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# Airport in the mountains

In 2003, the Kingdom of Swaziland embarked on construction of the USD150-million Sikhuphe Airport project. This formed part of King Mswati III's USD1-billion millennium project investment initiative to enhance Swaziland's position as a leading tourist destination in the region. GIBB, one of Africa's largest multi-disciplinary consulting engineering and science companies, were responsible for designing the key structures of the Sikhuphe airport, a project that highlighted their expertise and multi-disciplinary workmanship.

*The control tower at Sikhuphe. The mountainous nature of Swaziland made designing and building the airport difficult.*

**THE KINGDOM OF** Swaziland determined the need for an international airport capable of accommodating large international aircrafts.

The project area is situated in the Swazi lowlands at Sikhuphe, which is close to Siteke and the sugarcane plantations and game parks to the East, yet in close proximity of the capital Mbabane and Manzini. Finding sufficient flat ground to accommodate both the runways and the control buildings was not an easy task.

The project was multi-faceted and these diverse divisions were disseminated among several consultancies. The Swazi consultancy of DTA was asked to design all of the critical installations and buildings associated with administrating the airport.

"DTA subcontracted GIBB to do the structural design of the airport's critical structures, including the control tower, the air traffic control building and the fire station. Of the most interesting facet of this project was the control tower," says GIBB engineer, Pat Masterton.

*Because of the position of the land, the control tower had to be built on ground at a level below the runway, yet still be capable of reaching high enough to see the ends of the runways.*

## The control tower

"The contract for the construction of these buildings was awarded to Stefanutti Stocks. The design of the control tower was particularly interesting and challenging," Masterton continues. "Because of the position of the land, it had to be built on ground at a level below the runway, yet still be capable of reaching high enough to see the ends of the runways."

This resulted in having to design a much taller tower, than would normally be expected, with a total height of 57 m and consequently, this presented a number of unique design challenges.

There are also a number of unusual shaped transformations incorporated in the architectural concept of the tower. The main structure encompasses a rounded triangular shape (47,8 m high with 200 mm thick concrete walls) built on a hexagonal base, which is founded 5 m below ground level on rock. Above the 47,8 m high tower walls is the technical level, which is constructed on a cantilevering, octagonal shaped, composite slab and comprises a 16-sided structural steel cage. This in turn

*The completed control tower.*

*Continued opposite ...*

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supports the actual Visual Control Room (VCR) or cab. The cab is octagonal in shape and is built on a composite slab supported on a upstand beam. There is a circular shaped balcony at a slightly lower level. The VCR itself is imported from the UK and is lifted up onto the structure using a tower crane.

The Natural Frequency of the tower became an area of concern and calculations indicated that based on the ratio of the mass, moment of inertia and height of the tower, the natural frequency of the structure was in a zone where a more in-depth look into the design was required. The natural frequency of the tower fell just outside the 10% range of the wind vortex shedding frequency that would cause resonance of the tower under certain design wind speeds.

## Tower methods

Different methods to change the natural frequency of the tower, without completely changing its architectural aspects, were considered. The design selected was to reduce the functional height of the tower by increasing the rigidity of the lower portion of the tower. To do this, wing walls were added as braces at the bottom of the tower. These wing walls are constructed from the foundations up to a level of 2,6 m above the lower entrance to the tower. Both the mass of the tower and the effects of moment of inertia had to be kept in mind when designing the wing walls. By adding the wing walls, it was possible to increase the moment of inertia of the tower and to achieve a reduction in the effective length, without sufficiently increasing the mass.

The shape transformations at the top of the tower, together with the size of the steel cage and VCR at the top of the tower, also change the wind vortex shedding frequency to the benefit of the design with a final solution that reflects the architectural intentions, whilst at the same time providing a robust structural solution.

## Tower construction

Stefanutti Stocks opted for a slip formwork construction, similar in principle to the many other pours that they have successfully done at other airports. "It was a pleasure to work with this professional team and the entire pour went ahead with minimal complications, with the most unpleasant being that it was poured during the heart of winter and low concrete temperatures lead to slow progress at night," concludes Masterson.

It is expected that the airport will be in operation later this year and Swaziland will then be able to celebrate having a modern, fully functional international airport capable of receiving the large aircrafts that fly to Europe and Asia. ■