FIELD SURVEY ON DAMAGES IN THE EPICENTRAL AREA OF THE EARTHQUAKE (M = 6.2)

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Summary

On 16th October, 1970, the south-eastern area of the Akita prefecture in the north-eastern district of Japan has suffered the earthquake of M = 6.2. Authors have carried out the field survey on damages due to the earthquake mainly in the epicentral area.

Within 20 km from the epicenter, there are constructed 4 dams of various types. The dynamic behavior of these dams during the earthquake was much interesting to us. The damages due to the earthquake were no so much even then these will be discribed in this report mainly on these dams.

1. Earthquakes

Informations about the earthquake from Japan Meteorological Agency are as follows:

Main shock

date	Oct. 16, 1970, PM 2^h26^m (Japan time)
epicenter	N 39°12' E 140°45'
magnitude	6.2
depth	0

After shock

date	Oct. 16, 1970, PM 7^h43^m (Japan time)
epicenter	N 39°14' E 140°47'
magnitude	4.9
depth	10 km

The epicenters of these earthquakes are located a little to the west of the centerline of the Honshu Island and at the area covered by the tertiary.

2. Characteristics of the Ground Motion

Within 20 km from the epicenter, there are dams and bridges where seismographs have been installed but in allmost all the cases, earthquake records scaled out in the main shock because of the reason that seismographs had been set in high sensitivity.

Summary of informations on the ground motion during the main shock given by official engineers and inhabitants is as follows.

A) At the Yuda Dam site (17 - 18 km far from the epicenter)
At first, severe vertical motion was felt followed by a horizontal tremor having short period.

B) The Ainono villlage (epicentral distance is ca. 13 - 15 km)
They were at first conscious of being lifted up, and then falling down.

C) The Iwaigawa village (in the epicentral area)
The ground vibrated so severely in all the direction that it could not be expressed.

D) The Yokote city (epicentral distance is ca. 20 km)
Official survey engineer felt at first the vertical motion, next horizontal one and could not walk.

From these informations and facts later discribed, ground motion during this earthquake in and near the epicentral area seemed to be shock motion acompanied by severe vertical motion.

