Learning Map of the Mid Niigata Prefecture Earthquake in 2004

On the afternoon of October 23rd 2004, a disastrous earthquake struck Chuestu, Japan, making a sacrifice of precious life, and causing serious economic damage. This large-scale earthquake led to various kinds of disasters, i.e., numerous slope failures and collapses, because it occurred directly underneath the Chuetsu region known for its susceptibility to landslide disasters. Immediately after the earthquake the people of Chuetsu suffered extremely; post-earthquake rehabilitation was initiated through enormous efforts or residents and great support from the various organizations. During the intervening period following the Chuestu earthquake, the landslide scars have been treated and, similarly, the people's remembrance of the terrible circumstances surrounding these earthquake disasters has faded.

We, the committee of slope engineering, geotechnical engineering, aim to provide effective information through this "Learning Map" which will be widely distributed to the public and will preserve people's experiences and memories of the Chuetsu earthquake, and inform them of the weak conditions of our native terrain so that careful future planning will be encouraged. This "Learning Map" is produced as a guide for travelers in and around disaster-stricken sites in the Chuetsu region, thus only the relatively large-scale landsides and collapses with special features appear on this map; many other landslides were omitted.

The Sub-committee on Slope Engineering, Committee on Geotechnical Engineering, JSCE

View of “ Sato-yama* ”

(* : "Sato-yama" which doesn't really translate directly into English. It's the small mountain forest consisting of undeveloped woodlands near populated areas. It falls within the category of fields, including rice fields, wetlands, secondary forests, beautiful streams, and ponds in the Japanese traditional style.)

< Rice terraces >

The river-mountain landscape of rice terraces is a distinct feature of the area around Yamakoshi village, so-called “Beautiful rice terraces landscape of Japan”. Rice terraces were seriously affected by the earthquake, including damage to domestic and agricultural water supplies. In the aftermath, the residents tried diligently to recover to their normal way of life.

This rice terrace landscape experiences spectacular changes throughout the four seasons. In the spring, the rural landscape quickly changes into new active, energized air. Transplanting of new rice crops gives us a feeling of vitality; Sato Mountain is colored with green. In the autumn harvest season, the field of vision opens bringing a feeling of freedom. And wintertime snow imparts a spiritual silence and friendly impression.

A view of rice terraces in around the old city hall of Yamakoshi village

< Heavy snow fall area >

In winter 2006, heavy snow fell in Yamakoshi village (310 cm), and 390 cm fell in Tanesubara. Once the snow began to melt, more landslides occurred. Frequent snowfall for long periods of time caused rooftops to fill with snow.

A view of snow fall in Shiotani village

< Nakayama tunnel to hand-excavate >

Every day the villagers of Yamakoshi go out and go back the surrounding mountains. To access the nearest hospital they must go traverse the mountain passes where the depth of snow during the winter can reach several meters. Several case of missing persons occurred during such conditions. Between 1933(Showa 8) and 1949(Showa 24), the brave and determined people of this area used simple tools to hand excavate the longest tunnel (922 m, although only 877 m of tunnel remains after a failure near the entry) of its kind. This accomplishment changed the lives of these people. Although the tunnel has been replaced by a parallel tunnel that is large enough for cars to pass through, it remains a testimony to the enduring spirit of the humanity to overcome adversity.

New Nakayama tunnel and old Nakayama tunnel where constructed by hand-excavate

Old Nakayama tunnel

< Birthplace of colored carp >

The many ponds on this map are colored carp farming industry

During Japan’s Edo Period(1603 ～ 1868), colored carp evolved from merely a food to a national symbol of strength and perseverance. The carp farming 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 >

Cow fighting is traditional event in this area. It was recorded as a type of cultural heritage of the nation. Near the Oziya stadium of cow fighting, there was a monument of a fighting cow. The Chuetsu earthquake cracked the monument and made it look more realistic, thus improving the image of the monument.

A monument of fighting cow near the Oziya stadium

< Grave of burglar >

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.

