（様式２）

学位論文の概要及び要旨

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題　目　Study on Runoff and Water Balance in the Northern Loess Plateau
(黄土高原北部における流出と水収支に関する研究)

学位論文の概要及び要旨

Introduction:

In Chinese Loess Plateau, especially, in the northern Loess Plateau, environmental degradation and ecological destruction caused severe land erosion and high risk of desertification. Vegetation cover is respected as an effective measure to resist land desertification. Apparently, the available water resources are necessary to guarantee the landscape engineering into practice. However, the average annual precipitation in Loess Plateau is only 400 mm with different-seasonal distribution which results in the water resources are relatively deficient. Consequently, clarification of the runoff characteristics and estimation of the annual water resources are significant for the implementation of the landscape engineering in the northern Loess Plateau.

The research activities of this study were conducted on Liudaogou Basin in the northern Loess Plateau with the aims to clarify the surface runoff characteristics, to evaluate the effects of the check dam systems on runoff redistribution, and to estimate the annual available water resources in the northern Loess Plateau.

Methodology:

The research approach mainly used in this study is data analysis. The essential data were obtained from the field observation and the numerical calculation.

(1) The main characteristics of the surface runoff were clarified through analyzing the data which were achieved by field observation and numerical calculation of the surface runoff. According to the actual topographic and ground conditions of Liudaogou Basin, a numerical calculation model was developed basing on conventional kinematic wave theory combined with the hypothetical channel networks. The digital elevation data was obtained by using a topographic map of Liudaogou Basin for generating the hypothetical channel networks of the study area. Validity of the model was tested and verified by numerical simulation of the observed surface flow. The runoff numerical calculation in recent years (2005-2008) was carried out using the developed runoff calculation model.

(2) Based on analysis of the data obtained from the field observation and numerical calculation of the surface runoff, each component of annual water budget and monthly water income and expenditure was estimated. Further, index of annual water balance and index of monthly water income and expenditure were respectively established. According to the annual water budget, the annual available water resources were approximately evaluated.

(3) Effects of the check dam system on runoff redistribution were clarified through comparison of the numerical calculation results between a control case of the original situation without a check dam and the present situation with the check dam system in the year of 2006. As an effective engineering control measure for mitigating the land erosion and the sediment transportation, the check dam was constructed in many gullies in Loess Plateau. A check dam system, a check dam combined with the sediment filled area which was formed in front of the check dam, significantly impacts on the runoff redistribution in every small basin. For the purpose of clarifying the effects of the check dam, a numerical calculation model of runoff calculation of the sediment filled area was developed basing on the actual conditions of a

sediment filled area in Liudaogou Basin. Applicability of this model was validated by fit to the observed data of the groundwater level at the sediment filled area. The calculational method of evapotranspiration over the grassland was used in the model to approximately estimate the actual evapotranspiration over the sediment filled area. Numerical calculation in the year of 2006 was respectively carried out for three cases such as Case 1, the original situation without a check dam; Case 2, an assumed case with a check dam but without sediment filled area; Case 3, with a check dam system.

Results & Conclusions:

(1) For the surface runoff characteristics:

- The necessary conditions of the surface flow generation for saturated topsoil condition and unsaturated topsoil condition are the rainfall intensity $\geq$ 0.6 mm/5min and the rainfall intensity $\geq$ 2.6 mm/5min respectively.
- Mechanism of the surface flow generation caused by the low intensity with long duration rainfall and the high intensity rainfall were clarified respectively.
- The surface flow is seriously influenced by the rainfall intensity after generating, and the surface runoff will disappear soon after the end of rainfall.
- The mean rainfall intensity is a major influence factor of the surface runoff rate.
- The runoff rate in the normal year is approximately 10 % - 15 %.

(2) For the annual water balance and the monthly water income and expenditure

Index of the annual water balance and index of monthly water income and expenditure were established. Moreover, the annual available water resources were roughly estimated in the normal year.

(3) For the effects of the check dam system

According to the numerical calculation results in 2006, effects of the check dam system on runoff redistribution are as follows.

- The surface runoff was significantly reduced to 40 % of the original condition without a check dam.
- The total water input was redistributed at the sediment filled area. Redistribution ration to evapotranspiration and infiltration from the runoff was 49.3 %, 11.6 % respectively.

Combined with the related studies of the check dam system on reducing the soil erosion, the effects of the check dam system mainly manifests in the following areas.

- Increase the available water resources in every basin and increase rainfall probability within the range of Loess Plateau.
- Reduce soil erosion and sediment transportation
- Create the farmland and promote the agricultural production

Recommendations:

(1) In this study, a conventional runoff calculation model, which was developed by kinematic wave theory combined with hypothetical channel networks, was primarily validated to the runoff calculation of a small basin in Loess Plateau. The calculation model can also be applied to other basins in the northern Loess Plateau.

(2) In this study, the numerical calculation method was preliminary used on runoff calculation at the sediment filled area to analyze the effects of the check dam system on runoff redistribution. The model developed method can be applied to other sediment filled areas in the northern Loess Plateau.