HACTL SuperTerminal 1

Jim Daly Kieran Flynn Mike Harley Armstrong Yakubu, Foster & Pa

Introduction

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ST1 plays an important social role for its employees and their families, with a huge range of recreational facilities including a fully equipped 1500m² sports centre with three squash courts, badminton courts, a swimming pool, tennis and basketball courts, a jogging track lacing through the landscaped roof garden, and locker room and shower facilities for all staff. Along the building's southern edge is a roof-level canteen with executive dining terrace looking onto the roof garden. At the building's heart, a triple-height glazed atrium - arranged around internal lift cores containing exhibition space at roof level and a large staff common room below - brings natural light deep into the building. All these amenities reinforce the principle that incorporating leisure elements into the workplace can help people enjoy their work environment, and consequently their jobs.

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South and east façades of ST1.

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West façade, showing profile of Express Centre roof against the Terminal.

The resulting space is dramatic - close to 300m long, 16m wide, and 45m high, it became known as 'the canyon' to the design team... and there are two of them! They create a weather-protected airside interface, give fresh air and natural daylight to the heart of the building, and also give HACTL the best possible advertising as the glazed façades expose the CSS to public view. Cost studies showed the capital cost of the roadway roof to be less than weather-protecting the internal façades of each CSS, the internal façades of the warehouse core, the link bridges, and the low-level canopies for the airside interfaces.

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A large building creates a large roof. Although the Terminal roof mostly houses plantrooms and empty container storage areas, it still offers 10 000m² of space for the 25m heated and cooled outdoor pool, the tennis, basketball and five-a-side football courts, the barbecue areas, and the jogging track, all set into the landscaped roof garden with its flowering mature trees and various indigenous Hong Kong flora blooming at different times of the year. The various structures of the BSS and CSS roofs also add to the landscape, and the BSS roof opens up here to create the exhibition hall. This exhibits models showing how the building functions and also lets visitors view the very impressive BSS spaces.

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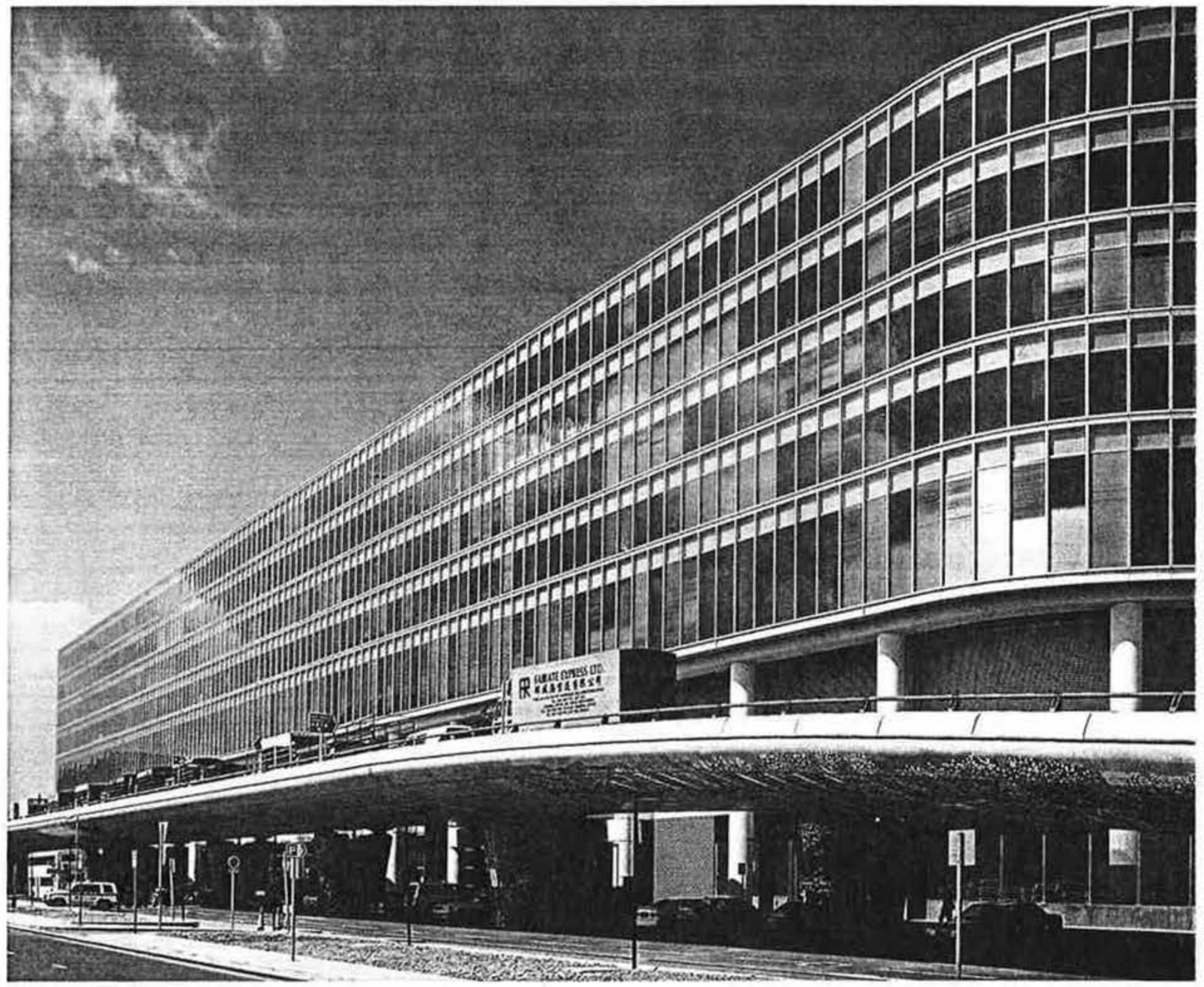
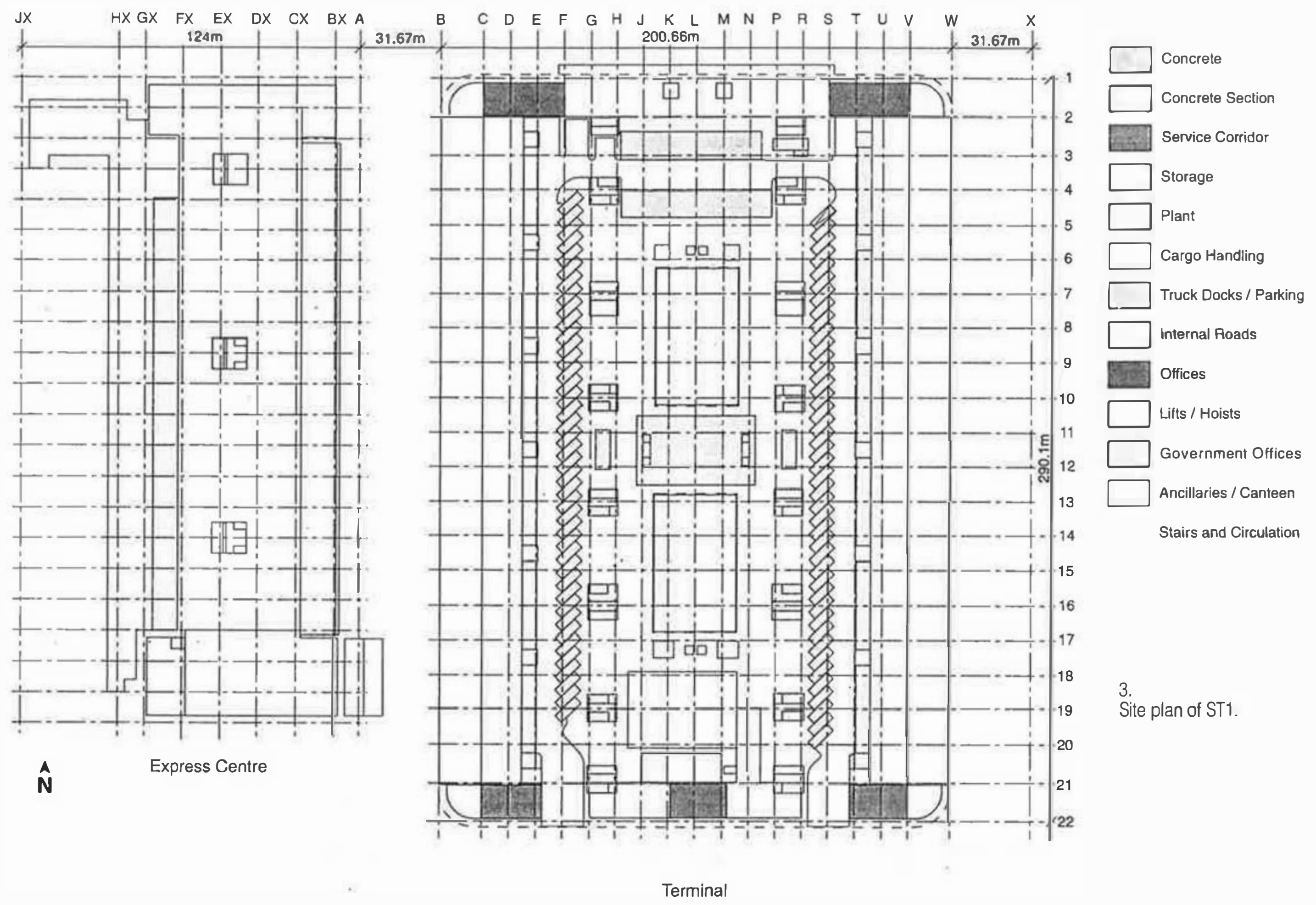
The two-level, 200m x 90m Express Centre provides a gross floor area of 50 000m² and can handle 200 000 tonnes of cargo pa. Its primary role is to give express cargo and courier operators their own dispatching and sorting facilities and offices.

