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# PREFAB architecture

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# Distinctive steel buildings on the rise

The first issue of Prefab Architecture for 2007 ushers in three splendid buildings which have adopted extensive use of prefabrication in concrete and steel construction. Despite the heavy reliance of prefabrication, each building comes with its own distinctive feature and character, adding vibrancy to the surroundings.

The first project, De Royale Condominium stands majestically in central Singapore. The 36 storeys in each twin tower feature maximised repetition and standardisation which were achieved while maintaining the architectural concept. Intense planning during the early stages of design enabled the design team to incorporate extensive usage of precast concrete and steel elements into the architectural features. A complex and distinctive roof feature was created with pre-assembled steel segments to minimise complications.

The newly built National Library demonstrates that steel construction can also be cost effective through the adoption of performance-based fire safety engineering. Instead of the traditional sprays and paints on all the beams, the fire safety specialists' design allowed the majority of the steel floor beams to be either unprotected or have reduced applied fire application while maintaining the building's structural integrity in the event of a fire. With extensive use of prefabrication and 'green' technology, the National Library won a Merit Award (Institutional Buildings Category) under the Best Buildable Design Awards 2006 and the BCA Green Mark Platinum Award in 2005.

Marina South Pier, the new waterfront gateway to Singapore, set out to capture the splendor of its surrounding by integrating steel structure and reinforced concrete construction. To achieve the highly artistic and complex wavelike roof structure, the design team turned to prefabricated and modular roof trusses. For easy installation at site, the aluminum roof was designed with an integrated rainwater discharge, ceiling and lighting provision together with the truss system. The well-executed design earned the Marina South Pier the 2006 Singapore Institute of Architects Design Award (Transportation Building).

By Phua Hui Chun




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# de Royale - Housing fit for royalty

by Tay Seok Cheng, Head of Project Division, JGP Architecture (S) Pte Ltd

**Project Team:**

**Client:** Hoi Hup Holdings Pte Ltd
**Architect:** JGP Architecture [S] Pte Ltd
**Main Contractor:** Straits Construction Co (Pte) Ltd
**C&S Engineer:** LBW Consultants
**M&E Engineer:** K G Goh Consultants

View from Jalan Rama Rama

# de Royale

The twin towers of de Royale, at 36 storeys, are referred to as 'the duke' and 'the duchess'. As one of the tallest developments in the precinct, the de Royale development comprises 204 units of which there are 2+1 [study], 3 bedroom apartments, 3+1[study] and 4 bedroom penthouses. With the unique diamond-shaped roof as a distinct feature, this development bears a dramatic charm that sets it apart from other buildings. The circular entrance with its surrounding planters and water features provides an interesting focal point achieving a sense of grandeur whilst the soft sounds of flowing water provide a relaxing mood upon entering de Royale.

Located in central Singapore, de Royale is bounded by PIE to the north and in close proximity to HDB Hub and Toa Payoh MRT Station. Immediately to the south and east are established residential apartments. Further to the southeast direction is the vibrant Balestier Road branching to Thomson Road and the city. Nearby buildings in the vicinity include the modern clubhouse 'SPAN', and the conservation building Sun Yat Sen Nanyang Memorial Hall.

## Design Concept

Taking into consideration the client's priorities for exclusivity, maximisation of view, orientation and privacy, the Architect's strategic design approach resulted in two identical towers of 36 storeys providing a gateway effect into the residential precinct.

By aligning the towers on an axis and diagonal to the site configuration, the apartments within the towers provide maximum views, good sun orientation, privacy and reduce overlooking. A clear segregation for traffic and pedestrians is allowed for by locating the communal facilities on a 2nd storey environmental deck above the car park.

Designed with the needs of different users in mind, the facilities define the environment. The Park-like concept continues with a water court and a sky terrace deck. The 25 m long lap and spa pool bring the feel of the development to a more intimate level. Its geometric shape provides a sculptured relief when viewed from the tower apartments.

## Elevation Treatment

Simplicity and clarity are the driving forces in the elevation design. Visual interest is created through the rhythmic insertion of horizontal planes that are juxtaposed against the strong vertical form of the towers. The cantilevered canopy and roof features are introduced to create a coherent visual reference between the blocks to enhance their implied 'interaction'.

