Construction Waste Minimization and the Application of Prefabrication Technology in Hong Kong

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Today’s presentation

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   - Construction Waste Definition
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   - Government Action
   - Low Waste Building Technologies

2. Objectives of the Survey & Methodology

3. Results & Discussion
   - Construction Waste Generation on Building Sites
   - Current Low Waste Construction Practices in Hong Kong
   - Prefabrication Construction & Precast Elements in Buildings

4. Case Study

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1. Introduction – Urban Environment in Hong Kong

- Hong Kong is a dense mega-city with a dense urban environment where available space is limited, development rate is fast and land prices are expensive.

- The construction of high-rise buildings is consequently a common practice in Hong Kong, to maximize profit and land use.

- Over the years, Hong Kong has experienced a high housing demand in a very short period of time, requiring a massive production of residential buildings.
1. Introduction – Construction Waste Definition

- Construction waste is a mixture of surplus materials arising from various activities including site clearance, excavation, construction, refurbishment, renovation, demolition and roads works. (EPD)

- The inert portion of waste is known as public fill and includes debris, rubble, earth and concrete which is suitable for land reclamation and site formation.

- The non-inert substances of waste include bamboo, timber, vegetation, packaging waste and other organic materials. It is subject to recovery of reusable/recyclable items, and is disposed of at landfills.

Source: EPD
1. Introduction – Waste Generation in Hong Kong

- In Hong Kong, the construction industry is consuming and generating a significant amount of building materials and building waste.

- In 2004, about **20 millions tones (56,000 tpd)** of construction waste were generated, of which:
  - **12%** was disposed of at landfills and **(6,600 tpd)**
  - **88%** was disposed at public filling areas **(49,600 tpd)**

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**Graph:**

- Quantity of construction waste disposed of at landfills and public filling areas in Hong Kong (CEDD)

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1. Introduction – Waste Generation in Hong Kong

- Hong Kong is running out of both reclamation sites and landfill space (EPD).

- “with the current trend, our landfills will be filled up in 6 to 10 years, and public fill capacity will be run out by mid 2006”.

- In recent years, construction waste represents about 38% of the total intake at three existing landfills.

- There is an urgent need for waste reduction measures implementation.

Source: EPD and CEDD

Quantity of solid waste disposal by category in 2004 (EPD)
1. Introduction – Government Action

- In 1998, the government published a ten year Waste Reduction Framework Plan.
- The target set for the construction industry was to reduce the construction waste going to landfills by 25% between 1999 and 2004.

- The government is implementing new regulations and actions such as:
  - Construction waste landfill charge
  - Trip-ticket system
  - Waste management plan
  - Promoting the use of recycled aggregates derived from construction waste
  - Promoting low waste building technologies

<table>
<thead>
<tr>
<th>Government waste disposal facilities</th>
<th>Charge per ton</th>
<th>Type of C&amp;D waste accepted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public fill reception facilities</td>
<td>HK$27</td>
<td>Consisting entirely of inert construction waste</td>
</tr>
<tr>
<td>Sorting facilities</td>
<td>HK$100</td>
<td>Containing more than 50% by weight of inert construction waste</td>
</tr>
<tr>
<td>Landfills</td>
<td>HK$125</td>
<td>Containing not more than 50% by weight of inert construction waste</td>
</tr>
<tr>
<td>Outlying Islands Transfer Facilities</td>
<td>HK$125</td>
<td>Containing any percentage of inert construction waste</td>
</tr>
</tbody>
</table>
1. Introduction – Low Waste Building Technologies

- Since the 1980’s, the Hong Kong Housing Authority has recommended the use of precast units and modules, reusable formwork and other environmentally friendly construction methods.

- The private sector heavily rely on **conventional construction methods** involving in-situ concreting, timber formwork, wet trades ad bamboo scaffolding.

