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A technique to discriminate landslides

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ABSTRACT

This paper describes an innovative way of distinguishing landslide-prone regions by simple and direct measurement and statistical interpretation of a topographic map. For this purpose, the topographic maps are enlarged and the contour interval and cross-slope distances are measured. A frequency distribution histogram based on chi-square method is constructed from the measurements. Generally, two fundamental patterns emerge from the histogram: the landslide-prone area shows several peaks whereas the remaining area shows just a single peak.

The technique was used to study the landslide-prone areas of the western Kyushu District of Japan. Six sub-regions were categorised depending upon the scale functions and probability parameters. The landslide-prone and safe areas were accurately discriminated under 0.1 to 1 % confidence level. The analysis independently discovered most of the hazardous areas that were later verified in the field.

INTRODUCTION

This paper describes an innovative method of identifying landslide-prone areas by carrying out measurements, analysis, and interpretation of topographic maps. A case study of landslide study in the western Kyushu region of Japan is also presented here.

Japan is formed by a long chain of islands extending in a north–northeast direction between latitudes 24° and 46° N. It occupies an area of about 480,000 km², of which 85% is mountainous and prone to landslides. Further, heavy precipitation (annual mean about 1,800 mm) is another important factor triggering landslides. Most landslides are found either on soil or on weathered bedrock.

CHI-SQUARE DISTRIBUTIONS

Chi-square is a popular statistical procedure as any dichotomous or non-dichotomous types of data can be easily analysed. This procedure is also called a goodness-of-fit test (Schefler 1988). The procedure involves measuring the distance between contour intervals by drawing normal lines. A goodness-of-fit test, tests for independence, and tests for homogeneity are made by this method. From values of the observed frequencies (O), expected frequencies (E) and their difference (O-E), the chi-square (χ^2) distribution is computed as $\chi^2 = \sum (O-E)^2/E$ for the required level of confidence.

The landslide-prone areas in the western Kyushu District of Japan were discriminated using chi-square distribution of contour intervals and cross-slope distances. For making the study less strenuous, the topographic maps (1:25,000) of the area were enlarged (about 4 times), and the contour intervals and cross slope distances were measured (Table 1). The data were used to construct a frequency distribution histogram (Fig. 1).

A detailed study of this area was carried out by Hirashima (1999). Two regions were found to be stable from the study of histograms of the topographic contours, clearly demonstrating the effectiveness of this method.

Fig. 2 shows a typical chi-square plot for the Sasebo "C" area. The absence of a single peak indicates that the area is susceptible to sliding. The randomness (? errors) in the distribution values, other than the statistical error reflects the potential features of uneven slopes or the landslide susceptible areas. Fig. 3 compares the plots of a landslide susceptible location with those of a safe area. The single peak and multi-peak characteristics are clearly discerned on the plot.

Table 1: Data obtained from topographic maps

Interval measured on the map (mm)	Actual topology interval (m)	Occurrence frequency
1	6.25	0
2	12.5	8
3	18.75	15
4	25	30
5	31.25	11
6	37.5	12
7	43.75	4
15	93.75	2

