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ONE MUSEUM PARK WEST: CONVERTING A HIGH-RISE TOWER'S STRUCTURAL DESIGN TO UNBONDED POST-TENSIONING

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One Museum Park West is a prime example of the benefits of converting conventionally reinforced slabs into unbonded post-tensioned slabs. The 55-story high-rise condominium tower (Fig. 1) was originally designed with an 8 in. (203 mm) thick concrete flat plate using reinforcing bar. A multitude of very deep transfer girders on the sixth floor were also designed without post-tensioning (PT). Because the project was over budget, the concrete and forming contractor requested that the PT supplier conduct a Value Engineering Analysis (VEA) to reduce the cost of the structure, though there were some concerns by a few members of the construction team about using PT in a floor system with a complex, irregular shape (Fig. 2).

Two value-engineered options were presented to the construction team:

1. Option A:
   - (a) Retain all the interior columns.
   - (b) Use a 6 in. (152 mm) thick flat plate slab with PT.
   - (c) Use PT in the transfer girders.
2. Option B:
   - (a) Retain the 8 in. (203 mm) slab thickness but with an unbonded PT system.
   - (b) Delete some transfer girders.
   - (c) Delete some interior columns.
   - (d) Use PT in the transfer girders.
   - (e) Reduce the depth of the transfer girders.

In Option A, the transfer girder depths would decrease due to the reduction in dead load resulting from the use of thinner slabs. The main disadvantage in this option was that a 7.5 in. (191 mm) slab would still be required for plumbing in the bathrooms per code requirements of the city of Chicago. Accordingly, this would have increased the forming costs. Ultimately, the Owner chose Option B, based on the enhanced value (described in the following) and the reduction in the overall cost. Even though it used more concrete and had a taller building height than Option A, Option B had less concrete and building height than the original design.

Fig. 1—One Museum Park West, Chicago, IL.

Initially, the decision was to use PT in all floors; but in the end, PT was only used in the sixth floor (transfer floor) to roof level due to the construction schedule of the first five floors. To meet the construction schedule deadlines, a consulting structural engineering company was hired to design the structural floor system in partnership with the PT supplier. Together, they ensured that the quantities of the PT and reinforcing bar materials were in compliance with the initial VEA. This alternate structural design was incorporated into the Structural Engineer of Record's design documents.

The 8 in. (203 mm) thick flat plate floor had banded tendons in the east-west direction and the uniform

Fig. 2—Irregular floor plan.

tendons in the north-south direction (Fig. 3). Approximately one-third of the columns were eliminated on all levels above Level 6. Stud rails were introduced in four columns to deal with punching shear. The post-tensioned transfer girder depths varied from 6 ft 6 in. (2.0 m) to 8 ft (2.4 m), which was a 25% reduction in depth compared to the conventionally reinforced transfer girders. The transfer girders had between 46 and 142 PT tendons. To balance the dead load, the transfer girder tendons were stressed in five stages at the completion of the sixth, 18th, 30th, 42nd, and 53rd floors.

The structural design was based on 5000 psi (34.5 MPa) concrete. However, the concrete contractor decided to provide 8750 psi (60.3 MPa) concrete. Although the higher strength concrete cost more, it allowed for stressing the tendons the day after concrete was poured. This resulted in a short 3-day cycle per a typical floor and reduced the construction schedule by several weeks.

At some locations, the tendon lengths were very short due to building plan geometry. Initially, 10% more tendons were added to compensate for potential seating losses and meet the required effective forces. These "stand-by" tendons would be stressed only when there were under-elongations. Since this "insurance" would cost an additional $75,000, the owner deleted them and asked for a plan to prevent elongation problems. The PT supplier developed procedures for the PT installer to keep the anchor cavity, the jack grippers, and the stressing tails extremely clean. Furthermore, at the recommendation of the PT supplier, the Structural Engineer of Record allowed for 5% overstress when there were under-elongations in the short-length tendons. Consequently, the actual field elongations were exceptionally satisfactory.

Because many interior columns were deleted, more space was opened up for residential use to the delight of the Architect. This revision helped in the marketing of the column-free condominiums to the delight of the Owner. The quantity of PT in the building increased from 35,000 ft (10,688 m) in a few cantilevered balconies (original design) to 1.6 million ft (487,680 m) in 49 floors (final design). The concrete contractor indicated that the value engineering resulted in a savings of $4 million due to the items listed as follows:

- Reduction in the number of columns, which reduced the concrete, reinforcing bar, and forming costs.
- Deletion of several transfer girders.
- Reduction of the depth of remaining transfer girders.
- Reduction of the reinforcing bar in slabs.
- Reduction of the number of caissons, though the size of the remaining caissons did increase.
- Reduction of building height due to the reduction of transfer girder depths. As a result, there were cost savings in the shear walls, curtain walls, elevator, and vertical mechanical/electrical/plumbing and piping/conduit.

