INDUSTRIALIZED BUILDING SYSTEM:

SYSTEM FORMWORK

by

Fatihah Ismail

Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Civil Engineering)

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CERTIFICATION OF APPROVAL

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Approved by,

(Assoc. Prof. Dr Nasir Shafiq)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2008

CERTIFICATION OF ORIGINALITY

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

FATIHAH ISMAIL

ABSTRACT

The government encourages the usage of IBS thru an organization called Construction Industry Development Board (CIDB). The advantage of using IBS are (a) reducing rectification works (time factor) and lowering the total coast of construction, (b) less material wasting, (c) permitting hybrid applications, adaptable to standardization and Modular Coordination. (MC) and (d) reduce number of labour during prefabrication. There are several types of IBS available but this report specifically discuss on characteristic and advantage of system formwork. Formwork start to evolve from it conventional form that is from timber to steel, aluminum, plastic, PVC and glass fiber. Data collected via email, journal study, feedbacks from forum joined. The comparison between timber formwork with other system formwork has been tabulated in Table 5.3. These include company such as TAC System Formwork Sdn Bhd, Fuvi Form Sdn Bhd, Plastech Industrial Systems Sdn Bhd, Intellectual Builders Sdn Bhd, and PLAS Tech Sdn. Bhd. The general improvement of system formwork in comparison with the conventional formwork are (a) strength: to carry the concrete and working load, (b) lightness without strength reduction (c) Durability without prohibitive coasts: maximum usage of materials, (d) good and accurate finish straight from the formwork: reduce the costly labour element of making good and patching, (e) erection and dismantling times, and (f) ability to employ unskilled or semi-skilled labour. With all the improvement been made to the formwork, system formwork had been proven to be the ideal solution of time and cost reduction in construction especially to high rise building with repetitive design.

ACKNOWLEDGEMENT

Special thanks to Dr. Nasir Shafiq after a year of guidance, finally I came out with this report.

Mr. Vijay from Sunrise, my former internship supervisor, without you I will never ever start my final year project. Not forgetting Mr. Sim Polan from Mivan who has feed me with tons of information.

Finally to my family who are always understand my condition that I can't frequently visit you guys as before.

Thanks to everyone!

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IBS Survey Report 2003 describe two pilot projects that were initiated by the Government using IBS, and it was along Jalan Pekeliling which involved 3,000 units of low cost flats and 40 shop lots and the Rifle Range Road Flats in Penang. Both using pre-cast concrete element to build these high rise low coast flats. Nowadays, more and more projects have adopting IBS in order to share the benefits offers by this system. The projects are Kula Lumpur City Center (KLCC), government quarters Putrajaya, KL Sentral and KLIA.

1.1.1 Five Types of Fully Developed IBS In Malaysia;

- Pre-cast Concrete Framing, Panel and Box systems
- Steel Formwork Systems
- Steel Framing Systems (steel portal frame system. Alternative to the heavier traditional hot-rolled sections.
- Prefabricated Timber Framing Systems
- Block Work Systems

There are several types of IBS available in Malaysia and this report focused on one of the element IBS that is system formwork. The reason of choosing system formwork to be discuss in further details was based on statistical data of Percentage Wastage of Various Trades for Public Housing Projects and Private Residential Buildings in Table 1.2. Table 1.2 is the result of study in Wastage in Building Construction by Poon, C.S et al. (2001). 100% of timber formwork used, will be construction waste. Thus the major contribution to construction waste is used formwork. By improving conventional formwork system, eliminate a huge amount of waste at site and increase IBS score.

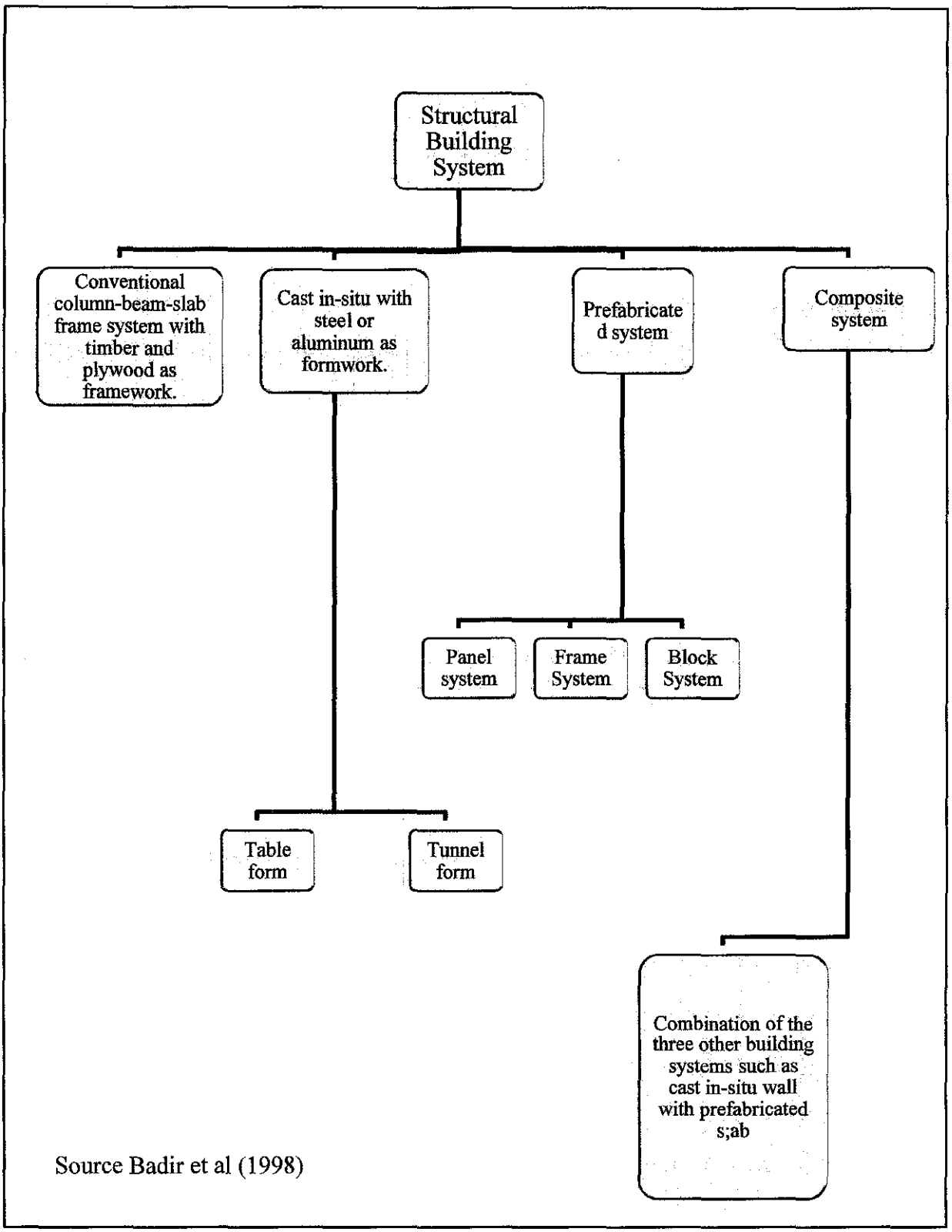


Figure 1-1: Type of IBS

1.1.2 Improvement In Construction Industries

CIDB claims that IBS will provide construction industries with following advantage:

- Reduce labour during prefabrication of component and site work.
- Less materials and wasting
- Higher control of the project thus reducing rectification works and lowering the total cost of construction.
- Open Building Concept i.e. permitting hybrid applications, adaptable to standardization and Modular Coordination. (MC)

"In October 2003, the Ministry of Works tabled an IBS Roadmap 2003 – 2010 to the Cabinet and subsequently had it endorsed by the Cabinet as the blueprint for the industrialization of the Malaysian construction sector. This blueprint, produced by the IBS steering committee and working groups organized by the Construction Industry Development Board (CIDB), will be a reference point for the implementation of programmes by all parties towards industrializing the construction sector. The implemented programmes are envisaged to meet the objective of total industrialization of the nation's construction sector by 2010"

Fusion Magazine Malaysian Industry-Government Group For High Technology (MIGHT)

"The Industrialized Building Systems (IBS) promises elevated levels of expertise throughout the industry, from manufacturers, installers, engineers, planners, designers, and developers. The benefits of IBS are numerous and far reaching. Reduced construction time, better site management, reduced wastage are but a few of these benefits, that will ultimately produce better products for the population."

YB Dato' Seri S. Samy Vellu, Minister of Works, Malaysia
IBS Roadmap 2003 - 2010

1.1.3 IBS Score (Extracted From IBS Score Sheet Guideline 2003)

By using IBS Content Scoring System (IBS Score), contactor able to measure the usage of IBS in whole project in a systematic and structured system consistently. By using IBS Score, government will offer full levy exemption imposed by CIDB for developers whose utilization of IBS components exceeds 50%.

The IBS score attribute:

- The use of prefabricated and precast concrete component
- Off-site production of components
- The use of standardized components
- Repeatability
- Design using Modular Coordination

IBS Score indicate:

- Higher reduction of site labour
- Lower wastage
- Less site materials
- Cleaner construction site
- Better quality product due to controlled condition
- Neater and safe construction sites
- Faster project completion thus reduce total construction costs (condition apply)

The higher IBS Score imply more benefits gain from IBS such higher reduction of site labour, lower wastage, less site materials, cleaner environment, better quality, neater and safer construction sites, faster project completion as well as lower total construction costs. Table 1.1 below extracted from IBS Score Manual 2003.

Table 1-1: IBS Factor For Structural System

SYSTEM	FLOOR / COLUMN/BEAM [5][6]	Precast concrete slab[1]	In-situ concrete on permanent metal formwork	In-situ concrete using reusable[3] system formwork	In-situ concrete using timber[4] formwork	Steel flooring system	Timber frame flooring system	No Floor[7]
CONCRETE	Precast column and beams	1.0	0.9	0.7	0.6	1.0	1.0	1.0
	Precast column and in-situ beams using reusable[3] system formwork	0.9	0.8	0.6	0.5	0.9	0.9	0.6
	Precast column and in-situ beams using timber[4] formwork	0.8	0.7	0.5	0.4	0.8	0.8	0.4
	Precast beams and in-situ columns with reusable[3] system formwork	0.9	0.8	0.6	0.5	0.9	0.9	0.6
	Precast beams and in-situ columns using timber[4] formwork	0.8	0.7	0.5	0.4	0.8	0.8	0.4
	In-situ column and beams using reusable system[3] formwork	0.7	0.6	0.5	0.3	0.7	0.7	0.5
	In-situ column and beams using timber[4] formwork	0.6	0.5	0.3	0.0	0.6	0.6	0.0
STEEL	Steel columns and beams	1.0	0.9	0.7	0.6	1.0	1.0	1.0
TIMBER	Timber frame system	1.0						
ROOF SYSTEM	Prefab timber roof truss	1.0						
	Prefab metal roof truss	1.0						
	Timber[4] roof trusses	0.0						

(1) Precast concrete slabs include half slab, hollow core slab, and precast prestressed planks.

(2) Precast concrete includes products of factory precasting, site precasting or the use of tilt-up systems.

(3) Reusable formworks include plastic, fiberglass, steel, aluminum and other metal formworks that can be used repeatedly.

(4) Timber formwork (and timber roof trusses) means the timber components are sized, cut and fabricated in-situ to form the formworks and the required temporary works. This is commonly referred to as stickbuilt formwork. Timber includes plywood.

(5) For structural system using load bearing wall, whether precast or in-situ, the factor can be determined from the table by treating the wall as a wide column.

(6) The IBS factor for tunnel formwork system is 0.6

(7) This is for structures without floor. Refer examples in Section 6.

As discussed earlier, there are several type of IBS available in Malaysia and this report focused on one of the element IBS that is system formwork. The reason of choosing system formwork to be discuss in further details was based on statistical data of Percentage Wastage of Various Trades for Public Housing Projects and Private Residential Buildings in Table 1.2. Table 1.2 is the result of study in Wastage in Building Construction by Poon, C.S et al. (2001). 100% of timber formwork used, will be construction waste. Thus the major contribution to construction waste is used formwork. By improving conventional formwork system, eliminate a huge amount of waste at site and increase IBS score.

1.1.4 System Formwork

Formwork act as mould to fresh concrete to produce satisfactory dimension and surface appearance, Wilshere, C.J. (1998). Patent Formwork is sometimes called system formwork, and is usually identified by the manufacture's name.

System formwork has these following criteria:

- Strength: To carry the concrete and working load
- Lightness without strength reduction: To enable maximum-size units to be employed
- Durability without prohibitive coasts: To gain maximum usage of materials.
- Good and accurate finish straight from the formwork: To reduce the costly labour element of making good and patching, which in itself is a difficult operation to accomplish without it being obvious that this kind of treatment was found necessary.
- Erection and dismantling times
- Ability to employ unskilled or semi-skilled labour.

1.2 PROBLEM STATEMENT

1.2.1 Construction Waste That Can't Be Recycle

Like many industrial countries, construction waste has become an important environmental problem of the construction industry. Timber formwork is one of the major contributors to construction waste. Therefore, in order to achieve the reduction on one of the significance construction waste, modification needed for current method of formwork. This leads to system formwork that can be use for more multiple times. Table 2.1 below explains further on type and percentage of wastage in building construction.

Table 1-2: Percentage Wastage of Various Trades for Public Housing Projects and Private Residential Building.

Trade	Material	% Wastage	
		Public Housing (%)	Private Residential (%)
Concrete	Concrete	3-5	4-5
Formwork	Timber broad	- (Large panel formwork and precast element was adopted)	100
Reinforcement	Steel bars	3-5	1-8
Masonry	Brick and block	3	4-8
Dry wall	Fine aggregate	3	-
Wall screeding	Ready mix cement	7	4-20
Floor screeding	Ready mix cement	1	4-20
Wall plastering	Plaster	3	4-20
Ceiling plastering	Plaster	3	4-20
Wall tilling	Tiles	8	4-10
Floor tiling	Tiles	6	4-10
Installation of bathroom fitting	Sanitary fitting	6	1-5
Installation of kitchen joinery	Kitchen joinery	1	1-5

Source: Poon et al. (2001)

1.2.2 Hazardous Site

Construction industry has been labeled as "Dirty, Dangerous, Difficult" industry as the result of low emphasis on occupational safety by Malaysian Construction Industry Master Plan.(2008), in Challenges Facing The Malaysian Construction Industry. In 2004, the construction industry has the third highest fatality rate compared to the other sectors (refer to Table 1.3).

Table 1-3: Accident and Fatality Rate by Sector, 2004

Industry	Employment ('000)	No. of Reported Accidents	Share of Reported Accidents	No. of Deaths Reported	Fatality Rate
Agriculture	1,407	5,677	8.2%	62	1.1%
Mining	43	533	0.8%	8	1.5%
Manufacturing	2,972	26,690	38.6%	195	0.7%
Electrical	NA	496	0.7%	10	2.0%
Construction	767	4,445	6.4%	77	1.7%
Trading	NA	12,948	18.7%	143	1.1%
Transport	594	4,151	6.0%	73	1.8%
Finance/Insurance	695	605	0.9%	5	0.8%
Services	2,943	5,295	7.7%	65	1.2%
Public Services	1,042	8,325	12.0%	131	1.6%
Total	**10,463**	**69,165**	**100.0%**	**769**	

Source: Social Organization, Economic Report 2006/2007 Ministry of Finance

1.2.3 Usage of Foreign Workers

40K foreign workers for construction

CLAB GIVEN APPROVAL TO BRING IN WORKERS TO ASSIST IN 9MP DEVELOPMENT PROJECTS' ROLLOUT

by **Tamimi Omar**
FD@theedge.com

CONSTRUCTION Labour Exchange Centre Bhd (Clab) has received approval from the government to bring in 40,000 foreign workers to assist the construction sector in light of the Ninth Malaysia Plan (9MP) development projects' rollout.

Its general manager Azlan Mohd Isa *(pic)* said: "We have been receiving demand of between 50 and 60 general construction workers per day since June 16, 2006."

"The government has already approved 40,000 foreign workers to meet the need for construction workers, which consist of 20,000 Indonesian workers, 15,000 Pakistani workers and 5,000 from India," he told *FinancialDaily* in an interview.

He added that the allocation of the 40,000 foreign workers by the government was made until there is a need for more labour.

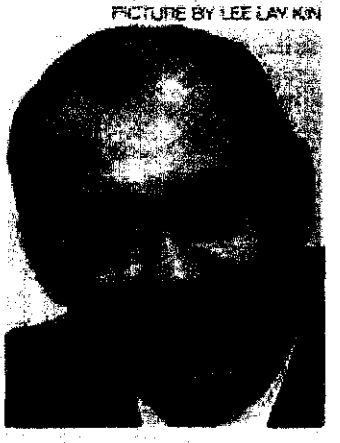
Azlan said Clab has 1,850 foreign workers registered under its organisation and is ready to bring in 10,000 workers this year.

Clab was formed under the Construction Industry Development Board (CIDB) and approved by the government to manage foreign workers to assist the construction industry in the area of manpower.

It was established in July 2002 following an amnesty programme, which deported 385,000 construction workers representing 42% of the total number of foreign workers then.

Clab's board members and advisory council consist of CIDB, Master Builders Association of Malaysia, Persatuan Kontraktor Melayu Malaysia, Real Estate and Housing Developers Association, Guild of Bumiputra Contractors and Persatuan Kontraktor India Malaysia.

PICTURE BY LEE LAY KIN



Aside from increasing the labour force, he said, Clab is setting up its own pool of workers who have gained specialised skills.

This is to retain these skilled workers in the country for re-distribution to contractors, and organisations which need them.

Azlan said with the retention of skilled workers, Clab hopes to draw more members to its fold. As of July 31, 2006 Clab members totalled 540.

He said Clab also offers to re-distribute workers once a construction project is finished, thus eliminating the need for employers to keep workers until the workers' contract period is done.

Clab has also created a means by which these workers' skills can be enhanced and accredited so that construction companies would have a supply of skilled workers.

To have access to CLAB's pool of foreign workers, construction companies must register with CLAB and pay an annual membership fee of RM20 or RM50 for three years.

Figure 1-2: SUN, 1st September 2006

Malaysian currency has been flown out from this country due to the high money-changing rate to other country. This affects our economic growth. By having less foreign worker in construction industry, we can minimize the outflow Ringgit. Reducing wet-trades through IBS, the dependency on foreign workers will also diminish, thus gaining the billions of Ringgit currently being transferred out by the foreign workers to their home countries, and reducing inherent social problems involving these foreign workers.

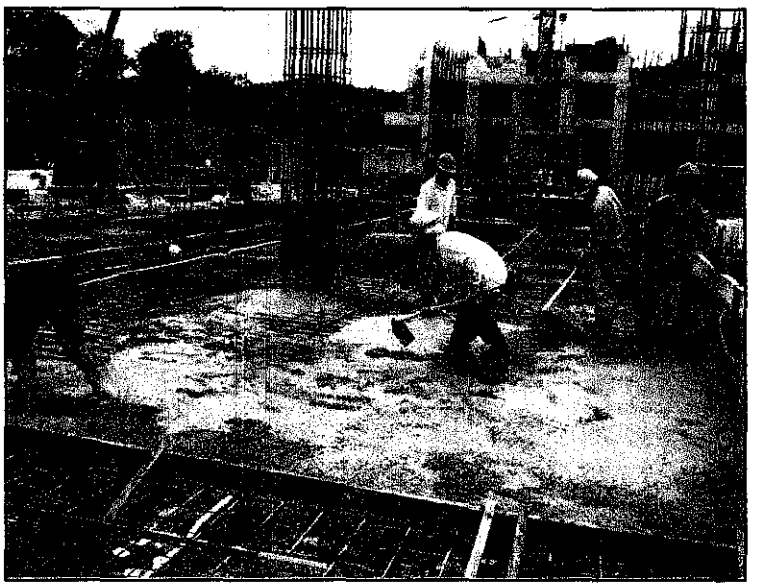


Figure 1-3: Foreign Worker Monopoly Construction Industry in Malaysia

A study in University Malaysia Pahang on industrialized building system (February 2008) conclude that Malaysia local construction industry still at the level where quality, productivity, safety and excessive rely on unskilled foreign workers is unsustainable and not in line with the future development of Malaysia.

For Malaysia to be a worldwide competitor, Malaysian government has formulated a roadmap called IBS roadmap 2003-2010 to promote the usage of IBS in the local construction industry. One of the targets is to reduce the level of foreign workers to only 15% by the year 2010.

In Figure 1.3 summaries the main current construction problem in Malaysia:

- Usage of foreign worker giving negative impact to our social and cultural context.
- Not environmental friendly since construction produce a lot of waste that can't be recycled.
- Dirty and hazardous construction site due to high waste produce and no proper storage provided.

1: Illegal foreign workers squatters. Create social problem in surrounding area.

2: Dangerous site. Poor site supervision due to untreated slope failure.

3: Material without any proper storage system.

Figure 1-4: Construction Site In Kuala Lumpur

1.3 OBJECTIVE

The principle aim of the research is to explore and discover about Industrialized Building System in Malaysia. In this Final Year Project Research the scope of study has been narrow down to one of IBS type that is system formwork.

- To prove the efficiency and benefits of system formwork in all aspects in comparison with conventional formwork thus
- Able to establish that system formwork is the best solution in environmental management system, health & safety environment, and cost effective by identifying the room for improvement for system formwork.

With all these, constituencies will be at least a grade higher in understanding system formwork.

1.4 SCOPE OF STUDY

Industrialized Building System covers wide area in construction industry. This report concentrates on one of the IBS type that is system formwork.

This report includes:

- Formwork characteristic
- General comparison between conventional formwork and system formwork
- What type of system formwork available?
- Formwork reusability

Research includes the study on several system formwork manufacturers in Malaysia and comparing each brand of system formwork. Although system formwork has similar advantages, different brand incorporate slightly different features with own technology advancement. It is important therefore, to be familiar with each company's advantage so that the benefits of system formwork can be fully utilized. At later stage of the analysis, there will be a comparison of pros and cons of implementation of this new construction method. The final part will focus on economy of scale that system formwork offer.

During the analysis of system formwork, there will be a study on targeted area that implements system formwork the most. The purpose of this activity is to perceive the details clearly on system formwork implementation and witness the system formwork outcome.

