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PRESIDENT'S MESSAGE

NEW PRECAST PRESTRESSED SYSTEM SAVES MONEY IN HAWAII HOTEL

NEW LOAD FACTORS FOR PRESTRESSED CONCRETE HIGHWAY BRIDGES
Clifford L. Freyermuth

COMPARISON OF CONCRETE POLYMER COMPOSITES PRODUCED BY HIGH ENERGY RADIATION
M. Levitt
D. J. McGahan
P. R. Hills

COMPUTERIZED DESIGN OF POST-TENSIONED CONTINUOU BEAMS AND FLAT PLATES
Hugh M. O'Neil

FINITE ELEMENT ANALYSIS OF PRESTRESSED CONCRETE VOIDED BRIDGE DECKS
J. C. Jofriet
G. M. McNeice
P. Csagoly

A LOOK AT OSHA—GOVERNMENT REGULATIONS WITH A DIFFERENCE
Edwin L. Slagle

READER'S COMMENT

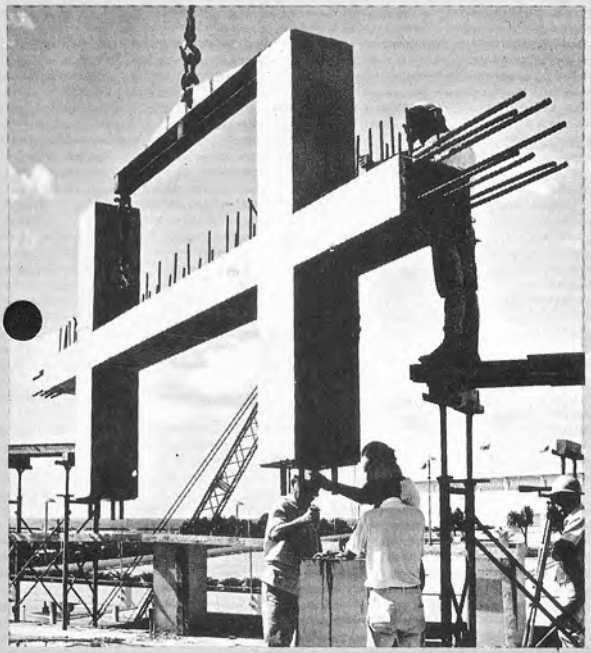
REVIEWS OF CURRENT PUBLICATIONS

ABSTRACTS OF PCI SPECIAL PUBLICATIONS

1973 PCI AWARDS PROGRAM

CALL FOR PAPERS—FIP/PCI CONGRESS, NEW YORK, 1974

INDUSTRY ITEMS



ARCHITECTURAL
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A PCI Construction Feature

NEW PRECAST PRESTRESSED SYSTEM SAVES MONEY IN HAWAII HOTEL

Describes how a new erection technique, a splicing device, a high strength grout, a camera, and mass production combined to save both time and money in constructing the new precast prestressed Ala Moana Hotel in Honolulu, Hawaii.

A new construction method, a special grout, mass production, and a camera combined to save both time and money in the construction of the Ala Moana Hotel in Honoulu, Hawaii (see Fig. 1).

Owned by Ala Moana Hotel Corporation, a partnership of American Airlines and Dillingham Corporation, the hotel features a 38-story, 896-room tower and a 13-story, 308-room wing. The $24 million structure has 1.1 million sq ft of floor space.

The structural system that eventually cut both time and money was developed by PCI member Alfred A. Yee, President of Alfred A. Yee & Associates, Hawaii, in association with The Hawaiian Dredging and Construction Co., Ltd., a subsidiary of the Dillingham Corporation and the builder of the hotel. The hotel is operated by Flagship Hotels, a subsidiary of American Airlines. Yee has received patents on the joint detail plan. The system is composed of precast concrete H-shaped structural-architectural units that form a moment resistant frame. These units are joined at midstory levels, rather than the more usual floor level position.

