

# Construction and Performance of Curtain Wall Systems for Super-Highrise Buildings

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# What is curtain wall

A curtain wall system is a lightweight exterior cladding which is hung on the building structure, usually span from floor to floor. It can provide a variety of exterior appearances but is characterized by narrowly spaced vertical and horizontal caps with glass or metal infill panels.

Curtain wall systems provide a finished exterior appearance and most often a semi-finished interior as well. They are also designed to accommodate structural deflections, control wind-driven rain and air leakage, minimize the effect of solar radiation and provide for maintenance-free long term performance. Most of today's systems are constructed of lightweight aluminum alloys or steel sections

# Development of Curtain Wall Systems in Hong Kong

## 1<sup>st</sup> Generation – Early to late 1970's

**features:** mainly non-proprietary products design by local window manufacturers.

**common systems:** stick-type, spandrel and cover, unit-in-frame types

**material:** aluminum sections, fabricated locally and erected in-situ using manual means

# Development of Curtain Wall Systems in Hong Kong (Cont.)

## 2nd Generation – Early 1980's to early 90's

**features:** mainly proprietary products usually in standard design out from the manufacturer's inventory

**common systems:** stick-type, spandrel and cover, unit-in-frame and sometimes unitized types

**material:** sections in aluminium or its alloys, fabricated overseas and delivered to site for installation.

# Development of Curtain Wall Systems in Hong Kong (Cont.)

## 3<sup>rd</sup> Generation – mid 1990's onward

**features:** mainly proprietary or expert products usually tailor-designed and made for highly specific purposes

**common systems:** majority are in unitized types

**material:** sections in aluminum alloys, some in stainless steel, large areas of glass was also used, large amount of accessories and fixing components are involved, components fabricated overseas (incl. China) and delivered to site for installation.

# Development of Curtain Wall Systems in HK

## 4<sup>th</sup> Generation – 2000's onward

**features:** mainly proprietary or expert products usually tailor-designed and made for highly specific purposes, and with clear objective to meet stronger structural requirements as well as other energy and environmental considerations

**common systems:** usually in unitized types, multi-layered glazing or in glass wall design

**material:** similar to those of the 3<sup>rd</sup> generation but with more use of structural glass to form large area of building elements

**“Curtain wall”** means a non load-bearing enclosure fixed on to the load-bearing structure with its dead loads, imposed loads and wind loads transferred to the structure through fixings.

Every curtain wall shall safely sustain and transmit to the load-bearing structure the combined dead loads, imposed loads and wind loads without such deflection or deformation as will cause the curtain wall damage or impair its stability.

# Use of Curtain Wall Systems in buildings

- 1) Office buildings
- 2) hotels
- 3) Shopping centers
- 4) Public/Functional buildings
- 5) Residential buildings
- 6) Other types



The city profile of Hong Kong as viewed from the Kowloon Peninsula. Generations of tall buildings sprung up from the harbour side since the 1970's can be seen.



Aerial views of the downtown  
area of Central District





Close up seeing the building  
façades of some high-rise  
buildings in downtown areas





Buildings using Curtain wall of the first generation  
- The office zone of East Tsim Sha Tsui developed in the late 1970's

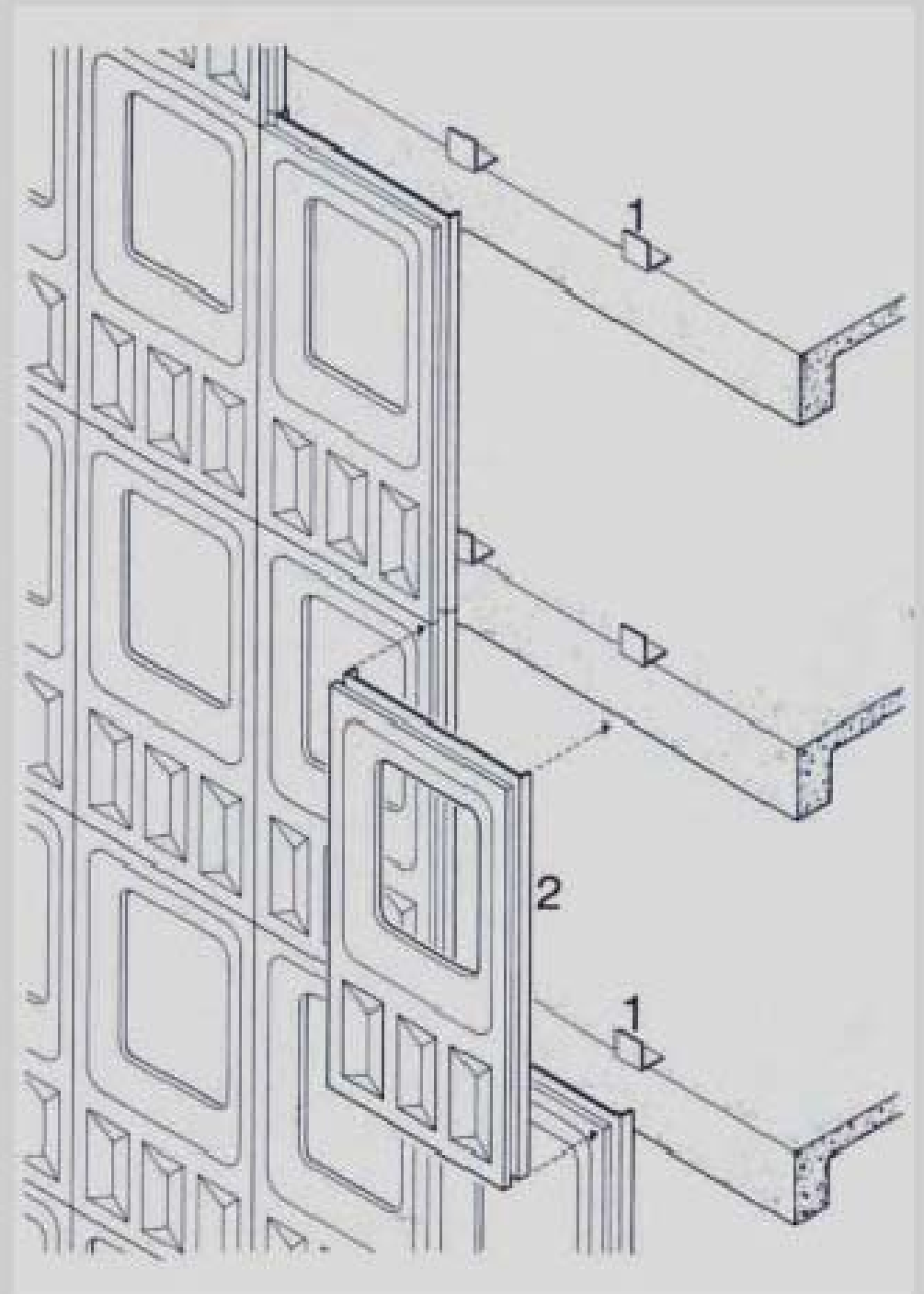
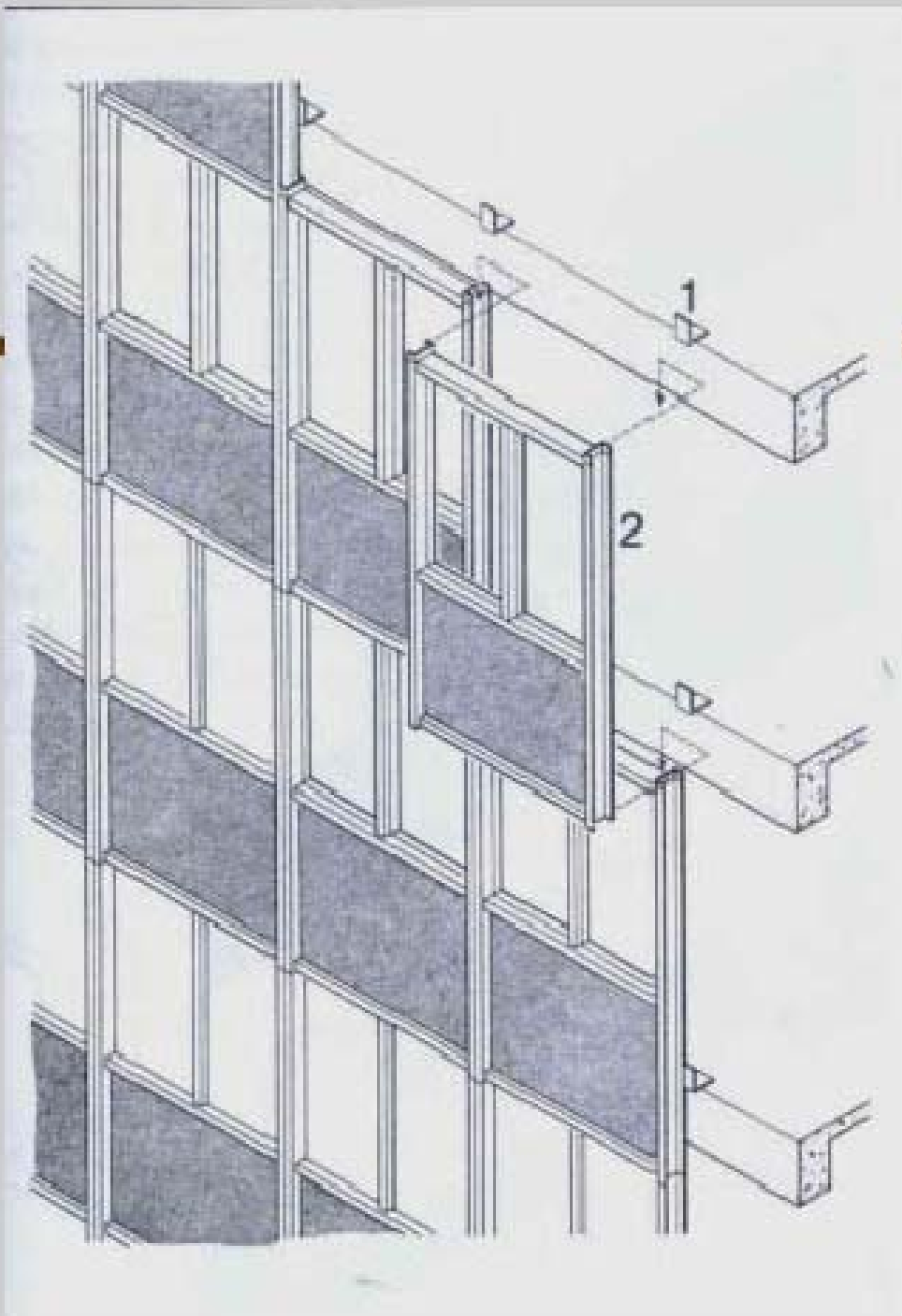
# Merits of using curtain wall in buildings

- 1) Can produce simple, neat and elegant building form
- 2) Can provide larger unobstructed exterior wall area
- 3) Make the dead load of a building lighter due to the omission of solid external walls
- 4) Reduce the use of formwork and in-situ concrete during construction
- 5) Provide a reliable and almost maintenance-free external envelop for building

