



GEOSYNTHETICS

PLAY IT AGAIN

Aviation fuel storage at Hong Kong's Chek Lap Kok Airport is being expanded using the same high-specification geosynthetics as the original scheme. Steven Flynn and Brian Davies report.

Chek Lap Kok, Hong Kong's international airport, was heralded as "the biggest civil engineering project in history" during its construction in the 1990s.

The claim was justified. Formed from two small rocky islands, the airport was one of the world's most geotechnically challenging projects and was developed at high speed.

Using land reclaimed from the sea, in areas up to 90m deep, it took only 30 months to create a 12.48km² foundation platform – four times the original size of the two islands, extending out into the South China Sea (*GE* supplement, December 1996).

A major element of the development was construction of a HK\$1.8bn (£123M) aviation fuel receiving, storage and distribution facility at Sha Chau Island, 6km north of the airport and 2.5km from the airport apron.

Chek Lap Kok opened in 1998,

and by 2005 it was handling 40.74M passengers a year. These numbers meant the airport fuel storage facility had to be expanded.

This project, Contract P311, involves design, construction and commissioning of three 17,000m³ tanks, including bunding and associated services, which will be integrated into the aviation fuel system.

Construction of the three tank bases began in November 2005, to the same design and with the same environmental lining as the older structures. The original facility comprises a refueller calibration area and hydrant system and one of the largest aviation fuel tank farms in the world, with a capacity of 172,000m³ in a total of nine storage tanks: six 22,800m³ capacity tanks and three smaller ones of 11,000m³ capacity each.

Twin pipelines mean it can supply 59,000 litres/min direct to aircraft in their parking bays at the

two terminals.

The design had to take into account not only the potential hazards of building on a man-made island, but the presence of a 12.5km² marine reserve at the southern tip of the airport site.

The area is an important feeding ground for the endangered Chinese White Dolphin – the largest surviving population of about 180 of these mammals is in Hong Kong waters – so a huge effort had to be made to maintain its ecological security. Surrounding wetlands, sea grass beds and mangrove communities also had to be protected.

This meant the choice of construction materials and techniques was influenced not only by their ability to function in the difficult conditions, but by their ecological impact.

To prevent any fuel leaks or spillages entering the groundwater or the sea, the design had to provide

a bunded area around the tanks, protected by a high security lining membrane within the bund and directly beneath the tank bases.

After extensive evaluation, the lining system chosen was an environmentally friendly pre-hydrated geosynthetic bentonite clay barrier incorporating a 4.6mm thick inert central core of polymer-protected natural sodium bentonite, laminated between a 116g/m² woven geotextile carrier fabric, and a 200g/m² nonwoven geotextile cover layer.

The Rawmat HDB composite membrane, delivered in 2m wide by 50m long rolls, is manufactured by UK company Rawell Environmental and supplied by Thoron X-Calibur. The highly flexible, self-sealing membrane was chosen because it can withstand the potential differential settlement of the reclaimed ground within the bunded area, without damaging the seal across the body of the bund or at the numerous plinths and stanchion penetrations.

Its simple installation procedure meant there was no need for a specialist subcontractor, and there were no weather-related delays despite a typhoon during the original project.

The recent work will maximise the airport's operational efficiency and increase the capacity of the facility to 220,000m³.

Owner Hong Kong Airport Authority awarded the design and build contract to China National Chemical Engineering Group



Facing page: the aviation storage facility at Chek Lap Kok Airport is one of the world's largest, supplying up to 59,000l/min to aircraft. Centre left: Granular fill is placed on the geosynthetic barrier and compacted. Left: The prehydrated bentonite membrane is fixed to the tanks' ring beams.

Corporation (Hong Kong Area). The 2.9m high ring beams on which each of the three 34m diameter tanks are located were built with grade 40/20 concrete and filled with granular fill compacted to a density of 95%. The bund was built using the original reclamation formation of high saline marine dredged sand compacted to a density of 98%.

The same prehydrated geosynthetic bentonite clay barrier was chosen for the tank bases and the bund lining because of its performance on the first phase of the facility. The product is unique among bentonite membranes because its prehydrated formulation provides a barrier in saline conditions, giving hydraulic conductivity of about $5.4 \times 10^{-12} \text{m/s}$.

Unlike other bentonite membranes, it swells in saline conditions and provides a barrier without the need for initial hydration with fresh water.

The membrane was laid on the compacted granular fill within the ring beam of the tank, the rolls were overlapped and an immediate seal was formed between the sheets of the membrane by applying Rawpaste Mastic, a bentonite mastic, within the 150mm overlap. No welding was required as the bentonite bonds the sheets together to form the seal.

More bentonite mastic and a prehydrated bentonite fillet (Rawseal HDB Fillet) was applied to the vertical face of the ring wall and the membrane then turned 100mm up the wall and secured

with an aluminium fixing bar.

The membrane was then confined with a 200mm layer of compacted granular fill before the 50mm sand/bitumen mix onto which the 10mm steel tank base plate was placed.

An area of 3,500m² of membrane was laid beneath the base of the three tanks. Installation of the lining under each tank was completed in three working days. The operation involved laying the membrane, backfilling and compaction of the cover material and placing the sand bitumen layer to site directly beneath the tanks' base plates.

Work is now focused on installation of the prehydrated bentonite membrane between the tank bases and the bund wall.

This part of the contract requires 18,000m² of membrane.

Installation is more complex as it has to be sealed to the external face of the tank ring beams and to the stanchions and foundations to the pipe work within the bund.

Once installed and sealed to the various protrusions, this membrane will be covered with granular fill and compacted to 95%. The tough lining has a CBR puncture resistance of 2300N which, combined with the self-healing properties of the bentonite clay, ensures a robust and effective system. Work is due to finish this month.

The project is due for completion in December.

Steven Flynn is commercial director at Rawell Environmental and Brian Davies is a director of X-Calibur Construction Systems.

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