PREFAB architecture

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Prefabrication for large scale projects and small ones too

Rejuvenating a World Class Airport such as the Changi Airport is not an easy task, considering the 24-hour non-stop operation and the huge annual handling capacity of 23 million passengers each year at its Terminal 2. The challenges lie in overcoming the restrictive site constraints as well as to upkeep the image of one of the best international airports in the world with minimal disturbance to the passengers.

The article on the refurbishment of Changi Airport Terminal 2 demonstrates how opting for prefabrication in place of conventional cast in-situ operation can facilitate the upgrading work at one of the busiest airports in the world without causing significant disruption to its business operations. At a cost of S$ 240 million, the upgrading work is expected to be completed in 2006 and will add capacity to its departure and transit lounge, further enhancing Changi Airport's position as an aviation hub in the region.

To counter one of the common misconceptions about prefabrication - that it only benefits large projects - is a humble terrace house with a Gross Floor Area of 330 square metres along Lucky Gardens. For this project, the designer ingeniously harnesses the buildable concepts of using lightweight steel frame, full cladding with glass façade and metal cladding to create a cosy and contemporary look for the house.

The Esparis is another classic project where the contractor redesigns the structural system to maximise the manpower and cost efficiency by adopting a high level of prefabrication. It is also the first private residential project to explore the use of the precast household shelters in Singapore, resulting in at least 40 percent manpower saving. Obtaining a buildable score of 87 points (COP 2004), The Esparis has become one of the most buildable residential landmarks in Singapore.

By William Lim

Rejuvenating a World Class Airport

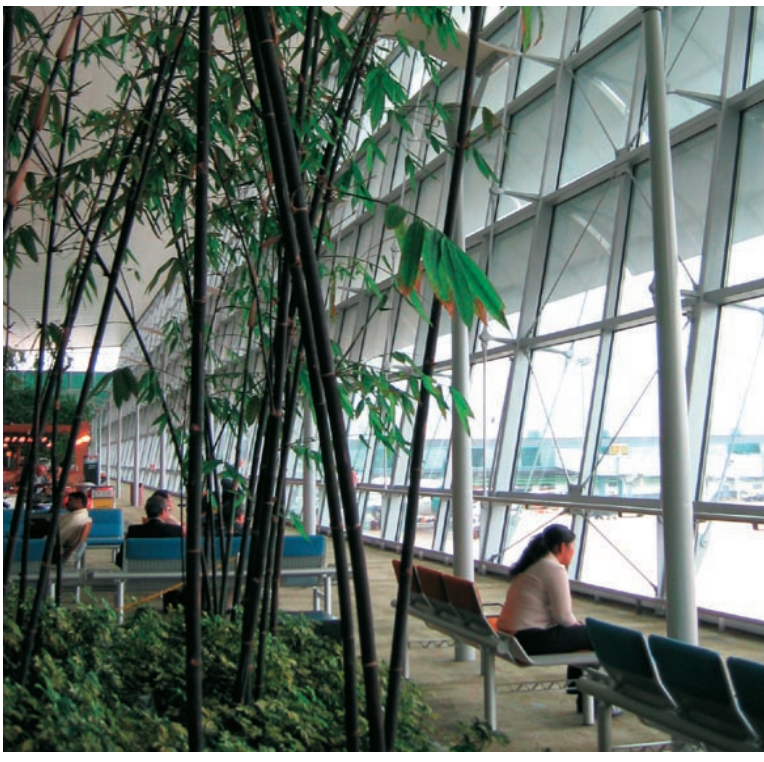
By Olivia Chan
RSP Architects Planners & Engineers Pte Ltd

