Supports for Traveling Cranes: Case History

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Abstract: Tight sight conditions and a short construction schedule necessitated the use of two travelling cranes during the construction of a hotel. Steep slopes at the south and basement walls at the north posed interesting structural design challenges for these crane supports. Problems encountered in the selection of the crane system and the design of its supports are described; the solutions to these problems are illustrated.

Introduction

Located on a wooded 10-acre site within the 95-acre Arboretum office/retail development, Wyndham Hotel in northwest Austin, Texas, is a 478-guestroom development. The hotel is nine stories in height with 512,000 sq ft of space. Within the glass skylighted 20,400 sq ft atrium are seating areas, alfresco dining, a cafe, and a grand stair to the plaza level. The lobby bar, terrace, and fine-dining areas overlook a panoramic view of the wooded site and hill country, including a man-made retention lake. The first two levels include ballrooms, meeting rooms, an auditorium, an exhibit hall, restaurants, conference facilities, and a complete health club with indoor pool and solarium. Auxiliary facilities include a swimming pool, terraces, a jogging trail, and an entertainment lounge. The hotel opened in August 1986.

In order to maximize the available area in front of the hotel and to take optimum advantage of the panoramic view to the south, the building was sited near the bluff line (Fig. 1). Outdoor terraces and the exterior swimming pool overlook a pedestrian walk which follows the curvilinear bluffs as it forms the southern boundary of the site. The area along and below the bluff required protection from environmental damage during the construction period. Many specific trees throughout the site were also designated for preservation. The amount of space available between the hotel tower and the closest point on the bluff was minimal for working conditions.

The economics of the project dictated a specific opening date. The limited construction time and the tight constraints of the site led to the general contractor's decision to utilize two travelling tower cranes (one at the north side and the other at the south side) parallel to the long axis of the building. The southern set of tracks actually curved to the north slightly at the western end.

This paper describes the various factors that affected the selection of the crane system and its support system during construction.

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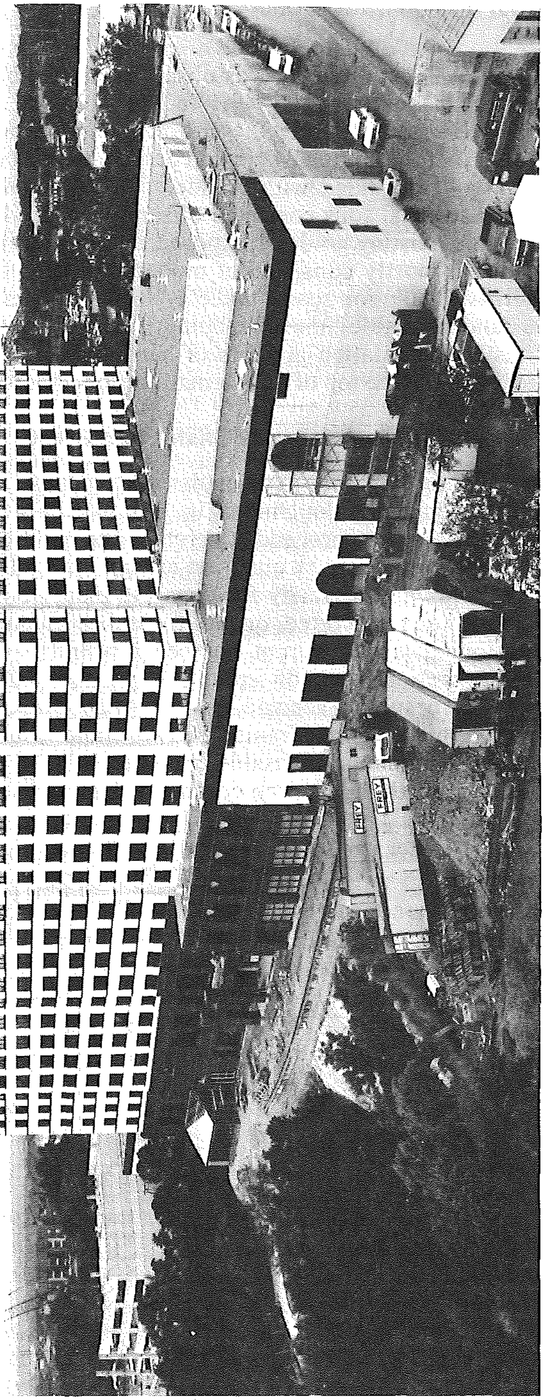