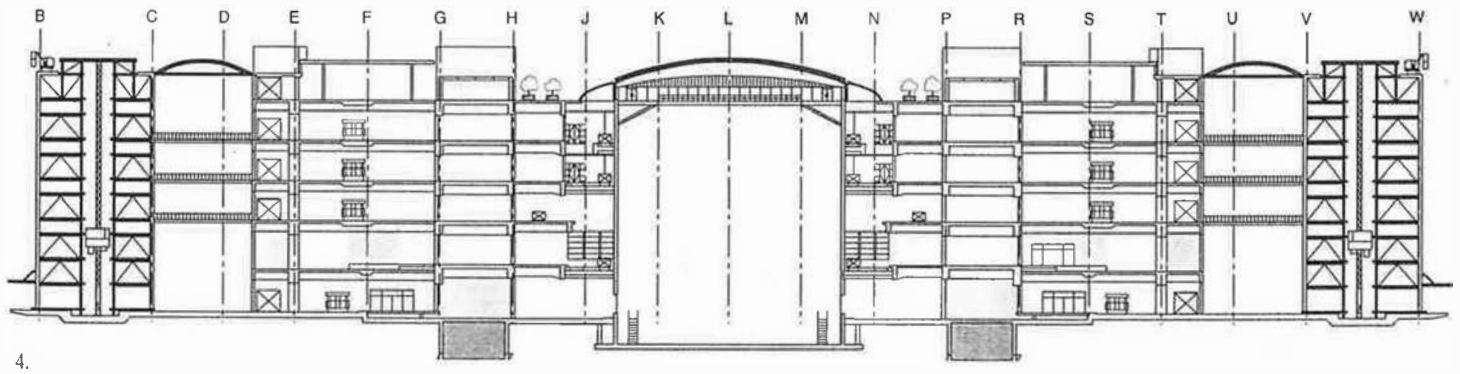
The curved roof structures are the most expressive parts of the building. The initial steel design was replaced by a twin-skin concrete solution that did not suffer from the same condensation/corrosion problems and was built at a lower price; these roof structures reflect the Express Centre's division into seven bays on each level. The north bookend bay houses HACTL's own ramp maintenance facility with associated training rooms, offices, rest areas, and changing rooms. The south bookend bay contains an automated 6.1m container storage and handling system for large consignments like Grand Prix and luxury cars, as well as larger livestock like racehorses, elephants - and the odd killer whale! Immediately south of the north bookend is the strongroom area, with four airside and four landside armoured truck docks and a central high security vault for processing high value consignments, eg diamonds, cash and gold bullion.

10.
South façade of Terminal.

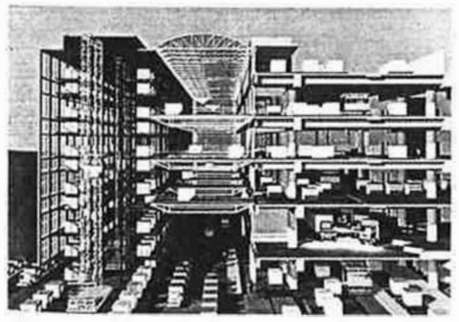




3.
Site plan of ST1.



4.
Cross-section through Terminal.



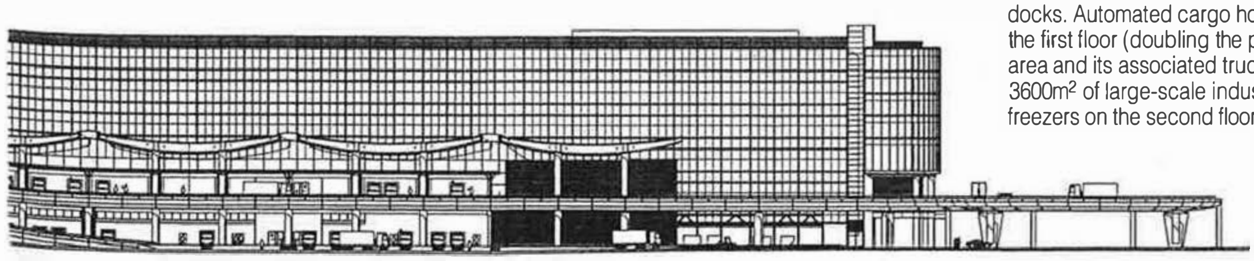
5.
Computer-generated image of part of the Terminal, showing (l-r) stand-alone container storage (CSS), 'roadway', operations and truck dock levels.

The Terminal

The six-level, 200m x 290m Terminal processes air cargo containers for international trade. Fully computer- controlled by HACTL's own systems, the building acts as a giant conveyor along which robot stacker cranes lift, pigeonhole, and store cargo, enabling it to be unpacked and processed through Customs and Excise before getting onto lorries for delivery. The Terminal has 240 000m^2 of operational, office, and ancillary space.

