Challenge of Remote Preventive Work at Mt. Usu

Use of long-distance remote construction technology in built-up area

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Summary of Mt. Usu

Mt. Usu erupted on March 31, 2000 after laying dormant for 23 years. Since the initial eruption, craters have continued to open up and the ongoing volcanic activity, consisting of hot mud flows and effusions of cinders and volcanic ash, is causing enormous damage. With a danger of rain-induced mud and rock avalanches from build-ups of volcanic ash around craters, nearby built-up areas came under threat. To avert the danger, it was decided to construct a debris basin by remote control at a location 1.2 km away from the control vehicle. Technology suitable for remote construction work had been developed for use at the foot of Mt. Fugendake during the eruption of the volcano Unzendake, in Shimabara, Nagasaki Prefecture, and this was adopted for use in the project.

Outline of remote construction technology

The remote construction technology used to carry out construction work at the site had been proposed for assessment under the fiscal 1994 Test Field System of the Ministry of Construction. (To date, technology from nine companies has received a positive technical assessment under this system.) This technology has already seen various applications, such as in the removal of stone and the construction of debris dams. The expertise and practical experience gained through implementing such work in the past was fully exploited in carrying out the remote construction work at this site.

Characteristics of remote construction at Mt. Usu

Two areas around the volcano were in particular danger of rain-induced mud and rock flows: Itayagawa in the Izumi and Irie districts of Abuta Town (bisected by the river Itayagawa), and the hot spring resort of Nishiyamagawa on Lake Toya (through which the river Nishiyamagawa flows) (Photos 1, 2, and 3).

Both are within evacuation areas, to which entry was either prohibited or restricted. A Task Force on Mt. Usu Debris Flow Damage was set up by the Ministry of

Photo 1. Aerial photo showing the site (Source: Asahi Koyo Co., Ltd.)

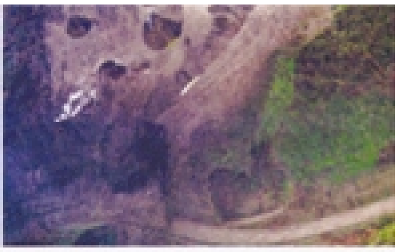

Photo 2. Itayagawa area (photos taken by the joint venture)

Volcanic ash deposited around the upper reaches of the Itayagawa river pose a mud-slide danger for the national highway.

Photo 3. Nishiyamagawa area

Rains washed sediment into the Nishiyamagawa river, washing out bridges and blocking the watercourse.

Construction to look into methods of preventing damage from debris flows caused by deposited volcanic ash. The team proposed using remote construction methods to build a debris basin and supported Hokkaido Muroran District Public Works Management Office in placing an order for the work. This report describes the debris control work in the Itayagawa area.

1. Problems with long-distance remote control (1.2 km or more)

The Itayagawa Disaster Damage-Related Emergency Debris Control Work was to be carried out in an off-limits built-up area (as of May 30) approximately 1.2 km from the construction yard (in which the remote control vehicle was set up and construction equipment was stored). Only daytime access to the site was permitted, so it was necessary to move equipment to the site every day under remote control using a wireless link to cameras aboard the equipment.

Experience had been gained in the remote operation of equipment from a distance of 1 km or more during the remote work at Fugendake, but in that case radio signals were relayed via existing radio equipment. At the Itayagawa site, however, there was a problem with the existing equipment because, without a line-of-sight path from the operations base at a distance of more than 1 km, relay stations would be required. To overcome this problem, cooperation from the Ministry of Posts and Telecommunications was obtained for the exclusive use of certain channels in the regular construction radio band (Table 1).

Table 1 Construction radio band

Equipment	Frequency band	No. of channels
Wireless telecontrol signals	420 MHz band, 2 W	8
Video signals	2.5 GHz band, 2 W	8

2. Remote operation of construction equipment in a built-up area

National Highway 230 runs through the neighborhood, and this was used as the access route for construction equipment on its daily journey to the site. Using a regular highway for this purpose necessitated overcoming the following difficulties:

(1) Obstructions (road signs and overhead cables)

In order to ensure problem-free access to the site under remote control, it was necessary to check in advance for obstructions such as road signs, overhead cables, utility poles, and traffic signs. This was done by traveling the route with a camera attached to the equipment. Safe remote operations also relied on the equipment meeting certain restrictions, such as boom heights, arm lengths, and radio antenna heights.

(2) Radio interference

The route to the site is bounded by houses, an expressway, and an expressway interchange. Such structures can obstruct radio transmissions, and could interfere with remote operations from the control vehicle. This situation was very different from that at the Fugendake site, where the work took place on open land without significant obstructions. Accordingly, it was necessary to carry out a careful radio-wave survey and test the radio equipment on site and along the route in advance work commencement.

(3) Safety provisions

National Highway 230 passes through areas to which residents were permitted to return home on a temporary basis. To prevent residents and others involved in disaster prevention work driving onto the highway, it was necessary to place barricades and sandbags at several intersections using remotely operated vehicles.

A camera-equipped vehicle, a modified rough terrain hauler, was stationed where the road was out of sight, as shown in Photo 4, so that the view from this position could be seen on a monitor.

