

Creating a fairytale in Hong Kong

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Abstract

Yet another XL reclamation project is underway in Hong Kong: some 200 hectares of new land are being reclaimed from the sea in Penny's Bay to facilitate the building of a new Disney Theme Park in Hong Kong. The contractor responsible for the works is the BHD – Hong Kong Construction Joint Venture. Both joint venture partners have a long and successful track record in Hong Kong. The work involves the removal of over 42 million m³ of unusable mud, 50,000 m³ of which contaminated, and the supply of some 70 million m³ of sand for the reclamation.

One of the contract requirements was close to zero differential settlement after delivery. A number of techniques are applied to the newly placed sand-body to achieve this goal. The settlement process is speeded up by deep compaction, the totally treated volume is about 40 million m³

The contract also involves the building of a 2 km seawall, a 1.5 km revetment along the eastern seawall and a 2 km access road. This part of the work involves some 2 million m³ of rock.

The entire project is to be completed within a period of 32 months, work started in May 2000 and the completion date is scheduled for 7 December 2002. Planning of the project is therefore all-important, as is the sequencing of the work, using such a large number of equipment simultaneously in a relatively small area. The agreed work schedule is, to say the least, quite ambitious. To be able to meet the programme, a sizable dredging fleet was turned out, including a dozen-odd trailing suction hopper dredgers, a cutter suction dredger, a water injection dredger and a handful of grab-dredgers.

But what makes this project a real challenge is that it is to be executed under the strictest environmental supervision. Water and air quality are measured daily, noise levels are restricted, the well-being of local wildlife and corals in particular is closely monitored. All dredging operations, both mud-removal and sand deposits take place within a 4 km silt screen that is placed around the work site.

On the south-eastern side of Hong Kong's Lantau Island, a dozen or so trailing suction hopper dredgers were sailing to and fro during the past year. Hong Kong waters have not seen a dredging fleet of this size since the completion of the Chek Lap Kok airport in 1996. The ships are carrying mud and soft alluvial material from the future reclamation and sand to the site, where one of the largest reclamation projects in the long history of

dredging in Hong Kong is under construction: the building of a new fairytale theme park. This article describes the ins and outs of this mega-project.



Penny's Bay

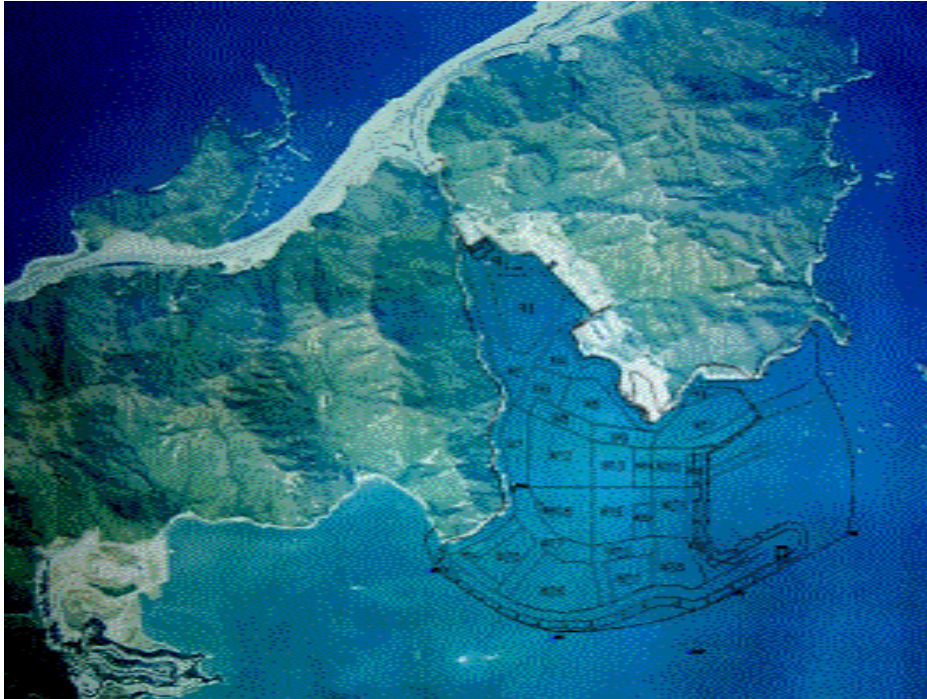
The location chosen by the Civil Engineering Department of the Hongkong Government, the Employer and their Engineer Scott Wilson (Hong Kong) Ltd. for the future theme park is Penny's Bay on Lantau Island. An area of about 200 hectares of new land is to be reclaimed from the sea in this bay. BHD's share of the works is about US\$ 500 million.