An unobstructed view of the Apron from Transit Lounge

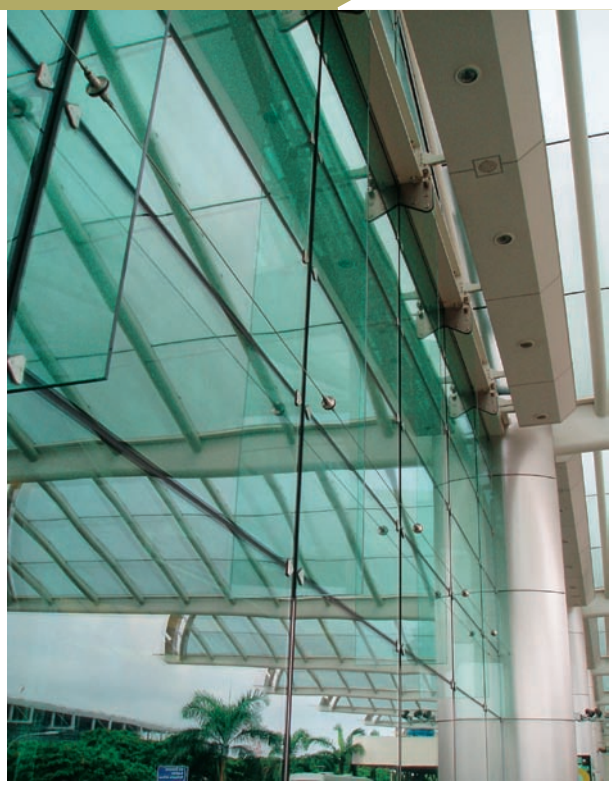
Alternating 3-dimensional glass 'leaves' and metal ceilings

To upkeep international expectations as a global transportation hub and to maintain the status of a world class airport is no mean feat. The success of Singapore Changi Airport as a regional aviation hub lies in its constant effort to create an unforgettable experience for transit passengers and visitors to Singapore. In a recent upgrading exercise expected to be completed next year, the designer has chosen the concept of 'Garden City' and extended it into Terminal 2, simultaneously using modern materials to improve its interior finishes.

With 24 hour operation around the clock at the airport, the challenge of this project lies in overcoming site constraints such as limited working space and meeting the operational requirements of the airport. In addition, causing minimal disturbance to the passengers during the upgrading works is a high priority as well. More often than not, the passengers do not even realise that a major upgrading is going on behind the eye-catching hoardings at Changi Airport's Terminal 2. To achieve this, the upgrading work has been divided into more than a hundred and sixty phases. The subtleties of the upgrading work are also enhanced by the designer's creative use of curtain wall systems, steel structures, skylights and aluminium sunshades.



A transient corner amidst the hustle and bustle of the airport



Glass fins support the curtain wall facade

The prominent entrance canopy and curtain wall facade

Canopy and Curtain Wall Façade at Departure Kerbside

The new canopies outside the Departure Hall consist of 17 modules of 15 metres wide 'leaves' that cantilever 22 metres from the new curtain wall façade covering the entire width of the elevated road. Each 'leaf' is constructed using a combination of fritted, translucent and clear laminated glass panels that are extended out asymmetrically from the central stem. The external edge of the 'leaves' consists of two prefabricated circular steel sections which are rolled into desired curvature and shape off-site. The two curved steel members are welded and erected on site with a set of jigs prefabricated for levelling control. The distinctive formation of large and small leaf blades overlapping each other allows weather protection and permits the release of warm air through the gap between the two blades. As the glass panels are incorporated into the steel structure, the natural lighting diffuses into the entire drop-off zone and shading for the check-in areas. The new canopies serve as a prominent architectural feature creating a sense of arrival and grandeur.

Passengers get the first hint of the lush landscape features through the entire façade at the drop-off zone. A stunning visual connection between the Departure Hall and the kerbside is achieved using a curtain wall system where insulated glass panels are braced by 5 metre long cantilevering glass fins and patch supported cast fittings. Clear and fritted insulated glass panels are employed for the maximum transparency of the façade between the Departure Hall and the kerbside drop-off zone, apart from reducing the glare from the afternoon sun.

The skylight behind the facade is a continuation of the steel structure of the canopy with fritted, translucent and insulated laminated glass units. It has a width of 10 metres

Interior view of curtain wall facade of the Departure Hall

and allows diffusion of natural lighting to the transition space at the entrance and the plants below. The skylight modules duplicate those of the canopy 'leaf' across the entire façade. Above these skylights, a prefabricated aluminium fixed louvre system is installed onto the steel structure at every 5 metre interval. During the day, the interplay of natural lighting and landscape creates dynamism while at night, the glass canopies glow to illuminate the departure kerbside drop-off zone and the elevated road beaconing for departing passengers.

Departure Hall Ceiling

The architectural and lighting design concept is similarly employed at the double volume Departure Hall. The artificial lighting complements the 3-dimensional leaf-shaped glass alternating with perforated aluminium ceiling spanning from the North side of the Departure Hall to the South. The 3-D shapes of both ceiling types are achieved by intersecting cones of different geometries to maximise the repetitive units in the module, taking into consideration the limitation in size and installation difficulties. The laminated glass panels are capped with extruded aluminium sections on two sides and hung onto extruded aluminium "I" profile suspended from the steel structure above. Arrays of fluorescent lights of warm and cool colour temperatures are installed with dimming control system for day and night scenes. Coupled with adjustable down lights at the aluminium ceiling, the Departure Hall is brightened up with a softening lighting effect.

