A consideration of operational risk for slope disaster in the NOTO Peninsula earthquake

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NOTO Peninsula earthquake of seismic intensity a little over 6 occurred in Ishikawa in 2007. By this earthquake, the damage occurred in many civil engineering facilities. Above all, the damage of the slope holds about 80% of the damage amount of money in the total civil engineering facility. On the other hand, road disaster prevention inspection is established in 1968 and checks the situation of the slope, the effect of the existing measure method of facility, the history of the disaster. Therefore, in this paper we compared the true damage that occurred by NOTO Peninsula earthquake with the judgment result of risk of the road disaster prevention inspection, and examined the effectiveness of the judgment method of road disaster prevention inspection. As a result, check was inapplicable, and there were about 80% damage points in the total slope damage number. At the damage point out of a prevention inspection object, surface of deform held most. In addition, about 60% of the damage points were judged appropriately when we converted it into a reconstruction cost.

1. INTRODUCTION

The natural disaster such as an earthquake or the typhoon occurs in Japan. And in late years, large-scale natural disaster occurs. In March, 2007, NOTO Peninsula earthquake (M6.9) occurred. By this earthquake, the damage amount of money of the whole civil engineering facility was about 24,200,000,000 yen. In particular, the damage amount of money of the civil engineering facility is about 19,300,000,000 yen and occupies about 80% of the total damage amount of money [1)]. Figure 1 shows the damage point of road facilities by the NOTO Peninsula earthquake.

On the other hand, for improvement of the disaster prevention power of road installations, road disaster prevention inspection [2)] (the following, the prevention inspection) is carried out from 1968. The prevention inspection is classified into an earthquake countermeasure, a heavy rain and a heavy snow countermeasure. By the prevention inspection of the earthquake countermeasure, collection of information that is necessary for a judgment of the quake resistance of the road structure (a road, a bridge, a tunnel) is performed. By the prevention inspection of a heavy rain and a heavy snow countermeasure, three phases of (measures required, continual observation, measures unnecessary) evaluation is performed in an inspection point.

This study focuses attention on the road slope and compared the damage result of the prevention inspection with the damage by the NOTO Peninsula

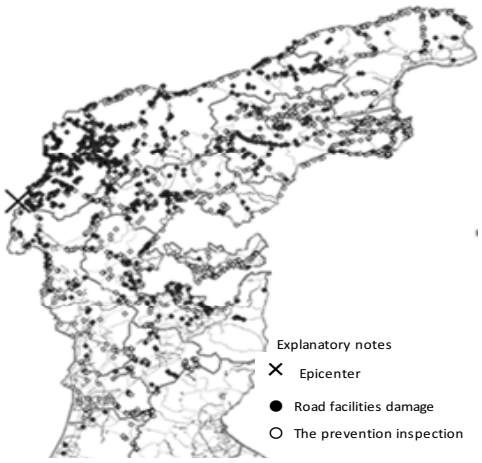

Fig.1 Road facilities damage spot by the NOTO Peninsula earthquake

Table.1 The judgment standard of the degree of risk of the slope for the heavy rain and heavy snow countermeasure

General Evaluations	Evaluations of Contents
Judged necessary measures	Point where factor with possibility to disaster is obviously admitted.
Perform continual observation	The point that manage by monitor with Continual observation for the time being although the necessary is assumed in the future.
Do not need-especially new measures	The point that becoming the factor of the disaster is not discovered , do not need particularly new correspondence.

Table.2 The Disaster spot number of public civil engineering facility

Road	River	Bridge	Steep slope	Shore	Erosion and Sediment control	Landslide	Total
646	151	19	9	8	6	3	842

earthquake, and examined the effectiveness of the judgment technique of the prevention inspection. An object facility is Ishikawa management road (a supporting national highway, a prefectural road, a major regional road).

