Study on damage of concrete structure and strength test of volcanic ash by Mt. Usu volcanic eruption.*[1]

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Abstract

Japan suffers many active volcanoes and earthquakes disaster as a result of its topographical characteristics. We have recently experienced volcanic hazard such as Mt. Usu, Mt. Fugen in the Unzen mountain system, and Mt. Oyama of Miyake Island. With Japan such a populated country, this volcanic activity threatens the safety of regional residents, transportation, and property. The observation in directly is necessary for the fallout, ash, gas, and pyroclastic flows resulting from volcanic eruption as well as topographical changes and mud flows of volcanic ash. During period of acting, it is necessary to protect life-line structure and monitor influence to the area. Further, many popular tourist resorts of our country are located in areas of volcano in activity, and damage caused shocks to the regional economy and industry. Also, there are many case that these volcanic disaster breaks out cyclically in Japan. However, despite the cyclic occurrence of volcanic eruption in Japan, life must go on in the face of danger because there are so many prominent volcanos in our crowded archipelago.

The main purpose of this research is to examine about in particular the damage caused by the Mt. Usu eruption, The intense crustal fluctuations that around March 28, 2000. The volcano become active for first time in 23 years at 13:00 on March 31 of the same year. Several damage woe the life and economy of residents to the important sightseeing industry, to means of communication such caused to as a main railroad line and main road in Hokkaido to concrete structures, and so on. A second purpose is to investigate an effective use for the voluminous volcanic ash resulting from the eruption as concrete mixture component and the characteristics of the resulting concrete are examined by processing measure to get rid of a large quantity volcanic

The results are as following, (i) the structures related to transportation infrastructure, river drainage, irrigation, life-line services, and property such as road bridges, drainage systems, building, residence etc. were damaged causing by ash, stone, gas, crustal fluctuations, mudflows, etc. with some certain characteristic types of damage observed, (ii) experiments using volcanic ash of the 2000 Mt. Usu volcanic eruption in concrete showed that the strength

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characteristics are good, (iii) the manual of measures for volcanic damage to infrastructure and concrete structure is should be maintained in sufficient information to do at ordinary times because of the volcanic hazard must be classified by the damage as earthquakes.

1. Introduction

Japan suffers many active volcanoes and earthquakes disaster as a result of its topographical characteristics. We have recently experienced volcanic hazard such as Mt. Usu, Mt. Fugen in the Unzen mountain system, and Mt. Oyama of Miyake Island. With Japan such a populated country, these volcanic activities threaten the safety of regional residents, transportation, and property. The observation in directly is necessary for the fallout, ash, gas, and pyroclastic flows resulting from volcanic eruption as well as topographical changes and mud flows of volcanic ash. During period of acting, it is necessary to protect life base and monitor influence to the area. Further, many popular tourist resorts of our country are located in areas of volcano in activity, and damage caused shocks to the regional economy and industry. Also, there are many case that these volcanic disaster breaks out cyclically in Japan. However, despite the cyclic occurrence of volcanic eruption in Japan, life must go on in the face of danger because there are so many prominent volcanos in our crowded archipelago.

The main purpose of this research is to examine about in particular the damage caused by the Mt. Usu eruption and the intense crustal fluctuations that around March 28, 2000. The volcano become active for first time in 23 years at 13:00 on March 31 of the same year. Several damage was the life and economy of residents to the important sightseeing industry, to means of communication such caused to as a main railroad line and main road in Hokkaido to concrete structures, and so on. A second purpose is to investigate an effective use for the voluminous volcanic ash resulting from the eruption as concrete mixture component and the characteristics of the resulting concrete are examined by processing measure to get rid of a large quantity volcanic ash.

2. Outline of investigation

2.1 Survey

2.2.1 Survey in site and information

A survey was carried and in a accessible area around the eruption once the volcanic activity was stabilized. The damage to between concrete structures in the area was surveyed several times between July 10 and mid October as shown in Fig.
2.1.1, and information was gathered from the organization responsible for each structure. The data are summarized in this research.

2.2 Experiment

Two types of volcanic ash from the Mt. Usu eruption were selected as the experiment mixtures. One type accumulated at a hot spring resort on the shore of Lake Toya and sandbags.The other was sampled directly by the authors for concrete mix proportion tests near Lake Toya to the north side of the Konpira volcanic crater.

Experiment concrete was made with ash that passed a sieve 0.074 mm after passing a sieve 5 mm and drying in a furnace at 110℃ for 24 hours. The aggregate used as recycled aggregate obtained from scrap to the further the resource saving.

The experimental mix proportions were as shown in Table 2.2.1. Strength tests were carried and the concrete after 4 weeks and 3 months following standard curing.