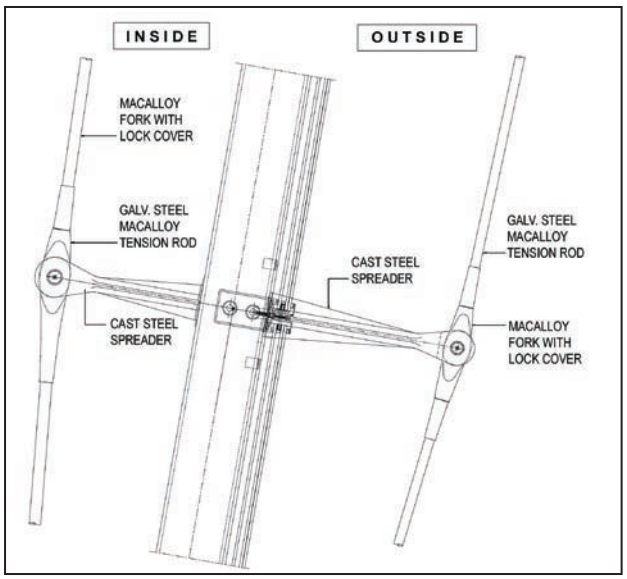
Skylight at Immigration Threshold

Above the triple volume Immigration Threshold is another strip of skylight that echoes the skylights at the entrance. These modular grids of prefabricated aluminium louvres and glass panels provide effective shading while allowing ample daylight to highlight the immigration entrances and the F&B outlets at the level above.

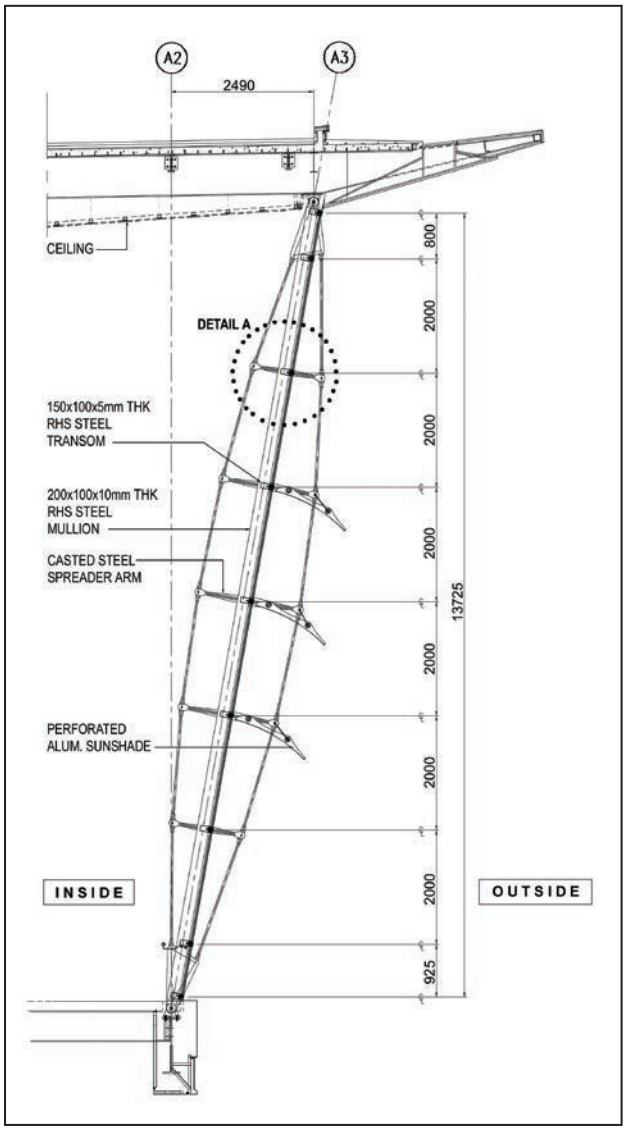
F&B outlets at the double-volume Transit Lounge

