DAMAGE TO CIVIL ENGINEERING WORKS AND RESULTING CIVIL DEFENCE PROBLEMS

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Introduction

Detailed studies of the damage to many of buildings, bridges and other structures increases our knowledge of earthquake forces and their effects. Here no more than a summary can be given of the type of damage caused to various works with a suggested reason for this in some cases. Damage to roads, bridges, culverts and water supplies are briefly considered with an outline of the Civil Defence action taken during the emergency period.

Roads

For a distance of about 25 miles south of Inangahua and through the upper and lower Buller Gorges roads were seriously affected by slips, cracks and subsidences.

Slips were most prevalent on sidlings where the bank above the road dropped on to the road, all or part of the road subsided or sometimes both occurred when a complete section of hillside slipped as happended in many places in the Buller Gorges. Most of the extensive slips, eighteen to twenty chains long or more, comprised a rubbly mixture of clay and rock, generally wet and difficult to shift with heavy machinery because of sticky wet clay. All the State Highways, and the County road, into Inangahua were blocked by extensive slips. The County road (Browns Creek Road) had only one slip about 10 chains long and some surface damage. This road was the first to be cleared to give vehicle access to the township.

Cracks in sealed roads were very prevalent, but the displacements generally no more than a few inches. The pattern of cracking on the roads could be related quite clearly to small changes in ground formation, such as minor terracing in old and new gravels, small swamp areas or soft ground. Lateral or diagonal cracks across the road generally followed some underlying ground weakness such as change in formation or terrace. Cracks parallel to the centre line occurred where the road crossed soft or swampy ground. The seismic oscillations caused the edges of the road to move outwards and sometimes downwards, leaving a series of parallel cracks generally nearer the outer edges of the road.

Over a very wide area road fills subsided, particularly bridge approach fills. One of these about 20 ft high at a railway overbridge 70 miles south of Inangahua, after settling 14 inches and leaving exposed the vertical concrete rear face of the abutment, was the cause of one of the few fatalities following the earthquake. A motorist approached at speed in the morning darkness ...

Bridge approach fills settled by varying amounts from fractions of an inch to about three feet. This settlement can be attributed to either recompaction of the filling or settlement of the ground beneath or a combination of both.

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The seismic oscillations must have generated very high earth pressures against bridge wingwalls as many of them were cracked at the junction with the abutments or moved bodily when unattached to the abutment. Reinforced concrete wingwalls on large culverts near Inangahua were completely demolished by excessive earth pressure.

Observations of displacements of bridges indicate that movements in excess of 12 inches occurred within a few miles of Inangahua. This degree of movement is also confirmed by the displacement of a steel tank stand under a large concrete tank at Inangahua. Relative movement between the stand, which moved with the ground, and the tank, remaining relatively still because of its inertia, is traced by a scratch mark on the base of the tank. This trace of the earthquake movement shows a maximum displacement of 14 inches, but actual ground movements could have been greater than this.

Bridges

Within 25 miles of Inangahua, 50 highway bridges have been examined and 30 of these show displacement or damage. (Fig 1)

The damaged bridges (twenty) show a remarkable pattern of similarity of damage. Damage occurred to bridges as far as 10 miles south of Inangahua (i.e. 20 miles south of the epicentre) but between 5 and 10 miles the damage was minor.

The general pattern of damage suggests that a strong seismic impulse created high earth pressure at one end of a bridge, this causing horizontal shearing damage at connections between beams and abutments. On the tops of piers, holding down bolts of adjacent simple spans were bent towards each other, indicating a transmitted longitudinal impulse movement from one end of the bridge to the other. In one instance, with a steel span continuous over a central pier, the one line of holding down bolts were all bent in the same direction. This is positive evidence of a major impulse movement in one direction along the superstructure of the bridge.

Timber bridges on timber piles had the top pile cap connections sheared and tops of piles at some abutments were displaced up to two feet toward midstream. Damage was often at one end only. Increased earth pressure appeared to be the primary cause of this damage. Timber bridges generally suffered the least damage because of their flexibility and will be the easiest to repair.

Monolithic concrete bridges cracked at wingwalls, abutment beam connections, pier beam connections and tops of concrete piles.

