A LOOK BACK : CIVIL ENGINEERING IN HONG KONG 1841-1941

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Preface

This brief wide-ranging general artical written as a contribution to mark the 50th Anniversary of the founding of the Hong Kong Institution of Engineers (from 1947-1975, The Engineering Society of Hong Kong). It was originally published in three parts in Asia Engineer, the Journal of the Hong Kong Institution of Engineers (July, August and September 1997).

In this reprint, the opportunity has been taken to make minor corrections, mainly typographical, and to add 17 illustrations which should make the article more interesting. The author would like to express his thanks to Henderson & Associates, the publishers of *Asia Engineer,* for their kind agreement for the article to be reprinted in the Journal

Introduction

Before the British arrived in 1841 the population on Hong Kong Island, who lived in or around 20 small villages, was less than 6,000 (about a third being afloat), whilst in Kowloon there were probably around 2,000 souls and, in the New Territories (then part of San On district) about 100,000 persons living in some 600 villages. At this time granite quarrying around the harbour was a thriving industry (for example at Quarry Bay and Hok Un), much of it being used locally with some being exported by boat to Canton (Guangzhou). The abundance of old lime kilns around the seashore indicates that there was no shortage of lime for the production of cementing material.

Civil engineering works were generally simple and geared to meet the needs of the rural and fishing communities. As a result a network of rural paths, some paved with granite setts, and footbridges were constructed, an example of the latter being the existing Pin Mo Bridge at Shui Tau (near Kam Tin) which was built in 1710 (49th year of K'ang Hsi), a simple twin-span structure with the decking formed by

two long roughly-hewn granite slabs. Near villages adjacent to the sea stone jetties were built, the largest almost certainly being that at Kowloon City with its 21 spans, each with five longitudinal slabs supported on granite piers, which was completed in 1875 with a wooden extension added in 1892, and connected to the older Walled City by a wide road.

Reclamations were formed, for example, at Sha Tau Kok, Nam Chung and Luk Keng (near Starling Inlet), Shuen Wan and Yuen Long. These were sited on the tidal flats behind rock/mud/stick bunds located at low water level, and incorporated horizontal timber plank sluice gates. It took seven years for the salt to leach out of the sea bed with quarterly flushings before the land could be put to agricultural use.

Irrigation schemes were constructed throughout the rural areas involving construction of temporary dams across streams, simple pedal-operated wooden paddle-belt machines for raising water (usually around a metre), small bunds, catchwater channels and even bamboo pipe-aqueducts to cross low-lying ground. To provide power for traditional village industries, wooden water-wheels were installed adjacent to streams.

Harbour Works

On the signing of the Convention of Chuen-pi in 1841, Captain Belcher of HMS *Sulphur* undertook a hydrographic survey of Hong Kong Island and the surrounding waters with separate scales indicating sea miles and cables, statute miles and furlongs, and yards. The chart's emphasis was on water depths in fathoms, rocks and coastlines with the general shape of the hills and prominent landmarks shown only for navigational purposes.

As the years passed, the benefits of Hong Kong's natural deepwater harbour were exploited and, by the turn of the century, some 40% of China's foreign trade was passing through Hong Kong which had by this time become one of the world's principal ports with its fine dockyards and excellent workforce devoted to shipbuilding and repairing - indeed "a sort of Far Eastern Marine Clapham Junction".

Shelters

Hong Kong has been hit by many severe typhoons causing tremendous damage to shipping, a violent one occurring in 1841 wrecking the cutter *Louisa* on which Captain Elliot, the British plenipotentiary in China, was travelling to Hong Kong from Macau. In order to protect the smaller-sized shipping, mainly junks and sampans, from excessive danger during storms, major typhoon anchorages protected by heavy rockfill breakwaters were constructed at Causeway Bay in 1883 (c23ha, now Victoria Park) and another in 1915 at Mong Kok Tsui (Yau Ma Tei - 65ha which has recently been reclaimed). Meanwhile, a 4ha tidal basin and smaller boat basin with slipway were completed around 1905 at the Admiralty dockyard in Victoria (now Central) to afford protection and berthing for naval vessels.

A small basin was constructed in Tsim Sha Tsui in 1885 for the Water Police and, about the same time, another larger one for the Royal Naval torpedo depot. Around the turn of this century, a further anchorage was built adjacent to the old coal briquette works lying near to the end of Austin Road (the Camber Typhoon Shelter).

Docks

Soon after the partial destruction in 1857 of the Couper Dock at Whampoa on the Pearl River as a result of the *Arrow* incident, the first granite dry dock in this region, the Lamont Dock in the 4½ha dockyard site at Aberdeen was commissioned and was a complete success from the start; it received its first ship in 1860 and could accommodate a 50-gun steam frigateof 110m length on the blocks. Subsequently the larger and deeper Hope Dock, 125m long, 30m wide at the top and 15m wide at the bottom with an entrance width of 26 metres and 6.7m clearance at neap tides, was constructed adjacent to the Lamont Dock and completed in 1867, in its time being the best in Asia and one of the finest in the world. It could take the largest vessel visiting Hong Kong, even at low water; only one ironclad in the whole of the Royal Navy would be unable to enter without first being lightened by stripping it, for example, of its heavier armament and machinery.