Skylight at Immigration Threshold

Skylight above the connecting bridges and planters at entrance



Detail A - Bowstring main spine spreader arm



Typical section of Bowstring facade

Apron Extension at Transit Area

Adjacent to the newly re-organised and refurbished retail and F&B outlets in the transit area, an oasis has been created by extending the main building over the apron service road, which also serves to shelter the baggage sorting area below. Passengers are offered a direct view of the aircraft movement at the Apron in this transit lounge. To minimise the size of the structure for the curtain wall and the roof, bowstring mullions are simply designed with cast steel struts fitted with tension bars and perforated aluminium sun shading screen. The bowstring mullions are pin-jointed at top and bottom at 5 metre intervals. Clear and fritted insulated laminated glass panels with varying lighting intensity allowance are provided for maximum transparency and glare reduction for the comfort of passengers.

Conclusion

To create a 'Garden City' within Terminal 2, the upgrading work is characterised by ample landscaping using lush tropical plants and the extensive adoption of curtain wall systems, aluminium louvres, perforated aluminium screens, skylights, glass and metal ceiling. The structural and architectural systems used allow off-site fabrication of standardised modules prior to installation on site. This helps to overcome the constraints imposed on this project and minimises the inconvenience to the passengers. Rejuvenated with prominent architectural features such as the leaf-shape canopy, 3-dimensional leaf-shape Departure Hall ceiling and diffusion of natural lightings through new skylights and curtain walls, the world class Changi Airport will continue to leave an everlasting impression on the passengers.

Project Team

Client:
Civil Aviation Authority of Singapore
Architect:
RSP Architects Planners & Engineers Pte Ltd / Gensler (San Francisco office)
Structural Engineer:
RSP Architects Planners & Engineers Pte Ltd
M&E Engineer: Squire Mech Pte Ltd
Quantity Surveyor:
Davis Langdon & Seah Singapore Pte Ltd
Landscape Architect: Cicada Pte Ltd
Lighting Designer:
Lighting Planners Associates (S) Pte Ltd
Interior Designer:
Gensler (San Francisco office)/ RSP Interiors Pte Ltd
Main Contractor:
Takenaka Corporation

Simple prefabrication for a **simple house**

By Michael Tan
Tan + Tsakonas Architects

Calcium silicate partition board used for bathroom walls

Extensive use of glass facade

On a long, narrow site, varying in width from 9 m to 5.5 m from front to rear, Tan + Tsakonas Architects (TTA) were given a golden opportunity to experiment with buildable concepts for an individual house along Lucky Gardens. The existing building, a dilapidated corner terrace house, shared a party wall with a row of terraces which indelibly showed their age. The open space, however, on the other three sides afforded a chance to create a side facing house.

The design brief called for adequate accommodation for a young family with two children and elderly live-in parents. The owner wanted a simple and contemporary look and feel for the house without resorting to intricate details. Specifically, the house had to be easy to build, constructed in double quick time and cost effective.

Party Wall

Conceptually, TTA decided to enhance the height and width of the party wall to serve as a visual anchor for the new house. This also served to separate it from the neighbouring terrace houses. The new house was framed by this party wall when viewed from the North. The North Elevation, which is the side of the house, was fully clad in a glass facade without the house becoming too hot, whereas the East and West Elevations, which faced direct sunlight, was built with opaque walls. The enhanced party wall also served as a wind scoop to catch prevailing winds and channel them into the house.

Buildability

Although individual houses are inherently small projects, it is possible to use a considerable degree of prefabrication when building them. On such a long and narrow site with a standard building grid along the length of the structure, there are plenty of opportunities to create standardised building elements apart from the structural framing.

For this project, the width of the windows along the North Elevation were found to be suitable for standardisation, as was the length of the metal decking for the Bondek slab on the 2nd storey. TTA decided on a constant grid of 3,500 mm which utilised the maximum available length of the Bondek sheets, and yet allowed two window panels per grid.

Buildability requires early consideration as design decisions taken at the initial stage have consequent implications. From the schematic design stage, TTA decided to build in steel. In contrast to the usual reinforced concrete structure which requires formwork carpentry, a lengthy on-site curing period, and is heavy to boot, steel framing is light in nature and allows for prefabrication, quick installation and reduced dead load on the building foundations. All beams and columns were therefore steel UB sections. Columns were concealed along the party wall, but free standing and cladded in timber along the North Elevation.

