

WORLDSBE Conference 2017 Hong Kong  
5-7 June 2017

# Research and Development of Noise Mitigation Measures for Public Housing Development in Hong Kong

Mr. John HO  
Chief Civil Engineer/1  
Hong Kong Housing Authority



Organisers:



International Co-owners:





# John H.L. HO

Chief Civil Engineer/1

Hong Kong Housing Authority (HKHA)



To **supervise** the Civil Engineering Section of Housing Department



To **oversee** all work covering planning, design and contract management of **infrastructure works** to support the public housing development programme as well as managing the **research and development studies** in respect to **noise mitigation measures**.



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



# Introduction



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction

# Introduction



- Hong Kong in *high density living environment*.
- Close proximity to heavily trafficked roads or other noise sources.
- HKHA have applied a host of noise mitigation measures to *reduce the impact and nuisance* & to create a *healthy living environment* to our residents.

# Introduction

## Environmental Assessment Study (EAS)

to demonstrate compliance to EPD on the noise limit under-

- Road traffic noise limit under Hong Kong Planning Standards and Guidelines (HKPSG)
- Fixed and railway noise limit under Noise Control Ordinance Cap.400



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
For Buildings and  
Construction



# Specific Design to Tackle Noise Issues



Organisers:



International Co-owners:



Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability



# General Principle of Noise Mitigation Measures

## Principles of Mitigation Measures

### At Source



Low noise road surfacing

### At Propagation Path

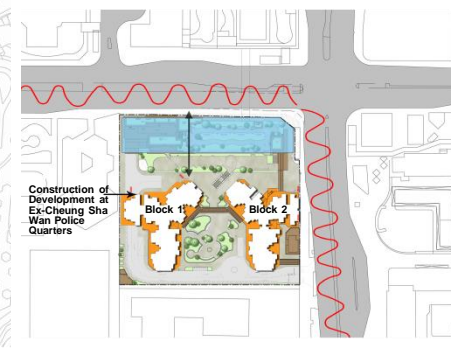


Noise Barrier

### At Receiver End



Building setback



Acoustic Windows



Noise Enclosure



Non noise sensitive building



Acoustic Balcony



Acoustic Windows

## Compliance Considerations

- Value for Money
- Site & Technical Constraints
- Urban Design Aspect

➔ **A Balanced Solution**



Organisers:



International Co-owners:

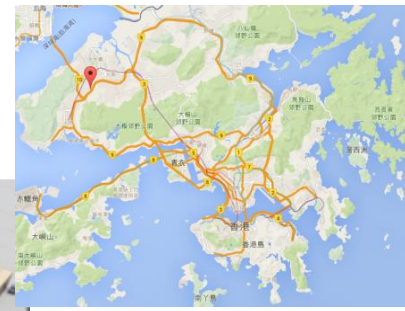




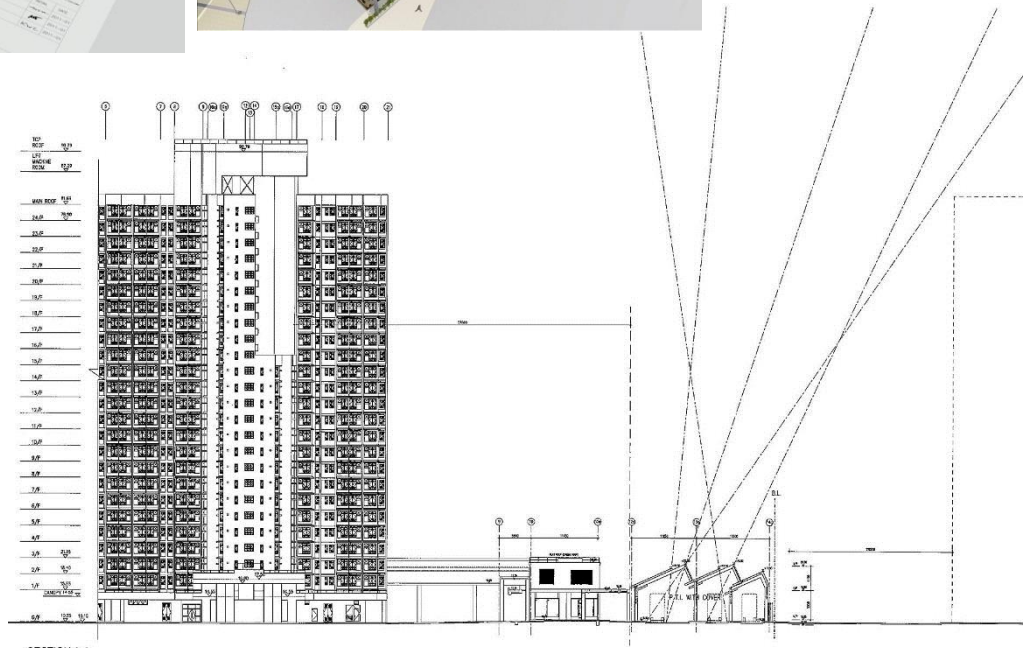
# Special Noise Cover for Public Transport Interchange (Mitigation Measures at Source)



No. of Blocks	9
No. of Flats	4905
Population	12900



**Hung Fuk Estate,**  
NW part of Hong Kong





# Specific Building Block Design

(Mitigation Measures at Receiver End and on Propagation Path)

Passive Design Approach

Sau Mau Ping (South) Estate



## Optimized Block Disposition

- Setback
- Reduced view angle

## Vertical Green Noise Barrier





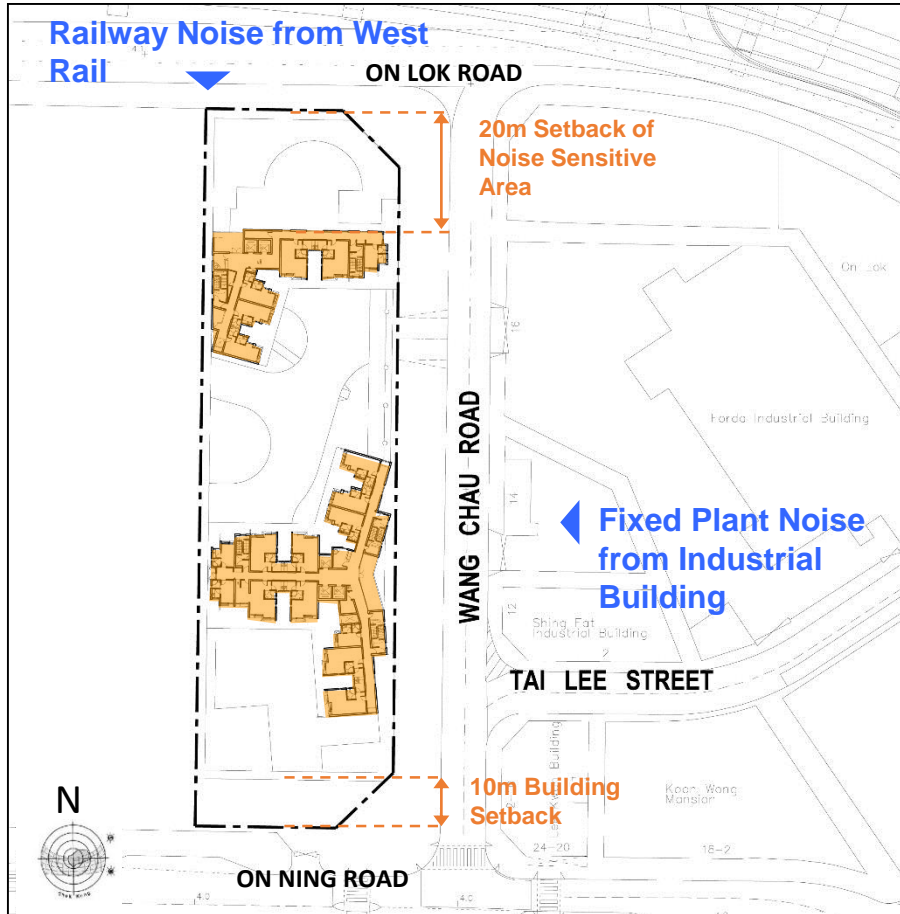
# Specific Building Block Design

(Mitigation Measures at Receiver End and on Propagation Path)