The roof further enhances this 'interaction' by protruding 9 meters out of the building roof. The elevation uses more glass and metal to reflect today's contemporary design. The cantilevered canopies and roof features were done using precast concrete which allowed speedier construction and minimised difficulties at site.

## Repetition and Standardisation

The extensive use of prefabrication in the 36-storey towers has resulted in high buildablity, cost effectiveness, fast construction, less defects and a safer working environment. Without losing the distinct quality of the twin towers in the urban landscape, the architectural design featured maximised repetition and standardisation to build the twin towers.

View from PIE

View from entrance

Prefabricated breakfast counter

Prefabricated vanity basin

The towers are direct mirror images of each other. Out of the 204 dwelling units, there are 146 units of 3-bedroom apartments and 48 units of 2+1 bedroom apartments leaving only 10 non-typical types distributed in the penthouse and 2nd storey units. More than 95 percent of the units formed the mass of repetition in the twin towers. The high repetition percentage encouraged the use of precast concrete. And the elaborate architectural features were completed without compromising the buildability of the development and safety of the workers.

The window height and door dimensions were standardised for better detailing and more economical production. This resulted in fewer components for the elevation treatment, yet did not lose the desired effect of the architecture design intent.

Precast wall installation

Precast bay window installation

## Prefabrication Components

The components that gave rise to high prefabrication volume were used for the following.

*Bay windows*

These include areas where the bay windows stand proud on the external wall. In other areas the bay windows were designed with a flush profile giving different forms of expression to the facade. The bay window components were designed with 'wrapped around corners' to conceal the columns in the facade.

*Cantilever canopy*

The cantilever canopy acts as a sunshade component and also divides the vertical stack of the building. At the same time the regular floor to floor horizontal sunshade fronting other facades express the different stack of unit types in the tower.

*Bridging beams*

These form the aesthetic break between the vertical features that rise 36 storeys and the floor to floor horizontal elements of the façade.

*Vertical fins*

The vertical fins featured at the roof top express the likeness of the twin towers.

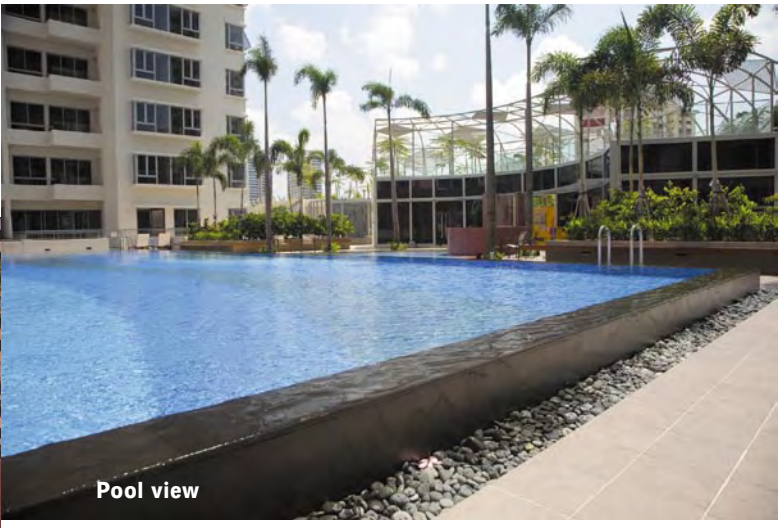
Roof terrace above club house

*Steel roof feature*

A complex steel roof feature was designed at the top of each tower. Due to limited access for on-site assembly, each roof section was pre-assembled and transported to site in two segments for final assembly and finishing on site. With only a single lift, the precision fitted steel artwork was installed on the tower roof. The pre-assembled construction method allowed speedier construction and minimised the construction difficulties such high-rise buildings are known for.

