

# Formwork for High-rise and Complex Structures

prepared by Wong Wai-man, Raymond  
as part of his presentation series  
for the sharing of his long-year of construction studies  
in the related field

1

There are a few fundamental methods to construct buildings, they are:

- In-situ Reinforced concrete
- Structural steel
- Precast
- Combination of the above methods

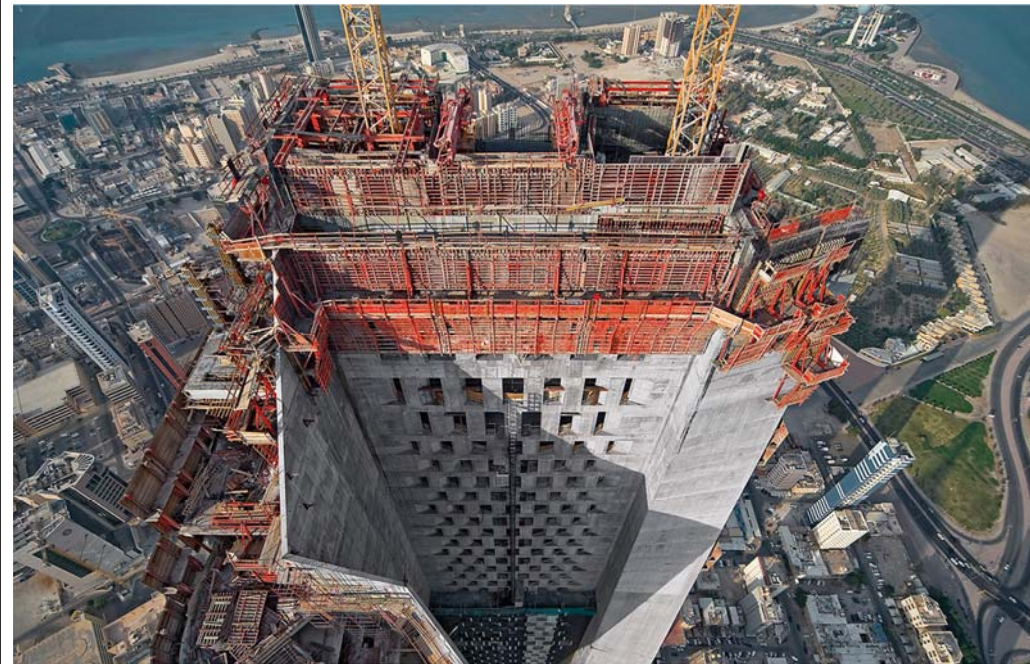
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There are only 3 work components for working with in-situ Reinforced concrete, that is:

- Formwork erection
- Reinforcement fixing
- Concreting

Out of these components, formwork is costly and demanding highest level of technological input, as well as other work and resources related planning.

3



The use of formwork in construction can be a very challenging operation<sup>4</sup>



6

## 1. Introduction

Formwork system is the key factor determining the success of a construction project in terms of

- speed

A formwork system if not appropriate designed to fit the actual site condition will have low efficiency and affect the speed of work (e.g. wrong selection due to insufficient experience in using the system, inefficient fixing method, difficult location of work, more labour intensive etc.)

7

Formwork system is the key factor determining the success of a construction project in terms of

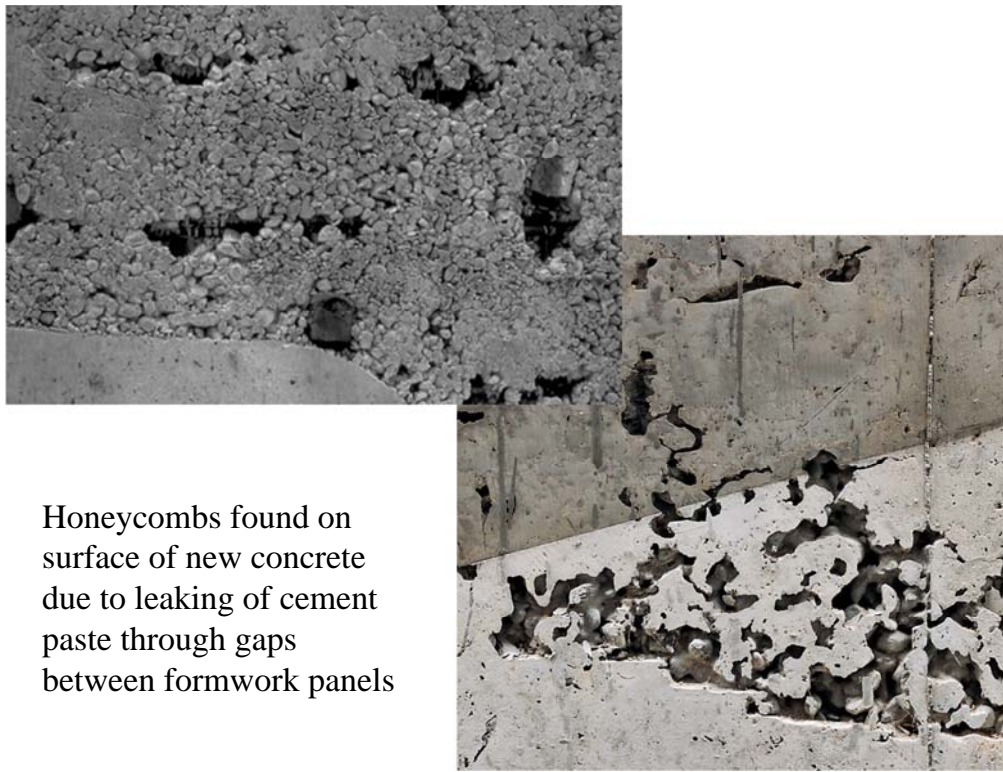
- quality

quality of concrete can be affected by formwork in the following ways:

- a) the accurate shape of the formwork panel
- b) dimensional accuracy of the formwork
- c) the verticality, leveling or alignment of the formwork
- d) the tightness of joining of the panels
- e) whether the panel surfaces is in good condition

8





Honeycombs found on surface of new concrete due to leaking of cement paste through gaps between formwork panels

- Formwork system is the key factor determining the success of a construction project in terms of
  - cost
 cost of formwork include material (plywood and hardwood waling), cost of cutting, material wastage, labour to assemble and erection, striking and transportation of formwork panels, replacement of reused panel etc.

10

Formwork system is the key factor determining the success of a construction project in terms of

- safety of works
- dangerous occur due to:
- often need to work at height,
- panels are heavy for human worker
- unstable formwork erection will cause collapse and harm people working on it
- working area nearby the formwork are usually congested and not easy to get access into.

11

## 2. Classification of Formwork

- Sizes
- Location of use
- Materials of construction
- Nature of operation
- Brand name of the products.

12

## 2.1 Classification according to sizes

### small-sized formwork

- operation by workers manually
- timber and aluminium

### large-sized formwork

- crane facilities are required in the operation
- reduce the number of jointing and to minimize the number of lift.
- stiffening components - studs and soldier.

13



large-sized formwork (often also called panel form, gang form)



## 2.2 Classification according to location of use

- Different elements in the structure have different design and performance requirements in the use of formwork.
- Some systems are more adaptive for specific location of use, such as
  - Irregular frame structure – traditional timber form or aluminum form
  - Cross Wall – gang form, climb form or jump form
  - Floor – table form, aluminum form
  - Repeated regular section – tunnel form

16





Aluminium formwork system for residential housing block

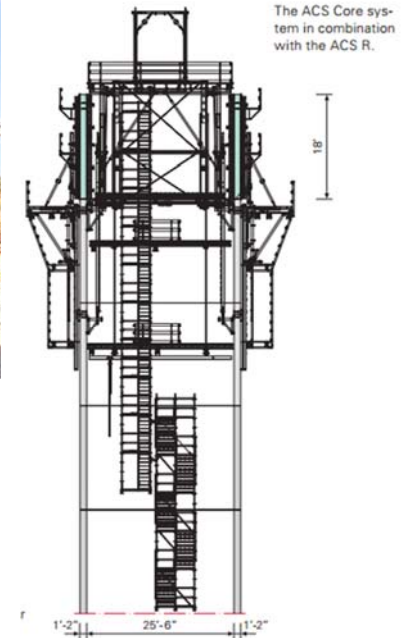


Timber formwork for irregular-grid podium structure



Steel panel form (Gang form)

Systems for construction of core wall or large load-bearing walls



Jack-lifting form

18



Floor formwork using manual system (propped small panels)

19



Floor formwork using large panel, propped

20





Using table form for slab

21



Table form for the flat slab structure

<https://www.youtube.com/watch?v=8e3sL5Ew8Eg>

22



Table form unit  
before erect  
onto position

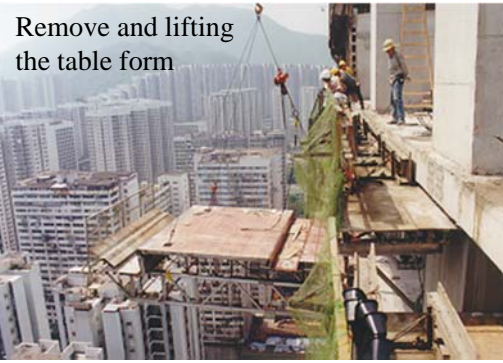
23



Table Form

24

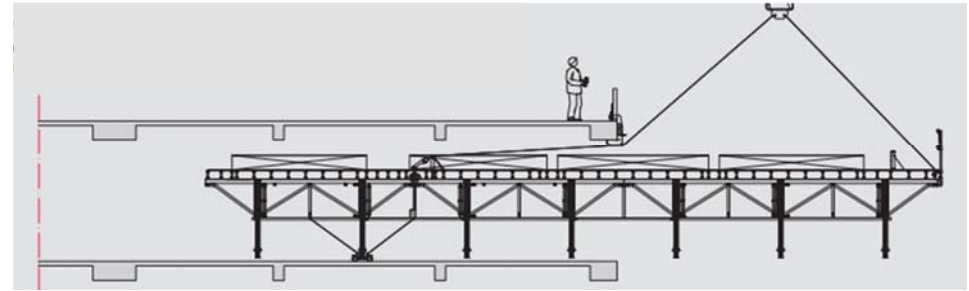




Remove and lifting the table form



25



Lifting device to remove the table form

Ways to remove and lift the table form

26



Formwork for stairs



27



Gantry form/tunnel form system for the construction of station facilities





Jump form system used in public housing project

Climb form in the construction of the 50-storey Manulife Tower



## 2.3 Classification according to materials

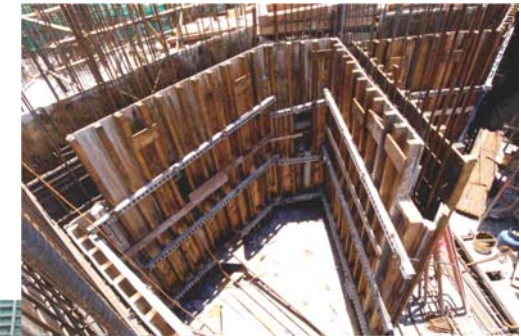
- Timber
  - most popular formwork material
  - low initial cost
  - high adaptability to complicated shape
  - labour intensive and environmental unfriendly
- steel
  - hot-rolled or cold-formed sections
  - heavy weight
  - suitable for large-sized panels
- Aluminium
  - stiff and light weight
  - higher material and labour cost
  - excellent finish
- Plastic (UPVC, GRP)
  - limited use due to lack of rigidity