Concrete bridges with steel girders suffered sheared or bent holding down bolts and in some cases spans were displaced laterally because of orientation relative to the maximum impulse direction. Some abutments cracked badly because of earth pressure impulse causing movement towards the river, with the top of the abutment restrained by the superstructure. (Fig 2)

Foundation cylinders of 4 ft and 6 ft diameter and heavily reinforced were sheared by horizontal movement. (Fig 3)

A close study is being made of all the bridge damage to seek an explanation of the similarities observed. It appears that the severity of the damage not only decreases with distance from the earthquake centre as would be expected but also the amount of damage can be possibly related to:

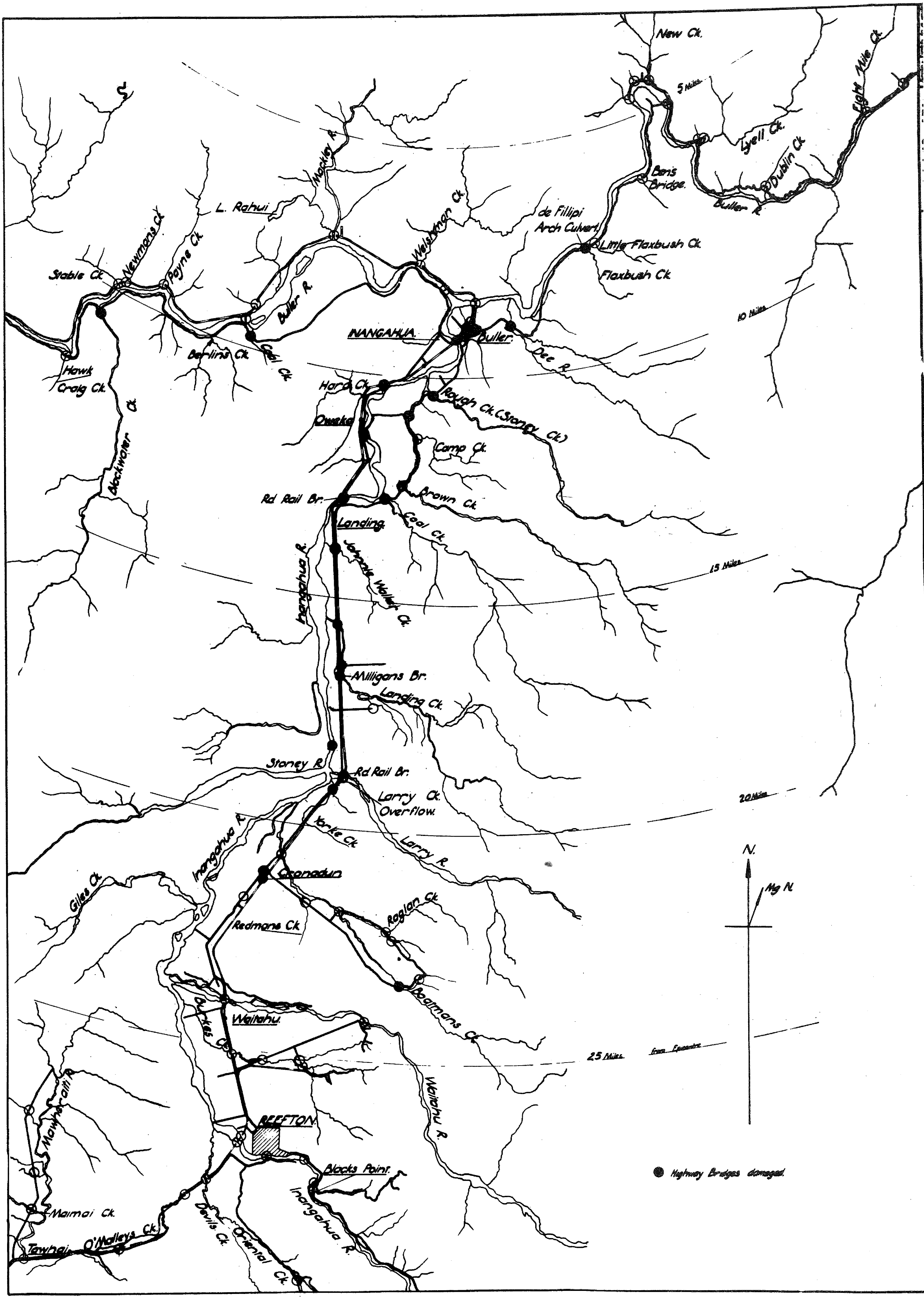

FIG. 1. MAP SHOWING HIGHWAY BRIDGES IN INANGAHUA COUNTY

(1) The length of a bridge - longer bridges sustained more damage than short ones.