2. THE PREVENTION INSPECTION

(1) Experimental overview

The prevention inspection in 1996 judges degree of risk at the slope for the heavy rain and the snow measures. Described in the road earthquake disaster measure manual (preseismic countermeasure), for example, ridge topography and slope with many cracks occurs slope disaster [3]. Described in the prevention inspection, risk assessment method in heavy rain countermeasure and heavy snow countermeasure give close agreement with inspection method that described in the road earthquake disaster measure manual. Table 1 showed the judgment standard of the slope in the prevention inspection. At present, in the case the evaluation for the earthquake disaster of slope, not only think about the earthquake disaster countermeasure but also think about the measure of the slope failure by cause except the earthquake measure. We suppose that this evaluation result is effective as evaluation technique for the earthquake in this study.

(2) Classification of the road facilities damage and the identification of the slope disaster.

Table 2 showed the damage point number of public facilities by the NOTO Peninsula earthquake. At first, identification of the disaster occurred point of the slope is necessary to grasp the damage of the slope by the NOTO Peninsula earthquake.

The damage of road facilities to show in table 2 becomes all damage including the slope damage. Therefore, we extract the slope disaster from this damage. We use a disaster date (a restoration top view, a restoration cross section and a restoration method of construction) for the extraction of the slope disaster. Table 3 is the result that extracted of the slope disaster.

According to the disaster date, there is not information to make the position of the slope disaster clear. The specific result of the disaster point is expressed in the latitude longitude of the disaster point. Therefore, we quote the browsing system fundamental geospatial date and the aerial photograph of the goo map and identify the disaster point.

(3) The identification of the position of a disaster point and the prevention inspection point

Table.3 A classification result of the damage situation

		Disasters data (Damage of road facility)	
		Slope	Other
Road classification	Supporting national highway	13	82
	Prefectural road	27	97
	Major regional road	18	144
Total		58	323

Table.4 The enforcement situation of prevention inspection at the slope disaster point

		Slope of disaster		
		Inspection spot		
		In	Out	Other
Road classification	Supporting national highway	4	9	0
	Prefectural road	0	27	0
	Major regional road	5	12	1
Total		9	48	1

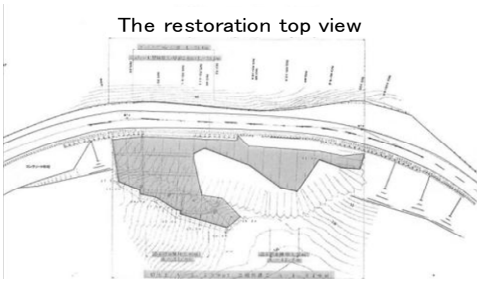

Fig.2 A figure of restoration top view of the disaster spot

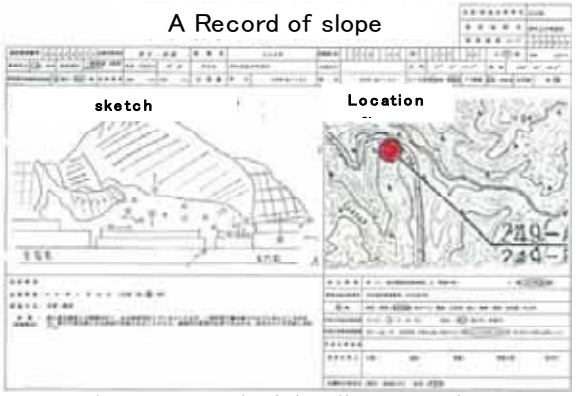

Fig.3 A record of the disaster point

Table.5 Definition of prevention inspection result with “Correct” and “Incorrect”

			Slope disaster	
			Happen	Not happen
Total inspection point	Inplementation	Measures required	Correct	Incorrect
		Continual observation	Near Correct	Near Correct
		Measures unnecessary	Technical-Incorrect (error of the first kind)	Correct
	Not Inplementation		Select-Incorrect (error of the second kind)	Correct

Table.6 The comparison result of the slope disaster（About the disaster number）

	Correct	Near Correct	T-Incrrect	S-Incorrect	Other	Total
Slope of disaster	7	2	0	48	1	58

（unit：number）

It is necessary to identify a damage location and the prevention inspection point in detail to grasp a slope disaster by the earthquake. The prevention inspection point is already grasped in latitude longitude. Therefore, we identify the position of a disaster location and the prevention inspection point. Figure 2 and figure 3 showed the example of the data which used for the identification. About 83% slope damage understands a thing than this besides a prevention inspection point. The comparison result of the identification of the damage point and the prevention inspection point is given in table 4.

