POST-TENSIONING IN STAYED COLUMNS

POST-TENSIONING INSTITUTE ®

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Contemporary architecture offers new challenges for engineering. Prestressed concrete is often used to reduce structural member size and weight, making challenging projects possible. The following case study will feature a post-tensioned residence specializing in detailed construction methods, quality installation, and advanced materials. Sustainability and technology advancement are the primary goals. The Engineer brought an innovative solution for this project.

The residence, located in Curitiba, Brazil (Fig. 1), has four levels: basement, ground floor, first floor, and roof. The project provides a total area of 12,380 ft^2 (1150 m^2) with an open view of the surrounding land and environmental preservation area.

The architect and owner designed this residence based on modern architecture with Scandinavian influence. The architectural concept was applied in wide and integrated environments, with the beauty of fair-faced concrete finish and the use of natural materials such as wood, stone, and marble flooring. Due to a desired wide span on the ground floor, the columns were not continuous for the entire structure height. Additionally, rigorous deformation control was necessary to accommodate the glass façade.

Fig. 1—Front elevation.

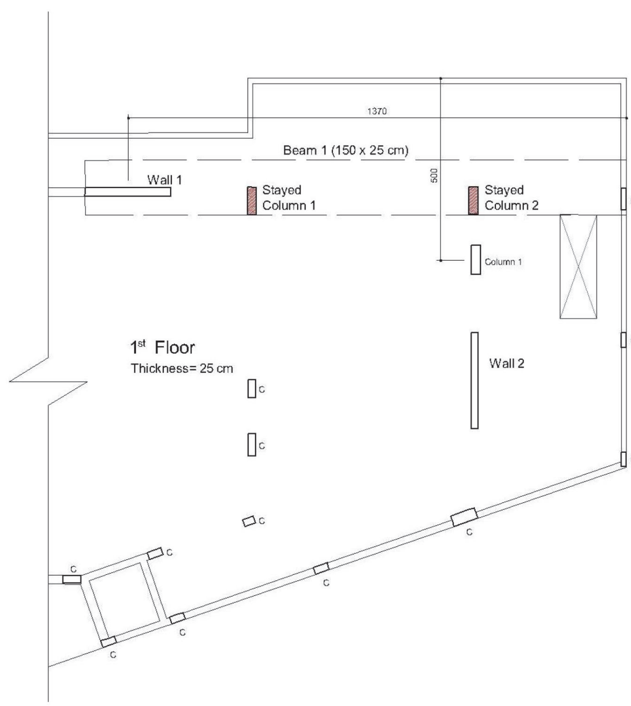

Fig. 2—First-floor plan.

An innovative solution was necessary to meet the architectural constraints of a 42 ft (13 m) span, 16 ft (5 m) cantilever, and desired 10 in. (250 mm) slab thickness (Fig. 2 and 3). The Structural Engineer developed a solution using post-tensioning (PT) for the residence.

All slabs were designed with 0.5 in. (13 mm) unbonded tendons. Due to the architectural thickness limitation on the first floor, it was not possible to design beams and slabs with a thickness greater than 10 in. (250 mm) to resist demand stresses from the long span and cantilever.

The roof level was also challenging with a 20 ft (6.1 m) cantilever, but it was possible to design deeper profile PT beams.

The Structural Engineer designed two stayed columns that support the first floor from the roof (Fig. 4 to 6). The stayed columns would behave as tensile elements to support the first floor. It was possible to transfer and support the loads from the first floor using two post-tensioned beams on the roof slab, transferring the capacity to the roof level, which has flexibility in its thickness.

Beam 2, located on the roof slab, had a tendon profile to accommodate the stress demand caused by the stayed columns (tensile element) that it supported (Fig. 7).

Concrete tensile elements are susceptible to cracking. The residence has an impeccable finish and needed to maintain a high construction standard. It was not possible to risk cracking a column.

Using post-tensioning, the designer compressed the stayed columns, using thread bars to optimize the space. This method of post-tensioning is often used in ground anchor systems and bridge applications. The idea was to compress the tensile columns until the tensile stresses were less than the compression inserted by the post-tensioning in the element.

Each column had two longitudinal thread bars that should receive 66 tons (60 tonnes) of force on each bar for Stayed Column 1 and 50 tons (45 tonnes) of force on each bar for Stayed Column 2 (Fig. 8). The thread bar had compatible corrugated tubes so that the post-tensioning would be bonded to the surrounding concrete.

Non-prestressed threaded bottom bars were added to the first-floor slab to accommodate the transfer of force from the stayed column into the slab. As Beam 1 was only 10 in. (250 mm) thick, a built-in support plate was necessary to further transfer the compression forces from the stayed

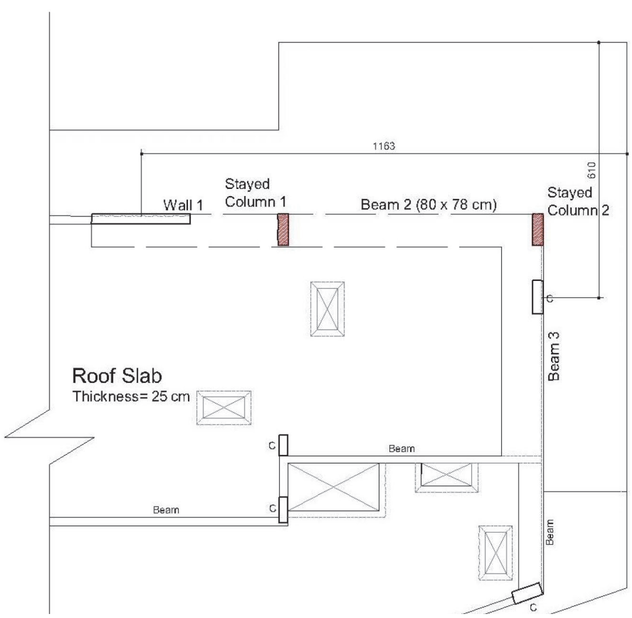

Fig. 3—Roof plan.

