Formidable design and construction challenges posed by Clifton project

THE EVENTIDE APARTMENT PROJECT in Clifton stands out as an achievement in civil engineering excellence.

This valuable site is located in the heavily built-up area between Clifton 'Moses' Beach and Victoria Road, Cape Town. The ten-storey RC-framed apartment building was built off a base platform which was cut into the mountain slope with 27 m high laterally supported rock faces to three sides of the site. The excavation was blasted out of the granite bed-rock with due care taken to protect the surrounding environment.

The RC-framed structure required many innovative solutions to satisfy the unusual architecture of this prestigious development

STRUCTURE

Project background and architectural requirements

Kantey and Templer were appointed as civil and structural engineers in support of a large professional team. The client brief was to design the best apartment block in Cape Town to match the prestige of this spectacular site.

Architecture JV Stefan Antoni and Dennis Fabian Berman prepared a design proposal to comply with stringent building line restrictions in order to protect view corridors of neighbouring properties. The envelope of the building was eventually agreed upon after extensive negotiations between the developer, local residents and the City Council.

Pre-construction sales demand for these apartments was strong and the project was given the go-ahead in May 2003. The professional team had been engaged in an 'at-risk' capacity to this stage. The project presented us with a host of engineering design challenges as an outcome of the fixed building envelope as well as various commitments made to entice buyers.

These design challenges included:

- A terraced elevation with each successive higher slab footprint cutting back on three sides
- The nine levels of apartments were sold with a clear floor to soffit headroom that would not allow for transfer beams
- Most of the apartments chose to have a pool on the suspended cantilever balcony. Many buyers opted not to build the pool at this stage but required the structure to have sufficient capacity to exercise this option later
- All the apartments were sold to first-time buyers who took the opportunity to custom-design each unit
- Shear (bracing) walls were to be located out of the way of the apartment footprints to allow for architectural freedom
- Two large vehicle lifts in lieu of ramps were included to access the parking at each level
- The parking area at the rear of the building encroached on the building line along Victoria Road, necessitating the construction of a nine-level bridge structure to support parking decks at each level

Excavation and lateral support

The excavation to form the building platform for the Eventide apartment block was one of the largest ever undertaken for a residential development on the Atlantic seaboard. In order to meet the requirements of the City of Cape Town that the top floor of the development be no higher than the existing road level, combined with the need to create sufficient apartment space to make the scheme viable, it was proposed to create a vertical excavation face some 27 m high against the boundary line of three sides of the site. One of these boundaries was the kerb line along Victoria Road.

Geologically the site is situated in terrain composed of and underlain by granites of the Cape Granite Suite with a relatively thin cover of transported (colluvial) and/or residual soils. The granite ranges from completely weathered very soft rock locally near the top and more typically as medium weathered to unweathered hard to very hard rock with isolated joints as the depth increased.

The excavation volume totalled approximately 42 000 m^3 of which some two thirds was classed as hard rock.

To minimise disturbance of the neighbouring property owners and the risk of damage to adjoining properties, a strict monitoring programme was implemented. Each blast was monitored using recording vibration monitors. The resulting ground vibrations were reviewed and the blast designs modified to ensure compliance with the specifications.

The bulk of the excavated material was removed from site by means of two tower cranes which had to be moved around the site as the excavation depth increased.

Permanent lateral support of the excavation face is achieved by means of eleven rows of ground anchors at 3 m centres both ways. The upper 4 m portion of the excavation face is supported by soil nails and a 150 mm layer of mesh reinforced gunite.

Anchor lengths vary from 10 m to 26 m. Groundwater drainage is achieved by means of vertical wick drains attached to the excavation face before gunite application. In areas of groundwater concentration horizontal drains were installed into the excavation face.

An extensive programme of monitoring ground movement was undertaken with accurate survey readings taken every two weeks. No discernable movement of the surrounding buildings was recorded; however, some settlement of the roadway surface over approximately a 40 m length occurred with associated movement of the upper portion of the excavation face.

The excellent cooperation between the principal contractor, WBHO, and the sub-contractors, Frankipile and Ross Demolition and Kantey & Templer, resulted in a well-executed project with the minimum disturbance of the surrounding property owners and neighbours.

City Council requirements

The developer obtained permission to occupy 'subterranean' space beneath the proposed future Victoria Road widening line. The City insisted that this component of the structure be a separate structural entity functioning as a bridge such that the main building could be demolished without affecting the 'bridge' structure.

A 1,5m deep earth fill zone under the sidewalk had to be provided that would carry a myriad of services running along Victoria Road.

The bridge structure was built to conform with the City's requirements in terms of design

▶ *Right:The 'cleavage' portion at the west elevation showing the RC fin walls*

to bridge vehicular loading applied to the street level structural deck as well as the use of galvanised reinforcing throughout with a minimum of 50 mm cover. The 'bridge' component was separated from the main structure with an expansion joint.

Foundations

The RC-framed structure was designed to bear on pad footings cast onto hard granite. A safe bearing capacity of 2,0 MPa was used and the blast platform was cut to a level of 8,050 above sea level. The lift service basement was excavated to 5,300 above sea level. This level included an area incorporating the two large vehicle lifts, two passenger lifts and the lift motor room area to service all four lifts. The entire area was tanked with RC walls around the basement perimeter. Groundwater permeating the rock fissures surrounding the basement footprint is collected into perimeter subsoil drains which discharge to a well sump. The sump is drained with permanent pumps.