Steel feature at roof level

Pool deck



Pool view

View at children's playground BBQ area

*Perforated steel staircase*

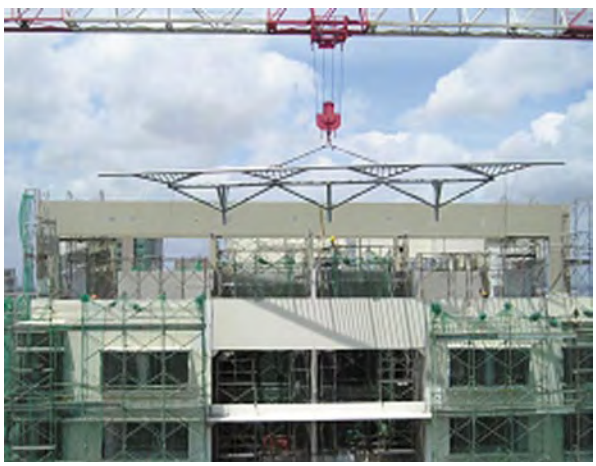
The perforated steel staircases were used to create savings in GFA and generate more usable space in the dwelling units. Since the stairwell is straight and with typical floor height throughout, the highly repetitive steel staircase components were prefabricated in the factory and assembled on site.

*Interior feature*

The prefabricated vanity basins, breakfast counters and solid kitchen surfaces with integrated basins used 'Corian', a patented material from Dupont. Corian is very versatile and can be joined and formed in various sizes and shape in the factory. Cleaning and removing scratches and cuts is a breeze.

## Conclusion

The intensified prefabrication during the early stages of design enabled the project team to integrate architectural features into the structural precast elements and build an expressive and modern 36-storey residential skyscraper with character. The interpretation of a 'form follows function' façade expressed the different unit types onto the form. A number of new ways of design through the use of prefabrication e.g. corners of building wrap with glass and modulated expression of façade were introduced in this project. Putting up the roof feature that is unique to this development was carried out without too much hassle, all thanks to prefabrication.



# Dazzling new waterfront gateway

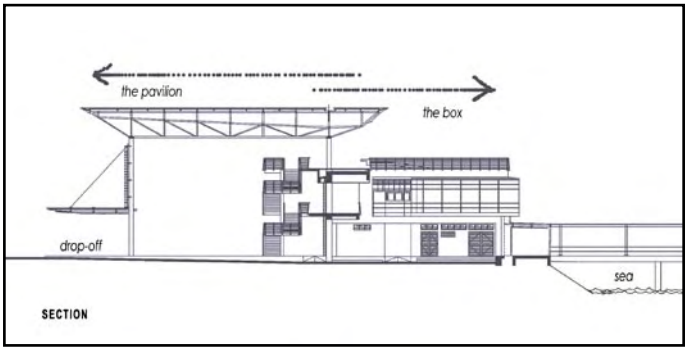
By Lee Hoen May, Senior Architect,
Surbana International Consultants Pte Ltd.

Designed to replace the 73-year-old Clifford Pier, Singapore's new waterfront gateway the Marina South Pier (MSP) has been creating waves with its eye-catching form. This public landing point serves Singapore's Southern Islands visitors or harbour cruises passengers, as well as shipping agents of vessels anchored at the South-eastern waters of the Singapore port. The MSP, which won a 2006 Singapore Institute of Architects Design Award (Transportation Building) recently is poised to shape the waterfront lifestyle and leisure scene in the Marina Bay area.

As the gateway to Singapore, the design of the terminal building captures the splendour of its surrounding as a waterfront building within a Garden City.

The triple volume steel pavilion structure contains the holding hall and small kiosks. The design provides an open, user-friendly environment with all its facilities visible from the open hall while carefully screening off the necessary enclosure required of the security of the jetty and immigration areas.

Maintaining the spatial relationship with the 'pavilion', the reinforced concrete box, houses the offices, food court and