30

Typical set for a large-scale project using traditional timber formwork



Detail of wall formwork using manual operable timber panels

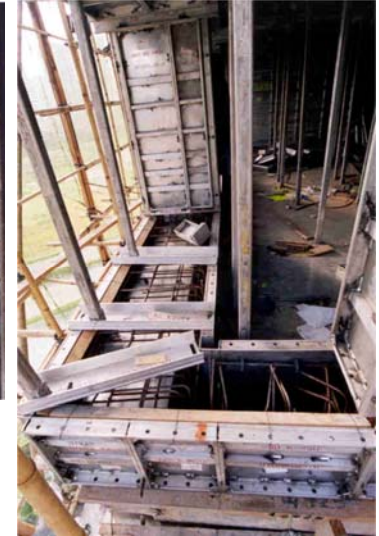


32





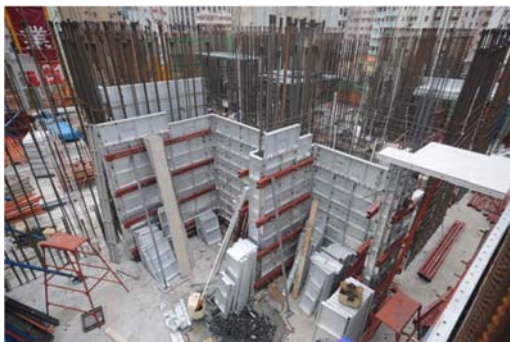
Examples of steel form in the form of large panel shutters



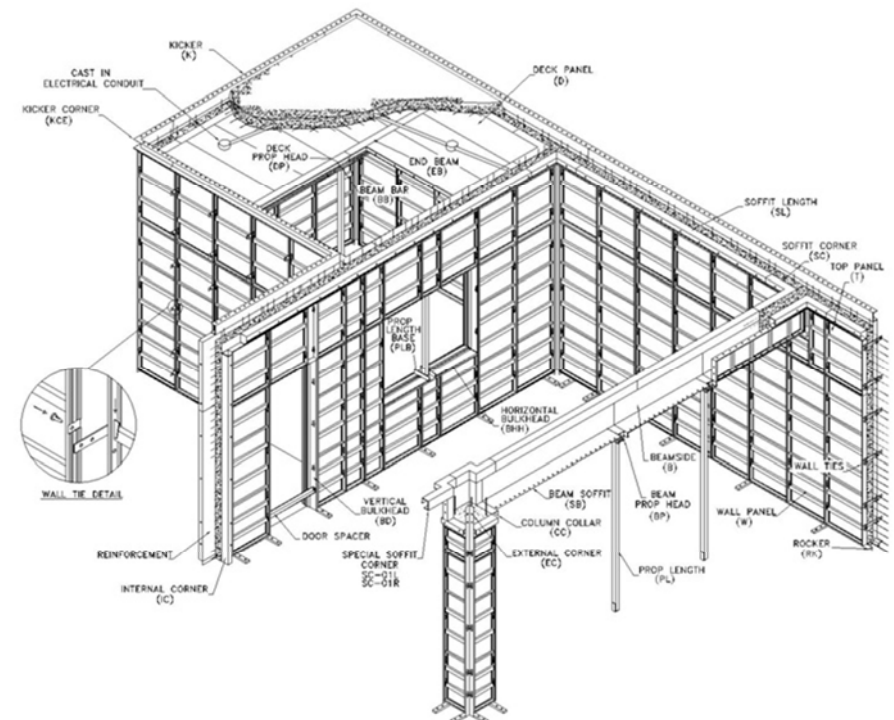
Detail of a typical aluminum formwork system for apartment-type building

<https://www.youtube.com/watch?v=FT1bktj-zRI>

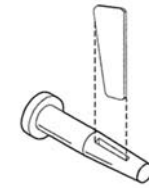
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Detail of a typical aluminum formwork system for apartment-type building

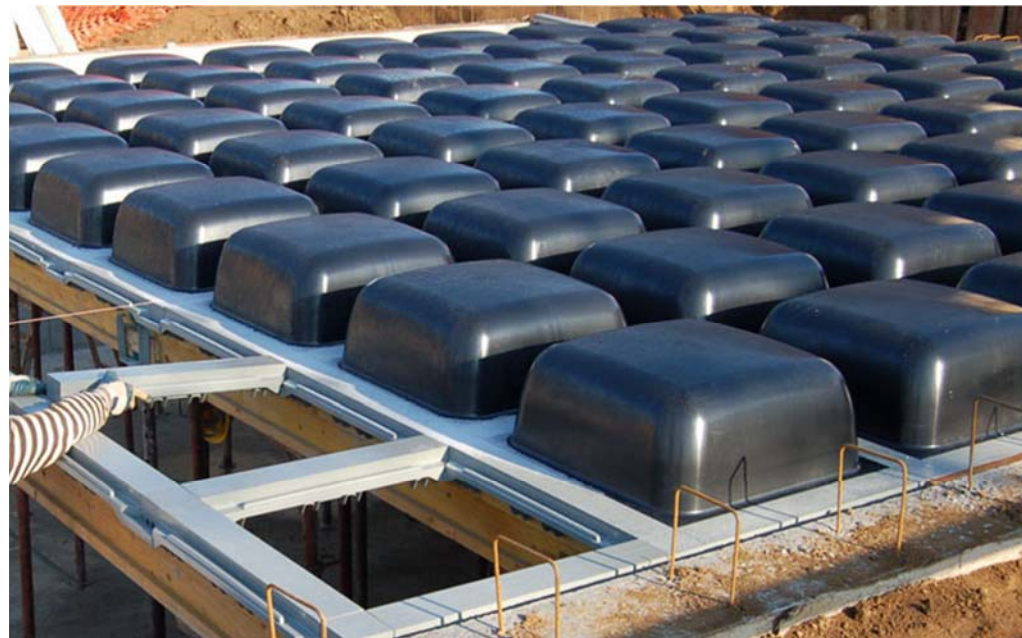






Column formwork using plastic materials (UPVC, GRP)

Formwork using glass reinforced plastic materials for waffle floor



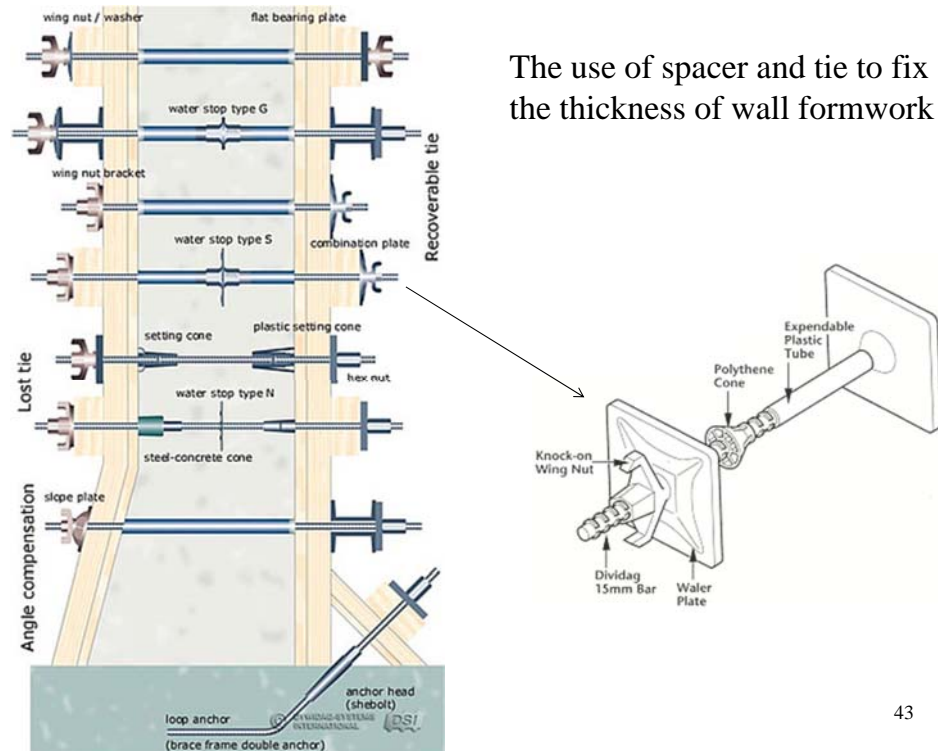


## 2.4 Classification according to nature of operation

- Manually operated formwork
- Self-lifted formwork
- Crane-lifted formwork
- Gantry, traveling and tunnel type formwork system

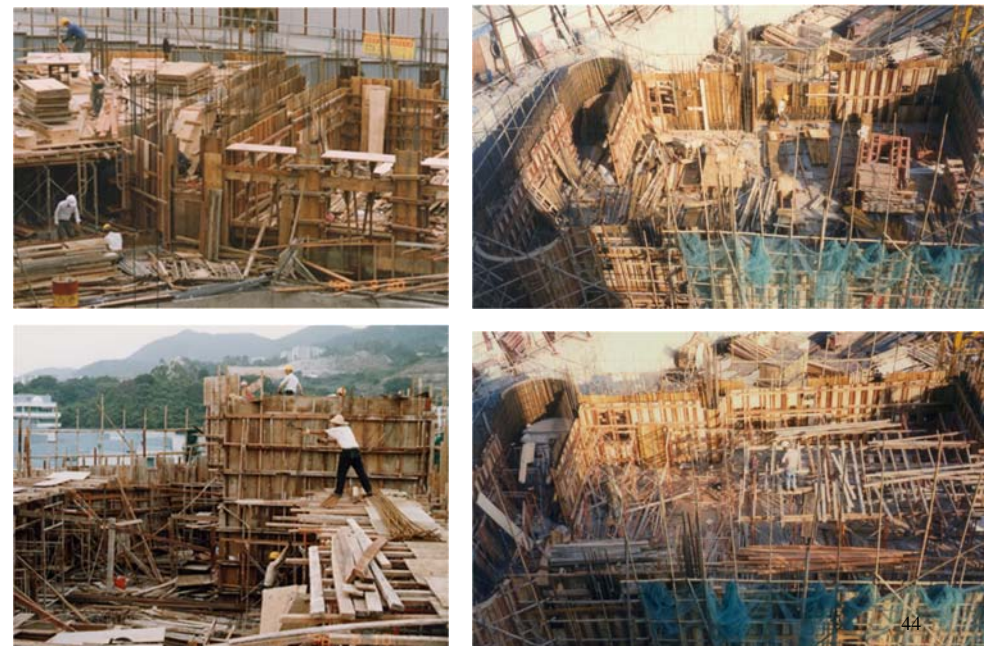
41

Manual operated formwork – the good practice cases



43

Manual operated formwork – the poor practice cases



44





Climb form operated by the use of a series of synchronized hydraulic jack systems

