9001:2000 Quality Management System - Requirement
ISO 9002 : 1994	Quality System - Model for quality assurance in production, installation and servicing	
ISO 9003 : 1994	Quality System-Model for quality assurance in final inspection and test	

These changes will require the user to approach quality management as a series of processes. The traditional 20-elements structure used in the 1994 series is replaced by 'Process Approach'. The new process-based structure is consistent with the Plan-Do-Check-Act (PDCA) improvement cycle that has been used widely by many successful organizations. PDCA cycle is also known as 'Deming Wheel' or 'Shewhart cycle' (Santos *et al*, 2000).

They changed the title from quality assurance to quality management. Apparently the revised standard not only addresses the quality assurance of product and/or service conformity, but also includes the need for an organization to demonstrate its capability to achieve customer satisfaction. However one common feature is that both structure based on process approach model. One of the advantage of version 2000 is that better compatibility with ISO 14001 standard.

Among the additional requirements in version 2000 ([www.bsi.org.uk/iso-tc 176-sc2/FAQs](http://www.bsi.org.uk/iso-tc_176-sc2/FAQs)) are as follows:

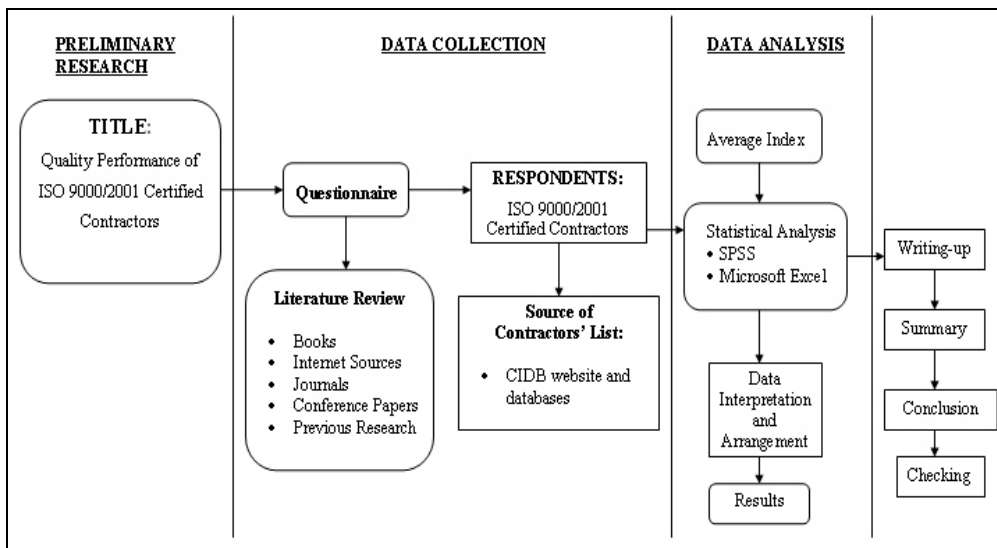
- Continual improvement
- Increased emphasis on the role of top management
- Consideration of legal and regulatory requirements
- Established of measurable objectives at relevant functions and levels
- Monitoring of information of customer satisfaction as a measure of system performance
- Increased attention to resource availability
- Determination of training effectiveness
- Measurement extended to system, process and product
- Analysis of collected data on the performance of the QMS

The concept of ISO 9000 has been viewed in various ways; as a means of improving the overall quality of operations; as the requirements of customers to be complied with; as a necessary response to competition; as a way to reduce cost; as a means to improve the flow of activities and coordination in the organization; as a strategy to have better sales through an improved quality image; as a way to maintain competitive edge in the industry, etc. (Bhuian and Al-Zamil, 1996; Lamprecht, 1992). Thus, the impact of ISO 9000 standards may vary depending on how it is perceived by construction companies. A contractor's quality assurance system is very important to her/his clients, who will gain confidence that "getting it right the first time", will always be the contractor's norm (Bubshait and Al-Atiq, 1999).

One of the notable changes in version 2000 is the requirement on continual improvement. This requirement basically meant that an organization needs to make concerted effort to gradually improve their quality performance. In this version 2000, there are several clauses that relate to continual improvement. Among these clauses, it is found that *clause 8.5.1 of ISO 9001:2000* clearly described the continual improvement requirement.

## METHODOLOGY

The general framework of this research is as shown in Figure 1 below:



**Figure 1.** Research Framework

The collection of primary data was done by using a structured questionnaire. The questionnaire for this research consisted of a few different types of questions, namely open and closed questions. The large part of this questionnaire consisted of closed questions, where the respondent was asked a question and required to answer by choosing between a limited numbers of answers. The answers for some parts of the closed questions were based on Likert Scaling. The Likert scale chosen was range from 1 to 5, where 1 means 'not satisfactory at all', and 5 means 'most satisfactory'. Generally, the questionnaire designed for this study consisted of four parts. Part A covered basic company profile. Part B provided overview information of contractors' ISO QMS. Part C was designed to ascertain the areas of improvement after ISO certification. In part D was designed to explore the overall quality performance.

Before data analysis can be carried out, all the data collected was first processed. Data processing includes checking and verifying the returns, coding, and cleaning of data. Basically, descriptive statistics were used to analyze the frequency, percentage, and mean for each of the questions according to their suitability. In addition, Average Indexing technique was used in analyzing Section C of the questionnaire, which covered on areas of improvement after ISO certification. The average index value for each aspect of achievements was calculated based on the formula below (Al-Hammad et al., 1996):

Average Index = 
$$\frac{\sum a_i x_i}{\sum x_i}$$

Where  $a_i$  = value of scale ( $i = 1,2,3,4,5$ )  
 $x_i$  = respondent frequency ( $i = 1,2,3,4,5$ )

In order to rank areas of improvement by contractors after ISO certification, average index method was implemented in this study by using five categories of scales to describe the different level of achievements. The scales that have been used were as follow:

- 1 = not satisfactory at all
- 2 = less satisfactory
- 3 = neutral
- 4 = satisfactory
- 5 = most satisfactory

The classification of the rating scales was based on the classification proposed by Abd. Majid and McCaffer (1997). The proposed classification of the average index for this study has been combined into only three levels of achievements, which were:

‘Not satisfactory’	$1.00 \leq \text{average index} < 2.50$
‘Neutral’	$2.50 \leq \text{average index} < 3.50$
‘Satisfactory’	$3.50 \leq \text{average index} \leq 5.00$

**FINDINGS OF THE SURVEY**

This survey was carried out in November 2006. The list of certified contractors was obtained from Technology Development Division, Construction Industry Development (CIDB) head office at Kuala Lumpur. Altogether 190 questionnaire forms were then mailed to ISO 9001:2000 certified contractors throughout Malaysia and 51 (26.8%) forms were completed and returned. This percentage of returned questionnaires had been expected for a mailed and questionnaire-based survey research. A better survey results would be achieved through personal interview method. However, due to time constraint and limitation of resources that would not be feasible.

**Respondent’s Background**

The first section of the questionnaire is to ascertain the basic company profile of the contractors. From the total number of contractors that have participated in the survey, it is found that 92% of them are registered as grade G7 with CIDB. Grade G7 is the highest grade of contractor based on CIDB registration structure. That provides an indication on the present scenario in the industry that majority of the contractors that have been certified to ISO QMS are of higher grade contractors. A total of 73% of the respondents were contractors operating in the Central region, which includes the state of Selangor and the Federal Territory of Kuala Lumpur.

## Reasons for Contractors Going For ISO Certification

It would be quite interesting to know what are the driving factors attributed the Malaysian contractors to get themselves certified to ISO QMS. Thus a question was asked on the main reason for the contractors to go for certification by providing list of answers for them to tick. According to Figure 2, the highest answer received (75%) is to improve the quality performance, the second highest (45%) answer is to enhance competitiveness and the third highest (41%) answer is to increase marketability. Judging from answers picked up by contractors it is awesome to note that our contractors are quite committed in their quest to improve their quality performance when they decided to apply for ISO certification. Apparently this phenomena is in line with strategic thrust 3 as outlined in the Construction Industry Master Plan (CIMP), 2006-2015.

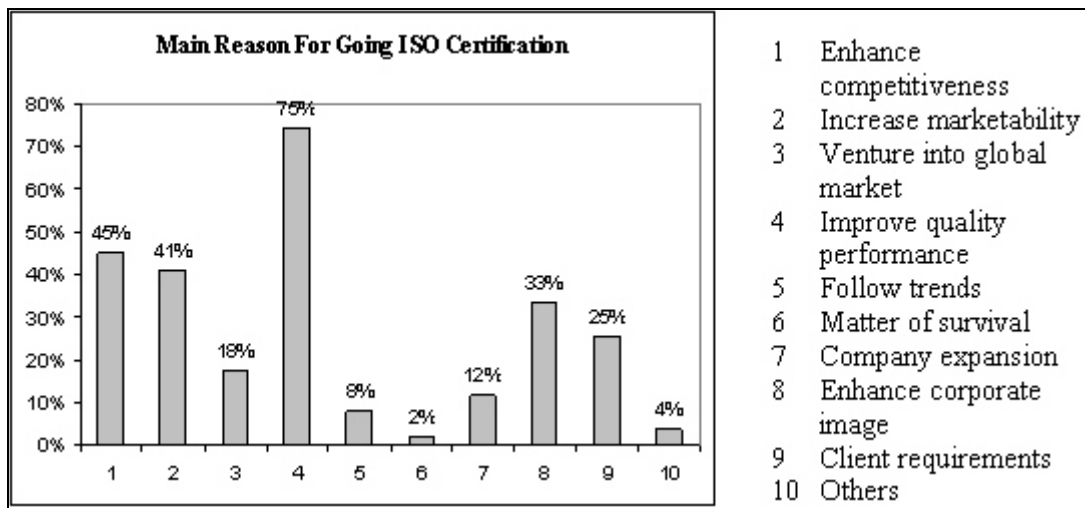


Figure 2. Main reason for contractors going for ISO certification

## Approaches for ISO Certification

Next is to know what are the common approaches adopted by our contractors to get themselves certified and which certification bodies are commonly involved in the construction industry. Based on the feedback gathered (Figure 3) majority (55%) of the contractors engaged consultant to assist them in getting certification. The balanced distribution of respondents is equally divided between others (23%) and those respondents (22%) that utilized CIDB DIY Scheme. The other approach means that the contractors used their own internal resources in order to get them certified. This is interesting because it indicated that there were contractors that have invested in training programs in an effort to get their staff equipped with essential knowledge for them to develop their respective QMS.

