ALTERNATIVE SOLUTION USING POST-TENSIONING FOR CHANGE-IN-USE OF EXISTING BUILDING

By

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POST-TENSIONING INSTITUTE ®

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INTRODUCTION

A change in the use of a building often requires cutting of an existing slab to make an opening to accommodate the needs of the prospective user. The size of the required opening could vary in size depending on the purpose. The opening could be a small 12 in. (305 mm) diameter penetration for an M/E/P pipe, or a large opening on the order of 20 ft (6.1 m) long to provide new escalators or stairs connecting two levels occupied by the same tenants in a commercial/office building environment. Although openings are routinely implemented in existing buildings, each project is distinctive, posing unique challenges. This article discusses such a project that required creation of two openings in a precast joist and soffit beam floor system on the 12th and 13th floors of an existing 24-story building constructed in the mid-1980s in Miami, FL (Fig. 1).

PROJECT DETAIL

The two proposed stair openings are intended to provide floor-to-floor connection within the office layout. Several joists were cut and two conventionally reinforced structural members were designed: an 18 x 32 in. (460 x 810 mm) transverse beam element providing supports to the joists, and an 18 x 36 in. (460 x 910 mm) girder (Fig. 2) to support the transverse beam element. Web openings were detailed allowing M/E/P to pass across (Fig. 3). During the construction phase, it was realized that running the M/E/P ducts through the girder would require many additional bends in the ductwork, providing unacceptable airflow. This prompted a redesign of the support. It was determined that the maximum depth of the girder was 20 in. (510 mm) to accommodate all the M/E/P below the joists and girder. Calculations showed that the heavy transfer load of the severed precast joists collected by the transverse beam could not be carried by a 20 in. (510 mm) deep reinforced concrete girder. An unbonded post-tensioned (PT) girder system was studied and found to provide the most favored solution addressing the given geometric and scheduling constraints.

PT GIRDER

The loads and reactions obtained from an earlier concrete girder analysis (Fig. 4) were used to run a PT girder analysis. A harped tendon profile was adopted with the low point at the transverse concrete beam location (Point A in Fig. 4) for efficient load balancing. The 20 in. (510 mm) depth available for the PT girder was found to be sufficient for strength and service conditions. The 18 in. (460 mm) width that was initially proposed in the concrete girder option was not sufficient to accommodate the high PT force (756 kip [3400 kN]). To accommodate all the tendons within the girder cross section, a wider girder width was required. The PT girder was widened, filling in the clear space between the precast joists (Fig. 5).

IMPLEMENTATION

The proposed girder was modeled to be supported by an existing interior beam on one end and a spandrel beam on the other end (Fig. 6). The existing precast

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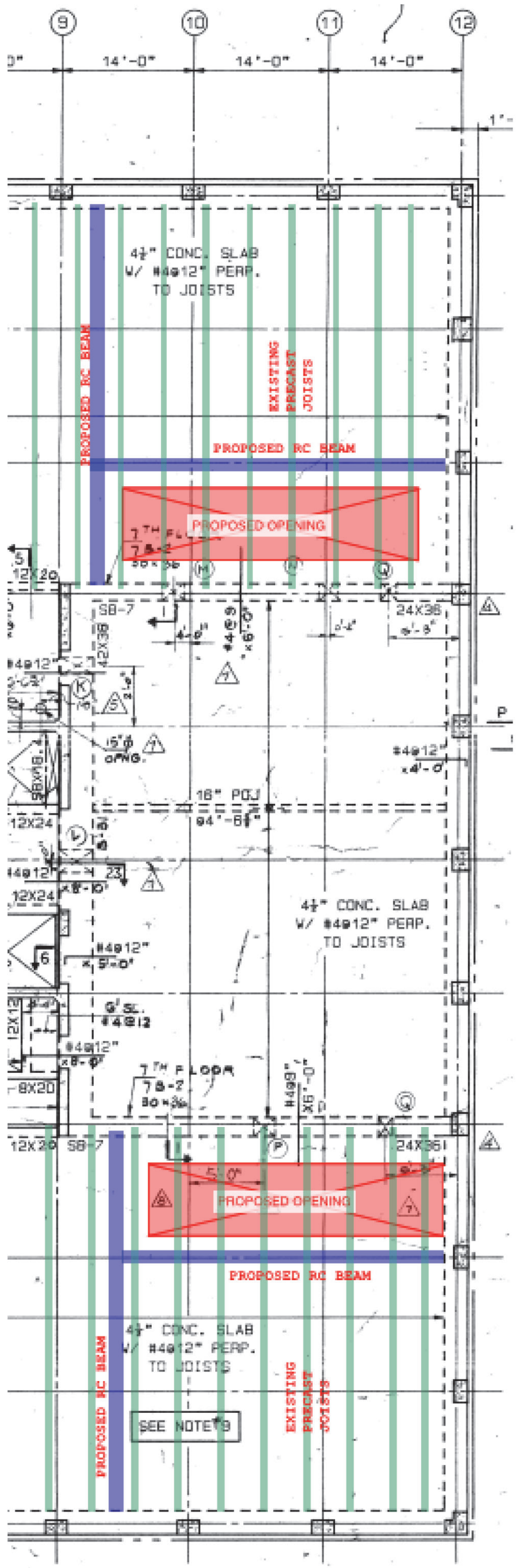