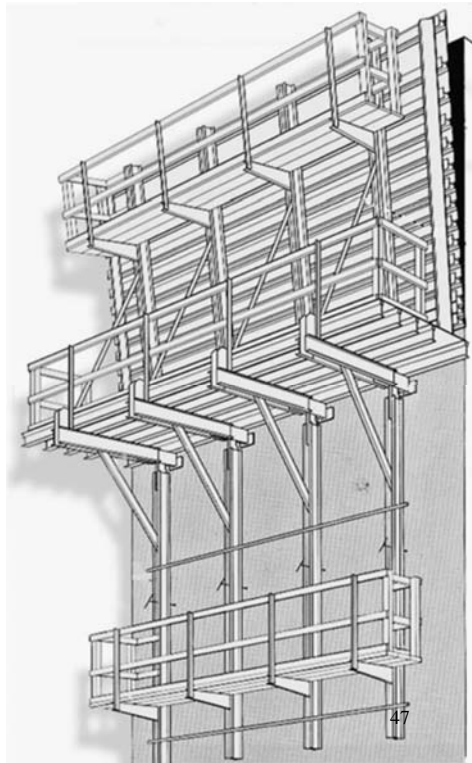
[http://bst1.cityu.edu.hk/e-learning/building\\_info\\_pack/index.html](http://bst1.cityu.edu.hk/e-learning/building_info_pack/index.html) 45



Jump form for the construction of a high-rise residential tower – lifting action is done by a series of screw jack systems 46



Manually operated jump form using build-in hand jack



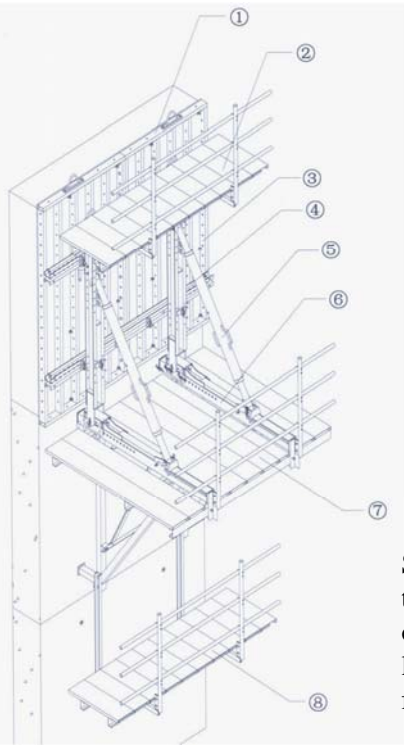
Manually operated jump form using build-in hand jack





1. 模板
2. 上平台
3. 次背楞
4. 主背楞
5. 斜撑
6. 模板支架
7. 中平台
8. 吊平

1. Form
2. Up platform
3. Wale
4. Strongback
5. Brace
6. Main bracket
7. Middle platform
8. Finishing platform



Standard unit and the climbing operation of large-panel type formwork

49

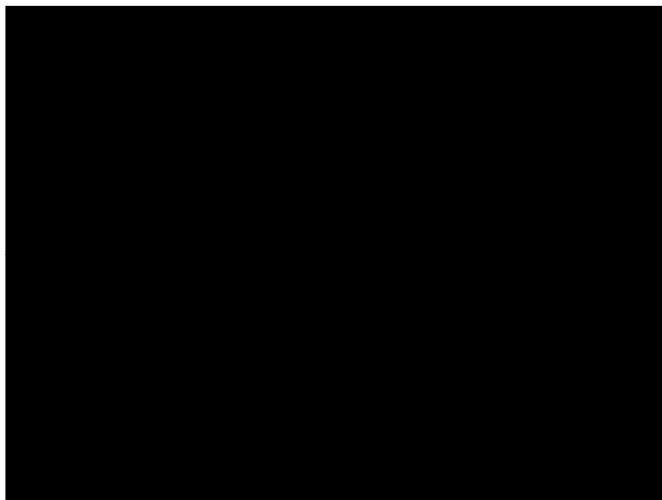
- Construction of the 600m-long elevated expressway for the Lantau Link using a type of traveling gantry form



- Structure of the Shui Hong Station of the West Rail projects



Example of extremely large and complex mechanical formwork system for super high-rise construction



51

## 2.5 Classification according to brand name of the product



52



## 2.7 System and products



## 2.7 Formwork in reality - in typical site environment



## 3. Considerations when using formwork

### 3.1 Design related considerations

- shape of the building
- Architectural features on building exterior
- Internal layout
- Structural form
- Consistence in building dimensions
- Span and Headroom
- Repetitive nature
- Finishing standard

## 3. Considerations when using formwork

### 3.2 Construction related considerations

- Complexity of the built environment
- Speed of work
- No. of possible reuses
- Construction planning and arrangement
- Area or volume of cast per pour
- Involvement of other construction technique
- Dependence of work
- Provision of construction joint
- Accessibility to work
- Feasibility of introducing alternative design



## Examples of some crucial built situations

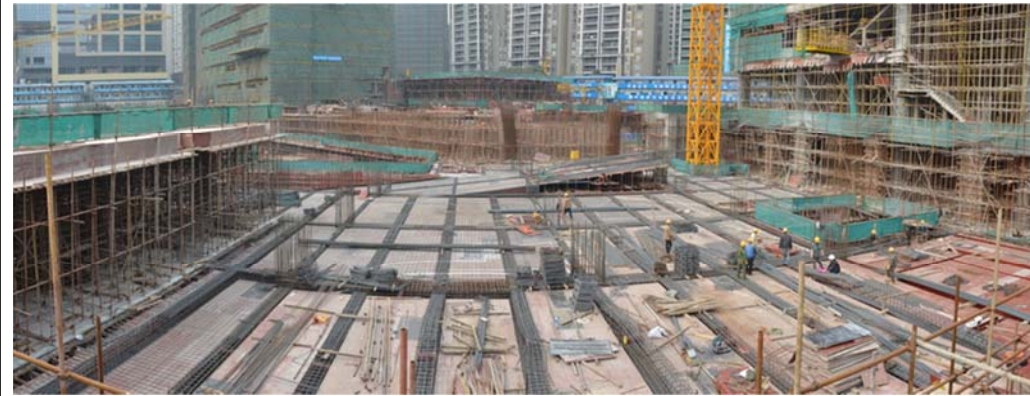


very large site

57



very large site



very large site, Terminus Building of Express Rail at West Kowloon



very crowded site



Sloped site



Work within congested and difficult space



Work involvement  
high-headroom spaces



Working high-headroom





Phasing  
arrangement to  
be considered



Examples where special techniques are involved in the construction



Incorporation of tensioning and  
complicated phasing arrangement

67

Examples where special techniques are involved in the construction

Incorporation of  
precast elements



68





Examples where complicated construction jointing requirement are involved

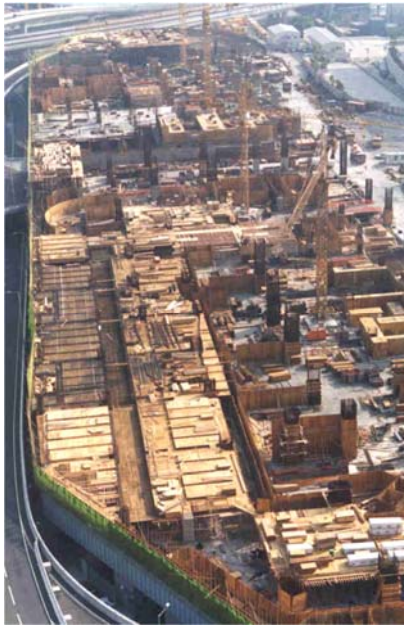


70





## Accessibility problems in formwork process

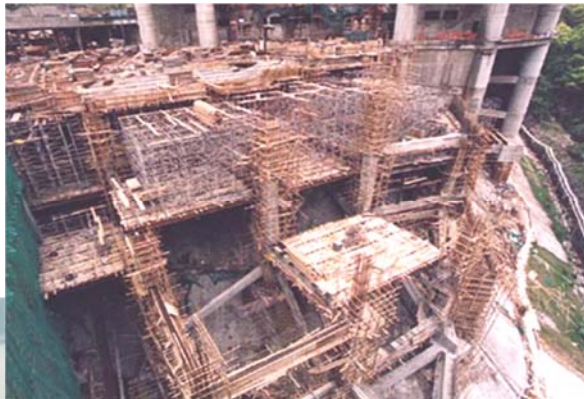


73

## Accessibility problems in formwork process



## Accessibility problems in formwork process – more examples



75



very large site



very crowded site

Sloped site



76



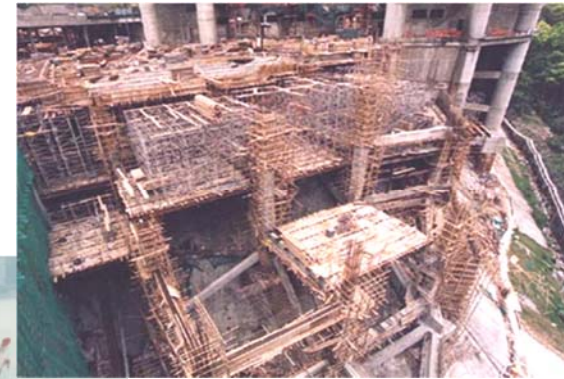
Incorporation of precast elements



Incorporation of tensioning and complicated phasing arrangement

77

Accessibility problems in formwork process– more examples



78

## 4 Examples of Application

### 4.1 Festival Walk – using traditional manual-type timber formwork



Festival Walk as seen in 1996

79

80



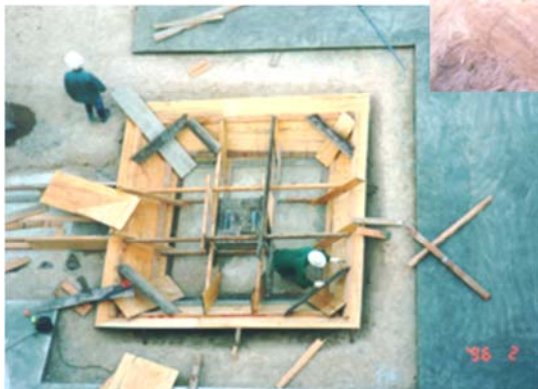
- large span structures up to 32m in length, cast-in-situ, some are post-tensioned.
- 3 atrium spaces, averaged 35m in span, and with 25m headroom
- Average headroom for each floor is about 4.5m



- Basement -- top-down approach.
- non-repeated layout
- structure subdivided into 6 main phases.
- great number of construction jointing

