POLYCENTRIC CITIES

The Future of Vertical Urbanism

Drainage of Rainwater from ‘Wind-Driven Rain Spaces’

Colin Thoms, *CEO*, Fast Flow Ltd

Background of my Company

- Fast Flow is a Rainwater Management Specialist for buildings and it designs and installs complete rainwater systems in all types of buildings throughout Asia and Australia.
- The products used in these systems are designed by Fast Flow and made for us under contract manufacture.
- To support this, Fast Flow has a strong Research and Development program geared towards finding solutions to every day rainwater drainage challenges.
- Fast Flow has contributed to the Standards for Rainwater Drainage of Roofs in Buildings in Singapore, China and the US.

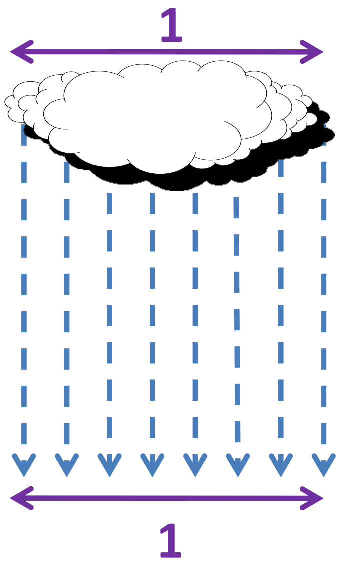
Today’s presentation is titled ‘Wind-Driven Rain Spaces’.

This is a somewhat unofficial name because virtually nothing of what I am about to relate is dealt with under any Building Code or Standard nor is there a common name being used by the various stakeholders such as Architects, Engineers, Constructors or Developers.

What is Wind-Driven Rain?

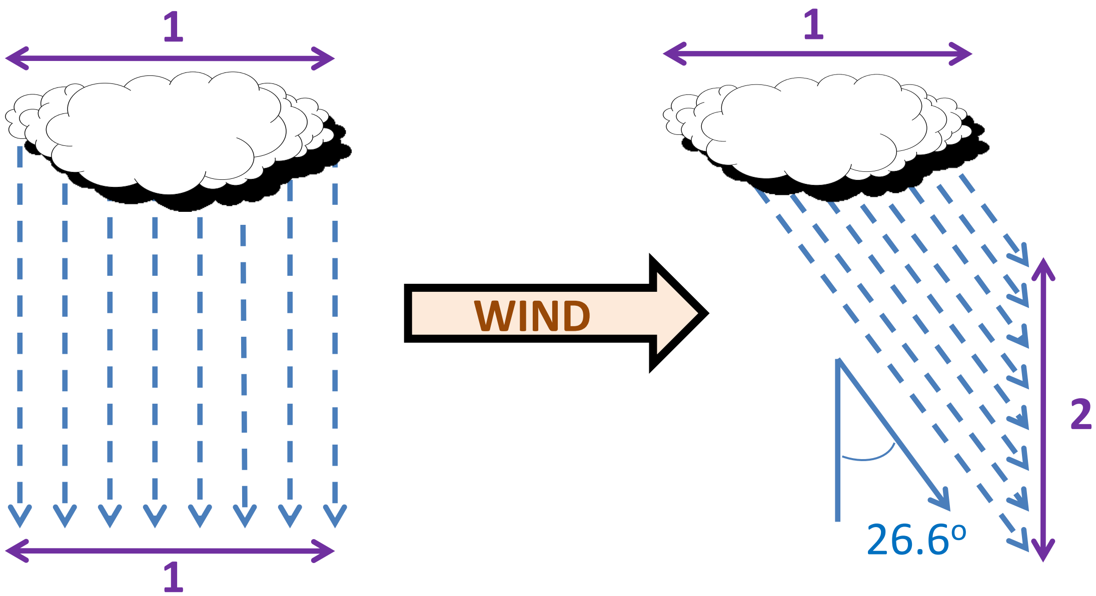
- *Wind driven rain (or driving rain) is one of the most important sources of moisture affecting building facades.*

- *Many modern buildings are now designed with spaces which whilst effectively covered are subject to wind-driven rain.*



Most Building Standards think of rain as simply this!

What is Wind-Driven Rain?



What are Wind-Driven Rain Spaces?

- Balconies
- Sky bridges
- Recreation areas
- Multi-storey car parks

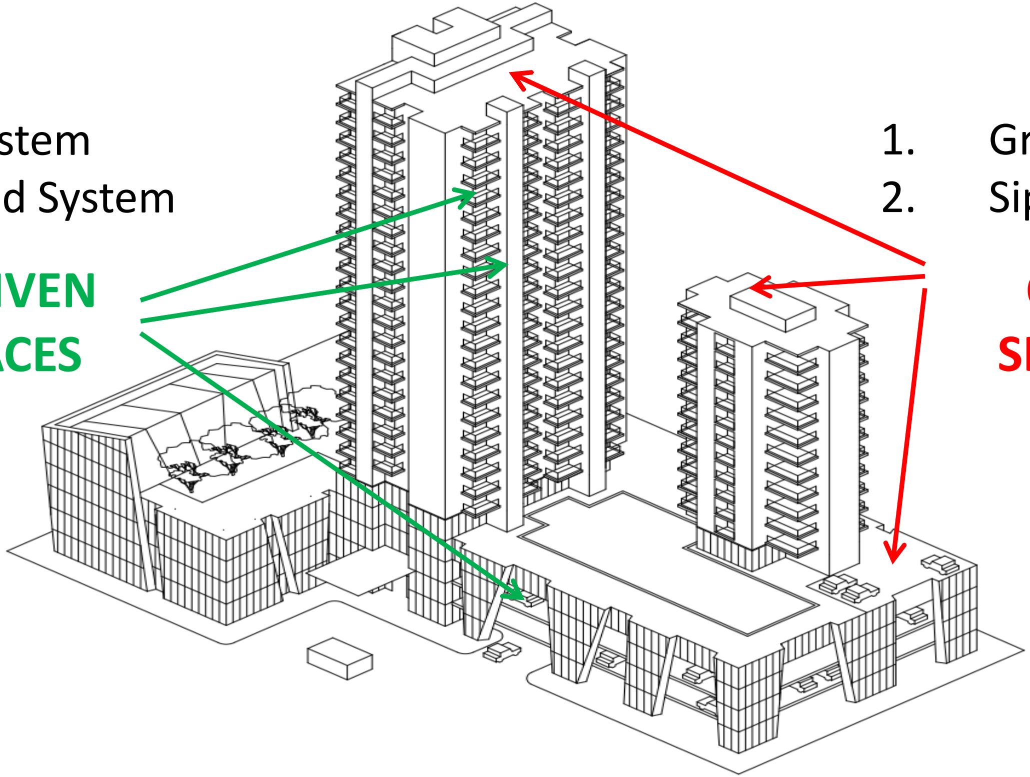
- Lobbies
- Corridors
- Canopies
- Mechanical Rooms

