Hong Kong International Airport—construction

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The new Hong Kong International Airport was built on a remote island site at Chek Lap Kok in just seven and a half years. This paper describes how construction progressed from the initial advance works contract awarded in January 1991 to the opening of the completed, state-of-the-art airport and its massive 515 000 m² terminal building in July 1998. It details the HK\$ 44 billion package of contracts let by the main client, the Hong Kong Airport Authority, and the methods of construction management used to ensure safe completion both on time and within budget. It also addresses the unique construction support facilities and services which were provided by the Authority to support the 21 000 people working on site during the peak construction phase.

On 29 November 1995 the airport committee of the Sino-British joint liaison group signed agreed minutes on membership of the Hong Kong Airport Authority (AA), which paved the way for establishment of the AA on 1 December 1995. Prior to this, the planning, design and construction had been progressing on a phased basis under the auspices of the provisional airport authority (PAA) to complete the airport to the maximum extent possible by June 1997.

Any civil engineering project evolves on a logical progressive basis. The airport project evolved over the years by taking account of, not only engineering logic, but also the incremental release of funds to the PAA as the project progressed. This

step-by-step funding had a significant influence on how the construction strategy developed. This paper follows the chronology of construction contract awards and sequence of construction.

The airport is one of the ten projects that together make up the government's Airport Core Programme as described elsewhere in a companion paper.¹ The factors which influenced the design of the various airport facilities are also described in a companion paper.²

A list of all significant contractors employed in the construction of the airport project is given in Appendix 1.

Fig. 1. Project construction programme

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Budget and programme

Construction of the airport was initially based upon the recommendations of the *New Airport Master Plan*.³ This envisaged a construction programme starting at the beginning of 1992 with a target date for opening of mid-1997, together with a costed implementation programme which set the project budget control total. It was not possible to implement fully these plans until the PAA was reconstituted as the AA in December 1995. In 1996 the government announced the new airport would open in April 1998, and at that time the construction programme was revised and the costed implementation programme was updated. The construction programme (Fig. 1) was implemented in five phases

- advance works
- site preparation
- initial contracts
- main works
- integration and trials.

Advance works

Advance works contract (AWC)

In 1991 the project site comprised two islands. The larger one, Chek Lap Kok (302 ha), was inhabited by three fishing villages and the smaller one, Lam Chau (8 ha), was uninhabited. Following rehousing of the villagers, an advance works contract was awarded in January 1991. The purpose of this contract was to provide basic infrastructure on the otherwise barren island of Chek Lap Kok. This was done by removing the tops of the three highest hills from +120 m PD (project datum) to form plateaux at about +95 m PD. The material arising from this was used to reclaim a bay to +6 m PD, which is about 4.7 m above mean sea level, in the north-east corner (Fig. 2). Here a heavy-duty quay wall was built together with a pair of 1 MW electricity generators, a potable water treatment plant, raw and sea-water distribution systems, offices, accommodation blocks and a canteen. This was sufficient to provide facilities to support the AA's own staff and the site preparation contractor's workforce during the intensive mobilization period.

The award of the site preparation contract (SPC) was delayed by seven months due to funding difficulties but work was able to continue on a step-by-step basis by utilizing the dredging resources of the advance works contractor. A completion certificate was issued for the AWC on the same day that the site preparation contract was awarded on 30 November 1992.

Pre-ordered earthworks plant

It was also recognized that the site preparation contractor would require a significant amount of large-scale earth-moving plant. This was not readily available on the world market and purchase of such equipment would have taken up to 6 months

to manufacture and deliver.

The duration of the SPC was not sufficient to allow such a lengthy mobilization period, so the AA decided to buy some new plant which was novated to the successful SPC tenderer. This pre-ordered plant comprised 17 Caterpillar 785 dump trucks (136 t payload), four Demag 285 hydraulic face shovels (19 m³ bucket capacity) and six Ingersoll-Rand DMM2 hydraulic drill machines (250 mm hole dia. capacity). All this plant was delivered, tested and commissioned on site before the SPC was awarded (Fig. 3).

Site preparation contract (SPC)

Six joint ventures were prequalified and invited in November 1991 to submit bids to undertake the site preparation works. The scope of the works was to form a platform at about +6.5 m PD, which was 1248 ha in size with a perimeter about

Fig. 2. (top). Chek Lap Kok and Lam Chau islands at the time of the advance works contract (February 1992).

Fig. 3. (above). Demag 285 shovel and Caterpillar 785 truck assembly on site as part of the pre-ordered plant (October 1992)

17 km long. The works would involve dredging about 60 Mm³ of unsuitable marine mud, removing about 95 Mm³ from the island of Chek Lap Kok, Lam Chau and the two Brothers Islands and placing the material in reclamation, and importing and placing about 86 Mm³ of marine sand. All work had to be completed within 31 months of the award of contract.

When tenders were returned in March 1992 they were significantly above the AA's budget and parallel tender estimate. A way had to be found for the AA to become less dependent on the world's limited resource of trailer dredgers. This was done by inviting tenderers to submit alternative tenders based on the use of a land borrow area (instead of importing marine fill) and increasing the contract period to 41 months. The alternative tenders were submitted in June 1992 and were within budget and found to be competitive. The PAA did not have funds available to award the contract but a letter of intent was sent to the lowest and conforming alternative tenderer in July 1992. The contract sum was HK\$ 9.1 billion. During the interregnum the AA negotiated extensions to the scope of works with the advance works contractor so that critical work to remove marine muds could continue.

The joint-venture contractor was able to mobilize quickly using the facilities provided under the AWC and the pre-ordered earthworks plant. The joint-venture also had fully developed its sub-contracting strategy during the tender period. The contractor was therefore in a position to award major sub-contracts quickly for the dredging works, land excavation works, seawall construction and geotechnical instrumentation works. Large earth-moving plant of the scale demanded by the SPC had never been used in Hong Kong and it was necessary to bring skilled workers from overseas. The Hong Kong government had introduced a special labour importation scheme whereby contractors could bring workers from overseas for fixed-term contracts to assist the construction of the Airport Core Programme projects. The first of these arrived in February 1993 to coincide with the start of production work on site.

The first task was to remove the unsuitable marine muds from the sea-bed to expose alluvial material which had a net cone penetration test tip resistance of more than 500 kPa. The depth of water varies from zero, adjacent to Chek Lap Kok and Lam Chau, to 15 m in places. The average thickness of mud which had to be removed was 8 m, increasing to 15 m in places. Most of the mud had to be taken to the government marine dump south of Cheung Chau some 40 km away from the site. Grab dredgers had to be used in shallow waters. More economical trailer suction hopper dredgers (Fig. 4) were used in waters where the depth exceeded 5 m. At peak production 10 trailer dredgers were used for mud removal. These varied in hopper capacity from 2500 m³ to 14 000 m³.

