# Study of Risk Management at Sabo (Erosion Control) Office under Direct Control of The Central Government

Toshio Mori,[1)] Takayuki Nagai[2)] and Tetsuo Sakaguchi[1)]
*1) Sabo Frontier Foundation, Sabo-kaikan, Hirakawa-cho 2-7-4, Chiyoda-ku, Tokyo 102-0093 Japan*
*2) Shikoku Mountain Sabo Office, Ministry of Land, Infrastructure and Transport, Japan*

## Abstract

Most of areas that have implemented the sabo (erosion control) projects under direct control of the Ministry of Land Infrastructure and Transport (MLIT) in Japan have a history of large-scale sediment-related disasters which resulted in their direct control. Even as disaster safety improves, there remains the possibility of a disaster equivalent to or larger than the one which resulted in the government taking direct control of these projects. The disaster prevention system in Japan is generally described as follows. Due to recent mergers of municipalities, the number of municipal offices that provide local residents with information for safety and security has been falling year by year. The area covered by one local authority is now larger than the area before the merger. It may also be difficult to know the disaster status of the entire area to be covered. As experienced by past large-scale disasters, municipalities and prefectures may give priority to disaster response in urban areas. Actions for erosion-related disasters that mainly occur in mountainous areas may possibly be delayed. These conditions are not necessarily satisfactory for prevention of erosion-related disasters. If a large-scale disaster occurs, surveys should be conducted in mountainous areas from the initial stage of the disaster. Status of the erosion-related disaster must be known and transferred, and authorities concerned need to establish a system that can take actions for erosion-related disasters.

In this study, the roles in the local disaster prevention system for sabo offices under direct control that have implemented sabo projects at areas where there may be potential occurrence of large-scale disasters are selected and summarized. The system for cooperation with other authorities is also studied. This paper first describes the basic concept for sabo risk management for large-scale erosion-related disasters, and then describes specific examples for study.

**Keywords:** Nankai Earthquake, risk management plan, large-scale slope failure

## 1. Preface

In general, when a disaster such as a heavy rain with a scale greater than planned or a large-scale earthquake has occurred, various types of damage occur from large to small, irrespective of whether in a city area or mountainous area, and so it becomes difficult to cope with all the damage appropriately. In particular, population and assets are concentrated in a city area, so it expected that more damage would occur in cities compared to mountainous areas. Many of the present large-scale disaster response plans assume the handling of disasters in a city area.

In the meantime, also in a mountainous area, many examples were confirmed in the past as well, where heavy damage was caused by an occurrence of erosion-related disasters induced by a heavy rain and earthquake. It can be said that the Niigata Prefecture Chuetsu Earthquake that occurred in 2004 was a typical disaster that suggests the possibilities of bringing destructive damage to local communities in a mountainous area, induced by an earthquake. Meanwhile, when focusing on disasters having occurred over the most recent years, we can see that in 2004, Japan was hit by 10 typhoons, and 2,347 cases of erosion-related disasters occurred, which was the greatest number in history, claiming 54 human lives. Also, when hit by Typhoon No. 14 in September 2005, erosion-related disasters brought heavy damage mainly to mountainous areas in southern Kyushu. Moreover, the Central Disaster Management Council of the Cabinet Office forecasts that there are high probabilities of occurrence of large-scale earthquakes like Tokai, Tonankai, and Nankai Earthquakes in the near future, causing erosion-related disasters in many places. When considering situations as stated above, it can be said that prior studies of how risk management ought to be put in place with reference to erosion-related disasters in mountainous areas are important problems requiring urgent attention.

Even though the Japanese government has disaster policies not only at the national level but also at the level of local governments and public institutions, based on the Basic Law on Natural Disasters, the communication system among these concerned offices, however, assuming a possibility of formation of large-

pp. 695–703 

scale natural dams, has not yet been established.

In addition, while each of the Sabo offices directly controlled by the central government has some experts on erosion-related disaster prevention, prefectural governments have very few of them and almost none in city, town or village offices.

Meanwhile, due to the merger of municipalities at a rapid pace, the number of mayors of city, town and village offices, who have the primary responsibility to lives and properties of the people, has sharply decreased. Particularly, the number of towns and villages in a mountainous area, with many places being exposed to the possibility of erosion-related disasters, has gone down to more 40% for the past seven years from 1999 to 2006. Merger of small municipalities into a part of large cities may result in a further delay in grasping damage in mountainous areas when a disaster takes place.