Operationally, it was developed like an onion, with the two central BSSs at its core. Operations and processing run mostly east/west and west/east. On the east and west façades, 260m-long CSSs (steel-framed racking structures accessible on two sides) pigeonhole export cargo containers ready for processing. The cargo then passes via bridges to the warehouse floors where it is unpacked and converted to bulk and vice versa. The bulk cargo is then placed in 'bins' (steel mesh cages where cargo is held on a consignee basis) and stored in the BSS. Bulk cargo distribution systems on Levels 1, 3, and 4 - a total of 130 automatic bin carriers - transfer import cargo into the BSSs, link each BSS, and transfer cargo between parts of the operational levels to the central Customs and Excise Hall. This is between the BSSs on Level 1 before onward transfer to the bulk cargo truck docks, also on Level 1. The process is reversed for export cargo.

The ground and first floors at the building's north end house a perishable goods handling centre, adjacent to the airport apron to minimise the distance between aircraft and the centre's truck docks. Automated cargo hoists transfer goods to the first floor (doubling the perishable handling area and its associated truck docks), and to the 3600m^2 of large-scale industrial cold-rooms and freezers on the second floor.



6. Stacker crane within void between CSS racking, from roof level.

7.
Roadway viewed from upper bridge.

HACTL's central computing system identifies any item of cargo as soon as the inbound aircraft leaves its country of origin and tracks it until it is collected. Offices along the fully-glazed north and south façades around the operations core provide some 12 000m^2 of space for HACTL staff, airline representatives, government departments, banks, and recreational facilities. The basement houses all major plant areas including fire services storage tanks and pump rooms, seawater-cooled chillers and pumps, plumbing water storage tanks and pumps, eight 4.5MVa substations, and three 1.5MVa diesel-driven standby generators.

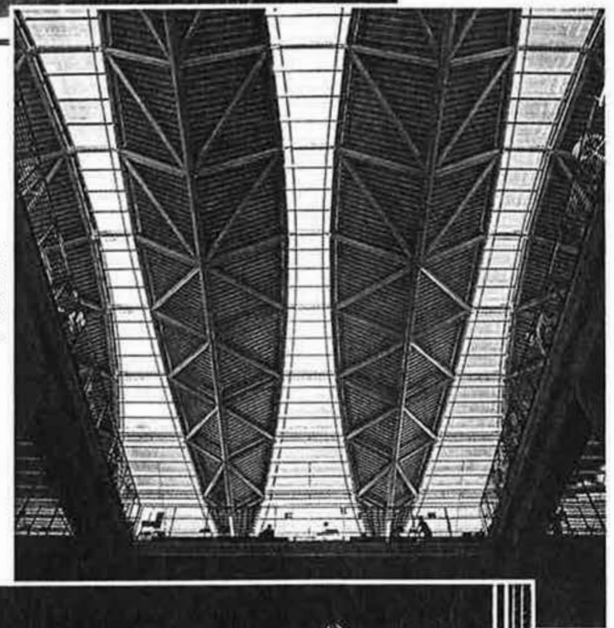
Also in the basement are the main north/south services distribution corridors which serve the primary vertical cores.

The Terminal's visually striking features are the blue steel structures throughout the CSS and the BSS. It is important to remember that, unlike sea cargo containers with their inherent structural strength, lightweight air cargo containers or pallets have virtually none. When moved in any direction, they must be continuously supported. In the Terminal this is done by powered roller decks, right angle decks / turntables, and castor mats incorporated in all container-moving machinery - and all supported by the blue steel structures. The actual machinery is always painted yellow.

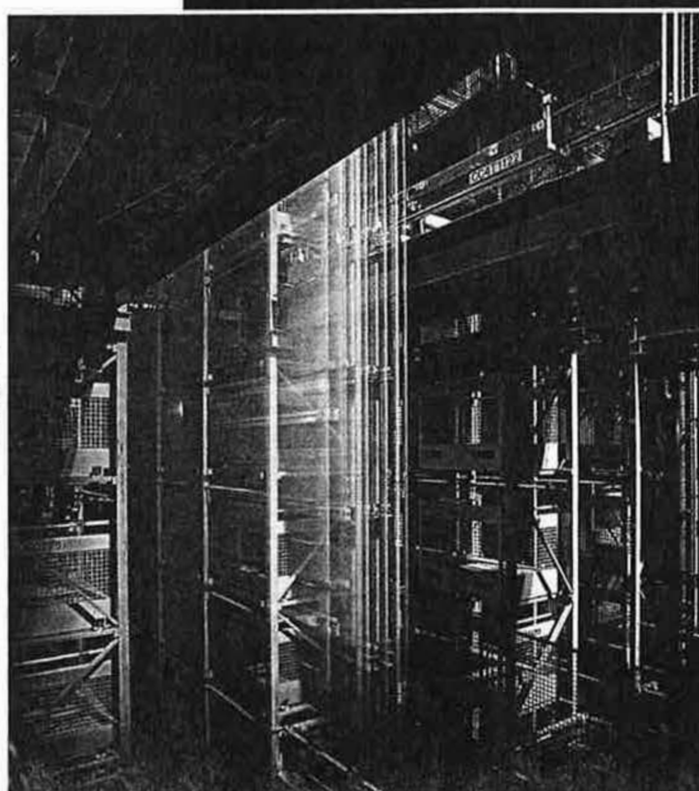
A key design feature of the Terminal is the CSS arrangement. Each CSS is essentially a stand-alone structure, giving the commercial advantage (in a very tight programme) of being buildable separately, thus enabling testing and commissioning of the CSS system while the rest of the building was still going up. The CSS' 16m separation from the building creates roadways - primarily for dolly access as well as for firefighting vehicles - in what is a very deep building. The efficiency of an air cargo terminal is determined by its number of points of airside cargo access; the better the access, the more cargo that can be processed simultaneously. Separating each CSS from the main building creates six lines of airside interface instead of two, which is why the Terminal has a unique airside interface length approaching 2km.

The roadway roof is made of steel 'butterfly wing' trusses clad with weatherproof louvres, which add natural ventilation in the non-air-conditioned parts of the building.

Glazed rooflights spanning between the trusses bring natural light to the dolly roadway and warehouse floors. The glazed façades of each CSS are open at low level along their entire length, drawing make-up air through the (internally unclad) CSS and venting it through the louvre system. Heat from the high level motors driving the stacker cranes and powered roller decks is vented by high level louvres in the CSS cladding.