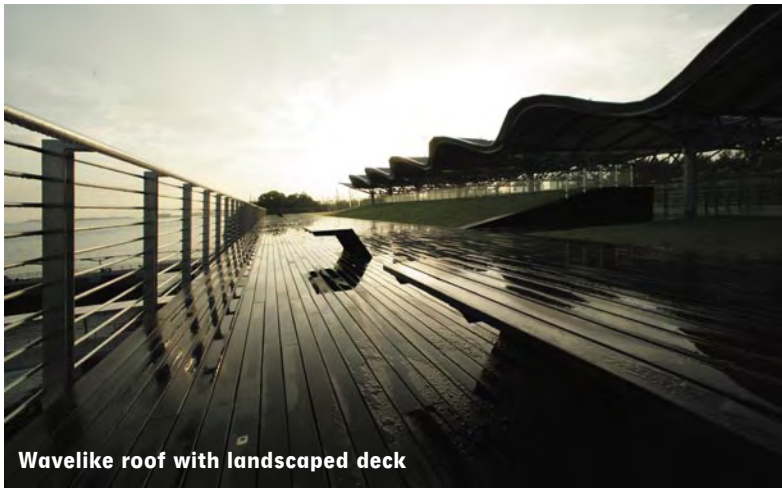

**Schematic section of Marina South Pier- the 'pavilion' vs the 'box'**

**Project Team:**

**Client:** Maritime and Port Authority of Singapore
**Architect:** Surbana International Consultants Pte Ltd.
**Structural Engineer:** Surbana International Consultants Pte Ltd.
**M&E Engineer:** Surbana International Consultants Pte Ltd.
**Project Manager:** Surbana International Consultants Pte Ltd.
**Main Contractor:** Toa Corporation / Ando Corporation
**Quantity Surveyor:** Surbana International Consultants Pte Ltd.
**Landscape Designer:** Surbana International Consultants Pte Ltd.
**Façade Specialist:** Mero Asia Pacific Pte Ltd.

Landscaping into the building

Modular detailing to wavelike roof



Wavelike roof with landscaped deck

café and is anchored by two end staircases. An open veranda on the 2nd storey eatery further enhances the waterfront dining experience. On the ground level are the long jetties, which extend out into the sea to serve the passengers.

The landscaping for this project employs a tropical garden concept. Greenery surrounding the terminal has worked its way into the 'pavilion' and has been integrated into the spaces around the kiosks, the staircase and the glass lift. By bringing the garden into the 'pavilion', the terminal building also resembles a pavilion in the garden.

To ensure a continuous green promenade along the waterfront, an elevated garden has been integrated on the roof level of the 2-storey building. The sloping lawn serves as an enchanting viewing deck as well as a unique gathering place for visitors. The roof deck also enables the 'Box' to link to surrounding developments in the future.

## Design Strategies

The building design was conceptualised with two main components: the 'box' and the 'pavilion'. Sustainable design was adopted as much as possible. Although the 'box' is a reinforced concrete structure, sustainable wall systems such as curtain wall external cladding, dry internal partition walls and glass partitions are used. Whereas, the 'pavilion' was designed as a steel structure with an integrated metal roofing system and glass cladding. Underneath the 'pavilion' are the standalone shops and kiosk structures, surrounded by lush landscaping.

The design allowed these components to be constructed in a parallel timeframe, where the majority of the facades were cladded to enhance speedy site construction.

Aluminium fins to facades

## Wavelike Steel Roof Truss System

In order to achieve the highly artistic and complex wavelike roof structure, all internal trusses linking members were detailed to be modular for easy fabrication. All trusses were prefabricated and hoisted in place enabling faster construction on site.

The aluminium roof was designed with an integrated rainwater discharge, ceiling and lighting provision together with the truss system. The well-coordinated design allowed for an easy execution on site as well as a neat roof without exposing the unsightly services.

## Façade & Canopy

*Aluminium Fins*

The aluminium fins, detailed to complement the glass structures, are found on the main drop-off and linkway as well as screening to the service areas. The detail was repeated across the building for consistency as well as aesthetics. In addition, they provide ample shading to the building and reflect the tropical theme of the structure.