For the purpose of this presentation these spaces are referred to as ***'Wind-Driven Rain Spaces'.***

Types of Rain Water Drainage System

1. Gravity System
2. Pressurised System

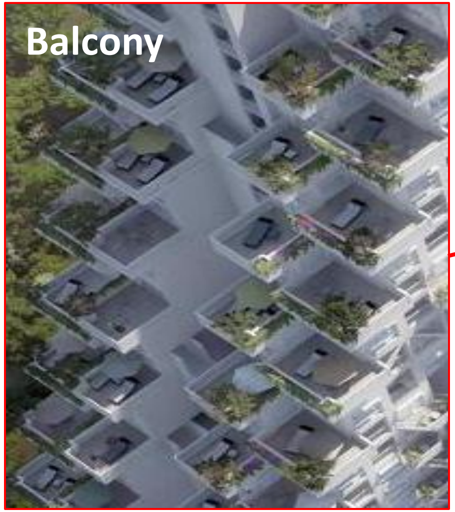
WIND DRIVEN RAIN SPACES



1. Gravity System
2. Siphonic System

OPEN TO SKY SPACES

Open to Sky Spaces



Wind Driven Rain Spaces

Definition of Wind-Driven Rain Spaces

All “*Wind-Driven Rain Spaces*” are defined as being spaces which have at least one external façade wall which is unprotected from wind-driven rain’ making them susceptible to an ingress of water into that space.

Each and every individual space, that is a space which is compartmentalized by a separating or dividing walls [e.g. Apartment balconies] to form its own unique space must be provided with a rainwater outlet or grating designed to provide for the Rate of Run-Off of that individual space.

How much Wind-Driven Rain are we talking about?

- Having established that there is a need to consider wind-driven rain entering covered spaces in buildings the next question is how much are we talking about?

- In the absence of any Code or Standard from any of the various authorities in the countries and markets we are working in, we have adopted some guidelines which we promote through our commercial offerings.

- But it is less than ideal.

How much Wind-Driven Rain are we talking about?

In the markets we are in, the following criteria has been adopted.

- Rain will fall at an angle of 26.6° that is 1m of horizontal rain will hit the façade over 2m in height. *This is reflected in the formula on the next slide.*

- Countries/Markets adopting the above criteria are
  - Singapore, Malaysia, Thailand, Turkey, Australia, China, Philippines, Indonesia.

- The use of this criteria is for calculating rain hitting façades abutting roof areas and increasing the rate of run-off of that roof.

How much Wind-Driven Rain are we talking about?

- **Catchment Area**
  - The definition of the catchment area to be used in calculating the Rate of Run-Off of a Wind-Driven Rain Space is the maximum vertical opening area in any one plane. The naming convention used by Fast Flow of this vertical catchment area (in m^2) is $\mathbf{A_{WDR}}$.

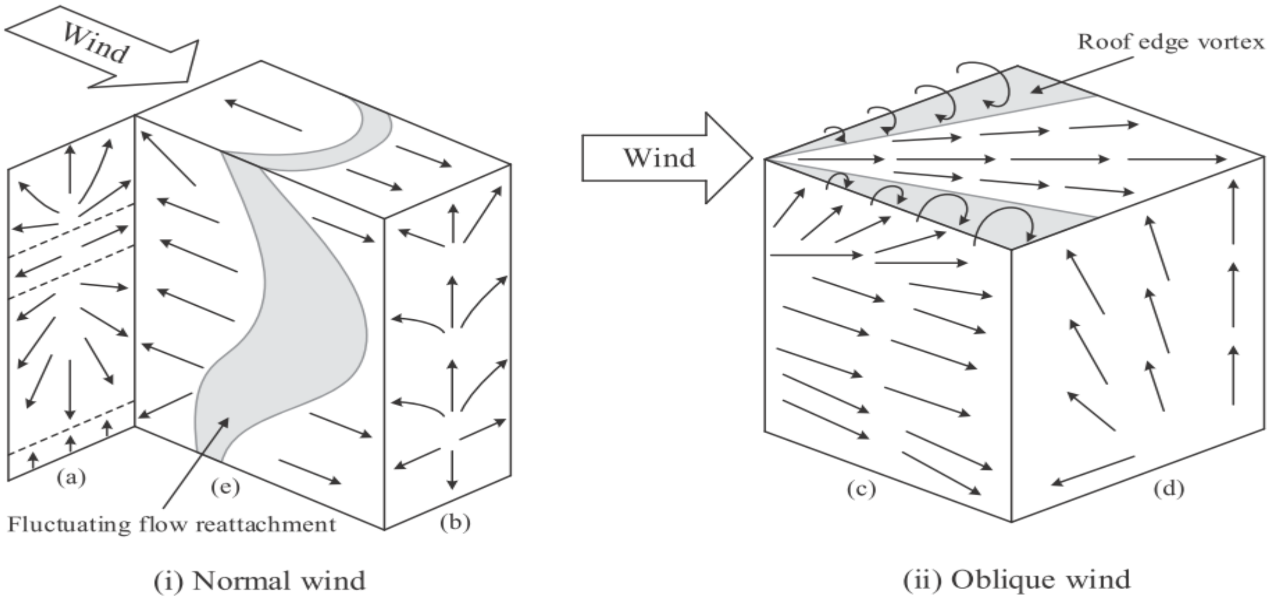
- **Rainfall Intensity**
  - The Rainfall Intensity **I** (in mm/hr) to be used in calculating the Rate of Run-Off of a Wind-Driven Rain Space should follow the Rainfall Intensity as used for the roof areas or carefully chosen to represent actual conditions.

How much Wind-Driven Rain are we talking about?

- **Rate of Run-Off**
  - The Rate of Run-Off (l/sec) for Wind-Driven Rain Spaces is
    - **$Q_{WDR} = F_R \times A_{WDR.} \times I/3600$**
      - [Where F_R is the Factor of Risk due to angle at which Wind Driven Rain is falling.
      - F_R is 0.5 in the countries I gave earlier and is set as default…..
      - …..unless the specifier modifies it]

What is a suitable F_R?

F_R varies with shape of building & wind orientation



Mao, Jiachen & Gao, Naiping. (2015). The airborne transmission of infection between flats in high-rise residential buildings: A review. Building and Environment. 94. 10.1016/j.buildenv.2015.09.026.