Currently, 37 Sabo offices directly controlled by the central government work on erosion-related disaster prevention projects. What is needed is grasping information on damages by such disasters as soon as possible in and out of their jurisdiction, analyzing it professionally and providing it to related offices so that they can prevent occurrences of secondary disasters as much as possible.

The Minister for Land, Infrastructure and Transport, instead of governors, is authorized to exercise power by implementing such projects by Sabo offices directly controlled by the central government, when one of four conditions are met. This is a case, for example, when benefit of such project is not limited to one prefecture.

In Japan, Sabo offices directly controlled by the central government deals with projects in six percent of the national land, most of which had been launched due to large-scale erosion-related disasters in the past. Therefore, when such a disaster occurs in Japan with one of the four conditions met, it is necessary to examine whether or not it should be handled by Sabo offices directly controlled by the central government. As part of its efforts, it is indispensable to constantly grasp information on large-scale disasters.

Based on the viewpoints as mentioned above, this paper has studied how risk management ought to be put in place with reference to erosion-related disasters in mountainous areas in Shikoku, where erosion-related disaster is likely to occur at the time of the next Nankai earthquake, focusing on Sabo offices under direct control of the central government.

## 2. Techniques of studies for devising a risk management plan

In this study, we have decided to carry out studies according to the process shown in Fig. 1 when devising a risk management plan for mountainous areas in Shikoku. Notice that this plan is currently under study, and this paper discusses the result of studies up to “4.3 Preparing scenarios when risk events have occurred”.

## 3. The risk management policy

Areas where Sabo projects under direct control of the national government are implemented have features such as having a history of disasters causing destructive damage to local communities. They are also very difficult projects in terms of technology as well, requiring much expense and many days for recovery and reconstruction from this kind of damage. We have determined that the risk events to be addressed shall therefore be large-scale disasters that are highly likely to occur in actual situations, those which are difficult to handle for prefectural or municipal governments when they have occurred, and disasters that bring damage to wide areas.

In the meantime, the Nankai Earthquake can be counted as a large-scale disaster that is predicted to occur with high probabilities in Shikoku in the near future. The Nankai Earthquake is the so-called subduction zone earthquake, being an earthquake that occurs with periodicity of once every 100 years–150 years like the Tokai earthquake Its periodic occurrences of 8 times have been confirmed in recorded history, and studies are being made in consideration of this periodicity with regard to the probability of occurrence of the next time Nankai Earthquake as well, and it can be thought that the accuracy of prediction is high. Most of the examples of being hit by disasters in the past Nankai Earthquake are related to damage caused by tsunami and the collapse of houses, but examples of damage in mountainous areas are also confirmed. Several examples among them are large-scale erosion-related disasters that caused the movement of oil blocks one million cubic meters or more in volume[1].

Based on the points mentioned above, we have decided to address this risk management plan to erosion-related disasters that will likely be caused by the Nankai Earthquake, especially studying large-scale disasters that are difficult to be handle for prefectural or municipal governments in terms of expenses and technical aspects, and disasters that bring damage to wide areas, with a view to establishing a disaster prevention