Vast volumes

In order to get some idea of the sheer size of the works, follow here some of the key Figures. Even before the actual filling operation for the reclamation could start, some 42 million cubic metres of uncontaminated mud and 50,000 m³ of contaminated mud had to be removed from the site. The sand volume needed for the reclamation is around 70 million m³. The settlement of this sand body will be accelerated by deep compaction, the deep compaction volume is about 40 million m³. In one area the sub-soil treatment is different and the excess pressurised water is drained off by means of vertical drains, a total of 2.6 kilometres of band drains are placed. This area is the future water pond. The work also includes removing silt and overburden from the marine borrow areas, before suitable soil can be extracted, as well as placing and removing surcharges on the reclamation site. This is a volume of about 6 million cubic metres. Finally, the contract requires the building of a 2 km seawall, a 1.5 km revetment along the eastern seawall and a 2 km access road. This part of the work involves some 2 million m³ of rock.

And all this is to be completed within a period of 32 months, the work started in May 2000 and the completion date is scheduled for 7 December 2002 within very ambitious

environmental constraints. Planning of the project is all-important, in order to meet the programme. So is the sequencing of the work, when such a large number of equipment is to be deployed simultaneously in a relatively small area. The agreed work schedule is, to say the least, quite ambitious.



Monitoring measures

The Hong Kong government is very keen on protecting the environment, which resulted in very strict regulations and requirements for the dredging work in this project. A considerable amount of time, effort and money goes into monitoring the ecological and environmental effects of the work. Water and air quality and noise in the surroundings are measured frequently and the wellbeing of local wildlife is monitored. A special team, including independent consultant Maunsell and the so-called Environmental Checker (EC) are involved full time. All these measures caused the original budget for this item to be overrun by some 500%!

Scanning the subsoil

No less than 1200 CCPT's were used to pinpoint the top of the hard clay subsoil, the target dredge levels. A solid foundation for the reclamation was found at levels varying from -10 m to -39 m, in some spots even -45 m. This meant that a mud layer of up to 33 metres thick was to be removed. This prior to the filling works.

Up for grabs

Work started with removing the thick layer of unsuitable mud from the bottom of the sea. The original seabed level at the site varied from -3 m to -7 m, while the top of the hard

clay subsoil was found at between -10 and -39 metres. Initially, three grab dredgers were used for mud removal, a deviation from the Hong Kong tradition of using large numbers of grabs for this type of work. The grabs created sufficient depth for the small trailers like HAM 312 . The smaller trailers in turn dredged an access channel and lowered the level of the working area for the larger vessels such as Geopotes 15, Amsterdam and Rotterdam.

The dredging of the Sea wall trench was a particular case as dredging took place to a strength of 2 mPa of the underlying strata . The Engineer, the Employer but in particular the end user have very stringent requirements with regards to the differential settlement criteria.

Once the grabs and trailers cleared the way for the new generation jumbo hoppers such as the HAM 318 or the Rotterdam, with hopper capacities of some 23000m³, mud removal operations were speeded up in order to make the time table as specified in the contract.

Designated dumpsites

The removed mud was taken to a number of designated dump sites for which BHD obtained special dumping permits. For non-contaminated mud they are located North of Lantau, South Chung Chau, near the Nine Pins Islands and in the PRC south of Danggang for mud removed from the PRC borrow area. A separate permit was issued for the contaminated mud, which was to be deposited in the special dump-pit at East Cha Chau.