A grave of burglar in Tanesubara

Material cooperation

- **Yuzawa sabo office Ministry of Land, Infrastructure, Transport and Tourism**
- **Kanto regional forest office Forestry agency**
- **Nagaoka regional branch Niigata prefecture**

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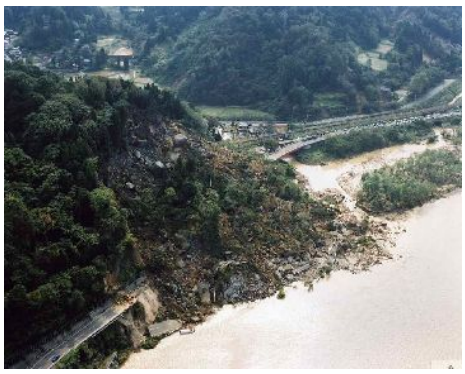
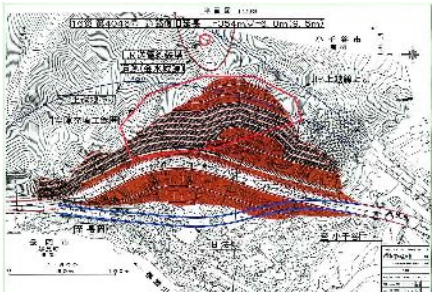
①The bedrock collapse in Myoken（Siraiwa）

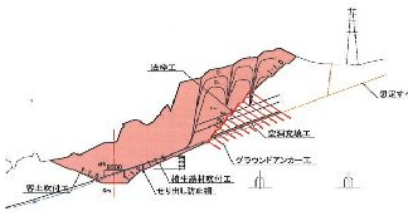
This landslide (bedrock collapse) struck three persons who were driving on a country road. Only the son was miraculously rescued. Only the son was miraculously rescued. The sandstone slope inclined to the river forming a structure that could easily slip (called Nagare-ban in Japanese、it means “dip slope”). When the earthquake occurred, the layers slipped and part of the road was destroyed as the landslide slid towards the river. The JR Jyoetsu line tunnel was destroyed as it was partly submerged by the same deposits. Various methods for rebuilding tunnels and bridges were considered, but at present, the anchor method has been applied. A World War II underground tunnel was filled in to avoid having a weak zone below the ground surface that could collapse. Part of the destroyed road will remain a memorial to the tragic earthquake even though the rebuilding activities have been completed.



A view of the collapse situation from the sky over northern side
(Offered by Niigata prefecture)

Stabilized slope and restored road
(Offered by Niigata prefecture)





The plane chart and crossing chart of stabilized method. Unstable slope were reinforced with anchor method and slipped layers were removed.
(Offered by Niigata prefecture)

② The Slide in Hashiwatashi

Slipped surface as smoothly (The mark of collapse) and rock layer remained at the side of the collapse

This field is very close to the Myoken field. The pictures show a surface as smoothly slipped looks like a skiing slope (inclination 22 degree). 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 tuffaceous 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 slope 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.

Tuffaceous sandstone of slipped surface

A view of the collapse situation and restored road from upper side of slope

③ The Landslide in Oguriyama

Chuetsu earthquake caused this landslide occurred at the foot of other old, large landslide. One part of the landslide deposit resulted in a debris flow that slid into swamp but the other part of landslide was stopped by a check dam (Sabo dam). There was no damage to the express train line or the road located at foot of this landslide. In this case, the Sabo dam effectively prevented a disastrous debris flow. In the Oguriyama landslide, flora such as Obakisumire (*Viola brevistipulata*), Nirinsou (*Anemone flaccid*), Tanukiran (*Carex podogyna*), and Kusasotetsu (*Matteuccia struthiopteris*), and rare flora such as Katakuri (*Erythronium japonicum*), Kibanaikarisou (*Epimedium koreanum*) grow from early spring to autumn and make the landscape of "Sato-yama" more beautiful.

The soil mass at the top of landslide was excavated and the slope surface was reinforced by a concrete frame to control soil erosion. In the lower part of landslide, an embankment was constructed and a drainage channel installed. Also, a Sabo dam was constructed. These structures were used rehabilitate the carp farm and protect the beautiful landscape. More study is needed concerning the harmonization between methods of controlling disasters and protecting the environment.

Situation of landslide that mountain stream in end buries and is carried out.