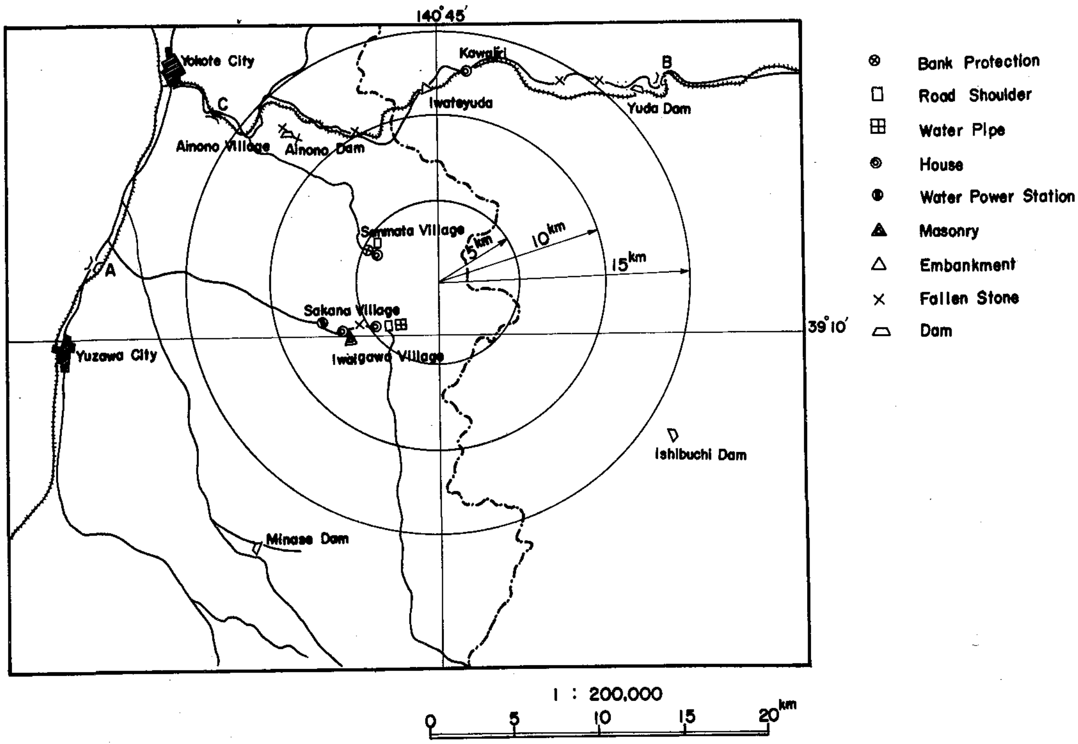

Fig. 1 Distribution of the Damages

3. Damages

Damages of the structure are as shown in Fig. 1. Number of the damages at any particular site may generally depend upon the number of the structure existing indicating there by that the intensity of the earthquake do not always relate directly with the distributions of the damages in some eases. But author's survey shows that damages of the structures have mainly been found out in the narrow long area lying from the Iwaigawa village to the Kawajiri village via the Sanmata village.

1) Dams

Within 20 km from the epicenter, there are 4 dams as follows:

Name	Type	Height (m)	Epicentral distance(km)
Ainono	Earth-fill	40.8	Ca. 13
Ishibuchi	Rock-fill	53.0	17 - 18
Minase	Composite rock-fill and concrete gravity	65.0	19 - 20
Yuda	Concrete gravity-arch	87.5	17 - 18

These dams in general suffered no damage and in some cases damage was so slight that their functions were not affected by the earthquake. But for reference, outlines and damages of these dams are discribed as follows.

A) Ainono dam

Ainono dam is a homogeneous type earth dam with 40.8 m height. Material of the main part of the dam consists of clayey soil and the internal friction angle ϕ and the cohesion C are $\phi = 9.06°$, $C = 2.5$ ton/m^2 respectively in quick shear tests and $\phi = 15.12°$, $C = 3.0$ ton/m^2 in quick consolidation shear tests respectively for the specimens compacted normally. The upstream face is 1 : 3.5 slope and protected by the thrown rubble from sliding down the slope due to the rapid draw down.

The downstream face is 1 : 2.5 slope but at the toe it is lined by stone work.

Stability of the slope was studied by circular slip line method. Safety factor to the sliding of the downstream face is 1.12 in design while the horizontal seismic coefficient is taken as 0.15.

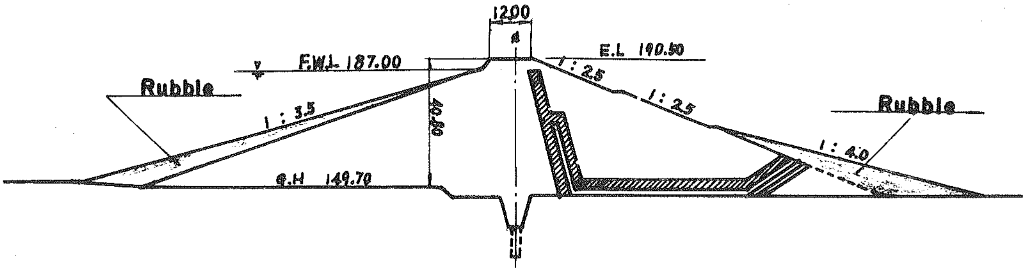

Fig. 2 Typical Cross Section of the Alnono Dam

As regards the damages of the dam body, there were only 2 fissures with ca. 30 m length along the dam axis at the top. These fissure may have been caused by the shape of the upstream-face near the top, that is, the masonry parapet wall with 4 m height was built vertically at the upstream side of the top. No other damage was found out in the dam, except the intake tower suffered some damages. This is a hexagonal reinfored concrete structure. In controll room at the top of the tower, walls were found cracked, and the glass of the windows were broken down etc.