Fig. 1—Existing floor plan showing proposed openings at 12th and 13th floor.

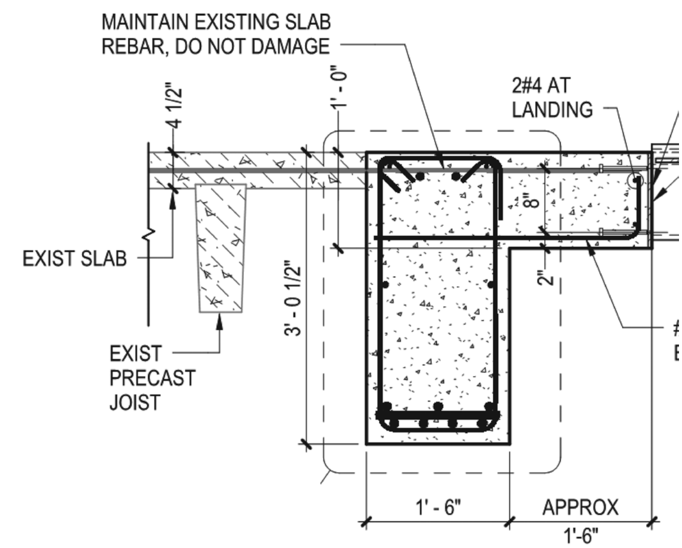

Fig. 2—Proposed 36 in. (910 mm) deep reinforced concrete (RC) girder.

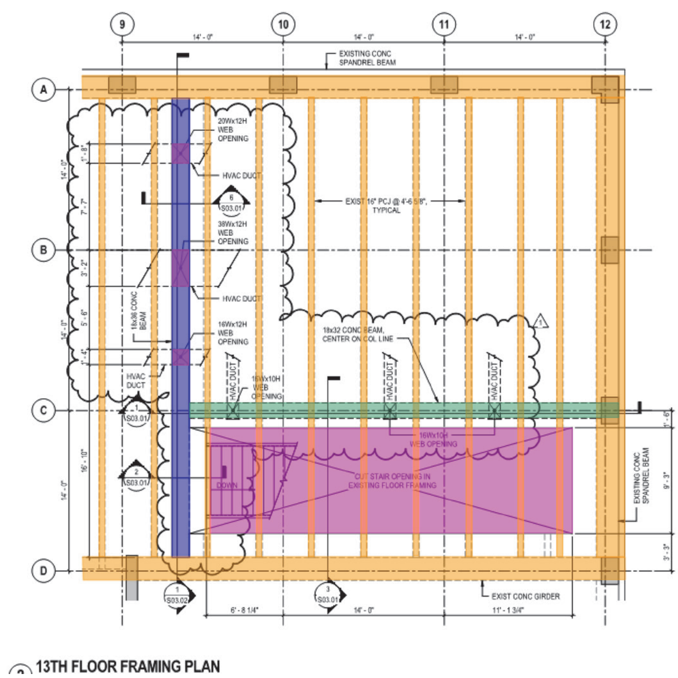

Fig. 3—M/E/P conflicts with proposed 18 x 36 in. (460 x 910 mm) RC girder.

beam capacities were verified and found to be satisfactory. The PT girder was detailed to have a simple support condition at the dead end by providing a sliding bearing on a hollow structural steel (HSS) section (Fig. 7). This sliding bearing allowed the PT girder to freely shorten without transferring any transverse force on the end support beams. The PT system used was an encapsulated 1/2 in. (13 mm) single-end stressed system.

