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A CASE STUDY OF CHARACTERISTICS OF DAMAGES CAUSED BY TYPHOON EWINIAR 2006 IN SOUTH KOREA

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ABSTRACT

During recent years, the climate of Korea has clearly been divided between dry season and rainy season due to the global warming and other reasons, and a record breaking rain is falling every year. The mountain slopes in Korea receives significant damage generally during the seasons of high rain front and typhoon. In 2006, the rainy season started in July and Typhoon EWINIAR which hit South Korea between July 26 and 28 caused significant damage to various slopes and roads. This paper presents a case study of the damages and characteristics of the damages to cut slopes, fill slopes, and roads caused by the concentrated heavy rains for 3 days in the regions of Inje and YangYang.

INTRODUCTION

Most of the landslides that occur in Korea are avalanche of sand and stone that flow due to the weathering of the parent rock on a mountain slope. They usually occur during the period of concentrated rains between June and August, and the thawing season which is between March and April.

During recent years, the climate of Korea can be clearly divided between dry season and rainy season due to the global warming and other reasons, and a record breaking rain is falling every year. In Korea, the collapse of mountain slopes happens mainly during the seasons of high rain front and typhoon which cause enormous property damage and casualties.

Typhoon EWINIAR, which landed near Jindo Island in Jeollanam-do province on July 10, 2006, was a middle size typhoon with a central air pressure of 998 hPa and maximum wind velocity of 19 m/sec. It perished near Hongcheon at about 10 pm on the same day. However, it caused a concentrated heavy rain in Gangwon region after it deteriorated into a temperate depression. Figure 1 shows the locations of disembarkation and disappearance of Typhoon EWINIAR. Figure 2 provides information about Typhoon EWINIAR and brief summary of the damage caused by this typhoon. Figure 3 provides the summary of damages to various structures at different locations in the Kangwondo Region. This paper presents the results of a study performed to understand the reasons of damages on the sites of collapses of natural slopes and cut slopes in addition to roads that happened in Gangwon province during the concentrated heavy rains of July 2006.

