501 WORLD WAY—FIRST PARKING STRUCTURE AT LOS ANGELES INTERNATIONAL AIRPORT

By

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A landmark post-tensioned building was completed in 1965, the very first of what would eventually be eight multilevel parking structures at Los Angeles International Airport (LAX). Still in daily use today, it is located at 501 World Way and is now designated as "P5" for the terminal it primarily serves, Terminal 5. With an elevated floor area of slightly over 200,000 ft^2 (18,500 m^2) and 71,000 ft^2 (6600 m^2) on grade, the building provides parking for 700 cars. Structural framing consists of monolithic one-way post-tensioned beams and slabs, with the four-span beams spaced typically at 20 ft (6 m) on center. The two exterior beams span 59 ft 6 in. (18 m) and the two interior beams span 57 ft 6 in. (17.5 m). The total out-to-out building dimension in the east/west (beam span) direction is 237 ft 8 in. (72.5 m) and in the north/south (slab span) direction it is 314 ft 10 in. (96 m). The slab thickness is 5 in. (127 mm), the beam is 12 in. (300 mm) wide and 36 in. (900 mm) deep, and columns are 24 in. (600 mm) square. The floor-to-floor height is 10 ft 6 in. (3 m).

The building is founded on spread footings, except for a few locations where cast-in-drilled-hole piles were used to clear underground airport utilities. All members are cast-in-place, all tendons are unbonded, and all slab and beam concrete is lightweight with a density of 110 lb/ft^3 (1762 kg/m^3). Figure 1 shows part of the south elevation of the building, as seen from the entrance to Terminal 5, across World Way. Figure 2 shows the airport in plan with the location of P5, along with the other seven parking structures (courtesy of Google Earth).

This type of framing is commonly referred to as a "clear-span" garage because there are no columns in the parking or driving areas. 501 World Way was not the first cast-in-place post-tensioned clear-span garage built in southern California, but because of its location, it was certainly the most prominent of the early ones. Because of the attention this building attracted and its successful performance, it led the way for clear-span post-tensioned concrete beam and slab framing to become the prevalent method for parking structure construction throughout California.

Fig. 1—South elevation.

Fig. 2—LAX plan (courtesy of Google Earth).

This building is very personal for me. In 1964, I had been working as a Structural Designer for T.Y. Lin and Associates for over a year when I was assigned to be the Project Engineer for 501 World Way. Under the supervision of Lin's Chief Structural Engineer Ray Itaya, I personally designed every structural member in the building and

observed much of the construction. One of the great joys of being a structural engineer is to physically see the results of your work; it is hard to describe the feelings of pride and satisfaction that I feel when I see and use this building at my home airport, which is still in service now after almost a half century. Based on my personal observations made over the years, the building has been fully loaded with cars at peak hours (Fig. 3 and 4) and almost empty at slack hours ***every day*** now for 49 years, and despite this punishing loading cycle, it remains in good structural condition today.

Fig. 3—Top Deck Level 4.

Fig. 4— Level 3.

The building was designed for eight levels (seven elevated) but only four (three elevated) were built initially and the upper levels were never added. Original seismic framing was with 10 in. (250 mm) thick by 60 ft (18 m) long shear walls perpendicular to the beams (in the north/south direction on two interior column lines) and rigid beam-column frames parallel to the beams in the east/west direction. This was before the era of seismic moment-resisting frames (SMRF), or "ductile frames," so the seismic rigid frames were designed as nonprestressed beams and columns, using moments and shears from a static frame analysis with code-prescribed lateral seismic loads. Seismic beam moments were resisted with nonprestressed reinforcement only (capacity provided by the tendons was ignored). Governed by the 1963 Los Angeles City Building Code (the City of Los Angeles has had its own building code since 1937), no particular attention was paid to containment or ductility beyond that required for gravity members.

501 World Way performed well in the Sylmar earthquake in 1971 and the Northridge earthquake in 1994. Contributory to that may have been the fact that it was a three-story building designed for seven stories, and it was about 30 and 25 miles (48 and 40 km) from the epicenters, respectively (however, significant structural damage was recorded in buildings as far as 85 miles [137 km] from the epicenter of the Northridge event). Nonetheless, the earthquakes produced no significant damage to the building and it was fully functional after each one.

One interesting design decision, influenced by the fact that lightweight concrete was used in the floor system, was the use of an expansion joint in each direction. In the east/west direction, parallel to the beams, an expansion joint was placed in a short 10 ft (3 m) bay near the center of the building using a double-slab cantilever (Fig. 5). South of this joint, down the center of the building (perpendicular to the beams), a north/south expansion joint was placed at the center column line, with two beam spans on either side of the joint, thus separating the building into three independent pieces. It was decided that a north/south joint was not required north of the east/west joint because the northeast corner of the building is notched (Fig. 2) and the east/west building dimension is substantially reduced in this area.

The beam on the east side of the joint is cast monolithically with the column; the beam on the west side of the joint rests on a corbel cast with the column, with steel plates placed at the bottom of the beam and top of the corbel to provide a sliding surface (Fig. 6). As with many such "sliding" details, this one was met with limited success and produced significant spalling over the years. Although the spalling was largely cosmetic (the corbel concrete provided fire protection for the structural steel

Fig. 5—East/west expansion joint.

Fig. 6—North/south expansion joint at corbel.

assembly inside but did not function structurally), a major retrofit of the corbels was executed about 10 years after the building went into service. In retrospect, the north/south expansion joint caused more problems than it solved. The 238 ft (72.5 m) building dimension in the four-span beam direction would generally be considered adequate without an expansion joint by today's standards, particularly with normalweight concrete in the floor system.

501 World Way was extremely important and influential in establishing cast-in-place post-tensioned concrete as the dominant framing system for clear-span parking structures in California. It has functioned well, under both gravity and seismic loads, in a highly visible location now for almost a half century.

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