(2) Stiffness and rigidity of fixings - solid bridges rigidly fixed even at one end only suffered with sheared holding down bolts.

(3) Orientation of bridges - strong seismic impact did more damage longitudinally than laterally to any bridge.

Culverts

Damage to small culverts became evident later by gradual subsidence of the road surface caused by fill material dropping through gaps between displaced pipes. In several cases pipes pulled apart aided by sideways movement of earth fill pushing on wingwalls. At Inangahua displacements of 22 inches and 11 inches were measured between three adjacent pipes.

Where culverts had been laid in soft or swampy ground they settled bodily.

Water and sewerage

Underground pipe lines were not extensively damaged except in Westport, but several other towns reported a few pipe fractures attributable to the earthquake. These were at Reefton, Greymouth, and Hokitika which are about 20 miles, 75 miles, and 100 miles from Inangahua respectively.

Civil Defence engineering work

Immediate inspection of bridges and roads was essential. On the State Highway and Brown Creek Road to Inangahua all bridges were useable, only the roadrail bridge at Landing was sufficiently damaged to be put out of use. All available earthmoving machinery and fleets of trucks were brought into the area as soon as possible under Ministry of Works control, to tackle the slips blocking the roads. Within three days of the earthquake a road access was available to Inangahua via the State Highway and the County road (Browns Creek Road).

Liaison and co-ordination between activities was important but difficult to maintain in the early stages. Government Departments, such as Ministry of Works, Railways, N.Z. Electricity Department, Post Office had a vast amount of work thrust upon them, but this was not channelled through the local Civil Defence Committee and is described elsewhere.

Emergency engineering work under the local Civil Defence Controller comprised mainly inspections and reporting on damage and safety of structures, buildings, and slips. For quick reconnaissance work the Air Force Iroquois helicopters were retained after the personnel evacuation and these machines proved to be invaluable.