The smaller 100m-long dry dock at the Hung Hom dockyard in

Kowloon, mainly for ships in the coastal trade, was opened in 1868 to be followed soon afterwards by a shorter 80m-long dock. A few years later (1876) the 140m-long Cosmopolitan Dock and dockyard at Tai Kok Tsui were commissioned. Subsequently the much larger 168m-long Admiralty Dock at Hung Hom was completed in 1888 and later extended in length by some 8 metres in 1903, to be followed by further lengthenings in 1911 and 1931.

In the summer of 1907, the 170m-long Admiralty dry dock in Victoria, with an entrance width of 29 metres and 9m clearance at lowest spring tides, and Tai Koo's great ashlar-faced 238m-long 27m entrance-width graving dock (now a car park in the Tai Koo Shing development) at Quarry Bay, the latter capable of accommodating the largest ship then afloat (the liner *Oceanic*), were both commissioned. By laying down the former dock where it did and extending the original dockyard, with an 8ha reclamation which was started in 1900, the Navy sealed the long-held hopes of making Victoria a coherent city with a continuous commercial waterfront. Due to difficult foundation problems, including removal of a 1.2 to 1.8m layer of hard porous coral and the need to install hundreds of steam-driven hardwood piles through the underlying decomposed granite to secure the site, the naval dry dock finally took seven years to build whereas the larger commercial dock at Tai Koo was finished in five.

The whole of the Tai Koo dockyard development took seven years to completion in 1908, a remarkable achievement in so much that it not only included the large dock but also excavation of some 1.3M cubic metres of hillside to form a 21ha site, which included a 8ha marine reclamation, and the adjacent section of the 23m-wide cut for King's Road, and the building of an entire complex of slipways, workshops and all the ancillary works which are needed to make a large dockyard a world of its own. It is interesting to note that Admiralty engineers in 1908 regarded locally-made cement as unsurpassed in fineness and tensile strength (at 28-days around 750lb/sq in or 5.2MPa), and it was used exclusively when building the new naval and Tai Koo dockyards.

Wharfs

By 1843 there were several comparatively small piers and jetties on the Island located between East Point and Sheung Wan. Pedder's

Wharf, one of the oldest landing stages, originally consisted of a simple wooden pier which needed to be replaced as successive reclamations advanced the seafront. In the mid-1880s when it was rebuilt it was still the principal landing place on the Island, being by this time a substantial wooden structure. Numerous other piers and jetties have always been scattered along the north shore which generally served the smaller-sized coastal and harbour shipping, larger ocean-going vesselsmaking increasing use of the deep-water facilities in Kowloon. In 1911, the main piers in the central district were Queen's Pier (rebuilt in the mid-1920s), Kowloon (Star) Ferry Pier, Blake Pier (previously Pedder's Wharf) and the old P&O Jetty By 1930 there were still some 30 piers and jetties on the Island jutting out into the harbour. The effects of severe typhoons caused immense damage to vessels and facilities, and heavy loss of life, for example that in 1874 resulting in the deaths of 2, 000 persons; old photographs show a devastated harbour with the remnants of numerous piers sticking out of the wreckage-strewn waters.

By 1887, on the Mainland there were three principal jetties, ranging in length from about 110 to 145 metres lying just north of the south-west tip of Kowloon peninsula and a 150m-long vertical seawall to the south. The dock area itself incorporated a 12km-long narrow-gauge steel tramway system which was manually operated along the wharfage and through the extensive godowns. As a result of the devastating 1906 typhoon, in which 10,000 lives were lost (over 2% of the total population), enormous damage was caused to the existing wharfs and to the new Star Ferry pier which was completely severed and marooned from the land. A 200m-long 13m-wide wharf with 9 metres of water at low tide was added to the complex in 1916 which was long and deep enough to allow the largest ship visiting Hong Kong at that time to come alongside. By 1925 there were already 18 deep-water berths available in Kowloon.

Early in the century there were also piers and wharves for passenger ferries and commercial vessels in other locations, for instance in 1904 a berth was constructed at Lai Chi Kok to serve the oil tank farm and, shortly afterwards, at the end of Boundary Street there was a 36m-long 2m-wide pier with sufficient depth of water to enable freight to be transferred to and from steam launches.

Reclamation

Victoria Harbour, the *raison d'etre* for Hong Kong's foundation, formed the focal point around which the new settlers clustered and around which the banks, business houses, the shipyards and, later, commercial factories were built. Hemmed in by hills both to the north and the south, the population around the harbour became concentrated on the limited flat or less steeply sloping land available along the coast. Expansion was only possible by reclamation into the sea (and later by higher buildings), spoil being obtained from nearby hills thus providing additional building land. Until the advent of motor vehicles, reclamations were unable to benefit from more remote fill sources, like the Peak where site development necessitated balanced cut and fill. In all several hundred hectares of land were reclaimed in the hundred years up to 1941 (compared with many thousands in the 50 years following).

