Outside the collapsed Vector building, D. F. Moran (left) consults with his contracting manager, about the application of epoxy injection repairs to the 25 cracked concrete tilt-up panels.

D. F. Moran, Consulting Structural Engineer

With more than 32 years of experience as a consulting structural engineer primarily in earthquake engineering, Donald Moran is regarded as one of the nation's leading experts in design of earthquake resistant structures. For over 40 clients, who include some of the country's largest corporations, he has made earthquake risk analyses of individual plants and structures to estimate the maximum probable loss. Alone and in collaboration he has published over 15 papers on earthquakes, including those in Kern County, Calif. and Nevada and Eureka, California.

Mr. Moran was recently appointed Chairman of the committee of the Earthquake Engineering Research Institute to prepare a report on the San Fernando earthquake of February 9, 1971 for the National Oceanic & Atmospheric Administration (U.S. Department of Commerce). He is a vice president of EERI, which is a non-profit corporation composed of about 90 engineers, geologists, seismologists and scientists nationwide who devote their time to the improvement of earthquake engineering.

Immediately after the quake Myers Bros. Construction Company, Inc., Los Angeles -- the general contractor for the entire building reconstruction--placed wood shores on the outside of the panels to brace them in their bent condition, and to prevent them from falling.

The consulting engineering firm of Wheeler & Gray was called in for the rehabilitation work and the structural engineer made a building survey. For a short time, some thought was given to replacing the 25 fractured panels and 3 demolished panels, but the cost would have been close to $33,000 and the time delay excessive.

Arthur E. Farley, vice president of Myers Bros., then recommended restoring the integrity of the cracked tilt-up panels by automated epoxy injection. The structural engineer concurred because he was personally familiar with the epoxy injection system, having previously specified it for repairs of various structural members. Some earthquake-damaged structures were repaired by this method following the Santa Rosa earthquake.

[illegible] Angeles Department of Building & Safety, permission was received from them to inject the cracks in one panel and test the cores to justify the epoxy injection method.

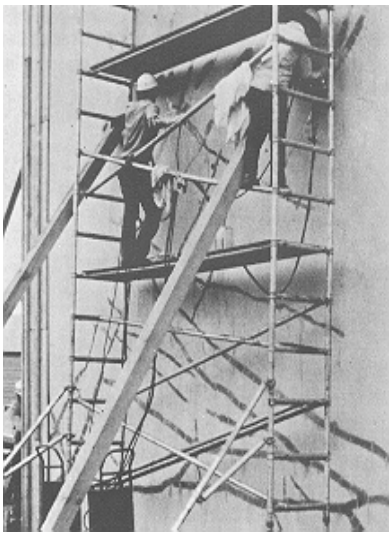
Crack injection for test purposes was completed at 5 p. m. The next morning at 8 o'clock, four 2-in. dia. cores were taken in the injected cracks and four in adjoining sound concrete. Two bonded and two unbonded cores were tested for compressive and shear strengths by California Testing Laboratories, Inc., Los Angeles, with the results shown in Table I. It should be pointed out that the bond strengths obtained were exceptional, considering the epoxy adhesive had been allowed to cure for only 24 hours.

Based on the successful core tests, the Department of Building and Safety granted a permit for the use of a low viscosity epoxy adhesive and the crack injection process for complete repair of the wall panels of the Vector building.

After cutting out most columns, Myers Bros. straightened the panels into their original upright position, and the cracks to be injected were marked by the structural engineer. It is interesting to note that many of the panels marked for injection had previously been marked "replace."

Epoxy injection proceeded in the usual manner. The fine diagonal cracks were sealed for pressure pumping by a temporary seal, and the larger horizontal cracks near the ground line with a high viscosity epoxy paste adhesive.

The entire crack injection process took about two working weeks, at an approximate cost of $280 per panel, compared with the $1300 per panel for replacement. The total savings in panel construction costs were $25,000 and the savings in rebuilding time at least 30 days.



Structural injection resin is injected into cracks through ports made at intervals in the temporary seal. Pumping continues until the liquid adhesive appears at the next immediate port.

1999 update:

Los Angeles County (with FEMA funding) is now one of the leading proponents of epoxy injection for structural repair of cracked slabs, decks, columns, bridges, dams and walls (poured-in-place, cast or CMU).

ChemCo Systems structural epoxy injection products are currently being used for repair of the 365 ft. high Pacoima Dam, near Valencia, CA, which is near the epicenter of the Northridge earthquake. The current phase of work requires injection of the upper 80 feet of all vertical cold joints (both upstream and downstream faces) which opened laterally during the seismic event.

Table 1. Results of Tests on Concrete Cores*

Tests	Compressive Strength		Shear (single) Strength	
Mark (panel location)	3	6	4	7
Condition	Bonded Crack	Sound Concrete	Sound Concrete	Bonded Crack
Height	3.90	3.90		
Dia. or dimensions	1.93	1.93	1.93 x 3.15	1.93 x 3.30
Area	2.93	2.93	6.08	6.37
Max. load	8300	11500	4500	4520
Strength, psi	2833 (Comp)	3925 (Comp)	740 (Shear)	710 (Shear)
Fracture	Outside of bond line			Outside of bond line

*The purpose of the tests was to obtain comparative results of the compressive strength and shear strength (along the bonded plane) of the sound undamaged concrete and the cracked concrete that had been bonded with an epoxy compound (California Testing Laboratories, Inc. - Laboratory Report #42731, March 31, 1971).