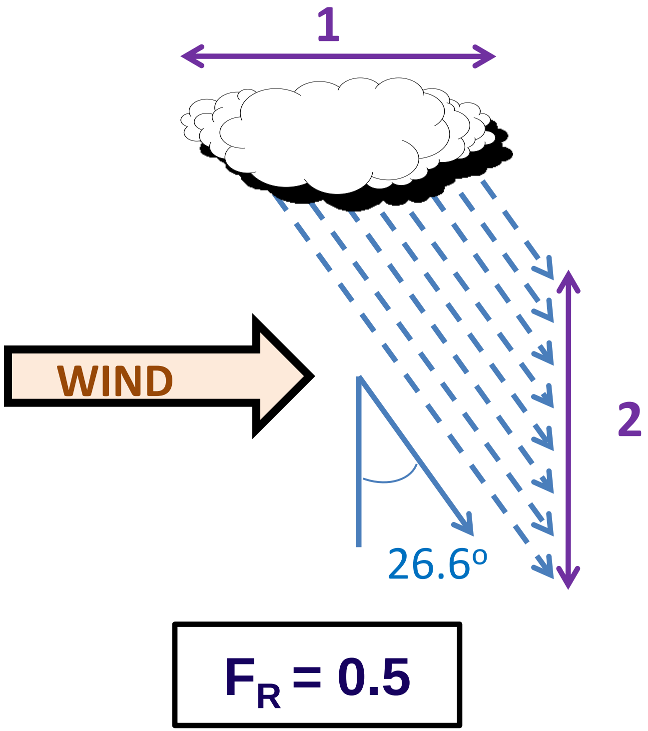
What is a suitable F_R?

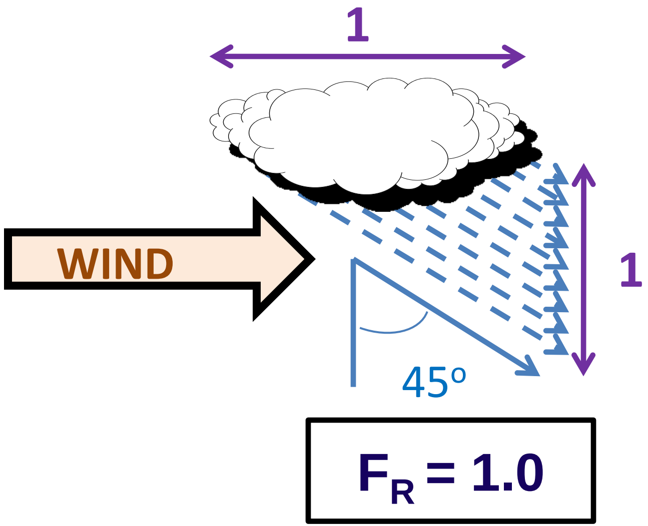
F_R varies with height of building

Wind velocity increases with the increase of height.

Variation of wind velocity with height

WDR Factor F_R



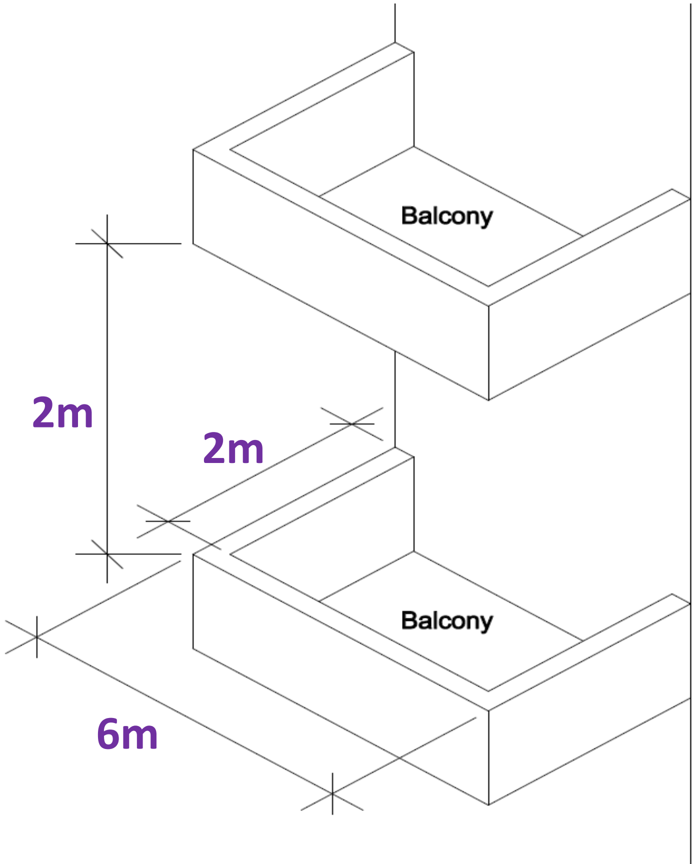


How much Wind-Driven Rain are we talking about?

How much Wind-Driven Rain are we talking about?

Illustration:

- $A_{WDR} = 2m \times 6m = 12m^2$
- If $I = 200mm/hr$ & $F_R=0.5$
- $Q_{WDR} = F_R \times A_{WDR} \times I/3600$
- $Q_{WDR} = 0.33$ l/s

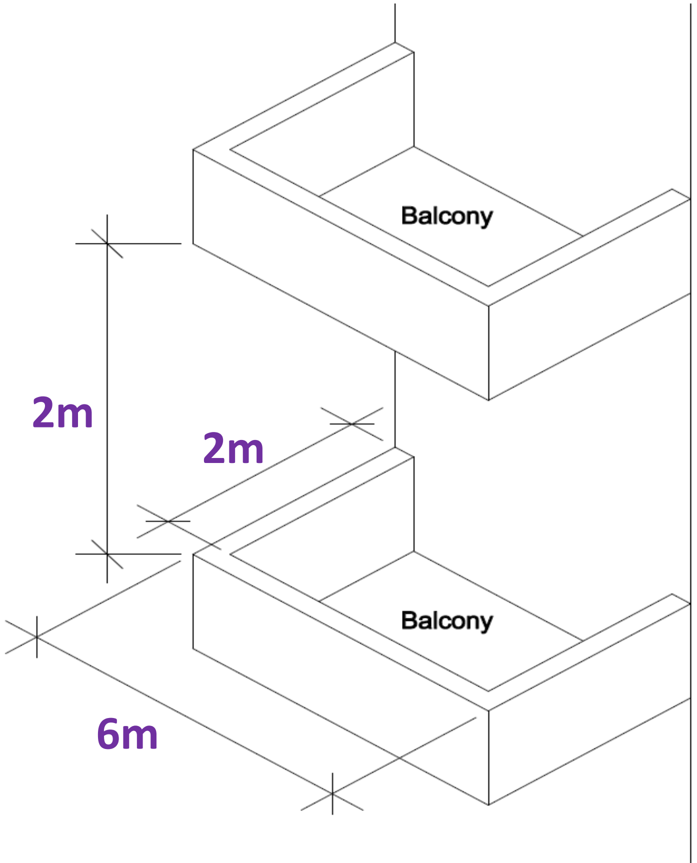


How much Wind-Driven Rain are we talking about?

The balcony has a step down of 40mm. This stepdown provides a reservoir with a capacity to retain 480 litres of water before it overflows the balcony area.