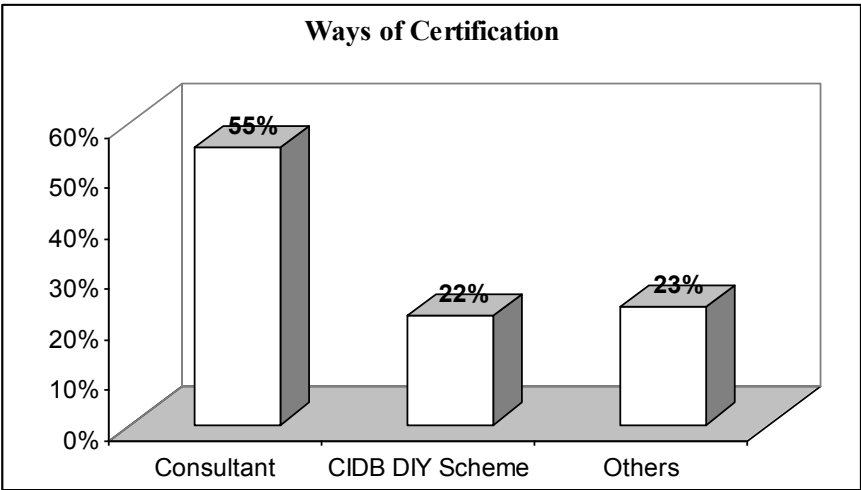


Figure 3. Certification Approaches by Contractors

As mentioned above majority of the contractors engaged the services of the consultant to develop their QMS. Therefore it is interesting to know the range of fees needed for the said purpose. An open-ended question was asked for the respondents to write down the approximate expenditure involved in acquiring the consultancy services. Due to the sensitivity of this information, 43% of the contractors chose not to disclose this data. However, for those that were willing to share this information, it was observed that 31% had to spend in the region of RM10,001 to RM30,000, as shown in Figure 4. Amazingly there were respondents (8%) that have spent more than RM 50,000 for the consultancy services. Generally the amount of fees would depend on size of the company and the level of complexity the project managed by them. Hence those that have spent considerable amount of money to be certified were those among the big players in the construction fraternity.

Nevertheless taking cognizance of the answers received, broadly it can be deduced that the contractor required approximately RM 30,000 in getting the consultancy services to develop their ISO QMS.

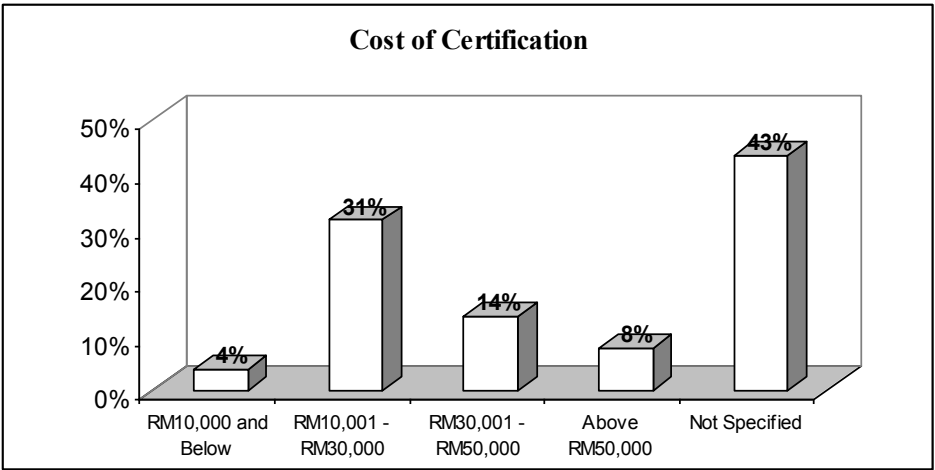
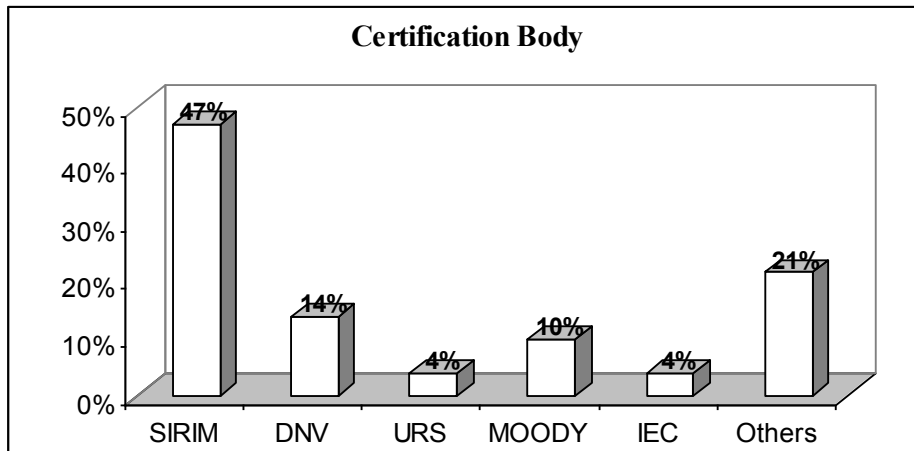


Figure 4. Cost of Consultancy Services



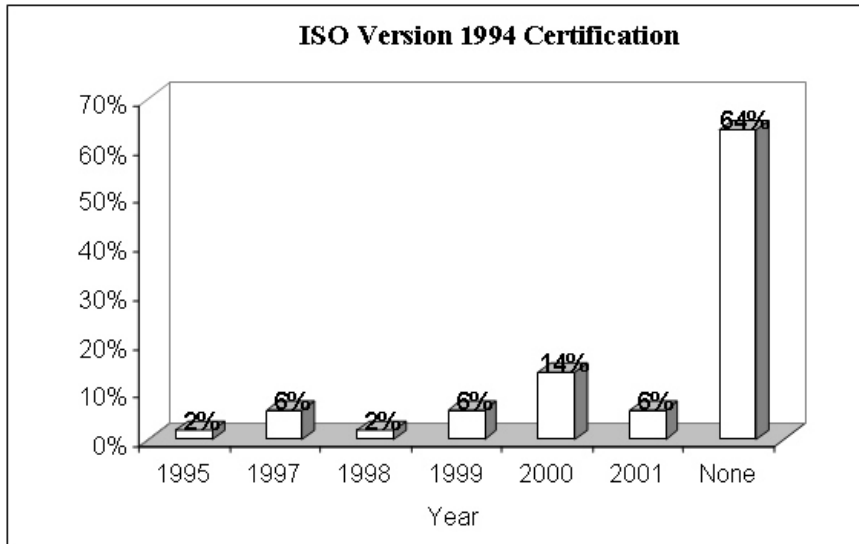
In terms of certification bodies, from Figure 5 unveiled that most of our contractors preferred (47%) our local certification body i.e. SIRIM. This is followed by DNV (14%) and MOODY (10%). However, it is interesting to note that there are few other certification bodies that are involved in our construction industry e.g. Lloyds, BM Trada, URS, IEC, WCQ etc.