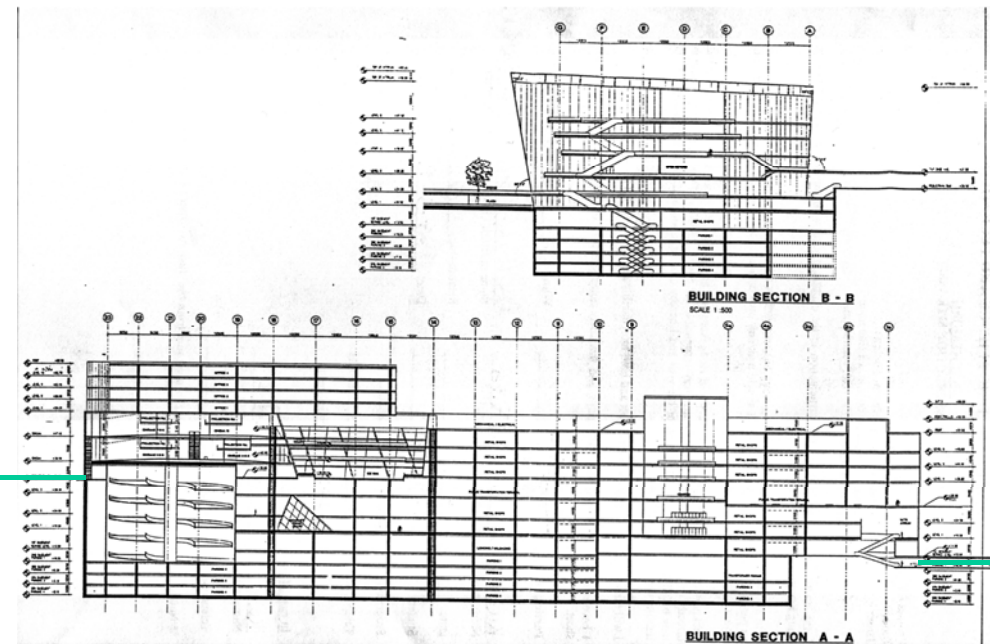


Using the ground surface as formwork soffit



Formwork forming the shape of the drop panel of the flat slab using blinding concrete

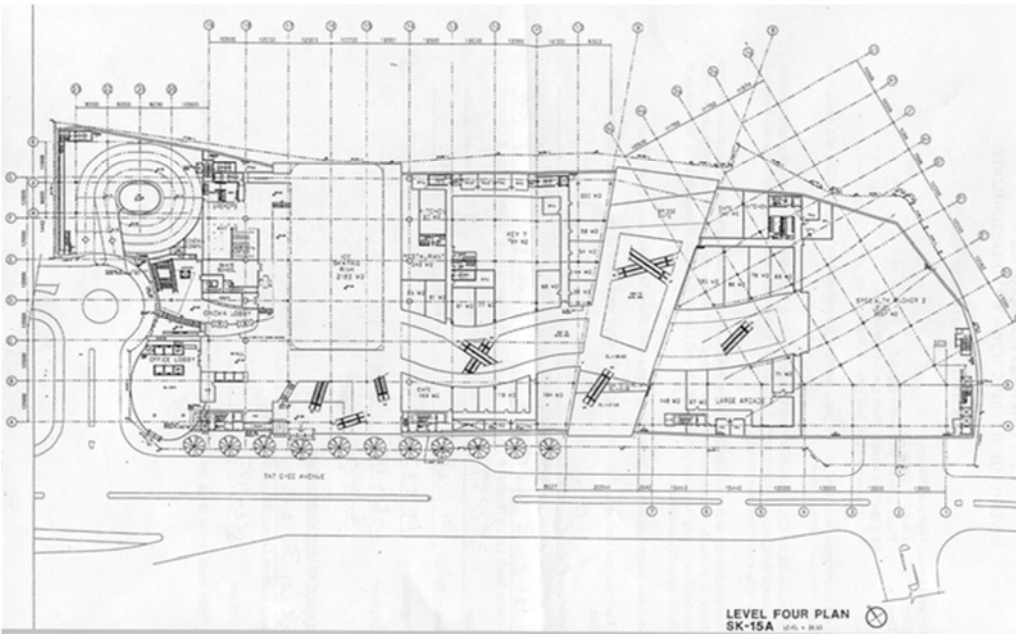
83



**Building Section along Tat Chee Road**

84





Floor Plan at Tat Chee Avenue Level

85



Progressing stage of superstructure & basement construction (1)

86



Progressing stage of superstructure & basement construction (2)

87



Progressing stage of superstructure & basement construction (3)

88





Progressing stage of superstructure & basement construction (4)

89



Progressing stage of superstructure & basement construction (5)

90



Construction of the superstructure in complicated phases

91



Superstructure constructed using traditional manual timber formwork







Construction of the superstructure at its final stage (observe the complicated sectioning arrangement of formwork)



Steel fixing for the superstructure structure

94

Formwork for the vehicular ramp



Other complication/features of the formwork system



96



## Other complication/features of the formwork system



97



The office tower supported by a transfer structure

98



Complicated spacing arrangement within the superstructure

99



100





The skylight roofing taking shape

Escalator spanning below two levels of the shopping mall

101



The skylight roofing taking shape

Intermediate frames

Main frame

102



Installing the glazing panels for the skylight



#### 4.2 Belcher's Garden – using traditional manual-type timber form

104



- situates on sloped site with area around 24,000 sq m.
- level difference about 65m.



105

Forming the sloped beams on the formed slope



106

Construction of the podium structure



107

Other features of the project:

- 10-level podium, used as carpark, shopping mall and recreational facilities
- Six 48-storey residential towers built on top of podium
- huge size of podium and sophisticated typographic environment of site, demands complicated phasing and sectioning arrangements

108



Falsework to support the transfer plate



109

View of the transfer plate located on top of the podium structure ready for the commencement of the upper towers



The falsework system and the formwork being erected for the construction of one of the transfer plates for a tower block. Note a completed one at the rear.



Closer look at the transfer plates lining in row format with the centre one recently completed while the other on the sides soon ready for the placing of concrete





Detail look at the transfer plate with the reinforcing bars being fixed near the building core location. Note also the hose pipe forming ducts inside the plate for the insertion of tendons for post-tensioning work after concreting.



The transfer plate with the formwork for the first residential floor as seen on the upper level of the podium structure



Overview of the tower blocks seated on the transfer plate above the gigantic podium structure. Note the complicated spatial environment especially the working height in this job.



Overview of the tower blocks and the transfer plate in relation to the layout of podium structure



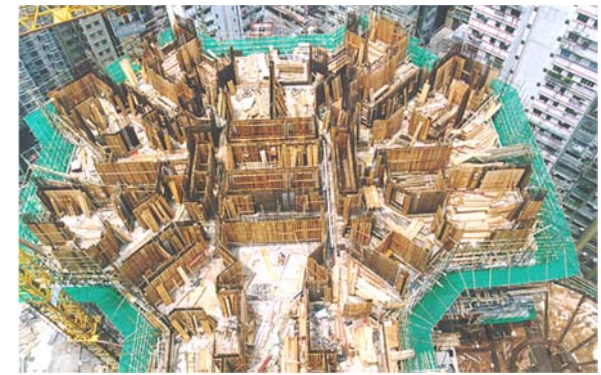


The tower structure and the podium as seen from the side and street level. Note the overhanging portion of the transfer plate supporting the tower block.

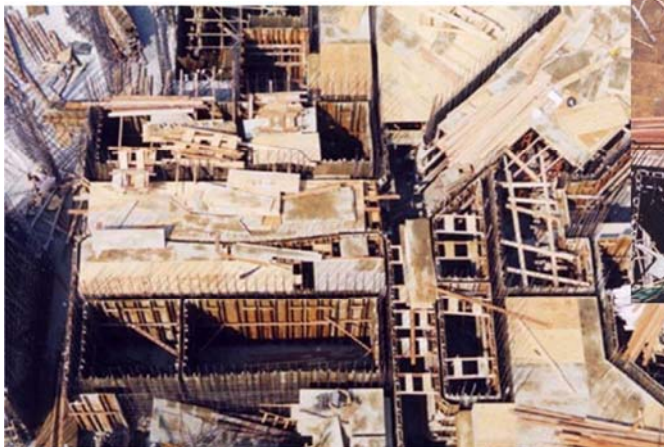


## Superstructure

- irregularity in layout
- complicated architectural features in external envelopes
- large amount of short-span slabs
- large amount of shear walls in the structure
- use of manually operated timber panel forms



Detail of the floor form layout from an elevated position



Detail of the wall formwork





Detail of wall and floor formwork arrangement as seen from the floor interior



121

#### 4.3 Lee Garden Hotel Redevelopment – Climb form for core, composite slab and structural steel outer frame

122

- 50-storey office building
- inner core constructed in reinforced concrete
- outer frame in structural steel
- RC core constructed using the VSL climb form -- self-lifting formwork system using hydraulic jacks



123

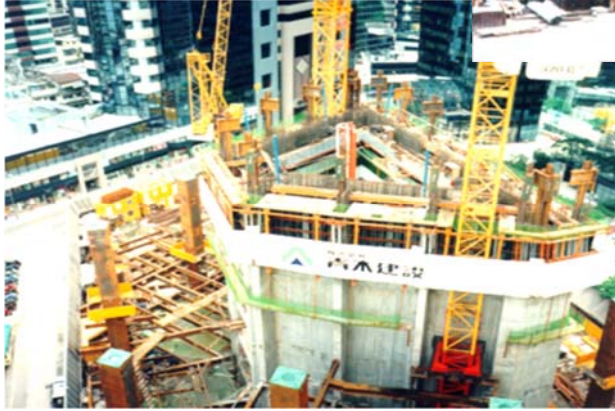
Assembling of the climb form on the ground slab level



124



The climb form at its trial operation



125

Details of the Climb-form system



Gantry frame, shutters, rail tracks, and scaffold detail

126

More detail on the rail track for the panel shutters



127



Detail of the guide wheel and locking pin



128



section of the core wall changed



129

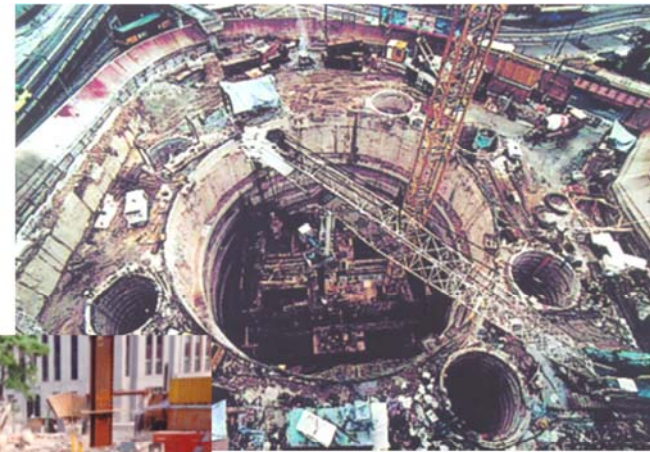
#### 4.4 Cheung Kong Center

130

- 62-storey office building
- Jump form system for core
- composite slab and concrete-filled steel tube as the outer frame



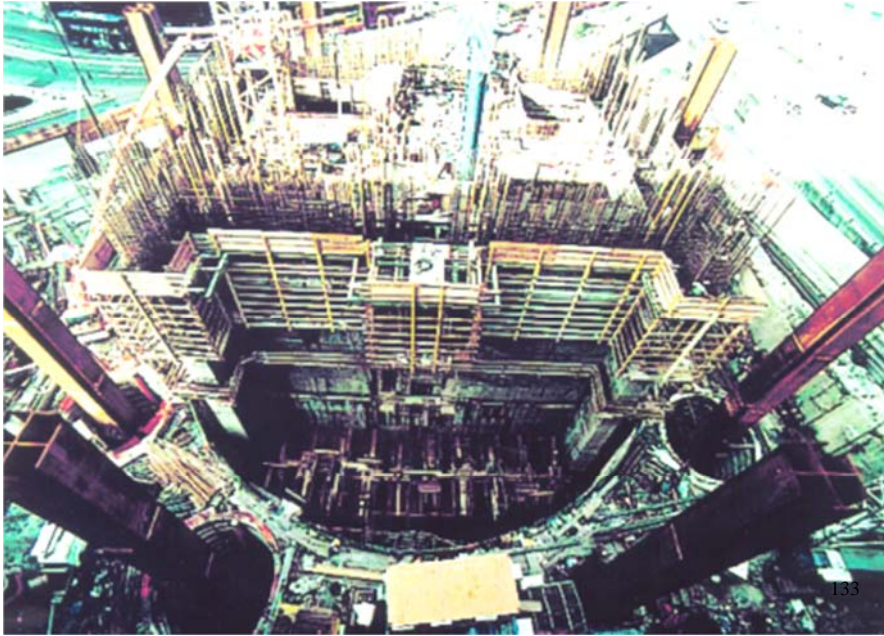
Layout of the Jump Form rising from the foundation raft



132



Overall layout arrangement of the  
Jump Form as seen from an elevated position



Formwork arrangement  
as viewed from the side



The gantry frame that  
mounted the panel  
shutters rigidly within  
the core wall layout





Detail seeing the arrangement of the formwork system with the panel shutters in position



137

Form system as seen from the inner shaft



138

#### 4.5 Gateway – Climb form for core and table form for slab

- 3 detached building towers each of 38-storey high
- structure of towers –
  - central core with averaged 12m span RC columns around
  - post-tensioned flat slab system,
  - core wall - VSL climb form, partially in large panel gang forms
  - slab – aluminium strutted flying form system



139

140



External view of the climb form for the construction of the core wall



Some sections at the sides of the core wall are formed using large panel shutter



141



Floor slab as seen from various elevations

142



Wall section of the core before the enclosing with panel shutters.