6m x 2m x 0.04m = 0.48 m²
= 480 litres

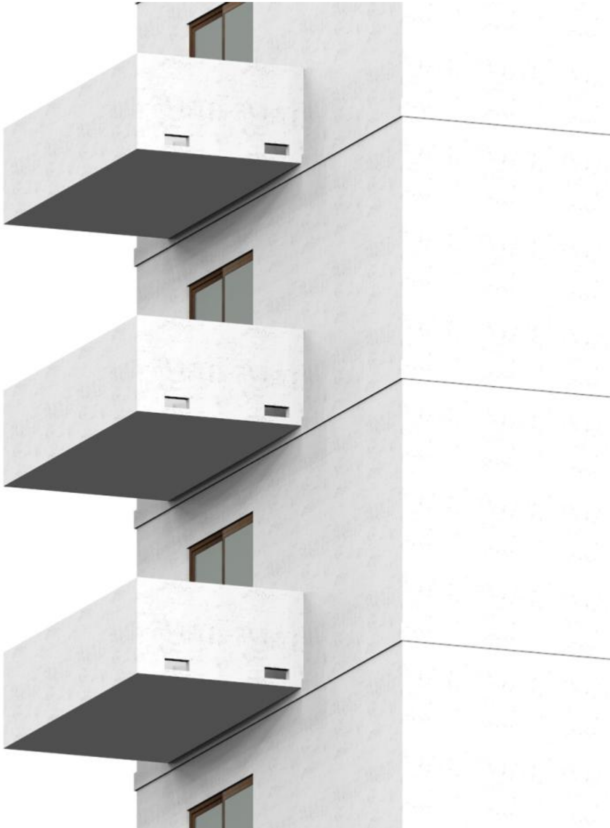
480 l @ 0.33 l/s = 1,440 seconds
= 24 minutes