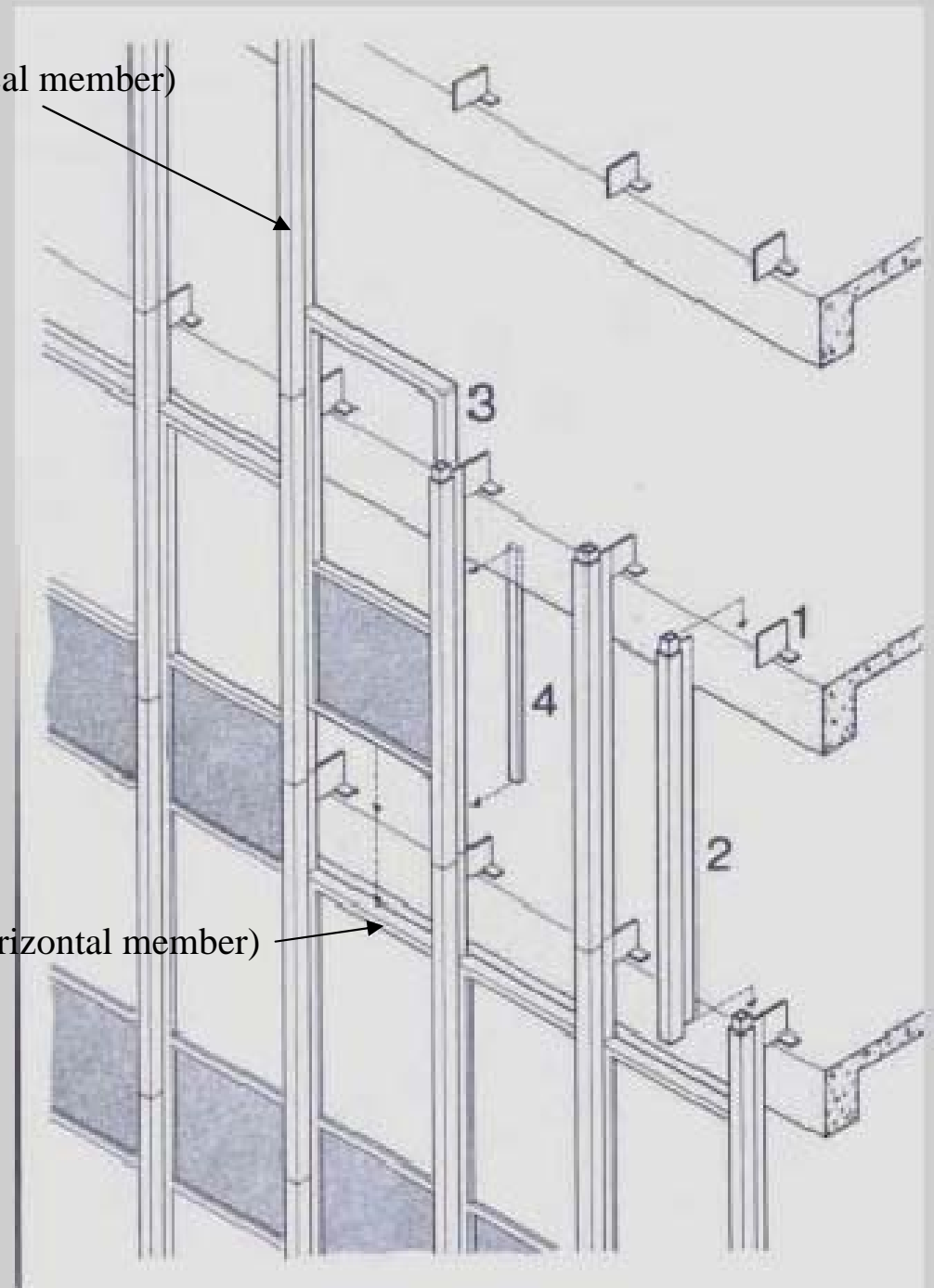
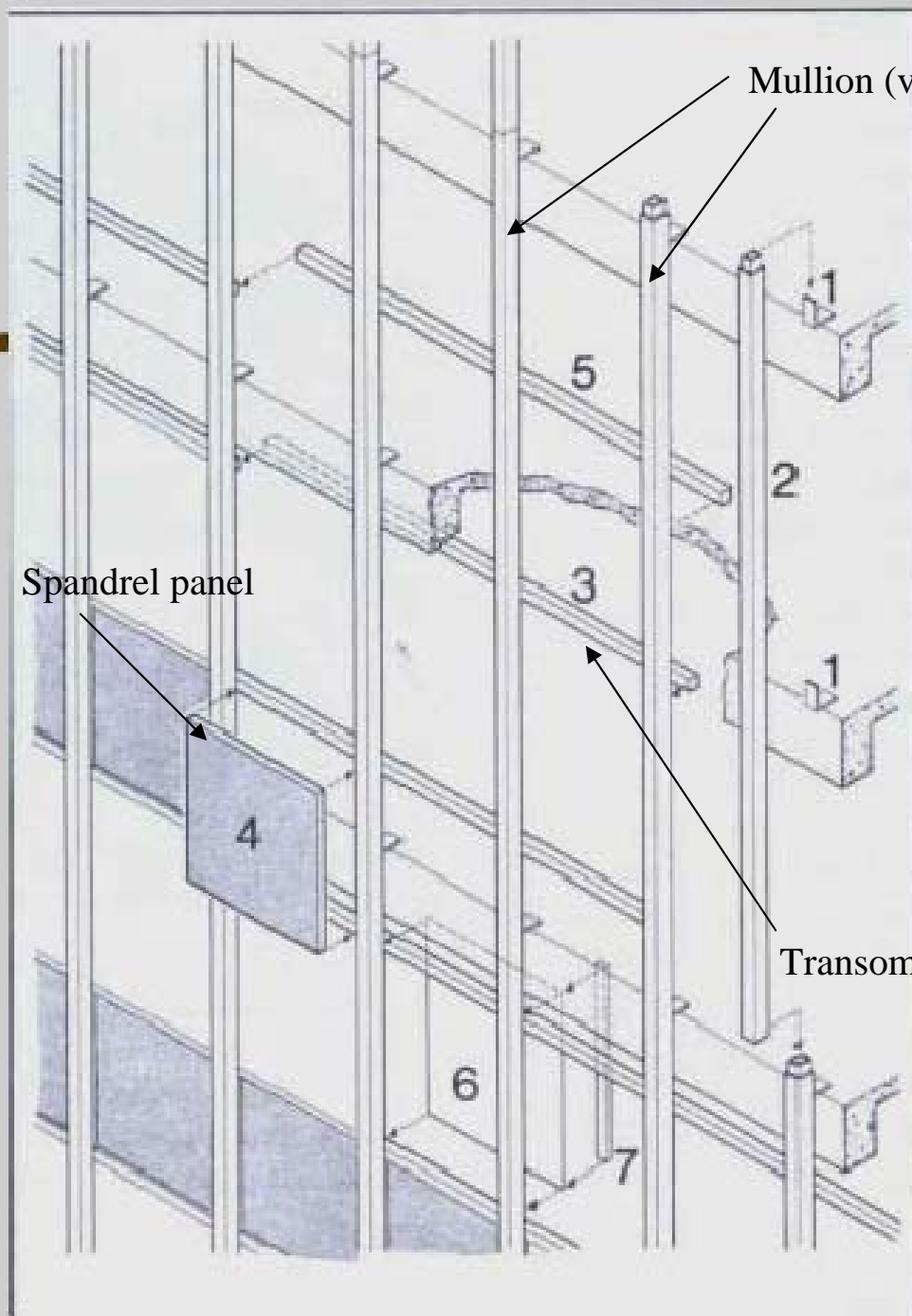
# Common types of curtain wall systems for high-rise buildings

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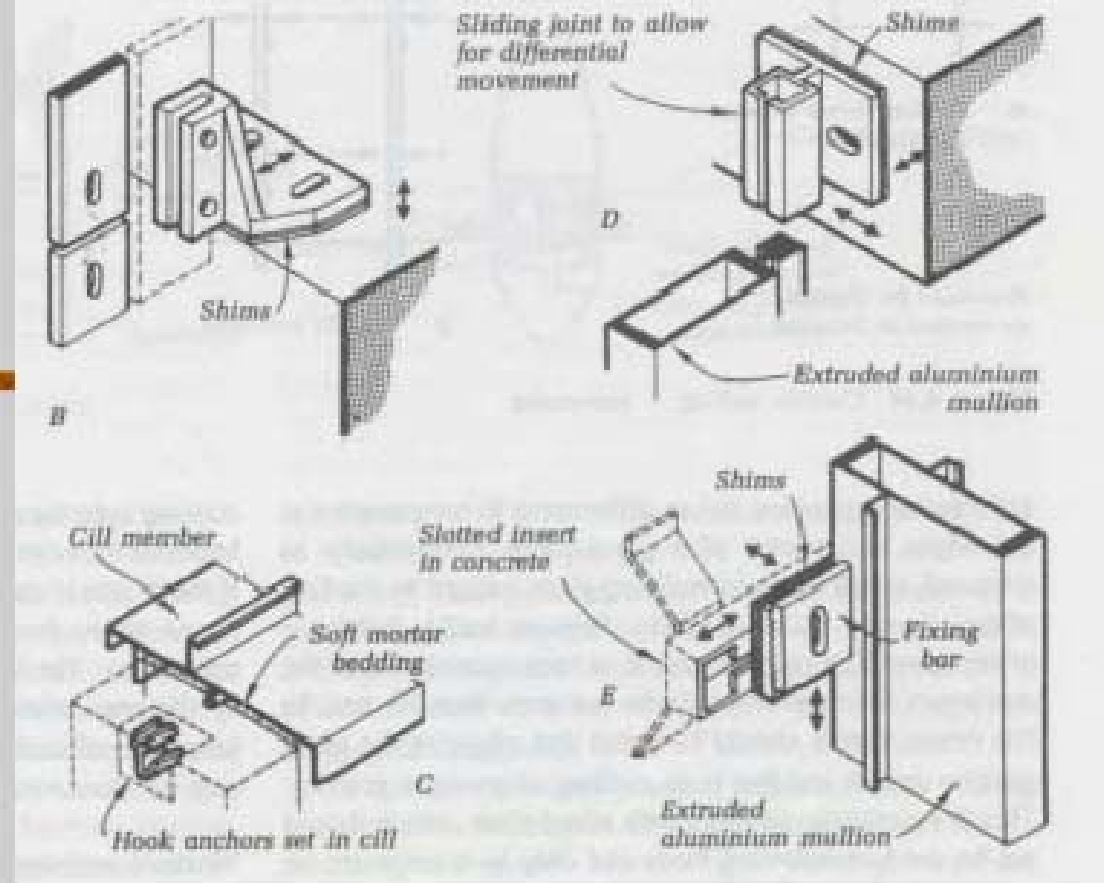
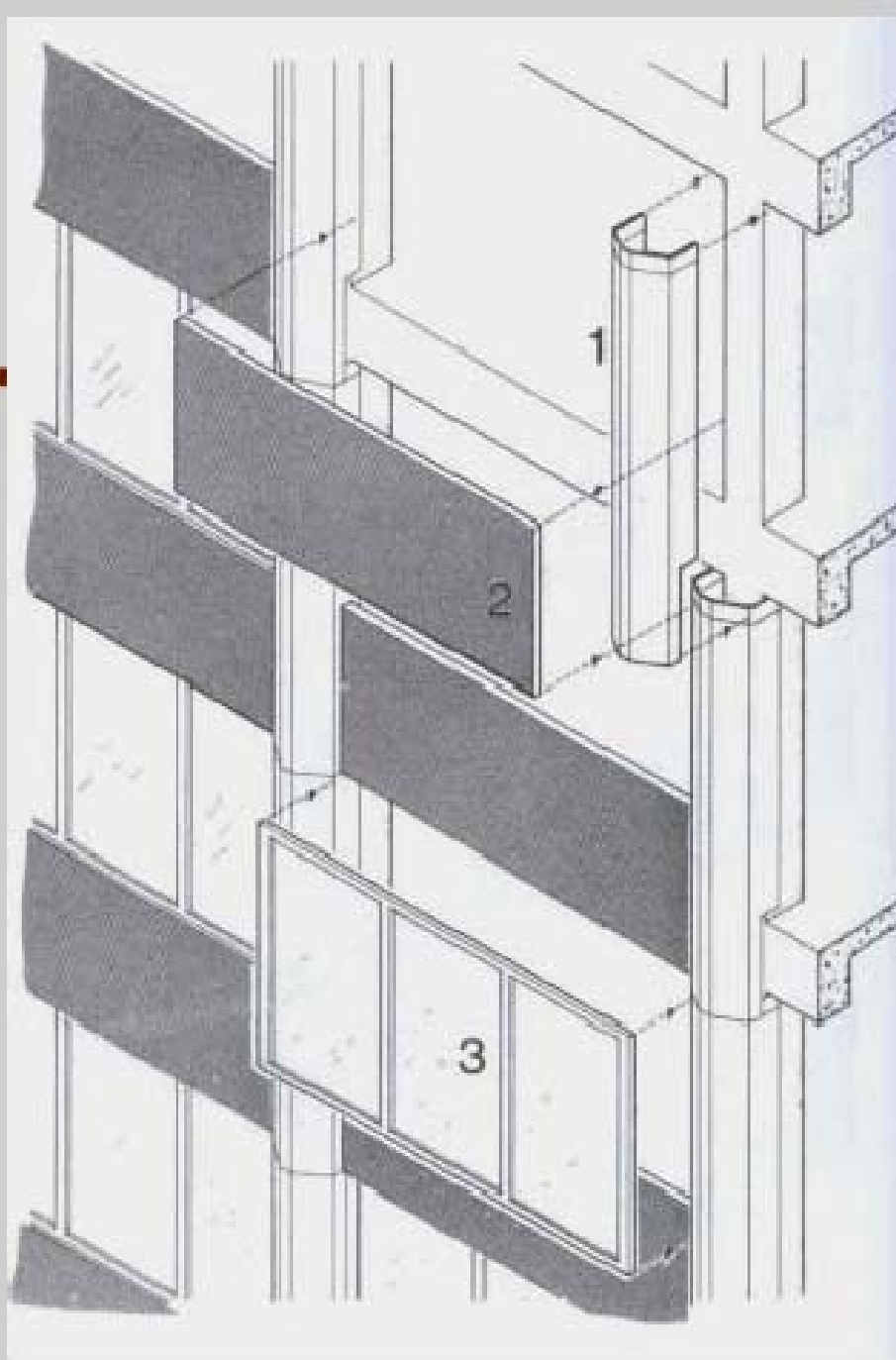
- 1) Stick system
  - 2) Unit system
  - 3) Panel system
  - 4) Unit and mullion system
  - 5) Column-cover and spandrel system
  - 6) Various types of glass wall system
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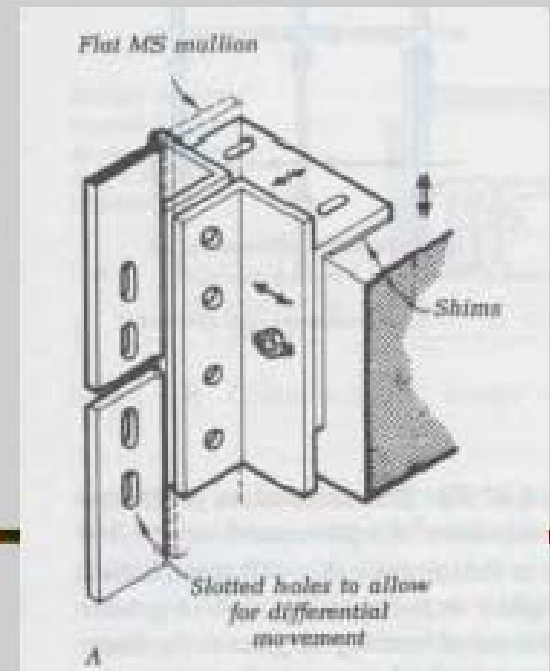
Unit System (Left) and Panel System Curtain Wall