FIG. 1. View of Completed Building

General Subsurface Conditions

The site generally sloped down towards the south. Fill consisting of boulders, cobbles, and clay was observed in the southeast portion of the site covering approximately 40% of the site area. Also several surface cavities were noted during the site investigation and soil borings. It is suspected that the southeast portion of the site used to be a gorge area that was subsequently filled with boulders, cobbles, and clay. In the nonfill areas, the surficial soils consisted of sandy clay and clay to depths of 0–3 ft below the existing grade or exposed outcrop of limestone. In the gorge area, the fill mostly consisted of moderately hard tan Edward limestone boulders with solution seams and clay seams. Moderately hard to hard tan porous and dolomitic limestone comprised the next lower stratum; below this was the foundation medium of hard gray limestone with occasional calcite crystals. The top of this formation sloped down from north to south.

Construction Sequence and Crane Selection

The building plan was rectangular with a large atrium opening in the center—a rectangular doughnut (Fig. 2 shows the site plan). The construction sequence was to proceed concreting one quadrant at a time and cycle upwards from quadrant to quadrant at each floor. That is, when quadrant number 1 was getting ready for concrete placement, quadrant number 4 would have been concreted; quadrant number 3 would have been ready for posttensioning; and quadrant number 2 would have been formed. This cyclical operation went on sprialing upwards until all the floors were completed. In such a scheme, even though construction activities proceeded on all four quadrants, heavy crane use was limited to two quadrants. The maximum usable crane hook length could serve only half the building width; hence, the contractor had to select either four station-

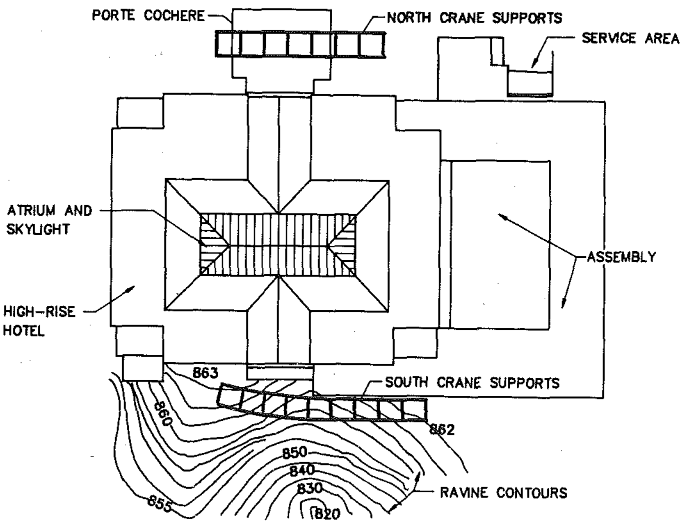

FIG. 2. Site Plan Showing Building, Cranes, and South Ravine

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ary cranes, one at each corner, or two travelling cranes that could serve the two halves of the building. The economics of renting and operating the two cranes, versus using four cranes, more than offset the extra cost needed for additional foundation work associated with tracks for the travelling cranes. Constraints due to property lines, adjacent buildings and materials handling logistics dictated that travelling cranes be located at the north and south faces of the building, and they travelled east to west.

Structural Design Challenges

Locating these cranes at the north and south faces of the building led to a challenging structural engineering assignment. The building's south face was very close to the edge of a bluff with a very steep ravine immediately on the south side. At the south edge, the crane supports were to be designed such that they could support the crane loads, including lateral loads due to wind and crane operation, and be adequately safe against overturning and or sliding down the ravine. The north crane posed another challenge. Its crane track was above the basement level; if the crane was to be functional before the basement walls were structurally ready to support any lateral load due to crane operation, then this wall should be redesigned as a cantilever retaining wall. However, such a redesign would require substantial extra cost. Alternately, if the crane supports could be designed in such a way that the crane loads do not impose additional lateral load on the soil, then this redesign of the basement wall could be avoided and the extra cost saved. The crane manufacturer had tight limits on the maximum deflections for which the support structure should be designed.