At the 12th floor opening, the stressing ends of the tendons were directed through the existing concrete girder support (Fig. 8) by drilling holes for each of the 32 tendons. The stressing ends were terminated with barrel anchors seated on a 1.5 in. (38 mm) thick bearing plate. This allowed the PT beam to be placed in one pour. Reinforcing bar dowels were used on the face of the supporting girder for shear transfer (Fig. 9). The face of the supporting girder was scanned to locate the longitudinal and shear reinforcement. PT tendon locations were marked on the side face of the girder, avoiding the existing reinforcing bar, and drilled through to pass the tendons and reinforcing bars (Fig. 10 and 11). The existing floor slab along the length of the PT girder was chipped out. This had the two benefits of creating a deeper beam and making it very easy for the contractors

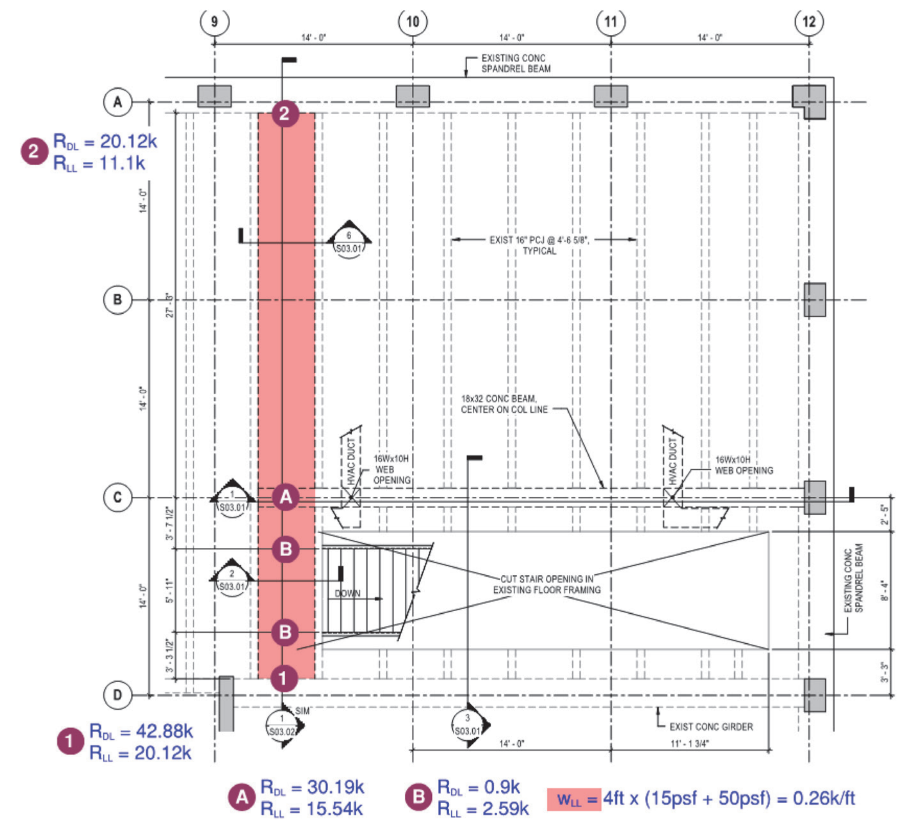

Fig. 4—Loads and reactions.