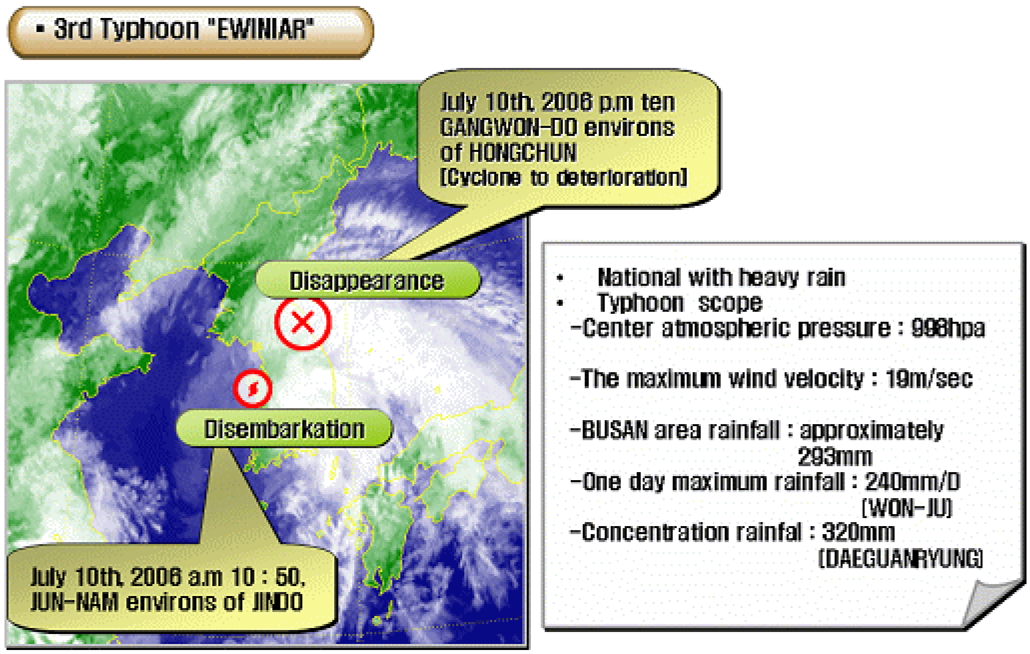

Fig 1. Locations of Disembarkation and Disappearance of Typhoon EWINIAR

Classification	2006 Local severe rain (7.7 ~ 7.29, 23days)
Accumulation precipitation	**Hongcheon 1,208,** Jecheon 1,024, Seoul 990
Human life damage	63man(landslide **20**, A river and a valley torrent30, etc 13)
Suffering people generating	9,340man(Kangwondo **5,000**, Gyeonggido 1,500)
Property damage	Institution damage : 1 trillion 922,800 million won

Fig 2. Information about Typhoon EWINIAR and Brief Summary of the Damages

Division	Hoengseong	Yanggu	ongcheon	Pyeongchang	Inje	Yangyang
Road	71 places / 15,220m	48 places /7,343m	53 places /4,673m	135 places /62,444m	197 places /93648m	16 places /26,000m
Bridge	-	-	-	10 places/865m	7 places/192m	-
Stream	87 places /20,654m	81 places /73,772m	86 places /33,908m	390 places 346,104m	126 places /95,095m	30 places /24,050m
House damage	26 buildings	40 buildings	50 buildings	1,212 buildings	515 buildings	198 buildings
Casualties	1	-	-	9	14	-

Fig 3. Summary of Damages to Various Structures at Different Locations in the Kangwondo Region

DAMAGE TO CUT SLOPES

Stone falling

In the damaged area, rocks partially fell down from the cut slope due to weathering of the face of the rock or the penetration of water into the joint face. However, there was no serious damage to the roads primarily because the slopes were equipped with facilities to block the falling rocks. Figure 4 shows the pictures of stone falling and the blocks to prevent damage or blockage of the roads.

Fig 4. The Damage Example due to Stone falling

Shallow failure due to surface run-off

It was estimated that the collapses occurred when the underground water flew along the joint face of the loose and stiff layers after the concentrated rain. As a result the soil lost its shear strength at the interface, which caused the slope to fail. The common size of the collapse was 50cm ~ 1m in depth and 1m ~ 2m in width. Figure 5 shows the schematic of the slope failure due to surface runoff and Figure 6 shows a picture of the failure caused by surface runoff.

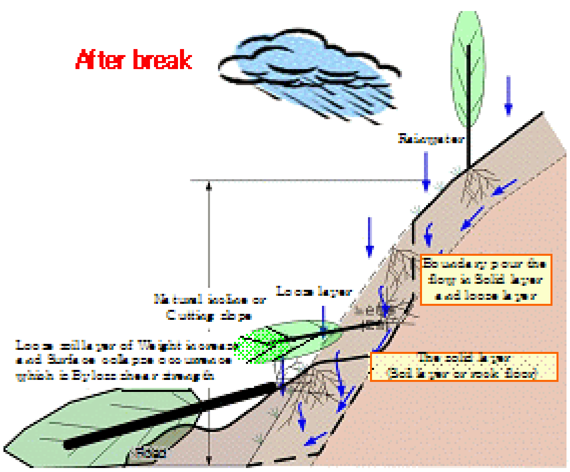

Fig 5. Schematic of slope failure due to surface runoff

Fig 6. Picture of slope failure due to surface runoff

Circular arc failure

Some cut slopes and natural slopes failed in a more or less arc pattern primarily due to (1) the process of freezing, melting, and weathering, (2) the increase in self weight of the soils, and (3) the reduction in shear strength of soil caused by heavy rains. In this rainy season, the surface runoff also caused some slopes to fail in the arc pattern. Figure 7 shows the schematic of the arc type failure of the slopes and Figure 8 shows a picture of the arc type failure of a slope.