## Long Ching Estate, Yuen Long



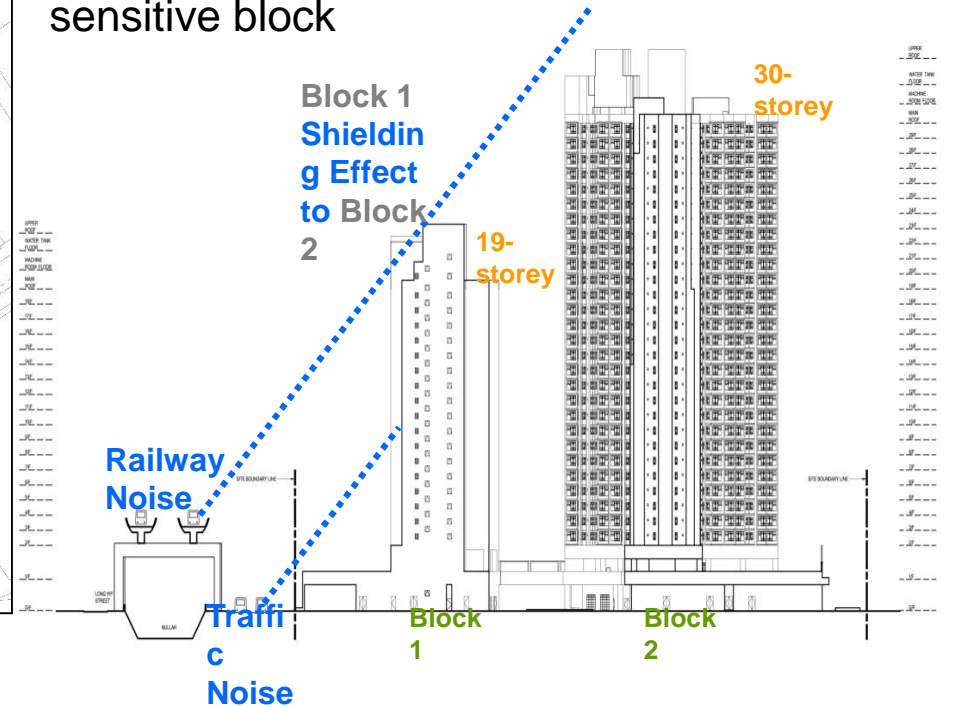
No. of Blocks	2
No. of Flats	437



### Optimized Block Disposition

Single aspect building (SAB) design

SAB provide screening for other noise-sensitive block



# Innovative Noise Mitigation Measures developed for

## Public Housing Development in Hong Kong



Organisers:



International Co-owners:



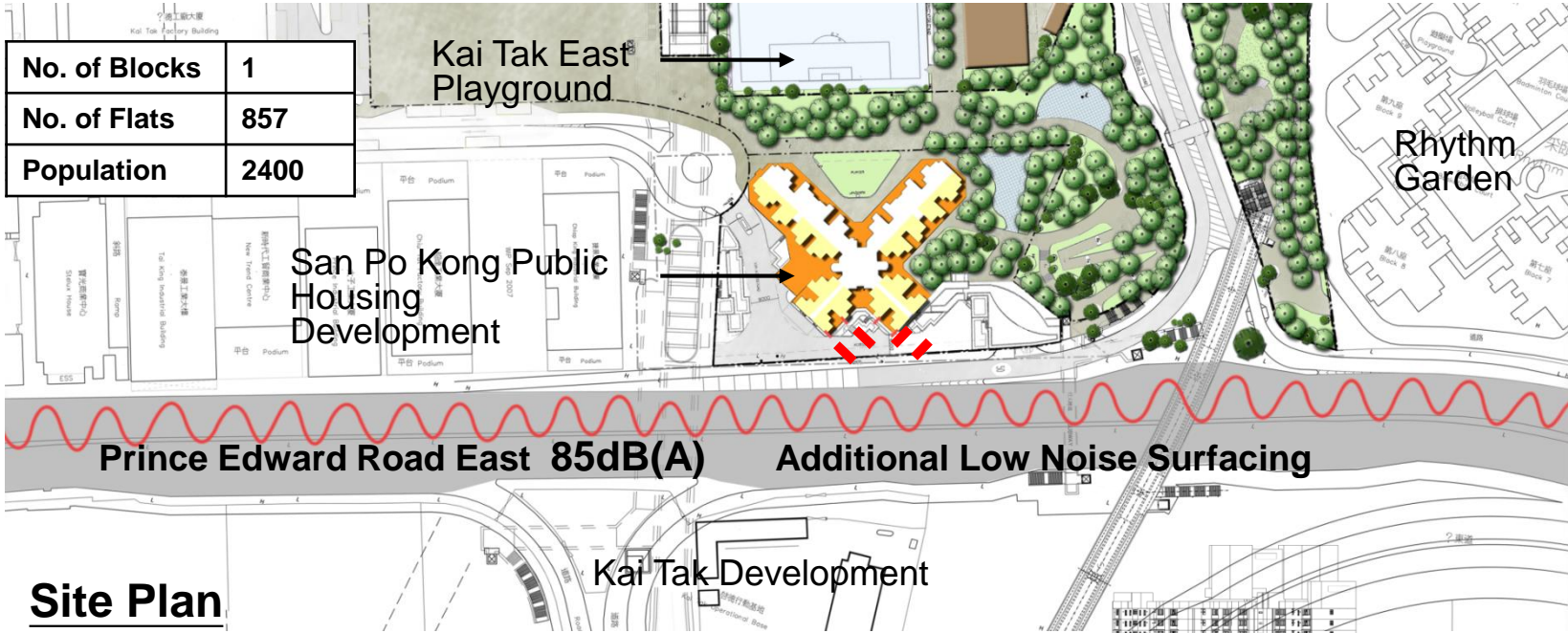
Sustainable Buildings and Climate Initiative  
Promoting Policies and Practices for Sustainability





# Acoustic Window

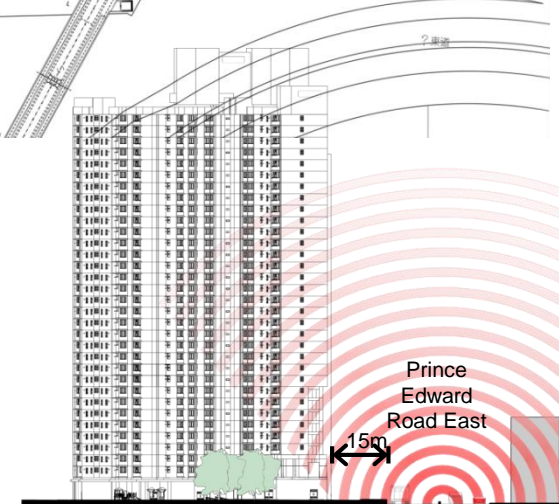
Designed in 2009, and completed in early 2017



## Noise Mitigation Measures:

- Set Back & Orientation **3dB(A)**
- Low Noise Road Surfacing **2dB(A)**
- Architectural Fins **2dB(A)**
- Flat with Acoustic Window **8dB(A)**

