# BRIEF REPORT ON VISIT TO THE EPICENTRE OF THE 2 MARCH 1987 EDGECUMBE, NEW ZEALAND, EARTHQUAKE



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The Edgecumbe earthquake (37.92°S, 176.79°E), magnitude $m_b$ 6.1, occurred on a Monday afternoon, 2 March 1987 at 142$_{pm}$ local time (0142 U.T.) at shallow depth (about 12 km) below the Rangitaiki Plains (about 210 km southeast of Auckland on the North Island of New Zealand). The chief communities affected were Edgecumbe (population about 1,500), the pulp mill town of Kawerau (9,000), and the regional centre of Whakatane (15,000), all within 20 km of the epicentre (Fig. 1).

There was no loss of life and few injuries during the earthquake, attributable partly to a magnitude 5.2 foreshock 7 minutes before the main shock, which sent most people outside. However, there was spectacular surface faulting, and damage to bridges, a railway, and to some common structures. Damage may have amounted to $Can 250 million, though most of this occurred in just two large industrial facilities, namely, the Bay Milk Products processing plant at Edgecumbe, and the Kawerau pulp and paper mill.

I was able to arrange a visit to the area on April 18 and 19, during a private holiday to New Zealand. My visit, 7 weeks after the earthquake, fell during Easter weekend, which made it almost impossible to make contacts for inside site visits. In addition, the extent of damage at the world-scale Kawerau pulp mill was sensitive information because the delay in production might affect world pulp prices.

Nevertheless, my observations may be valuable, and should be seen as an introduction to the extensive reports that will soon be available from the New Zealand engineers.

## Surface Faulting

The earthquake was a shallow-focus, normal faulting event, causing local extension of the earth's crust. One main and five smaller sub-parallel fault traces were formed, all were downthrown to the west. The largest was 7 km long and had 1 to 1.5 m of vertical movement (Fig. 1). These sharp scarps show the fault displacement had propagated through hundreds of metres of loose alluvial fill, and in some cases the modern fault break reactivated a pre-existing scarp. The downthrown side of the main fault moved down relative to sea level, important in this poorly-drained plains area because river stopbanks were lowered and some land may now be too wet to farm.

The fault breaks formed suddenly at the time of the earthquake and offset many of the roads crossing them. A farmer's wife, driving to see if her land was damaged, "sailed through the air" at a point where the road formerly had a slight dip (a pre-existing fault scarp reactivated in 1987!) but where there was now a 1 m-wide chasm and a 1.5 m-drop in level.

Much to the sorrow of geologists, the roads department quickly graded and repaired the roads, although they had not sealed them by the time of my visit (perhaps because geodetic monitoring was still showing continued creep, which would have rebroken the seal).

[Rai]lways

The railway line crossing the plains showed spectacular bending of railway lines (especially at Edgecumbe station), indicating compression, not the extension expected. This is most easily explained by local extension near the faults being compensated by compression away from them. About 30 km of the line was extensively damaged. The railway line was out of service for a week or so, and, even though open when I visited, had speed restrictions because the railbed was not sufficiently straight and level.

Bridges

Damage to both road and rail bridges in the Rangitaiki Plains area was minimal, although many bridges had been closed for safety inspection for short periods. Settlement of the fill approaches to the road bridges was ubiquitous, and quickly fixed by a few loads of gravel. Most of the road bridges were reinforced concrete (many cast-in-place), while the railway bridges were wood trestles. Damage that I saw was limited to minor cracking at the concrete abutment supports for the bridge spans and to longitudinal compression of steel bands on the decks of the railway trestles. These bridges, especially the railway ones, were relatively old and may have been built without any seismic design provisions.

Riverslea Shopping Mall

This partially-opened shopping mall (8000 $m^2$) in Edgecumbe was declared a total write-off because of structural damage and will be torn down and rebuilt on the same site. It was worth about $Can 0.8 M, and was a one-storey structure with partial mezzanine floor. The building was standing, but mostly stripped of contents by the time of my visit. However, despite this, I could see only superficial damage from the exterior (it was not possible to get in). The superficial damage included compression failures in the asphalt parking lot, settlement of the concrete pavements, separation of pavement slabs by up to 50 mm (including stretching of 15-mm rebars), hammering between column bases and pavement slabs, mis-alignment and deformation of lightweight exterior infill panels, separation of flexible caulking along joints between pre-cast exterior wall slabs, partial failure of suspended ceiling panels, and some cracked exterior glass.