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CREDITS

Project: One Museum Park West, Chicago, IL
Owner: Enterprise Companies
Concrete and Forming Contractor: Adjustable Forms, Inc.
Consulting Structural Engineering Company: Larson Engineering
PT Supplier: AMSYSCO, Inc.

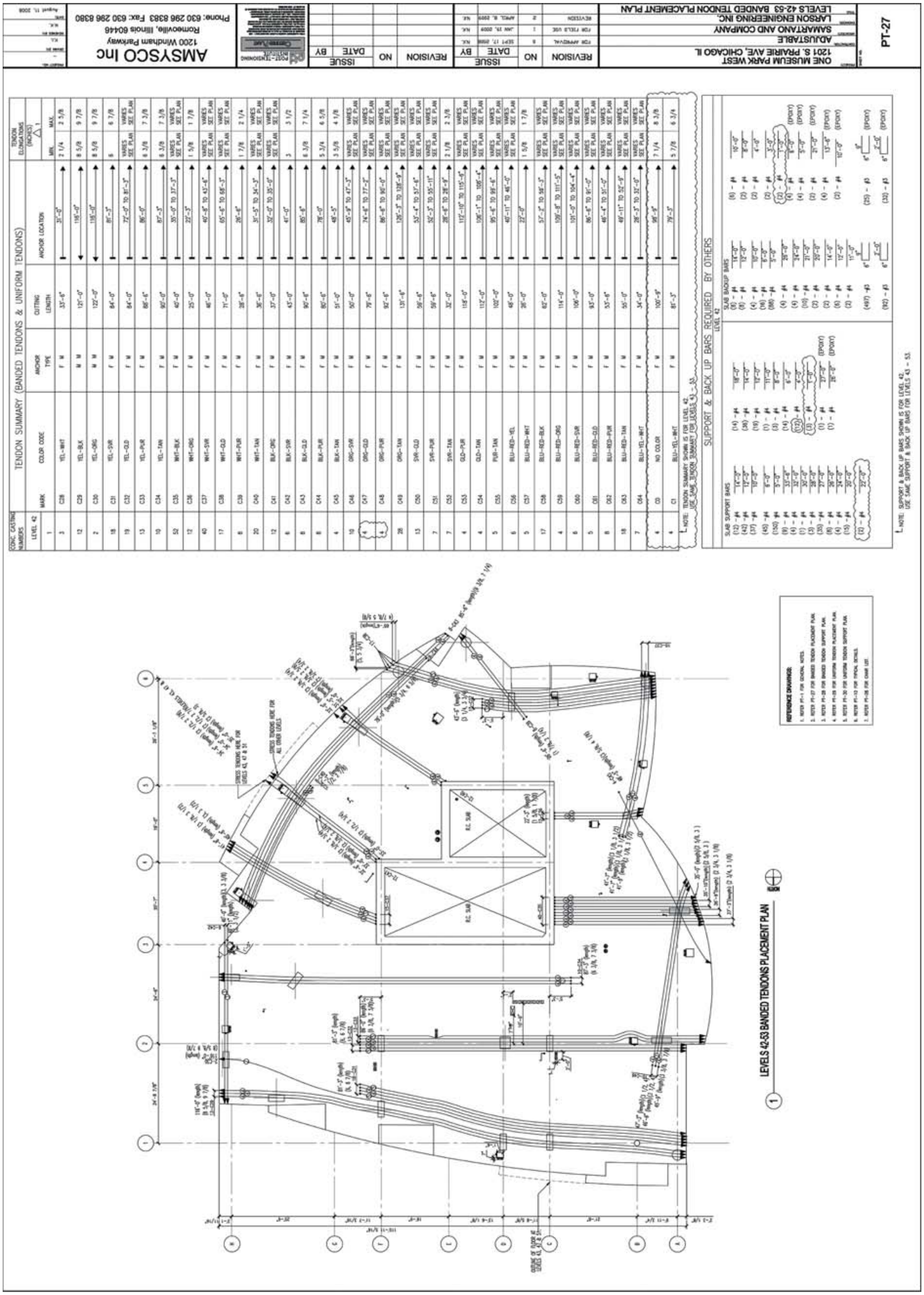

Fig. 3—Representative tendon placement plan.