A 700 mm thick fill zone between the rock platform level 8,050 and the soffit of the RC surface bed was taken up by a myriad of services buried in sandy backfill material. The 150 mm thick surface bed was cast on the compacted backfill and the walls of the ground floor apartments are built off the reinforced concrete surface beds. The surface beds were reinforced so as to avoid excessive jointing which would interfere with the design of floor finishes.

RC frame

The RC frame was designed to incorporate the following features:

- RC flat slabs with no transfer beams: 280 mm thick RC flat slabs were used in the apartment area with 340 mm thick slabs over the larger spans of the parking garage
- Column layout to suit the 'cut-back' effect of the balconies without excessive cantilever spans
- Balconies designed to carry swimming pools
- Span/depth ratios of the slabs to control de-

EVENTIDE APARTMENT PROJECT

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KEY PLAYERS

Client Robow Investments No 47
Project managers C J Beech & Associates; Greenhill Property Services
Architects Stefan Antoni Architects; Dennis Fabian Berman Architects
Structural and civil engineers Kantey & Templer
Contractor WBHO Cape
Sub-contractors (earthworks) Frankipile and Ross Demolition

▶ *Above: Site conditions – showing restricted working space for excavation activities and new concrete structure sharing the base level*
Insert: Aerial view of excavation nearing completion.
Lift shaft and ground floor construction starting

flections and thus prevent cracking to expensive floor finishes
- The ten-storey frame was braced for wind and seismic loading by the use of RC shear walls. Shear walls were located around the substantial lift shaft (two vehicle and two passenger lifts) and around the opposite side of the parking area
- RC fin walls as an architectural feature were used in a load bearing function on the north side of the 'cleavage'. This was done to reduce the number of columns required in that area. The RC fin walls stepped back in a terraced fashion
- The slab at level 8 includes a large double-volume component with heavily loaded columns extending through the void
- Two fire escape staircases (nine floors) were designed with precast flights to assist the contractor
- Balcony door thresholds were given a 60 mm weather step and the top of structural slab sloped to full bores located on the outer perimeter area
- Balconies were designed with an upstand edge beam to support glass balustrade insets. Safety glass balustrades are secured with epoxy grout into formed slots into the top of the RC upstand beams. A shaped 'eyebrow' feature was included as an architectural feature around the perimeter of each floor
- The main lift shaft was cast ahead of the slab decks and bearing pockets were strategically positioned to support the slabs

In satisfying the above criteria a structural solution was arrived at that was neither symmetrical nor grid-like. A decision was taken to analyse a computer-generated model the entire RC frame to determine the interaction effects of the out of symmetry layout. This exercise required the specialist input of Dr Andrew Lloyd of ZLH Consulting Engineers, who modelled the entire RC structure on STAADPRO software. The analysis ran many different load permutations. The effect of seismic loading on the shear walls and certain column to slab connections resulted in some large stress concentrations. Heavy column and slab reinforcing was required in some areas to counter the seismic effect.

Stormwater diversion

An existing stormwater gulley draining a large area of the slopes of Lion's Head traversed the property.

In order to accommodate the development this stormwater route had to be diverted to the side of the site. We installed a temporary diversion pipe fixed to the south flank of the excavation for the duration of the construction phase.

The existing stormwater pipe crosses under Victoria Road around the middle of the site, thereafter it is diverted in the newly built services zone to a vertical 400 mm diameter uPVC dropper pipe located at the northeast corner of the site. Stormwater plunges 18 m vertically to an RC stilling well, at which point it discharges to another RC stilling further 6 m below via an inclined 400 mm diameter uPVC pipe. The lower stilling well drains to the sea via a 450 mm diameter RC stormwater pipe. This system is designed to give the City Stormwater Authority access for maintenance purposes.

Environmental management

The client employed the services of an environmental officer to monitor the construction phase.

The construction phase impacted heavily on neighbours in the area. The excavation and blasting phase was the most severe. Daily rock blasts were kept within prescribed acceptable vibration standards. PPS meters were set up at strategic positions around the site to monitor the shock felt by adjacent properties. All blasts were covered with heavy-duty rubber mats and soil over-burden to prevent 'fly rock' damage beyond the site boundaries.

IN CLOSING

The Eventide apartment project has presented a number of formidable challenges in a broad civil and structural engineering context. The main features that make this project stand out from other ten-storey apartment buildings are:
- The 27 m deep laterally supported excavations against three sides of the site boundary and in a built-up environment
- Numerous architectural requirements accommodated in the structural solution
- Building a separate 'bridge' structure to support Victoria Road and associated underground services
- Stormwater diversion through the site

This project provided a wide variety of unusual challenges for civil engineers to solve in the urban context. The chosen solutions had to take careful consideration to satisfy the environmental expectations and to assist the architects in achieving their aesthetic goals. □

Source:
http://www.saice.org.za/downloads/monthly_publications/2007/CivilEngFeb07web/#/0