The new vertical support technique was designed to overcome a difficulty in joining precast units. Designers and builders are continually working on new joinery for structural precast members that will provide continuity at minimum cost. This new technique appears to be a promising one.

HIGH STRENGTH GROUT

Yee's detail uses a cast steel splice sleeve designed to take reinforcing bars at both ends. The interior of the sleeves are filled with a non-shrink, high strength, metallic reinforced grout, especially formulated for this use.

Basically the hotel is composed of H frames stacked on top of each other with precast, prestressed, prefinished slabs laid directly on the H frame beam.

Structurally, the H frames provide lateral resistance in the direction of their framing. Immediately before setting each H section, the cast steel sleeves embedded in the already erected column sections were filled with the special grout. The upper section was

Fig. 1. Ala Moana Hotel in Honolulu, Hawaii, nearing completion.

then lowered into place (see Fig. 2) with its lower end protruding reinforcing bars sliding into the sleeve sockets in the lower section, squeezing the excess grout into the connection joint and filling the void between the column concrete sections (see Fig. 3).

Laboratory tests showed that the grout develops such high strengths that a pull of 240,000 lb (a force producing stress in the bars approximating the yield strength of the #18 reinforcing bars) was required to draw the bars apart. After the grout was placed in the connectors, crews guided the next H unit into place. The grout was finished to 1.5 in. inside the column faces before it was sprayed with a membrane curing compound. Yee said that the recess confines the vertical compression forces within the contained area of spiral ties in the column section and avoids surface spalling that vertical loads can cause. He added that laboratory tests for "isolated steel sleeves indicated that the effective reinforcing stresses obtained were about 100,000 psi in compression when the grout was 4 days old and 60,000 psi in tension in 28 days." The grout's average strength was 8000 psi at 8 days and 10,000 psi at 28 days.

Cast steel sleeves producing ultimate strength of the reinforcing bars have now been developed by Yee's firm in cooperation with a Japanese company.

The grout, developed by Master Builders, reached 24-hour compressive strengths of at least 3500 psi enabling the crew to remove the shoring the day after the grout was injected. This also

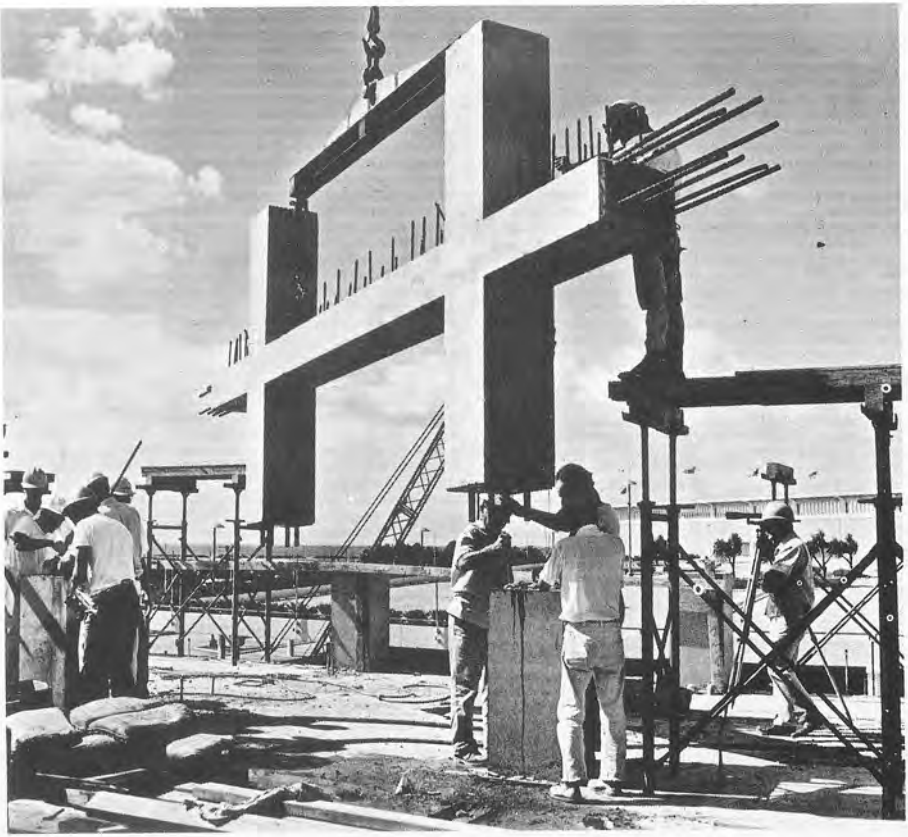

Fig. 2. Precast concrete H frame being swung into position.

