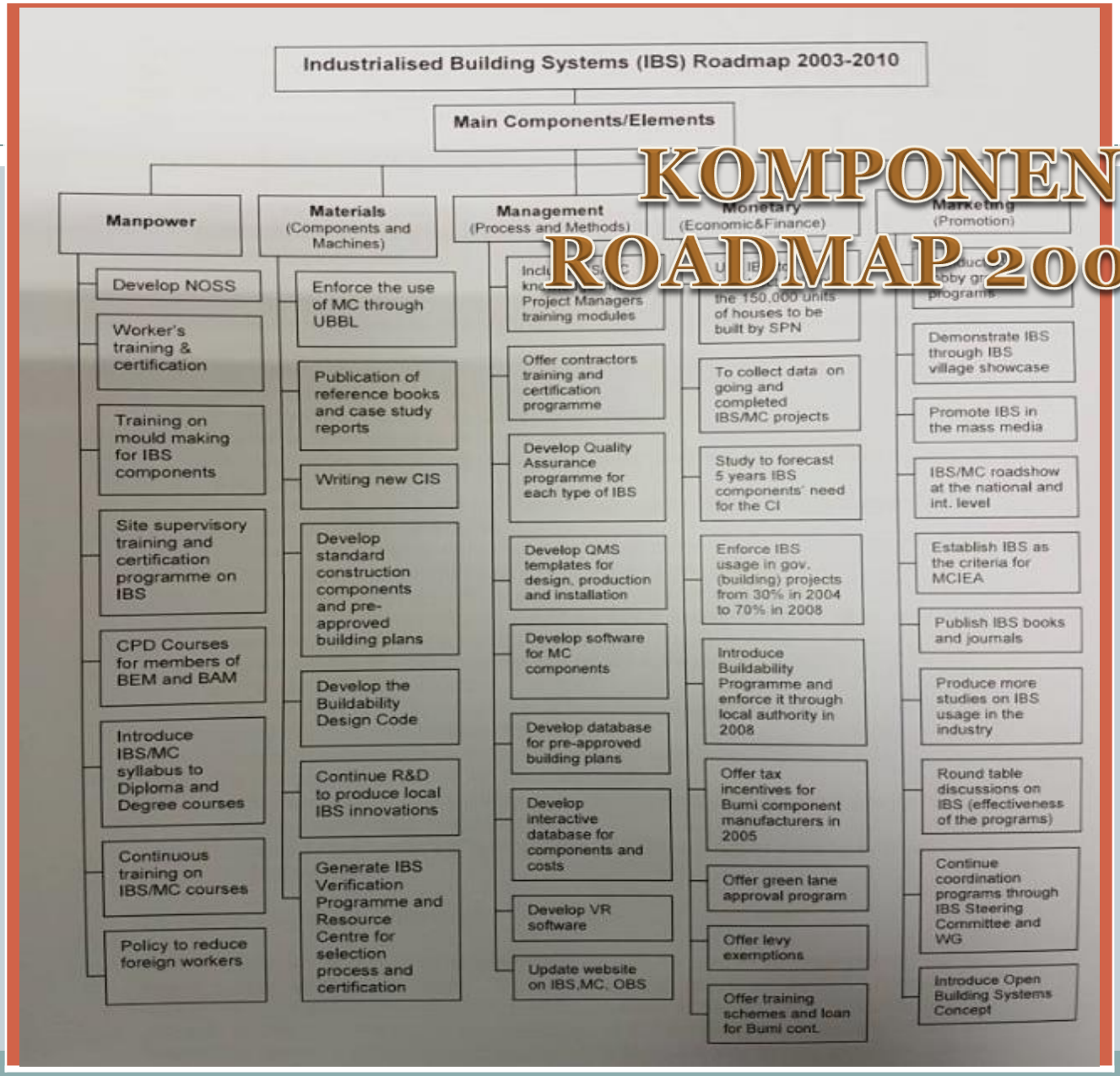
Ir. Mohd Azhari b Mohd Salleh
JAPK, Cawangan Kejuruteraan Awam dan Struktur,
Ibu Pejabat JKR Malaysia
Midvalley

ISU-ISU IBS SEBELUM PERLAKSANAAN..

Realising the implementation of IBS is still to make headway, CREAM has taken the initiative from the problem identified earlier and has conducted three workshops session with the industry (Hamid, 2006). After a lengthy deliberation with the stakeholders, it was concluded that the factors contributing to the delays of IBS implementation are as follows:

- Not popular among design co[illegible]
- Lack of knowledge among des[illegible]
- Mindset change and Education
- Cost more – chicken and egg problem
- Private sector adoption
- Proprietary systems make it hard to be adopted by designers
- Poor quality products
- Joints are not standardised making it hard to design as the design will have to be fixed to a particular manufacturer
- Push factor
- Lack of technical know-how e.g. structure
- Recent development – Earthquake resistance design
- Volume and economy of scale
- Monopoly of big boys, limiting opportunities to Bumiputera contractors. Need training for Bumiputra contractors
- Low offsite manufacturing of construction components. To guarantee quality, mechanization and standardisation
- To consider IBS design that promote energy conservation
- Sustainability of construction industry, Govt. to lead during downturn
- Require onsite specialised skills for assembly and erection of components
- Lack of special equipments and machinery which hampered work. More local R&D, Support Services, Technologies and Testing Labs
- Capacity building for contractors to secure project in construction (G1-G7)
- How to use IBS in their projects
- Below 10% IBS construction involvement from Bumiputera contractors
- Lack of knowledge and technology background
- Mismatch between readiness of industries with IBS targets by CIDB
- The cost depends on volume and types of projects
- Earthquake resistant design pertaining to IBS components (e.g jointing system, seismic performance and design guidelines)
- Earthquake protection of IBS buildings (base isolation and rubber damping systems)
- No standard joint

KOMPONEN IBS ROADMAP 2003-2010



General principles of IBS

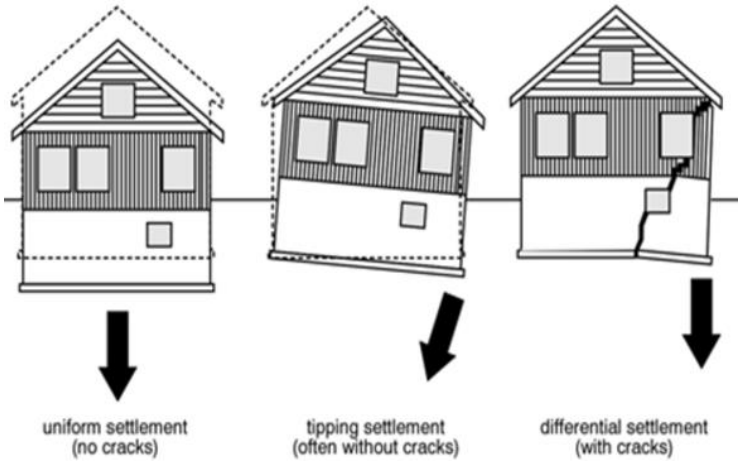
1. Industrial production of components; prefabrication; pre-cast (under controlled environment, can be in factory/site)
2. Labour reduction
3. Open building system – standard components; Moduler Coordination: MS1064

IBS COMPONENTS AND SCORE

- Add IBS Score tables and formula

Untidy construction site

IBS failures



Clean, well organised site

PERLAKSANAAN IBS

- The use of IBS has been made compulsory in the construction of public buildings and the adoption was supported by the government through programmes, incentives and encouragement policies stipulated under the IBS Roadmap 2003-2010. Despite acknowledging its benefits, the construction industry is still not rapidly embracing IBS. This is mainly due to its traditional and conservative nature where anything new or different faces implementation barriers. In addition, there is a lack of knowledge to help traditional contractors to successfully transform to IBS.

CRITICAL SUCCESS FACTORS (CFSs)

A STUDY CONDUCTED BY CIDB

The Critical Success Factors (CSFs) to the implementation of Industrialised Building System (IBS) > (points 1 -4)

Good working collaboration will solve the problem related to complex interfacing between systems and ensure efficient process sequence in manufacturing plant and at site (Pan et al2007, Na and Liska, 2008; Haas and Fangerlund, 2002). ***e.g: Singapore approach***

Effective communication channel across the supply chain need to be established in order to coordinate the process and deal with critical scheduling from the beginning until the project completion (Pan et al, 2008; Blissmas, 2007; BSRIA, 1998) , e.g: ***SPB incl (CPM/S-curve), CDM C***

Successful implementation depends on organisation ability to expedite learning curve from one project to another (Neala et al2003). Therefore, continues improvement and learning can develop company understanding on the processes and the principal behind it as the knowledge will multiply as experience mount up (Treadway, 2006). ***Case studies, technical talks, knowledge sharings***

Coordination of design, manufacture,transportation, and installation process is vital to the success of IBS (Haas and Fangerlund, 2002; Li, 2006; Vrijhoef et al, 2002 and Lessing, 2006). 68 ***QA/QC/Method Statements***

The Critical Success Factors (CSFs) to the implementation of Industrialised Building System (IBS) > (points 5 – 8)

Key decisions on strategy, application, design, logistic and detail unit should be made as early as possible between all parties involved (Gibb, 1999 & Neale et al, 1993). It should not be used as an afterthought, or as a late solution to shorten construction time, but rather as an integral part of the design from the earliest possible stage of the project (Gibb, 1999 and Blissmas et al 2006).

Successful implementation requires an experience workforce and technical capable in design, planning, organizing and controlling functionwith respect to production, coordination and distribution of components (Warszawski, 1999).

Information and Communication Technology (ICT) is vital and reliable support tool to improve tendering, planning, monitoring, distribution, logistic and cost comparison process by establishing integration, accurate data and effective dealing with project documents (Eichert and Kazi, 2007 and Hervas and Ruiz, 2007) eg ***BIM and BEYOND BIM - VR***

It requires partnership and close relationship with suppliers and sub-contractors from the early stage of project sequences (Kamar et al2009; National Audit Office Report (2005); Pan et al 2008 & Pan et al 2007). \

The Critical Success Factors (CSFs) to the implementation of Industrialised Building System (IBS) > (points 9 – 12)

Extensive planning and scheduling of activities in advance is critical in which lead to better project performance, coordination, better scope control and ensure smooth project sequence (Haas and Fangerlund, 2002). *Eg: Well programmed CPM/Scheduling/CDM*

Improvement in procurement strategy and contracting is important in order to achieve long term success (Pan et al2007 and Pan et al2008). The negotiations, procurement and contract should allow the contractors and manufactures to contribute their knowledge, experience of design, construction and planning of the building. ***Develop a win-win contracting procedures***

Risk Management strategy is important when to offsite to deal with late design changes, late payment and contract problem (Housing Forum, 2002 and Hassim et al 2008). By assessing the potential cause of delays and disruption at all stage of the supply chain, contingency measure can be planned to minimised effect of such effort. ***Broader Risk Management outlooks***

It requires emphasis on design and process standardisation and more effective use on the concept of repetition. Products are documented in systematic ways to ensure that 69everything is repeated in the same manner for installation (Mole, 2001 and National Audit Office Report, 2005). ***Catalogue and PAPs***

The Critical Success Factors (CSFs) to the implementation of Industrialised Building System (IBS) > (points 13-16)

High demands will be raised on the management of supply chain and logistic activities(Lessing et al2005). It needs to be coordinated in a manner that allows the constructors gain the full control of the process with the intention to improve efficiencies and competitiveness (Malik, 2006). *Eg Managements off suppliers. Kilang to Site>Different supply team ie conventional and IBS , they are in different ball game*

it also depends on 'top-down' commitment and corporate motivation. This in return will ensure the right motivation and commitment from the whole team (BSRIA, 1998). ***Incentives, quality circulars, get togethers..***

Skilled labour which is supported by quality training at all level is essential to success of offsite as it is in more traditional form of construction. It requires tremendous education and training effort of trades especially people involved in those handling, positioning and erecting the finished product (BSRIA, 1998 and Thanoon, 2003). ***CIDB / factories certifications, competent staff***

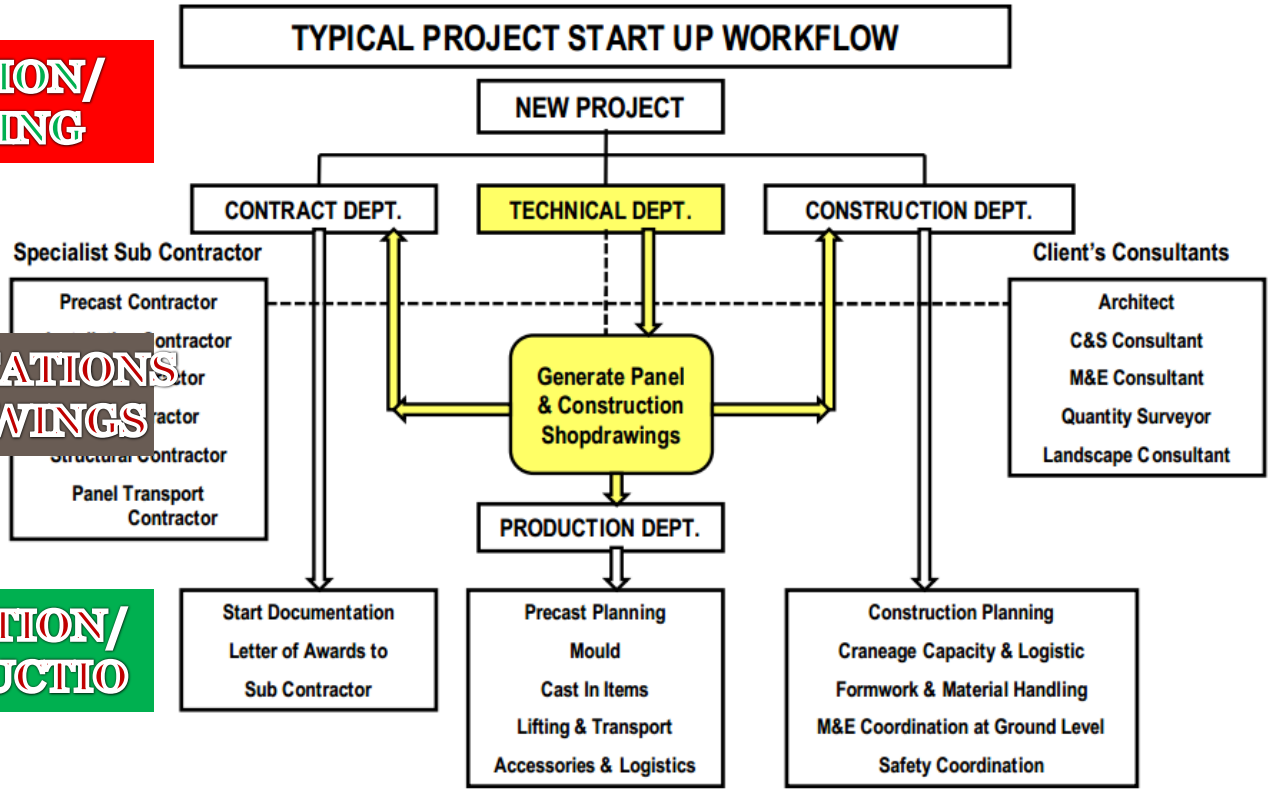
Any ventures need to strategies and business approaches and position in the new playing field (Malik, 2006). The management needs to establish clear business need in offsite and build strategic plan around it including effective combination of cost and production knowledge (National Audit Office Report, 2005).