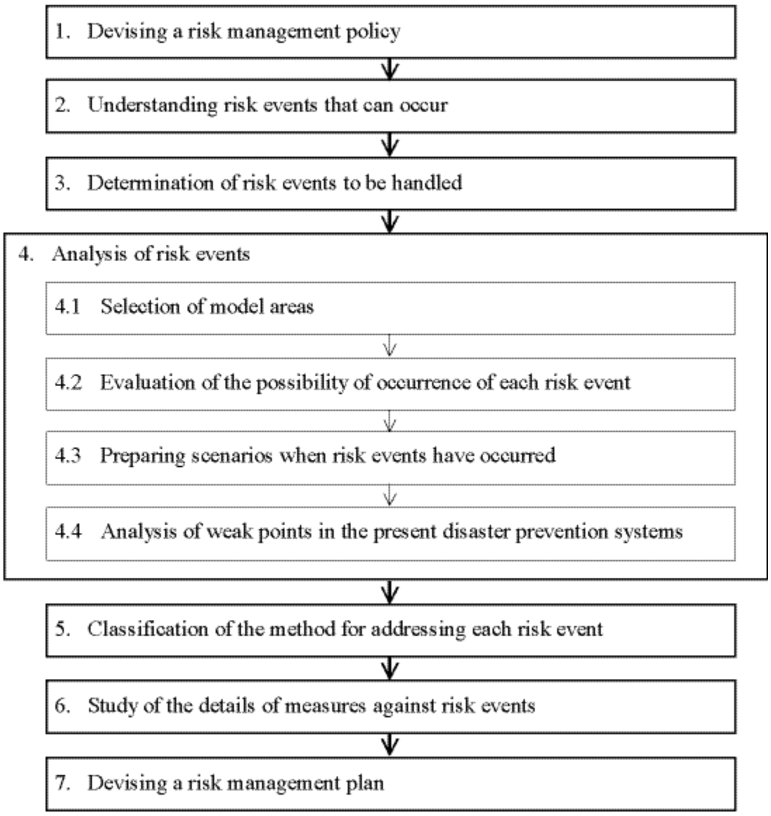


**Fig. 1.** Flow for studying a risk management plan as a Sabo office under direct control of the national government

system that can address these appropriately.

## 4. Understanding risk events that can occur

When specifying risk events in mountainous areas in Shikoku at the time of the Nankai Earthquake, a technique was employed to estimate such events by referring to the estimated distribution of seismic intensities at the time of the next Nankai Earthquake as prepared by the Central Disaster Management Council, places where erosion-related disasters occurred in the past in mountainous areas in Shikoku, the topographical and geological features of Shikoku, the situation of improvements in roads, and the situation of land use. Fig. 2 shows the estimated seismic intensities at the time of the next Nankai Earthquake as prepared by the Central Disaster Management Council, and the distribution of locations where large-scale erosion-related disasters have occurred in the past[2]. Notice that among the places where large-scale failures occurred, typical examples of disasters to be caused by the Nankai Earthquake are the 3 examples of the Arima Great Failure, Toji Mountain Landslide, and Kanagi Failure.

### *4.1. Techniques to estimate the situation of damage*

We have decided in this study to estimate what kind of erosion-related disasters occur in the next Nankai Earthquake by analyzing the degree of damage caused by such disasters that were witnessed at the time of the Chuetsu Earthquake that occurred in Niigata Prefecture in 2004.

At the time of this earthquake, damage was caused by landslides in 131 places, by steep slope failure in 115 places, and by debris flow, etc. in 21 places within Niigata Prefecture. Major features of the damage resulting from erosion-related incidents caused by this earthquake can be summarized as follows[3,4].

[1] The collapses of houses occurred not only due to seismic movements, but also due to many landslides and slope failures.

[2] Due to the cutting off of roads used for daily needs at many places associated with slope failures, communities in mountainous areas were isolated from the outside world.

