

Recognition Methods Research On Flood damage Of Highway Slope In Mountainous areas

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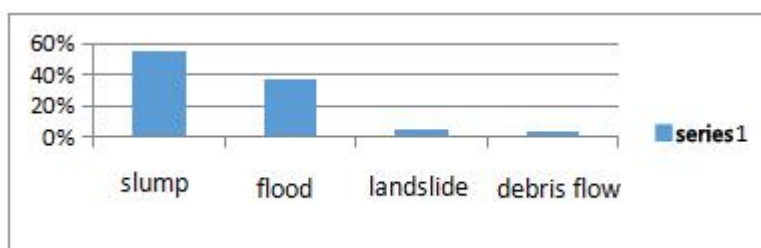
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Abstract This paper introduces the effect factors of flood damage of highway upper slope in mountainous areas, predicting model and main points of identification technique. Combining with the application example of north mountainous area by Jizhou District, shows the method's validity and practicability.

The flood damage of highway upper slope in mountainous areas often caused by strong precipitation process. Displacement of soil slope phenomena are extremely popular, where there is slope, there is movement of rock and soil slope. Combining internal stress of rock mass and external stress such as a strong precipitation, to form to slump, and lead to the destruction of along the highway.

Result and Analysis on investigation about flood damage losses of highway in the whole area, researchers found there were 67 flood damages in recent 3 years. Among those, pavement damages, highways and bridges destroyed, Pavement damages initiated by slump and by debris flow respectively were 55%, 37%, 5% and 3%. The frequency comparison of all kinds of the flood damages of highway in the area shown in FIG 1.



The flood damage of slope evaluation factors

The flood damage of highway slope in mountainous areas often caused by the slope runoff generated by strong rainfall, and the infiltration process. The size of radial flow of slope determines the damage degree of flood damage of slope to existed highway slope. Considering the main influencing factors of the mechanism, the researchers selected four factors, such as rainfall factor, terrain slope factor, geotechnical type factor and vegetation coverage factor, to evaluate the strength of slope runoff.

①Rainfall factors (J)

The short duration heavy rainfall in Tianjin mountainous areas is more common, and the 24h rainfall of 25mm may cause serious highway slope disaster. According to the expert survey, the research group selected the index of "annual average rainfall greater than 25mm days" to reflect the effect and influence of rainfall factor, and divided into five grades, the impact of the value shown in Table 1.

Table1 Rainfall factor classification table

Grade of rainfall factors (J)	<1d	1~3d	3~7d	7~15d	>15d
influence degree	weak	weaker	medium	stronger	strong
influence value	0.10	0.25	0.50	0.75	0.90

② Topographic slope factor

Slope is an important parameter to reflect the terrain factors. Combining with the grading requirements of highway project on terrain slope, the influence of terrain slope factor on slope runoff intensity is divided into five levels and endow the influence value, shown in Table 2.

Table 2 terrain slope factor classification table

Grade of terrain slope factor (J)	0°~6°	6°~15°	15°~25°	25°~35°	>35°
influence degree	weak	weaker	medium	stronger	strong
influence value	0.05	0.20	0.40	0.75	0.90

③ Rock type factor (Y)

For different types of rock and soil mass, when the ability of resistance to erosion is strong, infiltration rate is low; that is easily to promote overland flow, erosion intensity is small. According to the experts' opinion, the influence degree of rock type on slope runoff intensity is divided into five grades. Shown in Table 3.

Table 3 geotechnical type factor classification table

Grade of geotechnical type factor (Y)	hard rock	Gravel Soil, extremely soft rock	cohesive soil	sand formation	Loess, silty soil
influence degree	weak	weaker	medium	stronger	strong
influence value	0.10	0.40	0.60	0.75	0.90

④ Vegetation coverage factor (Z)

According to the experts' opinion survey, the study group divided the vegetation type and coverage degree on the slope runoff intensity into five grades, the impact of which is shown in Table 4.

Table 4 Vegetation coverage factor classification table

Grade of Vegetation coverage factor (Z)	>80%	50%~80%	20%~50%	5%~20%	0%~5%
influence degree	weak	weaker	medium	stronger	strong
influence value	0	0.10	0.50	0.75	1.00

Flood damage of slope assessment model

The study team used the index of the slope runoff intensity to representation of slope runoff intensity, considering rainfall factor (J), terrain slope factor (D), rock type factor (Y) and vegetation coverage factor (Z) to calculate slope runoff intensity index. The calculation model is as follows:

$$P=a_1 \times J+a_2 \times D+a_3 \times Y+a_4 \times Z \quad (\text{Equation 2-1})$$

P represents the slope runoff intensity index; J, D, Y, and Z represent the influence degree of rainfall, terrain slope, rock type and vegetation coverage respectively. a_1 , a_2 , a_3 , a_4 represent the weight coefficients of rainfall, terrain slope, rock type and vegetation coverage.

The weight determination method uses AHP, through the expert opinion survey, the analysis and calculation of the impact factor weight value shown in Table 5.

Table 5 the impact of each factor weight table

factor weight	rainfall factor (J)	terrain slope factor (D)	vegetation coverage factor (Z)	rock type factor (Y)
weight value	0.35	0.30	0.15	0.20

According to the regional distribution characteristics of runoff intensity index (P), the slope runoff intensity can be divided into weak, medium and strong level. According to the formula 4-1, the calculated range is between 0.055 and 0.915, The corresponding level of runoff intensity range to the possibility of flood damage correspondence as shown in Table 6.