- Since 2001, the government has implemented incentive schemes promoting the use of **green and innovative building technologies**:
  - Joint Practice Notes No. 1 in 2001
  - Joint Practice Notes No. 2 in 2002
    (e.g. promoting non-structural prefabricated external walls)

<table>
<thead>
<tr>
<th>LWBT in Public Housing Projects</th>
<th>LWBT in Private Housing</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Large panel formwork</td>
<td>• Aluminum formwork</td>
</tr>
<tr>
<td>• Prefabricated steel</td>
<td>• Plastic Formwork</td>
</tr>
<tr>
<td>reinforcement system</td>
<td>• Drywall plus infill</td>
</tr>
<tr>
<td>• Precast concrete elements</td>
<td>• Metal bamboo matrix</td>
</tr>
<tr>
<td>• Semi-precast slabs</td>
<td>system scaffold</td>
</tr>
<tr>
<td>• Precast staircase</td>
<td></td>
</tr>
<tr>
<td>• Drywall partitions</td>
<td></td>
</tr>
<tr>
<td>• Precast bathroom</td>
<td></td>
</tr>
<tr>
<td>• Machinery sprayed plaster</td>
<td></td>
</tr>
</tbody>
</table>
2. Objectives of the Survey and Methodology

Objectives of the Survey:
- To investigate the current use of prefabrication and precast concrete elements in building projects;
- And its impact on construction waste reduction and design concepts;
- To identify benefits, disadvantages and barriers to the use of prefabrication in buildings.

Methodology:
- A questionnaire survey was conducted with 130 professionals in the building industry in 2005.
- Response rate of 36%
- The majority of respondents were experienced engineers (23%), architects (21%) and builders (19%) from both public and private sectors.
3. Results & Discussion –
Construction Waste Generation on Building Sites

- **Formwork** is the most waste producing construction method (when using timber formworks) followed by:
  - (2) Packaging & protection
  - (3) Finish work
  - (4) Masonry work
  - (5) Scaffolding work
  - (6) Material handling
  - (7) Concrete work
  - (8) Hoarding

- **Wastage percentage** of construction materials on buildings sites: about 16% to 20%.

In Hong Kong, most of the waste arising from temporary works is due to the use of timber formworks (30% of total identified waste).
(Poon 2004)
3. Results & Discussion – Current Low Waste Construction Practices in Hong Kong

- The four most frequently used low waste construction techniques:
  - (1) Steel hoarding
  - (2) Drywalls
  - (3) Precast concrete units
  - (4) Steel system formworks

- There is significant difference between 2001 & 2005 for Metal scaffolding showing a decrease in frequency of use. This might be due to:
  - Wider use of prefabrication
  - Higher initial cost compared with bamboo scaffolding

Ranking of the frequency of use of construction methods in 2001 & 2005
3. Results & Discussion – Prefabrication Construction & Precast elements in Buildings

- Most frequently used precast elements in building projects:
  - (1) External facades walls
  - (2) Staircases
  - (3) Floor slabs
  - (4) Internal partitions
  - (5) External elements
  - (6) Bridge decks and footbridges
  - (7) beams
  - (8) Bathrooms
  - (9) columns

- There is significant difference between 2001 & 2005 for External façade walls showing an increase in 2005. This might be due to:
  - The implementation of new incentive scheme Joint Practice Note No.2
3. Results & Discussion – Prefabrication Construction & Precast Elements in Buildings

Examples of prefabricated elements:
- Precast facades
- Semi-precast slabs
- Precast staircases
- Precast bathrooms

Source: Low Waste Building Technologies
The Hong Kong Polytechnic University
4. Case Study – The Orchards

- **Building Type:** Private Residential
- **Building Location:** 3 Greig Street, Quarry Bay, Hong Kong
- **Project Description:**
  - Two 48-storey residential towers
  - 432 residential units
  - 144 car parks
  - Clubhouse at podium
  - 2 sky gardens at 17/F & 32/F per tower
- **Total Site Area:** 5,740 m²
- **Gross Floor Area (GFA):** 56,756 m²
- **Contract Period:** 630 days (2001-2003)
- **Contract Sum:** HK$497.5 million

Client: Braemar West Ltd.