143





## Other Features

- slab is cast in two separated sections in a staggered manner with a lapse of 2 to 3 storeys to convenient tensioning works, as well as to obtain better operation arrangement in the handling of the formwork



145

## Flat slab and post-tensioning arrangement



146

## Dropped panel at the column head and detail for slab joining to the core wall



147

## 4.6 Harbourfront Landmark

- Steel panel form for shear walls & table form for slab

148



- 62-storey residential development with 3 attached towers on a 6,500 sq m site.
- Shear walls to form compartment units, centered with a core structure.
- Walls -- steel form system
- Slabs -- aluminum-strutted flying form system



149

General detail of the steel form for wall



150



Detail of large panel wall formwork

151

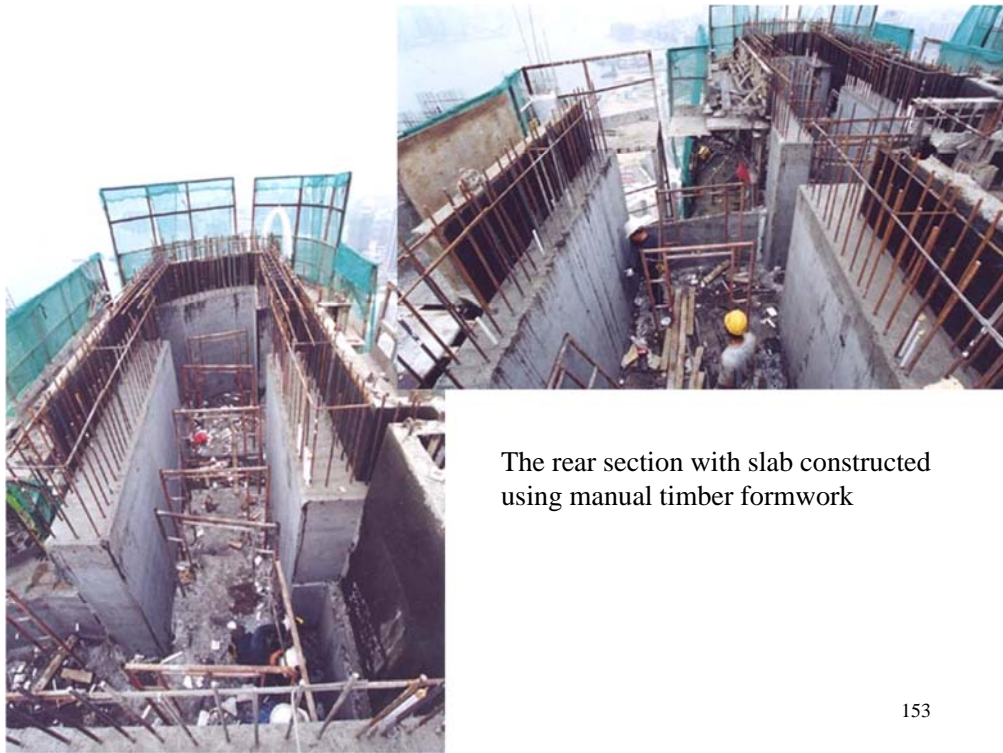


The rear elevation with ellipse-shaped core wall serving as kitchen and store room



152

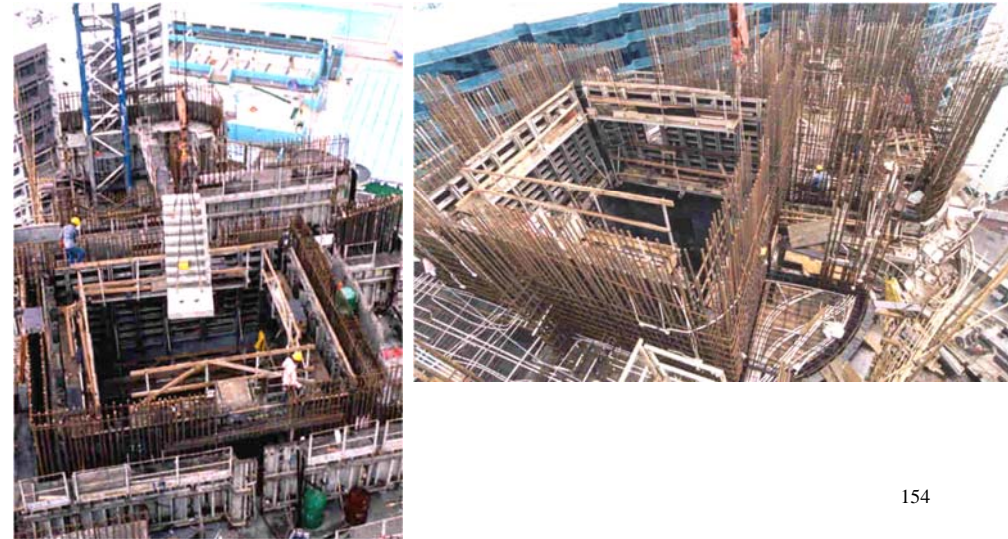




The rear section with slab constructed using manual timber formwork

153

- central cores -- constructed in form of vertical shaft.
- inner structures – slab, lift walls & landings are cast-in-situ using timber forms
- stair flights -- prefabricated



154



Releasing the table form



155



Placing the table form



156



Forming the inner walls and stair landing within the core shaft



157

## 4.7 Park Avenue – Aluminum form

158

- four 46-storey high residential towers on transfer plate
- aluminum formwork – the MIVAN system
- structure consist of a large number of shear wall



159

Mock up of the Aluminium Form before installation in full scale



160



General detail of the aluminium form – walls and beams



161

General detail of the aluminium form – walls and beams



162

General detail of the aluminium form – walls and beams



163

General detail of the aluminium form – wall (view from interior)



164





General detail of the aluminium form – Floor



165



General detail of the aluminium form – stair



166

General detail of the aluminium form – stair



167



General detail of the aluminium form – Plant box and external features



168



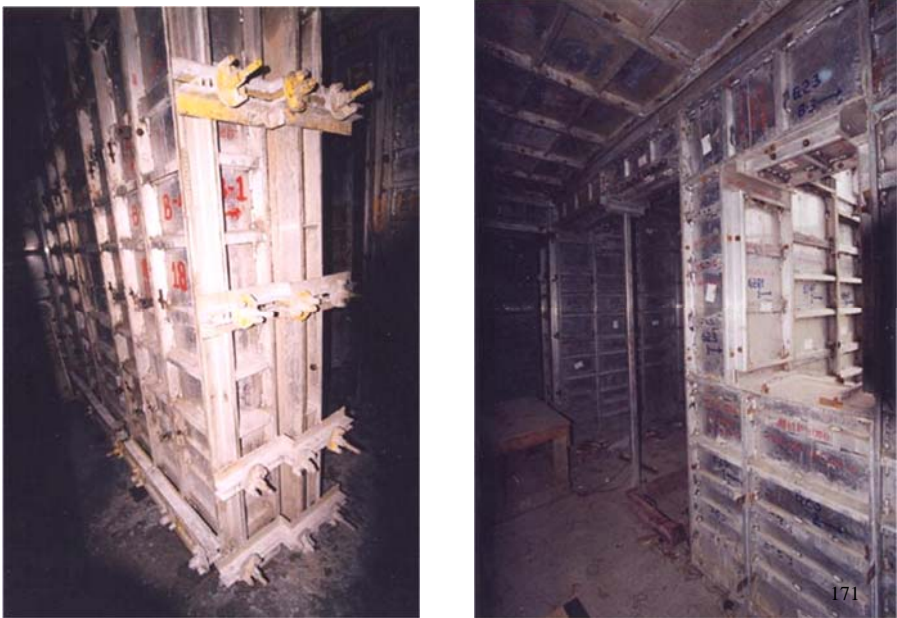
General detail of the aluminium form – Plant box and external features



General detail of the aluminium form – Plant box and external features



Close up detail



Close up detail







173

## Problems encountered in the using of the Aluminium Form

- Too many formwork accessories that make installation very difficult
- Complicated external wall and spatial design magnify the installation problem
- Inconsistent in the major structural elements require frequent amendment to the formwork
- Resulted to a very long learning curve



174

Problem of too many insistently sized components



175

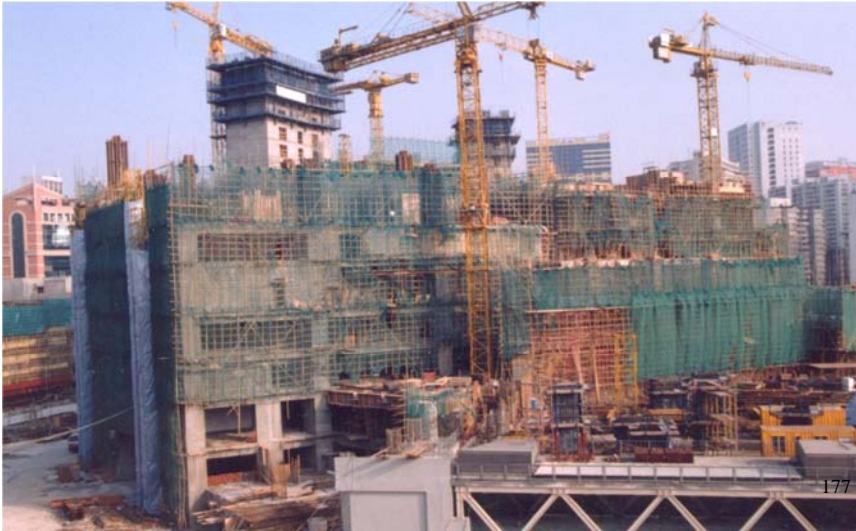
## 4.8 Nina Plaza

176



## Formwork Features

- Climb form for the core wall (3 isolated cores)
- Modified steel table form for floor slab
- Traditional timber form for podium structure



