The R8.4 billion King Shaka International Airport outside Durban is the first greenfield airport of its kind to be built in South Africa, comprising state-of-the-art aerodrome facilities and infrastructure capable of handling 7.5 million passengers per annum. As a complete replacement of the much smaller Durban International Airport, it includes a world-class cargo handling facility which is unique to Africa, and a 3.7 km long runway capable of handling new generation large aircraft such as the 555-seat Airbus A380. The mammoth task of providing a fully functional airport within an already tight construction period of 33 months was further complicated by the addition of over 250 civil engineering variation orders during the project life-cycle.
THE KING SHAKA International Airport (KSIA) is situated on a massive 2 000 ha site in La Mercy, 35 km north of the Durban city centre. The development of the site was planned for a phased expansion with the first build (ready in 2010) having operational capacity up to 2015.

The Ilembe EPC Consortium, led by Group 5 and WBHO, was awarded the contract for the design and construction of the new airport facility in June 2007, and was responsible for handing over a fully functional airport to the Client (Airports Company of South Africa associated with Dube Tradeport) by the end of April 2010. Such a large and multi-disciplinary project required the assembly of a comprehensive team of professionals including PDNA, GOBA, BKS and Y&S for the design and construction supervision of all civil and structural engineering works on the site.

Some of the key design elements unique to the airport are discussed below.

**PASSENGER TERMINAL**

The focal point and most significant building on the site is the passenger terminal and associated air corridor complex. Located over a previously filled valley, the 100 000 m² building comprises a basement, arrivals level, departures level and offices and plant room block. Light-weight structural steel mezzanine floors were installed to support the baggage handling system and control offices. The air corridor, of some 500 m overall length, faces onto the airside and feeds a series of fixed bridge links to the aircraft.

Rock at depths from 5 to 15 m below ground level provided a piling solution comprising driven cast in-situ 225 tonne piles. Reinforced concrete pile caps of 1 to 15 piles support all column loads.

Value-engineering the optimum spans required for the terminal architectural module with available building systems, indicated a 725 mm deep reinforced cast in-situ concrete coffer slab system providing a 15 m regular grid. Using the proprietary and readily available quick strip coffer system achieved rapid construction with concrete pours reaching 1 100 m³.

The air corridor utilised 250 mm conventionally reinforced flat slabs, providing fast construction and flexibility.

Structural steelwork is featured extensively as a principal structural element, both as an architectural feature and as a cost-effective structural system. The structural system is in essence a primary one-way girder.
support system spanning 60 and 30 m. The girders are spaced at 35 m centres, with a secondary orthogonal system supporting the purlins and roof fabric. Some 5 000 tonnes of structural steel were supplied, the delivery programme and access period for erection being critical for the accelerated construction programme.

Future module-based expansion of the passenger terminal was factored into the current design.

CONTROL TOWER
The highest point on the site, due to the visual control requirements, is the control tower cab – now a defined iconic landmark. The operational requirements dictated a three-floor module, comprising 360° clear uninterrupted sight lines at the top controller level. The tower is located over a deep-filled valley with bedrock level at 20 m which required a piled solution.

Given the construction and programming constraints, the following sequence of activities was undertaken to erect the cab in position:

- The shaft was constructed using reinforced concrete placed with the sliding shutter technique.
- The cab steelwork frame was erected about the shaft at ground level.
- The external façade cladding was installed.
- A steel lifting frame with four support arms was erected at the top of the shaft, designed to become part of the final structure.
- The partially constructed cab of some 350 tonnes was hung from the support points, and using a post-tensioning jack and strand system, jacked up to the final location by wedging and retracting the jacks.
- The assembly was aligned by polyurethane wheels to run against the shaft face, and the complete lift was undertaken in seven days.
- The framework was then completed by erecting the central portion of the radial roof structure using the tower crane.

3 Bulk storm water conveyance and spill management infrastructure in the southern precinct
4 Runway and taxiway system layout
5 Landscaping in front of the passenger terminal being completed
This unique one-off project required extensive innovative skills at every level, covering concept, design, detailing, fabrication, erection and implementation.

**Bulk Storm Water Management and Pollution Control**

As mentioned above, the airport site covers approximately 2 000 ha, of which 660 ha were developed/enhanced under this project. Approximately 30 km of 450 mm – 1 800 mm diameter pre-cast concrete pipes drain two major catchments via four outfalls into sensitive wetlands. The total attenuated discharge from the site during a 50-year storm is approximately 90 m³/sec.