**Total Reduction : 15dB(A)**



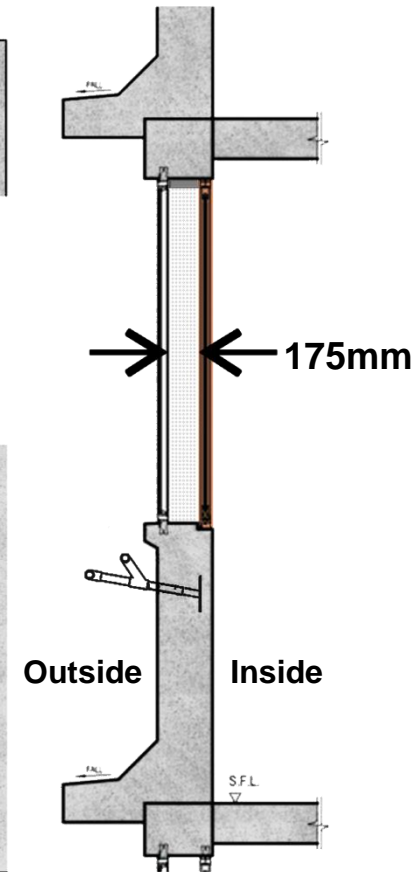
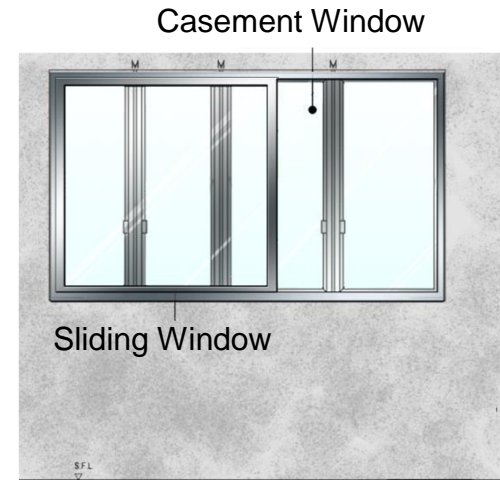
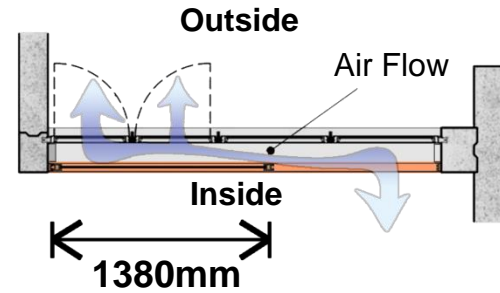
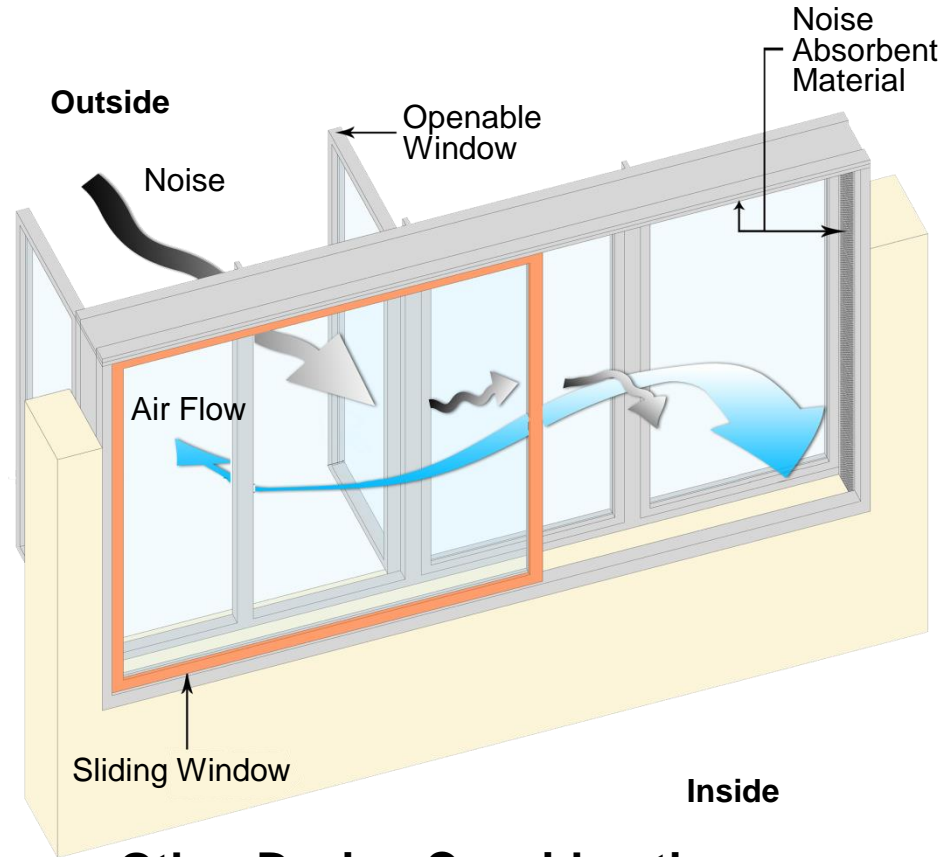
Organisers:



International Co-owners:



# Acoustic Window



## Other Design Considerations :

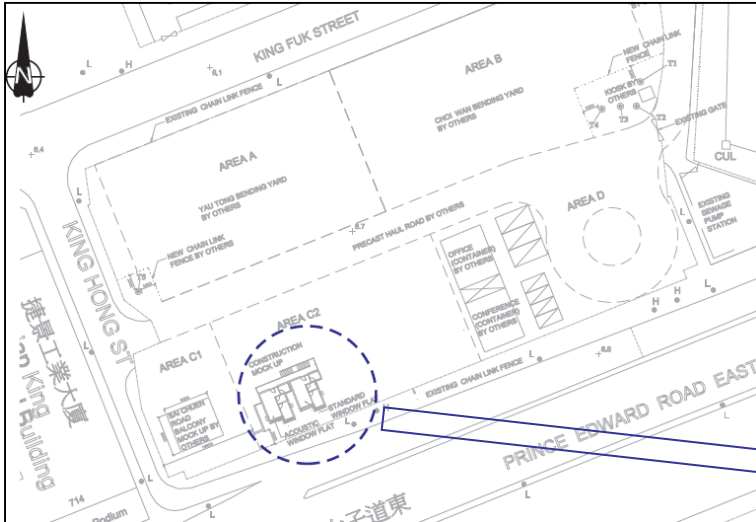
- Simple to operate
- Easy reach for clothes hanging
- Easy to clean
- Safe and durable