Quite apart from the cost of replacement, the loss of use of the mall while it is being rebuilt is a serious blow to the town of Edgecumbe and to its attempt to remain an important local shopping centre.

Bay Milk Products, Edgecumbe

This very large industrial facility processed milk from farms on the Rangitaiki Plains into butter, cheese, milk powder, casein and other milk products. The most spectacular damage was to vertical stainless steel tanks about 5 m in diameter and 10 m high used for storing and processing the milk. Many of these tanks were said to have suffered compressional failure at their base, and had been carted to a nearby field to await repair. I was not allowed to visit the plant, but examination from a distance suggested damage to pipework may have been heavy.

I did however observe the milk powder store, which was adjacent to the road. This fairly-new structure was basically an open shed about 200 m long and 20 m wide formed by 150-mm section arch-shaped steel I-beams at about 4-m spacing. (As I was unable to enter the building, these estimates are very rough). The columns were linked horizontally by U-section steel of about 80-mm section and cross braced by 40-mm section diagonal steel braces every second or third bay. The exterior was vertical corrugated steel.

When I visited, the steel sheathing was missing along about one third of one side and the entire shed was leaning lengthwise. The one base flange of a 150-mm column that I saw was bent. Inside, every one of the diagonal braces had failed.

Whakatane Hospital

Whakatane lies about 12 km from the closest fault break, but sits partly on the soft ground of a river estuary. I toured the 6-storey clinical building of this general hospital with the clerk of works, an engineer. Although press reports suggested the building was extensively damaged and closed by the earthquake, in fact the damage was mostly functional and superficial rather than structural, and the building was closed mostly because the hospital board had decided to use the opportunity to remove asbestos cladding fire protection. The building was concrete (I think all poured-in-place) and was 10-12 years old, and so designed for the seismic provisions of a building code two editions before the present.

Despite this, it had performed well structurally, the chief flaw being compressional failure of rigid pipes carrying wiring that crossed the separation gap between the two independent blocks that make up the building (Fig. 2). The functional performance of the contents was less satisfactory.

Key components in the roof-top machinery room, such as the main electrical switch boards were not tied to the walls, and had moved several inches, fortunately without toppling or otherwise breaking the circuits. An important water cooler used in surgery had been bolted rigidly to the floor slab and had sheared its mounting bolts; it had been remounted on a massive steel and spring cradle that conforms to the current New Zealand code (Fig. 3). Water tanks in the room provided both storage and pressure for the hospital and sat in low trays designed to catch small leaks. A pipe connecting two tanks failed (Fig. 4), and the trays were too small to contain the water, which then cascaded down one stairwell making the evacuation of patients difficult. The mounting of ventilation ductwork suspended from the ceiling proved to be too flexible and the ducts separated in some instances.

On the main floors, partitions were constructed with hollow steel "2 x 4" studs pop-riveted together. Many of these connections had failed, in part because poor supervision had allowed retaining washers to be missed, and the rivets had then pulled out.

Houses

Most houses were typical New Zealand structures with a wood frame, horizontal wooden board siding and a foundation of concrete piers ("piles"), and had behaved well. It was impressive to see substantially undamaged houses tens of metres from a fault break. However, many brick veneer houses lost their bricks, apparently due partly to a lack of ties between bricks and frame. In Kawerau, about 75% of the brick chimneys fell through the roof. Some concrete block structures fell apart completely, apparently because of lack of sufficient steel reinforcing. Many of the houses sit on wooden piles, and in one case I saw, the house had fallen sideways off the piles (Fig. 5). None of the piles was cross-braced, and the flexible joints at the joist level and at the bottom where the timber pile sat on a concrete pad provided hinging points. An unusual but not rare foundation type is the pole house, where a house is carried over steep terrain by a grid of 500-mm timber posts. In a few houses, some of these posts had snapped during the earthquake, supposedly because they had been located poorly and were already highly stressed by having been pulled into line.

The most recent edition of the New Zealand code allows some of the shear strength of house walls to be carried by the interior sheetrock lining, so reducing the shear resistance required in the structure itself. I understand that examination of some new houses after the earthquake has suggested that the additional shear resistance gained in the older houses was a desirable bonus.