A view of the stabilized slope

OObakisumire
(B.N. Viola brevistipulata)

Katakuri
(B.N. Erythronium japonicum)

④ The large landslide in Kamisawa River (Mt. Dainichi)

To go to the landslide zone, the group came to Siotani Village by a prefecture route. From there they walked northeast 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 Kamisawa River, a branch of the Imo River, where an earthquake caused this large landslide. The landslide, located at Mt. Dainichi (390m high), was surrounded by a curved ridgeline (inclination 15°). The ground consisted of a weak plane with rice fields and fish farms. In the landslide, the soil/rock deposit displaced about 50 m, the upper part was a collapse zone, the middle part was a topsoil failure and crack zone, and upheaval occurred at the lowest part. The landslide moved in the southeast direction: the upper part was about 100 m wide, and the middle and bottom parts were about 40 m and 60 m wide, respectively. Boring data showed the depth of slip surface to be about 60 to 80 m. 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.

The cliff of left side were occurred by movement of soil mass

The cliff,inclined rice field and trees were occurred by landslide

⑤ The disaster in Yubu area

Yubu village is located on a rather gentle slope with rice terraces in the valley, this landscape is peculiar of landslide terrain. The Chuetsu earthquake caused the old landslide near Yubu village to reactivate. The soil/rock deposit of the landslide extended about 1.0 km along the Yubu River and restricted flow in the river. Half of the houses in Yubu village collapsed or were damaged by the earthquake and cracks in the upper portion of the landslide extended into the ground of Yamakoshi Junior High School damaging the third floor of the building. Many hillslopes within a large area near the Yubu River either failed or experienced extensive cracking. To stabilize these slopes anchor and facing concrete frame methods were used. Landslides were also stabilized by subsurface water drains (catchment wells) and Sabo dams and embankments were constructed in the valley. Of particular interest is an embankment constructed with soil/rock material of the landslide deposit at Yamakoshi to prevent reactivation of the landslide in Yubu.

Landslide of Yubu River from sky over
(Offered by Niigata prefecture)

The snow fall collapse area in Yubu

The restored river and road in Yubu

⑥ The 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, thus using the reinforcement method at the upper part was difficult. At the upper part of slope, the slope failure was reinforced by concrete frame. The snow shelter was repaired and restructured. At the lower part of slope, a retaining wall was constructed combined with 'green' methods.

The large slope failure near the Haguro tunnel (left side)
(Offered by Forestry agency)

Stabilized slope in Takezawa and restored Yubu river

Collapsed houses by Landslide
(Offered by Niigata prefecture)

Damaged snow barrier

⑦ The blockage of river in Higashitakezawa

In the Higashi Takezawa area, a large landslide (350 m long, 290 m at the base, and total volume of 1.3 million m^3) occurred near the left bank of the Imo River. Geological and soil attributes of landslide included weak rock and fine sandstone, and soil layers that inclined toward the river forming a "Nagare ban". The slip soil mass about 70m length left from old landslide. So that the top of landslide was formed 25m high, and its inclination was 25 degree.

The lower part of soil mass crossed the river, slid into Route 291 facing the coast. The soil/rock mass of the landslide created a natural dam 320 m in length that crossed the Imo River. The water level of the dammed river increased causing serious inundation damage to an upstream village and, on the other side, the landslide dam threatens downstream property in the event that it fails and results in a large and rapid debris

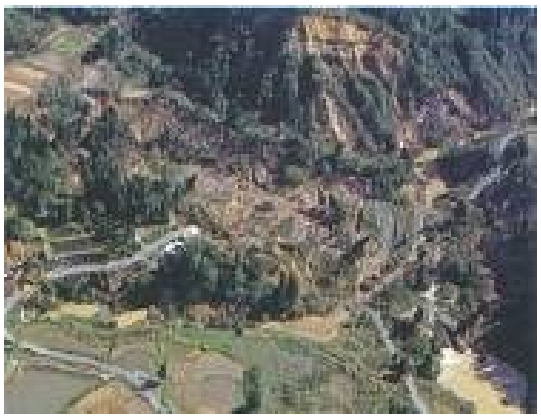
A view that water began to collect in the upstream of Sabo dam in Imo River by landslide
(Offered by Ministry of land, infrastructure transport and tourism)

flow or flood. Urgent rehabilitation in this area initiated only two months after the earthquake; a continuous drainage pump station was completely installed and the water level was reduced by a temporarily channel. The survey team could go inside the inundated area from April 2005. Here, two new Sabo dams were structured and the failure slope was reinforced by concrete frames.