## Glass Cladding with Spider Clamp Design

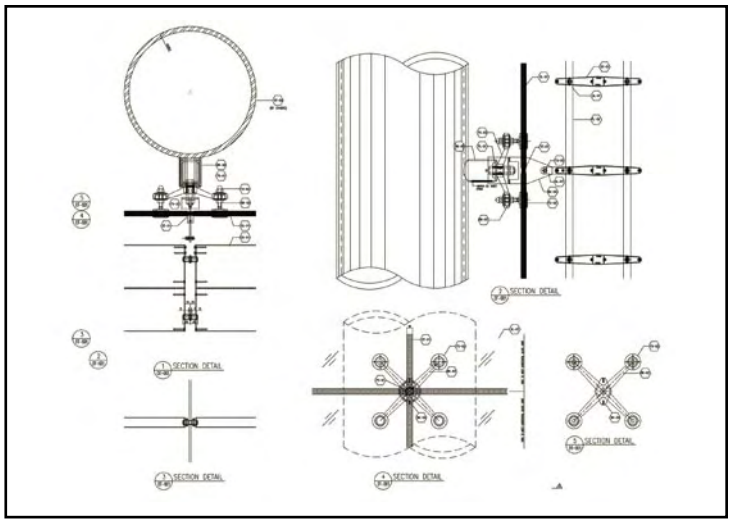
The spider clamp details to the glass facades were repeated for all the glass canopies and facades. The design allowed for easy assembly and fast construction with components precisely calibrated off-site. The detail was applied to the drop-off façade and canopy, waterfront linkway canopy as well as the glass enclosure to the central lift.

As glass is so brittle, extensive care and effort was spent to ensure the structural support detailing allowed for sufficient movement to reduce the stresses in the glass pane.

Each connection of the spider clamp point-supported glass system supports a pane of glass at all corners through a hole with a stainless steel rotule. The rotule is then secured by a stainless steel spider, which is fastened to the main structure of the building.

Three main movement features that give the glass freedom to move with the forces of nature have been incorporated in the stainless steel spiders. The first of the main movement features is the ‘fixed hole’. This gives no movement to the rotule when it is secured to the spider and is located in the upper left corner of a glass panel. The ‘slotted hole’, located in the upper right corner of the glass panel allows the rotule to slide in the left and right direction only. Finally, the ‘free hole’, located in the bottom left and right of a glass panel give the glass freedom to move in all directions.

Made in stainless steel and aluminium, the rotule secures the glass to the structure through the holes located at each corner of the glass. The rotule is fastened to the glass before hoisting and then secured to the spider with four stainless steel nuts and two stainless steel washers. The design of the rotule allows for the movement in the structure. Ten degrees of rotation are allowed in all directions on the stem of the rotule. This gives the glass freedom to move with the forces of nature and reduces the stress and bending on the glass panes.




Drop-Off Porch showing the Spider Clamp Point Supports

## Conclusion

With its unique architecture, the Marina South Pier sets the design datum for its future counterparts. The Green Promenade at the roof level and the continuous drop-off are specially designed to address the need for connectivity with its future neighbours. The three-dimensional wavy roof was a great challenge for the project team. The application of glass facades and canopies further enriched the space with the unobstructed views to the sea and sky and the landscaping beyond. Designed in totality with the environment and operational needs, the project was executed successfully with its well-crafted details, precise engineering and extensive prefabrication.

# A sustainable library standing proud

**Project Team:**

**Client:** National Library Board
**Architect:** DP Architects Pte Ltd
**Conceptual Design Architect:** TR Hamzah & Yeang Sdn Bhd Arkitek
**Structural Engineer:** Maunsell Consultants (S)
**Conceptual Design Engineer:** Buro Happold (S) Pte. Ltd.
**M&E Engineer:** Beca Carter Hollings & Ferner Pte Ltd
**Project Manager:** Rider Hunt Levett Bailey
**Main Contractor:** Nishimatsu Lum Chang JV
**Quantity Surveyor:** Rider Hunt Levett Bailey
**Landscape Designer:** DLQ Design Pte Ltd
**Interior Designer:** Woodhead Wilson Pte Ltd
**Fire Engineering Consultant:** Arup Fire Singapore Pte Ltd

# National Library

Singapore's brand new National Library, which replaced the nostalgic old building at Stamford Road in 2005, is five times larger now. The new Library is a world-class, state-of-the-art civic and cultural institution that incorporates public spaces such as an open Plaza, gardens at three levels, and a programming zone within the building design, extending the library-going experience beyond the collections.

