Steel in *Motion*

By Reneé Pretorius

A retractable structural steel roof makes all-weather shopping possible at a South African mall.

Developer
Attfund Limited, Menlo Park, South Africa

Architect
Bentel Associates International, Johannesburg, South Africa

Structural Engineer
LC Consulting, Sandton, South Africa, SAISC member

Engineering Software
Prokon

Detailing Software
StruCad

Steel Contractor
Cadcon Ltd., Menlo Park, South Africa, SAISC member

General Contractor
WBHO, Bergvlei, South Africa, SAISC member

How do you construct an all-weather space that is open to fresh air in good weather conditions, but still creates an inviting space when the weather is less than ideal?

This challenge is what sparked the idea of a retractable roof—the first of its kind in the country—for the central piazza of the Clearwater Mall in Roodepoort, South Africa.

The earthy feel and clean look of the two-story shopping mall and its parking facility was achieved by combining a range of building materials such as exposed steel, concrete, laminated timber, sandstone cladding, and glass. Developers further challenged the architect to come up with a retractable roof that would be aesthetically pleasing but

affordable.

This sliding roof is an example of multi-disciplinary integrated technology. The roof not only automatically opens and closes at certain times of the day, but also has sensors to make it operate according to rain and wind conditions. It features an override function, as well, so that it can be opened or closed manually according to the circumstances.

Roof Structure

The oval shaped piazza has a two-part roof. The main, rectangular portion consists of a 40 m long × 15 m wide (131.2 x 49.2′) movable steel truss system clad with concealed-fix steel roofing. The steel truss system slides over the rim of the surrounding fixed, glazed areas, which are shaped to fill in the gaps between the steel roof and the piazza. These glazed areas ensure that the piazza has sufficient natural light, even when the roof has to be closed during the day due to bad weather.

To achieve a lightweight structure, engineers designed the roof to rest in its closed position on an I-beam support system connected with tension rods to decrease deflection and increase moment resistance capacity. This effectively created an unusual truss system between the I-beams and the rods. The I-beam support system forms the parallel rails that support the wheels of the movable steel structure. Each rail is supported by two V-shaped columns constructed from laminated timber beams. The V-columns rest on single concrete columns with specially shaped steel connecting plates on each side, bolted through the laminated timber.

The material initially chosen for the tension rods was stainless steel, but this proved to be too expensive. EN8 steel rods (85 to 95 ksi) with 20 micron-thick electro zinc plating for corrosion protection were substituted.

The retractable part of the roof consists of a series of parallel but shallower flat trusses. The trusses are cross braced using tension rods and designed to accommodate the uplift loads that result from wind suction forces, as well as the normal gravity loads and lateral forces.

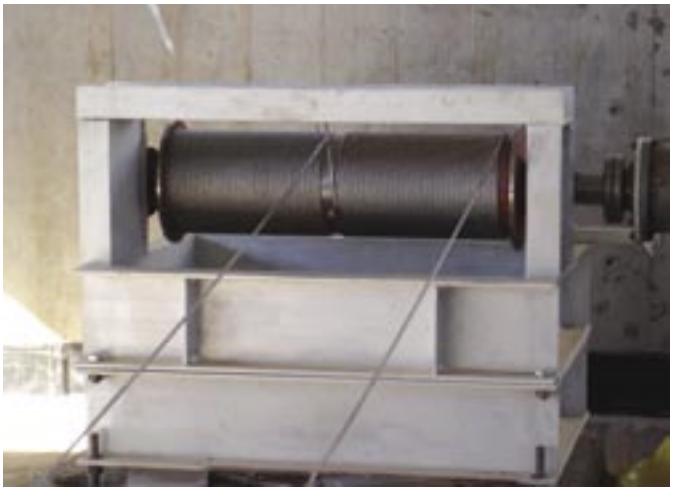
Putting it into Motion

Thirty-eight sets of wheels are connected to the roof trusses of the sliding structure. A cable pulls the roof forward or backward while reeled onto a single winch drum driven by an electric motor. The motorized winch and associated electronic equipment are housed on and protected by the waffle slab. The winch features springs to add flexibility to the cable. This "single drum" concept proved to be the most practical and cost-effective solution to ensure that both sides are pulled evenly, which prevents crabbing. Crabbing occurs when one side of the roof is pulled ahead of the other side, causing it to become stuck.

Construction of the project was completed in just over one year. The sliding roof required 194.1 tons of structural steel. The total cost of the roof and its associated finishes was about R 2.7 million ($408,000).

Reneé Pretorius is Editor of Steel Construction*, the official journal of the Southern African Institute of Steel Construction (SAISC). This article originally appeared in the February 2005 issue of* Steel Construction.

Parallel steel rails support the 38 sets of wheels attached to the movable steel structure.



An electric-driven winch spools the cables that pull the roof forward and backward.