Some of the people who were lucky enough to lease the first lots of land fronting on the sea, which had been auctioned in 1841, extended their lots by illicit reclamation over the foreshore absorbing such land as could easily be reclaimed, a procedure which was soon forbidden. Quite early, probably in 1842-3, some valuable land was reclaimed in Victoria, part of which was subsequently occupied by the Hong Kong Cricket Club (now Chater Garden).

The first formal *praya* (waterfront) reclamation scheme was partly carried out in 1851, by the filling of a small creek in the Bonham Strand area, but as might be expected it aroused stiff opposition from affected lessees who claimed marine rights. This, compounded by the destruction of part of the original *praya* wall by severe typhoons in 1867 and 1874, delayed matters but, despite these problems, by 1886 an 8km-long near-continuous strip of land (the major discontinuance being the section adjacent to the naval and military areas), perhaps broadly averaging around 100m wide was formed between Kennedy Town and North Point, the seawalls providing much needed access for handling marine cargo. In 1887 further reclamation was recommended to alleviate overcrowding in the city. As a result, the Praya Reclamation Ordinance was gazetted in 1890 and a year later Paul Chater (later Sir Paul) initiated a band of reclamation, totalling 26 hectares and extending three kilometres westward from Murray Road along the northern foreshore

of the Island This was completed in 1904, partly with filling material obtained from Chinese territory. The limits in Victoria of these two earlier major reclamations are marked by Des Voeux Road and Connaught Road respectively. During the next 30 years reclamation continued on the Island, the largest schemes being those at Tai Koo for the dockyard (21ha which included 13ha of land site formation, completed 1908), Wan Chai (36ha, completed 1929) and around North Point (nearly complete before the Pacific war), together with a smaller reclamation at Shau Kei Wan.

Soon after the cession of Kowloon under the Convention of Peking in 1860 there was some reclamation adjoining deep water in Tsim Sha Tsui, primarily for wharfs, and at Hung Hom for the dockyard, to be followed by extensive reclamation in Tai Kok Tsui and Yau Ma Tei and, to a lesser extent, at To Kwa Wan, Sham Shui Po and Lai Chi Kok, the latter two both lying just to the north of Boundary Street. Subsequently an important reclamation was formed by the Kowloon-Canton Railway in Tsim Sha Tsui and Hung Hom bays (16ha, completed 1910) primarily for its own use which included three deep sea berths on the extreme south - east tip of the Kowloon peninsula. In the period after 1922 there was considerable reclamation in and near Kowloon just as there was in Wan Chai on the Island. Large areas were reclaimed at Sham Shui Po (26ha, completed 1928), Kai Tak (83ha, completed 1931) and Lai Chi Kok (c35ha), all these areas lying in the New Territories close to the old Kowloon/China boundary with much of the filling being obtained from Kowloon Tong, then being developed as a garden city. Just before the Pacific war, reclamations were also started in three other areas of Kowloon Bay, at Ma Tau Kok, Ngau Tau Kok and Kwun Tong.

Roadworks

Construction of Queen's Road in Victoria was started in May 1841, only four months after the British landed on the Island, by the Royal Engineers following the alignment of a narrow bridle/tow path high above the beach which extended some 7 kilometres from the water's edge at Kennedy Town on the west to within a short distance of Happy Valley on the east. Another road, from Wong Nei Chong to Shau Kei Wan was built at the same time, a causeway with two bridges being constructed to carry it across what is now known as Causeway Bay.

The roads (some sections being only bridle paths) that followed included one from Shau Kei Wan to Sai Wan in 1845 and subsequently onto Stanley, another from Victoria to Aberdeen in 1846, one from Aberdeen to Stanley in 1848 and, at about the same time, another to Pok Fu Lam. These early roads and tracks were shown on the first contoured topographic survey (scale 4 inches to a mile, say 1:16,000, with 100ft contours) of Hong Kong Island which was carried out by Lieutenant Collinson of the Royal Engineers. The map was first published in 1845 and the quality was such that it remained in use, with periodic revisions, for some 50 years.

As might have been expected, the early roads were poorly constructed and often damaged in the summer rains with the wooden bridges being frequently washed away. Gradually the lesson was learnt and roads were surfaced and bridges constructed with masonry. Even so, as late as 1890, an editorial reported "The recent rains once again worked up Queen's Road into a quagmire. Some months ago the road was re-metalled on a principle which it was believed would be sufficiently strong to withstand the wear and tear of *jinricksha* wheels, but it is now as bad as ever..... Until jinrickshas were introduced Queen's Road was always fairly clean, even in the wettest weather."