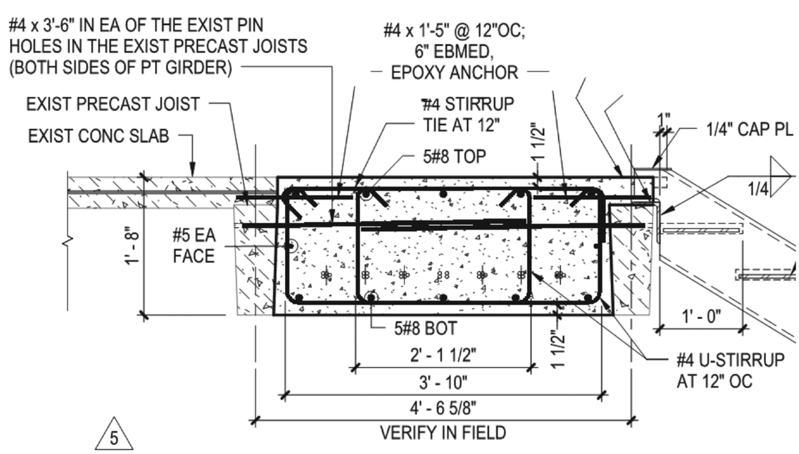

Fig. 5—Proposed alternate PT girder cross section.

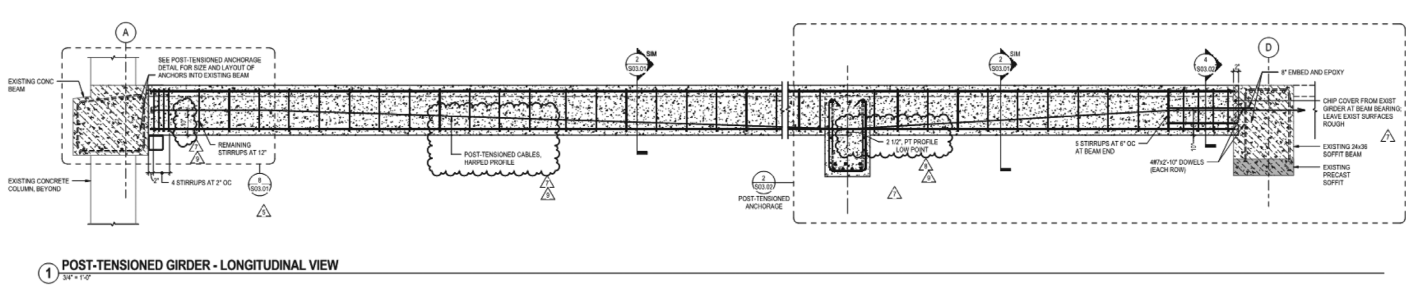

Fig. 6—Proposed alternate PT girder longitudinal section.

to install the tendons and reinforcing bar. The existing slab at the stressing anchorage had to also be removed to accommodate stressing operations.

On the 13th floor, due to the offset of the opening for the stair, the PT girder was close to the end of the supporting girder. Due to the reinforcing bar congestion in the existing concrete girder and the proximity to a column, it was not possible to drill holes in the existing concrete girder to pass the PT tendons and have the stressing anchors installed, similar to what was done on the 12th floor. This necessitated placing the girder in two parts using a 4 ft (1.2 m) pour strip (Fig. 12). The tendons, stressing anchors, and fixed anchors were kept within the first pour. The 4 ft (1.2 m) pour strip of the girder was conventionally reinforced (Fig. 13) and placed as stage two, after all the girder tendons were stressed. Shoring was kept in place until the secondary pour achieved required compressive strength. Formwork was designed to fully engage the floor framing at the pour to prevent differential movement of the formwork to the existing framing, and then shored down to the floor below to distribute the construction loads.

The transverse beams supporting the joists were poured together with the PT girders (Fig. 14). Access holes were core drilled into the floor slab to enable concrete placement (Fig. 15) into the transverse concrete beams. Initial condition stresses dictated that concrete strength required at the time of tendon stressing was at least 4500 psi (31 MPa) (Fig. 16). The formwork was removed after the second pour attained the designed compressive strength of 6000 psi (40 MPa). The slab openings were successfully made and the stairs installed (Fig. 17).

CONCLUSIONS

An unbonded PT girder system proved to be the best solution for the existing constraints of this project. Many challenges were faced while implementing the design, including accommodation of the support condition and stressing of PT tendons in the girder. It would have been hard to provide the stair openings as requested by the client without the use of the versatile unbonded PT girder system.

