



# Health facility seismic vulnerability evaluation

– a handbook –



# Health facility seismic vulnerability evaluation

## A handbook

Disaster Preparedness and Response Programme (DPR)  
Division of Country Support, Country Policies, Systems and Services (DCS/CPS)  
World Health Organization, Regional Office for Europe (WHO/EURO)

## Keywords

Address requests about publications of the WHO Regional Office to:

Publications

WHO Regional Office for Europe

Scherfigsvej 8

DK-2100 Copenhagen Ø, Denmark

Alternatively, complete an online request form for documentation, health information, or for permission to quote or translate, on the Regional Office web site (<http://www.euro.who.int/pubrequest>).

© World Health Organization 2006

All rights reserved. The Regional Office for Europe of the World Health Organization welcomes requests for permission to reproduce or translate its publications, in part or in full.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Where the designation “country or area” appears in the headings of tables, it covers countries, territories, cities, or areas. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

The mention of specific companies or of certain manufacturers’ products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

The World Health Organization does not warrant that the information contained in this publication is complete and correct and shall not be liable for any damages incurred as a result of its use. The views expressed by authors or editors do not necessarily represent the decisions or the stated policy of the World Health Organization.

# CONTENTS

<i>FOREWORD</i> .....	<i>v</i>
<i>PREFACE</i> .....	<i>vi</i>
LIST OF FIGURES AND TABLES .....	vii
1. INTRODUCTION .....	1
2. SEISMIC VULNERABILITY OF HEALTH FACILITIES .....	3
2.1. Health facility vulnerability/damageability factors .....	3
2.2. Structural vulnerability.....	3
2.2.1. Background .....	3
2.2.2. Architectural and structural configuration problems .....	4
2.2.3. Assessment of nonstructural vulnerability.....	5
2.3. Nonstructural vulnerability .....	5
2.3.1. Background .....	5
2.3.2. Nonstructural elements and causes of nonstructural damage .....	6
2.3.3. Assessment of nonstructural vulnerability.....	6
2.4. Administrative/organizational vulnerability .....	8
2.4.1. Background .....	8
2.4.2. Administrative aspects.....	9
2.4.3. Organizational aspects .....	9
2.4.4. Assessment of administrative/organizational vulnerability.....	11
3. HEALTH FACILITY INTEGRATED VULNERABILITY EVALUATION METHOD .....	12
3.1. Basis of the method .....	12
3.2. General vulnerability evaluation .....	13
3.2.1. General data .....	13
3.2.2. Seismic exposure and preparedness.....	14
3.2.3. Health facility performance.....	14
3.3. Structural vulnerability evaluation .....	14
3.3.1. General building data.....	14
3.3.2. Occupancy load .....	15
3.3.3. Soil category .....	15
3.3.4. Existing damage.....	16
3.3.5. Vulnerability indices/modifiers.....	16
3.3.6. Determining the structural vulnerability level .....	16
3.4. Nonstructural vulnerability evaluation.....	16
3.4.1. Nonstructural risk ratings.....	16
3.4.2. Determining the nonstructural vulnerability/consequences level.....	18
3.5. Administrative / organizational vulnerability evaluation .....	19
3.5.1. Capability assessment.....	19
3.5.2. Spatial distribution of services .....	20
3.5.3. External interdependence.....	20

4. SEISMIC RISK MITIGATION STRATEGIES.....	21
4.1. Reducing structural vulnerability.....	21
4.2. Reducing nonstructural vulnerability.....	23
4.2.1. Mitigation measures.....	23
4.2.2. Mitigating damage to equipment and furnishings .....	24
4.3. Reducing administrative/organizational vulnerability .....	25
5. SUMMARY .....	27
REFERENCES .....	30
FURTHER READING .....	31
ANNEX 1. Health facility vulnerability evaluation forms .....	32
ANNEX 2. The main building types used for health facilities in Europe .....	41
ANNEX 3. Grading of seismic damage to buildings according to EMS-98 .....	46
ANNEX 4. Seismic exposure estimation.....	48
ANNEX 5. Seismic damage to health facilities.....	52

## **FOREWORD: “Hospitals safe from disasters” a priority for preparedness programmes**

*The World Health Organization Regional Office for Europe is, within the framework of the strategy of “Matching the services to country needs” and in line with the World Health Organization global strategic priorities of “Health Action in Crises”, committed to assist its 52 member states in strengthening the capacity of their health systems to respond to future crisis situations.*

*The health sector in general and hospitals and health facilities in particular play an essential role in the response to all kinds of natural or man-made disasters, as the protection of human beings and their health is of primary importance in all emergencies. Strengthening health systems to enable them to provide reliable services in crisis situations, when systems typically tend to be overwhelmed, needs to be promoted as a key area of concern in all European countries. Increasingly, as societies confront new challenges and threats, preparedness efforts have to be adapted accordingly. When chemical, biological, radiological or nuclear threats – or terrorist attacks – are added to the already extensive list of potential technological and natural hazards, essential health services must become better prepared to respond and to function adequately in crisis situations.*