Table 1. Typical Chek Lap Kok drill-and-blast parameters

Drilling-and-blasting parameters (primary)	Quantity	Units
Chek Lap Kok drill quantity	65.3	Mm ³
Annual drill requirement	24.0	Mm ³ /year
Hole diameter	216	mm
Bench height	15	m
Typical drill pattern	6.5 x 7	m x m
Drill penetration rate	23	m/h
Drill productivity	850	m ³ /h

During a 36 month period a total of 70 Mm³ of mud were removed from site, with the maximum output of 14 Mm³ in one month.

The land-based earthworks was sub-contracted into two approximately equal parts. The sub-contractor in the northern half adopted a philosophy of using a mixed fleet of new and old trucks of varying capacity but with a restricted speed limit. The sub-contractor in the southern part used a single size fleet of new trucks operating at a higher speed limit. Therefore, the two sub-contractor's operations were physically segregated to avoid safety problems that would have been associated by mixing the two philosophies. Consequently, the safety record was good although there was regrettably one fatal accident involving a haul truck.

The joint venture sub-contracted the supply of explosives. This sub-contractor provided a down-the-hole service to the two earthworks sub-contractors. Packaged explosives and detonators were issued from a site-based magazine under the supervision of the mines division of the Hong Kong government. Ammonium nitrate and fuel oil (ANFO) was manufactured in an emulsion plant on site and delivered to the face by 12 t capacity mix-and-place trucks. The geology of Chek Lap Kok is highly variable and therefore each blast had to be uniquely designed. Where 13 m benches were formed drill holes would be 216 mm dia. with 2.0 m sub-drill, 9 m of explosive column and

Fig. 4. The J.F.J. de Nul trailer suction hopper dredger working at Chek Lap Kok in 1994—the largest capacity dredger in the world at the time.

6 m of stemmings produced from drillings. Typical blast parameters are given in Table 1. Explosives weighing 25 t would yield about 50 000 m³ of product and explosive consumption was 80 t/day on average. A daily feature was the shot firers' meeting when all parties would send a representative to be briefed about the blasts that had been designed and planned for the following day. There were two blasting periods; one at lunch time and the other being at the shift change at the end of the day before dusk. The blast evacuation zone was generally 500 m. There was not one injury from a blasting accident throughout the whole contract.

The product was categorized at the face into one of three gradings of material. Type A material was rock of particle size of 2 m or less. This material was taken and end-tipped on the alignment of the southern runway zone. Type B material was decomposed rock of which 100% was less than 300 mm in size. This material was end-tipped in areas at which it was anticipated that buildings would have to be constructed on piled founda-

tions. In practice it was found that much material was generated which did not fall into one or other of these specified gradings. It was inevitable that a mixture of these two sorts would arise due to the variable geology. This material was classified as type A/B and a pragmatic approach adopted whereby the contractor was allowed to place unprocessed type A/B mixtures in those areas where it was not essential to use either type A or type B. The bulk of material was end-tipped into the sea but in areas where the factor of safety of the advance face was less than 1.1 it was necessary to place a blanket of material in advance by using bottom-dump barges. Soundings were taken in front of the advancing tip faces to ensure that mud waves were not building up.

Seawalls were constructed in parallel to reclamation works. Dredging to a specified minimum level or minimum CPT value of 680 was carried out using grab dredgers which removed a total of 9 Mm³ of mud. A total of 2.1 km of vertical seawalls were made from concrete blocks and 12 km of sloping seawalls constructed using rock products aris-

Fig. 5. Sham Wan village—one of three accommodation camps constructed to house the workforce living on site and Chek Lap Kok (May 1996)

ing from Chek Lap Kok. Filter layers and armour rock was processed by taking product from the blasted face and sorting using a combination of grizzly screens, back hoes and grapples. The sorted products were then loaded on to barges and towed to the site and placed by grab barges.

The contractor's alternative tender was based on the importation of marine sand to provide the balancing quantity of material required to complete the platform. This was done using four borrow areas at the Brothers Islands, east of Sha Chau, Urmston Road and Ninepins. A total of 46 Mm³ of overburden mud had to be removed so as to expose suitable filling material. A fleet of up to 18 trailer dredgers (Table 2) worked continuously for 20 months delivering material 24 hours a day, 7 days a week. This was known as the 'sand train' and it delivered a total of 86 Mm³, some of which was dumped in its final position, some was re-handled by cutter dredger and some was pumped ashore.

When dealing with such very large quantities of material it is essential to monitor progress rigorously to ensure programme objectives are being achieved. This was done using state-of-the-art computer survey techniques. Hydrographic surveys were carried out utilizing the AA's own dedicated survey launch operating independently of the contractor's own survey units. Land excavation and reclamation was surveyed by aerial photographs which were scanned to produce orthophotos and digital terrain models from which volumes and areas were readily calculated.⁴

The final account was settled for a sum within budget some 37 months after award of contract which was four months before the planned contract completion date. This success was due to a number of factors where the AA and the contractor worked together, such as

- high technical and managerial skills
- overall quantities were not varied from those initially contracted
- continuity of work for the dredgers and earthworks plant
- pragmatic utilization of land-based materials 'as dug'
- quick and accurate volume surveys to monitor progress.

Construction support

The airport at Chek Lap Kok had characteristics that were unique in the history of construction industry of Hong Kong, some of which are

- it was an offshore site
- it was remote from the urban areas
- no infrastructure or municipal services were available
- a workforce in excess of 21 000 existed
- overfull employment in construction industry was predicted

Table 2. Trailing-suction hopper dredgers used at Chek Lap Kok

Trailer	Hopper capacity: m ³	Mud: Mm ³	Sand: Mm ³	Total: Mm ³
J.F.J. de Nul	11 750	7.1	8.1	15.2
Lelystad	10 330	4.0	6.2	10.2
Vasco Da Gama	10 156	7.8	0.2	8.0
Volvox Hollandia	9000	5.1	9.8	14.9
Prins der Nederlanden	8960	11.2	0.5	11.7
Geopotes 15	8825	2.3	3.2	5.5
Geopotes 10	8645	7.7	18.1	25.8
HAM 310	8225	4.4	14.2	18.6
Delta Queen	8128	4.1	6.1	10.2
Cornelis Zanen	8000	5.3	3.3	8.6
Barnet Zanen	8000	1.9	7.1	9.0
Volvox Delta	8000	minor	quantities	
Volvox Hansa	6000	8.8	0.1	8.9
Rigelstar	6000	3.9	9.0	12.9
Sanderus	5000	6.5	0.0	6.5
Apollo	4850	9.4	0.0	9.4
Johanna Jacoba	4100	1.1	0.0	1.1
Coronaut	2500	7.1	0.0	7.1
Total		97.7	85.9	183.6