The sample of this study basically includes peninsular Malaysia activities and concentrates in Mont'Kiara area.

CHAPTER 2

LITERATURE REVIEW

2.1 FORMWORK EVOLUTION

In order to overcome the major problem in construction industry that is construction waste production that can't be recycle, a method of reducing construction waste has been introduced that was lean production. Lean production is a method that use less human effort, less manufacturing space, less investment in tools, and less engineering time to develop a new product.

One of the important principles under a lean production paradigm is termed 'lean assembly'. This refers to simplifying the process of assembly through industrialisation, modularisations, standardisation, and continuous flow processes. The methodology's emphasis on reduction of process variation (or its converse smoothness). The reduction of operations required for a production process means less chance of the occurrence of errors, waste and rework. This follows from the same logic that the fewer the number of operations, the higher the quality of the product and a predictive timeline, resulting in cost savings.

Based on lean production concept. Formwork had evolved from its conventional form that is timber / plywood to several other materials that can reduce construction waste and more environmental friendly.

2.2 RESPONSIBILITY FOR FORMWORK

Formwork act as a mould to fresh concrete. It gives shape to the concrete and will determine the concrete surface quality. By having high quality of concrete finish, less amount of work need to be done such as plastering and concrete surface leveling. Therefore, require less project resource and time to touch-up the concrete surface to desired quality.

Hoffman, & Gustafson (1999) emphasis on personnel safety during handling of formwork. Safety at site includes prevention of any type of formwork failure . Formwork failure may cause expense of the formwork itself, and personal injury or damage to the completed portions of a structure. All personnel within site area should be under safety protection during construction. Project specifications should also require that debris be cleaned from form material and the bottom of vertical element forms, and that form-release agents used be compatible with appearance requirements and future finishes to be applied.

2.3 REUSING TIMBER FORMWORK

According to Ling Y.Y and Leo K.C from National University of Singapore, formwork cost can takes up to 60% of construction cost. High formwork reusability will reduce concrete structure cost.

Timber formwork can't be reused as many as other type of formwork. This is due to:

i. Handling of material by workers. Excessive force during handling or striking operation by unaware workers of economics of using formwork.
ii. Complex design structure need unique formwork. This unique formwork will reduce reusability due to design limitation.
iii. During formwork erection and striking process, special care needed to avoid formwork from crush or strip.

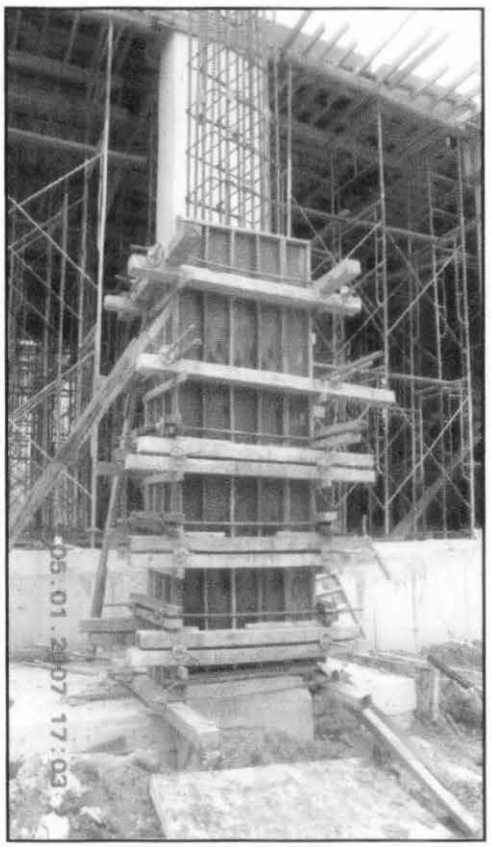


Figure 2-1: Timber Formwork

Timber formwork should have certain characteristic in order to serve it purpose. Timber formwork should be:

i. Easy to work with. Should not split when nailed.
ii. Hard enough to withstand damage from erecting and stripping of formwork.
iii. Ideally, to be light to be handle manually.
iv. Stiff to avoid deflection by load or pressure during concreting.
v. Stable condition (right amount of hemicelluloses-wood sugar. Formwork should not be susceptible to whether.
vi. Correct amount moisture so that it will not wrap and swell after concrete is placed.

The quality of component used to fabricate formwork will determine the numbers of reuse of timber formwork. Before cycling the formwork, the supervisor must observe that no mechanical weak points are introduced into the structure, Schwörer, A. (2007). Cycling or reusing system formwork after concrete structure in a section within one level has harden and whole set of formwork is dismounted and used to mount a formwork for a second section of the concrete component and so on.

2.4 TYPE (MATERIAL) OF FORMWORK

2.4.1 Aluminum Formwork

Aluminum system formwork form by small and connected aluminum framed panels. Poon, C.S et al. (2001) specified that: "Aluminum system formwork is made of a high strength aluminum alloy with a 4mm thick skin plate and 6mm thick ribbing behind to provide the stiffness of the panels. The standard panel size is approximately 2 m × 0.6m and 1m × 0.45m for wall and slab respectively. These sizes are chosen with an approximate weight of 10kg with the aim that an Asian worker could handle the panels independently.

Figure 2-2: Aluminum Formwork Formation

The panels are pre-cast panel hence manufactured within a factory environment. Each panel labeled as per formwork modulation drawing component for easy installation at site. Cost wise, in short term consideration, the system is more expensive than steel and timber by 35 per cent and 20 per cent respectively. But, the addition in cost will be offset by saving in handling equipment due to its lightweight and recycling potential. It saves timber and concrete waste.

Figure 2-3: Aluminum Formworks at Meridin Mont'Kiara

2.4.2 Plastic Formwork

Plastic formwork is made of UPVC form used to cast circular columns of diameter ranging from 150 to 3,000mm. A ribbed plastic profile wind spirally into a tube. The column forms using plastic formwork is strong, lightweight, easy to strip and has a high quality surface finish. Unlike timber formwork that need grease to be apply to inner formwork surface to avoid part of the timber stick on concrete plane, plastic formwork incorporates the inherent non-sticky exterior of extruded plastic thus no form oil is necessitate. Square timbers, act as stabilization are fixed at the foot of the column formwork to stop the formwork from displacement. Movement while concreting also being put into consideration by using vertical bracing timbers. Plastic can be recycling as normal after dismantle work, Poon, C.S et al. (2001).

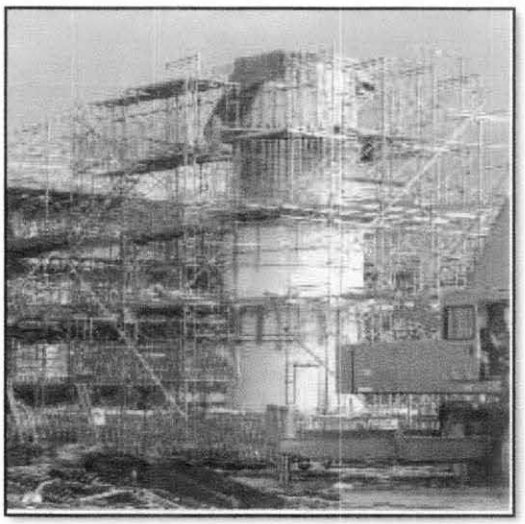


Figure 2-4: Erection of UPVC Column Formwork

Figure 2-5: UPVC Formwork

Source: Poon, C.S. (2001)

2.4.3 Steel Formwork

Advantages,

- has very high re use rates,
- tens of thousands of uses possible
- example, cast cement in hollow blocks use a steel form.
- very smooth surfaces are possible.
- strong and can be stripped late.
- fast to install in simple walls and the like
- low versatility (short walls can't be formed as nobody cuts steel for a single use),
- many flooring systems use steel form as re-enforcement for single use.

Disadvantages,

- costs are 6 to 10 times a plywood form and much higher for specialty forms.
- the thicker the surface of the steel sheet, the greater the weight.
- release agents are demanded as, if not used, cleaning labor will quickly overcome any economy gained by durable surfaces.
- steel dents easy, so if your boys claim it is 'strong as steel' soon your formwork will be very much less than flat.

Source: Tommy Sanford, (2007)

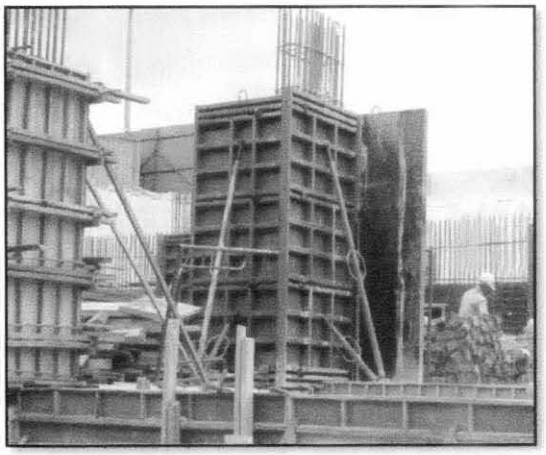


Figure 2-6: Application of Steel Formwork

2.4.4 Fiber Glass Formwork

According to Tommy Sanford, (2007), a good use for fiberglass pans would be center floor decks in a high rise where the underside of the floor was visible, or in custom arch designs on exterior of building. Picture of fiberglass formwork below from www.sciglobal.com/falsework/fglass.html

- Very smooth clean lines in unusual shapes are possible.
- Many re-uses, 1000's depending on handling.
- Strips fast.
- Long lead times. Building fiberglass forms requires first to build a form to shape the glass, and then each cast has considerable work before your first concrete cast is possible.
- Not as heavy as steel, but usually cast in such large sections weight exceeds the ability of non-mechanized handling.

Figure 2-7: Fiberglass Formworks

2.4.5 Concrete Itself As Formwork

Commonly called "pre-cast". Shapes that are built in such a way that when concrete is added it will build the final structural shape and are never "stripped'.

Advantages:

- A single form can be used to build components of a large cast increasing form repeats and decreasing the amount of forms needed.
- It is possible to cast light shapes to build beams and hold dead loads.

Disadvantages:

- Concrete is heavy.
- Set times before handling are a factor.
- Must be built strong enough to resist normal loads plus handling loads (increased re-bar).

Formwork materials - permanent formwork for a column. In this case steel spiral formed on a machine primarily used for air ducts. Concrete pipes are also popular permanent column forms. Figure 2-6 extracted from http://www.builderbill-diy-help.com/formwork-materials.html

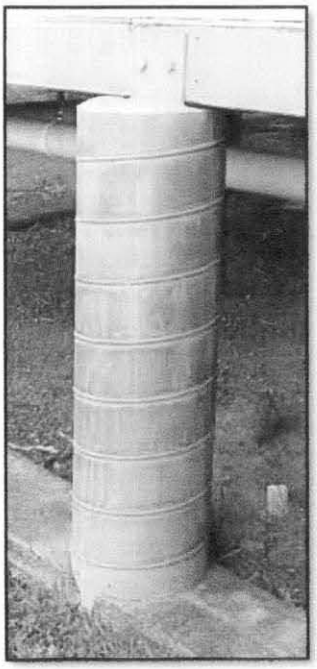


Figure 2-8: Concrete Formwork

2.4.6 Latex, Rubber Formwork

Rubber formwork used in the production of small molded concrete pieces that would be extremely hard by other means. The formwork able to stretch during erection of the panel. This type of formwork usually been applied as a cottage industry type business making moulded garden ornaments etc.

Source: http://www.builderbill-diy-help.com/formwork-materials.html

2.4.7 Fabric Formwork

Fabric formwork usually in rolls form of particular widths to suit the needed size. Not like other formwork material, fabric formwork tools are a Stanley knife, a staple gun and normal tools for cutting and fixing the braces and perimeter frame.

For cutting fabric at the corner, staple the fabric in designed position to holds the corners together as the normal methods. Before the pour, a sheet of standard plastic vapour barrier is laid on top of the fabric to stop the footing absorbing moisture if it is required.

Below are fiber formwork attribute quoted from Bradley. B. (2007)

- The fabric come ready made up in tube sections to form the desired diameter of the column.
- The fabric tube is simply cut to length with a Stanley knife.
- In the manufacture, tabs are made vertically along a center line.
- The loose sleeve of fabric is fitted over the rebar.
- The tabs are then nailed to a straight length of 4" x 2" timber.
- The 4" x 2" timber is then positioned, and braced to hold it plumb.
- For the first foot or so a guy hold the base of the tube in the correction position with a boot on either side.

- During the pour, it is possible for a guy to feel and guide the rebar cage, to make sure that it is in the correct position.
- Unlike conventional formwork, because this is a throw away, one off system there is never any reason for undue haste to strip the formwork.
- Therefore the fabric can be left in position to act as a perfect curing membrane

Figure 2.7 to 2.10 are the pictures from a project for a church in Nicaragua.

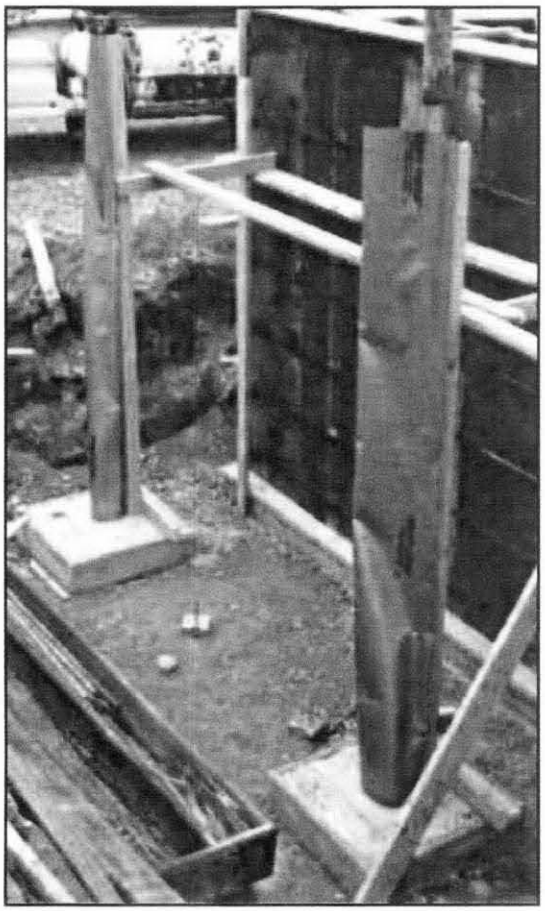


Figure 2-9: Two Empty Tubes Ready To Pour

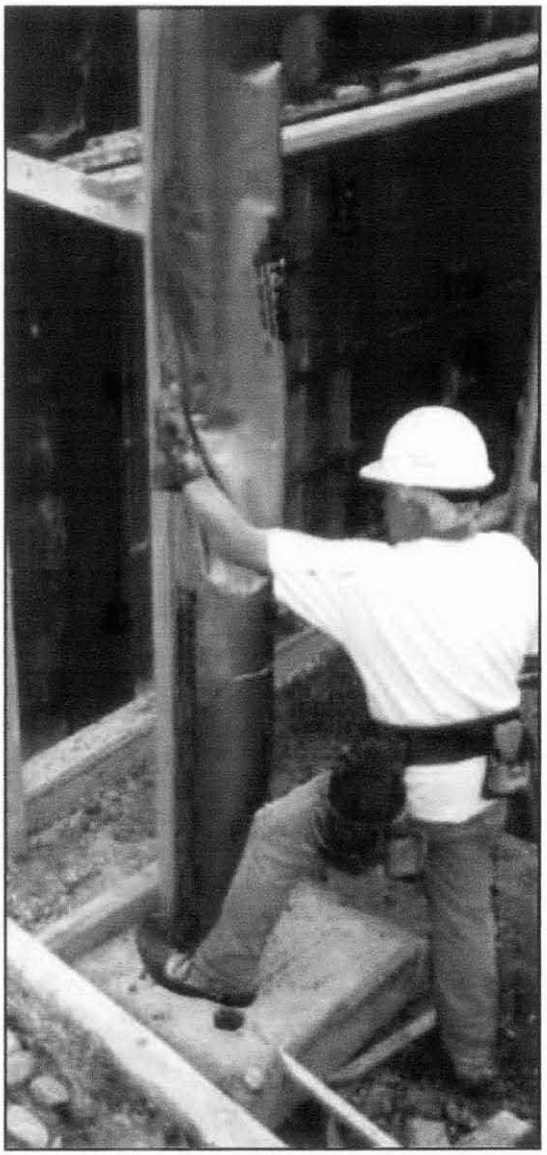


Figure 2-10: Concrete Being Poured, About Half Full

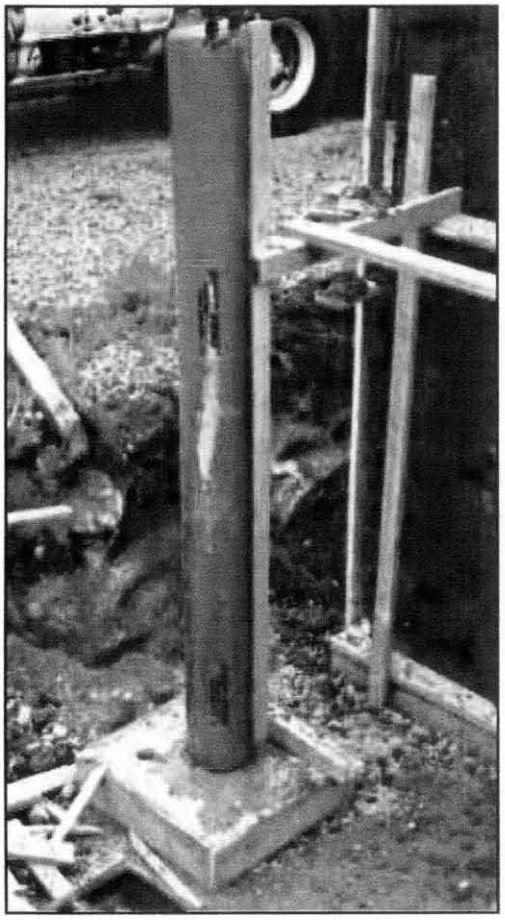


Figure 2-11: Fabric formwork - Column just filled

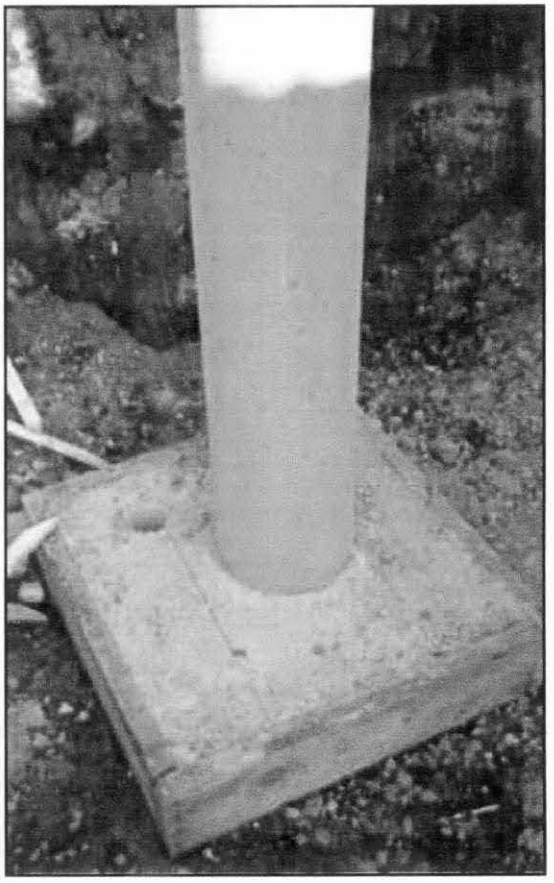


Figure 2-12: Fabric formwork - Stripped column

CHAPTER 3

METHODOLOGY

3.1 RESEARCH DESIGN

The objective of this project has been determined after a general research study was done about industrialized building system. Time taken during earlier stage of Final Year Project progress very slow due to the learning curve as this is a very new topic for the author. Below are steps taken to produce background study of this report.

3.1.1 Selection, Analysis And Statement Of The Research Problem.

3.1.1.1 Defining Problem Statement

Table 3-1: Formulation Research Question

Characteristic of Research Question	**Research Question**
Evocative question & adhere in the reviewers memory. • Make it timely. (contemporary social or theoretical concern)	What are the main concerns or current issues in construction industry that the government tries to minimize or eliminate? *Hazardous surrounding,* *high waste production,* *large numbers of illegal foreign workers that effecting social, economical and our health)* *construction time limitation since rain throughout the year.*
• Provocative paradox	Why the level of acceptance of using system formwork still very low even though CIDB has encourage the use of IBS by introducing IBS score that measure the exceptional levy to CIDB for any development? Why some project still using timber formwork since this activity will reduce IBS score?
• Distinctive approach. (involve a new methodology or a new conceptual approach)	If the construction site use the system formwork, will the site be 100% problem free as claim by the system formwork manufacture? Is there any way to further improve system formwork so that obligation can be made to all development in Malaysia to use system formwork?

Relevant to society or a social group.	As the pay master of a project, will developer benefits from system formwork? Missing piece / gab From personal experience, though system formwork able to overcome current problem at site, system formwork itself creates its own problem/set back. How can system formwork been further improve?
Ground question	Why the level of acceptance of system formwork in construction industry still very low? Was this cause by of lack of awareness of the benefits offer?

Current construction problem in Malaysia.

- Usage of foreign worker giving negative impact to our social and cultural context.
- Not environmental friendly since construction produce a lot of waste that can not be recycled.
- Dirty and hazardous construction site due to high waste produce and no proper storage provided.

The results of IBS are:

- Reduce labour during prefabrication of component and site work.
- Less materials and wasting
- Higher control of the project thus reducing rectification works and lowering the total cost of construction.
- Open Building Concept i.e. permitting hybrid applications, adaptable to standardization and Modular Coordination. (MC)

3.1.2 Research Objective

3.1.1.1 Formulating aims and objectives in from research question

Research area/topics/ideas/problem question

Topic	:	Industrialized Building System: System Formwork
Idea / Issue	:	Improvement of construction industry by reducing negative implication from construction.
Current problem	:	Flexibility of a design and poor site condition.
Question arising	:	System Formwork creates new problem such as time consuming for designing.
How aims can be accomplished	:	• Study on current situation in Malaysia. • Identify room for improvement by reading others research. • Conduct site visit to observe current site condition in order to understand on details the existing problem. • Comparing few brand of system formwork and their features. (list down the characteristic of system formwork based on brand) • By comparing few brands of system formwork, the weaknesses of system formwork can be identified and method to improve the current system can be distinguished.

