On the afternoon of October 23rd 2003, a devastating earthquake hit Chuestu, Japan, causing loss of life and serious economic damage. Mountainous Japan is a continual victim of landslides due to earthquakes that cause slope failure. The people of Chuestu have rebuilt their lives and property, and the memories of the disaster have begun to fade, but the lessons learned from this tragedy should not be forgotten. Japan is a country perched on dangerous ground. The object of this study of slope failure from earthquakes includes a comparison between the scales of landslides in the field.

Page 2：View of Sato-yama*

(*： ″Sato−yama″ which doesn't really translate directly into English. It's the small mountain forest where is undeveloped woodlands near populated areas. It is the category of field, where including nature of rice field, wetland, secondary forests, beautiful streams and ponds in Japanese traditional style.)

River-mountain landscape of Tanada (it means "rice terraces") was feature of Yamakoshi village, "Beautiful Tanada landscape of Japan" was focused. Tanada was affected terribly and life water supply constructions were seriously damaged by earthquake, people here tried hardly to reset the normal situation.

Tanada landscape had wonderful change following four seasons. In the spring, rural landscape of…quickly changed into new active, energized air. New rice transplanting sent us a felling of vitality; Sato-yama was colored with green. In autumn, harvest season, field of vision was opened to bring a freedom feeling. And snow, a winter perfume gave us the spiritual silent such a friendly impression.

In 2006, the record snowfall in the village of Yamakoshi was a depth of 310 cm, and 390 cm in Tanesubara. Landslides easily occurred as the snow turned first to ice and then melted. Frequent snowfall for long periods of time caused rooftops to fill with snow.

Every day the villagers of Yamakoshi go out into the mountains that surround them. To get to the nearest hospital they must go through the mountain passes where the depth of snow during the winter can reach several meters. Several case of missing persons occurred under these conditions. Between Showa 8 and Showa 24, the brave and determined people of this area used simple tools to hand-excavate the longest tunnel (922m, although 877m remains after entry failure) of its kind. The accomplishment changed the lives of these people. Although it has been replaced by a parallel tunnel that is big enough for cars, it remains a testimony to the enduring spirit of the human ability to overcome adversity.

During Japan's Edo Period, carp evolved from merely a food to a national symbol of strength and perseverance. The carp faming industry flourished in this area, but suffered damage from earthquakes. The rebuilding of this industry has continued and recently a carp exhibition was held to show how this venture has been revitalized.

Cow fighting is traditional event in this area. It was recorded as the immaterial cultural heritages of nation. Near the Oziya stadium of cow fighting, there was a monument of fighting cow. Chuetsu earthquake cracked the monument, made it look more similar and thus resulted in better image of monument.

In Yamakoshi village, a legend is told of a landslide and a burglar. A long time ago, a thief sought refuge in the village after committing a crime. The burglar's family was hidden by a village family until he was arrested and buried alive in a Japanese pan. The locals believe that if buried this way, the thief would never be reborn. Despite their efforts, the village was cursed from that time on.

Page 3.① The Land slide in Myoken（Siraiwa）

This landslide field was hit by slope failure when three persons were traveling near it by car. Only the son was miraculously rescued. The sandstone slope inclined to the river forming a structure that could easily slip (called Nagare ban in Japanese). When an earthquake occurred, the layers slipped and part of the route was destroyed as it slid to the river as part of the landslide. A JR Jyoetsu line tunnel was destroyed as it was partly submerged by the same deposits. Various methods for rebuilding tunnel and bridges were considered, but the present anchor method was applied. A World War II underground tunnel was filled in to avoid having a weak construction point below the ground's surface. Part of the destroyed route will remain a memorial to the tragic earthquake, even though the rebuilding activities have finished.

②The Slide in Hashiwatashi

This field is very close to the Myoken field. The pictures show a surface as smoothly slipped as a skiing slope (inclination 22). On the upper part of the surface there remains a sandstone layer with a thickness of about 3.0 m which can be clearly seen. The sandstone layer was shaken by an earthquake and collapsed along the slip surface. The tuffaceaous sandstone measuring some millimeters thickness was found on the slip surface. Tuffaceous sandstone is a mixture of volcanic ashes and sand in sediment; this was the key answer as to why the high strength sandstone collapsed. Furthermore, this had the same white stone as the Myoken slop whose soil layer was "Naganre Ban" and thus formed a topography that easily slipped down. These two fields of "Nagare Ban" directly face a national route and

train line, but fortunately no accident happened there.