How is rainwater drained from the space

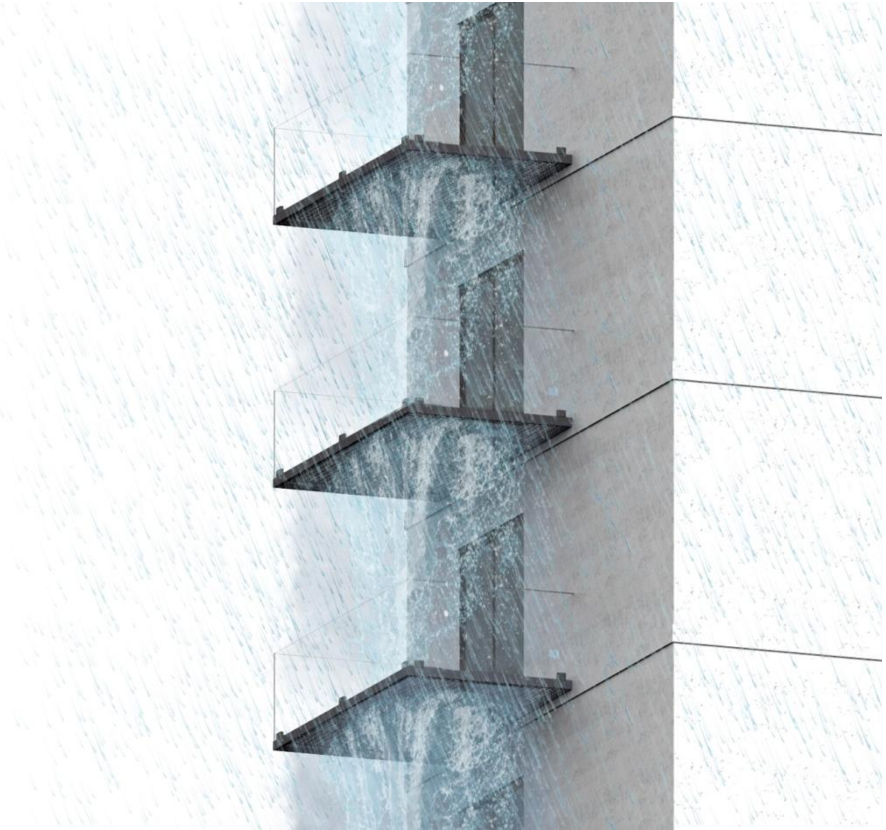
Solution 1: Perforated

Solution 2: Scupper

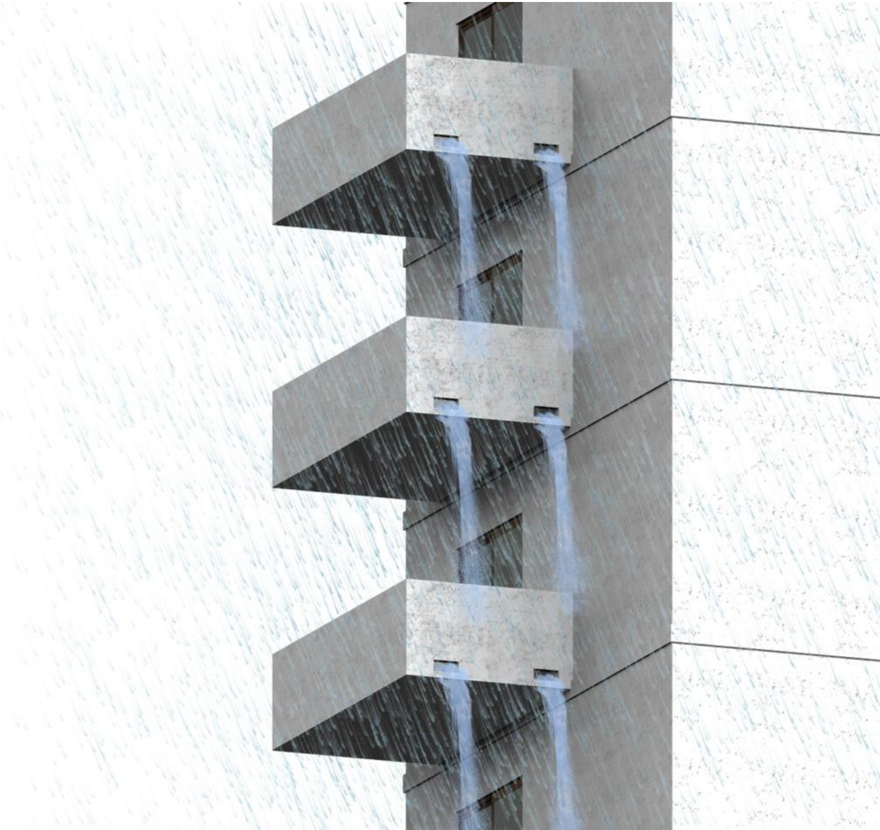


How is rainwater drained from the space

Solution 1: Perforated

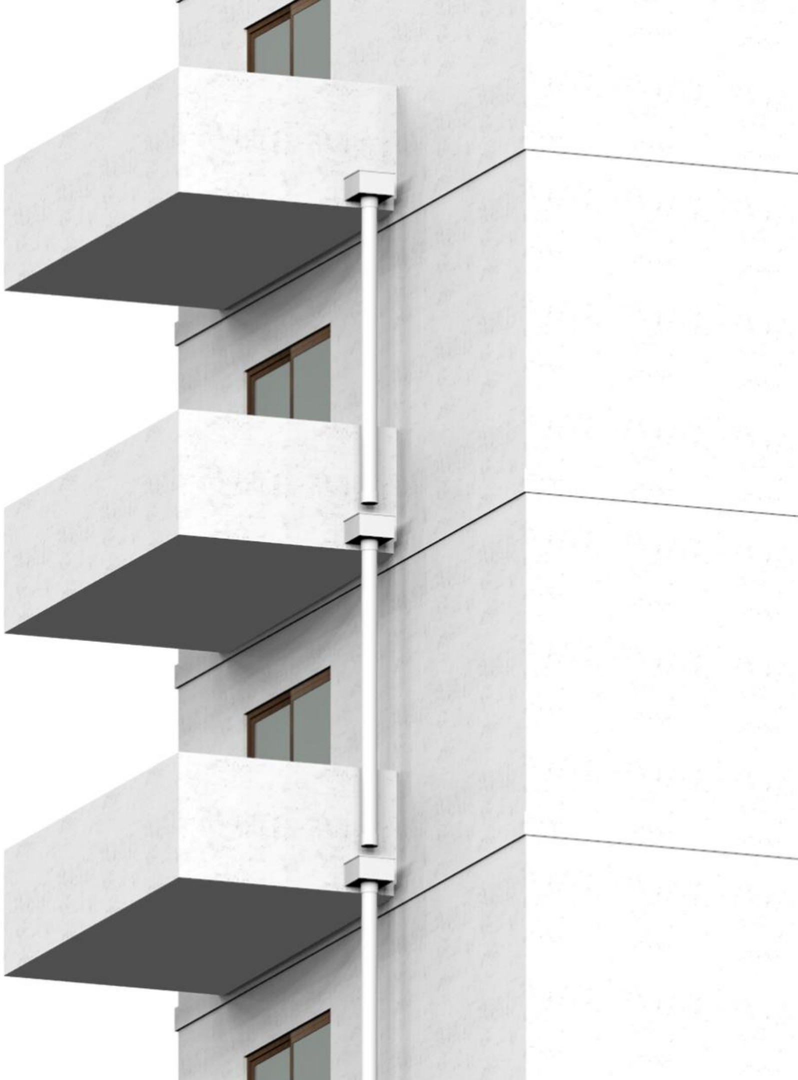


Solution 2: Scupper



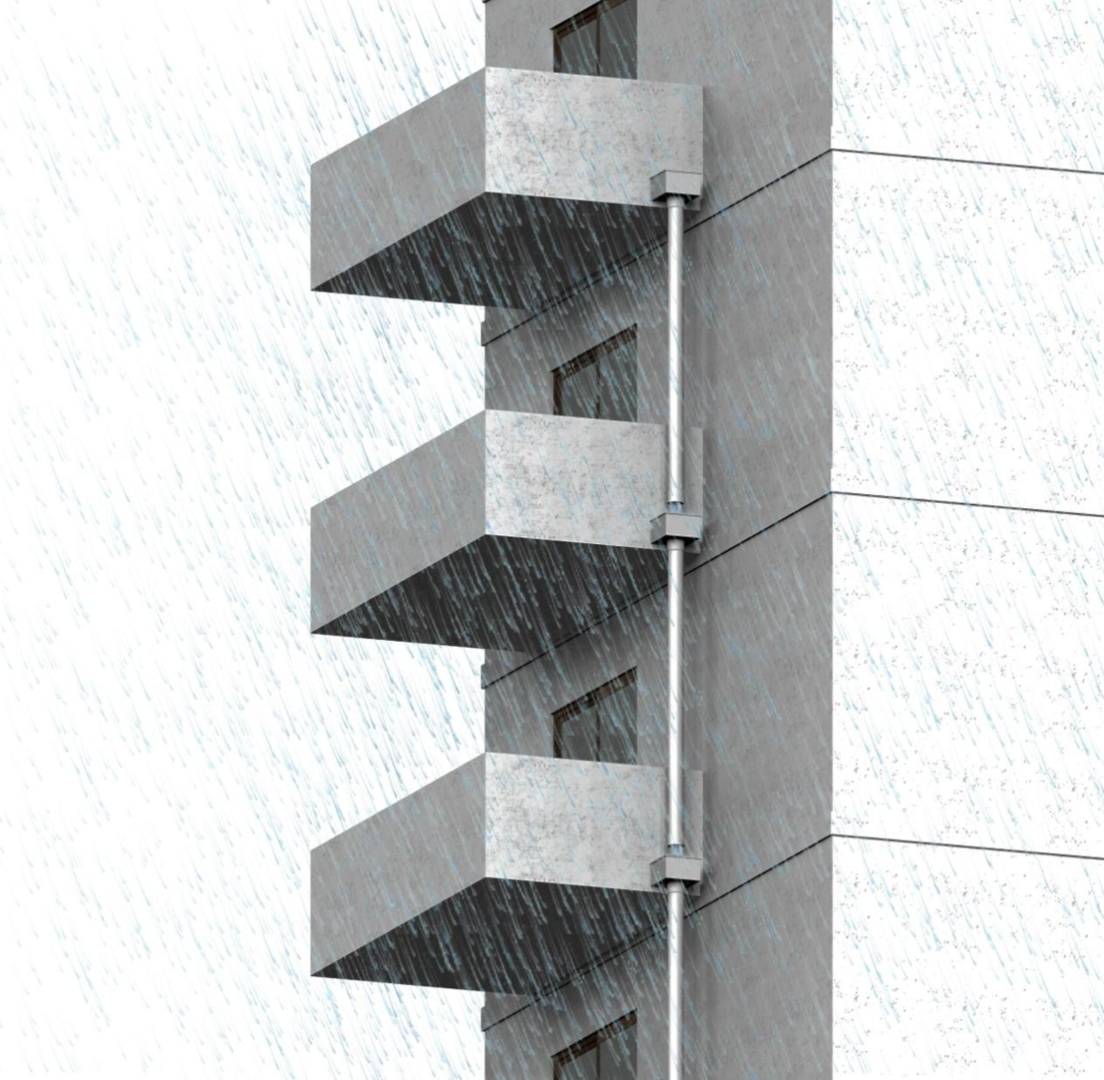
The 3rd solution has been adopted in some low to medium rise buildings. But it has many concerns and limitations.