3.2 RESEARCH METHODOLOGY

The data collection was based on selected interview method and conducted interview in selected site. No standard questionnaire being produce for this research due to analysis result of IBS 2003 survey conducted by Construction Industry Development Board Malaysia. Only 6% from the total number of questionnaire sent to developer, contactor and consultant all around Malaysia received feedback. This was such a waste of afford and no concrete conclusion or solution can be made based from this kind of survey. For this reasons, semi-structured interview been conduct in qualitative survey.

3.2.1 Qualitative survey

A qualitative survey is an in-depth understanding of system formwork. Qualitative research relies on reasons behind various aspects during implementation of system formwork. Characteristic of system formwork been viewed from different angel to identify missing pieces of information in application point of view.

By referring to Marshall et al (1998), qualitative researchers consist of four methods for gathering information: (1) participation in the setting, (2) direct observation, (3) in depth interviews, and (4) analysis of documents and materials.

This research emphasizes on the quality of meaning in consumer perceptions and attitudes; for example, in-depth interviews and focus groups. The survey only done on specific group to ensure high numbers of feedbacks and related parties involvement to obtain high accuracy results.

Family Health International, (2003) identified some qualitative research methods that are participant observation, in-depth interviews, and focus groups. Each method is particularly suited for obtaining a specific type of data. In this case, a rare and new technology (system formwork) feedbacks need to obtain from a knowledgeable person who has involved in implementing system formwork for years.

3.2.2 Semi-structured Interview

According to Angrosino, Michael V. (2002), a crucial element in the focused interview structure provided by interviewing people whom experience a particular event. The question were open-ended question to allow for descriptive answers, more flexibility and unanticipated responses. Questions asked also vary on interviewee background, positions and early responds.

Basic questionnaire are:

1. What do you think about system formwork?
2. Is system formwork will reduce construction cost? If yes, why is that so?
3. During handling of system formwork, how do you describe the procedure in comparison with conventional formwork?
4. There is so many type if system formwork available, what type of system formwork do you prefer the most?

Questions may vary on interview situation.

3.3 PROJECT ACTIVITY

1. Involve in a forum that discuss industrialized building system issue that is at http://www.realestate.net.my/forum/viewtopic.php?t=1260 on February 2007.

2. Read on current issues of IBS in our local newspapers or any pamphlet received by mail.

3. Conduct a visit to Sunrise Bhd to gather information for system formwork.

4. Research.
    a. Check on previous newspaper cutting for IBS in Malaysia
    b. Member of IBS Modular Bulletin; http://ibsmodular.blogspot.com/
    c. Browse journals, reports, books and webpage.

5. Interview via online.

6. Survey on Mivan Formwork.
    a. Visit Sunrise Bhd. Sunrise Bhd has been using system formwork almost 20 years in all it development.
    b. A staff from Sunrise (Mr. Vijayan Balan, Senior Development Executive) had assisted me in system formwork survey and introduces me to Mr. Sim from Mivan Far East marketing department.

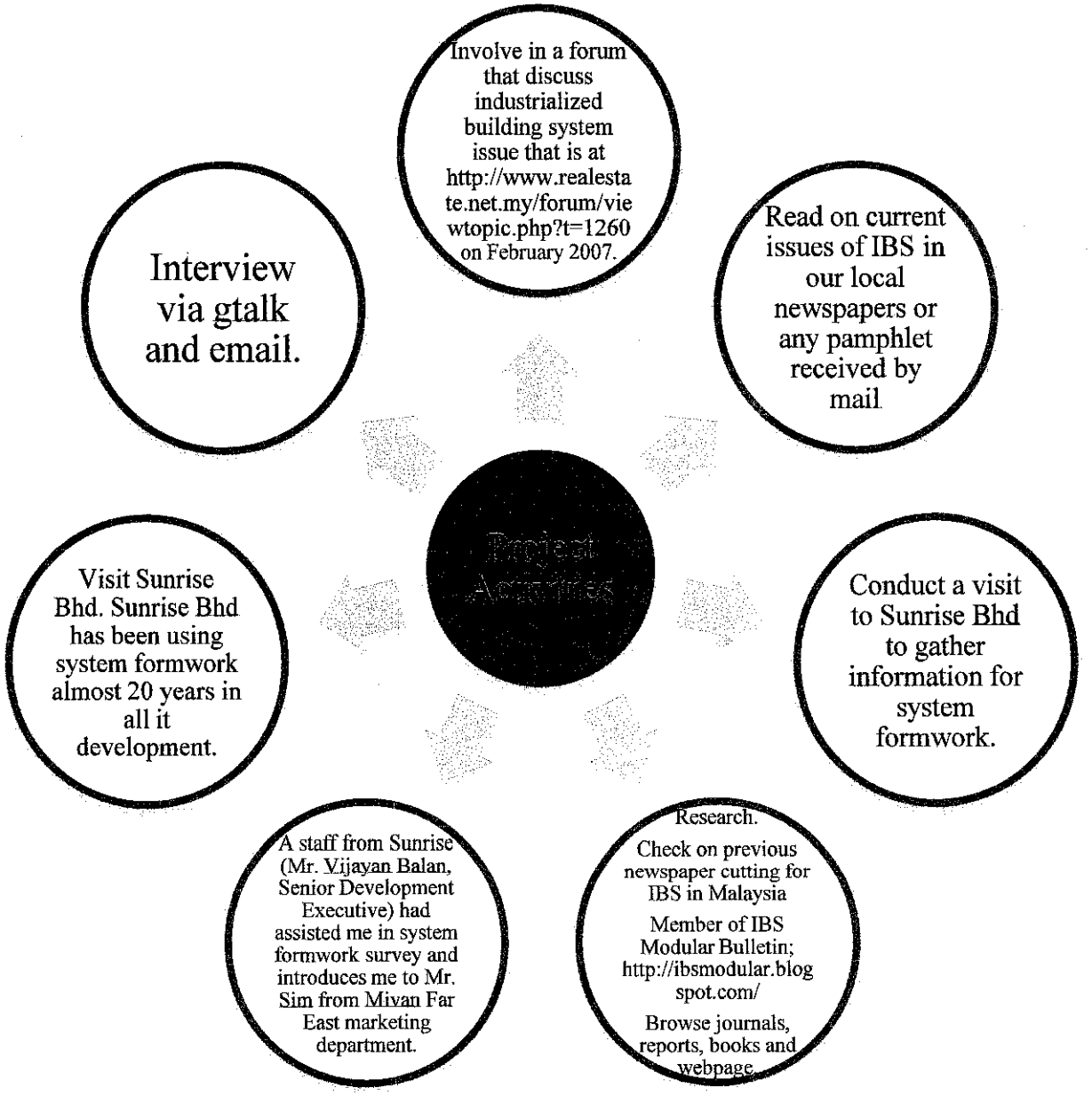
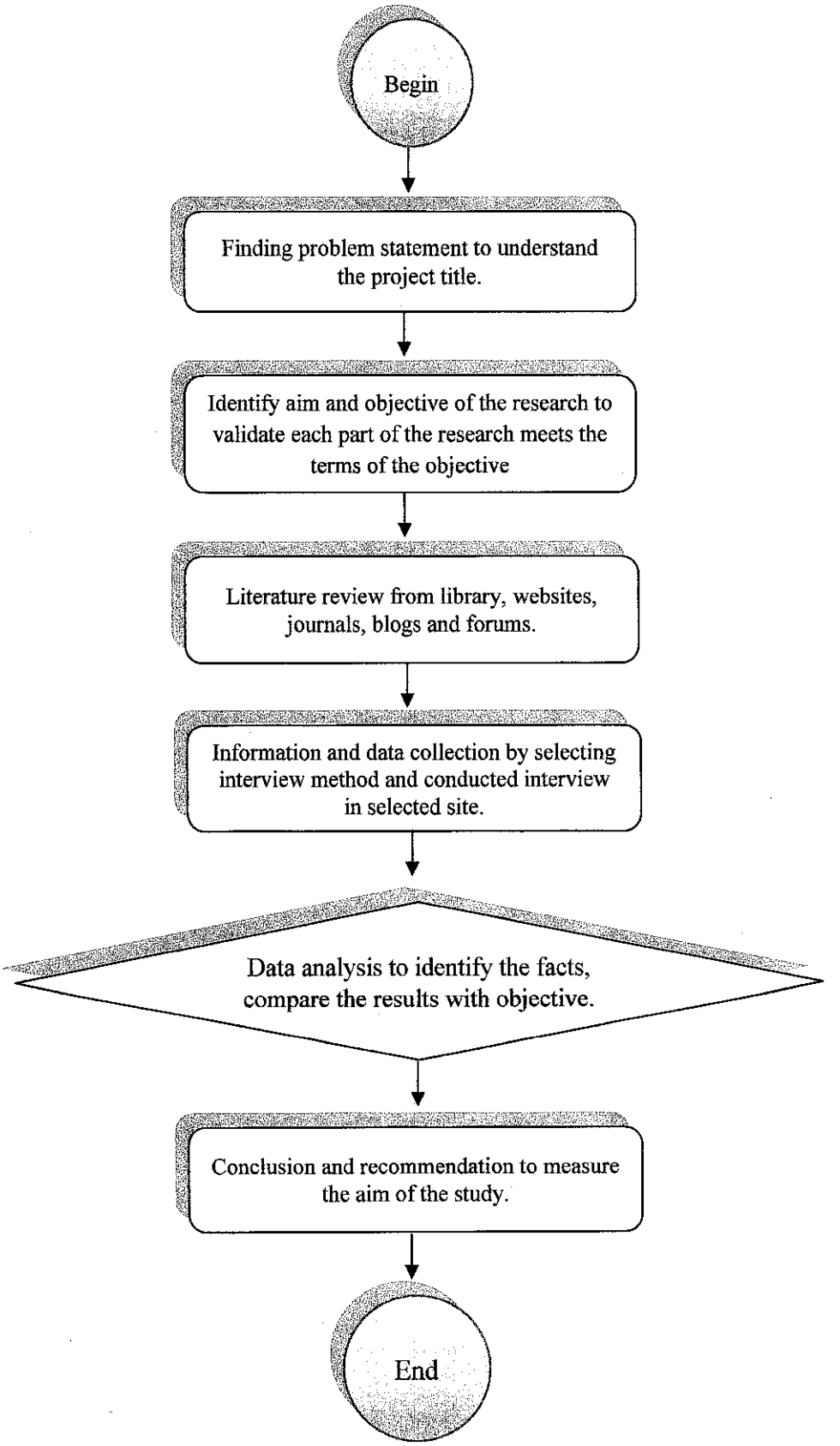


Figure 3-1: Summary of Project Activities

3.4 KEY MILESTONE: OVERALL RESEARCH METHODOLOGY



3.5 RESEARCH METHODOLOGY

Figure 3-2: Research Methodology

Qualitative survey

One of the chosen method is email survey as part of the distribution method, also as a back up survey. Email surveys are both very economical and very fast. More people have email than have full Internet access. This makes email a better choice than a Web page survey for some populations. There is practically no cost involved once the set up has been completed. An email questionnaire might be able to gather several thousand responses within a day or two.

Semi-structured Interview

Basic questionnaire are:

What do you think about system formwork?

Is system formwork will reduce construction cost? If yes, why is that so?

During handling of system formwork, how do you describe the procedure in comparison with conventional formwork?

There is so many type if system formwork available, what type of system formwork do you prefer the most?

Figure 3-3: Details of Research Methodology

3.6 METHOD JUSTIFICATION

Figure 3.4 justified why chosen method suite this research the best.

Questionnaire Distribution	Target Population
• Minor percentage in the questionnaire whereby the questionnaire are not answered. This might have slightly affected the results and the actual scenario of the construction market. • Respondents only represented 15% of the target sample • Due to time constraints, only small sample size samples are possible . Thus, the result might not portray the actual situation happening in the market.	• The target population is the respondents of whom the author is interested in; the group about which the author wishes to draw conclusions.

Figure 3-4: Method Justification

3.7 HAZARD ANALYSIS

Industrialized Building System: System Formwork analysis mainly based on research and communication via email. Therefore, the tools involved are personal computer and printer. Below is the analysis of Final Year Project working condition.

Work place : Personal work place and Computer Based Training (CBT) Laboratory.

Hazard checklist :
- LCD screen quality
- Seat character
- Keyboard shape and position
- Mouse size and wrist support condition

3.7.1 LCD Screen

Symptom : Slight headache and eye irritation.

A similar discomfort when standing for some time near certain mosquito killing devices which use a violet fluorescent tube to attract the insects.

Effect : Unable to work continuously with such a display for as long as they can with a traditional CRT.

Prevention to minimize effect:

Reduce (even drastically) the brightness settings. Bright screen cause tired eyes.

Adjusting the font quality and refresh rate of your computer. Is one of the steps suggested by Michael C. B., (*2004).* A font smoothing technology called ClearType, which uses the colored sub-pixel components of LCD display pixels to increase the perceived resolution, while at the same time reducing the contrast and sharpness of the (larger) individual pixels. It can be enabled in the Appearance tab of the Display Properties, under Effects...

Ilse Hagen (2007), recommended that computer screen must slightly below the eye level and at least 20-26 inches from eyes to reduce neck pain and minimized eyes starain.

Proper cleaning of screen. Monitors that are clean and dust free are less likely to cause eye irritation.

Take time to rest the eyes even for short periods. Walk away from computer and look out the window. This can contribute a great deal in reducing computer strain.

3.7.2 Keyboard and mouse

Symptom : Muscle strain and fatigue (hands, arms, neck, shoulders).

Effect : Chance of developing Repetitive Strain Injuries or Carpal Tunnel Syndrome.

Prevention to minimize effect:

A slight flexing of the wrist and slight twisting of the hand is required resulting in less pressure in the carpal tunnel area for greater comfort.

John J. Triano, (2005), suggested to relax to allow body to re-equilibrate the muscle biochemistry. It applies the 3 R's of Anti.Fatigue™, Re-Aeration, Relaxation and Recovery. Anti Fatigue™ (2008).

3.7.3 Seat

Symptom : Tension at neck area.

Back pain and sitting fatigue cause by poor access or inadequate clearance and excessive reach.

Effect : Sleeping problem due to back pain

Prevention to minimize effect:

Pillow to support spine area or use adjustable seat.

Stand, stretch and walk for at least a minute or two every half hour. A twenty minute walk will help even more, promoting healthy blood flow that brings important nutrients to all the spinal structures. In general, moving about and stretching on a regular basis throughout the day will help to keep joints, ligaments, muscles and tendons loose, which in turn will help to feel more comfortable, more relaxed and more productive.

Develop increased awareness of sitting habits, leading to corrective action which promotes both short-term and long-term back health.

Rani Lueder (2003), highlighted that ergonomic design for personal computer is very important to ensure student able to work under healthy and safe working condition. Furniture that is selected should be suitable for the types of tasks performed and be adaptable to multi-purpose use. Workstations must be designed carefully to meet the need of the staff and to accomplish the goals of the facility. By improving these entire characteristic, research developments of Industrialized Building System: System Formwork will be more effective.

CHAPTER 4

RESULT & DISCUSSION

4.1 GENERAL COMPARISON

System formwork provides contractor the extra edge in delivering the high quality of concrete structure within shorter duration. Below is the general comparison between conventional formwork and system formwork.

Table 4-1: Comparison between conventional formwork and system formwork

Conventional timber formwork	System formwork
Double the cost of using steel panel in long run	High initial cost but balanced by the long terms savings in timber formwork
Labour intensive for erecting and striking formwork	Less labour force required for erecting and striking formwork
Longer construction duration	High efficiency, twice faster than timber formwork system
Plastering need for leveling concrete surface	Better quality concrete products, concrete surfaces suitable for applying tiles and paints directly
Reusability depends on handling technique. Regularly 2-3 times of reusing.Several sets of timber forms needed for a high-rise block	Reused over 100 times, one set of forms sufficient to complete a block and can be reused in another sites
Timber waste produced	Waste steel scrapped for recycling, less waste produced
Plastering required before applying tiles and paints	Elements usually completed with necessary fixtures and finishes, no need for further finishing works

Table 4-2: Relative Comparison Of In – Situ "Aluminum Form" System With Conventional Construction

No	FACTOR	CONVENTIONAL	IN – SITU ALUMINUM FORM SYSTEM	REMARKS
1	Quality	Normal	Superior in – situ casting of whole structure and transverse walls done in a continuous operation, using controlled concrete mixers obtained from central batching, mixing plants and mechanically placed through concrete buckets using crane and compacted in leak proof moulds using high frequency vibrators	Superior quality in "System housing"
2	Speed of construction.	The pace of construction is slow due to step – by – step completion of different stages of activity the masonry is required to be laid brick by brick. Erection of formwork, concreting and deshuttering forms is a two – week cycle. The plastering and other finishing activities can commence only thereafter.	In this system, the walls and floors are cast together in one continuous operation in matter of few hours and in built accelerated curing overnight enable removal and re-use of forms on daily cycle basis.	System construction is much faster.
3	Aesthetics.	In the case of RCC structural framework of column and beams with partition brick walls is used for construction, the columns and beams show unsightly projections in room interiors.	The Room – Sized wall panels and the ceiling elements cast against steel plates have smooth finishing and the interiors have neat and clean lines without unsightly projections in various corners. The walls and ceilings also have smooth even surfaces, which only need colour/white wash	
4	External finishes.	Cement plastered brickwork, painted with cement – based paint. Finishing needs painting every in three years.	Textured / pattern coloured concrete facia can be provided. This will need no frequent repainting.	Permanent facia finishes feasible with minor extra initial cost

No	FACTOR	CONVENTIONAL	IN – SITU ALUMINUM FORM SYSTEM	REMARKS
5	Useful carpet area as % of plinth area.	Efficiency around 83.5%	Efficiency around 87.5%	More efficient utilization of land for useful living space.
		Consumption of basic raw material		
6	Cement.	Normal	Consumption somewhat more than that used in conventional structures.	Although greater consumption strength and durability is also more
	Reinforcing Steel	Reinforcing steel required is less as compared to the in situ construction as RCC framework uses brick wall as alternative.	It may, however will be slightly more than corresponding load – bearing brick wall construction for which, requirements of IS 456 have to be followed for system housing	Steel requirement is more, as it is required for the shear wall construction. But shear wall construction increases safety against earthquake.
7	Maintenance	In maintenance cost, the major expenditure is involved due to : • Repairs and maintenance of plaster of walls / ceiling etc. • Painting of outer and inner walls. • Leakages due to plumbing and sanitation installation.	The walls and ceiling being smooth and high quality concrete repairs for plastering and leakage's are not at all required frequently.	It can be concluded that maintenance cost is negligible.

4.2 ADVANTAGES OF SYSTEM FORMWORK

i. In contrast to most of the modern construction systems, which are machine and equipment oriented, the formwork does not depend upon heavy lifting equipment and can be handled by unskilled labors.

ii. Fast construction is assured and is particularly suitable for large magnitude construction of respective nature at one project site.

iii. Construction carried out by this system has exceptionally good quality with accurate dimensions for all openings to receive windows and doors, right angles at meeting points of wall to wall, wall to floor, wall to ceiling, etc, concrete surface finishes are good to receive painting directly without plaster.

iv. System components are durable and can be used several times without sacrificing the quality or correctness of dimensions and surface.

v. Monolithic construction of load bearing walls and slabs in concrete produces structurally superior quality with very few constructions joined compared to the conventional column and beam slabs construction combined with filter brick work or block work subsequently covered by plaster.

vi. In view of the four – day cycle of casting the floor together with all slabs as against 14 to 20 – day cycle in the conventional method, completed RCC structure is available for subsequent finish trades much faster, resulting in a saving of 10 to 15 days per floor in the overall completion period.

vii. As all the walls are cast monolithic and simultaneously with floor slabs requiring no further plasters finish. Therefore the time required in the conventional method for construction of walls and plastering is saved.

viii. As fully completed structural frame is made available in one stretch for subsequent – finishing items, uninterrupted progress can be planned ensuring, continuity in each trade, thereby providing as cope for employing increased labor force on finishing item.

ix. As the system establishes a kind of "Assembly line production" phase – wise completion in desired groups of buildings can be planned to achieve early utilization of the buildings.

The comparison of aluminum props with timber props explained further in Figure 4.1 and 4.2 below.