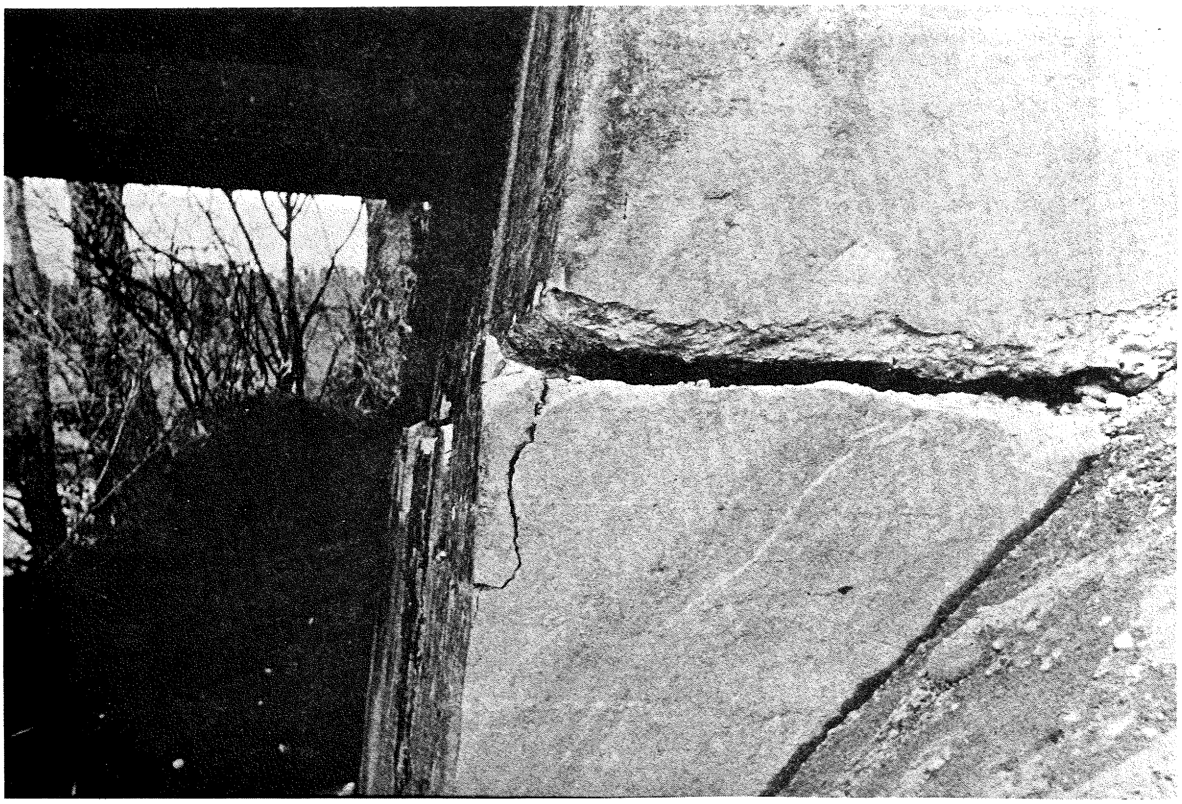

Fig 2. Combined rail and road bridge, Inangahua Junction. Three inch relative movement, horizontally and vertically, at fracture through mass concrete abutment.
photo G.L. Evans

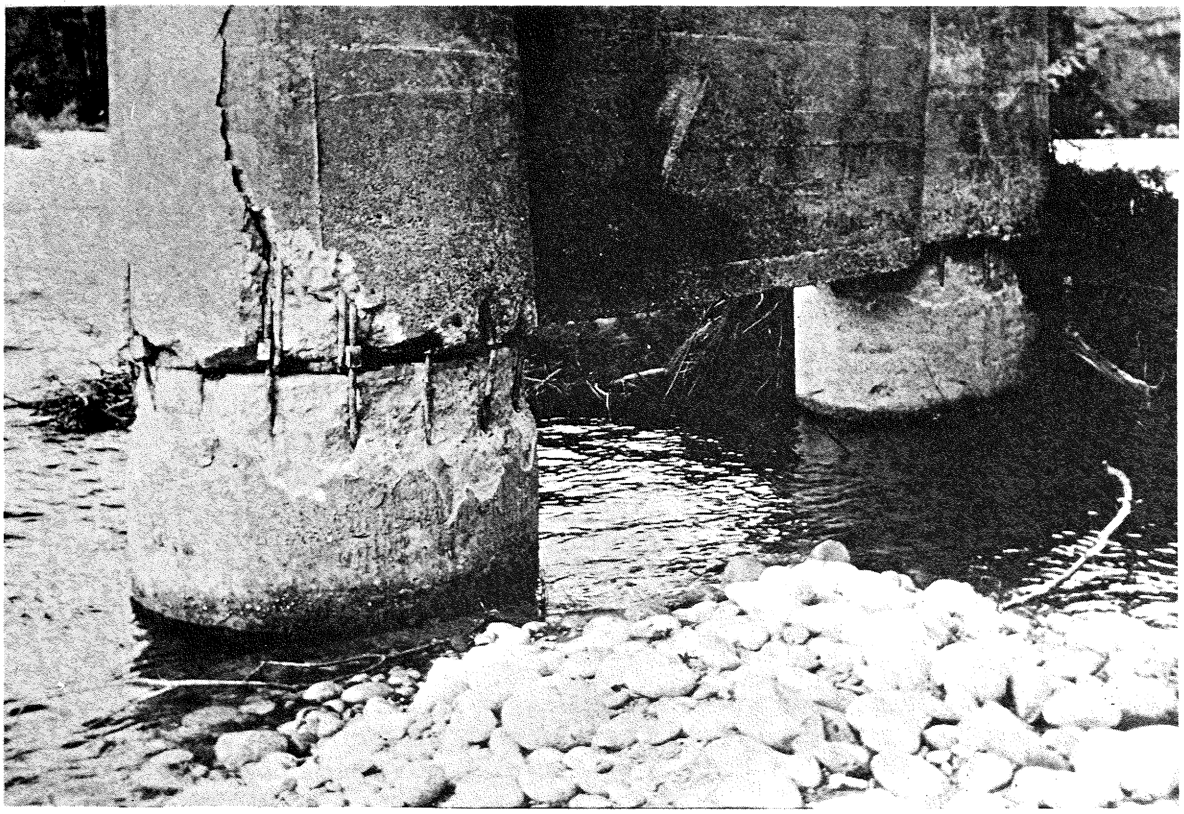

Fig 3. Combined rail and road bridge, Inangahua Junction. Fracture at construction joint of 6 ft diameter reinforced concrete pier cylinders
photo G.L. Evans

