THE ARUNDEL

POST-TENSIONING INSTITUTE ®

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PROJECT SUMMARY

The Arundel is a 15-story apartment building located in Hanover, MD, that was completed in August 2017 (Fig. 1). The building features 233 ultra-luxury apartments and is located off Interstate 295 at 7787 Arundel Mills Boulevard. The Arundel is part of the Arundel Preserve mixed-use development which includes a hotel, retail stores, restaurants, a parking structure, other residential buildings, and a planned 63 acre (25 hectare) office park.

The building is a cast-in-place concrete frame consisting of post-tensioned (PT) flat plate construction for the typical floors, reinforced concrete core walls, and a hybrid pile cap, and PT mat foundation supported on auger cast piles. The structure is all cast-in-place (CIP) concrete from the bottom of the auger cast piles 80 ft (24 m) below grade to the pergola roof over an outdoor rooftop entertainment space. Typical floor plates are 7-1/2 in. (190 mm) thick PT concrete. Additionally, the building has three unique structural design features that advance the state of practice of the use of post-tensioned structural cast-in-place concrete for building construction.

USE AND ADVANTAGE OF POST-TENSIONING IN STRUCTURE

It is quite possible that this building would never have been constructed had it not been for post-tensioned (PT) concrete. The proposed building was situated on top of a preexisting below-grade stormwater management vault. The owner was faced with three options for this site: 1) move the vault at exorbitant cost in dollars and schedule impact; 2) bridge over the vault with a 5.5 ft (1.7 m) thick conventionally reinforced concrete transfer mat; or 3) bridge over the vault with a 4 ft (1.2 m) thick PT transfer mat. The 4 ft (1.2 m) thick PT transfer mat was selected due to significant cost efficiency and to maintain a ground floor slab elevation that matched the surrounding site grading. A thicker transfer mat would have raised the ground floor elevation which would have complicated grading around the building and it would have increased the overall height of the building, which was restricted to 187 ft (57 m) by county zoning ordinance. Moreover, the PT transfer mat saved over $100,000 when compared to the non-prestressed transfer mat.

BRIDGING OVER EXISTING UNDERGROUND VAULT

The site for this new building is part of a larger mixed-use development, and it contained a 126 ft long x 36 ft wide

Fig. 1—The Arundel.

(38 x 11 m) underground stormwater management (SWM) vault as part of the runoff management for the larger development. The existing SWM vault took up more than half of the new building footprint (Fig. 2). This was a significant obstacle to constructing a new residential tower on the site. The owner was faced with the challenge of either moving the vaults at exorbitant cost or constructing on top of the existing vaults. The structural design team devised a solution to bridge over the vaults using a 4 ft (1.2 m) thick PT transfer mat. The mat spans over the vault and is supported by one-hundred and twenty-three 18 in. (460 mm) diameter auger cast piles to the east and west of the vault (Fig. 3). A PT mat was selected to reduce the required mat thickness and the overall building height. To increase shear capacity and to reduce long-term deflections, the structural engineering team specified 10,000 psi (69 MPa) concrete.

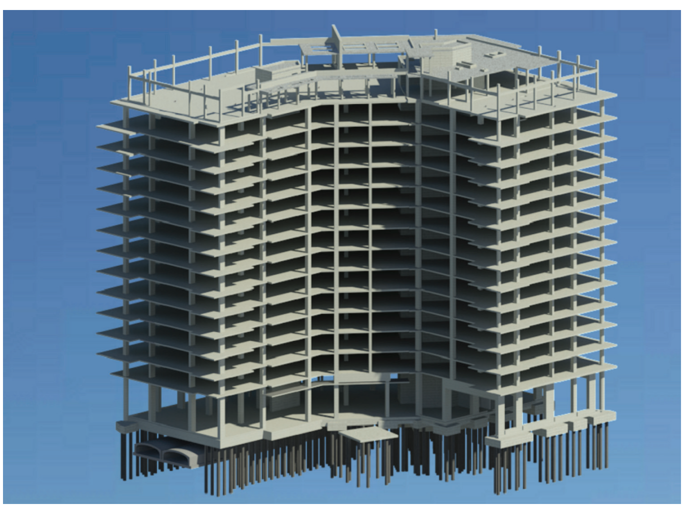

Fig. 2—Revit model captures building bridging over underground tanks.

