Innovation Management in Infrastructure Development

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Innovation Management:
Hong Kong Housing Authority’s Experience

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Hong Kong Housing Authority
Fulfilling the Housing Authority’s Mission : Forging Ahead into the Future

- **Vision**
  To help all families in need gain access to adequate and affordable housing.

- **Mission**
  - To provide affordable quality housing, management, maintenance and other housing related services to meet the needs of our customers in a proactive and caring manner;
  - To ensure cost-effective and rational use of public resources in service delivery and allocation of housing assistance in an open and equitable manner;
  - To maintain a competent, dedicated and performance-oriented team.

- **Core Values : 4Cs**
  Caring, Customer-focused, Creative, Committed
Hong Kong Housing Authority’s portfolio:

• A stock of about **700,000** flats in over **1,100** domestic buildings
• An average production of about **15,000** new flats per year

*We are cash tight but rich in talents!*
Fulfilling the Housing Authority’s Mission:
How to apply our talents...

According to our Core Values: 4Cs

- Caring
- Customer-focused
- Creative
- Committed
Fulfilling the Housing Authority’s Mission: Why should we innovate?

Core Values: 4Cs as cornerstone

Committed to Caring for Customers, & be Creative – We conduct Research & Development (R&D) activities, and we drive innovations.
Research & Development (R&D) Work

- **R&D activities** are activities and studies to explore, develop and put into use new processes, products or materials, technologies, and systems in the planning, design, construction and maintenance of public housing development.

- Indeed, many of our inventions, be they products, services or systems, have now become part of our daily life and our habit!
Categories of R&D Work

We categorize R&D according to the building development and construction processes:

<table>
<thead>
<tr>
<th>Planning and design</th>
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<tbody>
<tr>
<td>Materials</td>
</tr>
<tr>
<td>Design tools and methods</td>
</tr>
<tr>
<td>Construction technologies</td>
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<tr>
<td>Management techniques and performance indicators</td>
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<tr>
<td>Procurement and contracting</td>
</tr>
<tr>
<td>Testing, investigation and monitoring techniques</td>
</tr>
<tr>
<td>Information technology</td>
</tr>
<tr>
<td>Environment and sustainability</td>
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<tr>
<td>Safety</td>
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</table>
Managing Innovations:

Developing R&D Strategy
Identifying innovative Trends in the New Era
Developing structures and systems
Monitoring effective implementation
Collaborating with stakeholders
to innovate and advance the frontiers of our human knowledge
R&D Strategy

- **R&D** serves to improve our delivery of the Public Housing Construction Programme.
- Our R&D activities are primarily **applied research** in the field of construction.
- We have identified **innovative trends** – **quantum leaps** in improving the quality of product & process, advancing frontiers of human knowledge, and enhancing human capital. We hope that the industry can **collaborate** with us in spearheading these R&D activities.
We innovate with an aim to enhance:

- Sustainability
- Safety
- Health & Hygiene
- Environment-friendliness
- Cost Effectiveness
- Quality and Durability
- Value for Money
We manage R&D with an upward spiral.

We manage R&D work according to a 5-staged life cycle:

1. Exploration
2. Piloting
3. Monitoring
4. Reviewing
5. Mass Application
Current Stock of R&D Items

<table>
<thead>
<tr>
<th>Stage of R&amp;D</th>
<th>Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Exploring</td>
<td>11</td>
</tr>
<tr>
<td>2. Piloting</td>
<td>26</td>
</tr>
<tr>
<td>3. Monitoring</td>
<td>3</td>
</tr>
<tr>
<td>4. Reviewing</td>
<td>1</td>
</tr>
<tr>
<td>5. Completed</td>
<td>89</td>
</tr>
<tr>
<td>6. Mass Application</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total as at May 2010</strong></td>
<td><strong>150</strong></td>
</tr>
</tbody>
</table>
### How do we drive R&D?