IBS RECIPE : WORKING IN TANDEM, COORDINATED SYSTEMS

INITIATION/ PLANNING

DOCUMENTATIONS AND DRAWINGS

PRODUCTION/ CONSTRUCTION



Summary of CSFs study

‘ Strategy, people and process were identified as the main elements of the framework. The framework depends largely on the strategy, meetings of human capability and capacity, and improvements to the process. The enabling factors are Information Technology (IT) and continuous improvement. The outcome of this research showed that the main problems that are preventing contractors from embracing IBS are rarely purely technical in origin. They are more related to the organisational strategy and soft issues which underpin the capability of the organisation to successfully implement IBS. This led to the fact that IBS is best handled as a holistic process and requires a total synchronisation of construction, manufacturing and design. In addition, factors such as project management, procurement, rationalisation, standardisation, repetition, collaboration, integration, supply chain partnering, planning, skills and training were found to be essential and they need to be carefully considered during the transformation process’

IBS talk-talk

- 3S…SSS.. Standard, System IBS, Simple (simplicity)– tie IBS
- Top down commitment- start from policy.. IBS complete solution.. 1.Kilang, developer, contractor.. 2 manufacturer,, 3 manufacture dan installer dan bina.. Atau: Simpan dulu dan keluar-keluar, Precaster dan Installer, Vendor development program (eg cottage industry – eg nak buat lattice bar sahaja etc),
- Contractor lost opportunity: what government can help the new SMEs
- Skilled labour: IBS, BIM Planner, modeller, etc..
- In IBS they are Plants and Production. Kalau people– achitect mesti faham IBS, kalau designer mesti pakar shop drawings
- Strategies and business approach. Developer kata buat IBS rugi 20%. So kena secure numbers (houses) that is break even etc..
- Berapa lama boleh dapat return IBS..

1) Efficient process sequence in factory and at site

QUALITY ASSURANCE STAGES

- DESIGN (JKR, PERUNDING AND OTHERS)
- PRODUCTION/CASTING/STORAGE/ TRANSPORTATION (SYSTEM PROVIDERS/CONTRACTORS)
- CONSTN. STAGE – PREFABRICATING /INSTALLATION (CONTRACTORS)
- SUPERVISION – audit/component inspections/General requirements (JKR AND OTHERS)

QA / QC DI KILANG

NO.	ITEM	CHECKLIST			REMARKS
		YES	NO	N/A	
6	Age of precast component lifting	√			* Lifting the precast component from mould to storage yard at 15 Mpa (10 hrs) * Transport the precast component to the construction site after 7 days
7	Concrete testing	√			* Cube test day 1-28, slump test, others
8	Storage of finish product	√			* Stacking and protected
9	Precast concrete component production process	√			* Mould preparation, bar installation, concreting with vibrating, cutting, lifting, curing and transportation is carried out properly
10	Precast concrete component dimensional accuracy	√			* ± 10 mm

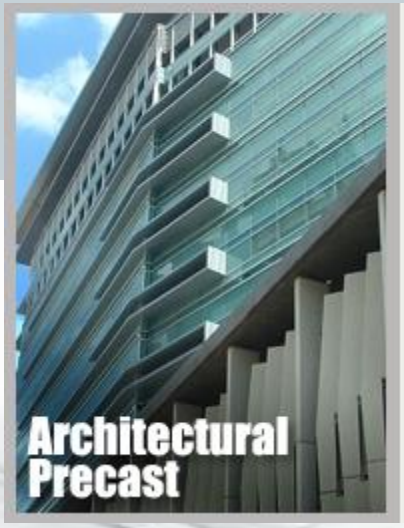
INSPECTED BY :	INSPECTED BY :

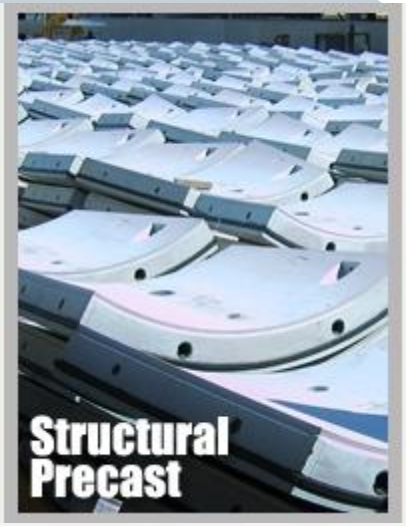
KILANG-KILANG PRECAST

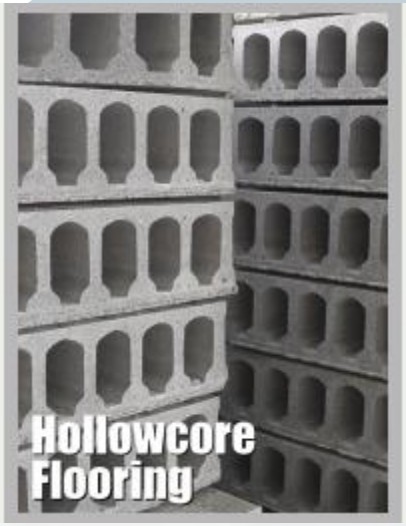
QA /QC di Kilang

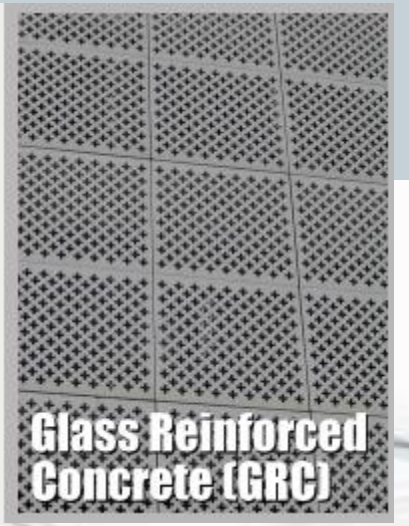
QA /QC di Kilang

PRECAST PRODUCTS





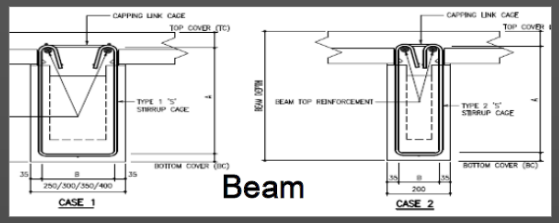




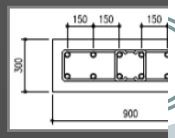
housing Facade

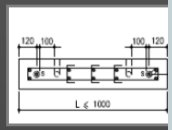
Singapore approach..

Structural Elements –Modular Dimensio



Beam





Column

S/N	Component Type	Modular Dimension
1	Beam	Width: 200,250,300mm Depth : 500,600mm with incremental of 50mm
2	Column	Width: 200,250,300mm with incremental of 50mm Length : incremental of 100mm
3	Slab thickness	125,150,175,200mm incremental sub-module of 25mm

Transformation of Site Machinery

- Provide financial incentives for contractors to procure machinery
- Improved cash flow of contractors
- Improved productivity
- Implemented Construction Quality Control Management System

MODULAR DIMENSION NG

INCREASE SITE MACHINES

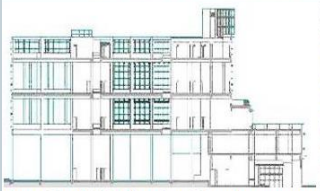
Higher and Denser Developme

Develop Precast Solution for Super High-rise Building Design

R&D In Product

Reinventing the pr
production concep

Multi-storey production facilities



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Mechanised Production Processe

Production of Flat Panels & Solid Walls

Conventional horizontal production using flat moulds

Optimisation of factory production space

Vertical Production Using Battery Mo

Productivity Improvement Thru' Wor Process Transformation....

- Encourage more adoption of market available machinery and hand tools
- Develop/customise machinery to re-engineer work processes

Develop a Customised Mechanized Materials Handling System

Further improvement to prototype:

- Stability and manoeuvrability
- Diesel powered– noise and smoke
  - Customised battery/fuel cells of suitable size & capacity
- Increase load carrying capacity

Improve Productivity of Precast Production

- **Mould cleaning and oiling**
- **Mould assembly & fixing of reinforcement**
- **Concreting and Compaction**
- **Leveling & Trowelling**

Promote Higher Level of Mechanisation & Automate The Precast Production System

Automated Precast Production System

- Very efficient for production of standardised products
- Flat and with minimum protrusion and profile
- Minimum dowels or projection bars

<u>Complementing the precast automation process</u>:

- A need to customise the production system to suit local practice

CURRENTLY

•Widths of PC Planks are highly standardised (1.0m & 2.4m)

• Planks lengths required are formed by dividers.

– Large Panel Slab (LPS)

NEW PRODUCT

Casting & de-moulding of LPS slab

High quality off form finish requires minimal touch up on site

‘Conventional’ practice

Construction Technology

Conventional Method:

- Manually tracking and coordination of delivery and installation
- Precasters deliver components basing on contractor’s demand schedule
- Tower crane & mobile cranes for handling
- Construction activities subjected to weather condition

Improvement in construction technology

Advanced Construction Technology:

- **Construction mechanisation & automation**
  - **Tools & equipment**
  - **Automation of concrete batching plants**
- **Automated building system (ABS)**
- **Computerised & Integrated Construction Management System**

Automation of building system

Explore Ways to Improve PC Installation & Hoisting Operations

- Computerised crane system that integrated with assembly and precast plants.
- High capacity pc components lifting hoist

Computerised crane and hoisting

C D M

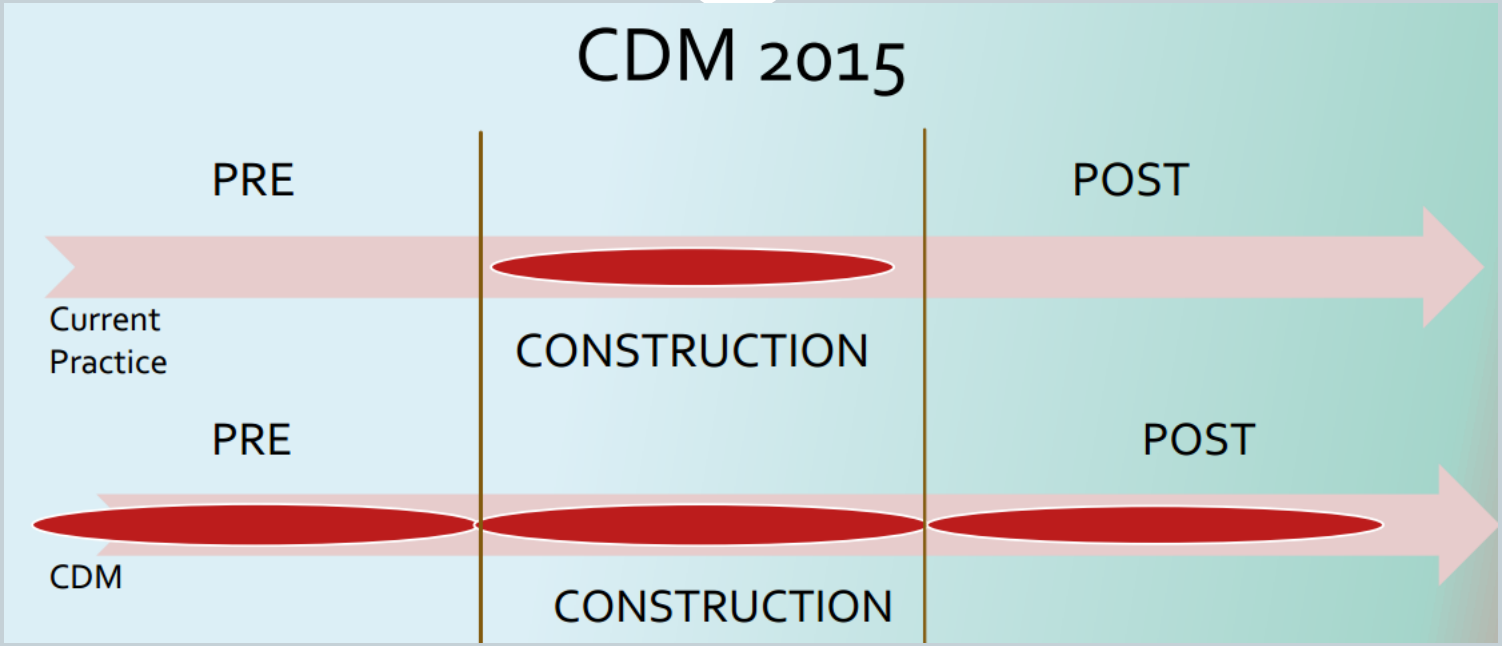
- The Construction (Design and Management) Regulations (CDM) are the main set of regulations for managing the health, safety and welfare of construction projects.