The National Library of Singapore comprises a 15-storey block and an adjoining curved 16-storey block. Both the main reference library (known as the Lee Kong Chian Reference Library) and the National Arts Council's Drama Centre are located in the 15-storey block. The adjoining 16-storey block houses the library's ancillary offices and small activity and exhibition spaces with an observation pod at its topmost level. The National Library has three basement levels, with Basement 1 housing the Central Lending Library, a community library branch and the other two lower levels contain the car parks and other services.

In this single phase project, DPA was appointed as the Project Architect by the design & build contractor, Nishimatsu-Lum Chang Joint Venture. T. R. Hamzah & Yeang Sdn Bhd was the Architect-of-Design appointed by the National Library Board and was responsible for the concept schematic design and generic design development.

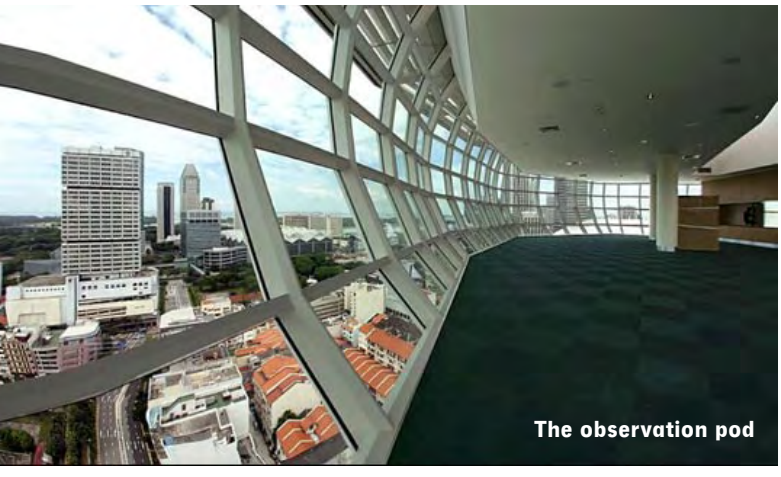
## Structural Buildable Features

The super-structure was designed with a steel structure frame with 'Bondek' flooring which acted both as the temporary formwork and the floor slab at the same time. Preassembled staircase flights were used to speed up the construction and reduce the congestion of scaffolding within the staircase shaft. Other systems such as top-down construction, plunge-in columns, and jet grouting piles were also used to reduce construction time.

## Architectural Buildable Features

*Facade*

The façade design intent was developed by TR Hamzah & Yeang together with Arup Façade (NLB's Façade Consultant). Prefabricated, unitised curtain walling was adopted for the majority of the floors. The modular, interlocking, factory-finished panels provided reliable quality levels with an established approach to preventing air and water ingress while at the same time, delivering high quality finishes with good construction speed. In addition, the sun-shading components were modularised and coordinated carefully with the curtain-wall system and the internal partitions.



The observation pod

The curvilinear block, thinner in width and smaller in size, speaks of the flexibility and less institutional kind of activities the library caters to

*Building Form*

Essentially, the project was configured from two blocks from ground level up, with two distinct but complementary forms linked by bridges at the upper levels. A three-tier-theatre is housed within the rectangular block for drama and performances at its lower levels.

The other curvilinear block is thinner in width and smaller in size and features spacious public sky gardens. It caters mainly to the less 'institutional' kind of activities and spaces for the library's ancillary activities.

*Core Placement and Circulation Patterns*

The building circulation is simple, navigational to visitors and convenient for everyday staff use. On a typical floor, other elements include lifts and lift lobbies, stairs, toilets, M&E spaces and shafts.

## M&E Buildable Features

Prefabricated M&E circular-ducts were used to reduce the amount of work and congestion requiring only joining of the ducts on site. This method enabled the site to be free from large material storage. The major electrical plants are centrally located at the roof providing easy access for maintenance and servicing.

Integration of architectural, structural and M&E design details

The spacious sky garden

Vertical M&E risers have been strategically located at each block to facilitate economical, efficient distribution and maintenance. The modular Air Handling Units were installed in vertical stacks permitting efficient vertical routing of chilled water pipes and fresh air ducts. The repeated layout for AHU rooms on each floor allowed the riser ducts and pipe works to be installed from roof to basement. The alignment of repeated layout of main toilets and wet areas on all floors also reduced the required piping works.

