Terrace Structure Designing Based on Rainfall Erosivity and Soil Erodibility

Machito Mihara [1], ***Janya Sang-Arun*** [2] and ***Hisashi Mori*** [1]

[1]Tokyo University of Agriculture, Faculty of Regional Environment Science
1-1-1 Sakuragaoka Setagaya-ku, Tokyo 156-8502, Japan
[2]Mea Fah Luang University, School of Agricultural Technology
333 Moo. 1, Tasud Sub-district, Muang district, Chaing Rai, Thailand, 57100

Abstract: The objectives of this study are to discuss the relation between the density of rill formation and the geomorphological features in bench terrace of Doi Tung, and to propose the revised equation for indicating vertical interval between terraces in northern Thailand.

According to the results of direction and density of rill formation evaluated by image analysis, it was concluded that geomorphological features affected rill formation in bench terrace of Doi Tung. In addition, the results of statistical analysis indicated that vertical interval was in inverse proportion to average land slope, and it had a close relation with soil compaction factors. Thus, a revised equation for indicating vertical interval was proposed in this study.

Keywords: terrace structure, rainfall erosivity, soil erodibility, image analysis, correlation analysis, multiple regression analysis

1 Introduction

The hilly and mountainous land covers a large part of total area in northern Thailand. In upland fields of sloping area, soil erosion is one of the serious environmental problems. Soil erosion affects not only soil productivity but also water environment in down stream. There are many measures for soil and water conservation in upland fields of sloping area. Terrace construction is one of the effective measures for controlling soil erosion. Some equations for designing terrace structure were developed in USA. But it was judged that vertical and horizontal intervals of bench terraces in Doi Tung were not in agreement with the calculated ones.

In this study, the components of the equation for indicating vertical interval were discussed from a viewpoint of soil conservation. So the relation between the geomorphological factors such as vertical interval, horizontal interval, and average land slope etc., and the soil erodibility factors such as soil physical and chemical properties was investigated on the basis of image and statistical analysis. Consequently, the equation for indicating vertical interval of bench terrace in Doi Tung, northern Thailand, was proposed in this study.

2 Research area and methods

Research site located in Land Development Department (LDD) project site of Chiang Rai, Thailand is shown in Fig.1. Terrace structure in LDD projected site was surveyed by leveling, and soil erosion in bench terrace was observed. In order to investigate the direction and density of rill formation in bench terrace, the relation between geomorphological features and rill formation was considered on the basis of image analysis.

Additionally, vertical interval *V.I.*, horizontal interval *H.I.* and average slope *s* (Fig.2) were surveyed in projected site of LDD. Physical and chemical properties (Table 1) of soils sampled in each terrace were analyzed for calculating rainfall erosivity and soil erodibility.