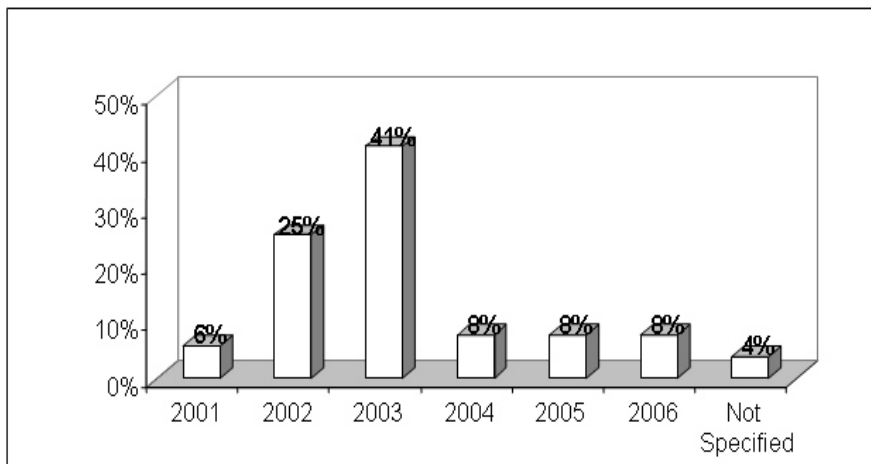
**Figure 5.** ISO certification bodies for contractors

### **Advantages of Current ISO Standard Version 2000**

As mentioned above, those who have been certified to version 1994 need to convert to version 2000 by year 2003. A question was asked to know when did the respondents first certified to version 1994 and later converted to version 2000. Followingly they were also requested to share the differences they experienced between these two versions. From the survey conducted shows that quite small numbers (Figure 6) of contractors (36%) were certified to version ISO 1994. Thus majority (64%) of our contractors have been certified to version 2000. In addition from the data collected showed that few of our contractors were certified to ISO 9000 since 1995. This implied that the awareness about the importance of ISO 9000 certification in our local construction landscape started somewhere in the year 1995 however the reception at that juncture was rather low. From Figure 7 exhibited the trend of the contractors certified to version 2000 and noticed that a sudden increased in numbers of the contractors certified to version 2000 in the year 2003. The drastic rise in numbers may be due to the fact that many contractors were converting from version 1994 to version 2000.



**Figure 6.** ISO 1994 certification



**Figure 7.** ISO 2000 certification

For those that have experienced in implementing the two versions were requested to share the advantages of the new version. A question was asked and they were required to select the answer yes or no to the list of answers provided. With reference to the feedback received, the most favorable answers (Figure 8) pick up by contractors are listed as follows:

- Emphasis on measurable performances (37%)
- Quest for continual improvement (33%)
- Improve customer relationship (27%)
- Improve compliance to legislative requirements (23%)

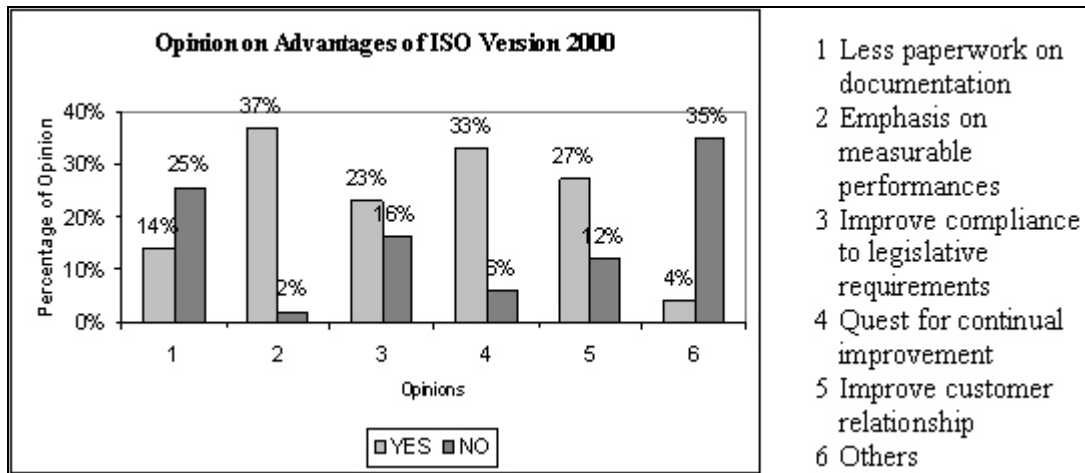


Figure 8. Opinions of contractors on advantages of ISO version 2000

### Overall Benefits after Having Certified to ISO

Generally the contractors' perception of implementing ISO 9001:2000 is additional financial burden to the project cost. The later could be an immediate impact however in the long run it is expected to generate saving to the contractors because of continual improvement in managing their projects. Therefore this survey is to probe the probable benefits. A question was asked whether the respondents agreed that after implementing ISO QMS has resulted in improving company competitiveness and project productivity. The respondents were requested to choose the answer yes, no or partly. The outcome of the survey (Figure 9) shows majority of the contractors were in opinion that ISO 9000:2001 certification helped to improve their company competitiveness (80%). Where else in Figure 10 shows a large number of contractors acknowledge that ISO 9001:2000 certification improved their project productivity (74%). In the nutshell these results implied that by implementing ISO 9001:2000 QMS can generate added value to the contractors in the long term business gain.

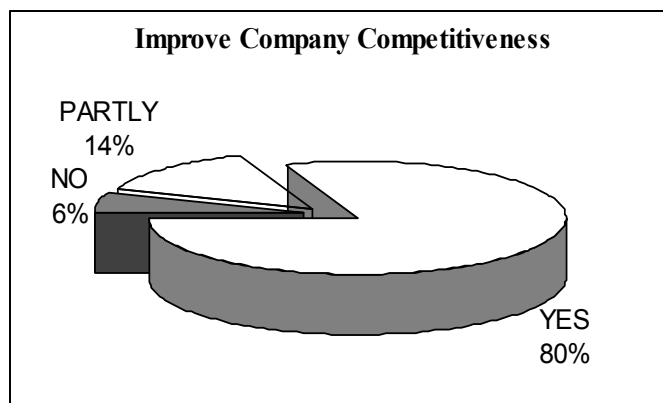
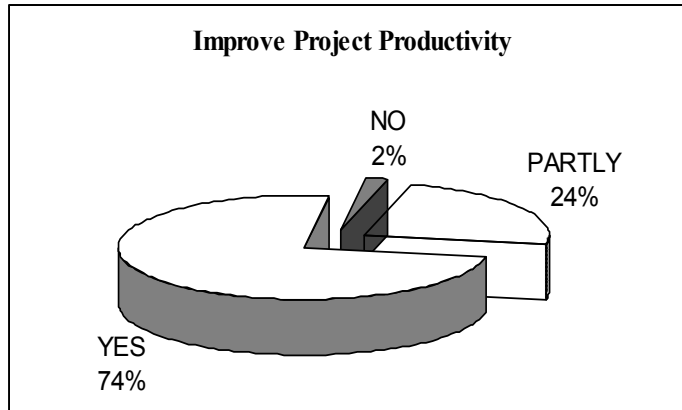


Figure 9. Opinions on whether ISO helps improve company competitiveness



**Figure 10.** Opinions on whether ISO helps improve project productivity

Another pertaining issue raised in implementing ISO QMS is the difficulty in maintaining the developed system. As a result a question was designed with regard to the said issue. From the response received, surprisingly majority (86%) of the respondents felt that they did not have any difficulty in maintaining the developed QMS. The remaining of the respondents (14%) encountered difficulty in maintaining the QMS. Hence one can deduced that our contractors do not encounter profound difficulty in maintaining their developed QMS.

### Overall Quality Performance

Another area that this survey intended to explore is on overall quality performance. However for the purpose of this survey, it is limited to two simple and commonly parameters used by contractor i.e. delay in project completion and wastage of material.

Table 2 shows the comparison experienced by respondents on the average of percentage project delay before and after ISO certification. Unfortunately 45% of the respondents left this question unanswered. Based on the majority (29%) answers received indicate the range of delay before ISO certification was 10%. After ISO certification majority (35%) of the contractors stated that the range of delay is 5%. Therefore by having ISO certification indicates that a contractor can improve to a certain extend their ability to deliver the project on time.

Table 3 below shows the comparison experienced by respondents on average wastage of material before and after ISO certification. However for this question the number of respondents left unanswered reduced to 27%. By considering the response received majority (39%) of the respondents recorded an average of 10% wastage of material before ISO certification. After implementing ISO QMS majority (51%) of the respondents stated that their average wastage of material was 5%. This reflects that by executing ISO QMS effectively, a contractor can decrease their wastage of material which would eventually improve their saving.

**Table 2.** Average delay of contractors

<b>Average Delay</b>	<b>BEFORE ISO</b>	<b>AFTER ISO</b>
	<b>Respondents</b>	
5%	6%	<b>35%</b>
10%	<b>29%</b>	6%
15%	2%	0%
20%	8%	6%
Others	10%	12%
Not Specified	45%	41%
Total	100%	100%

**Table 3.** Average wastage of material

<b>Average Wastage</b>	<b>BEFORE ISO</b>	<b>AFTER ISO</b>
	<b>Respondents</b>	
5%	16%	<b>51%</b>
10%	<b>39%</b>	6%
15%	12%	8%
20%	2%	0%
Others	4%	8%
Not Specified	27%	27%
Total	100%	100%

