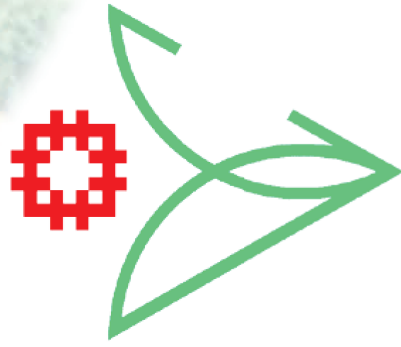


**First International FIG Workshop on Monitoring High Rise and Tall Engineering Structures**  
**Development and Practices**

# **Building Monitoring Survey of Public Housing Estates in Hong Kong**

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**Hong Kong Housing Authority**



# Content



1. Introduction
2. Current Practice of Monitoring Survey for Public Housing Estates
3. Brief Review of Other Building Monitoring Technologies
4. Survey Data Management
5. Conclusions

# Introduction – History of HKHA



- Public housing development since 1954
- Provide low-cost housing estates for the low-income people
- Resettlement Department



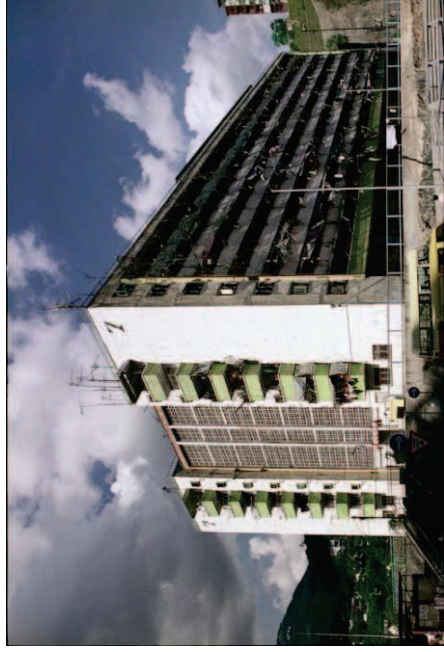
# Introduction – History of HKHA



- Governor Sir Murray MacLehose announced “Ten Year Housing Programme” in 1972
- Hong Kong Housing Authority founded in 1973
- To construct and manage all public housing