Because the proposed structure was inherently light, piling was not necessary. Instead a 250 mm thick reinforced concrete raft with thickened 400 mm banding at the structural grid serves as the foundation as well as the 1st storey slab. The absence of piling work alone resulted in time savings of two months as well as cost savings of approximately S$ 80,000. It also minimised disturbance to the adjacent neighbours in terms of noise and reduced the possibility of damage to existing buildings. The team also made further time and cost savings from the omission of pilecaps and ground beams.

Other design decisions based on buildability include having a metal deck roof as well as metal sheet cladding

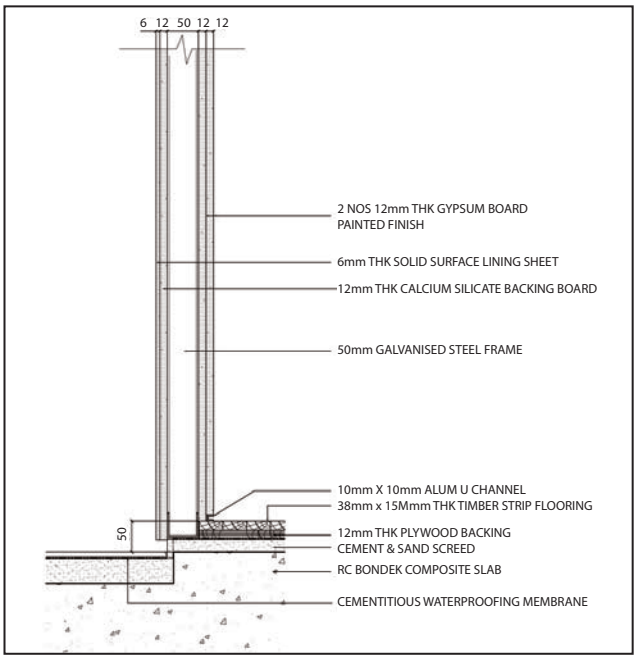
for external walls. Basically, the idea here is to work with light materials with large coverage. Compared to bricks or terra cotta tiles, metal sheets are light and easy to handle. Each sheet also covers a larger area which means that installation is carried out quickly.

Continuing along the same line, all the interior walls of the house were constructed using insulated gypsum board partition. In contrast to typical office partitions which are sometimes flimsy, double sheets of 12 mm thick gypsum boards were mounted on each side of the partition to give the partition wall a solid feel. The insulation provides resistance to heat and sound transmission between rooms.

Buildability was also one of the main criteria when it came to the building finishes. Bathroom walls were not bricked and tiled. Instead, calcium silicate partition boards were used with a 6 mm overlay of solid surfacing material