Behind the Sabo dam is a stabilized slope where soil mass were cleared

⑧ The blockage of river in Terano

A 1.04 million m^3 landslide occurred along the left bank of the Imo River and a surface failure occurred along the right bank. The landslide confined Imo River by a natural dam (maximum length = 260 m, maximum base = 125 m, volume = 303 m^3) and as a result, the nearby road was blocked. Similar to the Higashitakezawa site, the potential failure of this dam represented a major hazard to downstream areas, and thus a channel was quickly built to decrease the water level upstream. In 2005, three new Sabo dams were constructed, the slope failure was reinforced by concrete frames, and a new road was built opposite the landslide.



A view of the landslide in Terano area
（Offered by Asia air survey co.ltd.）

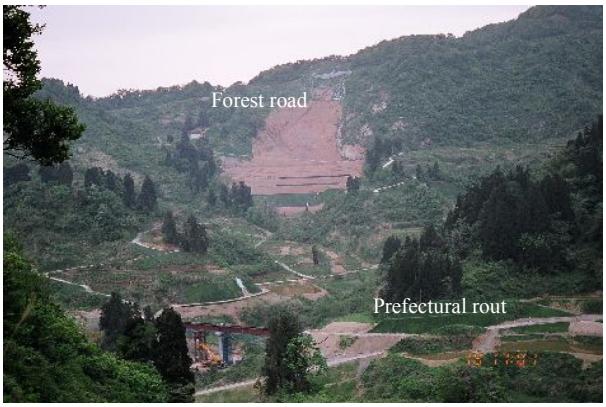
Sabo dam in downstream of land slide area of Terano

Stabilized slope and the Lake established by blockage of river

⑨ The slope failure in Kazeguti pass

In the Tanesubara area, upstream on the Imo River, slope failures frequently occur. Near the Kazekuchi pass, a large landslide (length = 500 m; width = 100 m) cut through a forest road and another prefectural route. At the upper part of this failure, the weathered rock layer collapsed along 30－35 degree sloping bedrock. The lower part was an old landslide on a gentler slope with rice farms. One part of the landslide moved and deposited soil downstream to the Sabo dam.Solutions to this landslide problem included the rebuilding both the forest and prefectural roads. In the upper part of the landslide, the unstable mass was removed and reinforced by a concrete frame, while soil deposits were stabilized with retaining walls. In the lower part, the slope was reformed and some drainage channels were constructed.

The weathered rock layer collapsed in upper part, the lower part was an old landslide
(The arrows indicates the direction where unstable mass moved) (Offered by Forestry agency)



Restored roads and stabilized slope in Kazeguti pass

⑩ The landslide in Nigorisawa

The slope of this landslide was the terminal portion of an old landslide. This recent landslide occurred due to the earthquake and even though it was only the terminal portion its length was 130 m and width was 70 m. The deposited soil struck homes, killed two people, cut through a prefectural road, and a portion reached the Ohta River. At upper part of the landslide experienced many cracks that clearly showed the movement of the failure.

Geology of the failed area consisted of weak weathered rock that could be penetrated by a knife. Because rainfall raised the ground water level rapidly after failure, a well and boring works were installed for underground drainage. At the terminal portion of the landslide, steel piles were installed to stabilize the slope.

Collapsed houses by landslide

Damage situation by landslide


Collapsed houses were removed, and the slope is stabilized

Others disasters

Point i Landslide in Hitotumine

A rice farm on the slope was displaced by a large landslide and habilitation of the area became very complicated because the forest road was damaged. Thus, damages resulting from the landslide, such as avalanches, displacement of the rice farm, falling trees, ground cracking, and rock failures or compressions near the terminus were estimated. However, to better estimate damages, it is necessary for safety experts to go inside this landslide area.

In the landslide, the soil rock deposit displaced

Point ii Flood control reservoir at downstream of Imo River

In the Imo River watershed, many soil disasters occurred and heavy rain probably caused large volume of soil and water move to downstream. Because of these water and sediment inputs, a flood control reservoir was constructed to control downstream sedimentation.