# Introduction – Standard Design



Mark I – 1950s

Mark II – 1960s

Mark III – 1960s



Mark IV – 1965 ~ 1969

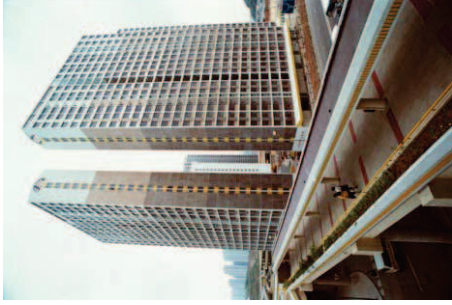
Mark V – 1966 ~ 1971

Mark VI – 1970s

# Introduction – Standard Design



Twin Tower – 1970s ~ 1980s



Slab – 1970s ~ 1980s



Cruciform – 1980s



H-type - 1980s



Double-H – 1980s



Trident – 1980s



# Introduction – Standard Design



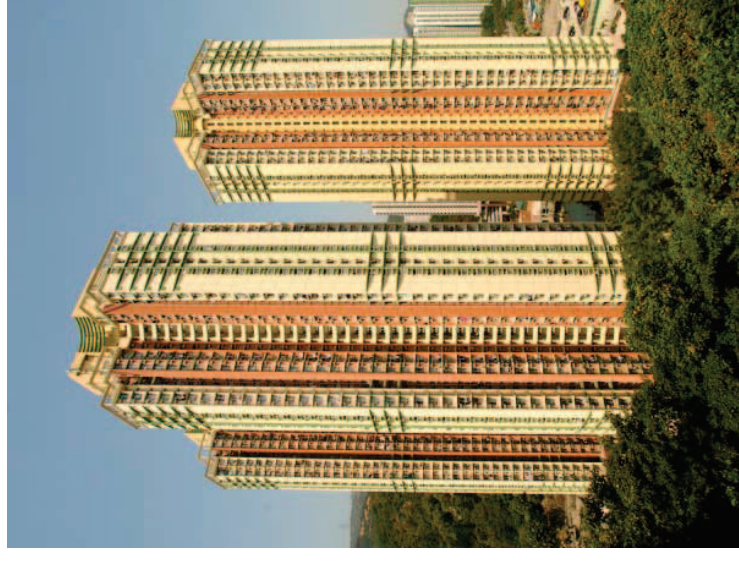
Harmony



New Cruciform



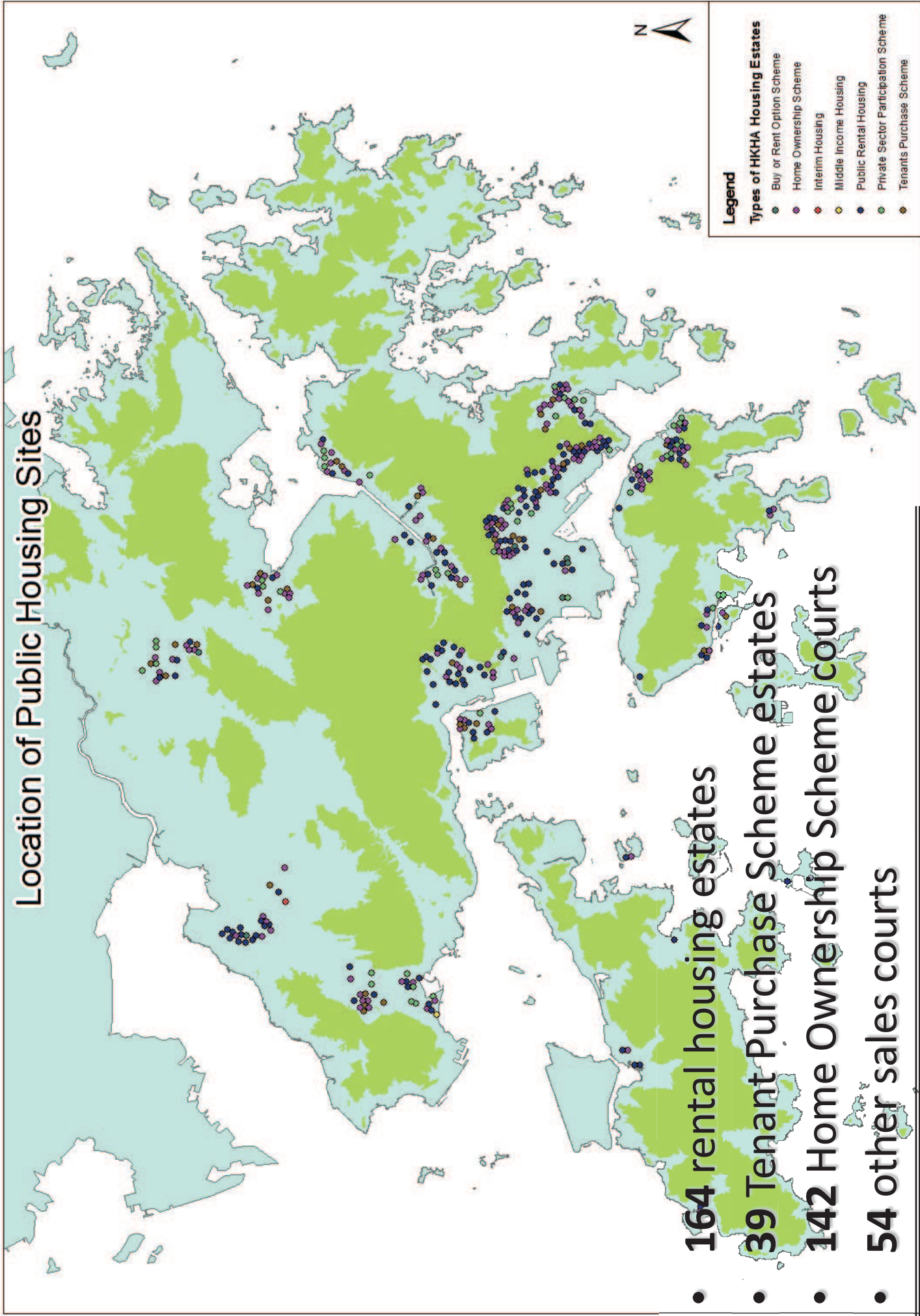
Concord



New Harmony



## Location of Public Housing Sites



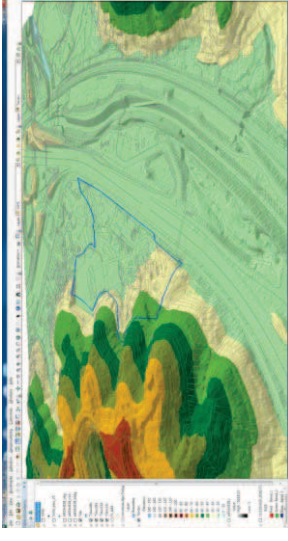
- **164** rental housing estates
- **39** Tenant Purchase Scheme estates
- **142** Home Ownership Scheme courts
- **54** other sales courts

**Total 399** estates



# Introduction – Land Surveying Unit

- Established in 1984
- Provides land & engineering surveying and GIS
- Feasibility study of potential sites, design, demolition, construction (foundation and building), maintenance, civil engineering works and tree management.