Stick System (Left) and Unit and Mullion System Curtain Wall



## Fixing and Fastening Detail for the Curtain Wall Sub-frame



Column Cover and Spandrel System

# Stick System

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Curtain wall in stick system is a cladding and exterior wall system which is hung on the building structure from floor to floor. It is assembled from various components to include steel or aluminum anchors, mullions (vertical load taking member), rails vision glass, spandrel panels, insulation and metal backing pans. For the fixing of the system, there are various hardware components such as anchors, connectors, brackets, cramps, setting blocks, corner blocks, gaskets and sealants etc.

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Glazing area

Spandrel area

Typical stick system wall –  
the Gateway at Tsim Sha Tsui



# Unit System

Unit systems are composed of modulated panels that are fabricated in factory and delivered to site in 1-piece for installation. The panels are fully provided with all the glazing and/or the spandrel panels, incorporated with the required insulation and other architectural features, thus requiring very limited 2<sup>nd</sup>-fixed installation works on site.

The panels are usually spanned in a floor-to-floor arrangement and may be designed in a number of standard/optional panels such as fully glazed, glazed with opaque panels, fully opaque in metal or stone slab, louvered panels, or other special modules like the corner or bayed units. In order to get the best benefit of using this system, units are often produced to an optimistic large size so as to minimize the number of units used.



Typical unitized system wall – the Cheung Kong Center



Curtain wall for the  
Cyberport Office Blocks



## Unit and mullion system

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This is a combination of the stick system and the unit system and may be regarded as a compromise of the two. It is more suitable for use in medium-sized projects so as to balance the factors of lead time, ease of installation and economy of scale.

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## Panel system

A panel curtain wall system is similar to a unit system, the difference being that a panel system has homogeneous sheet or cast panel with few joints and may not have separate mullions.

Unit systems are made up of smaller components fabricated together to form much complex panels that capable to perform heavier duties or other more specific requirements. However, due to the relative simplicity of the system, curtain wall of panel system design may not be able to fulfill the usual requirements most high-rise buildings required under Hong Kong's environment. Its use is therefore more limited to certain kinds of buildings like those of standardized design for low-income classes or for buildings of industrial purposes. In this case, the panels can be constructed of sheet materials and manufactured in large quantity in very low cost.

# Column-cover-and-spandrel system

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Column-cover-and-spandrel system consists of column covers, which are usually made of alloyed aluminum, metal sheet or other laminated/fibre-reinforced sheet, and with glazing components and spandrel panels that fit between them. It resembles certain similarity to a unit-and-mullion system except that the structure of the building is exemplified by the column covers.

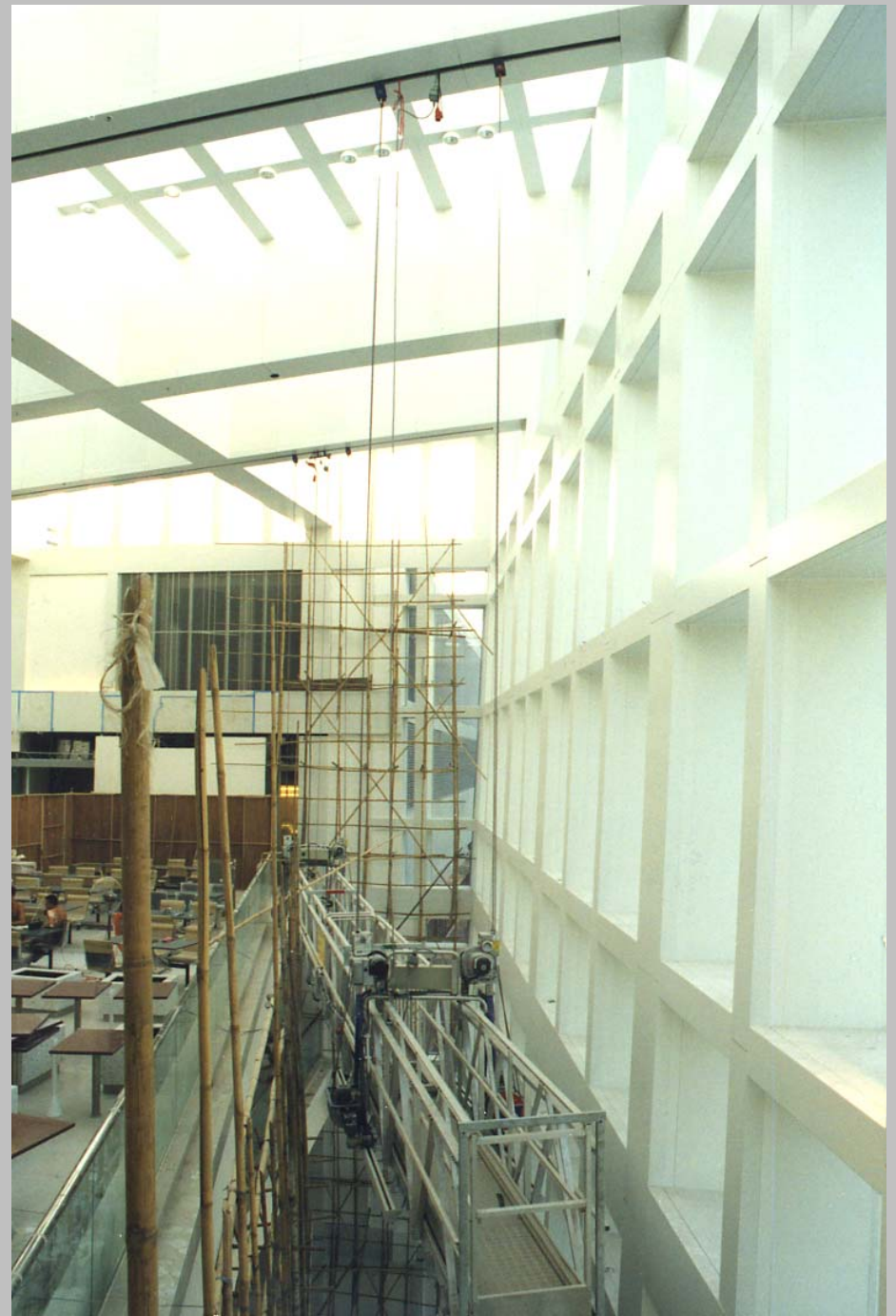
With the exception of the stick system and the unit system, other curtain wall systems are seldom used in Hong Kong.

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# Structural glazing system

The merit of using structural glazing system as external wall is to minimize the unglazed elements as much as possible, leaving glass panel almost as the only glazed surface on the wall. This can be done by providing larger mullion supports which span outward away from the structural floor of a building. Special clamping devices such as a spider bracket can be used to hold the glazing panel in position. Structural sealant is used to seal up the gap between the glazing panels.

Structural glazing system often called also as the glass wall. It can sometimes be supported using a structural steel frame instead of by the building frame itself thus easily give a free and open form of design to building.