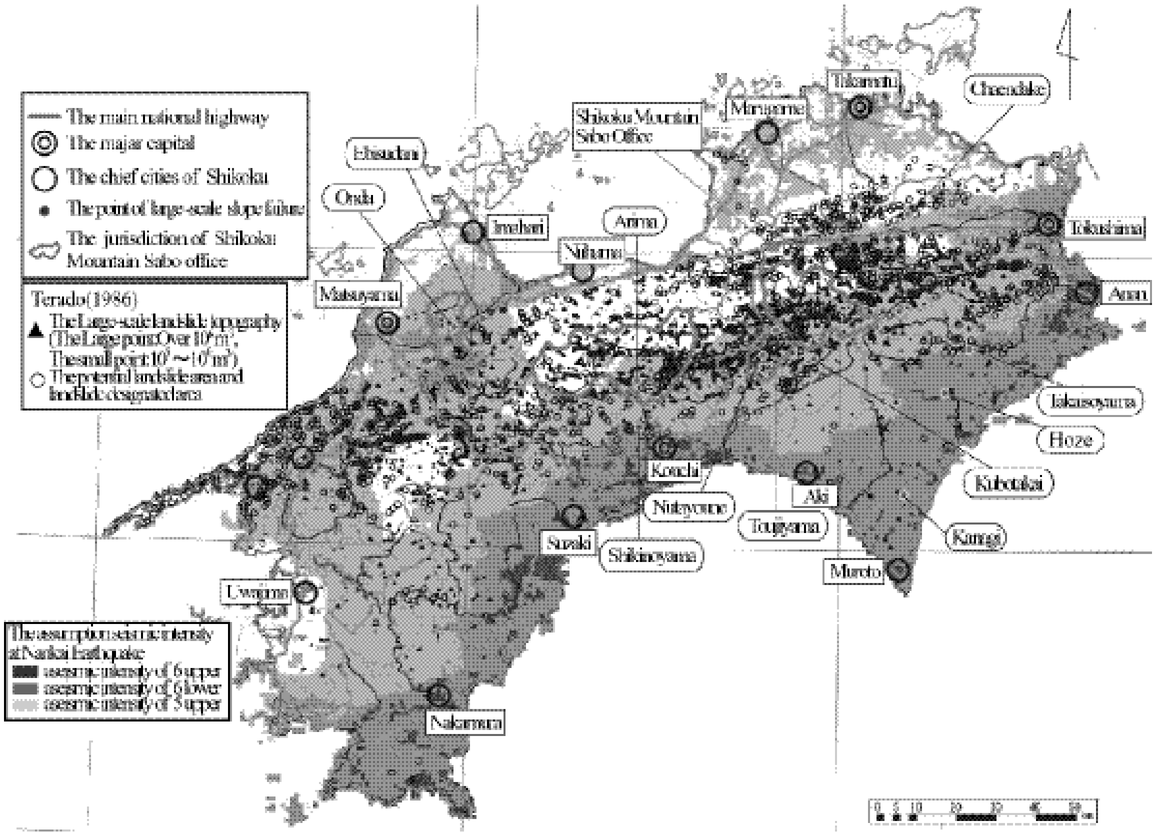


**Fig. 2.** Estimated seismic intensities at the time of the next Nankai Earthquake and the distribution of places where large-scale erosion-related disasters occurred in the past and landslide hazard areas

[3] Many natural dams were formed in the Aikawa River, Asahi River, Imo River, etc. that are the tributaries of the Shinano River, and their filling caused inundation damage, etc. in the upper reaches.

[4] In mountainous areas like Yamakoshi Village and others, great damage was caused to the bases of community industry, including the collapse of terraced rice paddies and carp culture ponds.

Niigata Prefecture and Shikoku have different geologies, and while the Niigata Prefecture Chuetsu Earthquake was a near-field earthquake, the Nankai Earthquake is a subduction zone earthquake. Therefore, it is difficult to use the damage at the time of the Chuetsu Earthquake as a guideline in estimating the damage by the Nankai Earthquake in Shikoku. However, we think it possible to understand the tendencies to damage caused by erosion-related disasters that can occur at the next Nankai Earthquake, by referring to the seismic intensities of the next Nankai Earthquake estimated by the Central Disaster Management Council, the existence of known landslide areas in Shikoku, the natural environment of such places as those where large-scale erosion-related disasters occurred in the past, and the social environment including for example the amount of improvements in roads and the existence of urban areas.

### *4.2. Topographical and geological features of Shikoku*

Shikoku has an area of 18,297 km$^2$ (about 5.0% of the national land), but steep slopes of 15° or more in gradient account for 77.6% of it (47.9% on average all over Japan), so Shikoku has a relatively steep topography. Meanwhile, the geological structures of Shikoku are complex and fragile, with the Median Tectonic Line, Mikabo Tectonic Line, and Butsuzo Tectonic Line running from east-northeast to west-southwest, forming a belt structure, with the Ryoke belt and Izumi strata group being distributed in the inner belt to the north of the Median Tectonic Line, and with the Sanbagawa belt, Shimizu tectonic belt, Mikabo green rocks, Chichibu belt, Kurosegawa tectonic belt, and Shimanto belt being distributed in the outer belt to the south of the Median Tectonic Line from north to south in this order. Also, dip slopes such as the Sanbagawa belt, etc. surrounded by the Median Tectonic Line and the Sanbagawa Tectonic Line have many landslide topographies, with the number of landslide hazard areas in Shikoku being 2,685 (12.6% of the total in Japan), making it prominent among Japanese regions for the frequent occurrence of landslides[5,6].

### *4.3. Potential damage caused by erosion-related disasters at the time of the next Nankai Earthquake*

Based on the foregoing, when considering the existence of landslide hazard areas, the geographical features, the existence of communities, the degree of land use, and the degree of improvement in key roads in Shikoku, the following matters can be assumed as potential erosion-related disasters that can occur at the time of the next Nankai Earthquake and the resulting damage.