### **Areas of Improvement after ISO Certification**

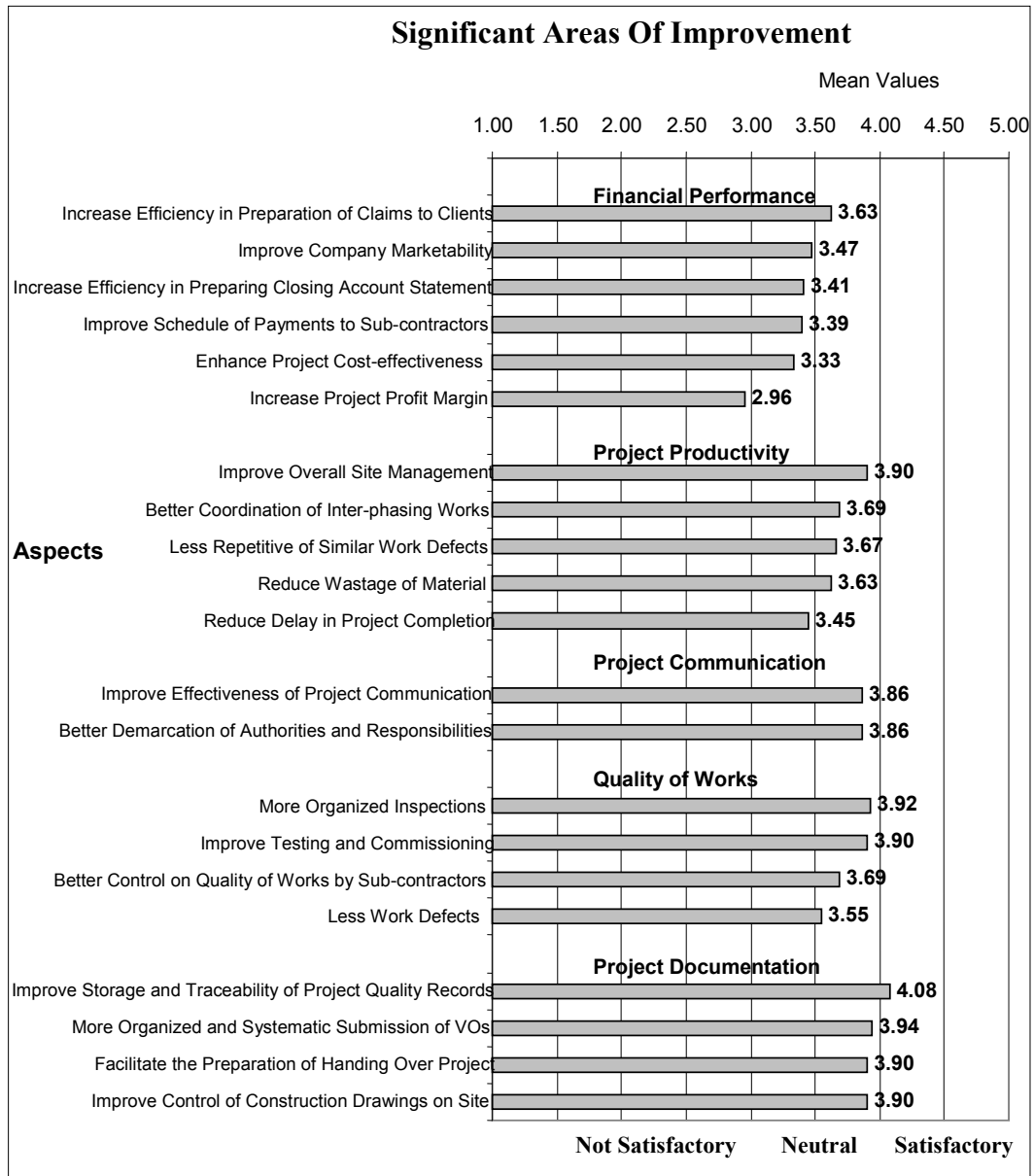
After having certified to ISO QMS a contractor is expected to improve in various aspects in managing their project. Otherwise it would be meaningless of having ISO QMS certification. Any positive outcomes of this study may help to motivate more contractors to apply for ISO QMS certification. Hence it is crucial to collect evidence on areas of achievement or rather improvement by contractors after having certified to ISO 9001:2000. This was attained in the third section of the questionnaire. A list of identified improvement areas was provided under subheadings namely financial performance, project productivity, project communication, quality of works and project documentation. The contractors were asked to asses in order of 1-5 (1-not satisfactory at all, 5-most satisfactory) of their achievement on each of these identified areas. The average index or mean values for the all the aspects of achievements by

contractors are shown in Figure 11. From the bar chart, we are able to observe that a total of 15 aspects were considered satisfactory for the contractors after ISO certification. The rest of 6 aspects were only considered on a neutral achievement level and there were no aspects which were considered not satisfactory by the contractors.

Based on the 15 work areas satisfactory achievement we can rank them according to the highest mean values scored. Therefore the top seven most significant achievements are listed below:

- Improved storage and traceability of project quality records (4.08)
- More organized and systematic submission of VOs (3.94)
- More organized of inspection (3.92)
- Improved overall site management (3.90)
- Improved testing and commissioning (3.90)
- Facilitate the preparation of handing over project (3.90)
- Improve control of construction drawings on site (3.90)

With reference to the above findings, one can concludes that the most outstanding area of improvement after having ISO QMS certification is enhancing in project record keeping. The main contributing factor probably due to improvement in control of records as required under clause 4.2.4, ISO 9001:2000. However it is expected that would be a short term area of improvement after certification. However for the long term goal the eminent achievement should be towards continually improve project productivity and enhance customer delight. Eventually that would leads to improving cost effectiveness of the project and maintains long term relationship with the customer. Then only it is worth of investment by contractor in getting the referred certification.



**Figure 11.** Significant areas of improvement for different identified work activities.

## Overview on Current Practice in Project Quality Planning

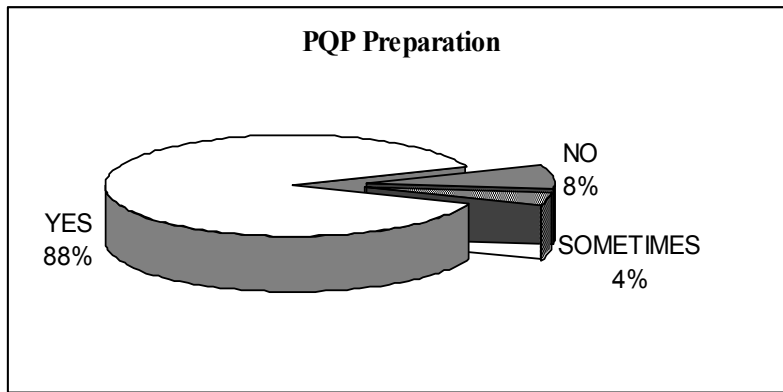
According to requirement under clause 7.5 ISO 9001:2000 the contractor needs to provide evidence of having proper project planning. However this does not specifically mean that they must prepare Project Quality Plan (PQP). But it is advisable to have one so as to ensure proper planning. As long as they can provide evidence in meeting the ISO requirement then non-compliance report (NCR) will not be issued by auditor. Instead clause 8.2.4, ISO 9001:2000 requires the contractor to prepare Inspection and Test Plan (ITP). Thus another



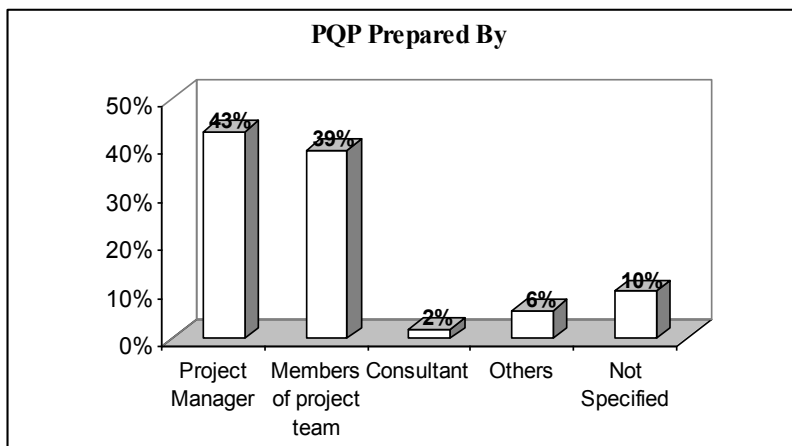
area that this study intended is to evaluate the current practice on effective quality planning by certified contractors. This leads to deliberate several issues as listed below:

- Do our ISO contractors prepared PQP and ITP?
- Who prepared them?
- Were those documents approved by client or consultant?

Figure 12 exhibited that 88% of respondents prepared PQP. Figure 13 provided an indication that this document is prepared mostly by Project Manager (43%) followed by members of project team (39%).

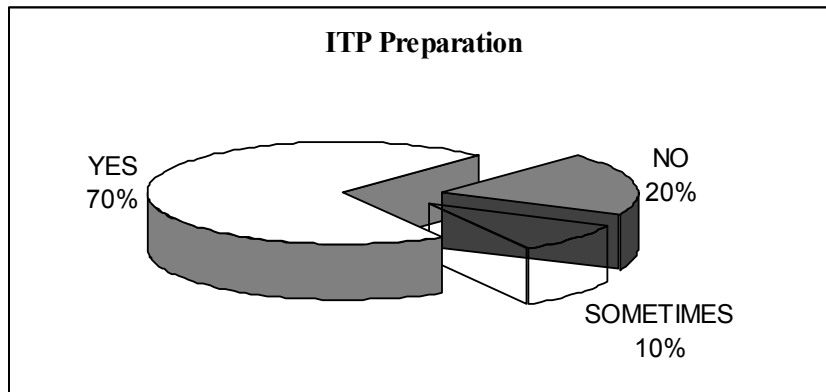


**Figure 12.** Preparation of PQP by contractors

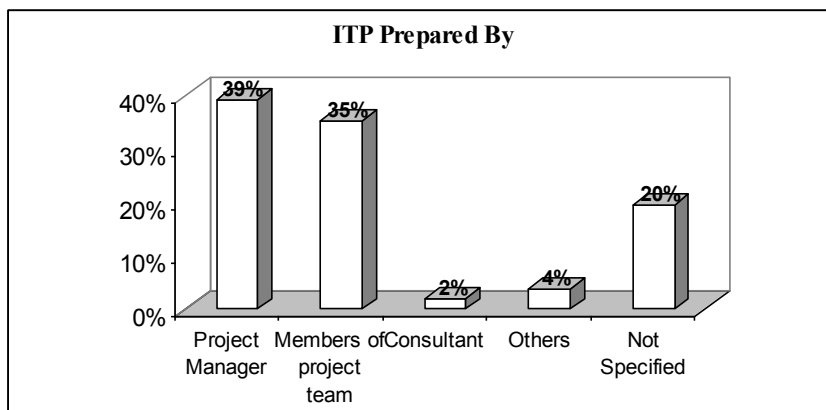


**Figure 13.** Personnel of contractors who prepare PQP

Next is to examine the practiced in preparing ITP. Figure 14 showed that 70% of the respondents prepared ITP and Figure 15 indicated that this document was prepared mainly by Project Manager (39%) followed by members of project team (35%).