Glass wall and skylight for the Festival Walk Shopping Mall



Glass wall for the Terminal Building at Hong Kong Chek Lap Kok International Airport





Glass wall used for the  
Hong Kong Convention  
and Exhibition Center



Glass wall for the  
Cyberport Development

The glass wall for the  
International Finance Center  
(Hong Kong Station)



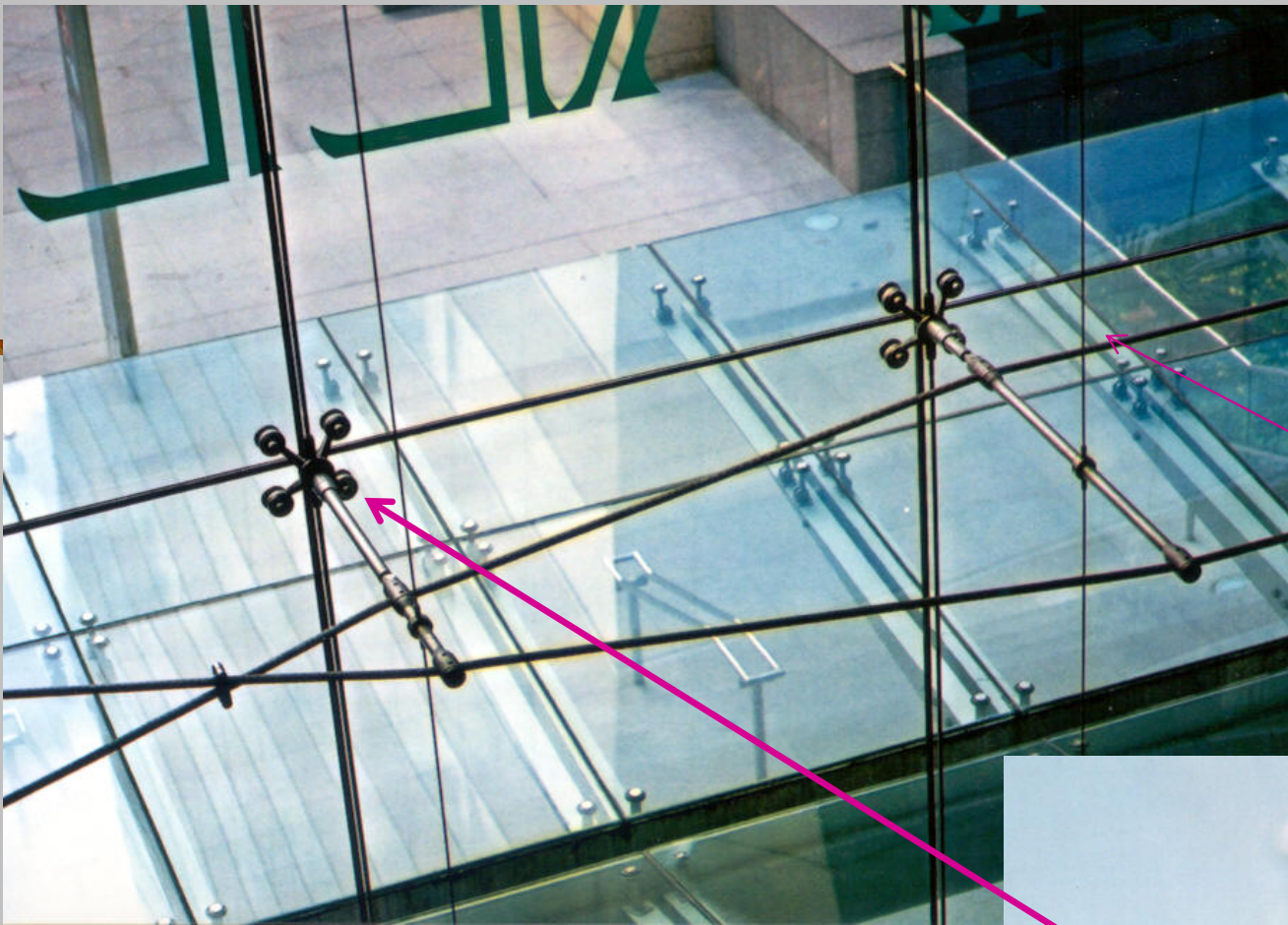


Glass Hubs at podium roof of the International Finance Center



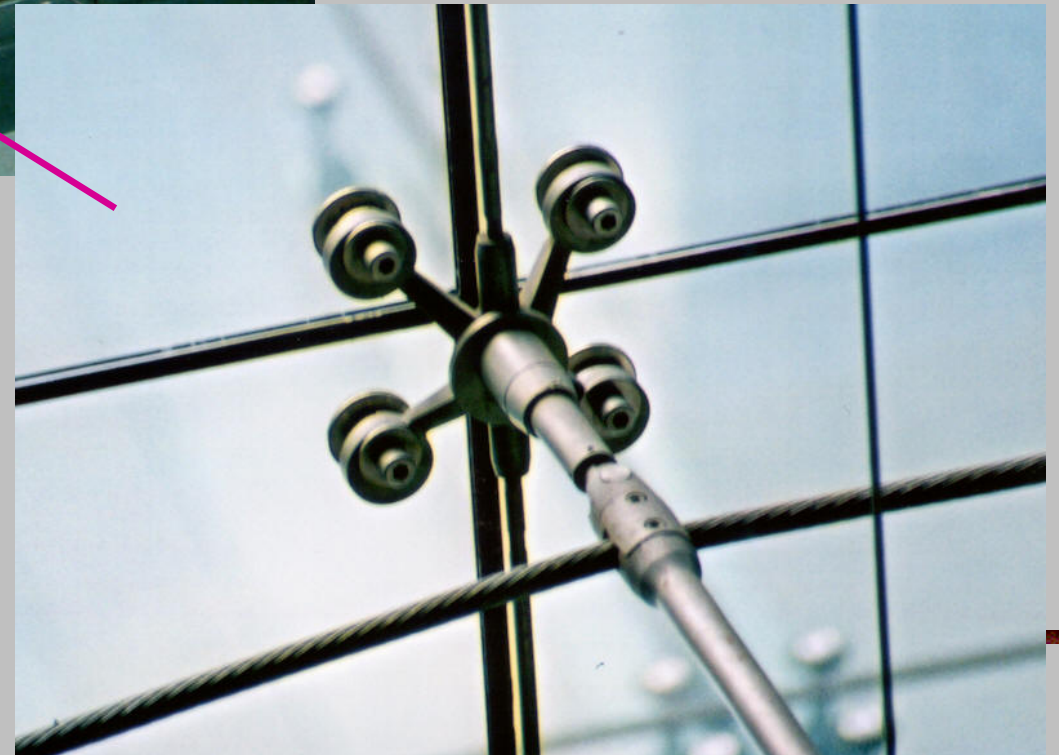
Glass Wall and  
Skylight used in the  
International Finance  
Center I Retail areas





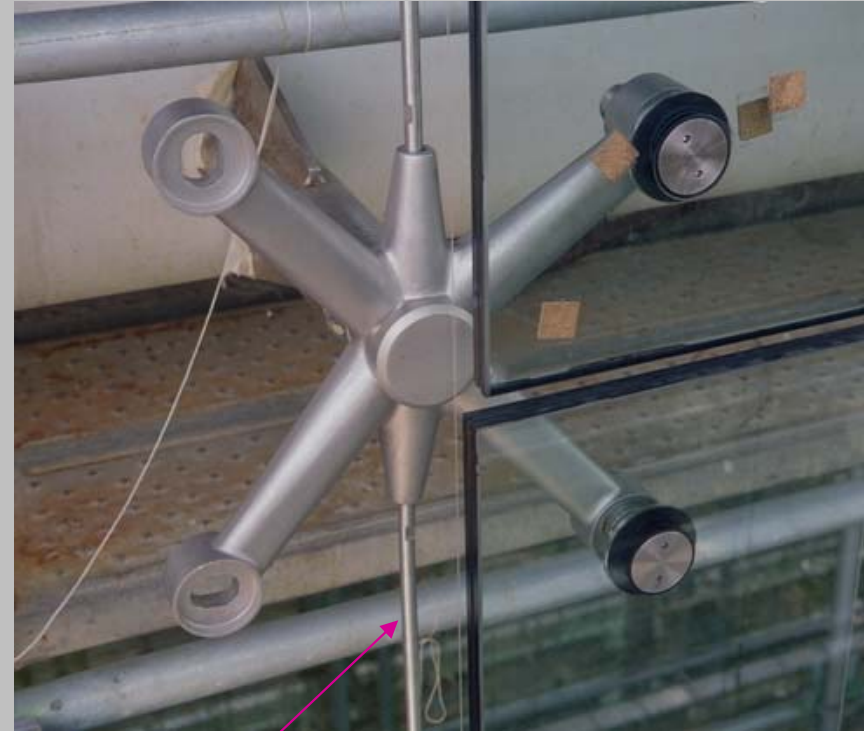
Detail of the cable  
mullion/transom  
and spider clamp

Wire mullion/Transom





Spider clamp anchored firmly to transom member behind



Spider clamp further secured to a steel wire mullion

Detail of the cable mullion/transom and spider clamp

Large area glass wall as entrance  
lobby for deluxe commercial building

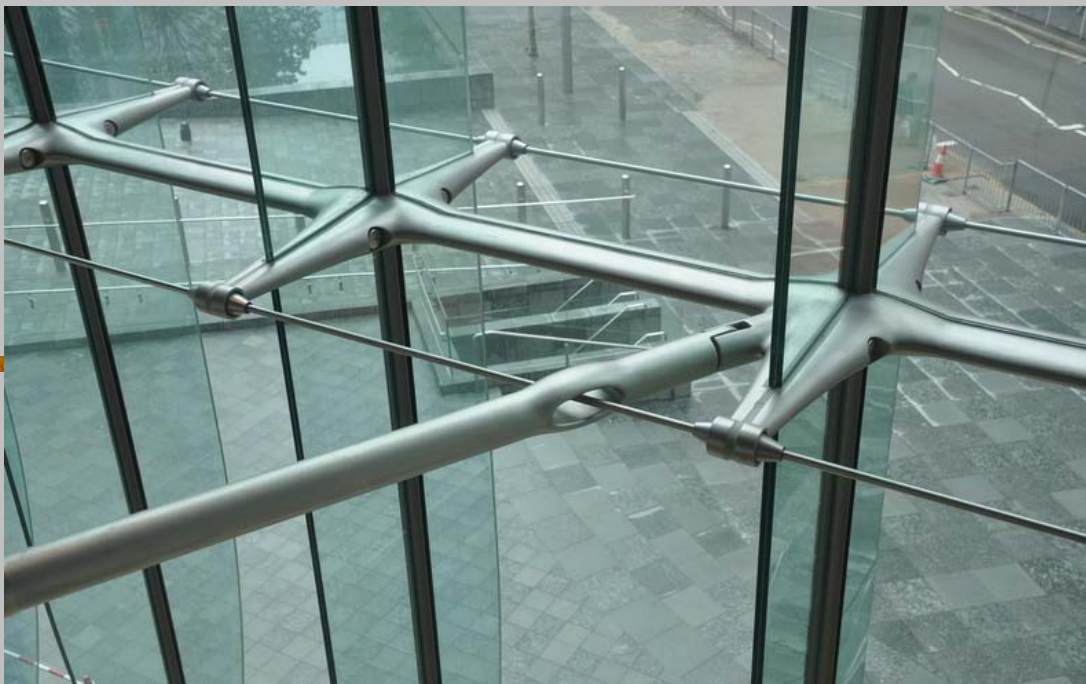




Steel clips to hold the mullion members

Steel transom members to hold and stiffen the glass panels and mullion





# Functions and performance requirements of curtain wall for high-rise buildings

situations where buildings in Hong Kong are expected to face

- Very large building envelop (say, up to 50000 sq m)
- Typhoon situations (wind speed up to 60m/s)
- Thunderstorm situations
- Extreme temperature difference
- Exposure to salty or polluted atmosphere
- Long period of air-conditioning/cooling time

# Functions and performance requirements of curtain wall for high-rise buildings

- 1) strength and stability – dead load and wind load
- 2) weather resistance – ability to keep out water & wind
- 3) thermal insulation and condensation – max 30W/sq m
- 4) sound insulation – 25dB or above
- 5) fire resistance – usually no specific requirement if enough separating distance from relevant boundary is provided

# Testing of curtain wall

- 1) air infiltration
- 2) water penetration under static & dynamic pressure
- 3) structural adequacy under static & dynamic pressure
- 4) vertical and horizontal seismic movement
- 5) hinge and frame test
- 6) in-situ pull-out test

# Installation process

- 1) transportation, storage and handling
- 2) anchorage and connection provision
- 3) installation arrangement
- 4) final fixing and inspection