We have different modes for R&D drivers in different periods:

<table>
<thead>
<tr>
<th>Mode of Development</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Centrally driven</strong> (by Development &amp; Standards Team)</td>
<td>Before 2003</td>
</tr>
<tr>
<td>2. <strong>Housing Authority Research Fund</strong> (Quality Reform in year 2000)</td>
<td>2000 ~ 2005</td>
</tr>
<tr>
<td>3. <strong>Project-driven</strong> (Decentralized)</td>
<td>After HARF since mid 2003 until now</td>
</tr>
</tbody>
</table>
## Points, Lines & Plane...

We parallel the mode of Quality Drivers in **3 Generations** -

<table>
<thead>
<tr>
<th>Mode of R&amp;D</th>
<th>Period</th>
<th>3 Generations of Quality Drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Centrally driven (by Development &amp; Standards Team)</td>
<td>Late 1980’s to 2003</td>
<td><strong>Points</strong>: Discrete modules with Task Forces on Quality, Safety, PASS, R&amp;D, Specifications &amp; Standards etc.</td>
</tr>
<tr>
<td>2. Housing Authority Research Fund (HARF)</td>
<td>2000 ~ 2005</td>
<td><strong>Lines</strong>: Quality Reform, Quality Task Force, HARF Steering Committee</td>
</tr>
<tr>
<td>3. Project-driven (Decentralized)</td>
<td>After HARF since mid 2003 until now</td>
<td><strong>Plane</strong>: Directorates in R&amp;D Steering Committee, D&amp;C Management Board, <strong>Project Teams’ ownership</strong></td>
</tr>
</tbody>
</table>
We steer R&D:
R&D Steering Committee

Deputy Director
(Development & Construction)

Assistant Director /
Project Sub-division 1

Assistant Director /
Project Sub-division 2

Assistant Director /
Development & Procurement

Chairperson

Chief Structural Engineer

Secretary

Member

Member

Knowledge Manager
We monitor R&D activities.

- **R&D Steering Committee** oversees our R&D work throughout the five stages of its life cycle, from initiation to mass application.
- **Liaison Group on Construction Quality** provides a platform for us to obtain feedback from Estate Management Division and identify strategic areas for R&D.
- **Development & Construction Management Board** monitors the Programme of Activities including R&D performance goals.

  - We apply result-oriented guiding principles –
    1. Cost effectiveness
    2. Quality products through **innovation**
    3. Quality housing through **sustainable development**
We need Collaboration in the industry!

- **Housing Authority as the client** – initiate, procure and apply innovative ideas in projects including prototyping, piloting and mass application;
- **Academic institutions and professionals** – explore innovative ideas, develop prototypes and take measurements in research;
- **Contractors** – put R&D findings into pilot practice before mass application;
- **Regulators** – consider and approve innovative application for use in HA’s projects; promulgate it through circulars where applicable.
We strengthen internal collaboration.

(1) Functional division of work in the organization:
   Corporate teams (client & central functions) vs Project Teams (project functions)

(2) Multi-disciplinary matrix organization, comprising professional, technical and site staff of different grades -
   - Architects & Landscape Architects
   - Engineers – CE, GE, SE
   - Housing Managers
   - Planners
   - Surveyors – ES, LS, MS, QS
We advocate innovation.

We have about 150 R&D items since year 2000, & 20:80 rule for Corporate team + Project teams.

Now that we have Project-driven R&D…

R&D is everybody’s business!
A hot topic worldwide: R&D for Sustainable Development
R&D for Sustainable Development

Green & Sustainable Planning & Design
- Micro-climate Studies and Air Ventilation Assessment and its Verification
- Vertical Green Panel + Green Roof
- Noise Mitigation Measures – Arc Screen Design and Acoustic Window Design
- Universal design - Tactile Guide Path System with Multi-sensory Map
- Life Cycle Assessment & Life Cycle Costing Method and its Review
- Expected Working Life of Buildings
- Recycled and Green Materials
- Energy saving and Carbon reduction

Health & Hygiene in Design
- Common W-trap system
- Mail Box Type Disposal System for Recycling Materials
- Fungal Resistance Test for multi-layer Acrylic Paint

Advanced Design & Construction Technologies
- Enhanced Structural design
- Precast components
- Quality control on Building Materials and Components
R&D for Sustainable Development:
(1) Green & Sustainable Planning & Design
Sustainability
Micro-climate Studies & Air Ventilation Assessment

- Since 2004, *micro-climate studies* and *Air Ventilation Assessments* were employed as one of the design tools of public rental housing estates.