8.
Butterfly wing roof trusses over the centre of ST1.



9.
Stacker cranes operating within BSS.

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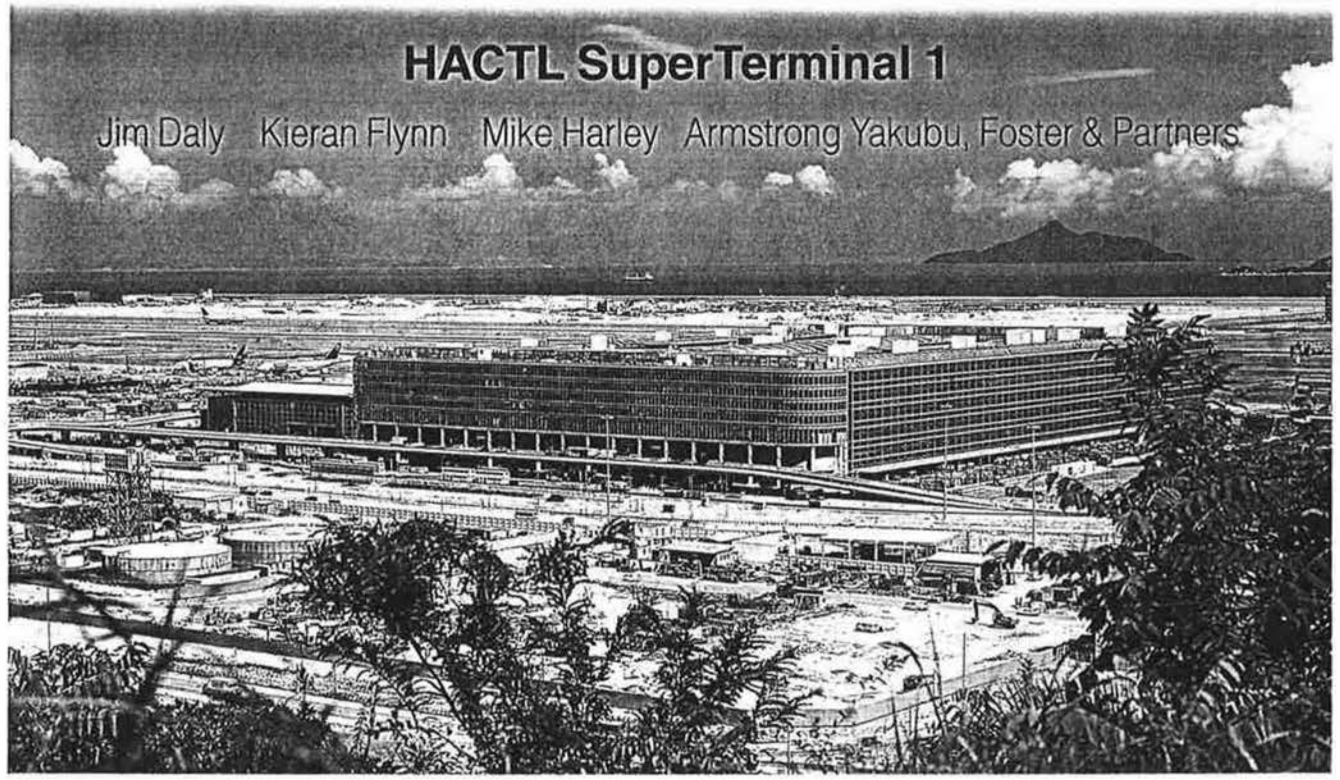

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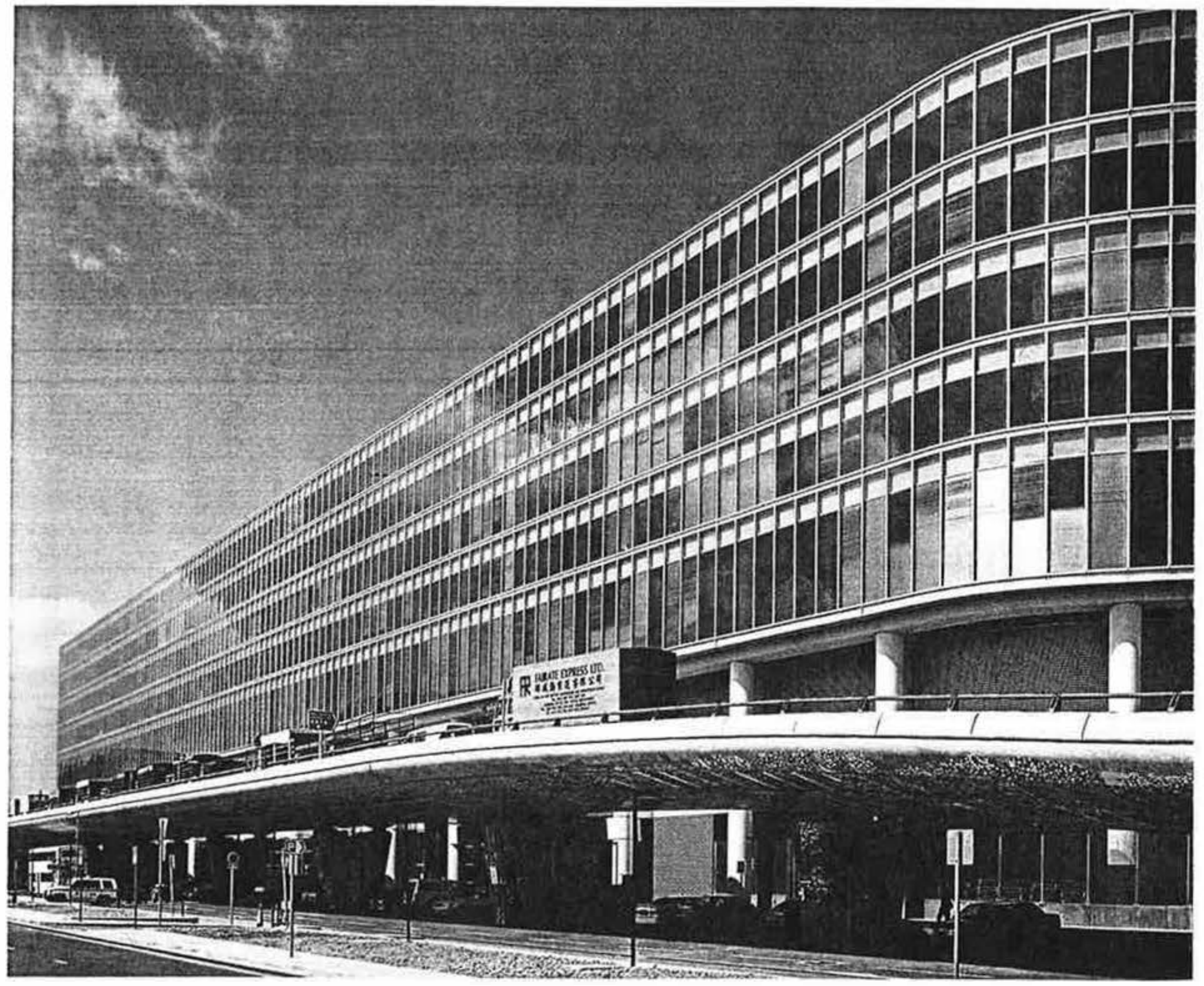
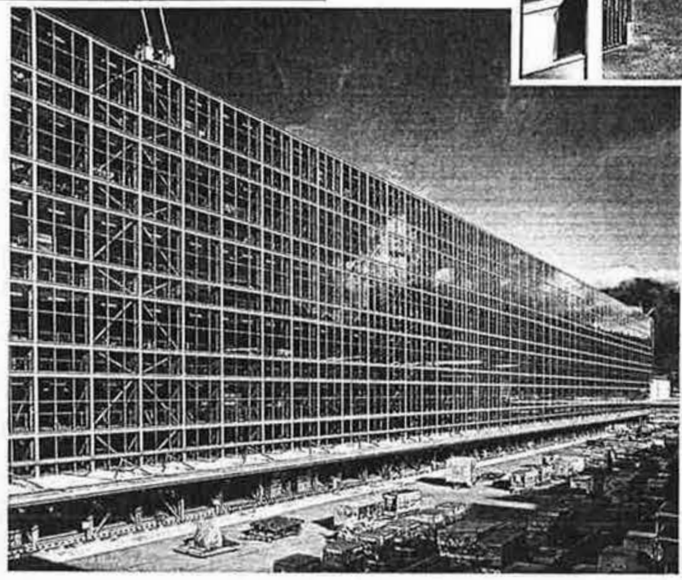
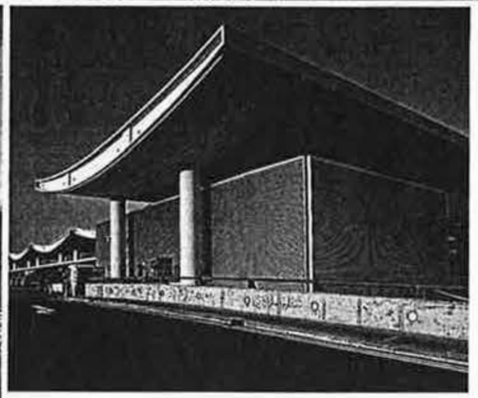


11.
Entrance to dolly train lift in Express Centre (right foreground).

13 above:
West façade of Express Centre.