- 6th April 2015,the Construction (Design and Management) Regulations 2015 replaced the 2007 Regulations.

CDM

- Osha (occupational and safety health act) requires for projecr below 20mil must have SSS, for project above 20 mil must have safety and heath officer SHO
- Employ right people (designers, contractors and team members) at the right time
- Constrcuction all modes but especailly IBS are high risks and accidents will cause delay because precast components in IBS especially requires additional large machineries and crainage for lifting and installations.. Whose to blame when an accident happen on.. Of course the contractor.
- competent designers and stakeholders

CDM – SAFETY IN MIND



Complying with CDM 2015:

- No-one is harmed during the work.
- Building is safe to use and maintain while giving you good value.
- Effective planning will also help ensure that your work is well managed with fewer unexpected costs and problems.

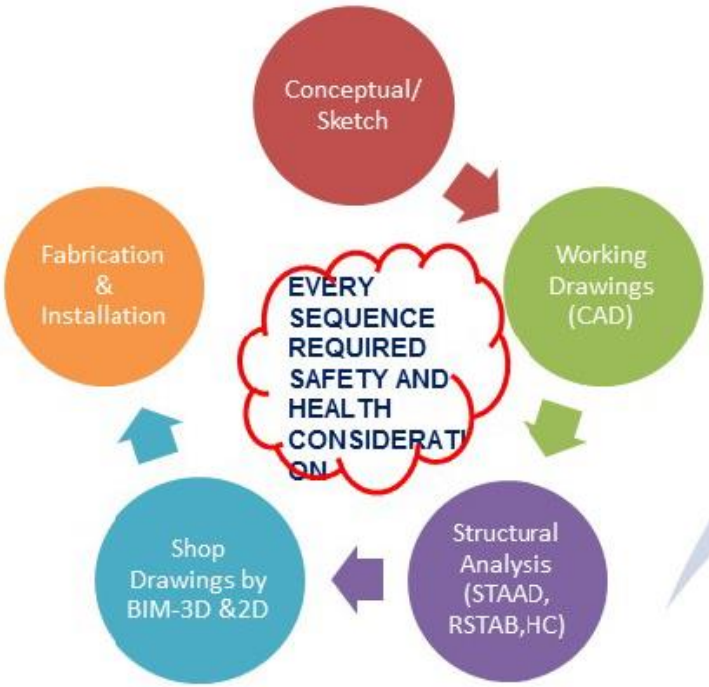
What is CDM 2015 about?

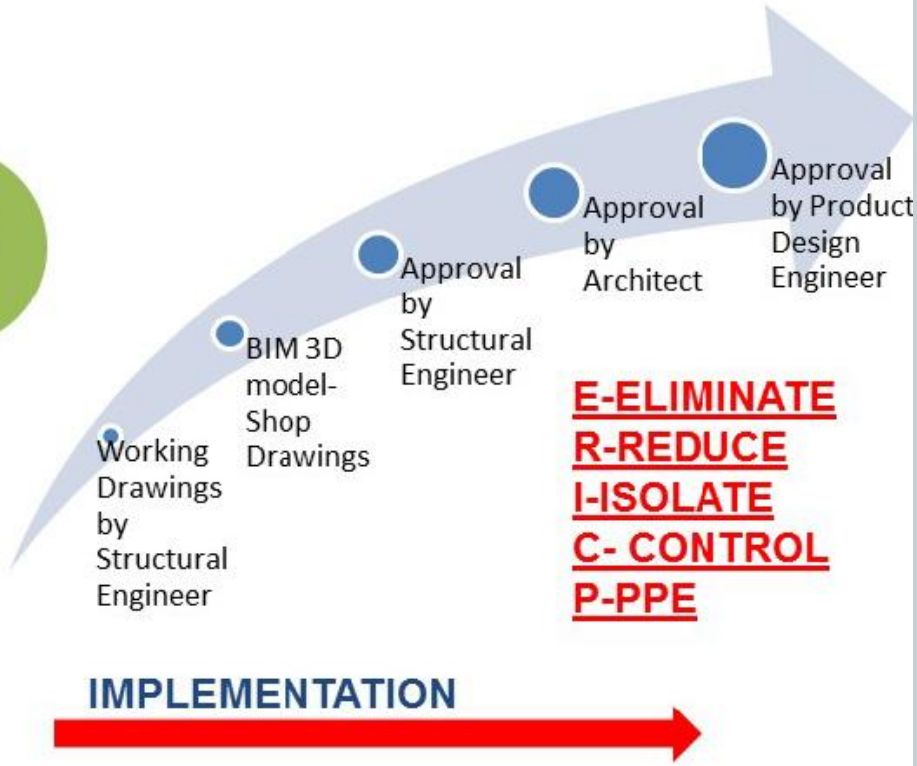
- CDM 2015 applies to all construction work.
- The Regulations set out the requirements for managing health and safety on construction PROJECTS
- A project is more than a construction site

Designer's Roles and Responsibilities in CDM

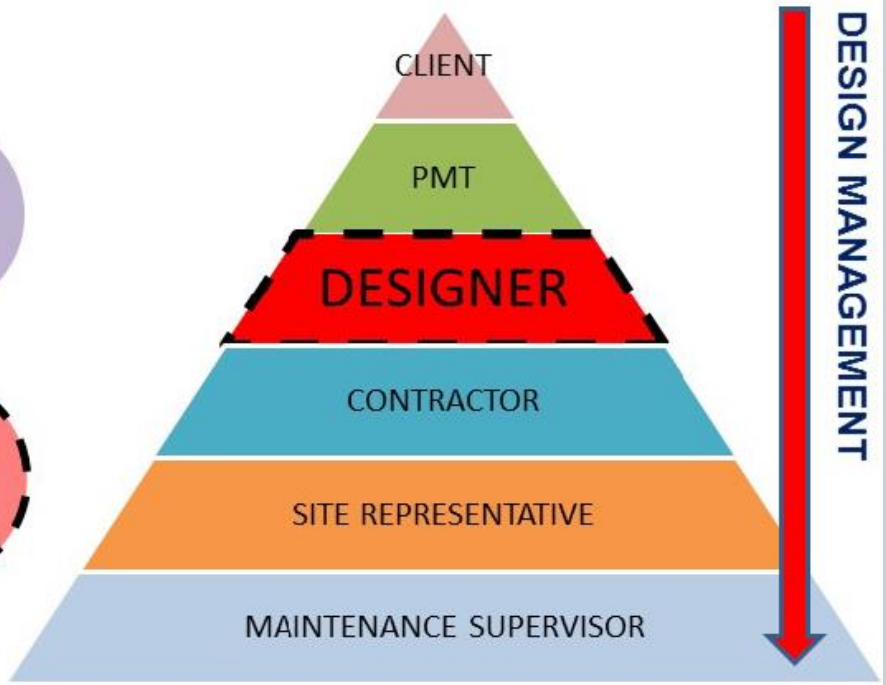
- Designers can be the architects/engineers/maintenance surveyors who contribute to or have responsibility for the design and/or drawing up of the specifications of any part of the project works.
- The role of a designer is to identify and minimize hazards which may give rise to risks;
  - reduce risks due to design and inform relevant parties of the remaining risks;
  - cooperate with the Project Supervisor and other designers;
  - provide information for incorporation into the *health and safety file.*

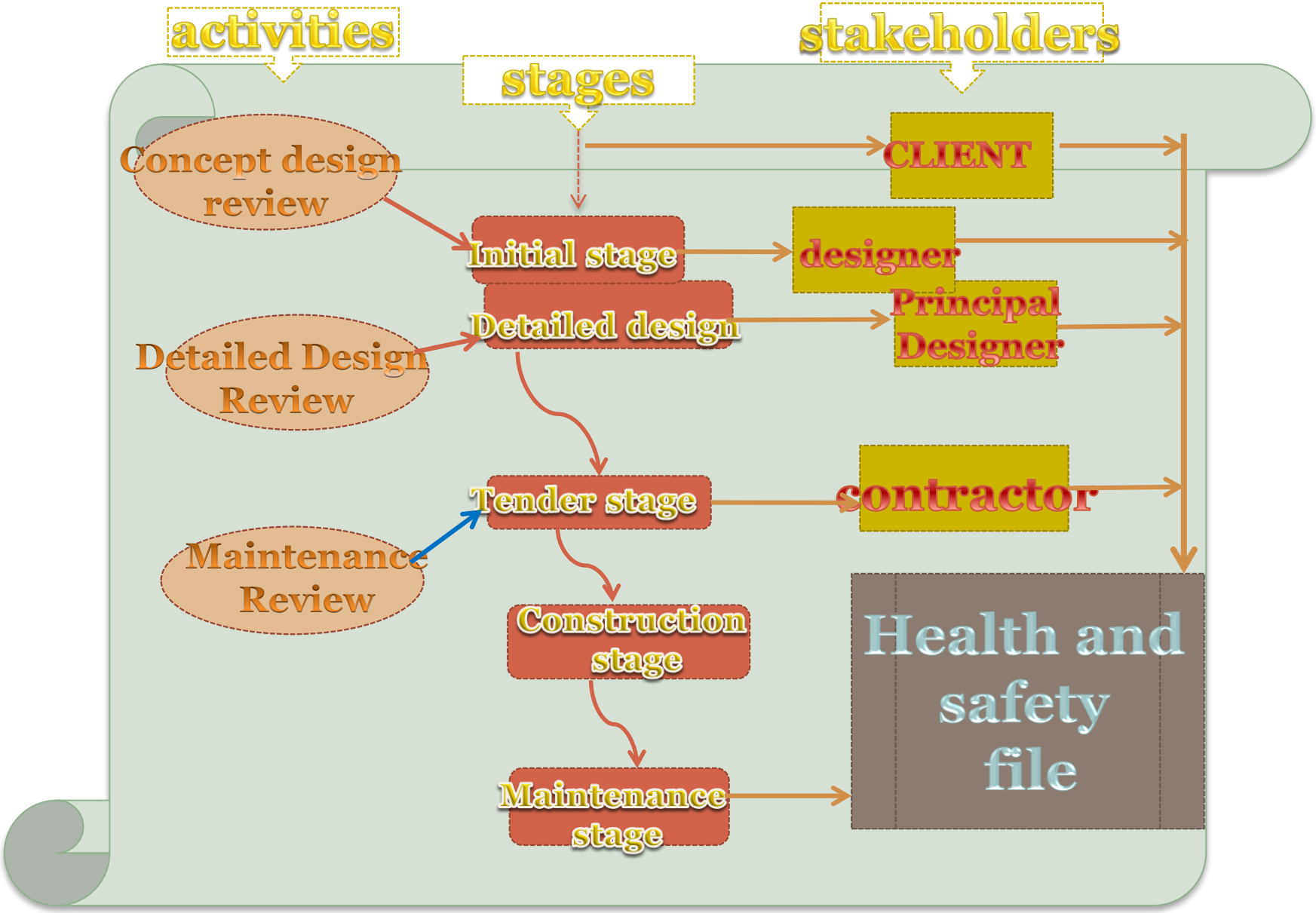
CURRENT-DESIGN PRACTICED PROCESS





CONSTRUCTION DESIGN MANAGEMENT (CDM)




activities
stages
stakeholders
Concept design review
Initial stage
CLIENT
designer
Detailed design
Principal Designer
Detailed Design Review
Tender stage
contractor
Maintenance Review
Construction stage
Health and safety file
Maintenance stage

Malaysia government has encouraged the use of Industrialised Building System (IBS) construction. IBS is a potential method to improve overall construction performance in term of quality, cost effectiveness, occupational safety & health, waste reduction, image and productivity.

- Good site management, planning and control of overall process in project life cycle. This in turn, leads to recommendation that experience and well-trained workers are the critical for IBS contractors. Project Manager must be able to work with multi trade involved in IBS. Engineers with good technical knowledge in analysis, design, manufacturing and construction have the ability to produce systematic IBS systems. If the components are skillfully designed, erection can be carried out efficiently. Furthermore, complying with good practices in design and construction leads to high quality precast concrete structure.
- The integration of IBS components or modules into the building requires the various parties and supply chain to cooperate closely. This requires very careful definitions and management of interfaces between contractors and suppliers and a good communication channel. It has been suggested that by implementing integrated approach in design and construction, fragmentation . gap could minimised.
- Partnering with suppliers and sub-contractors from the earliest project stages is vital to ensure efficient and timely delivery of components and services.
- Components production must also include a commitment to IBS design. Initiating good working
- Collaboration between design team, manufacturer and project coordinator can identify and deal with problem early and push forward improvement in productivity and quality

Virtual Reality - VR

- **But what's there in it for BIM?**
- Imagine walking your clients through the actual life sized model of an on-going architectural venture of yours.. Or imagine yourself sitting virtually inside the model and evaluating every nook and cranny of it… This is definitely more fruitful than sitting at your table and zooming into a 15' screen. The acceptance and expansion of VR has been growing exponentially. Ever since embracing the idea of VR, the AEC (Architecture, Engineering and Construction) sector has benefited a great deal. As per the reports, companies began seeing faster project approvals, increased positive client interactions and higher client satisfaction. The "what's important" and "what's not important" checklist can be prepared smoothly so as to save valuable time and money for the company as well as the client.
- With all the rapid progress happening, it is not surprising that architects, engineers and construction techies are already exploring the length and breadth of this technology. There are almost 50+ VR software and hardware tools available right now, that can redefine the way BIM is implemented and interpreted.