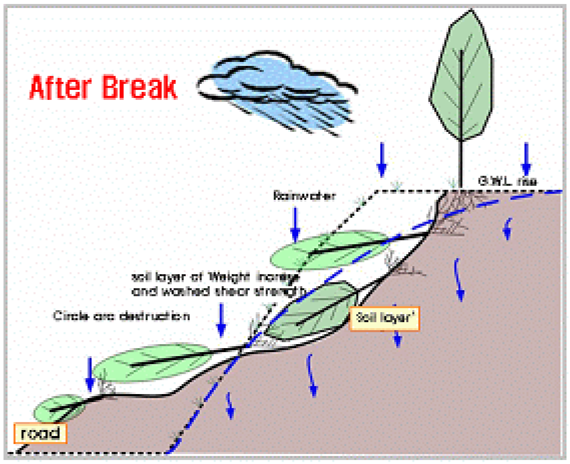

Fig 7. Schematic of arc type failure

Fig 8. Picture of arc type failure

DAMAGES TO FILL SLOPES

Transection segment

At places where fill slopes were constructed on bedrock, the water from valleys and roads penetrated the fill layer and flew on the face of the rock and washed off soil which resulted in the collapse due to the loss of the soil from the fill layer. Reinforcing stone walls and retaining walls constructed on these fill slopes collapsed due to the loss of the soil layer. Figure 9 shows the picture of failure of fill slope.

Fig 9. The damage example by banking section

Fill segments

Another type of damage that occurred on the fill slopes was due to washing out of the fill after the fallen soil from the adjacent cut slope blocked the flow of the water. Figure 10 shows the pictures of fill slope failures due to washing of fill materials.

Fig 10. The damage example due to washing of fill material

DAMAGES TO SECTIONS ADJACENT TO STREAMS

Loss due to water impacting

Heavy rains caused significant flow in the streams. The bank protection facilities like retaining walls constructed at locations where streams meandered, failed because they could not endure the impact of water caused by concentrated heavy rain. Figure 11 shows the schematics of failure to roads at stream banks and Figure 12 shows the picture of such a failure.

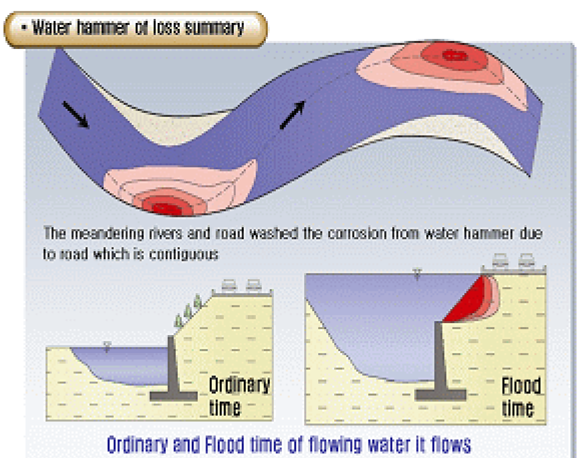

Fig 11. Schematic of water-impacting portion

Fig 12. Picture of failure due to water impact

Damage by the extraneous materials transported by the water

Typical mountainous roads in the region had valleys and slopes on both sides which are connected by crosswise drain pipes to drain water from one side to the other as shown in Figure 13. Damage to these roads was observed after the July 2006 heavy rains. Based on the observations made, it was concluded that the extraneous materials transported by the water that poured from the valley on the right side blocked the draining function of the crosswise drain pipe and forced the water to flow above the roads. The increased water pressure washed away the roads. Figure 14 shows the damage to the road caused by overflowing water.

