RESEARCH ON BROAD SENSE WARNING SYSTEM OF LANDSLIDE HAZARD

Geng Dayu

滑坡灾害的广义预警系统研究

耿大玉 著

SEISMOLOGICAL PRESS
地震出版社

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图书在版编目(CIP)数据

滑坡灾害的广义预警系统研究 = Research on Broad Sense Warning System of Landslide Hazard / 耿大玉著 .—北京：地震出版社，2001.12

ISBN 7-5028-2043-4

Ⅰ.滑… Ⅱ.耿… Ⅲ.滑坡—预警系统—研究—英文 Ⅳ.P642.22

中国版本图书馆 CIP 数据核字（2001）第 016737 号

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责任编辑：薛广盈

责任校对：王花芝

出版发行：地震出版社

北京民族学院南路 9 号　　邮编：100081

发行部：68423031　68467993　　传真：68423031

E-mail：seis@ht.rol.cn.net

经销：全国各地新华书店

印刷：北京地大彩印厂

版（印）次：2001 年 12 月第一版　2001 年 12 月第一次印刷

开本：850×1168　1/32

字数：250 千字

印张：9.25

印数：0001～1000

书号：ISBN 7-5028-2043-4/P·1120（2598）

定价：28.50 元

Foreword

The mitigation method for reducing the effects of the main natural hazards of the European Alps—torrent disasters and snow avalanches is the "Forest Technical System for Torrent and Avalanche Control". This entails complex and comprehensive methods which contain hazard mapping for avoiding hazards, measures for regulating the catchment area (watershed management) and technical control works (correction of torrents, check dams, debris sorting dams, debris retention dams, draining of slipping slopes). These complex and comprehensive methods have been well developed in Austria during the last 115 years by a governmental organization named "Forest Technical Service of Torrent and Avalanche Control". Hazard mapping is used in Austria since the early seventies, and a law to regulate hazard mapping was applied in 1975. Warning as a mitigation measure is used against snow avalanche danger in skiing areas. In the Alpine region systems using automatic meteorological stations and computer assistance are well developed and are used by special avalanche experts.

Alarming and warning technology for slope failure and debris flow is well developed in Japan and China but in Europe it is hardly applied. In Europe the development of alarming technology or warning systems for slope failure, landslides or debris flow is just beginning. A big disaster—a high speed train was derailed when it was hit by a debris flow and three people were killed—was the beginning for this development for highways and railroads. The University of Agricultural Science–Vienna is a center for this

development in Austria.

The goal of this book was two fold: Firstly to collect alarming and warning technology and methods used mainly in China, Japan and other parts of the world for mitigation of slope failure, and secondly to develop a framework for applying these methods in developing and developed countries.

The findings of the book regarding alarming tools are very helpful for the development of alarming systems in Austria. The warning systems are adaptable for different purposes and technological development and are in this sense useful for any society.

A main point of the book was also the practical aspect of the work and therefore the designing of a real example-plan. The city of Baoji in the Shaanxi Province of the P.R.China was selected for this purpose. In co-operation with the Technical University of Vienna—Univ. Prof. Bruckl Ewald—it was possible to survey a big landslide and develop a plan for the warning system for this city.

At this point I would like to thank Dr.Geng Dayu and Prof. Bruckl Ewald for the excellent and fruitful co-operation and the valuable results.

Wolfgang Weinmeister
Vienna, 2001-10-25

中文序

灾害预警直接关系到减灾工作的成效，特别是在减轻人员伤亡方面。因此，预警系统研究对居民区的减灾，特别是对于人口稠密的城镇地区十分重要。然而，由于灾害预警系统同时涉及监测预报、信息处理、灾害应急和灾害管理等诸多方面，其相应的理论与应用研究都有一定的难度，故灾害预警系统的全面研究尚不多见，以往的成果常局限于灾害预警系统的某个环节，如规划设计、仪器研制、试验研究等。本书则通过对灾害预警系统的全面研究，提出广义的预警系统，包含监测、报警、响应、反馈等多重环节，颇有新义。本书的特点有：

一、先进性。作者以我国的特定地区为研究对象，充分利用自己多年来在国外进行同类课题研究的有利条件，站在本领域的前沿，洋为中用，兼收并蓄，博采众家之长，充分反映国际上的最新进展。介绍了将多种地球物理技术用于预警系统的研究、开发与建设的国内外最新成果。