1. Concealment v. Aesthetics.
2. Maintenance v. Concealment
3. Capacity

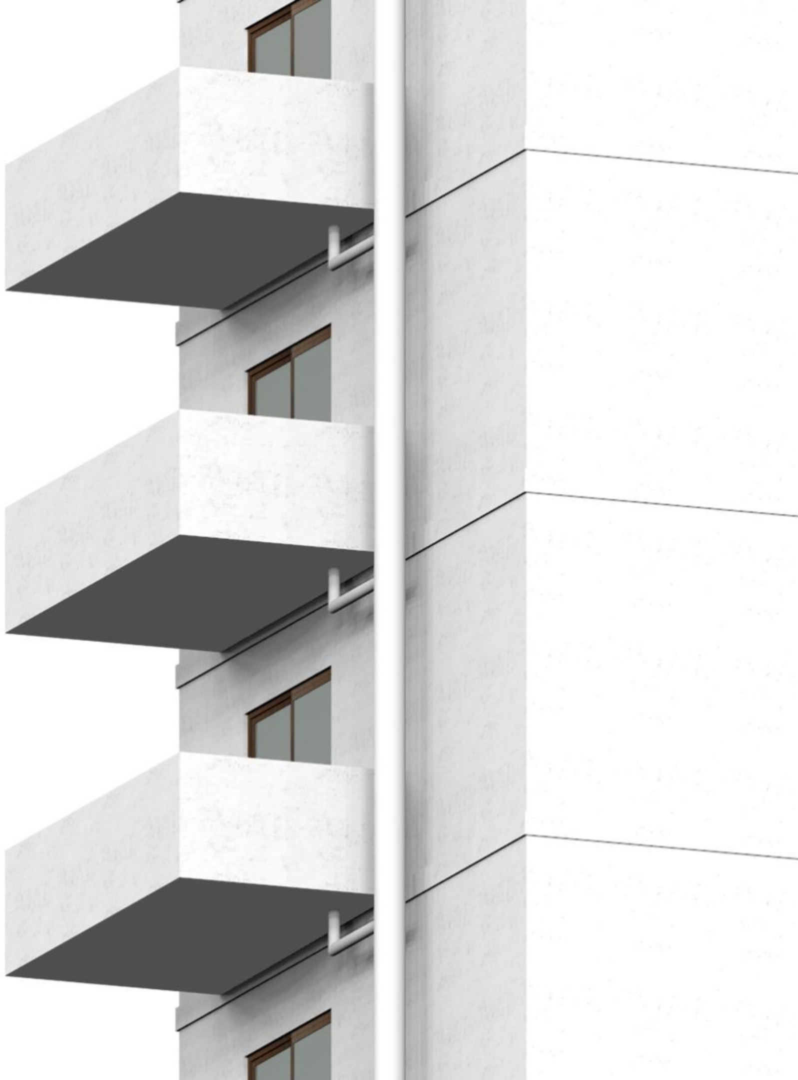


The 3rd solution has been adopted in some low to medium rise buildings. But it has many concerns and limitations.

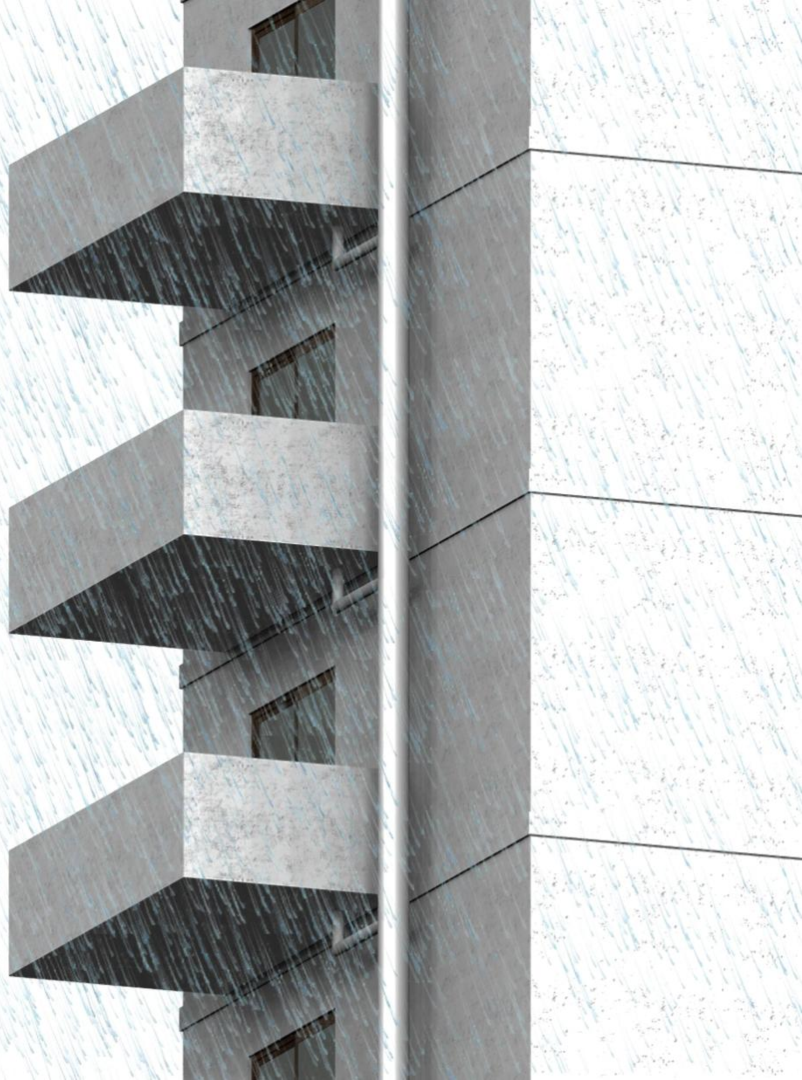
1. Concealment v. Aesthetics.
2. Maintenance v. Concealment
3. Capacity



The 4th solution is the most used for high-rise. There is however a major misconception of how this solution works. It has evolved from historical practice, maybe ‘rule of thumb’ or ‘best guess’ approach. But it has ‘No Basis in Engineering’.



The 4th solution is the most used for high-rise. There is however a major misconception of how this solution works. It has evolved from historical practice, maybe ‘rule of thumb’ or ‘best guess’ approach. But it has ‘No Basis in Engineering’.



Test Report Reference. 54S070713/EPK
dated 12 FEB 2007

TEST RESULTS:

1. Pipe Junction: 75 x 50mm Standard Tee

Q (l/s)	Observations
0.0 - 2.2	No spouting of water from backflow pipe observed.
2.3	Minor spouting of water from backflow pipe observed.
3.4	Regular spouting of water from backflow pipe observed.
> 3.6	Major spouting of water from backflow pipe observed. (see Photo 1)

Photo 1: Spouting of water from backflow pipe

Test Report Reference. 54S070713/EPK
dated 12 FEB 2007

TEST RESULTS (CONTINUED):

2. Pipe Junction: 100 x 50mm Standard Tee

Q (l/s)	Observations
0.0 - 1.9	No spouting of water from backflow pipe observed.
2.0	Minor spouting of water from backflow pipe observed.
3.0	Regular spouting of water from backflow pipe observed.
> 4.0	Major spouting of water from backflow pipe observed. Water often fills up to the rim of backflow pipe. (see Photo 2)

Photo 2: Spouting of water from backflow pipe

The capacity of a 75mm Vertical Pipe with 50mm branches at every floor entering is 2 l/sec.