- Design, orientation and disposition of building blocks is enhanced through optimum use of natural recourses such as local wind direction, natural ventilation, daylighting, and solar radiant.
In collaboration with Department of Biology, Chinese University of Hong Kong and Shui On Building Contractor Ltd..
In the form of modular prefabricated external cladding.
Aim of enhance the provision of greening in the congested urban environment.
Enables easy assembling on-site and future maintenance.
Carries the multiple benefits of enhancing visual comfort, strengthening ecology and reducing heat island effect.
Study findings suggested the vertical green panel covered wall is about 16 ºC cooler than bare concrete wall in a hot afternoon.
Providing green roofs in low-rise structures with extensive planting, such as commercial centres, carparks and refuse collection compounds wherever feasible for new housing developments.

By 2009/10, over 8,000 square meters of green roofs were completed in more than 18 new estates in using different types of vegetation.
Sustainability

Noise Mitigation Measures

Innovative Arc Screen Design
- Developed an innovative arc screen design to alleviate the traffic noise problem in Sai Chuen Road PRH Development in Sham Shui Po.
- Using a prototype installation in Dongguan to verify by in-situ noise measurements.
- Close liaison with EPD
- Achieve noise reductions of 2.5 dB(A) on the lower floors to 6.4 dB(A) on higher levels.

Special Acoustic Window Design
- For more severe noise problem such as sites situated very close to trunk roads with heavy traffic, the design of acoustic windows is being investigated allowing residents to enjoy more open views.
- Laboratory tests of this window design concept gave promising results.
Universal Design
Tactile Guide Path System with Multi-sensory Map

- To enhance universal accessibility for all residents including persons with visual impairment in 2005 as an integral part of tactile guide path system.
- Installed at strategic locations of housing estates.
- Provide visual, tactile and voice messages to provide directions for all people, regardless of their age or quality of vision.
- Collaborate with Hong Kong Society for the Blind to develop the multi-sensory map.
- Pilot projects at Redevelopment of Shek Kip Mei Phase 1 and Kwai Chung Estate.
- Multi-sensory map together with tactile guide path system has became a standard provision for new public housing estates since August 2006.
Sustainability

Life Cycle Assessment (LCA) & Life Cycle Costing (LCC) Method

- The HA has, since 2005, developed LCA and LCC method to assess and determine more accurately and effectively the use of new materials at the design stage. New materials which are more environment-friendly and cost effective from the life cycle perspective have been progressively used in pilot projects since 2006. e.g. East Harbour Crossing Site Phase 4 (Yau Lai Estate).

- The Consultants were Business Environment Council, the University of Hong Kong and Davis Langdon & Seah Management Ltd.

- The deliverables were –
  (a) A LCA & LCC database for >100 building materials; and
  (b) A computerized combined LCA/LCC “Decision Making Tool”.

Final Report has been launched onto HA’s web site for “Knowledge Sharing”.

Way Forward

- After implementation for 5 years, further review would be carried out for updating and expanding the database of building materials.
Expected Working Life of Building

Findings
With appropriate maintenance and monitoring regime, working life for housing buildings built after 1992 is at least 100 years…
Recycled & Green Materials:
Wider Use of Grade 200 Recycled Rock Fill

Benefits

- Sustainable
- Cost Saving
- Time Saving

Backfilling to Voids between Footings/Caps and Underside of Suspended Ground Floor Slabs
Recycled & Green Materials:
Recycle & Reuse of Marine Mud

Cement-Stabilisation for Backfilling

- Marine mud is stiff, moist, low strength and high compressibility
- Mix 5% cement and 15% granular material

Mix marine mud with other materials

Backfill cement-stabilized marine mud around substructure
Recycled & Green Materials: Recycle & Reuse of Marine Mud