While the built-up areas were slowly expanding the road system was developing and, by 1908, Hong Kong could boast a network of 153 kilometres of roadways on the Island with cut hillside slopes typically being 75° and filling contained by masonry retaining walls. At this time a writer commented "vehicular traffic is confined chiefly to handcarts, rickshaws and chairs suspended from poles borne on the shoulders of coolies, there being but a few pair-pony gharries and a Victoria or two used by the Chinese". Around the turn of the century when Lugard and Harlech Roads were constructed encircling the Peak, local inhabitants were displeased - they thought it "likened the effect of putting a halter around the neck of the Hill of Great Peace". Fortunately no adverse consequences became apparent! The diamond jubilee of Queen Victoria in 1897 was marked by a proposal to build a road around the Island; the scheme was opposed by the military and, after lengthy delays, the section below Mount Davis along the 45m contour (Victoria Road) was commenced.

The advent of the motor car stimulated upgrading the existing

carriage roads and by the end of 1915 Pok Fu Lam, Aberdeen and Deep Water Bay were all accessible by car, to be followed by Repulse Bay in 1917, Shek O in 1923 and finally, in 1924, direct vehicle access to the Peak itself. After this date road construction on the Island was usually limited to road improvement, for instance to Kellett Road in 1928 and in the following year to Barker Road.

The timing of the development of much of the road network can be readily deduced from the names of streets named after Governors, military leaders and other prominent residents, for example on the Island - Pottinger Street, Bonham Strand, and Kennedy, Hennessy, Chater, Sassoon and Stubbs Roads, and in Kowloon - Robinson (later renamed Nathan), Mody, Cameron and Ho Tung Roads, Kadoorie Avenue and Braga Circuit.

In Kowloon by 1887 a fairly comprehensive road system was in place south of Austin Road. The first 850 metres of the 30m-wide Robinson (Nathan) Road from Middle Road, some 1.1 kilometres of MacDonnell Road (later Canton Road), and Des Voeux Road (later Chatham Road) were all started. Many of the intersecting roads, for example Granville and Kimberley Roads, were already built. To the north of Austin Road the road network was concentrated in the southern Yau Ma Tei district with the 15m-wide 1.6km-long Station Road (later Shanghai Street) reaching Mong Kok Tsui. A small independent road system was already constructed in the Hung Hom area near the docks, for example Bulkeley Street and Gillies Avenue.

By the turn of the century there were some 35 kilometres of roads in Kowloon which included the first two original direct links into the newly-leased New Territories, that is those to Kowloon City and the Tong Mi area. In particular the road network in the new development at Yau Ma Tei was well under way and the Hung Hom road system had been enlarged and connected to the extension of Des Voeux (Chatham) Road. In order to relieve pressure on Victoria's densely built-up areas with their unhealthy conditions and at the same time to provide an easy access to facilitate opening up of the New Territories, the Harbour Master in 1901 proposed the construction of a cross-harbour bridge between Pottinger Street on the Island and Robinson (Nathan) Road, there being no engineering difficulty or "any practical obstruction or even inconvenience to shipping", the deck being 12 metres above high

water with a swinging or lifting central span. Nevertheless the scheme was not proceeded with and Hong Kong had to wait another 70 years before a fixed cross-harbour connection was constructed.

The main road network in Kowloon continued to expand with Sham Shui Po being linked to then existing road system in 1916 with a 6m-wide 700m-long road, part of which was formed on a 3.4m-high embankment. The first section of Waterloo Road, Argyle Street and much of Prince Edward Road were completed by 1924. At this time, Nathan Road had been already extended by Coronation Road (later also part of Nathan Road) nearly up to the old international boundary. By the outbreak of the Pacific war in 1941, part of Kowloon Tong, then a garden city, was developed to the west of Waterloo Road together with an adjoining section of Boundary Street and extensive additions were made to the subsidiary road networks, in particular in the Mong Kok, Sham Shui Po and To Kwa Wan districts.

When the New Territories was leased in 1898, it was a quiet rural area with a scattering of small market and fishing towns which depended on a network of footpaths and ferries for access. Shortly afterwards a good deal of road construction was begun, partly for military and civil governmental purposes, and partly to enable farmers to bring their produce more easily to the urban areas. The first section of the New Territories ring road, that from Kowloon to the administrative centre Tai Po, comprised a 4.3m-wide carriageway following the zig-zag course of the old footpath and was completed in 1900.

Au Tau creek was bridged in 1916 with an 11-span 95m-long reinforced concrete structure supported on hollow 340mm concrete box piles, where previously a local punt service was available, to join the 6m-wide stretches of road from Fan Ling and Castle Peak (Tuen Mun). Two years later the coastal road from Sham Shui Po to Castle Peak was started which at the time was aptly considered to be Hong Kong's *La corniche* and, in 1920, the whole of the 90km-long New Territories ring road was finally completed. About 1927, the Tai Po road bridge adjacent to the railway was reconstructed with a 7-span reinforced concrete structure. Improvements were carried out to the Fan Ling/Sha Tau Kok road in 1929, much of which had only been in service for two years, generally making use of the disused railway formation. Subsequently a new road was built from Au Tau to Shek

Kong village in 1936, thus providing access to the proposed second airfield site at Pat Heung. In the following year the first roadworks on the outlying islands were undertaken at Muk Wo (Mui Wo) on Lantau, primarily to provide access to the ferry pier.