- Window frame installed with precast facade in factory



# Acoustic Window

## On-site tests with twin mock-up flats

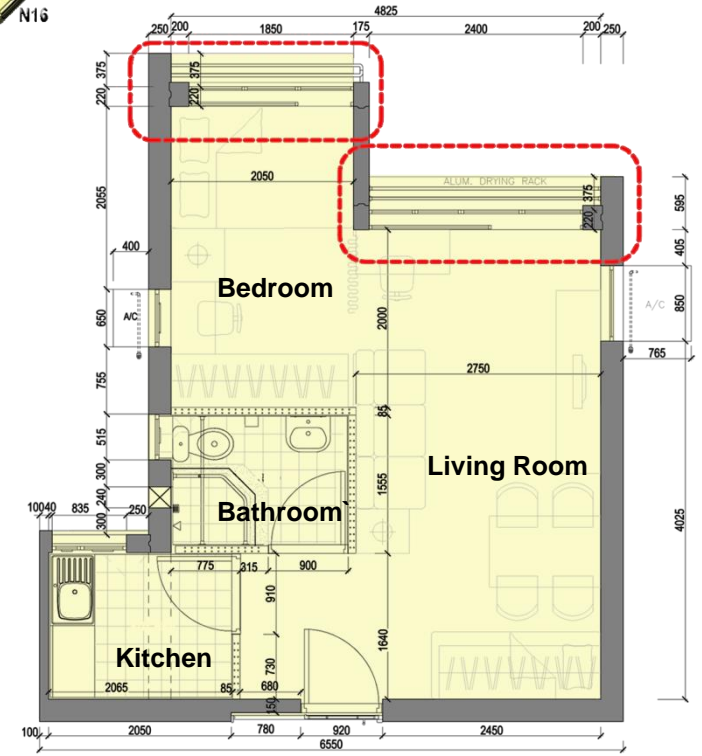
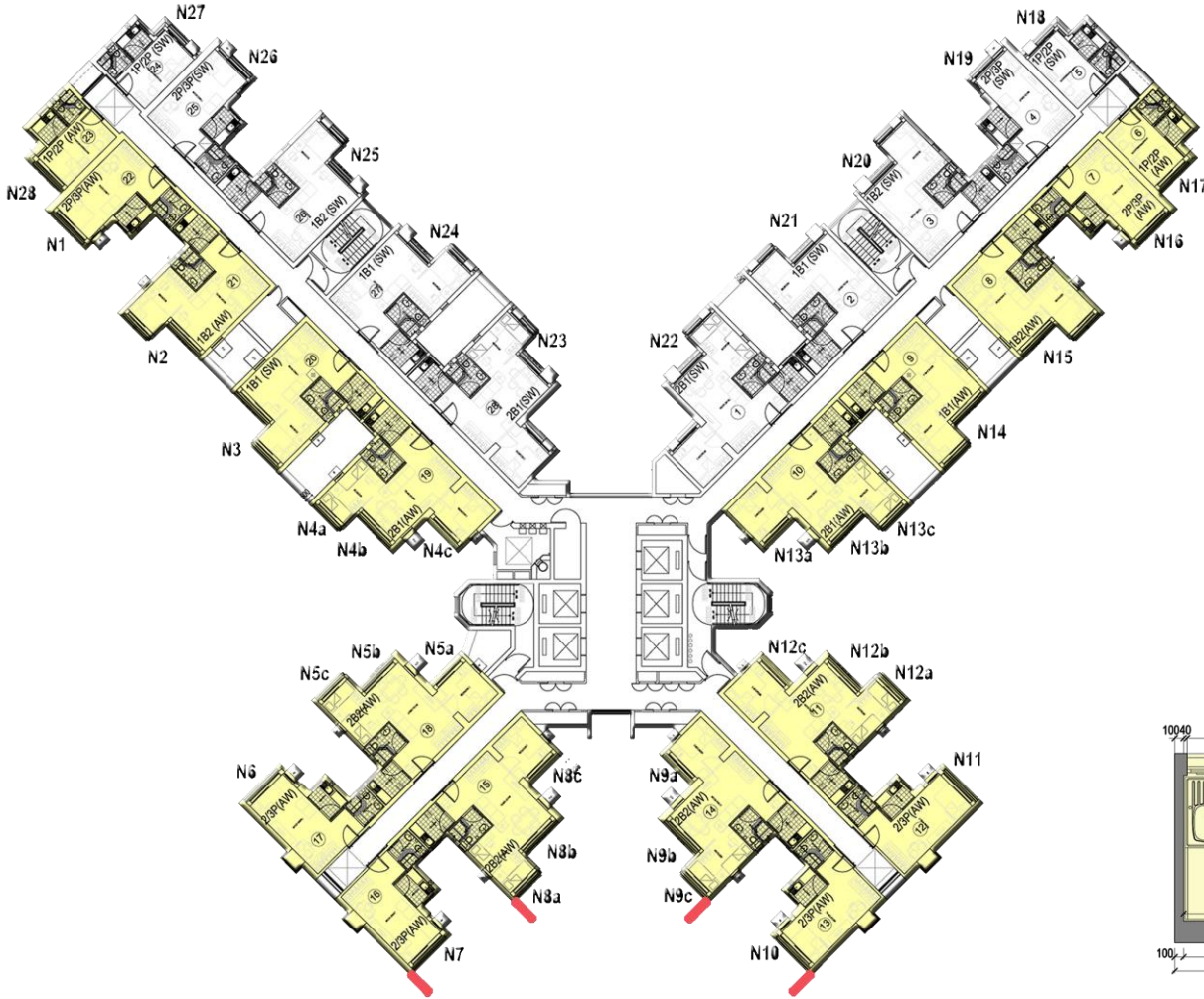


**Mockup Flat - Layout Plan**

- To evaluate the sound attenuation of acoustic window over standard window for modular flat
- Using actual window prototype and under in-situ noise situation.
- About 10 measurement points at interior of modular flat give representative results.



# Acoustic Window



No. of flats with acoustic windows = 540  
( 63% of development)

Flat with Acoustic Window



# Acoustic Window



Noise Reduction up to **8dB(A)**



Panoramic View of the Harbour



Organisers:



International Co-owners:

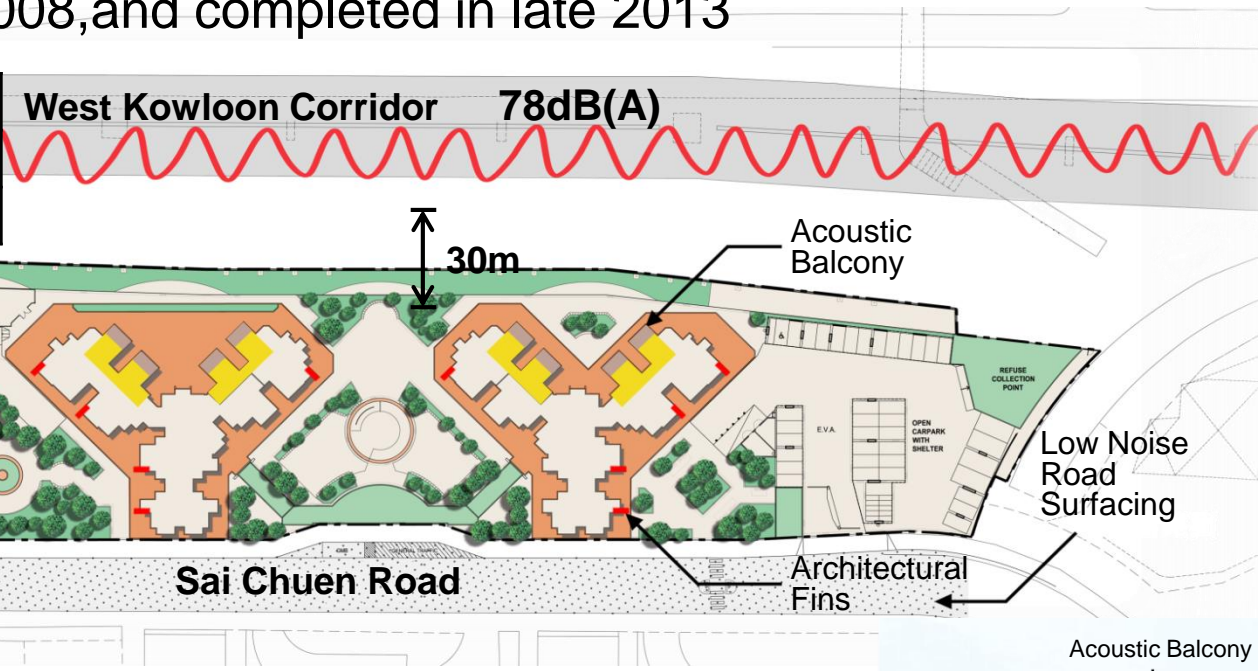




# Acoustic Balcony (Arc Screen to First Generation)




Designed in 2008, and completed in late 2013

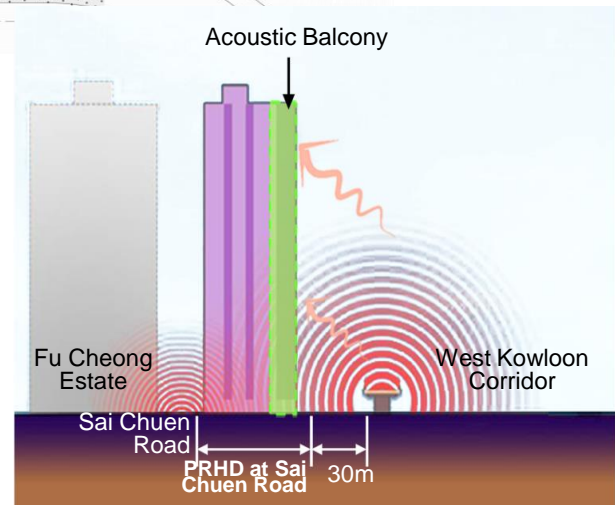
No. of Blocks	2
No. of Flats	1488
Population	3800



Site Plan

## Noise Mitigation Measures:

-  Low Noise Road Surfacing
  -  Architectural Fins
  -  Acoustic Balcony
- } 4dB(A)
- } 2.5 - 6.4dB(A)