Significant design challenges included:

- The attenuation of storm flows back to pre-development levels required a combination of at-source attenuation and the construction of attenuation structures. Approximately 120 000 m³ of storage had to be created within the airfield itself.
- Acceptable storm water quality could not be achieved without the use of structural and non-structural measures. Of particular concern was the treatment and management of the first flush coming off the aprons, and the fuel storage areas. Large-scale oil-water separators were constructed to minimise environmental impact.
- Catastrophic fuel spillage had to be limited/avoided. The inclusion and integration of diversion and containment systems in the event of a catastrophic failure led to complex solutions, including automatic hydrocarbon detection, actuated diversion and containment of storage had to be created within the airfield itself.
- Roadbed preparation by proof rolling
- Sourcing, management, movement and design up front to accommodate earthworks component of this project was one of the most critical risks during the early stages of the contract. Sourcing, management, movement and control of approximately 6 million m³ of earthworks required close interaction between the design team and the various contractors. The system of controlled access roads, haul roads and location of borrow pits and spoil areas required careful planning and design up front to accommodate the high volume of vehicles moving around the site. Approximately 5 000 people per day were accommodated on site on average.

**Runway and Taxiways**

The intricate runway and taxiway systems are designed to accommodate aircraft movements for new generation large aircraft such as the Airbus A380. The effective runway length is mainly a function of prevailing wind and temperature, slope and altitude at the airport. The runway at KSIA is effectively 500 m longer than the old Durban International Airport, ensuring that large heavy aircraft, e.g. Boeing 747s, will be able to take-off without take-off weight restrictions.

The construction of the runway and parallel taxiway commenced during an extremely wet season in 2007. The primary underlying weathered Berea Red material was found to be very sensitive to moisture fluctuations and thus proved difficult to manage and use. The pavement designs were based on maximum utilisation of the material available on site to limit importation costs of suitable material. A balance had to be struck between the two options of mixing the in-situ Berea Red sand found on site with locally available white sand and imported gravel to reduce construction costs. Actual load configuration and tyre pressure of the design aircraft (at maximum take-off weight) was applied on a linear elastic model of the pavement. Responses measured for each layer were then used in transfer functions or failure models to determine the life of the respective pavement layers, and eventually the overall pavement life of the whole structure. The following pavement structure was adopted for the runway and taxiways:

- 40 mm modified binder SMA
- 80 mm continuously graded asphalt surfacing
- 125 mm G1 crushed stone base layer compacted to 88% of ARD
- 175 mm C3 stabilised upper sub base compacted to 97% of MADD
- 200 mm C3 stabilised lower sub base compacted to 97% of MADD
- 175 mm G7 upper selected layer compacted to 95% of MADD
- 800 mm Type 1 fill (typically dune sand fill) compacted to 100% of MADD
- Roadbed preparation by proof rolling

**Other Information**

The project was truly multi-disciplinary, encompassing virtually all aspects of civil engineering, including:

- Bulk earthworks (± 6 million m³)
- Roadworks in massive cuts and fills
- Runway and taxiways (asphalt ± 400 000 m³)
- Parking facilities (multi-storey parkade and open parking, 4 500 bays)
- Concrete pavements (apron concrete ± 32 000 m³)
- Bridge construction (elevated roadway)
- Piling
- Cast in-situ concrete work
- Precast concrete work
- Water-retaining, cast in-situ concrete
- Building structures (46 structures including passenger terminal, cargo terminal and control tower)
- Large diameter sewer and water mains (steel, HDPE and mPVC)
- Large diameter storm water pipes (up to 1 800 mm diameter)
- Structural steel work (± 5 000 tonnes)
- Cable ducting (475 km)
- Multiple pump stations
- Waste water treatment works (2 off)
- Emergency spill control infrastructure

With over 500 contractors (including vendors) involved in the construction phase at multiple locations across the site, the timing and sequencing of activities required extensive thought and innovation. Careful planning during both the design and implementation phases of the project was thus essential in order to ensure integration of the various disciplines and stakeholders.

While the extremely tight design and construction programme of approximately 33 months presented its own set of unique challenges, the following aspects could in themselves be regarded as uniquely challenging on the project:

- Numerous Client changes during the course of the contract which required the re-engineering of certain aspects of the works, including major items such as the shifting of the entire trade zone approximately 400 m further north, structural revisions to the central terminal building, new landside retail additions, changes to landside parking areas, additions to the multi-storey car park, additional buildings, changes to the cargo terminal apron, additional taxiway B between taxiway F and taxiway N, etc.
- Being such a large site, the bulk earthworks component of this project was one of the most critical risks during the early stages of the contract.
- The system of controlled access roads, haul roads and location of borrow pits and spoil areas required careful planning and design up front to accommodate the high volume of vehicles moving around the site. Approximately 5 000 people per day were accommodated on site on average.

All building and surface infrastructure under the original contract was handed over to the Client in stages, with the final handover in April 2010 – on time and ahead of the much anticipated 2010 World Cup.