3. COMPARISON OF PREVENTION INSPECTION RESULT AND NOTO PENINSULA EARTHQUAKE DAMAGE

(1) Definition of the prevention inspection result with "Correct" and "Incorrect".

Definition of the prevention inspection result and damage result is given in Table 5. "Correct" expresses that the true damage accords with the prevention inspection result.

Both "Technical-Incorrect" and "Select-Incorrect" mean "error of the first kind". "Technical-Incorrect" means "Technical" from that involved in evaluation method of the prevention inspection. "Select-Incorrect" means "Select" from that involved in the extraction method of the prevention inspection point. We do not focus on "Incorrect" number to consider the damage of unexpected road administrators. The “Incorrect” means “error of the first kind”.

(2) Comparison of a prevention inspection result and the damage result

The comparison result of the prevention inspection result and the damage result is given in table 6. As for the slope disaster, the numbers of 7 were “correct”, and the numbers of 48 were “S-incorrect”. Next, we clarify a restoration cost at each evaluation of the prevention inspection result. Table 7 shows the restoration cost at each evaluation of the prevention inspection result. As shown in figure 4, represents a ratio of the number of “Correct” and “S-Incorrect”, in the case focused attention on the number of slope disasters and restoration cost. As shown in Figure 4(a), represents the ratio of the number of each "Incorrect" and "S-Incorrect", in the case focused attention on the slope disaster number. As shown in Figure 4(b), represents the ratio of the amount of money of each "Incorrect" and "S-Incorrect", in the case focused attention on the restoration cost. As shown in figure 4(a), the ratio of "Incorrect" accounts for about 15% of the total, and

Table.7 The comparison result of the slope disaster（About a restoration cost）

	Correct	Near Correct	T-Incrrect	S-Incorrect	Other	Total
slope of disaster	2,075,935	133,015	0	1,329,805	3,346	3,542,101

（denomination：1,000yen）

Table.8 The classification result of the slope disaster

	Correct	Near Correct	S-Incorrect	T-Incrrect	Other	Total
Slope of failure	1	1	6	0	1	9
Natural hill of failur	4	1	6	0	0	11
Surface of deform	2	0	36	0	0	38
Total	7	2	48	0	1	58

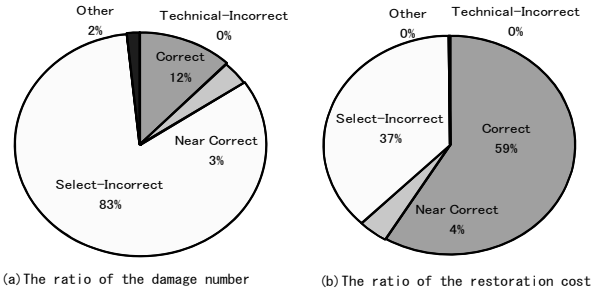

Fig.4 The ratio of the slope disaster of the "Correct" and "Incorrect"

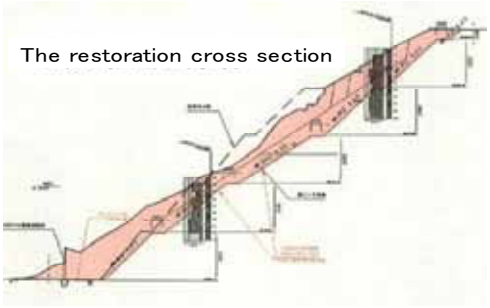

Fig.5 The restoration cross section of the disaster point that we judged the slope of failure

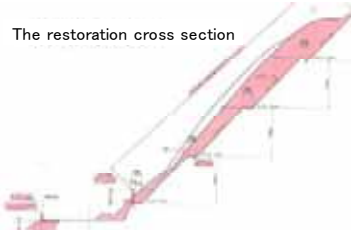

Fig.6 The restoration cross section of the disaster point that we judged the natural hill of failure

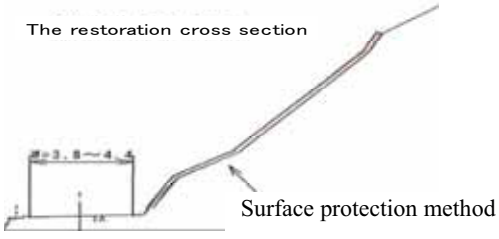

Fig.7 The restoration cross section of the disaster point that we judged the surface of deform

"S-Incorrect" accounts for 80%. On the other hand, as shown in figure 4(b), the restoration cost of "Incorrect" accounts for about 60% of the total, and "S-Incorrect" accounts for about 40%.