Production of Eco-Block

- Recycled Aggregates
- Block Casting Machine
- Marine Mud
- Cement
- Eco-paving block
Building Services:
Energy Saving and Carbon Reduction
New Buildings

- HA produces approx. 15,000 Domestic Flats or 20 Domestic Blocks per annum
- For the purpose of estimating the electricity consumption by BS Installations, New Harmony 1 Standard Block is taken as Reference Building

On Average

- 40-Storey Domestic Block
- 20 Flats per floor
- Totally 800 Flats

596 kWh/Flat

14.4 kWh/GFA (m²)
New Buildings
How Are We Doing?

kWh / GFA(m²) / Annum

2000 Design

2009 Design

January
Edition

January
Edition

January
Edition

January
Edition

January
Edition

January
Edition

January
Edition

January
Edition

January
Edition

January
Edition

January
Edition

24.9

16.5

15.4

14.0

13.1

18.3

14.6

14.4

5.0

10.0

15.0

20.0

25.0

30.0

Decrease illumination level of the lighting system
Decrease the capacity of all lifts from 1,000kg to 900kg
Employ electronic ballasts in lighting system & T5 tubes in exit signs
Decrease the number of lifts from 6 to 5 and employment of lightweight lift car decoration
Increase the illumination level of the lighting system to 85 lux to comply with the Barrier Free Access Design Manual
Adopt New Lighting Design with 2 illumination levels controlled by motion / photo sensors and manual push switches
Adoption of Variable Speed Drive System in Booster Pumps
Upgrade motors from EFF2 to EFF1
Renewable Energy
Renewable Energy Lighting
R&D for Sustainable Development:
(2) Health & Hygiene in Design
Health and Hygiene
Common W-Trap System

- The outbreak of SARS in March 2003 has aroused concern from the public over the problem of dried up floor traps with possible transmission of virus into the bathroom / kitchen from a contaminated soil and waste stack.
- Collaboration with Department of Building & Construction, City University of Hong Kong to study the common trap system.
- A series of reiterative tests successfully verified the operational stability.
Health and Hygiene
Common W-Trap System

- Buildings Department approved in principle to the use of Common W-trap for connection to the floor drains in toilets and/or kitchens of PRH flats.

- Implemented in all new PRH projects since the first completed project, East Harbour Crossing Site 3 (Yau Lai Estate), in 2008.

Way Forward
- Continue to study on the drainage system to prevent loss of water seal and blockage of pipe at lower floors by adopting fluid dynamic engineering.
Health and Hygiene

Mail Box Type Disposal System For Recycling Materials

To provide convenience to PRH tenants -
- Provision available on every domestic floor;
- Easily Accessible location from common area i.e. corridor or lift lobby; and
- Easily reachable level by all users (including the elderly and wheelchair users)

To provide Hygienic Environment -
- Separated collecting points with self-closing hatch doors
- Washable finishes; and
- Designated space for collection bins.

Implementation
- The pilot project is East Harbour Crossing Site Phase 5 (Yau Lai Estate) to be completed in Mid 2011.

Way Forward
- To collect feedbacks from the tenants and the Estate Management; and to further enhance the users friendliness.
R&D for Sustainable Development:
(3) Advanced Design & Construction Technologies
Enhanced Structural Design

Cost-Efficient Structural Design Software (CESD)

**Features**

- To optimize structural layout and reinforcement quantities
- In-house developed software package validated by HKUST as a proven optimization software applicable to HA residential blocks
Enhanced Structural Design: Reduced Shear Links at Pile Cap and Transfer Structure

Features

- To optimize shear reinforcement provision for thick plate structure i.e. raft footing, pilecap and transfer plate
- Unconventional approach based on sophisticated analysis of stress distribution

Stress Distribution Diagram in Raft Footing

Shear Reinforcement

Shear Reinforcement REDUCED
Precast components:
Standardized Precast Facade and
Semi-precast slab with Fabric Reinforcement
Precast components:
Volumetric Bathroom, Kitchen, Staircore and Liftcore

Volumetric precast elements
- give better waterproofing quality, speed of construction and economy of scale
- have great potential for large scale application