Handling of the  
window units



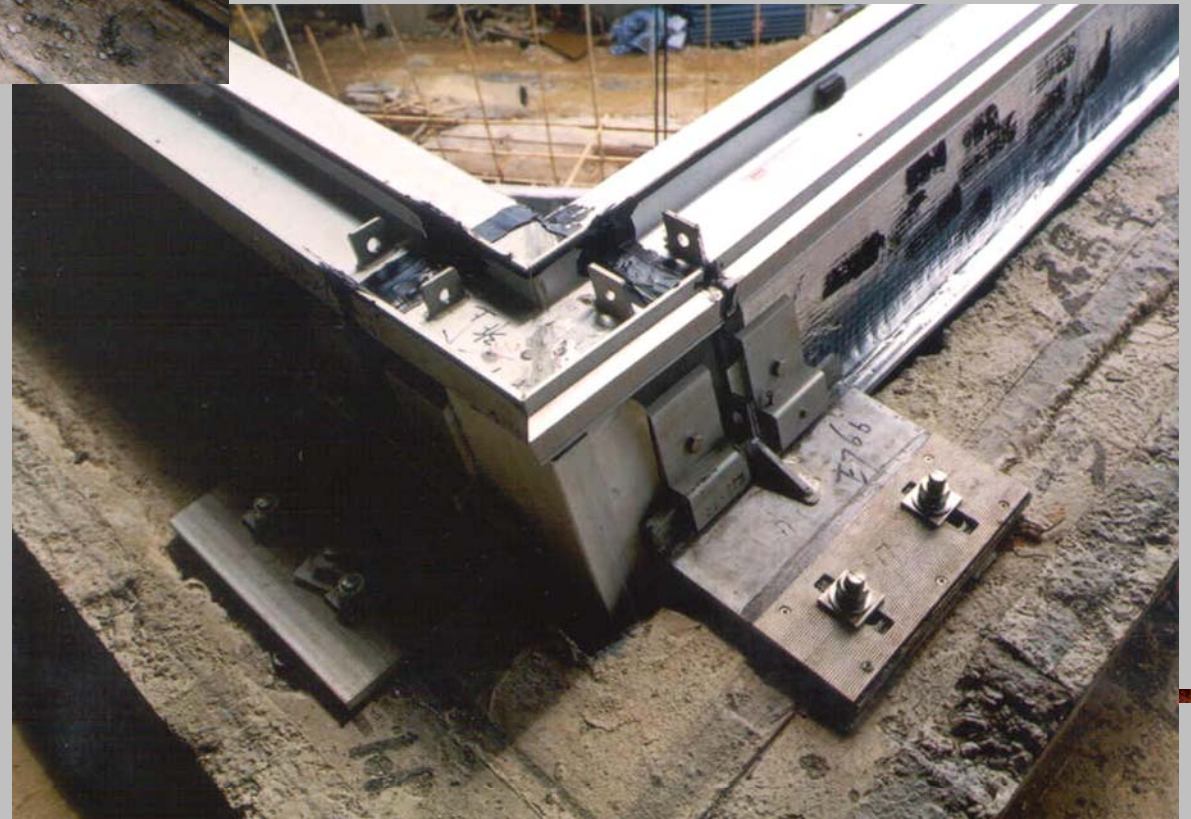


Built-in anchor and  
hanging brackets



Wall fixing bracket  
with 2-way  
dimension  
adjusting slot

Detail of fixing (basically  
fixed onto build-in anchor  
by bolt and bracket)





Inner lining to be provided in the interior side of the curtain wall





Setting up of a mock-up wall section as sample before installation

# Cases for References

# Shun Hing Plaza

- 68-storey office building constructed in composite form (core wall plus external steel frame)



## Installing of the curtain wall





Close up of the mullion frame at the external faces of building



Close up of the  
walling frame with  
mullion and  
transom in position



Wall to cover the  
bracing members  
located in the  
building exterior





Fixing the mullion onto  
the floor structure



Detail of the fixing bracket





Wall framing components



# The Center

- A 80-storey office building constructed in structural steel frame (mega-structure).





The configuration of the building frame

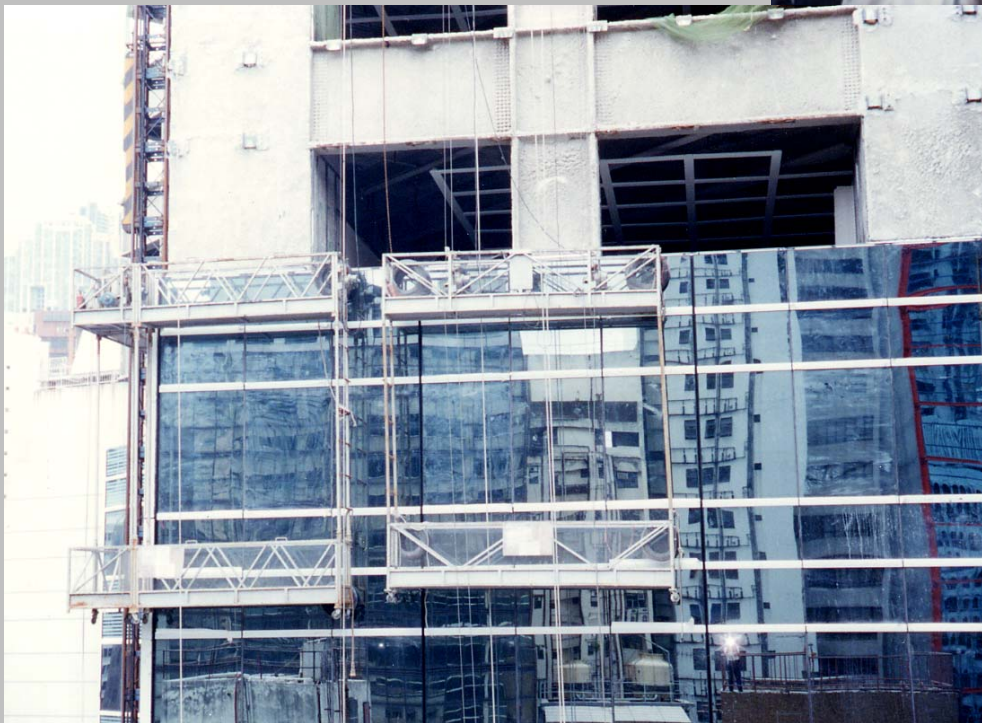


A separating line between the curtain wall and the building structure — work suspended pending to the approval of the fixing detail



Gondola set up to facilitate the installation of the curtain wall units





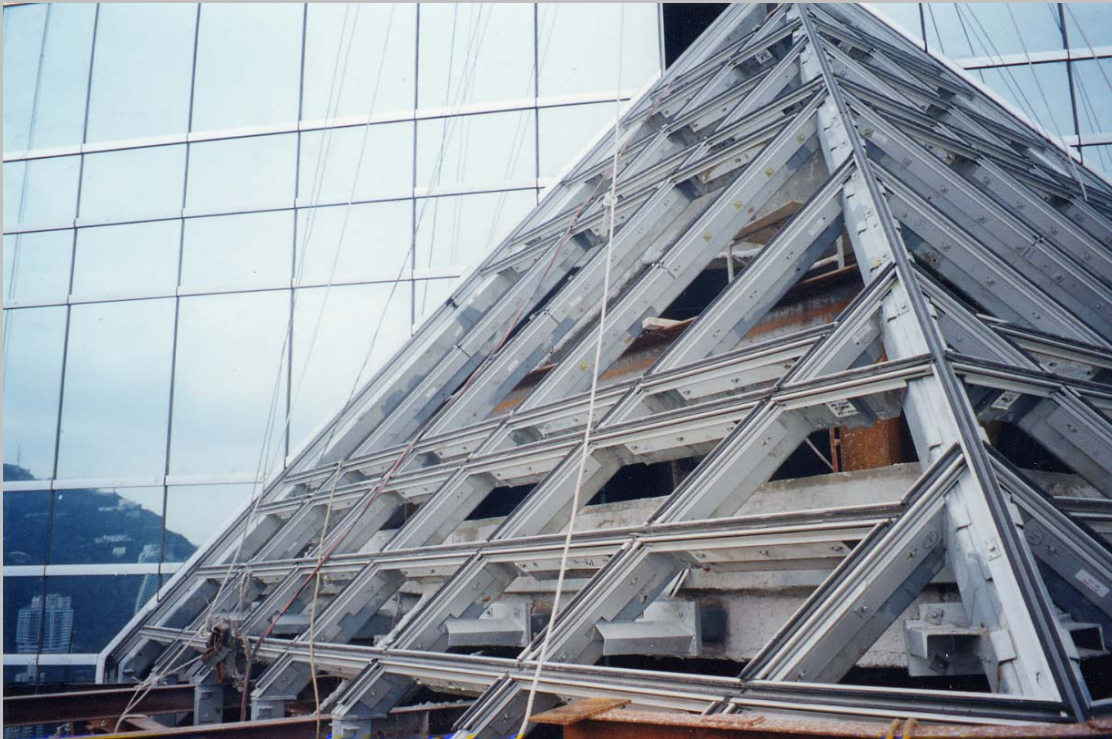
Hanging, fixing and  
joining detail of the units

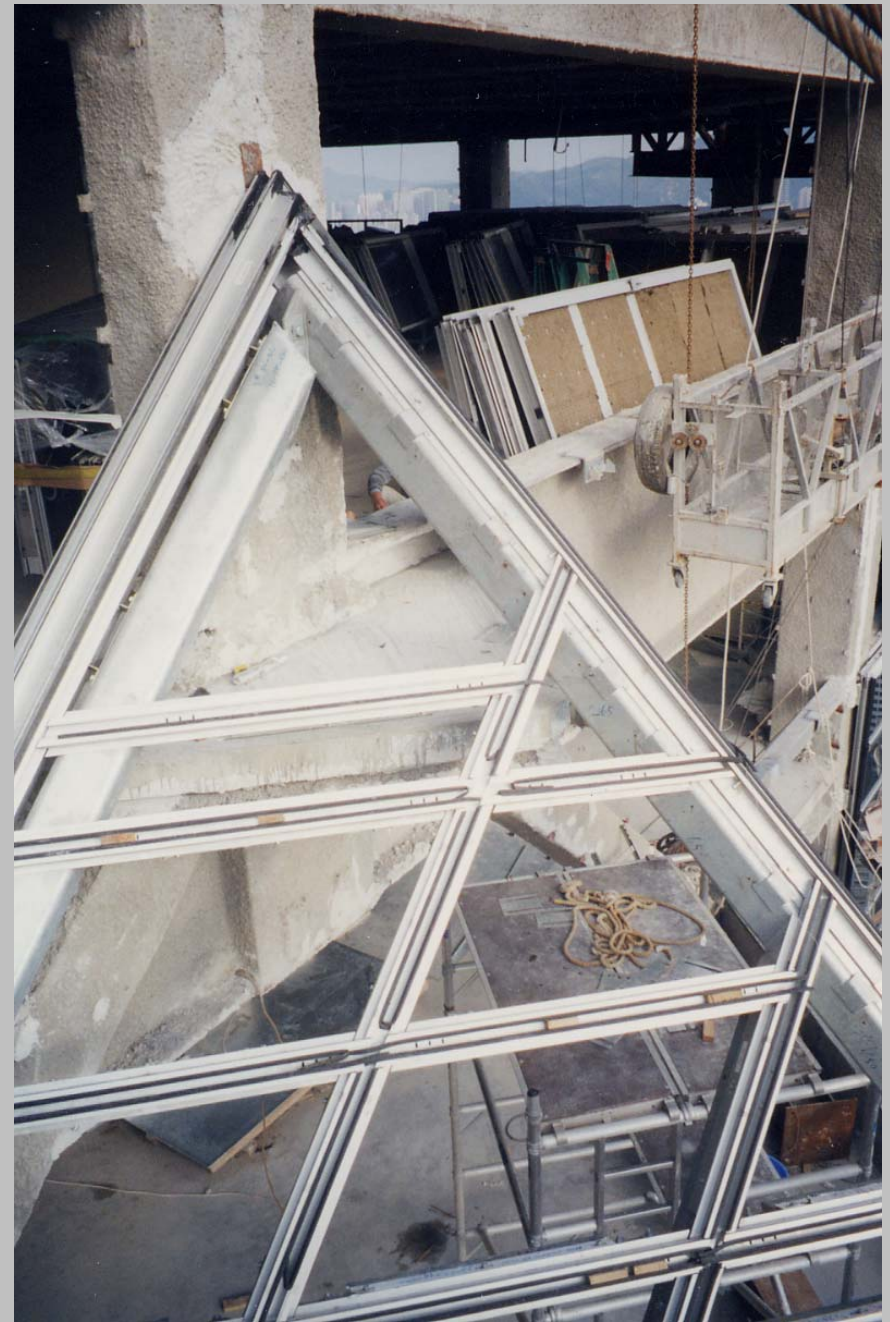
Pyramid feature at  
the building corners