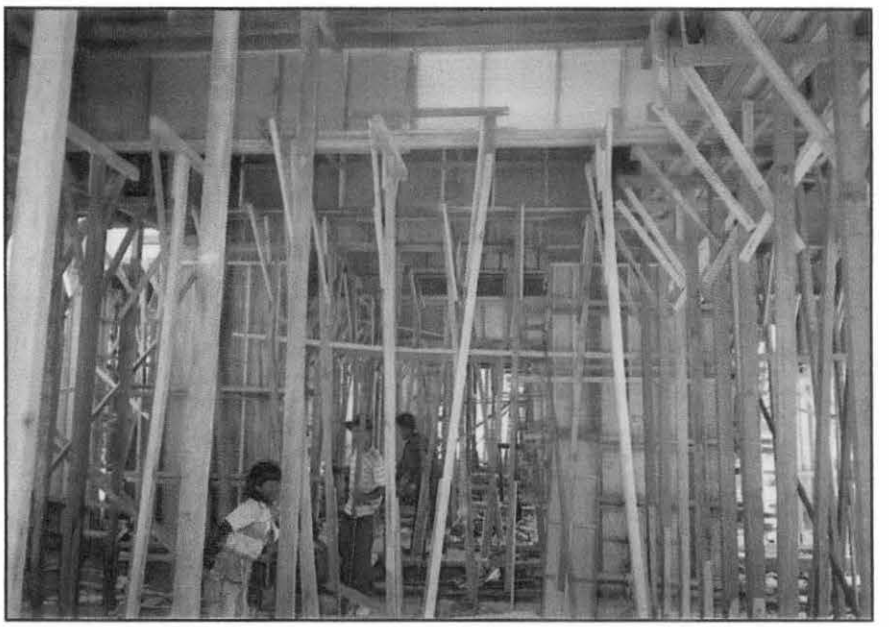


Figure 4-2: Congested Construction Site

Figure 4-1: Regular Spacing of Props

4.3 SYSTEM FORMWORK MANUFACTURER

Table 4-3: System Formwork Manufacturer

No.	Company	Address	Contact
1	Mivan Far East Sdn. Bhd	501, 4th Floor, Block B Glomac Business Centre 10 Jalan ss 6/1 Kelana Jaya 47301 Petaling Jaya Selangor Darul Ehsan	Tel : 603 7803 2806 Fax : 603 7803 3437 Email : JimL@farcast.mivan.com
2	PERI Formwork Malaysia Sdn.Bhd.	Helmut Schleich Unit 19-04-7, Level 7 PNB Damansara 19 Lorong Dungun, Damansara Heights 50490 Kuala Lumpur.	Tel : 603 2093 6823 Fax : 6032092 5876 Email : helmut.schleich@perimalaysia.com
3	TAC System Formwork Sdn. Bhd	159A-C, Jalan Kenari 23A, Bandar Puchong Jaya, 47100 Puchong Selangor Darul Ehsan	Tel : 603-8070 7562 Fax : 603 8070 4075 Email : info@tacsystemformwork.com
4	Hiform (M) Sdn. Bhd	Lot 1084 Jalan Sekolah, Rantau Panjang, 42100 Klang, Selangor Darul Ehsan	Tel : 603 3291 7353 Fax : 603 3291 7290 Email :
6	Seng Seng Builders Sdn Bhd (Contractor)	Level 3, Kim Mansion, No.332-B, Chulia Street, 10200 Pulau Pinang	Tel : 604 2611 870 Fax : 604 2611 872 Email : enquiry@ssbuilders.com.my
7	Plastech Industrial Systems Sdn Bhd	Unit B-5-17 & 18, Block B Pusat Perdagangan Pelangi Square, Pelangi Damansara PJU6, Persiaran Surian, 47800 Petaling Jaya, Selangor Darul Ehsan.	Tel : 603-7727 2068 Fax : 603-7727 0623 Email : fernnie@plastechind.com

4.4 TYPE OF SYSTEM FORMWORK

Table 4-4: Material of System Formwork Characteristic

Character	Large Panel Steel	Aluminum	Timber	Plastic	Fiber Glass Formwork
Material	Mainly consist of large pieces of steel formwork.[1]	All made of aluminum including panels and accessories. All materials could be recycled. Environmental friendly.[2]	From lumber and glossed plywood.[3]		Permeable fabric to allow excess water and air trapped within the fabric formwork to escape through the weave of the fabric, ensuring there are no voids formed. Usually use as scour protection.
Construction speed	6 days per floor[4]	4-5 days per floor.[5]	10-15 days per floor[6]	Much easier to strip (due to its flexibility) therefore, time efficient.	Cast in such large sections weight exceeds the ability of non mechanized handling.

[1] Poon, C.S., Ann T.W, Yu, L.H. Ng, L.H. Ng (2003) *Comparison of Low-Waste Building Technologies Adopted In Public and Private Housing Projects in Hong Kong.*

[2] Liu, S.W., Mo, K., Lai, K.H. (2000), *Value Engineering in The Proposed Development at TKOTL 55 Area 72 Tseung Kwan O*

[3] Ling Y. Y. and Leo K. C. (1999), *Reusing Timber Formwork: Importance of Workmen's Efficiency and Attitude.* Elsevier Science Lt.

[4] Poon, C.S., Ann T.W, Yu, L.H. Ng, L.H. Ng (2003) *Comparison of Low-Waste Building Technologies Adopted In Public and Private Housing Projects in Hong Kong.*

[5] Liu, S.W., Mo, K., Lai, K.H. (2000), *Value Engineering in The Proposed Development at TKOTL 55 Area 72 Tseung Kwan O*

[6] Poon, C.S. (2001), *Low Waste Building Technology.*

Character	Large Panel Steel	Aluminum	Timber	Plastic	Fiber Glass Formwork
Labour	Less labour force required for erecting and striking formwork. Tower cranes needed for lifting formwork.[7] Tower cranes needed for lifting formwork.[8]	Unskilled labour is required. 50-50 labourers are required.[9]	Semi-skilled carpenter. Hand lift timber board from floor to floor.[10]	Unskilled labour	-
Durability	Steel formwork could be reused 100 times. One set of formwork sufficient to complete a block and can be reused in other sites.[11]	120 – 150 times reuses. Over 80% materials could be reused from one building to another one.[12]	Usually damage badly after first dismantling.	Strong & lightweight Resist rain and chemical damage on site.[13]	1000's depending on handling.

[7] Poon, C.S., Ann T.W, Yu, L.H. Ng, L.H. Ng (2003) *Comparison of Low-Waste Building Technologies Adopted In Public and Private Housing Projects in Hong Kong.*

[8] Poon, C.S. (2001), *Low Waste Building Technology.*

[9] Liu, S.W., Mo, K., Lai, K.H. (2000), *Value Engineering in The Proposed Development at TKOTL 55 Area 72 Tseung Kwan O*

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[11] Poon, C.S., Ann T.W, Yu, L.H. Ng, L.H. Ng (2003) *Comparison of Low-Waste Building Technologies Adopted In Public and Private Housing Projects in Hong Kong.*

[12] Liu, S.W., Mo, K., Lai, K.H. (2000), *Value Engineering in The Proposed Development at TKOTL 55 Area 72 Tseung Kwan O*

[13] Poon, C.S., Ann T.W, Yu, L.H. Ng, L.H. Ng (2003) *Comparison of Low-Waste Building Technologies Adopted In Public and Private Housing Projects in Hong Kong.*

Character	Large Panel Steel	Aluminum	Timber	Plastic	Fiber Glass Formwork
Quality	Better quality concrete products, concrete surface suitable for applying tiles and paints directly. Reduce cost on skim coating.[14]	Very good in alignment, vertically and finish, thus minimizing the costs of plastering and finish work.[15]	High tendency to deflect.[16] Plastering need for leveling concrete surface.[17]	Available in any size and shape. Has a high quality surface finish. Superior off form finish. Non-stick to concrete	Minimal filling of the fine segment joints.
Wastage	No particular material wastage. Waste steel scrapped for recycling, less waste produced. Can be reused in another sites.[18]	No particular material wastage. Amount of slurry and concrete debris are much less.[19] Can be reused in another sites.[20]	To ensure reused timber is in adequate condition, inspection must be carried out. 100% of timber formwork used will contribute to construction waste.[21]	100% recyclable.[22]	

[14] Poon, C.S., Ann T.W, Yu, L.H. Ng, L.H. Ng (2003) *Comparison of Low-Waste Building Technologies Adopted In Public and Private Housing Projects in Hong Kong.*

[15] Liu, S.W., Mo, K., Lai, K.H. (2000), *Value Engineering in The Proposed Development at TKOTL 55 Area 72 Tseung Kwan O*

[16] Turanlar Group. (2006), *Modular Panel Formwork.*

[17] Poon, C.S. (2001), *Low Waste Building Technology.*

[18] Poon, C.S. (2001), *Low Waste Building Technology.*

[19] Liu, S.W., Mo, K., Lai, K.H. (2000), *Value Engineering in The Proposed Development at TKOTL 55 Area 72 Tseung Kwan O*

[20] Poon, C.S. (2001), *Low Waste Building Technology.*

[21] Wilshere, C.J. (1998), *Laing Engineering and Temporary Works Office.*

[22] Poon, C.S., Ann T.W, Yu, L.H. Ng, L.H. Ng (2003) *Comparison of Low-Waste Building Technologies Adopted In Public and Private Housing Projects in Hong Kong.*

Character	Large Panel Steel	Aluminum	Timber	Plastic	Fiber Glass Formwork
Flexibility	Last minute change is not recommended .Easy to handle but with mote joints.[23]	Longer lead time required. Last minute change is not recommended. Easy to handle but with mote joints.[24]	Very flexible. Suit all types of construction work. Timber and plywood can be easily cut, bent and modified to cater for any irregular shape.[25]	Available in any size and shape but last minutes change is not recommended.	Cast in such large sections weight exceeds the ability of non-mechanized handling.
Cost	High initial cost but balanced by the long terms savings in timber formwork.[26]	-	Double the cost of using steel panel in long run.[27]	-	
Others	-	-	Not environmental friendly because use up natural source.	Dramatically reduce injury risk.[28] Allows it to stretch when being stripped off the piece	

[23] Poon, C.S., Ann T.W, Yu, L.H. Ng, L.H. Ng (2003) *Comparison of Low-Waste Building Technologies Adopted In Public and Private Housing Projects in Hong Kong.*

[24] Liu, S.W., Mo, K., Lai, K.H. (2000), *Value Engineering in The Proposed Development at TKOTL 55 Area 72 Tseung Kwan O*

[25] Abdul Kadir M.R., Jaafar, M.S, Ali, A.A.A., (2006), *Construction Performance Comparison Between Conventional and Industrialized Building System in Malaysia.*

[26] Poon, C.S. (2001), *Low Waste Building Technology.*

[27] Poon, C.S. (2001), *Low Waste Building Technology.*

[28] Poon, C.S., Ann T.W, Yu, L.H. Ng, L.H. Ng (2003) *Comparison of Low-Waste Building Technologies Adopted In Public and Private Housing Projects in Hong Kong.*

4.5 FEATURES OF SYSTEM FORMWORK

Table 4-5: Features of System Formwork Based on Manufacturer

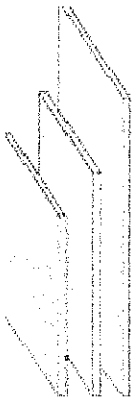
	Mivan Far East Sdn. Bhd	TAC System Formwork Sdn. Bhd	Peri Malaysia Sdn. Bhd	PLAS Tech
Experience	20 years	10 years	38 years	
Construction Cycle	Up to 4 days per floor	Up to 4 days per floor	-	
Size	Sub-multiple of 300mm	Deck panel / slab : 450mm x 1400mm Wall panel : 600mm x 2050mm	Cross-sections up to 80 x 120 cm	
Design Features	Available in wide variety of sizes based on a standard module, usually multiples and sub-multiple of 300mm. Casting wall and floor slab together in inverted U shape	Designed to suit Malaysian as well as Asian building industry.	The system do not integrate. Several system per structural section.	3 times lighter in weight when compared to other metal formwork systems
Repetition	>100 times Manufactured from durable materials: can be reused with minimal replacement for damage items that usually pin connection.	>250 times	200 times	200 times

	Mivan Far East Sdn. Bhd	TAC System Formwork Sdn. Bhd	Peri Malaysia Sdn. Bhd	PLAS Tech
Concrete Finish	No need plastering work. Increase construction progress by less architecture finishes	Requires a 2-3mm skim coat before decoration, thus eliminating the need for plastering. In addition, all the elements of the building are accurately dimensioned and are vertical, horizontal and square in plan and section as intended, so that remedial works to correct inaccuracies are eliminated.	Fair-Faced Concrete	Produce a smooth and superior finishing that only require skim coat
Flexibility	Capable of being adapted so that non-standard width inserts of traditional formwork material can be included where lengths or widths are not exact multiples of the unit panels.			Comes with different modular sizes in width and height together with a complete range of accessories to meet your building requirements.
Previous Project	High ris building	Service appartment, condominium and low cost landed properties.	Industrial Structure & High rise residential	
Previous Client	Sunrise Bhd, Villaraya Holding Sdn. Bhd and Asia Quest Sdn. Bhd.	GuocoLand, Sunway City Berhad and Putra Perdana Berhad		
Formwork Material	Aluminium	Aluminium	Steel	Plastic

	Mivan Far East Sdn. Bhd	TAC System Formwork Sdn. Bhd	Peri Malaysia Sdn. Bhd	PLAS Tech
Special features		As service collars can be accurately located and cast-in as the slab concrete is being poured, leaks are eliminated. This is a major hidden saving, as builders are very reluctant to admit the true costs of locating and remedying leaks – these costs get swept into the "contingency" figure. In addition, the bad publicity that a "leaky building" attracts has a very damaging effect on a Developer's reputation.	Expertise and advice, concept planning, detailed design, hire service, pre-assembled formwork, on-site assistance and training	
Other	Quick and easy to install and dismantle. Reduces labour cost for using unskilled labour. In addition, perfect concrete surface minimizes labour cost for finishing touch.			

4.6 CASE STUDY

4.6.1 TAC System Formwork



- Deck panel / slab : 450mm x 1400mm
- Wall panel : 600mm x 2050mm
- Sub modular increment : 25mm
- All panels are multiple of 25mm
- Heaviest panels is 32 kg

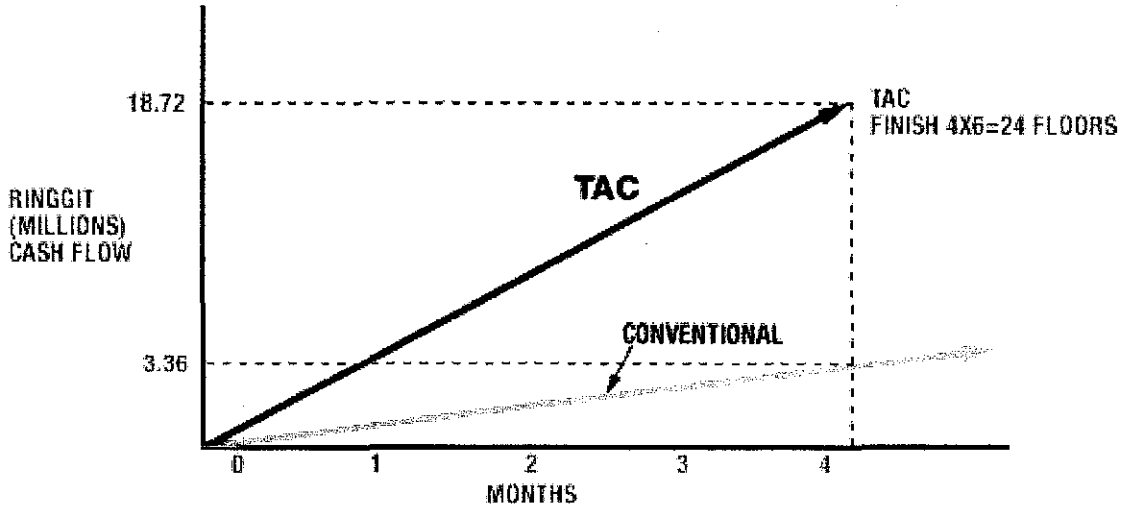
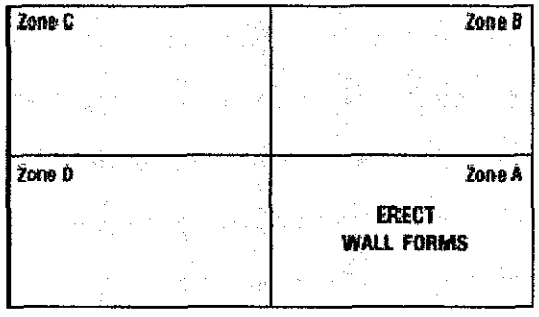
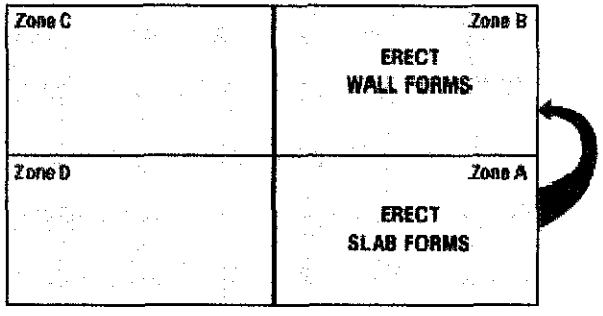


Figure 4-3: TAC Cost Comparison. TAC Formwork System: Business Report

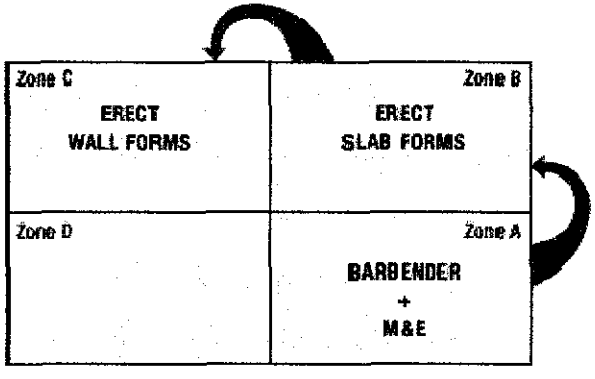
A simplistic example: Assume a rectangle building; divide floor into four work zones.



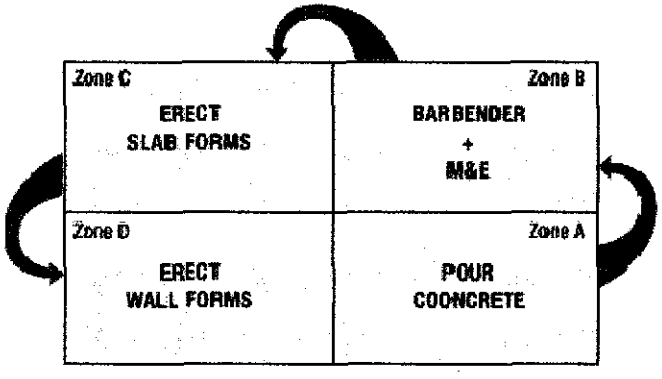
DAY 1: Wall Forming Team starts in Zone A.



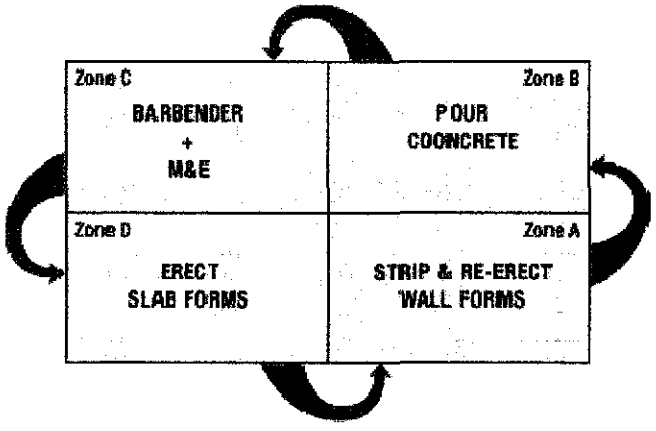
DAY 2: Wall forming team moves to Zone B; and slab forming team starts in Zone A.



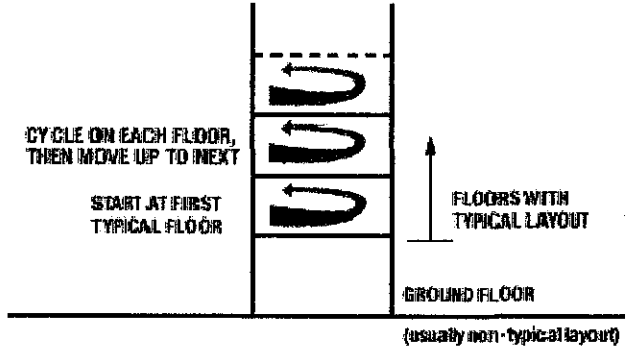
DAY 3: Wall forming team moves to Zone C; slab forming team moves to Zone B; and Barbender+M&E starts in Zone A.



DAY 4: Wall forming team moves to Zone D; slab forming team moves to Zone C; Barbender+M&E moves to Zone B; and pouring concrete team starts in Zone A.



DAY 5 (Typical):
Now all teams are on cycle.



EXAMPLE

Figure 4-4: TAC Construction Cycle. TAC Formwork System: Business Report

4.6.1.1 TAC Formwork Specialty

TAC Formwork offers several advantage to the users. Part of features are: (based on TAC System Formwork System: Business Report)

1. High Quality

   No plastering needed only 2-3mm skim coat. True saving by eliminating leaks at joints. Save cost on locating and remedy leaks. Benefits developer due to high quality building. The system provides an inherent safety features in the use of props which need not be removed to release the slab forms. Overlooking of re-propping in one of the commonest causes of fatal accidents on building sites.

2. Special

   No scaffolding needed as the TAC System provides its own work platform brackets, which ascend the building as it being constructed. There is the added advantage that the infrastructure can now proceed in parallel with the building construction, as the contractor has unimpeded (without hindrance) access to the base of the building.

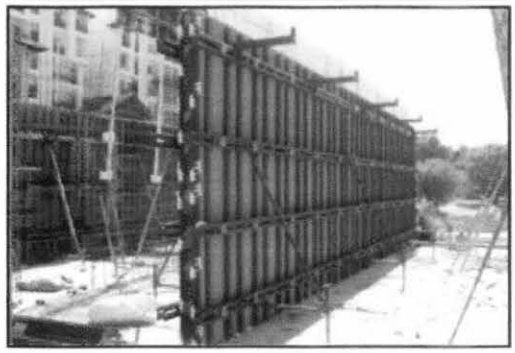
3. Cranage

The crane is not required for the movement of the forms up the building as the construction proceeds due to the lightweight property. Thus the crane is available for concrete and steel placing and other materials movement. The crane is only required for moving the forms down from the top of the completed building.

4.6.2 PLAS Tech

PLAS Tech Component from http://www.plastechind.com/Benefits.asp

Wall



Handset Wall

Gangset Wall

Figure 4-5: PLAS Tech Formwork.

4.6.2.1 PLAS Tech Advancement

Simplicity

PLASTECH™ only need a panel clamp or lock pin with wedge to hold the panels together instead of bolt and nuts to ensure a fast efficient one piece connection. Due to tis simplicity, the system only requires general workers to erect the lightweight panels with minimum supervision.

Durability

PLASTECH™ has an impact resistance face sheet that makes the panel rugged for typical construction site handling. The panel can be reused over a hundred times unlike the conventional wooden formwork system which has limited reusability.

Quality Finishing

PLASTECH™ durable form face produce a smooth and superior finishing that only require skim coat. This will greatly reduce your finishing cost compare to conventional and metal formwork which often has dented and uneven form face.

Lightweight and speed

PLASTECH™ is 3 times lighter in weight when compared to other metal formwork systems available in the market. Unlike conventional timber and other formwork systems which relied heavily on carnage where work can be disrupted due to breakdown on the cranes, this system can be easily handset using minimum workforce to transfer from floor to floor. This will ensure that the construction schedule will not be delayed and also allowing the cranes to be used for other purposes.