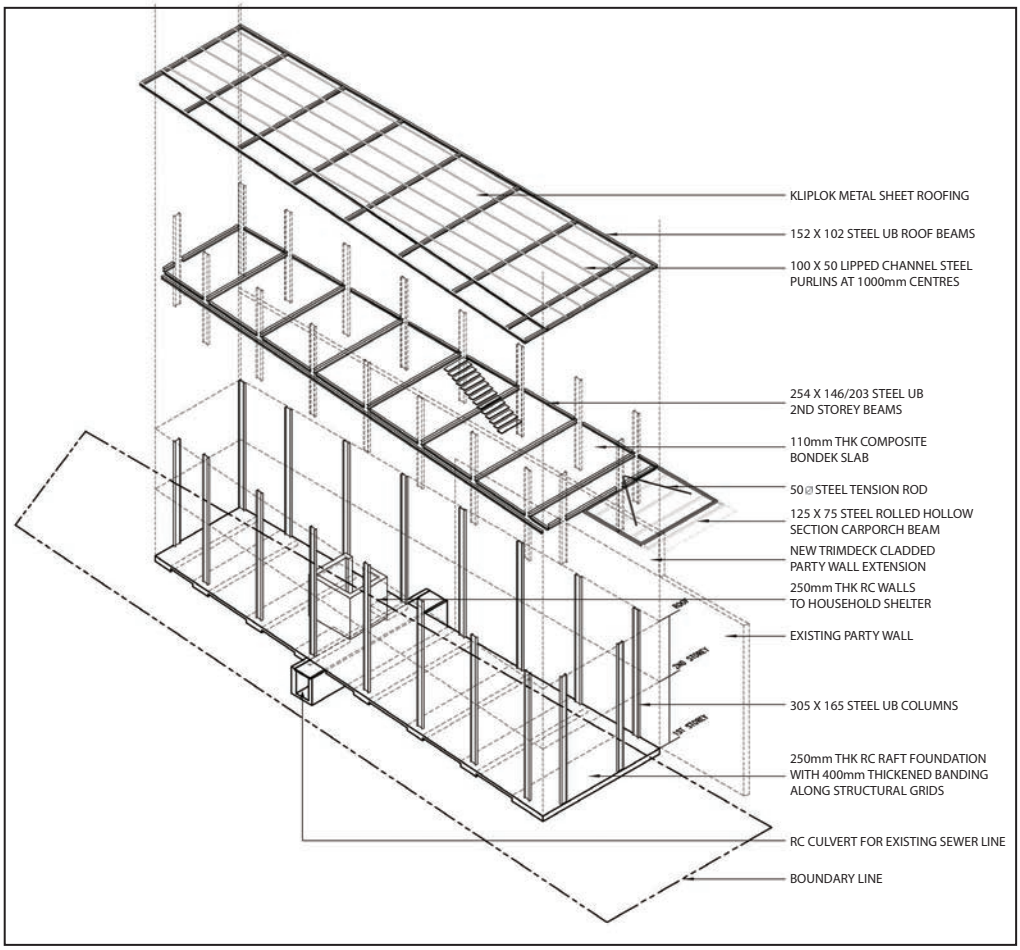
Exterior view

Full cladding in glass facade



Internal face of bathroom wall constructed using calcium silicate boards with solid surface lining sheets

Insulated gypsum board partition for all interior walls



Buildable structural system

at the shower area where the walls are frequently wet. All other walls were simply painted. Judicious use of warm and textured materials such as the maple timber strip flooring at the 2nd storey , oak timber veneer fitments and timber cladding to columns were used to provide a simple contrast to the clean background of walls and ceilings.

In summary, the following principles were adopted for the project :

- Early buildability consideration at the schematic design stage
- Standardisation of structural grids and other elements
- Use of lightweight building materials to avoid imposing unnecessary dead loads on the structure
- Optimum use of materials to suit their manufactured sizes
- Use of light materials with large area coverage for speed and ease of installation

The push to design more buildable structures is often seen in the context of overall construction productivity with particular emphasis to reduce dependency on site workers.

For individual house owners, however, being able to move in sooner rather than later translates into significant cost savings. A shorter construction period reduces the owner's interest burden if a housing loan is involved. The owner's holding cost is reduced because of the need for alternative accommodation during the construction period is shortened. Property tax is also higher when it is under construction. It therefore made economic sense for the house owner to construct the proposed house as quickly as possible.

And this house certainly illustrates that highly buildable houses need not necessarily equate to boring houses.

Project Team

Client: Mdm Yam Lee Foon
Architect:
Tan + Tsakonas Architects
Structural Engineer:
Aston Consulting Engineers
Main Contractor:
Caines Associates Pte Ltd
Lighting Designer:
Lighting Technologies Pte Ltd
Landscape Designer:
Tan + Tsakonas Architects
Interior Designer:
Tan + Tsakonas Architects

Picturesque view of The Esparis during nightfall

Precast solutions save time and cost

By Wong Meng Heng / Poon Chip Wah
Team Design Architects Pte Ltd

Pool illuminating the precast facade

Elegant view of precast components

The recently completed Esparis Executive Condominium has set precedence as the first private condominium project in Singapore to use precast household shelters. Adopting nearly all precast elements for the construction, this project has achieved a high buildable score of 87 points (COP 2004), well above the mandatory minimum of 65.

The Esparis comprises five blocks of 10-storey apartments, ideally located close to the adjacent Sea Shell Park. Nestled amidst lush greenery, the designer embraces a minimalist style using cool colors, clean finishes and uncluttered line architecture for this contemporary living habitat. Tiers of planter boxes inconspicuously blend the development boundaries into the neighboring park to create an unrestricted flow of natural and green space.

Notwithstanding its high buildability and efficient design features, The Esparis offers a total of 274 units, ranging from 2-bedroom, 3-bedroom, 3 bedroom+study, and 4 bedroom units and the penthouse. A central linear 50-metre lap pool with rain shower pavilion, poolside barbeque pavilion and an exclusive spa facility are also incorporated in the development to complement its spa resort theme.