*Fire Safety Engineering*

This project featured fire safety engineering that reduced the amount of the fireproof material to be used on the steel structure. Traditionally, structural steel beams are coated with sprays, boards or paints to protect the structural steel during a fire. This protection can be expensive, and require maintenance throughout the building's lifetime.

Performance-based fire safety engineering allowed the majority of the steel floor beams to be either unprotected or to have reduced applied fire protection, while maintaining the building's structural stability in the event of fire. This enabled the steel structure to be expressed architecturally and led to the cost-effective construction of the building.

The fire safety specialists also developed a performance-based solution enabling the two blocks of the Library building to face each other without any additional fixed fire protection systems.

**Composite steel beams with bondek slab were used for erection purpose**

**Stairmaster system using standardised pre-assembled steel staircase system**

Sky terrace and garden

The open type library plan with a high ceiling and glass exterior walls characterise the library space

## Construction Technology

*Top-Down Construction*

The Top-down construction adopted in this project significantly reduced the construction time. This method of construction was most appropriate for the concurrent construction of the basement and superstructure. This method required the first storey structure to be completed first to have full access for the construction of the basement and superstructure.

*Use of Plunge-in Column*

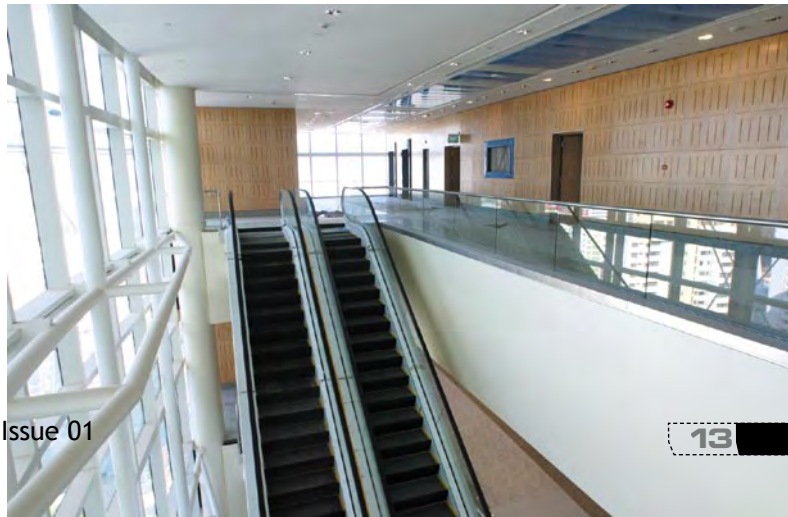
To carry out basement construction simultaneously with the superstructure installation, plunge-in columns were incorporated into the bored piles during piling work. These plunge-in columns had dual functions. The plunge-in columns had designed to support the construction load of the superstructure while basement construction was on-going. Eventually they served as permanent columns after they were encased by reinforced concrete.

*Jet Grouting*

Due to the top 15 m deep layer of soft soil within the site and its close proximity to the existing MRT underground railway protection zone, and the deep basement top-down construction method, two layers of jet grouting were injected into the soil after the diaphragm wall construction to reinforce the soil resistance. The use of jet grouting enabled the excavation to proceed without having to construct the temporary steel strutting to support the diaphragm wall. As a result, the basement construction had less obstruction enabling work to progress rapidly.

*Basement Slabs*

The basement slabs at B1 and B2 are 350 mm thick cast-in situ reinforced concrete flat plate, with supporting columns on approximately 9 m by 9 m grids. Punching shears at the interfacing of columns were checked and designed with the provision of adequate shear links within the slab. The B3 slab design was primarily controlled by water uplift pressure. As a result, an 850 mm thick flat slab floor system with the design of pile caps as drop panels was adopted as the floor system.