# Current Practice of Monitoring Survey for Public Housing Estates

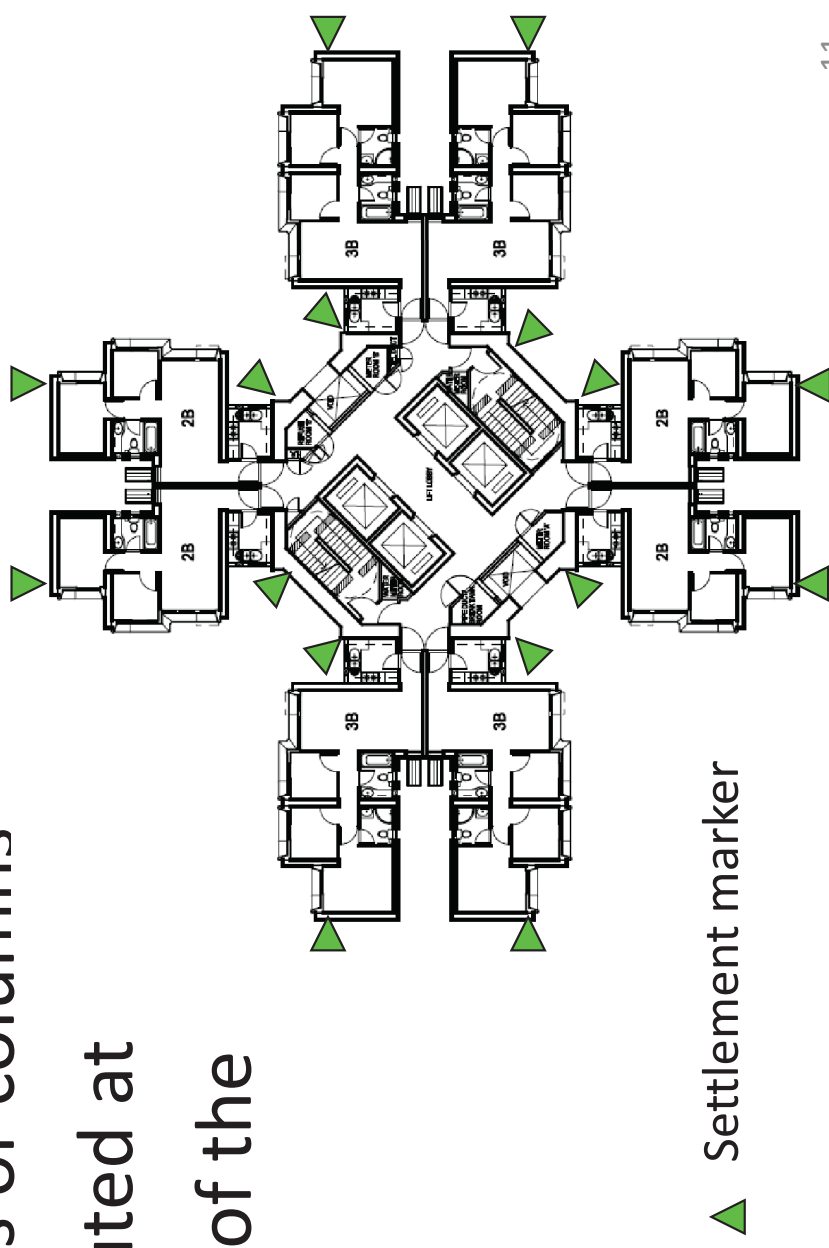
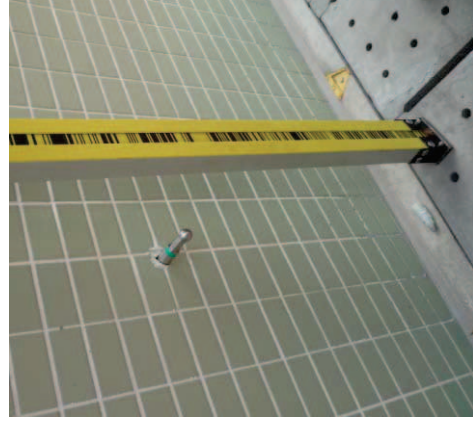


- Departmental guidelines
- All domestic blocks under construction or in maintenance period to be monitored
- Settlement monitoring
- Verticality checking

# Current Practice of Monitoring Survey for Public Housing Estates



- Settlement Monitoring
  - Engineer specifies locations of markers at structural walls or columns
  - Evenly distributed at the periphery of the building



# Current Practice of Monitoring Survey for Public Housing Estates



- About 20 nos. for a standard block
- 0.5m above ground level and 2.2m headroom
- Initial survey when 3/F completed
- By levelling method
- Hong Kong Principal Datum