Matahina Dam

This rockfill dam was about 15 km from the closest fault break. It was undamaged by the earthquake, although loose rock rolled down the downstream face, and surveys show that the dam as a whole moved downstream up to 200 mm. There were 5 strong ground motion recorders on the dam, they recorded up to 0.33 g at the base and 0.43 g at the top, including substantial energy at periods as long as 3 sec.

Strong Ground Motion Records

In addition to the strong ground motion records of the main shock from the Matahina Dam (none from a free field instrument), field units were deployed soon after the main shock and should give interesting records from some of the larger aftershocks. I found personal experiences from some observers interesting. One, who was working at the Bay Milk factory, reported that people were unable to stand during the main shock (M 6.2), but also that they had tried to stand during the aftershocks (M about 5 to 5.6) but could not. This suggests that ground motion near to the source of even the moderate earthquakes was significant.

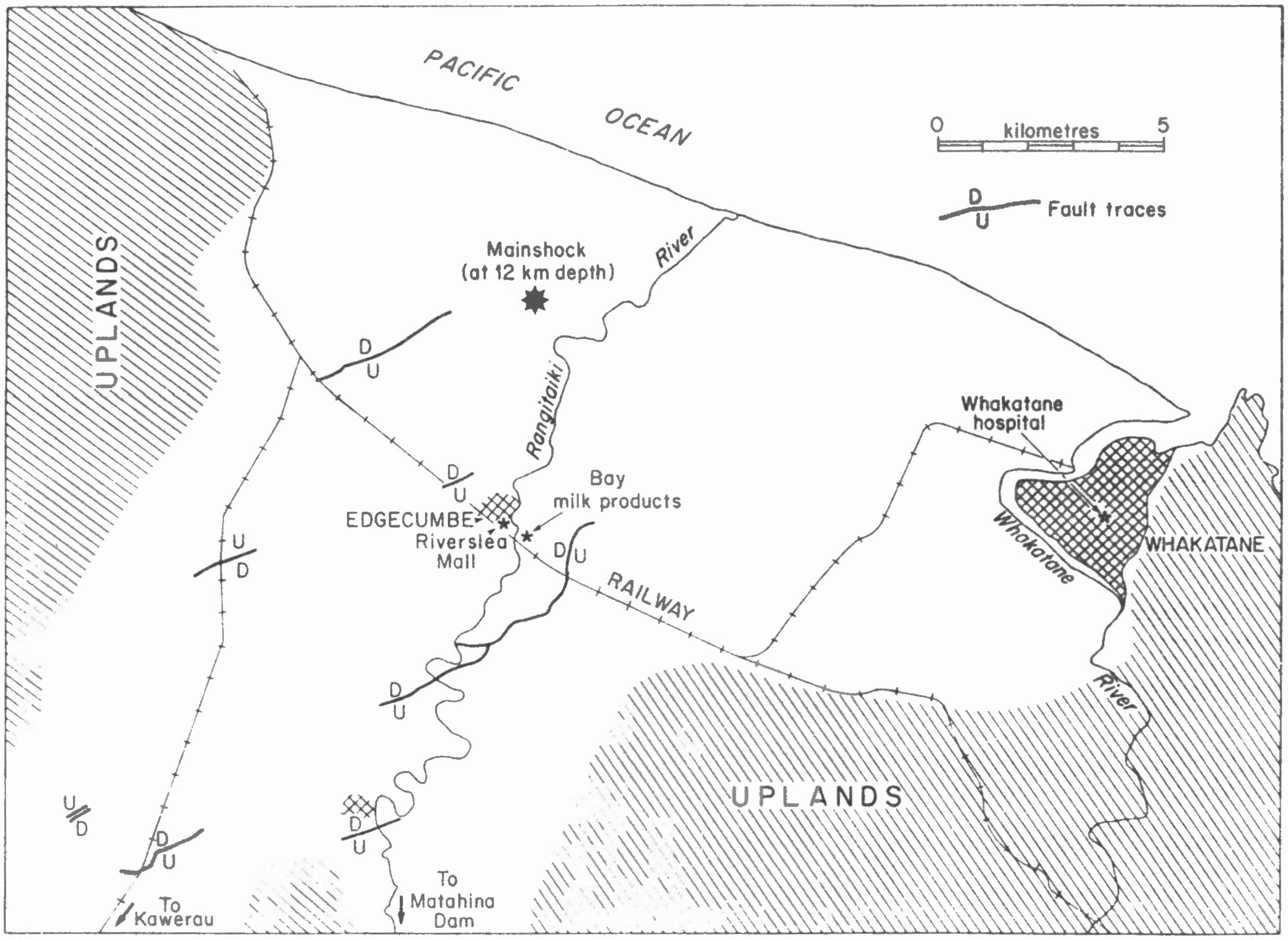


Figure 1. Map showing the extent of the Rangitaiki Plains, the main shock location and surface fault breaks, localities mentioned, the railway line, and the location of the facilities discussed in the text.

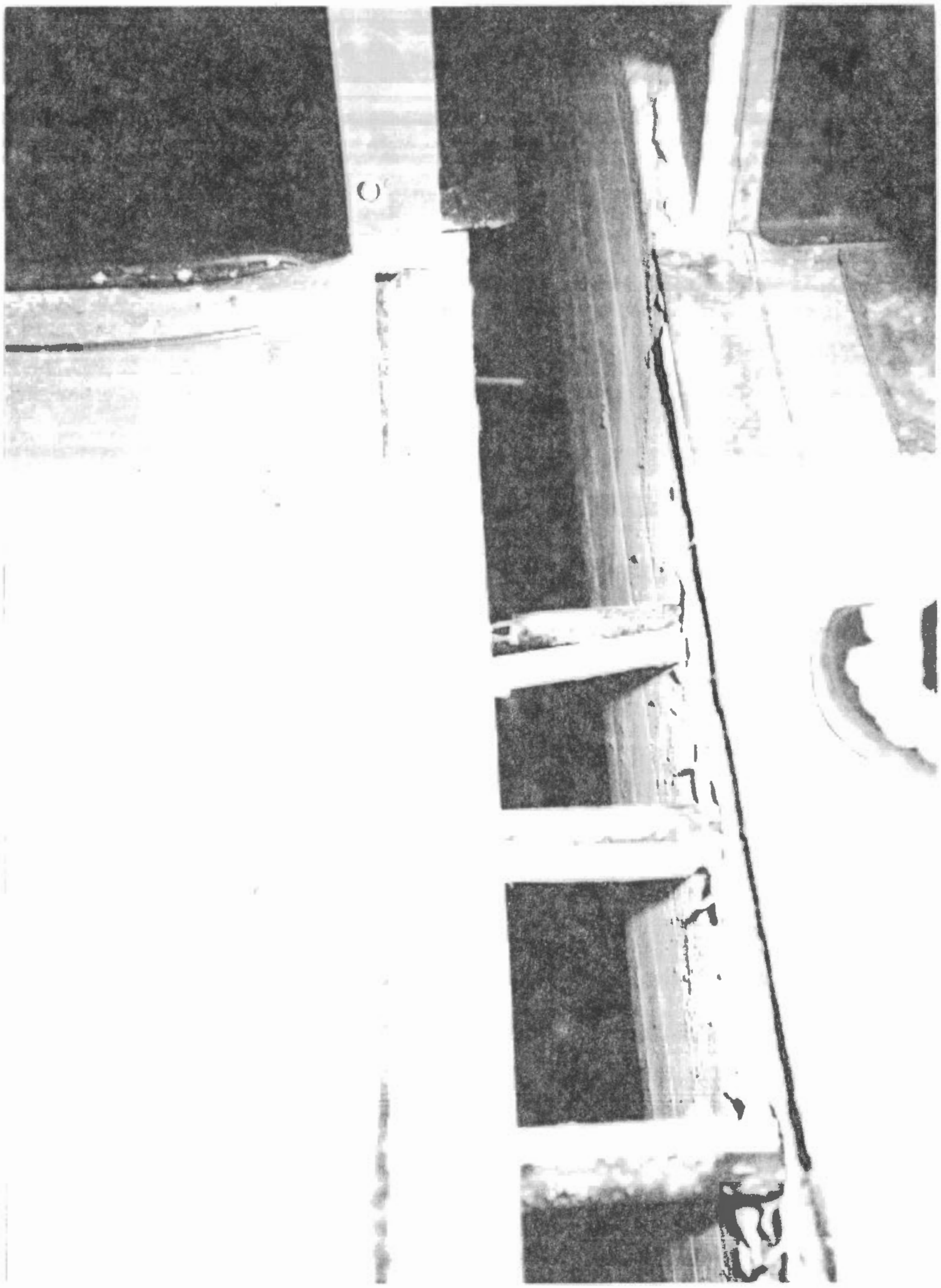

Figure 2. Compressional failure of rigid pipes containing wires, separation gap between 2 blocks of Whakatane Hospital building.