Structural System

Initially the plan for the structural system was to use precast beams and slabs for the horizontal components while the vertical components were to be cast in-situ. After some deliberation, the contractor redesigned the structural system as flat plate and adopted precast installation for all vertical elements. The new structural system comprised cast in-situ flat plate with peripheral beams supported on internal shear walls, precast facade walls and columns. The 200 mm thick flat plate provides an even ceiling to the unit giving more space for M&E services. Vertical precast elements used included the structural columns, load bearing walls, non-structural façades and internal partition walls.

Distinctly different from conventional residential developments, the redesigned system possessed numerous benefits as it minimised the extent of finishing works on-site and required only gondolas instead of external scaffolding. Finishing works were confined to solely painting and treatment works to the precast façade joints.

Careful planning was carried out to size up and locate

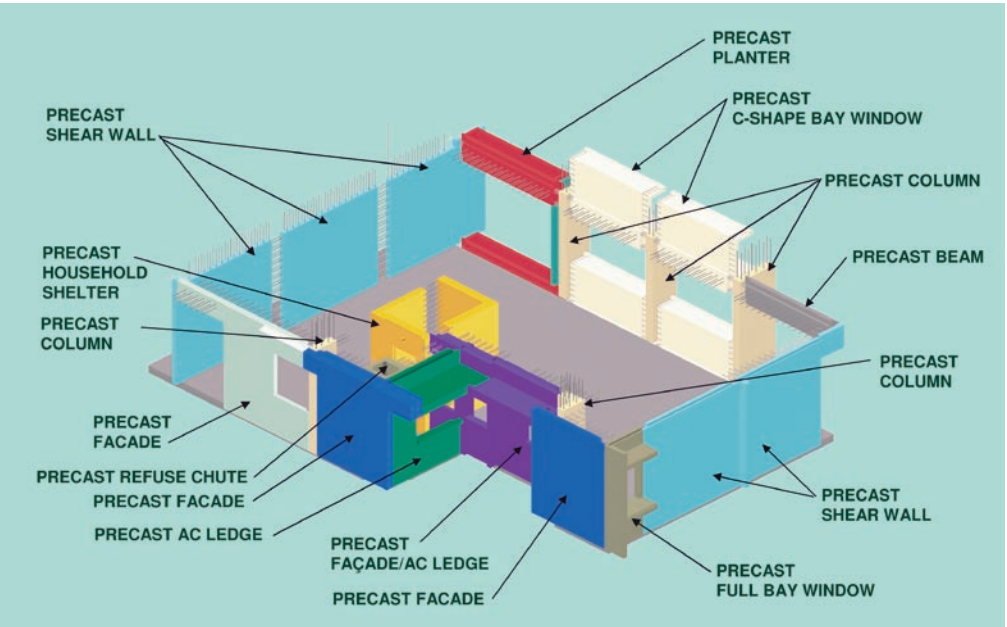
structural members at strategic positions to facilitate faster construction, while maintaining the aesthetic quality of the structure. In the absence of niches common in conventional construction due to varying thicknesses of the beams, columns and brickwalls, the simplification of wall connections was made possible. Also, the internal and external walls came out as flat vertical surfaces. Coupled with the integration of crystallised waterproofing system and the polyurethane sealant at the precast joints, the team managed to produce a better weather-tight external wall system.

The design of the E-deck was also kept simple by switching from the original conventional beam-and-slab system to a flat plate system. Using flat plate reduced the resources required for formwork construction and also increased the headroom for the basement. In addition, the construction of the E-deck was further improved with the use of upstand elements instead of sunken floors to create planter boxes and other similar features.

Other precast components used included the bay window, planter box, air-con ledge integrated with façade panel, staircase, refuse chute, household shelter, canopy, shear wall, parapet wall and lightweight precast concrete panel. The extensive use of prefabrication resulted in consistency of high quality finishes and easy construction.

Lightweight Precast Concrete Panel

For the partition walls, the contractor chose lightweight precast concrete panel over brickwall. And to minimise the hairline cracks common along the joints of precast partition panels, the contractor decided to create a recess along the edges of the panels for fibre mesh to be inserted. Special steps were adhered to during the installation process. In particular, the joints at the ceiling level and the upper portion of the vertical joints between adjacent panels and columns could only be grouted after at least 3 storeys had been constructed above. This allowed structural deformation and movement due to dead load to take place before all joints are grouted. Hairline cracks were noticeably reduced by following the above treatment.