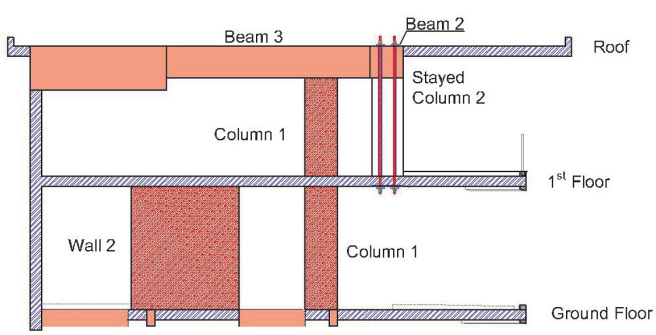

Fig. 4—Cross section showing stayed column.

Fig. 5—Stayed column during construction.

Fig. 6—Completed structure.

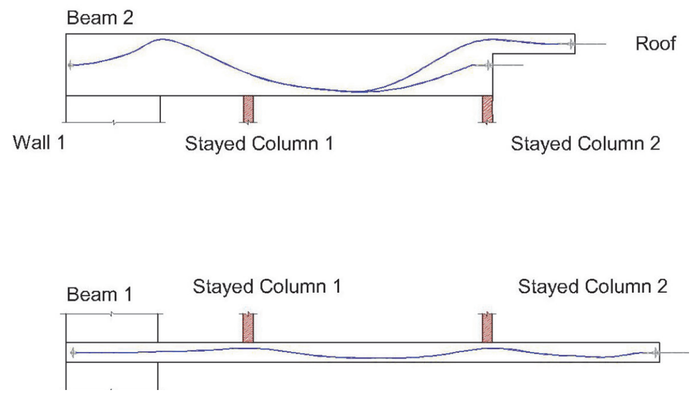

Fig. 7—Tendon profiles in Beam 1 and Beam 2.

columns. Thread bars have higher shear resistance compared to stirrups. Design calculations showed that mild steel stirrups would not provide sufficient shear resistance to resist the force from the stayed columns on Beam 1. Therefore, four threaded crossbars were added to resist the shear demand. These bars ensure the transfer of the Beam 1 load to the stayed columns (Fig. 9). Thread bars were post-tensioned from the roof, and the PT installer injected grout in the corrugated tube through the first floor with the aid of an injection pump to ensure that there were no voids in grouting and to increase the adhesion of the concrete to the threaded bars.

The result was a safe, innovative residence with a high construction standard. The post-tensioning solutions allowed the architectural project to be safely, efficiently, and durably constructed while maintaining aesthetics and execution within the highest levels of efficiency.

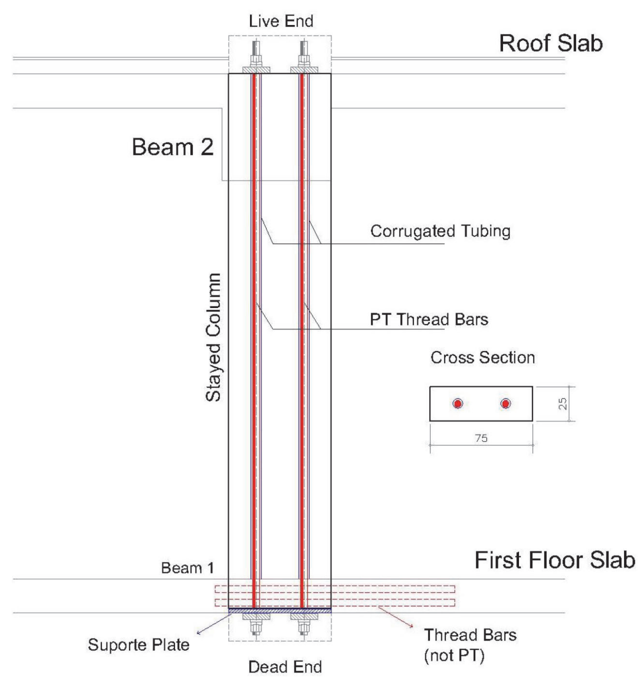

Fig. 8—PT thread bars in stayed column.

TEAM

Owner: Roberta Pfeiffer Jirascheck
Architect: Sum_architecture
Structural Engineer: Eran Fraga
Construction Manager: Greenwood
Post-tensioning supplier/installer: Evehx Engineering

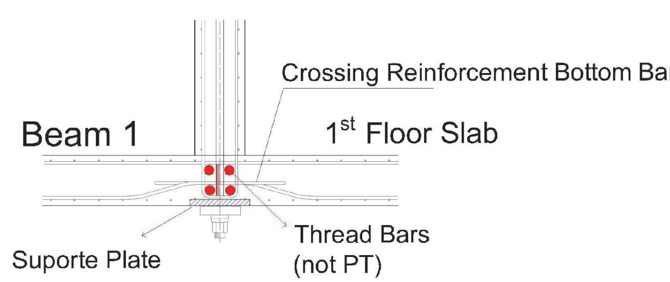

Fig. 9—Thread bars in Beam 1.