Precast Components
- Precast bathroom
- Precast bathroom-cum-kitchen
- Precast staircore
- Precast liftcore
Quality Control: Product Certification

Benefits
- Greater confidence
- Consistent quality
- Better image
- More business
- Higher competitiveness

Hong Kong Accreditation Service (HKAS)

Materials produced in factories

Regular factory surveillance on process and sampling & testing of products

Independent Certification Bodies

Existing Product with Product Certification
- Ready mix concrete (QSPSC)

Coming Products with Product Certification in 3 stages
1. (by 5/10) - Fire Rated Timber Doors, Panel Walls Partitions
2. (by 8/10) - Cement Products, Tile Adhesives
3. (by 12/10) - Tiles, Repair Mortars

Issuance of Product Certificates at regular intervals
Quality Control:
RFID on Building Component, Concrete Cube, Concrete Truck and Dump Truck

**Benefits**
- Unique Identification
- Improve Traceability
- Enhance Data Management
- Real time Monitoring
- Minimize human errors
- Streamline the Work Flow

*Extend RFID application to concrete cubes, concrete and dump trucks*

- Barcode Reader taking reading
- Concrete Cube with 2D Barcode
- Different Types of RFID Tags
- RFID Tag installed inside the facade
Next we examine a few innovative trends.

1. Site Safety
2. Procuring for Innovations (3-envelope System)
3. Building Information Modeling (BIM)
Innovative Trends (1)

1. Site Safety – *It is never safe enough!*
2. Procuring for Innovations (3-envelope System)
3. Building Information Modeling (BIM)
Site Safety - (1) Promoting Safe Practice

The three directions in promoting safe practice - above and beyond regulatory standards

- **Improve physical conditions**
  - Widely adopt mechanization and prefabrication
  - Extensive hard paved construction
  - Video surveillance for tower crane
  - Full height protective barrier to lift shaft opening

- **Strengthen site and safety management**
  - HA Safety Auditing System (also a performance monitoring tool)
  - Pay for Safety
  - Safe Working Cycle
  - Restrict tiers of subcontracting

- **Enhance safety awareness**
  - Silver Card
  - Trade test
  - Safety training of site superintendents
  - Toolbox talks and safety induction
Accident Rate per 1000 Worker Compared to Local Construction Industry Average

- Site Safety - (2) Tracking Safety Performance

Accident Rate per 1000 Workers

- Construction Industry
- HA New Works
Safety Climate Index Surveys
• 794 returns from 9 new works building contracts (2008)

OBSERVATIONS

STRENGTHS
• Factor 2 - Safety Resources and Support
• Factor 5 - Personal Involvement in Safety and Health

AVERAGE
• Factor 7 - Safety Promotion and Communication
• Factor 1 - Corporate and Management Commitment

WEAKNESSES
• Factor 6 - Safe Working Attitude
• Factor 3 - Awareness of Risk-taking Behaviour and Hazards
• Factor 4 - Perception of Safety Rules and Procedures
Site Safety - (4) Performance Monitoring

**System enhancements**
- HASAS version 1.4 from January 2009 and onwards
- Mandate checking of tower crane lifting operation
- Instigate generic checklist for high risk activities
- Introduce “Critical Pass” elements
- Forge Safe Working Cycle, Safety Climate Index
- Strengthen link to Pay for Safety Scheme

**Regulatory Actions**
- Unsatisfactory safety performance, occurrence of serious accident or near miss incident with potentially serious consequence
  - **Trigger CRC to interview** the contractor
  - **Additional safety audit**
  - **Close monitoring** of the contractor’s safety performance
Innovative Trends (2)

1. **Site Safety**

2. **Procuring for Innovations (3-envelope System)** - How can we get plenty of innovative ideas despite a tight budget?

3. **Building Information Modeling (BIM)**
Procuring for Innovations: Incentivizing Innovations

Remember ‘2 Envelope Systems’?
– to select designers (or ‘contractors’) based on evaluation of both
  (1) Technical and (2) Price - envelopes (proposals)

- HK Housing Authority aims to move Construction from 4Ds to 4Cs:
  from Dirty, Dangerous, Demanding, Damaging/Disruptive
to Caring, Customer-focused, Creative, Committed
launched a ‘3 Envelope’ System in 2009, with the additional Envelope
requiring Tenderers to propose any specific Innovations.