Versatility

PLASTECH™ system can be used either by man handle or crane handle for any concrete structures; single or multiple directions walls, floor slabs, retaining walls, liftcore, columns, beams, treatment plants, precast components, water reservoirs etc. It comes with different modular sizes in width and height together with a complete range of accessories to meet your building requirements.

Ease of maintenance

PLASTECH™ is easy to maintain as it is non-stick to concrete unlike other metal formwork systems where concrete often stick on the face and back and requires release agents and massive cleaning on the surface on every cycle.

Low cost

PLASTECH™ system gives your project the lowest overall cost solution when compared to conventional and metal formwork systems. It reduces dependent on skilled labour and is less dependent on cranage to carry out the job. The system along with our highly experience engineering and field team will turn your project site into an efficient "production factory" to achieve lowest construction cost and faster completion period that will give your company the competitive edge.

PLAS Tech Advancement quoted from Plastechind Benefits Report (2006)

4.6.3 Sunrise Bhd

It is a well known developer that monopoly the development in Mont'Kiara. Most of the project in Mont'Kiara were by Sunrise Bhd. and has implemented system formwork in all of its high rise development. Sunrise has allies with Mivan Far East as system formwork manufacture for nearly 20 years and specifically identifies the system formwork as their secret recipe to success.

The high initial cost will be pay off by high number of reusability. Amount of saving is more that what have been allocated as a start up cost. By using system formwork, the company has been applying economies of scale concept where investing an amount of money to gain further benefits by having high fixed cost and declining marginal cost. High number of reusability with minimal maintenance cost (only for replacing pins).

4.6.4 Mont'Kiara Meridin

A project by Sunrise Bhd. which is still in construction stage. Mont'Kiara Meridin using system formwork with 5 days per floor cycle. The schedule completion date will be in August 2008. Currently progressing on tract even delay in appointing contractor by few weeks. Mont'Kiara Meridin is using set of formwork from Mont'Kiara Bayan since these two projects having about similar layout. The set of formwork do not need any adjustment to fit Mont'Kiara Meridin. This situation has reduce the project cost for both projects. As what have been plan currently, the same system formwork will be use in MK28; a project that still in design stage.

Type of Development	: Residential
Total Unit	: 282 unit
No of Unit per Floor	: 12 unit
Level	: 32 storey
Basement	: 6 with 6 level of cabana unit
Tower Block	: 1
Project Theme	: Modern contemporary
Current Status	: Construction stage
Land Area	: 4.8 acre
Proposed Selling Price	: RM350 per ft2
Building Height	: 155m

4.6.4.1 Layout Plan

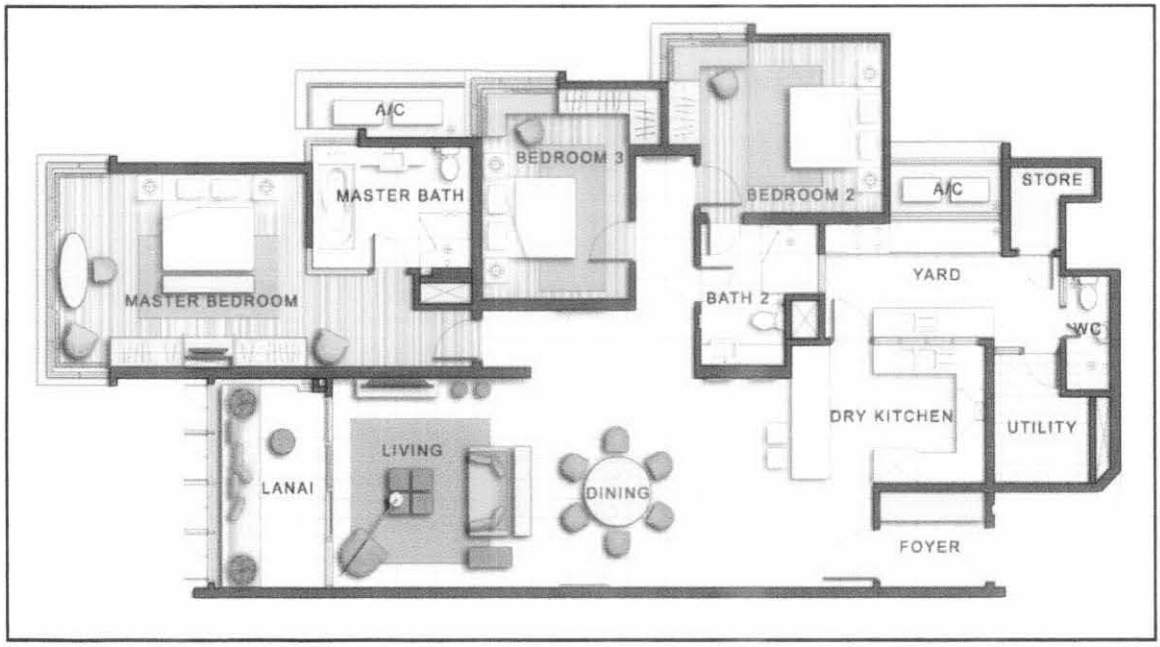


Figure 4-6: Mont'Kiara Meridin Layout Plan

Figure 4-7: Construction Using Mivan Formwork

Figure 4-9: Overall View of Mivan Formwork Product

Figure 4-8: Aerial View of Mont Kiara.. Saturated With Fomrwork Construction Building

4.6.5 Mivan Far East

- Aluminum formwork
- Light-weight form work. Easy to move.
- Best for repetitive level
- Even though it is more expensive, the system formwork provide more accuracy for the concrete and will make the concrete higher quality.
- Shorten the construction time due the concreting cycle time has been reduce.

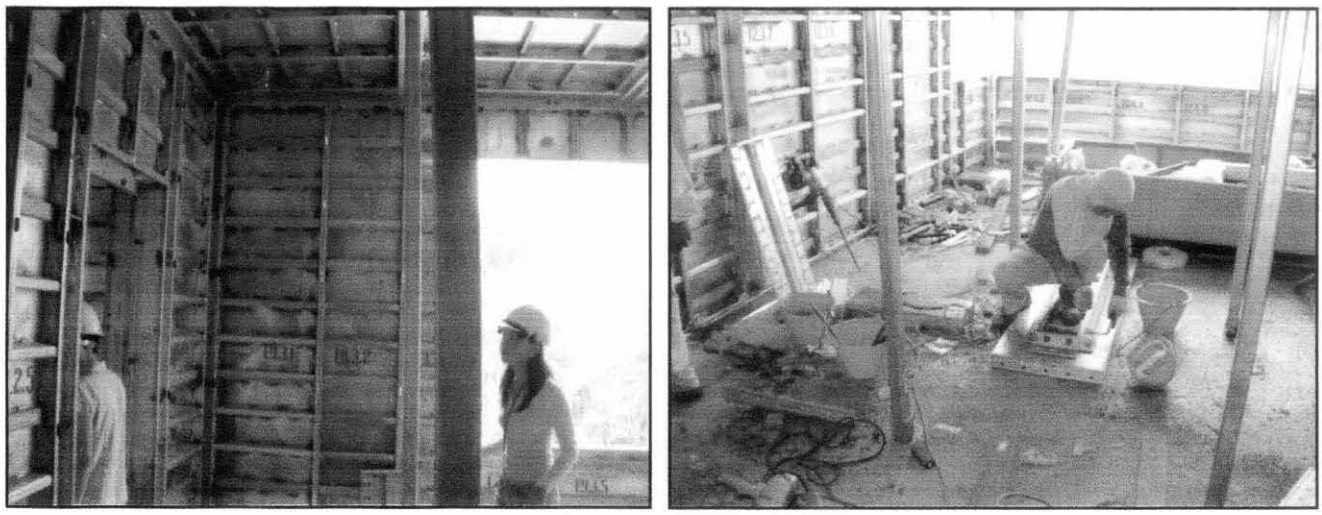


Figure 4-10: Erection of System Formwork

The formwork system is precisely-engineered system fabricated in aluminum. Using this system, all the elements of a building namely, load bearing walls, columns, beams, floor slabs, stairs, balconies etc can be constructed with cast in place concrete. The resulting structure has a good quality surface finish and accurate dimensional tolerances. Further, the construction speed is high and the work can be done in a cost effective manner.

The modular nature of the formwork system allows easy fixing and removal of formwork and the construction can proceed speedily with very little deviation in dimensional tolerances. Further, the system is quite flexible and can be easily adapted for any variations in the layout.

The availability of concrete from ready mix concrete facility has augured well for the use of this work system. The quality of the resulting concrete is found to be superior. Structurally, the adoption of the closed box system using monolithic concrete construction has been found to be the most efficient alternatives. The stresses in both the concrete and steel are observed to be much lower even when horizontal forces due to wind or earthquake are taken into consideration.

The formwork system can be used for construction for all types of concrete systems, that is, for a framed structure involving column beam –slab elements or for box-type structure involving slab-walls combination. The formwork is designed using the most economical assortment of panel sizes with the help of the state-of-the art design software.

Mivan Formwork fulfilled the following requirement:

- Available in wide variety of sizes based on a standard module, usually multiples and sub-multiple of 300mm
- Manufactured from durable materials: can be reused with minimal replacement for damage items that usually pin connection.
- Produce desires finish: No need plastering work. Increase construction progress by less architecture finishes
- Casting wall and floor slab together in inverted U shape
- Lightweight so that individual unit panels can be handle without mechanical aid: Crane breakdown did not effect the site progress
- Formwork can be assembled and dismantled easily by unskilled or semi-skilled labour
- Capable of being adapted so that non-standard width inserts of traditional formwork material can be included where lengths or widths are not exact multiples of the unit panels.

Figure 4-11: Lightweight Formwork Panel.

Formwork panels are lightweight: Easy to move from one zone to the other zone. No crane needed since each panel weight only 25kg and environmental friendly since aluminum can be recycle.

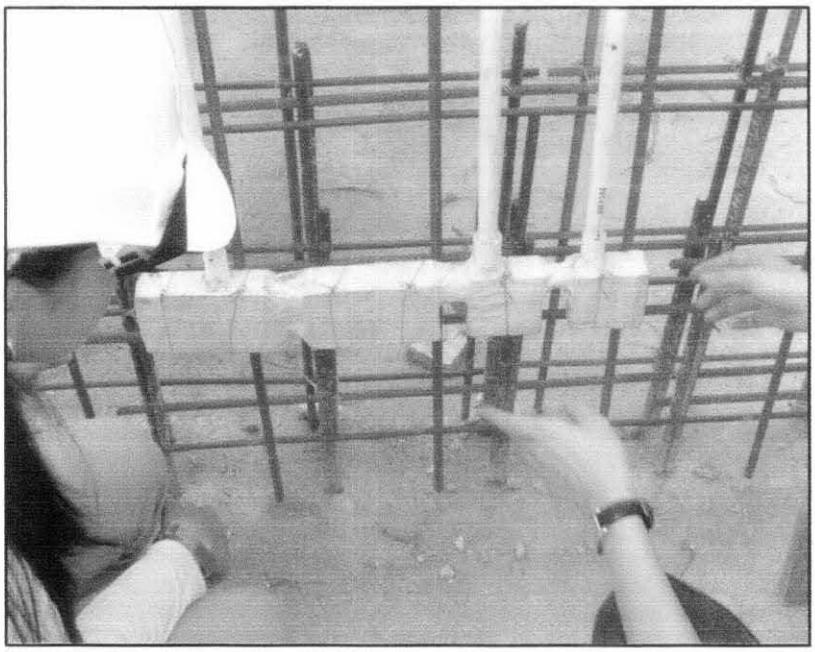


Figure 4-12: Pre-fixed M&E Wiring

Allowance for opening before concreting. No wall hacking required. Increase speed of construction