*Lessons learnt from previous crises clearly indicate that sound preventive efforts largely pay off in subsequent emergencies. Preparedness programmes are more effective when they are designed and implemented as a continuous process, based on a sound analysis of hazards and vulnerabilities. Ministries of health, as the government institutions responsible for securing and coordinating the public health response in crises, require political support, including appropriate financial and human resources, to ensure that the health system is prepared for and able to cope with disasters, with reliable hospitals and health facilities being of utmost importance to provide essential services to victims.*

*The WHO Regional Office for Europe, specifically the disaster preparedness and response programme in synergy with other relevant technical units, is committed to cooperating closely with WHO Member States and other stakeholders to achieve tangible results at the country level and to contribute globally to the WHO global expected results. Reliable health facilities – as functioning safe havens for disaster victims in the aftermath of a crisis – have been identified as a potential indicator for the effectiveness of national preparedness programmes. The international Kobe conference in early 2005 and the resulting Hyogo framework for action have highlighted the importance of “hospitals (being constructed in a way that makes them) safe from disasters”.*

*The WHO preparedness and response programme offers technical support to countries to effectively promote evidence-supported interventions to prepare for crisis situations, so that avoidable suffering and death are minimized, health systems are protected and repaired, and national authorities and communities enabled to prepare, respond, recover and mitigate the effects of natural and man-made disasters within and across the Region.*

*This handbook has been developed with the assistance of the Institute of Earthquake Engineering and Engineering Seismology to provide practical guidance to hospital managers in assessing the vulnerabilities of health facilities, identifying structural and functional gaps and weaknesses, and collaborating with technical experts to ensure that hospitals and health facilities are constructed in a way that ensures that health services remain functional in the aftermath of disasters, when they are needed most.*

Dr Gerald Rockenschaub  
Regional Adviser, Disaster Preparedness and Response  
WHO Regional Office for Europe

## PREFACE

*A severe earthquake is one of nature's most terrifying and devastating events, resulting in widespread destruction. Apart from causing, in most cases, huge economic and social disruption, such events also have a sudden and massive impact on the health status and health conditions of the population affected. Experience from past earthquakes throughout the world clearly shows that the health facilities in the affected area are the key to launching an immediate response. There is a widely held expectation that hospitals and other health facilities are prepared to deal with any crisis. In general this may be a valid perception, but past events have demonstrated that health facilities may be particularly vulnerable to earthquakes and therefore rendered unable to respond. The seismic vulnerability of hospitals, if compared to other buildings and installations of equal size and construction, is more complex since it is generated by their structural, functional, technological and administrative/organizational performance.*

*Given the importance of an efficient response to emergencies and the need for a functional health care infrastructure in the aftermath of a disaster, hospital administrators must assess a facility's vulnerability to earthquakes and obtain estimates of existing risk levels in order to ensure a proper response to emergency needs. A reliable and comprehensive hospital assessment can be carried out only by taking into account all three main vulnerability categories – structural, nonstructural and administrative/organizational – in that order.*

*In the light of the principal issues regarding vulnerability reduction in health facilities emanating from the World Conference on Disaster Reduction held in Kobe, Japan in January 2005, the WHO Regional Office for Europe asked the Section for Risk, Disaster Management and Strategic Planning at the Institute of Earthquake Engineering and Engineering Seismology in Skopje to develop a seismic vulnerability evaluation method for health facilities. The method that has been developed will enable hospital administrators to perform a preliminary (qualitative/quantitative) vulnerability assessment, identify possible weak elements in the facility and the main vulnerable areas, and decide on priorities for any necessary further “in-depth” investigations. It takes account of characteristic European features such as the predominant types of building used for health facilities, and uses existing methods for vulnerability assessment and the European Macroseismic Scale for determining the possible seismic demand. Nevertheless, the method is also suitable for the other WHO European Member States in, for example, the Caucasus and central Asia.*

*The Institute of Earthquake Engineering and Engineering Seismology is indebted to the Regional Office for recognizing the need to carry out such an activity as well as for financial support. The authors believe that the proposed method will be widely promoted in the European Region of WHO. Comments and suggestions from the scientific community and from professionals in the field that will result from its implementation will contribute to its improvement, calibration and adjustment to the variety of seismic exposure conditions existing throughout Europe.*

15 July 2005

Dr Goran S. Trendafiloski  
Principal Project Investigator

## LIST OF FIGURES AND TABLES

Fig. 2.1. Samples of complex plans (a) and irregular vertical shapes (b) .....	4
Fig. 2.2. Methods for assessing structural vulnerability.....	5
Fig. 2.3. Effects of earthquakes on nonstructural elements .....	7
Fig. 2.4. Major clinical relationships.....	9
Fig. 3.1. Structure of the HVE method.....	12
Fig. 3.2. Expected damage grade and vulnerability vs total vulnerability index.....	17
Fig. A2.1. M3.1 masonry building type.....	41
Fig. A2.2. RC1 building type .....	43
Fig. A2.3. RC2 building type .....	43
Fig. A2.4. RC5 building type .....	44
Fig. A2.5. RC6 building type .....	45
Fig. A4.1. Status of aseismic design codes in WHO European Member States.....	48
Table 2.1. Nonstructural elements in a health facility .....	6

预览已结束，完整报告链接和二维码如下

[https://www.yunbaogao.cn/report/index/report?reportId=5\\_29725](https://www.yunbaogao.cn/report/index/report?reportId=5_29725)