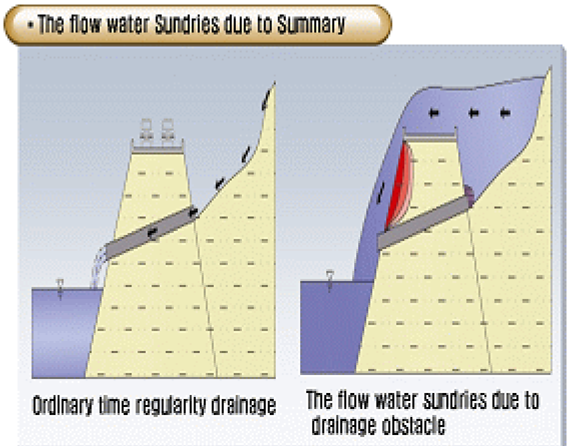

Fig 13. Damage due to flow of extraneous material

Fig 14. Damage to a road due to overflowing water

DAMAGE DUE TO FALLING ROCK AND SOIL

The collapse of the slopes in Gangwon-do region, due to the concentrated heavy rain, occurred mainly in natural slopes, especially the rocks and soil in the valleys. The damaged areas were valley with colluvium that had big rock mass on the rock face, and there were thick forests in the valley. Due to the rainfall, the extraneous materials transported from the upper part paralyzed the function of the crosswise drain pipe at the lower part of the road, and the concentrated rainfall overflew and eroded the filling part of the road. Figures 15 and 16 show the schematics of damages to roads due to falling of rocks and soil. Figures 17 and 18 show pictures of road failures due to falling of boulders.

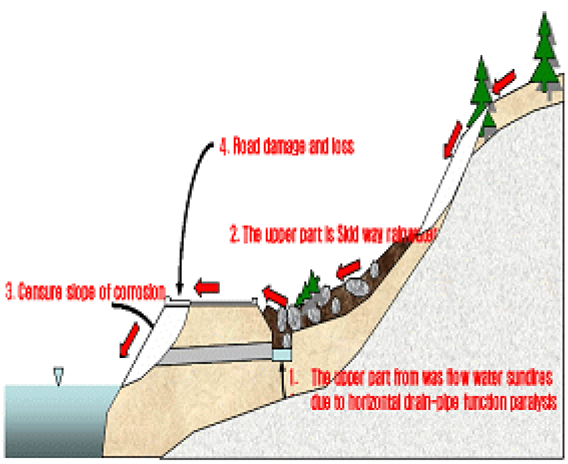

Fig 15. Road breakage by the boulder flow

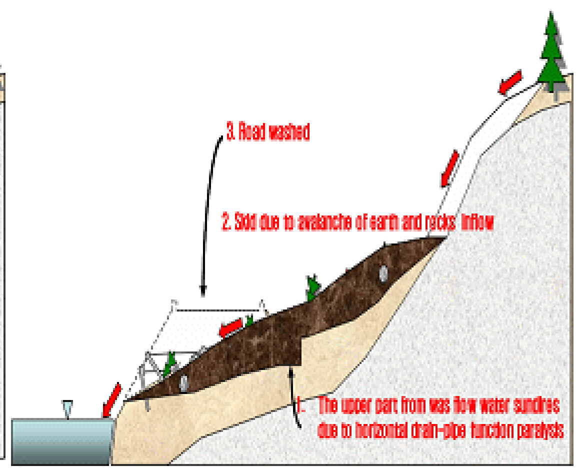

Fig 16. Road breakage example

Fig 17. Loss of road by the boulder flow

Fig 18. Loss of road example

CONCLUSIONS

A case history of damages in the regions of Inje and YangYang caused by the concentrated heavy rains for 3 days from July 26 to July 28, 2006 is presented. The conclusions of the investigation are as follows:

(1) Most of the collapses of the slopes were minor washout of soil. So there were no serious casualties, but the massive loss of rocks and soil that occurred in the valley parts caused the washout of many roads.
(2) To prevent the repetition of similar damages, it is recommended to develop and improve the breeds of plants that fit the characteristics of domestic atmosphere and apply them to the actual sites.
(3) It is recommended to set up structures like control dam that can decrease the movement energy of rocks and soil in the places where valleys are formed.

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