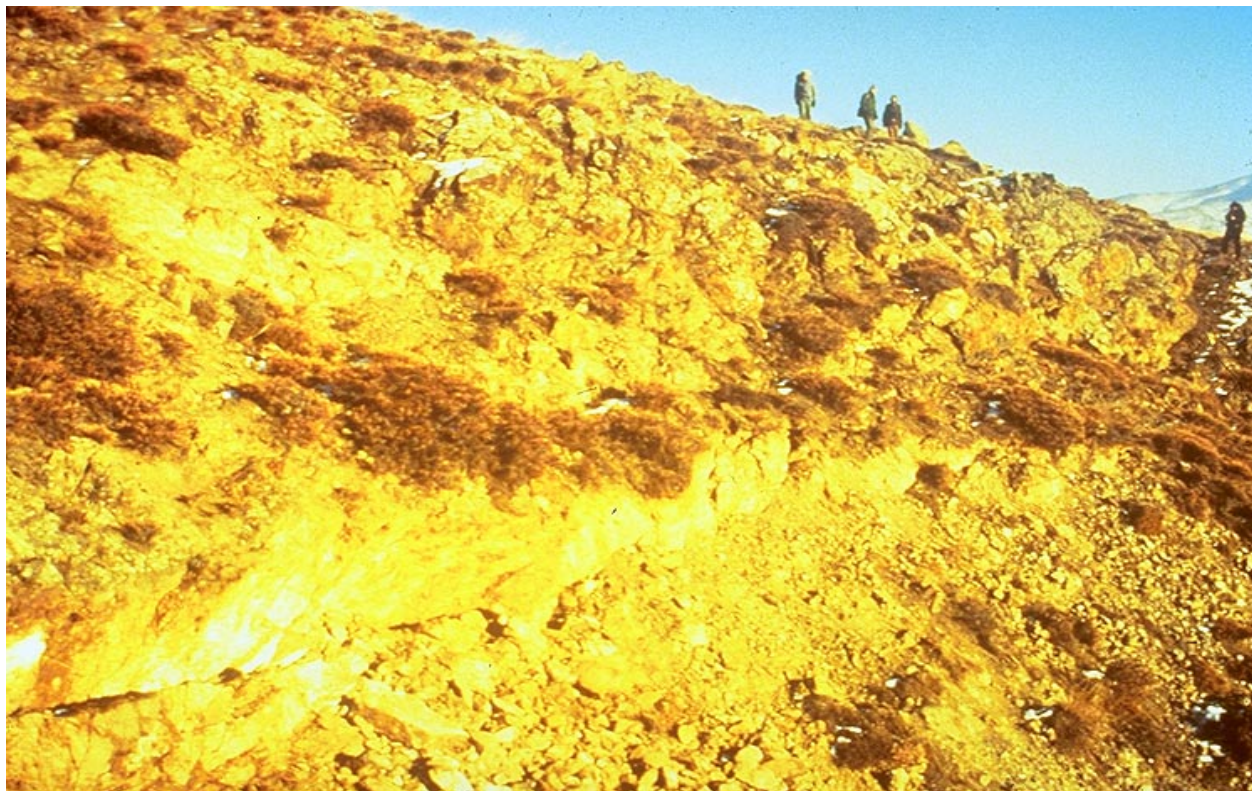




Photographed by H. S. Lew, National Institute for Standards and Technology

DAMAGE TO 9-STORY PRECAST CONCRETE FRAME BUILDINGS IN LENINAKAN

Collapsed and damaged nine-story precast concrete frame buildings in Leninakan. Poor diaphragm action due to lack of connections between the floor planks (flexicore precast floor panels) contributed to the failures.



SURFACE FAULT RUPTURE

The vertical displacement of the upthrown block was 1-1/2 m, typical of a $M = 6.8$ earthquake. The fault broke the surface over 15 km and is assumed to be the causative fault. Professor Millernovsky (USSR) had mapped the fault 30 years earlier.