Table 3. Construction support facilities

Facility	Quantity
Vertical seawall	2.1 km
Marine cargo handling areas	5
Roll-on/roll-off berth	1
Ferry pier for 1500-seater boats	1
Small boat harbour	1
Pontoon landing points	4
Transshipment centre on the mainland	1
Electricity supply at 11 kV	21 kVA
Electrical distribution system	18 km
Electrical sub-stations	33
Raw water distribution system and storage system	20 km
Potable water treatment plants	2
Sewage collection system, screening plant and submarine outfall	1
Accommodation camps capable of accommodating people in three classes of room together with village support facilities (Fig. 5)	3
Number of beds in camps	8400
Area canteens	5
Fire stations	2
Cottage hospital	1
Bus terminus	2
Paved roads	25 km
Stormwater drainage system	20 km
Rock suitable for crushing into aggregates	8 Mt
Helicopter pad	3

- its reliance on large numbers of imported workers
- there was a multitude of contractors working for many developers.

The AA chose to manage these factors positively and not merely allow contractors to fend for themselves. This was done by the AA constructing facilities and providing services which collectively were known as 'construction support' and the AA in effect became a management contractor who provided primary services to all contractors, developers and other third parties working on the project site. These services were provided by the AA when it was better placed to do so than contractors for reasons of economy of scale, safety and timeliness of availability. Construction support facilities that were provided are shown in Table 3.

The AA provided the following services free of charge to contractors which resulted in lower tender prices for construction contracts

- a project site security system and personnel for identifying and screening all personnel arriving at the site
- a docking and marine cargo handling management system
- fire fighting and emergency rescue team available 24 hours a day, 365 days a year
- advice on safety, environment and industrial relations matters
- cleaning and maintenance of common areas.
- a chartered ferry service which delivered up to 12 000 workers to the site by boat daily (Fig. 6)
- a rock crushing licence to sell 8 Mt of crushed rock product
- two ready-mixed concrete batching plants

Fig. 6. Ferry and bus interchange for construction workforce daily commuters (May 1996)

The AA awarded a number of construction support licences (Appendix 1) following an open competitive tendering process. The successful licensees were able to sell goods and services at controlled prices. Generally, construction contractors were not compelled to use these services but could set up their own facilities (but not sell to others) if they chose to do so. Thus healthy competitive markets were established on site. The following licences were awarded

- two workforce accommodation camp operation and catering licences
- a primary health care service staffed with doctors and registered nurses
- two fuel suppliers
- a materials testing facility
- a waste disposal service
- a land transportation service
- printing services.

In addition, construction support provided assistance to the AA's own project staff thus relieving them of this burden so as to concentrate on their core mission of construction of the permanent works. Such support included the following

- operating and maintaining the AA's marine fleet of 14 vessels
- operating and maintaining the AA's fleet of 200 land-based vehicles
- maintaining the AA's portfolio of 100 site buildings
- operating and maintaining 200 radios and mobile telephones
- providing an escort service and logistics support to up to 2000 visitors who visited the construction site weekly.

Construction contract packages

The framework for the contracting strategy was based on the *New Airport Master Plan*. There were four groups of developers which were responsible for the various construction contracts which comprised the overall airport project (Appendix 1)

- the AA
- the Hong Kong government
- the aviation franchisees
- the commercial partners.

The largest developer on the project was the AA. It had to provide a passenger terminal building, one runway together with associated taxiways and aprons, a road expressway, a railway corridor, a primary and secondary road distribution system, utilities, storm water systems, waste and grey water systems, communications systems, sea-cooling water systems and a ground transportation centre. The budget of design and construction of the AA's direct works was established in February 1994 at HK\$ 44.447 billion and was never changed.

The Hong Kong government was responsible for the design and construction of the

- air traffic control complex
- government flying service facility
- air mail centre
- regional police headquarters
- landside fire station.

The government works department responsible

for the design and construction contracts was the Architectural Services Department (ASD). The Authority was responsible for management of co-ordination issues and interfaces and the provision of construction support services to ASD's contractors. Liaison with ASD was via the AA's representative and his delegates.

Franchisees were responsible for the design and construction of various aviation-related facilities which were essential to the operation of the airport and in which private enterprise was willing to make an investment. These facilities comprised

- two air cargo handling facilities
- three aircraft caterers
- one fuel delivery, storage and hydrant distributor
- a base maintenance operator
- three line maintenance operators.

Again, the AA's construction management role was primarily one of co-ordination and interface management. This was quite substantial as each site was an island within an island which had to form a cohesive whole. Each franchise agreement included a construction schedule which was administered by an AA representative who had powers to instruct variations, value such variations and award extensions of time to the franchisee. The franchisee entered into construction contracts with its own contractors.

Other business partners provided airport-related services; many of these were not essential to be in place before the opening of the new airport but were vital for its commercial success. Such enterprises included an hotel, airline headquarters, a freight forwarding centre and over 120 retail tenancies in the terminal building. These agreements also contained construction schedules and details of designated AA representatives who had similar powers to those in the franchise agreements.

The contracting strategy was continually adapted as funds were released to the PAA under the step-by-step financing arrangement which continued until both the government's financial support agreement was in place and the AA itself was properly established in December 1995. This meant that contracts were funded and awarded on a just-in-time basis in order to preserve the date for airport opening. This stop-go scenario, where contracts were awarded on a stand alone basis, was both more complex and more challenging to the AA than if the whole project could have been financed and planned as a total entity. This can be illustrated by the terminal building which was designed, and tender packages prepared, on the basis of four major components

- the structural and builder works
- the building services

- the fit-out works
- the communication systems.

In the event the terminal building was contract-ed quite differently with

- a foundations contract
- a superstructure contract
- the building services contract
- over 20 direct or nominated sub-contract fit-out packages
- nine direct systems contracts.

Initial contracts

There were five contracts which were awarded early as it was envisioned that these needed to be brought to an advanced stage at the earliest opportunity, either because they had a long period for offshore development and manufacture or their site works had a significant impact on other works. The first contracts to be awarded following the SPC were the automated people mover and the baggage handling systems contracts. Both systems had to be developed to meet the unique demands of Chek Lap Kok and both

required a long offshore manufacturing phase. It was also important to award three civil works contracts early. The airfield tunnels were needed to take aircraft servicing vehicles under the southern runway, and it was necessary to award this contract in advance before the design of the runways and taxiways was complete (Fig. 7). Similarly, it was necessary to award an early contract for the construction of 25 km of storm water culverts. These were obviously in the deepest excavations on the site and had to be installed first. The third contract was to build a primary electrical substation for the electricity supply company—permanent electricity distribution was needed early for testing and commissioning the electrical equipment.