Virtual Reality

- Constructability information at design stage provides significant opportunity to improve the effectiveness and efficiency of building construction. One important aspect of constructability information is the visualization of the construction process that will help the designer to explore various construction schemes and their impact to cost and schedule. ie Virtual reality 3D graphical animation system with the database of constructability assessment information system. VR animation system is designed to provide the users with interactive visualization of various predefined of construction methods.

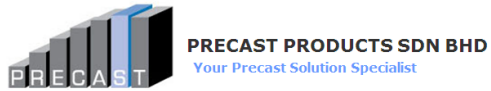
- ADD VIRTUAL REALITY SLIDES

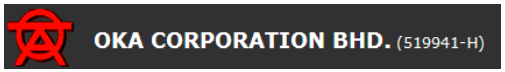
JKR products and Issues

- Success factor in design point of view
- Fast production of technical drawings
- PAPs, IBS Catalogues/Guidelines, Specs and Addendum
- How the construction can be executed without delay at site
- Acceptance by our client?-
- SPB, Circulars, Method Statements and Shop drawings
- Cast on site (focus on quality, roles of designers and QS)
- IBS system – understanding the contribution from each components – Safety, Functionality and Buildability
- Workplace safety – Safety procedures, cranes and equipment
- Virtual Construction – displayed for clarity

PELAKSANAAN IBS: PRE-APPROVED SYSTEM PROVIDERS

Pre-Approved System Providers Interested Parties (30 suppliers)





etc...

System formwork

This system were used since 1984. It was the most economical and efficient system for the construction of high rise building.

Common systems

The companies that being implementing the similar to this type of formworks are:-

1.PASCAL FORMWORK - German
2.SGB - Brittain
3.EFCO FORMWORK - Australia

PKNS Engineering & Construction Bhd (PECB)

PLASFORM FORMWORK SYSTEM – 64 UNITS SECTION 7

PKNS Engineering & Construction Bhd (PECB) TUNNEL FORM SYSTEM – 260 unit Kondo Kristal, Section 7, Shah Alam

Common systems

50 storey NAZA TOWER doka system (timber panels)


doka
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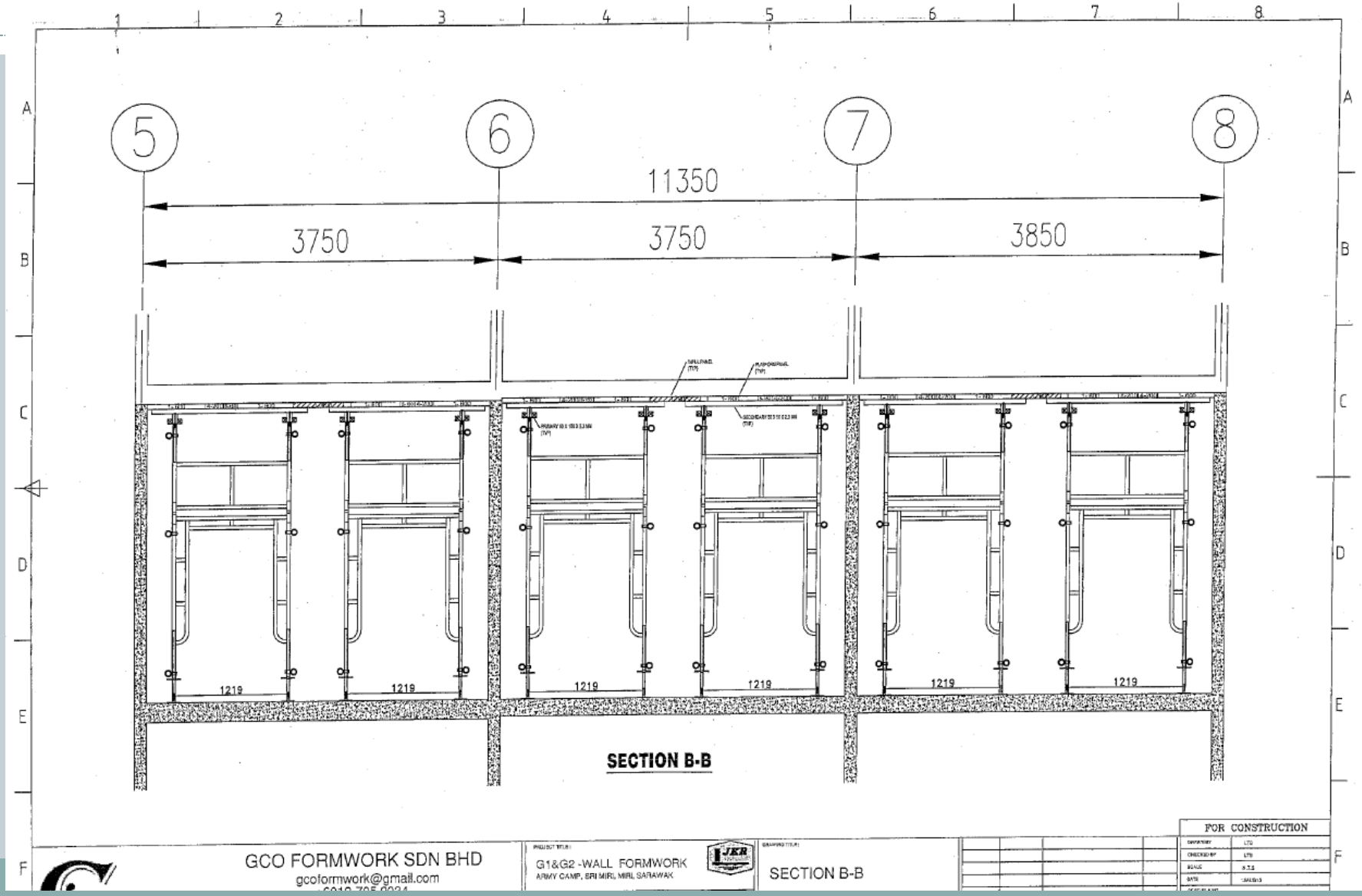
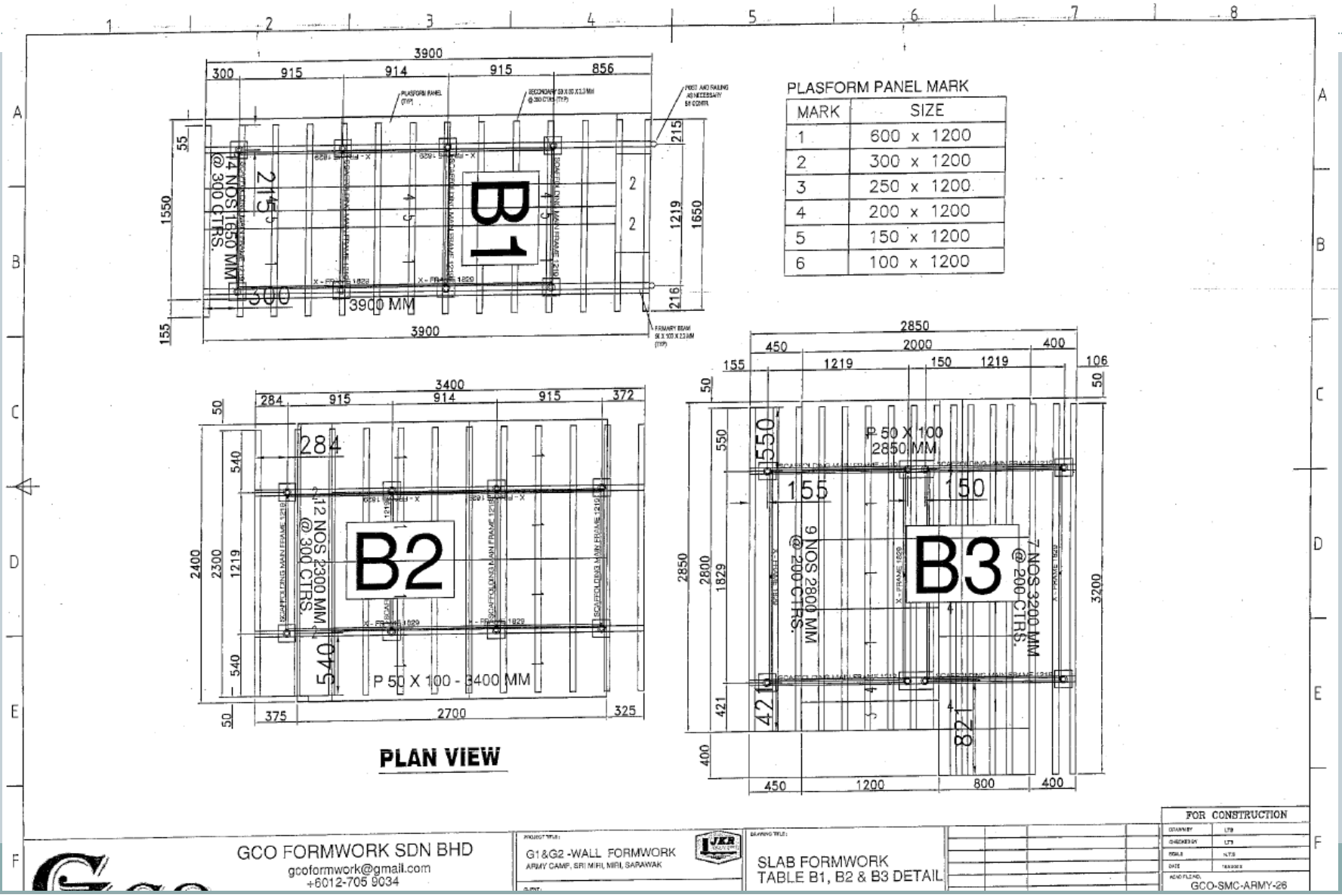
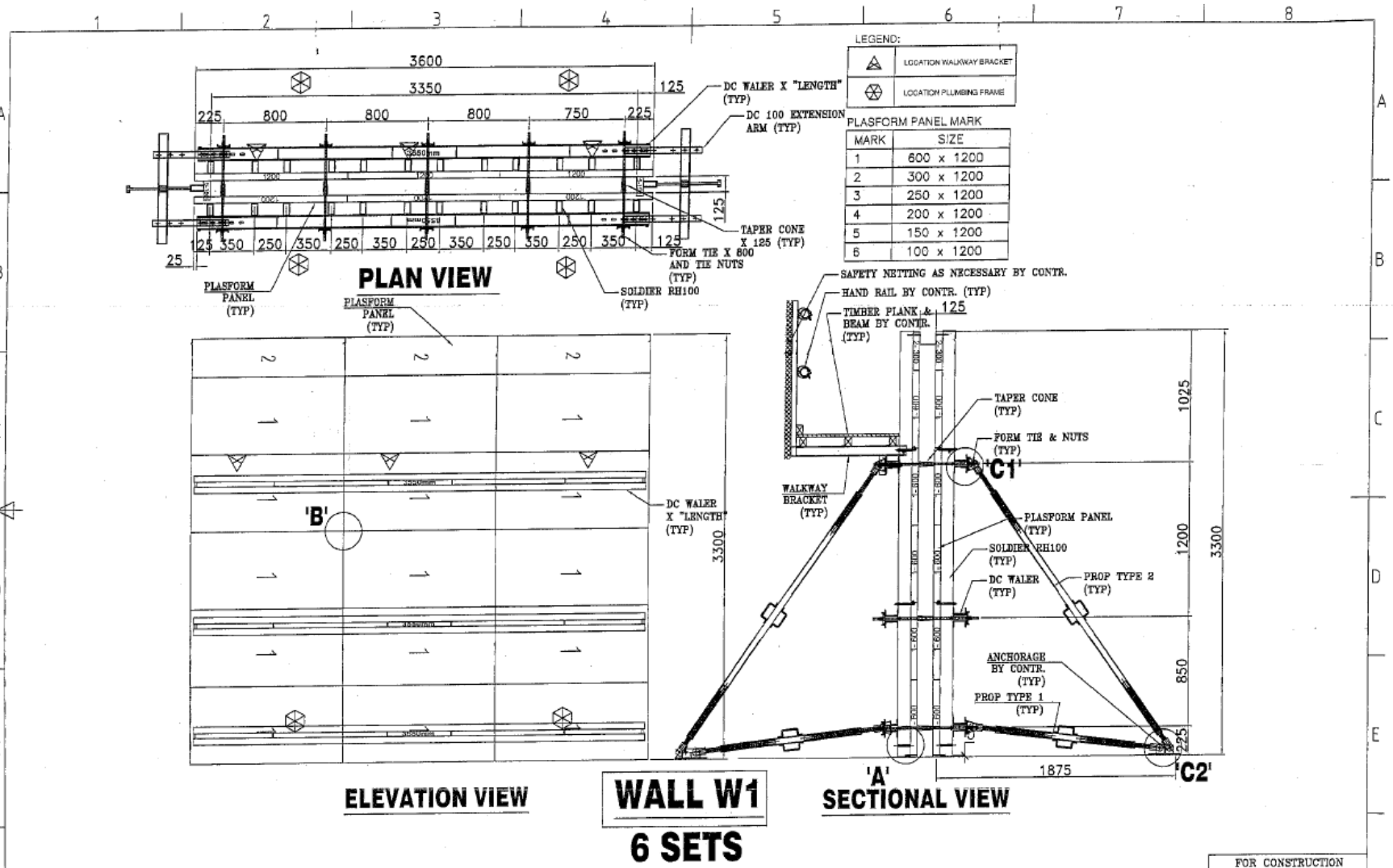
Formwork support