Arrangement of the climb form for one of the building cores



178

Side view of the form seeing the platform and the jacking rod



179

Overview of the formwork arrangement for the core and the floor



180



Floor formed in staggered manner



Propping arrangement and the layout of the table form as seen from the underside



181

182

Finished look of the completed building



183

#### 4.9 Some advanced self-climbing systems used in various forms of development - IFCII

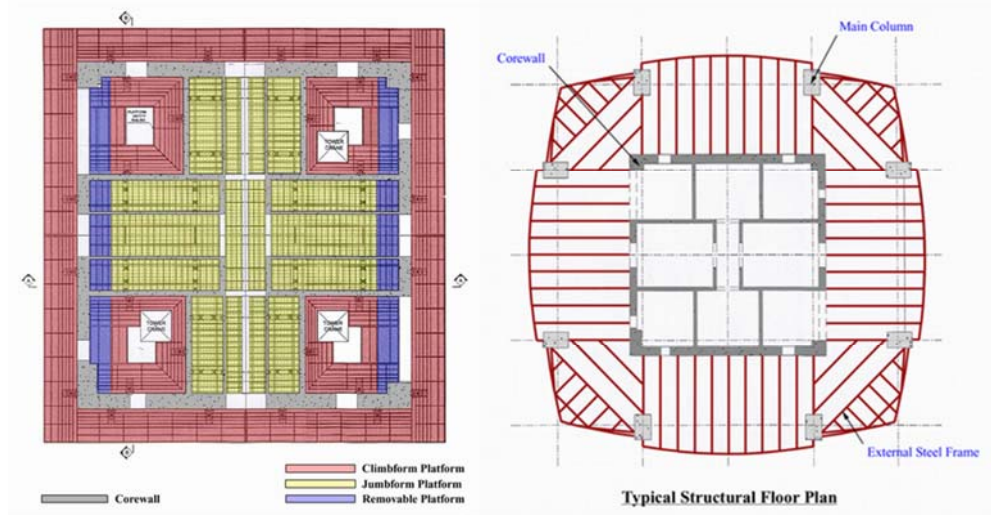
184





185

## Building frame and core wall layout



186

## Formwork at its opened mold



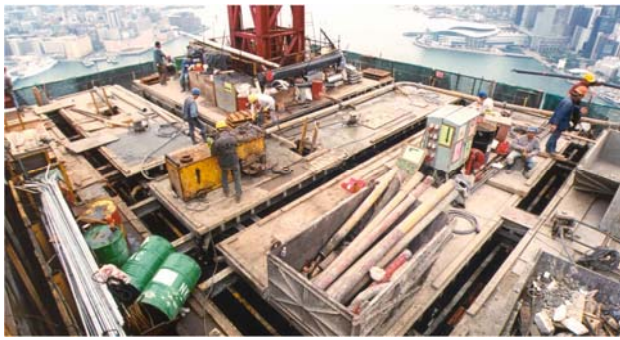
187

## Close up view of the hydraulic jack



188

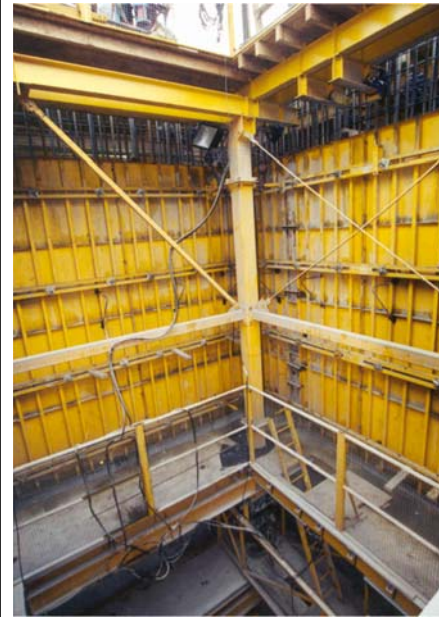




Setting up of the climb form at the deck level



Deck at the topping out level



Gantry frame, scaffold and Panel shutters as seen in the form interior

190



Linking the core and the inner wall/slab construction



Finished look of the completed building



192



#### 4.10 Some advanced self-climbing systems used in various forms of development – Residential Development at Repulse Bay

193

#### Formwork Features

- A curved apartment-type tower structure of 28-storey high
- 5 parabolic-shaped stair-core constructed using climb form
- Modified steel table form for the floors



194



Detail of the staircase core



195

Junction detail between core and the floor slab



196





The table form for the casting of floor



197

The hydraulic jack mounted on the external face for the lifting of the climb-form system



198

Finished look of the completed building



199

4.11 Some advanced self-climbing systems used in various forms of development – Chartered House

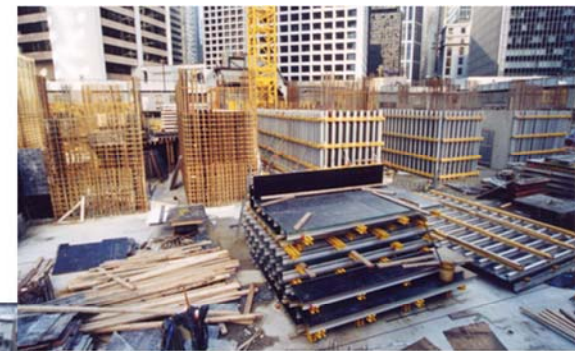
200





201

Large panel formwork for the ground floor core wall



202

Modifying the large panel form into the climb form by adding in the gantry frame and jack system



203

Overview of the climb form



204





Arrangement  
between the core  
wall and the floor



Layout of the core wall and  
the gantry/jack system  
within the core wall shaft



Placing a section of  
the table form onto  
the floor slab



Material hoist for the lifting  
of the table form units 208





The floor slab and the tensioning arrangement



#### 4.12 Some advanced self-climbing systems used in various forms of development – Urban Renewal Authority Mong Kong Redevelopment

210



211

Forming the transfer plate and the lower section of core wall using manual timber form



The lower section of core wall below the transfer plate

212



Erection and trial operation of the slip form system



213

Erection of the slip form on top of the transfer plate



214



Arrangement for the core wall and floor formwork

215

Layout/gantry frame arrangement above and below the deck level



216





Close up detail of the hydraulic jack system



Finished look of the completed building



#### 4.13 One Island East Project in Quarry Bay







Close up look of the formwork system incorporating with the former shutter, work platform and the stabilizing frame



Table form for constructing the floor slab



Close up detail of the attaching core wall and the floor formwork in the form of reduced-size table

223



Material hoist for the lifting of the table form units and the climbing-type safety screen covering the building exterior

224



#### 4.14 Self-climbing formwork system with the incorporation of some precast works – Concord Project in Fanling Wah Ming Estate

225



226



Detail of the jump form for constructing the core wall



Detail and layout of the jump form for constructing a typical wing



228





Close up seeing the operation detail of the jump form and the guide rail for the panel shutters



229

#### 4.15 Aluminum formwork to cope with the use of other precast elements – Lee Tung Street Redevelopment project

230







233



Erection of the precast facade before the placing of the formwork



Precast facade



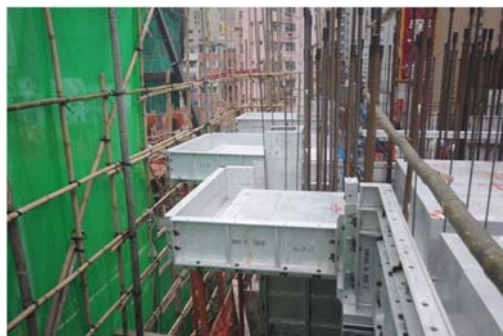




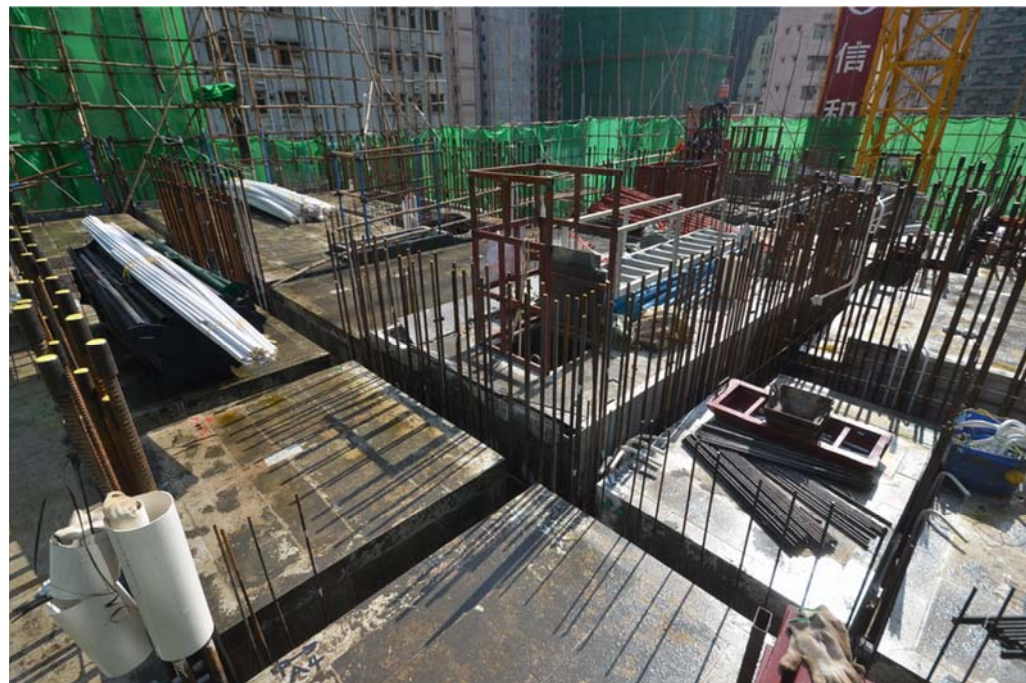
Precast facade connecting to the floor slab by link bars