The construction packaging strategy was developed based on three main factors

- engineering discipline
- system or structural completeness
- geographical location.

The AA's general conditions of contract have a project manager (who is an AA employee) to

Fig. 7. Eastern vehicular tunnel being constructed beneath the southern runway (December 1995)

Fig. 8. Completed passenger terminal building foundation and start of superstructure columns (September 1995)

administer each contract impartially. The duties and powers of the project manager are loosely based on those of the engineer under the Institution of Civil Engineers *Conditions of Contract*. The individual contracts were allocated to one of three project managers depending on the predominant engineering discipline of civil works, electrical and mechanical works or building works. Contracts were also sensibly packaged so that wherever possible a whole system would be the complete responsibility of a single contractor. Finally, the whole of the site was divided into four major geographical areas and a major contract was awarded for each of these, namely

- the terminal building
- the airfield works
- landside infrastructure works
- the ground transportation centre works.

Each of these geographical areas was under the control of one of the AA's construction managers, who in turn reported to a project manager. The construction manager was responsible for all co-ordination issues arising from all contractors with-

Fig. 9. Roof module fabrication yard showing paint shop in centre and assembly jigs to the right (April 1996)

in the geographical area notwithstanding the contractor was in contract with the AA itself, the government or a business partner. Each geographical area had in the order of about 20 main contractors.

Terminal building

The contract to build the foundations of the terminal building was awarded in June 1994. The works comprises 460 bored piles, 450 driven H-piles, 2600 tension anchors, a 280 m long multi-cell tunnel 36 m wide by 10 m high, 50 000 m² of ground slab and associated cast-in services (Fig. 8). The terminal building is located on the shoreline of the original island of Chek Lap Kok and extremely variable ground conditions were encountered. This resulted in variations to the design to the foundations as the works progressed. The original duration of the contract was set at 11 months but extensions of time were awarded and the actual construction period extended to 19 months.

In January 1995, the contract was awarded for the construction of the remainder of the passenger terminal building (PTB). At HK\$ 10.1 billion it was the highest value contract awarded in the

whole of the Airport Core Programme; however, it should be noted that almost 50% of this total was for prime-cost sums for sub-contracts to be awarded later once funding was available. The contractor was a joint venture comprising companies from the UK, the People's Republic of China, Japan and Hong Kong. The contract also included options for a scheme to widen the concourses, which increased the gross floor area from 490 000 m² to 516 000 m², and these were exercised within 28 days of the award of contract.

There was a relatively long mobilization period while the joint venture procured special table formwork, awarded sub-contracts for concrete works and obtained visas for imported workers. The first permanent works concrete was placed in May 1995 and peak production rates of 10 000 m³/week was achieved in December 1995. Ultimately, a total of 240 000 m³ of concrete was placed by the time concreting operations were completed in December 1996. By civil engineering standards this is not an exceptionally large amount of concrete but the total number of pours was in the order of 10 000 and gives some idea of the complexity of the building, and good planning

Fig. 10. Roof modules being placed in the passenger terminal building (July 1996)

was required to achieve these production rates. All concrete was provided using on-site batching plants and using Chek Lap Kok aggregates. The quality of the concrete was of a high standard and the great majority was fair-faced concrete with a painted surface coating.

One of the more technically challenging parts of the contract was the fabrication of the steel frame for the roof of the PTB. The roof structure was designed to be formed from orthogrid space frames forming barrel-vault modules designed to span 36 m from column to column. The bottom flange of each beam is exposed in its final condition and this architectural requirement imposed engineering constraints on the size of the frame members. It meant that the width and depth of every beam had to be the same and varying loads could only be catered for by varying the flange thickness. This meant that the quality of fabrication and welding had to be of a high standard. Steel for the roof was fabricated in England and Singapore prior to receiving a first coat of paint before being shipped to Hong Kong, where it was assembled. The contractor set up five jigs on site, the largest one being capable of holding a 36 m x 54 m long module with the rise on the barrel vault being 6 m (Fig. 9). The smooth-flowing alignment of the geometry of the roof demanded good dimensional tolerance control. The average

cycle time for the main assembly of a module was 23 days followed by six days for painting. A completed module was lifted from the jig by a 1000 t crawler crane and placed in an adjacent paint shop where it received two coats of white epoxy paint. The crane lifted it from the shop and placed it on two harnessed pairs of multi-wheeled trans-

Fig. 11. (below and bottom). Roof module being transferred into position using launching beams traversing to the centre of the passenger terminal building (July 1996)

Fig. 12. Roof of passenger terminal completed and weather-tight (June 1997)

porters, which took it to store where it was fitted out with purlins, roof sheeting, walkways and skylights.

In total 136 modules were assembled, each weighing anything between 40 and 140 t. The first module was lifted into position on 31 December 1995 using another 1000 t crawler crane (Fig. 10). A beam launcher supported by temporary towers was used to move modules laterally into the centre of the building where they could not be placed directly using the large cranes (Fig. 11). Individual members were then welded *in situ* to

form a stitch between adjacent roof modules. The final module was lifted into position on 23 December 1996.

The roof covering comprised layers of metal decking, cementitious boarding to provide a sound insulation layer, thermal insulation, a vapour barrier and two layers of PVC waterproof membrane (Fig. 12). The perimeter of the building was then glazed at departure level and a proprietary panel cladding system was fixed at arrivals and apron levels.

There are 38 frontal gates which comprise a

Fig. 13. Roof cantilevering 36 m out from the passenger terminal building to cover the departures forecourt

Fig. 14. Check-in area
(December 1997)

bifurcated fixed link to separate arriving and departing passengers, each connected to pairs of apron drive airbridges. The fixed links were fabricated and erected *in situ* whereas the apron drives were manufactured offshore and brought complete to Hong Kong.

The building services contract was awarded on 30 January 1995 on the same day as the passenger terminal building contract. At HK\$ 1.88 billion it was reputed to be one of the largest single building services contracts ever awarded. The works comprised four major disciplines of electri-

cal, ventilation, fire and hydraulic services. These two major contracts were awarded on the same day because of the close dependency of one upon the other, both as to the need for the works to progress in parallel and for each contractor to assist the project manager to co-ordinate the design and construction of the works.

