The Prevention Disaster Program of Flood in 2013 for the 4th Grade Students of Kawatanaka Primary School, Tokushima Prefecture, Japan and Underflow Channels Revealed in 2016

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Abstract. The Typhoon No. 18 caused flood on September 15, 2013 in the Kawata River basin, Yoshinogawa City, Tokushima Prefecture. The Kawata River is a raised river bed of 36.7 m with banks to 40.5 m above sea level. The heavy rain did not destroy the banks but made the river level 39.4 m high and then pressed the underflow channel. As the Kawatanaka primary school is located at 36.2 m height, it was not submerged although the underflow channel overbanked the adjacent playground. An educational program on the prevention and reduction for natural disaster, which consists of science, social studies and presentation, was conducted to 18 students of the 4th grade in the period of integrated study in the Kawatanaka primary school from September 17, 2013. On the first day, flow current markings from 625 holes, 30 cm to 1 mm in diameter, on the playground were observed. The flow currents showed direction from SE to NW. On the basis of their observations on the flow currents that water runs from high to low, the students considered the phenomena as a result of tilting of the ground. They conducted activity as their homework to confirm their hypothesis to know if there is any tilt in the ground. They took plastic bottle filled with water and reviled that the ground had 1 to 2 degrees’ tilt to the NW during the experiment. On the bases of the difference between E to W flow of the Kawata River and their SE to NW estimated current flow on the playground and the fact that the bank of the river was not destroyed, the students suggested that the heavy rain had pressed the underflow channels. The suggested channels were found on the playground, where new school buildings were constructed in 2016, by one of the students who studied the program in 2013.

1. Introduction

As the predictability for natural disasters of students in primary schools is not developed well, the Ministry of Education, Culture, Sports, Science and Technology, Japan has been promoting the prevention and reduction study of the disaster in primary and junior high-schools [1]. However, the school teachers do not know how to deal with the task due to the lack of guidelines of the Ministry.

The prevention and reduction study for the natural disaster in the school has to make students and teachers safe. However, the lessons are not enough. When the natural disaster occurs, it is not enough for the students to know how to escape from such disasters. They shall know the mechanism how
does it occur in order to survive. The significance of the study can be felt in case they suffer from the same disaster.

The heavy rainfall-related disasters frequently occur in Yoshinogawa city, middle Tokushima Prefecture [2]. As Kawamata and Murata [3] have reported the prevention of flood disaster for the 4th grade students in Kawatanaka Primary School, the hydrological approach to the typhoon flood disaster of the students is reported.

2. Submergence by the typhoon No.18, September 15, 2013

2.1. Outline of geography
Kawata is on the Yoshino River which flows from the West to the East and is the largest river in the Tokushima Prefecture. The area is developed on the alluvial fan made by Kawata River [4, 5], which runs from the North to the South for 16 km long and is 120 m wide in maximum and runs and flows together with the Yoshino River at Kawata-Kitajima. The flatter plain, discharge zone of alluvial cone is used for the rice field.

The Kawatanaka Primary School is situated 36.2 m above sea level in the middle of the fan and on the western bank of the Kawata River. The river is a raised bed river and its river bed is 36.7 m high with banks up to 40.5 m and usually flows underground due to coarse grains of the fan deposits.

2.2. Floods in the past
Many floods were recorded in the last 400 years in this area. Recently four submergences occurred. The typhoon No.23 on October 20, 2004 submerged 150 houses up to the floorboard and 90 houses above the floorboard. The typhoon No.9 on August 8, 2009, submerged 48 houses up to the floorboard and 34 houses above the floorboard. The typhoon No.15 on September 29, 2011 submerged 19 houses up to the floorboard and 4 houses above the floorboard. The typhoon No.18 on September 15, 2013 submerged one house up to the floorboard.

2.3. Flood caused by the typhoon No.18 on September 15, 2013
The amount of rainfall precipitation was 228 mm. The Kawata River surface reached 39.4 m above sea level, but its banks were not destroyed. A house, many rice fields and roads around the intersection points of the alluvial fan were submerged.

The Kawatanaka Primary School was built in 1881. The eastern end of the school is attached on the bank of the Kawata River. Its playground (54 m x 88 m) on the coarse-grained debris of alluvium fan was overlaid with topsoil and flattened. The school was not damaged by the flood, but the spouts, eruption holes of running water, were observed on the playground.

3. The playground on September 17, 2013
The schools were closed due to the typhoon on September 15 and during a national holiday on September 16. It was fine on September 17. Dried playground showed many cracks and holes with current marks indicating fountains on September 15. As the spouts occurred in the northern part of the playground, they were considered to be the traces of the underflow channel.

4. Activity of the fourth-grade class
There were eighteen students in the fourth-grade class (10 years old) in the Kawatanaka Primary School, but no victim of the flood. They started to study the prevention and reduction of flood disaster in the period for integrated studies [6] for two continuous hours in a week, which combined natural sciences, social sciences and presentation, from September 17 [3]. As the school teachers could arrange learning materials by themselves in the period for integrated studies, the typhoon flood disaster was studied by the hydrological approach.
4.1. Observation and suggestions

The students observed the surface of the ground, counted 625 holes and measured the irregular shapes from 1 mm to 30 cm in diameter and up to 80 cm deep. And the students found the holes occurred mainly in the northern part of the ground. However, there was no regularity among the distribution, diameter and depth.