The electromagnetic type acceleration seismometer were installed at the top of the dam and the foundation but almost all the records scaled out in the main shock. Maximum acceleration at the top at the time of main shock, was interpreted to be at least 200 gals horizontally and 100 gals vertically from other data. Hence, safety factor of slide of the downstream face is calculated as 0.8 by the same computation as adopted in design.

This shows the difference between the design seismic coefficient and the max. acceleration of earthquake motion.

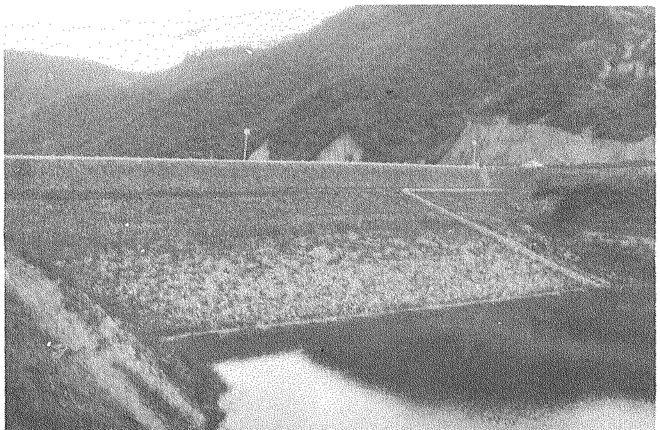

Photo. 1 View of the upstream side of the Ainono Dam

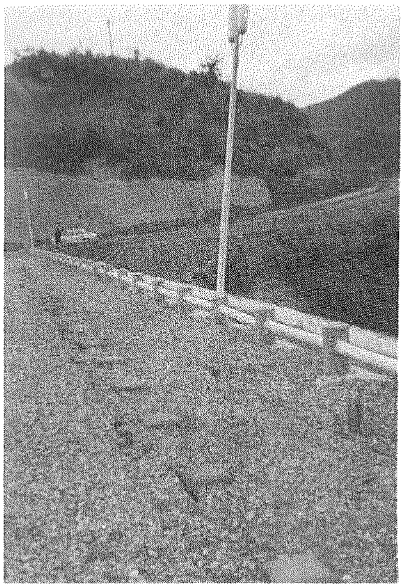

Photo. 2 Fissures on the top of the Ainono Dam

Photo. 3 Intake tower of the Ainono Dam

(B) Ishibuchi dam

Ishibuchi dam is a rock-fill dam faced with reinforced concrete slab on the upstream face and its height is 53.0 m. Main part of the dam consists of sound rock with 7 kg or more weight.

The upstream slope is 1 : 1.3 and backed by rubble stone with max. weight 15 ton and the backing layer is 3 - 5 m thick. Size of the concrete slab placed on the rubble layer is normally 10^m x 10^m and 0.4 - 0.6^m thick.

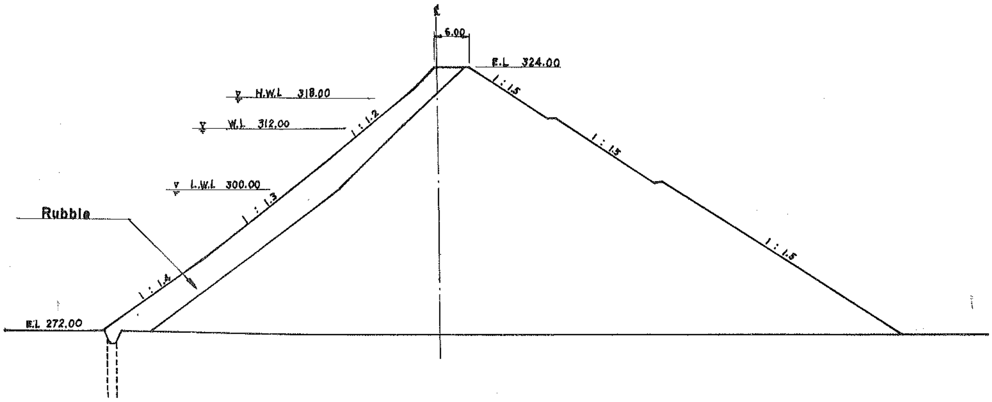

Fig. 3 Typical Cross Section of the Ishibuchi Dam

At the expansion joint of the slab, copper water stop have been used.