12.
West façade of Terminal, showing exterior of CSS.



14.
Detail of Express Centre.

A typical bay comprises an operational express warehouse floor, some 36m x 45m in extent, with a service core centred to the side and shared with the next bay. Fully-glazed offices are located on mezzanines above both levels arranged around the service core. Continuous rooflights across the building separate each pair of bays from its neighbours. Goods lifts in the service cores link the operations floors to a central Customs and Excise Hall on the ground floor mezzanine.

As in the Terminal, the Express Centre has full disabled persons access, provided for the Level 1 mezzanines by inclined wheelchair platform stairlifts in each core.

Express cargo handling is very labour-intensive and straightforward. Import cargo is delivered to the east face of the building on each level, and processed in the main operations areas before being transferred to the truck docks on the west face for onward delivery. Two-level operation is made possible by two large hydraulic lifts that can raise fully-loaded 20m long dolly trains (equivalent to a 40ft container truck); the lifts are enclosed in a fully-glazed shaft.

The operations areas are naturally ventilated; the east and west façades are open at low level (protected with typhoon shutters) and glazed above.

The roof is insulated by its naturally-ventilated double concrete skin (which also incorporates drainage and concealed high-level lighting). The exposed sprinkler and drencher system fire service pipework curves to match the profile of the concrete.

The mezzanine offices are air-conditioned, and cooled in the same way as the Terminal offices; AHUs within the cores leave the profiled roof structures free of ductwork. The building is mostly glazed to maximise daylight awareness and to expose its multi-functional nature to public view - as with the whole complex.

External works

The elevated road which links and accesses Level 1 of both buildings complements their structure, using forms carefully designed to prevent unsightly drip stains and generally to minimise visual impact.

The parapets incorporate planters to further soften the visual impact. In the external areas generally, truck and car parking and roads are all incorporated into landscaped areas planted with flowering trees and shrubs.

Foundations

The original main island had a peak of 121m, which was systematically blasted away leaving only its spur of Pak Sha Tsui in the south east corner of the reclamation still proud above reclamation level. This spoil, supplemented with marine sand and brought in massive 100 tonne tipper trucks, was used as fill for the new airport.

Worryingly, the spoil frequently contained large granite fragments up to 2m in diameter, very different from the stated 300mm graded down quality.

This was important, since in view of available plant and time constraints Arup believed that heavy duty steel H-piles would be the foundation system.

The likely presence of such large rock fragments questioned the wisdom of this. A further problem was that although PAA had tried to dredge most of the marine and alluvial deposits, this was unlikely to have been completely successful, and significant settlement of the fill and resulting negative pile friction were likely. With the client's approval, a trial pile-driving contract was negotiated using the heaviest available universal bearing piles (305 x 305 x 223kg/m) in Grade 55C steel. It was calculated that this grade would offer at least 10% price advantage over the then statutorily approved steel pile grade. The object of this test contract was two-fold; to evaluate drivability of the steel H-piles in a suspect site and to gain formal government acceptance of this higher steel grade.

The latter was achieved, but the 12 successfully test-driven piles though were statistically too few to fully satisfy concern about encountering undrivable boulders.

A further problem was fill settlement, and its effect on road and apron pavements. Clearly this was nothing like what had occurred at Kansai Airport's artificial island[1], and comfort could be gained from the fact that a two-year construction period would ensure that by the time the (Airport) apron, roads and external works were installed, perhaps 70% of final settlement would have occurred. Geotechnical engineers are understandably cautious, and their predictions required allowance for further settlement up to 200mm. A flexible pavement that could be made good relatively easily where settlement did occur was clearly an attractive solution. PAA had decided on *Pavlok* interlocking concrete blocks, which appeared sensible, but HACTL were not convinced that the surface would be smooth enough for their dolly trains - diesel / LPG driven tugs pulling up to six solid-wheeled unsprung trailers. Also, main utility connections to and from the building were fitted with a series of 'rocker' joints to accommodate differential settlement.

Fortunately, the client was convinced by a series of entertaining tests using dolly trains with empty containers at a marshalling area in a sea-cargo container facility. The great advantage of *Pavlok* over, say, a macadam surface, is that settlement can be made good locally at minimal cost and, more importantly, with insignificant disruption to cargo operations. This still left one major problem, however. At the airside interface where the dolly trains deliver (or receive) containers to the container handling system, they must be either horizontal or preferably lean at 1:100 towards the Terminal. The solution was to provide a 4m wide cantilevered slab extending from the Terminal for these interface locations, and to use either transition hinged slabs or *Pavlok* paving beyond this.

15
Truck dock area in Terminal.

Structure

Structurally, the Terminal is relatively simple. Cargo-handling and truck-docking requirements dictated a 10.5m x 13.5m planning grid, enlarged in two areas to 21.0m x 13.5m to accommodate road traffic manoeuvring needs.

From early on, Arup aimed to integrate the structure with the M&E systems, incorporating smoke extract / ventilation / air-conditioning ducts to minimise the building's overall height. Much time was also spent developing acceptable column head / beam details, and minimising structural depths and concrete quantities. One problem encountered on the Kai Tak Terminals had been impact-induced stress cracking of the concrete slabs. Fork-lift operators should lower loads gently onto warehouse floors, but most drop them from well over 150mm. The solution for ST1 was to provide top and bottom anti-crack steel and to design slabs (but not their supporting structure) for 25kPa wherever fork-lift traffic was anticipated. Generally, 40N and 60N concrete was used for horizontal and vertical structural elements respectively. The basement to the south of the Terminal is ground-bearing, and to allow for relative settlement with the piled Terminal building, is connected by two fully articulated connecting services corridors.

The most obviously glamorous parts of the structure are the steel roofing systems over the CSS roadway, the two BSSs and the exhibition area. After prolonged negotiations with the Hong Kong Fire Services Department (FSD) it was agreed that the steel roof over the CSS roadway would have a two-hour fire rating. For the architect's delicate butterfly wing truss concept, intumescent paint on the relatively slender members clearly could not provide the necessary rating, and cladding them with fire-rated board would be singularly unattractive. The only possible solution appeared to be a water-filled tubular system, but clearly the thermal capacity would be inadequate unless the water was circulating. The solution proved simple and elegant: provide sprinklers in the steel tubular structure itself, and connect the whole system to the fire service drencher system. In the event of fire, any activated sprinkler would go on receiving cold water, ensuring that surrounding steelwork remained well below 550°C.

The idea seemed sound theoretically, but the client and a very sceptical FSD had to be convinced.

At the time Arup was reviewing the tender for the Terminal roof steelwork - including the CSS roadway roofs - from Seele Hong Kong, who had already established a reputation for the successful use in Germany and Austria of water-filled tubular steel structures for hot water heating systems in large glazed façades. The parallel was clear, and after brief discussions with the enthusiastic Seele, a quotation for two sample butterfly wing trusses was agreed by Anthony Charter. Arup Fire made arrangements with the UK Loss Prevention Council (LPC), and two units were shipped to Darlington in April 1996, where they were tested and witnessed by LPC and Arup (see Fig 5, p29).