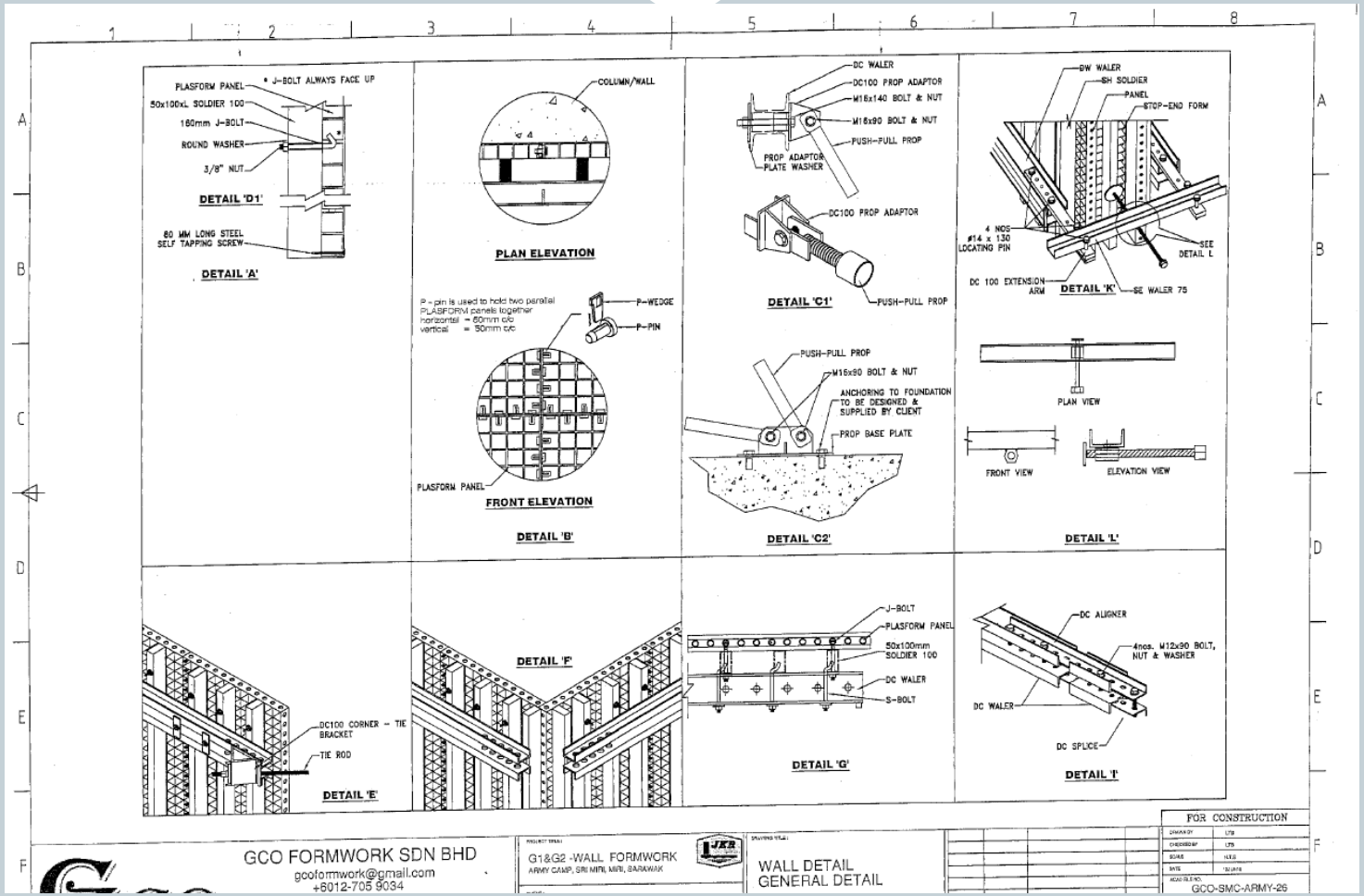


Formwork-individual panels




LEGEND:
LOCATION WALKWAY BRACKET
LOCATION PLUMBING FRAME
PLASFORM PANEL MARK
MARK | SIZE
1 | 600 x 1200
2 | 300 x 1200
3 | 250 x 1200
4 | 200 x 1200
5 | 150 x 1200
6 | 100 x 1200
3600
3350
225 800 800 800 750 225
125
DC WALER X "LENGTH" (TYP)
DC 100 EXTENSION ARM (TYP)
TAPER CONE X 125 (TYP)
FORM TIE X 600 AND TIE NUTS (TYP)
SOLDIER RH100 (TYP)
PLASFORM PANEL (TYP)
125 350 250 350 250 350 250 350 250 350 250 350 125
25
PLAN VIEW
PLASFORM PANEL (TYP)
DC WALER X "LENGTH" (TYP)
'B'
3300
ELEVATION VIEW
SAFETY NETTING AS NECESSARY BY CONTR.
HAND RAIL BY CONTR. (TYP)
TIMBER PLANK & BEAM BY CONTR. (TYP)
125
TAPER CONE (TYP)
FORM TIE & NUTS (TYP)
'C1'
WALKWAY BRACKET (TYP)
PLASFORM PANEL (TYP)
SOLDIER RH100 (TYP)
DC WALER (TYP)
PROP TYPE 2 (TYP)
ANCHORAGE BY CONTR. (TYP)
PROP TYPE 1 (TYP)
1025
1200
850
3300
225
1875
'A'
'C2'
SECTIONAL VIEW
WALL W1
6 SETS
FOR CONSTRUCTION
GCO FORMWORK SDN BHD
gcoformwork@gmail.com
+6012-705 9034
G1&G2 -WALL FORMWORK
ARMY CAMP, SRI MIRI, MIRI, SARAWAK
WALL DETAIL
WALL - W1

General data-fasterners

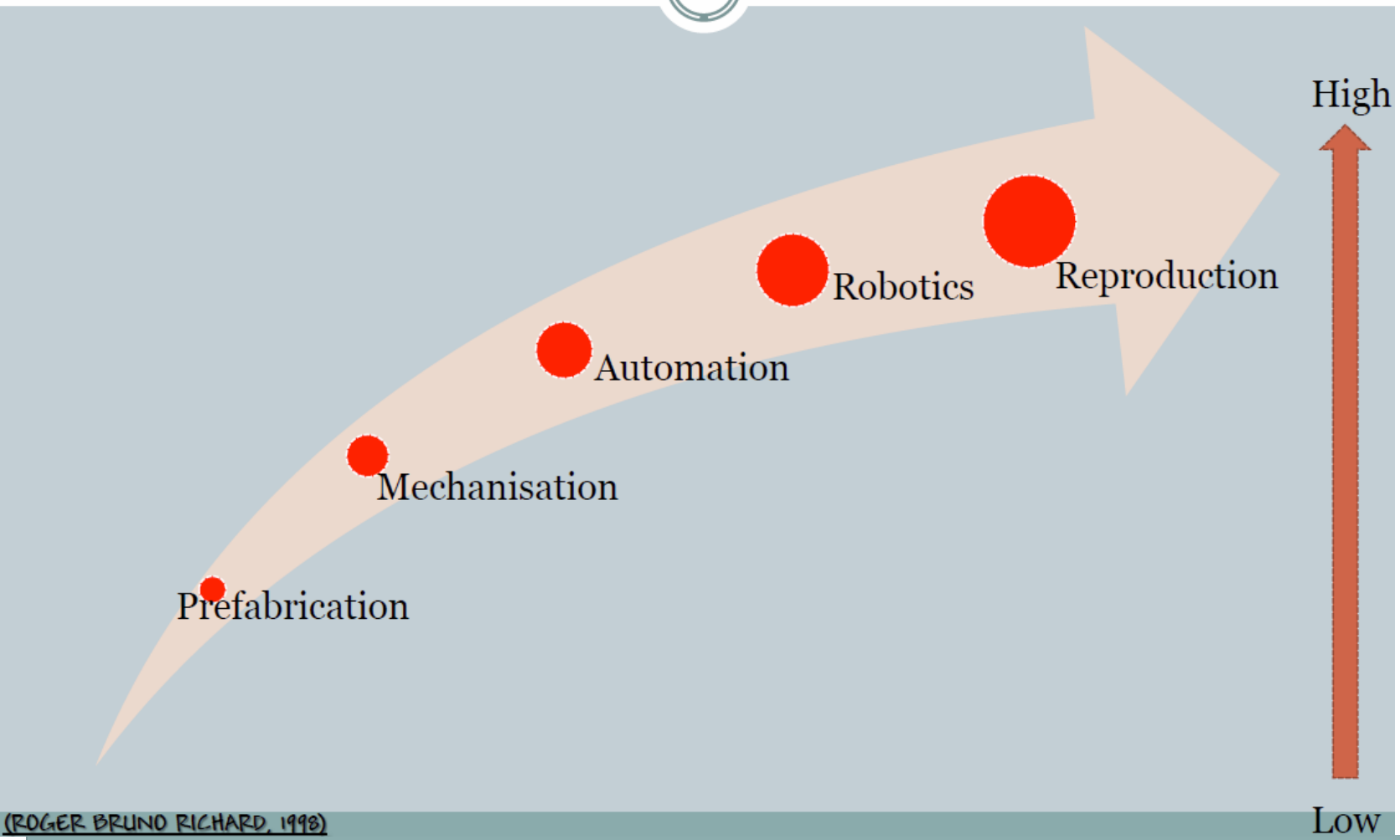


BIM and Mechanisation – CIDB CONCEPT

NEED FOR MECHANIZATION IN CONSTRUCTION INDUSTRY

1. The work can be done speedily.
2. The work can be done in time.
3. Large quantity of materials can be handled, so the size of the project can be increased
4. The complex projects involving high grade material.
5. High quality standards can be maintained.
6. Time schedule can be kept.
7. Optimum use of material, man power and finance.
8. Due to shortage of skilled and efficient man power.

DEGREE OF INDUSTRIALISATION



(ROGER BRUNO RICHARD, 1998)