- 1st (Technical) envelope only relates to Client Design and proposal,
hence must conform to that.

- But 2nd envelope will list any ‘alternatives’ as innovations (in 2a);
  and secondly list corresponding benefits and costs (in 2b).

- Unsuccessful tenderers will be paid a one-off lump sum for acquisition of
  intellectual property right for their innovations, specially on Design & Build
  projects as in the pilot project now underway.
Procuring for Innovations: The Three-envelope System

Total non-Price Score: 45%

Envelope 1: Corporate + Technical
Envelope 2: Innovation
Envelope 3: $$$

Price Score: 55%
Procuring for Innovations: Assessment, Scoring & Selection of Innovation Proposals

**Step 1** – Open *Envelope 2a* and Assess Technical Submissions

- **Envelope 2a** Technical Submission
- **Accept Proposal**
  - If Complying with All 5 Assessment Criteria
  - **Assess & Classify Benefit Level**
    - HIGH (0.8%)
    - MEDIUM (0.5%)
    - LOW (0.2%)

**Step 2** – Open *Envelope 2b* and Prioritize Proposals

- **Envelope 2b** Price Adjustment
- **Accept Proposal**
  - If Price Adjustment Is Reasonable
  - **Prioritize Proposals**
  - By Price Adjustment (lowest first)

**Step 3** – Select Proposals

- **As Many As Possible**
- **Total Technical Score > 5%**
- **Total Price Adjustments > $200M**
Innovative Trend (3)

1. Site Safety
2. Procuring for Innovations (3-envelope System)
3. Building Information Modeling (BIM) – How to avoid clashes and wastes in design and construction in this 3-dimensional and 4-dimensional world?
The creation and use of coordinated, consistent, computable information 3D presentation about a building project in design and construction.

**Building** - The design project, as you envision it for the client

**Information** - information embedded in the building components

**Modeling** - The digital description that can be explored and evaluated before you build
Building Information Modeling (BIM)

Terrain Modeling
Building Information Modeling (BIM)

Site Context, Visual and Environmental Impact
Building Information Modeling (BIM)

Optimization of Design by an Integrated Team of Innovators

- Arch
- SE
- BSE
- CE
- GE
Building Information Modeling (BIM)

BIM Process Shifts the Design Curve

Patrick MacLeamy, CEO of HOK
BIM Centre at 12/F, Block 3, HAHQ set up in 2009

- Facilitate sharing of BIM skill & promote its use
- For training and demonstration, design review and group discussion
- For project teams and consultants to work together on BIM projects
- For testing of new software and hardware
Impossible > Impractical > Possible > Expected > Required
Way Forward for HA

- R&D is in our DNA, plus HA’s core value of 4Cs in our genes. R&D is everybody’s business.
- Continuous improvement with R&D and innovation is part of our business culture.
- We will continue to work in partnership with the industry for sustained quality improvements, through R&D and innovation.
We need Collaboration!

- **Housing Authority as the client** – initiate, procure and apply innovative ideas in projects including prototyping, piloting and mass application;

- **Academic institutions and professionals** – explore innovative ideas, develop prototypes and take measurements in research;

- **Contractors** – put R&D findings into pilot practice before mass application;

- **Regulators** – consider and approve innovative application for use in HA’s projects; promulgate it through circulars where applicable.
Food for Thought

千里之行，始於足下
The journey of a thousand miles start with a small step.

行百里者，半於九十
Walk 100 miles, and 90 is the half-way mark.

Rome is not built in a day…

If we can do better, good is not enough!
+ The best is the enemy of the good.
Trick for Success in R&D!

Teamwork
Recognition & Rapport
Integrity & Integration
Creativity & Courage
Knowledge sharing
I would like to leave you all with a thought for today. This one is attributed to George Bernard Shaw. He said:

"If you have an apple and I have an apple and we exchange these apples, then you and I will still each have one apple. But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas."

Thank you!