Building Monitoring Survey of Public Housing Estates in Hong Kong

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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
- Concord
- New Harmony
- New Cruciform
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

▲ Settlement marker
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

- **Verticallity Checking**
  - Engineer specifies locations of markers at external building corners
  - Linear scales will be fixed below the verticallity marker at 1/F
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

<table>
<thead>
<tr>
<th>Type of Foundation</th>
<th>Works Stage</th>
<th>Survey Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-stressed precast concrete pile</td>
<td>Construction (24 months)</td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Maintenance (24 months)</td>
<td>2-monthly</td>
</tr>
<tr>
<td>Driven steel H-pile</td>
<td>Construction (24 months)</td>
<td>2-monthly</td>
</tr>
<tr>
<td></td>
<td>Maintenance (24 months)</td>
<td>3-monthly</td>
</tr>
<tr>
<td>Large diameter bored pile</td>
<td>Construction (24 months)</td>
<td>3-monthly</td>
</tr>
<tr>
<td>Footings on rock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Socketted steel H-pile</td>
<td>Maintenance (24 months)</td>
<td>6-monthly</td>
</tr>
<tr>
<td>Mini-pile</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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 tiling
  - 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

Photogrammetric levelling with special targeted rods (Barazzetti, et al., 2011)
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 $\rightarrow$ intensity
  – Building block usually over 100m high $\rightarrow$ scanning ray distance 150m to 200m from ground
  – Construction site in lack of stable 3-D control points for registration $\rightarrow$ 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

- Automated total stations
- Automated GPS receivers
- Control workstations
- Database server
- Web server
- Map server

Internet / Intranet
- SMS Alert
- Survey reports
- User PC
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