同时，在深入分析当今人为灾害致灾原因的基础上，指出人们思想观念方面的预警亦不容忽视，并由此强调了可持续性发展的重要性。

二、跨学科性。由于灾害预警系统的优化研究涉及诸多学科，因此，作者采用跨学科的方法，发挥学科交叉的综合减灾优势，书中不仅反映了滑坡、泥石流减灾中不同学科的实际应用，而且反映了自然科学与社会科学的结合使灾害预警收到事半功倍的效果。

三、应用性。本书不仅提出了灾害预警系统的模型，而且结合具体地区（如宝鸡、重庆）的滑坡减灾实际情况，给出了预警系统建设的设计方案，包括高科技手段的应用与减灾管理

的结合。如上下结合、专群结合、土洋结合，并提出在一个地区实施市、区、乡三级预警系统的构想。

四、可交流性。本书采用英文版，不仅我国的学者可以了解国际同行在滑坡、泥石流减灾方面的研究成果，也便于国际同行，尤其是发展中国家的同行，了解我国在本领域的长足发展。

预祝本书的出版为促进我国灾害预警研究的发展作出贡献。

郭增建教授
中国地震局兰州地震研究所名誉所长
中国地球物理学会天灾预测委员会主任
2001 年 12 月

Preface

*B*eing a scientist on hazard mitigation in China, I was fortunate to get support from Austria Academy Exchange Service (ÖAD) to carry out a research project " Study on the Countermeasures Against Environmental Geological Hazards in Urban Area" in 1995. My supervisor, Professor H.W. Weinmeister, the former leader of the Institute of Forest and Mountain Risk Engineering (Institute of Torrent and Avalanche Control, WLS), University of Bondenkultur, Vienna, kindly invited me to carry out the study in his institute. As my project was under a very large topic, I concentrated on a small part of it, i.e. to focus on concrete "Countermeasure" and concrete " Hazard". In this regard, Professor Weinmeister suggested me to take the warning systems for slope hazard and as I know that Professor Weinmeister's institute is experienced in slope hazard mitigation with honour in Europe. And the warning system is really a cure for many kinds of hazards in the world. However, being a geophysist, I hoped that my work should use the technology of environmental engineering geophysics. Fortunately, I joined the Project IDNDR 12, " Cause and Effect—Model of Large Landslide", of Professor Brueckl Ewald, leader of the Section of Geophysics, Vienna University of Technology, supported by Academy of Austria in 1997. In the next year, I was luckily selected as a member of "Chun-Hui" project to solve the environmental problems in Three Gorges area Yangtze River, Chongqing City. Encouraged by the Ministry of Education of China and local governments, the cooperative relation between my Austria colleagues and Chinese

colleagues was set up. Some cooperative projects were as follows: "Physical modeling study of the stability of slopes under the effect of reservoir fluctuation and rainstorm in Three Gorges area"; "Numerical simulation of the effect of reservoir fluctuation on stability of slope and instability prediction"; "Slope stability active monitoring based on piezo-electric sensitive array"; "Remote sensing and date transmission with internet for landslide monitoring in Three Gorges"; "Reservoir caused landslide hazard mitigation by environmental geophysical methods in Three Gorges"; "Geophysical research Baoji landslide"; "Unitary model both of hazard control and development functions in urban regions nearby Three Gorges reservoir" and "Application of engineering geophysics in geological hazard investigation".

The book in your hand is based on the research of the projects mentioned above. The main idea of the book is that the model of broad sense warning system is really different from a piece of equipment of alarming or warning. It is associated with the whole society of the region threatened by hazard, rather than with a small group of people or some kinds of vehicles. In fact, I've have found some examples in China, Japan, Italy and USA which are similar to this model. However, to some extent, they have the characteristics of their own. I hope that people may get some idea to modify their warning system from the general complete model of the broad sense warning system discussed in this book. As those projects still not finished, some detail of related data can hardly be collected and shown. Therefore, this research built up a model of study, rather than a practical engineering method.

It is clear that natural disasters lead to great losses to lives and properties in the world and become the major factors hampering the sustainable development of economy. In this book severe situation of slope hazards (landslides, debris flows and rock falls) is overviewed.