The capacity of a 100mm Vertical Pipe with 50mm branches at every floor entering is 2 l/sec.

Courtesy of Fast Flow Research and Development

How is rainwater drained from the space

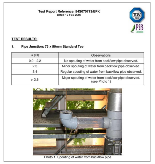
Ø75mm

Max. 5 l/s

EN 12056-3 Table 8

Max. 2 l/s

Tested



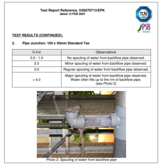
Ø100mm

Max. 10.7 l/s

EN 12056-3 Table 8

Max. 2 l/s

Tested



Ø150mm

Max. 31.6 l/s

EN 12056-3 Table 8

Max. Unknown

Untested

All Gravity Flow

IS THERE A BETTER WAY?

1968

An alternative system of rainwater drainage for roofs was invented by Olavi Ebeling, from Finland. It was subsequently co-developed with Per Sommerhein (Norwegian) of UV System fame.

The ‘Siphonic System’ was born.

1988

Siphonic Drainage started to aggressively replace gravity systems in low-rise buildings in Europe.

1993

Fast Flow entered the Singapore and Asia markets as a distributor of the UV-System

1998

The adoption of ’siphonic rainwater solutions in Singapore was fast. We followed that success with entry into Malaysia (1998) and China (1999).

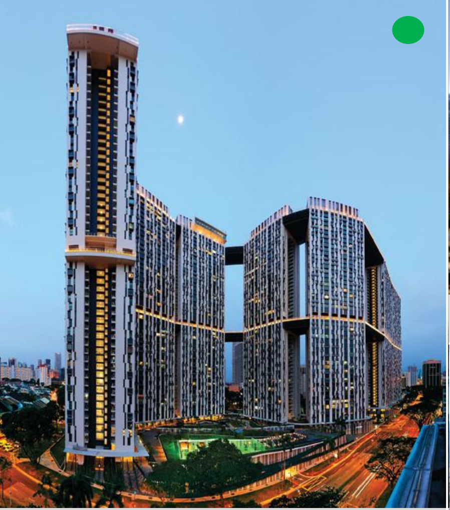
But the nature of buildings in Asia is different from Europe.

1998

The market was looking to develop the use of ’siphonic’ in high-rise.

However, the use of ‘siphonic’ in high rise was not practiced anywhere due to technical complexities (which still exist today), so it was a new challenge.

But through time solutions were developed.



The Pinnacle@Duxton, Singapore

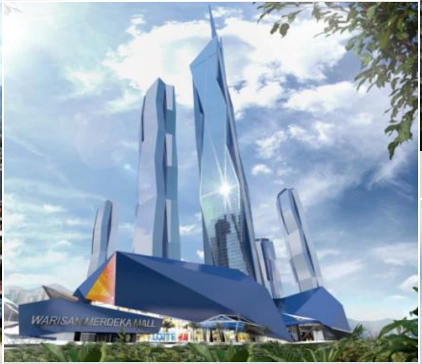
Hilton Surfers Paradise, Australia

CCTV Headquarters, China

The Intermark, Malaysia

CapitaGreen, Singapore

Jewel Gold Coast, Australia



Menara Warisan Merdeka, Malaysia

Sky Habitat, Singapore

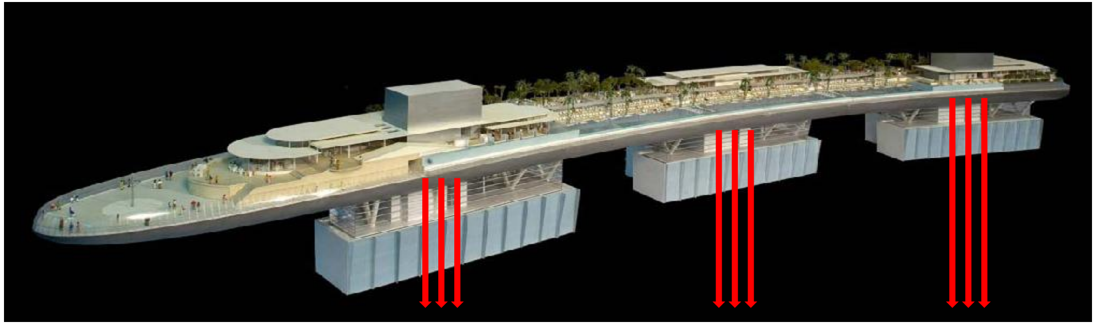
ION Orchard, Singapore

Magnolias Ratchadamri Blvd., Thailand

ICON Residence, Malaysia

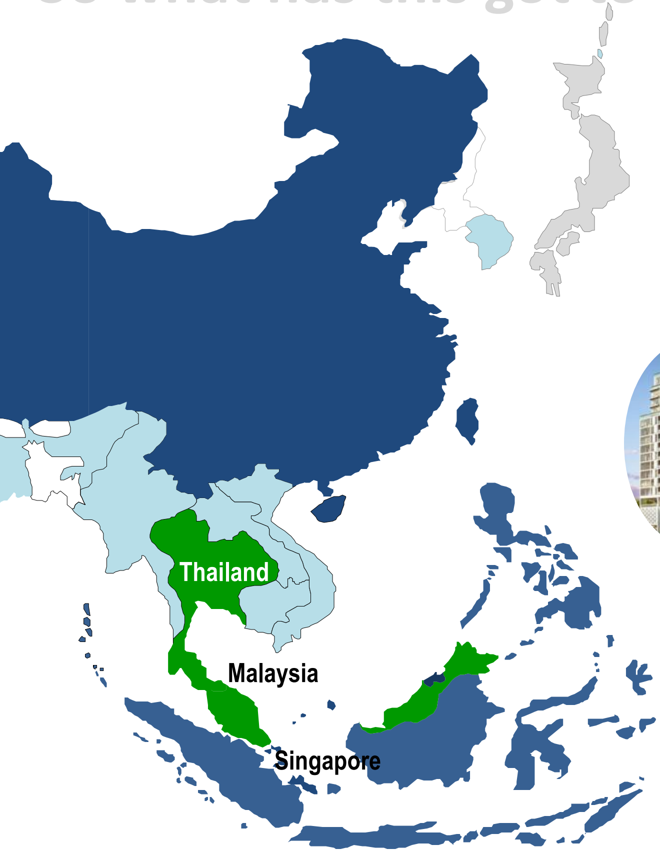
Guoco Tower, Singapore

- Most industry players are aware that 'siphonic' drainage allows designers to shrink pipe system sizes, collect water from multiple roof outlets for discharge through a common stack. It has opened major opportunities for innovative solutions in High-Rise.
- As an example, the main high rise building of Marina Bay Sands Sky Park in Singapore. Its 200m above street level and about 340m in length.
- Has a catchment area of 12,400 sqm and 1,136.6 l/s run off.