# Current Practice of Monitoring Survey for Public Housing Estates



Benchmark of Lands Department



Establish temporary benchmark



Survey settlement markers

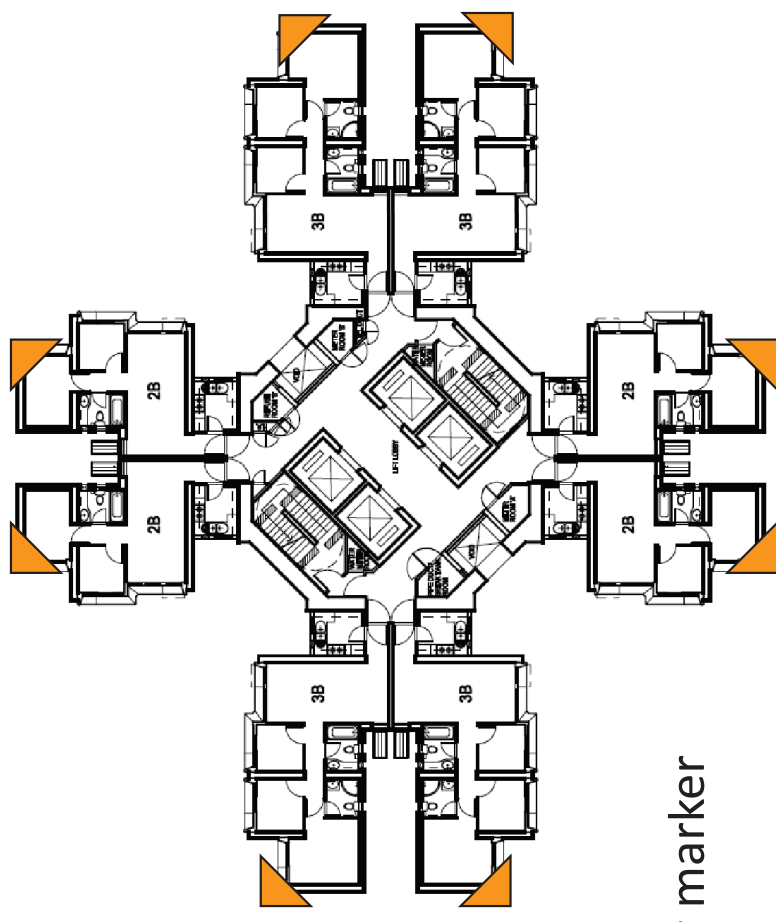
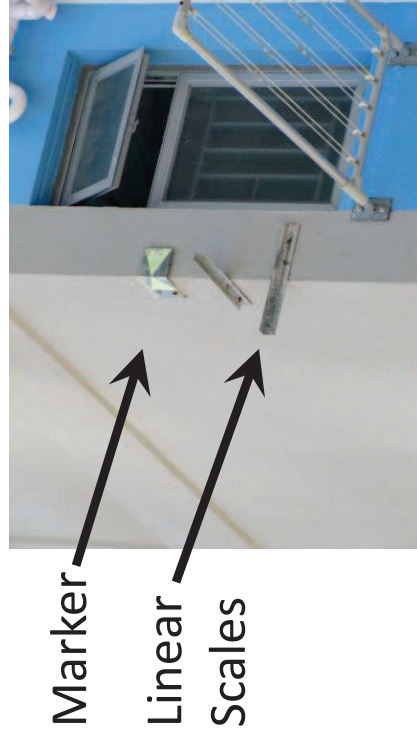
# Current Practice of Monitoring Survey for Public Housing Estates



- Verticality Checking

- Engineer specifies locations of markers at external building corners
- Linear scales will be fixed below the verticality marker

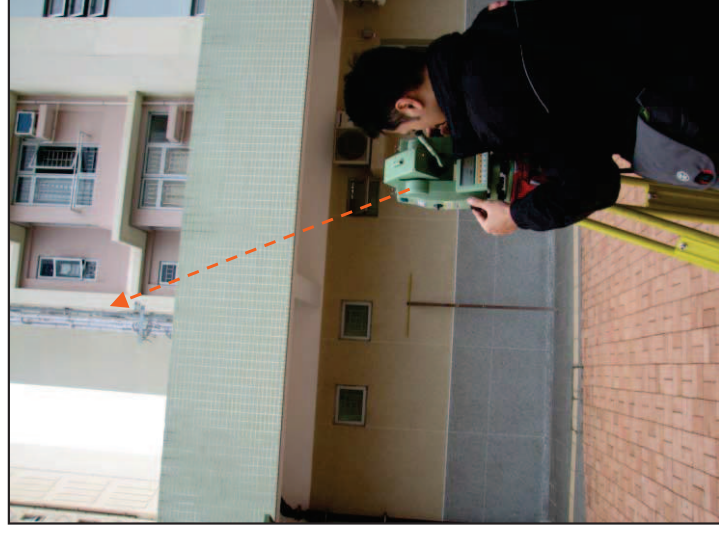
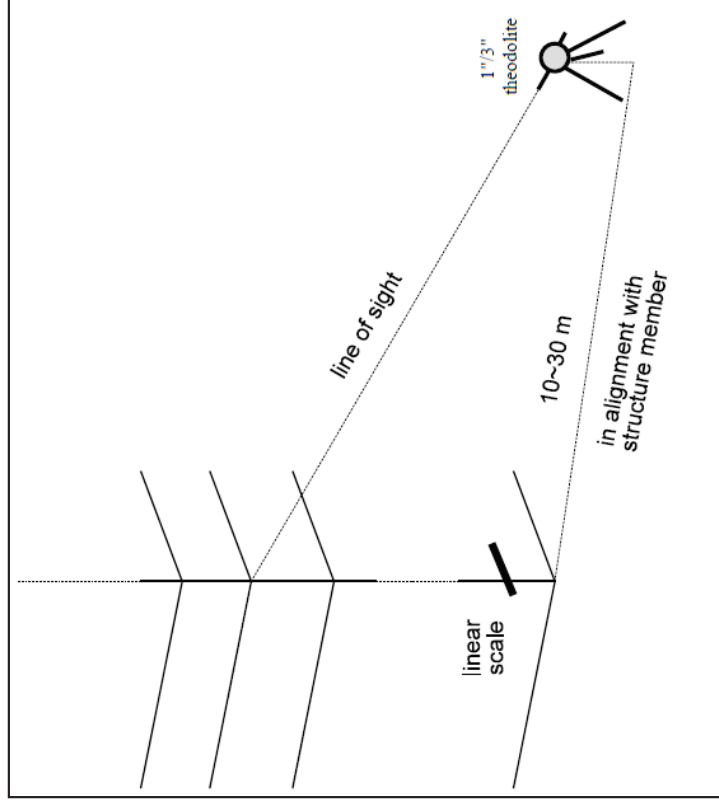
marker at 1/F