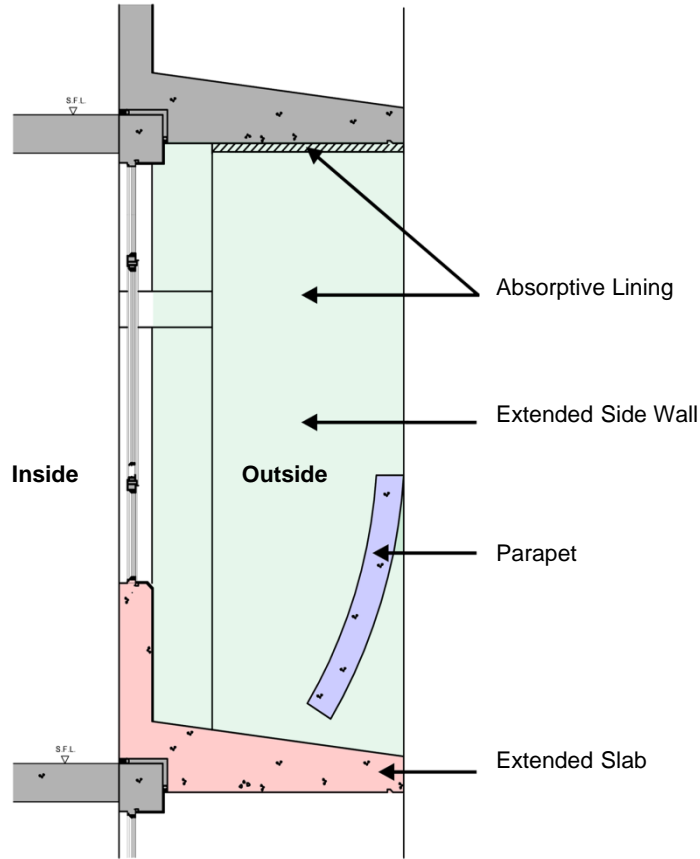


Site Section





# Acoustic Balcony (Arc Screen to First Generation)



## Preliminary Design - ARC SCREEN

# Acoustic Balcony (Arc Screen to First Generation)

## Arc-screen - Full scale Mock up at Dongguan

### Measurement Scenarios



Scenario 1 – Unmitigated



Scenario 2 – Concrete with gap



Scenario 3 – Concrete without gap



Scenario 4 – Concrete with absorptive surface



Scenario 5 – Polymethyl methacrylate (PMMA) parapet with gap

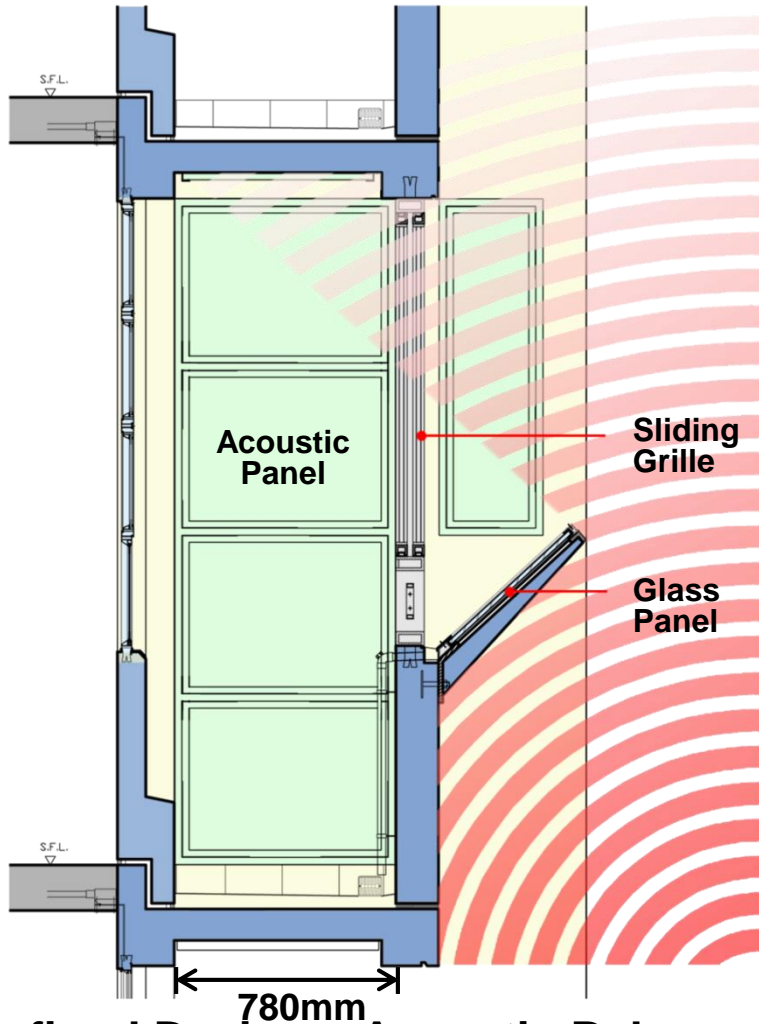


Scenario 6 – Polymethyl methacrylate (PMMA) parapet, ceiling & side walls with absorptive surface

About 10,000 measurement readings were taken. Measurement points were placed inside and outside windows and at different height from floor.



# Acoustic Balcony (Arc Screen to First Generation)

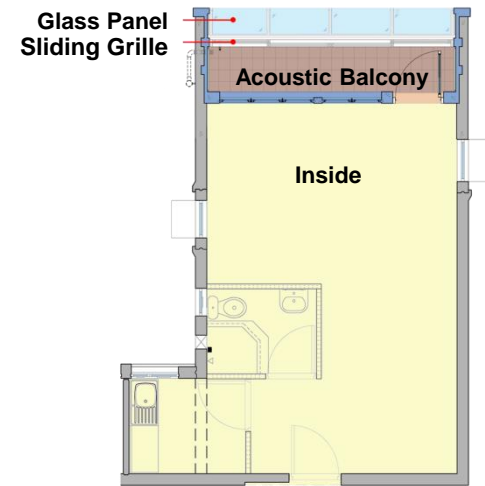
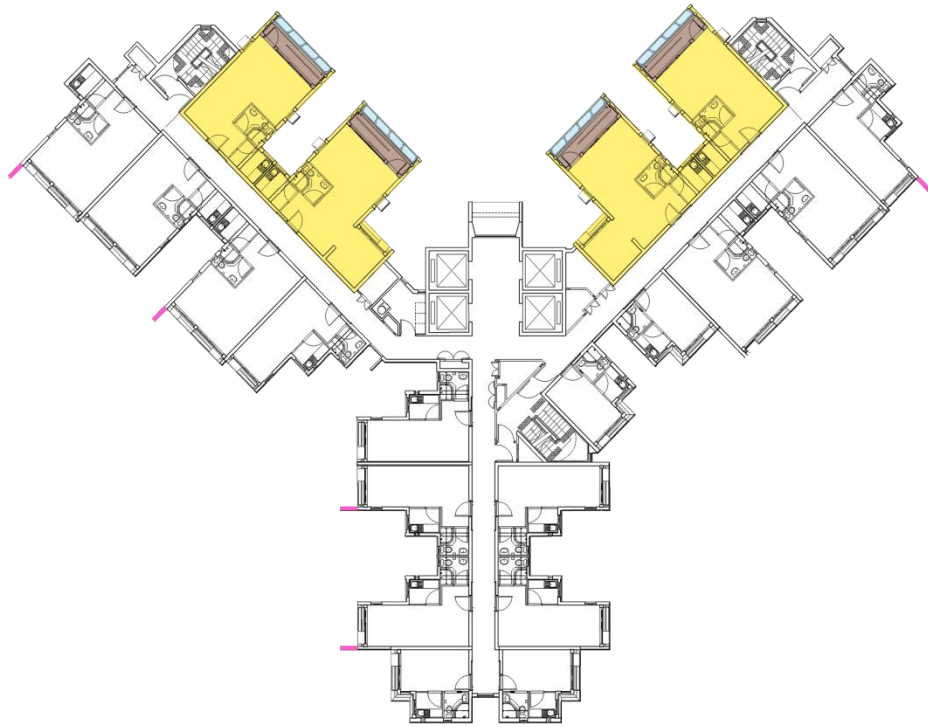