[1] Occurrence of large-scale failures and damage by inundation in the upper reaches caused by the formation of natural dams associated with such failures, and damage by inundation in the lower reaches caused by the collapse of the natural dams

[2] Isolation of communities as a result of roads being cut off at many places due to erosion-related disasters

[3] Damage to evacuation areas and the cutting off of evacuation routes at many places as a result of erosion-related disasters within isolated communities

[4] Damage to industrial infrastructure as a result of the collapse of landslide areas normally used for terraced rice paddies or orchards

The above 4 damage phenomena can be classified as follows from the perspective of risk management.

Firstly, with regard to the occurrence of large-scale failures in [1], although their frequency of occurrence is low, it can be said that they are damage phenomena with a high possibility of causing destructive damage to local communities once they occur.

Next, as for the isolation of communities and damage to evacuation areas, etc. within them in [2] and [3], these phenomena may easily occur, for example even due to a rockfall on a slope alongside a road, which has a high frequency of occurrence, and it can be said that they are damage phenomena with high possibility of causing large secondary disasters depending on the number of households within the affected communities and the configuration of ages of local residents. However, when such damage has occurred, cooperation is required not only with the departments in charge of sabo (erosion control) but also with departments in charge of roads, the Self Defense Forces, the Fire Defense Agency, etc. Therefore, as the plan for risk management of a department in charge of sabo, its own perspective needs to be clarified when negotiating with the relevant organizations.

Finally, the damage to industrial infrastructure caused by the collapse of a landslide area in [4] is not so great in terms of instantaneous damage when it has occurred.

Therefore, we have decided in the risk management plan to be prepared in this study to make thorough studies of the damage phenomena of [1] by selecting model areas with regard to the likelihood of occurrence and the damage scenario when they have occurred.

## 5. Large-scale erosion-related disasters

### *5.1. Selecting out points to be studied*

As stated previously, at the time of the Nankai Earthquake, examples of disaster phenomena, the so-called large-scale failures, were confirmed, as in the Arima Great Failure, Toji Mountain Landslide, Kanagi Failure, etc., but the number of such examples is small. For this reason, it is impossible at the present time to predict the location in which a large-scale failures will occur, as are expected at the time of the next Nankai Earthquake, by estimating quantitatively or qualitatively the correlation of the estimated seismic intensities, magnitude, and the quantity of soil blocks to be moved at the time of the Nankai Earthquake, by using statistical techniques. However, when studying a risk management plan, it is desirable that the present disaster prevention system be evaluated by assuming concrete disaster phenomena and after organizing the situation of damage caused thereby in the form of a scenario. Therefore, in this study, we have decided to assume large-scale erosion-related disasters thoroughly in model areas by selecting model areas to be studied based on the way of thinking as shown in Fig. 3. The area where landslide hazard areas are concentrated most in Shikoku is the middle reaches to upper reaches of the Yoshino River. Although there is no large community in this area, there are national roads such as Route 192, Route 32, Route 439, etc. as well as JR's Dosan Line, being the area on which key transportation links will depend when transporting rescue supplies and personnel supplies to Kochi Prefecture at the time of the Nankai Earthquake. The area in which such landslide hazard areas are concentrated includes examples of large-scale failures in the past such as the Arima and Toji Mountains. However, it is thought that only Kochi Prefecture will be affected by large-scale erosion-related disasters when they occur in the Arima and Toji Mountains. However, the "Nuta/Yone District" is located in their vicinity, and large-scale landslides are recognized as having the possibility of affecting multiple prefectures at the time