Crane Support Design

The cranes were counterweighted with concrete blocks so that there would be no uplift. The carriage wheel base was 19-ft-8-in. (6-m) center to center of axles, and the 19-ft-8-in. (6-m) center to center of wheels in any one axle. Each crane was on eight wheels, four in front and four in back. The maximum vertical load for each wheel was 105 kips (48,000 kg); the maximum horizontal load at each pair of wheels was 30 kips (13,600 kg). The crane structural requirement was that the maximum vertical deflection of the support system should not exceed 3/8 in. (10 mm).

To avoid the steep ravine in the south as much as possible, the south track was located as close to the building as crane clearances would permit. At the west end, the crane track was curved towards the north, into a cavity in the building plan, thus permitting the crane to swing further away from the ravine (Fig. 2).

The basic structural support system for the crane rails consisted of a long reinforced concrete beam under each rail supported on concrete drilled piers at 20 ft (6 m) on centers, with concrete cross-tie beams at each pier. The piers were battered so that they could better resist the horizontal loads. The bottom of the piers were founded on unweathered hard limestone. The pier loads were resisted both in bearing and side shear. Different pier slopes were investigated; the final design slope was selected to reduce the difficulty in drilling at the ravine edge, yet achieve the required factors of safety against overturning and sliding.

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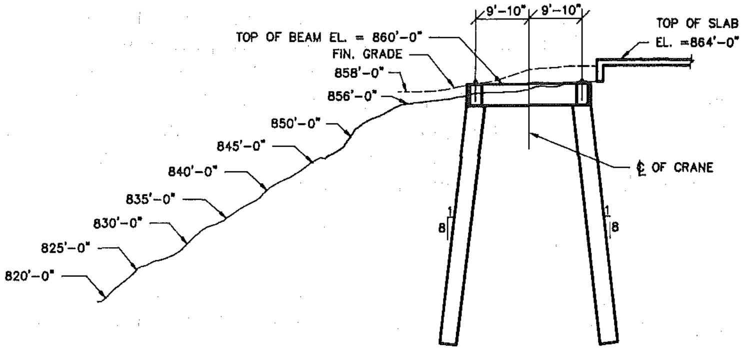

FIG. 3. Support System for South Crane

Two sloping piers with the cross-tie beam constituted the trestle which resisted the applied vertical and lateral loads (Fig. 3). The longitudinal beams under the rails were designed for moving loads and for the vertical and lateral bending due to crane positions in between the piers.

For the north crane support system, the piers were jacketed with a soft void-form casing above the level of the basement so that the lateral load due to crane operation was not transmitted to the basement wall (Fig. 4).

The cross-tie beams and the longitudinal beams were cast directly on the ground, using no special side forms. One full bay of support [approximately 30 ft × 20 ft (9 m × 6 m)] with four piers and the two crossbeams and two longitudinal beams were built for each crane. Then the cranes were mounted on this system of supports, and were later used to complete the remaining portion of the support system under each crane. Usual precautions such as end deadman were added on later. Fig. 5 shows the crane in operation.

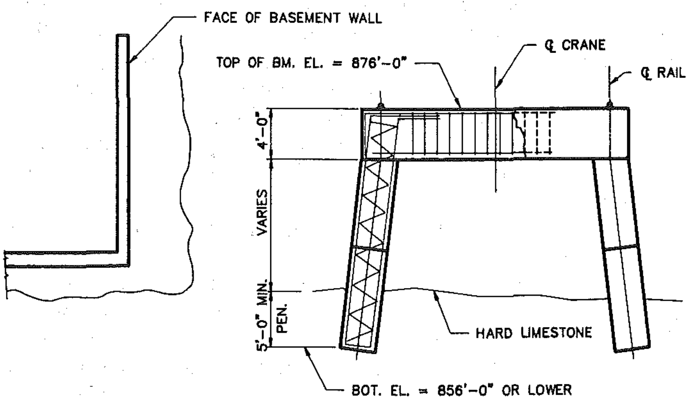

FIG. 4. Support System for North Crane; Longitudinal Beams and Rails Not Shown for Clarity (Typical) (Note: Drill 32 in. ϕ Pier and Use Sonotube to Break Bond with Adjacent Soil for Top 8 ft of Pier)