The tendering of nominated fit-out sub-contracts was delayed because funding was not available until the AA was established in December 1995. This resulted in the AA not being able to nominate the first packages until May 1996, at which time the contractor objected to the nominations collectively because of the lateness and their incompatibility with his own contract programme. This impasse was broken by the AA negotiating terms for the withdrawal of the notice of objection. These included a commercial settlement for all claims submitted up to July 1996 and agreement to work to a new programme to completion which would ensure an April 1998 airport opening date. A supplemental agreement was signed by the AA and the contractor in September 1996 which settled these matters. It was necessary to negotiate concurrently a separate agreement with the building services contractor to ensure both would be working to the same programme to completion.

Ultimately there were 22 nominated sub-contracts, two domestic sub-contracts and eight direct contracts for what were all originally included as prime-cost sums in the passenger terminal building contract. These, together with the

Fig. 15. Dynamic compaction roller

12 other direct contractors working for the AA in the PTB, gave the project manager's team an enormous task to carry out his duty to co-ordinate the design and construction activities of all contractors. For example, the nominated sub-contractor for the internal metal walling in public areas had to be given all the interface requirements by the project manager who gathered the information from all other contracts before the design of the panelling design could be finalized and be released for offshore manufacture. Some idea of the magnitude of this problem can be imagined when the total length of wall cladding to be installed under this package was over 40 km. The fit-out works were substantially complete by February 1998 (Figs 13 and 14).

Airfield works

The contract for the airfield works was awarded in the sum of HK\$ 2.4 billion on April 1995. The major works comprised the construction of the southern runway (3800 m long by 60 m wide), three parallel taxiways, two cross-field taxiways, the passenger aircraft aprons and the cargo aprons, giving a total paved area of 370 ha. The runway had to be complete within 17 months to allow instrument landing system calibration flights to start in November 1996 to match the programme for commissioning the overall air traffic control systems for the new airport.

The site preparation of the runway area had been left unprofiled and in flat platforms compacted to 95% standard Procter dry density. The first operation was to profile the earthworks by relocating 2 Mm³ of material and improving the density to 95% and 98% modified Procter dry density to depths of 2 m and 300 mm, respectively. The

earth was re-handled by using a mixed fleet of self propelled scrapers and articulated trucks loaded by back-hoes. Compaction of the marine sand was achieved by using up to 40 passes of a 20 t high-energy impact roller towed by four-wheel drive tractors (Fig. 15). The final compaction was carried out by watering and four passes of a towed 15 t vibrating roller. All formations were proven by the passage of a pneumatic-tyred 200 t proof roller, which simulated the maximum aircraft wheel loadings.

Runway pavement construction comprised a 400 mm thick layer of crushed aggregate base course (CABC). The specified minimum 10% fines values of 180 kN for this material could not be guaranteed from the aggregates arising from Chek Lap Kok, and the contractor had to import 3 Mt of aggregates from China to produce the CABC and other materials requiring this higher quality aggregate. The contractor set up a marine aggregate unloading facility to handle materials brought to the site by barge. From there the aggregates were blended to the right proportions using one of three pug mills, each having the capacity to process 200 t/h of material. The pug mills loaded product into the back of articulated dump-trucks which delivered the CABC to pavers which spread the material in specified thickness which were compacted using vibrating rollers.

The contractor set up a hot mix asphalt plant on site which had a capacity to produce 200 t/h, which was delivered to three paving machines. The total quantity of asphalt placed was 480 000 t and the maximum production recorded in a seven-day period was 12 000 t.

The third form of paving employed was concrete block paviors which were used where con-

Fig. 16. Southern runway viewed from the west (August 1997)

crete stands were required in areas of high residual settlements on reclamation. The blocks were manufactured in China to a strict tolerance so that the gaps between blocks were 2 to 4 mm to ensure good interlocking properties. The total quantity of blocks placed was 400 000 m² and the maximum production achieved in a seven-day period was 8000 m². Outputs were very significantly lower than this in times of rain and also where the areas were small, irregular in shape or had inserts such as manholes.

The runway contractor was also responsible for the fuel hydrant and distribution system works. This comprised 18 km of 600 mm dia. pipework with 13 mm wall thickness. Pipes were manufactured in 10 m lengths in the USA and sprayed internally with epoxy coating and wrapped with protective tape externally in Malaysia. The pipes were welded together at the side of the trench and then lowered into position following X-ray inspection of every weld. The whole system was charged with aviation fuel and tested to a pressure of up to 28 bar.

The main contractor was also responsible for the airfield ground lighting, the high mast light-

Fig. 17. Road and rail approaches to the ground transportation centre (December 1997)

ing and the grassing works. The ground lighting contractor had to co-ordinate closely the installation of the base cans, which house the lights, into the sub-base works as this proceeded. The asphalt was then placed before coring at the location of the cans and the light fitting installed. There were 7000 lights in the contract which were wired in series on a constant current with voltage up to 6000 V.

The first aeroplane to land on the new runway touched down on 20 February 1997. This was followed by a daily test plan whereby a Federal Aviation Administration aircraft made a series of landings, flights and takeoffs to test the air traffic control systems installed and operated by the Civil Aviation Department (Fig. 16).

Ground transportation centre

The passenger terminal building and the air-field works are used to process and transport people who are travelling by air. There is an equal challenge to process and transport people on the ground; at Chek Lap Kok this is done at a ground transportation centre immediately adjacent to the passenger terminal. This allows people to arrive

and depart by high-speed train, by private car, by taxi, by tour coach or by bus. All these works were awarded to a single contractor on 1 January 1996 following the completion of a separate contract for the piling works.

The design and construction of the railway works on Chek Lap Kok were entrusted to the AA by the Mass Transit Railway Corporation (MTRC), which was responsible for the design, construction and operation of the whole of the new airport express railway. The railway station itself was of reinforced concrete and built on three floor levels with a concrete roof covered by aluminium cladding (Fig. 17). Passengers are enclosed in an air-conditioned environment by a curved glazed atrium and are able to walk across bridges and ramps to and from the passenger terminal building protected from the weather. The main contractor was also responsible for the building services works and the fit out works carried out by two nominated sub-contractors.

Other railway works constructed by the AA included a traction sub-station, the track formation at grade, the approach and departures viaducts and a cleaning platform at the end of the lines.

Fig. 18. Southern commercial area (December 1997)

The track-related works were subsequently installed by the MTRC system-wide contractors.