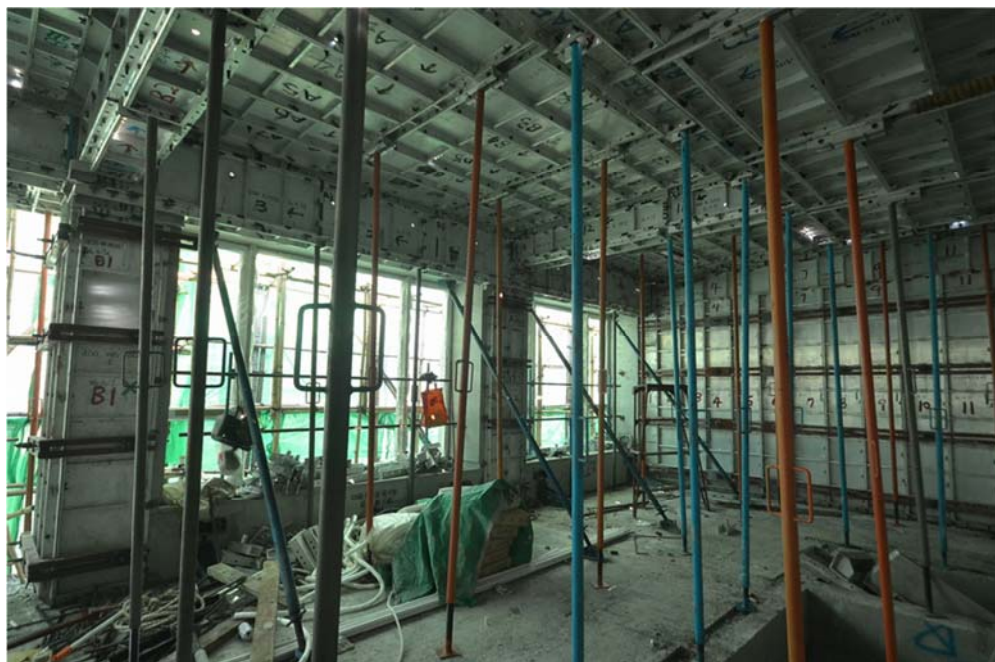




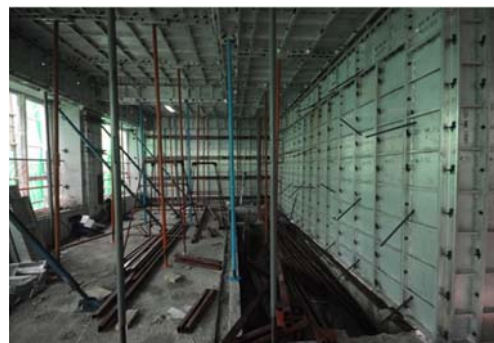




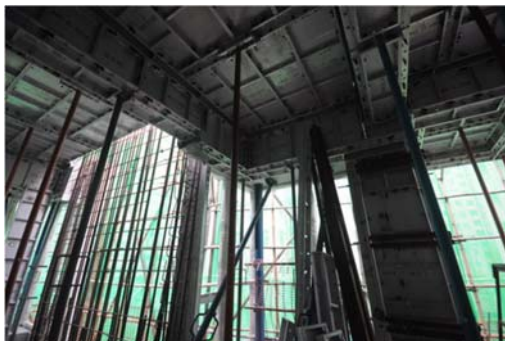
246



247

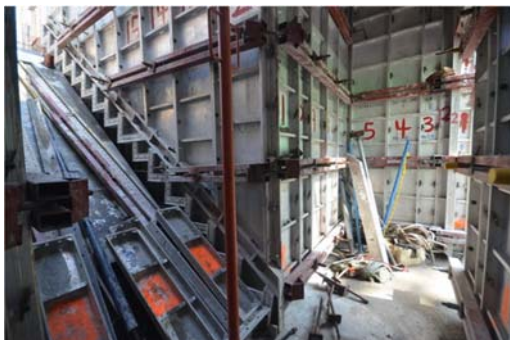






Aluminum form for the staircase

250



#### 4.16 Steel form to cope with the use of other precast elements – the Celestial Height (Kau Pui Lung Road, To Ma Tau Wai)

252





253



254



255



256





#### 4.16.1 Formwork Systems used in Civil Jobs – Ma Wan Elevated Expressway

258

#### 4.16.1 Formwork Systems used in Civil Jobs – Ma Wan Elevated Expressway



259

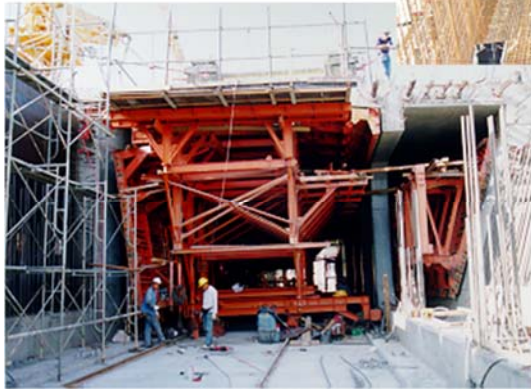
Complicated  
falsework is required  
in the forming of the  
elevated expressway  
section



260



Gantry-type traveling formwork for the casting of the repeated expressway section



261

#### 4.16.2 Formwork Systems used in Civil Jobs – West Rail Sui Hong Station

262

#### 4.16.2 Formwork Systems used in Civil Jobs – West Rail Sui Hong Station



263

Setting-up of the gantry form for the construction of the station structure



264

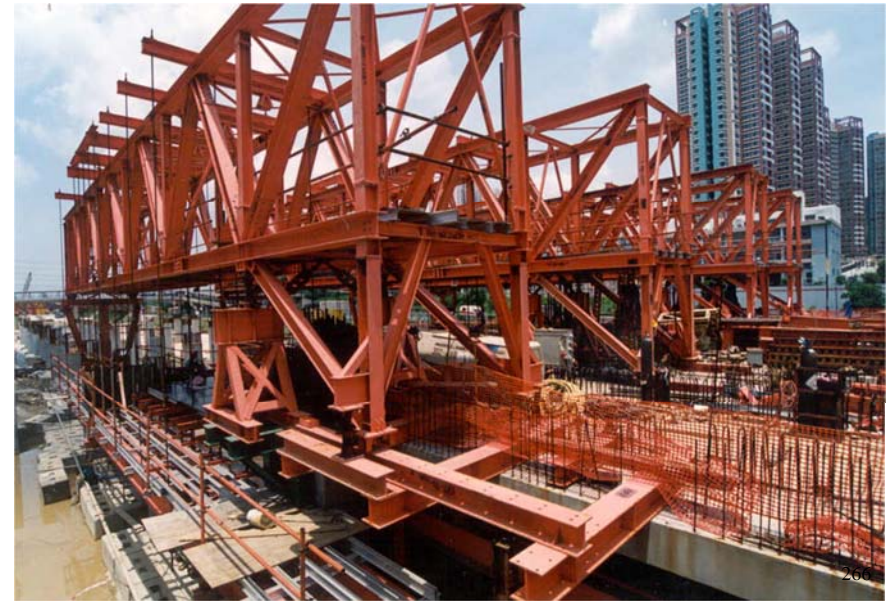




A suspended soffit supported by hangers from the gantries. The soffit will be used to cast the suspended slab of the station structure

265

Detailed view of the gantry system and the suspended station slab



266



The construction of the station's superstructure using usual large-panel gang form from the suspended slab



267

#### 4.16.3 Formwork Systems used in Civil Jobs – West Rail Depot at Pat Sheung

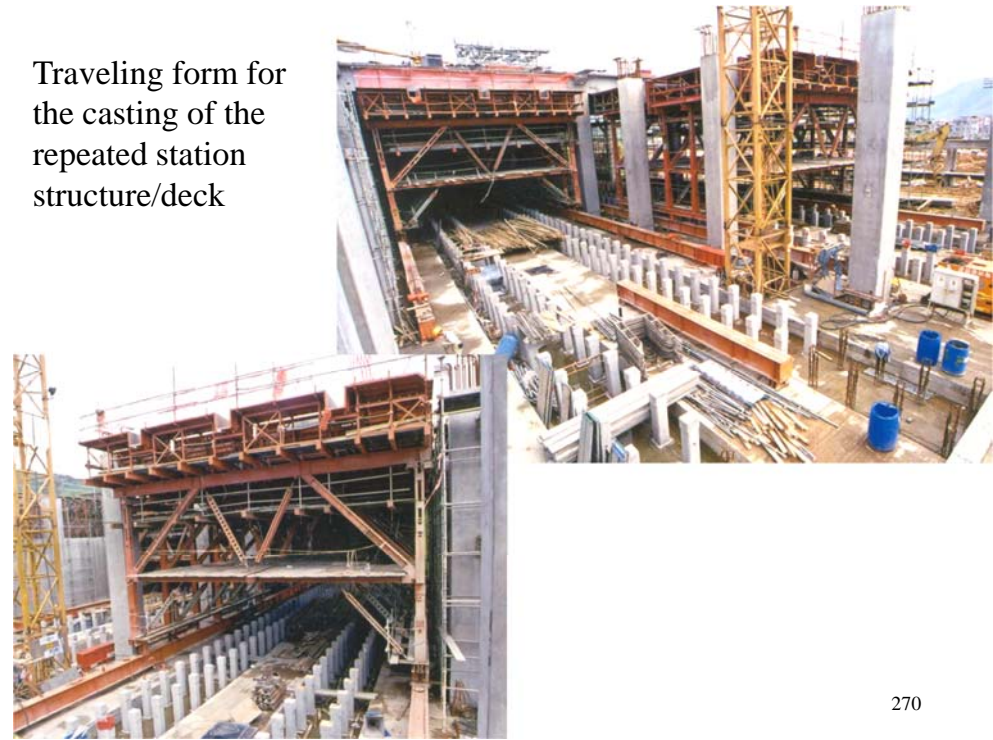
268



#### 4.16.3 Formwork Systems used in Civil Jobs – West Rail Depot at Pat Sheung



Traveling form for  
the casting of the  
repeated station  
structure/deck



The tunnel form in  
position (above)  
and after  
concreting (below)

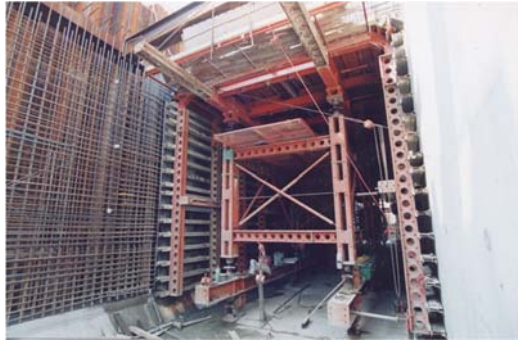
271







Actual tunnel section being completed



273

#### 4.16.4 Formwork Systems used in Civil Jobs – Airport Ground Transportation Centre

274



275

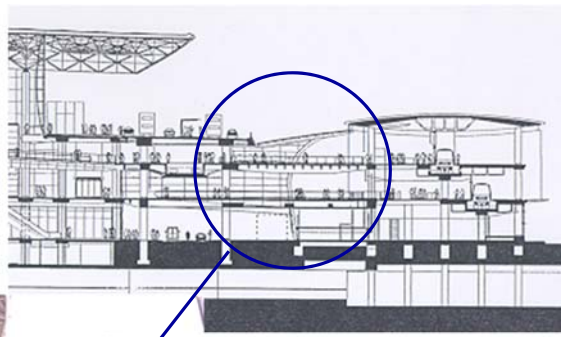
Traveling form for the forming of the passenger access linking the  
Airport Terminal Building and the Ground Transportation Center



276



Detail of the double-decked passageway – waffle floor for the upper deck



277



278



Forming the hollow-section curved roof of the GTC



279



Gantry supporting the roof soffit that formed the underside of the roof structure



280





The roof portion above column head that formed using normal soffit panel supported by props