30 STOREY HOTEL IN 15 DAYS

FOUNDATION

FLOORING ELEMENTS

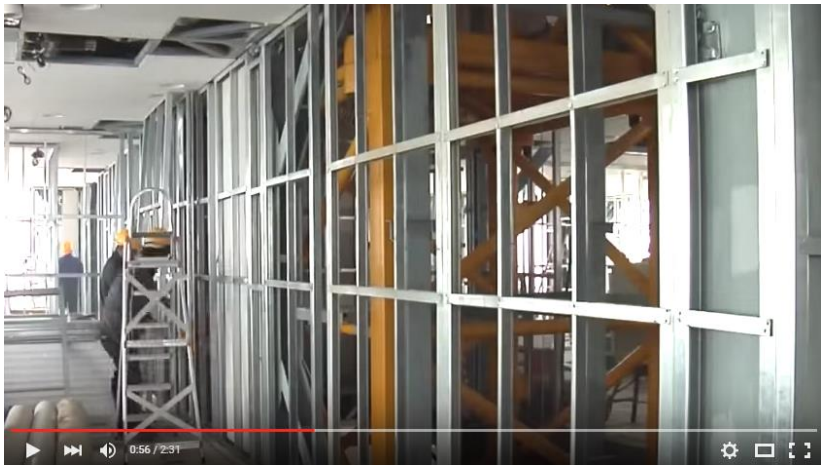
FIXING OF SERVICES

LIGHTING TESTINGS

TRANSPORTION AND INSTALLATIONS

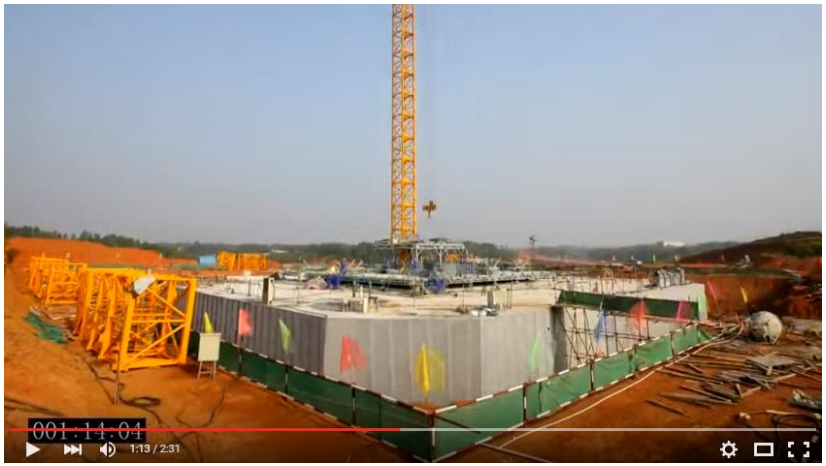
CONSTRUCTION IN PROGRESS

FIXING OF STAIRCASE AND CLADDINGS



FURNITURES AND SHADES

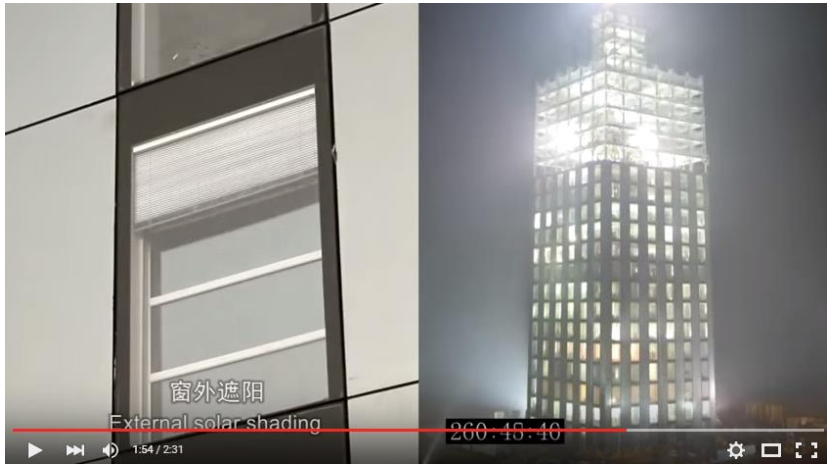
24 HOURS WORKFRAME

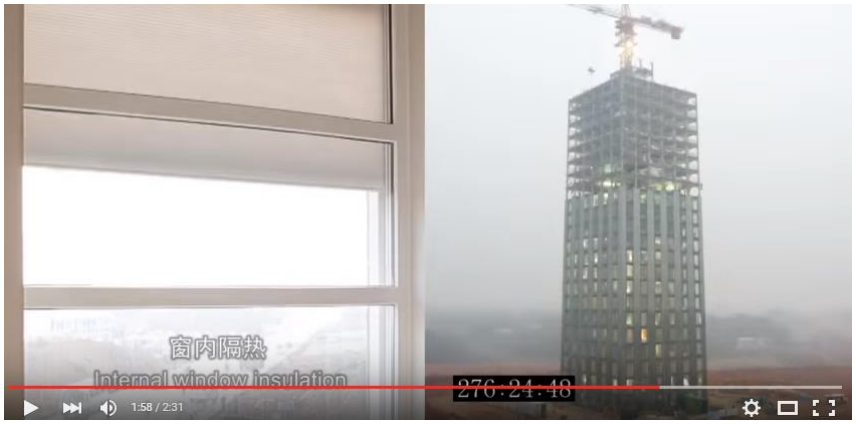


EARTHQUAKE RESISTANCE

- ENERGY EFFICIENT BUILDING

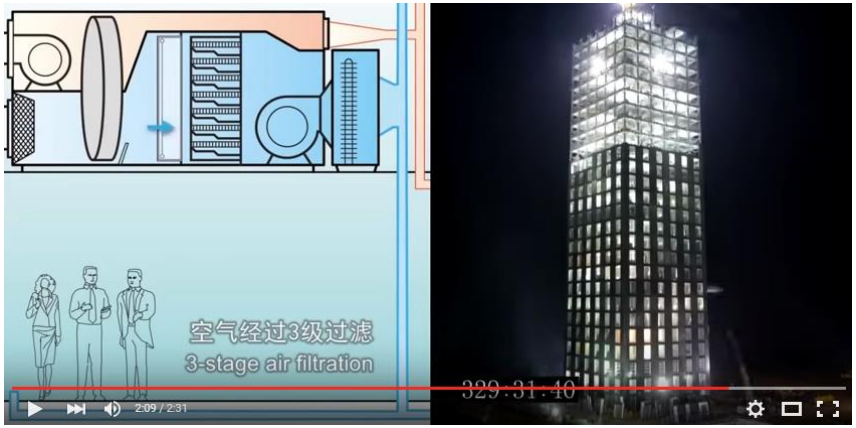
ECO FRIENDLY COMPONENTS




窗内隔热
Internal window insulation
1:58 / 2:31
276:24:48


新风热回收
Heat recovery fresh air
2:01 / 2:31
284:01:00


20倍净化
20 times purer air
2:06 / 2:31
314:02:16


空气经过3级过滤
3-stage air filtration
2:09 / 2:31
329:31:40


种类
室内 Indoor
室外 Outdoor
粉 尘
PM0.3μm 1428 96062
PM2.5μm 25 1866
PM10 μm 1 78
甲醛等VOC
挥发性有机物
0
二氧化碳
CO2 ppm 720 440
室内比室外洁净20倍以上
Indoor air is 20 times cleaner than outdoor air
2:13 / 2:31
344:57:18

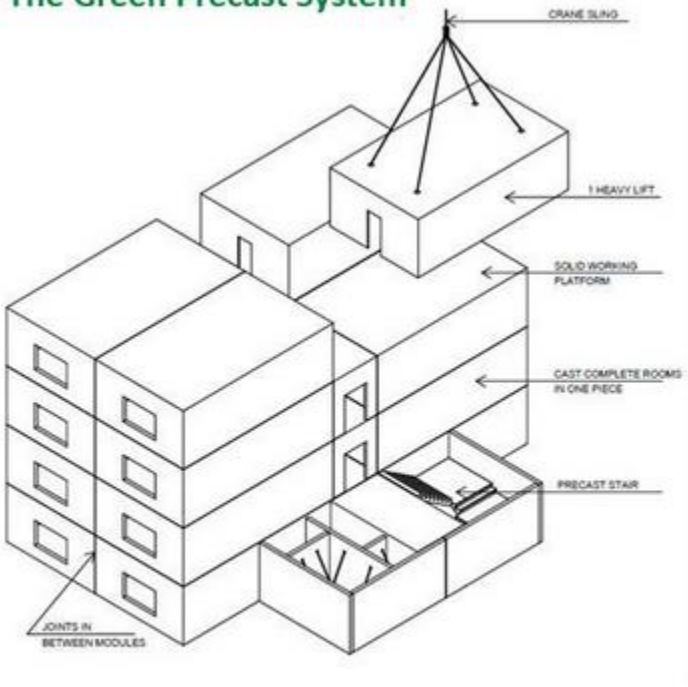

2:20 / 2:31
360:00:00


T30
17000m² hotel
2:28 / 2:31

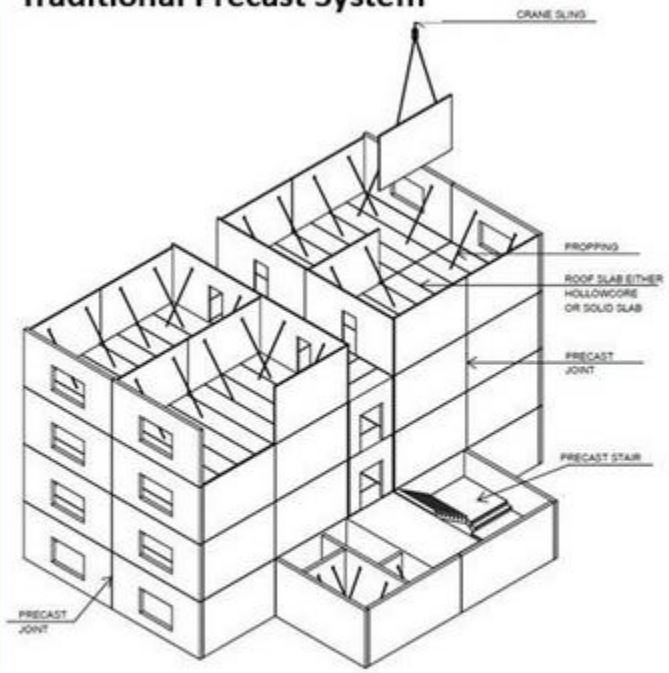

可建 远大 可持续建筑
9度抗震 5倍节能 20倍净化
BSB BROAD SUSTAINABLE BUILDING
9M earthquake resistant 5x energy efficient 20x purer air
www.broad.com
2:30 / 2:31

MODULAR BUILDINGS

The Green Precast System



Traditional Precast System



The Green Precast System provides developers a highly flexible building system that delivers strength, cost and time savings, durability, thermal and acoustic efficiencies and provides structurally superior resistance to natural disasters.

CSU student accommodation

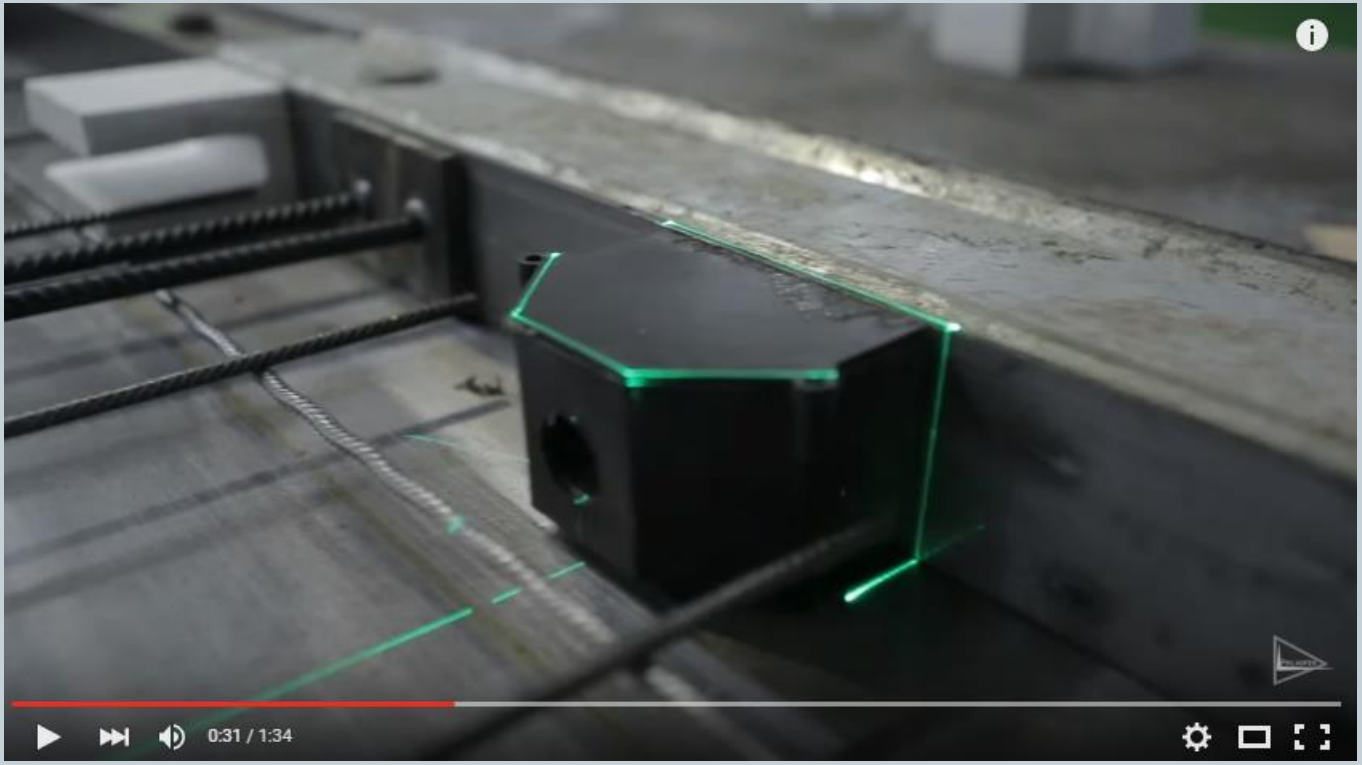
PRECAST PLANT-WORLD LARGES

- THE LARGEST PRECAST PLANT OF THE WORLD
  Morton Group built a greenfield site to build the world largest precast plant with an annual precast output that enables the construction of buildings with a total floor space of 525.000 m2.
- SOUTH AFRICA