The tests were completely successful - even with the full propane gas fire load, the water temperature in the butterfly wing trusses couldn't be got above 40°C. The system was an inefficient water heater, and FSD's acceptance appeared likely. There was, however, one further obstacle - corrosion; despite Arup R&D's assertion that without oxygen there could be no corrosion, FSD were not impressed. The pragmatic solution was to look at samples of existing pipework in the original Terminal 1 (now over 20 years old): corrosion was virtually unmeasurable and FSD approval was obtained.

The CSS roadway trusses comprise a single bottom chord and two top, acting as a vierendeel with buckling of the top chord restrained by three horizontal 'purlins' between each butterfly wing. The design of the CSS racking structure itself (a separate commission by DEMAG) could adequately resist typhoon / seismic loading-induced moments, but the resulting deflections would have caused unacceptable distress to the external glazed CSS façades. To temper this movement, the CSS roadway trusses were designed as props, transferring the CSS wind / earthquake loads to the main Terminal structure.

The structure over the BSSs, spanning 33m, did not have to be fire rated as it was above a fully-automated unoccupied area, where the public or FSD personnel could not be at risk. Its roof system has a curved bottom chord and is framed conventionally. For architectural reasons the supporting columns are quite slender, and not able to resist the arching thrust of the trusses; to counter this the trusses are fixed at one end, with Glacier sliding bearings at the other.

Depending on operational or recreational requirements, various surface finishes are provided for the horizontal flat roof itself. Essentially, the roof structure is 'upside down'. Directly above the concrete is a liquid-applied membrane (HLM 5000), then a slip membrane, insulation, lightweight screed to falls, sand levelling, and the applied precast concrete / brick finishes. Jeene waterstop systems (developed in Brazil and manufactured in the USA) were used for all roof level expansion joints, and for certain roadway / truck dock locations on Levels 0 and 1.

The Express Centre, though much smaller than its sibling, is architecturally perhaps the most exciting part of the development. Being primarily labour-intensive, the container handling systems had minimal requirements, giving much freer range to the design team's creativity. Fosters' inverted barrel vaults add a brilliance to this facility which a more pedantic and economic approach could not have achieved. The client, however, was not easily convinced, and various schemes - including a steel solution that suffered from potential internal condensation / corrosion problems - were addressed and costed. Fortunately the original concept won the day and the elegant, seemingly light and dynamic, solution was adopted.

Fire engineering

After the constraints of the cargo handling system and the road traffic requirements, this was the next most important design criterion for the whole development. In view of the extremely dense population figures, and the firefighting problems encountered in high-rise buildings, the Hong Kong FSD are understandably conservative. Without the input of Arup Fire, ST1 would have looked very different and cost the client far more.

The gross floor area of each Terminal level is 58 600m^2, and the total enclosed building volume well in excess of 2Mm^3. HK FSD have adopted the pragmatic approach that 28 000m^3 (1Mft^3) is the maximum volume that can be successfully addressed by a firefighting team. Each such volume needs to be physically separated from its neighbour, either by a two-hour fire-rated wall / fire shutter, or by a continuous drencher water curtain - essentially (and theoretically) to contain all fire and smoke emissions.

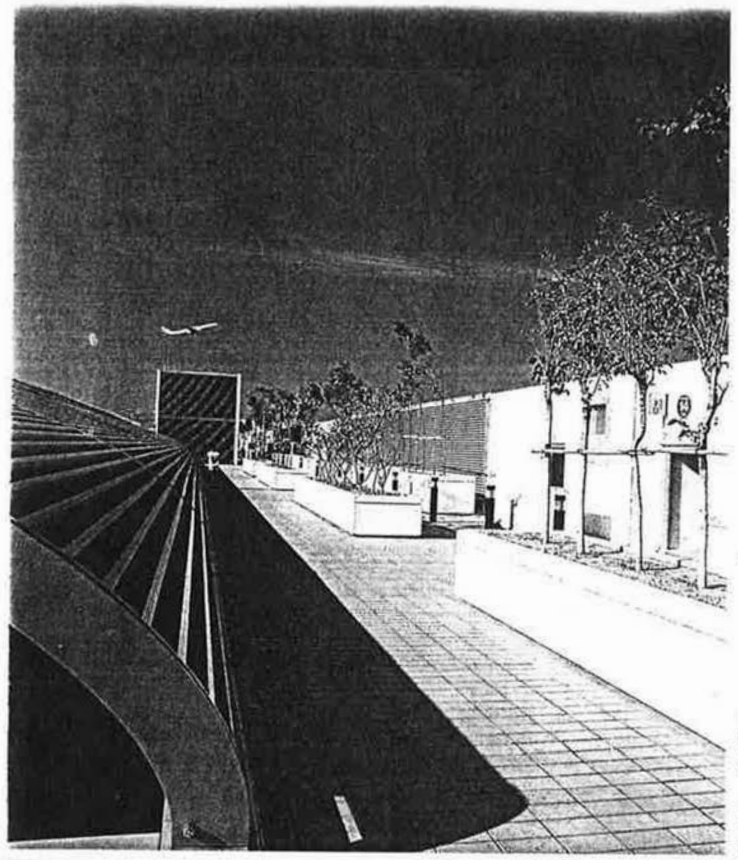
The very nature of air cargo operations requires uninterrupted space and this concept is most important in the CSS and BSS areas where volumes are well in excess of the prescribed provisions. Fortunately precedents had already been established on Kai Tak Terminal 2, which had automatic cargo handling systems with no operating personnel and only short, transient activities by small maintenance teams.
Each CSS, with a volume over five times the normally permissible, theoretically needed protection from adjoining facilities by a two-hour fire-rated separation. This entailed two-hour fire-rated protection to the steel CSS roadway canopies (sic) and to the steel CSS inter-link conveyor bridges - in reality a relatively small price to pay in view of FSD's original requirement for a two-hour fire-rated structure for each CSS, which would have caused the client additional expenditure of S$30M. Essentially, Arup Fire's argument was based on the assertion that the main operational building (ie excluding the north and south offices) was contained within the area E'-T'/2-21.

To meet Building Department and FSD demands, emergency vehicle access to Levels 0 and 1 had to be fully equivalent to access at ground level. This entailed a four-hour fire separation between these levels, and provision of firefighting facilities (particularly hydrants) to ensure that firefighters at Level 1 would be able to treat the fire as if they were approaching it from ground level. This was provided.

Within the Terminal itself, FSD's pragmatic requirement for a 28 000m^3 volume limit for operational areas was achieved primarily through drencher water curtains and fire shutters. Drencher curtains are inevitably extremely hazardous to HACTL's automated systems and sensing equipment; a small fire setting off drencher curtains to a particular compartment could be potentially far more damaging through water than from the fire itself. To counter this, FSD eventually accepted that drencher operation could only be activated by a confirmation of both a heat and smoke detector.