The works also included the provision of facilities for motor vehicular transport. Vehicles will arrive at Chek Lap Kok by means of a six-lane expressway elevated to departures level by an approach ramp which is seven spans long, 20 m

wide and 20 m above ground level. The lower deck is used as a transfer area for pedestrians to circulate. Below this is a service road at grade and below the service road lies the utilities corridor which provides all the services necessary to support the PTB. Construction of this part of the works was troublesome because of the multi-layer nature of the work which had to be carried out in a long and narrow congested works area with limited access.

The vehicles are brought down to ground level from kerb level by way of another post-tensioned concrete viaduct. Vehicles can then rejoin the expressway at grade, go to a multi-storey car park, a coach park or taxi stand or join the local at grade road distribution system. Arriving passengers find all their land transportation at facilities provided at grade which were constructed by the main contractor for this package of work.

Infrastructure works

An international airport needs extensive infrastructure support facilities, notably a road and utility distribution system on the scale of a small town. A large contract to provide infrastructure

Fig. 19. Airport substantially completed (March 1998)

Table 4. Infrastructure support facilities

Facility	Quantity
Ground level local roads	25 km
Expressway	5 km
Bridges	5
Communication ducts and associated pits	101 km
Stormwater drains	96 km
Manholes	1400
Ductile iron water pipes	56 km
Sea water pipes	24 km
Sewerage main	17 km
Buildings including services and finishes	40
Security fencing	9 km
Soft landscaping (excluding airside grass)	135 km

facilities to the south and eastern parts of the island was let in September 1995 (Fig. 18).

This contract was not technically difficult but the logistics and co-ordination management required provided the main challenges. Key quantities are given in Table 4.

In addition to this package the AA managed a number of other stand-alone construction contracts which had to be awarded individually for programming or logistical reasons. These were for the following facilities

- 33 kV primary electrical sub-station containing transformers and switch gear
- sea-water pumping station to house four 900 mm dia. pumps
- sea-water pumps (22 ranging from 70 l/s to 680 l/s)
- 33 kV electricity supply system for 81 MVA capacity
- 25 km of high voltage and 17 km of low voltage distribution
- 13 km of gas distribution system
- 1600 street lights and 193 km of associated cable works
- one grey-water treatment plant of 4900 m³/day capacity.

Communications systems

A modern international airport requires an up-to-date integrated communications system. This comprises two major parts: that which is inside the passenger terminal building and that which cover the rest of the airport site. The overall design resulted in a seamless link between the two parts to produce a single integrated communication system. This design was packaged and let in ten contracts for the detailed design, manufacturing, installation, testing and commissioning. The packages and some of the items provided are (see Appendix 1)

- flight information display system
- public address system
- telephone system
- trunk mobile radio systems
- closed-circuit television system
- access detection and control system
- building management system and SCADA
- fibre-optic and copper cabling
- systems integration
- traffic surveillance and control system.

Basically, the system comprised a network linking four primary nodes, ten secondary nodes and fifty user nodes. A node in simple terms is a computer room which has been constructed by other

contractors and fitted out with the standard of finish and facilities normally found in any computer room. The primary and secondary nodes were equipped with the airport operational database (AODB) computers which provided the nerve centres. The nodes are connected together by a local area network which comprises fibre optic and copper cables laid in the ducts and other cable containment provided by other contractors. This provided the backbone links which the other systems contractors could hook on to by connection into the cable termination points.

Each system was tested and commissioned on a standalone basis before they were all integrated and tested together. To assist this a special building was constructed and fitted out on site to carry out as much testing and integration as possible using simulation. This allowed much of the computer software to be debugged in advance of the hardware being transferred and installed in the works and helped shorten the period during which the systems works were on the critical path.

Concluding remarks

The Hong Kong construction industry has an excellent record in overcoming enormous challenges in order to complete major projects on time and within budget. Nowhere is this better illustrated than the achievements seen on the airport project and on the Airport Core Programme as a whole. The challenges were made even greater when it was announced in late 1996 that construction of the second runway and an extension to the passenger terminal building should start before opening of the airport. Due to Hong Kong's continued economic growth, it is planned that the second runway should be operational before the end of 1998, to be followed shortly thereafter by opening of the north-west concourse extension to the passenger terminal building.

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Appendix 1: List of all contractors and nominated sub-contractors