Using lightweight precast concrete panel as interior wall

Installation of precast household shelter

Installation of vertical precast elements

Full height windows offering unrestricted flow of natural and green space

Front elevation of prefabricated roof steel trellis

Household Shelters

The household shelters consisted of two L-shaped hollow-core wall panels fabricated off-site. Each L-shaped wall panel weighed less than five tonnes, well within the lifting capacity of most common tower cranes. Panels were first lifted to a predetermined position and secured with props fastened to the concrete floor. Hollow core provisions were then filled with concrete after installing the vertical continuity reinforcement bars.

The use of precast household shelter was shown to reduce the reliance on site manpower for this project. Compared to the 17.5 mandays required for conventional cast in-situ method, the precast household shelter required only 9.3 mandays. Manpower savings of more than 40 percent was thus achieved.

Roof Steel Trellis

Cast-in-situ trellis is always a concern during construction due to the extensive shoring and support requirements. The project team at The Esparis chose to use steel trellises at the penthouse to infuse a sense of dynamism into the development. This simplified the construction of the trellis and reduced the wastage of resources required for the shoring.

Close-up of precast facade

Scaffoldless construction site

Retaining Wall System

The retaining walls along the North boundary of The Esparis were originally designed as two-tier free-standing structures which would have required a massive amount of resources to construct. The contractor decided to redesign and use the retaining wall system which involved bagwork construction using non-woven geotextile bags filled with sand. Change was also necessary to overcome site access constraints and to avoid the risk of deep excavation which required a 4.5 m high concrete retaining wall. This solution proved to be more labour-efficient and less time consuming.

Conclusion

The high degree of prefabrication that was applied at The Esparis enabled the project team to achieve its innovative design intention with exemplary quality and speedy completion within the budget.

Project Team

Developer:
Cliffmont Pte Ltd
Project Architect:
Team Design Architects Pte Ltd
M & E Engineer:
Squire Mech Pte Ltd
C & S Engineer:
Meinhardt (S) Pte Ltd
Quantity Surveyor:
Davis Langdon & Seah Singapore Pte Ltd
Landscape Architect:
Cicada Pte Ltd
Main Contractor:
Ando Corporation

The Esparis Executive Condominium - Pasir Ris

***ANDO** Corporation* a pioneer and leading general contractor in Japan since 1873 is well reputed for our innovative, technological advanced building construction and precast technology.

Established in May 1985, ANDO Corporation (Singapore Branch) has always placed great emphasis on quality of products and providing good customer service to our valued client.

New Clifford Pier - Marina South

In Japan, ANDO is one of the leading precaster and precast contractor with 3 precast plants in Sagamihara (Kanagawa), Sakura (Chiba) and Nagoya. ANDO provides full range of precast engineering include precast system feasibility study, design of steel moulds and hoisting system, detailed design and integration of full precast system and structural connections details.

Tech Semiconductor (Phase 1 in 1992) is our first precast construction project in Singapore. Since then, we completed Tech Semiconductor Phase 2 (1996), Wacker Siltronic AG Wafer Fab (1999), STMicroelectronics AMK 8 – Wafer Fab (2001), United World College Basement Carpark (2003) and The Esparis Executive Condominium (March 2005).

STM AMK - 8 Fab Building - Ang Mo Kio

The Esparis Executive Condominium developed by City Development Limited is the first condominium project undertaken by ANDO. Vertical precast components were used to construct the 5 tower blocks. Various buildability features were adopted to achieve a high buildability point of 87 (based on COP 2004).

The Esparis project achieved the following recognition during the project duration:

a. Bronze Award for Safety Innovation Teams Convention 2003
b. Certificate of Merit for Annual Safety Performance Award 2004 & 2005

The Methodist Church of Singapore - Upper Bukit Timah

ANDO Corporation is honored to be the first recipient of CDL's Environmental, Health & Safety Excellence Award 2004. The award is in recognition of our continuous effort in improving and promoting green technology to minimise environmental impact, Safety and Health at the work site, in line with our commitment to comply with ISO 14001 and OSH 18001.

Beside our expertise in Cleanroom factory and precast construction, we constructed the NKF Building (Merit award in Construction Excellence), The Methodist Church (Institutional Development) and Alteration & Addition Works at Changi Airport Terminal 2 Arrival Hall, to name a few.

ANDO is committed to meet clients' high expectations in Quality, Safety and green technology through continuous improvement to achieve ***Total Customer Satisfaction.***

National Kidney Foundation (Headquarter) - Kim Keat

ANDO Corporation

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