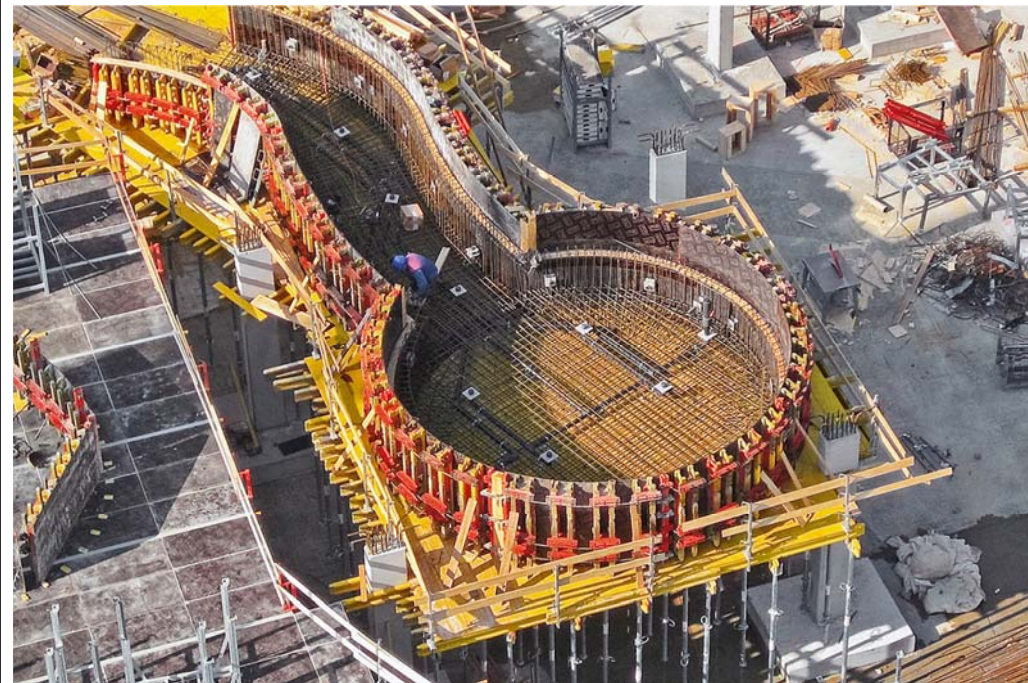
281



Other examples of using formwork for structures with complicated shape (overseas examples)



282



285

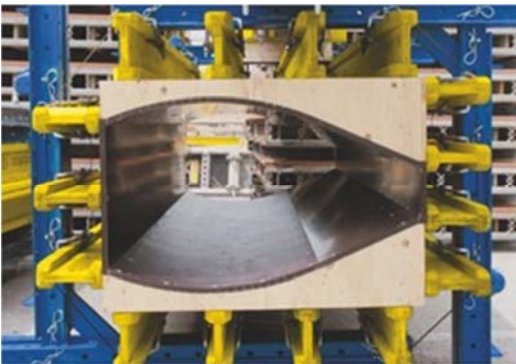




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286



287

Comparing some  
formwork cases for  
circular structures



Circular ramp in  
Festival Walk

288



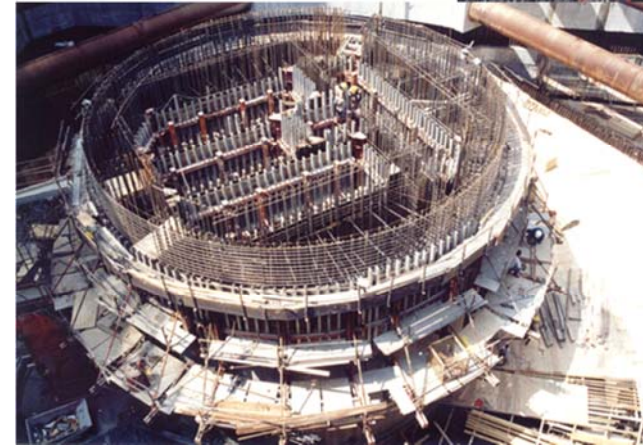
## Comparing some formwork cases for circular structures



Circular ramp in IFC-I

289

## Comparing some formwork cases for circular structures



Circular ramp in IFC-II

290

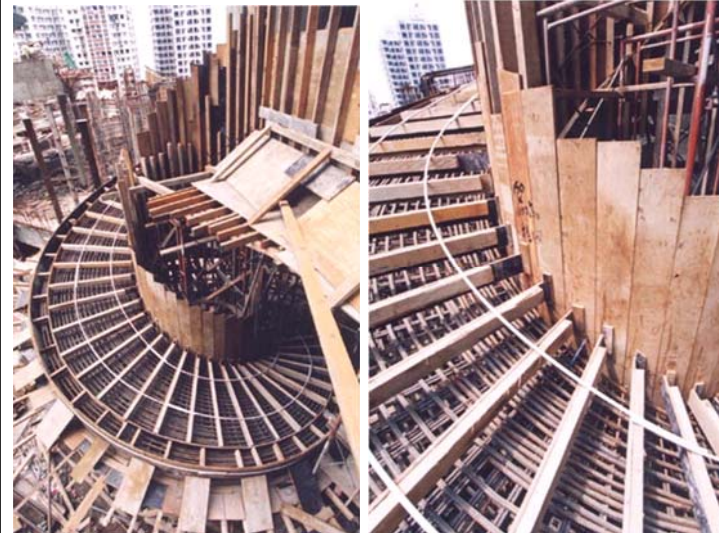
## Comparing some formwork cases for circular structures



Circular ramp in Metropolitan in Hung Hom

291

## A spiral-shaped stair

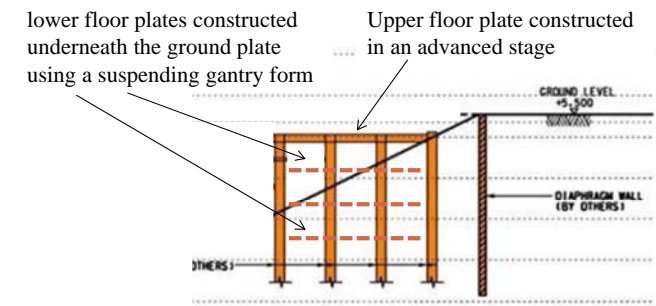


292



#### 4.16.5 a Gantry-type Formwork Systems used in the Terminus Building of the HK Express Rail in West Kowloon

293



First set-up for the erection of the suspending rail to support the gantry form



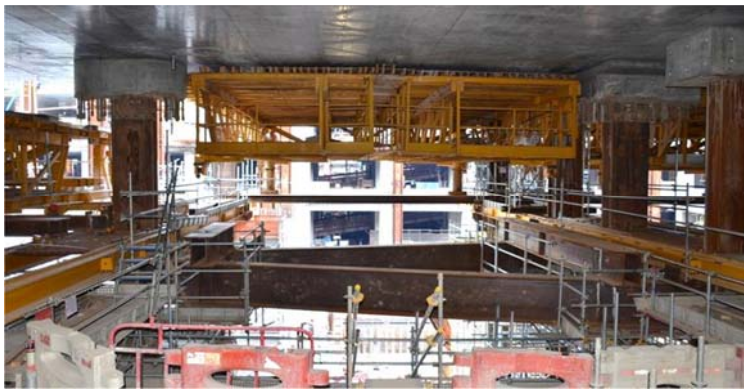
First set-up for the erection of the suspending rail to support the gantry form











The gantry form for the floor plate before and after the striking of the form



Construction of the -3 plate using the same set of gantry form but supported





Closer see of the working condition of the gantry form



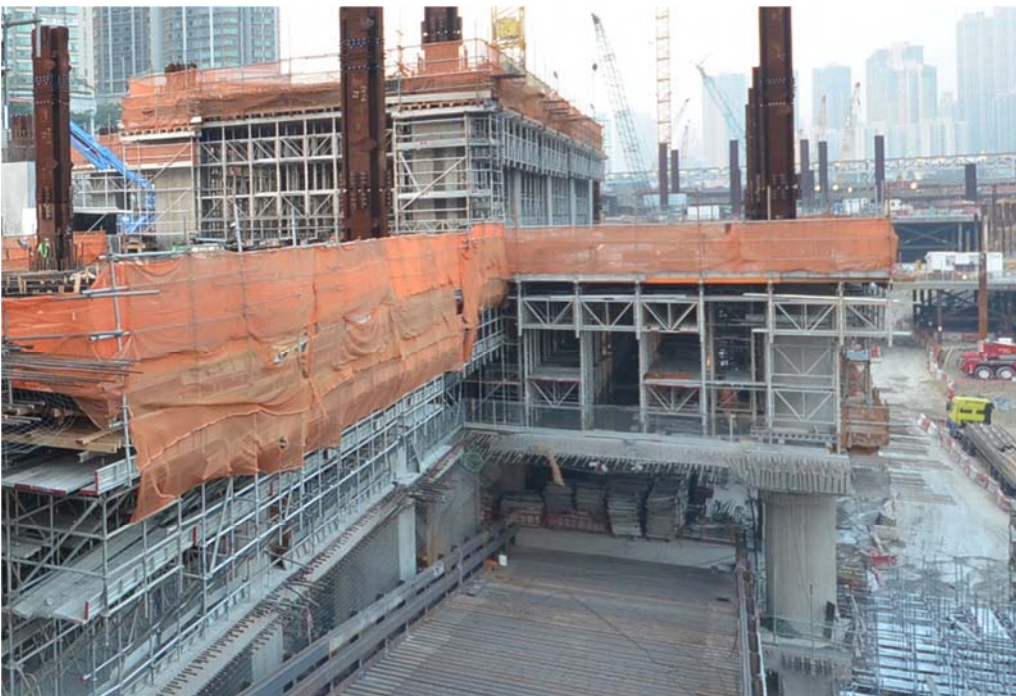
Another set of gantry form used in the central core (in the lowest floor only to avoid the uneven ground on the







Setting up detail of the gantry



Other floor plates were constructed using typical aluminum prop works



Construction detail for usual floor plates



Failure in working with Formwork –  
Formwork Collapse during the concreting process

313

## Formwork Collapse Cases – The Festival Walk



314

Formwork  
Collapse Cases –  
a portal beam in the  
Ma On Shan Station  
of the KCR East Rail  
Extension



315

A portal beam formwork similar to the one collapsed



316





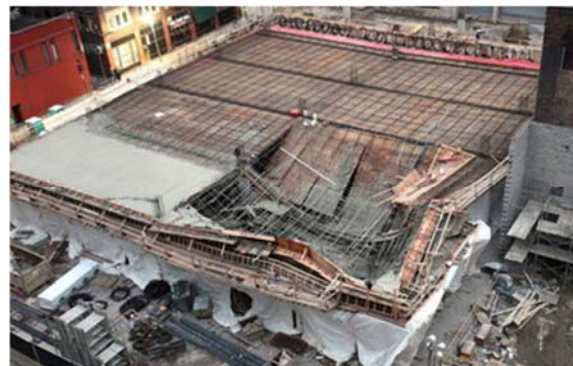
Formwork Collapse Cases -  
Industrial Building in Kwai  
Fook Rord, Kwai Chung, 1995

317

Formwork Collapse -  
Science Park Phase 3



318



320



## Summary

Small-size site can hardly produce the benefit by the making use of advance formwork system due to less cost repetition and congested working space.

The structural form of the building is one of the critical factors to determine the choice of formwork.

System products contribute much in the success of formwork application.

The choice and arrangement of utilizing formwork is highly depended on individual site/project environment.

More collaboration between client, design teams and contractor in the planning stage can help in the effective use of more advance formwork systems and to save cost.

## End of presentation

If audiences wish to see more about the presentation materials from Raymond Wong, please use this link and see other related topics from his web-base information archive.

<http://const-infobank.org/>

Thank you.