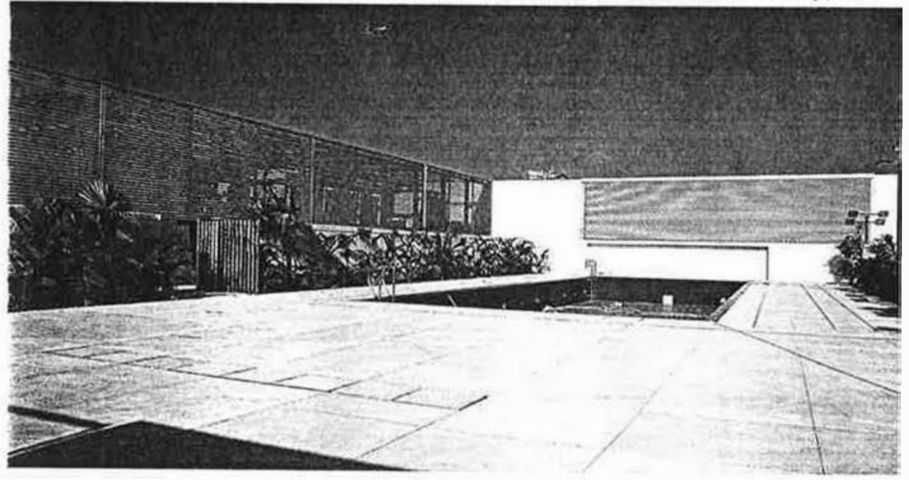
Other FSD issues included provision of smoke extract systems for all occupied areas of the Terminal as well as the BSSs, where FSD were insistent that for political rather than practical reasons firefighters had to be seen to be actively involved, despite the provision of proven in-rack sprinkler systems. For the CSSs and CSS roadways (and for the Express Centre generally), FSD were satisfied that passive ventilation / smoke extract systems were acceptable.

12 fireman's lifts and staircases (with staircase pressurisation) provide firefighting access to all areas in the Terminal, but in view of the Express Centre's relative size and low overall height, it required only one fireman's lift and staircase (without staircase pressurisation).



16.
Part of
roof garden.

17 below.
Rooftop
swimming pool.



Mechanical systems

General

On all levels, air-conditioning / ventilation systems ducts were incorporated into the structural design. Below this structural and air-handling systems zone, the design team introduced the concept (successfully deployed earlier on the Toyota Plant in the UK) of providing two 500mm deep spacial zones for primary and secondary M&E distribution systems.

Later, Arup engineers in London and Hong Kong developed with the architects a planning grid principle in all operational areas that split the building in plan into a series of north-south and east-west running zones. Zones were allocated exclusively to one service - electric traywork, pipework, light fittings, etc. Also a horizontal planning grid was established with all east/west running services installed in the lower spatial zone or within the structural zone and all north/south running services in the higher zone.

Adopting these principles ensured that services clashes during construction were effectively non-existent and the final appearance of all services looks planned, organised, and neat. In office areas, services and structure were again integrated, with all main chiller water pipework, fresh air ductwork, and sprinkler pipework running through cast-in holes and slots in the structural beams. The main services distribution routes to both the offices and operations areas are through two 260m long north/south running service tunnels, each 9m wide x 3m high, located in the basement with 11 vertical services cores directly on top of each basement corridor.

This building presented a myriad of space types to challenge the M&E engineers - from designing services for a snake examination and livestock room at one end of the spectrum to a karaoke room at the other! In addition there are forklift vehicle battery charging rooms, computer suites, the sports centre, and the kitchen, canteen, and restaurant.

The Express Centre was simpler in terms of M&E installations, with minimal air-conditioned spaces and electrically-driven cargo-handling systems. The building is open along both sides on Levels 0 and 1, the client requirement for an open-plan layout helping to ensure that 90% of it could be naturally ventilated. No smoke extract systems or staircase pressurisation systems were required. The services installation is fully integrated into the structure and architecture, with curved sprinkler pipework in slots cast in the roof structure and warehouse-type luminaires flush-mounted in cast-in openings in the roof structure.

Mechanical services

Cost benefit analyses determined that seawater cooling and electrical heating provided the best capital / running cost balance for the client. The building is cooled using five 3.4MW centrifugal seawater-cooled chillers to offset the effects of Hong Kong's high temperatures and humidity. Chilled water is distributed by three variable-speed pumping systems to all office areas at the north and south end of the building and Levels 3 and 4 of the operations area. Office areas are cooled by ceiling void mounted fan coil units connected to perimeter slot diffuser units and internal louvre face diffusers, and the operations areas by small AHUs between beams located 'within' the structure. Elsewhere, large central AHUs with return air fans are used. Fresh air comes via roof-mounted supply units, with heating provided to most of them to offset the 7°C outside winter air temperature. In addition perimeter fan coils in office areas are fitted with heaters. Cooling in computer suites is by floor-mounted, fine-control computer room units with humidity control.

The building also contains three large industrial refrigeration centres (cold room and freezers), the concept and scheme design for which was developed by Arup engineers with the client. Each refrigeration centre has its own refrigeration plant-room and heat reflection plantroom. Screw-type compressors provide cooling with water-cooled condensers, the condenser water being circulated to the building perimeter where it is cooled by fan-cooled radiators. Each refrigeration centre is subdivided into six or seven chillers and freezers, and has an original unique feature whereby some rooms can operate either as a chiller or freezer - done by flicking a single switch in the refrigeration plantroom. Also, all refrigeration rooms are monitored and controlled via the building management system (BMS) where amongst many features, room temperature set points can be adjusted and individual rooms shut down. In general, chiller room temperature is 1°C and freezers are -18°C.

A combined normal and smoke ventilation system is provided in the operations area. Statutory regulations require duty and standby fans, so for normal ventilation it was decided to run both fans at low speed, reducing noise and machine wear and extending fan and water life. In smoke mode only one fan operates, at high speed. In total 68 fans were installed with average capacity of 30m^3/sec.

There is also a specialised truck exhaust fume extract system. Because trucks have to drive into the heart of the building, potentially dangerous gas concentrations must be kept below the maximum allowable safety levels, and to minimize inadvertent actuation of smoke detectors by vehicle exhaust in the truck dock areas. The system comprises a low-level extract duct and grills built into the structure, effectively removing the fumes at source as trucks reverse to unload or load goods.

The Express Centre has simpler ventilation and air-conditioning systems, again with seawater-cooled chillers. Three 625kW units are provided. Fan coils cool the small core office areas, and chilled water is provided to oil coolers on the two enormous dolly train lifts.