Table 6 slope runoff intensity index corresponds to the possibility of highway flood damage

Grade of slope runoff intensity index	weak	medium	strong
P	0.055~0.35	0.35~0.45	0.45~0.915
Possibility of flooding disaster of highway slope	Less occurs	May happen	Prone to happen

The application of north mountainous area by Jizhou District evaluation model analysis

Researchers have taken the comprehensive investigation those 9 roads below and other roads in mountainous areas. The duration is about 15 days, getting 12 slope hazard points, the basic data information is as follows:

Table 7 The basis data of mountain flood damage risk table

Highway name	Types of geotechnical	Geotechnical type factor influence	Terrain slope	Terrain slope factor influence	rainfall is greater than 25mm days	Rainfall factor influence	Vegetation coverage	Vegetation coverage factor influence
North Jinwei Road	Gravel Soil	0.40	60°	0.9	12d	0.75	75%	0.1
Sangyuan Section, Maping Road	Gravel Soil	0.40	55°	0.9	11d	0.75	82%	0
Xinshui chang Section, Yulong Road	Gravel Soil, extremely soft rock	0.40	57°	0.9	9d	0.75	77%	0.1
Yangjiayu Section, Luoyang Road	Gravel Soil, extremely soft rock	0.40	62°	0.9	11d	0.75	83%	0
Chuancangyu Section, Limutai Jingguan Road	Gravel Soil	0.40	66°	0.9	12d	0.75	74%	0.1
Gan Jian Section in the front of Jin Qian Road	hard rock	0.10	59°	0.9	12d	0.75	81%	0
Guoxi Section, Guoying Road	hard rock	0.10	71°	0.9	10d	0.75	84%	0
Shuangan Section, Caigou Road	hard rock	0.10	56°	0.9	10d	0.75	78%	0.1
Huliyu Section, Huji Road	hard rock	0.10	63°	0.9	10d	0.75	76%	0.1

Those data can be put into Equation 2-1 to calculate the magnitude of surface runoff intensity of each mountain section and determine the probability of flood damage, and make a preliminary judgment on the time node and the type of flood damage as follows:

Table 8 The probability of flood damage pre-judgement analysis table

Highway name	runoff intensity index P	The possibility of occurrence	Time	the type	control program
North Jinwei Road	0.6275	Prone to happen	June to August	Slump	biological control
Sangyuan Section, Maping Road	0.6125	Prone to happen	June to August	Slump	protecting mesh
Xinshuichang Section, Yulong Road	0.6275	Prone to happen	June to August	Landslide	protecting mesh
Yangjiayu Section, Luoyang Road	0.6125	Prone to happen	June to August	Slump	protecting mesh
Chuancangyu Section, Limutai Jingguan Road	0.6275	Prone to happen	June to August	Slump	protecting mesh
Gan Jian Section in the front of Jin Qian Road	0.5525	Prone to happen	June to August	Collapse	anti-sliding retaining wall
Guoxi Section, Guoying Road	0.5525	Prone to happen	June to August	Collapse	anchor retaining wall
Shuangan Section, Caigou Road	0.5675	Prone to happen	June to August	Debris flow	Retaining Structures& biological control
Huliyu Section, Huji Road	0.5675	Prone to happen	June to August	Debris flow	Retaining Structures& biological control

According to model, the researchers identified the high risk area of the slope disaster scientifically and accurately , and quickly identified the type of disaster through the identification technology, targeted to develop a scientific and feasible control scheme, so that the degree of damage of flood damage risk was with a minimum Level.

The preventive effect of comparative analysis

In 2015, the north mountainous areas by Jizhou District road on the slope of the flood damage hazard factors have been greatly curbed and eradicated, flood damage got the greatest degree of control, compared with 2014, the contrast diagram of preventive effect of the pre-identification technology is as follows:

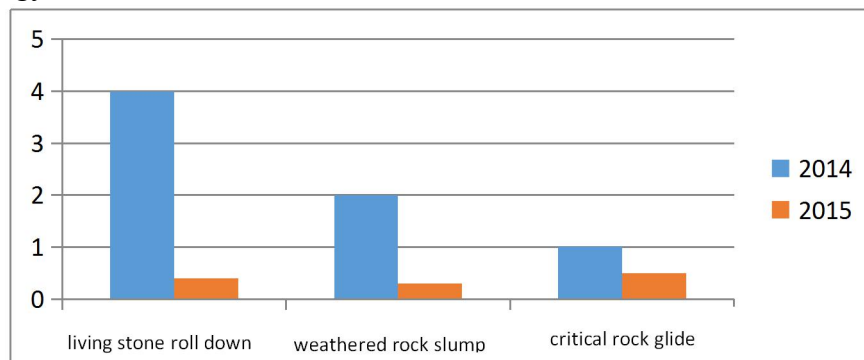


Chart2 the contrast of active flexible protecting nettings prevention adversities effect.

By comparing the 2016 and 2015 on the loss varying diagram of the flood damage of highway upper slope, we can clearly see that the mountain slope flood damage identification technology is fruitful and remarkable in disaster reduction for reducing the loss of flood damage, improving the pre-disaster prevention , accuracy of disaster preventive work.

Concluding remarks

Flood damage prevention needs the researchers continue to strengthen the evaluation system research, identification methods to be innovative, taking efficient and scientific identification of technical guidance to deployment in prevention and control system, promoting the level of disaster prevention and reduction in mountainous roads.

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