The downstream face is gently graded 1 : 1.6 taking in to account the earthquake effect and finished carefully with rubble stone.

At the time of earthquake, the reservoir level was about 10 m below the normal water level. Due to the earthquake, top of the dam settled down about 19 mm and moved 5 mm horizontally to the upstream direction and hand rail at the top was found buckled.

Leakage water increased immediately after the earthquake from 95 ℓ/sec to 115 ℓ/sec but a day after returned to the normal condition.

The function of the dam was not affected by the shock.

C) Minase dam

Minase dam is a composite rock-fill and concrete gravity dam 66.5 m in height and 215 m in length (rock-fill dam: 146.8 m and concrete gravity dam: 68.2 m) and is located at 19 - 20 km far from the epicenter

In construction works of the dam, sluicing water of about 4 times of the dam volume was used.

Upstream surface grades 1 : 1.35 and is covered by reinforced concrete slab with 10^m x $10-15^m$ width and $0.3 - 0.5^m$ thickness. Copper plates and sica joint (polyvinyl chloride) were used for the expansion joint. The concrete slabs was designed as a beam placed on the elastic foundation taking in to account the settlement of the dam.

Downstream face grades 1 : 1.65 and the stability of the slope during the earthquake was studied statically.

As to the gravity dam, the upstream face grades 1 : 0.06 and the downstream face is 1 : 0.88. By the earthquake, only imperceptible fissure was detected out at the joint of the concrete dam and the rock-fill dam.

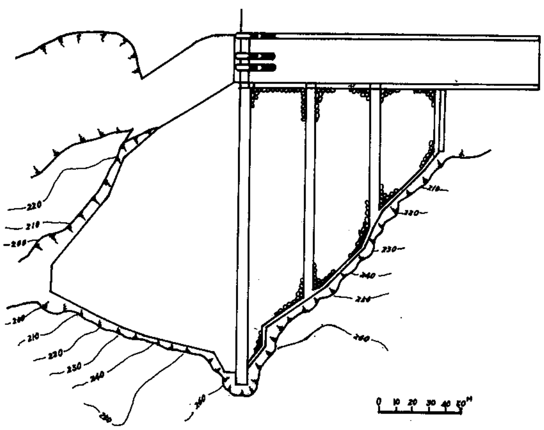

Fig. 4(a) General Plan of the Minase Dam

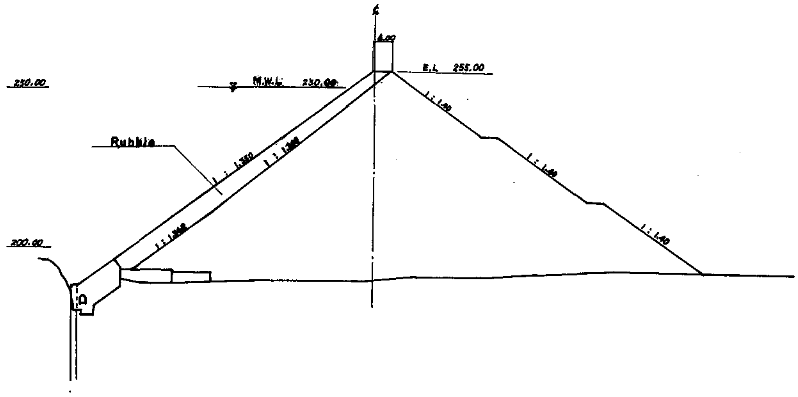

Fig. 4(b) Typical Cross Section of the Minase Dam

D) Yuda dam

This is a concrete gravity-arch dam having 87.5 m hight and is located 17 - 18 km from the epicenter.