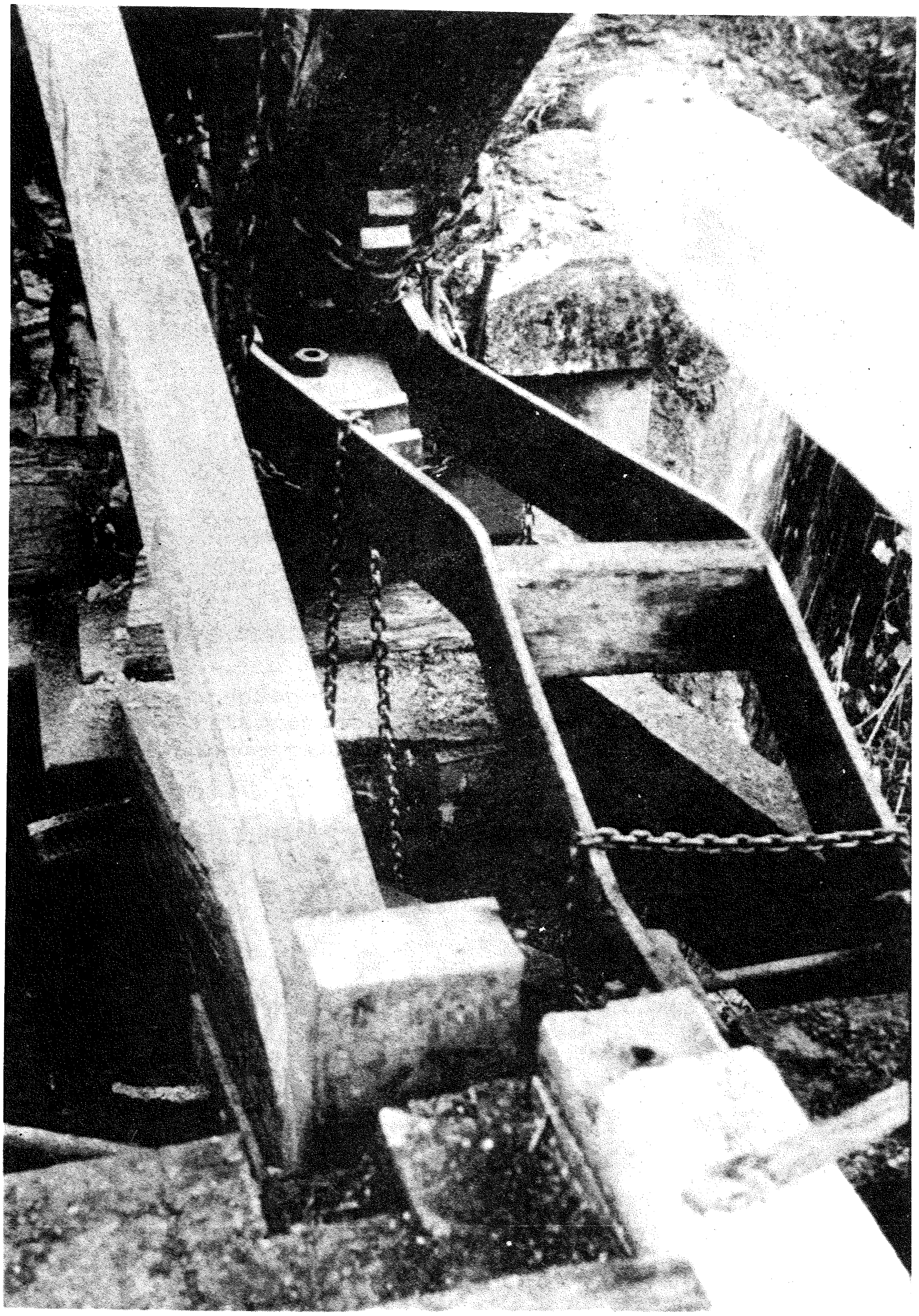

Fig 4. Combined rail and road bridge, Inangahua Landing. Buckling of end of bottom chord of truss, caused at both ends by relative inward movement of abutments.
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