Construction of the debris basin

The objective was to construct a debris basin of approximately 37,000 m^3 capacity without human workers in attendance. The dam was designed to collect the avalanche of mud and rock before it reached the built-up area if volcanic ash deposited around the craters should

Photo 4. View of site from remote control room

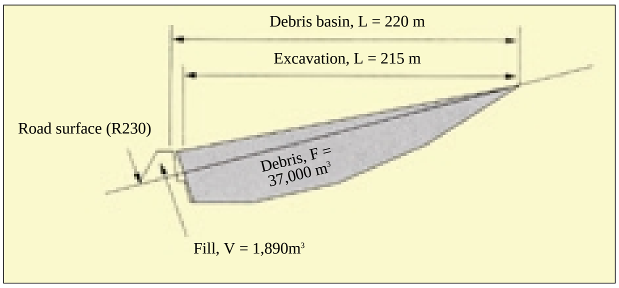

Fig. 2 Longitudinal section through debris basin

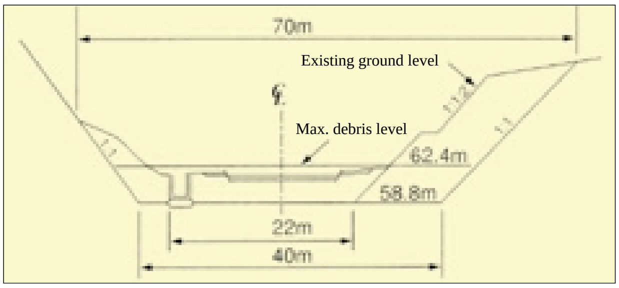

Fig. 3 Cross section of debris basin

Table 2 List of equipment used for remote work

Equipment	Specification	Quantity
Remote control vehicle	410-ton truck	1
Hydraulic shovel	1.3 m^3, equipped with a breaker	1
Crawler dump truck	12.5-ton	1
Crawler dump truck	7-ton	1
Mobile camera-equipped vehicle	1.3 m^3, hydraulic shovel	1
Auxiliary camera vehicle	5-ton, rough terrain hauler	1

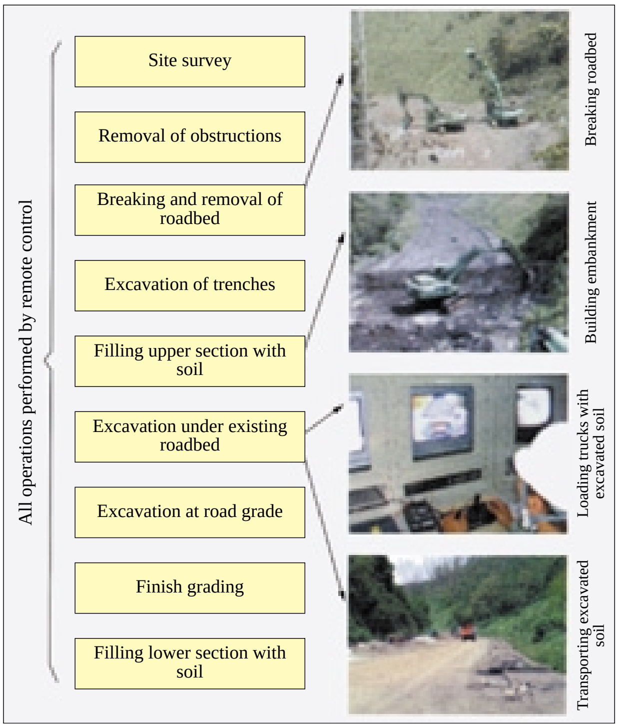

Fig. 4 Work execution block flow diagram

Photo 5. Remote control vehicle with remote control operations in progress

flow down the mountain during rain.

All work was carried out with remotely controlled construction vehicles without human intervention at the actual work site.

1. Work execution

After a careful survey of the equipment access route, obstructions, land elevations, ground subsidence, and fissures, the start and end points of the work within the site were verified. A CCD camera-equipped vehicle was used to transmit video for this purpose.

Based on the results of this survey, all existing utility poles, telegraph poles, road signs, overhead wires, and other obstructions were removed from the site. The road surface and curbs of the national highway and the foundations for the above obstructions were chipped away with a breaker, and then the soil was excavated with a hydraulic shovel to a depth of about 4 m below the original road surface. To prevent ponding during rain or as a result of springs, trenches were excavated to remove surface water in advance of the main excavation. The excavated soil was moved away to the primary disposal area under remote control, using two rough-terrain haulers. Once the excavation was sufficiently large, an embankment was built across the lower end of the site using fill. Approximately 1,890 m^3 of material was used to construct a basin with a finished capacity of 37,000 m^3 (Figures 2 and 3).

(1) Detailed execution procedure

With a limited amount of visual information available from the site during remote work, a careful site survey was carried out before beginning actual excavation work. Accurate operation is very hard to achieve by remote control as compared with hands-on work. Taking this into account, a conservative execution plan was drawn up so as not to overly burden the operators, and equipment work capacities were generally taken to be half the usual values. The plan was to carry out the work based on the procedure shown in Figure 4.

(2) Equipment used

Table 2 lists the equipment used for the remote control work.

(3) Actual operating conditions

Given the small size of the site and the depth of excavation, there were initial concerns about radio interference and consequent reduced productivity. These concerns were overcome by the installation of a 20 m antenna tower, and the work is now advancing smoothly (Photo 5).

2. Construction schedule

Productivity at the Itayagawa river site is to be boosted by increasing the amount of remote control equipment in use. To further facilitate the work, the control base is to be moved forward (on June 10, 2000) along with the temporary disposal area. As regards the work in the Nishiyamagawa area, plans are in place for a site survey and for removal of debris from washed-out bridges blocking the watercourse. We are looking forward to success with these works despite the difficulties encountered.