**Refined Design – Acoustic Balcony**

**On Site Precast Balcony**



# Acoustic Balcony (Arc Screen to First Generation)



Flat with Acoustic Balcony

No. of flats with acoustic balcony = 276 ( 19% of development)

# Acoustic Balcony (Arc Screen to First Generation)

## Noise Monitoring at Building Completion





# Acoustic Balcony (Arc Screen to First Generation)



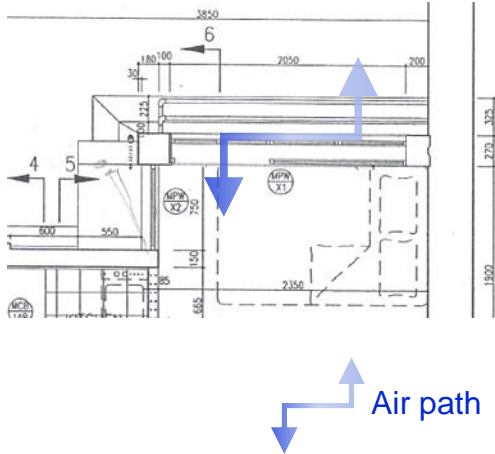
Noise Reduction up to **6.4dB(A)**





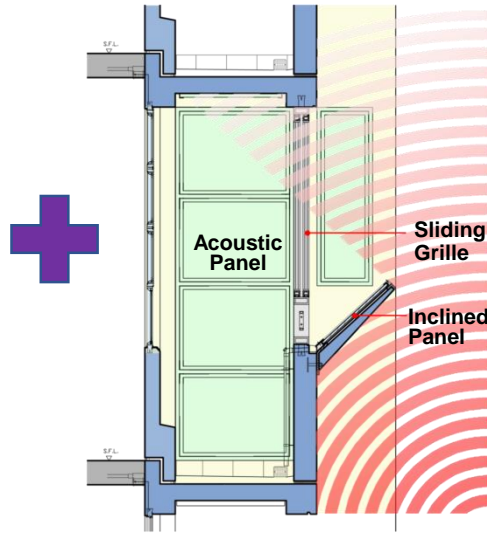
# Acoustic Balcony (Enhanced Design)

## Design Concept



**Acoustic Window**  
(San Po Kong Public Housing Development)

Noise attenuation  
max. 8 dB(A)

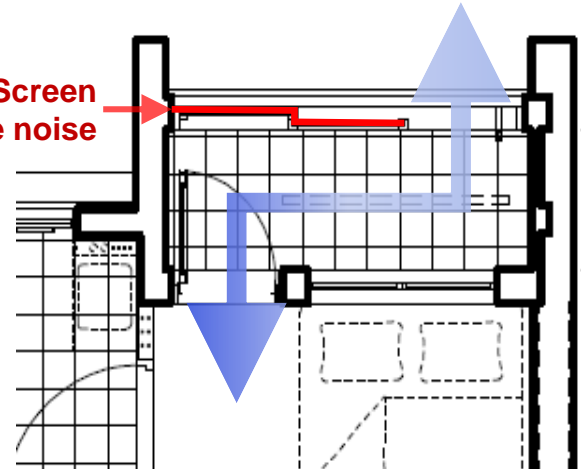


**1<sup>st</sup> Generation Acoustic Balcony**  
(Wing Cheong Estate)

Noise attenuation  
~2 to 6 dB(A)

Limtation  
Only for Wing Cheong Estate  
(Site specific)

Sliding Screen to mitigate noise



**Enhanced Acoustic Balcony**  
(Full scale mock-up at a vacant school at Yue Wan Estate)

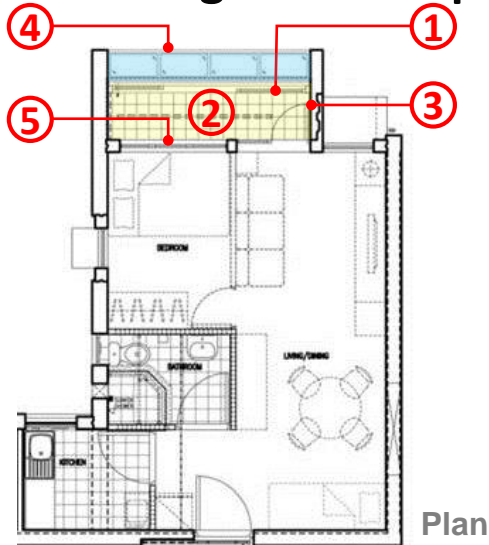
**Better Noise Attenuation**  
~6 to 10dB(A)\*

**Better Ventilation**  
Sufficient air flow.

**User-friendly Application**  
Prescriptive approach for window calculation.

# Acoustic Balcony (Enhanced Design)

## Noise Mitigation Component



Plan

### Main Features –

1. **Sliding screen** in front of balcony door
2. **Plenum configuration** of balcony for better air flow (concept of acoustic window).

### Optional Features to further reduce noise-

3. **Acoustic panel** at wall and ceiling
4. **Inclined panel** outside the parapet
5. **Acoustic windows** at living areas



Sliding Screen



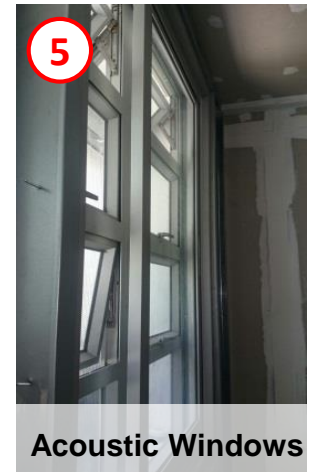
Acoustic Balcony



Acoustic Panel



Inclined Panel



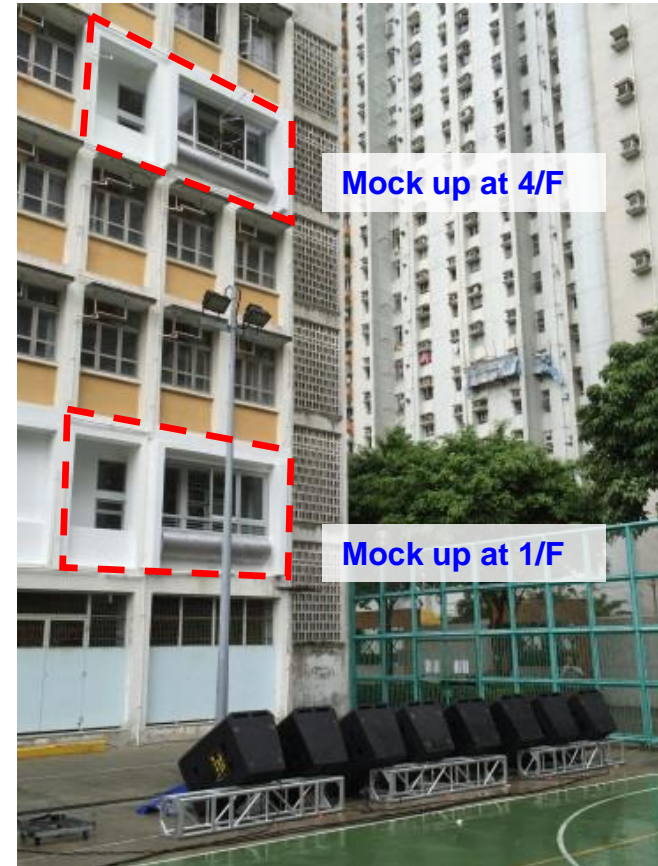
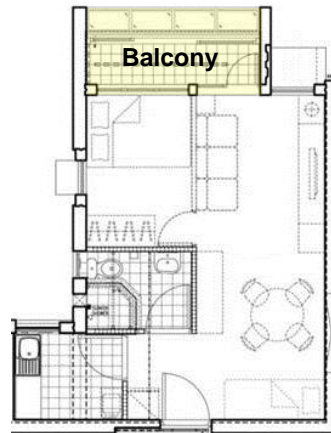
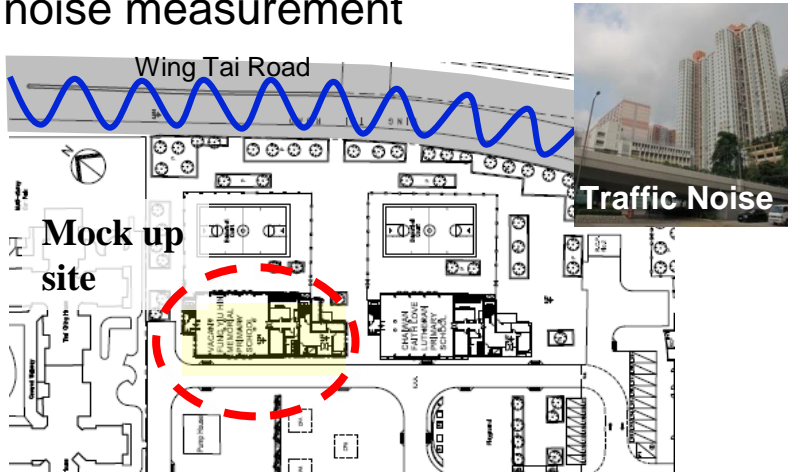
Acoustic Windows