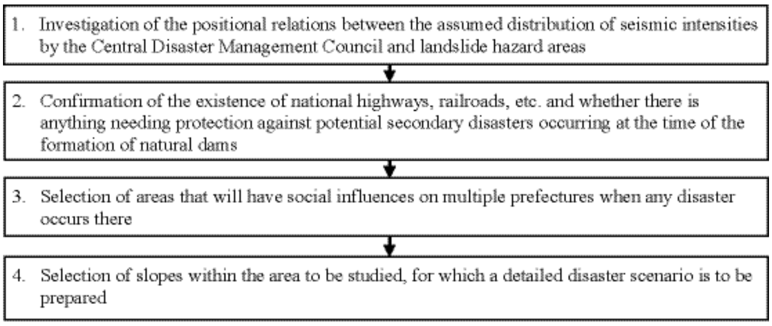


**Fig. 3.** Techniques for selecting the points to be studied

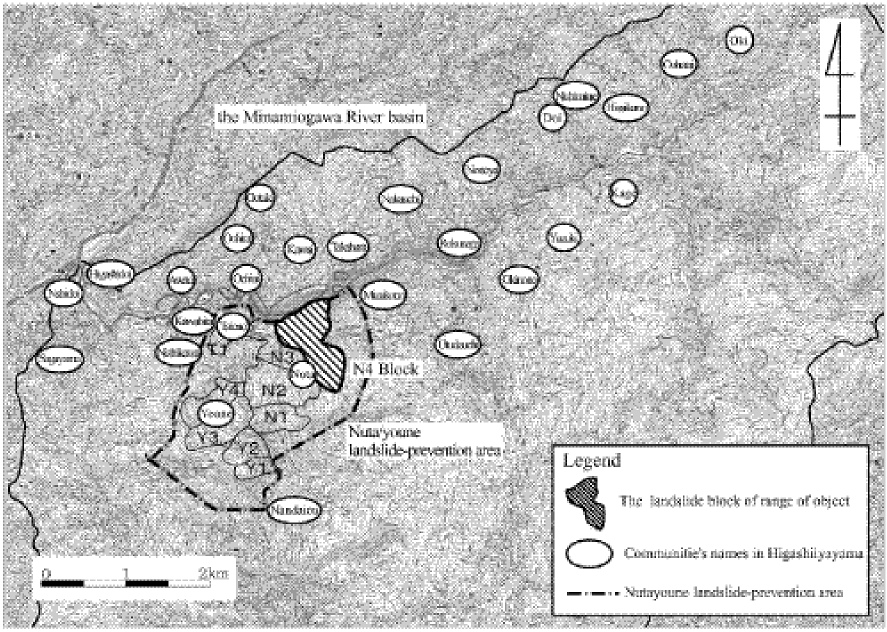


**Fig. 4.** Outline of the area to be studied

of occurrence of a disaster as a result of cutting off roads (National Route 439, etc.) at many places. Therefore, we have decided in this study to select the "Nuta/Yone District" as a model district to be studied.

## *5.2. Outline of the points to be studied*

Fig. 5.2 shows the outline of the Nuta/Yone District. The Nuta/Yone District is located on gentle slopes of 200 m–700 m in altitude on both banks of the Minami-Daiogawa River, which is a left tributary of the Minamiogawa River which itself is a right tributary of the Yoshino River, with a maximum length of about 1,000 m and a maximum width of about 2,000 m. The volume of moving sediment is about 11.1 million $m^3$, and the area of the landslide prevention zone is 410.8 ha, a shattered zone landslide district of the largest class in Japan. Geologically it belongs to the Mikabo belt, and the surface soils are used for rice paddies because of their high water retention. This district faces the main flow of the Minamiogawa River, a Class A river, and when sediments produced by landslide movement have flown out into the river, not only there will be damage by backwater as a result of the formation of natural dams, but there is also a possibility of causing tremendous damage to the lower reaches as a result of propagation of hydraulic bores produced by natural dam failures, and therefore it was designated as a landslide prevention zone under direct control of the national government on March 27, 1982. There exist around it 27 communities of various sizes from large to small, and within the landslide prevention area, there also are the 3 communities of Tateno, Nuta, and Yone. There exist 9 landslide blocks in the Nuta/Yone District, and the slope about which a large-scale failure is assumed in this study is Block N4, which faces the main flow of the Minamiogawa River within the Nuta District, as shown in Fig. 4 with hatching.

**Table 1.** Sizes of large-scale failures assumed with the model slopes to be studied

| Sizes of landslide failures/channel clogging | | | Remarks |
|---|---|---|---|
| Landslide length | 1,080 | m | Measured the horizontal distance from source to riverbed |
| Landslide width | 490 | m | Measured with the topographical map and calculating the average width |
| Relative height | 380 | m | Read from the topographical map |
| Landslide area | 487,500 | $m^2$ | Measured from the topographical map |
| Damming height (H1) | 70 | m | 1/7 of the average width |
| Damming width (D) | 150 | m | Measured with the topographical map |
| Damming length (L) | 780 | m | Measured with the topographical map |
| Soil volume dammed (V2) | 4,095,000 | $m^3$ | Calculated as 1/2*H1*D*L |
| Filling height (H2) | 70 | m | Assumed that it is equal to damming height (H1) |
| Filling area (A3) | 350,000 | $m^2$ | Measured with the topographical map |
| Filling volume (V3) | 8,166,700 | $m^3$ | Calculated as 1/3*A3*H2 |