FAILURE MECHANISMS OF STONE-BEARING-WALL BUILDINGS
Shows the failure of the stone bearing wall systems at the corners where the two walls meet.



FAILURE MECHANISMS OF STONE-BEARING-WALL BUILDINGS
Shows damage to a stone bearing wall building in Leninakan. The floor planks were not tied to the supporting bearing walls.



FAILURE MECHANISMS OF STONE-BEARING-WALL BUILDINGS

Shows the failure of a typical 4-story stone bearing wall building in Leninakan. The failure has exposed both the exterior and interior walls, revealing the method of construction of the walls as well as the flooring system. The floor is of light weight concrete planks with simple, narrow supports on the walls. Note that the floor planks at the fourth level have also fallen.



Photographed by H. S. Lew, National Institute of Standards and Technology

FAILURE MECHANISMS OF STONE-BEARING-WALL BUILDINGS

Shows damage to an old stone bearing wall building in Leninakan which was a hat and glove factory.



CORNER REINFORCEMENT OF STONE WALLS IN LENINAKAN

In their newer stone bearing wall buildings, Soviet engineers built a reinforced concrete member at the corner that provides continuity to both walls along the edges. In this slide, failure of the stone wall appears to have been arrested by this member. There were many cases, however, where this member many not have helped to stop the failure at the corner. Further study is required to evaluate the beneficial effects of this system.