(3) Consideration of the characteristic of the slope disaster

In the case focused attention on the number of slope disaster and restoration cost, a ratio of "Correct" and "S-Incorrect" change greatly. To investigate of the above-mentioned cause, the number of 58 slope disasters are classified into three kinds "Slope of failure", "Natural hill of failure", and "Surface deformation". The classification of the slope disaster uses the restoration top view and the restoration cross section of the damage point. We show below the example of the restoration cross section of the disaster spot that we spoke by the above. As for figure 5, the slope of failure, figure 6 the natural hill of failure, figure 7 as surface of deform.

With the criterion mentioned above, we show the result that classified in table 7. We show each criterion in table 8. In consequence, the numbers of 9 were slope of failure; the numbers of 11 were natural hill of failure; the numbers of 38 were surface deformation. Surface of deform the number 36 were "S-Incorrect".

As shown in figure 8(a), show the ratio of the result that classified of the slope disaster in the total number of "S-Incorrect". In addition, figure 8(b) show the ratio of the restoration cost in the total number of "S-Incorrect". In the case focused attentions on the slope disaster number, surface of deform holds about 75% of the total. From this, it became clear that a lot of surface of deform that the restoration cost was occurred by the NOTO Peninsula earthquake. On the other hand, in the case focus attention of a restoration cost, the surface of deform holds about 25% of the total.

Table.9 The criterion of the slope disaster

Slope of failure	Collapse soil is mentioned in the disaster point of the law side.
Natural hill of failure	Collapse soil is mentioned in the disaster point of the natural hill.
Surface of deform	A restoration method of construction for the slope is carried out, and there is not a mention of the collapse soil.

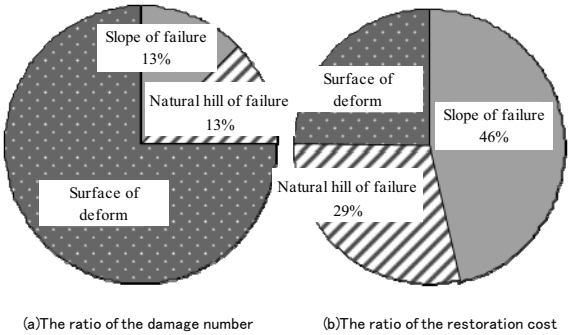

Fig.8 The classification result of the slope disaster in the "Select-Incorrect"

4. CONCLUSIONS

In this study, we examined the effectiveness of the risk assessment method of the prevention inspection for the NOTO Peninsula earthquake damage in 2007.

① About 80% of the total of the slope disaster are "S-Incorrect" that is a disaster out of an inspection point.

② In the case focused attention restoration cost of slope disaster, "S-Incorrect" account for approximately 40% of the total.

③ In the case focused attention "S-Incorrect" of slope disaster, surface of deform account for approximately 70% of the total. Restoration cost account for approximately 20% of the total.

The result clearly showed that NOTO Peninsula earthquake damage was caused by out of the prevention inspection point. On the other hand, in the case focused attention restoration cost of slope disaster, relatively-massive damage place was made appropriate judgments adequately in the case focused attention restoration cost of slope disaster, we consider the judgment method of the prevention inspection an effective means of the NOTO Peninsula earthquake.

However, in the case focused attention the number of disaster, about 80 percent of all was damaged out of the prevention inspection point. And about 70% of disaster out of he prevention inspection point was surface of deform. In the case focused the number of slope disaster, there is room for the improvement at the surface of deform of the prevention inspection point.

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