Page4:③The Landslide in Oguriyama

Chuetsu earthquake caused this landslide occurred at the foot of other old, large landslide. One part of landslide deposit resulted in a debris flow that slid into swamp but other part of landslide was stopped by a check dam (Sabo dam). There was no damage at express train line and road located at foot of this landslide. In this case, the Sabo dam was very efficiency to prevent against debris flow. In the Oguriyama landslide, the damp of flora such as Obakusure**, Nirinsou**, Tanukiran**, Kusantetsu** etc and the rare of flora such as Katakuri**, Kibanaikarinu** etc growing from early spring to autumn those make landscape of Sato-yama more beautiful.

Soil mass at top of landslide was excavated at upper slope and the slope surface was reinforced by concrete frame to control soil erosion. At the lower part of landslide, embankment and drainage channel was applied. Also a Sabo dam was constructed. These structures were used rehabilitate carp farm and protect beautiful landscape. It needs study more about the harmonization between control disasters and protect environment.

(**：These are flower name in Japanese)

④The large landslide in Shimonosawa

To go to the landslide zone, the group came to Siotani Village by a prefecture route. From there they walked in a NE direction to a large landslide measuring 650 m in length, 450 m wide, and a volume of 7,500,00 m3. The scene is the right bank of the Kamezawa River, a branch of the Imo River, where an earthquake caused this large landslide. The landslide, located at Dainichi mountain (390m high), was surrounded by a curved ridgeline (inclination 15 °). The ground was a weak plane with rice fields and fish farms located on it. In the landslide, the soil rock deposit displaced about 50m, the upper part was cave-in zone, the middle part was topsoil failure and crack zone, and upheaval occurred at the lowest part. The landslide moved in a SE direction, the upper part was about 100m wide, and the middle and bottom parts were about 40m and 60m wide respectively. Boring data showed the depth of slip surface to be about 60 to 80m. Fortunately, the debris flow did not occur downstream and thus no serious damage happened there. The reinforcement methods were: soil was removed at the upper part and embankment was established at the lower part, combined with drainage channels. These constructions prevented further effects from the landslide.

Page 5：⑤The disaster in Yobu

Chuetsu earthquake caused the old landslide near Yubu village re-slide. Soil rock deposit of the landslide stretched 1.0 km in length along Yubu River and confined the river. Haft of

houses in Yubu village were collapsed or damaged, cracks on the upper part of landslide developed into the ground of Yamakoshi junior school that damaged 3 floor building of the school. Many slopes in a large area near Yubu River were failed or cracked.

Solutions was an embankment with material was taken from deposit soil rock of the landslide at Yamakoshi at the embankment prevents reaction of landslide in Yubu area.

⑥The large slope failure in Takezawa

In the Takezawa area, close to the old city hall of Yamakoshi, there were many slope failures near the entry of Haguro Tunnel that connects Takezawa. A large slope failure of 200 m length and 80 m base occurred. The slope was strong weathered rock that collapsed under quake influences, and caused the prefecture route to be submerged in 5m of soil, and 3 houses to completely collapse. Around the landslide field, the steep slopes failed, and at the old city hall, a part of the old slope re-collapsed.

In Takezawa, the average snowfall is about 3m per year, so many snow barrier were established on dangerous slopes. About half of the snow barriers were damaged by the earthquake. The weak sand was easily eroded making the reinforcement method at the upper part difficult. At the upper part of slope the slope failure was reinforced by concrete frame. Snow barrier was repaired and restructured. At the lower part of slope, the retaining wall in combining with green methods was applied.

Page6:⑦The Natural dam in Higashitakezawa

In the Higashi Takezawa area, a large landslide L=350m, B=290m occurred near the left bank of the Imo river with mass movement of 1,300,000 m3. Geological features of landslide were weak rock and fine sand stone, and soil layers that inclined toward the river forming a “Nagare ban***”. The slip soil mass leaved topsoil from the old landslide about 70m that formed avalanche high 25m, inclination 25degree at top slope. The lower part of soil mass crossed the river, slid to route 291 facing to coast. The soil rock of landslide created as natural dam in 320m length crossing …river. The water level of the occupied river increased causing serious inundation damage to an upstream village, and on the other side the natural dam threatens downstream because if it was broken it results in a large and rapid debris flow. There were some urgent activities to rehabilitate the landslide field, only 2 months after the earthquake, a 24h drainage pump station was completely structured, and the water level was reduced by a pillar way. Until Apr. 2005 survey team could go inside the inundation field. Here, two new Sabo dams were structured and the failure slope was reinforced by facing concrete frames.