# Acoustic Balcony (Enhanced Design)

## Verification of Noise Performance by Full Scale Mockup

Prototypes (including features ① to ⑤) inside an existing vacant school building for on-site noise measurement

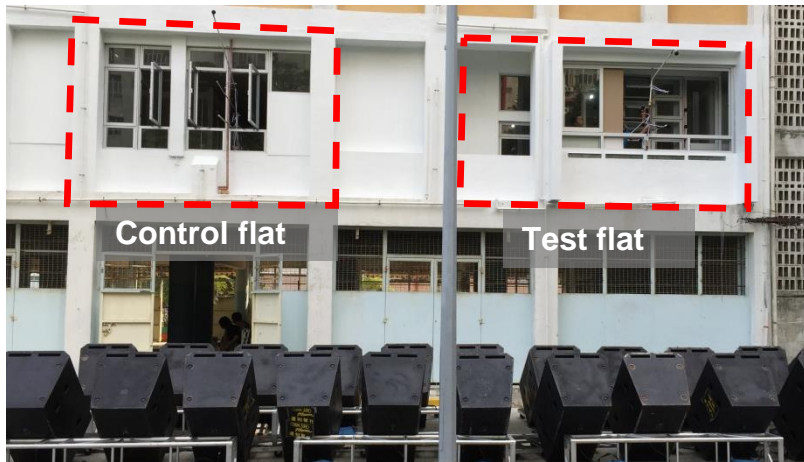


Mock-up Flats with Acoustic Balcony at different levels



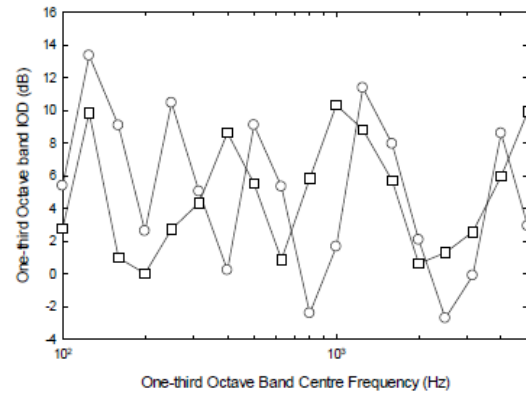
# Acoustic Balcony (Enhanced Design)

## Testing Data Analysis

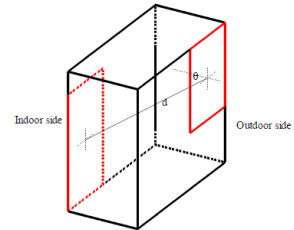


Max Noise Reduction (for balcony with the optional features) **around 10 dB(A)**

## Interpretation of noise results



## Further simulations for other flat types



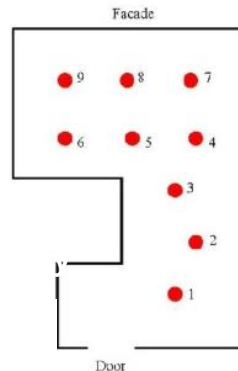
The major difference between old 1/2P (3/4P) and the new 1/2P (3/4P) is the depth of the balcony. The room constants (RC) of the two rooms are the same basically. So, the correction for RIL is thus mainly due to the balcony configuration and the outdoor opening size of the balcony. The base unit window configurations are unchanged.

The noise reduction across the plenum chamber attached to an enclosure of room constant RC can be approximated by

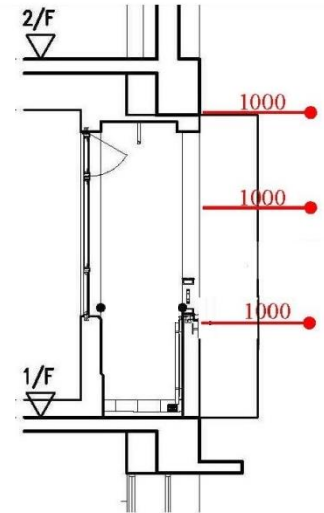
$$NR = -10 \log_{10}(S_{\text{outdoor}} / (4\pi r^2) + 1/R_{\text{in}}) - 10 \log_{10}(S_{\text{outdoor}} / RC) + \text{Constant}$$



## Indoor Microphones setup



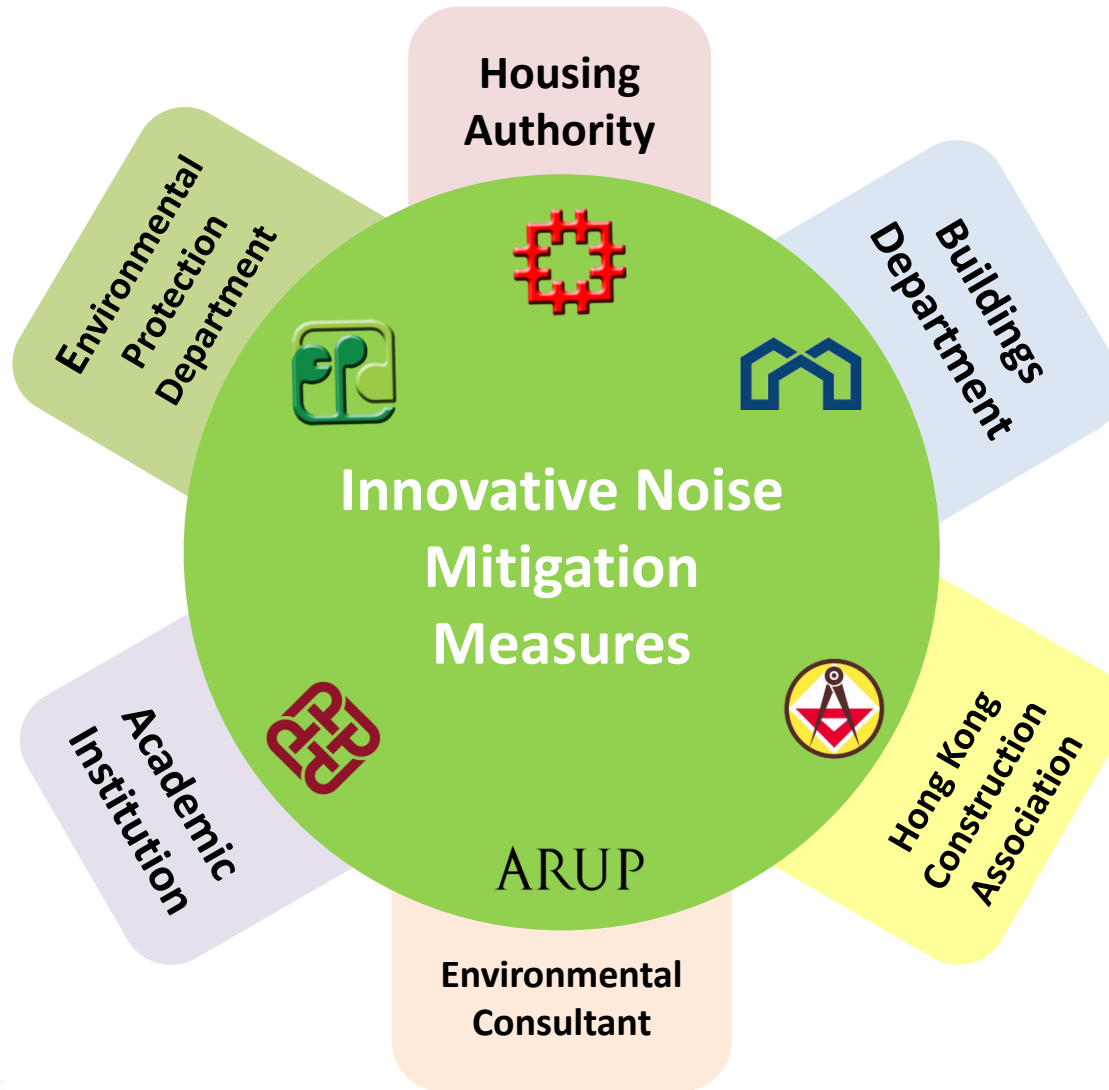
Point	distance in metres from		
	inner window pane	Side wall	Floor
1	5.12	1.4, right-hand-side wall	1.45
2	4.12	1.0, right-hand-side wall	1.30
3	3.12	1.4, right-hand-side wall	1.65
4	2.12	1.0, right-hand-side wall	1.20
5	2.12	2.3, left-hand-side wall	1.00
6	2.12	1.0, left-hand-side wall	1.65
7	1.0	1.1, right hand side wall	1.40
8	1.1	2.2, left-hand-side wall	1.60
9	1.0	1.0, left-hand-side wall	1.20