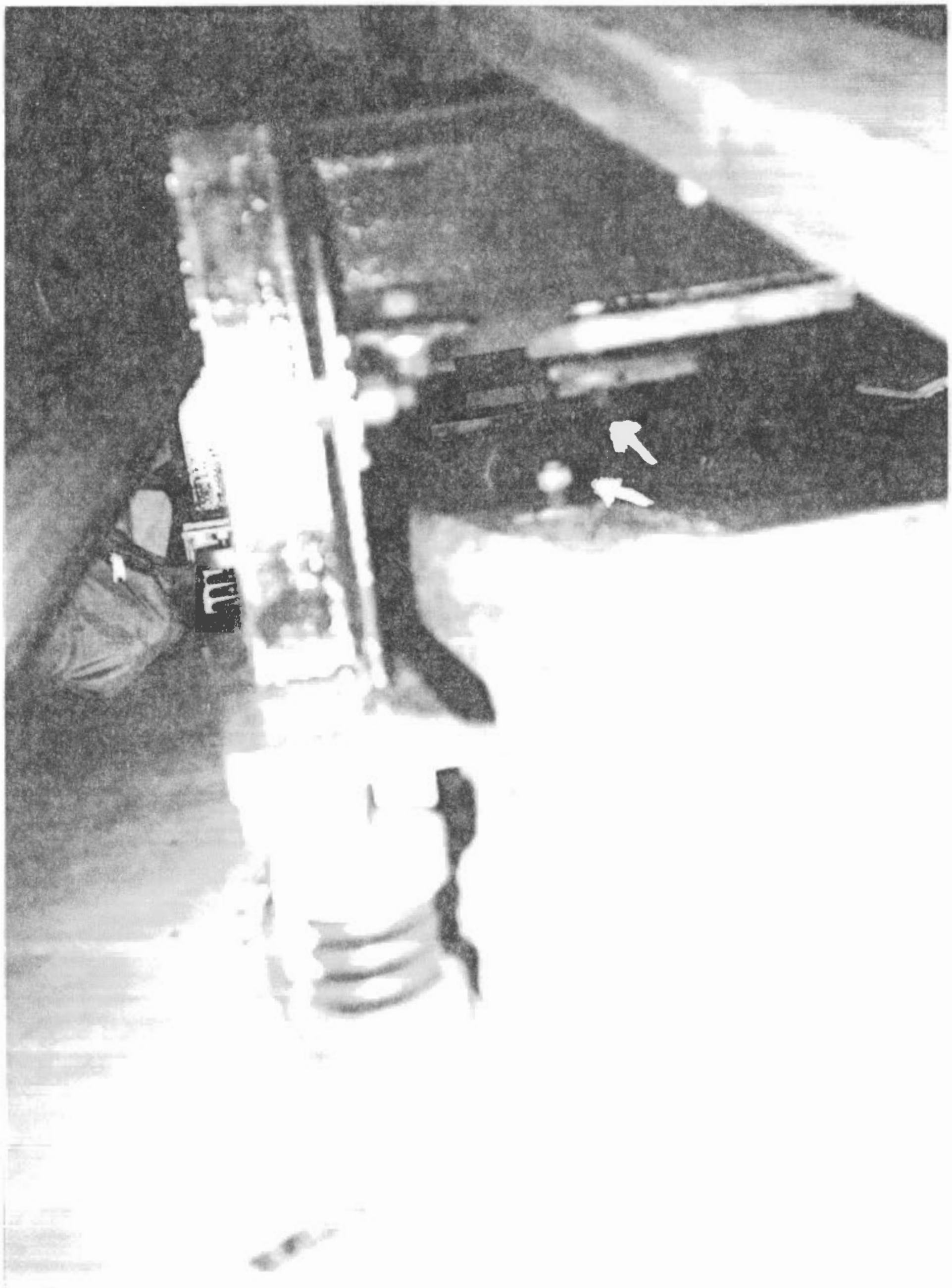

Figure 3. New, earthquake-resistant, cradle for water cooler, Mechanical room, top floor, Whakatane Hospital. The original rigid bolt mounting (arrow) failed during the earthquake.