### *5.3. The sizes of large-scale erosion-related disasters assumed in model areas*

The shapes of Block N4 in the Nuta/Yone District were plotted on a topographical map of 1: 25,000, and the sizes of failures and the sizes of channel clogging as estimated from the present situation of slopes were used. The result is shown in Table 1. Notice that when a large-scale failure has occurred in Block N4, it may clog a channel directly under it, thereby forming a natural dam, and so a supposition was also made about the size of the natural dam that will be formed with the assumed large-scale failure.

### *5.4. The damage scenario for model areas*

Considering the social environment such as the degree of improvements in roads, the existence of communities, etc. in the area to be studied, the damage scenario when large-scale erosion-related disasters as assumed in 5.3 has been organized chronologically. Its result is shown in Table 2.

Several communities exist within the model areas, and when a large-scale failure has occurred as a result of an earthquake with a natural dam having been formed in association with it, there is a possibility that the damage as shown in the scenario will occur. When a large-scale earthquake like the Nankai Earthquake has occurred, it is possible that the occurrence of damage as shown in the scenario will be minimized even when a large-scale erosion-related disaster has occurred, by having an investigation with high mobility conducted by a sabo office under direct control of the national government, by using a helicopter at the stage immediately after the occurrence of the earthquake, and by confirming whether any large-scale erosion-related disaster has occurred at an early stage.

## 6. Conclusion

Based on the disaster scenario as shown above, weak points in the present disaster prevention system shall be picked out, and after having studied how to solve them, the “Sabo Risk Management Plan” is to be developed as the final output of this project. Cooperation with other departments is indispensable when making responses to disasters such as the isolation of communities, the occurrence of large-scale failures, and the formation of associated natural dams, as have been assumed in this study. Therefore, when devising a risk management plan for addressing such disasters, in order to make it a viable plan, it is necessary to discuss the sharing of roles with other departments and how the system should work, and to seek a common understanding when devising the plan. In particular, when large-scale failures as supposed in Section 5 above have been caused by the Nankai Earthquake outside of the jurisdiction of the sabo office under direct control of the national government, as was also seen at the time of the Niigata Prefecture Chuetsu Earthquake as well, there is then a possibility that effective cooperation systems with the prefectural and national governments will fail to be established, delaying initial response, with the result that measures taken thereafter may come too late. In Shikoku as well, at present no cooperation system that addresses large-scale erosion-related disasters has been established between the prefectural government and the sabo office under direct control of the national government, and there is a possibility that situations similar to those in the Niigata Prefecture Chuetsu Earthquake may occur at the time of the next Nankai Earthquake. The Shikoku Mountain Range Sabo Office carries out studies in view of this situation, by holding a liaison meeting to discuss the measures against erosion-related disasters to be caused by the Nankai Earthquake with the prefectural government’s departments in charge of sabo, thereby studying how the cooperation system with the prefectural and national governments