The backing structure of  
the pyramid feature





Detail of the backing frame before placing of the glass panes

Forming the inverted pyramid feature at one of the building corners



Seeing the window from  
the pyramid's interior



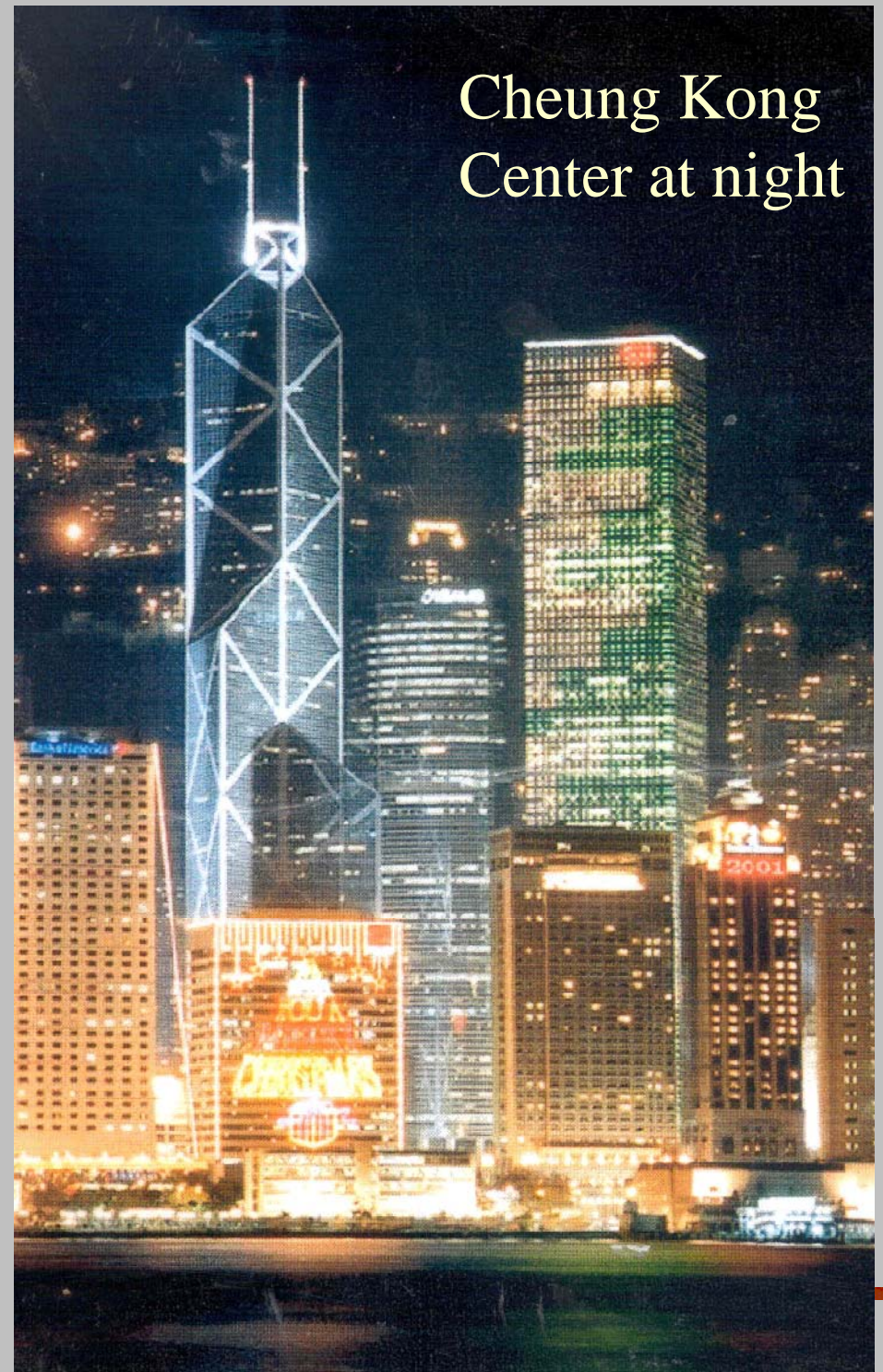


Wall cleansing machine and the sliding door on the penthouse

# Cheung Kong Center

- A 62-storey office building in composite construction









Installing the curtain wall during the construction of the superstructure

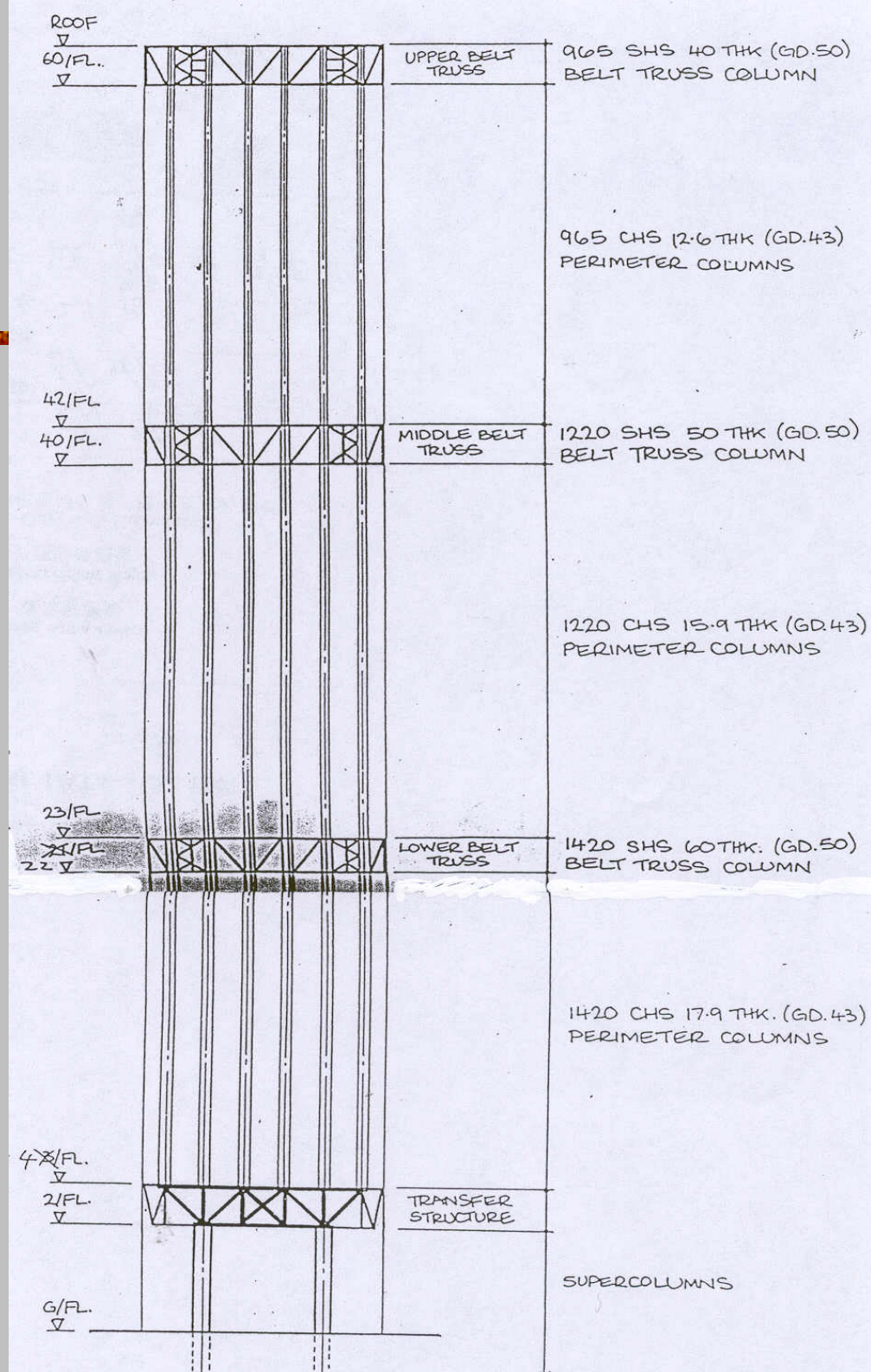


**Belt truss at  
building top**

Curtain wall installation close to the building top

## Belt-truss and Outrigger systems

## Transfer Truss system





Backing frame for the louvered panels at the transfer truss level