Drainage

In 1843, a particularly bad year for disease, some essential drainage was begun and, by 1847, 740 metres of city drains had been laid in Victoria. At Happy Valley the muddy waters discharging from the surrounding hills via Wong Nei Chong (literally yellow mud stream) created swamp and healthwise lethal conditions, in particular following heavy rain. By 1846 the rice and sweet potato farmers at Happy Valley were bought out and the flat land drained, thus making the area less unhealthy than before. In spite of drainage improvements in and around the city, the mortality rate amongst European troops remained exceptionally high, for instance in 1851 it reached 24% compared with 10% for the civilian population, this latter percentage being swollen by the deaths of seamen. In the early days, to avoid flooding in low-lying areas, main drainage nullahs (large open channels) were constructed, the earliest in the central district probably being the Murray Barracks Nullah, which ran through the naval dockyard area, and the winding Victoria Barracks Nullah. At East Point, an impressive 6m-wide and 3.6m-deep nullah, the Bowrington Canal (now decked and located under Canal Road) which carried the run-off from the Happy Valley catchment area was planned as early as 1842. In Wan Chai, Stone Nullah Lane was located above a stream which ran below Hospital Hill (to the east of Morrison Hill).

The quality of design/workmanship in the original drainage system clearly left a lot to be desired as, in 1860, a very heavy rain storm is reported to have burst most of the drains and also caused the collapse of some houses in Canton Bazaar (off Queen's Road opposite to the naval dockyard). During the violent typhoon in 1874, mounds of soil were again thrown up by bursting drains. The sewers also had other uses, for instance in 1863 twenty-two prisoners were known to have escaped from the old gaol in Hollywood Road by way of the monsoon drains whilst, in the next two years, the ingenuity and engineering skill displayed by "drain gangs" was such that a godown, jewellery store and even the vaults of a bank were entered by using storm-water drains

from which tunnels were excavated to locations under the floors

A lady, appalled by the primitive standards of hygiene in 1879, wrote ".....no sort of effective drains or sewers have been provided .... whatever sewerage finds its way [into rain-water conduits] is simply deposited along the whole harbour front, thus poisoning what else might be a pleasant situation.....the arrangements for the daily (or among the poorer classes only bi-weekly!) removal of nuisances from every house (for subsequent conveyance to the mainland as an article of agricultural commerce) form a very unpleasant page in the sanitary statistics.....". Environmental concern clearly was not created in the late 20th century.

Matters were not improved by Governor Hennessy (1877-82)'s deep conviction that for the local inhabitants their traditional earth system of sanitation was preferable to western flushing toilets. Even at the eve of the Japanese invasion of Hong Kong in 1941, the primitive system of collection and disposal of sewage was common, collection being based on an estimate of six taels (227 grammes) per person per day. In view of the above it is not surprising that a report recommended in 1882, amongst other things, that the city should be completely re-drained and a cholera outbreak in the following year gave timely impetus for new main drains and sewers tobe laid. Nevertheless it was not until soon after the first serious outbreak of plague in 1894 that the main drainage system in the principal urban area had been practically completed. Legislation was then passed in 1896 making drainage for houses compulsory. Records indicate that the main storm-water drains around the turn of the century were formed with mass gravity retaining walls and incorporated a half-round dry-weather flow channel; where appropriate these drains were covered with simply-supported concrete or granite slabs. Subsequently more open nullahs were constructed, often running along the centre-lines of road reserves, for instance in Kowloon along Nam Cheong Street (Sham Shui Po) which was completed in 1912 and Waterloo Road (both of these now having been decked, mainly to effect much needed road improvements). As a result of continuing enhancements to the drainage system, in particular those relating to nullah and stream training works, plague was virtually eliminated by 1924 whilst deaths from malaria, although still numerous at the outbreak of the Pacific war, gradually declined.

Railways

The first railway to be built was the Peak tramway, a 1.4km-long 1.5m-gauge steam-driven funicular-railway rising 370 metres along steep rugged terrain, which was opened in 1888. A contemporary description stated that "A splendid feat of engineering skill has made the Peak accessible to all." Nevertheless during the following year, as a result of exceptionally heavy rainfall, the track was breached by a major landslide, a debris flow originating from a fill slope on the Peak. A few years later, in 1904, a conventional electric tram service was implemented along the northern side of the Island between Shau Kei Wan and Kennedy Town. Both of these are still running today. Railway track, with locomotives, trucks and steam-operated cranes were widely used around the turn of the century for transporting/ handling freight in the dockyards and site constructional materials.