▲ Verticality marker

# Current Practice of Monitoring Survey for Public Housing Estates

- Marker on 1/F as reference
- Markers on 11/F, 21/F, 31/F and roof
- By alignment survey technique



# Current Practice of Monitoring Survey for Public Housing Estates



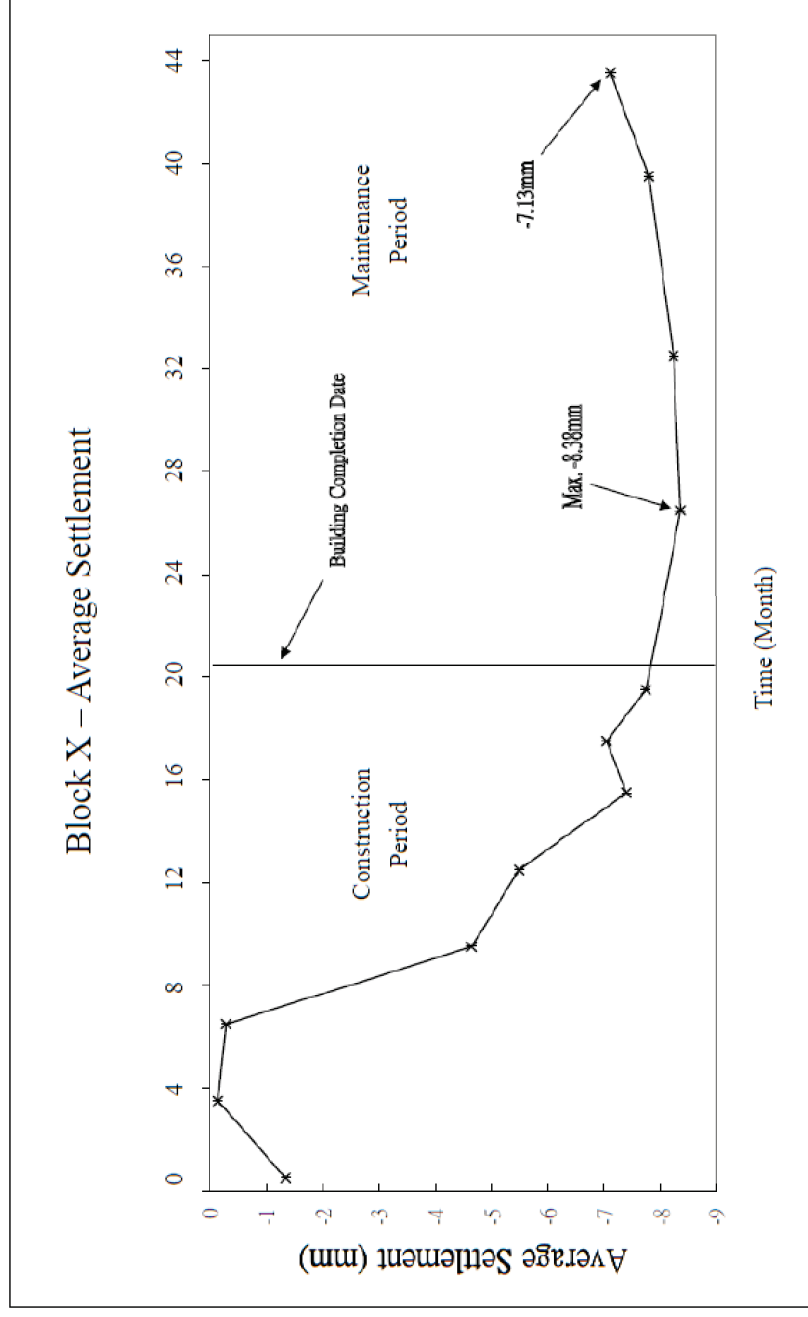
Type of Foundation	Works Stage	Survey Frequency
Pre-stressed precast concrete pile	Construction (24 months)	Monthly
	Maintenance (24 months)	2-monthly
Driven steel H-pile	Construction (24 months)	2-monthly
	Maintenance (24 months)	3-monthly
Large diameter bored pile Footings on rock Socketted steel H-pile Mini-pile	Construction (24 months)	3-monthly
	Maintenance (24 months)	6-monthly