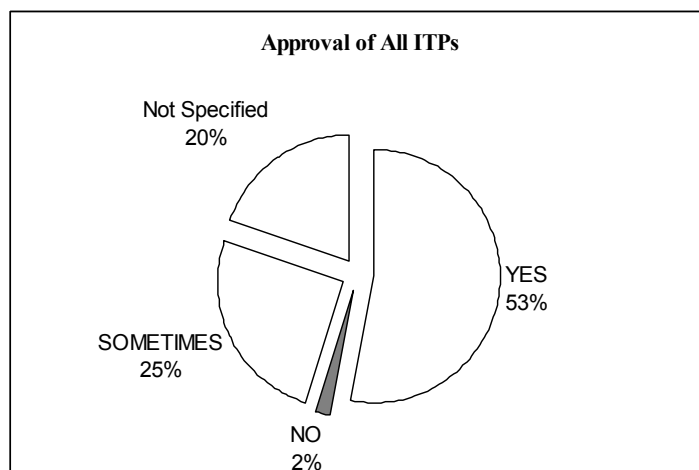


**Figure 14.** Preparation of ITP by contractors



**Figure 15.** Personnel of contractors who prepare ITP

Figure 16 manifested that 53% of contractors whose ITPs were approved while 25% of contractors whose ITPs sometimes approved.

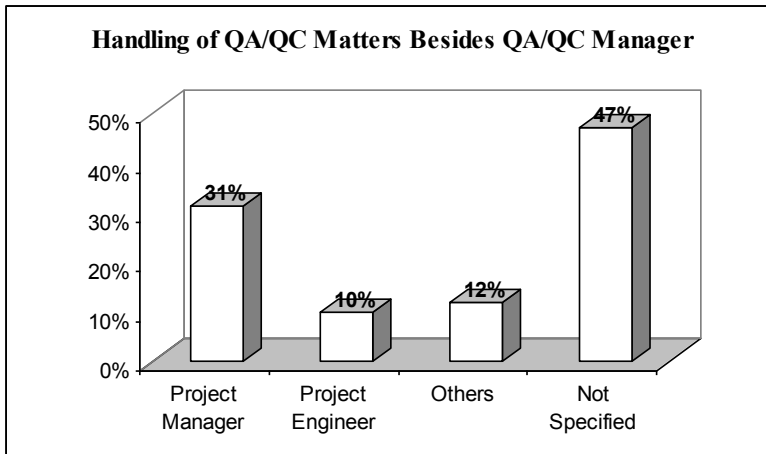


**Figure 16.** Approval of contractors' ITPs by clients/consultants

The contractors were also asked whether they appoint a QA/QC Manager in their companies. Figure 17 showed 47% of them said they do while a majority of 53% did not appoint. This shows that currently majority of our ISO certified contractors do not employed QA/QC Manager to oversee matters regarding QMS. For the contractors who do not appoint a specific QA/QC Manager, they were further asked who was normally assigned to handle matters related to quality issues. Referring to Figure 20, 47% did not specify who was in charged of handling QA/QC matters. However 31% of the contractors assigned Project Manager to oversee matters related to quality.



**Figure 17.** Appointment of QA/QC Manager in contractors' companies



**Figure 18.** Personnel of contractors handling quality matters besides QA Manager

## DISCUSSION

The findings of this survey are intended to address several arguments raised by contractors with regard of benefits attained after having certified to ISO 9001:2000. Firstly the findings showed that the present number of ISO certified contractors were mainly of grade G7. This is a good sign as they are supposed to provide leadership in their quest to sustain quality in

construction industry. Followingly it is interesting to note that the main reason of our contractors to implement ISO QMS is to improve quality performance. This is in contrary with the study conducted by Lee (1998) in Hong Kong where he discovered the main reason for the contractor to be certified to ISO QMS due to customer pressure. Later another similar study was conducted in Hong Kong by Dissanayaka *et. al* (2001) found that the main motivator for contractors going for ISO certification was to quality to tender for public project. Currently our customers or clients do not emphasize on ISO certification which resulted in poor response of contractors going for ISO certification. Notwithstanding that scenario CIDB has issued a directive to all G7 contractors which required them to be certified to ISO 9001 by January 2009. This bold and laudable measure by CIDB is expected to elevate the performance of our G7 contractors to a higher level. Indeed ISO QMS is paramount for contractors to venture into global market.

While in the aspect of developing QMS, presently the contractor preferred to appoint consultant to develop their respective QMS which would involve an expenditure of approximately RM 30,000. Alternatively it is advisable for the contractor to opt for CIDB DIY scheme which imposed the fee of RM 10,000. In the area of maintaining the QMS, the survey results also indicated that only a minority of contractors encountered some difficulties in maintaining the established system. According to several literature reviews expounded that difficulty in maintaining the system mainly due to lack of commitment from top management. Thus once certified it is essential for the top management to persistently mobilize necessary resources to ensure effectiveness and continuity of the established system.

Based on the data collected illustrated that majority of contractors generally benefited from ISO certification. The later enable to enhance company's competitiveness and improve project productivity. In term of overall project performance, majority of ISO certified contractors agreed that they were able to complete their projects in due time and also able reduce their percentage wastage of material. Consequently it can generate saving which ultimately may influence the profitability of the project. Hence in the long run it can be considered as trade off with the amount of fund involved in developing the QMS.

Another finding of this survey is that the immediate area of improvement after ISO certification is improved project record keeping. This is consistence with the finding by Dissanayaka *et. al* (2001) in Hong Kong discovered that the major positive outcome from ISO certification is more systematic in record keeping. That area of achievement, enable the contractor to solve several prevailing issues related to storage, retrieval and traceability of project records especially at the site office. Proper record keeping is imperative during the project closing in particular in compiling information that can be classified as lesson learned for future undertakings. Another area of improvement that needs to be highlighted from this finding is improving project communication. The average mean scored is 3.86 which is considered satisfactory. In view of the mentioned finding construed that by implementing ISO QMS also can to a certain extend helped to improve the project communication.

At the glance there are few areas that need to be improved. In terms of quality planning not all ISO contractors prepared PQP, albeit it is not mandatory but it would a good practice for all ISO contractors to prepare PQP. In case of ITP, surprisingly not all ISO contractors prepared. According to clause 8.2.4, ISO 9001:2000 requires contractors to prepare ITP and need to be approved by client or consultant. Further more that document must be readily available at project as required under clause 4.2.3(d), ISO 9001:2000. Otherwise the

contractors may potentially encounter problems with their clients if any failures or non conformance of products crop up in the event of executing the project. For the majority group of the contractors that did not engaged QA/QC did not specify (47%) any officer assigned to matters pertaining to quality. This is not a good practice. Beside QMR, it would be a good practice for a contractor to assign an officer that oversees quality activities at site. Probable reason may be due to shortage of staff or they might engage contract staff for that matter. However it is interesting to probe further into the said issue.

## CONCLUSIONS

Taking into account of the above discussion, several conclusions can be derived as follows:

- 1.1 Based on the data captured indicated that Malaysian contractors were exposed to ISO 9000 certification ever since the year 1995. However the level of reception at that time was rather low.
- 1.2 The main reason given by the majority of our local contractors in seeking for ISO 9001:2000 certifications was to improve quality performance.
- 1.3 By implementing ISO QMS, overwhelming consensus received from contractors denoted the general benefits attained after certification is improving project productivity as well as enhancing company competitiveness.
- 1.4 The overall quality performance demonstrated by ISO certified contractors were the ability to complete the project on time and to reduce wastage of material.
- 1.5 Taking into consideration the overall assessment made by the respondents or rather the contractors, out of 15 significant areas of improvement in project management after having certified to ISO the top 7 can be ranked as follows:
  - Improve storage and traceability of project quality records (4.08)
  - More organized and systematic submission of VOs (3.94)
  - More organized of inspection (3.92)
  - Improve overall site management (3.90)
  - Improve testing and commissioning (3.90)
  - Facilitate the preparation of handing over project (3.90)
  - Improve control of construction drawings on site (3.90)

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# CONTRACTORS' WILLINGNESS TO PAY FOR IMPROVING CONSTRUCTION WASTE MANAGEMENT IN MALAYSIA

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## Abstract

The objective of this study is to determine contractor's WTP for improved construction waste management and highlights the WTP values and reasons for the rejection of the WTP based on different contractors' category. Data was collected through interviews with contractors registered with the Construction Industry Development Board of Malaysia (CIDB) in the Klang Valley, specifically in Kajang, Petaling Jaya, Subang Jaya and Seri Kembangan of Selangor State. The results show that 68% of the contractors surveyed reported a positive willingness to pay (WTP) for improved construction waste collection and disposal services while the rest were not willing. For the reason of WTP rejection, most of the respondents stated that government or CIDB should provide these services at no charge. Contractors are willing to pay an average maximum amount of RM 69.88 per tonne for the improved services. Moreover, contractor's views on the average maximum willingness to pay is significantly different among the three groups, which are higher for the G6G7 contractors (Group A) than the G4G5 (Group B) and G1G2G3 (Group C) contractors. It was found that none of the contractors are willing to pay more than RM200 per tonne for waste collection and disposal services. During the survey, the waste collection and disposal services was in the region of RM50.00 per tonne. These are expected to rise because of closure of dumping sites in the Klang Valley. Such a situation makes it more important for source reduction, reuse and recycling practices to come into play. In conclusion, this paper recommends some research questions for the future researches that might be useful to the policy makers as well as decision makers of the construction industry in their efforts to overcome the construction waste management problems in Malaysia.