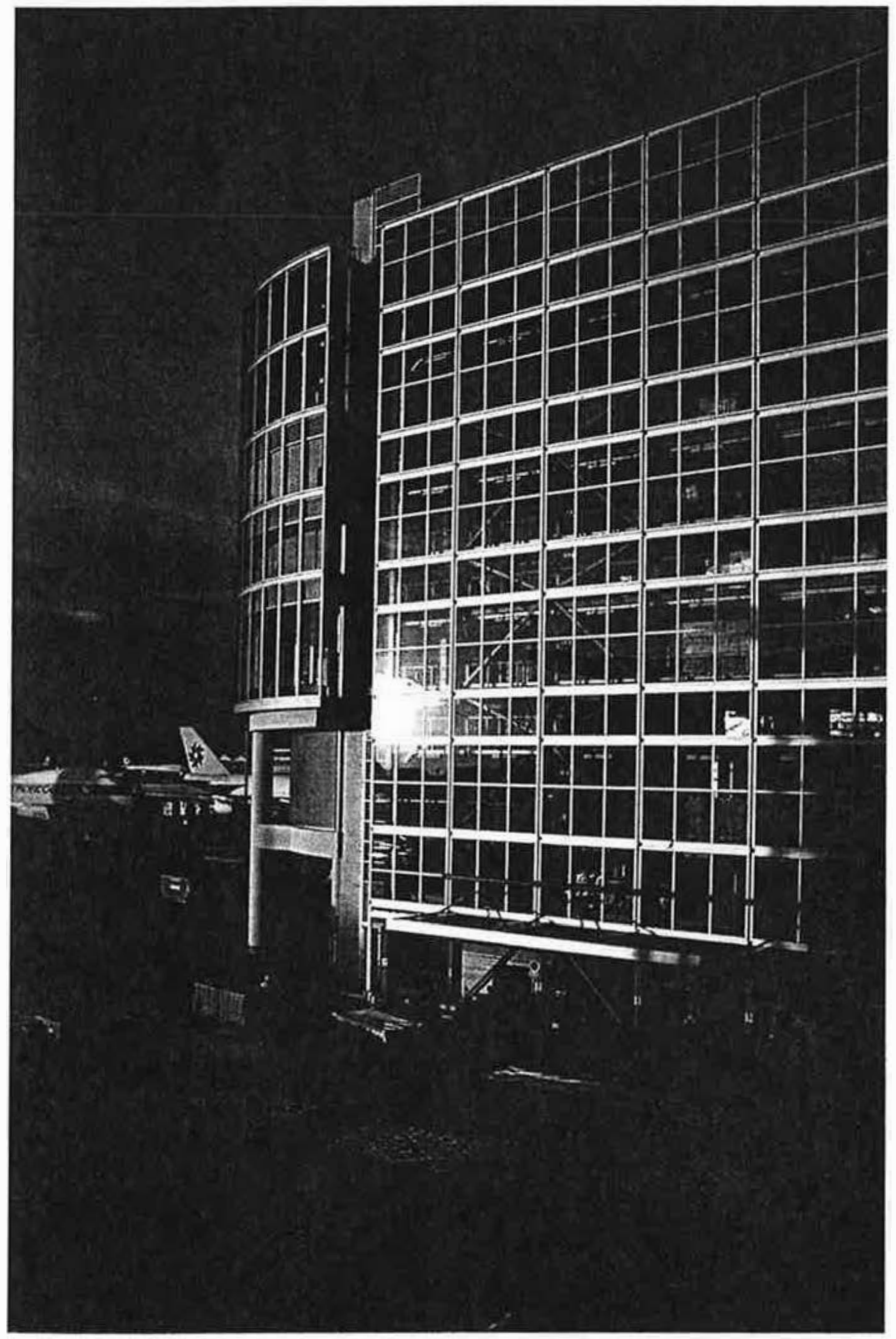
The fire services systems for both buildings comprise sprinkler, drencher, hydrant / hose reel, CO_2 gas flooding, and street hydrant systems inside and outside. The sprinkler system is a 1200m^3 storage tank with eight pumps (duty and standby) serving both the Terminal and Express Centre. The sprinkler classification varied from Ordinary Hazard (OH) category II in office areas to High Hazard (HH) category III in the BSSs. Because of the amount and size of in-rack sprinkler protection needed and the overall size of the building, some 80 000 sprinkler heads are installed. The drencher tank is 550m^3 capacity with five pumps serving both buildings, the system being designed to supply the largest compartment for 30 minutes.

There are also dry pipe systems in computer suites. CO_2 systems are installed in dangerous goods stores and battery charging rooms. During the FSD's inspection a real drencher test had to be carried out, and a 'dry (anything but!) run' was carried out a few days before the inspection to ensure no problems on the big day.

Plumbing and drainage systems in both buildings serve the many shower, toilet, and cleaning facilities. There is also a rainwater recapture system which includes a large tank and pumping system in the basement. The captured rainwater is used to irrigate the large planter areas on the roof.

One significant and not particularly surprising aspect of air cargo terminal operations is the huge amount of waste packaging generated, particularly timber pallets. Previously, subcontractors removed most of this, generally to landfill sites, but HACTL's heightened environmental awareness led to the provision of a purpose-built refuse treatment facility in the basement, converting timber pallets into woodchip, suitable for newsprint, chipboard production, or agricultural requirements.

18.
The Terminal at sunset.



Electrical installation

China Light and Power provide a double-ended supply to the site. Eight substations feed the Terminal and one the Express Centre, through 27 1.5MVa transformers with 40.5MVa of electrical power. Approximately 50% of connected power is dedicated to cargo-handling. For fire or other major emergency, three standby generators are provided with a capacity of 4.5MVa. In addition, HACTL are provided with independent UPS systems for their primary and secondary computer control rooms in the north and south offices respectively.

Early on, copper bus duct was chosen instead of higher voltage distribution via cables with provision of localised transformer stations, primarily on grounds of initial capital savings.

Inevitably, a building of this scale and operational diversity has a vast range of lighting systems. Lighting design expertise from Arup R&D was invaluable in establishing a framework for selecting suitable systems and units for all the external areas and a some within the building. Arup's proposal to use high frequency fluorescent tubes in the offices (to improve one particular aspect of that environment) was, however, not accepted by the client. Much time was spent on the operational floors' lighting systems to find the most efficient and architecturally acceptable solution. Initially eight different systems were considered and tested, but this was relatively quickly reduced to two, based on four 250W units per bay in lieu of the client's preferred two 500W units. The final solution was the GEC *Lowmount 400* luminaire with a 250W fitting.

The Terminal has 14 passenger lifts, 12 firefighting lifts, five cargo lifts and two escalators (in addition to 34 automated cargo hoists), whilst the Express Centre has four passenger / cargo lifts and the two large dolly train lifts. The design of the latter, with their full 22 tonne load, was a project in itself.

Finally, and perhaps most important, are the BMS / AFA (automatic fire alarm) / SAC (security alarm control) group of systems. The BMS is easy to comprehend, but not easy to effect. AFA is statutorily essential, and critical to gaining a temporary occupation permit (TOP).

SAC, however, was a much greyer area. Security for HACTL is a key issue; statutory requirements insist on clear egress from any point of the building, but HACTL - dealing essentially with high value cargo - must restrict unauthorised access to many areas and preclude egress of small but dutiable or illegal items. This is achieved by massive CCTV networks and AFA interlocked systems, allowing free escape in fire but minimising illegal infiltration. In the early stages it was decided that BMS / AFA / SAC would be let as one subcontract (to Honeywell), as they were closely interdependent.

Testing and commissioning the M&E systems was an enormous task. The main building contractor appeared either unwilling or unable to offer this overall service, and after prolonged negotiation with the client it was finally agreed that Arup would additionally test and commission, and a team of engineers came to Hong Kong. For a building as apparently (initially) simple, an experienced team of testing / commissioning engineers was essential. The team provided both a management and a hands-on role and was assisted by all the services subcontractors' teams.

Reference

(1) DILLEY, Philip *and* GUTHRIE, Alistair. Kansai Airport Terminal Building. *The Arup Journal*, *30*(1), pp14-23, Spring 1995.

Credits

Client and project managers:
Hong Kong Air Cargo Terminals Ltd
Lead consultant, engineering design, building project management, supervision and testing/commissioning:
Ove Arup & Partners
Architectural consultant:
Foster and Partners
FSD consultants:
Loss Prevention Council
Quantity surveyors:
Levett & Bailey
Main building contractor:
Gammon-Paul Y JV
Cargo handling systems contractors:
Mannesmann Demag Fordertechnik
Murata Machinery Ltd
Piling contractor:
Vibro/B+B Construction
Key architectural subcontractors:
Josef Gartner (vertical cladding)
Seele (roof steelwork and cladding)
Key M&E subcontractors:
Honeywell (BMS/AFA/SAC systems)
Schindler (lifts/escalators)
Young-Drake & Scull (electrical/MVAC installation)
Illustrations:
1: Mike Harley
2: Foster and Partners
3, 4: Jennifer Gunn/Sean McDermott
5: Ove Arup & Partners
6-18: Colin Wade