9 Nos. Dia.150mm Siphonic Stacks

So what has this got to do with drainage of Wind-Driven Rain Spaces?

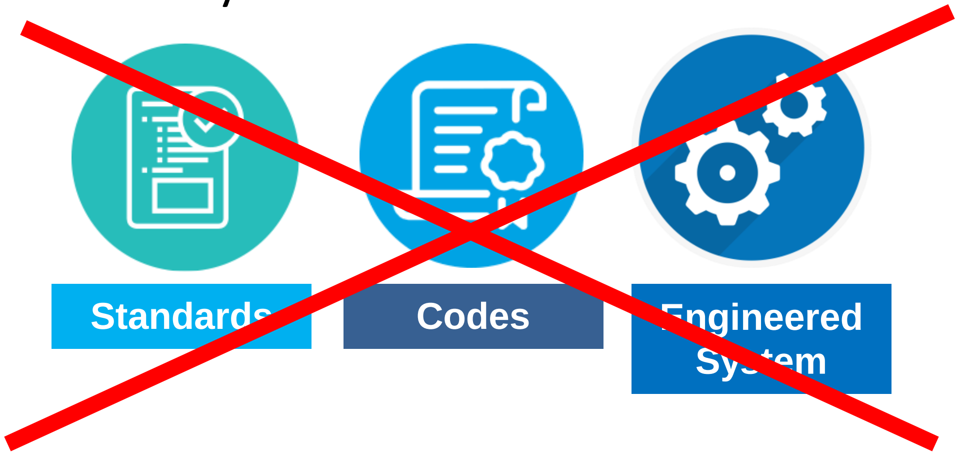


For 10 years between 1998 and 2008 our practice was to use ‘siphonic’ (with some gravity) to solve drainage of these spaces. But ‘siphonic’ is not an ideal solution because making it work requires a lot of technical skill due to the way ‘siphonic’ systems functions.

Summary so far...

2007

Wind-Driven Rain Spaces do not officially exist.



TODAY

NO SIGNIFICANT PROGRESS!

So, is there a better WAY?

Yes, there is a better WAY!

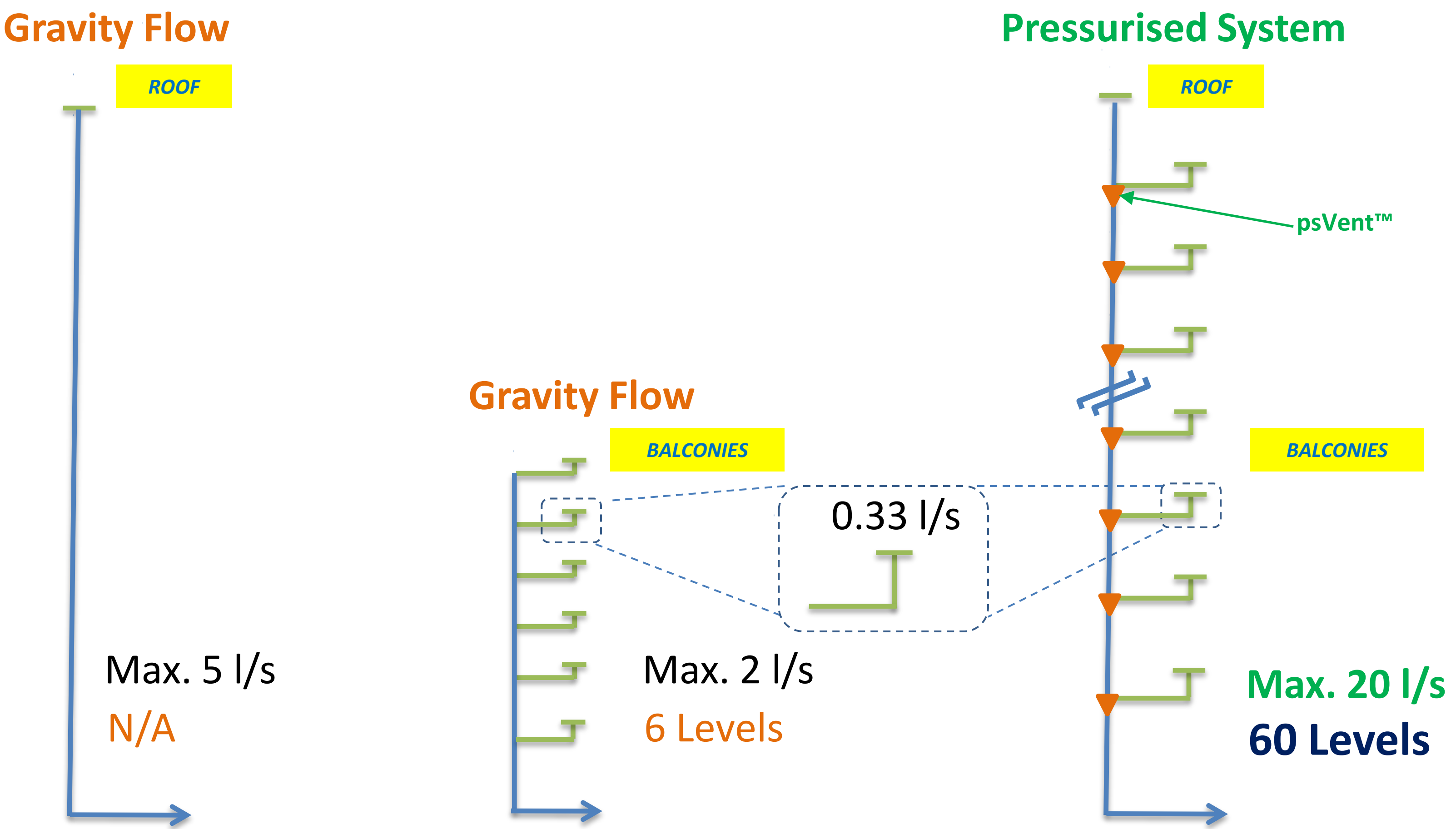
1998

Pressurised System R&D Program

2007

Patent applied and granted as a Technology Patent

Dia. 75mm Vertical Pipe




The Scotts Tower, Singapore


Westwood Residence, Singapore


Watertown, Singapore


Siamese Surawong, Thailand


W Hotel Residence, Malaysia


MK22, Malaysia


Iconsiam, Thailand


Tallahassee, Australia


D’Sara Sentral, Malaysia


Siamese 39, Thailand


The Trilinq, Singapore


Villa Rachatewi, Thailand

What should we take away from this presentation?

- “Wind Driven Rain Spaces” are a significant subject of drainage for high rise buildings.

- Current Building Codes and Standards ONLY covers open to sky roof drainage. It is not appropriate to be used for the design of Wind Driven Spaces drainage.

- More development needs to be done to provide building standards and guidelines on how to properly drain “Wind-Driven Rain Spaces”.

- **<u>There is</u>** a better engineered way to drain Wind Drive Spaces.

Thank You