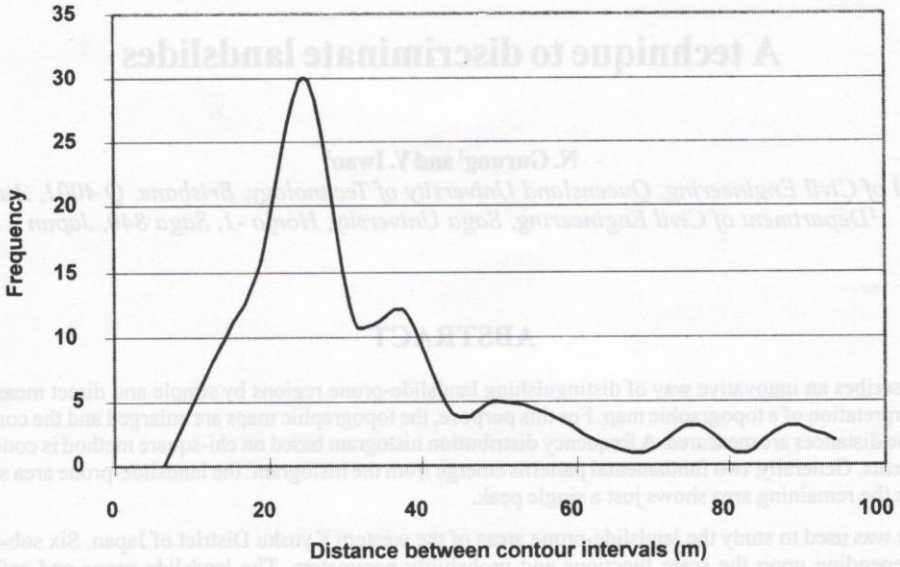

Fig. 1: A Chi-square plot

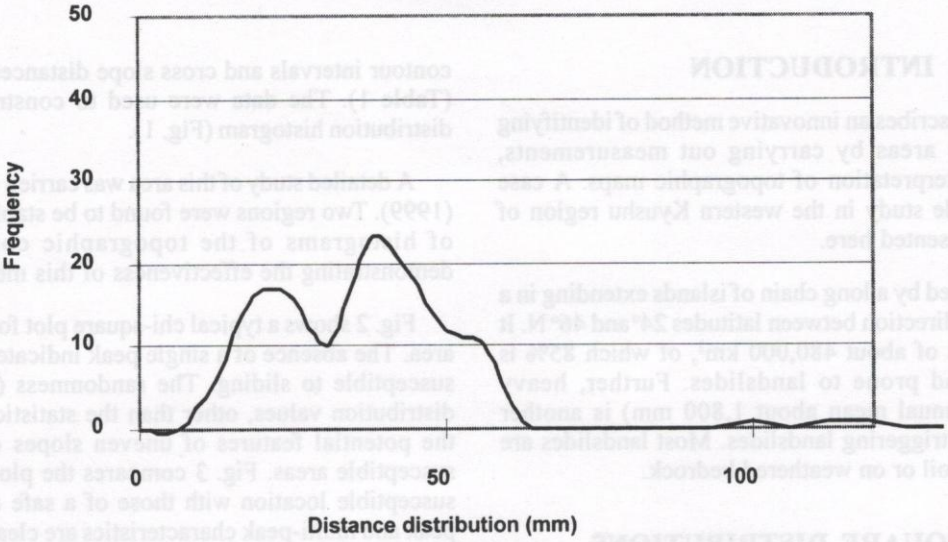

Fig. 2: Chi-square plot of Sasebo "C" area

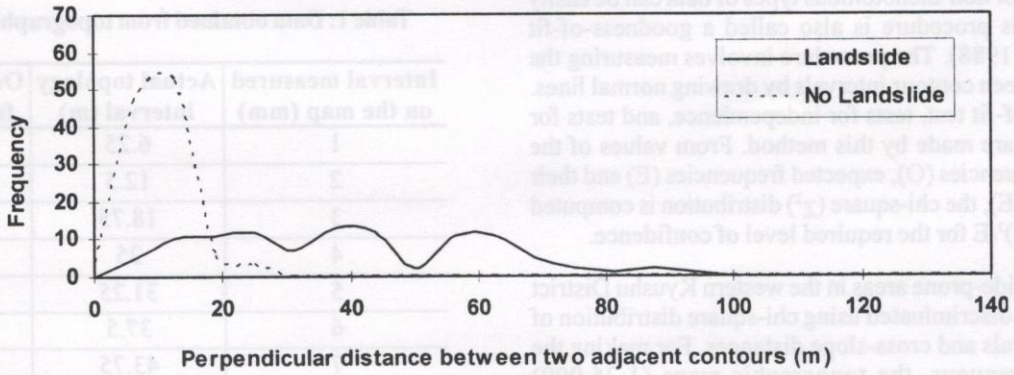

Fig. 3: A comparison between plots of landslide-prone and safe areas

Fig. 4 presents a comparative diagram of frequency versus contour spacing for no landslide zones (i.e. safe areas) A and B of the Sasebo region. The maximum frequency for the safe area B is observed to occur at 3 m contour interval.