Checking the numbers

A survey launch with a multibeam echosounder verified whether the required dredge levels were actually reached. Apart from these bathymetric surveys, grab dredgers took soil samples to a 25 x 25 m grid and vibro-core samples were taken on a 50 x 50 m grid as well as seismic soundings.

These surveys were conducted while work on site continued, which meant the survey vessels had to manoeuvre amongst a large number of dredgers and other ships. One can imagine that this was not the easiest of surveys ever done. Once satisfied that sufficient mud was removed, so-called settlement plates were placed on the dredged surface to a 100 x 100m grid to provide accurate information of the settlement of the sub-strata.

Settling and surcharges

The reclamation areas had to be raised to levels varying between 6.5 m and 10 m PD. This meant that in some places a sand layer of up to 45 metres thick was needed. Expected settlements were to be compensated for. For this reason an extra overfill of about 0.6 m on average was placed over and above the required surcharge levels. However, settling specifications, and thus the overfill needed, varied per area. For instance in work area W3 (see map) there is a maximum surcharge level of +20 m PD.

The filling operations starts with placing first a sand blanket of 3 metres. Subsequently, a so-called basal vibro-core is carried out to ensure that there are no silt pockets left behind or enclosed. The grid is 50 x 50 m. The maximum allowable inclusion of silt is 400 mm. After confirmation that there are no large enclosures, the filling can continue.

Lots of sand, little time

There are a number of possible filling methods used. In some cases it is the strict environment constraints that dictate the working method deployed. But, broadly speaking, when there is sufficient depth for the trailers to access the working area, the dredger will simply open its bottom doors and dump its load on the spot. When the site gets too shallow for the ships to enter, they revert to rain-bowing, unloading their sandy cargo through a nozzle at the bow. In Hong Kong, however, the issued environmental permit stipulates that this method may not be used in the water. A third method is pumping the sand ashore via a floating and land pipeline. All these methods have but one goal: to get as much sand in place in as little time as possible.

But when accuracy becomes an important factor, exactly how much sand goes where and when, different methods are used. For instance in Area W3, a special zone where soft marine deposits are left in the sub soils, the sand is to be deposited in a controlled manner by a special spreader barge Tisnix which is able to place layers of 1 metre thick, layer after layer. A number of the layers are reclaimed by a cutter suction dredger from a re-handling pit.

Allowed borrowing

A total amount of around 70 million cubic metres of sand is thus used for the land reclamation in this project. The necessary sand is found in various marine borrow areas in Hong Kong and the PRC. Again, BHD obtained special permits to excavate sand in these locations. They are: East Lamma Channel and Po Toi, both in Hong Kong waters, and Wailing Ding near the Wanshan Island in the PRC. The mining licences for this last area in the PRC were obtained after lengthy negotiations with the Chinese authorities.

As in the mud-removal phase, here too the sand quality is checked by vibro-coring on a 100 x 100m grid. The result: 32 cubic metres of sampling material and 16.000 sieve analyses.

Seventeen trailers

For a sand-fill operation of this magnitude, a great number of trailing suction hopper dredgers, no less than seventeen, were deployed.

And then there were the other dredgers, such as a cutter suction dredger, a water injection dredger and different units of grabdredgers.



Apart from the actual marine works, such as de-mudding, dredging and sand-filling, there are a number of associated activities to be carried out under the same contract. They include:

- Deep compaction
- Instrumentation
- Vertical drain installation
- Surcharge removal
- Seawall construction
- Access road construction

Zero differential settlement

The deep compaction works are carried out by subcontractor Bachy – Soletanche, another familiar name on HAM project sites in and outside Hong Kong. A sand body with a volume of about 40 million m³ is to be treated in this way. The objective here is to meet the contract requirement of close to zero differential settlement after delivery. The end user of the new land was very particular about this requirement.