Figure 4. Failure of water supply pipe, mechanical room, top floor Whakatane Hospital.

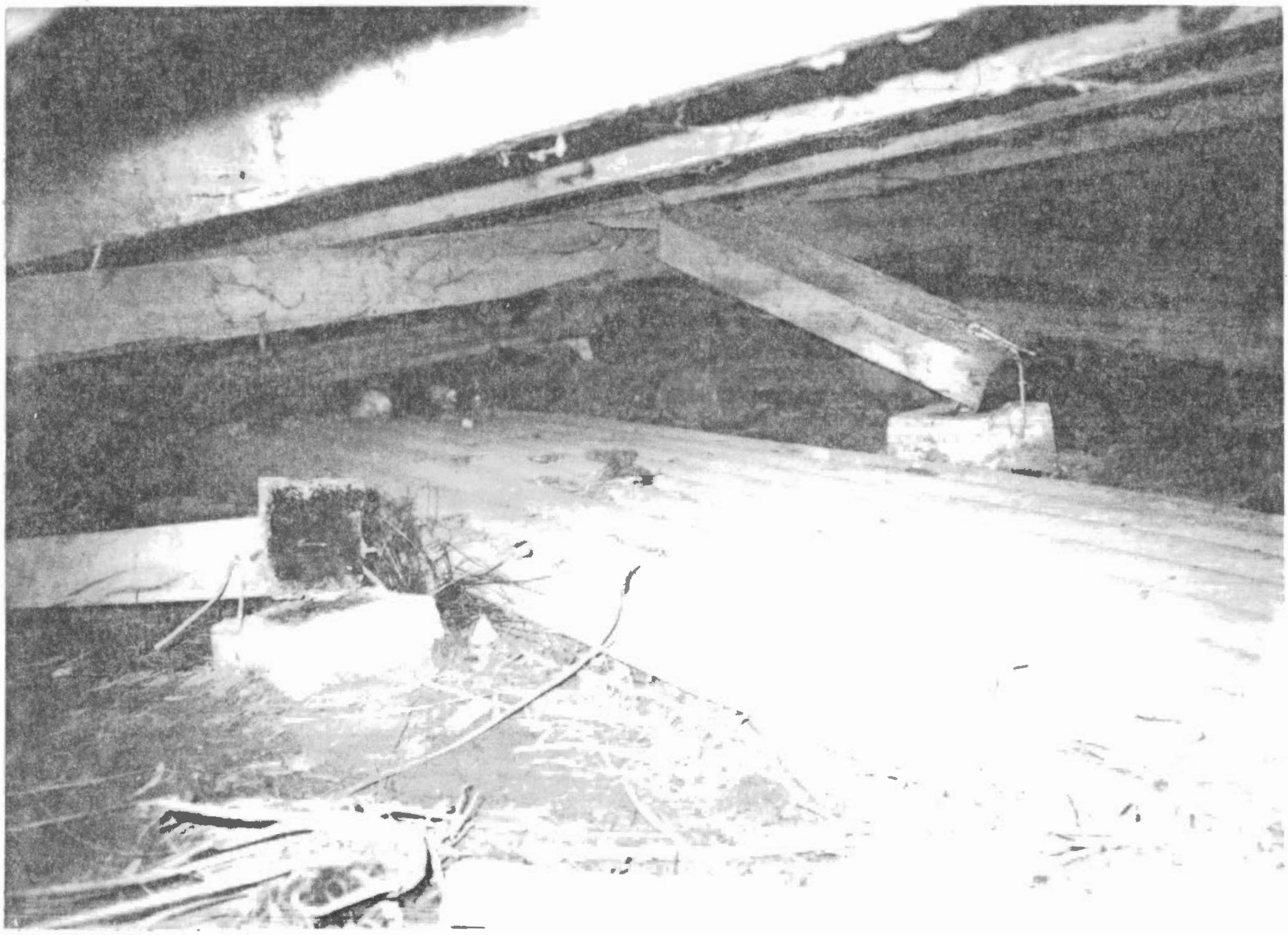

Figure 5. Failure of timber piles, house at Edgecumbe.