Similar studies were also carried out in the following four regions of Kyushu: Jyugyomori of Fukuoka Prefecture, Otobara and Shimouke of Oita Prefecture, and Ishikura of Saga Prefecture. Six locations were selected from each region and landslide susceptibility was analysed using the chi-square method. At Location A (Jyugyomori of Fukuoka Prefecture), the landslides were determined at 99 % confidence level, whereas at Location F (Otobara of Oita Prefecture) they were delimited at 99 % confidence level. Similarly, at Location C (Ishikura of Saga Prefecture) the landslide-prone areas were identified with 99.9 % confidence level (Table 2).

Table 2: Summary of Chi-square analysis for landslide-prone regions of Kyushu

Region	Susceptibility	Location					
		A	B	C	D	E	F
Jyugyomori (Fukuoka Prefecture)	Landslide	1%					
	Stable						
Otobara (Oita Prefecture)	Landslide						1%
	Stable						
Ishikura (Saga Prefecture)	Landslide	0.1%		0.1%			
	Stable						
Shimouke (Oita Prefecture)	Landslide				0.1%		
	Stable						

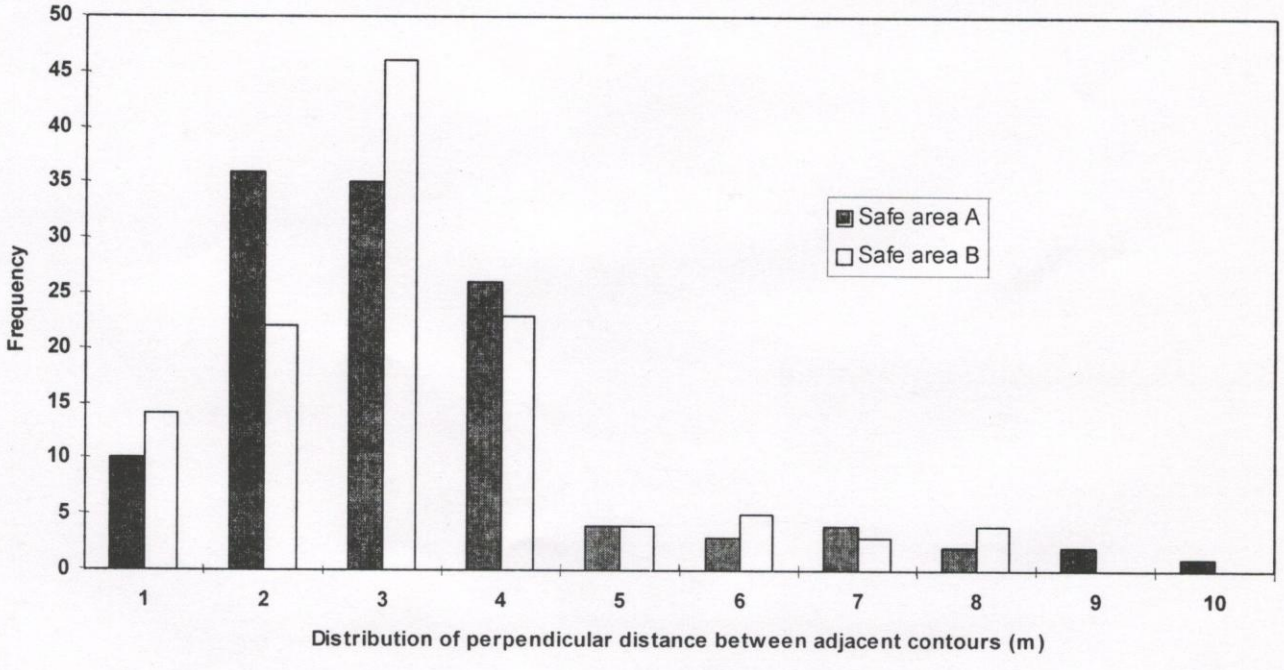

Fig. 4: A comparative frequency diagram for two safe areas in the Sasebo region

CONCLUSIONS

Chi-square analysis was carried out for dichotomous types of data to discriminate landslide hazard zones. The topographic data were classified into two fundamental patterns by studying frequency distribution histograms of contour interval and spacing. The landslide-prone areas distinctly showed some irregular multi-peaks while the safe areas had only one peak. The active landslides of western Kyushu were accurately discriminated by this method under 0.1 to 1 % confidence level.

REFERENCES

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