## Site Measurement inside flat

# Collaboration with Stakeholders

Driving Innovation through collaboration with stakeholders and expertise



Organisers:

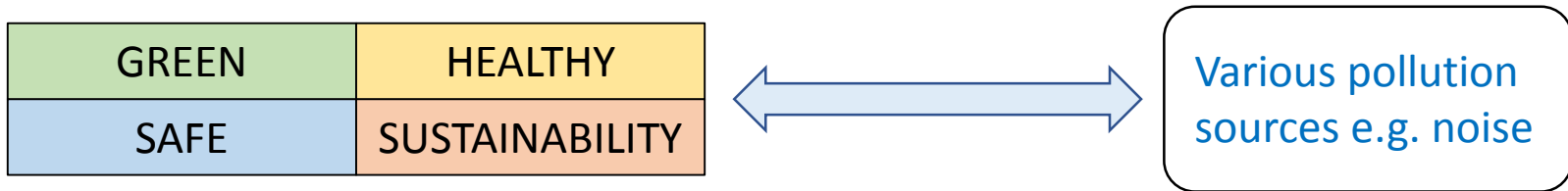


International Co-owners:

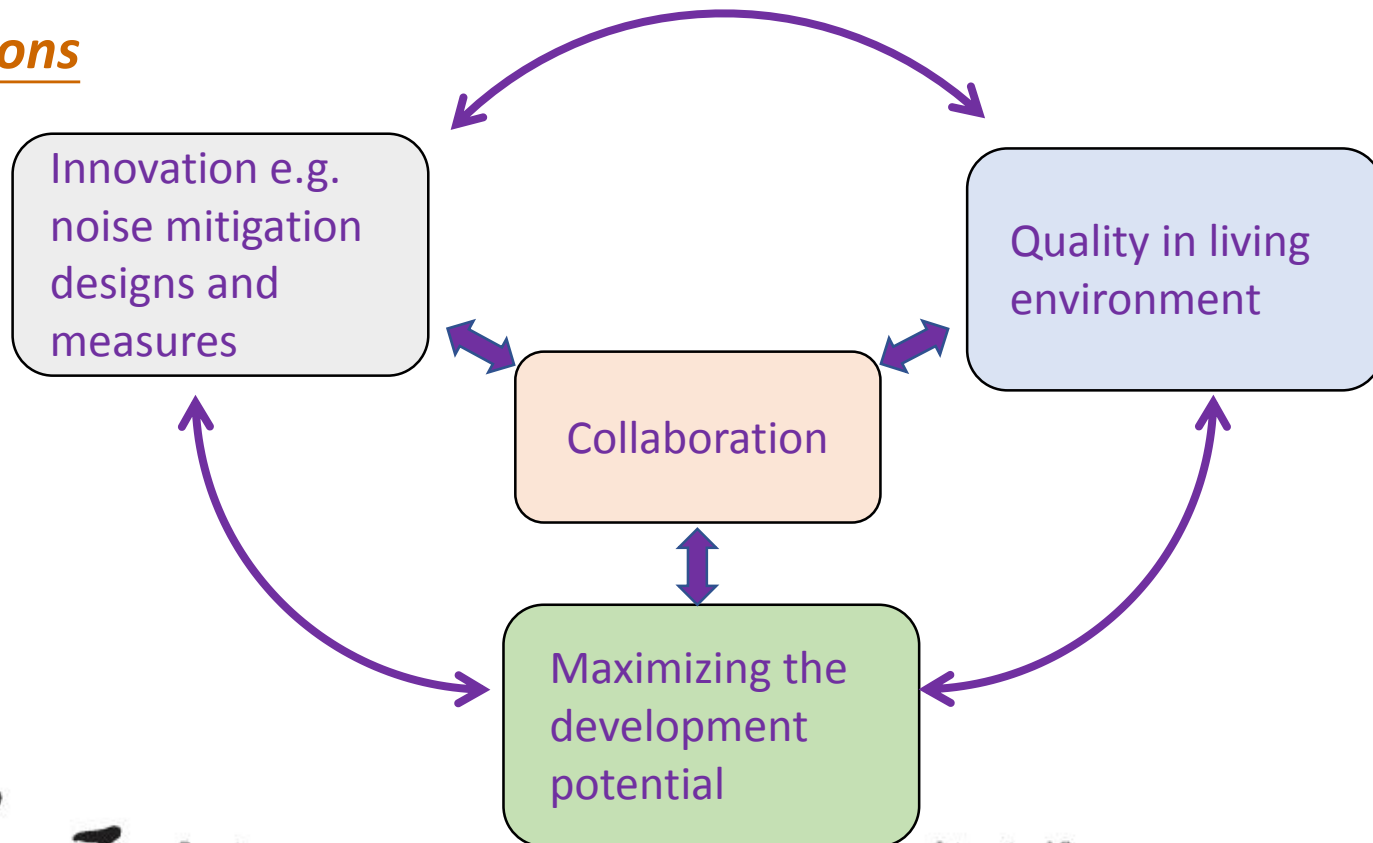


# Conclusion

## Challenge for developer/ designer in hyper density urban (Hong Kong)



## Solutions





# Conclusion

*We uphold our 4Cs Core Values –*

*Caring, Customer-focused, Creative, Committed to*

*build a sustainable community in a*

*high density urban environment*



Organisers:



International Co-owners:



# Thank you

For details of Hong Kong Housing Authority's Sustainability Initiatives, please visit –

**English Version**

[http://www.housingauthority.gov.hk/hdw/video/videoshell\\_Environmental\\_corporate\\_Eng.html](http://www.housingauthority.gov.hk/hdw/video/videoshell_Environmental_corporate_Eng.html)

**Putonghua Version**

[http://www.housingauthority.gov.hk/hdw/video/videoshell\\_Environmental\\_corporate\\_Mand.html](http://www.housingauthority.gov.hk/hdw/video/videoshell_Environmental_corporate_Mand.html)

**Cantonese Version**

[http://www.housingauthority.gov.hk/hdw/video/videoshell\\_Environmental\\_corporate\\_Cant.html](http://www.housingauthority.gov.hk/hdw/video/videoshell_Environmental_corporate_Cant.html)



Organisers:



International Co-owners:



Sustainable Buildings  
and Climate Initiative  
Promoting Policies and Practices for Sustainability



Global Alliance  
for Buildings and  
Construction