**Table 2.** Damage scenario as assumed by large-scale erosion-related disasters caused by the Nankai Earthquake

| Timing | Time after the occurrence of the disaster | Situation of damage by the disaster |
|---|---|---|
| Initial response | Occurrence of a disaster | ● A strong shaking of slightly more than 5 to slightly more than 6 on Japanese seismic intensity scale occurs mainly in Kochi Prefecture and Tokushima Prefecture. |
| | | ● In mountainous areas in Shikoku, the shaking becomes slightly more than 5 on Japanese seismic intensity scale, steep slope failures and slope failures occur in various places, and human damage occurs in some places. |
| | | ● In areas with weak ground in coastal areas and in alluvial plains alongside rivers, buildings fall as a result of liquefaction or sand boiling. |
| | | ● Gaps, faulting, and damage can be observed in roads and bridges, and traffic becomes difficult in various places. |
| | | ● Block N4, facing the Minamiogawa River in the Nuta/Yone District, slides. With a terrific noise, trees slide down in a lump while remaining standing by giving off a cloud of dust, thereby clogging the channel. |
| | | ● A large-scale slide cliff is formed, and in part of the Nuta District on the sliding cliff, the falling of houses, destruction/cracking of roads, abnormal springing of water, subsidence in farmland, etc. occur. |
| | | ● Collapsed debris arrives at part of the Kawai District on the opposite bank, burying houses, farmland, and roads. |
| | | ● Due to failures and deposited sediments, traffic on National Highway Route 439 is cut off at many places. |
| | 12 hours later | ● Inundation occurs in houses and farmland alongside the river in the Takahara District. |
| | | ● Inundation occurs in farmland alongside the river in the Mitsukono District. |
| | | ● Inundation occurs at the Higashi Toyonaga Power Station of Shikoku Electric Power, which adjoins the upstream side of the end of the failure block. |
| | | ● Bridges and dams, etc. in the main flow of the Minamiogawa River are washed away. |
| | | ● Inundation occurs in part of National Highway Route 439 as a result of filling, and traffic is cut off in more sections. The only road that connects the upstream of the Minamiogawa River with its downstream is completely cut off at many places. |
| | | ● From Higashi Doi (around the Toyonaga Station) to Ochiai, a four-wheeled vehicle is passable. Since traffic is difficult upstream beyond this area due to soil blocks damming up, investigation of the extent of damage has to be done visually from a helicopter or on foot. |
| | | ● A situation occurs in which the entry of construction work vehicles, equipment and supplies, etc. is limited to transportation by air. |
| | | ● A filling advances in upper reaches, a breach due to overflow in a day or two is expected, and local residents in lower reaches start evacuation. |
| | 24 hours later | ● An overflow begins. |
| | | ● In the Tateno District at the confluence with the Minami-Daiogawa River, farmland in the form of a sandbank is washed away due to an overflow. |
| | | ● A large quantity of sediment, boulders and fallen wood that had formed a natural dam flow down with hydraulic bores, and damage sabo facilities (consolidation work; existing dams built by other governmental organizations) in the main flow of the Minamiogawa River. |
| | | ● In the Ochiai District (with a post office) right under the clogged channel, a flooding of sediments and inundation cause damage to entire communities alongside the river. |
| | | ● Part of the bridges and levees alongside the main flow of the river are damaged. |
| | | ● In the Kawahira District (with a police substation and a school), Awao District, Nishikawa District, Nishidoi District, and Higashidoi District (with a post office, a school, and the Toyonaga Station of the Dosan Line), houses are washed away, rice paddies and fields are inundated, road failures occur, and bridges are washed away. |

should be developed, including the sharing of roles. In these liaison meetings, opinions are exchanged including a study meeting about the data acquired at the time of occurrence of large-scale erosion-related disasters in the past such as the Niigata Prefecture Chuetsu Earthquake, etc., problems when addressing disasters by relevant organizations, issues, and the present status of the organizations participating in the liaison meeting.

Also, it is planned that a common understanding be sought about the sharing of roles between the prefectural government and the Shikoku Mountain Range Sabo Office, how the collaboration system should work, etc. when large-scale erosion-related disasters have finally occurred in Shikoku at the time of the Nankai Earthquake.

The risk management plan of the Shikoku Mountain Range Sabo Office to be devised in this study shall also include content reflecting the result of discussions in this liaison meeting, thereby aiming to achieve its goals with full viability.

## References

Ministry of Land, Infrastructure and Transport (2005) White Paper on Land, Infrastructure and Transport in Japan 2005, pp. 5–6 (in Japanese)

Tsuneo Terado (1986) Large-scale landslide topography and regional character in Shikoku Island, The thesis of geology, pp. 221–232 (in Japanese)

Ministry of Land, Infrastructure and Transport Hokuriku Regional Development Bureau (2006) Earthquake In Niigata — Annual Report of Hokuriku Regional Development Bureau —, pp. 6–7 (in Japanese)

Ministry of Land Infrastructure, and Transport Hokuriku Regional Development Bureau (2004) Erosion-related disaster in Shikoku mountain, pp. 1–3 (in Japanese)

Ministry of Land, Infrastructure and Transport Shikoku Regional Development Bureau Shikoku Mountain Range Sabo Office (2004) Erosion-related disasters in Shikoku Mountain Range, pp. 1–5 (in Japanese)

Minoru Saitou (1976): An outline of geology and landslide in Shikoku, Symposium of The Japanese society of irrigation, 51st anniversary symposium of Drainage and Reclamation Engineering branch office in Chugoku-Shikoku-in, The Japanese Society of Irrigation, Drainage and Reclamation Engineering branch office of Chugoku-Shikoku, pp. 1–4 (in Japanese)