# Current Practice of Monitoring Survey for Public Housing Estates



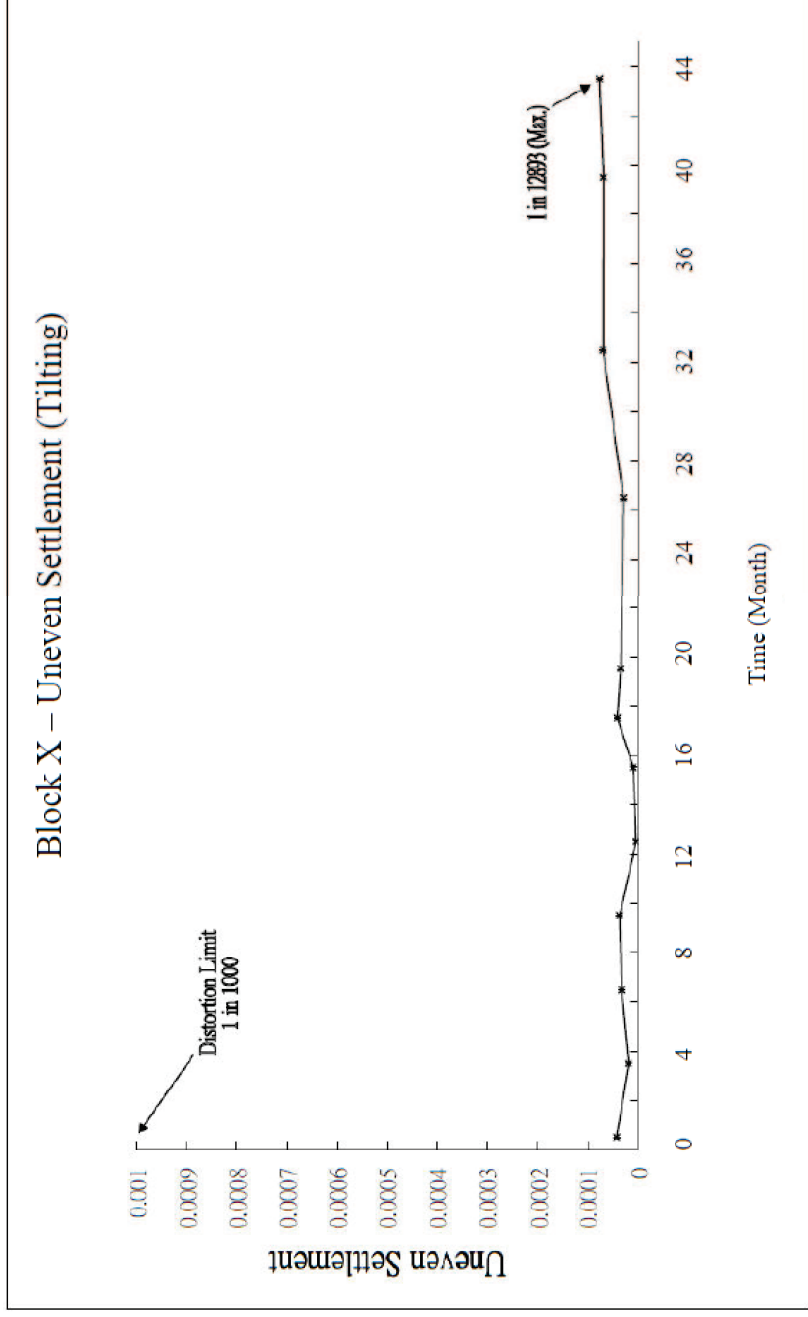
- Survey result to structural engineer for analysis
- Calculate average settlement



# Current Practice of Monitoring Survey for Public Housing Estates



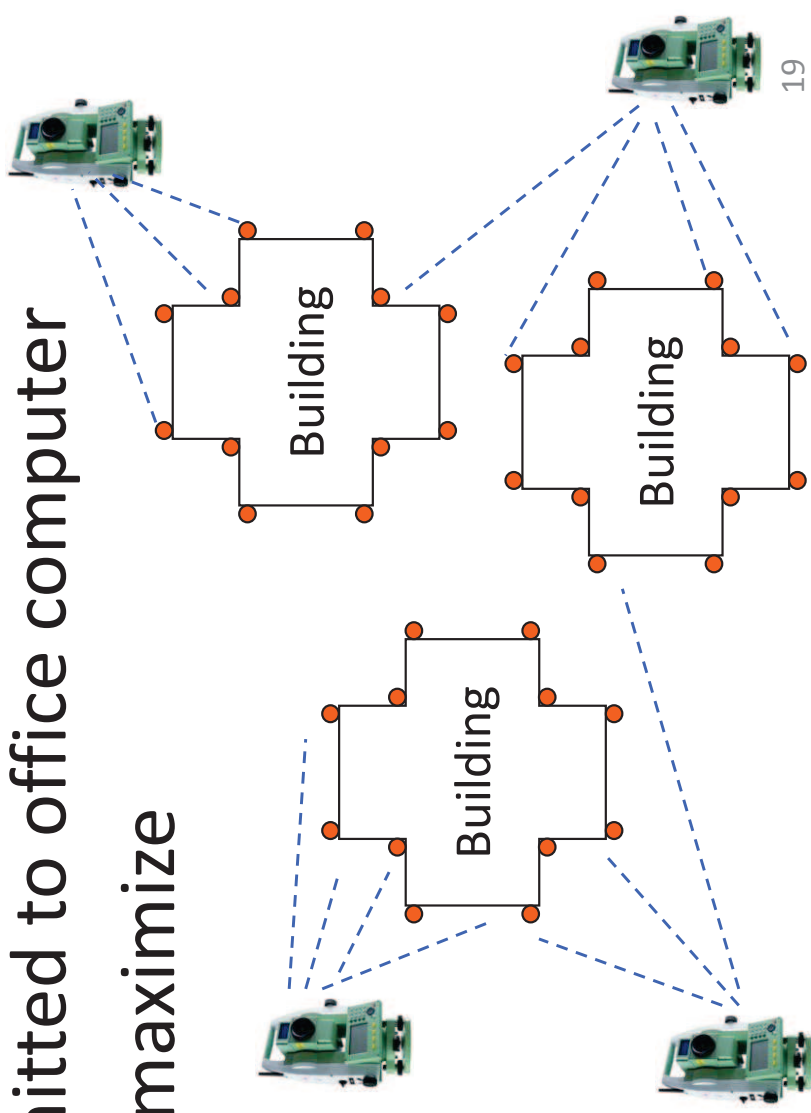
- Calculate tilting (or uneven settlement)