The deep compaction method used in this case is the Vibro-float method. A so-called poker is jetted into the ground and energy is applied at its end whilst retrieving the poker at 1 m intervals. The developed gap is gravity filled from the top. On average, a compaction of 6% by volume is achieved with this method. The contract requires 5%. Not the entire sand body is to be deep compacted through and through. In some zones only limited deep compaction is needed, whereas others are full depth zones. Pre and post CPPT's are taken to monitor the works.

Installing instruments

The instrumentation of the reclamation site is another activity carried out by specialist subcontractor Bachy - Soletanche. The types of Instrumentation to be installed include:

- Casa grande piezo-meters
- Vibrating wire piezo-meters
- Magnetic extensio-meters
- Inclinometers with extension meter

The instruments are installed in 33 co-called instrumentation clusters. Again, the end user was very particular about the instrumentation part of the works.

Removing surcharges

An entirely different method used to speed up the settlement process, is to place a surcharge on the reclamation. It goes without saying that this surcharge has to be removed at the end of the day. Surcharge removal, 6 million cubic metres in total, is also an in-house activity of BHD. Large land-based earth-moving equipment that can shift about 110,000 m³ per week is used.

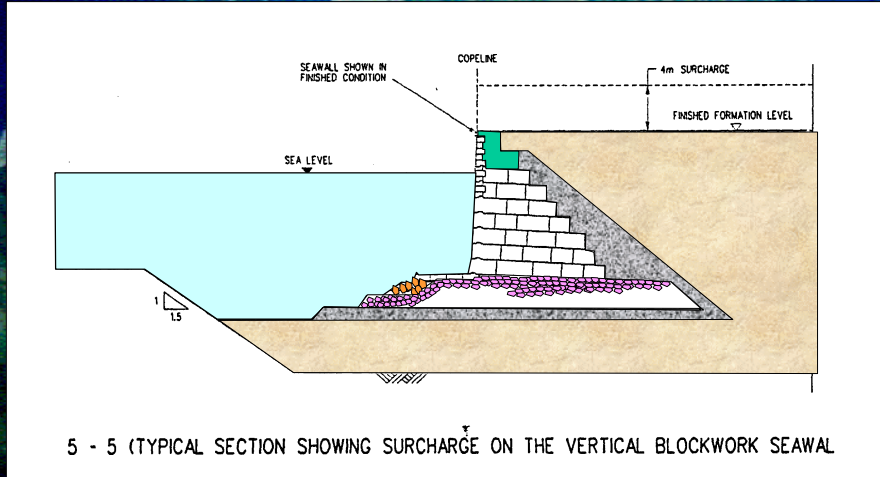
Stripping rigs

In some cases soils are drained using so-called vertical drains. These are strips that are installed into the sub-soils through the reclaimed sand-body by special rigs, two in this case. This too, is an in-house activity of BHD. The two rigs combined have the capacity to install about 40 km per day, which means they have to work around the clock to install the total of 2.6 million metres of drains needed in this project. The vertical drains are installed in the special area W3, a future recreational area. The installation of vertical drains in this zone was a very critical activity, causing considerable changes in the working sequence.