Upstream face of the dam is cylindrical shape with constant radius. Downstream face is circular shape but the radius increases with the level. Design seismic coefficient is 0.12 horizontally and design dynamic water pressure to the upstream face of the dam is evaluated by Westergaad's formula.

Stress distributions were investigated by model experiments and the numerical studies by using the trial load method.. Electro-magnetic acceleration seismographs are installed at 3 locations, top of arch, and on rock foundation on the arch center line respectively and one in the pit at the left bank.

The dam suffered no damage, but control house was suffered slight damages as will be mentioned later. In the after shock, max. accelerations parallel to the arch center line are horizontally 119 gals at the top of the dam and 55 gals at the rock foundation and vertical max. acceleration is 68 gals at the top of the dam.

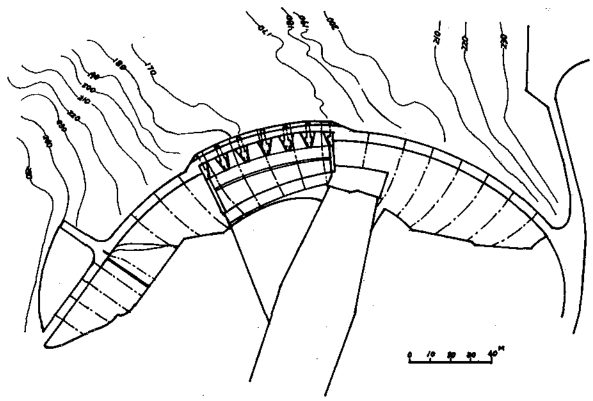

Fig. 5(a) General Plan of the Yuda Dam

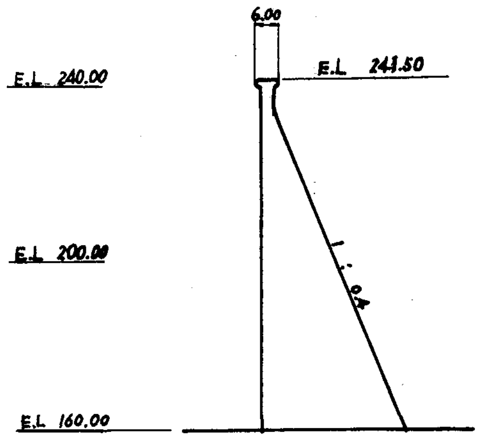

Fig. 5(b) Crass Section of the Crown Cantiliver, the Yuda Dam

2) Houses

Damages of the houses are concentrated within the narrow long area as previously mentioned.

In this area, domestic houses are wooden one, roofed with galvanized iron sheet and most of them seem to be built newly. This fact may be one of the reasons that damages were not so heavy.

A) Kawajiri village

Normal wooden houses were not suffered apparently but some go-downs and some mortared frame houses cracked on the walls.

B) Sanmata village

This village is located at the epicentral area. 10 or more domestic houses were found shattered at the foundations that are generally masonry works and several houses slided about 10 cm on the foundation.

Photo. 4 and 5 show brick works slided by the earthquake. Frictional coefficient of the brick obtained by the simple test at the site was about 0.55. Even if the vertical ground motion taken into account the horizontal max. acceleration seems to exceed 300 gals.

These facts may point out that ground motion was a shock in the village.