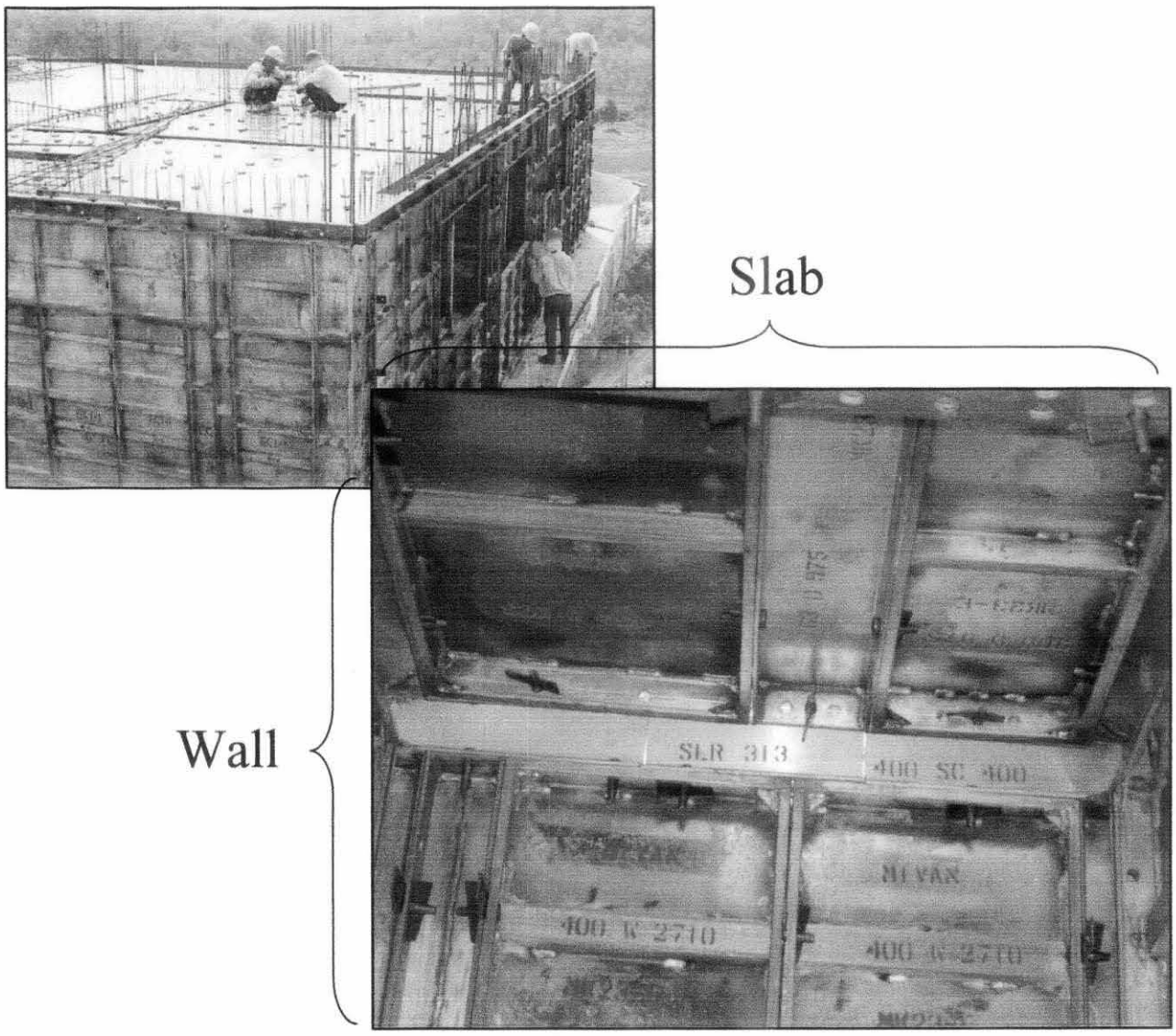


Figure 4-13: Monolithic Design. Integrity Between Slab And Wall

Figure 4-14: Formwork Stripping

4.6.5.1 Four Days Cycle of Formwork

Figure 4-15: Day1, Erecting Steel Wall and M&E Fixing

Figure 4-16: Day 1, Erecting Wall Formwork

Figure 4-17: Day 2-Morning. Deck Slab

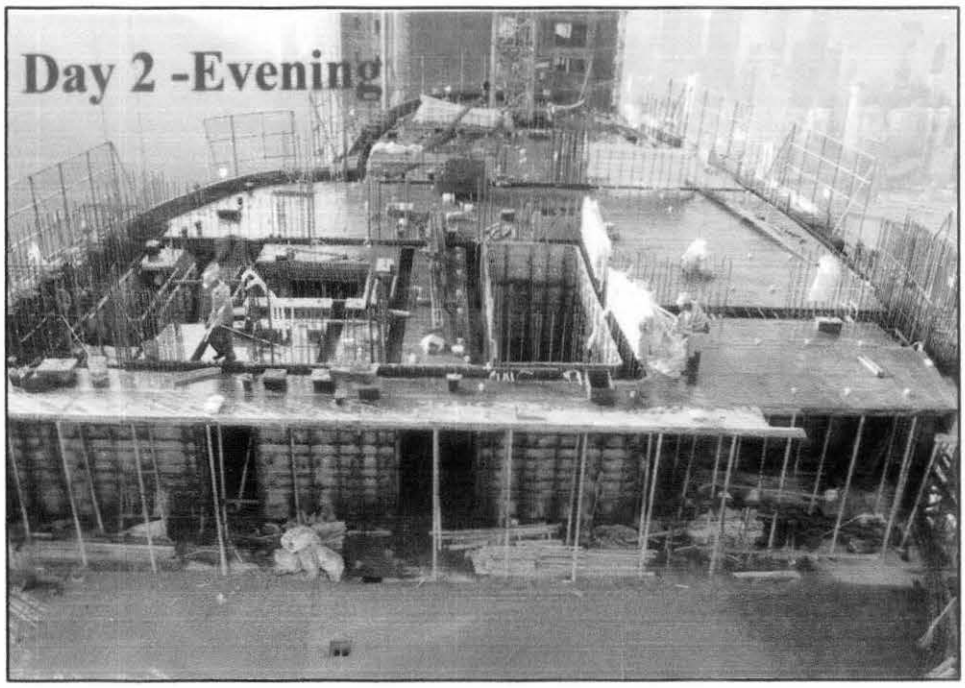


Figure 4-18: Day 2-Evening. Deck Slab

Figure 4-19: Day 3-Morning. Deck Steel

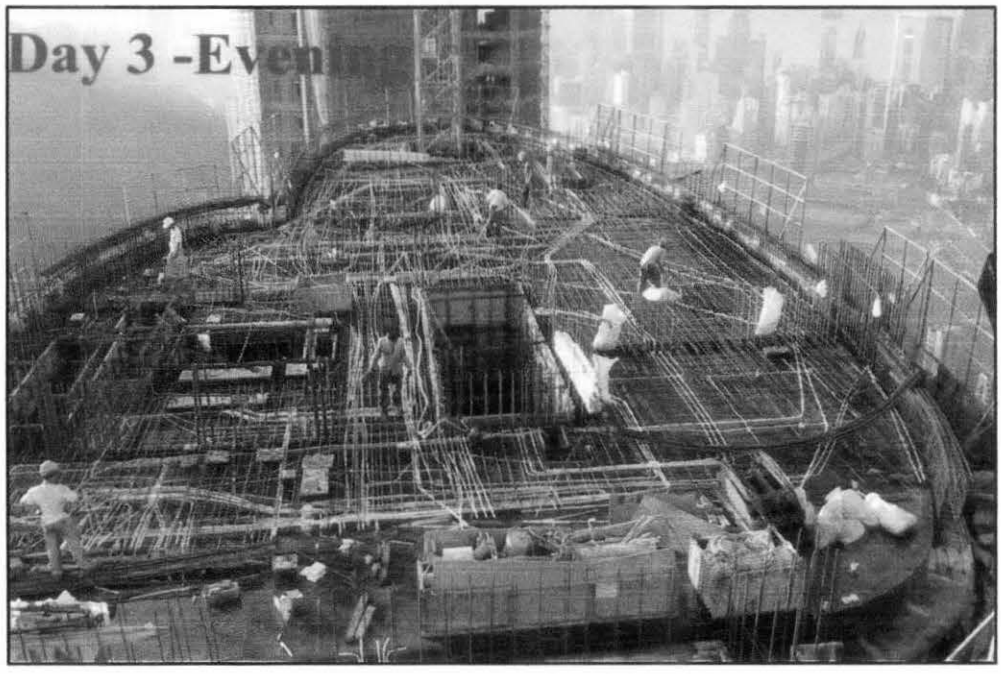


Figure 4-20: Day3-Evening. M&E Fixing

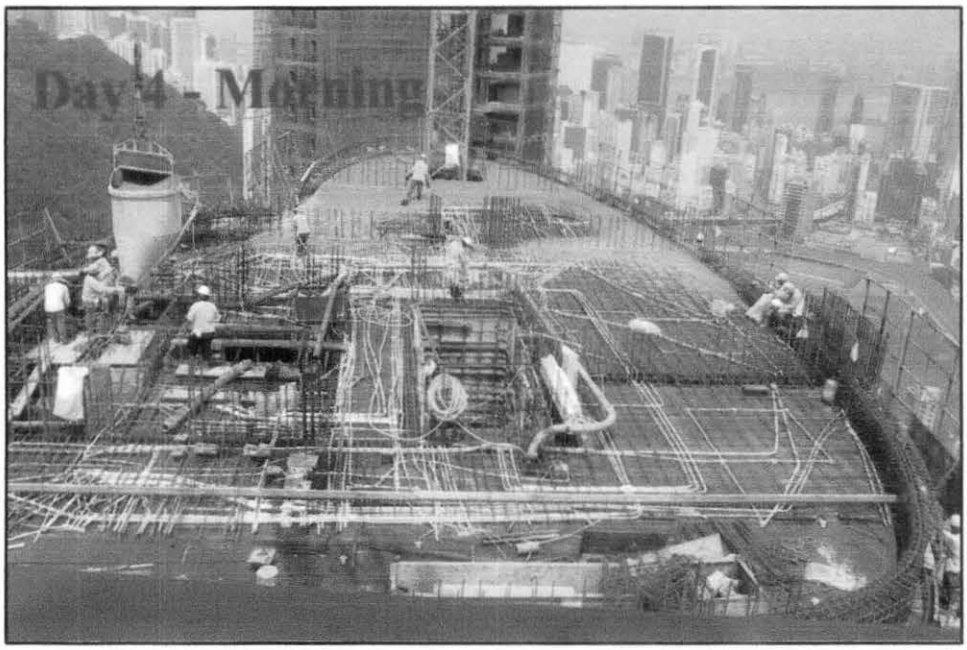


Figure 4-22: Day 4-Morning. Concrete Pouring

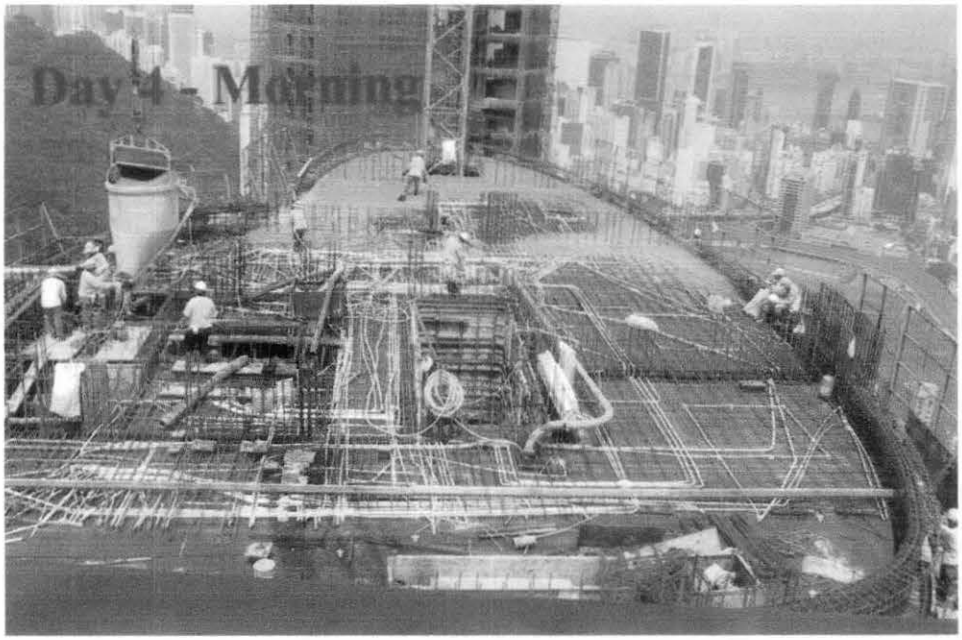


Figure 4-21: Day 4-Evening. Concrete Pouring

4.6.5.2 Mivan Awards

Table 4-6: Mivan Far East 2007 Annual Report

2006	**BUILDING MAGAZINE SPECIALIST CONTRACTOR OF THE YEAR AWARDS 2006** Winner of the Best Fit-out Contractor Category
2006	**NISO/ NISG OCCUPATIONAL SAFETY AWARDS** Winner of Construction Specialist Contractor Award
2006	**ROSPA OCCUPATIONAL HEALTH & SAFETY AWARDS** Winner of Silver Award
2006	**CONSTRUCTION NEWS QUALITY IN CONSTRUCTION AWARDS 2006** Winner of 'International Performance' category- Mivan-Kier Joint Venture
2005	**CONSTRUCTION MARKETING AWARDS 2005** Winner of the Bid Management Category
2005	**CONTRACT JOURNAL WEB AWARDS 2005** Winner of usability and most popular vote categories
2005	**BUILDING MAGAZINE SPECIALIST CONTRACTOR AWARDS 2005** Winner of Design Integration category and shortlisted in Fit-out category
2005	**ROSPA OCCUPATIONAL HEALTH & SAFETY AWARDS** Winner of Bronze Award
2004	**BCCB INTERNATIONAL EXPERTISE AWARDS 2004** Joint winner of the UK Construction Firm of the Year Category for the turnkey construction of apartments in 26 towns throughout Romania
2004	**NORTHERN IRELAND EXPORTER OF THE YEAR AWARDS 2004** Winner of the New Markets category for recent successes in supply of formwork to Dubai
2003	**BCCB INTERNATIONAL EXPERTISE AWARDS 2003** Winner of the UK Construction Firm of the Year Category for specialist construction on Mission: SPACE at Epcot Florida

2003	**NORTHERN IRELAND EXPORTER OF THE YEAR AWARDS 2003** Winner of the New Markets category for recent successes in supply of formwork to India
2003	**MUSEUMS & HERITAGE AWARD FOR EXCELLENCE 2003** Winner of 'Project on a Limited Budget' for British Empire & Commonwealth Museum, Bristol (designer: rfa Designers)
1996-97	**QUEENS AWARD FOR EXPORT ACHIEVEMENT 1996 & 1997**
1994	**STAR (AL KAWKAB) MEDAL OF JORDAN** Presented by King Al Hussain bin Talai of the Hashemite Kingdom of Jordan for works to the Al Aqsa Mosqu

4.7 COMPLETED PROJECT USING SYSTEM FORMWORK

Figure 4-23: Mont Kiara Aman

Developer	Sunrise Bhd
Building	2 Blocks of 32 Storey Condominiums
Area	12,552 m2
Cycle	6 Days per Floor
Awarded	April 2003

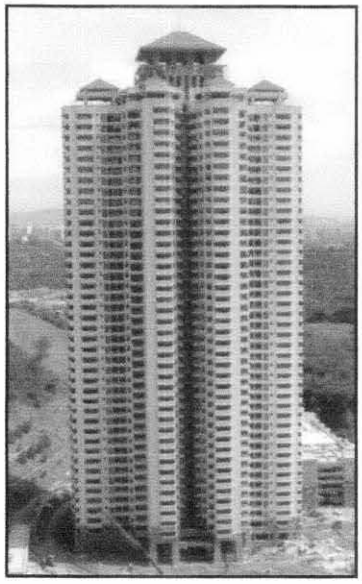


Figure 4-24: Mont Kiara Damai

Developer	Sunrise Bhd
Building	42 Storey Condominium Tower
Area	5,925 m2
Cycle	4 Days per Floor
Awarded	November 2001

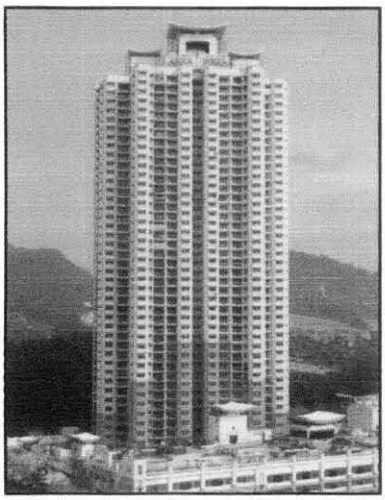


Figure 4-25: Mont Kiara Bayu

Developer	Sunrise Bhd
Building	42 Storey Condominium Tower
Area	5,925 m2
Cycle	4 Days per Floor
Awarded	November 2001

Developer	Villaraya Holding Sdn. Bhd
Building	2no 12 Storey Medium Cost Apartments
Area	8,000 m2
Cycle	10 Days per Floor
Awarded	September 2001

Figure 4-27 : Kajang Villa

Developer	Gallant Acres Sdn. Bhd
Building	6no 16 -22 Storey Medium Cost Apartments
Area	14,351 m2
Cycle	4 - 5 Days per Floor
Awarded	October 2001

Figure 4-26: Palm Springs Damansara

Developer	Asia Quest Sdn. Bhd.
Building	2no. 28 Storey Condominiums
Area	4,641m2
Cycle	7 Days per Floor
Awarded	October 2001

Figure 4-28: Kiaramas Mont Kiara

Figure 4-29: 156 Terrace Housing, Klang

Developer	Spec Bina Sdn. Bhd
Building	2 Storey Terrace Houses
Area	1,379 m2
Cycle	2no Units per Days
Awarded	November 2002

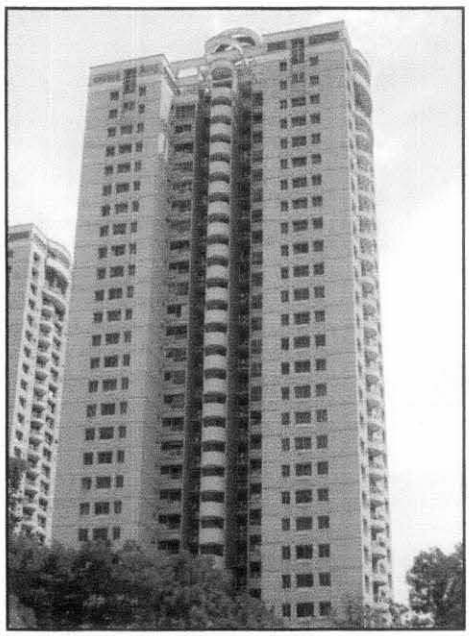


Figure 4-30: Mont Kiara Pelangi

Developer	Sunrise Bhd
Building	2no. 27 Storey Condominium Blocks
Area	3,330 m2
Cycle	4 Days per Floor
Awarded	February 1994

Figure 4-31: 184 Terrace Housing, Klang

Developer	Spec Bina Sdn. Bhd
Building	2 Storey Terrace Houses
Area	1,213 m2
Cycle	2no Units per Days
Awarded	May 2003

CHAPTER 5

CONCLUDING REMARKS

Greater speed of construction, simpler construction process, reduced environmental impact and reduce reliance on traditional labours. Ahamd (2006).

Campaign to reassure that IBS systems are able to provide fast, economical and high quality products should be carried out. The awareness campaigns may include seminars and short courses. For example, CIDB in collaboration with universities, manufacturers and professional bodies have carried out extensive seminars and roadshow to give exposure to contractors and engineers about the IBS system.

Incentive, Contractors adopting the IBS system are given incentive such as levy exemption based on the percentage of IBS usage in a project.

5.1 BENEFITS OF IBS

Alter the role of contractor from builders to assemblers by moving the manufacturing work offsite. This will result to low site labour and definitely low material at site and eventually low wastage that leads to more environmental friendly working condition.

IBS introduce labour-reducing system in order to ease the dependency on foreign labour in the local construction industry and saves the country from loosing out foreign exchange.

Pre-cast component has always been recognize as high quality product. This is simply because, the manufacturer attain more control on fabrication process ambiance. For this reason, by implementing IBS, a project could has a high quality structure and finishes thus a step closer towards global competitiveness.

As a pre-fabricated material, IBS product will reduce rectification work by having quality material and lowering the total cost of construction in long term.

Finally to sum up all the benefits of IBS; IBS persuade the construction industry to engage a more systematic approach and methodology in construction.

5.2 BARRIERS TO THE ADOPTION OF SYSTEM FORMWORK

Based on survey that been collected (thru phone conversation and reference to other studies), level of acceptance of system formwork in Malaysia is still very low. Several major factors have been identify as a setback of system formwork application.

As claim by the manufacture, system formwork provides cost reduction. This only imply for large project due to repetition of formwork panel. The more the repetition of the formwork, the lower the construction cost but high initial overhead cost (Ahmad Baharuddin Abd. Rahman & Wahid Omar (2006)). As small projects, traditional construction methods are more cost effective. Small contractors are reluctant to adopt system formwork and prefer to continue using the conventional method of construction. Small contractors lack financial back up and system formwork involves very intensive capital investment. However, many big company in IBS industry have shown good tract records in building successful IBS projects especially in Mont'Kiara area.

Most building professional do not concern about waste reduction at site. The most important factor to them is delivery and next is cost. Regardless what is the method use, as long as it's value for money, the method will be put into practice.

In Malaysia, availability of technical expert for system formwork is still very low. The industry is lacking skill and knowledge in applying system formwork.

Schwörer, Artur. (2007) stated that in development of high-rise building, wall repetition is a good situation to adopt system formwork. A difficulty of using system formwork in high-rise building is the changers in wall thickness through out the building height. Yuosre F. Badir, *et al.*(2002) agree with the fact that to change the thickness of the concrete wall, at least the central part must be replaced. Therefore, the panel will need to be adjust since system formwork is not very flexible. This process is a tedious procedure that may lead to delay in progress if no proper plan executed.

System formwork needs depth of the concrete cover of the concrete wall is fixed. The depth of the concrete cover is fixed in the known formwork system by the associated system element. To change the depth of the concrete cover, the associated system element must be replaced in any case. As a result, a specific formwork system according to prior art is suitable for producing exactly only one type of concrete wall at a building site.

Limited knowledge in structural analysis and design in construction leads to difficulties during exercising system formwork. The most common problem are improper assembly of the component that normally involved beam to wall and wall to beam connection. Poor connection may cause structure defect at joints.(Ahmad Baharuddin Abd. Rahman & Wahid Omar (2006))

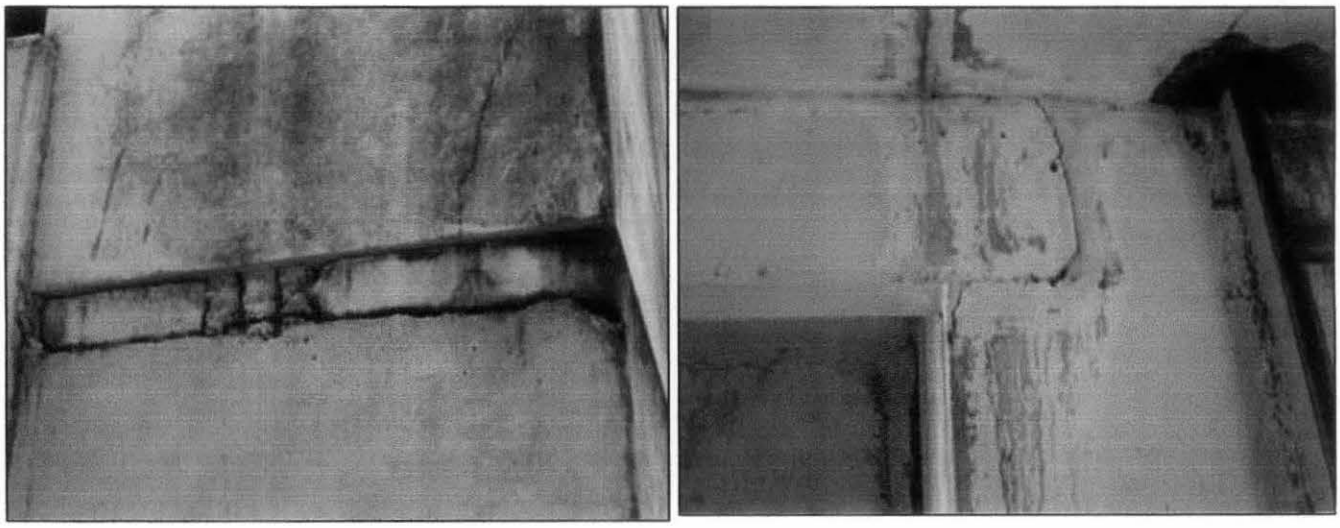


Figure 5-1: Poor Connection System Leads to Issue of Comfort and Safety

APPENDIX A

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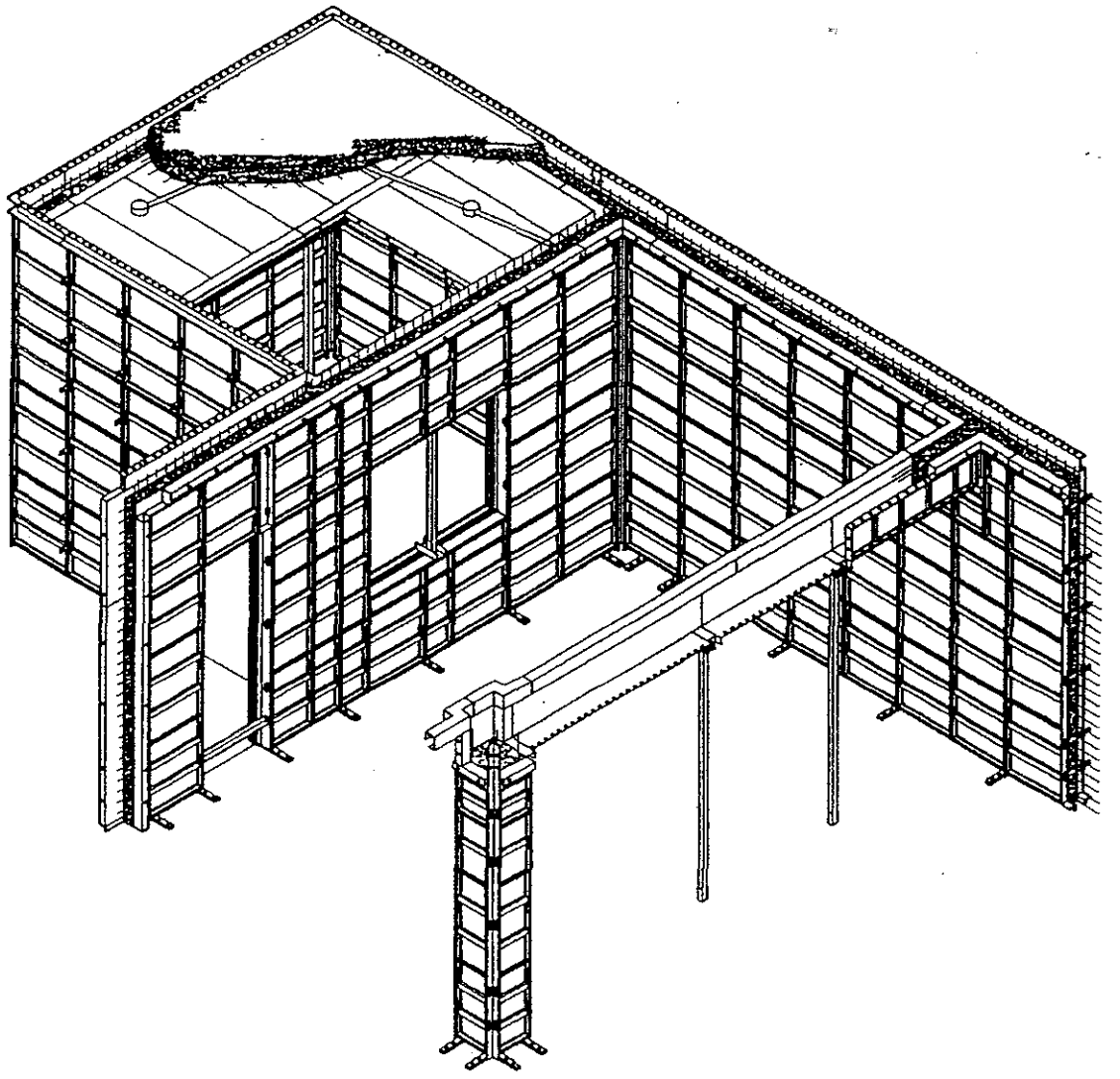
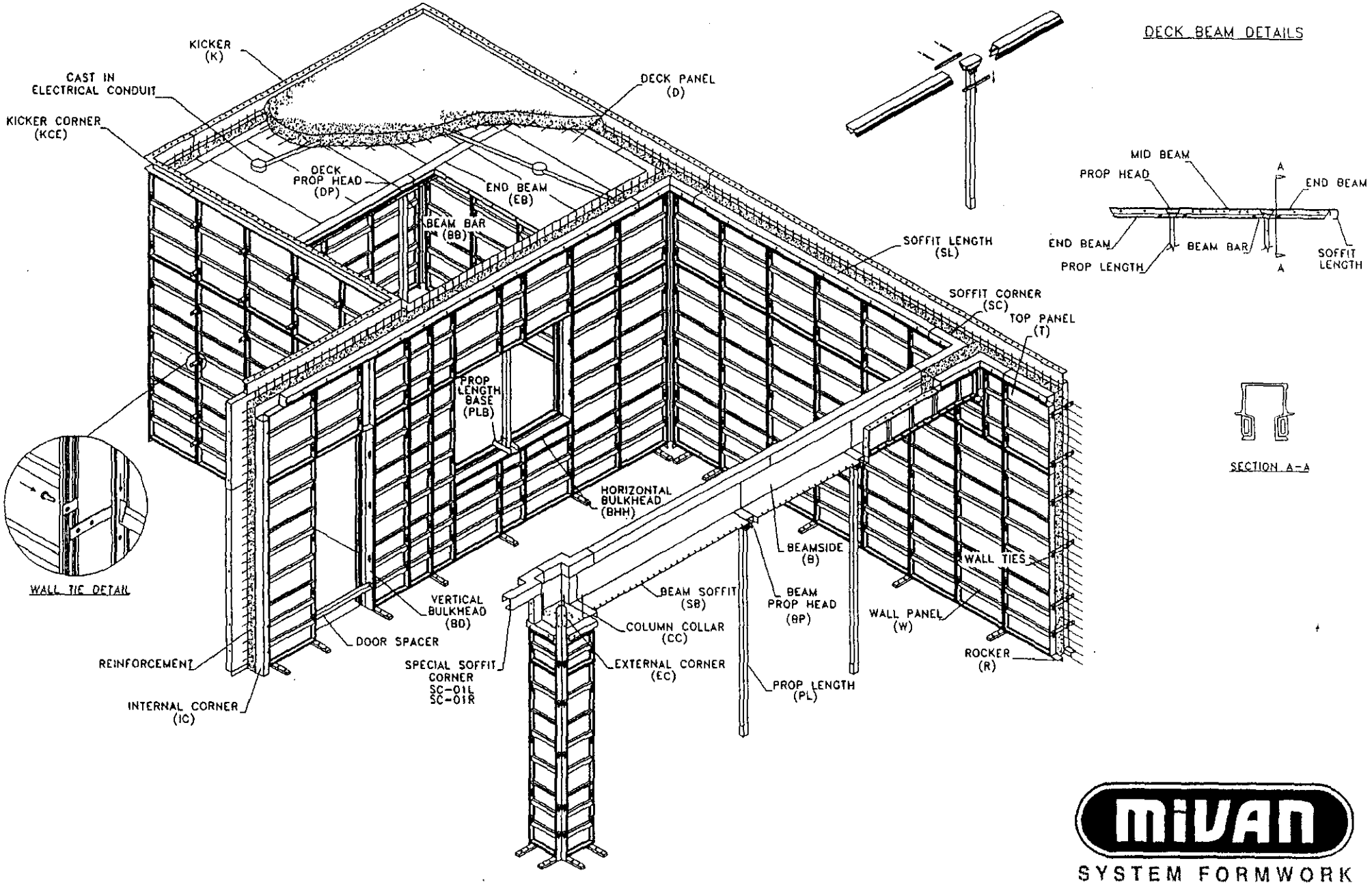
APPENDIX B

mivan
FORMWORK

FORMWORK PROCEDURES MANUAL





DECK BEAM DETAILS

SECTION A-A

miVAN
SYSTEM FORMWORK

PRE-CONCRETE ACTIVITIES

FORMWORK

2. LEVEL SURVEYS

A concrete level survey should be taken on all sites and remedial work carried out prior to the erecting of formwork.