## Challenges

*Existing H-Piles*

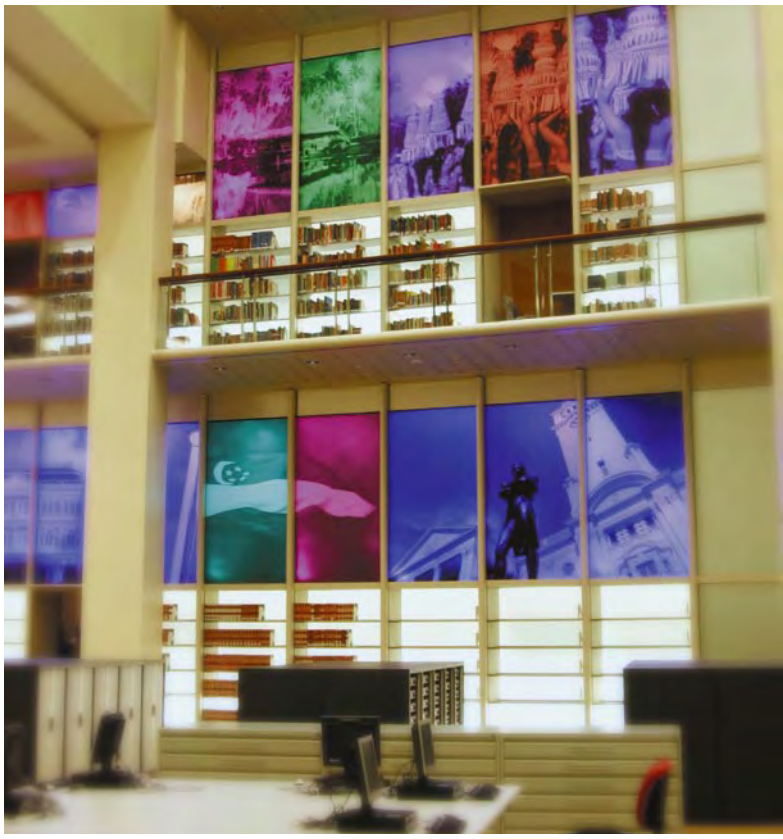
One of the major challenges at the site was the presence of more than 1,000 old H-piles within the site. Some of these H-piles coincided with the new proposed column / bored pile locations. Due to top-down construction methods used at site, it was not advisable to shift the column / bored pile locations. Instead the old steel H-piles had to be extracted from the ground prior to jet grouting. As for the remaining H-piles that could not be extracted, the contractor had to carry out the basement excavation with due consideration and once the basement excavation was completed, the existing H-piles were cut off.

*Site Limitations*

Another major construction challenge of this project was the erection of a 27 m long-span plate-girders and a 34 m mega-trusses. There were a total of twenty plate-girders and two mega-trusses in this project. The weight of these long-span structures varied from 20 ton to 140 ton. To hoist these long-span structures up to the 3rd, 5th and 7th storey level, a 300-ton crawler crane was deployed at the site. Since the crane manoeuvres were restricted to a particular zone, the ground floor slab within this zone was strengthened to support the crane.

*Conclusion*

This project is a construction milestone. The architects and engineers have given great attention to the Library's internal and external environment and optimised the advances and progress made in the application of the latest advances in construction technology. Every aspect and component of the building was examined for buildability. Productivity and quality were enhanced through the adoption of extensive prefabrication in this project. The use of 'green' and 'state-of-the-art' materials were widely adopted for the project enabling the birth of a library standing proud with public-friendly and animated spaces.



**Composite steel beams with bondek slab were used for erection purpose**

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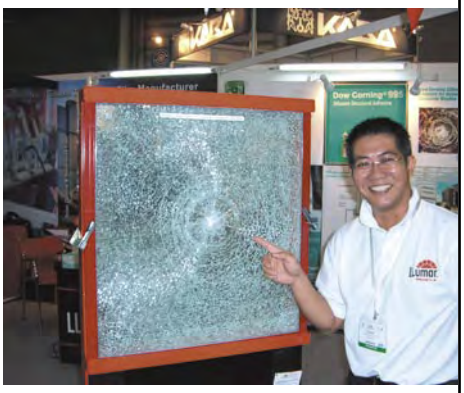

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- **Singapore Police HQ/CNB/CID,**
- **Neighborhoods Police Center & K-9 (Dog Unit)**
- **HDB Singapore Hub, Toa Payoh**
- **Changi Naval Base, Changi**
- **Nanyang Technological University**
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