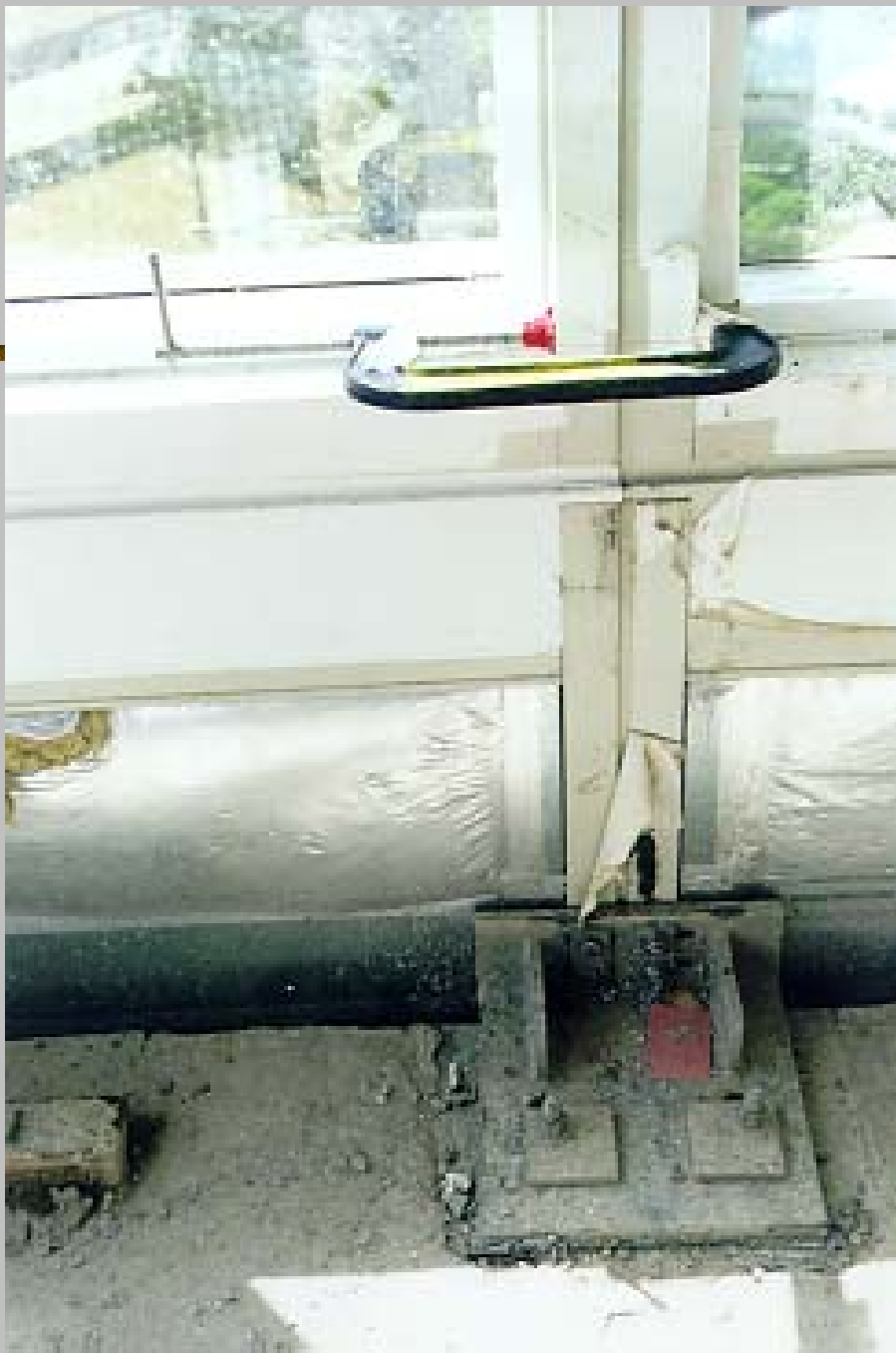


Installing the standard panels on typical floors



Fixing detail of the panels





Fixing detail of the panels



Detail of the louvered panels

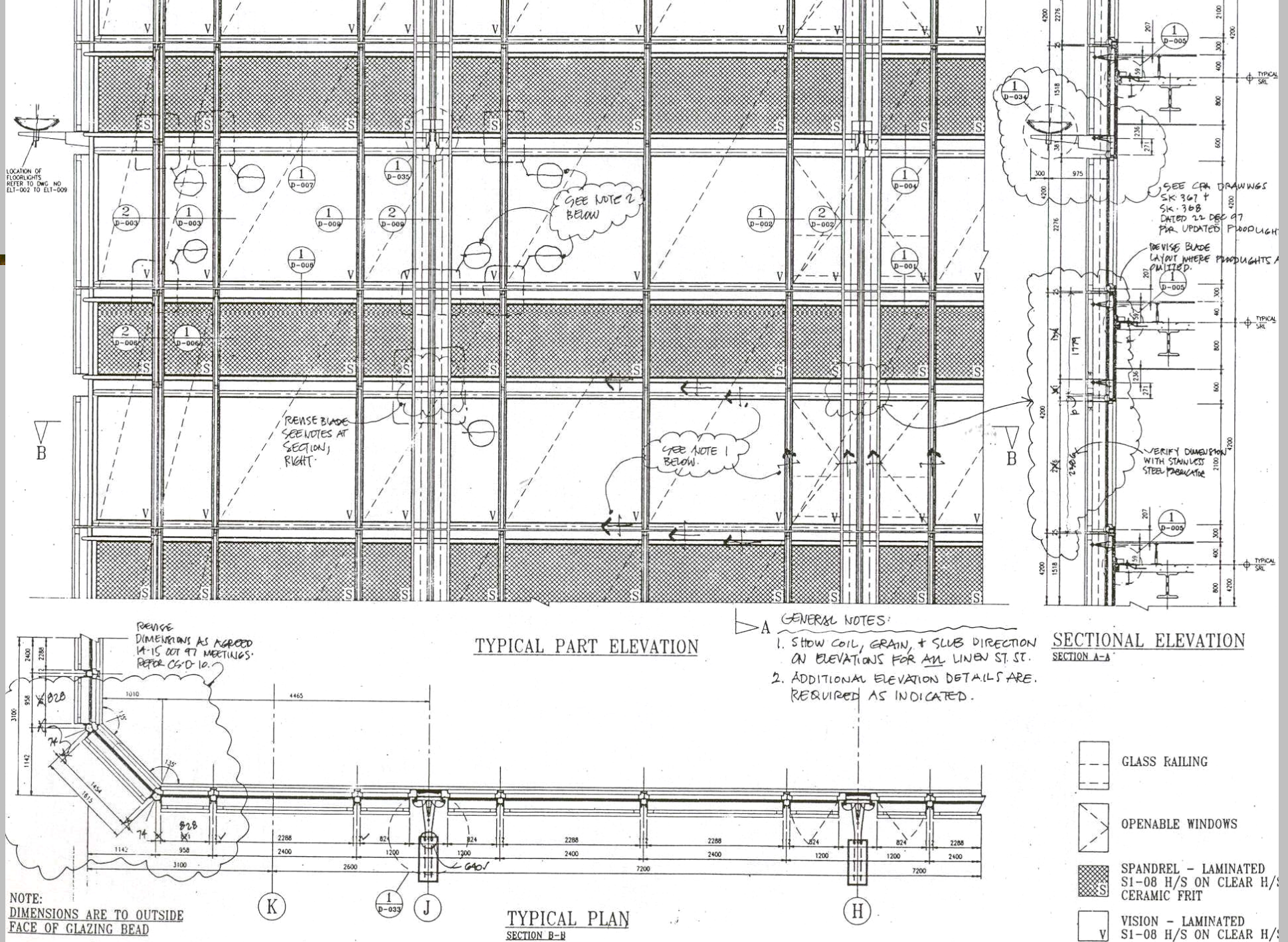


Exterior detail of the standard panels



Exterior detail of  
the standard panels





Elevation and sectional detail of typical panels



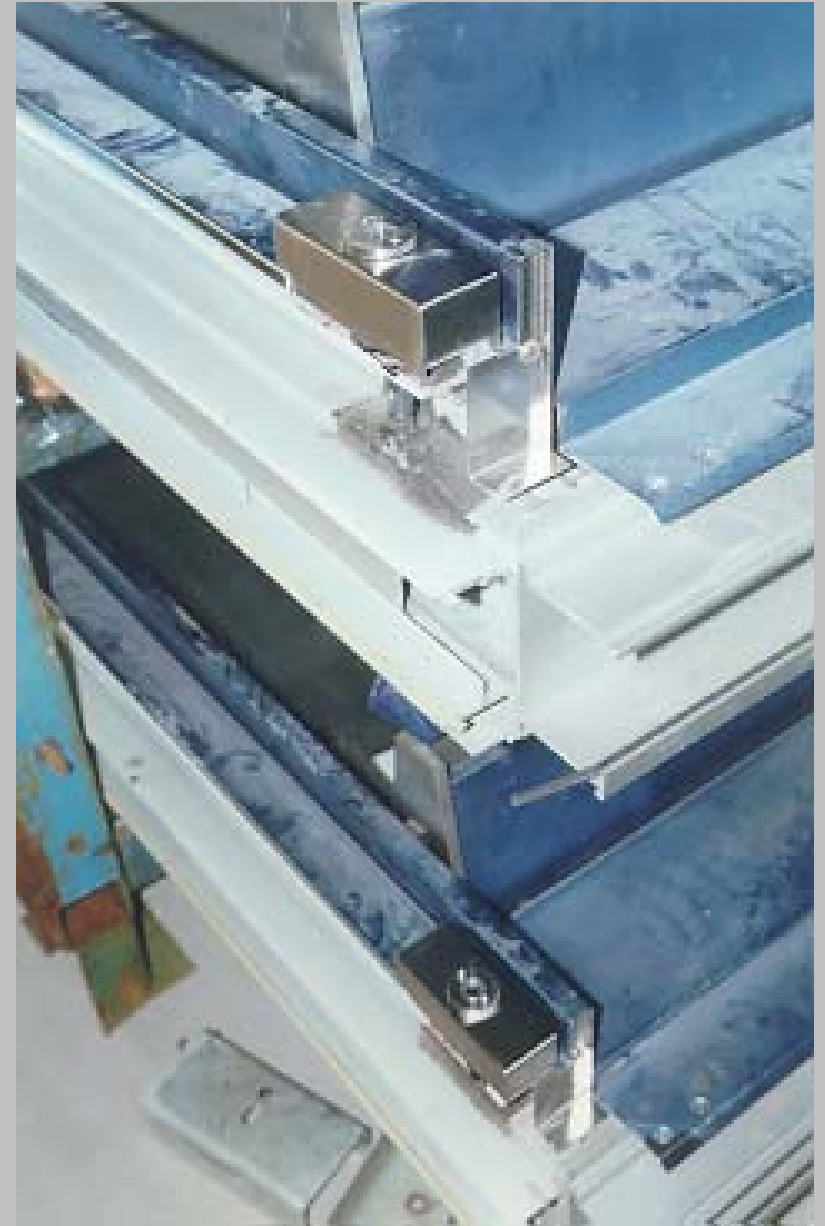


Storage arrangement of the panel units inside building interior





Close up of standard panels seeing the section and junction detail of the units





Stainless steel entrance canopy forming part of the building façades



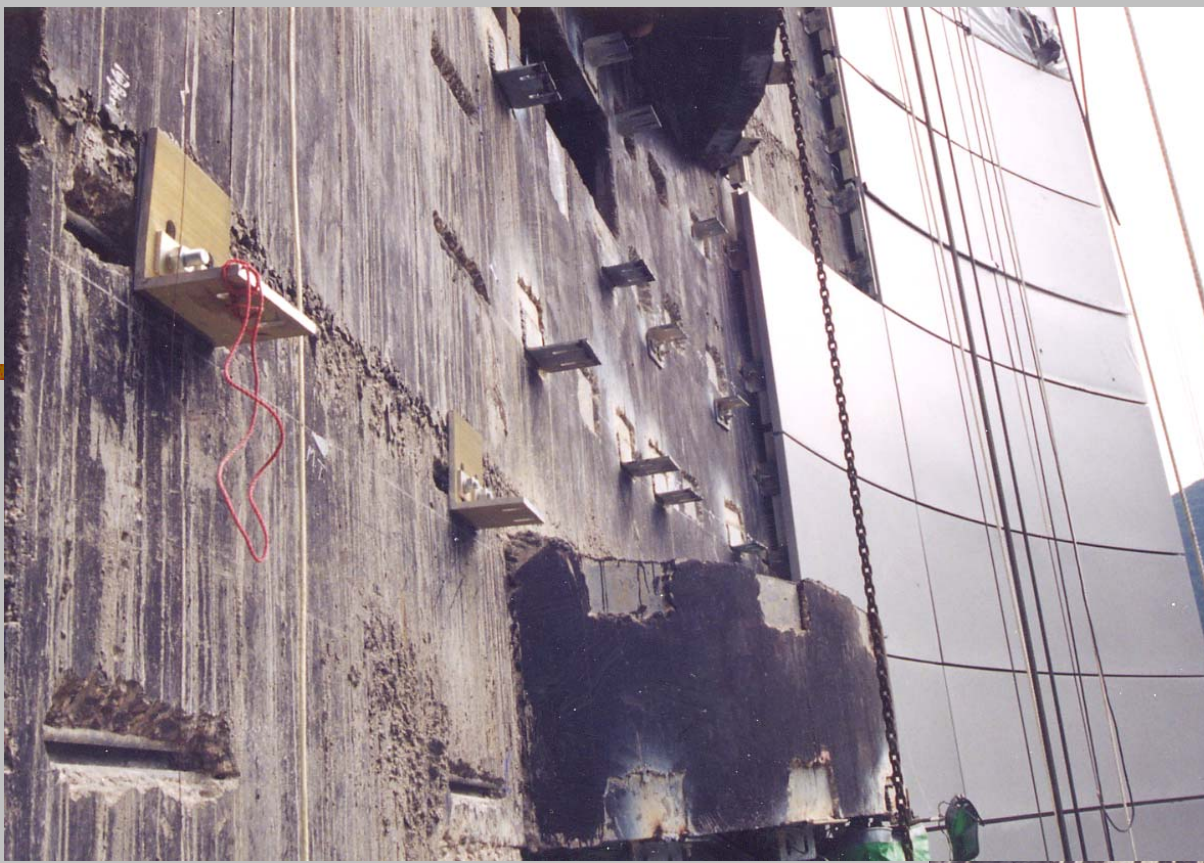
# Residential Development at Stubbs Road

