Effect of Emergency Measures to Minimize Debris Flow Disaster after the Pyroclastic Material Deposition in Gendol River due to the 2010 Eruption of Mt. Merapi, Indonesia

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INTRODUCTION

Mt. Merapi in Central Java, Indonesia is one of the most active volcanoes in the world. The surrounding area of Mt. Merapi has been suffered from pyroclastic flow and debris flow disasters caused by volcanic eruption. Since there are densely populated areas including Yogyakarta City at the southern foot of Mt. Merapi, the Government of Indonesia started the national disaster control program consisting of structural and non-structural measures from the 1970s. According to the sabo master plan reviewed in 2001 (hereinafter referred to as "Review Master Plan (2001)"), currently implemented structural measures are aimed at controlling debris flows caused by a major eruption occurring once in decade, which supplies approximately 5 million m^3 of pyroclastic material. However, the 2010 eruption of Mt. Merapi that began on October 26, 2010 was the largest in record, and its scale was rated once in more than 100 years. According to the analysis of radar images, the eruption occurred on October 26, 2010 removed ~6 million m^3 of mainly non-juvenile material from the summit (Surono et al., 2012). Most of the removed material was flowed down to Gendol River. Furthermore, on November 5, 2010, the largest pyroclastic flow occurred and flowed down to the point 15 km from the summit through Gendol River. Volume of lava dome and non-juvenile material which collapsed due to the pyroclastic flow was estimated to be ~5 million m^3 and 10 million m^3 respectively (Surono et al., 2012). According to the above, total 20 million m^3 of materials were flowed down to Gendol River from October 26 to November 5, 2010. This amount is equivalent to four times the design pyroclastic flow amount assumed in Review Master Plan (2001). Due to the pyroclastic flow, the riverbed of Gendol River increased remarkably. Especially in the river section between 10 km and 13 km from the summit, the river channel was completely buried, and surface of the pyroclastic flow deposits became higher than the surrounding area. Because of that, the disaster risk of debris flow, which frequently occurs in the rainy season after the volcanic eruption, was remarkably increased.

EMERGENCY MEASURES

In order to try to minimize the damage from debris flow, Mt. Merapi Lahar Control Office, the execution agency of sabo works for the Mt. Merapi area, carried out several emergency measures during the rainy season between 2010 and 2011 in coordination with organizations concerned. As of 2010, there were 19 sabo dams on Gendol River. Reservoir of the dams to the 14th from the upstream were already filled with the pyroclastic flow material, while remaining five sabo dams located between 16 km and 19 km from the summit were still empty. In order to guide the debris flow to the five downstream sabo dams, emergency measures consisting of temporary guide channels and embankments were implemented. The guide channel is a minimum 30 meter wide unlined channel formed by excavating the pyroclastic flow deposits. The excavated materials were dumped on the both bank of the channel as the temporary embankment. For the excavation and embankment work, common heavy equipment, a backhoe, was used. The riverbed slope where the guide channel was constructed was 5 % (1/20) to 2.57 % (1/39). The guide channel had to be constructed in the rainy season, but the work could be proceeded during a sunny time because of a simple construction work.

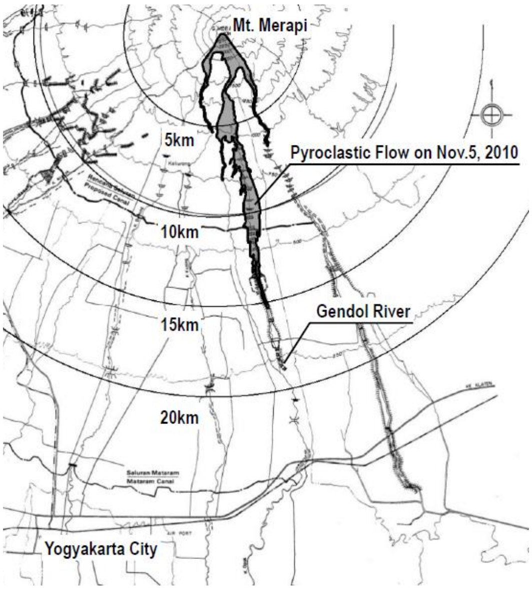

Fig. 1 Pyroclastic flow on Nov. 5, 2010

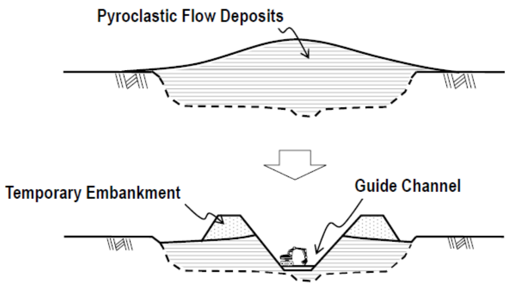

Fig. 2 Schematic diagram of guide channel

DISCUSSION

In the first rainy season after the 2010 eruption, the number of debris flow occurrence days in Gendol River was 34 days. Despite the high frequency, flooding of the debris flow did not occurred in the section where the guide channel was constructed. Although it was a simple construction work and required regular excavation work for the maintenance, it was effective enough to prevent flooding of debris flow. However, some problems are also clarified. Although the inside of the pyroclastic flow deposit was high temperature, heavy equipment had to be operated manned. Every time debris flow ran down, the heavy equipment needed to be evacuated to higher place.

CONCLUSINON

The emergency measures consisting of guide channel work and the temporary embankment work on the pyroclastic flow deposits achieved some positive results. These measures may be applicable to similar cases in other volcanoes. In order to ensure safety during construction work, it is necessary to prepare evacuation routes for heavy equipment. It is also necessary to consider unmanned construction work.

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