Photo. 4 Slip of the brick laying, the Sanmata village

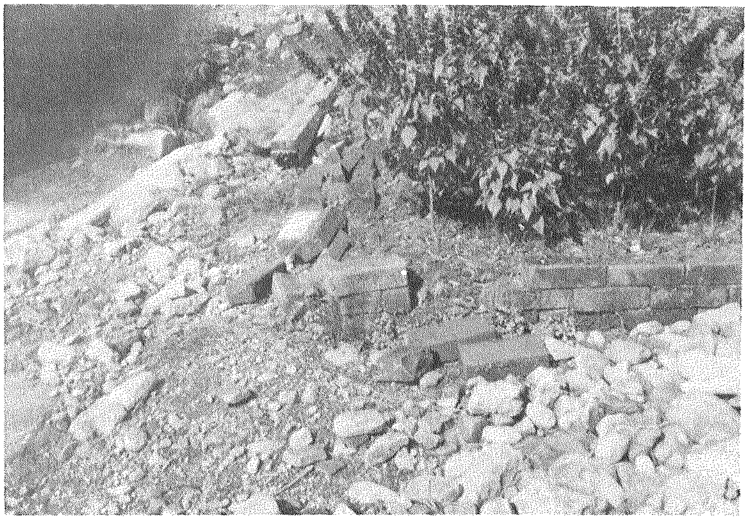

Photo. 5 As Photo. 4

C) Iwaigawa village

This village is also located at the epicentral area. Domestic houses in general were found suffered slight damage, and some old domestic houses with thatched roof were found titled.

The wooden school structure suffered no damage but the attached gymnasium made of light gage steel frame was damaged as shown in Photo. 6 and 7. Diagonal members for reinforcing were broken due to shearing off of the rivets, and interior wall plates waved and fell down.

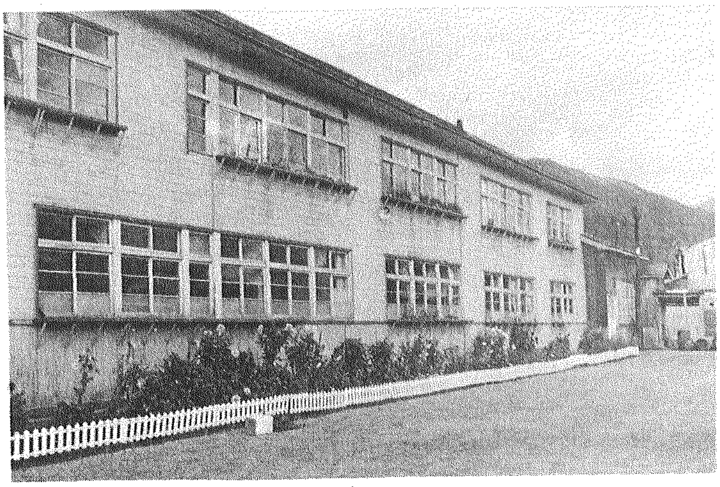

Photo. 6 The school structure suffered no damage, the Iwaigawa village

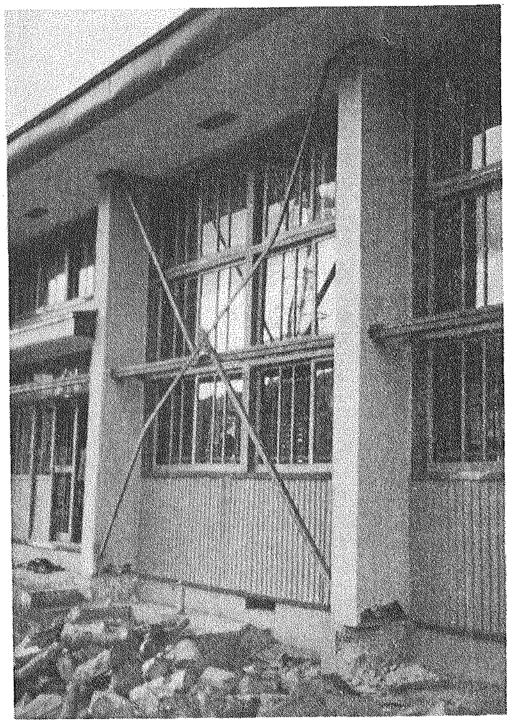

Photo. 7

Diagonal member broken due to the shock, the the gymnasium of the same school as Photo. 6

D) Control house of the Yuda dam

The house is 2 storied reinforced concrete structure built on the rock foundation, and is located at 17 - 18 km for from the epicenter. The structure did not suffered any damage but at 2nd floor almost all the window glass glazed directly to the steel frame were cracked and those glazed with gum gasket to the steel frame were a little cracked.