- A 66-storey residential building with internal and external shear walls forming the major part of the building structure

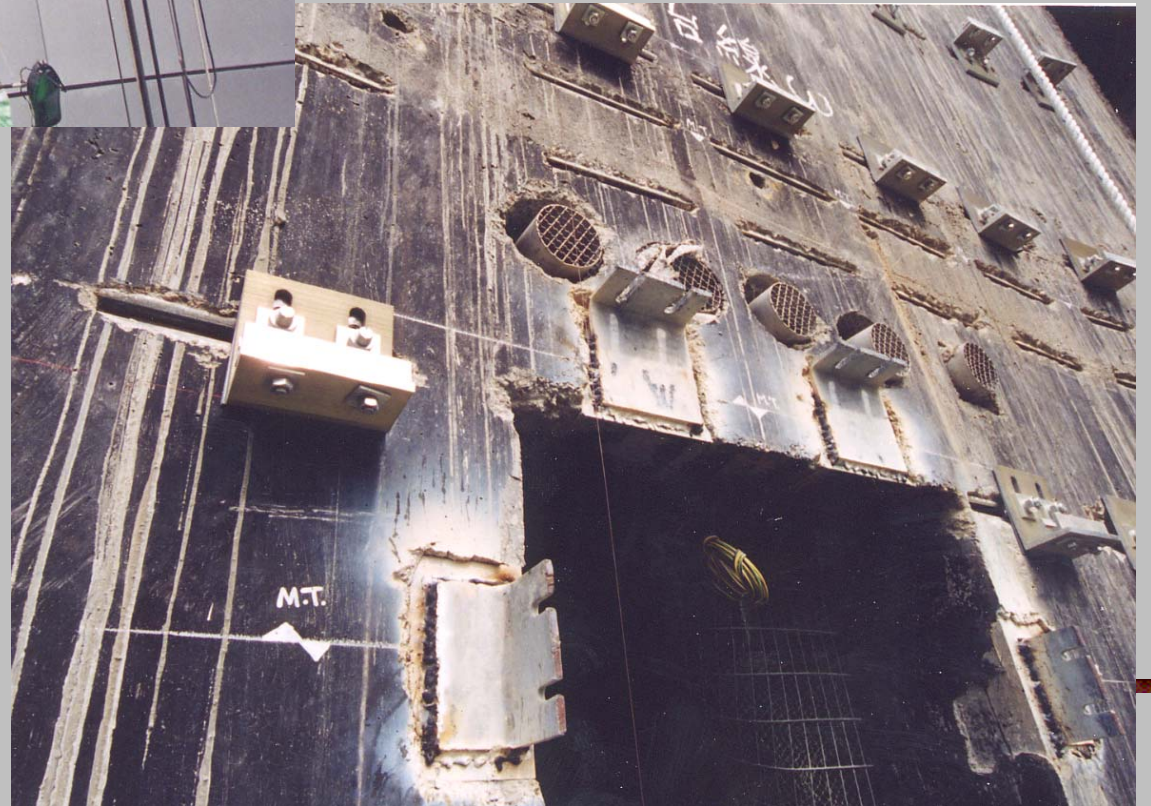




Backing arrangement to the building exterior before the fixing of the wall panelling



Detail of the built-in anchor channel and the fixing bracket





Touching up of the  
window and wall units

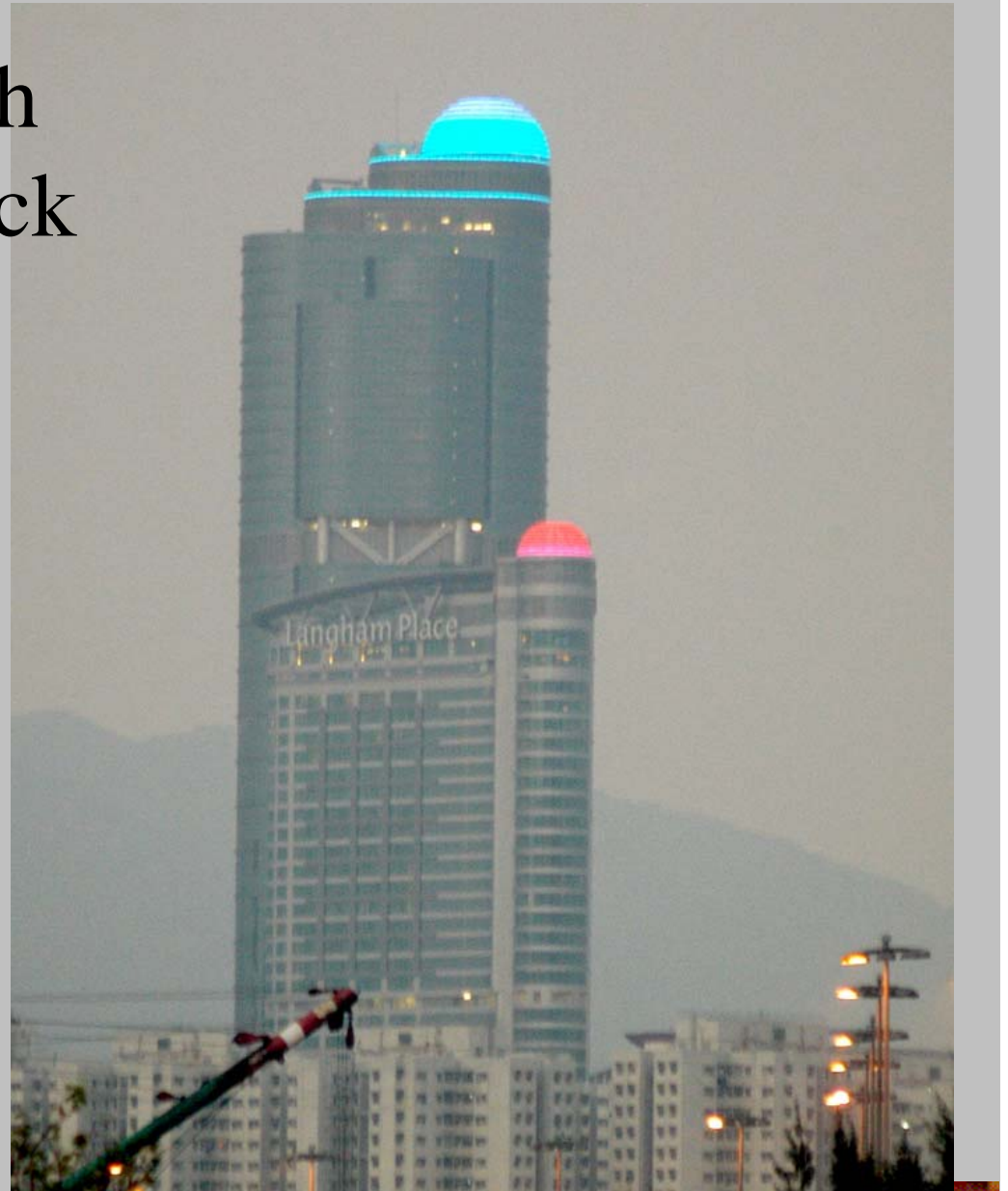




Detail of the fixing at  
the rebate window

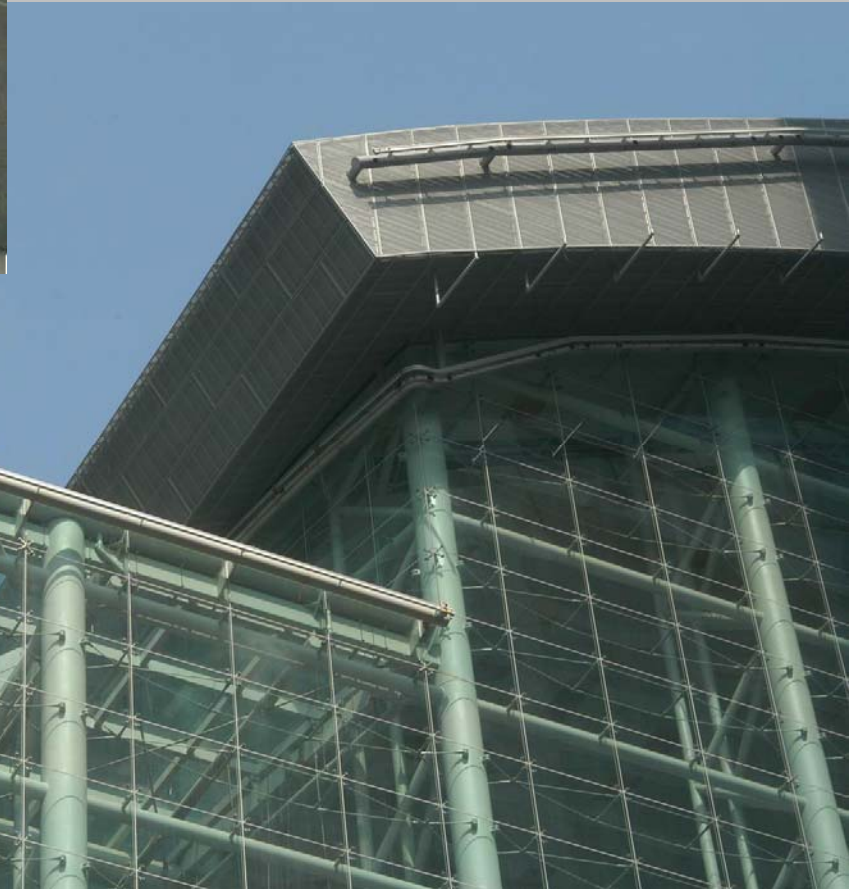


# Langham Place - Commercial Complex with hotel, retail and office block



# Langham Place - Commercial Complex with hotel, retail and office block











# Maintenance Consideration

common problem sources where failures to curtain wall often occur

Design failure – selection and appropriateness of the system, non-compliance to design and performance standards, imperfection in the jointing design and detailing, improper use of materials etc.

Construction and structural failure – wrong location or method of fixing, improper anchorage and connection provision (including failure in welding), failure in the walling components, unpredicted deflection or deformation appears in the background structure, poor supervision and workmanship.

# Maintenance Consideration

common problem sources where failures to curtain wall often occur (cont.)

Aging and deterioration – discolouring and surface damaging due to weather action; corrosion due to air pollution, acid rain, or electro-chemical effect to dissimilar metals; aging and hardening of the glazing compound or sealing gasket, deteriorating of the insulating materials that lead to further dampening of the walling materials/components, disfiguring or loosening of the fixing and connections, loosening or broken-off of the glazing or other fitting items.

# Maintenance Consideration

## Signs to observed during maintenance inspection

- Sign of distress and deterioration of the entire wall system,
- cracked, loose or missing glass panels,
- bulging, bowing, separation, delamination, rotation, displacement of panels,
- marks of water, staining and rust,
- damaged and missing parts, corrosion, loosening or other defects,
- extrusion, wrinkle, split, missing or other signs of deterioration of the sealing materials.
- moisture appears around or behind the curtain wall.



End of Presentation