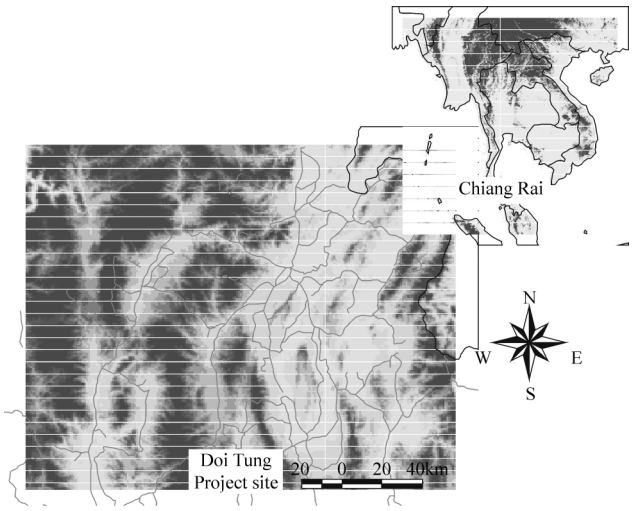

Fig.1 Location of research area

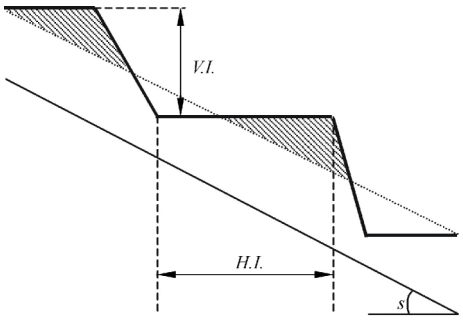

Fig.2 Measurement points in each terrace

Table 1 Soil physical and chemical properties analyzed

Physical properties	Chemical properties
Particle size distribution, %	Total nitrogen, 10^{-5}kg/kg
Specific gravity	Total phosphorus, 10^{-5}kg/kg
Dispersion ratio, %	
Ignition loss, %	
Dry density, g/cm^3	
Wet density, g/cm^3	
Saturated permeability, cm/s	
Erosion ratio, %	

3 Results and discussion

3.1 Relation between geomorphological features and rill formation in bench terrace

Terrace structure in LDD project site was shown in Fig.3. According to the results of cross leveling, the point of about 15 m in horizontal interval was likely to be lower than other points in terrace.

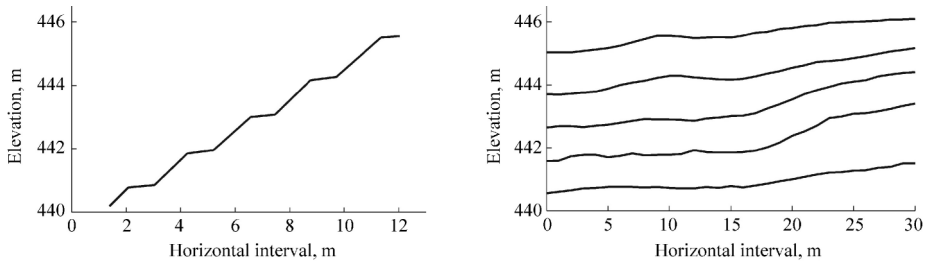

Fig.3 Profile and cross leveling in Doi Tung Project site

For investigating the direction and density of rill formation, the relation between geomorphological features and rill formations in bench terrace was analyzed with image analysis methods. A series of four photographs (Photos.1 to 4) illustrates rill formation on bench terrace. Around the point of about 15 m in

horizontal interval where was likely to be lower, the density of rill erosion was higher than other points in terrace.

3.2 Comparison between observed and calculated vertical interval based on former equation

Terrace construction is one of the effective measures for controlling soil erosion. Some equations for designing terrace structure were developed in USA. The vertical (*V.I.*, m) and horizontal intervals (*H.I.*, m) of terrace are expressed as follows.

$$V.I. = XS + Y \quad (1)$$

$$H.I. = 100\ V.I. / s \quad (2)$$

where X is the constant for geographical location, S the average land slope above the terrace in percent, Y the constant for soil erodibility and cover condition and s the average slope in percent, respectively.

The farmers constructed bench terraces of agricultural fields in Doi Tung Development Project site of Chaing Rai under the direction of Land Development Department (LDD). The observed *V.I.* and *H.I.* in those terraces were 0.432 m—1.124 m and 0.423 m—1.247 m, respectively, whereas the calculated *V.I.* and *H.I.* were 8.34 m—17.28 m (X = 0.12—0.24, Y = 0.30—1.20) and 13.03 m—25.79 m, respectively, as average slope of terraces was 67%. It was considered that the observed *V.I.* and *H.I.* of bench terraces in Doi Tung were not in agreement with the calculated ones based on Eqs.1, 2.