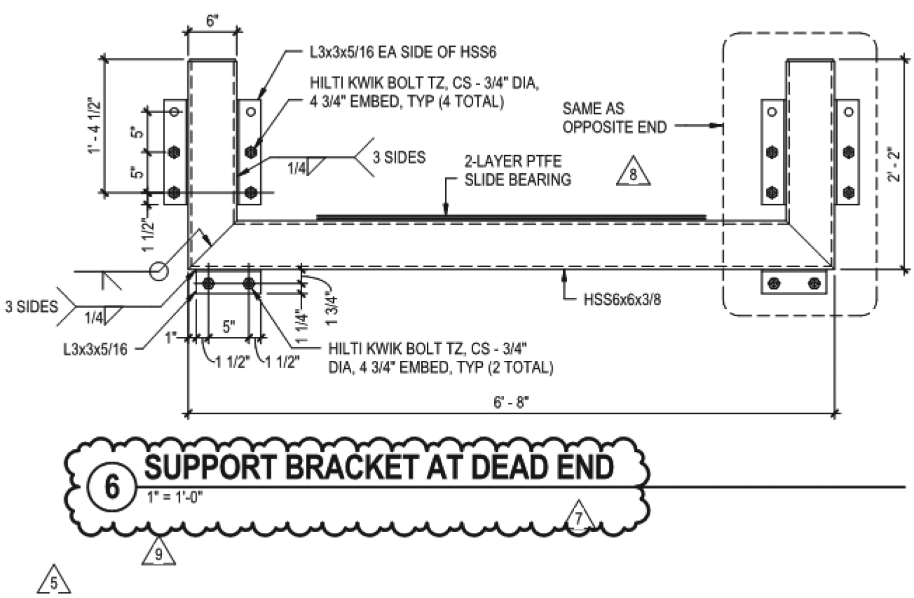

Fig. 7—PT girder simple support detail at fixed end.

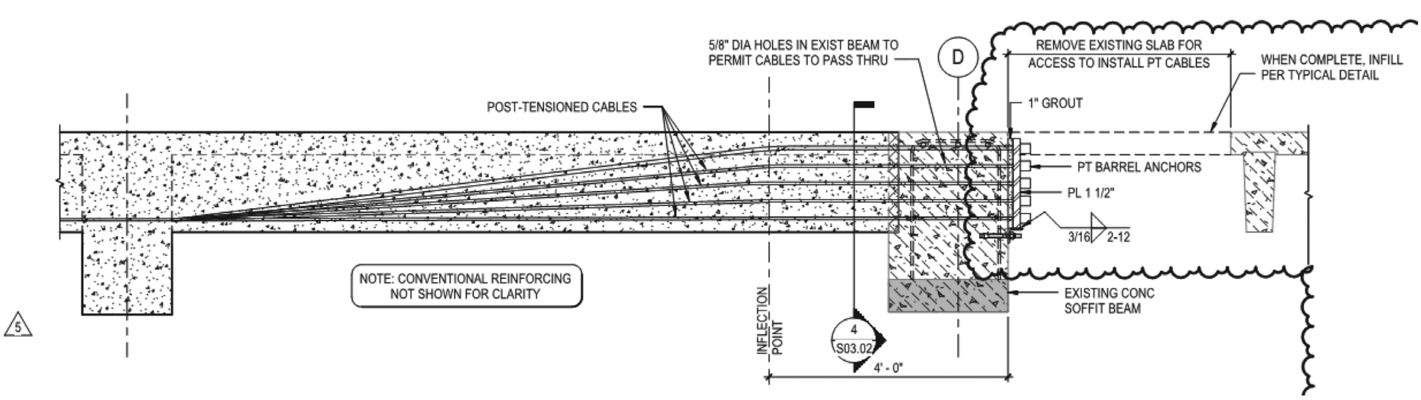

Fig. 8—PT girder support detail at west end showing tendon and anchors (12th level).