Fig.2.1.1 The map of site survey point (A,B,C,D)

Table.2.2.1 Mix proportions

Case	Type of volcanic ash	W/(C+V) (%)	W (kg)	C (kg)	Volcanic ash : V (kg)	Recycled aggregate (kg)	High-performance water-reducing agent (kg)	Slump (cm)	Air content (%)
1	none	40	180	450	0	1531	10.0	0.8	1.0
2	good	40	214	430	107	1420	11.7	10.7	1.8
3-1	Contains soil and sand	40	180	360	90	1624	9.0	4.2	0.6
3-2	Contains soil and sand	40	210	400	100	1531	10.0	6.5	0.8

3. Survey results and mix proportion test results

3.1 Survey results

Damage to road pavements, building walls, etc. was caused by the impact of volcanic

stones flying from the nearby Nishiyama volcanic crater south of Lake Toya hot spring. From south side of Lake Toya to Uchiura Bay neighborhood, many crustal fluctuation are visible this area. Volcanic craters formed along national highway route 230 shown in Photo 3.1.1.A. In the same area, the piers and foundations of bridges and other structures, including the drain shown in Photo. 3.1.1.B related to transportation and life-line infrastructure had risen up and been damaged. Bridge piers, roadbed, and tunnels along the Doou (Hokkaido Central) national expressway, the Muroran main line of JR Hokkaido Co. Ltd, Hokkaido prefecture roads, municipal roads etc. were damaged by crustal fluctuations as shown in Photo. 3.1.2. Example of pushing up, cracking, support failure are shown in Photo. 3.1.3.

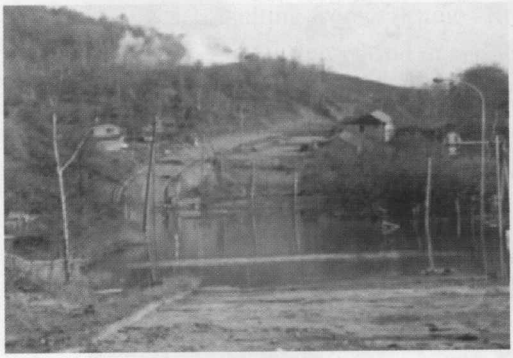

Photo.3.1.1.A Volcanic craters formed and depression with water along national highway route 230 (Point D)

Photo.3.1.1.B Road drain damaged by crustal fuctuationsof volcanic activity (Point A)

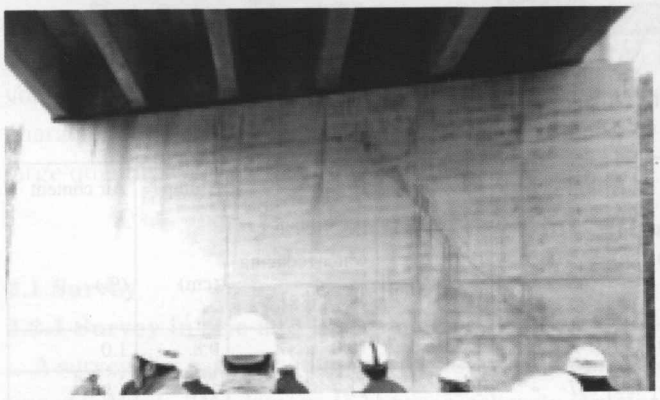

Photo.3.1.2 Bridge abutment damaged by crustal fluctuations of volcanic activity along Doou Expressway (Point B)

Photo.3.1.3 Cracking and support failure by crustal fluctuations of volcanic activity along Doou Expressway (Point B)

Structures on the shore of Lake Toya at north side of the Konpirayama crater were washed away volcanic ash mudflows. Especially intensive charge place is on the slope from nearby volcanic craters. Particularly serious damage was caused by volcanic ash mudflows to the national highway route 230 near Nishiyama river in Lake Toya hot spring resort. The RC beam of the Konomi bridge on national highway route 230 was washed away and pushed out by poured over volcanic ash mudflows from Nishiyama river, as shown in Photo. 3.1.4. And the bridge beam laid over on the several tens meters toward lower stream to Lake Toya.

Pouring mud flows flowed into the 1F classroom of on the Toyako-onsen elementary school near river. The pouring mud flows were destroying window panes and frames. Also the Mizu-umi-dokusyono-ie of wooden-frame mortar structure used as community center by surrounding residents and children was completely destroyed, as shown in Photo 3.1.5.

Photo.3.1.4 RC beam road bridge on route 230 washed and pushed away by river poured over mud flow (Point C)

Photo.3.1.5 First floor F classroom of elementary school damaged by river poured over mud flow (Point C)

3.2 Mix proportion test results

The results of strength tests on mix proportions such including volcanic ash are shown in Table 3.2.1. Experiments using volcanic ash in concrete of case 1, 2, 3-1, and 3-2 showed that the strength characteristics are good.