The worldwide development of natural hazard warning system is summarized, including the relative achievements on slope hazard reduction in China. To strengthen the ability of natural hazard prevention, the model of broad sense warning system is developed, based on the practices of slope hazard mitigation. The system is shown with some advanced examples of slope hazards warning system in different countries. It has been shown that the regional broad sense warning system against slope hazards is an engineering system including scientific and technological countermeasures ("hard" countermeasures) and municipal administration as well as public education ("soft" countermeasures). It needs a special department of the local government which is in charge of recognizing the potential of forth-coming hazards, managing the financial support, coordinating activities of the "soft" and "hard" countermeasures, setting up and promulgating primary codes and education programs and carrying out hazard mitigation in case of emergency. A complete broad sense warning system consists of four subsystems and a central database. Detection subsystem includes monitoring section, assessing section and prediction section. Management subsystem includes interpret section, decision-making section and modification section. Response subsystem includes disaster response channels, individual response and public response. Feedback subsystem includes real-time data section, comparison section and feedback section. Central database is the heart of the warning system, carrying on all tasks of data processing, stability analysis, hazard assessment and prediction.

The application of hi-tech., including GPS and RS (remote sense) for monitoring, GIS for mapping, etc., will make the real-time detective subsystem feasible. Some sensors for different natural hazard processes are described. The applications of environmental engineering geophysics are functional and economical for the

potential slope hazards investigation and for the estimation of the environmental limitation. Meteorological, hydrological and seismological studies can be used for estimation of the antecedent and threshold of the events. Special training programs should be developed to give people different levels of education. That will be of importance for management subsystem and for response system. The feedback subsystem equipped with hi-tech. methods should become an essential part of the warning system.

In this warning system, not only modern advanced technology with automatic instruments but also traditional experiences with simple methods of local inhabitants are used in the regional monitoring and warning. Scientists, engineers, government officials and local residents should all together take part in hazard mitigation. Therefore, the result of hazard reduction will be better than any other kind of warning methods. In other words, as the broad sense warning system needs the activities and cooperation of the whole community, and the functioning of the broad sense warning system will benefit the whole community in return. From some local hazard reduction experiences, it is clearly shown that the self- rescue and rescue-each-other by local residents in emergency are very efficient when the warning system applied. The functioning of the broad sense warning system will bring economic benefit and social benefit to the society. It is proved to be among the most efficient scientific methods backing the worldwide recognized notion of sustainable development, which means a kind of economic development well planned and controlled, leaving as little negative effect as possible to the living environment of man-kind and without possibilities to be stopped by itself. In fact, it is really the cure to the man-induced hazards, including slope hazards. The practice of the system in China serves as a good example for developing countries.

This work was carried out at the Institute of Forest and

Mountain Risk Engineering (former Institute of Torrent and Avalanche Control, WLS), University of Bondenkultur, Vienna, and the Dept. of Geophysics, Vienna University of Technology. The funding was made available firstly by Austria Academy Exchange Survive (ÖAD), then by the two institutes mentioned above and Earthquake Engineering Institute of Shaanxi Province, Seismological Bureau of Shaanxi Province, P. R. China.

First of all, I would like to thank Austria Academy Exchange Survive (ÖAD), who gave me a chance to begin my advanced study as a guest scientist in this field. Meanwhile, I would like to express my sincere acknowledgement to Science and Technology Committee of Shaanxi Province, P.R. China who supported me with the research project "The Application of Environmental Engineering Geophysics in Geological Hazard Mitigation since 1999. This book used part of the result of that project.

I would like to give my special appreciation to Prof. H. W. Weinmeister, head of WLS, University of Bondenkultur, Vienna and Prof. Bruckl Ewald, head of the Dept. of Geophysics, Vienna University of Technology. Without their help, advice and support, the work would not be possible.

I am grateful to my Austria colleagues of the two universities, who have helped me a lot to keep my work going on smoothly.

Particular mention must be made to the colleagues in USA, Japan, Austria and China, from whom some data used in my work are collected, e.g. USGS hazard information database, Tottoti University of Japan, the research groups of China-Austria Cooperative Landslide Research Project in Baoji and Slope Hazard Mitigation Research Projects in Chongqing, Three Gorges Reservoir Area.

I also want to extend my gratitude to my University—The Huaihai Institute of Technology who offered substantial supports to

me during the whole process of publication.

Geng Dayu
Huaihai Institute of Technology
Lianyungang, 2001-10-1

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