(***：”Nagare ban” is Japanese , it means “dip slope”

⑧:The natural dam in Terano

A landslide of 1,040,000 m3 occurred at the left bank of the Imo River, while surface failure occurred at the right one. The landslide confined Imo river by a natural dam (Lmax=260m, Bmax=125m, 303m3) and at a result, the route nearby was occupied. Like the Higashitakezawa field, the breakage of the natural dam with a potential for large debris was very dangerous for downstream areas, and thus a channel was quickly created that decreased the water level upstream. In 2005, 3 new Sabo dams were established and slope failure was reinforced by concrete frames. And the new route was structured on opposite sight of landslide

⑨：The slope failure in Kazeguti pass

In the Tanesubara area, upstream on the Imo River, slope failures occurred frequently. Near the Kazekuchi pass, a large landslide measuring the length was 500m and the wide was 100m cut through a forest road and another prefecture route. At its upper part, the weathered rock layer collapsed along 30-35 degree bedrock. The lower part was an old landslide with a quite plane slope with rice farms. One part of the landslide moved and deposited soil downstream to the Sabo Dam.

Solutions to this landslide included the rebuilding of the forest road and prefecture route. At the upper part, the unstable mass was removed and reinforced by a concrete frame, while soil deposit was stabilized with retaining walls. At the lower part, the slope was reformed and some drainage channels were established.

Page 7:⑩landslide in Nigorisawa

Slope of landslide was end part of old landslide. It was failed by earthquake. Event though it was end part the length was 130m and wide 70m, deposit soil hit houses and killed 2 persons, cut over prefecture route and a part reached into Ohta River. At upper part many cracks occurred that clearly showed the movement of landslide. Geological feature was weathered weak rock that could be dig by knife.

Rainfall raised ground water level rapidly, catchment well and boring works were applied for underground drainage. At the end part, steel piles were used to stabilize slope.

Others disasters:

i). Rice farm on the slope was moved by large landslide, habilitation was very complicated because of forest road was damaged. Thus the damage of landslide such as avalanche, rice farm movement, trees felt down, cracks occurred, the rock was fail or compressed at the end part could be estimated. However, it needs more experts of safety to go inside this landslide field.

ii) Flood control reservoir at downstream of Imo River:

In the Imo River watershed, there were many soil disasters occurred,heavy rain probably caused large volume of soil and water move to downstream. By this reason The flood control reservoir was created to control the sedimentation at downstream.

iii) Large scale Sabo dam:

Landslide, debris flow of soil deposit occurred in rain time was stopped by many large scale Sabo dam.

Page 8:

Disaster concept, geological and topological features:

The Chuetsu earthquake occurred on the 23rd of October, 2004. It was recorded as M7 on Kawagichi. After the main earthquake, aftershocks measuring M6 continued, and in Nagaoka, Oziya,Uonuma,Kawaguchi area received related damage. Especially Yamkoshi village (Nagaoka City) is known as a homeland of carp, and for the beautiful landscape of Sato-yama. But frequent slope failures and landslides caused serious losses and isolated the villages. A number of landslides filled the river and created natural reservoirs that submerged and damaged houses.

The 300～700 meters high watershed in the mountainous area called Higashiyama was surveyed. The Imo River originally starts as a small, intermediate river but is now eroded. Along the river, slopes had a valley topography with landslides of various scale distributed on these slopes. The Neogene geology was structured by young mudstone and sandstone and had fold form. These fold line formed by mudstone and sandstone layer easily caused landslide occur rent. At northern part of center area in the map, volcanic stone on 600～700m high mountainous area from… distributed to NNE direction？？？

Slope and slope stabilization method

Retaining wall: to avoid slope and embankment failure. It was often made by concrete but sometimes a gabion, a kind of steel baskets with rock stone fill inside, was used.

Facing concrete frame: to avoid slope failures and surface erosion caused by rainfall.

Sabo Dam: Stopped the debris flow that occurred upstream. Often made by concrete, but steel was also used.

Underground water drainage: Rainfall and melting snow causes groundwater levels to increase. The water pressure makes the topsoil unstable and landslides can easily occur. Catchment wells combined with boring pipes are applied to reduce the water pressure and stop the landslides.

Soil removal and embankment: The soil is cleared at the top of the landslide to minimize its driving force and to establish an embankment at the end of the landslide to increase its resisting force.

Piling and Anchor method: The pile stabilize the unstable soil of the landslide by fixing it into the stable bedrock. Anchor reinforcement is created by pretension under the plates or frames located on the surface of the unstable layer, while tension is transferred to the bedrock by nails.

The end.