Photo 1 Front view of bench terrace

Photo 2 Transforming into grid data

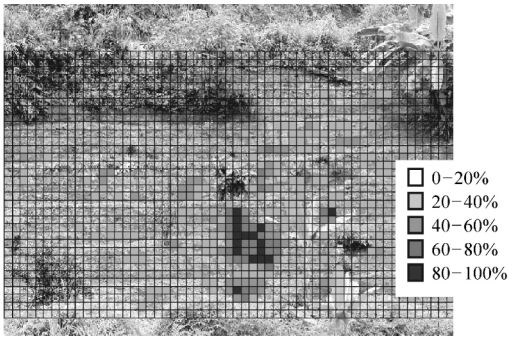

Photo 3 Rill density calculated in each mesh

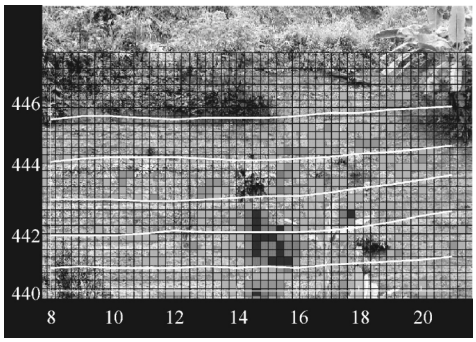

Photo 4 Pasting cross leveling results

3.3 Relation between geomorphological factors and soil properties

The components of the equation for indicating vertical interval were discussed from a viewpoint of soil properties using correlation and multiple regression analysis. According to the results of correlation analysis, *V.I.* was in inverse proportion to s. In addition, the results of multiple regression analysis indicated that *V.I.* was expressed as follows.

$$V.I. = 1.52\ Gr. + 3.09\ C.S. + 2.54\ C. + 2.93\ W.C. + 176.82\ D.D. + 0.50\ D.R. + 0.93\ M.E. - 2.00\ T.P. - 407.34 \quad (3)$$

where *Gr*. is the gravel in percent, *C.S*. the coarse sand in percent , *C*. the clay in percent, *W.C*. the water content in percent, *D.D*. the dry density in g/cm^3, *D.R*. the dispersion ratio in percent and *T.P*. the total phosphorus of soil in 10^{-5} kg/kg, respectively. It was considered that soil compaction factors became dominant in the results of multiple regression analysis. On the basis of correlation and multiple regression analysis, the revised equation (Eq.4) for calculating *V.I*. was derived as follows.

If Eq.3 is transformed Compaction factor,

$$Y = \beta \cdot \text{Compaction factor}$$

as *V.I*. is in inverse proportion to *S*

$$V.I.\ (\text{cm}) = X / S\ (\%) + \beta \cdot \text{Compaction factor} \quad (4)$$

The value of β may be approximately 10^{-2} from the relation between *V.I*. in Eq.3 of 43.2—112.4 and *Y* values of 0.30—1.20. Consequently, the equation for indicating vertical interval was follows.

$$V.I.\ (\text{cm}) = X / S\ (\%) + 10^{-2} \cdot \text{Compaction factor} \quad (5)$$

A revised equation for indicating vertical interval was proposed in this study.

4 Conclusion

The objectives of this study are to discuss the relation between the density of rill formation and the geomorphological features in bench terrace of Doi Tung, and to propose the revised equation for indicating vertical interval between terraces in northern Thailand.

According to the results of direction and density of rill formation evaluated by image analysis, it was concluded that geomorphological features affected rill formation in bench terrace of Doi Tung. In addition, the results of statistical analysis indicated that vertical interval was in inverse proportion to average land slope, and it had a close relation with soil compaction factors. Thus, a revised equation for indicating vertical interval was proposed in this study.

Reference

G.O. Schwab, D.D. Fangmeier, W.I. Elliot and R.K. Frevert, 1993, Soil and water conservation engineering, John Wiley & Sons, Inc, pp.153- 171.

R.H. Howeler, 1996, The use of farmer-participatory research methodologies to enhance the adoption of soil conservation practices in cassava-base cropping systems in Asia, Soil and Water Conservation Society of Thailand: From Concept to Adoption, pp.159-168.

W. Critchley, Samran Sombatpanit, S. M. Medina, 2001, Uncertain steps? Terrace in the tropics, Response to Land Degradition, Oxford & IBH Publish Co. Pvt. Ltd., pp. 325-338.