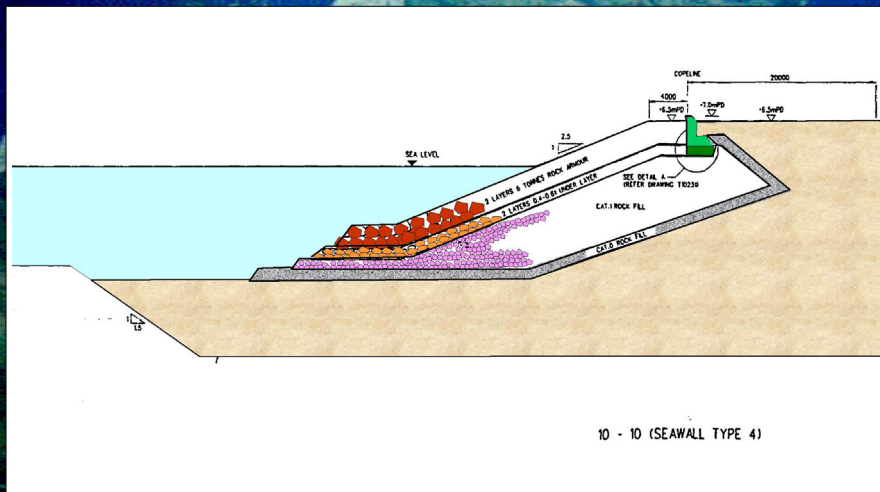
Classic seawalls

The second joint venture partner, Hong Kong Construction Ltd., is responsible for the construction of the various seawalls, both vertical and sloping, revetments and access road. This part of the contract involves the supply and placement of about 1.9 million tons of rock. The rock originates from Chinese quarries in the PRC. Two large box culverts are also constructed in order to drain surface water from the area.

Vertical Seawall



Sloping Seawall



The seawall is to be constructed on the south side of the project, about 2 km long and consists of two sections. A vertical seawall and a sloping seawall, with a cat 1 rock core. The designs used for the seawalls are fairly classic and well-proven, often used in Hong Kong. At the Eastern seawall a 1.5 km revetment is to be made.

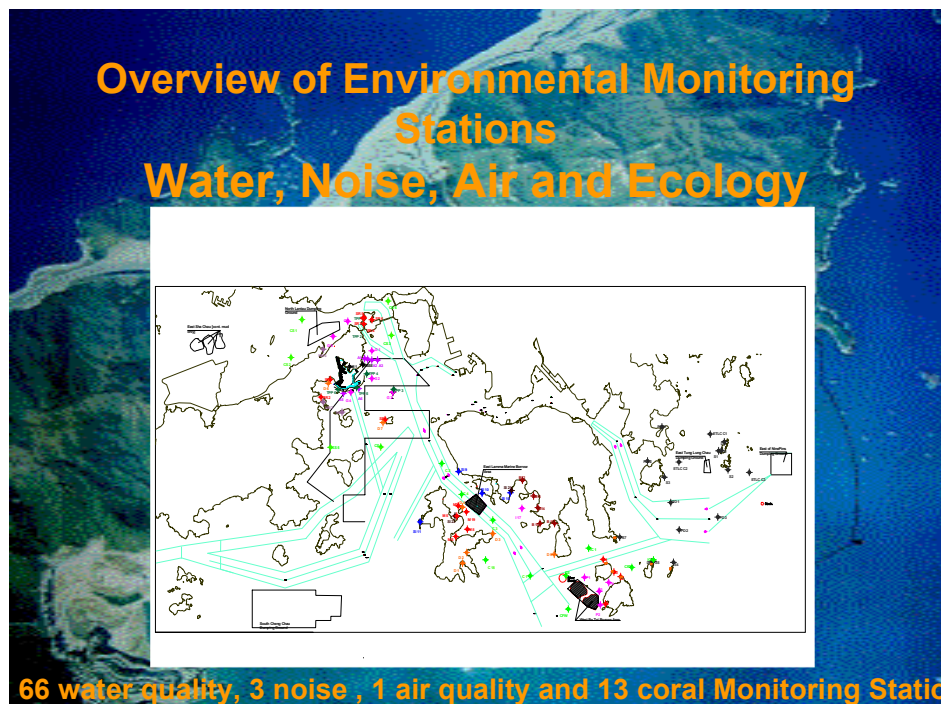
The design for this revetment was changed, originally the eastern seawall was to be filled with public fill, this was later cancelled.

The construction of the 2 km access road to the China Light & Power's power station, is another one of Hong Kong Construction's activities. Three culverts were to be constructed underneath the road.

