Iconic new building for DIRCO

Completed in just 24 months from the start of construction in May 2007, the DIRCO project placed the professional team under immense pressure to produce economical designs within a very short period of time. Coupled with this was the challenge of bringing an unusually eclectic, asymmetrical design to reality. The geometric complexity of this structure, accentuated by the combined vertical and horizontal curvatures of the longitudinal floor beams, presented many challenges to the design team, workshop detailers, fabricators and erectors

BUILDING FOR DEPARTMENT OF INTERNATIONAL RELATIONS & COOPERATION

Technical Excellence category

BACKGROUND

The vision of the Department of International Relations and Cooperation (DIRCO) is an African continent that is prosperous, peaceful, democratic, nonracial, nonsexist and united, and which contributes to a world that is just and equitable. DIRCO's new premises in Soutpansberg Road, Pretoria, is a literal embodiment of the Department's vision.

Boasting impressive structural steel, thin stone cladding and woven 'spider' columns, the dramatic building is the central feature of a 150 000 m^2 campus.

1 Spiral staircases and spider columns are prominent features of the new DIRCO building in Pretoria

KEY PLAYERS

Client Department of International Relations & Cooperation
Professional Team Aurecon Civil & Structural Engineers / Iliso Consulting JV
TC Design (architects)
Main contractor Imbumba-Aganang JV

Completed in 2009 the building is set to welcome the world's dignitaries to South Africa and effectively showcase DIRCO to promote national interests.

Aurecon was appointed as the lead consultant for the structural and civil engineering of the building, in joint venture with Iliso. The contract included an imposing office building, new on-site guest accommodation and full refurbishment of the existing guest house in Waterkloof Heights. Aurecon was responsible for 85% of all the structural engineering works, which included façade engineering, the fire sprinkler systems as well as the air-conditioning system.

DESIGN APPROACH AND AESTHETICS

The guideline brief for the project was to portray an image that would promote national interests and present the DIRCO building as a 'gateway for South Africa to the world'. It was critical that the quality of the engineering design would be flawless and would fully express the architect's vision. It was the engineering behind several of the unusual features of the building that enabled the structure to have such an imposing, unique presence. Among these features were the successful execution of the complex spiral staircases, the challenging spider columns and complicated stack bond blockwork.

The architect's brief to the structural engineer was to design steelwork that "radiates a high-tech experience with extreme attention to detail". Resultantly, a combination of intricate architectural and structural exposed steelwork makes up various elements of the building. This kind of focused attention to detail within the building's structure creates its distinctive look and feel.

Key elements of the engineering design include:

- An internal 'street' between the north and south wings features composite bridges on each level connecting the two wings. Composite steel sections were used to enable 17 m clear spans. Some of the bridges only span halfway over the street as the architect wanted to create the illusion of open space in the street and hence these bridges and the link walkways are hung from the steel roof trusses enclosing the street. The bridges cross two expansion joints in the east-west direction of the building and independent slotted holes were introduced in the main beams to allow for horizontal movement.
- The main steel trusses over the street form an arch complementing the curved concrete clad spider frames externally.
- The main entrance features partially covered trusses, which allow natural light to enter the building. In turn, these trusses support a copper display ring which accentuates a feeling of grandeur when walking through the main entrance.
- To the east and west, the street is closed off with glazed façades.
- To the north and south of the building, the external steel balconies and spiral staircases create a strong aesthetic impact.

CONSTRUCTION OVERVIEW

The DIRCO building consists of five blocks spread over a large footprint. The contractor treated the blocks as separate buildings, each with its own site agent and foreman. An extremely short design and construction period meant that thorough planning of the design was of critical importance.

According to the information schedules, approximately four to five fully designed slabs per week had to be issued to the contractors. This placed Aurecon under pressure to produce design drawings and bending schedules within a short space of time. A performance specification was drawn up which was then given to design engineers in different offices to be used as a guide for the design of the slabs. These were conventionally reinforced 425 mm thick waffle slabs with 325 mm deep coffers, which allowed for easy monitoring of quality.

The southern building is accessed from the northern side via enclosed glazed bridge links which connect the two buildings. These bridges are also a display for three-dimensional art works on the inside, and mosaic art features on the outside. The requirement of a 17 m clear span concrete slab over the street area necessitated the use of a composite slab system consisting of steel beams supporting Bond-Dek decking panels with a 150 mm thick concrete slab. This is an excellent example of how innovative construction eliminates the need for expensive multi-volume propping.

The complexity and sophistication of the building provided many construction challenges, including the following:

Trusses

The geometric complexity of the structure, accentuated by horizontal curves, long spans, expansion joints, additional

loads applied by the hangers, and horizontal movement of both wings, induced a straightening effect in the arched steel trusses. In order to overcome this, concrete kicker boxes were designed at either end of the trusses to withstand the horizontal forces. These forces were taken up by the roof slab and concrete columns either side of the street, while slotted holes were provided on one end of the steel trusses to accommodate horizontal movement of the north and south wings.