All level surveys should be taken from a T.B.M. (Temporary Bench Mark).

A record of all surveys should be kept on file by the allocated Supervisor.

In certain cases it is good practice to mark the slabs with paint indicating a plus (+) or minus (-) as the survey is being conducted. This eliminates unnecessary circulation of paper copies to site personnel, and the Supervisor can identify at a glance any remedial work required.

High spots along the wall line to be chipped off to the proper level.
Low spots along the wall line should be packed to the required level, using plywood or timber. Packing the corner and the centre of the wall length to the required level will normally be adequate, as the formwork when pinned together will bridge across low spots.

Concrete (+8mm) and above must be chipped to the (correct level).
After concreting, level surveys should also be carried out on the top of the kickers. One reason for structural deviation from the centre line can be on a - level kicker. This in turn means the formwork is not plumb.

Kickers are manufactured with a 26mm slotted hole on the face to allow for adjustment after concreting.

As with the concrete level survey, proper records of the kicker survey should be kept on file by the allocated Supervisor.

Also a deviation survey requires to be carried out and kept on file.

PRE-CONCRETE ACTIVITIES

4. CONTROL / CORRECTING OF DEVIATIONS

A study of the deviation and kicker level survey should confirm what, if any, corrective action is required.

If the kicker requires adjustment for level, loosen the holding - in bolt by turning anti-clockwise, adjust kicker to the required position and retighten the bolt.

Once the vertical formwork is fixed in position, the external corners should be checked for plumbness. This will determine if further action is required to control the deviation.

In addition to the kicker levels, the formwork can be pulled by using bottle screws and chain blocks. If the formwork requires to be pushed adjustable props can be used.

METHOD OF ERECTING FORMWORK

It is important maximum efficiency to define a sequence of erection to be followed by each team. One side is erected using only on upper and lower pin and wedge connection. Later, ties are inserted at the other connections and fixed with pin and wedge. Then the previously installed pins is removed and those ties inserted and pinned. Subsequently, panels for the other side are inserted between the existing ties and fixed with pins and wedges.

The Advantages of This Erection Method Are As Follows :-

(1) Rooms can be closed and squared by assembling only one side of wall panels. If misaligned, it is easier to shift rows of single panels.

(2) If steel reinforcement is likely to interfere with the placement of the ties, it can be seen and corrected without delaying the panel erection.

(3) Enables fast start up of deck teams as the first rooms can be closed quickly.

(4) Continuous steel reinforcement for the walls, creates a barrier between the two sides of the formwork, so the work proceeds at the pace of single erector.

Special care must be taken at the lift shafts. The interior panels will align properly on their own because they are set on the kicker from the formwork below. Ensure the kickers are level and will not effect the verticality of the lift shaft. However, the matching panels are set on the concrete that may not be level. If the concrete is too high in place, it can distort the alignment of the four sides of the lift shaft and must be broken out to allow a level base.

Care must be taken so that the concrete and in particular the reinforcement does not become contaminated due to excessive or negligent application of the releasing agent.

The ends of walls and door openings should be secured in position by nailing timber stays to the concrete slab. Walls require to be straightened by using a string line and securing in place by nailing timber stays to the concrete slab. During this operation verticality of door openings also require to be checked for plumb. Where possible, door spacers should be fitted.

7. SETTING KICKERS

Where there is a continuous vertical wall, e.g. lift shaft, external face of the building etc., a kicker forms the perimeter of the slab and also acts as the connecting component for the vertical formwork on the next level.

After casting of the first level of formwork, two levels of kicker are required, one coming off the previous floor to which the formwork is fixed and the other fixed to the top of the wall formwork which forms the perimeter of the slab.
This kicker remains in place after concreting and is used to start the wall form on the next level.

Connecting Kickers To Wall Panels

Ensure kickers are properly cleaned and oiled prior to fixing in position. To prevent the pin being dislodged during concreting, pins should be inserted in a downward direction through the bottom rail of the kicker and top rail of the wall panel.

Kickers are manufactured with a 26mm x 16.5m vertical slotted hole. Prior to concreting, a 16mm dia M.S bolt is fixed to the kicker, located tight to the bottom of the slot. This bolt remains fixed to the casted concrete with a flat washer and nut to act as anchor. After concreting the slotted hole allows for an adjustment if required for improvement on the level of the kicker, which also controls the verticality of the formwork.

Aligning Kickers

Kickers should be checked for alignment using a string line : A straight kicker will ensure the wall on the next level is also straight.

The method used to align kickers.

Steel vertical soldiers fixed in place using a tie-rod, through the cast in PVC sleeve, which will be used later for the fixing of the wall mounted scaffold brackets.

Where the end of two kickers meat, a B.K.S. (strap across the top of the kickers) should be used, keeping the two adjoining components flush.

DURING CONCRETING

9. STAND BY DURING CONCRETING

At least two operatives should be on stand by during concreting, to cover both sides of the wall being casted. During concreting, the ideal position is slightly in front of the pour, checking pins, wedges and wall ties as the pour is in progress.

Pins, wedges or wall ties missing could lead to a movement on the formwork and the possibility of the formwork being damaged. This effected area will then require remedial work after striking of the formwork.

Things to look for during concreting :-

(a) Dislodging of Pins/Wedges due to vibration.
(b) Beam/Deck props adjacent to drop areas slipping due to vibration.
(c) Ensure all bracing at special areas stays intact.
(d) Overspill of concrete at window openings etc.

Operatives on stand by should have the following equipment (at hand) :-

(a) Pins and Wedges
(b) Adjustable props
(c) Masonary nails
(d) Joinery saw and hammer
(e) A few lengths of timber for additional bracing, (if required).

The first panel in a row is the most difficult to remove as it is also held by the adjacent panels. If properly cleaned and oiled prior to concreting and using the panel pullers provided, the panels will come away with ease.
The remainder of the wall panels on this wall will strike easily by breaking the bond to the adjacent panel using the panel puller as mentioned above.

To strike internal corners the wall ties are removed first as the wall ties prevent the removal of the internal corner.

As the wall panels are being removed, removal of the wallties can commence. The same situation applies to the sleeves as to removal of the wall ties, the sooner they are extracted from the wall the less time consumed. Also less damage will occur therefore maximum uses can be achieved per sleeve.
Sleeves are removed by using long nose pinch pliers. Ensure the sleeves are being stored in a proper container when removed and returned to the preparation location as they can be prepared for the next use.

When moving the formwork to the next area, proper stacking of panels is a clear sign of a well run operation. Stacking at the right place and in the right order greatly benefits the following erection work, and prevents clutter that impedes all activities.

Striking of the external walls also requires urgent attention to enable the installation of the working platform bracket.

POST CONCRETING ACTIVITIES

12. CLEAN, TRANSPORT AND STACK FORMWORK

Cleaning

All components should be cleaned with scrapers and wire brushes as soon as they are struck. Wire brush is to be used on side rails only.
The longer cleaning is delayed, the more difficult the task will be.
It is usually best to clean panels in the area where they are struck.

Transporting

There are 3 basic methods recommended when transporting to the next floor level :-

(a) The heaviest and longest which is full height wall panels can be carried up the nearest stairway.

(b) Passed up through void areas.

(c) Raised through slots specially formed in the floor slab for this purpose. Once they have served their purpose they are closed by casting in a concrete filler.

Striking

Once cleaned and transported to the next point of erection, panels should be stacked at the right place and in the right order.
Proper stacking is a clear sign of a well managed operation and greatly aids the next sequence of erection as well as preventing clutter and impeding other activities.

POST CONCRETING ACTIVITIES

14. STRIKE WALL - MOUNTED WORKING PLATFORM

The lower level of scaffold must be struck on the day of casting the floor above, and prepare for fixing the following day.

Safety should be the priority in everyone's mind during this operation, first principle is to ensure the working platform is free from any debris.

One member of the team should be on the working level above to receive the material from the level below. Another team member should be on the lower level and it is **COMPULSORY** this person wears an approved **Safety Harness and Fall Arrest Block.**

The Fall Arrest Block is attached to the bracket above, using a quick release shackle. The Fall Arrest Block will be moved to its next fixing point by the helper on the level above.

Remove the toe-board and decking, passing them to the helper above. This is followed by the removal of the handrail.

The scaffolders must ensure that no part or parts are left partially removed, as this will endanger themselves and their fellow workers.

Another section of the team will follow behind to remove the scaffold brackets and the same crew will be responsible for fitting the scaffold bracket on the next level.

As there are two complete levels of scaffold brackets, one team member will be on the upper level and another inside the building on the level below.
The worker on the upper level will require a rope attached to a S type steel hook which he will hook to the scaffold bracket below.

The worker inside the building will then commence to unscrew and remove the tie nut, thus releasing the scaffold bracket, and allowing the worker holding the rope on the upper level, to gently raise the rope while the tie rod is being gently knocked through from the inside, until the bracket is completely free from the building. At this stage, the safety bracket is pulled to the next level in preparation for fixing to the level above.

INSTRUCTIONS

16. TO BE IMPOSED ON EVERY WORKER, ARE THE FOLLOWING THINGS NOT TO BE DONE

* Do not lay bottom panel contact face down, when starting a stack
* Do not drop equipment from any height
* Do not use panels as ramps, bridges or scaffold
* Do not use hammer and wedge to pull panels together
* Do not drive wedge until full length of panels are butted together
* Do not use extreme hammer force when installing wedges
* Do not erect elements not properly cleaned and oiled
  (Deck panel faces are oiled after erection)

SAFETY

(a) Ensure all scaffold brackets are in good condition and have not been damaged since the last installation.

(b) Ensure platform is fully decked out and toe-board and handrail installed.

(c) Penetration holes in the slab for transferring panels must be covered when not in use until cast with concrete.

(d) Any workers working above platform level must wear safety belt attached to a secured formwork component or the wall steel.

(e) When removing of the timber batons from the floor after casting ensure no nails have been left exposed.

(f) Pins and wedges to be removed with care especially on the external of the building.

(g) Handling of equipment.

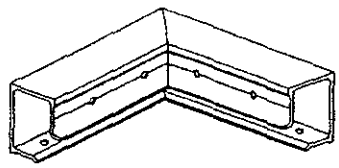
(h) Formwork not to be stacked on the scaffold.

WALL COMPONENTS

FORMWORK

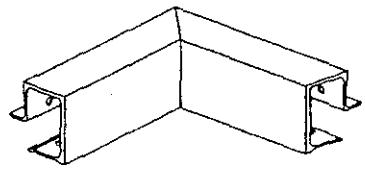
OTHER COMPONENTS

MiVAN FORMWORK



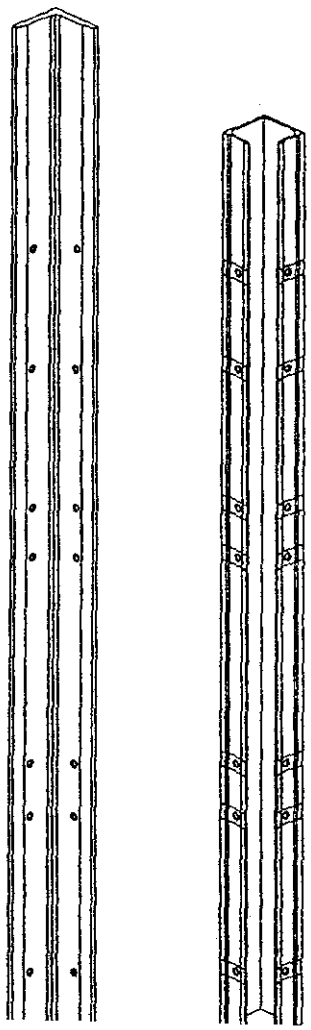
INTERNAL SOFFIT CORNER

The Internal Soffit Corner forms the vertical internal corner between walls and/or beam faces and horizontal internal corners between wall/beam face and soffit of slabs.



EXTERNAL SOFFIT CORNER

The External Soffit Corner forms the vertical external corner between walls and/or beam faces and horizontal external corners between wall/beam face and soffit of slabs.



EXTERNAL CORNER

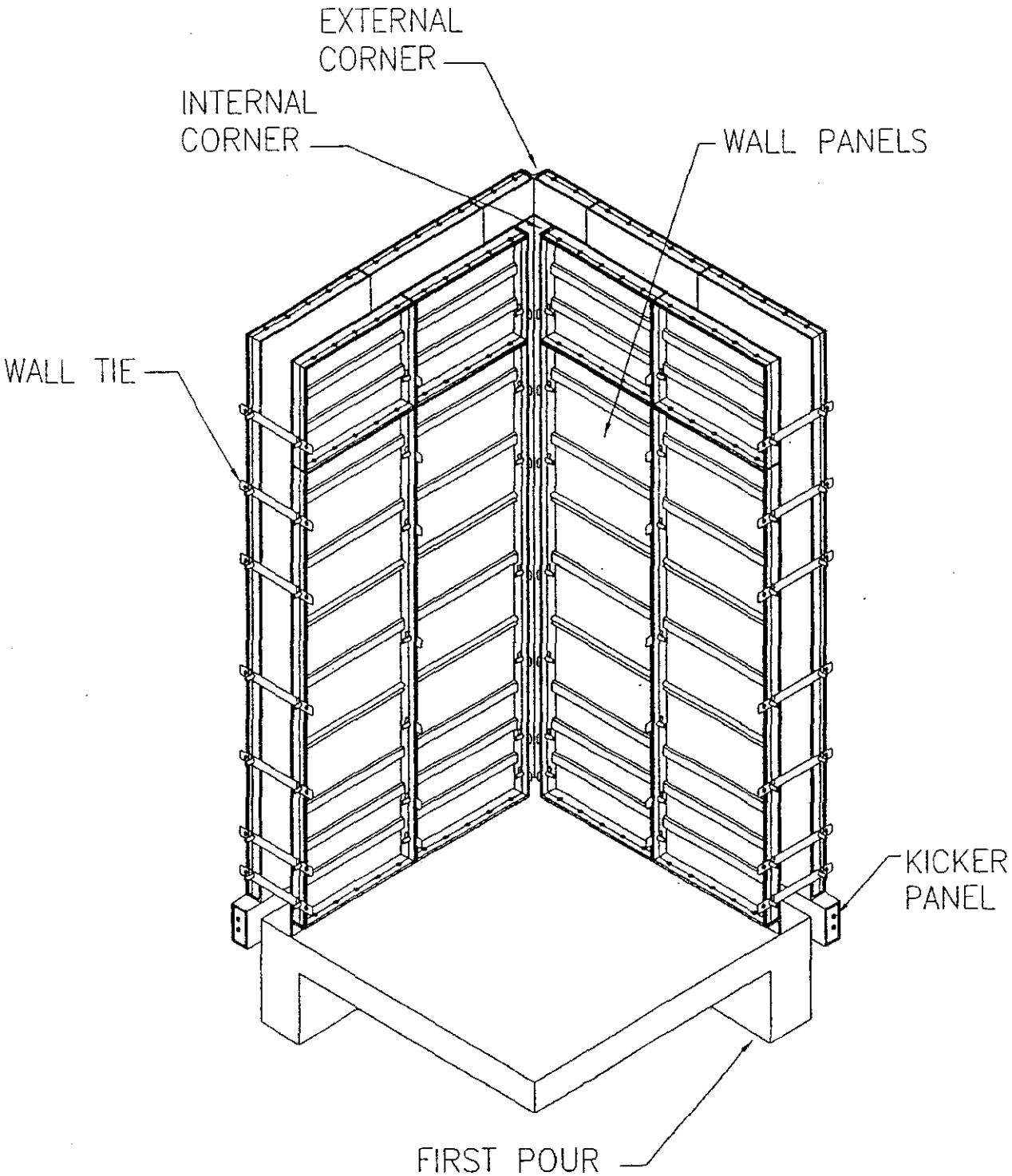
The External Corner connects vertical or horizontal formwork together at right angles.

INTERNAL CORNER

The Internal Corner connects 2 pieces of vertical formwork together at their internal intersection.

WALL ASSEMBLY DETAIL

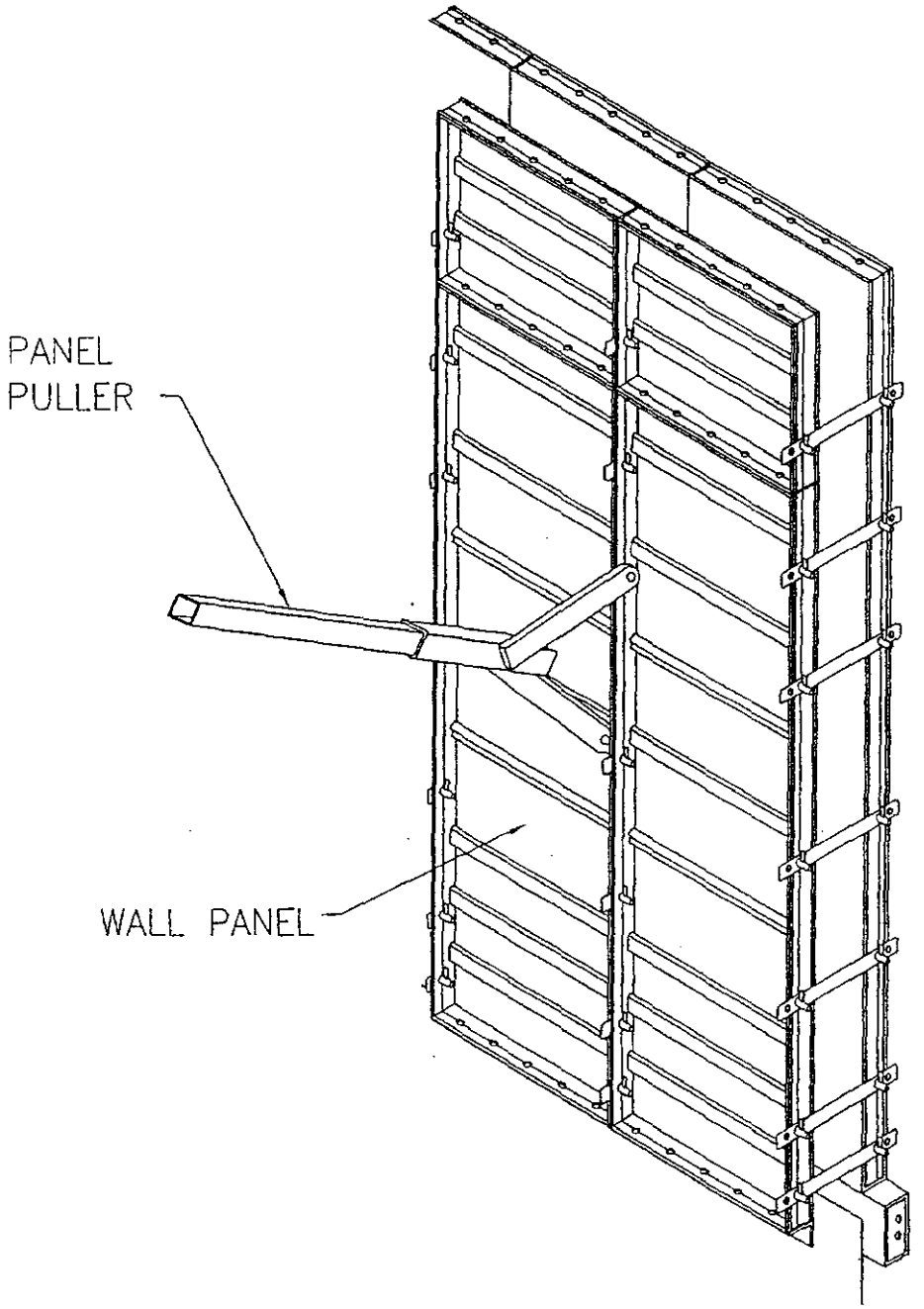
MIVAN
FORMWORK



PANEL-PULLER

FORMWORK

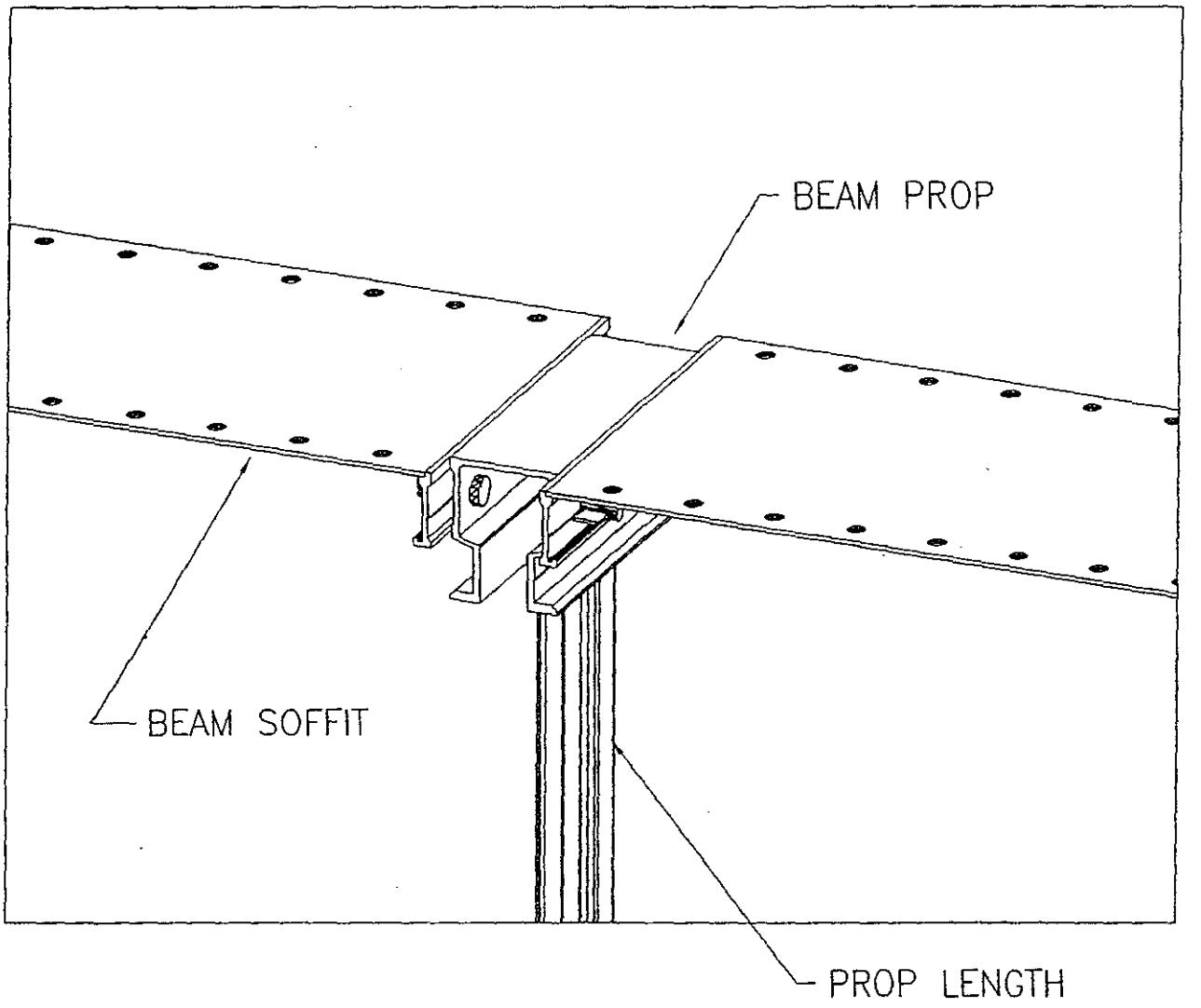
The Panel Puller is used to aid striking of the wall formwork. One of the circular lugs is inserted into one of the panel holes. The other lug rests on the outside of the adjacent panel. Force is applied downwards on the Panel puller which in turn forces one of the panels away from the other.