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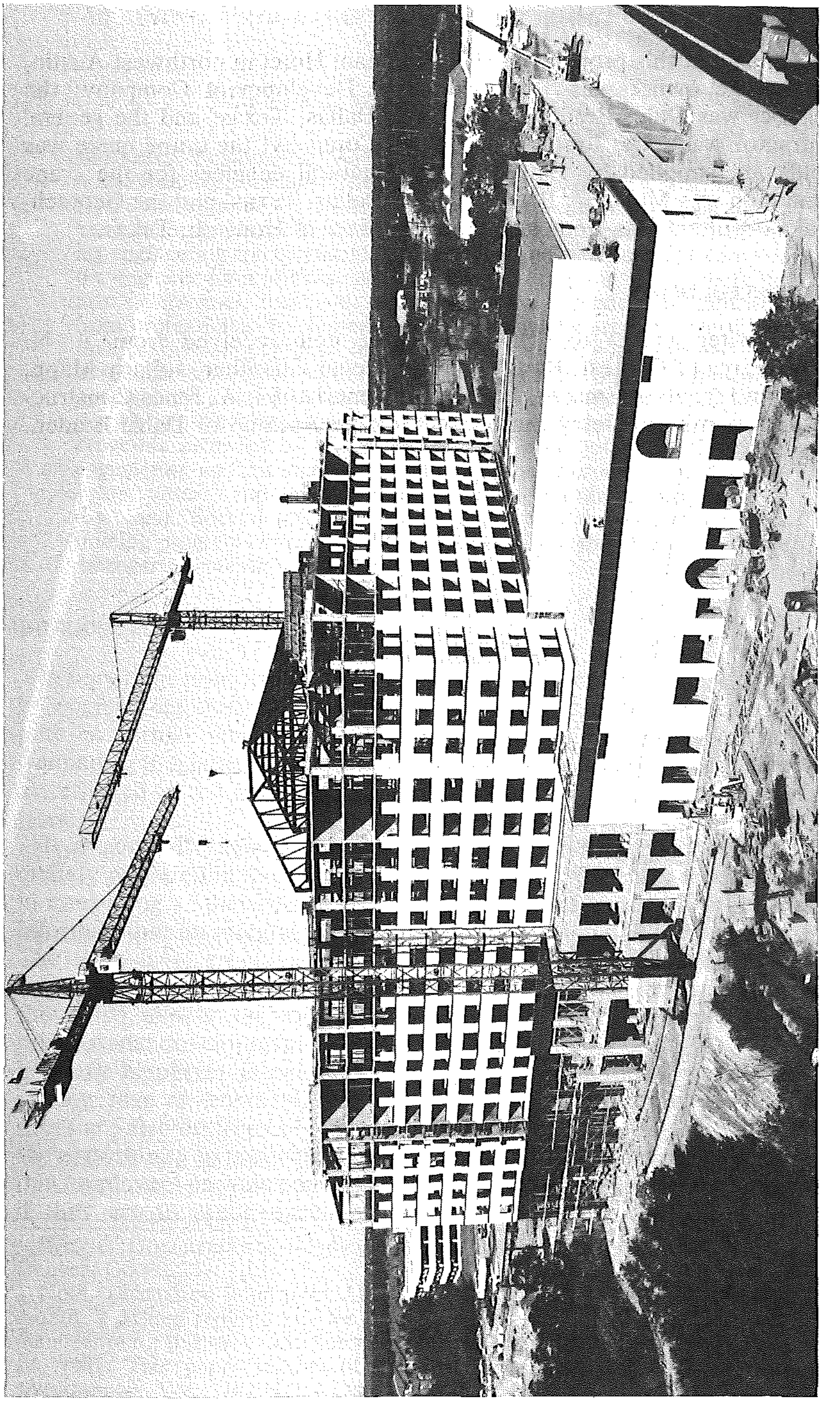

FIG. 5. View of South Crane

CREDITS

The name of this project was the Wyndham Hotel in northwest Austin, Texas. The owner was Trammell Crow Development Company; the architect was Dahl. Braden. PTM, Inc., Dallas, Texas; and the general contractor was J. A. Jones Construction Company; the crane make was Wolffkran, supplied by Emscor. The structural engineer for the crane foundation was Mullen & Powell, Inc. of Dallas, Texas, and the Geotechnical Consultant was Geotest Engineering Inc. of Houston, Texas.

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