# Brief Review of Other Building Monitoring Technologies



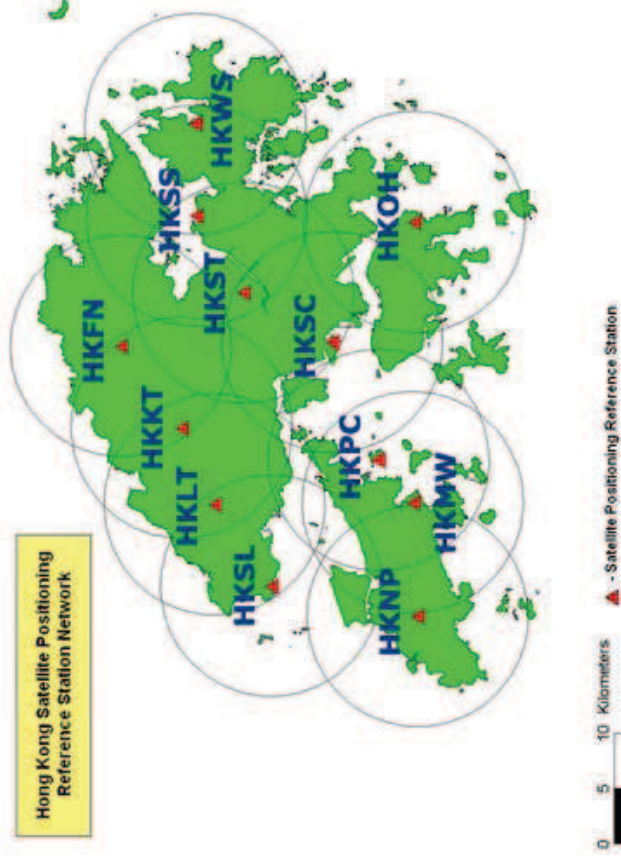
- Robotic Total Station
  - Automatic target recognition
  - $x, y, z$  : settlement, displacement and tilting
  - Data can be transmitted to office computer
  - Open field of view maximize
  - cost effectiveness
  - High setup cost to observe all points if stations are fixed



# Brief Review of Other Building Monitoring Technologies



- Global Positioning System
  - Hong Kong Satellite Positioning Reference Station Network (SatRef)
  - 12 Continuously Operating Reference Stations
  - Deploy rover receivers only with aid of SatRef



# Brief Review of Other Building Monitoring Technologies



- Need clear sky window
- Difficult to mount receivers on top of each floor during construction
- Applicable to completed buildings only

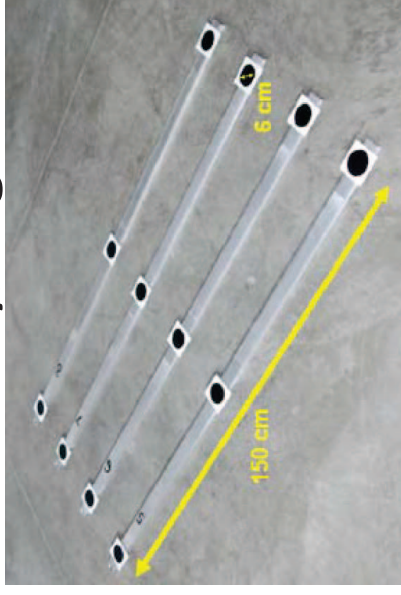
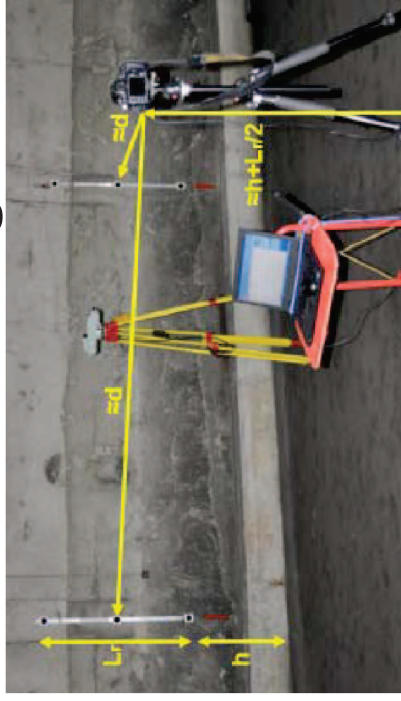


# Brief Review of Other

# Building Monitoring Technologies



- Terrestrial Photogrammetry
  - Level accuracy 26mm with non-metric camera as tested in a Hong Kong construction project (Dai & Lu, 2010)
  - Photogrammetric levelling (Barazzetti, et al., 2011)
    - Good for elongated structures only, e.g. tunnel



