When "Skyhooks" Are Not Available

by M.J. Chow, P.E., and T. Popoff, P.E.

Construction for a 23-story midtown residential tower proceeded smoothly until the roof was poured. A group of five 7th floor columns then failed under the dead load of the over-lying 16 floors and roof. The damaged columns rotated and crushed, resulting in column shortening of as much as three inches and up to two inches of lateral movement (photo 1). All work stopped and temporary emergency shoring was installed to support the 8th floor slab.

Photo 1: Column damage included buckled reinforcing bars.

Besides the safety issues, there was a severe potential impact on the cost and timely completion of the project.

Mueser Rutledge Consulting Engineers (MRCE) was called in to design a repair scheme that would minimize the effects on construction cost and schedule. Initial investigations confirmed that the tops of five columns had failed for lengths varying between a few inches to a few feet. Concrete found to be weaker than specified had spalled, exposing buckled steel reinforcing bars at the columns with the most damage. The remaining 7th floor columns were intact and judged safe. Contract drawings were reviewed and column design loads obtained from the structural engineer of record.

While designing the repair, MRCE evaluated whether other work could proceed while the repairs were being performed. Obviously, additional load was not permissible above the damaged columns until repairs were completed. Furthermore, the remainder of the roof could not be constructed until the combined strength of temporary supports and repaired columns were adequate to support design dead loads. Other work on the building that did not increase load on the damaged columns or interfere with repairs was allowed to proceed.

The repair scheme limited most of the temporary load transfer system to the 7th floor; therefore, the use of shoring down to the foundation level was unnecessary. As a result, sub-contractor work below the 7th floor was able to continue throughout the repair period.

MRCE designed the repairs over the weekend following the failure; remedial work started Monday morning. Each damaged column was repaired using the sound portions of the existing structure as support for the steel jacking frames. Steel posts and hydraulic jacks were set between steel load transfer beams to carry loads of 300 tons around the damaged part of each column to sound structural members. Damaged portions of the columns were removed after the loads were jacked onto the transfer beam/jacking post system (photo 2).

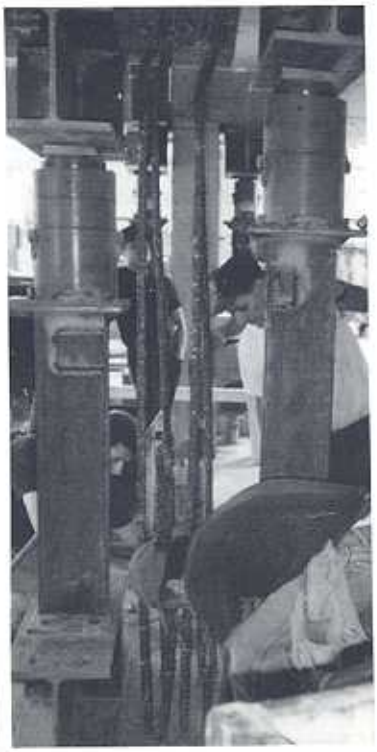

Photo 2: Transfer beam/jacking post system.

Two different repair schemes were developed to replace the damaged concrete. At two columns, as much as eight inches of damaged concrete was removed and replaced with 5000 psi concrete. At the three other columns, where a few feet of damage had occurred, the damaged concrete was removed and replaced by steel columns (photo 3). The

replacement steel columns were then encased in concrete.

During the repair, unexpected cracking of concrete occurred at the base of one column. As a result, the repair scheme was modified to transfer loads through the 7th floor slab to sound concrete of the 6th floor column. No further cracking occurred once the transfer was made.

After the repair concrete developed sufficient strnegth, the load in the transfer beam/jacking post system was released and the steel jacking frame was removed.

The repair concrete strength was checked by tests completed prior to the execution of critical stages of the repairs including jacking loads onto the transfer system, concreting the remainder of the roof, continuation of other construction above the repaired columns and the release of load in the jacks.

Following design, about one month was required to construct and jack the load onto the transfer system, and complete the column repairs. An additional week was required for the repair concrete to develop sufficient strength to permit unloading of the transfer system and removal of the temporary supports. ■

Photo 3: Checking placement of hydraulic jack.

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A Formwork Second

Partially seasoned stock is preferred for formwork since fully dried lumber swells excessively when it becomes wet, and green timber will dry out and rot during hot weather, causing difficulties of alignment and uneven surface.

Another Formwork Second

White pine makes good form lumber because it is not inclined to warp and twist.