In order to use the volcanic ash for a resource as material of construction, the impurities in gathering volcanic ash are avoided to mix such as vegetable matter and garbage as shown in Photo. 3.2.1.

Because eruption volcanic ash occurs voluminously in our country, the efficiency using volcanic ash, and the tests such as strength and durability properties of concrete specimen to investigate the most effectively mix proportion and conditions utilized volcanic ash in simultaneously proportions are very important. For a great example, tests have been continuing from the first 20th century by Dr. Isami Hiroi who was the head in the Otaru harbor office at that time.

Table.3.2.1 The results of concrete strength test with Mt.Usu volcamic ash.

Case	1	2	3-1	3-2
Condition of volcanic ash	None	Fine	Contain soil and sand	Contain soil and sand
a: Strength at age of 4 weeks (kgf/cm2)	456	338	341	340
b: Strength at age of 3 month (kgf/cm2)	473	378	368	388
The development of strength (b/a) (%)	103	112	108	114

Photo.3.2.1 The volcanic ash of gathering site at the lakeside of the Lake Toya nearby Konpirayama volcano crater (Point C)

3.3 Future subject

Volcanic activities are continuing to cause damage in this area and others, including Mt. Oyama in Miyake Island, as shown Photo. 3.3.1, in and elsewhere. Guards of mudflows must be maintained when the volcanic activity have stabilized like the case of Mt. Fugen in the Unzen mountain system as shown in Photo. 3.3.2.

Also, such damage is inevitable, just like earthquake damage. The volcanic hazard given its inevitability must be classified by the damage which it causes to concrete structure, as earthquakes. A manual of measures for volcanic damage to infrastructure such as concrete structure, hazard map, etc. are very important. They should be maintained in sufficient information from these volcanic hazards to do in usual state.

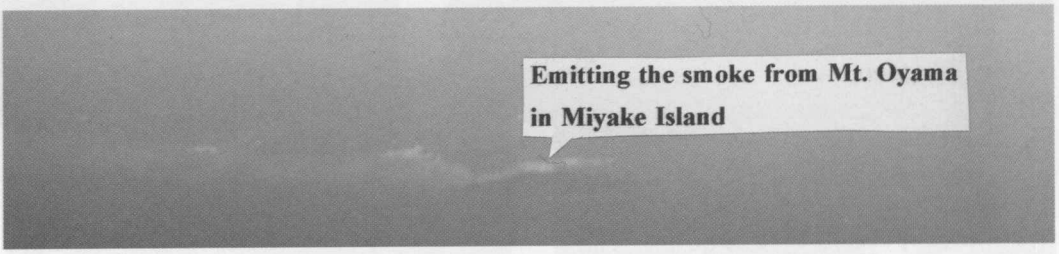

Photo.3.3.1 Continuing volcanic activities and emitting the smoke with H_2S from Mt. Oyama in Miyake Island.

Photo.3.3.2 Guards of avalanche mudflows, sand and stone maintained at Mizunashi river of Mt. Fugen in the Unzen mountain system.

4. Conclusion

The following conclusion can be drawn from this study on damage to concrete structures by Mt. Usu volcanic eruption and strength tests of concrete made with the volcanic ash.

(1) Many life-line's structures related to transportation infrastructure, river drainage, irrigation, life-line services, and property were damaged in the 2000 Mt. Usu volcanic eruption. The damages were caused by ash, stone, gas, crustal fluctuations, mudflows, etc. The certain characteristic types of damage were observed to infrastructure such as road bridges, drainage systems, etc. The volcanic activity has stabilized now, although it still continues even in 2001 summer.

(2) Experiments using volcanic ash of the 2000 Mt. Usu volcanic eruption in concrete showed that the strength characteristics were good. In order to use the volcanic ash for a resource as material of construction, the impurities in gathering volcanic ash are avoided to mix such as vegetable matter, garbage, etc.

(3) The manual of measures for volcanic damage to infrastructure and concrete structure and the hazards map should be maintained in sufficient information to do in usual, because

the volcanic hazard which causes to infrastructure, concrete structure etc. must be classified by the damage as earthquakes.

Acknowledgement

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Reference

1) H.SAKURAI, K. OKADA: Some concrete structure damage of and strength test of volcanic ash by Mt. Usu volcanic eruption, proceedings of JCA Conference, 2001.
2) H. Sakurai et.al: Long term mortal strength test, Memoirs of The Kitami Institute of Technology Vol. 28, NO. 2, March 1997.