# Brief Review of Other

## Building Monitoring Technologies



- Laser Scanning
  - Virtually unlimited no. of monitoring points
  - Whole building profile, cracks on facades
  - Measured surface, scanning angle → intensity
  - Building block usually over 100m high → scanning ray distance 150m to 200m from ground
  - Construction site in lack of stable 3-D control points for registration → establish control points every time from outside the site

# Survey Data Management



- Current Situation
  - Over 110 buildings and structures being monitored
  - Large volume monitoring survey record being kept
  - Survey data accessed by land surveyors, structural engineers, architects and property services managers
  - Traditional means of dissemination : hardcopy and email
  - Storage of data by individual project teams

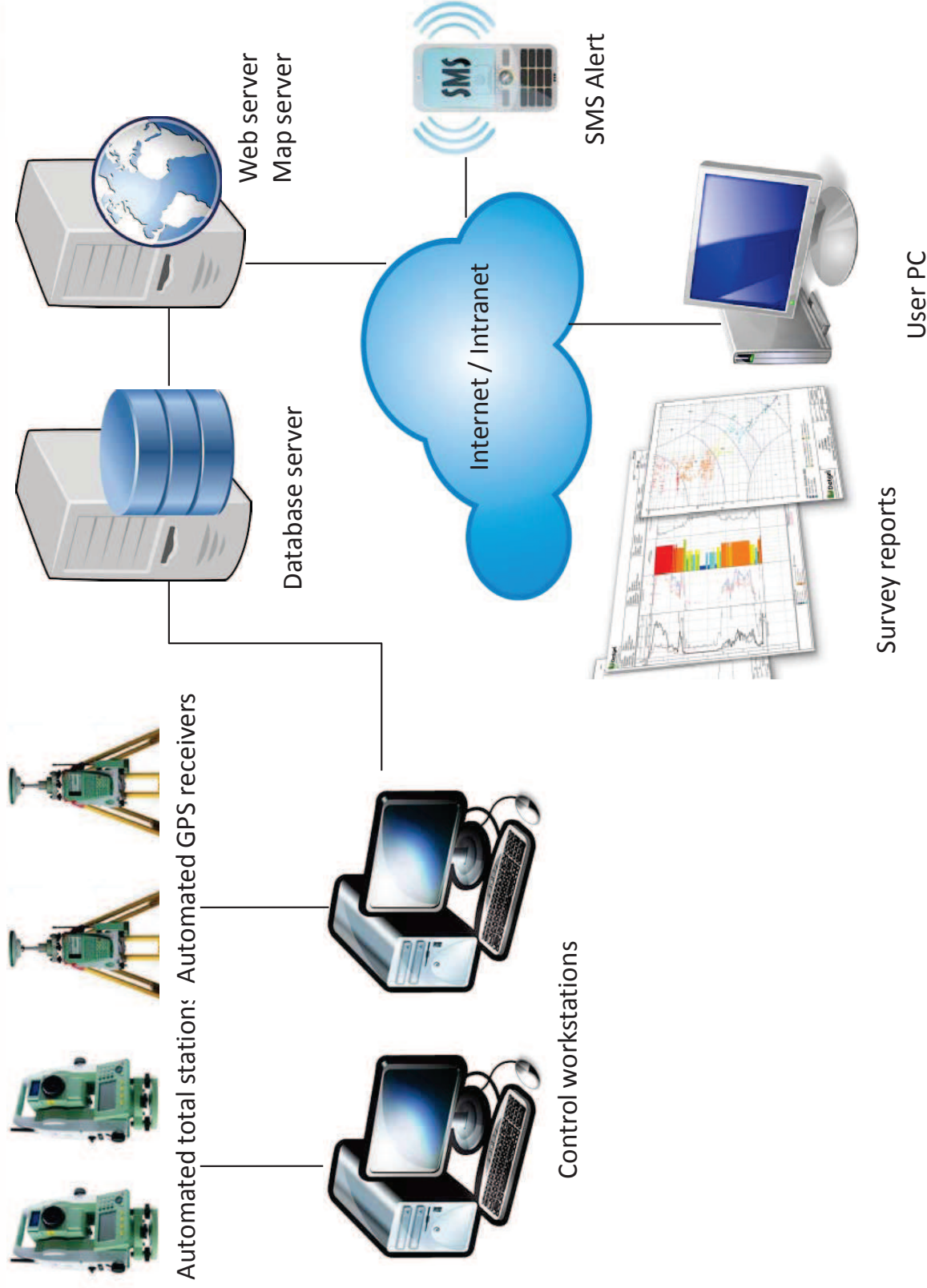


# Survey Data Management



- **Proposed Monitoring Survey Information Hub**
  - Automatic deformation monitoring system (ADMS)
  - Data source from total stations, GPS receivers, piezometers, tiltmeters and manual input for non-automated devices
  - WebGIS : map browsing, spatial queries and textual searching
  - Reporting
  - Alarming
  - Handling of survey requests

# Survey Data Management



# Conclusions

- HKHA to provide affordable quality housing
- LSU to safeguard stability of building either under construction or during early occupation period
- Traditional monitoring methods are effective
- Newer technologies worth exploring
- Monitoring Survey Information Hub (MSIH) enhances the dissemination, storage and management of survey data



# Conclusions

- MSIH to be further expanded for monitoring of slopes, retaining walls, bridges and reclaimed ground.





Thank you  
Q & A