In 1905, the Government took over a part of the concession to build a section of the Kowloon-Canton Railway (KCR), namely that between Kowloon and the Chinese border. The 34km-long railway which was completed in 1910 involved construction of five tunnels, 48 bridges (the largest span being 30-53 metres on an irregular skew over-bridge at Hung Hom), 66 culverts, workshops and stations, drainage channels and a little roadwork, the creation of a 16ha reclamation in Kowloon (in Tsim Sha Tsui and Hung Hom bays), and many cuttings and end-tipped embankments, including those along the exposed seaward sections between Sha Tin and Tai Po. In all some 2. 6M cubic metres of materials were handled in the earthworks. A contemporary technical discussion indicated that slopes of 1:1 were generally adopted in cuttings on which "turf grew excellently..... Good results were obtained by plastering bad decomposed rock faces with a mixture of lime, sand and gritty red earth". Labour guilds kept the rates of wages relatively high (those for the building trades and for dressed granite even approaching those in England) and regulated the quantity of work to be undertaken by the various classes of workmen.

The 2.2km-long 5.2m-wide horseshoe-shaped brick-lined Beacon Hill tunnel, which at the time was longer than any in China itself, was ranked as one of the outstanding engineering achievements of its day. To gain access to the south face it wasnecessary to build a temporary 3km-long metre-gauge railway from the nearest jetty at Tai Kok Tsui.

The tunnel was driven at a rate of about 18 metres/week through granite - surprisingly the most serious problems encountered appear to have concerned the labour, rather than the tunnelling itself, on account of *fung shui* difficulties and the prevalence of malaria.

To finalise the KCR project, an 11.5km-long narrow-gauge (600mm) branch line was constructed in 1911-1912 from Fan Ling to Sha Tau Kok on the border, mainly using track and plant which had been utilized in connection with the building of the Beacon Hill Tunnel, and operated until 1928. The civil engineering work was relatively simple, the deepest cutting and embankments being about 5 metres. For most of the route the railway shared bridges with the adjacent road but beyond Wo Hang some six bridges and numerous culverts needed to be built.

Water Supply

The original inhabitants and new settlers in 1841 obtained their water supply from hillside streams. To augment these sources the first five wells for the city water supply were sunk in 1851. In 1859, the Government realised that the old haphazard supply system was totally inadequate and, following a prize competition for the best plan, implemented a small reservoir scheme in the Pok Fu Lam valley, the dam being little more than a stream intake, from which water was conveyed in 1863 through a 250mm cast-iron pipe to tanks above the city of Victoria.

From that time the history of Hong Kong's waterworks was a continual struggle to catch up with the needs of an ever-increasing population and virtually never succeeded until recent years (when the Territory's water shortfall was imported from China). The original Pok Fu Lam scheme was soon scrapped and a new reservoir, with its 11m-high earth dam and a much greater capacity (300 million litres), was completed further upstream in 1871 when the population had risen to about 125,000. The reconstruction of the supply conduit, by means of a brick culvert along the 150m contour (Pok Fu Lam and Conduit Roads), became operational in 1877.

The first stage of the Tai Tam scheme, the principal feature being a 40m-high masonry-faced rubble concrete dam, was completed in 1889

with impounded water being conveyed through a 2.2km-long 2.5m-diameter tunnel, mainly in granite, and by a 5km-long conduit winding along the northern shore of the Island beneath Bowen Road to the first two slow sand filter beds above the city, and thence into the service reservoir located at a lower level. The distribution system involved laying, between 1890 and 1892, some 30 kilometres of 75-350mm-diameter cast-iron mains together with the installation of a system of fire hydrants. Major *fung shui* problems were encountered during the tunnelling works, rumour being that children were to be selected for burial alive to ensure success; fortunately no ritual sacrifice was needed!

On an uncontoured 1895 version of Collinson's plan (1845), there is an interesting feature clearly marked "overhead tram" extending 2.3 kilometres between Quarry Bay and Quarry Gap. It seems likely that it would have been used to transport materials and, perhaps, workmen associated with the early Tai Tam reservoir works. As part of the Tai Tam scheme a furthersmall high-level reservoir at Wong Nei Chong was completed in 1899. Around this time the Braemar reservoir (now Choi Sai Woo Park) and further smaller reservoirs near Quarry Bay were built, primarily to meet the needs of the large commercial Tai Koo sugar refinery and dockyard complex.

With the population already rising to about half a million, three further concrete dams within the Tai Tam valley, the largest Tai Tam Tuk being 50m high, and associated reservoirs were completed between 1904 and 1917. The upper (42m high) and reconstructed lower (20m high) concrete dams, the latter being previously a privately-owned dam built in 1890 for a paper works, impounding the Aberdeen reservoirs were later finished in 1931 and 1932 respectively, thus completing the last economical water storage development on the Island.