Contract no.		Contractor	Date of award
C023	Kiosks and desks	Nederlandse Kunstof Industrie BV	Jan. 1998
C031	Fit-out of authority's offices in passenger terminal building	Collections Interiors Ltd	Oct. 1997
C032	Additional glazed screens in passenger terminal building	Seele GmbH and Co. KG	Dec. 1997
C072	Public area seating	Wilkhahn Wilkening and Hahne GmbH and Co.	Mar. 1997
C075	Broadloom carpet to public areas	Brintons Ltd	Mar. 1997
C255	Site investigation and laboratory testing	Intrusion Prepakt (Far East) Ltd	Sept. 1993
C256	Marine site investigation and laboratory testing	Lam Geotechnics Ltd	Oct. 1993
C201	Site preparation contract	Airport Platform Contractors JV, Comprising: Nishimatsu Construction Co. Ltd, Costain Civil Engineering Ltd, Morrison Knudsen Corporation, Jan De Nul NV, Ballast Nedam BV, China Harbour Engineering Co.	Nov. 1992
C301	Passenger terminal foundations	Gammon Construction Ltd-Nishimatsu Construction Co. Ltd JV	May 1994
C302	Passenger terminal building	The BCJ Joint Venture, Comprising: Amec Construction plc, Balfour Beatty Construction International Ltd, China State Construction Engineering Cooperation, Maeda Corporation, Kumagai Gumi (HK) Ltd	Jan. 1995
	NSC365—lifts	Ryoden Lift and Escalator Co. Ltd	Feb. 1995
	NSC366—escalators	Constructions Industrielles De La Méditerranée SA	Feb. 1995
	NSC367—walkways	Constructions Industrielles De La Méditerranée SA	Mar. 1995
	NSC370—aircraft loading bridges	PT Bukaka Teknik Utama-Ramp JV	Mar. 1995
	NSC371—pre-conditioned air	Air-A-Plane Corporation	Mar. 1995
	NSC422—ground transportation centre substructure	Leighton Contractors (Asia) Ltd	Apr. 1995
	NSC066—glazed balustrades to public areas	MBM (HK) Ltd	June 1996
	NSC067A—binnacles	European Manufacturing Joint Venture Ltd	July 1996
	NSC067B—internal wall cladding systems, east of gridline II	Permasteelisa SpA (HK)	July 1996
	NSC067C—internal wall cladding systems, west of gridline II	Permasteelisa SpA (HK)	Aug. 1996
	NSC068—glazed screens and structural glazing	Seele (Hong Kong) Ltd	June 1996
	NSC069—hard flooring to public areas	Grant Ameristone Ltd	July 1996
	NSC070—metal suspended ceilings to public areas	G&H Montage (Hong Kong Project) Ltd	July 1996
	NSC074—painting and decorating to public areas	SKK (Hong Kong) Ltd	Sept. 1996
	NSC077—signage and graphics	Cevasa Imagen SA	Sept. 1996
	NSC079—manufacture and supply of door furniture	Allgood Continental Ltd	June 1996
	NSC080—landlord areas	YEK/Essman/KR Wong/Yiu Wing JV	July 1996
	NSC083—public toilets	Yearfull Interior Contracting Co. Ltd	July 1996
	NSC085—communications and control rooms	Vaford Contracting Co. Ltd	June 1996
	NSC086—apm maintenance building	Chatwin Engineering Ltd	June 1996
	NSC087—fixed link bridges	Shun Shing and Penta Ocean	July 1996
	NSC088—check-in islands/reclaim units	Nederlandse Kunstof Industrie BV	Aug. 1996
	NSC089—government areas	Vaford Contracting Co. Ltd	Sept. 1996
C303	North-west concourse piling	Franki Contractors Ltd	Nov. 1996
C304	North-west concourse and apron works	Zen Pacific-Shui On Joint Venture	Oct. 1997
C320	Passenger terminal building—building services	The AEH Joint Venture, Comprising: Aster Associate Tempopianti SpA, Ellis Mechanical Services Ltd, Hsin Chong Aster Building Services Ltd	Jan. 1995
C321	North-west concourse—building services	Hsin Chong Aster Building Services Ltd; Aster Associate Tempopianti SpA; Ellis Mechanical Services Ltd	Jan. 1998
C350	Automated people mover	New Hong Kong Airport People Mover System Joint Venture, Comprising: Sumitomo Corporation, Mitsubishi Heavy Industries Ltd, Kawasaki Heavy Industries Ltd, Nissho Iwai Corporation, Kobe Steel Ltd	Feb. 1994
C360	Baggage handling system	Siemens-Swire-Vanderlande	Feb. 1994
C361	Baggage trolley mechanical recirculation system	Associated Engineers Ltd	Nov. 1997
C362	Terminal building baggage trolley	Wanzl Metallwarenfabrik GmbH	Sept. 1997
C365A	North-west concourse lifts	Ryoden Lift and Escalator Co. Ltd	Feb. 1998
C366A	North-west concourse escalators	Constructions Industrielles De La Méditerranée SA	Feb. 1998
C367A	North-west concourse walkways	Constructions Industrielles De La Méditerranée SA	Feb. 1998
C370A	North-west concourse aircraft loading bridges	PT Bukaka Teknik Utama and Ramp International Incorporated	Feb. 1998
C372	Fixed ground power	Siemens Ltd	Apr. 1995
C373	Aircraft parking aids	Safegate International AB	May 1997
C375	Passenger and hand baggage security screening system	EG&G Astrophysics Research Corporation	Apr. 1997
C376A	Baggage security screening system	Vivid Technologies Inc.	Dec. 1996
C376B	Baggage security screening system	EG&G Astrophysics Research Corporation	Dec. 1996
C377	Level 3 baggage security screening systems	Invision Technologies Inc.	June 1997
C378	Level 3 baggage security screening trace detection equipment	Barringer Instruments Ltd	Sept. 1997
C381	Flight information display system	G.E.C. (Hong Kong) Ltd	June 1995
C382	Public address system	Hepburn Systems Ltd	June 1995
C383	Telephone system	Siemens Ltd	June 1995
C384	Trunked mobile radio	Marubeni Corporation and Hitachi Denshi Ltd	June 1995
C387	BMS and SCADA system	Control Systems International Inc. and Allen-Bradley (HK) Ltd	June 1995
C388	Voice and data cabling	International Computers Ltd	June 1995
C395	Closed circuit television (CCTV) system	Guardforce Ltd	June 1995
C396	Access control and detection	Guardforce Ltd	June 1995
C399	Master systems integration	Hughes Asia Pacific (Hong Kong) Ltd	May 1995
C401	Airfield works	Airfield Works Joint Venture, Comprising: Downer and Co. Ltd, Paul Y Construction Co. Ltd	Apr. 1995
	NSC560—airfield ground lighting	Thorn Hong Kong	May 1995
	NSC565—apron high mast	Au Chow Electrical Co. Ltd	Apr. 1995
	NSC841—aviation fuel hydrant system	Wah-Chang Engineering Corp. Pte Ltd	June 1995
	NSC470a—grassing	Gregori International SA	July 1996
C402	Northern runway works	ACG Joint Venture, Comprising: China Fujian Corporation for International Techno-Economic Cooperation, Heilit + Woerner Bau-AG.	Apr. 1997
C410	Landside infrastructure	Nishimatsu-Costain-China Harbour JV	Sept. 1995
	NSC470b—grassing	Gregori International SA	July 1996
	NSC472b—landscape planting and irrigationsystem, landside	Yee Sun Garden Ltd	Sept. 1996
C420	Ground transportation centre	Nishimatsu Construction Co. Ltd	Dec. 1995
	NSC423—ground transportation centre, building services	UDL Kenworth Engineering Ltd	Jan. 1996
	NSC425—ground transportation centre, escalators	CNIM Hong Kong Ltd	Jan. 1996
	NSC426—ground transportation centre, walkways	CNIM Hong Kong Ltd	Jan. 1996
	NSC427—ground transportation centre, fit-out, signage		