**Keywords:** *Construction waste management, Willingness to pay, Malaysian contractors.*

## INTRODUCTION

Malaysia, with a population of 24 million, is facing an increase in the generation and accumulation of waste (Awang, et. al. 1998, Begum, et. al. 2004a, Begum, et. al. 2004b & Agamuthu, 2007). This development is causing social, economic and environmental problems at a significant level. These problems are particularly serious in areas where intensive urbanization and population concentration lead to an increase of solid wastes and to a decrease of available land suitable for disposal (World Bank, 1992). Despite the massive amount and complexity of waste produced, the standards of waste management in the country are still poor (Nasir, et. al. 1995). These include outdated and poor documentation of waste generation rates and its composition, inefficient storage and collection systems, codisposal of municipal wastes with toxic and hazardous waste, indiscriminate disposal or dumping of wastes and inefficient utilization of disposal site space. However, Malaysia like most developing countries, is facing an increase in the generation of waste and of accompanying problems with the disposal of this waste.



In the last two decades, extensive building and infrastructure development projects have led to an increase in the generation of construction waste material. Construction waste, also referred to as construction and demolition waste, is as defined as mineral and non-mineral matter in variable composition from construction, demolition and renovation projects including excavated natural or fill soil and rock material generated during construction (Pereira, et. al. 2005). Waste generation is becoming an increasingly significant environmental problem associated with the construction industry, undermining its sustainability (World Bank, 1992). This is particularly true in urban areas where landfills are closing due to lack of land. The construction industry has a substantial impact on the environment. The environmental effects of the industry are in direct relation to the quality and quantity of the waste it generates (Begum, et. al., 2004a & 2004b).

The literature is limited on economic valuation or contractor's willingness to pay (WTP) for improved construction waste management in Malaysia. Most of the studies on solid waste management in Malaysia are descriptive in nature. To date there has been few studies conducted to estimate WTP for improved solid waste management system (Mourato, 1999, Othman, 2002 & Pereira, et. al. 2005). The objective of this study is to determine contractor's WTP for improved construction waste management and highlights the WTP values and reasons for the rejection of the WTP based on different contractors' category.

## METHODOLOGY

Data was collected through interviews with contractors registered with the Construction Industry Development Board of Malaysia (CIDB) in the Klang Valley, specifically in Kajang, Petaling Jaya, Subang Jaya and Seri Kembangan of Selangor State. There are seven categories i.e. G1, G2, G3, G4, G5, G6 and G7 of local contractors (Table 1) in which total 5,696 contractors have been registered in the Selangor state as January, 2001 (CIDB, 2002). In Table 1, G1 means grade 1 that indicates smallest contractor and G7 means grade 7 that indicates largest contractor and the middle grades G2 to G6 indicate smaller, medium and larger contractors in the CIDB. In this study, the "purposive stratified random sampling" method was used focusing on three major groups of contractors. In the first stage of the survey and sampling, the study was purposively selected the samples of the contractors who were involved in general building and construction activities. Then, the samples were stratified into three groups among the seven categories of contractors; Group A comprising G6 & G7 contractors, Group B comprising G4 & G5 contractors and Group C for G1, G2 and G3 contractors in order of their paid up capital, tendering capacity and minimum personnel resources requirement. The final survey was based on 130 samples of contractors i.e. 35 from Group A, 35 from Group B and 60 from Group C. The sample represents 2% of the total registered contractors in Selangor. Interviews were based on a set of questionnaires that was pre-tested and modified before being used in the survey. The category distribution of the samples were 27% from Group A (G6 and G7), 27% from Group B (G4 and G5) and 46% from Group C (G1, G2 and G3). In this survey, 19% of the respondents were public companies and 81% were private limited companies.

The survey was based on the open ended contingent valuation method (CVM) for collecting information of contractors' WTP (Carson, 1998, Field, 1994 & Folz, 1995). At first, contractors were asked the dichotomous question whether they were willing to pay (or not) for improved construction waste management services specifically waste collection and

disposal services. Contractors who answered “yes” were then asked the open ended WTP question how much they would be willing to pay for these improved services. Contractors who answered “no” were asked to give the reasons for not willing to pay. Additional questions were related to the contractors’ general characteristics such as type of company, category of grade, experiences in construction works, paid up capital, waste collection systems among others. In addition, the contractors were provided with a scenario for improved waste collection and disposal services proposed by a private waste collection and contractors were free to decide the WTP questions.

**Table 1.** Contractor’s Registration Criteria According to the CIDB Grade

# Group A – Degree holder in construction related fields.

Group B – Diploma holder in construction related fields or other degree holder with experience in construction works.

Grade	Tendering Capacity (RM)	Paid up Capital (RM)	Minimum Personnel Resources Requirement #
G7	No limit	750,000.00	1 Group A and 1 Group B (both minimum 5 years experience) or 2 Group A (one of whom must have 5 years experience)
G6	Not exceeding 10 million	500,000.00	1 Group A and 1 Group B (one of whom must have 3 years experience)
G5	Not exceeding 5 million	250,000.00	1 Group A or 1 Group B (minimum 5 years experience)
G4	Not exceeding 3 million	150,000.00	1 Group B
G3	Not exceeding 1 million	50,000.00	Course Certificate/experience
G2	Not exceeding 500,000.00	25,000.00	Course Certificate/experience
G1	Not exceeding 100,000.00	5,000.00	Course Certificate/experience

Source: CIDB 2002.

## PROFILE OF CONTRACTORS’ WTP

### Contractors’ WTP Responses

In the open ended contingent valuation questionnaire, the contractors were asked how much they would be willing to pay for improved construction waste management services specifically waste collection and disposal services. Table 2 summarises the responses of the contractors according to the willingness to pay. This study has found that 68.5 percent of the contractors reported a positive WTP response for improved construction waste collection and disposal services in their construction sites and 31.5 percent contractors were not willing to pay. Contractor’s views on willingness to pay were different among the groups, with the highest number of contractors that are willing to pay reported in Group C (73%), followed by 71% in Group A and 57% in Group B.

**Table 2.** Contractors' WTP Responses

Category	Responses			
	Yes		No	
	Number	Percent	Number	Percent
Group A	25	71.4	10	28.6
Group B	20	57.1	10	42.9
Group C	44	73.3	16	26.7
Total	89	68.5	41	31.5

### Rejection of the WTP

Table 3 shows the reasons for the rejection of willingness to pay for improved waste collection and disposal services in their construction sites. In the survey, around 37% of the respondents stated that they are not interested to pay for this service while 27% contractors reported that they are satisfied with the existing waste collection and disposal services. On the other hand, 54% contractors stated that they are already paying private contractors for waste collection and disposal services. About 66% of the contractors opined that government or construction industry should provide waste collection and disposal services at no charge. Only 2.4 percent contractor reported that they would be willing to pay, if the private agency could guarantee the service.

**Table 3.** Reasons for the Rejection of the Willingness to Pay

Reasons	Number of Respondents	Percentage of Respondents (41)	Total Not Willing Respondents	
			No.	%
Not interested to pay for this services	15	36.6		
Satisfied with the existing waste collection and disposal services	11	26.8		
Already paying to private contractor for waste collection and disposal services	22	53.6		
At no charge, Government or CIDB should provide waste collection and disposal services	27	65.8	41	100
Would be willing to pay, if the private agency could be guaranteed for this services	1	2.4		
Other reasons	-	-		

## Contractors' WTP Values

Table 4 summarises the maximum WTP values and their respective frequencies among contractors from the three groups. The results show that 24% of the Group A contractors reported RM100 WTP per ton of construction waste collection and disposal services and the second highest 20% reported for RM150 and RM50. For the Group B, the highest 20% contractors reported RM100 and RM70 WTP per ton of waste and the next 15 percent expressed their WTP value RM50. In the case of Group C, around 23% of contractors reported their maximum WTP value as RM50 and the next 11% expressed RM70 and RM40 respectively. However, the willingness to pay values of RM40 is the lowest and RM150 is the highest in Group A. The lowest WTP value is RM20 for Group B and RM 5 for Group C, and the highest WTP value of RM200 for Group B and Group C. It is found that none of the contractors are willing to pay greater than RM200.