After the turn of the century engineers were already looking to the New Territories to increase the supply of water for Kowloon, which had hitherto been dependent on two wells located to the north of Yau Mai Tei. As a result, the 35m-high concrete dam for the Kowloon reservoir was completed in 1910 and three further reservoirs in the vicinity were completed during the period 1925-1931 by which time the population was already approaching a million. A commercial reservoir was also built early this century to the south of Lung Wo Tsuen to provide water for Rennie's cotton factory at Junk Bay.

The Shing Mun Valley scheme was started in 1923 and initially a 2km-long 3m-diameter tunnel was driven to Shek Lai Pui. Subsequently the largest pre-Pacific war reservoir was constructed which was to double the Territory's total water storage capacity to 27,000 million litres; it was formed by the main Gorge Dam, which was the highest in the old British Empire at that time (1936), and the subsidiary 25m-high earth/rockfill/concrete core Pineapple Pass Dam. The remarkable Gorge Dam, 85m high with a bold and probably unique design, consists of a downstream shoulder of rockfill faced with pitching and an upstream face comprising a slender near-vertical reinforced concrete diaphragm wall supported by a massive concrete thrust block. Between the upper part of the thrust block and the downstream rockfill there is a narrow wedge filled with sand for the purpose of taking up any settlement of the rockfill and to cater for possible earthquake movement. Any leakage through the upper part of the diaphragm can be observed from an inspection gallery behind it. Elaborate experiments were made to determine the correct design of the reservoir overflow bellmouth in order to reduce vortexing and to neutralise the destructive vacuum forces which could occur at the base of the bellmouth overflow shaft. For this investigative work the young Geoffrey Binnie was awarded a *Telford premium* by the Institution of Civil Engineers. Subsequently preliminary investigations for the Tai Lam Chung scheme were started shortly before the outbreak of the Pacific war by which time the Territory's population had risen to about 1.6 million.

As a result of an acute water emergency on the Island, work started on a 300mm steel pipe cross-harbour main in 1929, the sixty-two 30m-long bolted sections taking less than 2 months to lay, and a further 450mm main was laid in 1935. Due to corrosion problems it was necessary to replace these pipes in 1939 with two 530mm steel pipes, protected with a 12mm-thick cement lining on the inside and a 60mm coating of vibrated concrete on the outside, which were laid on reinforcedconcrete blocks bedded on rockfill with a protective rubble mound on the east side of the pipelines to prevent damage from dragging anchors.

These pre-Pacific war water schemes not only involved building dams but also needed construction, often in difficult site conditions, of a multiplicity of extensive catchwaters, tunnels, trunk mains, treatment plants, service reservoirs, pumping stations and distribution mains in

order to deliver fresh water to the public. It is interesting to note that, in order to conserve fresh water, a salt-water mains system for flushing was investigated in 1921 and again in 1927 but was not pursued at that time.

Airfields

The original aerodrome was formed on a wedge of land comprising some 10 hectares (350m long by 275m wide) which had been reclaimed from the shallow waters of Kowloon Bay by a private housing development company established by Sir Kai Ho Kai and Mr Au Tak and bounded on the east and west by large open nullahs, with the first plane taking off in 1924. The reclamation then came under the control of Government in 1927 after the company failed. Government subsequently arranged for the airfield to be extended in 1929 and 1931 to some 83 hectares, partly using as a filling material hydraulic fill, obtained by dredging from the harbour, which was then covered with about a metre of decomposed granite and contained by a concrete blockwork seawall extending some 1.2 kilometres. The three open nullahs crossing the airport field were all covered by 1930, the concrete slab decks being propped by central piers.

A short 457m-long tarmac runway, primarily for civilian use on an east-south-east/west-north-west alignment, together with hardstandings, jetty, control building, offices and a new piled civil hangar near the south-western extremity of the airport were completed in the later thirties which enabled Kai Tak to become viable, not only for flying club and military purposes, but more importantly for scheduled commercial operations which began in 1936 at a time when mail took precedence to passengers One significant improvement noted at that time was the provision of a concrete slipway for seaplanes to replace the old tedious method of lifting them ashore with a steam-operated crane.

Reports that three Royal Air Force squadrons were being sent out to reinforce Hong Kong's defences shortly before the Pacific war prompted planning of a second airport, at a site near Pat Heung (Shek Kong). In 1938 the ground was levelled and grassed over but the scheme was abandoned in early 1940 with the realisation that it would be within range of Japanese artillery following their invasion of Guangdong

province.

In 1941, construction of a 457m-long tarmac-surfaced runway at Kai Tak for military use on an approximate south-east/north-west orientation, which had already necessitated the dismantling of the RAF hangar, was due to start on 8th December 1941, the precise day on which the Japanese invaded the New Territories and attacked Kai Tak airport.