Client’s Project Manager: Swire Properties Ltd.
Architect: Wong & Ouyang (HK) Ltd.
Structural Engineer: Meinhardt (C&S) Ltd.
Quantity Surveyor: H.A. Brechin & Co. Ltd
Main Contractor: Hip Hing Construction Co. Ltd
Prefabrication Manufacturer: Quon Hing

Source: Low Waste Building Technologies
The Hong Kong Polytechnic University
4. Case Study – The Orchards

Precast Concrete Elements:
- Semi-precast balcony
- Sunshade
- Precast facade
- Lost form panel
- Lost form column
- Precast staircase

<table>
<thead>
<tr>
<th>Element</th>
<th>GFA exemption</th>
<th>No. of elements / floor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-precast balcony</td>
<td>140 ft²</td>
<td>6</td>
</tr>
<tr>
<td>Sunshades</td>
<td>200 ft²</td>
<td>10</td>
</tr>
<tr>
<td>Precast facades</td>
<td>91 ft²</td>
<td>12</td>
</tr>
<tr>
<td>Lost from panels</td>
<td>49 ft²</td>
<td>10</td>
</tr>
<tr>
<td>Lost form columns</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Precast staircase</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td><strong>480 ft²</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Hip Hing Construction
4. Case Study – The Orchards

Precast Concrete Elements

Source: Low Waste Building Technologies
The Hong Kong Polytechnic University
4. Case Study – The Orchards

- Summary of resources consumption of precast elements against conventional method (Fong et al., 2004):

<table>
<thead>
<tr>
<th>Precast elements</th>
<th>Energy/ m²</th>
<th>Water/ m²</th>
<th>Waste/ m²</th>
<th>Cost/ m²</th>
<th>time</th>
<th>Manpower/ m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>60%</td>
<td>112% +12%</td>
<td>59% -41%</td>
<td>44% -56%</td>
<td>101% +0.25%</td>
<td>4 days/ cycle -20%</td>
<td>90.5 % -9.5%</td>
</tr>
</tbody>
</table>

- Summary of environmental performance compared with traditional construction:
  - Reduction of scaffolding work
  - Reduction of timber formwork
  - Reduction of on-site dust & noise nuisance
  - Water consumption reduction
4. Case Study – The Orchards

- Cost comparison (Fong et al., 2004):

<table>
<thead>
<tr>
<th>Conventional construction method</th>
<th>Low waste building technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timber formwork</td>
<td>Aluminum formwork</td>
</tr>
<tr>
<td>100</td>
<td>115-125</td>
</tr>
<tr>
<td>In-situ facade</td>
<td>Precast facade</td>
</tr>
<tr>
<td>115-125</td>
<td>100</td>
</tr>
<tr>
<td>In-situ staircase</td>
<td>Precast staircase</td>
</tr>
<tr>
<td>110-120</td>
<td>100</td>
</tr>
<tr>
<td>Traditional blockwall</td>
<td>Hardiwall system</td>
</tr>
<tr>
<td>100</td>
<td>170-190</td>
</tr>
<tr>
<td>Traditional plaster</td>
<td>Spray plaster</td>
</tr>
<tr>
<td>100</td>
<td>110-120</td>
</tr>
</tbody>
</table>

- Construction cost comparison:

(Low Waste Building Technologies, The Hong Kong Polytechnic University)

<table>
<thead>
<tr>
<th>Conventional cast in-situ method</th>
<th>Precast construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>HK$800/ sq.ft</td>
<td>HK$816/ sq.ft</td>
</tr>
<tr>
<td></td>
<td>Approximately 1% higher than conventional construction method</td>
</tr>
</tbody>
</table>
5. Conclusion

- The construction industry in Hong Kong is consuming and generating a significant amount of materials and waste.

- Formwork, packaging & protection and finish work are the major contributors to construction waste.

- Prefabrication reduces waste generation on building sites, as elements are produced in a factory environment, and finish work and wet trades are avoided on-site.

- Other low waste building technologies include reusable formworks, dry wall, spray plastering, tubular scaffolding and steel hoarding.

- Further studies will include a wider questionnaire survey, interviews with professionals of the construction industry, and case studies of existing and new building projects in Hong Kong.

- Low Waste Building Technologies Website: [http://www.cse.polyu.edu.hk/~cecsbpoon/lwbt](http://www.cse.polyu.edu.hk/~cecsbpoon/lwbt)
Thank You!

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