**Table 4.** Contractor's Willingness to Pay Values and their Respective Frequencies

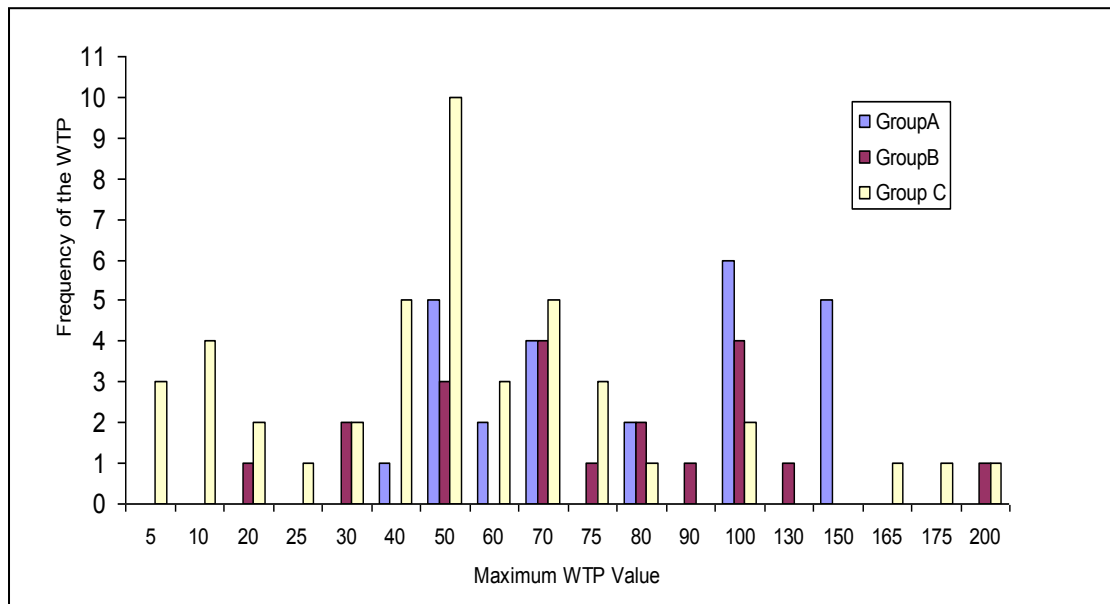
Maximum WTP Value in RM	Frequency of the WTP			Percentage of the Contractors		
	Group A	Group B	Group C	Group A	Group B	Group C
5	-	-	3	-	-	6.8
10	-	-	4	-	-	9.1
20	-	1	2	-	5.0	4.5
25	-	-	1	-	-	2.3
30	-	2	2	-	10.0	4.5
40	1	-	5	4.0	-	11.4
50	5	3	10	20.0	15.0	22.7
60	2	-	3	8.0	-	6.8
70	4	4	5	16.0	20.0	11.4
75	-	1	3	-	5.0	6.8
80	2	2	1	8.0	10.0	2.3
90	-	1	-	-	5.0	-
100	6	4	2	24.0	20.0	4.5
130	-	1	-	-	5.0	-
150	5	-	-	20.0	-	-
165	-	-	1	-	-	2.3
175	-	-	1	-	-	2.3
200	-	1	1	-	5.0	2.3
Total	25	20	44	100.0	100.0	100.0

Table 5 shows the average maximum willingness to pay value of the contractors in the three groups. The average maximum amount that the 89 respondents indicated their maximum WTP value waste collection and disposal services is RM 69.88 per tonne of construction waste collection and disposal services. The study also shows that the highest average maximum WTP value is RM88.00 for Group A, RM78.25 for Group B and RM55.80 for Group C contractors. However, the result indicate that the average maximum willingness to pay value tend to be higher for the larger contractors such as Group A (G6 & G7) compared to the medium contractors such as Group B (G4 & G5) and the small contractors as Group C (G1, G2 & G3).

**Table 5.** Average Maximum WTP Value for the contractors

Category	Average Maximum WTP
Group A	88.00
Group B	78.25
Group C	55.80
Total	69.88

Figure 1 shows the frequency of bid values for the three groups of contractors. It is found that the WTP values for Group A contractors are consistently higher than the WTP values for Group B and Group C contractors.



**Figure 1.** The Frequency of Bid Values for the Three Groups of Contractors

## CONCLUSION AND RECOMMENDATIONS

This study shows that 68% of the contractors surveyed reported a positive willingness to pay for improved construction waste collection and disposal services while the rest were not willing. For the reason of WTP rejection, most of the respondents stated that government or

CIDB should provide these services at no charge. The average maximum WTP value of the contractors in the three groups varies. Contractors are willing to pay an average maximum amount of RM 69.88 per tonne for waste collection and disposal services. The highest average maximum value they are willing to pay is RM88.00 for G6 and G7 contractors (Group A), RM78.25 for G4 and G5 contractors (Group B) and RM55.80 for G1, G2 and G3 contractors (Group C). The result of this study indicates that the average maximum WTP for the large contractors is higher than the medium and small contractors. This results highlight the difference of CIDB registration grade in the WTP for improved construction waste management. It was found that none of the contractors are willing to pay more than RM 200 per tonne for waste collection and disposal services. During the survey, the waste collection and disposal services was in the region of RM50.00 per tonne. These are expected to rise because of closure of dumping sites in the Klang Valley. Such a situation makes it more important for source reduction, reuse and recycling practices to come into play. It is inevitable that the construction industry will intensify efforts on source reduction, reuse and recycling.

This study used primary data which was limited in sample size compare to the total number of contractors due to some constraints such as study time, contractor's appointment and time schedule and the constraints of resource availability. Accordingly, there might be scope for further research on this subject within a larger sample size. But, still there is a number of research questions that require investigation as part of an overall construction waste management and environmental strategy. These are the current structure of construction waste flows by the source of generation, type of waste, intermediate and final disposal; practices, patterns and appropriate technologies for improving waste management i.e. reduce, reuse, recycling, waste treatment and final disposal as well as for improving the markets for recyclables; how should the design of waste management incentives and policies differ for large versus medium, small and very small quantity waste generators? Therefore, answers to these questions are of key recommendations for the future researches that might be useful to the policy makers as well as decision makers of the appropriate authority and project planners, developers and contractors of the construction industry in their efforts to overcome the construction waste management problems in Malaysia.

## **ACKNOWLEDGEMENT**

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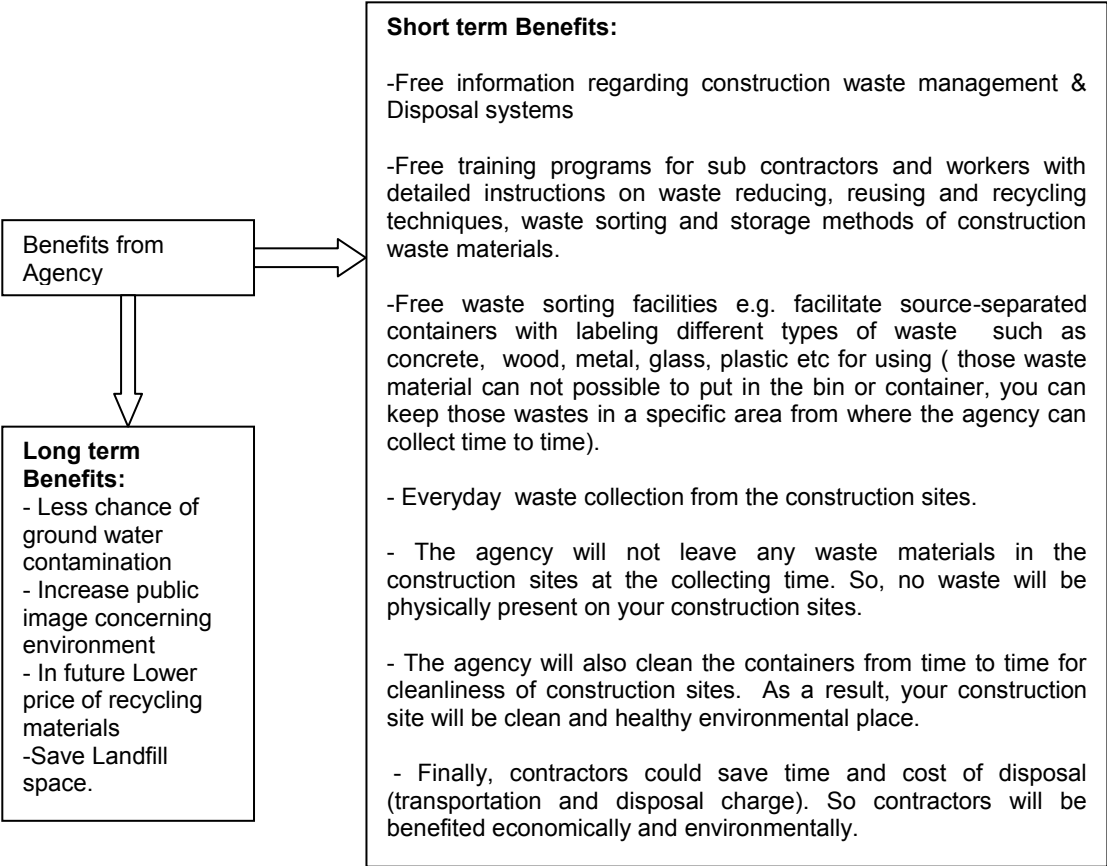
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Appendix I