Military/Defence Works

Prior to the British administration there were several forts in the New Territories going back to the early years (17th century) of the Ch'ing Dynasty, the oldest existing fort (1717) probably being that on Tung Lung Chau overlooking the narrow Fat Tong Mun passage in the eastern approaches to the harbour, and the largest still remaining at Tung Chung (60m by 80m) on the northern coast of Lantau which was completed in 1832. Little remains of the old 4m-high walled Kowloon City, a garrison fort (120m by 230m) with its sturdy granite parapet wall complete with embrasures and watchtowers, which was finished in 1847 soon after the British established themselves on Hong Kong Island.

Subsequently the British military have been involved in a considerable amount of civil engineering. The Royal Engineers were first involved in 1841 in the early construction of Queen's Road in Victoria. Perhaps their most impressive roadworks over the years, constructed before the Pacific war, has been Jat's Incline which provides access to the upper levels of the steep hills overlooking Kowloon. Nevertheless the main military engineering effort was expended on providing defences and back-up facilities (for example naval dockyards, aviation needs, storage depots, barracks and hospitals), principally against possible seaborne attack by Russia last century and later against the increasingly land/sea invasion threat by Japan in the 1930s. Novel defence measures included excavation of a cavern at Lei Yue Mun towards the end of the nineteenth century to house the sophisticated Brennan torpedo which, after launching down a ramp, was controlled from the shore with a wire attached to the rudder.

Regarding defence facilities, at the outbreak of the Pacific war in

1941 there were thirteen operational batteries (complete with underground ammunition magazines, living quarters and access roads) on the Island, the earliest emplacements for these being built around 1895, an underground battle headquarters off Queen's Road near the naval dockyard (completed in 1940) and scores of reinforced-concrete structures comprising pill-boxes, observation posts, seachlight positions, anti-aircraft sites, bunkers, shelters, ammunition and stores dumps, tunnels and water tanks. On Stonecutters' Island the Royal Navy built between the World Wars a huge ammunition depot which included eleven large underground magazines: earlier the first land-based explosives' depot was completed here in 1876 from where it was transferred to Green Island in 1906. Of the original six battery emplacements designed and constructed on Stonecutters' Island during the period 1880-1905, only one remained commissioned at the outbreak of hostilities.

The two battery positions on Devil's Peak in Kowloon overlooking Lai Yue Mun gap were constructed soon after the New Territories' lease was signed in 1898 and a redoubt on top of the hill was completed by the Royal Engineers in 1914. The guns however were removed in 1936 and transferred to the Island Subsequently the 18km-long Gin Drinkers' defence line was constructed during the mid-1930s across the hills to the north of the Kowloon peninsula and comprised a series of pill-boxes, trenches, bunkers and tunnels, the key feature being the underground Shing Mun Redoubt covering some five hectares on the northern flank of Smugglers' Ridge.

The decision to construct air raid shelters so that the whole urban population could be protected was not taken until 1940. In the space of about a year some 22 kilometres of 2.5m-size tunnels (of which about 80% still exist) were constructed on the Island and in Kowloon, including one adjacent to the Secretariat in Lower Albert Road which extended to Government House causing structural damage. In view of the urgent need for these tunnels, the project was arranged on a cost-plus basis and gave rise to rampant corruption, one architect involved even committing suicide to avoid giving evidence. The sub-standard pre-cast concrete breeze blocks made by the Director of Air Raid Precaution's girlfriend's firm are still (or least until recently) known in the trade as *Mimi laus*. Unfortunately the report on the Commission of Enquiry was never made public: it was taken into the Stanley internment

camp by the presiding judge but disappeared without trace after his death in 1944.

Conclusion

One must inevitably conclude that Hong Kong should be justly proud of its impressive civil engineering achievements during the first hundred years of British administration, many of which are still in existence and benefiting our society today. Needless to say the last fifty years have been even more impressive and we must all look forward with confidence over the next fifty years to the expertise and ingenuity of our civil engineers in providing the increasingly sophisticated facilities needed by our own community and to meet the future challenging needs of China.

About the Author

C Michael Guilford has spent most of his working life in Hong Kong with Scott Wilson Kirkpatrick, the penultimate twenty-one years as a Partner and the last five as a Consultant, before retiring in 1996. Much of his effort over the years has been centred on the original Kai Tak Airport development, the airport tunnel and runway extensions, the Plover Cove Water Scheme and a variety of projects associated with civil and geotechnical engineering.

Acknowledgement

The information for this wide-ranging general article has been obtained from numerous sources. My sincere thanks are offered to all who have in any way helped with my research. Any factual errors, however, are my own and the writer would welcome comments or views on the facts from any interested readers.

Addendum

Since this article was first published, a reader has kindly advised that the purpose of the "overhead tram" referred to in the section on *Water Supply* was not as suggested but to provide access to two blocks of flats used in the summer by the Tai Koo sugar refinery staff. It was probably erected in 1891 and survived until 1932 when both the flats

and cableway weredismantled. A further 850m-long cableway was also built about 1907 to transport foremen and miners, at that time constructing the Kowloon-Canton Railway Beacon Hill tunnel, to bungalows on a hill the other side of the valley from the north portal (most probably at Sha Tin Heights).