Gravel to coarse pebble of sandstone and Sambagawa green schists were present around the holes (figure 1). The students considered the rocks were erupted with water to the ground due to the difference of colour and size from the soils on the surface. The students also found the coarse-grained sand array from the erupted center, spout. The students considered the array would show the trace of the running water because the array resembled the melting ice cream on the cones and ripples in the sea and river, and estimated the current flowed from SE to NW. The direction was also supported by the erosion direction on the spout.

![Figure 1. Spout on the playground.](image)

The students expected water from the Kawata River flowed from E to W, since the playground was attached on the western bank of the river. But the estimation direction of the running water was not E-W but SE-NW. They detected that the difference between estimated and measured directions was caused by the tilting on the playground, because water should run from high to low.

To make a learning material to detect the tilt on the ground, the students were given homework for the subject matter. They made three kinds of levels as their homework; plastic bottle with water, plastic bottle with marble, and corrugated carton track for marble. The homemade levels showed that the ground had a tilt to NW, and the level of plastic bottle with water showed the tilting with 1 to 2 degrees. After they concluded, they watched the video film which had recoded the current flow in the playground on September 15 and could confirm that their conclusion was right.

4.2. Presumption about submerged area

The students measured the tilting direction on the roads surrounding the school. Their levels revealed the north tilting on the roads which seemed to be flat. The students expected the flood disaster would occur in the lower altitude above sea level and confirmed the direction of water flow with their levels and topographical map. The Kawata River is a raised bed river and its river bed is 36.7 m with banks
to 40.5 m above sea level. The heavy rain did not destroy the banks but made the river level 39.4 m high and then pressed the underflow channel. As the Kawatanaka Primary School is situated at a height of 36.2 m, it was not submerged although the underflow channel overbanked on the ground. The students memorized that the road at a height of 31.7 m was not submerged, but that the area below the road was submerged. The students plotted the submerged area on the topographical map. The submerged rice fields and roads were around the intersection points of the alluvial fan. Kawatanaka-Nakajima, where the Kawata River flows together the Yoshino River, was newly developed residential area and submerged. Those who moved from the prefectural capital Tokushima did not know its frequent flood disaster. The students searched the shift of residential area as compared with topographical 1/25000 maps published in 1958 and 2007 by the Geospatial Information Authority of Japan. The comparison revealed that the residential area shifted to lower land due to convenient life although the area was submerged frequently.

4.3. Hazard map published by Yoshinogawa city
The students found that their school was shown as a designated refuge place in the hazard map published by Yoshinogawa city. They knew that the underflow channel of Kawata River flowed forcefully on the playground of the school and the roads of the northern part of the school, and felt they could not come to the school at the time of flood.

5. Home learning
The students briefed their parents and neighbours about the prevention and reduction of the flood disaster during the presentation of their study [3]. Before the presentation there was no discussion about the flood and many parents did not know the presence of the hazard map. More than 50% families did not know frequent flood disaster in the area because they shifted within 10 years. The parents and neighbours were impressed from the presentation of the children and took interest in the disaster mitigation.

They discussed the prevention and reduction of the flood disaster in the family and confirmed designated refuge place and the route. At last, they requested the Tokushima Prefectural office for the prevention of flood disaster to maintain the raised bed river from debris. Finally, the Tokushima Prefectural office dredged out sludge from the Kawata River, which is not a raised bed river.

The students considered that the prevention of flood disaster was worth studying and that they would solve the problems related to disaster prevention by themselves. They knew that what they studied in the class was not mere knowledge for examinations but useful wisdom to live. It is an unexpected surprise that the study made the students to study other subjects on their own.

Figure 2. Underflow channels, piping, on the playground
6. Finding of underflow channels suggested in 2013
The students, who studied the prevention and reduction of the natural disaster in 2013, graduated from the Kawatanaka primary school in March and entered the Yamakawa junior high school in April 2016. When one of the students visited the primary school in summer holidays, he found vertical conglomerate strata on the playground where new school buildings were under construction. As he knew that particles should deposit horizontally in water, he found the vertical strata were extraordinary. He told his findings to his mother, and in response she called his class teacher namely (S.K.) who had shifted the school. The photo of construction site on playground of the school in August in 2016 is shown in figure 2. The funny strata are the underflow channels, pipings, which the students suggested in 2013. The pebble and cobble mainly of Sambagawa green schist filled channels of left end and center in figure 2. However, the construction crew did not recognize them, but found that the channels spouted out water on heavy rainy day. Therefore, we can conclude that the underflow channels, pipings, which the students suggested in 2013, were revealed in 2016.

This educational program organized for primary students on the “prevention and reduction for natural disaster” was based on proactive, creative and cooperative approaches in problem solving and inquiry activities with the self-education. The study of the prevention and reduction of natural disaster may be one of the best ways to develop the calibre and capability of stakeholders in the sustainable development.

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