BEAM ASSEMBLY DETAIL 1

MiVAN
FORMWORK

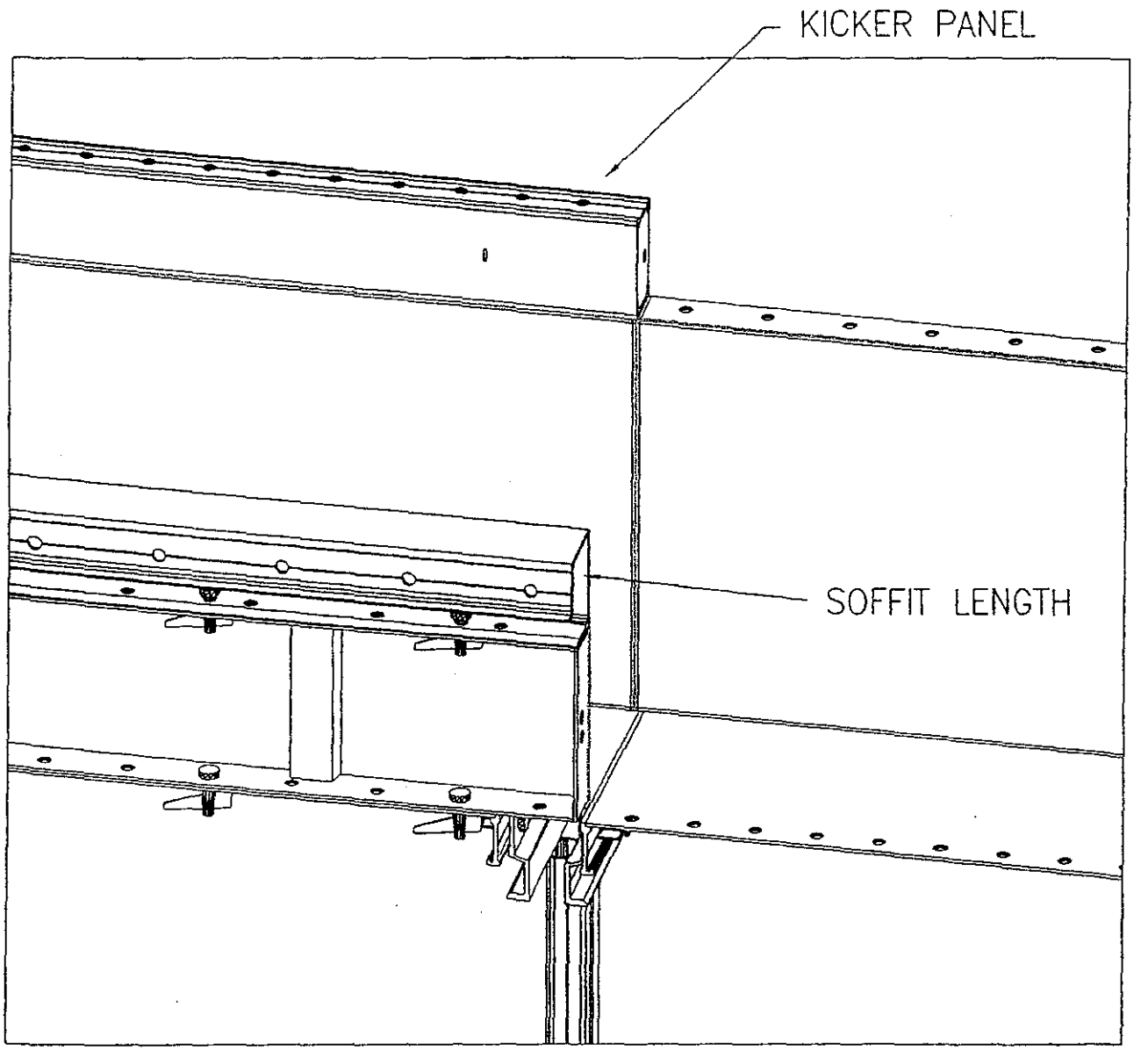
The first stage of erecting the beam and slab formwork is to connect the beam prop to the prop length. The beam soffit panels are then connected to the beam prop using pins and wedges.



BEAM ASSEMBLY DETAIL 3

MiVAN
FORMWORK

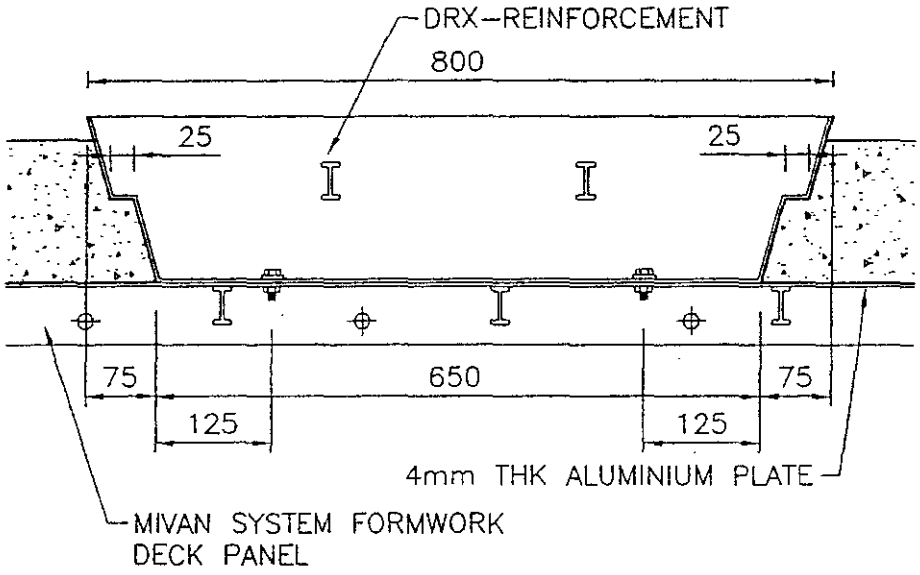
Next the kicker panels and soffit panels are fixed. The soffit panels provide a means of support for the deck panels and aligns the beam sides.



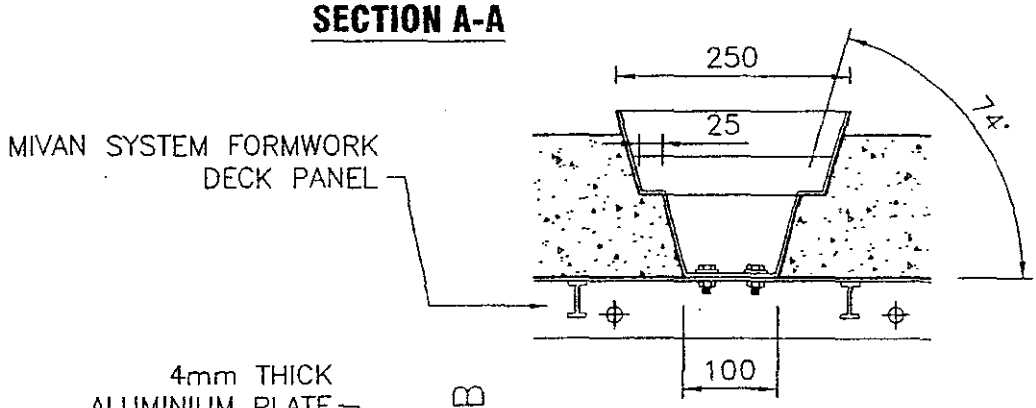
SLAB BOX-OUT DETAIL

MIVAN FORMWORK

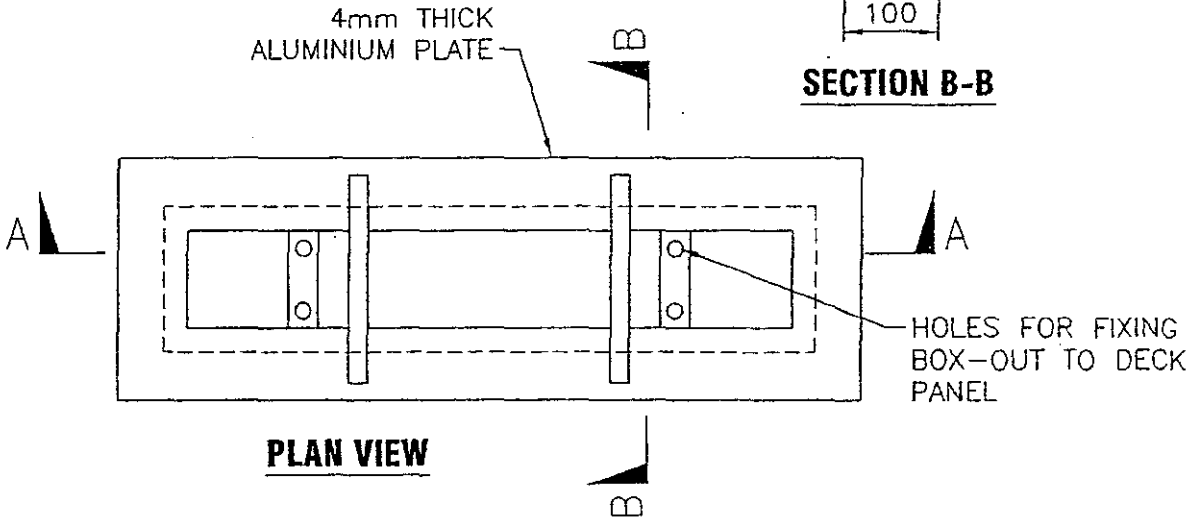
This detail shows a typical slab box-out. The box-out is used to form an opening in the slab to allow easy handling of formwork to the next floor. Similar box-outs can be manufactured to any dimension to form other voids in the slab.



SECTION A-A

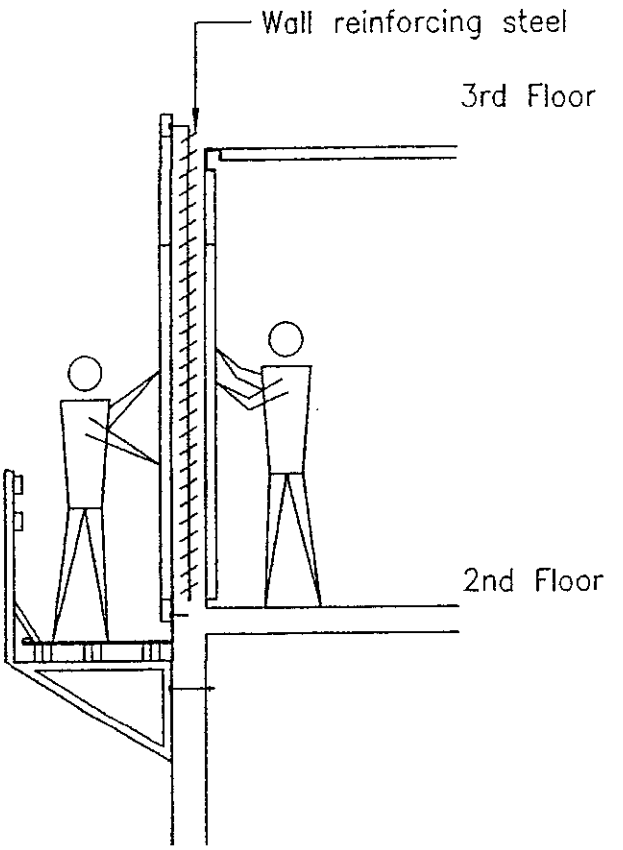


SECTION B-B



PLAN VIEW

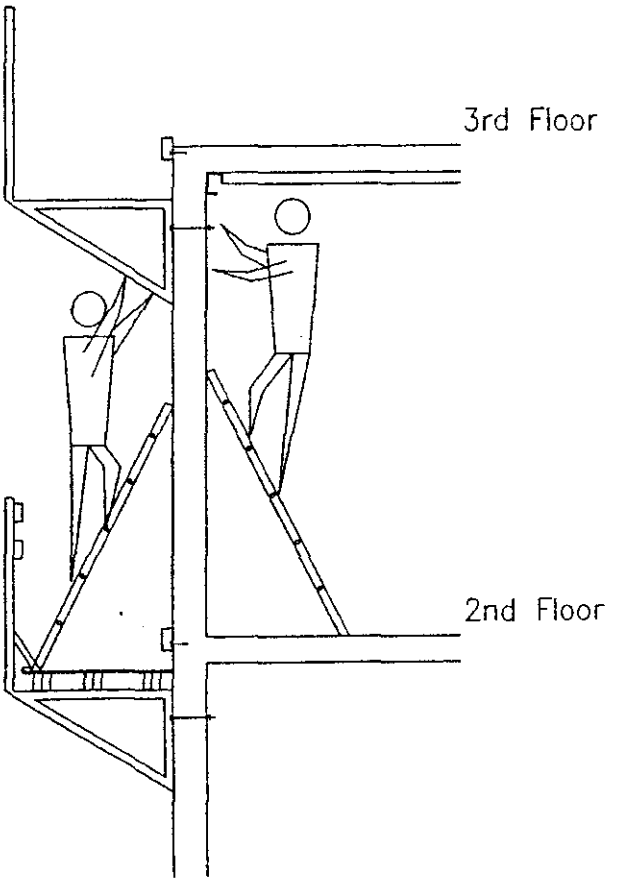
SEQUENCE No. 1



ACTIVITIES :

1. Erect all formwork on 2nd floor.

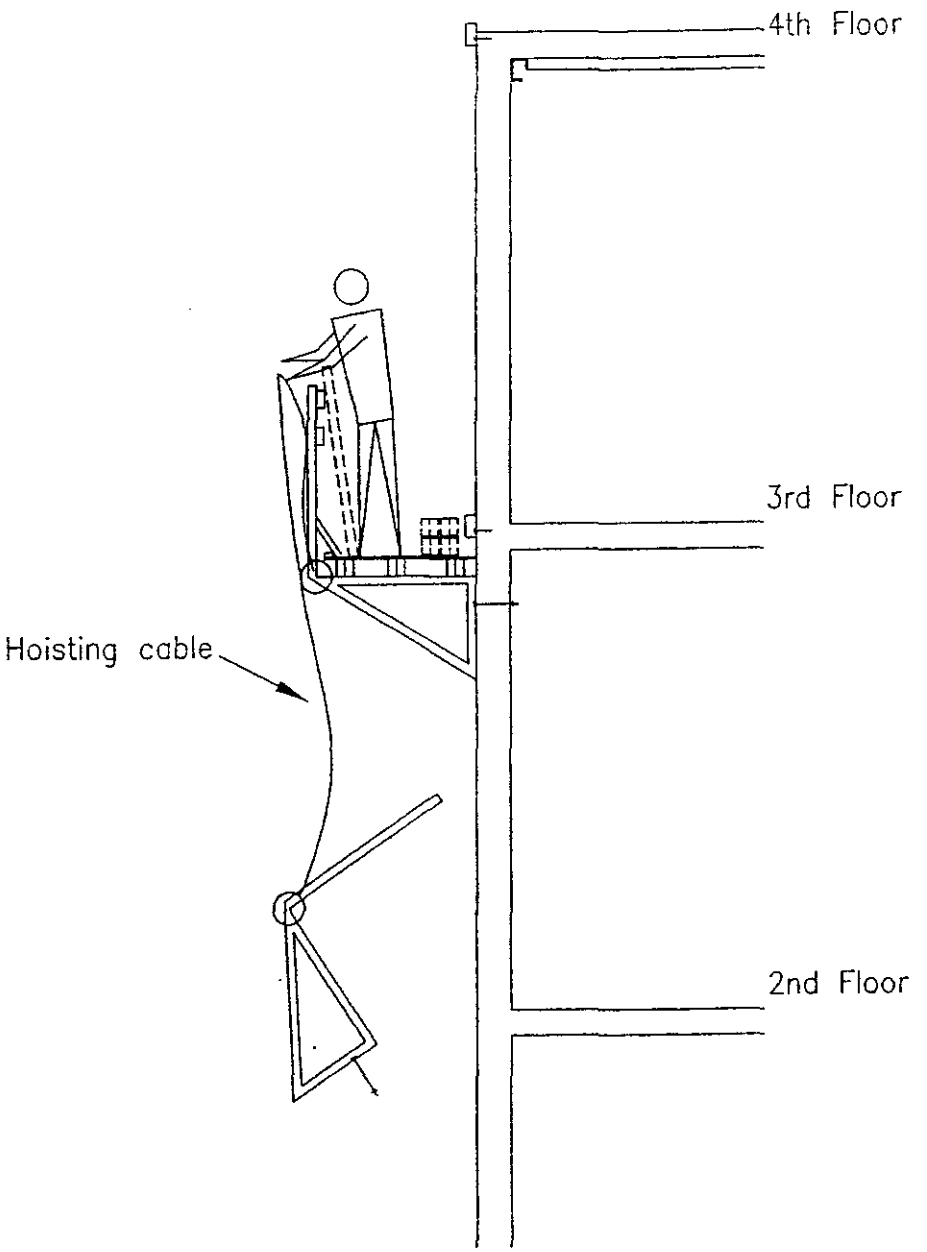
SEQUENCE No. 3



ACTIVITIES :

1. Position working platform bracket on 3rd floor level and secure nuts on tie rod on inside of building

SEQUENCE No. 9



ACTIVITIES :

1. Hoist 2nd floor working platform bracket up to 3rd floor level.
   (Brackets weigh about 16kg each)

DAY NUMBER		1	2	3	4	5	6	7	8	9	10	11	12
LOCATION / ACTIVITIES		LEVEL 1 WALLS + LEVEL 2 SLAB				LEVEL 2 WALLS + LEVEL 3 SLAB				LEVEL 3 WALLS + LEVEL 4 SLAB			
FLOOR SECTION A													
Set Out, Wall Seel & 1st Fix M. & E	1	Wall Steel				Wall Steel				Wall Steel			
Strike Wall Formwork	2					Strike Walls				Strike Walls			
Erect Wall Formwork	3		Erect Walls				Erect Walls				Erect Walls		
Strike Deck Formwork	4						Strike Decks				Strike Decks		
Erect Deck Formwork	5		Erect Decks				Erect Decks				Erect Decks		
Deck Steel & 1st Fix M. & E	6			Deck Steel				Deck Steel				Deck Steel	
Concrete Wall & Deck	7				Pour				Pour				Pour
Strip & Re-erect Props	8		Props 1				Props 2				Props 1		
			Level 1 Walls + Level 2 Slab				Level 2 Walls + Level 3 Slab				Level 3 Walls + Level 4 Slab		
FLOOR SECTION B													
Set Out, Wall Seel & 1st Fix M. & E	9		Wall Steel				Wall Steel				Wall Steel		
Strike Wall Formwork	10						Strike Walls				Strike Walls		
Erect Wall Formwork	11			Erect Walls				Erect Walls				Erect Walls	
Strike Deck Formwork	12							Strike Decks				Strike Decks	
Erect Deck Formwork	13			Erect Decks				Erect Decks				Erect Decks	
Deck Steel & 1st Fix M. & E	14				Deck Steel				Deck Steel				Deck Steel
Concrete Wall & Deck	15					Pour				Pour			
Strip & Re-erect Props	16			Props 1				Props 2				Props 1	
				Level 1 Walls + Level 2 Slab				Level 2 Walls + Level 3 Slab				Level 3 Walls + Level 4 Slab	
FLOOR SECTION C													
Set Out, Wall Seel & 1st Fix M. & E	17			Wall Steel				Wall Steel				Wall Steel	
Strike Wall Formwork	18							Strike Walls				Strike Walls	
Erect Wall Formwork	19				Erect Walls				Erect Walls				Erect Walls
Strike Deck Formwork	20								Strike Decks				Strike Decks
Erect Deck Formwork	21				Erect Decks				Erect Decks				Erect Decks
Deck Steel & 1st Fix M. & E	22					Deck Steel				Deck Steel			
Concrete Wall & Deck	23						Pour				Pour		
Strip & Re-erect Props	24				Props 1				Props 2				Props 1
					Level 1 Walls + Level 2 Slab				Level 2 Walls + Level 3 Slab				
FLOOR SECTION D													
Set Out, Wall Seel & 1st Fix M. & E	25				Wall Steel				Wall Steel				Wall Steel
Strike Wall Formwork	26								Strike Walls				Strike Walls
Erect Wall Formwork	27					Erect Walls				Erect Walls			
Strike Deck Formwork	28									Strike Decks			
Erect Deck Formwork	29					Erect Decks				Erect Decks			
Deck Steel & 1st Fix M. & E	30						Deck Steel				Deck Steel		
Concrete Wall & Deck	31							Pour				Pour	
Strip & Re-erect Props	32					Props 1				Props 2			

LEGEND : Wall Steel | Strike Walls | Erect Walls | Strike Decks | Erect Decks | Deck Steel | Pour Concrete | Props

1 SET OF WALLS | 1 SET OF DECKS | 2 SETS OF PROPS