Point iii iv Large scale Sabo dam

Landslide and debris flow of soil deposits that occurred during rains were stopped by many large scale Sabo dams.



Point v Damage of residential quarter

The slopes collapsed and there were a lot of ground movement in the residential quarters located on hill near Nagaoka City.

These were generated by the embankment that reclaimed from the valley and was made, and the damage occurred in the road and the house.

Disaster concept, geological and topological

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

The 300 - 700 meter elevation watershed in the mountainous area called Higashiyama was surveyed. The Imo River in this area 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 folded young mudstone and sandstone. These fold lines formed by mudstone and sandstone layers promoted the occurrence of the recent landslides. At the northern part of center area in the map, volcanic rocks at elevations of 600 – 700 m existed in the mountainous area from Kazeguti pass to the NNE direction.

<Abstract of main earthquake>

Occurred Date : 17:56 the 23rd of October, 2004.
Epicenter : N37.3° , E138.8°
Depth of Epicenter : 13km
Magnitude : 6.8
Maximum Seismic Intensity : 7 (JMA Seismic Intensity)

<Abstract of The disaster> **(Quotation from White paper on disaster management 2005)**

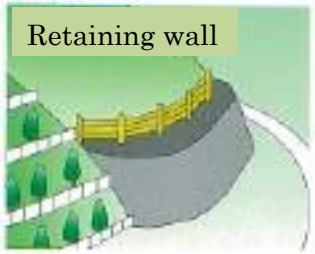
Human damage : 46 dead and 4,801 injured persons
Houses damage : 2,827 complete destruction houses and 12,746 partial destruction houses
Sediment disaster : 4 debris flow, 131 landslide, 90 Slope failure
Many roads, railways, rivers and other life line were damaged

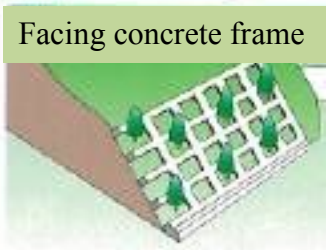
Explanation of term

Slope stabilization method

Retaining wall

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





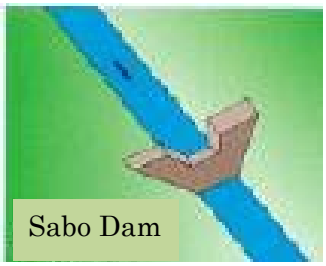
Facing concrete frame

To avoid slope failures and surface erosion caused by rainfall.

Solution for debris flow

Sabo Dam

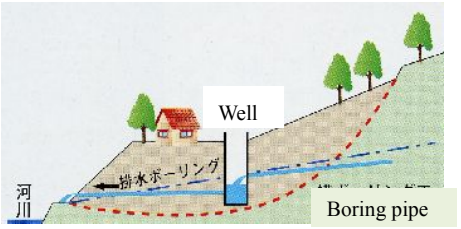
Stopped the debris flow that occurred upstream, Often made by concrete, but steel was also used.



Solution for landslide

Underground water drainage

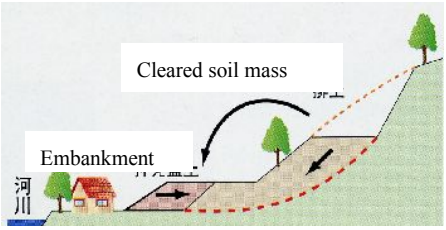
Rainfall and melting snow causes groundwater levels to increase. The water pressure makes the topsoil unstable and landslides can easily occur. Catchment wells combined with boring pipes are applied to reduce the water pressure and stop the landslides.



Underground water drainage

Soil removal and embankment

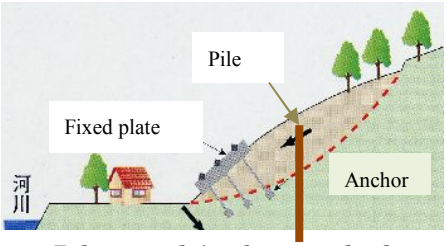
The soil is cleared at the top of the landslide to minimize its driving force and to establish an embankment at the end of the landslide to increase its resisting force.



Soil removal and embankment

Piling and Anchor method

The pile stabilizes 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 wire.



Piling and Anchor method