Environmental efforts

Hong Kong is very keen to protect its environment. As a result the work done by the joint venture is subject to many environmental regulations and limitations. The following measures have been taken:

- a 4 km silt screen and a temporary rock bund installed around the worksite
- installation of 66 water quality monitoring stations
- installation of 3 noise measurement station
- installation of 1 air quality measurement station
- installation of 13 coral monitoring stations
- ecological monitoring of wildlife



Silt screen

A silt screen was installed around the entire working area. The screen is to keep suspended solids particles stirred up by the dredging operations within the site boundaries. It was installed by hand from workboats, a labour intensive operation. The screen needs daily maintenance, another time-consuming activity, as it collects large quantities of floating debris like noodle boxes on the outside. The navigation lights often need to be replaced. These lights get stolen quite often.

Water quality

The water quality is monitored in the surroundings and is measured with sensitive receivers, located at the fish farms in Ma Wan, recreational area Ocean Park and residential area Discovery Bay. Some of the receivers are online with special dedicated underwater telephone lines and underwater receivers. It takes careful planning of the work to stay within the allowed limits. At times, it can be quite a challenge to comply with all the contractual stipulations, especially when fishing activities in the area have damaged the cables again. Or, when the noise background level goes up due to air conditioners in the residential area, and the allowable legal limits go down.

According to the instructions in the contract, 13 different coral monitoring stations were installed, where the corals are monitored constantly.

Eagles and dolphins

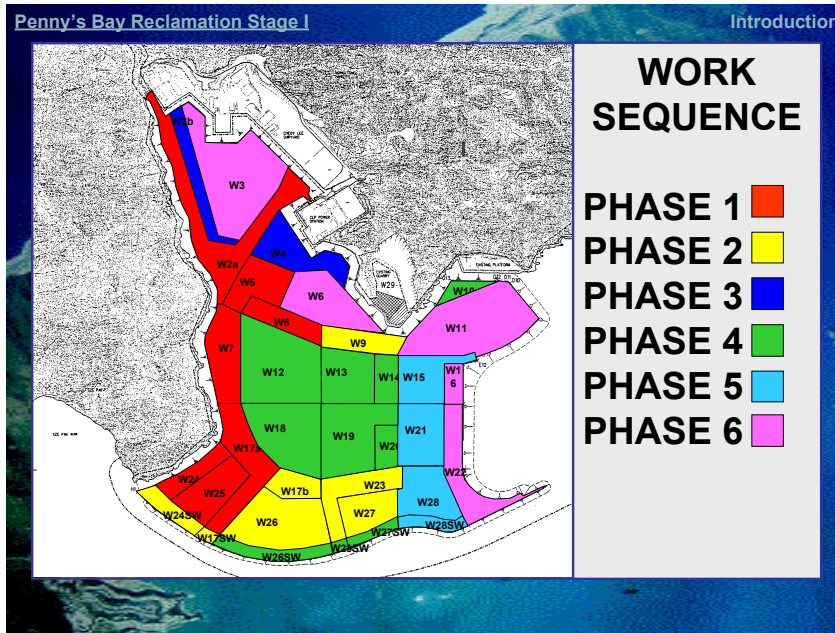
Environmental observers keep track of the movements of local wildlife, and two species in particular: the pink dolphin and the white belly sea eagle. They report twice a month. The observers spotted the dolphins near the silt screen, where they tried to socialise with the observer's vessel. A magnificent bird and one of the most interesting creatures on site is the white belly sea eagle. Mother is doing well and courting a new partner and new chicks have been spotted.

Ten tons of paper

All these environmental monitoring stations produce a tremendous amount of data and generates a huge amount of paperwork. Environmental reports alone provide a fulltime job for a staff of ten and use up some 10 tons of paper per year.

Milestones and handovers

As in many projects of this size and nature, the work is divided into phases. Each phase has its own delivery date, confirmed in the contract. It means the project knows a number of milestones and handover dates. The work on the Future Hong Kong Disney Theme Park is divided into six phases of which the first three are completed and handed over by the time this paper is published.



Situation at Present

The red section of stage 1 and the yellow section of stage 2 have already been handed over and completion certificates were issued.



Keywords:

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| reclamation | seawall |
| dredging | surcharge |
| mud-removal | environmental monitoring |
| deep compaction | multibeam echosounder |
| vertical drains | vibro core |