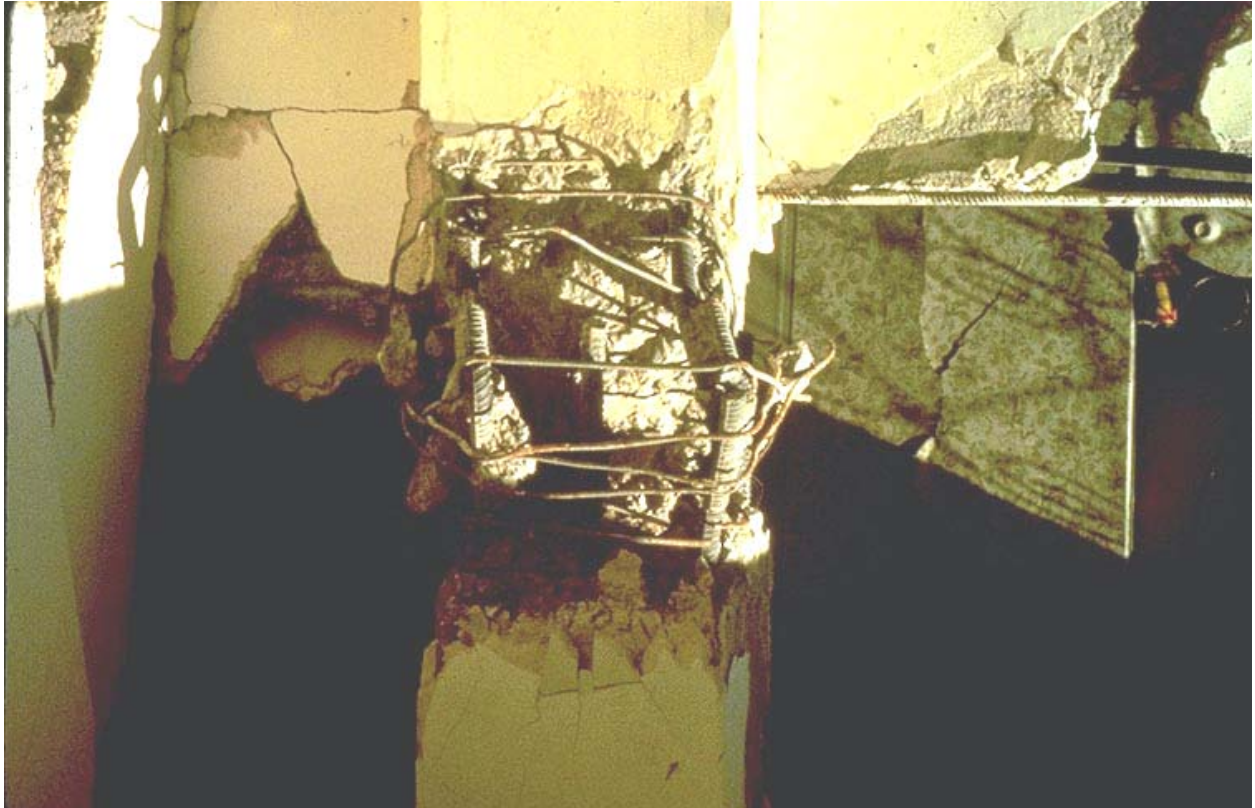
FAILURE MECHANISMS OF PRECAST CONCRETE FRAME-PANEL BUILDINGS

Shows the failure of floor planks of a building under construction which was to become the new building of the Polytechnic Institute. The floor planks, of lightweight concrete, hollow- core, and approximately 4 ft x 6 ft x 8 inches are simply supported on the beams over a 2 to 3 inch seat. There are no ties between the planks or between the planks and the beam reinforcement.



FAILURE MECHANISMS OF PRECAST CONCRETE FRAME-PANEL BUILDINGS

Brittle failure of welded rebars can be observed. Some rebars from the column above are not contained in the column below. This kind of failure at the connection between the precast column elements was very common.



Brittle failure of welded rebar can be observed. Some rebar from the column above are not contained in the column below. This kind of failure at the connection between the precast column elements was very common.



One of the collapsed cast-in-place and probably precast buildings of the granary. The building is at least the equivalent of a 10 to 15 story building. Collapse occurred in the third floor of the building which was a soft floor.



PRECAST CONCRETE PANEL BUILDINGS

In the Soviet design of precast concrete panel buildings, virtually every precast interior wall is used as a load-bearing element having shear capacity. This design gives a stiff, redundant structure. Floors and roofs are precast concrete planks, but with positive intrastructural connections between the various elements.

In this photo, the performance of precast frame-panel and precast panel buildings can be compared. Many precast frame-panel buildings in Leninakan collapsed and are shown in the foreground, including one under construction.

Precast panel buildings, in contrast, performed very well and are shown standing in the background. The difference in performance is due to the basic differences in their design as well as possibly to specific characteristics of the ground motion. Site amplification in the 1.0 to 2.5 second band was found in the strong motion records of the aftershock sequence recorded in Leninakan may have generated a greater load on the concrete frame-panel buildings.



DAMAGE TO 9-STORY PRECAST CONCRETE FRAME-PANEL APARTMENT BUILDING IN LENINAKAN

This slide shows the type of building that performed poorly in Leninakan—the precast concrete frame-panel building constructed in the 1970's. Although this one is still standing in Leninakan, 54 percent of these buildings in Leninakan collapsed, 41 percent required demolition, 5 percent needed repair, and none of them escaped damage.

Throughout the total area affected by the earthquake, 314 buildings collapsed, 641 needed to be demolished, and 1,264 needed repairs or strengthening. Only 712 (24 percent) remained inhabitable after the earthquake. Although at the present time, very little is known about what distinguishes those who survive in an earthquake from those who do not, the morbidity (injuries) and mortality (deaths) from the Spitak earthquake were clearly related to:

- structural factors of the building,
- search and rescue activities,
- evacuation procedures, and
- medical relief action in the immediate post disaster phase.

For example, deaths were 68 times and injuries rates more than 7 times higher in trapped than in nontrapped victims. This slide shows the failure of the building at the site fabricated joints. The precast floor planks contributed in a major way to the failure.



16-story lift-slab concrete building in Leninakan. The building is leaning about 1 meter to the right and is a total loss due to a general failure of the cast-in-place concrete shear core at the ground level.