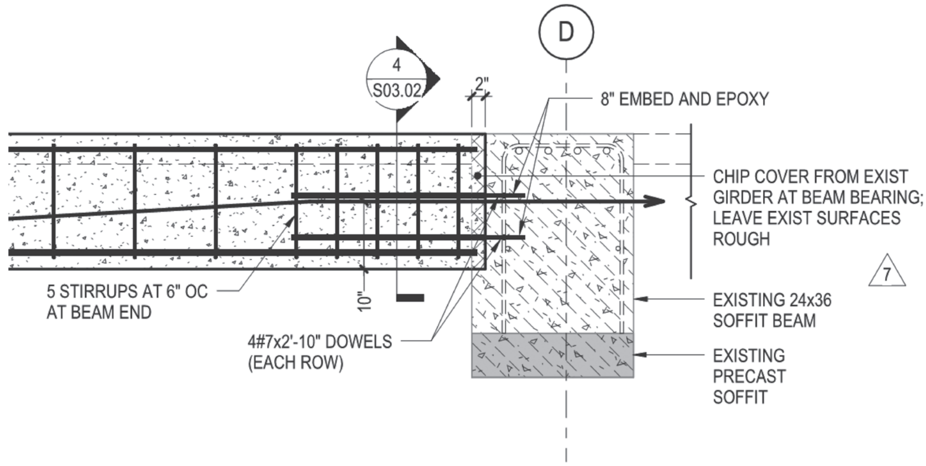

Fig. 9—PT girder support detail at west end showing reinforcing bar dowels (12th level).

Fig. 10—Concrete cross beam drilled at west-end to allow PT tendons (12th level).

Fig. 11—PT tendons installed (12th level).

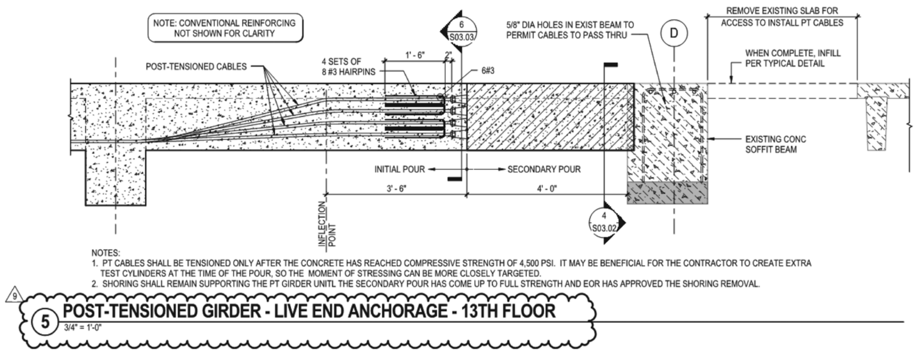

Fig. 12—PT girder support detail at west end showing pour break (13th level).

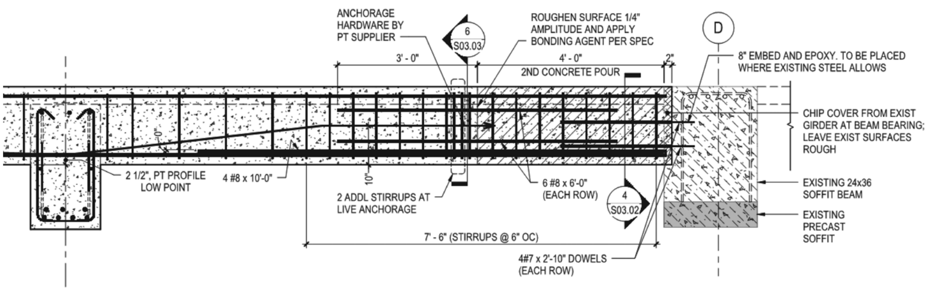

Fig. 13—PT girder support detail at west end showing reinforcing bar dowels (13th level).

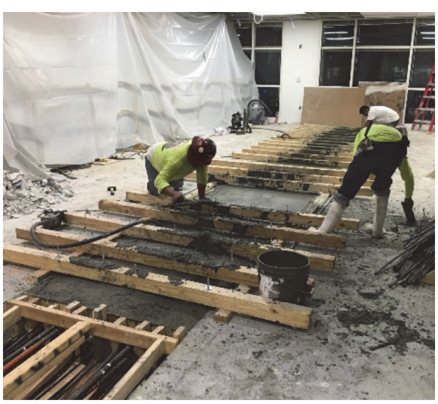

Fig. 14—Pouring of concrete for PT girder (13th level).

Fig. 15—Pouring of concrete through access holes for concrete transverse beam.

Fig. 16—Stressing of PT girder (13th level).

Fig. 17—Slab opening and stair.

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