CASTING OF PLANKS – INSTALLING STEEL FRAMING

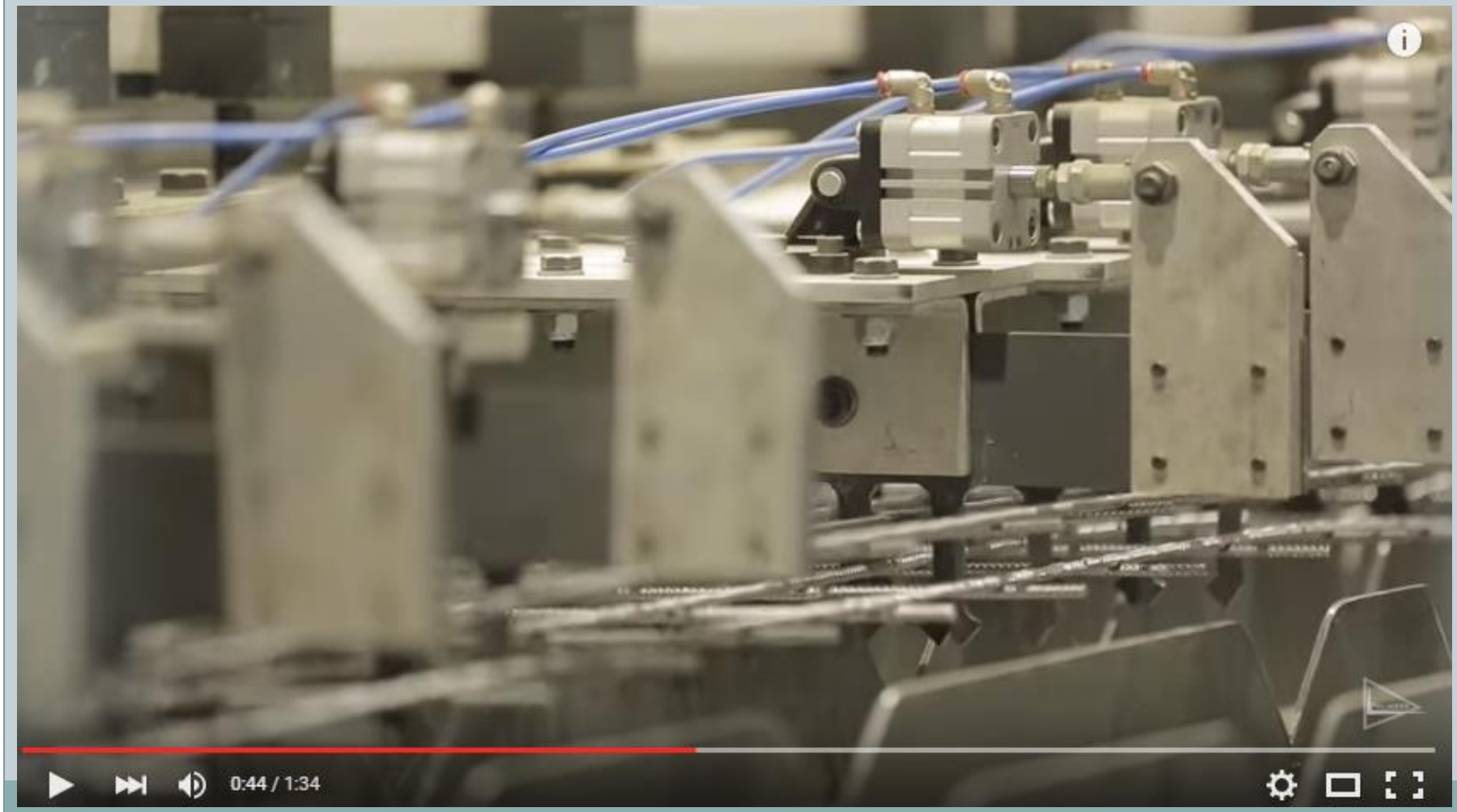
SETTING UP CASTING FRAME

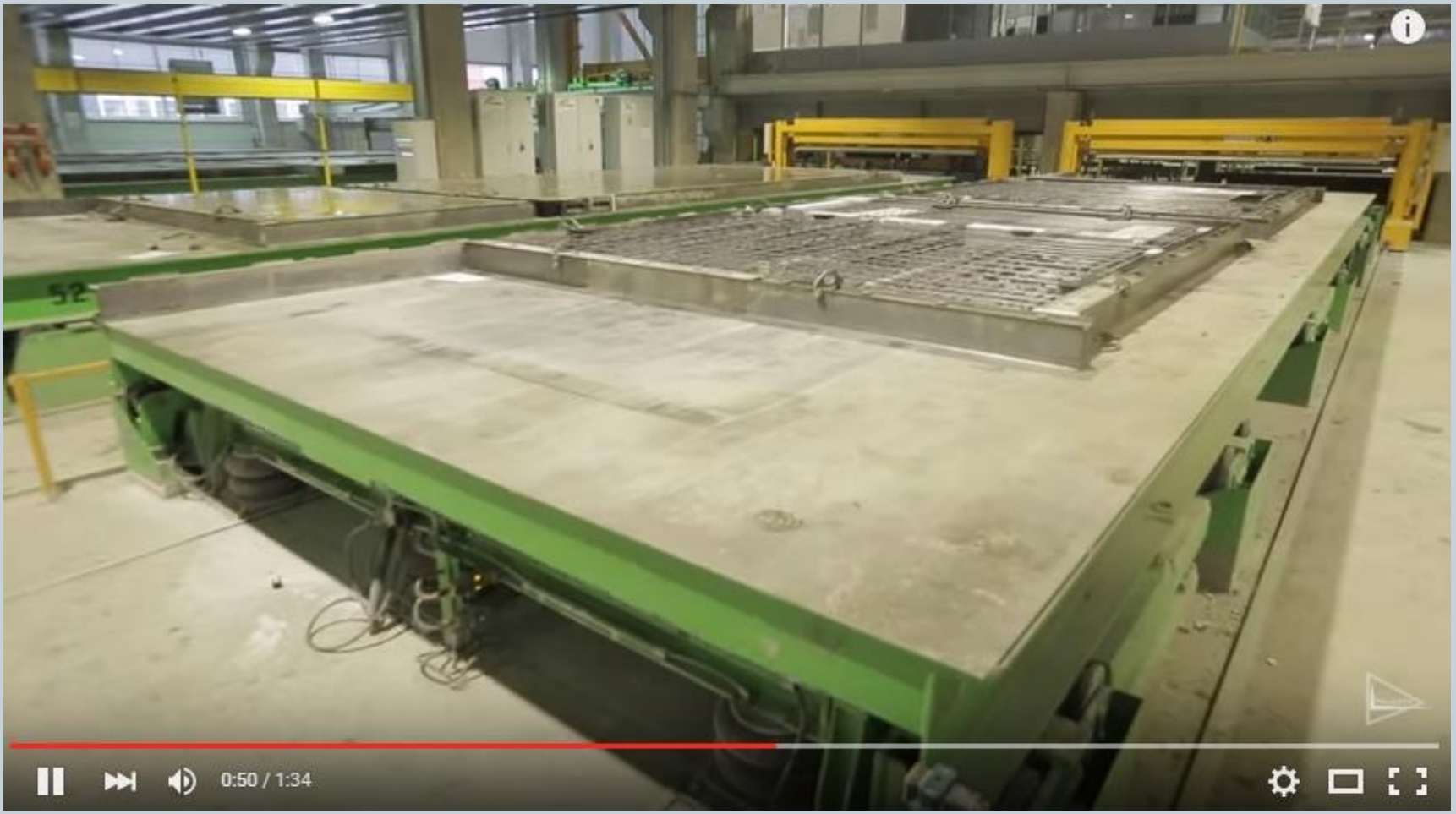
SCANNING OF MOULD



BAR FIXING FRAME

ROBOTIC BARS SPACERS TO DWG DETAILS

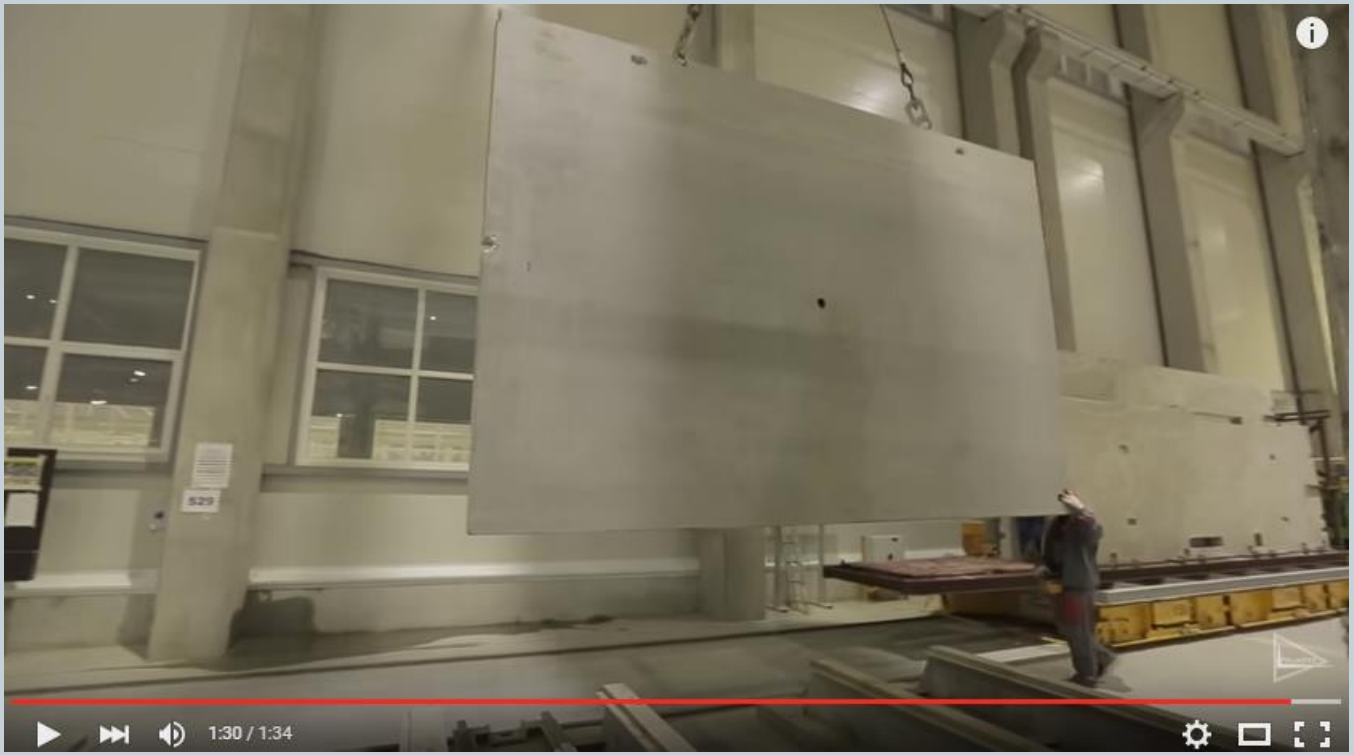



52
0:50 / 1:34


SOMMER


1:25
1:27 / 1:34

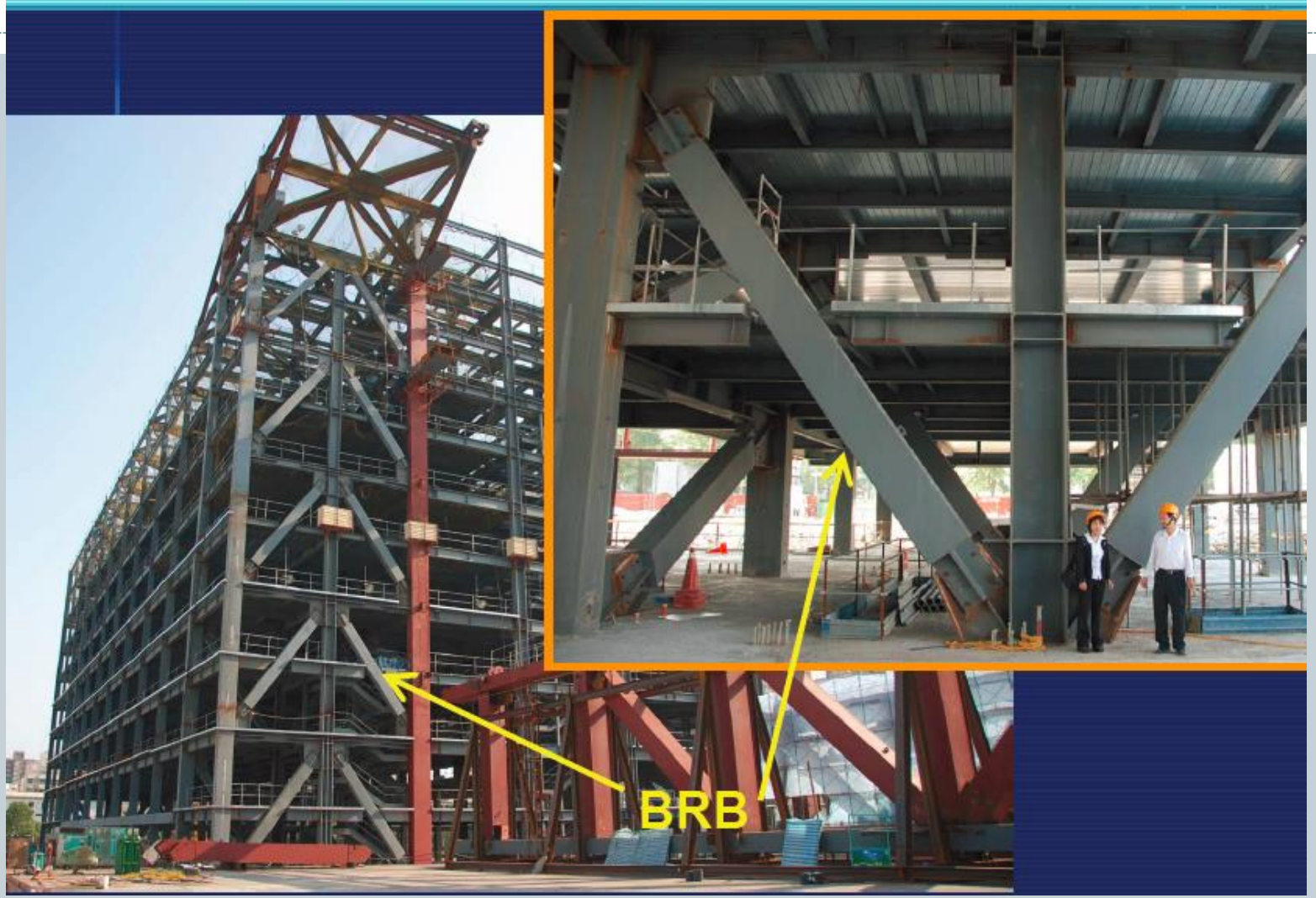
FINISH PRODUCT



EARTHQUAKE ZONES

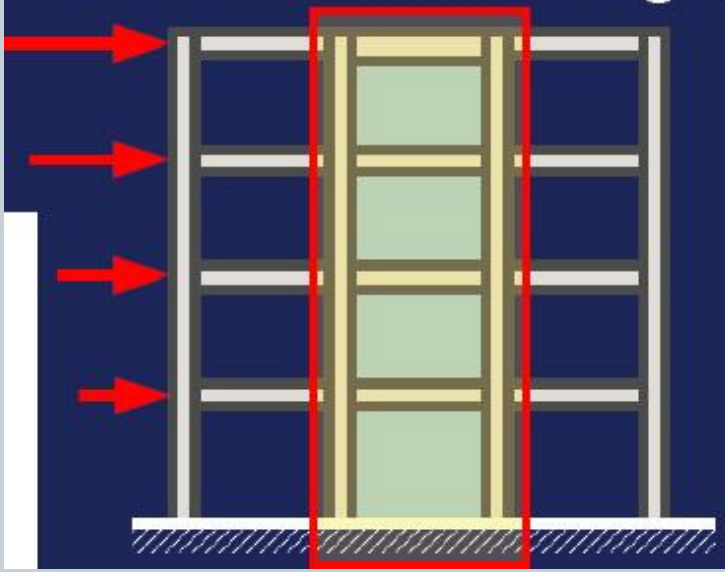
Buckling Restrained Braced Frame

Taichung City Government Building / 台中市政府大樓

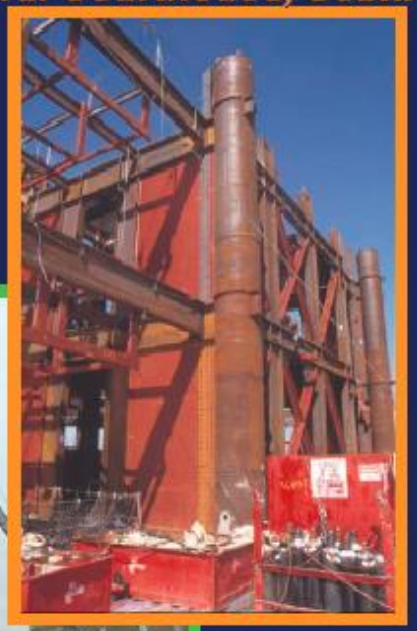


Steel Plate Shear Wall (SPSW)

- *Lateral force resisting system*
- *Thin steel plates are installed into a building's structural frames*
- *Effectively increase the structure stiffness and strength*