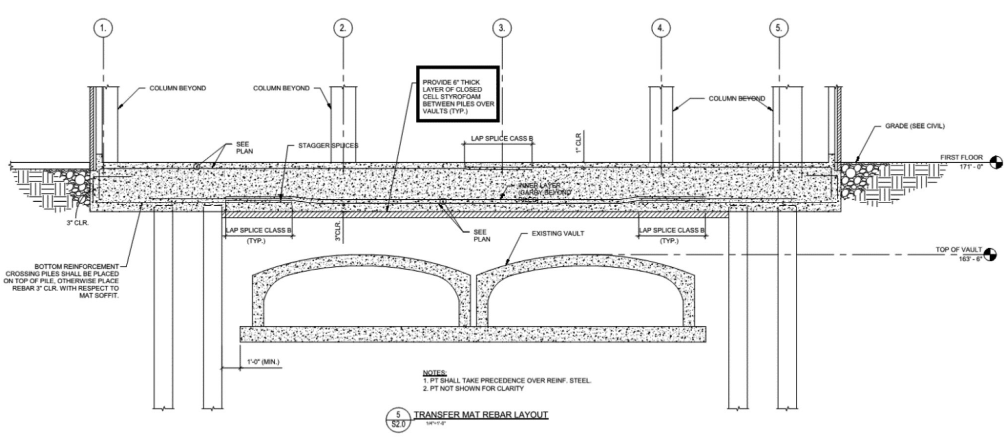

Fig. 3—Section through PT transfer mat.

The top of the mat also serves as the ground floor slab and ties into the slab-on-ground (SOG) to provide a contiguous ground floor slab. A 4 ft (1.2 m) wide temporary pour strip between the transfer mat and surrounding SOG helped to mitigate cracking in the SOG due to short-term movement and differential settlement. The mat contains over 27 tons (24 metric tons) of unbonded PT (Fig. 4 to 6). Low-strength EPS foam material was placed between the top of the vault and the mat to minimize any impact that building movement would have on the vault. It was critical that deflection of the transfer mat did not add unintended loading to the vault.

Initial modeling of the reactions on the piles during design development indicated that certain groups of piles were overloaded, and others received less load. Because space for piles was limited by the building footprint and vault outline, it was not possible to redistribute the piles. Again, PT provided an elegant solution. By fine-tuning the PT profiles in the north-south and east-west directions, the designers were able to redistribute loads to the piles without adding additional piles. This was another cost savings that the owner realized.

TACKLING LONG CANTILEVERS

The architect visualized living spaces uninterrupted by columns. This was especially important at the building corners with balconies and long expanses of glass. Typical slab cantilevers approached 12 ft (3.7 m) in length (Fig. 7). While the 7-1/2 in. (190 mm) thick cast-in-place two-way PT flat plate was optimal for typical spans, the long cantilevers demanded a creative solution to maintain a maximum 1/2 in. (13 mm) long-term deflection. For cost efficiency, the design team did not want to increase slab thickness to accommodate the long cantilevers, and the architect did not want drops or thickened slabs that would interrupt the exposed slab soffit. Instead, the structural team designed the cantilevers to minimize long-term deflections by locally increasing the PT forces and adding bottom non-prestressed reinforcement. The combination of added PT and bottom steel has the effect of significantly reducing long-term creep in the concrete that can lead to

Fig. 4—Transfer mat foundation spanning over SWM tanks. This photo shows post-tensioning cables that are profiled with high points over the piles and low points at midspan. The underground tanks are in the middle section of the mat.

Fig. 5—View of reinforcement between top and bottom mat of steel in transfer mat.

Fig. 6—Transfer mat ready to place.

Fig. 7—Twelve foot (3.7 m) long cantilever balconies at building corners.

Fig. 8—Transfer girder picking up column at second floor.

sagging at the tip of the cantilevers. This proved to be an elegant and efficient solution for the long cantilevers.

BONDED PT TRANSFER GIRDERS

There are areas at the ground floor that required long spans uninterrupted by columns. One example is the vehicle drive-thru under the north end of the building. To accommodate this requirement, the design team used a series of transfer girders (Fig. 8). The transfer girders are typically 48 x 60 in. (1200 x 1500 mm) and use bonded PT to reduce the overall impact of PT anchorage in beams with such a high concentration of force and to add redundancy provided by bonded PT. Redundancy is attained as the force transfer in bonded tendons occurs through not only the anchorages but also through the bond between the prestressing steel and the grout/corrugated duct/concrete. The transfer girders were stressed in three stages throughout building construction to slowly increase the PT force as the building load increases when additional floors are constructed.

Location: Hanover, MD
Owner: AP Parcel 4, Lot 4, LLC
Architect: Architects Collaborative, Inc.
Engineer: Kline Engineering & Consulting, LLC
Contractor: The Whiting-Turner Contracting Company
PT Supplier: CCL USA Inc.
Other Contributors: Schuster Construction & Schuster Ready Mix