3) Bridges, railway, roads and bankings

Several bankings suffered by the earthquake. Heavy damage of the banking was found at some hundreds meters from the Iwateyuda station, J.N.R. This railway banking is 6 - 7 m in height and constructed on the soft ground. Due to the earthquake the slope slipped at the toe and settled down flatly.

Near the end of the Sanmata village, we found out the road with cracked road shoulder.

Damages of bridge structures could not be detected but backing embankment of the abutments of the bridges were settled down at places in and near the epicentral area.

At the abutment of the Kurosawagawa Daiichi Steel Bridge of J.N.R. (C shown in Fig. 1), reinforced concrete retaining wall was found cracked.

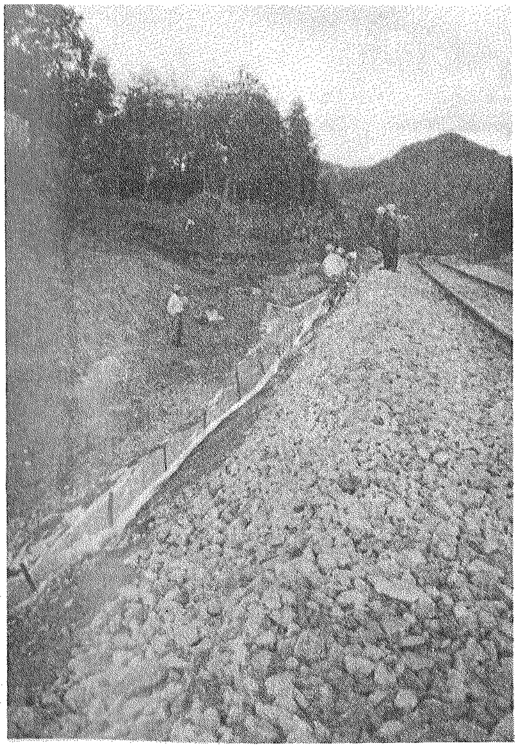

Photo. 8

The banking that settled down faltly due to the earthquake has been immediately reconstructed, near the Iwateyuda station.

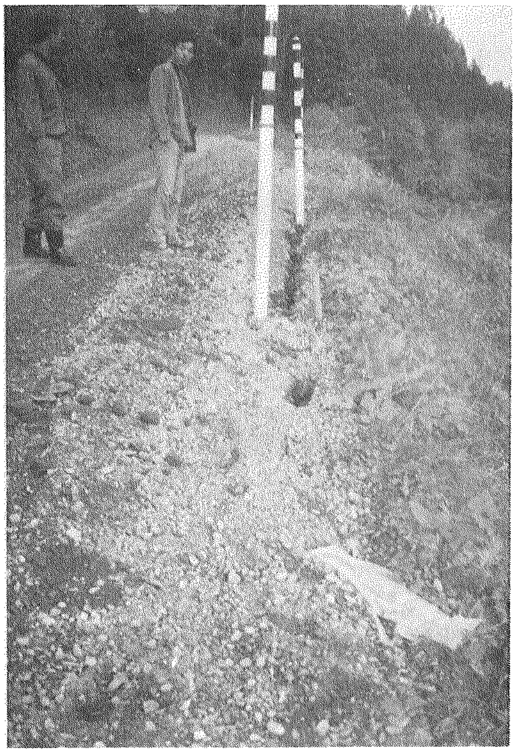

Photo. 9

The cracked road at the shoulder

4) Other damages

Simple water works at the Iwaigawa village was suffered so heavily that the function was stopped.

Small water power station situated at several Km from the epicenter did not suffer any damage.

Fallen stones were found in places as shown in Fig. 1.

Removal of the gravetones appeared near the Sakana village.

As previous mentioned, the damage due to the earthquake was not so severe in general but may be noticable as the damages in and around the epicentral area.

Acknowledgement

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