Spider columns

On the outside, vertically and horizontally curved spider columns drape from either side of the building, which tie up to the arched roof. The columns are very slender and are only fixed on top and at

2 The new DIRCO building is a celebration of texture, form and colour
3 Attention to detail differentiates the interior of the new DIRCO building
4 Glazing incorporated into the design of the new DIRCO building lets in ample natural light

the bottom. To brace these loose standing features, guyed wires were introduced to tie each column back to the ring beam of the building. Not having any horizontal or vertical bracing creates the impression that the spider columns are 'floating'.

UNIQUE AND UNUSUAL FEATURES

Spiral staircases

The consulting engineers were tasked with making the architect's vision for decorative multi-storey spiraling access and fire-escape staircases a reality. Although an engineering challenge to design, the staircases were to provide a key feature of the building, and their execution was a key aesthetic element of the entire project.

For this reason, the architect would not accept the stairs being suspended from above using cables, as is usually the case. It would have meant the spiral stairs had to span from floor to floor and that between floors the staircase would have had to pass through one complete revolution of the coil. Because a coil is an inherently unstable structure and the centre line of the coil is continually changing direction, any force applied to the coil is, in essence, an out-of-plane force. Under load, the staircase would act like a spring, uncoiling and twisting away from itself.

Resolving out-of-plane forces in a way that would produce a stable structure proved quite challenging. The first step towards a solution involved taking the coil and transforming it into a helix using the inner and outer stringers as the cords and making the stair treads into rigid links between the two, in effect producing a three-dimensional Vierendeel frame. This allowed the engineers to rely on frame action to resolve lateral forces and the stiffness of the cords themselves to absorb the vertical forces.

A critical part of getting these staircases to work was being able to shed their load to the concrete structure at each landing. The concrete landing had to support the weight of one flight of the staircase and the bending moment induced by half of the flight above

and below the landing. Because the majority of the landings are themselves cantilevers of the main structure, this required careful planning and calculation. Frame and plate models were created to help anticipate the behaviour of the structure and all stability checks, member selection and connections were designed by hand.

Blockwork

Another unusual aspect of the building's design is the blockwork. Externally and above ground floor, a reddish colour block has been used, while in the basement, a subtle grey was chosen. This had to be done in stack bond instead of a stretcher bond which posed various unique problems in that the façades on the east and west ends of the building were external walls that had to be designed for wind loadings. Because the brickwork inside would be plastered, the contractor opted for standard stock cement bricks. The external skin had to be married to the internal brickwork, although the mortar joints were not on the same level. This meant that alternative methods had to be used to connect the external stack bonded blockwork with the standard brick modules on the inside. In addition, due to the stack bond blockwork, 2 x 5,6 mm diameter reinforcements had to be introduced in every second layer of blockwork to minimise the amount of vertical cracking.

Spider columns

The architect wanted the spider column theme throughout the building. Due to the short construction programme, it would have been extremely costly and time-consuming for the contractor to do the columns with their changing shapes in off-shutter concrete. (Manufacturing special shuttering to create this effect would have caused delays). The solution used was to fix structural steel onto the cast-in-situ standard concrete columns with precast concrete finishing achieving the vertical and horizontal curved shapes. Double sliding fixing plates were introduced on the columns straddling expansion joints.

ENVIRONMENTAL IMPACT

Economy of light

The clever use of natural light means the building utilises as little electrical power for lighting as possible. Light shelves on the north façade serve three functions: the external portion shades the area of glass immediately below it; the top surface, clad in reflective steel, serves to bounce natural light back into the top glazed portion and provides a trafficable surface for access to clean the façade; while the internal portion of the light shelf is a continuation of the same principle. Coupled with light sensors that control the outer zones of lighting, the building envelope performs its task outstandingly well.

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Economy of water

The building's water model includes the following systems:

- Grey water is captured in large storage tanks in the basement and re-circulated to the toilets for flushing.
- Rainwater and borehole water are captured and retained for use in general irrigation.
- Porous planted paving is used extensively in order to reduce surface run off.
- A retention dam is incorporated on the site in order to control outflow into the municipal storm water system.

A positive work environment

Employees are one of an organisation's most valuable assets. In order for them to perform at their best, an environment commensurate with this sentiment should be created. DIRCO embodies this vision to perfection with careful design features that ensure employee comfort:

- Visual connectivity to the outside environment is maintained and natural light cleverly introduced via strategically placed glazing.
- Computer screen glare is reduced by the screening effect of the perimeter offices.
- The height of storage elements and desking has been minimised for maximum views of the outside environment.
- Wide circulation routes create adhoc meeting environments.

CONCLUSION

The DIRCO project is an engineering triumph of vision enacted and aesthetic challenges solved. The 150 000 m^2 campus showcases the Department and promotes national interests. This project has successfully provided the Department of International Relations and Cooperation with a home in which to enact its vision. The new DIRCO building is very different from the disjointed buildings that housed the Department previously. It has unified operations to present a world-class statement to international visitors. □

Source:
http://www.saice.org.za/downloads/monthly_publications/2010/2010-Civil-Engineering-dec/#/0