USA Federal Courthouse, Seattle



ING Building, Canada

VULNERABLE SYSTEMS

(五) 建築物的外觀形狀與耐震性

建築物的造形與耐震能力關係密切。一般而言，造形簡單規則的建築設計，能以較低的建材成本，興建耐震性較佳的建築物；外形花俏多變的建築設計，需要較高的建材成本，以彌補外形上不耐震的缺陷。擁有外形獨特多變的建築固然賞心悅目，但若是購買或建造樓房作為居住使用時，應審慎考量耐震安全、經濟性與建築造形三者之間的平衡。

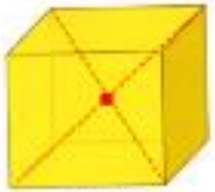
造形簡單規則的建築設計

外形花俏多變的建築設計

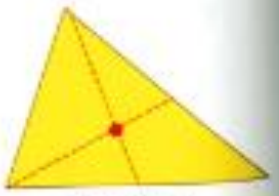
■ 重心愈高，穩定性愈差

「重心」是指物體的質量分佈中心，例如：實球的重心位於球心，正方體的重心位於兩個斜對角的交叉點，而三角形的重心則是位於兩條「中線」的交會點上。

實球的重心



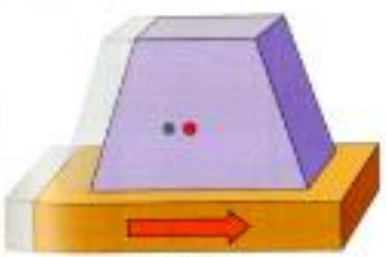
正方體的重心



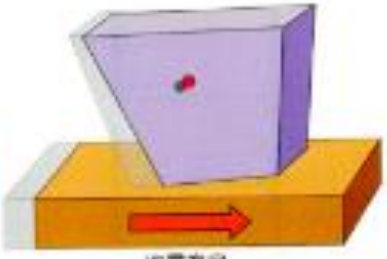
三角形的重心

物體的重心如果很高，輕輕一推便容易倒下。

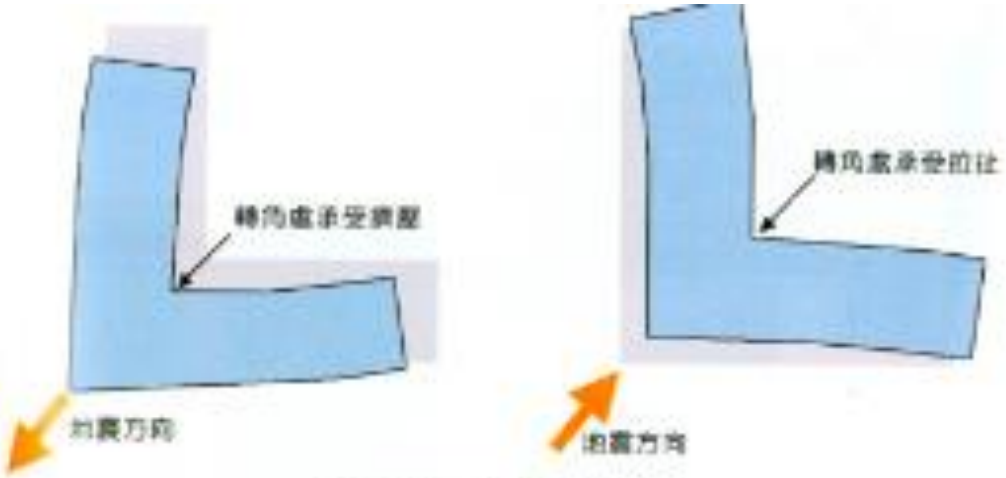
外形上寬下窄的物體，重心位置高，地震時，容易翻覆。所以，重心低的建築物相對上較為穩固。



地震方向



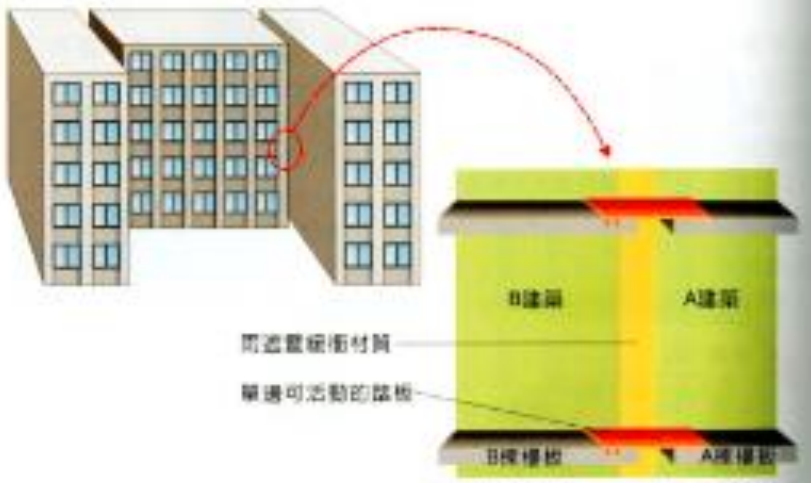
地震方向



平面形狀為L型的建築物俯視圖

除了L形外，口字型、T字型等平面形狀不對稱的建築，轉角處情況相似，也都容易於地震時發生破壞。

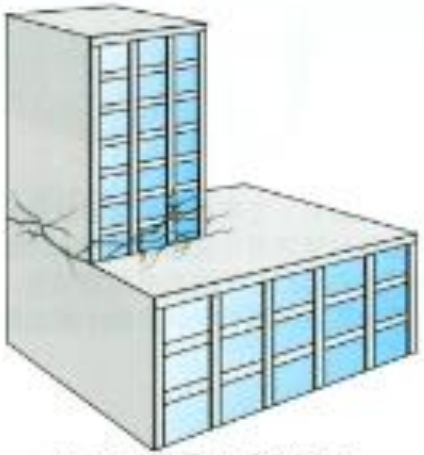
類似上述的建築設計，工程師通常建議採獨棟建造，以及保留適當的各棟間距，防範地震時發生碰撞。如果有功能上的需求，必須讓人們可以在各棟間往來行走，可將各棟空間走道，設計成類似捷運的車廂連結走道。通道間以緩衝材作為外牆，並以單邊可活動的踏板連接樓地板。



凹形建築採震縫設計，即樓層以過道相連

● **退縮建築容易局部受損**

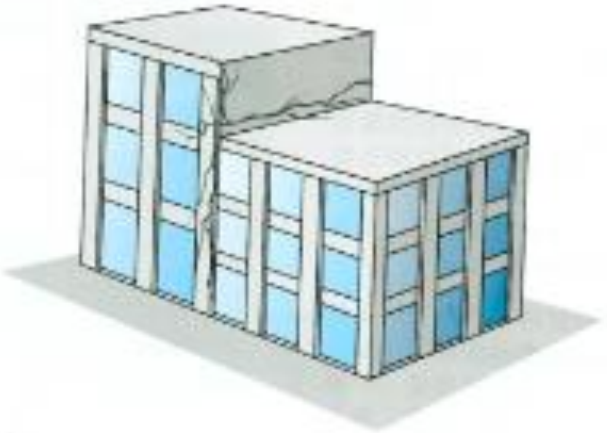
「退縮建築」是指建築的某個或某些樓層，樓地板面積突兀地大改變，建築物的立面形狀突然退縮。地震時，樓層振動或受力行為較為複雜，容易破壞。



退縮建築的樓層與鄰棟容易碰撞

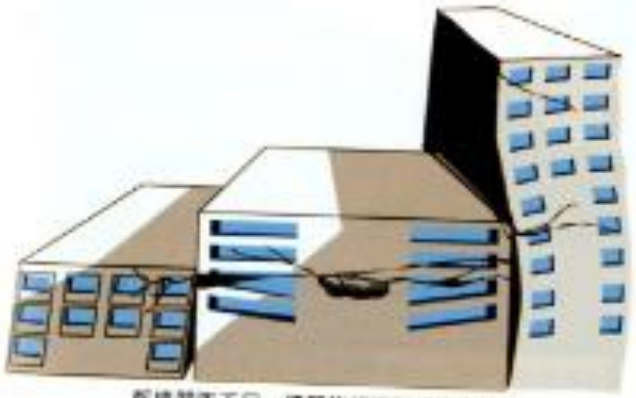
■ **梁線不連貫造成耐震力不佳**

一棟建築，樓地板高程不一致，梁線不連貫，當地震發生時，承受左右兩側橫梁與樓板夾擊的柱子，容易破壞。



■ **鄰棟間距不足**

建築物彼此間隔距離不足，地震時可能相互碰撞而震損。尤其，高度不同的建築，有不同的自然振動週期，更應預留足夠的變形空間，防範地震過程彼此發生碰撞。



鄰棟間距不足，建築物相互碰撞而震損

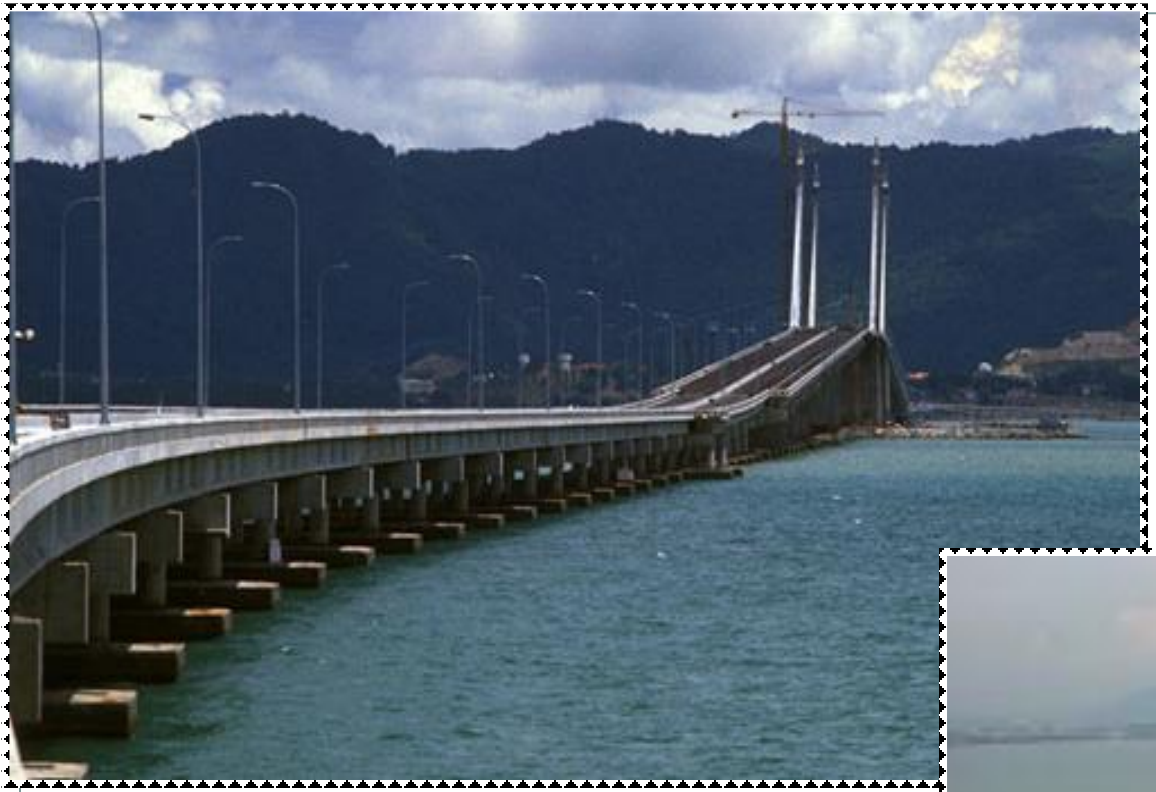
SEISMIC DESIGN FOR BRIDGES AND BUILDINGS

1980s

- PENANG BRIDGE
- KOMTAR BUILDING, PENANG
- SABAH FOUNDATION BUILDING, SABAH

2000s

- KLCC TWIN TOWERS



PENANG BRIDGE

KOMTAR BUILDING PENANG

SABAH FOUNDATION BUILDING SABAH

UTM
UNIVERSITI TEKNOLOGI MALAYSIA

Seismic Retrofit Strategies

Base Isolation:

Isolated structures

TWIN TOWERS

KLCC

OWNER:
China Central Properties Ltd. (Current owner is RREEF)

ARCHITECT:
Minoru Yamasaki & Associates

PROJECT LOCATION:
Dalian, China

PROJECT SCOPE:
Structural Engineering, Precast Cladding Engineering and Construction Engineering

\PROJECT DETAILS:
43-stories, 89,000 square meter, precast prestressed concrete, grade-A office tower located near the city centre of Dalian, Liaoning Province.

CHALLENGE:
This building is located in a high seismic zone on the northeast coast of China

SOLUTION:
Structural design for this building involved precast concrete beams, slab soffits and a

precastconcrete façade and parapet cladding system.

RESULTS:
This project was completed in record time as the precast design allowed erection of the building structure at a rate of one floor every three days. Completed in 1999.

Fig. 2. Artist's rendering of The Paramount. Photo courtesy: Kwan Henmi, Architecture and Planning. Artist: W. Yeliseyev.

At 39 stories and 420 ft (128 m) high, The Paramount (located in San Francisco, California) is the tallest concrete structure in addition to being the tallest precast, prestressed concrete framed building in Seismic Zone 4 (a double record). It is the first major high rise building to be braced by an architecturally finished exposed precast concrete ductile frame. The reinforcement used to create this seismic ductile frame includes post-tensioning and high strength reinforcing steel. All this represents a major milestone in the development of precast/prestressed concrete. The building is basically an apartment complex, although the lower floors accommodate retail space, vehicle parking and recreational amenities. This article presents the design considerations, construction highlights, research and development, and code approval process that led to the realization of this structure.

SEKIAN TERIMA KASIH