	and graphics, FF and E	Vaford Contracting Co. Ltd	Aug. 1996
	NSC470C—grassing	Yee Sun Garden Ltd	July 1996
	NSC472C—landscape planting and irrigation system, GTC	Yee Sun Garden Ltd	Sept. 1996
C430	Airfield tunnels	Downer-Paul Y-McAlpine Joint Venture	Nov. 1994
C451	Airport maintenance facilities	Chun Wo Construction and Engineering Co. Ltd and China Civil Engineering Construction Corporation JV	Aug. 1996
C452	Sea rescue facilities	China State Construction Engineering Corporation	Jan. 1997
C453	Airport ancillary buildings	Wah Seng General Contractors Ltd	July 1996
C454	Airfield fire stations and control centre	Downer-Paul Y-McAlpine Joint Venture	July 1996
C455	Aircraft recovery equipment store	Dickson-China Harbour JV	Nov. 1996
C456	Jet blast screens	R&M Warne-, Schallschutz und Industrieservice Niederlassung/Branch Office München	Mar. 1996
C471	Grass trials	Gregori International SA	Feb. 1995
C501	Stormwater drainage box culverts	Hsin Chong Construction Co. Ltd	Nov. 1994
C520A	Sea-water pumping equipment (north)	Young's Engineering Co. Ltd	May 1995
C520B	Sea-water pumping equipment (south)	Young's Engineering Co. Ltd	July 1995
C525	Waste-water treatment plant	Sociedade de Construções Soares Da Costa SA; and WABAG Water Engineering Ltd	May 1996
C531	Primary substation A	Gold Banner Construction and Development Ltd	Sept. 1994
C532	Electrical distribution system	Balfour Beatty Ltd	Apr. 1995
C534	Emergency power equipment	The China Engineers Ltd	Apr. 1995
C535	Sea-water pumping house (north)	Nishimatsu-CHEC Joint Venture	May 1995
C536	Traffic control and surveillance system	G.E.C. (Hong Kong) Ltd	Jan. 1997
C537	Road lighting	Electricity Advisory Services Ltd	Sept. 1996
C561	Airfield ground lighting—northern runway	Thorn Lighting CLK Ltd	May 1997
C902A	Initial workforce accommodation, employer's office and contractors' transit office	Shun Shing Construction and Engineering Company Ltd	May 1994
C902B	Workforce accommodation and offices phase II (base contract)	Shun Shing Construction and Engineering Company Ltd	Nov. 1994
C902C	Workforce accommodation and offices phase III (base contract)	Shun Shing Construction and Engineering Company Ltd	Nov. 1994
C904	Raw water submarine pipeline	Leighton-Lam JV	June 1994
C906	Temporary utilities, roadworks and bridges	China Fujian-Downer-McAlpine JV	June 1994
C907	Temporary ferry pier and berthing structures	UDL Kenworth Engineering Ltd	May 1994
C940	Rock crushing facility	Nishimatsu Construction Co. Ltd	Oct. 1994
List of construction support licences			
L01	Operation of rock crushing facility	Nishimatsu Construction Co. Ltd	July 1995
L02	Concrete batching facility (south)	Costain Building and Civil Engineering Ltd	Dec. 1994
L02A	Concrete batching facility (north)	Ready Mixed Concrete (HK) Ltd	Dec. 1994
L03	Servicing and cleaning of office and site staff accommodation,	Gardner Merchant Kelvin Hong Kong Ltd	Feb. 1996
L04A	Temporary fuel facility	Mobil Oil Hong Kong Ltd	Aug. 1995
L04C	Temporary fuel facility	Caltex Oil Hong Kong Ltd	Aug. 1995
L05	Waste disposal	The World Cleaning Services Co. Ltd	Aug. 1995
L08	Materials testing facility	MaterialLab Ltd	Apr. 1995
L11	Ferry services	The Hongkong & Yau-mat Ferry Co. Ltd	Oct. 1994
L12	Medical services	Airport Medical Services Ltd	June 1995
L15	Operation of the northern workforce accommodation, canteens and associated facilities at CLK	Gardner Merchant Kelvin Hong Kong Ltd	Nov. 1994
L15A	Operation of the southern workforce accommodation, canteens and associated facilities at CLK	Gardner Merchant Kelvin Hong Kong Ltd	Apr. 1995
L17	Temporary transportation services	CLK Bus Co. Ltd	Sept. 1995
L18	Printing services	UDO Holdings PLC/LDO Ltd Nevada	Feb. 1996
L31	Electricity supply	China Light and Power Ltd	TBA
L32	Telecommunications services	Hong Kong Telephone Co. Ltd	Dec. 1995
List of government contracts			
711	Government flying services	Architectural Services Department	Oct. 1995
712	Air mail centre	Architectural Services Department	Jan. 1996
713	Airport police station	Architectural Services Department	Oct. 1995
714	Sub-divisional fire station	Architectural Services Department	Oct. 1995
730	Air traffic control complex and tower (ASD Contract SSC 307)	Architectural Services Department	Oct. 1994
List of all commercial franchisees			
530	Permanent electricity supply	China Light and Power Co. Ltd	TBA
540	Town gas distribution system	Hong Kong and China Gas Co. Ltd	Feb. 1996
551	Telephone exchange building	Hongkong Telecom Ltd; New World Telephone Ltd; Hutchison Communications Ltd	Feb. 1997
806	Aircraft base maintenance facility	Hong Kong Aircraft Engineering Co. Ltd	Oct. 1996
811	Air cargo facility No. 1	Hong Kong Air Cargo Company Ltd (HACTL)	Dec. 1995
812	Air cargo facility No. 2	Asia Airfreight Terminal Co. Ltd (AAT)	Jan. 1996
814	Ground support equipment maintenance facility No. 1	Dah Chong Hong & Dragonair Airport GSE Service Ltd (DAS)	Feb. 1997
815	Ground support equipment maintenance facility No. 2	Ground Support Engineering Ltd	Mar. 1997
816	Business aviation centre	Hong Kong Business Aviation Centre Ltd	July 1997
821	Aircraft catering facility No. 1	Cathay Pacific Catering Services (HK) Ltd (CPCS)	May 1996
822	Aircraft catering facility No. 2	LSG Lufthansa Service HK (KSG)	Mar. 1996
823	Aircraft catering facility No. 3	Gate Gourmet Hong Kong Ltd	Feb. 1996
830	Nitrogen storage facility	Hong Kong Oxygen & Acetylene Company Ltd	Aug. 1997
840	Aviation fuel facility	Aviation Fuel Supply Company (AFSC)	Dec. 1995
845	Landside petrol filling stations (south)	Shell Hong Kong Ltd	May 1997
846	Landside petrol filling stations (north-east)	Shell Hong Kong Ltd	May 1997
847	Airside filling stations 1 to 3	Mobil Oil Hong Kong Ltd	Feb. 1997
848	Into-plane fuelling No. 1	AFSC Refuelling Ltd	Mar. 1997
849	Into-plane fuelling No. 2	AMR Airline Services Fuelling (HK) Ltd	Jan. 1997
850	Freight forwarding centre	Airport Freight Forwarding Centre Co. Ltd	Feb. 1996
856	Cathay Pacific headquarters and crew hotel	Airline Property Ltd	May 1996
857	CNAC/Dragonair headquarters	Hong Kong Aviation and Support Services Ltd and Profit Venture Development Ltd	Aug. 1997
858	Cathay Pacific stores building	Airline Stores Property Ltd	May 1997
859	Cathay Pacific flight training centre	Airline Training Property Ltd	May 1997
870	Airport hotel	Bauhinia Hotels Ltd	Mar. 1996
871	Multi-storey car park	Bauhinia Hotels Ltd	Mar. 1996