Scenario for the Respondent:

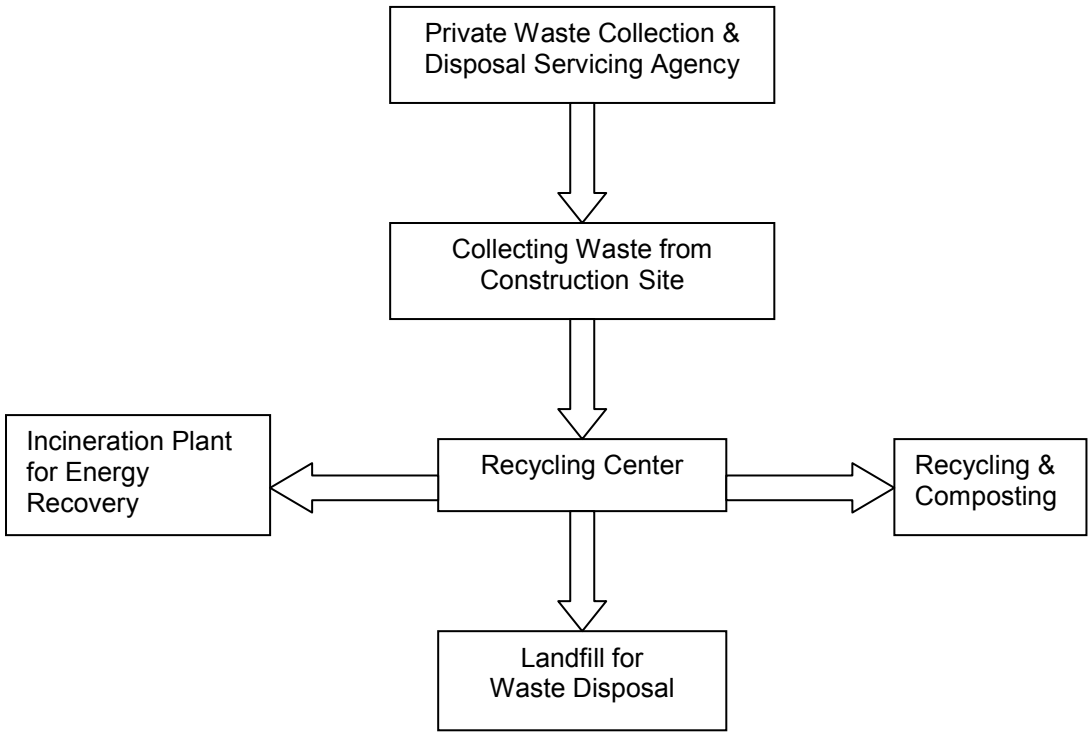
If any private waste collection and disposal servicing agency provides improved waste collection and disposal services for the construction contractors (those contractors are still disposing their waste by the private contractors, for them, this private agency will provide improved waste collection and disposal services rather than existing services), in that case this study wants to see your willingness and capacity. The agency’s goal will be reduced, reused and recycled of construction waste materials and then proper disposal. It is assuming that the contractors will get the following benefits from the private agency’s improved waste collection and disposal services.



At first, the collected waste will be brought in the agency’s recycling centre for recycling and composting of waste materials. After recycling, some waste (those that are suitable) will be sent to the incineration plant for energy recovery. The rest will be properly disposed at construction and demolition landfill or Govt. designated land.

In this research, the contractor or representative of the company will be asked to make a payment per ton of waste for this improved waste collection and disposal service. For this,

some contractor may be willing to pay more and others may be less. For their willingness to pay, they have completely independent to take decision how much they willing to pay. Respondents can not think that their answers are going to right or wrong because of in this view, there are no right or wrong answers in the following questions.



**Figure:** Flow chart of the private agency's waste collection and disposal systems.

## GUIDE TO AUTHORS

### Aims and Scope:

The Malaysian Construction Research Journal (MCRJ) is the journal dedicated to the documentation of R&D achievements and technological development relevant to the construction industry within Malaysia and elsewhere in the world. It is a collation of research papers and other academic publications produced by researchers, practitioners, industrialists, academicians, and all those involved in the construction industry. The papers cover a wide spectrum encompassing building technology, materials science, information technology, environment, quality, economics and many relevant disciplines that can contribute to the enhancement of knowledge in the construction field. The MCRJ aspire to become the premier communication media amongst knowledge professionals in the construction industry and shall hopefully, breach the knowledge gap currently prevalent between and amongst the knowledge producers and the construction practitioners.

Articles submitted will be reviewed and accepted on the understanding that they have not been published elsewhere. The authors have to fill the Declaration of the Authors form and return the form via fax to the secretariat. The length of articles should be between 3,500 and 8,000 words or approximately 8 – 15 printed pages (final version). The manuscripts should be written in English. The original manuscript should be typed one sided, single-spacing, single column with font of 11 point (Times New Roman). Paper size should be of Executive (18.42 cm x 26.67 cm) with 2 cm margins on the left, right and bottom and 3 cm for the top. Authors can submit the manuscript:

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**Type of fonts:** All text, drawing, graph must be written using Times New Roman

**Language:** Follow the spelling of the Oxford English Dictionary.

**Size/Page Setup:** Executive (18.42 cm x 26.67 cm)

**Paper title:** Arial, 16.

# CODIFICATION AND APPLICATION OF SEMI-LOOF ELEMENTS FOR COMPLEX STRUCTURES

**Author's name** (full name): Arial, 9pt. should follow below the title.

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**Abstract:** Arial Bold, 9pt. Left and right indent 0.25 inch.

**Abstract:** it should be single paragraph of about 100 – 250 words.

**Keywords:** Times New Roman Bold, 9pt (Italic). Left and right indent 0.25 inch.

**Keywords:** *Cooling tower; Finite element code; Folded plate; Semiloof shell; Semiloof beam*

Body Text: Times New Roman, 11 pt. All paragraph must be differentiate by 0.25 inch tab.

Heading 1: Arial Bold + Upper Case, 11pt.

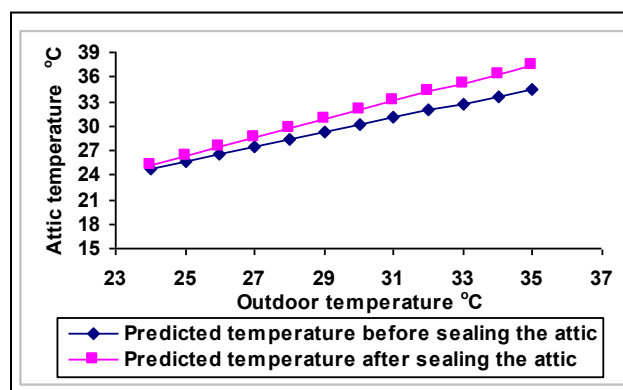
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**Units:** All units and abbreviations of dimensions should conform to SI standards.

**Figures:** Figures should be in box with line width 0.5pt. All illustrations and photographs must be numbered consecutively as it appears in the text and accompanied with appropriate captions below them.

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**Figure 8.** Computed attic temperature with sealed and ventilated attic

**Tables:** Arial, 8pt. Table should be incorporated in the text.

**Table caption:** Arial Bold + Arial, 9pt. Caption should be written above the table.

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**Table 1.** Recommended/Acceptable Physical water quality criteria

Parameter	Raw Water Quality	Drinking Water Quality
Total coliform (MPN/100ml)	500	0
Turbidity (NTU)	1000	5
Color (Hazen)	300	15
pH	5.5-9.0	6.5-9.0

(Source: Twort et al. 1985; MWA,1994)

**Reference:** Times New Roman, 11pt. Left indent 0.25inch, first line left indent – 0.25inch. Reference should be cited in the text as follows: “Berdahl and Bretz (1997) found...” or “(Bower et al. 1998)”. References should be listed in alphabetical order, on separate sheets from the text. In the list of References, the titles of periodicals should be given in full, while for books should state the title, place of publication, name of publisher, and indication of edition.

#### **Journal**

Sze, K. Y. (1994) Simple Semi-Loof Element for Analyzing Folded-Plate Structures. *Journal of Engineering Mechanics*, 120(1):120-134.

#### **Books**

Skumatz, L. A. (1993) Variable rate for municipal solid waste: implementation, experience, economics and legislation. Los Angeles: Reason Foundation, 157 pp.

#### **Thesis**

Wong, A. H. H. (1993) *Susceptibility to soft rot decay in copper-chrome-arsenic treated and untreated Malaysian hardwoods*. Ph.D. Thesis, University of Oxford. 341 pp.

#### **Chapter in book**

Johan, R. (1999) Fire management plan for the peat swamp forest reserve of north Selangor and Pahang. In Chin T.Y. and Havmoller, P. (eds) *Sustainable Management of Peat Swamp Forests in Peninsular Malaysia* Vol II: Impacts. Kuala Lumpur: Forestry Department Malaysia, 81-147.

#### **Proceedings**

Siti Hawa, H., Yong, C. B. and Wan Hamidon W. B. (2004) Butt joint in dry board as crack arrester. *Proceeding of 22<sup>nd</sup> Conference of ASEAN Federation of Engineering Organisation (CAFEO 22)*. Myanmar, 55-64.

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