was a factor in reducing construction time.

In fact, the only reason why construction could not proceed at a faster rate than one floor every 2½ days was because the high rise elevator shaft was cast in place.

CAMERA FILMS CONSTRUCTION

A camera was also helpful in reducing construction time. The project manager set up a time-lapse camera to film construction of the 13-story tower, the first section of the hotel to be built. He made a film of the procedure, exposing one frame every 3 seconds. The movie pointed out problem areas on the initial scheme which was originally planned to complete one floor every 4 days. A change in procedure to solve these problems enabled construction to jump 37 percent with one floor being finished every 2½ days. The film was also used to time different construction operations and help develop a timetable for construction.

PRECASTING HELPS CUT COSTS

The mass production of the precast concrete units enabled Yee to cut 8 months off the original schedule. At the

precast concrete plant, the 11-ton columns were cast upright in steel forms. The forms were designed to be stripped by only one man.

Lightweight aggregates also cut costs. Yee estimated that there was a $200,000 savings due to 20 percent less reinforcement and piling costs. He also said that lightweight aggregates increase earthquake protection because of its lower dead weight.

Overall construction differed only from the fifth floor down. Frames of the first five floors on both the tower and wing were primarily cast in place except for some precast joists and floor slabs. Exterior columns on these floors were 27 ft apart. The full height of the fourth floor in the wing and the tower is utilized for huge transition girders to permit doubling the span between columns from the fifth floor down. These large girders used 1600 cu yd of concrete and 500 tons of steel each plus some post-tensioning tendons.

Above the fifth floor, the H frames and floor slabs are all precast with only the closure sections cast in place.

Huge climbing cranes delivered the precast concrete units and the crews placed them so rapidly that delivery to the site governed the pace. Only minimum shoring was needed on floors until the in-place concrete cured. Successive floors were ready for plumbers, partition crews, and others just a few days after construction of the framework began.

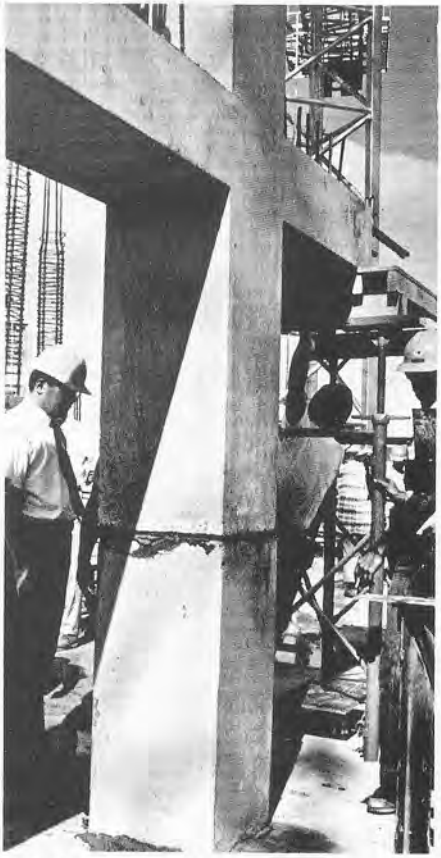

Fig. 3. Splicing H shaped precast units. The special high strength grout is visible around the joint between the two H frames.

CONCLUSION

The Ala Moana Hotel is open now and is a busy resort center.

The new splicing device and precast concrete column system has quickly become a model for planning of other major buildings around the world.

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